Attachment 1-5

Response to 2009 RAIs

**SOUTH TEXAS PROJECT
SUPPLEMENTAL RESPONSE TO GL 2004-02
EMERGENCY SUMP PERFORMANCE
RESPONSES TO
REQUESTS FOR ADDITIONAL INFORMATION
RECEIVED DECEMBER 2009
AE-NOC-10001951 STI: 32613722**

A. Debris Generation/Zone of Influence (ZOI)

Please respond to the following questions on debris generation testing. Note that the Pressurized-Water Reactor Owners Group (PWROG) is planning to respond to some of these issues generically. The licensee will be expected to respond to all of them. To the extent NRC staff accepts the PWROG's generic resolution, the licensee's request for additional information (RAI) responses may refer to the resolution document as appropriate, while adding site-specific information as needed.

RAI #1
Although American National Standards Institute (ANSI)/American Nuclear Society (ANS) standard 58-2-1988, "Design Basis for Protection of Light Water Nuclear Power Plants Against Effects of Postulated Pipe Rupture," predicts higher jet centerline stagnation pressures associated with higher levels of subcooling, it is not intuitive that this would necessarily correspond to a generally conservative debris generation result. Please justify the initial debris generation test temperature and pressure with respect to the plant-specific reactor coolant system (RCS) conditions, specifically the plant hot-and cold-leg operating conditions. If ZOI reductions are also being applied to lines connecting to the pressurizer, then please also discuss the temperature and pressure conditions in these lines. Please describe the results of any tests conducted at alternate temperatures and pressures to assess the variance in the destructiveness of the test jet to the initial test condition specifications.

Response to RAI #1

The current RoverD approach uses a 17D ZOI for fiberglass insulation which is consistent with the NRC accepted guidance given in NEI 04-07. Thus this question is no longer applicable.

RAI #2
Please describe the jacketing/insulation systems used in at South Texas Project (STP), Units 1 and 2, for which ZOI reduction is sought and compare those systems to the jacketing/insulation systems that were tested demonstrating that the tested jacketing/insulation system adequately represent the plant jacketing/insulation system. The description should include differences in the jacketing and banding systems used for piping and other components for which the test results are applied, potentially including steam generators, pressurizers, reactor coolant pumps, etc. At a minimum, the following areas should be addressed:

a. Please describe how the characteristic failure dimensions of the tested jacketing/insulation compared with the effective diameter of the jet at the axial placement of the target. The characteristic failure dimensions are based on the primary failure mechanisms of the jacketing system (e.g., for a stainless steel jacket held in place by three latches where all three latches must fail for the jacket to fail, then all three latches must be effectively impacted by the pressure for which the ZOI is calculated). Applying test results to a ZOI based on a centerline pressure for relatively low L/D nozzle to target spacing would be non-conservative with respect to impacting the entire target with the calculated pressure.

b. Please explain whether the insulation and jacketing system used in the testing was of the same general manufacture and manufacturing process as the insulation used in the plant. If not, please explain what steps were taken to ensure that the general strength of the insulation system tested was conservative with respect to the plant insulation. For example, it is known that there were generally two very different processes used to manufacture calcium silicate whereby one type readily dissolved in water but the other type dissolves much more slowly. Such manufacturing differences could also become apparent in debris generation testing, as well.

c. Please provide results of an evaluation of scaling the strength of the jacketing or encapsulation systems to the tests. For example, a latching system on a 30-inch pipe within a ZOI could be stressed much more than a latching system on a 10-inch pipe in a scaled ZOI test. If the latches used in the testing and the plants are the same, the latches in the testing could be significantly under-stressed. If a prototypically sized target were impacted by an undersized jet, it would similarly be under-stressed. Evaluations of banding, jacketing, rivets, screws, etc., should be made. For example, scaling the strength of the jacketing was discussed in the Ontario Power Generation report, "Jet Impact Tests -Preliminary Results and Their Application, N-REP-34320-10000," dated April 18, 2001 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML020290085), on calcium silicate debris generation testing.

Response to RAI #2
The current RoverD approach uses a 17D ZOI for fiberglass insulation which is consistent with the NRC accepted guidance given in NEI 04-07. Thus this question is no longer applicable.

RAI #3

There are relatively large uncertainties associated with calculating jet stagnation pressures and ZOIs for both the test and the plant conditions based on the models used in the WCAP reports. Please describe the steps taken to ensure that the calculations resulted in conservative estimates of these values. Please provide the inputs for these calculations and describe the sources of the inputs.

Response to RAI #3

The current RoverD approach uses a 17D ZOI for fiberglass insulation which is consistent with the NRC accepted guidance given in NEI 04-07. Thus this question is no longer applicable.

RAI #4

Please describe the procedure and assumptions for using the ANSI/ANS-58-2-1988 standard to calculate the test jet stagnation pressures at specific locations downrange from the test nozzle. As part of this description, please address the following points.

a. In WCAP-16710-P, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) of Min-K and NUKON Insulation, for Wolf Creek and Callaway Nuclear Operating Plants," please explain why the analysis was based on the initial condition of 530 degrees Fahrenheit (°F) whereas the initial test temperature was specified as 550 °F.

b. Please explain whether the water subcooling used in the analysis was that of the initial tank temperature or the temperature of the water in the pipe next to the rupture disk. Test data indicated that the water in the piping had cooled below that of the test tank.

c. The break mass flow rate is a key input to the ANSIIANS-58-2-1988 standard. Please explain how the associated debris generation test mass flow rate was determined. If the experimental volumetric flow was used, then explain how the mass flow was calculated from the volumetric flow given the considerations of potential two-phase flow and temperature-dependent water and vapor densities. If the mass flow was analytically determined, then describe the analytical method used to calculate the mass flow rate.

d. Noting the extremely rapid decrease in nozzle pressure and flow rate illustrated in the test plots in the first tenths of a second, please explain how the transient behavior was considered in the application of the ANSI/ANS-58-2-1988 standard. Specifically, please explain whether the inputs to the standard represented the initial conditions or the conditions after the first extremely rapid transient (e.g., say at one tenth of a second).

e. Given the extreme initial transient behavior of the jet, please justify the use of the steady-state ANSI/ANS-58-2-1988 standard jet expansion model to determine the jet centerline stagnation pressures rather than experimentally measuring the pressures.

Response to RAI #4

The current RoverD approach uses a 17D ZOI for fiberglass insulation which is consistent with the NRC accepted guidance given in NEI 04-07. Thus this question is no longer applicable.

RAI #5
Please describe the procedure used to calculate the isobar volumes used in determining the equivalent spherical ZOI radii using the ANSI/ANS-58-2-1988 standard. Please include discussions of the following points.

a. Please provide the assumed plant-specific RCS temperatures and pressures and break sizes used in the calculation. Please note that the isobar volumes would be different for a hot-leg break than for a cold-leg break since the degree of subcooling is a direct input to the ANSI/ANS-58-2-1988 standard and which affects the diameter of the jet. Also, please note that an under-calculated isobar volume would result in an under-calculated ZOI radius.

b. Please describe the calculational method used to estimate the plant-specific and break-specific mass flow rate for the postulated plant loss-of-coolant accident (LOCA), which was used as input to the standard for calculating isobar volumes.

c. Given that the degree of subcooling is an input parameter to the ANSI/ANS-58-21988 standard and that this parameter affects the pressure isobar volumes, please describe the steps taken to ensure that the isobar volumes conservatively match the plant-specific postulated LOCA degree of subcooling for the plant debris generation break selections. Please explain whether multiple break conditions were calculated to ensure a conservative specification of the ZOI radii.

Response to RAI #5

The current RoverD approach uses a 17D ZOI for fiberglass insulation which is consistent with the NRC accepted guidance given in NEI 04-07. Thus this question is no longer applicable.

RAI #6

Please provide a detailed description of the test apparatus, specifically including the piping from the pressurized test tank to the exit nozzle including the rupture disk system. Please also address the following related points:

a. Based on the temperature traces in the test reports, it is apparent that the fluid near the nozzle was colder than the bulk test temperature. Please explain how the fact that the fluid near the nozzle was colder than the bulk fluid was accounted for in the evaluations.

b. Please explain how the hydraulic resistance of the test piping which affected the test flow characteristics was evaluated with respect to a postulated plant-specific LOCA break flow, where such piping flow resistance would not be present.

c. Please provide the specified rupture differential pressure of the rupture disks.

Response to RAI #6

The current RoverD approach uses a 17D ZOI for fiberglass insulation which is consistent with the NRC accepted guidance given in NEI 04-07. Thus this question is no longer applicable.

RAI #7
WCAP-16710-P discusses the shock wave resulting from the instantaneous rupture of piping. Please address the following points regarding the shock wave:

a. Please describe results of analysis or parametric testing conducted to get an idea of the sensitivity of the potential to form a shock wave at different thermal-hydraulic conditions. Please state and justify whether temperatures and pressures prototypical of PWR hot legs were considered.

b. Please explain whether the initial lower temperature of the fluid near the test nozzle was taken into consideration in the evaluation, and if not, why not. Specifically, please explain and justify whether the damage potential was assessed as a function of the degree of subcooling in the test initial conditions.

c. Please provide the basis for scaling a shock wave from the reduced-scale nozzle opening area tested to the break opening area for a limiting rupture in the actual plant piping.

d. Please compare how the effect of a shock wave was scaled with distance for both the test nozzle, and compare that with the expected plant condition.

Response to RAI #7

The current RoverD approach uses a 17D ZOI for fiberglass insulation which is consistent with the NRC accepted guidance given in NEI 04-07. Thus this question is no longer applicable.

RAI #8

Please provide the basis for concluding that a jet impact on piping insulation with a 45 degree seam orientation is a limiting condition for the destruction of insulation installed on steam generators, pressurizers, reactor coolant pumps, and other non-piping components in the containment. For instance, considering a break near the steam generator nozzle, once insulation panels on the steam generator directly adjacent to the break are destroyed, the LOCA jet could impact additional insulation panels on the steam generator from an exposed end, potentially causing damage at significantly larger distances than for the insulation configuration on piping that was tested. Furthermore, it is not clear that the banding and latching mechanisms of the insulation panels on a steam generator or other RCS components provide the same measure of protection against a LOCA jet as those of the piping insulation that was tested. Although WCAP-16710-P asserts that a jet at Wolf Creek or Callaway cannot directly impact the steam generator, but will flow parallel to it, it seems that some damage to the steam generator insulation could occur near the break, with the parallel flow then jetting under the surviving insulation, perhaps to a much greater extent than predicted by the testing. Similar damage could occur to other component insulation. Please provide a technical basis to demonstrate that the test results for piping insulation are prototypical or conservative of the degree of damage that would occur to insulation on steam generators and other non-piping components in the containment.

Response to RAI #8

The current RoverD approach uses a 17D ZOI for fiberglass insulation which is consistent with the NRC accepted guidance given in NEI 04-07. Thus this question is no longer applicable.

RAI #9

Some piping oriented axially with respect to the break location (including the ruptured pipe itself) could have insulation stripped off near the break. Once this insulation is stripped away, succeeding segments of insulation would have one open end exposed directly to the LOCA jet, which appears to be a more vulnerable configuration than the configuration tested by Westinghouse. As a result, damage would seemingly be capable of propagating along an axially-oriented pipe significantly beyond the distances calculated by Westinghouse. Please provide a technical basis to demonstrate that the reduced ZOIs calculated for the piping configuration tested are prototypical or conservative with respect to the degree of damage that could occur to insulation on piping lines oriented axially with respect to the break location.

Response to RAI #9

The current RoverD approach uses a 17D ZOI for fiberglass insulation which is consistent with the NRC accepted guidance given in NEI 04-07. Thus this question is no longer applicable.

RAI #10

WCAP-16710-P noted damage to the cloth blankets that cover the fiberglass insulation, in some cases resulting in the release of fiberglass. The tears in the cloth covering were attributed to the steel jacket or the test fixture and not the steam/water jet. Please justify the assumption that damage that occurs to the target during the test would not be likely to occur in the plant. Please explain whether the potential for damage to plant insulation from similar conditions was considered. For example, the test fixture could represent a piping component or support, or other nearby structural member. The insulation jacketing is obviously representative of itself. Please provide the basis for the statement in the WCAP that damage similar to that which occurred to the end pieces would not be expected to occur in the plant. It is likely that a break in the plant will result in a much more chaotic condition than that which occurred in testing. Therefore, it would be more likely for the insulation to be damaged by either the jacketing or other objects nearby.

Response to RAI #10

The current RoverD approach uses a 17D ZOI for fiberglass insulation which is consistent with the NRC accepted guidance given in NEI 04-07. Thus this question is no longer applicable.

RAI #11
Please provide information that justifies that the Marinite® insulation is protected by the plate such that damage outside of 2D is not expected. Please provide information on the failure mode of the insulation and describe whether it is destroyed by the LOCA jet or whether it can be crushed by piping following a break. Alternately, please provide information that shows that all Marinite® that is installed in the general vicinity of the break is considered to be rendered into debris by the transient.

Response to RAI #11

Per the original plant design, the only Marinite (calcium silicate) insulation inside containment was installed on the Reactor Vessel nozzles. STPNOC has replaced all of the Marinite insulation with NUKON fiberglass insulation. This was accomplished for Unit 1 during the fall 2009 refueling outage when DCP 02-5326-126 was implemented by work order activity 477890 and for Unit 2 during the spring 2010 refueling outage when DCP 02-5326-128 was implemented by work order activity 477889. Thus this question is no longer applicable.

B. Debris Characteristics

RAI #12
The analysis assumption of 60 percent small fines and 40 percent large pieces for low-density fiberglass within a 5D ZOI is inconsistent with the Figure 11-2 of NRC staff's safety evaluation (SE), dated December 6, 2004 (ADAMS Accession No. ML043280641), on NEI 04-07, which considers past air jet testing and indicates that the fraction of small fines should be assumed to reach 100 percent at jet pressures in the vicinity of 18-19 pounds per square inch (psi). At 5D, the jet pressure is close to 30 psi, which significantly exceeds this threshold. Furthermore, the licensee's assumption that the size distribution for debris in a range of 5D to 7D is 100 percent intact blankets also appears not to be inconsistent with existing destruction testing data. These assumptions for low-density fiberglass debris size distributions appear to be based on the recent Westinghouse/Wyle ZOI testing discussed in WCAP-16710-P. However, that testing was not designed to provide size distribution information. Furthermore, given the assumption that insulation between 5D and 7D is 100 percent intact pieces that do not transport or erode, the licensee has effectively assumed a 5D ZOI rather than a 7D ZOI for low-density fiberglass. Also, it appears from the testing done by Westinghouse/Wyle for Arkansas Nuclear One (Entergy Operations, Inc. letter dated February 28, 2008, ADAMS Accession No. ML08071 0544), some damage was seen for Thermal Wrap even at 12D and at 7D. Considering that testing, please explain STP's treatment of Thermal Wrap with a 5D ZOI. Please describe the details of the jacketing and banding that support the same ZOI for both Nukon and Thermal Wrap for STP that is based on the Wolf Creek/Callaway testing. Please provide a detailed summary of the testing that was done, the similarity analysis for the insulation design, and a basis for the testing or other source of the debris distribution percentages that were assumed and why it is representative of the plant condition.

Response to RAI #12
The current RoverD approach uses a 17D ZOI for fiberglass insulation which is consistent with the NRC accepted guidance given in NEI 04-07. Thus this question is no longer applicable.

RAI #13

Please clarify what percentage of the small fines distribution represents fines and what percentage represents small pieces, and how the split between fines and small pieces was determined when preparing debris for head loss testing. This information is needed because the distribution of debris between the fine and small piece size categories has a significant impact on the measured strainer head loss, particularly for a strainer test that credits debris settlement.

Response to RAI #13

STP utilized 30% of the small fines as fine fiber debris for the ARL Large Flume Test.

Reference:

13.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.

C. Debris Transport

RAI #14

The December 11, 2008, supplemental response states on page 14 that 5 percent of small pieces of fiber are assumed to be trapped on wetted surfaces in congested areas due to changes in flow direction during blowdown. Please clarify whether this assumption is still part of the analysis, given that STP is now assuming a three-category size distribution for low-density fiberglass. If so, then please justify any assumption regarding this debris remaining trapped against a wetted vertical surface for any significant period of time.

Response to RAI#14

This RAI response has been written to support the applicability of analysis done to provide debris quantities for the July 2008 STP strainer head loss testing [14.1] to the RoverD methodology. The methodology [14.2] that defined the amount of fiber introduced in the July 2008 test is not relevant to the RoverD methodology because the RoverD methodology only uses the fiber debris amount from the July 2008 testing as a datum of comparison to the risk-informed CASA Grande generated and transported fiber quantities. All break locations where the debris quantities calculated in CASA Grande were below the datum would be considered to have passed deterministically. All other break locations would be dealt with using risk-informed calculations. More information about the RoverD methodology used for the debris generation and transport of fiber quantities for comparison to the tested fiber datum can be found in Attachment 1-2.

References:

14.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.

14.2 ALION-CAL-STPEGS-2916-005, *GSI-191 Containment Recirculation Sump Evaluation: CFD Transport Analysis*, Revision 3. October 2008

RAI #15

The December 11, 2008, supplemental response states on page 16 that one refinement to the 2004 NRC SE in the transport calculation for STP was that holdup of small pieces of fiberglass was assumed at each level of grating that washdown flow passed through. In addition, zero percent washdown of large pieces of fiberglass was assumed. Please provide the following additional information as a basis for these assumptions:

a. Please describe the extent and continuity of the grating below the limiting break locations, and provide the percentage of the cross-sectional area below these breaks where grating is installed.

b. Please provide adequate basis to justify that 40 to 50 percent of small pieces of debris will be held up on grating. Although results from the Drywell Debris Transport Study (DDTS) were cited in the supplemental response, based on the 30-minute duration of the cited tests, the DDTS recommendation was that no retention credit should be allowed for debris fragments that are smaller than openings in floor grating. Based on the information provided in the supplemental response, the NRC staff notes that the duration of spray operation at STP is not certain but could be significantly longer than 30 minutes (e.g., hours or days).

Furthermore, the staff also notes that a fraction of the debris held up on gratings could be exposed to concentrated streams of run-off flow (as opposed to fine spray droplets), which could further increase the tendency for erosion and washdown beyond what was observed in the DDTS results for the spray cases.

c. Please state whether and how the assumptions concerning capture of small pieces of fiberglass on gratings during washdown are currently credited in the STP transport analysis that consider a three-category size distribution for low-density fiberglass debris.

Response to RAI #15:

This RAI response has been written to support the applicability of analysis done to provide debris quantities for the July 2008 STP strainer head loss testing [15.1] to the RoverD methodology. The methodology [15.2] that defined the amount of fiber introduced in the July 2008 test is not relevant to the RoverD methodology because the RoverD methodology only uses the fiber debris amount from the July 2008 testing as a datum of comparison to the risk-informed CASA Grande generated and transported fiber quantities. All break locations where the debris quantities calculated in CASA Grande were below the datum would be considered to have passed deterministically. All other break locations would be dealt with using risk-informed calculations. More information about the RoverD methodology used for the debris generation and transport of fiber quantities for comparison to the tested fiber datum can be found in Attachment 1-2.

RAI #16

The December 11, 2008, supplemental response states on page 8 that a three-category size distribution is used for low-density fiberglass debris including small fines, large pieces and intact blankets. However, the discussion of debris transport refers in a number of places to small pieces of fiberglass (e.g., page 14, page 16, table 14, etc.). Please clarify whether these statements have been updated to reflect the revised debris size distribution on page 8.

Response to RAI #16:
This RAI response has been written to support the applicability of analysis done to provide debris quantities for the July 2008 STP strainer head loss testing [16.1] to the RoverD methodology. The methodology [16.2] that defined the amount of fiber introduced in the July 2008 test is not relevant to the RoverD methodology because the RoverD methodology only uses the fiber debris amount from the July 2008 testing as a datum of comparison to the risk-informed CASA Grande generated and transported fiber quantities. All break locations where the debris quantities calculated in CASA Grande were below the datum would be considered to have passed deterministically. All other break locations would be dealt with using risk-informed calculations. More information about the RoverD methodology used for the debris generation and transport of fiber quantities for comparison to the tested fiber datum can be found in Attachment 1-2.

References:

16.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.

16.2 ALION-CAL-STPEGS-2916-005, *GSI-191 Containment Recirculation Sump Evaluation: CFD Transport Analysis*, Revision 3. October 2008

RAI #17
Please provide the basis for considering a transport case with two sumps operating as the limiting condition for debris transport. Although debris would be distributed to an extra strainer, the staff observed that a design-basis case with three sumps operating would likely experience increased debris transport to the strainers in the analysis, and also in the head loss testing that credited substantial debris settlement using a flow rate based on the operation of two sumps. The increased debris transport associated with this condition may be more significant than the offsetting potential for additional debris sharing with a third strainer.

Response to RAI #17:

This RAI response has been written to support the applicability of analysis done to provide debris quantities for the July 2008 STP strainer head loss testing [17.1] to the RoverD methodology. The methodology [17.2] that defined the amount of fiber introduced in the July 2008 test is not relevant to the RoverD methodology because the RoverD methodology only uses the fiber debris amount from the July 2008 testing as a datum of comparison to the risk-informed CASA Grande generated and transported fiber quantities. All break locations where the debris quantities calculated in CASA Grande were below the datum would be considered to have passed deterministically. All other break locations would be dealt with using risk-informed calculations. More information about the RoverD methodology used for the debris generation and transport of fiber quantities for comparison to the tested fiber datum can be found in Attachment 1-2.

For particulate debris, the utilized (Revision 3) version of the STP Debris Transport calculation [17.2] indicates that for the two pump condition that was analyzed, the turbulent kinetic energy (TKE) and velocity conditions warranted assuming that the recirculation transport fraction of fine fiber, curled paint chips, Microtherm, epoxy, alkyd, IOZ, baked enamel and dirt/dust would be 100%. For these debris types, the increase in flow from a transport case with three sumps operating would result in no increase in recirculation transport because they are already transported at 100%. It would however reduce the amount of debris that is accumulated at each active sump by some amount.

The recirculation transport fractions for small paint chips and large paint chips for the governing case, i.e., Hot Leg (Case 1) break, based upon transport analysis for Cases 1 and 2 are 0%. This is because although there are areas of the recirculation pool with sufficient TKE and velocity conditions to result in suspension and transport, these regions do not reach the strainers. The potential impact of three-sump operation is discussed below.

The recirculation transport fraction for fine paint chips for Cases 1 and 2 is 41%. This transport fraction is based upon the size of the region where fine paint chips occur in regions of sufficient TKE and velocity conditions to result in suspension and transport. The potential impact of three-sump operation is discussed below.

An upper bound estimate of the increase in fine, small, and large paint chips transport due to the increase in pool recirculation velocity that would occur with three sumps in operation can be derived by assuming that for the Hot Leg (Case 1) break, all chips outside the reactor cavity transport to the sump. Making this assumption increases the transport fraction sum in the unqualified coatings outside the ZOI debris transport logic tree for Case 1 from 0.482 to 1.0. The same approach for the (Case 2).

The reactor cavity break case results in the same change in the recirculation transport fraction sum, from 0.482 to 1.0. Note that unqualified coatings outside the ZOI comprise only a portion of the total non-fiber debris loading.

The increase in total Case 1 particulate quantity from an assumed increase in transport fraction sum for unqualified coatings outside the ZOI from 0.482 to 1.0 is illustrated in Table 17-1, from 2256.8 lbm to 2412.5 lbm. The percent increase in total particulate quantity is 7%.

Table 17-1 Case-1 2-Sump versus 3-Sump Operation Particulate Transport Quantities

Break Case 1, Loop C hot leg	**Total Generated (lbm) (17.3)**	**2-sump operation transport fractions**	**2-sump operation transport quantity, (lbm)**	**3-sump operation transport fractions**	**3-sump operation transport quantity, (lbm)**
Microtherm lbm	64.5	0.947	61.1	0.947	61.1
Marinite lbm*	0.0	0.000	0.0	0.000	0.0
Qualified Coatings in ZOI					
Epoxy	23.0	0.947	21.8	0.947	21.8
IOZ	553.0	0.947	523.7	0.947	523.7
Polyamide Primer	10.0	0.947	9.5	0.947	9.5
Unqualified Coatings					
Epoxy inside Rx Cavity	1714.0	0.000	0.0	0.000	0.0
Epoxy outside Rx Cavity	294.0	**0.482**	141.7	**1.000**	294.0
Alkyds	247.0	1.000	247.0	1.000	247.0
IOZ	843.0	1.000	843.0	1.000	843.0
Baked Enamel	268.0	1.000	268.0	1.000	268.0
Latent Debris					
Dust & Dirt	170.0	0.830	141.1	0.850	144.5
Total:			2256.8		2412.5
% Increase:			1.1		

* Note that after completion of the utilized transport calculation and July 2008 testing, Marinite was removed from the plant and replaced with Nukon insulation in 2009 [17.4].

The increase in total Case 2 particulate quantity from an assumed increase in transport fraction sum for unqualified coatings outside the ZOI from 0.482 to 1.0 is illustrated in Table 17-2, from 3745.5 lbm to 3901.2 lbm. The percent increase in total particulate quantity is 4%.

Table 17-2 Case-2 2-Sump versus 3-Sump Operation Particulate Transport Quantities

Break Case 2, Reactor Cavity	**Total Generated,(lbm) (17.3)**	**2-sump operation transport fractions**	**2-sump operation transport quantity, (lbm)**	**3-sump operation transport fractions**	**3-sump operation transport quantity, lbm**
Microtherm lbm	13.5	0.947	12.8	0.947	12.8
Marinite lbm*	220.4	0.830	182.9	0.830	182.9
Qualified Coatings in ZOI					
Epoxy	23.0	0.830	19.1	0.830	19.1
IOZ	553.0	0.830	459.0	0.830	459.0
Polyamide Primer	10.0	0.830	8.3	0.830	8.3
Unqualified Coatings					
Epoxy inside Rx Cavity	1714.0	0.830	1422.6	0.830	1422.6
Epoxy outside Rx Cavity	294.0	**0.482**	141.7	**1.000**	294.0
Alkyds	247.0	1.000	247.0	1.000	247.0
IOZ	843.0	1.000	843.0	1.000	843.0
Baked Enamel	268.0	1.000	268.0	1.000	268.0
Latent Debris					
Dust & Dirt	170.0	0.830	141.1	0.850	144.5
Total:			3745.5		3901.2

* Note that after completion of the utilized transport calculation and July 2008 testing Marinite was removed from the plant and replaced with Nukon insulation in 2009 [17.4].

3-sump operation results in less than 10% increase in particulate loading. However 3-sump operation would increase the strainer area available for debris capture by 50%. Therefore, debris load definition based upon 2-sump operation provides a bounding condition for strainer testing debris load definition.

References:

17.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.

17.2 ALION-CAL-STPEGS-2916-005, *GSI-191 Containment Recirculation Sump Evaluation: CFD Transport Analysis*, Revision 3. October 2008

17.3 ALION-CAL-STPEGS-2916-002, *GSI 191 Containment Recirculation Sump Evaluation: Debris Generation,* Revision 3. Alion Science & Technology, October 2008

17.4 DCP #02-5326-126, Design Change Package (For Marinite Removal in Unit 1), 2009

RAI #18
Please provide a description of any testing performed to support the assumption of 10 percent erosion of fiber debris pieces in the containment pool. Please specifically include the following information:

a. Please describe the test facility used and demonstrate the similarity of the flow conditions (velocity and turbulence), chemical conditions, and fiber material present in the erosion tests to the analogous conditions applicable to the plant condition.

b. Please provide specific justification for any erosion tests conducted at a minimum tumbling velocity if debris settling was credited in the test flume for velocities in excess of this value.

c. Please identify the length of the erosion tests and how the results were extrapolated to the sump mission time.

Response to RAI #18:
This RAI response has been written to support the applicability of analysis done to provide debris quantities for the July 2008 STP strainer head loss testing [18.1] to the RoverD methodology. The erosion methodology [18.2] that helped define the amount of fiber introduced in the July 2008 test is not relevant to the RoverD methodology because the RoverD methodology only uses the fiber fine debris amount from the July 2008 testing as a datum of comparison to the risk-informed CASA Grande generated and transported fiber quantities. All break locations where the debris quantities calculated in CASA Grande were below the datum would be considered to have passed deterministically. All other break locations would be dealt with using risk-informed calculations. More information about the RoverD methodology used for the debris generation and transport of fiber quantities for comparison to the tested fiber datum can be found in Attachment 1-2.

References:

18.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.
18.2 ALION-CAL-STPEGS-2916-005, *GSI-191 Containment Recirculation Sump Evaluation: CFD Transport Analysis*, Revision 3. October 2008

RAI #19

The supplemental response, dated December 11, 2008, indicates that a significant percentage of small fines of low-density fiberglass were assumed to transport to the strainers (i.e., 95 percent). In addition, no large debris pieces were assumed to enter the containment pool. These analytical assumptions minimized the quantity of settled small and large pieces of fiberglass that were analytically assumed to erode in the containment pool. However, for the strainer head loss testing conducted by Performance Contracting, Inc. (PCI), the NRC staff considers it likely that a significant fraction of small pieces that were analytically considered transportable actually settled in the test flume, rather than transporting to the test strainer. The head loss testing did not model the erosion of this debris. The licensee's consideration of debris erosion, therefore, appears to be non-conservative, because neither the analysis nor the head loss testing accounted for the erosion of debris that settled during the head loss testing. Please estimate the quantity of eroded fines from small pieces of fiberglass debris that would result had erosion of the settled debris in the head loss test flume been accounted for and justify the neglect of this material in the head loss testing program.

Response to RAI #19

This RAI response has been written to support the applicability of analysis done to provide debris quantities for the July 2008 STP strainer head loss testing [19.1] to the RoverD methodology. The potential for more eroded fiber in the July 2008 test [19.2] is not relevant to the RoverD methodology because the RoverD methodology only uses the amounts from the July 2008 testing as a datum of comparison to the risk-informed CASA Grande generated and transported fiber quantities. All break locations where the debris quantities calculated in CASA Grande were below the datum would be considered to have passed deterministically. All other break locations would be dealt with using risk-informed calculations. More information about the RoverD methodology used for the debris generation and transport of fiber quantities for comparison to the tested fiber datum can be found in Attachment 1-2.

References:

19.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.

19.2 ALION-CAL-STPEGS-2916-005, *GSI-191 Containment Recirculation Sump Evaluation: CFD Transport Analysis*, Revision 3. October 2008

RAI#20
For a number of cases, the supplemental response stated that 17 percent of the latent debris was assumed to be captured in inactive holdup volumes in containment (i.e., inactive cavities and the inactive sump). For an additional case (i.e., Case 2), a similar treatment was applied to Marinite® and coatings debris. The NRC staff's SE on NEI 04-07 recommended that no more than 15 percent holdup in inactive volumes be assumed unless a pool-fill transport analysis was performed similar to the staff's sample calculation in Appendix IV to the SE. Please provide adequate justification for the assumption concerning the holdup of latent debris in inactive sump pool volumes.

Response to RAI #20:

This RAI response has been written to support the applicability of analysis done to provide debris quantities for the July 2008 STP strainer head loss testing [20.1] to the RoverD methodology. The methodology [20.2] that defined the amount of fiber introduced in the July 2008 test is not relevant to the RoverD methodology because the RoverD methodology only uses the fiber debris amount from the July 2008 testing as a datum of comparison to the risk-informed CASA Grande generated and transported fiber quantities. All break locations where the debris quantities calculated in CASA Grande were below the datum would be considered to have passed deterministically. All other break locations would be dealt with using risk-informed calculations. More information about the RoverD methodology used for the debris generation and transport of fiber quantities for comparison to the tested fiber datum can be found in Attachment 1-2.

For particulate debris, the contribution of an additional 2% (17% computed versus 15% NRC SE recommended maximum) of non-fiber debris for transport analysis Cases 1 and 2 are summarized below:

Table 20-1. Non-fiber Debris Transported to Inactive Cavities, Case 1 (Loop C Hot Leg)

Break Case 1, Loop C hot leg	**Total Generated, lbm** [20.3]	**17% case fraction**	**17% case quantity, lbm**	**15% case fraction**	**15% case quantity, lbm**
Microtherm	64.5	0.947	61.1	0.947	61.1
Marinite*	0	0.000	0.0	0.000	0.0
Qualified Coatings in ZOI					
Epoxy	23	0.947	21.8	0.947	21.8
IOZ	553	0.947	523.7	0.947	523.7
Polyamide Primer	10	0.947	9.5	0.947	9.5
Unqualified Coatings					
Epoxy inside Rx Cavity	1714	0.000	0.0	0	0.0
Epoxy outside Rx Cavity	294	0.482	141.7	0.482	141.7
Alkyds	247	1.000	247.0	1.000	247.0
IOZ	843	1.000	843.0	1.000	843.0
Baked Enamel	268	1.000	268.0	1.000	268.0
Latent Debris					
Dust & Dirt**	170	0.830	141.1	0.850	144.5
Total transported:			2256.8		2260.2
% Increase:			**1.0015**		

* Note that after completion of the utilized transport calculation and July 2008 testing, Marinite was removed from the plant and replaced with Nukon insulation in 2009. [20.4]

** Reflects adjustment from 17% to 15%.

The overall increase in transported particulate debris Case 1 is 0.15%, i.e., significantly less than 1%.

Table 20-2. Non-fiber Debris Transported to Inactive Cavities, Case 2 (Reactor Cavity)

Break Case 2, Reactor Cavity	**Total Generated, lbm [20.3]**	**17% case fraction**	**17% case quantity, lbm**	**15% case fraction**	**15% case quantity, lbm**
Microtherm	61.5	0.947	58.2	0.947	58.2
Marinite*,**	220.4	0.83	182.9	0.850	187.3
Qualified Coatings in ZOI					
Epoxy**	23	0.830	19.1	0.850	19.6
IOZ**	553	0.830	459.0	0.850	470.1
Polyamide Primer*	10	0.830	8.3	0.850	8.5
Unqualified Coatings					
Epoxy inside Rx Cavity*	1714	0.830	1422.6	0.850	1456.9
Epoxy outside Rx Cavity	294	0.482	141.7	0.482	141.7
Alkyds	247	1.000	247.0	1.000	247.0
IOZ	843	1.000	843.0	1.000	843.0
Baked Enamel	268	1.000	268.0	1.000	268.0
Latent Debris					
Dust & Dirt**	170	0.83	141.1	0.850	144.5
Total transported:			3791.0		3844.8
% Increase:			**1.0142**		

* Note that after completion of the utilized transport calculation and July 2008 testing Marinite was removed from the plant and replaced with Nukon insulation in 2009. [20.4]

** Reflects adjustment from 17% to 15%.

The overall increase in transported particulate debris for Case 2 is 1.42%, i.e., less than 1.5%. The limiting condition for strainer head loss is expected to be Case 1, the Hot Leg break. The maximum effect of using 17% versus the NRC SE-recommended maximum of 15% of debris transported to inactive regions for the governing break case is 0.25 %, which is expected to have had a negligible effect on the debris load definition for the July 2008 strainer head loss testing.

References:

20.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.

20.2 ALION-CAL-STPEGS-2916-005, *GSI-191 Containment Recirculation Sump Evaluation: CFD Transport Analysis*, Revision 3. October 2008

20.3 ALION-CAL-STPEGS-2916-002, *GSI 191 Containment Recirculation Sump Evaluation: Debris Generation,* Revision 3. Alion Science & Technology, October 2008

20.4 DCP #02-5326-126, Design Change Package (For Marinite Removal in Unit 1), 2009

RAI #21
Please provide the technical basis for concluding that no large debris pieces will be blown into upper containment. Please include a description of the extent and continuity of the grating above the limiting break locations, and provide a fraction of the cross-sectional area above these breaks where grating is installed.

Response to RAI #21:

This RAI response has been written to support the applicability of analysis done to provide debris quantities for the July 2008 STP strainer head loss testing [21.1] to the RoverD methodology. The methodology [21.2] that defined the amount of fiber introduced in the July 2008 test is not relevant to the RoverD methodology because the RoverD methodology only uses the fiber debris amount from the July 2008 testing as a datum of comparison to the risk-informed CASA Grande generated and transported fiber quantities. All break locations where the debris quantities calculated in CASA Grande were below the datum would be considered to have passed deterministically. All other break locations would be dealt with using risk-informed calculations. More information about the RoverD methodology used for the debris generation and transport of fiber quantities for comparison to the tested fiber datum can be found in Attachment 1-2.

References:

21.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.

21.2 ALION-CAL-STPEGS-2916-005, *GSI-191 Containment Recirculation Sump Evaluation: CFD Transport Analysis*, Revision 3. October 2008

RAI #22
Please provide additional information concerning the following debris transport assumptions regarding failed coatings debris:

a. A basis for the zero percent transport fraction for epoxy coating debris inside the reactor cavity for breaks that do not occur within the reactor cavity.

b. A description of the methodology for determining the transport fraction for failed epoxy coatings outside the reactor cavity, for which transport percentages from 41 to 48 percent were calculated for various scenarios.

Response to RAI #22:

This RAI response has been written to support the applicability of analysis done to provide debris quantities for the July 2008 STP strainer head loss testing [22.1] to the RoverD methodology. The methodology [22.2] that defined the amount of fiber introduced in the July 2008 test is not relevant to the RoverD methodology because the RoverD methodology only uses the fiber debris amount from the July 2008 testing as a datum of comparison to the risk-informed CASA Grande generated and transported fiber quantities. All break locations where the debris quantities calculated in CASA Grande were below the datum would be considered to have passed deterministically. All other break locations would be dealt with using risk-informed calculations. More information about the RoverD methodology used for the debris generation and transport of fiber quantities for comparison to the tested fiber datum can be found in Attachment 1-2. For a response in terms of RoverD's particulate methodology, see below:

Response to RAI 22a:

A 0% transport fraction for epoxy coating debris inside the reactor cavity for breaks that do not occur within the reactor cavity was used because (1) for breaks that occur outside the reactor cavity, e.g., Case 1, Hot Leg break, there is no flow into the reactor cavity, (2) the path out of the reactor cavity is sufficiently tortuous that this area will be essentially stagnant, and (3) any negligible flow from the reactor cavity that could occur will be to a region on the opposite side of the steam generator compartment from where the sumps are located.

Response to RAI 22b:

The process for determining the transport fraction for failed epoxy coatings outside the reactor cavity and for which transport percentages from 41–48% were calculated for various scenarios [22.2] is described below.

See Case 1 Hot Leg break in the figures below as the illustrative example and failed epoxy coatings for which the transport percentages are from 41–48% for fine paint chips.

1. The initial distribution of latent debris, unqualified coatings (fine paint chips), and fines in lower containment was developed in the Debris Transport calculation and is illustrated in Figure 22-1, below. Note that the active sumps are located at the 2:30 and 3:30 o'clock positions. The third, assumed inactive, sump is located at the 3:00 o'clock position.

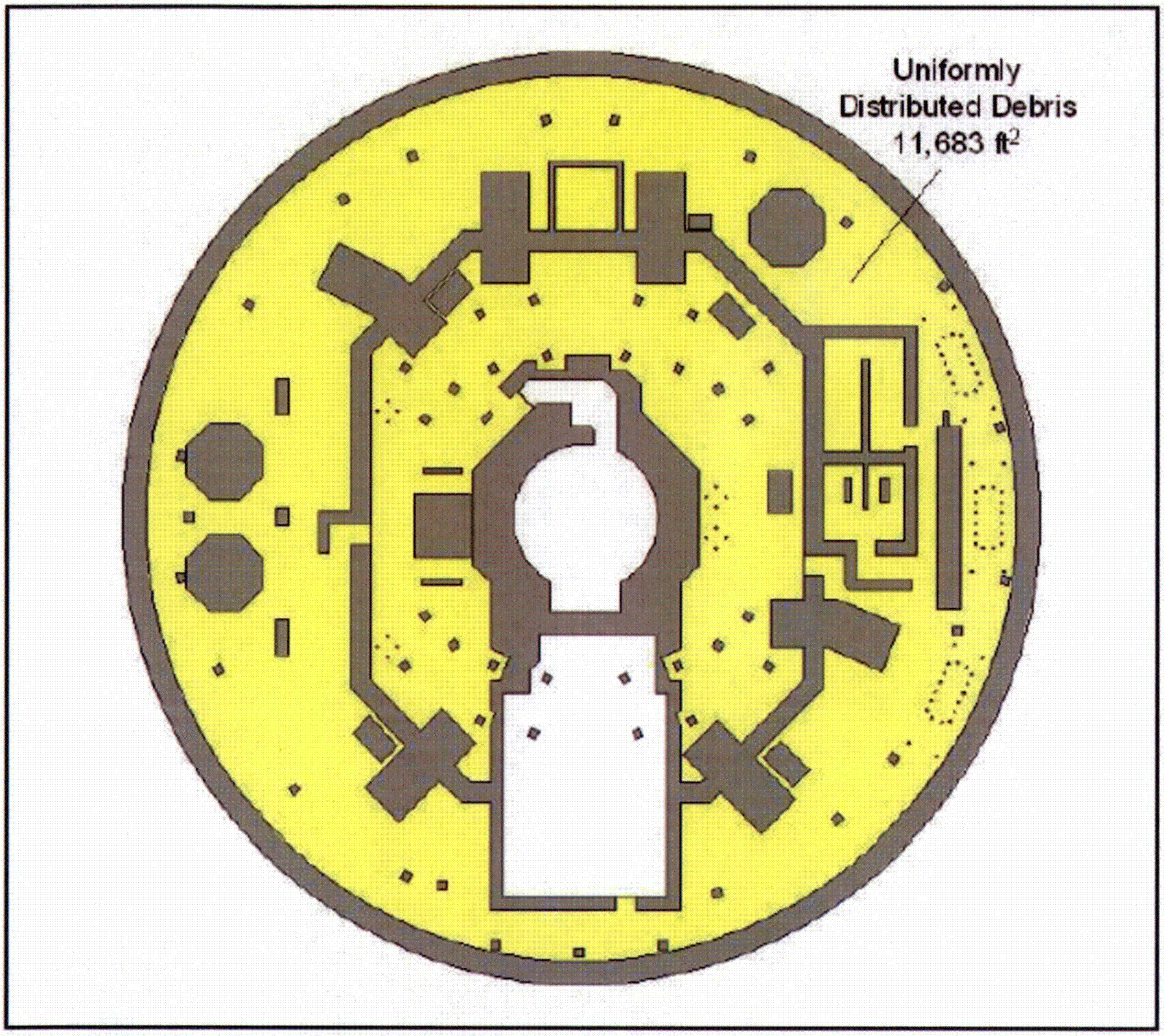


Figure 22-1 - Initial Distribution of Latent Debris, Unqualified Coatings, and Fines in Lower Containment for a Hot Leg Break, (Case 1)

2. Areas in the pool where turbulence and tumbling velocities are high enough to suspend and tumble the fine paint chips were determined from the CFD analysis in the Debris Transport calculation. Figure 22-2 shows this area for Case 1, the hot leg break condition.

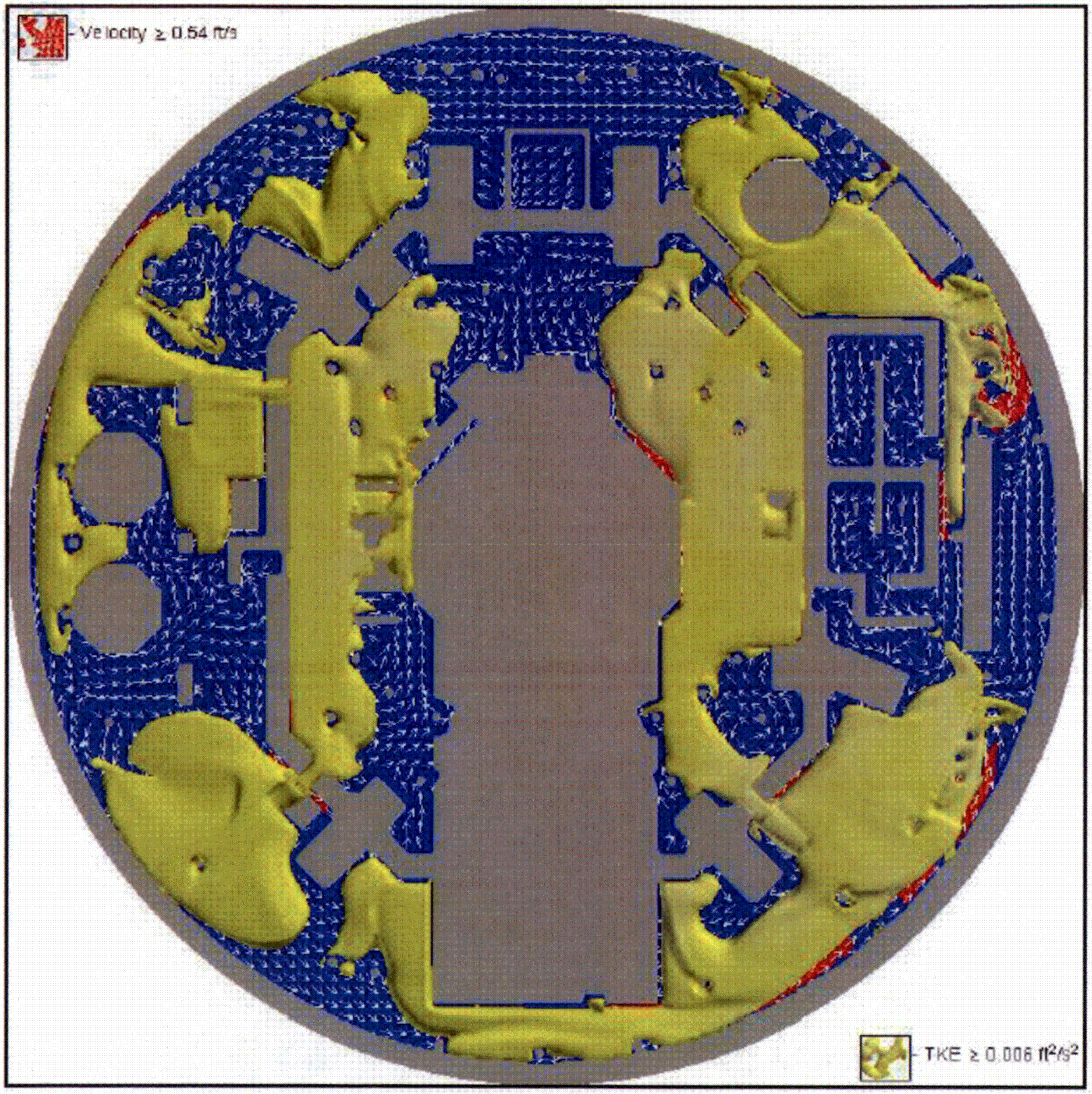


Figure 22-2 - Area of Sufficient Turbulence and Tumbling Velocities to Suspend and Tumble Fine Paint Chips

3. The area with sufficient turbulence and tumbling velocities to suspend and tumble the fine paint chips was overlaid on the area of initial distribution. Cross-hatching was used to identify the portion of the fine paint chips that were initially in the area where there is sufficient turbulence and tumbling velocity to enable transport to the sump. This area is shown in Figure 22-3, which was developed in the Debris Transport calculation. Note that a portion of the TKE regions in this figure was not included in the hatched area since the pool flow direction is toward regions of the pool where the chips would settle to the floor rather than transport to the strainers.

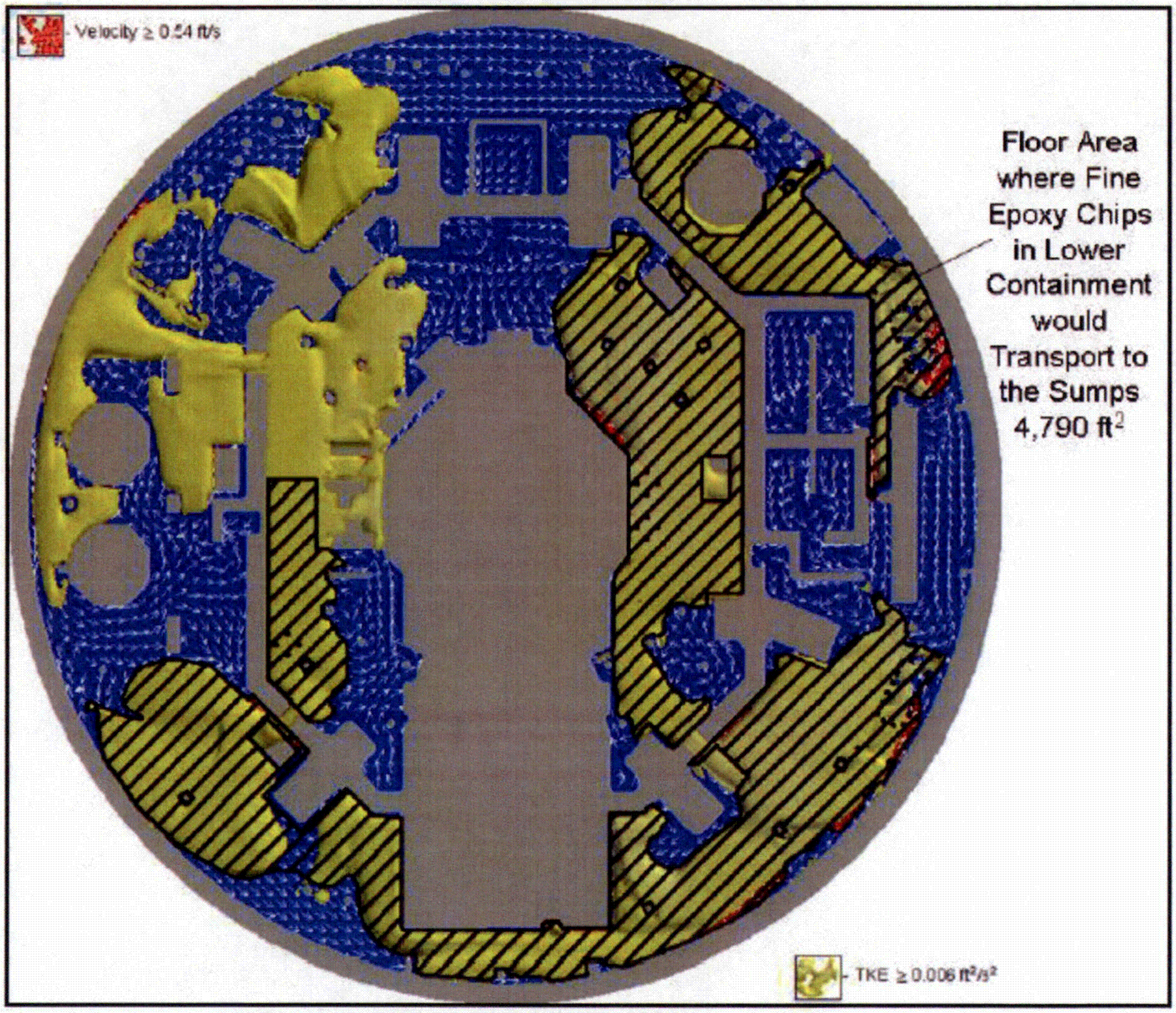


Figure 22-3 - Portion of the Fine Paint Chips Initially in Area Capable of Transport to Sump

4. The (cross-hatched) area from which fine paint chips could transport to the sump was determined to be 4,790 ft^2. The initial distribution area was determined to be 11,683 ft^2. Based upon this, the recirculation transport fraction for fine paint chips was determined to be 41%, i.e., 4,790/11,683. This analysis methodology was applied to all other debris types where a portion of the generated quantity was transported to the sump.

References:

22.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.

22.2 ALION-CAL-STPEGS-2916-005, *GSI-191 Containment Recirculation Sump Evaluation: CFD Transport Analysis*, Revision 3. October 2008

RAI #23

No transport of small or large pieces of debris was assumed to occur during the pool fill phase of the event, but justification for this assumption was not provided. The NRC staff expects that velocities in some parts of typical containment pools could well exceed the transport metric for debris in these categories during the pool-fill phase of transport. Flow conditions during the pool-fill phase of the LOCA were not considered by the testing, nor was the potential for some types of debris to enter a non-quiescent containment pool closer than 45 feet from the strainer due to the effects of blowdown, washdown, and pool-fill transport. The lack of modeling of these transport aspects of the head loss testing appeared to result in a non-prototypical reduction in the quantity of debris reaching the test strainer. Please provide the technical basis for not explicitly modeling transport modes other than recirculation transport, considering the following points:

a. As shown in Appendix III of the NRC staff's SE on NEI 04-07, containment pool velocity and turbulence values during fill up may exceed those during recirculation, due to the shallowness of the pool.

b. The pool-fill phase will tend to move debris from inside the secondary shield wall into the outer annulus away from the break location and nearer to the recirculation sump strainers.

c. Representatively modeling the washdown of some fraction of the debris nearer the strainer than 45 feet would be expected to increase the quantity of debris transported to the strainer and the measured head loss.

d. If credit was taken for the four openings in the secondary shield wall being raised above the containment pool floor level in making this determination, then please provide a description of any other flow paths through the secondary shield wall through which these debris types might transport during the pool fill phase.

Response to RAI #23

This RAI response has been written to support the applicability of analysis done to provide debris quantities for the July 2008 STP strainer head loss testing [23.1] to the RoverD methodology. The methodology [23.2] that defined the amount of fiber introduced in the July 2008 test is not relevant to the RoverD methodology because the RoverD methodology only uses the fiber debris amount from the July 2008 testing as a datum of comparison to the risk-informed CASA Grande generated and transported fiber quantities. All break locations where the debris quantities calculated in CASA Grande were below the datum would be considered to have passed deterministically. All other break locations would be dealt with using risk-informed calculations. More information about the RoverD methodology used for the debris generation and transport of fiber quantities for comparison to the tested fiber datum can be found in Attachment 1-2.

References:

23.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.

23.2 ALION-CAL-STPEGS-2916-005, *GSI-191 Containment Recirculation Sump Evaluation: CFD Transport Analysis*, Revision 3. October 2008

RAI #24

Please provide plots of velocity and turbulence contours in the containment pool that include the entire pool and which are based on the computational fluid dynamics model used in the debris transport analysis. Please also provide close-up plots of the velocity and turbulence contours in the region of the strainer and its immediate surroundings from the computational fluid dynamics model that was used to determine the flume velocities and turbulence levels for head loss testing. In addition, please provide a table of the head loss test flume (average) velocity as a function of distance from the test strainer. Please indicate which plant strainer is being modeled in the head loss test.

Response to RAI #24

This RAI response has been written to support the applicability of the July 2008 STP strainer head loss testing [24.1] to the RoverD methodology.

An overview of containment turbulence is shown in Figure 24-1 at three water depths. The figure shows that turbulence near the floor is generally lower than near the surface. Note that turbulence scale is clipped at a relatively low level of 0.02 ft^2/sec^2 to increase contrast of the relatively low levels of turbulence near the strainer active strainer banks.

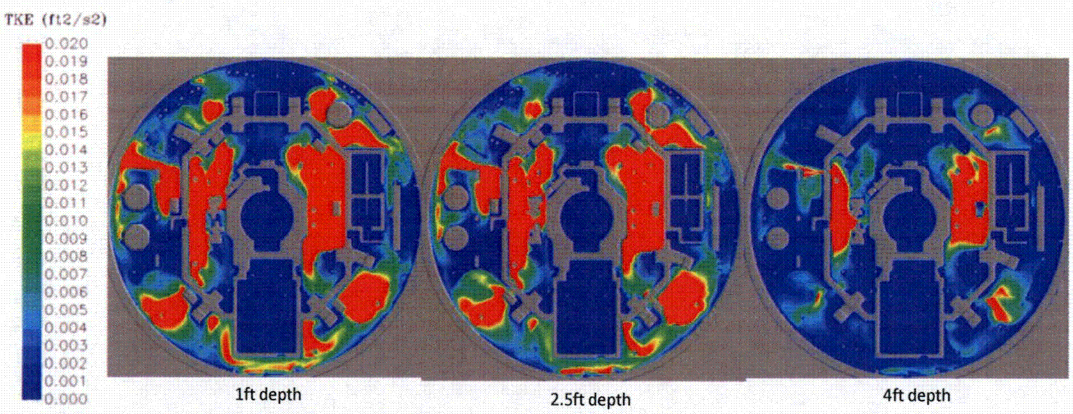


Figure 24-1. Turbulence in containment

Figure 24-2 shows the part of containment occupied by the strainer sumps. Note that the two sump operating condition is modeled, conservatively only choosing the two outer sumps A and C. The sump A strainer has a single approach whereas the sump C strainer has two approaches, one strong and one weak driven by a circulating type flow above the sump C mass sink in the CFD simulations.

Figure 24-2. Contour plot of velocity closer to strainer sumps

Flume approach velocities are given in Table 24-1. The relatively fast approach modeled in the head loss test is reflected in flume widths that lie between 5.6 and 9.3 inches. Reynolds numbers are still well into the turbulent range.

Table 24-1. Listing of flume velocities back from the strainer

Distance from strainer (ft)	Flume Width (in)	Flume Velocity (ft/sec)	Hydraulic Radius (ft)	Reynolds #
1	6.0	0.50	0.23	19285
4	7.3	0.41	0.28	18977
5	6.9	0.43	0.26	19065
10	8.5	0.35	0.32	18698
16	8.4	0.36	0.31	18737
21	6.9	0.43	0.26	19079
23	5.6	0.53	0.22	19370
27	9.5	0.32	0.35	18500
33	8.9	0.33	0.33	18614
36.5	9.3	0.32	0.34	18537

The head-loss flume did not model a single sump approach. A conservative average was determined from all three approaches for the two sumps, weighting the fastest approach at each 1 ft increment double in the average. The flume approach velocity thus represented a conservative approach velocity relative to the average plant condition under the already conservative conditions of only the outer two sumps operating.

The flume turbulence level is shown in a mid-water depth contour in Figure 24-3. Turbulence levels in the flume are lower than those calculated for containment but the differences are tempered by the fact that testing was conducted in water temperatures significantly lower than containment water temperatures. The ability of a given amount of turbulence to suspend debris is directly proportional to the viscosity of the water, which governs the debris settling rate. The turbulence level in the flume is sufficient to maintain prototypical suspension of fine debris when compared to suspension TKE values in NEI 04-07 [24.3). For large debris neither the containment nor flume turbulence conditions are expected to be sufficient to prevent settling of debris.

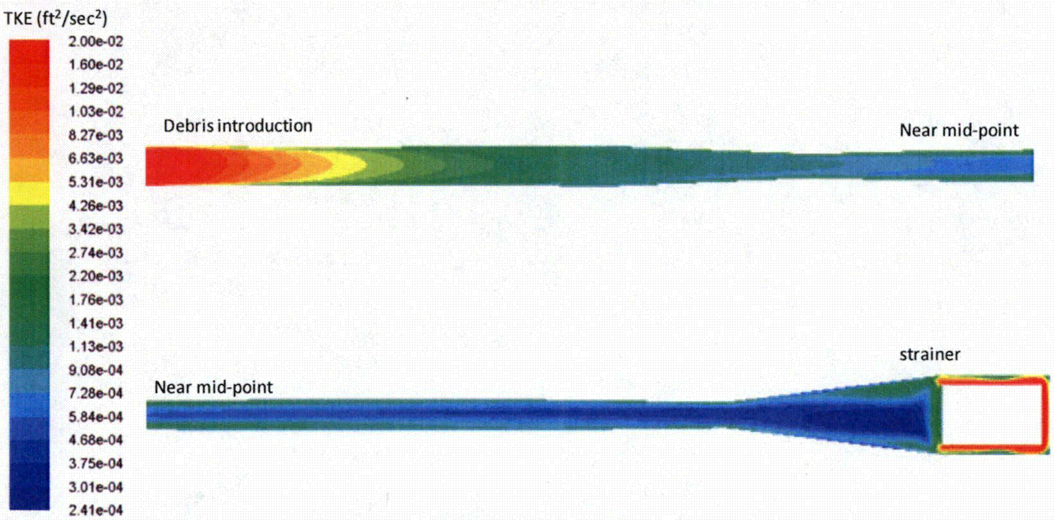


Figure 24-3. Turbulence contours in the head-loss test flume

References:

24.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.
24.2 Flume CFD by Alden Research Laboratory
24.3 NEI 04-07, Pressurized Water Reactor Sump Performance Evaluation Methodology, Volume 1, Revision 0, December 2004

RAI #25

Please discuss any sources of drainage that enter the containment pool near the containment sump strainers (i.e., within the range of distances modeled in the head loss test flume, e.g., 45 feet). Please identify whether the drainage would occur in a dispersed form (e.g., droplets) or a concentrated form (e.g., streams of water running off of surfaces). Please discuss how these sources of drainage are modeled in the test flume to create a prototypical level of turbulence in the test flume.

Response to RAI #25

This RAI response has been written to support the applicability of the July 2008 STP strainer head loss testing [25.1] to the RoverD methodology.

The regions where spray flows were introduced to the containment pool in the Debris Transport calculation [25.2] are shown in Figure 25-1 which is developed from Figure 5.8.2 of the Debris Transport calculation. In Figure 25-1, "Direct" regions provide spray; "Wash" regions provide concentrated flow.

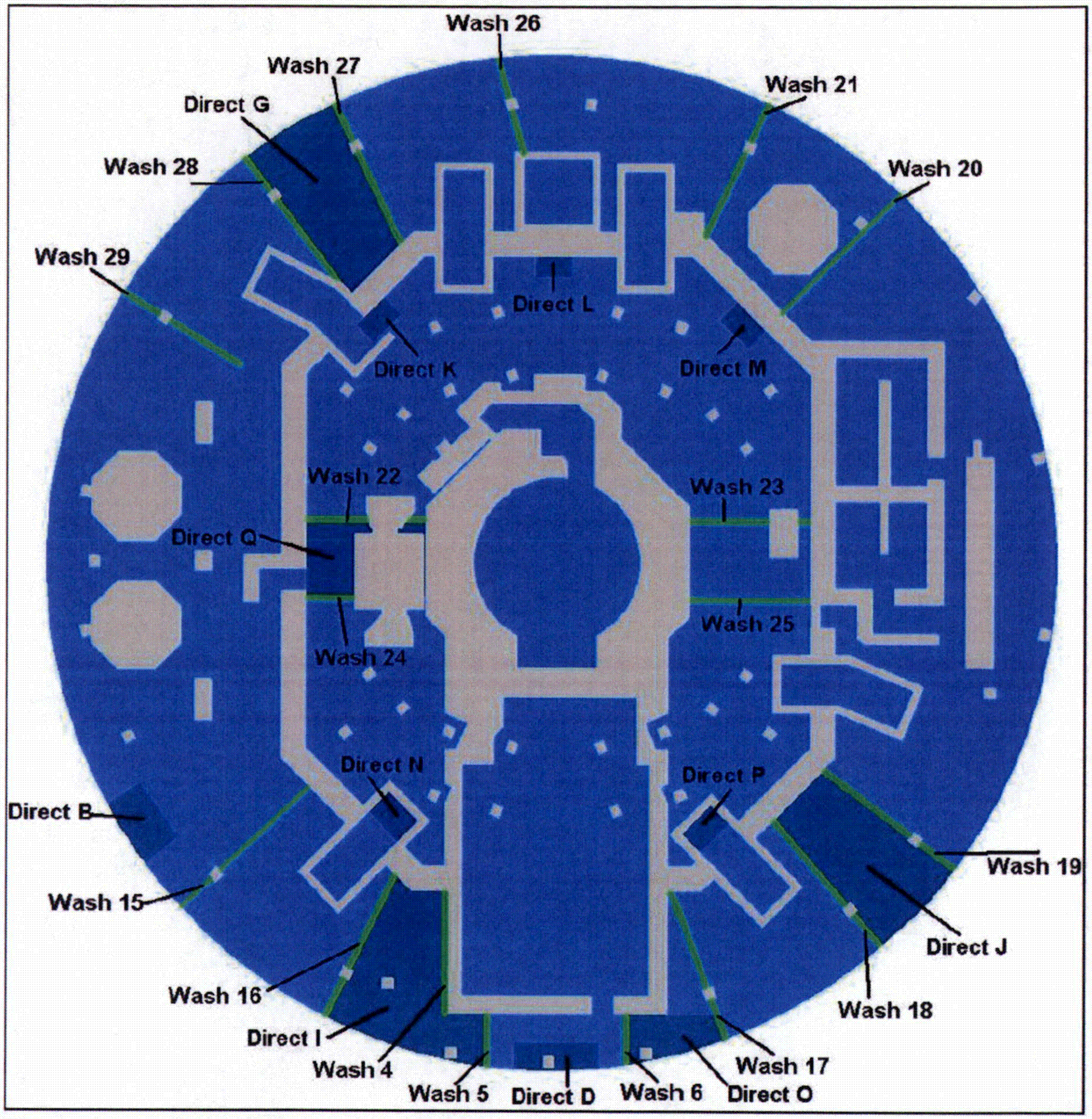


Figure 25-1 - Flow Paths to the Containment Pool

Figure 25-2 shows which Direct and Wash regions are within a 45-ft radius of the active sumps (shown in red lines). These are:

- Direct-J
- Direct-M
- Direct-P
- Wash-18
- Wash-19
- Wash-20
- Wash-23 (partial)
- Wash-25 (partial)

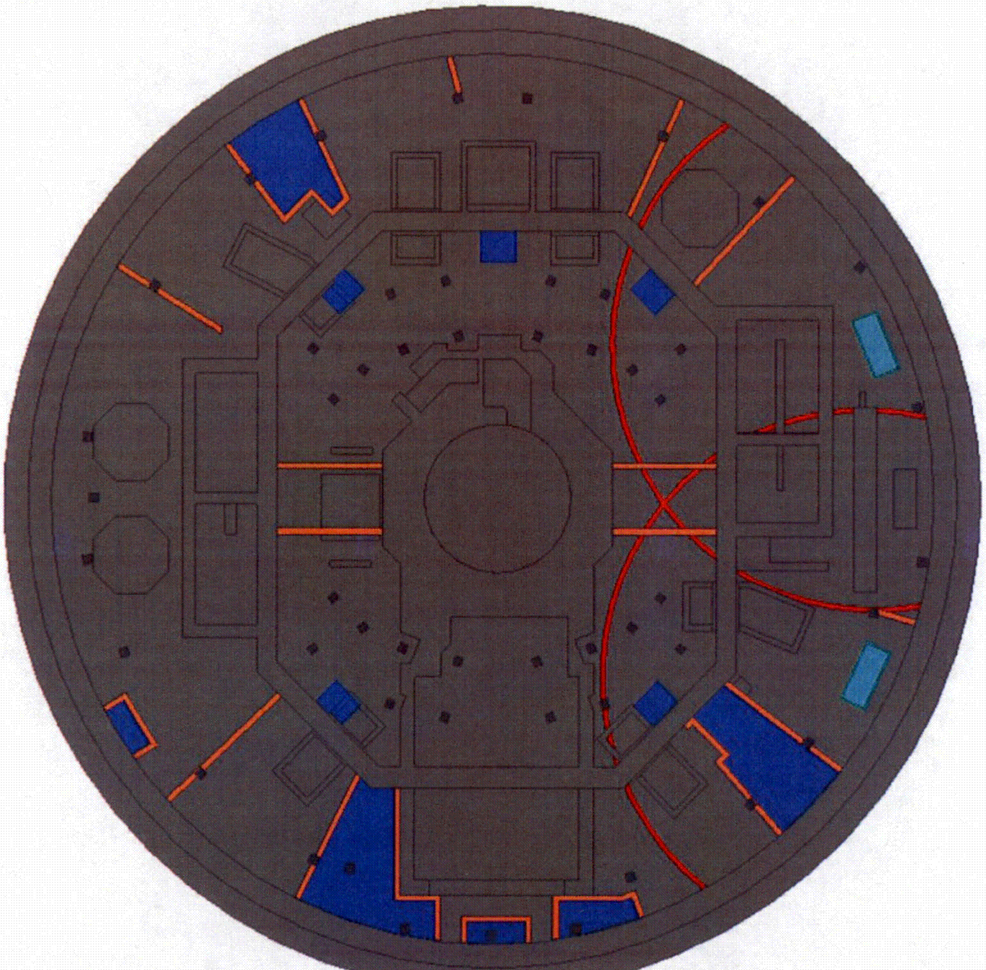


Figure 25-2 - Direct and Wash Regions within a 45-ft Radius of Active Sumps

The containment spray flow rates and velocities associated with each of the Direct and Wash regions are provided in Table 25-1, which is taken from Table 5.8.1 of the Debris Transport calculation [25.2]

Table 25-1 - Containment Spray Flows and Velocities

Region	Flow Split	Flow Rate (gpm)	Freefall Elevation (ft)	Freefall Distance (to 3.03 ft water level)[1] (ft)	Spray Velocity (ft/s)
Direct B	1.7%	88	109.75	106.72	29
Direct D	1.5%	78	109.75	106.72	29
Direct G	1.8%	94	109.75	106.72	29
Direct I	2.5%	130	109.75	106.72	29
Direct J	2.1%	109	109.75	106.72	29
Direct K	0.1%	5	109.75	106.72	29
Direct L	0.1%	5	109.75	106.72	29
Direct M	0.1%	5	109.75	106.72	29
Direct N	0.1%	5	109.75	106.72	29
Direct O	0.6%	31	109.75	106.72	29
Direct P	0.1%	5	109.75	106.72	29
Direct Q	2.7%	140	30.25	27.22	29
Wash 4	0.8%	42	109.75	106.72	29
Wash 5	0.2%	10	79.25	76.22	29
Wash 6	0.2%	10	79.25	76.22	29
Wash 15	3.6%	187	30.25	27.22	29
Wash 16	1.5%	78	30.25	27.22	29
Wash 17	2.2%	114	30.25	27.22	29
Wash18	2.3%	120	30.25	27.22	29
Wash 19	5.9%	307	48.5	45.47	29
Wash 20	4.2%	218	48.5	45.47	29
Wash 21	3.1%	161	30.25	27.22	29
Wash 22	13.5%	702	30.25	27.22	29
Wash 23	13.5%	702	30.25	27.22	29
Wash 24	13.5%	702	30.25	27.22	29
Wash 25	13.5%	702	30.25	27.22	29
Wash 26	0.1%	5	9.25	6.22	20
Wash 27	3.4%	177	9.25	6.22	20
Wash 28	1.7%	88	9.25	6.22	20
Wash 29	3.4%	177	9.25	6.22	20

Sources of drainage in the flume

Sources of drainage were not modeled in the flume as their influence can be seen as both inhibiting and promoting transport. Figure 25-3 shows the clearest example of this mixed transport influence according to contour plot of velocity to strainer sumps of Figure 24-2 of RAI 24 response. The sheeting action from the concentrated sheet of water causes out-flow velocities both towards and away from the strainer and effectively creates a hydraulic curtain through which debris not originating from the spill flow itself has difficulty penetrating. Turbulence generated by this water flow is swept into some of the flow paths toward the strainer; but as mentioned under original RAI

24 response, the turbulence in the flume is sufficient for fine debris suspension and neither containment nor flume is turbulent enough to appreciably affect settling or suspension of other debris sizes.

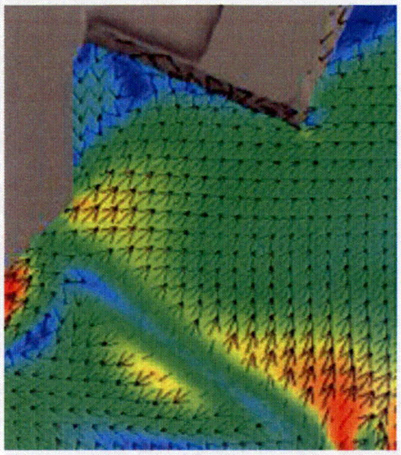


Figure 25-3 - Close-up of velocity pattern near Wash 19

References:

25.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.

25.2 ALION-CAL-STPEGS-2916-005, *GSI-191 Containment Recirculation Sump Evaluation: CFD Transport Analysis*, Revision 3. October 2008

RAI #26

Please identify any debris quantities added to the test flume prior to starting the test pump for the head loss tests and provide a technical basis for adding this debris prior to starting the test pump.

Response to RAI #26

This RAI response has been written to support the applicability of the July 2008 South Texas Project Test Report for ECCS Strainer Performance Testing [26.1] to the RoverD methodology.

Based on the AREVA NP Test Plan for STP strainer testing (Test 2) [26.2], 25% of the latent fiber debris was introduced along the length of the test flume prior to starting the recirculation pump. NUKON fine fiber was used as the debris constituent for latent fibers. A total of 0.25 lbm of NUKON fine fiber was introduced along the length of the test flume.

The location of post-LOCA debris before ECCS/CSS pump recirculation initiation is based on prototypical post-LOCA containment conditions indicating that the debris would be scattered to varying degrees throughout the containment floor areas with heavier debris concentration immediately adjacent to the actual LOCA pipe break location. This prototypical condition is consistent with and based on the methodology and objectives documented in NUREG/CR-6773 [26.3] regarding debris-transport tests for PWRs. Therefore, it is reasonable to expect some latent fiber to be located near the strainer and on the containment floor prior to the initiation of ECCS recirculation. Please note the following:

1. Various NUREG/CRs including 2982 [26.4] and 6773 [26.3] confirm that fine fiber debris settles quickly (one minute or less) in water temperatures as low as 120 °F which is considerably less than the actual initial post-LOCA expected water temperature of greater than 212 °F.

2. There is approximately 15 - 45 minutes following the post-LOCA event prior to the initiation of ECCS/CSS recirculation [26.5]. This would allow any fiber debris including latent fiber to be subjected to both a significant time period of water absorption/saturation and the greater than 212 °F temperature water which would result in ideal conditions for settlement of the fiber debris in the post-LOCA containment fluid as well as in the near field of the strainers. It should also be noted that the strainer/sump location is considered to be in a quiet zone when post-LOCA containment fill is complete. Regardless, some fiber debris is expected to be on the containment floor at the time of ECCS/CSS pump recirculation.

Therefore, it can be reasonably concluded that it is prototypical and representative that some fiber debris is located on the containment floor near the strainer/sump location when recirculation begins. The absence of some fiber debris near the test strainer during another licensee's initial qualification test at ARL was, in fact, observed to be a weakness in the test protocol by the Staff members who witnessed the test. In response to the comment, PCI and AREVA revised the Test Plan and Protocol to begin introduction of either 0.5 lbs or 25% of the design basis latent fiber quantity into the ARL test flume between the debris introduction drop zone and test strainer five minutes prior to pump start to address this concern. All subsequent tests have followed this refinement to the Test Protocol which was discussed with the Staff approximately six months prior to the STP test.

To further address the Staff's concern (i.e., RAI #26), PCI/ARL implemented a number of special tests (August – September 2009) to observe in clean water (i.e., no particulate or chemical debris) the transportability of latent fiber debris introduced five minutes prior to pump start-up (i.e., simulated initiation of ECCS/CSS recirculation). The use of clean water without particulate debris is very conservative, since the particulate debris would have 'mixed' with the fiber debris and resulted in significant trapping or settlement of the 'mixed' fiber and particulate debris. Implementation of the test without particulate debris is not prototypical of the licensees' expected post-LOCA conditions, but is very conservative with regard to the test protocol and test results. The test utilized various flow velocities that were bounding for various licensee facilities that were implemented in the ARL large flume test. ARL observed that the latent debris placed on the small flume floor, with the pump off, resulted in the subject fiber debris being transported at the various licensee flow velocities; but; very little of the debris reached the strainer. The flow velocity required to initiate the fiber debris movement was usually greater than the actual licensee flow rates and velocities. However, not much of the fiber debris was transported to the strainer. In order to actually transport the fiber debris to the strainer, flow velocities of more than 300% of the actual licensee flow velocities were required.

Since the fiber debris was observed to transport from its initial resting position, the introduction of some latent fiber debris prior to pump start was concluded to be realistic, representative, and prototypical of the actual STP post-LOCA containment conditions and LOCA scenario.

References:

26.1 AREVA NP Document 66-9088089-000, "South Texas Project Test Report for ECCS Strainer Performance Testing", August 2008.
26.2 AREVA NP Document 63-9086408-001, "South Texas Project Test Plan for ECCS Strainer Performance Testing", August 2008.
26.3 NUREG/CR-6773, *GSI-191: Integrated Debris-Transport Tests in Water Using Simulated Containment Floor Geometries*, December 2002
26.4 NUREG/CR-2982, *Buoyancy, Transport, and Head Loss of Fibrous Reactor Insulation,* Revision 1. July 1983
26.5 STPNOC Calculation NC-7032 "Containment LOCA Pressure / Temperature Analysis."

D. Head Loss and Vortexing

RAI #27
Please provide the vortex test conditions and observations. Page 50 of the supplemental response dated December 11, 2008, stated that the Froude (Fr) number was limited to < 0.25, but on page 38 it was stated that the Fr # = 0.459. Please explain this apparent discrepancy.

Response to RAI #27

RG 1.82 Revision 3 limits the Froude number to a value of < 0.25 for sump designs and conditions. However this document does not directly apply to strainer designs. The STP Sure-Flow® Suction emergency sump strainer configuration is such that the guidance provided in the subject RG does not really apply.

A Froude number of 0.459 was calculated for the STP strainer.

This aspect of the strainer design is concerned with vortex formation and potential air ingestion.

The PCI Sure-Flow® Strainer design incorporates three recognized and recommended means for vortex elimination and suppression:

1. Long flow path from water surface through the PCI Sure-Flow® Strainer, plenum, sump, and ECCS pump inlet piping.

2. PCI Sure-Flow® Strainer suction flow control device (SFCD) technology – the 'core tube' provides uniform approach velocity to all strainer modules.

3. PCI Sure-Flow® Strainer design utilizes a combination of recognized multiple vortex suppression devices – perforated plate, parallel disk plates, disk grill wires, core tube slots, module external bracing, and the resultant tortuous strainer internal flow path.

PCI Technical Document No. TDI-6005-07, *Vortex, Air Ingestion & Void Fraction, South Texas Project Units 1 & 2* addresses vortex formation and subsequent air ingestion associated with the strainer and concludes that these issues are not a concern for the STP strainers.

The PCI Sure-Flow® Suction Strainer technology has been extensively tested with regard to the issues of vortex formation and air ingestion. Testing has been performed by PCI and independently at the Fairbanks-Morse Pump Company (FMPC), the Alden Research Laboratory (ARL), and the Electric Power Research Institute's (EPRI) Charlotte NDE Center. The subject testing has been performed on both generic and customer specific basis for both pressurized water reactor (PWR) and boiling water reactor (BWR) nuclear power plants in vertical and horizontal strainer orientation configurations as well partially (i.e., small break LOCA (SBLOCA) and flood-up/rising water scenarios) and fully submerged post-LOCA conditions. In no case has sustained vortex formation been observed during the multitude of strainer tests that would result in subsequent air ingestion.

Vortex formation was not observed during the flume testing of the STP strainer at ARL with the conditions of 10" submergence (LBLOCA) and ½" submergence (SBLOCA).

Based on the above discussion, there is considerable empirical data that demonstrates that the STP Sure-Flow® Suction Strainer will not promote or support vortex formation, but will in fact suppress the formation of a vortex. Accordingly, air ingestion is also precluded, since there is no mechanism to draw air into the ECCS and CSS pumps' suction.

For both the Design Basis LBLOCA and the SBLOCA scenario, the STP Sure-Flow® Suction Strainer by design and supported by a multitude of tests does not promote vortex formation and subsequent air ingestion.

References:

27.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.

27.2 Regulatory Guide 1.82, *Water Sources for Long-Term Recirculation Cooling Following a Loss-of Coolant* Accident, Revision 3. November 2003

27.3 TDI-6005-07, *Vortex, Air Ingestion & Void Fraction, South Texas Project Units1&2*

RAI #28

Please provide debris sizing, amount of each debris size for each size category, and basis for the distribution chosen for the debris surrogates added to the head loss testing (similar to what was provided in the February 29, 2008, submittal that referred to an earlier test protocol no longer credited by the licensee). As discussed in the "NRC Staff - 10 Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing," dated March 2008 (ADAMS Accession No. ML080230038), and in Appendix II of the NRC staff's SE on NEI 04-07, the debris should be categorized into distinct sizes including fine debris in order to ensure that the test was conducted in a manner that realistically modeled transport of the debris. Please state what categorization was used and justify any method chosen that is not consistent with the NRC staff's SE and guidance.

Response to RAI #28

This RAI response has been written to support the applicability of the July 2008 STP strainer head loss testing [28.7] to the RoverD methodology. Specifically this RAI discusses the fine and small fiber distributions as well the particulate sizes used for the STP July 2008 test as well as their surrogate preparation and introduction to the test flume. The fraction of small fiber debris is not important to the current limit of fine fiber mass (191.78 lbm) being used in the RoverD methodology, but the preparation of the small and fine debris is important to the overall outcome of the July 2008 test.

For additional information, refer to Item (3.f, 4) in the updated content guide, Attachment 1-2.

RAI #29
Please justify that the debris addition sequence did not non-conservatively affect the ability of more transportable debris to reach the strainer. The supplemental response dated December 11, 2008, indicated that some fine fiber debris was added after less transportable debris and that coating chips were added in the first debris addition batch. The addition of less transportable debris prior to more transportable debris is likely to result in the entrapment of some debris that might otherwise reach the strainer.

Response to RAI #29

This RAI response has been written to support the applicability of the July 2008 South Texas Project Test Report for ECCS Strainer Testing [29.1] to the RoverD methodology.

The STP Design Basis test (Test 2) [29.1] debris addition sequence was conservative and prototypical for an integrated debris transport and head loss test. Accordingly, the STP ARL Large Flume Test debris addition sequence did not adversely affect the ability of transportable debris to reach the test strainer. The sequencing and concentration of debris slurries prepared for testing and the potential for debris to agglomerate during preparation and addition were treated conservatively and the actual and expected STP post-LOCA conditions within containment were represented.

Debris Introduction & Sequencing

The STP bounding debris head loss tests performed in July 2008, as documented in the test report, met the intent of the discussions between Staff and STP/PCI/AREVA/ARL (ADAMS Accession No. ML080310263) [29.6], and utilized the following sequence in order of debris addition:

- **Batch 1** (25% of latent fiber debris quantity)
- **Batch 2** (Microtherm powder, coating particulate (acrylic coating surrogate), IOZ particulate (tin powder surrogate), latent debris – dirt & dust, Marinite board powder, remaining latent fiber, LDFG (fine NUKON), and LDFG (fine Knauf ET)
- **Batch 3** (1/64' coating chips (acrylic coating surrogate), LDFG (small NUKON), and LDFG (small Knauf ET)
- **Batch 4** (eroded large LDFG (small NUKON) and eroded large LDFG (small Knauf ET)
- **Batch 5** (alternating quantities of aluminum oxyhydroxide and calcium phosphate)
- **Batch 6 - 8** (calcium phosphate)
- **Batch 9** (alternating quantities of aluminum oxyhydroxide and calcium phosphate)
- **Batch 10 – 12** (calcium phosphate)
- **Batch 13** (alternating quantities of aluminum oxyhydroxide and calcium phosphate)
- **Batch 14 – 16** (calcium phosphate)
- **Batch 17** (alternating quantities of aluminum oxyhydroxide and calcium phosphate)
- **Batch 18 – 20** (calcium phosphate)

- **Batch 21** (alternating quantities of aluminum oxyhydroxide and calcium phosphate)
- **Batch 22** (calcium phosphate)
- **Batch 23 – 37** (aluminum oxyhydroxide)

It should be noted that a 'batch', consisting of multiple debris types was not mixed together in a single container. Each debris type in a 'batch' was mixed in an individual container and separately added to the test flume. In addition, a specified number of pool turnovers took place between the additions of subsequent debris types.

Also, the debris types were sequenced from the most transportable to the least transportable. Batch 2 contained the most transportable debris consisting of particulate and fine fiber debris types. Batch 3 contained transportable coating chips and small fiber debris. Finally, Batch 4 contained the least transportable debris consisting of eroded large fiber debris. This was done to ensure that less transportable debris did not inhibit or interfere with the more transportable fiber and particulate debris utilized in the STP bounding debris head loss tests.

Coating Chip Sequencing

The addition of 1/64" coating chips introduced prior to some of the fiber debris did not result in a non-conservative debris introduction sequence; specifically debris such as the coating chips would not inhibit the transport of fiber debris to the strainer. The following discussion provides the basis for this conclusion.

NUREG/CR-6916, *Hydraulic Transport of Coating Debris* [29.3] was performed as a sub-task of GSI-191. The purpose of the subject NUREG/CR was to evaluate the settling and transportability characteristics of various type coating chips under plant specific conditions. Coating chips in the size range of 1/64" to 1/32" were evaluated which bound the 1/64" chips for STP.

The subject NUREG/CR states in part, ... *For the smaller sized chips (3.2 to 6.4 mm (1/8 to 1/4 inches) and 0.4 to 0.8 mm (1/64 to 1/32 inches)), the pieces sank immediately, or remained on the surface indefinitely. ... Generally the smaller size chips exhibited a greater tendency to remain on the surface indefinitely.*

The NUREG/CR also determined that the density of the coating chips based on the coating systems such as alkyds, alkalines, enamels, epoxies, IOZ, and IOZ epoxy combinations greatly affected the floating and settling ability of the coating chips. NEI 04-07 Volume 1[29.4] and Volume 2 [29.5] state that all unqualified coating systems and qualified coatings within the ZOI will fail as particulate. Only those qualified coating systems, primarily epoxy-based systems and/or combinations thereof outside of the ZOI may fail as coating chips. Epoxy coating systems typically utilized in nuclear power plants all have a density greater than water (i.e., 62.4 lbs/ft^3). Therefore, the epoxy coating chips would sink unless air is 'trapped' on the chip surface and/or the surface tension of the water prevents the sinking of the chips which would then result in the floating of the subject chips.

The PCI 'white paper' Performance Contracting, Inc., SSFS-TD-2007-004, *Sure-Flow Suction Strainer – Testing Debris Preparation & Surrogates* [29.2], addresses and discusses coatings and coating surrogates utilized for Licensee testing including the STP bounding debris head loss testing performed at the ARL Large Flume Test Facility. In almost all cases the Licensees did not provide specific 'coating brand names' for their coating systems. Therefore, PCI 'bounded' all Licensee coating systems by using acrylic (i.e., particulate (powder) and chips) coating materials (i.e., chips and particulate (powder)) as the coating surrogate. The acrylic coating chips and powder (particulate) can be manufactured in a wide range of densities that bound the actual coating systems. The Licensees specified 'generic' coating systems (i.e., acrylic, enamel, alkaline, epoxy, etc.) have a density range above 74.9 lbs/ft^3 but less than 110 lbs/ft^3 except for IOZ coatings. In the case of coating chips representing qualified epoxy coatings outside of the ZOI, PCI has documentation and specific testing that confirms an average acrylic paint chip specific gravity of less than 1.24, or a density of 77.4 lbs/ft^3.

Based on NUREG/CR-6916 [29.3], since the STP coating chips have a density greater than water, it can be concluded that the chips would immediately sink or float indefinitely due to water surface tension and/or trapped air on the chips. In either case, the STP coating chips in the size range of 1/64" would not affect nor inhibit the transport of the various types of subsequent debris and ultimately the strainer head loss test. In addition, the STP test report supports this conclusion.

Therefore, based on the PCI 'white paper, the conclusions reached in NUREG/CR-6916 [29.3] regarding coating chips, and the results documented in the STP test report, it can be concluded that the sequencing of fiber and particulate debris (coating chips) did not affect the transport of the subsequent debris being added to the test flume nor the STP bounding debris head loss test results. This conclusion is supported based on the following facts:

- There was one or more flume turnovers before the addition of the next debris type to ensure that the debris type had adequate time to transport within the flume, settle to the bottom of the flume, or float on the surface of the flume. The delay in the addition of subsequent debris would ensure that the previous debris was not prohibited from potential transport by the subsequent debris.

- One flume turnover for STP takes approximately 5.2 minutes based on the STP Design Basis scaled ECCS/CSS flow rates and ARL CFD model. At the slowest STP scaled flume flow velocity of 0.30 ft/s, debris added to the test flume could travel a distance of 94 ft during the approximately 5.2 minute duration required for one flume turnover. The STP test flume length from the point of debris introduction to the STP strainer module is approximately 33 ft. Therefore, the added debris could travel a potential distance of *more than 2.8 times* the length of the STP test flume before the subsequent addition of debris takes place based on the *lowest* STP scaled flume flow velocity. Subsequent added debris would not be prohibited from being transported by previously added debris.

- Floating and/or settled debris would not preclude the transport of subsequent debris since it is located at the outside 'extremes' of the flume flow boundaries, away from the subject debris.

In conclusion, the preparation, concentration, and introduction sequencing of fiber debris did not promote the agglomeration of the debris and did not inhibit the transport of same other than what would have naturally occurred in an open, free-flowing water stream such as would occur in the STP post-LOCA containment following initiation of ECCS/CSS recirculation.

References:

29.1 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.

29.2 Performance Contracting, Inc., SSFS-TD-2007-004, Supplement 1, Rev. 1, *Sure-Flow Suction Strainer – Testing Debris Preparation & Surrogates* (ML092430056 & ML092580203)

29.3 NUREG/CR-6916, *Hydraulic Transport of Coating Debris*, December 2006

29.4 NEI 04-07 Volume 1, *Pressurized Water Reactor Sump Performance Evaluation Methodology*, Revision 0. December 2004

29.5 NEI 04-07 Volume 2, *Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02*, Revision 0. December 2004

29.6 Discussions between the Staff and Licensees/PCI/AREVA/ARL (ADAMS Accession No. ML080310263)

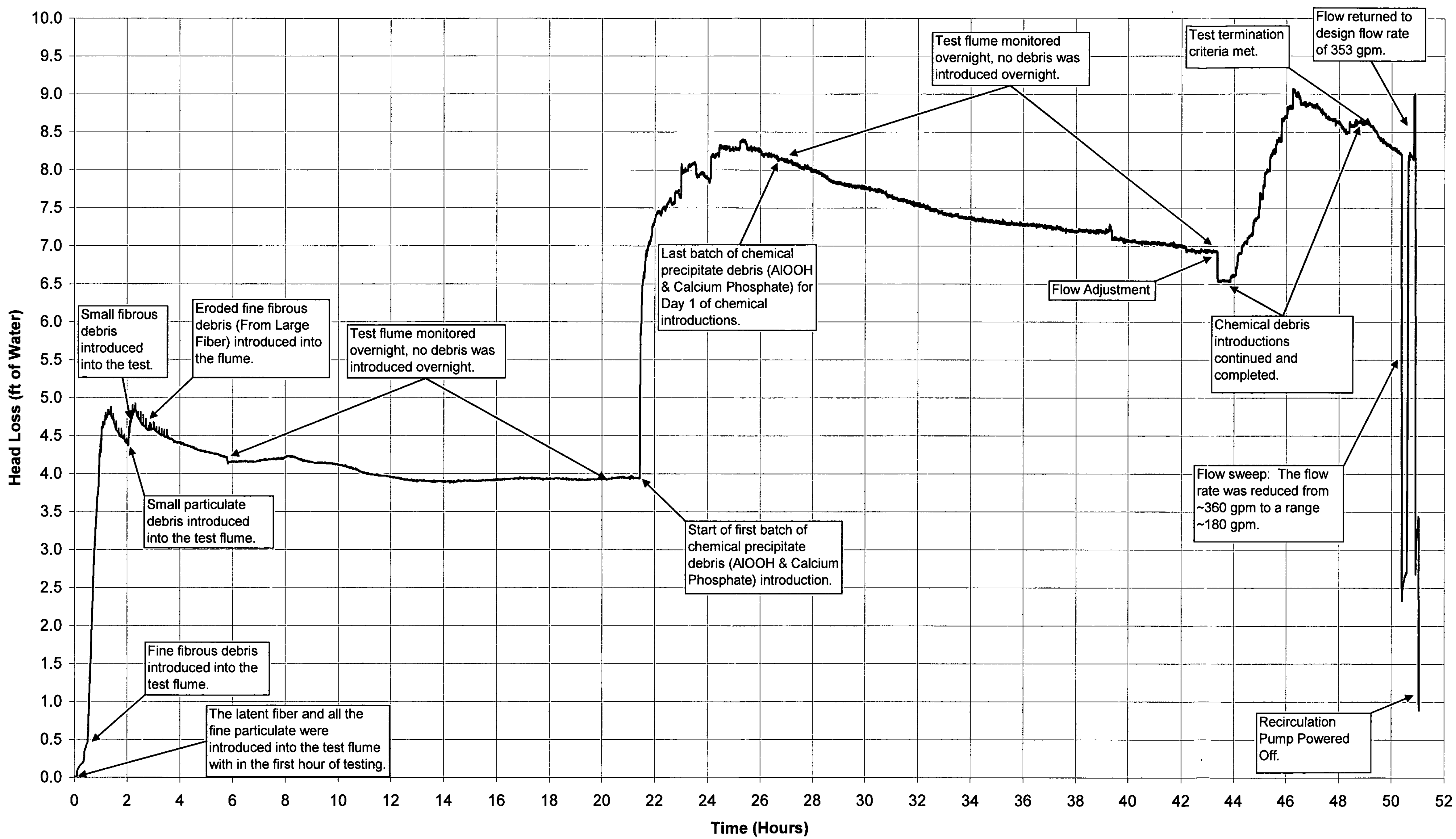
RAI #30
Please provide the head loss plots for the testing including annotation of significant events during the test. Please include the portion of the plot that shows the flow sweeps that were performed to determine whether boreholes were present in the debris bed.

Response to RAI #30

The plot of the head loss vs. time for the STP design basis test (Test 2) is provided below.

References:

30.1 AREVA NP Document 63-9086408-001, "South Texas Project Test Plan for ECCS Strainer Performance Testing", August 2008
30.2 AREVA NP Document 66-9088089-000, "South Texas Project Test Report for ECCS Strainer Performance Testing", August 2008


Head Loss (ft of Water)
Time (Hours)
Small fibrous debris introduced into the test.
Eroded fine fibrous debris (From Large Fiber) introduced into the flume.
Test flume monitored overnight, no debris was introduced overnight.
Small particulate debris introduced into the test flume.
Fine fibrous debris introduced into the test flume.
The latent fiber and all the fine particulate were introduced into the test flume with in the first hour of testing.
Last batch of chemical precipitate debris (AlOOH & Calcium Phosphate) for Day 1 of chemical introductions.
Start of first batch of chemical precipitate debris (AlOOH & Calcium Phosphate) introduction.
Test flume monitored overnight, no debris was introduced overnight.
Test termination criteria met.
Flow returned to design flow rate of 353 gpm.
Flow Adjustment
Chemical debris introductions continued and completed.
Flow sweep: The flow rate was reduced from ~360 gpm to a range ~180 gpm.
Recirculation Pump Powered Off.

RAI #31

Please provide the design maximum head loss and the basis for the maximum. It appeared that the structural limit may provide the maximum allowable head loss. Verify that the structural pressure limit of 5.71 feet is not exceeded during any phase of the LOCA response. Please provide head loss at lowest postulated sump temperature and compare it to the structural limit. State whether clean strainer head loss counts against the structural limit, or if only debris head loss needs to be considered. Page 51 of the supplemental response dated December 11, 2008, states that the total strainer head loss is 6.504 feet at 171 °F. It is unclear whether this includes the clean strainer head loss. The debris head loss will increase as temperature decreases. Please provide the outcome of extrapolations of the head loss test results to various temperatures required for head loss considerations.

Response to RAI #31

See Item (3.k,3) in Content Guide, Attachment 1-2.

RAI #32

Please provide information on whether the strainer is vented. The supplemental response dated December 11, 2008, states that the strainer will be fully submerged, but the response did not address whether there are vent paths above the submerged water level. If the strainer is vented, please justify that the strainer will function adequately in the vented configuration considering that the available driving head across the strainer is caused only by the elevation difference between the water upstream and downstream of the strainer.

Response to RAI #32

The emergency sump strainers are not vented.

Reference:

32.1 PCI Drawing "Strainer General Arrangement"; STP File No. 0415-0100025WN Rev. A

RAI #33
The supplemental response dated December 11, 2008, stated on page 53 that containment accident pressure was not credited to prevent flashing across the strainer. However, the tested head loss is much greater than the stated strainer submergence (10 inches for large break LOCA and 0.5 inches for a small break LOCA). The sump temperature is greater than 212 °F at switchover to recirculation. Therefore, some containment pressure is likely required to prevent flashing. Please provide the margin to flashing and the assumptions for the calculation.

Response to RAI #33

The application of the static water head and containment accident pressure for the strainer will result in no flashing using the very conservative strainer head loss.

Large Break Loss of Coolant Accident (LBLOCA)

The maximum strainer recirculation flow is 7,020 gpm. The minimum post-LOCA containment water level at the initiation of ECCS/CSS recirculation is Elevation (-)8'1" [Elevation (-)8.083'] which is 38" off the floor. The minimum strainer submergence was conservatively determined to be 10.1" for LBLOCA. The total strainer head loss (TSHL) includes the clean strainer head loss and the debris bed head loss based on the July 2008 strainer head loss testing. The TSHL is 3.8 ft. for 267°F.

At the start of recirculation (approx. 20 minutes post-LOCA) we have:

- Sump temperature is 267°F
- Containment pressure is 43.1 psia
- Submergence above the strainer is -8.083' – (-8.875') = 0.844 ft. of water [10.1"; 0.3 psi]
- TSHL = 3.8 ft. (1.5 psi)
- Vapor pressure for 267°F is 39 psia

The margin to flashing is containment pressure + submergence -TSHL - vapor pressure =
43.1 + 0.3 -1.5 -39 = 2.3 psi

In this case, post-LOCA containment over-pressure credit is needed in order to eliminate the issue of flashing.

Note that this evaluation very conservatively assumes that the debris bed including chemical precipitates is fully formed at the start of recirculation at a post-LOCA time of 20 minutes. Also note that the July 2008 head loss test showed that 50% of the debris head loss was due to chemical debris. Other chemical effects testing shows that there are no precipitates at this high sump temperature; and very little or none at much lower temperatures.

Small Break Loss of Coolant Accident (SBLOCA)

The minimum strainer submergence was conservatively determined to be 0.5" for SBLOCA. The sump temperature and containment pressure would be lower for a SBLOCA compared to the LBLOCA case evaluated above. The strainer flow rate would also be lower. The debris amounts transported to the strainers would be much less such that there would be open strainer areas. For these reasons, flashing is not expected to be an issue for the SBLOCA case.

References:

33.1 Regulatory Guide 1.82, *Water Sources for Long-Term Recirculation Cooling Following a Loss-of Coolant* Accident, Revision 3. November 2003

33.2 PCI Technical Document No. TDI-6005-07, *Vortex, Air Ingestion & Void Fraction, South Texas Project Units 1 & 2*

33.3 STPNOC Calculation MC06220 Rev. 6 "SI & CS Pump NPSH"

33.4 STPNOC Specification 4N129MS0096 Rev. 4 "Emergency Sump Strainers"

RAI #34
In addition to flashing, the potential for deaeration of the coolant as it passes through the debris bed should be considered. Please provide an evaluation of the potential for deaeration of the fluid as it passes through the debris bed and strainer and whether any entrained gasses could reach the pump suction. If entrained gasses can reach the pump suction, please evaluate how the net positive suction head required (NPSHr) for the pump could be affected as described in NRC Regulatory Guide 1.82, Revision 3, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident," Appendix A (ADAMS Accession No. ML033140347).

Response to RAI #34

In the response for RAI #33, the STP head loss value for the STP Design Basis conditions of the LBLOCA (7,020 gpm at 171°F) and SBLOCA (3,550 gpm at 171°F) are 6.504 and 0.8717 ft of water, respectively. The vortex, air ingestion, and void fraction analysis concluded that void fraction occurring at the strainer debris bed due to head loss and the accompanying post-LOCA conditions would be reversed and any voids would have collapsed before the strainer discharge fluid left the containment sump and entered the ECCS/CSS inlet lines. The net void fraction (i.e., net air production) is therefore 0%. Therefore, void fraction is not an issue for any of the post-LOCA fluid associated pressure and temperature combinations associated with the subject fluid flow from the strainer to the ECCS/CSS inlet lines.

It is recognized that a small amount of deaeration will occur due to the difference in the solubility of air in water resulting from the pressure differential across the strainer and debris bed. A conservative assessment was made of the theoretical void fraction (air ingestion rate) which is expected to be minimal.

The solubility of air in water is inversely proportional to the water temperature. In other words, the solubility is a maximum at the lowest water temperature of interest. In addition, the solubility is proportional to absolute pressure. The difference of solubility is 0.023 g Air / kg water per one atmosphere.

The STP bounding differential pressure for the strainer is 6.504' (i.e., Design Basis Maximum Allowable Head Loss). Therefore, 6.504' = 1.982 m = 0.192 atm.

Conservatively assuming that the water entering the strainer is fully saturated with air, the bounding difference of air solubility in water is as follows:

0.192 x 0.023 = 0.004416 g air / kg water

The densities of air and water are:

Air: 1.169 kg/m^3 at 25°C and one atmosphere

Water: 997 kg/m^3 at 25°C

The volume ratio of air and water therefore is:

(0.000004416 kg Air / kg Water) / 1.169 kg/m^3 x 997 kg/m^3 = 0.00377 or 0.377%

The subject solubility value is at the top elevation of the strainer, actually at the water surface above the top of the strainer that is in contact with the containment post-LOCA atmosphere.

At the ECCS/CSS pump suctions from the STP sump pit, the strainer discharge water experiences a pressure increase again due to the static water head (i.e., the water column above the ECCS/CSS pump suctions inlets within the sump). The minimum LBLOCA post-LOCA containment water elevation is -8'-1" (-8.083'). The ECCS/CSS pump suction inlets in the sump are located at centerline elevation -15'-9" (-15.75'). This would theoretically result in an elevation difference of 7.667', which is greater than the postulated strainer differential pressure of 6.504'.

It should be further noted that the aforementioned discussion was based on a water temperature of 25°C which is 77°F. The STP Design Basis minimum post-LOCA water temperature is 128°F which is almost double. Accordingly, at the STP Design Basis minimum temperature, the solubility of air in water would be approximately less than half of the conservatively calculated value of 0.377%.

Therefore, any void fraction that could occur at the strainer debris bed is minimal. If any should occur, it is reversed before the strainer discharge water leaves the sump due to the significant static head of water above the ECCS/CSS pump suction inlets within the sump. The net void fraction is therefore zero and is not a problem for any of the STP pressures and temperatures from the strainer to the ECCS/CSS pump suction inlets within the sump.

Reference:

34.1 PCI Technical Document No. TDI-6005-07, Vortex, Air Ingestion & Void Fraction, South Texas Project Units 1 & 2

RAI #35

Please address the potential for floating debris to collect on top of strainer during a small break LOCA and thus provide a potential air-entrainment pathway to the interior of the strainer.

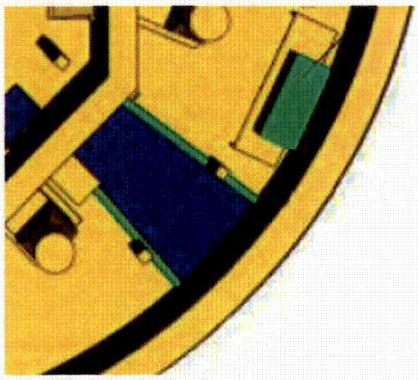
Response to RAI #35

For the SBLOCA case, the potential for floating debris to collect on top of the strainer and provide an air-entrainment pathway is rather small. The only portion of the post-LOCA debris load that could potentially remain buoyant is the low density fiber glass (LDFG) insulation. The amount of fiberglass insulation debris that is generated by the SBLOCA and transported to the sump area is very small compared to the design basis case (1.05 ft^3 vs. 226.4 ft^3). Industry testing has shown that this type of debris becomes saturated and sinks very quickly in hot water. During testing of the prototype strainer module with cold water (50 °F), there was a considerable amount of floating debris but no observed air ingestion with a submergence of ½ in. Subsequent testing with hot water (120 °F), did not yield any floating fiberglass insulation debris. Since there was no air ingestion with floating debris with minimal submergence for the cold water test and since the much hotter temperature water expected for the post-LOCA condition will minimize floating debris, this precludes any opportunity for an artificial vent to form between the strainer and the surface of the water.

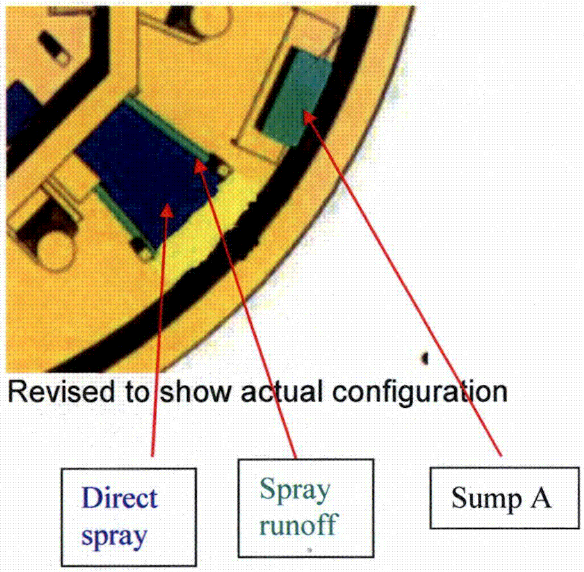
RAI #36

On page 21 of the December 11, 2008, supplemental response, one of the strainers (Strainer A) appears to be located near a region where runoff from spray drainage enters the containment pool. Given that the submergence of the strainers is minimal for the small break LOCA case (0.5 inches), please provide a technical basis for concluding that drainage of spray water near the strainer surface will not result in splashing and surface disturbances that would cause unacceptable air entrainment into the strainers and emergency core cooling system (ECCS) and containment spray pumps.

Response to RAI #36



From Page 21 of the Dec 11, 2008 response.



Revised to show actual configuration

The actual physical configuration for the runoff path for spray drainage near Sump A is not exactly as shown in the figure from the model for the transport analysis. As verified by plant walk down, the runoff path does not extend all the way the containment wall. Rather it stops at the structural support column. There is 5 ft. horizontal separation between the runoff path and the edge of the closest strainer module for Sump "A." The structural column provides shielding of the strainer module from the spray runoff. Because of the location of the column and the horizontal separation from the spray runoff, the strainer module would not be subject to splashing that could have an unacceptable air entrainment impact.

In the extremely unlikely event that the STP strainer modules were exposed due to the falling water, the design of the strainer and more importantly the fact that the strainer core tube is fully submerged will preclude the ingestion of air even if the upper portions of the strainer are not fully submerged.

E. Net Positive Suction Head (NPSH)

RAI #37
Please provide NPSH margin results for low head safety injection, high head safety injection and containment spray pumps, for the large break LOCA and small break LOCA cases, under conditions of hot-leg recirculation.

Response to RAI #37

The NPSH margin provided in Table 37-1 is the difference between NPSH available and NPSH required for LBLOCA. The total strainer head loss includes the debris bed loss and the strainer head loss. For a sump temperature of 212°F and higher, the NPSH available considered that the containment pressure was equal to the vapor pressure.

Table 37-1
NPSH Margin at Start of Hot Leg Recirculation, 5.5 hrs post-LOCA; 226°F
For Large Break LOCA

Pump	NPSH required, ft	NPSH available, ft	NPSH Margin, ft	Total strainer head loss, ft
LHSI	1.5	7.5	6.0	4.6
HHSI	1.1	7.4	6.3	4.6
CS	1.4	7.2	5.8	4.6

At the initiation of the SBLOCA (3,550 gpm strainer flow), the amount of post-LOCA debris generated will be significantly less than that for the STP Design Basis LBLOCA (7,020 gpm strainer flow). In addition, any post-LOCA debris as minimal as it is for the SBLOCA scenario will also ***not*** be readily transported to the strainer due to the significantly reduced strainer flow velocity associated with the SBLOCA scenario (i.e., 0.004 fps for 3,550 gpm). Due to a combination of reduced post-LOCA debris and the fact that the SBLOCA scenario may not result in actuation of the accumulators, the expected quantity of chemical debris precipitates as a result of the SBLOCA scenario will be significantly less. The combination of the above items will all result in a SBLOCA scenario strainer that has little if no debris on the strainer that would contribute to head loss. For all practical purposes the strainer will be free of any debris.

Thus there is only the clean strainer head loss for the SBLOCA case which is much less than the LBLOCA total strainer head loss. The lower flow for the SBLOCA case would reduce the clean strainer head loss compared to the LBLOCA case. The NPSH available would be slightly higher for the SBLOCA case since the piping friction loss is less due to lower flow. So for the SBLOCA case compared to the LBLOCA case, the NPSH margin would increase somewhat and the total strainer head loss would be much less.

Reference:

37.1 STPNOC Calculation MC06220 Rev. 6; SI & CS Pump NPSH

RAI #38
As requested in NRC's November 2007 content guide, please describe the methodology and assumptions used to compute the limiting pump flow rates for all pumps taking suction from the ECCS sumps

Response to RAI #38

Each of the 3 emergency sumps supplies water to the respective Containment Spray Pump, Low Head Safety Injection Pump, and High Head Safety Injection Pump for that Train.

The CS Pumps discharge to a common ring header piping arrangement. The CS Pump flow used for the NPSH evaluation is based on 2 CS Pumps operating which yields a higher flow per pump than if all 3 CS pumps were operating and discharging to the common ring headers.

The flow rates used for the Low Head and High Head Safety Injection Pumps are the maximum values given in the Technical Specifications.

RAI #39

As requested in the NRC's content guide, please provide the volumes of the water sources that contribute to the formation of the containment pool for the limiting minimum containment water level. Please include a specific discussion of both the large and small break LOCA cases. In particular, for small break LOCA cases, the accumulators and RCS volumes may not contribute to containment pool formation because the RCS pressure may remain too high for accumulator injection and because ECCS injection may result in the refill of the RCS with cooler water, even including the pressurizer steam space for a limiting break near the top of the pressurizer.

Response to RAI #39

See Item 3.g,8 in Attachment 1-2.

RAI #40
As requested in the NRC's content guide, please identify the methodology and any computer codes used to perform the suction piping friction loss calculations to determine the loss coefficients.

Response to RAI #40

The suction piping and fitting friction head losses are based on standard industry methodologies using Crane Technical Paper 410 and Cameron Hydraulic Data. The maximum pump flow rates were used. No computer codes were utilized for the calculations.

Reference:

40.1 STPNOC Calculation MC06220 Rev. 6 "SI & CS Pump NPSH"

RAI #41
As requested in the NRC's content guide, please state the criterion and methodology used by the pump vendor to determine the NPSHr for all pumps taking suction from the ECCS sumps.

Response to RAI #41

See Item 3.g,3 in Attachment 1-2.

RAI #42

Please provide the basis for considering the two-train NPSH results (based on the failure of one diesel generator) to be the limiting single failure. The NRC staff noted that other cases exist, such as the operation of three trains (no single failure), or the operation of a single train (which is permitted by the emergency operating procedures through operator actions to shut off redundant pumps). Please provide the NPSH results for these other cases and the basis for considering the two-sump case as limiting with respect to NPSH margin.

Response to RAI #42

The design basis for STP is to have a minimum of 2 out of the 3 Trains of ECCS and CS to be used for accident mitigation. Containment analyses consider operation of either two or three ECCS and CS trains at time of accident initiation. This is stated in the licensing basis (UFSAR Section 6.2.1 and 6.3.1). For 3 Train operation, the design basis debris loading will be split among the 3 sumps; and each of the 3 operating sump strainers will have a debris loading per sump that is less than the design case with 2 sumps in operation. Consequently the debris head loss will be less per sump strainer which will have a positive effect on the NPSH margin.

Use of only a single Train is not part of the deterministic design and licensing basis (single train use is discussed in the risk informed approach of RoverD as given in Attachment 1-3). The emergency operating procedures allow containment spray, high head safety injection, and low head safety injection pumps to be secured manually if certain specific criteria are met and permission from the Technical Support Center is obtained. However, the emergency operating procedures do call for 2 low head safety injection pumps to be operating. One low head pump is aligned for cold leg recirculation and the other is switched from cold leg to hot leg recirculation after a certain time post-LOCA. Thus 2 sumps would be in operation to supply the respective low head pump of the 2 Train operation. If any containment spray pumps and/or high head safety injection pumps are secured then there would be less flow through the sump strainer which would result in less debris head loss and there also would be less piping friction loss. This would have a positive effect on the NPSH margin.

The two operating sump case is the limiting case for NPSH margin.

RAI #43
Please state whether the NPSH results on page 58 of the December 11, 2008, supplementary response include debris bed and clean strainer head loss. If these additional loss terms are included in the results, then please provide NPSH margin results that do not include these terms, per the definition of NPSH margin in Regulatory Guide 1.82.

Response to RAI #43

See Item 3.g,16 in Attachment 1-2.

RAI #44
Please identify the volume of holdup assumed for the refueling canal and provide further information that justifies that the refueling canal drains cannot become fully or partially blocked such that additional hold up could occur, or the extent to which hold up could occur. STP has the potential to generate hundreds of cubic feet of fiber, as well as miscellaneous debris and other materials. It is not clear from the information provided in the supplemental responses that the existing design of the drains is sufficient to keep small and large pieces of debris from plugging the drains for the refueling canal. In particular, it is not clear why large pieces of debris (e.g., fibrous, miscellaneous, etc.) cannot be transported to the upper containment through blowdown or other transport processes. If debris larger than or similar to the size of the drain line ends up in the refueling cavity; it is not clear that temporary floatation and transport by surface currents to the drains would not provide a credible mechanism for blocking the drain lines. In a like manner, several small pieces of debris may be capable of causing partial or complete blockage of the drain lines as well.

Response to RAI #44

In support of the South Texas GSI 191 project, LTR-CSA-06-45 (Reference 44.1) states the justification that the refueling cavity drain lines will not be blocked following a design basis accident. This letter was written to Alion and prepared by Westinghouse in July 2006.

> Reference 44-1: LTR-CSA-06-45, "Refueling Cavity Drain Line," July 11 2006.
> This document is transcribed here:
>
> The South Texas Project refueling cavity includes the upper internals storage area, the top of the reactor vessel and the lower internals storage area (LISA). The LISA is the lowest part of the refueling cavity.
>
> Adjacent to the LISA is the fuel storage pit and the refueling canal (Reference 1). There are two horizontal 6" drains in the LISA which are located 21 ft. apart on the east and west sides. These horizontal refueling cavity drains are made from 6" schedule 40 piping with an inside diameter of 6.065". The drain lines run through the refueling cavity wall and discharge approximately 9" beyond the cavity wall. The drain lines are straight pipe runs with no turns or trash racks at either end to restrict flow. The lines are approximately 7'-6" in length. The bottom inside edge of the drain lines are located approximately 7" above the bottom of the refueling cavity floor (Reference 2).
>
> During refueling operations, the drain lines are closed using blind flanges. Prior to power operation, the drain lines are opened per procedure (Reference 3).
>
> Following a design basis LOCA inside containment, some of the debris generated during the blowdown of the RCS is assumed to be blown into the containment atmosphere and fall into the refueling cavity. In addition, some of the debris blown into the containment atmosphere is assumed to fall onto the operating deck next to the refueling cavity. This debris is assumed to be washed into the cavity as a result of the containment spray flow onto the operating deck on El. 68'-0".
>
> The maximum quantity of this debris expected to either fall directly in the refueling cavity or be washed into the cavity from the operating deck is 74 ft^3 of fiber insulation fines (individual fibers) and 184 ft^3 of fiber insulation small pieces (less than 6 inches on a side)

of fiber insulation (Reference 4). No other large debris types are expected in the refueling cavity. These quantities include debris that is transported to the fuel storage pit during power operation; there is a direct flow path between the refueling cavity and the fuel storage pit. This quantity of debris is conservative since all the debris falling on to the operating deck is assumed to be washed into the refueling cavity. No credit is taken for debris being washed into the cable chases or other openings located on the operating deck on El. 68'-0". No credit is taken for debris remaining lodged on the operating deck.

Even if all this fiber debris is transported to the refueling cavity, the drain lines are assumed not to become blocked with debris, thereby preventing water from reaching the containment emergency sumps on El. (-)11'-3". The justifications for this assumption are:

- The maximum flow through each drain line is 517 gpm based on all 3 containment spray pumps operating at a combined flow of 6180 gpm (Reference 5). The minimum containment spray flow based on 2 pumps operating at a combined flow of 3863 gpm (Reference 6) would produce a minimum flow through the drain lines of 323 gpm. The minimum flow through the drain lines would produce a flow velocity of approximately 3.58 ft/sec in the drain lines. Based on NEI 04-07, Table 4-2, the incipient tumbling velocity for 6 inch pieces of NUKON fiberglass is 0.12 ft/sec, (Reference 7). Thus, any fiberglass debris entering the drain lines would be swept through the drain lines based on the minimum spray flow into the refueling cavity.
- Since the fiberglass debris is assumed to be blown up into the containment atmosphere, it is expected that the debris would be evenly dispersed throughout the containment. Even if the debris is assumed to be concentrated near the break location, the drain lines are located 21 feet apart on opposite sides of the refueling cavity, such that a large concentration of debris would not land near both of the drain lines.
- The largest debris pieces expected to be transported to the refueling cavity are smaller than the inside diameter of the drain lines. Also, the fiber debris is not rigid and will bend to fit through the drain pipe if the piece is slightly larger than 6".
- There are no trash racks for the fibers to buildup on and block the flow.
- Even if the debris would accumulate inside the drain lines, the buildup of water behind the debris will provide a sufficient driving force to push the debris through the straight short section of piping.

Thus, the refueling cavity drain lines are not assumed to become blocked; and there is no water inventory holdup other than the water below the evaluation of the drain lines.

References:

44.1 LTR-CSA-06-45 by Westinghouse with the following references:

1. STP Drawing 6C189N5006, Rev. 9, General Arrangement RCB Plan at El. 68'-0".
2. STP Drawing 3C269S1517, Rev. 6, Structural RCB Internal S. St. Liner.
3. STP Procedure 0PMP04-RX-0019, Rev. 34, Rapid Refueling Mechanical Support.
4. Alion Calculation ALION-CAL-STPEGS-2916-006, Rev. 0, Fibrous Debris Transport to the Refuel Cavity.
5. STP Calculation MC-6220, Rev. 6, SI & CS Pump NPSH.
6. STP Design Basis Document Containment Spray, 5N109MB01024, Rev. 3.
7. NEI 04-07, PWR Sump Performance Task Force, "PWR Sump Performance Evaluation Methodology," Revision 1, Nuclear Energy Institute, December 2004.

F. Coatings Evaluation

RAI #45
In accordance with the NRC staff's "Revised Content Guide for Generic Letter 2004-02 Supplemental Responses," dated November 21, 2007 (ADAMS Accession No. ML073110389), please provide the specific types of qualified coatings used in containment and the substrates on which they were applied. Also, please justify how the WCAP-16568-P testing is applicable to the qualified coatings at STP.

Response to RAI #45

WCAP-16568-P SUMMARY OF CONCLUSIONS

- For untopcoated inorganic zinc primer, measurable coatings loss is observed at both distances tested. As the L/DBREAK ratio increased from L/DBREAK = 3.23 to L/DBREAK = 3.68, there was a significant decrease in coatings loss (from an average loss of about 0.3 mils at a L/DBREAK = 3.23 to an average loss of about 0.1 mil at a L/DBREAK = 3.68). At the larger L/DBREAK ratio, this coatings loss was observed to be generally limited to a 2-inch radius about the center of the coupon, or the location on which the core of the jet directly impacted the coupon. Based on conservatively extrapolating the test observations, it is concluded that L/DBREAK = 4.28 is an appropriate and defensible estimate of the ZOI for untopcoated IOZ.

However, for added margin, it is suggested that L/DBREAK = 5.0 be used to evaluate debris generation from untopcoated inorganic zinc coatings for post-accident containment sump performance evaluations.

- For all tests conducted with epoxy topcoats, no measurable loss of epoxy topcoat could be detected. This included testing of epoxy topcoats over both inorganic zinc primer and epoxy primer on steel substrates, and the testing of epoxy topcoats over both cementitious and epoxy fillers on concrete substrates. Post-test observations demonstrated that no jet impingement damage is observed for epoxy topcoats, regardless of the undercoat or substrate, at a minimum ZOI radius of L/DBREAK = 1.37.

However, it is suggested that a minimum ZOI radius, L/DBREAK, of 4 be used in debris generation calculations for sump performance. The use of this value may reduce the volume of containment affected by the jet by as much as a factor of 15, depending upon configuration of walls and structures in the containment. The use of L/DBREAK ≥ 4 is bounded by the data from the current test program and provides margin, should it be needed, for future use in either refined debris generation calculations for replacement sump screen sizing or evaluating previously unidentified or new debris sources.

STP QUALIFIED COATINGS USED IN CONTAINMENT AND ON SUBSTRATES

See Item 3.h in Attachment 1-2

APPLICABILITY OF WCAP-16568-P TO STP

The applicability of WCAP-16568-P to all DBA Qualified/Acceptable epoxy coating systems and untopcoated IOZ coating systems, which are similar in composition and applied in a manner consistent with how they were tested to demonstrate their qualification, is supported by both coatings manufacturers and coatings consultants, as described in Appendix E of WCAP-16568-P. Therefore, this data can be used to reduce the ZOI associated with DBA Qualified/Acceptable epoxy coating systems and untopcoated IOZ coating systems when assessing the amount of debris resulting from coatings for post-accident sump performance evaluations.

References:

45.1 WCAP-16568-P, Revision 1, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) for DBA- Qualified/Acceptable Coatings," June 2008.

45.2 0PGP04-ZA-0307, Calculation Number AC05001#2, Revision 1, "Painted Surfaces Inside RCB #2" December 15, 1999.

45.3 Calculation Number 9AC5001#1, Revision 6, "Painted Surfaces Inside R.C.B. #1," July 18, 1989.

RAI #46

The Keeler and Long report 06-0413, "Design Basis Accident Testing of Coating Samples from Unit 1 Containment, TXU Comanche Peak SES," dated April 13, 2006 (ADAMS Accession No. ML070230390), referenced in the licensee's supplemental response, only applies to degraded qualified epoxies and not original equipment manufacturer epoxy coatings. Please clarify the definition of unqualified epoxy coatings at STP, since unqualified epoxy coatings may be considered to be degraded qualified coatings and/or original equipment manufacturer coatings, and that the unqualified epoxies used at STP are similar to the coating systems tested by Keeler and Long.

Response to RAI #46:

See Item 3.h,1 in Attachment 1-2.

RAI #47
Please clarify/justify the use of unqualified epoxy coating debris in chip form in head loss testing given that a continuous debris bed appears to form during testing. From the NRC review guidance and SE, if there is a bed present, all coating debris should be treated as particulate and assume to transport to the sump, unless proper justification and/or data are provided.

RAI #47 Response:

See Item 3.h,5 in Attachment 1-2.

G. Debris Source Term

RAI #48
The supplemental response dated December 11, 2008, provides a three-sentence summary of how the containment is kept clean. Please provide a more detailed description of the containment foreign material control programs for STP, including reference to procedural requirements and brief description of methods used to clean or maintain cleanliness.

Response to RAI #48

See Item 3.i,1 in Attachment 1-2.

H. Structural analysis

RAI #49
The supplemental responses contain very limited information detailing the results of the structural analyses performed to demonstrate the structural integrity of the replacement sump strainers at STP. The responses provide only a brief qualitative statement of the results without any supporting quantitative data summarizing the results of the analyses as requested in the second portion of item 3.k of the NRC staff's March 2008 revised content guide for the GL 2004-02 supplemental responses. Please provide the actual and allowable stresses and show the design margins for the strainers and all associated welds and components.

Response to RAI #49

See Item 3.k in Attachment 1-2.

RAI #50

Item 3.k.3 of the revised content guide for the GL 2004-02 supplemental responses requests that the licensee "Summarize the evaluations performed for dynamic effects such as pipe whip, jet impingement, and missile impacts associated with high-energy line breaks (as applicable)." The STP initial and final supplemental responses state that no evaluations were performed with regards to the effects that high energy line breaks may have on the strainers. They also state that while the high head safety injection lines are within the vicinity of the strainers, there is no need to perform an evaluation on these lines since the lines are "used for accident mitigation and are not assumed to be the accident initiator." The NRC staff considers that this is not an adequate justification for exempting the lines from an evaluation. Please provide a more detailed synopsis of where the lines are located with respect to the replacement strainers, whether breaks are postulated on these lines in accordance with the licensing basis, or justify technically why no breaks need to be postulated (e.g., are there normally closed isolation valves or is the piping otherwise only pressurized during accident mitigation?).

Response to RAI #50

See Item 3.k,4 in Attachment 1-2.

I. Downstream effects/in-vessel

RAI #51
The NRC staff does not consider in-vessel downstream effects to be fully addressed at STP as well as at other pressurized-water reactors. STP's submittal refers to draft WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid." The NRC staff has not issued a final safety evaluation (SE) for WCAP-16793-NP. The licensee may demonstrate that in-vessel downstream effects issues are resolved for STP by showing that the licensee's plant conditions are bounded by the final WCAP-16793-NP and the corresponding final NRC staff SE, and by addressing the conditions and limitations in the final SE. The licensee may also resolve this item by demonstrating without reference to WCAP-16793 or the NRC staff SE that in-vessel downstream effects have been addressed at STP. In any event, the licensee should report how it has addressed the in-vessel downstream effects issue within 90 days of issuance of the final NRC staff SE on WCAP-16793.

Response to RAI #51

In-vessel fuel blockage is discussed in the RoverD description given in the Attachment 1-3, Section 6.

J. Chemical Effects

RAI #52

The licensee performed integrated head loss testing in a flume by adding chemical precipitates after other non-chemical debris. The NRC staff questions the transport of the calcium phosphate precipitate during the test since the plant's trisodium phosphate basket location relative to the sump strainers varies and in some cases may be less than the distance from the precipitate introduction point to the strainer section in the test flume. The staff also questions if fiber debris settlement within the narrow cross section of the test flume may create a pile of fiber that filters the calcium phosphate precipitate in a non-conservative manner since this precipitate settles more rapidly than the aluminum based precipitate. Given this concern, please justify why the head loss testing was appropriate in terms of calcium phosphate precipitate transport to the test strainer.

Response to RAI #52

This RAI response has been written to support the applicability of the July 2008 STP strainer head loss testing [52.2] to the RoverD methodology.

Based on the PCI / AREVA NP test protocol [52.1], the chemical debris surrogates are introduced into the test flume through the surface of the water at the upstream section of the test flume (see Figure 52-1 below). From visual observation, the chemical debris was observed to be transported to the strainer module. This was based on the gradual change in opacity of the water after the chemical debris was introduced into the test flume. After all of the chemical debris was added, the opacity of the flume water stabilized and remained constant during the remainder of the test. See Figure 52-2 and Figure 52-3 for chemical debris that was suspended in the water column within the test flume all the way up to the location of the test strainer module.

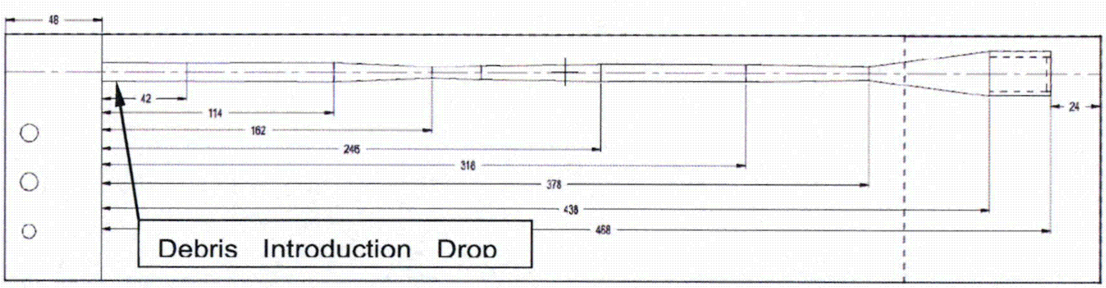


Figure 52-1: Debris Introduction Drop Zone for Non-Chemical and Chemical Debris

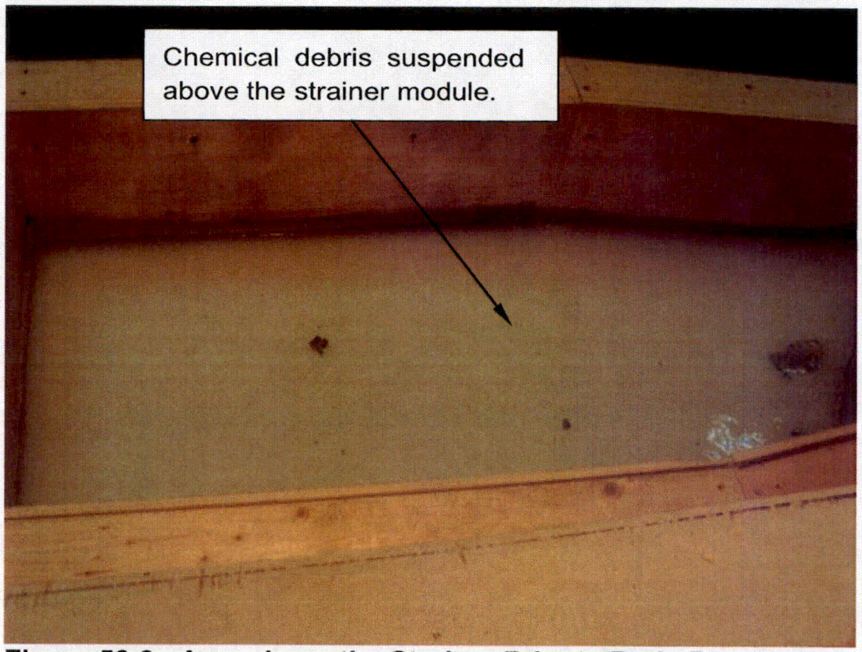


Figure 52-2: Area above the Strainer Prior to Drain Down

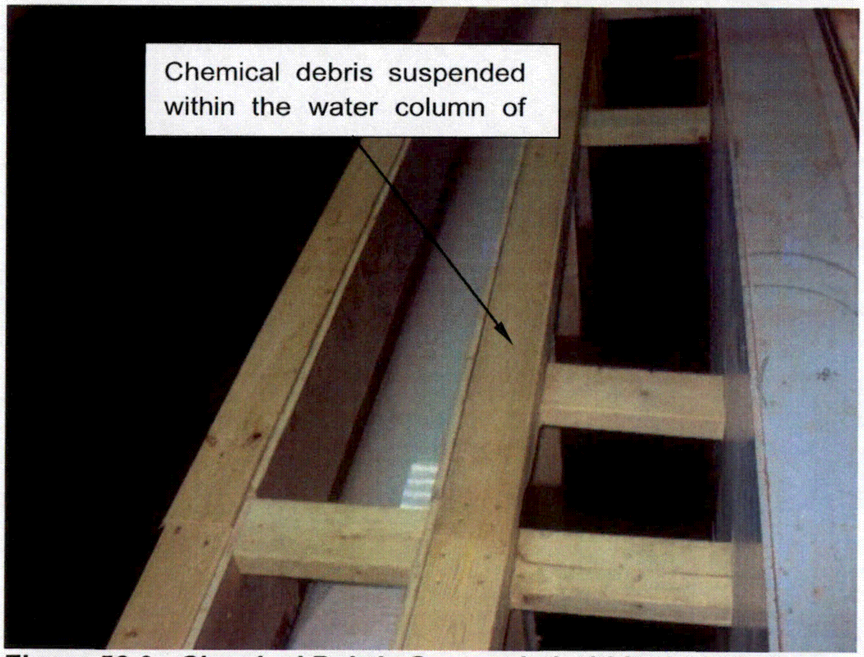


Figure 52-3: Chemical Debris Suspended within the Test Flume

Both aluminum oxyhydroxide and calcium phosphate were generated for the STP design basis test in accordance with the acceptance criteria presented in WCAP-16530-NP [52.3]. Though Figure 52-2 and Figure 52-3 show the chemical precipitate in suspension, it is difficult to visually distinguish between aluminum oxyhydroxide and calcium phosphate since both have a similar indistinguishable 'milky-white' color.

A closer look at STP post-LOCA operational activities and the various properties of calcium phosphate precipitates are needed in order to assess calcium phosphate transport during STP strainer qualification testing. It was stated that chemical precipitates do not form at temperatures above 140 °F based on a presentation given during an ACRS meeting on GSI-191 in May of 2007 [52.4]. Per STP post LOCA analysis, the STP sump temperature decreases to 171 °F after 24 hours from the start of the accident. Thus, chemical precipitation is not expected to occur at the start of ECCS recirculation, but at some time later in recirculation when the sump temperature is lower than 140 °F. During the start of ECCS recirculation, it is expected that a large amount of tri-sodium phosphate (TSP) located in the TSP baskets will dissolve at high temperatures and distribute throughout containment due to a combination of ECCS recirculation and containment spray.

Figure 52-4 shows the locations of the TSP baskets located in STP containment. One TSP basket is located in close proximity to the ECCS sumps. This has caused concern with the NRC Staff, regarding the non-conservatism associated with the introduction zone of chemical debris (i.e., calcium phosphate) relative to the location of the test strainer. Since chemical precipitates are expected to form during the recirculation phase, when the sump temperature is less than 140 °F, it is expected that most of the chemical precipitates would be dispersed throughout the containment (greater than the distance of the debris introduction zone relative to the strainer in the STP test flume configuration). This is based on the dissolution of the TSP during the initial high temperature post-LOCA period and subsequent flow into the strainers and ECCS. The combination of the ECCS and CSS would serve to both mix and distribute the dissolved TSP throughout the STP containment and prevent significant concentration in the immediate area of the strainers. Therefore, only a small portion of the total quantity of chemical precipitates is expected to form in the proximity of the ECCS strainers. During the STP strainer testing, the amount of the calcium phosphate precipitates that was used in the test was calculated and generated based on the total amount that would be formed in the STP containment based on the sump temperature being below 140 °F. The calculated total amount of calcium phosphate precipitant was then introduced into the test flume upstream of the strainer. Theoretically, even if some of the calcium phosphate precipitant were to settle or be artificially filtered out by the non-chemical debris upstream of the strainer, it is expected that the amount that reached the test strainer was greater than or equal to that of expected for the actual plant strainers. Under this basis, the STP test flume configuration is considered to be prototypical of the STP containment and the TSP basket locations are not a concern due to the mixing and distribution of the dissolved TSP by the combined ECCS and CSS.

The calcium phosphate transport was appropriately tested for STP head loss testing since calcium phosphate precipitate was generated per WCAP-16530 [52.3] guidance and sequenced in such a manner to prevent over concentration in the test flume, thus minimizing settling of the precipitate. Based on the total volume in the test flume and piping, one flume turnover is approximately 5 – 6 minutes. As seen in Figure 52-1, the distance between the drop zone and the front surface of the strainer module consists of a smaller volume of water compared to the total flume volume. Based on the volume between the debris drop zone and the front surface of the strainer module, it would take debris approximately 2 minutes to travel to the strainer once introduced into the test flume. Based on the STP Test Plan, there was one flume turnover between chemical introductions of aluminum oxyhydroxide and calcium phosphate, and two flume turnovers between consecutive batches of calcium phosphate. Thus, sufficient time was allowed between all batches of chemical precipitate to allow the precipitate to transport to the strainer prior to the next chemical introduction.

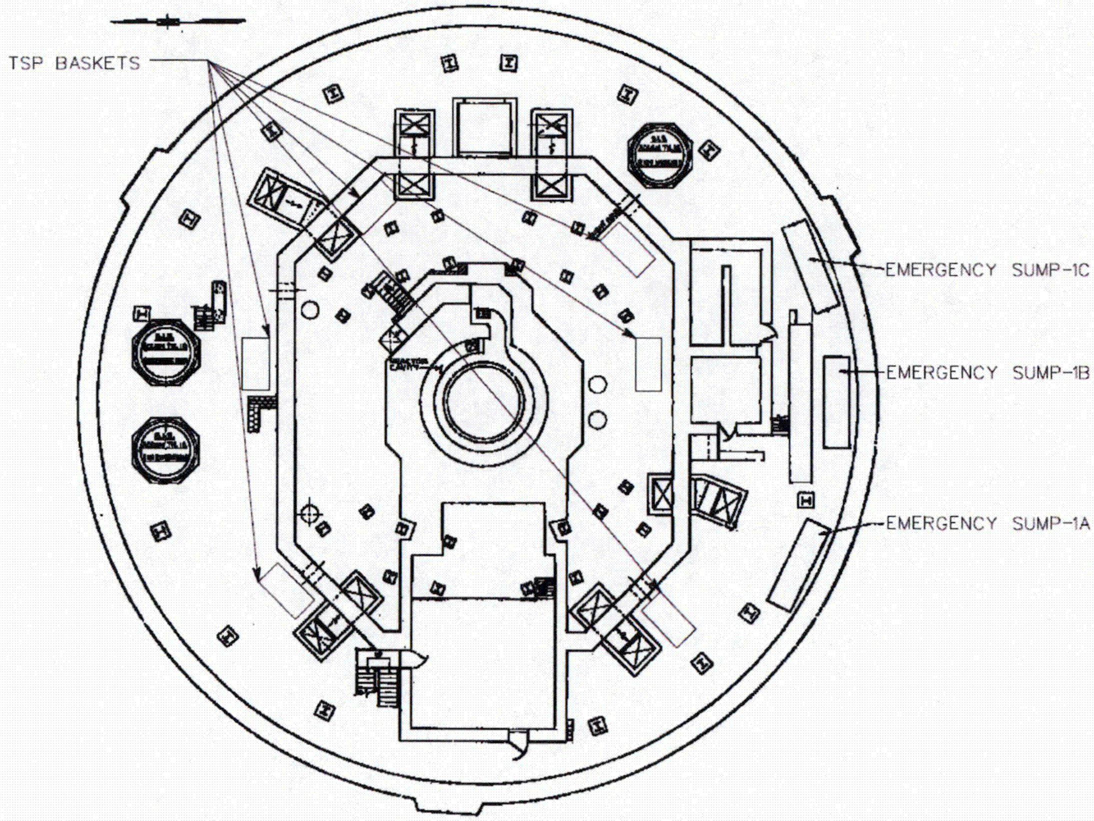


Figure 52-4: Location of TSP Baskets Located in STP Containment

References:

52.1 AREVA NP Document 63-9086408-001, "South Texas Project Test Plan for ECCS Strainer Performance Testing", August 2008
52.2 66-9088089-000, South Texas Project Test Report for ECCS Strainer Testing, Revision 0. AREVA, August 2008.
52.3 WCAP-16530-NP, Rev. 0 "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191", February 2006
52.4 ACRS Meeting on GSI-191, presented by Rick Reid, PhD (Westinghouse Electric Company), May 15, 2007.

1-6: Responses to Round 2 RAIs

1-6.1: Response to APLAB RAI 1.c

APLA-XI-4: Key Assumptions/Key Sources of Uncertainty

RG 1.200 defines a "key" source of uncertainty as an issue where no consensus approach or model exists and where the choice of approach or model is known to have an effect on the risk profile (e.g., CDF, LERF, ΔCDF, ΔLERF).[1] RG 1.174 and NUREG-1855 state that "consensus" refers to an approach or model that has a publically available published basis and has been peer reviewed and widely adopted by an appropriate stakeholder group. In addition, widely accepted PRA practices may be regarded as consensus models. Examples include the use of the constant probability of failure on demand model and the Poisson model for initiating events. Finally, models that the NRC has utilized or accepted for the specific application in question can also be considered "consensus."

RG 1.200 defines a key assumption as one that is made *in response to a key source of model uncertainty* where a different reasonable alternative assumption would change the plant's risk profile.

RG 1.200 states that "for each application that calls upon this regulatory guide, the applicant identifies the key assumptions and approximations relevant to that application. This will be used to identify sensitivity studies as input to the decision-making associated with the application."

Therefore, provide a table or other structured response that lists key sources of uncertainty. For each key source of uncertainty, identify the key assumption(s) that were made to address it and provide either a sensitivity study in terms of CDF, LERF, ΔCDF, and ΔLERF or use qualitative arguments as to why a different reasonable alternative assumption would not cause the risk acceptance guidelines in RG 1.174 to be exceeded.

This response should address:

a. L* approach for chemical effects
b. Head loss correlation
c. Success criteria for fuel blockage and boron precipitation (7.5 g/FA)
d. Fiber penetration model for sump strainer
e. The use of geometric, rather than arithmetic mean aggregated values from NUREG-1829
f. The continuum break model (vs. DEGB-only model)
g. The quantity and release rate of unqualified coatings

The response should evaluate each of these areas one-at-a-time and should include an aggregate analysis that quantifies the integrated impact on CDF, LERF, ΔCDF, and ΔLERF from the sensitivity studies that were performed.

[1] The staff's position is that cases where a consensus model <u>does</u> exist but the licensee choses an alternate model also represent key sources of model uncertainty if they have an effect on the risk profile.

Response to c:

Details on the success criteria for fuel cooling and boron precipitation are provided in Attachment 1-3, the RoverD description. In the case of core cooling, 15 gm/FA applies to MLOCA and LLOCA CLB. Full blockage of the fuel assemblies and core bypass will not cause fuel overheating for SLOCA (either CLB or HLB), MLOCA HLB and LLOCA HLB.

For BAP success criteria, the analysis relies on very small amounts of fiber that arrive on the core in CLB. Sensitivity studies are provided in the RoverD description.

1-6.2: Revised Response to SCVB RAIs

STPNOC responded to the RAIs below in a letter dated March 25, 2015 (ML15091A440). The responses are revised to be consistent with the exemptions requested in Attachment 2 and the response to RAI 17 has been added. Revised portions are identified with a change bar.

Containment and Ventilation Branch (SCVB)

NOTE: Round 2 RAI question numbers begin with the next sequential number from the April 15, 2014, RAI for this section.

10. Background: The response to question 3.a of the April 15, 2014, RAI, does not appear to provide adequate justification for not revising the Updated Final Safety Analysis Report (UFSAR) description of the containment heat removal analysis. The response to question 3.c refers to a proposed UFSAR description of the risk assessment given in Enclosure 3, Attachment 2 of the licensee's letter dated November 13, 2013, which does not provide a revised licensing basis description of the containment heat removal analysis.

    The licensee's response to question 4.a of the April 15, 2014, RAI, does not provide adequate justification for not revising the UFSAR description of the fission product removal analysis. The response to question 4c of the April 15, 2014, RAI, refers to a proposed UFSAR description of the risk assessment given in Enclosure 3, Attachment 2 of the licensee's letter dated November 13, 2013, which does not provide a revised licensing basis description of the revised fission product removal analysis.

    Please refer to the following excerpt taken from the licensee's response to question 3.b of the April 15, 2014, RAI:

    > As described in the LAR, the proposed exemptions from General Design Criteria (GDC)-35, "Emergency Core Cooling", GDC-38, "Containment Heat Removal", and GDC-41, "Containment Atmosphere Cleanup" are for approval of a risk-informed approach for addressing GSI-191 and responding to Generic Letter (GL) 2004-02 for STP Units 1 and 2 as the pilot plants for other licensees pursuing a similar approach. As further described, STPNOC seeks NRC approval based on a determination that the risk informed approach and the risk associated with the postulated failure mechanisms due to GSI-191 concerns meets the guidance, key principles for risk-informed decision making, and the acceptance guidelines in RG 1.174.
    >
    > STPNOC is not proposing to apply the risk-informed approach to revise the licensing basis for containment design described in the UFSAR. The proposed risk assessment evaluates a spectrum of Loss of Coolant Accident (LOCA) scenarios to quantify the amount of debris of various types that might be generated and transported to the emergency sumps, and how that debris might affect available NPSH [net positive suction head] for Emergency Core Cooling System (ECCS) and Containment Spray System (CSS) pumps taking suction from the sumps in the recirculation mode. It also evaluates potential transport of debris to the

reactor core. It calculates failure probabilities that are fed to the STP PRA.

Concern: The staff agrees that the currently licensed design and configuration of the CSS and ECCS as described in the UFSAR will not be impacted by the risk-informed resolution to GSI-191 except for the change in the sump strainer design. However, the NRC staff is not in agreement that the UFSAR description of the licensing basis containment heat removal analysis, which uses CSS; the licensing basis containment fission product removal analysis, which also uses CSS; and the licensing basis 10 CFR 50.46 analysis, which uses ECCS, will not be impacted by the risk-informed resolution to GSI-191. For breaks that produce less or no debris, the licensing basis analysis should be based on the deterministic approach without taking exemption from GDCs 35, 38, and 41. For breaks that produce large amount of debris and without taking exemptions from the GDCs (for example exemption from assuming single failure) it is not possible to meet the acceptance criteria for peak cladding temperature and containment heat and fission product removal, the risk-informed approach may be used and exemption from the GDCs may be requested for these specific breaks only.

The NRC staff has developed the flow chart shown in Figure 1 (on page 19 of this RAI) for defining the LOCA containment NPSH licensing basis analysis (which is the most significant part of containment heat removal analysis) for deterministic and risk-based GSI-191 resolution. The staff suggests the licensee to develop similar flow charts defining the deterministic and risk-based fission product removal and ECCS licensing basis analysis.

Question: RG 1.174 requires that the licensee should identify those aspects of the plant's licensing basis that may be affected by the proposed change, including but not limited to rules and regulations, UFSAR, technical specifications, licensing conditions, and licensing commitments. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," (SRP) Chapter 19.2, "Review of Risk Information Used to Support Permanent Plant-specific Changes to the Licensing Basis: General Guidance," Section III.1 also requires that the changes in the plant licensing basis should be appropriately reflected in licensing documents such as technical specification (TSs), license conditions (LCs), and UFSAR. Therefore, the current licensing basis for the containment heat removal described in UFSAR Chapters 6 and 15 must be revised by including the description for the breaks for which partial or complete exemption from GDCs 35, 38, and 41 is requested.

(a) Provide UFSAR revisions of Chapters 6 and 15 for the description of revised licensing basis analysis of the containment heat removal for the breaks for which exemption from GDC-38 is requested.

(b) Provide UFSAR revisions of Chapter 6 for the description of revised licensing basis of the analysis of the containment spray system – iodine removal for the breaks for which exemption from GDC-41 is requested.

(c) Provide UFSAR revision of Section 6.3 for the description of revised licensing basis analysis of the ECCS for the breaks for which exemption from GDC-35 is requested.

Response (a), (b), (c):

See the UFSAR markups provided for the staff's information in Attachment 3-4.

11. Please note that the use of risk-based approach for resolution of GSI-191 requires a change in the licensing basis for the CSS operating in the presence of debris. RG 1.174 describes an acceptable approach for assessing the nature and impact of proposed licensing basis changes. This RG requires that the licensee should identify all SSCs, procedures, and activities that are covered by the licensing basis change being evaluated.

The response to question 1.a of the April 15, 2014, RAI, states that the CSS is the only system for which the exemption from GDC-38 is requested. Note that the CSS has associated supporting systems such as the safety-related electrical, Emergency Diesel Generator (EDG), instrumentation and control (I&C), and cooling water systems. Therefore, as required by RG 1.174, please identify all the associated SSCs, procedures and activities that support the operation of the CSS for containment heat removal in the presence of debris.

Response:

Per STP UFSAR Chapter 3.1.2.4.9.1, GDC 38 is met by RCFC working in conjunction with CSS and ECCS (LHSI through the RHR heat exchangers) to remove heat from the containment. Only the CSS and ECCS functions are directly affected by debris since they are the containment heat removal functions that rely on the sump strainers in the recirculation phase. The RCFC cooling heat sink is independent. See Attachment 1-4 for discussion of defense-in-depth for containment heat removal.

No exemption is proposed to apply to the support systems for the CSS or the ECCS. The proposed exemptions apply only for the effects of debris. None of the CSS or ECCS support systems rely on the ECCS emergency sumps and strainers to perform their support function and thus will not be affected by debris.

SCVB-RAI-12

12. The response to question 1.b of the April 15, 2014, RAI, does not state which requirements of GDC-38 will not be met. The key GDC-38 requirements to be met for the CSS system design, concurrent with functioning of associated systems are as follows:

(1) Perform the safety function of containment heat removal, and rapidly reduce the containment pressure and temperature and maintain them at acceptably low level.

Response:

STPNOC proposes that the exemption would apply for this requirement for those LOCA breaks that could generate an amount of debris that is not bounded by the deterministic testing. Current STP design basis calculations are based on RCFC functioning in conjunction with CSS and ECCS, which can be affected by debris.

(2) Safety function (1) shall be performed **following any LOCA**

Response:

Using current deterministic assumptions, STPNOC's analysis and testing does not assure that the emergency sump strainers will be available to support the CSS and ECCS function for the effects of debris produced by LOCA breaks that can generate debris that is not bounded by plant-specific deterministic testing, as described in RoverD. The exemption is requested to address that scope of breaks not bounded by the deterministic testing. The applicability of the exemptions are described in Attachment 2.

(3) Safety function (1) shall be performed **in the presence or absence of Loss of Offsite Power (LOOP)**.

Response:

STP does not propose an exemption to this requirement. Debris affects only the function of the emergency sump strainers which do not perform any support function for emergency power for CSS in the event of a LOOP.

(4) Safety function (1) shall be performed **in the presence of a worst single failure**.

Response:

See Attachment 2. The STP application requests exemption to the requirement for deterministic methodology for the breaks not bounded by the deterministic testing in order to allow use of risk-informed methodology.

Note that requirement (2) covers all postulated LOCAs of any break size, including the most limiting from debris generation, containment peak pressure, and containment peak temperature standpoint.

Please provide the following information:

a. Is full exemption from the GDC-38 requirements (2), (3), and (4) requested? If so, irrespective of the break size, break location, or quantity of debris generation, all CSS trains along with their supporting system may be used. Please provide justification for the proposal of a full exemption from these requirements.

Response:

The STPNOC application specifically requests exemption to Item (4), which has a direct link to Items (1) and (2). No exemption to Item (3), LOOP, is needed.

b. Is a partial exemption from GDC-38 requirement (2) requested (i.e., for specific LOCAs only and full exemption from requirements (3) and (4))? If so, specify the LOCAs in terms of location, break size, and debris generation rate for which the exemption is requested from meeting requirement # (3) and (4), and provide justification for the exemption request.

Response:

See Attachment 2-4 for the scope of the requested exemption and the justification.

13. The response to question 2.a of the April 15, 2014, RAI, states that the CSS is the only system for which the exemption from GDC-41 is requested. Note that the CSS also has associated supporting systems to which GDC-41 may apply. Please list all the associated systems that support the operation of the CSS; such as the safety-related electrical, EDG, I&C, and cooling water systems. Therefore as required by RG 1.174, please identify all the associated SSCs, procedures and activities that support the operation of the CSS for fission product removal in the presence of debris.

Response:

No exemption is proposed to apply to the support systems for the CSS. The proposed exemptions apply only for the effects of debris. None of the CSS support systems rely on the ECCS emergency sumps and strainers to perform their support function and thus will not be affected by debris.

14. The response to question 2.b of the April 15, 2014, RAI, does not state which requirements of GDC-41 will not be met. The key GDC-41 requirements to be met for the CSS system design, concurrent with functioning of associated systems are as follows:

(1) Please list systems required to perform the safety function of controlling fission products, hydrogen, oxygen, and other substances that may be released into the reactor containment to reduce, consistent with the functioning of other associated systems, the concentration and quality of fission products released to the environment and to control the concentration of hydrogen and oxygen and other substances in the containment atmosphere to assure that containment integrity is maintained.

<u>**Response:**</u>

The CSS is the only system for which an exemption is requested. It is the only containment atmosphere cleanup function that is susceptible to the effects of debris. The CSS is credited in the removal of radioactive iodine from the containment atmosphere.

(2) Safety function (1) shall be performed <u>following all postulated accidents</u>.

<u>**Response:**</u>

Using deterministic assumptions, STPNOC's analysis and testing does not assure that the emergency sump strainers will be available to support the CSS function for the effects of debris produced by LOCA breaks that can generate debris that is not bounded by plant-specific deterministic testing, as described in RoverD.

(3) Safety function (1) shall be performed by providing suitable redundancy in components and features, suitable interconnections, leak detection and isolation, and containment capabilities.

<u>**Response:**</u>

STPNOC does not propose exemption to this requirement since these functions are not affected by debris.

(4) Safety function (1) shall be performed <u>in the presence or absence of LOOP</u>.

<u>**Response:**</u>

STPNOC does not propose an exemption to this requirement. Debris affects CSS only through the function of the emergency sump strainers which do not perform any support function for emergency power for CSS in the event of a LOOP.

(5) Safety function (1) shall be performed <u>in the presence of a worst single failure</u>.

<u>Response:</u>

See Attachment 2. The STP application requests exemption to the requirement for deterministic methodology for the breaks not bounded by the deterministic testing in order to allow use of risk-informed methodology.

(a) Is full exemption from the GDC-41 requirements (2), (3), (4), and (5) requested? If so, than irrespective of the break size, break location, or quantity of debris generation, all CSS trains along with their supporting system may be used. Please provide justification for the proposal of a full exemption from these requirements.

<u>Response:</u> See response to (b) below.

(b) Is a partial exemption from GDC-41 requirement (2) requested (i.e., for specific LOCAs only, and full exemption from requirements (3), (4), and (5))? If so, specify the LOCAs in terms of location, break size, and debris generation rate for which the exemption is requested from meeting requirements (3), (4), and (5), and provide justification for the exemption request.

<u>Response:</u>

STPNOC requests partial exemption; i.e., only Item 2 above. As stated above, STPNOC's analysis and testing does not assure that the emergency sump strainers will be available to support the CSS function for the effects of debris produced by LOCAs that generate and transport debris that is not bounded by testing, as described in RoverD. Forty-five weld locations have currently been identified on the pressurizer surge line and RCS main loop piping. To minimize the potential that a later analysis could cause the specific locations to change, the requested exemption is based on the break's ability to generate sufficient transportable debris, as described in RoverD. See Attachment 2.

15. The response to question 9.a of the April 15, 2014, RAI, states that the ECCS is the only system for which the exemption from GDC-35 is requested. Please note that the ECCS whose subsystems are High Head Safety Injection (HHSI) and the Low Head Safety Injection (LHSI) systems are not the only ones for which the proposed exemption to GDC-35 would apply. List all of the supporting system that support the operation of the HHSI and LHSI subsystems; for example the safety-related electrical, EDG, I&C, and cooling water systems. Therefore as required by RG 1.174, please identify all the associated SSCs, procedures and activities that support the operation of the HHSI and LHSI systems in the presence of debris.

Response:

No exemption is needed for systems that support ECCS. The debris affects only systems that rely on the emergency sump strainers as a support system. None of the support systems required for ECCS operability such as cooling water, instrumentation and control, and normal and emergency power rely on the emergency sump strainers to perform their function. The requested exemption for GDC 35 the ECCS support systems (And the requested exemptions for GDC 38 and 41 do not apply to the CSS support systems.)

16. The response to question 9b of the April 15, 2014, RAI, does not state which requirements of GDC-35 will not be met. The key GDC-35 requirements to be met for the ECCS design, concurrent with functioning of associated systems are as follows:

(1) Perform the safety function of transferring heat from reactor core at a rate such that (a) fuel and clad damage that could interfere with continued effective core cooling is prevented and (b) clad metal-water reactor is limited to negligible amounts.

Response:

The STPNOC proposed exemption would apply for this functional requirement. As discussed in prior responses and described in the RoverD methodology, the function of the ECCS emergency sump is assumed to fail for debris that exceeds the amount in the deterministic testing. Under these assumptions, failure of the sump and strainers will result in loss of cooling to the core.

(2) Safety function (1) shall be performed <u>following any LOCA.</u>

Response:

STPNOC's analysis and testing does not assure that the emergency sump strainers will be available to support the ECCS function for the effects of debris produced by LOCAs that generate and transport debris that is not bounded by testing, as described in RoverD. Consequently, STPNOC is requesting exemption for that scope of LOCAs that will produce and transport sufficient debris to exceed the debris forming the basis for the deterministic testing described in RoverD. See Attachment 2 for scope.

(3) Safety function (1) shall be performed by providing suitable redundancy in components and features, suitable interconnections, leak detection and isolation, and containment capabilities.

Response:

STPNOC does not propose exemption to this requirement since these ECCS support functions are not affected by debris.

(4) Safety function (1) shall be performed <u>in the presence or absence of LOOP</u>.

Response:

STPNOC does not propose an exemption to this requirement. Debris affects only the function of the emergency sump strainers which do not perform any support function for emergency power for ECCS in the event of a LOOP.

(5) Safety function (1) shall be performed in the presence of a worst single failure.

Response:

See Attachment 2. The STP application requests exemption to the requirement for deterministic methodology for the breaks not bounded by the deterministic testing in order to allow use of risk-informed methodology.

Note that requirement (2) covers all postulated LOCAs of any break size, including the most limiting from debris generation or peak clad temperature standpoint. Please provide the following information:

(a) Is full exemption from the GDC-35 requirements (2), (3), (4), and (5) requested? If so, irrespective of the break size, break location, or quantity of debris generation, all ECCS trains along with their supporting system may be used for performing safety function (1). Please provide justification for requesting a full exemption from these requirements.

Response: **See response to (b).**

(b) Is a partial exemption from GDC-35 requirement (2) requested (i.e., for specific LOCAs only and full exemption from requirements (3), (4), and (5))? If so, specify the LOCAs in terms of location, break size, and debris generation rate for which the exemption is requested from meeting requirement # (3), (4), and (5), and provide justification for the exemption request.

Response:

STPNOC is requesting a partial exemption as discussed in the responses above. The proposed exemption to GDC 35 would apply to Items (1), (2), and (5) for the scope of breaks described in (2). The technical basis is described in the RoverD methodology (Attachment 1).

17. In question 7 of the April 15, 2014, RAI, the NRC staff requested the licensee to provide the equivalent of UFSAR Section 6.2.1.5, which should describe the licensing basis of the minimum containment pressure analysis for performance capability of ECCS in the presence of debris for the risk-based analysis. Successful functioning of the LHSI, HHSI systems and the CSS in the presence of debris requires exemption from GDC-35 and GDC-38. Therefore, in the presence of debris during LOCAs, the description of the minimum containment pressure analysis for performance capability should be different

from what is described in the UFSAR Section 6.2.1.5. The licensee's response to question 7 did not describe the proposed containment analysis, including assumptions and inputs, performed for the calculation of minimum containment pressure input for the ECCS analysis that calculates the peak cladding temperature for risk-informed GSI-191. Please justify that the inputs and assumptions are conservative for the purpose.

Response:

There is no change to the existing licensing basis for containment design. The RoverD method is based on the deterministic scope of breaks being defined by plant-specific testing, which assumes current licensing basis assumptions. The risk-informed scope for which exemptions are requested assumes that all those breaks go to core damage and shows that the risk from breaks that could generate more debris than was in the testing scope is very small, in accordance with RG 1.174. LERF is the accepted metric for containment in a risk-informed application. For this application, LERF meets the criteria of RG 1.174. See RoverD evaluation of LERF in Attachment 1-3. The STP risk assessment shows that containment integrity is maintained as discussed in Attachment 1-4.

18. Please provide the following additional information with respect to your response to question 3.b of the April 15, 2014, RAI:

(a) Refer to the table on page 9 of Attachment 3 to the licensee's letter dated June 25, 2014 (ADAMS Accession No. ML14178A481), of major qualitative differences, for the subject "Sump Pool Treatment," please explain what is meant by: "No decay heat added. Mass and energy subtracted from the pool based on RELAP5-3D instructions."

(b) Refer to the table referenced in item a) for the subject "Pipe break mass/energy source," please explain what is meant by: "Communicated from RELAP5-3D via coupling interface as problem time progresses. The source is split by MELCOR into part liquid water, part steam, and part 'fog'."

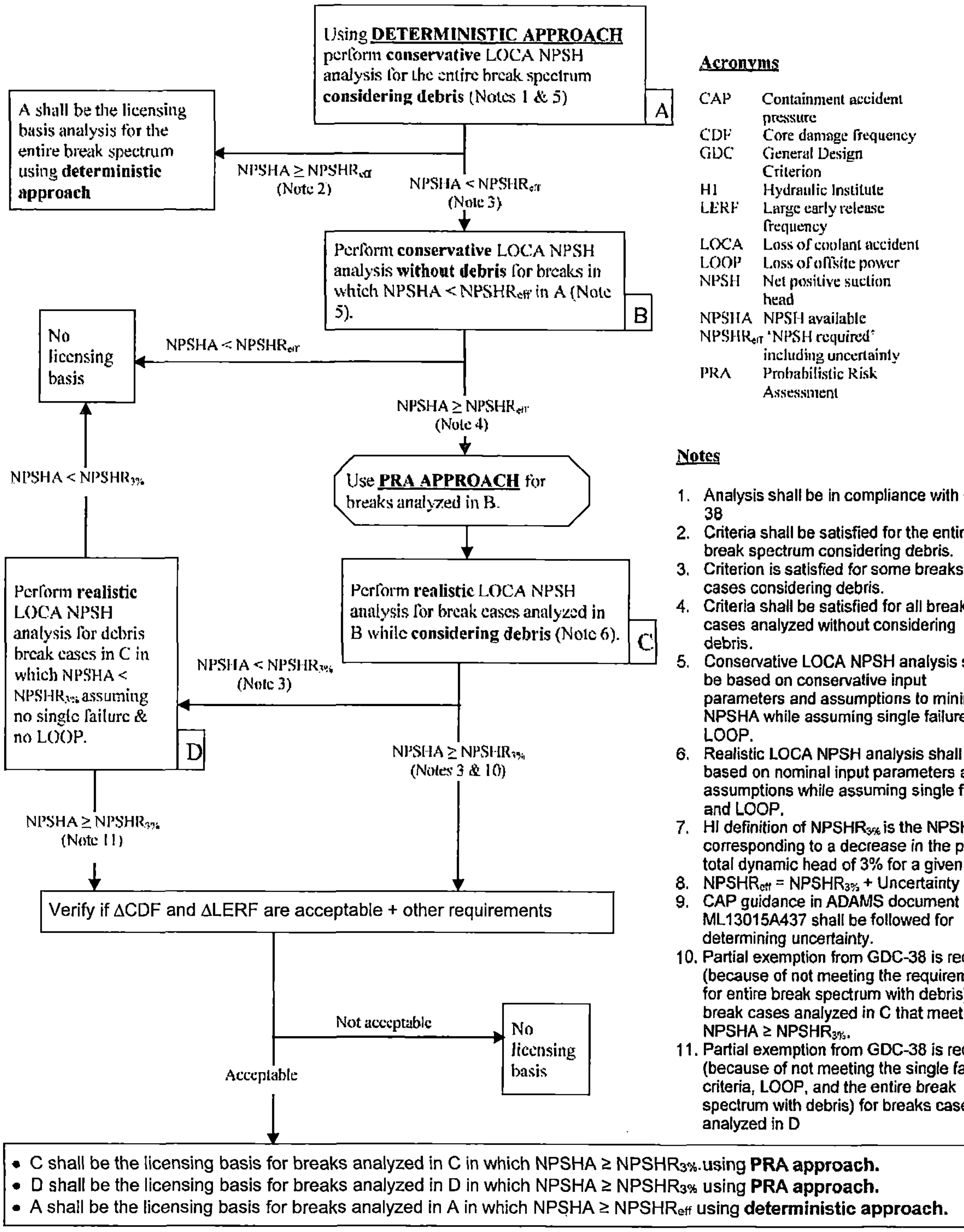
(c) Refer to the table under the heading "Summary Comparison of Main Parameter Values," on page 10 of Attachment 3 to the licensee's letter dated June 25, 2014, please provide the basis for selecting the RELAP-3D/MELCOR values of the parameters in the table below and how are they determined:

RELAP-3D/MELCOR	VALUE
Initial atmosphere temperature	119.93 °F
Initial containment pressure	14.94 psia
Initial relative humidity, partial pressure of water vapor	70%/ 1,184 psia
Initial RWST temperature	85 °F
Spray actuation times	15 s delay after setpoint, linear ramp to full flow
Fan cooler actuation times	15 s delay after setpoint

(d) Refer to the table referenced in item c) for the CONTEMPT and RELAP-3D/MELCOR analysis, please provide the basis for using different values of (1) thermal conductivity of concrete, (2) thermal conductivity of stainless steel, (3) specific heat capacity of concrete, (4) specific heat capacity of stainless steel, and (5) density of stainless steel.

Response (a), (b), (c), (d):

The RoverD methodology does not use RELAP5-3D or MELCOR for containment conditions.



Acronyms

CAP	Containment accident pressure
CDF	Core damage frequency
GDC	General Design Criterion
HI	Hydraulic Institute
LERF	Large early release frequency
LOCA	Loss of coolant accident
LOOP	Loss of offsite power
NPSH	Net positive suction head
NPSHA	NPSH available
$NPSHR_{eff}$	'NPSH required' including uncertainty
PRA	Probabilistic Risk Assessment

Notes

1. Analysis shall be in compliance with GDC-38
2. Criteria shall be satisfied for the entire break spectrum considering debris.
3. Criterion is satisfied for some breaks cases considering debris.
4. Criteria shall be satisfied for all break cases analyzed without considering debris.
5. Conservative LOCA NPSH analysis shall be based on conservative input parameters and assumptions to minimize NPSHA while assuming single failure and LOOP.
6. Realistic LOCA NPSH analysis shall be based on nominal input parameters and assumptions while assuming single failure and LOOP.
7. HI definition of $NPSHR_{3\%}$ is the NPSH corresponding to a decrease in the pump total dynamic head of 3% for a given flow.
8. $NPSHR_{eff} = NPSHR_{3\%}$ + Uncertainty
9. CAP guidance in ADAMS document ML13015A437 shall be followed for determining uncertainty.
10. Partial exemption from GDC-38 is required (because of not meeting the requirement for entire break spectrum with debris) for break cases analyzed in C that meet $NPSHA \geq NPSHR_{3\%}$.
11. Partial exemption from GDC-38 is required (because of not meeting the single failure criteria, LOOP, and the entire break spectrum with debris) for breaks cases analyzed in D

FIGURE 1: Flow Chart for Defining the LOCA Containment NPSH Licensing Basis Analysis for Deterministic and Risk-Based GSI-191 Resolution

1-6.3: Response to SNPB RAIs

SNPB Round 2 RAIs

The staff has reviewed the STP RELAP5-3D with the 1-D core analyses documented in 0PGP04-ZA-0328 Rev. 12 entitled "Core Blockage Thermal-Hydraulic Analysis" and has the following requests for information.

The staff recognizes that these analyses have the objective of demonstrating that under the blocked core inlet cases, sufficient water can match boil-off and maintain coolability. And, the RELAP5 analyses have shown the conditions for which this is true. However, the staff also recognizes that while sufficient water addition to the core is to be justified to match/exceed boil-off, precipitation of boric acid in the core with various blockages also needs to be addressed. As such, the analyses only address the first critical issue for long term cooling, but would require an evaluation of precipitation to be able to state that long term cooling has been demonstrated. Without the precipitation evaluation, long term cooling cannot be justified. It is noted that the RELAP5-3d code tracks the boron solute concentration, however it does not include boric acid build-up on the liquid density and the static head term in the momentum equation. As such, flow rates and thermal hydraulic behavior may be questionable. Also, transport properties with increased boric acid concentrations is also omitted in RELAP5-3D. Given these issues, the following RAIs are listed below:

1. For the small 2 inch cold leg break of Table 2, while water fills the steam generator cold sides spilling over to the hot side and refilling the core to keep it cooled, the question of precipitation could be an issue that represents failure for this case. That is, with the core totally blocked there is no means of flushing the boric acid build-up in the core that begins upon initiation of boiling. If it assumed no water can pass through the blocked region from cold side injection then switching to hot side injection should not flush the boric acid build-up from the core. It would be instructive to perform a precipitation calculation to show the timing for precipitation once the core begins to boil. Since the RCS pressure is fairly high the precipitation limit will be likewise higher, but it is not clear that the precipitation limit will not be reached. It appears that with the core totally blocked, precipitation cannot be avoided. Please explain and provide an evaluation of precipitation timing for this case.

   Response:

   Full blockage analyses are performed primarily to show adequate cooling flow in the extreme case where all the normal flow paths are blocked by debris. Based on measurements of filtration efficiency of the STP strainer design, there is insufficient debris penetrating the strainers to effectively block the normal flow channels. In the RoverD analysis it is shown that very little fiber arrives on the core in cold leg breaks. The amounts are so small that it is unlikely mixing flows will be impeded.

Therefore STPNOC has concluded that adequate circulation will be available to dilute boric acid.

2. The cases with one assembly unblocked (center and periphery) presented in Figure 32 shows adequate water enters the core to match boil-off. However as boric acid builds up in the core, the density increases degrading the flow into the core. Given that the downcomer level is fixed due to the break, flow would be expected to decrease as the density in the core increases. As such, calculation of the precipitation timing and mixing in the core needs to be evaluated. Since there is only one unblocked assembly bottom location, it is not obvious that the switch to simultaneous injection can flush the boric acid from the core that builds-up prior to the switch to preclude precipitation. Furthermore with only the one open assembly inlet path to the core regions, locations near the periphery can trap boric acid and cause local build up of concentration that may not be flushed out with hot side injection. It is not clear that precipitation can be precluded for these blocked cases. Please explain.

   Response:

   Full blockage analyses with a small unblocked channel are performed primarily to show the margin to adequate cooling flow in the extreme case where all the normal flow paths are blocked by debris. Based on measurements of filtration efficiency of the STP strainer design, there is insufficient debris penetrating the strainers to effectively block the normal flow channels. In the RoverD analysis it is shown that very little fiber arrives on the core in cold leg breaks. The amounts are so small that it is unlikely mixing flows will be impeded. Therefore STPNOC has concluded that adequate circulation will be available to dilute boric acid.

3. The case in Figure 32 with the bypass free shows adequate water enters the core for cooling. Please identify where the elevations above the bottom of the core where these bypass paths are located. If the first bypass is located above the bottom elevation of the core, this region of the core below the first bypass path will trap boric acid and build-up to potentially reach precipitation. It is not clear how the downward and then upward flow can flush the boric acid from this lower isolated region. If the bypass is located at the core bottom elevation it is still not clear if simultaneous injection can arrest the build-up of boric acid and flush the core through the bypass region. Please explain how precipitation is prevented and demonstrate that RELAP5-3D can predict the correct flows to flush the core under these unusual flow path configurations. Since the RELAP5-3D code does not include the density increases with boric acid concentration, please explain and demonstrate that the flow and mixing behavior in the core can be correctly calculated. What validation calculations have been performed to show that the omission in the momentum equation do not provide excessive flow and mixing behavior, noting that the transport properties are also omitted in the code.

Response:

Based on measurements of filtration efficiency of the STP strainer design, there is insufficient debris penetrating the strainers to effectively block the normal flow channels. In the RoverD analysis it is shown that very little fiber arrives on the core in cold leg breaks. The amounts are so small that it is unlikely mixing flows will be impeded. Therefore STPNOC has concluded that adequate circulation will be available to dilute boric acid.

4. Please describe how the advection term in RELAP5-3D is numerically expressed and demonstrate that numerical diffusion does not produce erroneous or excessive flow behavior that could change the conclusions of this analysis. Since advection and diffusion can play key roles in affecting the calculated liquid and steam velocities in the core, please demonstrate that RELAP5-3D can properly model these effects. It may prove advantageous to solve the transport equation with advection and diffusion in a 1-D pipe and 3-D volume using the same numerical approximation in RELAP5-3D for the advection and the second order viscous diffusion terms. Show that a step function density wave or concentration wave moving down the pipe does not suffer from numerical diffusion characteristic of the 1-D upwind differencing scheme that has been employed in RELAP5 code versions.

   It appears that the switch to simultaneous injection for some of the cases occurs at different times for the various breaks evaluated. For example, Figure 8 shows the switch time at about 32,000 seconds for the 2 inch hot leg break while Figure 27 shows about 22,000 seconds for the switch for the DEG hot leg break. Typically the switch time is an EOP action and occurs at one time that is sufficiently early enough that assures all break sizes are flushed prior to reaching the precipitation limit for the limiting case. These differences should have no impact on the analysis conclusions but please explain the basis and verify that the use of different timing has no impact on the results and conclusions and does not impact the EOP guidance for the operators.

Response:

The RoverD analysis relies on the current UFSAR hot leg switchover time and the RELAP5 analysis is not relied on. The RoverD analysis also shows that very little fiber arrives on the core in cold leg breaks. The amounts are so small that it is unlikely mixing flows will be impeded. Therefore STPNOC has concluded that adequate circulation will be available to dilute boric acid.

1-6.4: Response to SSIB RAI 66

SSIB RAI 66:
Assumption 1j of Volume 3 states that "switchover to hot leg injection would occur between 5.75 and 6 hours after the start of the event." Assumption 11a states "the current STP design basis evaluation methodology used to calculate the required hot leg switchover timing is appropriate with the exception of GSI-191 related phenomenon." When analyzing boric acid precipitation in regards to post-LOCA long-term core cooling, the mixing volume and percentage of voids in the core used in the analyses need to be justified. Improper modeling could result in non-conservative liquid volume after a LOCA. Ultimately, this could impact the hot-leg switchover time in a plant's emergency operating procedures. STP's calculation for hot-leg switchover time following a LOCA (NC-7136, Revision 1) was provided in response to SNPB RAI 4. An input for this calculation is liquid volume in the RCS. Please provide the mixing volume and percentage of voids in the core for STP licensing basis calculations used to determine the liquid volume in the RCS for hot leg switchover timing in the calculation to validate assumptions 1j and 11a. Please justify the use of these numbers and any assumptions made. The licensee can refer to NRC-approved methods, as appropriate.

Response:

The RoverD analysis relies on the UFSAR hot leg switchover time and the RELAP5 analysis is not relied on. The RoverD analysis also shows that very little fiber arrives on the core. The amounts are so small that it is unlikely mixing flows will be impeded. Therefore STPNOC has concluded that adequate circulation will be available to dilute boric acid.

In summary, STPNOC's evaluation shows that the small amounts of fiber that may accumulate would not affect core cooling or BAP, such that they would not affect closing GL 2004-02. STPNOC's analysis is similar in approach and conclusions to how the NRC staff addressed BAP in the SE to WCAP 16793-NP.