NRR-PMDAPEm Resource

From:	Singal, Balwant
Sent:	Tuesday, November 18, 2014 11:11 AM
To:	Harrison, Albon (awharrison@STPEGS.COM)
Cc:	Stang, John
Subject:	STP Risk-Informed Approach to Resolution of GSI-191 - Draft Request for Additional Information (Second Round) - TACs MF2400 and MF2401
Attachments:	MF2400-Draft-RAIs-Second Round.docx

Wayne,

By letter dated June 19, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML131750250), as supplemented by letters dated November 21 and December 23, 2013 and January 9, February 13, February 27, March 17, and March 18, 2014 (ADAMS Accession Nos. ML13338A165, ML14015A312, ML14015A311, ML14029A533, ML14052A053, ML14072A076, ML14086A383, and ML14087A126, respectively), STP Nuclear Operating Company (STPNOC, the licensee) submitted exemption requests accompanied by a license amendment request (LAR) for a risk-informed approach to resolve the issue of potential impact of debris blockage on emergency recirculation during design-basis accidents Generic Safety Issue (GSI)-191) for South Texas Project (STP), Units 1 and 2.

The NRC staff issued Request for Additional Information (RAI) by letter dated April 15, 2014 (ADAMS Accession No. ML14087A075). The licensee provided response to the RAI request by letters dated May 22, June 15, and July 15, 2014 (ADAMS Accession Nos. ML14149A434, ML14178A481, and ML14202A045, respectively). The NRC staff has reviewed the responses and has follow-up RAI request (second round). Please note that some of the RAIs may be a repeat from the first round, since the NRC believes that they did not receive a complete response to their request. Also, please note that these RAIs are Draft (for discussion before formal issue during the forthcoming public meeting) and the formal RAIs may look different as a result of the clarification calls and further staff review. Also, the numbering scheme is likely to be modified to identify the repeat RAIs.

Formal RAIs will be issued after the clarification discussion during the forthcoming public meeting on December 1, 2, and 3, 2014.

Thanks.

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Reference 1: South Texas Project Risk-Informed GSI-191 Pilot License Amendment Request (ML13323A128)
Reference 2: STP Request for Additional Information 04-15-2014 (ML14087A075)
References 3, 4 and 5: STP responses to the RAIs
Reference 6: Regulatory Audit Summary September 16 and 17, 2014

REQUEST FOR ADDITIONAL INFORMATION (RAI)

Note: The following numbering convention has been used in several communications between the staff and licensee and will also be used in this document:

Subject and RAI heading in Reference 2	RAI numbers
CASA GRANDE – General	APLA-I
CASA GRANDE – Plant Configuration	APLA-II-1, APLA-II-2, etc…
CASA GRANDE – LOCA Frequencies	APLA-III-1, APLA-III-2, etc…
CASA GRANDE to PRA Interface - General	APLA-IV-1, APLA-IV-2, etc…
STP PRA MODEL - General	APLA-V-1, APLA-V-2, etc…
STP PRA MODEL – Success Criteria	APLA-VI-1, APLA-VI-2, etc…
STP PRA MODEL – Human Reliability Analysis	APLA-VII-1, APLA-VII-2, etc…
STP PRA MODEL – PRA Scope	APLA-VIII-1, APLA-VIII-2, etc…
RESULTS INTEPRETATION – Quantification	APLA-IX-1, APLA-IX-2, etc…
RESULTS INTEPRETATION – Uncertainty Analysis	APLA-X-1, APLA-X-2, etc…

The following RAIs all have the same general subject (follow-up) and therefore will begin with the same designator: “APLA-XI.”

Probabilistic Risk Assessment Licensing Branch (APLA)

APLA-XI-1: Project Quality Assurance

Regulatory Guide (RG) 1.174 provides the NRC staff’s position on the quality assurance program for risk-informed change requests. Section 5, *Quality Assurance*, states in part: “… it is expected that for traditional engineering analyses (e.g., deterministic engineering calculations), existing provisions for quality assurance (e.g., Appendix B to 10 CFR Part 50, for safety-related SSCs) will apply and provide the appropriate quality needed.”

The LAR, Volume 1 states that CASA Grande “is a proprietary MATLAB application which was unavailable to the [quality] oversight team.”

During the regulatory audit conducted September 16 and 17, 2014 (reference 2), the NRC staff learned that the CASA Grande program was *not* in general developed under a software QA program but is presently being transitioned to such a program. Also during the audit, it was not clear what type of QA program was applied to the various calculations and analyses used to support CASA Grande (e.g., thermal-hydraulic analyses; CAD model to estimate debris source terms; derivation of relative weld failure frequencies; model abstraction of filtration and shedding) or used within CASA Grande itself (e.g., abstractions of test data into equations, correlations, assumptions). For calculations and analyses performed by contractors, consultants, or vendors on behalf of STP, it was not clear to the NRC staff (1) what QA program was implemented by each vendor and (2) how the licensee applied its engineering QA process to control the work by those suppliers (i.e., contractors, consultants, and vendors).

Therefore:

1. Provide a brief summary of the software QA (SQA) program for CASA Grande and the anticipated date when the CASA Grande software will become compliant with that SQA program. Describe any standards and documents (e.g., 10 CFR 50, Appendix B; NUREG/BR-0167 and referred standards in its Appendix C; NUREG/CR-4640) upon which the SQA is based.
2. Identify the QA program that was employed for the engineering analyses and calculations performed in support of the LAR and state whether this program meets 10 CFR 50, Appendix B requirements.
3. For each vendor or contractor that performed calculations or analyses used in the CASA Grande model, in response to NRC RAIs or in support of license amendment submittals, briefly describe the QA program employed. How were vendor QA programs assessed by STP for compliance with the STP engineering QA program? Do these QA programs meet Appendix B requirements?
4. How were vendor or contractor calculations or analyses reviewed and accepted into the STP engineering system?
5. Describe the QA process used to ensure that information derived external to CASA Grande (e.g., debris source term, filtration and shedding empirical equations, time-temperature curves, relative weld failure frequencies) was incorporated into CASA Grande consistently with those external analyses, including assumptions made. Define the process used to ensure that use of Monte Carlo sampling produced results consistent with stand-alone external analyses (e.g., when parameters of empirical equations are sampled, are results still consistent with tests?)

APLA-XI-2: Treatment of Unanalyzed Plant Conditions

RG 1.200, Revision 2, “An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities,” Revision 2 (ADAMS Accession No. ML090410014), Section 1.4, “PRA Development, Maintenance, and Upgrade,” states that plant information used in the Probabilistic Risk Assessment (PRA) (e.g., expected thermal-hydraulic plant response to different states of equipment) should be as realistic as possible. Verify that the conditional split fraction values (i.e., failure probabilities used by PRA) for sump failure and in-vessel failure are based on Containment Accident Stochastic Analysis (CASA) Grande simulations that represent accurately plant conditions for each accident sequence relevant to the license amendment request (LAR), or justify that the chosen failure probabilities are upper bounds for any plant conditions that might occur for a given scenario. For example, for plant conditions where a simulation is impractical, unnecessary, or not performed for any other reason, a split fraction value of 1.0 should be assigned or a qualitative argument should be made to select an existing CASA Grande result as bounding. Based on information provided in the LAR Volumes 2 and 3, this approach is already employed for pump states. Each of the 64 pump states identified in the LAR were assigned conditional split fraction values for sump and in-vessel failure that were based on:

- CASA Grande simulations (pump states 1, 22, 9, 26, 43)
- Qualitative arguments as to why existing CASA results are bounding (the 11 bounded states)

- Assigned a conditional core damage probability of 1.0 (48 other pump states)

A similar verification that assigned failure probabilities are realistic or bounding should be applied to all other unanalyzed plant conditions including but not limited to:

- Number of containment fan coolers not equal to 6
- Failure of containment isolation
- Failure of operators to secure one train of containment spray (CS) early
- Failure of operators to secure remaining trains of CS late
- Failure to switch to hot leg injection prior to securing CS trains
- Failure to swap to hot leg (HL) recirculation
- Failure of a running pump following a successful start
- Failure of one or more residual heat removal system heat exchangers

Therefore, provide the results of a systematic review of all accident sequences containing a top event corresponding to one of the seven generic safety issue (GSI)-191 failure modes. For each sequence, provide one of the following:

A. Confirmation that the split fractions assigned to sump and in-vessel failure were derived from CASA simulations that are consistent with the specific plant conditions associated with the sequence (i.e., availability of plant equipment, success/failure of operator actions, etc.).
B. Technical argument that the existing CASA simulation provides results that are applicable or bounding
C. Confirmation that the conditional split fraction value for sump or in-vessel failure were set to 1.0 for non-analyzed cases.

APLA-XI-3: Human Reliability Analysis

RG 1.174, Sections 2.3.1 and 2.3.2 state that the scope and level of detail of the PRA model must be sufficient to model the impact of the proposed change. Reference 2 includes a number of RAIs related the human reliability analysis (HRA) used in the risk assessment and the responses to Reference 2 describe a number of human actions that are important during a loss-of-coolant-accident (LOCA). Please describe how the dependency among multiple human actions (both those in the “clean plant” and “debris” models) in the same sequence was assessed for the debris PRA model.

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

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[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.

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.

APLA-XI-5: Validity of Assumption on Pump Configurations

In response to APLA-II-3, South Texas Project (STP) analyzed different pump configurations for Case 22 to verify Assumption 2b of Volume 3 of the LAR (reference 1), which stated that a combination of pumps failing in the same train would result in a bounding failure probability compared to other combinations with the same number of each type of pump (i.e., high head, low head, and CS).

The results of this sensitivity showed that the assumption was false for in-vessel failure probabilities. Therefore, non-conservative failure probabilities were assigned to PRA model top events for certain scenarios. This approach may result in an underestimation of the risk of debris.

Failure of the selected pump configuration (Case 22) to uphold assumption 2b calls into question the combinations of the other cases used to simplify the risk assessment. Therefore:

- Determine whether assumption 2b provides realistic or bounding failure probabilities for each pump state that is assigned a non-unity failure probability.

- Provide CDF, LERF, ΔCDF, and ΔLERF based on a PRA model that uses realistic or bounding failure probabilities for all possible pump configuration.

APLA-XI-6: Clarification on Response to APLA-IV-5

The response to APLA-IV-5 contains a figure showing that the smallest observed break size leading to debris-induced core damage was approximately 17 inches. This appears to conflict with the response to APLA-VI-1, which stated that "the largest break size below which no failures related to either the sump or vessel performance were recorded during the CASA Grande runs was a DEGB in a 5.189D inch pipe." Please clarify these seemingly contradictory statements.

APLA-XI-7: Fidelity between RELAP simulations and CASA Grande

The LAR Volume 6 describes the RELAP simulations that were used to determine whether core cooling could be accomplished with partial or complete blockage. Page 123 states that "all the safety systems were assumed to be available throughout the transient." Therefore, it would appear that Table 2.5.39 "Core Blockage Scenarios Summary" would only apply to scenarios where all ECCS and CS pumps are available (i.e., Case 1). The response to APLA-VI-1 states that "analyses performed in support of the LAR included consideration of a 6 inch hot leg break with *only one train* of ECCS available." [emphasis added] Please clarify if this refers to an analysis performed subsequent to the LAR. Provide additional details on this or any other analyses that are used to justify applying the results of Table 2.5.39 to pump states other than Case 1. Include a description on the quality assurance of these analyses in relationship to APLA-XI-1.

APLA-XI-8: State-of-Knowledge Correlation

RG 1.174 Section 2.5.2 states that the state-of-knowledge correlation should be accounted for unless it can be shown to be unimportant. In APLA-X-5, the staff asked why the state-of-knowledge correlation was not applied to the LOCA frequencies used by the PRA and CASA Grande. STP's response stated that "…dependence of the PRA and CASA Grande on different parameters of the LOCA break frequencies is sufficient so as not to warrant correlation between the PRA and CASA Grande."

This answer is unacceptable because the choice of LOCA frequency percentile affects both the absolute LOCA frequency (used by the PRA) and the shape of LOCA frequency vs break size curve (used by CASA Grande). Therefore, both the PRA and CASA Grande rely on the same underlying parameter and the state of knowledge correlation applies. This position was communicated to the licensee by the ACRS during the meeting on September 3, 2014 (ML14266A510) and by the staff during the audit conducted from September 15-17, 2014. Please revise your analysis by correlating the LOCA frequencies used by the PRA and CASA Grande. Provide updated CDF, LERF, ΔCDF and ΔLERF based on mean values resulting from the parametric uncertainty calculation that properly considers the correlation between the initiating event frequencies and the failure probabilities (sump and in-vessel) for debris-related events.

APLA-XI-9: Mean Values

CASA Grande characterizes epistemic uncertainty surrounding LOCA frequency using a bounded Johnson distribution, as described in the LAR Volume 3. NUREG-1829 reports baseline mean values by assuming a split lognormal distribution for individual experts but acknowledges that other "plausible" distributions could be selected and provides "reasonable" upper and lower bounds for the mean value based on different distribution shapes fitting the individual expert elicited values. This is discussed in NUREG-1829, Section 7.6.1. Confirm that the mean value derived from the bounded Johnson distribution falls within the upper and lower bounds described in this section.

APLA-XI-10: Selection of Johnson Parameters

In the response to APLA-X-4, STP stated that it was not possible to approximate the NUREG-1829 mean frequencies with different selections of the parameter λ. NRC independent analyses indicate otherwise; for example, the following alternative fits yields means that are relatively close to those tabulated in Table 2.2.2 of the Volume 3 submittal. Evaluate the sensitivity of the CDF and LERF on different selections of bounded Johnson distribution fits, such the alternative fit in the table below.

Size (in)	5^{th} (1/yr)	Median (1/yr)	Mean (1/yr)	95^{th} (1/yr)	γ	δ	ξ	λ
0.5	0.000068	0.00063	0.001853	0.0071	4.962538	0.671235	1.49E-05	1
1.625	5E-06	8.9E-05	0.000408	0.0016	4.551311	0.568039	8.48E-08	0.268427
2	3.69E-06	6.57E-05	0.000301	0.00118	4.594371	0.568322	5.61E-08	0.212914
3	2.1E-07	3.4E-06	1.59E-05	6.1E-05	6.024348	0.568377	2.31E-08	0.135431
6	6.3E-08	1.08E-06	5.16E-06	1.98E-05	6.194246	0.56465	4.59E-09	0.062491
7	1.46E-08	3.04E-07	1.67E-06	6.34E-06	6.529987	0.541377	1.4E-11	0.052616
14	4.1E-10	1.2E-08	1.94E-07	5.8E-07	6.142561	0.422624	1.69E-10	0.024278
31	3.5E-11	1.2E-09	3.21E-08	8.1E-08	6.207166	0.389148	1.77E-11	0.01

STP Round 2 RAIs – ESGB

Notes:

i. Round 2 RAI question numbers begin with the next sequential number from the Round 1 RAIs (i.e., #23 for chemical effects, #8 for coatings). Follow-up questions from the STPNOC responses to Round 1 RAI questions refer back to the Round 1 RAI number.

ii. In all cases, "*Enclosure 1*" refers to Enclosure 1 to Attachment 5, "*Quantification of Chemical Head Loss Epistemic Uncertainty; Basis for Incremental Chemical Head Loss Epistemic Uncertainty*" contained in the July 15, 2014 STPNOC Letter (ADAMS Accession No. ML14202A045).

Round 2 Chemical Effects

23. During the NRC staff audit in September 2014, representatives from STPNOC stated that the chemical effects evaluation model was being changed from the chemical "bump-up" factor multiplier discussed in the November 13, 2013 LAR (ADAMS Accession No. ML13323A190) to an alternate chemical model that uses an additive chemical head loss factor determined from the chemical loading term "L*." Assuming the bump-up factor approach is no longer being pursued, the NRC staff has reconsidered previous chemical effects related RAIs and determined that the following Round 1 RAI questions are no longer relevant to the new chemical model: 1a-d, 3, 4, 5, 9, 17, 18a-c. Please confirm that the staff's understanding is correct.

24. The NRC staff has reviewed the overview of an alternate chemical effects approach contained in Enclosure 1 to Attachment 5, "*Quantification of Chemical Head Loss Epistemic Uncertainty; Basis for Incremental Chemical Head Loss Epistemic Uncertainty*" contained in the July 15, 2014 STPNOC Letter (ADAMS Accession No. ML14202A045). This enclosure provides an overview of the alternate chemical effects method.
    a. Therefore, provide a detailed description of this chemical head loss model and its application to the STP plant-specific chemical effects analysis such that the NRC staff can perform a thorough review and evaluation.
    b. As part of the detailed description and based on CASA Grande realizations, provide a histogram showing chemical head loss (feet) on the x axis and number of occurrences on the y axis for the MBLOCA and LBLOCA categories. Please ensure the bin selections allow the staff to discriminate different outcomes that result in acceptable head loss.
    c. Discuss whether the chemical head loss determined from the L* method is independent of the debris bed or in some way correlated with the debris bed.
    d. Please describe in detail how the new chemical model will account for uncertainties. Some examples of uncertainties include: variability in chemical head loss behavior (e.g., an approximate 40% difference in head loss resulting from a change to the precipitate addition sequence in Enclosure 1, Figure 9), variability in head loss across different debris beds for the same type and quantity of precipitate, differences in corrosion/leaching behavior between test materials and plant materials, variability in temperature or pH compared to testing, other post-LOCA conditions (e.g., radiological) not present during testing.

25. The NRC staff has several questions related to Figure 14 in the aforementioned Enclosure 1 to Attachment 5.

    a. Given the head loss response to chemical precipitate addition shown earlier in Figures 1 and 2, it seems more appropriate to model head loss in a non-linear manner. Please discuss any plans to further develop the model.

b. The NRC staff does not agree that the 4th "Bahn" data point placement in this plot is appropriate given that the test loop was shut down at this point since the test loop head loss limit had been reached. Please discuss a plausible range of head loss for this test had it not been stopped and how that would affect the chemical head loss correlation.

c. Without consideration of item (b), the NRC staff calculated a greater chemical head loss (CHL) value (approximately 0.7 feet) when scaling a 13 feet of water result to the STP strainer test conditions according to Equation 2. Please provide a copy of the calculation showing the scaled value is approximately 0.4 feet.

d. While the staff agrees that comparison of chemical effects testing may provide insight, the relationship between flow and chemical head loss may be more complex than as shown by Equation 2. Please provide a basis for this scaling equation or discuss the limitations that may exist when extrapolating data over more than an order of magnitude in flow rates.

26. Figure 25 in Enclosure 1 shows new aluminum release equations that appear to be based on experiments run for Southern Nuclear Company.
    a. Please provide a copy of the Reference 17 (CHLE-SNC-005 Bench Test) Report that contains this data so that the NRC staff may understand how these tests were performed.
    b. Confirm that the orange line in Figure 25 represents the 1600 series tests.
    c. The aluminum release model appears to be predicting the same data as in figure 24, which was used to develop the model. Please clarify if any additional data was used to develop the model.

27. A limited release of aluminum during chemical effects testing is one of the key items STP is relying on for concluding STP has relatively minor chemical effects. In ESGB Round 1, RAI #13b, the NRC staff asked if the two parts of scaffolding had been tested to compare their aluminum release. The RAI response provided scanning electron microscope images along with energy dispersive spectroscopy (EDS) and x-ray photoelectron spectrometry (XPS) results.

Given that the two parts of scaffolding were used in different test conditions, that they were visually observed to have different texture and appearance, and that the Table 1 elemental compositions indicate potentially significant differences in key elements (e.g., Al, O, P), the staff thinks it is important to verify that the corrosion behavior of the two scaffolding parts is similar. For example, one way to verify similitude would be to run a direct comparison of aluminum release in bench tests at higher post-LOCA temperatures to determine if the aluminum release was reasonably similar. Please provide a comparison of the corrosion behavior of the two parts of scaffolding.

28. Since multiple tests suggest aluminum corrosion will be inhibited by phosphate after a relatively short time into the post-LOCA ECCS mission time, understanding the corrosion behavior of aluminum at elevated temperatures becomes very important. Recent aluminum corrosion testing by another licensee (see ADAMS Accession No. ML14184B509, Slide 18) showed that for their plant specific conditions, significantly longer test durations at 195^{o}F did not release an equivalent quantity of aluminum as shorter time at higher temperatures. Please discuss the relevance of these results to the STP chemical effects approach for aluminum release at higher temperatures. Please include in that discussion the range of postulated plant-LOCA temperature profiles relative to the CHLE test MBLOCA and LBLOCA profiles and if any adjustments are needed to the aluminum release rates at temperatures greater than 185 ^{o}F.

29. In Section 2.1.1 (“Zinc Phosphate”) of Enclosure 1 to Attachment 5, the discussion states the following:

    “*When zinc corrosion materials were included in the STP risk-informed tests, head loss response was observed during the initial hour of testing; however, additional tests indicated that the head loss response to the zinc product was likely the result of initial dissolution of a surface layer and not from transport of a continuously generated zinc corrosion product (Zn3(PO4)2•4 H2O). Therefore, the initial zinc product release is treated as a particulate source and not considered a zinc chemical product. Since Zn3(PO4)2•4 H2O is unlikely to transport to the strainer and, given that Option 1 CHL is intended to produce conservative or overestimated CHL response to identified precipitate loads, Zn3(PO4)2•4 H2O generation is ignored in the CHL correlation development*.”

    Given the significant quantities of zinc present, the NRC staff thinks it would be appropriate for a chemical model to account for zinc. Dissolution of galvanized steel or inorganic zinc coatings may occur at the lower pH before the trisodium phosphate (TSP) buffer fully dissolves to adjust the pH to an alkaline value. Dissolved zinc would then be available to react with the phosphate. In addition, some percentage of the galvanized surfaces could be susceptible to having zinc corrosion product knocked off by water falling from the pipe break, drains, etc. The staff recognizes it may be appropriate to model zinc products separately from amorphous aluminum hydroxide type precipitates if warranted by the head loss response across a debris bed representative of a sump strainer bed. Please provide the quantity of zinc that is included in the “particulate source,” how this amount of zinc affects head loss and if an additional zinc product should be included in the model.

30. Figure 21 in Enclosure 1 implies the WCAP-16530 release rate equations are being incorporated into CASA Grande which is not the case for aluminum. Please clarify which, if any, WCAP-16530 release equations will be used with the alternate chemical head loss model approach.

31. The chemical head loss (CHL) is determined based on chemical precipitate loading per strainer (g/m^2). Please describe how the plant-specific incorporation of this model accounts for the greater chemical head loading for the cases where less than three trains operate following a LOCA.

32. As discussed during the August 20, 2014 public meeting, the NRC staff did not agree with the logic contained in the response to Round 1 ESGB RAI #14a, please provide a modified response.

33. In the response to Round 1 ESGB RAI #21, the mass of 24 pound for a CRUD release following a LOCA is based upon the EPRI BOA estimates of fuel deposits that would affect a CRUD induced power shift (CIPS). While this may be an adequate prediction for CIPS susceptibility, it does not assess the total available transient CRUD layer in the primary coolant system. The fuel surface area is approximately 30 % of available RCS surface with other surfaces such as piping and Steam Generator tubing making up most of the remaining surface areas.

    The EPRI PWR Primary Water Chemistry Guidelines state, in part:
    "Core flow transients should be minimized to minimize particulate entrainment which will increase dose rates and particulate contamination levels in low flow regions. Wall shear, which is approximately proportional to the square of the coolant velocity, is the primary factor promoting particulate releases subsequent to shutdown. A smooth transition to one pump operation is considered appropriate to reduce shear and minimize particulate releases during the shutdown transient."

    During a reactor trip following a LOCA there is no "smooth transition" with liquid and gaseous flow plus solids entrainment. Thermal, hydraulic and chemical transients are all present, simultaneously. One of the most significant chemical changes is the presence of both hydrogen and oxygen in the water flowing to the sump as well as being recirculated back through the reactor core. This uncontrolled chemistry condition leads to both reductive and oxidative processes occurring simultaneously leading to particulate formation.

    The EPRI PWR Primary Water Chemistry Guidelines (Table 3-5 of Section 3.8) identifies analyses to be performed by Chemistry during a normal shutdown, including filterable and non-filterable: radioactive corrosion products, elemental nickel and iron. Therefore, the Chemistry department may have this information related to normal shutdowns and transient shutdowns.

    Therefore, the NRC staff requests that the licensee determine if historical information is available concerning crud release from normal shutdowns and unplanned trips and to re-evaluate the crud release estimate based on any additional information, including release from all RCS sources during a LOCA.

34. Please clarify the difference between the fiber amounts shown in the Table 2 and Figure 3 in Enclosure 1.

Round 2 Coatings

8. With respect to Round 1 coatings question number 1, your response is not consistent with the current NRC staff position on debris characteristics for unqualified coatings. The testing you referenced is not applicable to unqualified coatings. This position is described in staff review guidance available at ADAMS ML080230462. Please provide a revised analysis for the unqualified epoxy coatings in question.

9. With respect to Round 1 coatings question number 2, you state that a ZOI of 4D was used for inorganic zinc coatings. This position is inconsistent with the current NRC staff position. Based on the latest test data available the ZOI for inorganic zinc coatings should be 10D. A description of this position is available at ADAMS ML100960495. Please provide a revised analysis for the ZOI of inorganic zinc coatings.

10. With respect to Round 1 coatings RAI number 6, the reductions you credit for debris generated by unqualified coatings in upper containment is inconsistent with the current NRC staff position. Both the treatment of failure percentages and failure timing are based on EPRI testing that the staff has previously issued positions on. Staff guidance found at ADAMS ML080230462 describes the staff's position with respect to this testing. In addition the staff concerns regarding the failure timing being based on filter data (as described in the original question 6b and 6c) are not adequately addressed by your responses. Please provide a revised analysis for the unqualified coatings in upper containment.

SCVB-RAI-10

Background

The response to round 1 SCVB-RAI-3a does not provide adequate justification for not revising the Updated Final Safety Analysis Report (UFSAR) description of the containment heat removal analysis. The response to round 1 SCVB-RAI-3c refers to a proposed UFSAR description of the risk assessment given in Enclosure 3, Attachment 2 of the LAR which does not provide a revised licensing basis description of the containment heat removal analysis.

The response to round 1 SCVB-RAI-4a does not provide adequate justification for not revising the UFSAR description of the fission product removal analysis. The response to round 1 SCVB-RAI-4c refers to a proposed UFSAR description of the risk assessment given in Enclosure 3, Attachment 2 of the LAR which does not provide a revised licensing basis description of the revised fission product removal analysis.

Refer to the following excerpt taken from the round 1 RAI response to SCVB-RAI-3b:

> “As described in the LAR, the proposed exemptions from General Design Criteria (GDC) - 35, the "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.
>
> STP 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 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.”

The NRC staff has the following comments on the above response:

The staff agrees that the currently <u>licensed design and configuration</u> 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. The staff disagrees that the UFSAR description of the <u>licensing basis containment heat removal analysis</u> which uses CSS, the <u>licensing basis containment fission product removal analysis</u> which also uses CSS, and the <u>licensing basis 10 CFR 50.46 analysis</u> 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 GDC-35, 41 and 38. For breaks that produce large amount of debris with which 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 staff has developed the flow chart shown in Figure 1 for defining the LOCA containment Net Positive Suction Head (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.

<u>RAI</u>

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, FSAR, technical specifications, licensing conditions, and licensing commitments. SRP 19.2 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 chapter 6 and 15 must be revised by including the description for the breaks for which partial or complete exemption from GDC-38, -41, and -35 is requested.

(a) Provide UFSAR revisions of chapter 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.

SCVB-RAI-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. Regulatory Guide (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 structures, systems, and components (SSCs), procedures, and activities that are covered by the licensing basis change being evaluated.

The response to round 1 SCVB-RAI-1a states that the Containment Spray System (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.

SCVB-RAI-12

The response to round 1 SCVB-RAI-1b does not state as to 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.

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

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

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

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

(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.

<u>SCVB-RAI-13</u>

The response to round 1 SCVB-RAI-2a states that the Containment Spray System (CSS) is the only system for which the exemption from GDC-41 is requested. Note that the CSS also has associated supporting system to which GDC-41 would apply. List all the associated systems that support the operation of the CSS; such as the safety-related electrical, 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 <u>fission product removal</u> in the presence of debris.

<u>SCVB-RAI-14</u>

The response to round 1 SCVB-RAI-2b does not state as to 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) Provide systems 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.

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

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

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

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

Please provide the following information:

(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.

(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>SCVB-RAI-15</u>

The response to round 1 SCVB-RAI-9a, 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, EDGI&C, 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 HHSI and LHSI systems in the presence of debris.

<u>SCVB-RAI-16</u>

The response to round 1 SCVB-RAI-9b does not state as to which requirements of GDC-35 will not be met. The key GDC-35 requirements to be met for the Emergency Core Cooling System (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.

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

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

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

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

Note that requirement # (2) covers **<u>all postulated LOCAs</u>** of any break size, including the most limiting from debris generation standpoint 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, than 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.

(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.

<u>SCVB-RAI-17</u>

In round 1 RAI SCVB-RAI-7, the 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 round 1 RAI SCVB-RAI-7 did not provide what the staff requested. The staff requests to 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. Justify that the inputs and assumptions are conservative for the purpose.

<u>SCVB-RAI-18</u>

Please respond to the following comments on response to round 1 RAI SCVB-RAI-3b

(a) Refer to the table 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 RELAD-3D instructions”

(b) Refer to the table of major qualitative differences, 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”, please provide the basis for selecting the RELAP-3D/MELCOR values of the parameters in the table below and how are they determined:

<u>RELAP-3D/MELCOR</u>	**<u>VALUE</u>**	**<u>BASIS</u>**
Initial atmosphere temperature	119.93 ^{o}F	
Initial containment pressure	14.94 psia	
Initial relative humidity, partial pressure of water vapor	70%/ 1,184 psia	
Initial RWST temperature	85 ^{o}F	
Spray actuation times	15 s delay after setpoint, linear ramp to full flow	

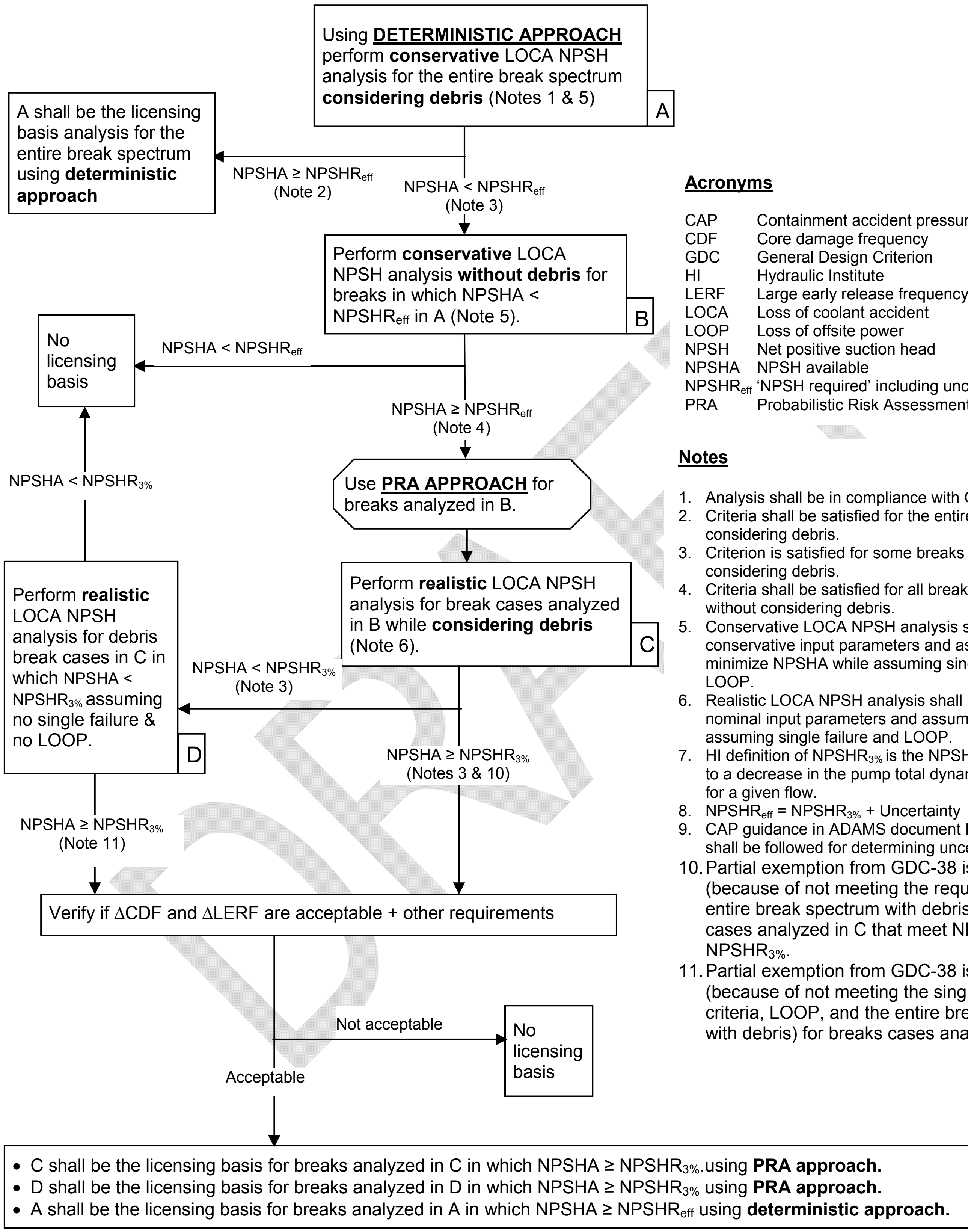
Fan cooler actuation times	15 s delay after setpoint	

(d) Refer to the table under the heading “Summary Comparison of Main Parameter Values”; 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.

<u>REFERENCES</u>

1. Letter from STPNOC to NRC dated November 13, 2013, “South Texas Project Units 1 and 2 Docket Nos. STN 50-498 and STN 50-499 Supplement 1 to Revised STP Pilot Submittal and Requests for Exemptions and License Amendment for a Risk-Informed Approach to Resolving Generic Safety Issue (GSI)-191 (TAC NOS. MF0613, MF0614, MF2400, MF2401, MF2402, MF2403, MF2404, MF2405, MF2406, MF2407, MF2408, AND MF2409)” (ADAMS Accession Number ML13323A183)

2. Letter from STPNOC to NRC dated June 25, 2014, “South Texas Project Units 1 & 2 Docket Nos. STN 50-498, STN 50-499 Second Set of Responses to April, 2014, Requests for Additional Information Regarding STP Risk-Informed GSI-191 Licensing Application (TAC Nos MF2400 and MF2401)” (ADAMS Accession Numbers ML14178A481 and ML14178A485)



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 ≥ 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

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 regonizes 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.

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.

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.

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.

6. 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.

<u>SSIB Round 2 RAIs</u>

Follow up to SSIB RAI 2 – The licensee stated that the values for size distributions for the fibrous insulation are documented in reference 46. Reference 46 was not included in the submittal. Please provide a summary of the relevant size information from reference 46. A table including the size distributions within the postulated ZOIs would probably provide the clearest response.

Follow up to SSIB Round 1 RAI 4 – The NRC staff believes that it is likely that the STP methodology discussed in the response to RAI 4 is acceptable and provides conservative transport results when considered within the probabilistic framework. However, LDFG congestion may not be the metric that dominates the likelihood of debris reaching the strainer based on break location. Although the use of the SG compartment transport fraction may be moderately conservative as claimed, the staff could not verify this. It was also not clear to the staff that the measure of fiber congestion within specifically defined volumes in containment provide the most important measure of debris amounts that may be generated or the probability that debris would be generated within those volumes. If one location is congested, but the fibrous debris in that area cannot be damaged by a break it is not relevant. Please verify that the methodology results in overall realistic or conservative transport fractions considering the possible break locations and the LDFG congestion.

Follow up to SSIB Round 1, RAI 6a – The RAI was not answered adequately. The DDTS states that if gratings do not cover an entire transport path that they may not be as effective in debris capture as noted in the test metrics. Simply using a ratio of open area to total area may not provide a realistic or conservative estimate of debris capture. The grated area likely has higher resistance to flow that will increase as it collects debris. Debris is generally assumed to be homogeneously distributed throughout the blowdown flow. If less volume of blowdown passes through the grating due to flow resistance, less debris is available to pass through or collect on the grating. The NEI baseline guidance assumes that small fines are debris that will pass through gratings, so no holdup of small or fine fibrous material is assumed using baseline methodology. The baseline further assumes small fines to be the basic constituent of the debris for transport purposes. There were no refinements regarding crediting gratings to reduce transport found in either NEI 04-07 or the NRC SE on 04-07. Therefore, STP should justify the assumption that the amount of debris captured by gratings in pathways that are not fully covered can be estimated using a simple ratio of the open area to total area. Please provide a justification that the debris capture metrics used in the evaluation are realistic considering the issue identified above.

Follow up to SSIB Round 1 RAI 7b –The response to SSIB RAI 7.b stated that the significantly longer washdown periods at STP, compared to the length of the DDTS washdown tests are inconsequential to the STP evaluation. The conclusion is based on a portion of the NEI guidance document, NEI 04-07, that found the erosion of fibrous debris by containment spray is less than one percent. The RAI did not question the erosion of fibrous debris by containment spray, but asked whether the washdown of fibrous debris through gratings would increase above that found during the DDTS if the washdown time is significantly increased? The staff is specifically interested in the small fiber washdown transport fractions provided in table 2.2.23 (Volume 3) of the licensee's submittal. These values are currently listed as 7-19% washed down in the annulus and 21-27% washed down inside the secondary shield wall. These are not fibrous erosion values. Please provide justification that the washdown values from a 30 minute test are applicable to the STP condition considering the clarification provided.

Follow up to SSIB Round 1 RAI 14 – RAI 14 requested the basis for the use of 1/16 inch as the value below which a filtering bed is assumed not to occur. The response to the RAI requires staff acceptance of the head loss correlation and a sensitivity study that showed no change in CDF if the criterion is reduced to zero inches. Because neither has been accepted at this time the acceptability of the response to RAI 14 is indeterminate. Additionally, the use of a 1/16 inch criterion below which chemical effects cannot occur is not supported by some industry tests that had 1/16 inch of fiber or less added. Some tests had measureable increases in head loss with less than 1/16 inch theoretical fiber on the strainer after chemicals were added to the loop. The staff agrees that it is unlikely that a head loss great enough to result in strainer failure will occur with such a low fiber load. However, the potential for the head loss to result in flashing or additional deaeration was not addressed. The sensitivity study was also conducted before corrections to pool level and CSHL values were implemented. The staff has no confidence in the head loss correlation used to perform the sensitivity study. The licensee should address the RAI considering the information provided in this follow up.

SSIB RAIs 15, 16, 17, 18, 21, and 22 requested additional information regarding the licensee's use of a correlation to calculate debris head loss. The NRC staff has established a position that correlations may not be used to calculate head loss unless the correlation is validated, under plant specific conditions, for the range of conditions to which the results will be applied. This position has been stated repeatedly since before the STP LAR was submitted for review. In general, the licensee's responses to these RAIs are not acceptable. The concerns originally transmitted in these RAIs will not be repeated. The NRC staff expects that any use of head loss correlations will meet the established staff position.

Follow up to SSIB RAI 27 - The licensee stated that the use of 0.220 ft. as the CSHL value was an error. The licensee performed sensitivity studies to determine the effect of using the correct value of 1.952 ft on overall CDF. The licensee stated that the change in CDF would be about 18% when the correct value is used. The licensee stated that a more accurate CSHL value would be used. Please provide the "more accurate" value of CSHL that will be used in future calculations or state that the value of 1.952 ft. will be used in future calculations.

Follow up to SSIB RAI 28 – The response to the RAI states that the use of a head loss correlation is essential to the risk-informed method because it provides understanding of subtle interactions between variable parameters considered in the analysis. The need to apply a 5X safety factor to bound uncertainties in the correlation indicates that confidence in the method is relatively low and that evaluation of interactions between the parameters may be significantly skewed. These relationships may be further mischaracterized by resorting to a limiting packing factor for the debris bed. The response provides a sensitivity study for safety factor values around the 5X value used in the evaluation. However, the response does not provide a basis for the values used in the study. The staff concluded that because there are uncertainties in many aspects of the model and that many of these are significant, that the 5x multiplier may not envelope these uncertainties. The RAI response does not address two significant issues that lead to model uncertainty. First, the uncertainty caused by non-homogeneous beds is not discussed. Second, the lack of testing to validate the model for plant specific conditions is ignored. Other uncertainties inherent to the use of correlations for head loss should also be addressed including statistical uncertainties arising from the use of test data, uncertainties arising from the use of the correlation, and uncertainties introduced by assuming that test conditions are representative of the plant. Please provide an evaluation of how the individual uncertainties within the model are accounted for and provide an estimate of the total uncertainty created by use of the model. This is related to APLA RAI XI-4.

Follow up to SSIB RAI 31 – The licensee described a calculation that evaluates the potential for the collection of gas bubbles in the STP strainer. The licensee cites Reference 58 which evaluates the transport of gas voids in the piping between strainer and ECCS and CS pumps. The details of this reference were not provided. It was also not described how it was determined that voids would not collect in the strainer. Please provide a summary of the relevant sections of reference 58 describing how it was determined that voids would not collect in the pump suction piping. Additionally please provide information that evaluates whether voids can collect within the strainer, and if they do, evaluate the effect.

Follow up to SSIB RAI 33 – In its response to SSIB RAI 33 the licensee stated that the CASA model overestimates the water level compared to computer aided design calculated levels. STP stated that the error will be corrected so that future submittals contain accurate pool levels. This portion of the response is adequate since a future submittal is required and this submittal will include corrected levels. However, the licensee should also verify that strainer submergence is adequate and that vortexing, deaeration, and flashing evaluations adequately reflect the corrected levels and that transport is not affected due to higher pool velocities. Please provide information that justifies that these areas are not adversely affected.

Follow up to SSIB RAI 34 – In response to SSIB RAI 34, the licensee stated that total CSS flow is determined by multiplying the random pump flow rate by the number of operable CSS pumps. These flow rates are randomly selected from between the maximum calculated flow rate and some minimum value. It was not clear that using random values is appropriate and it was not clear how the minimum values were calculated. The licensee also stated that for all two and three train cases that CASA uses the higher two train flow. The staff agrees that use of the two train flow is conservative. Please summarize the relevant information from reference 42, provide the methodology used to determine the minimum flow rates, and provide the basis for using random flow rates for each event instead of calculating event specific flow rates.

Follow up to SSIB RAI 41.c – The staff has accepted the use of mitigative measures to address defense in depth. STP credited backwash of the strainers as a mitigative measure. However, STP stated that they have not proceduralized backwash of the ECCS strainers. STP should either revise the LAR submittal to remove the credit for strainer backwash as a mitigative measure or provide information on how such an action would be decided upon and initiated in the event that it is required.

^^^^^^^^^^^^^^^^^^^^^^^^^^^^^NEW SSIB RAIs NEW^^^^^^^^^^^^^

43) CASA uses a distribution for the temperature at which chemical effects are assumed to occur and a distribution for the conventional head loss bump up factor. Volume 3 states that chemical effects are assumed to occur below 140 ^{o}F and that the conventional head loss bump up factor is 5. Please state which methodology is intended and update the documentation or the model to reflect the intended methodology.

44) CASA does not implement the bed compression aspects of the 6224 Correlation. Volume 3, equations 33-38 imply that the compression function is implemented in CASA. The staff understands that this issue was addressed by implementing a limiting bed compression for all debris head loss calculations. Please verify that this has been accomplished and provide updated results based on the updated method. Please provide the basis for the assumption that the limiting bed compression chosen is appropriate.

45) The NRC staff discovered several concerns with the model used for fiber penetration through the strainer. Considering the issues described in this RAI, the NRC staff does not have confidence that the debris penetration model accurately represents the expected debris penetration and in-vessel fiber accumulation that could occur in the plant. Please provide information that justifies that the CASA Grande calculations for fiber penetration are meaningful and represent the plant conditions:

    a. Assumptions and modeling techniques regarding debris arrival timing and filtration may be resulting in non-conservative bypass results. In the response to Round 1 SSIB RAI 6b it was stated that early arrival of debris at the strainer resulted in higher filtration and lower total bypass. The response to SSIB RAI 11b stated that debris transported during pool fill are placed directly on the strainer at the initiation of the LOCA. This is also related to the “non-intuitive results found during a sensitivity study provided to the staff for review. The reason that the result is non-intuitive is that it is non-physical. Debris arrival timing should not have a significant effect on filtration if realistic timing is used. The staff understands that placing fiber on the strainer at the start of recirculation is conservative with respect to head loss, but concluded that it is non-conservative with respect to strainer penetration. The staff concluded that it is likely more conservative to assume homogeneous mixing of fiber in the pool at the start of recirculation rather than assuming that some fiber transports to the strainer prior to recirculation. This is based on the relatively short time during which significant bypass occurs and the longer time over which head loss becomes more risk significant. Please provide information that justifies the STP approach is conservative or incorporate a methodology that is more appropriate.

b. If the existing model or a model that results in penetration being highly dependent on arrival timing early in the event is maintained, justify why the model is not more correlated to the amount of debris arriving at the strainer regardless of timing. If debris arriving at the strainer at the initiation of the LOCA affects the calculated bypass amount please justify this model behavior. Does the model assume that early arriving material can pass through the strainer? If not, please justify the assumption. Also, please provide justification that less debris would bypass the strainer in the plant if debris arrives at the strainer earlier in the scenario, that is, the model accurately reflects plant performance.
c. How are the uncertainties resulting from applying bypass test results to the plant condition accounted for in the model? Are there conditions potentially present in the plant that would result in more bypass than occurred in the relatively controlled test conditions?
d. How are uncertainties associated with the strainer bypass calculation accounted for? The calculation appears to be very sensitive to arrival timing. Also, how are uncertainties that arise from testing and the translation of test results into bypass models accounted for?
e. The staff noted that changing the time step in the CASA debris penetration model has a significant effect on the output (amount of debris reaching and accumulating in the core). CASA uses a relatively inaccurate method to integrate the mass balance equations for debris accumulated in the core, especially early in the accident sequence after initiation of recirculation. Describe how STP determined that the time step interval and integration method provide appropriate results (ideally, the conditional probability of failure by exceedance of the cold-leg break fiber limit should be independent of the computational time steps).
f. The staff noted that one input parameter to the CASA Grande code to compute the filtration efficiency is one order of magnitude more than that determined by testing and documented in Volume 3 of the submittal (Table 2.2.28, parameter m_{test}: the upper bound is 0.0003723 1/g; instead a value of 0.003723 1/g was apparently used in the CASA Grande computations in support of license submittals). The result of this error is overestimation of the filtration efficiency, which causes underestimation in the amount of fiber penetration and in-vessel accumulation. Sensitivity studies suggest that this error would underestimate the

cold-leg break in-vessel fiber limit failure contribution to the CDF by about an order of magnitude. Include comparisons of filtration efficiencies and shedding rates computed by Monte Carlo sampling to test data.

46) The staff examined the relationship between break size, and CASA failure predictions. There are discontinuities in the results that suggest that failures due to certain break sizes are not predicted or are much less likely to occur than would be expected. For example one break sized at about 5 inches results in a failure. With respect to break size, no additional failures occur until the break size reaches about 10 inches. This behavior appears to be non-physical. Please discuss this observation and provide an evaluation of whether this behavior affects the results of the analysis.

47) The NRC staff understands that the CAD model used to determine debris generation amounts was developed under an Appendix B program, and therefore has confidence that its output is accurate. The staff has less confidence in the debris generation values used in CASA. Please describe the methodology used to import the CAD values into CASA and provide information that describes how the debris generation amounts used by CASA were validated to be accurate. Please include information that demonstrates how the interfaces between the CAD model or its input to CASA were validated to be correctly implemented and describe whether raw CAD values were validated to be the same as those used in CASA.

48) Section 5.4.3 of the submittal indicates that almost 100 % of the break scenarios generate less than 10 ft^3 of fiberglass debris (the probability of generating more than 10 ft^3 is smaller than 10^{-12}). Using a density of 2.4 lb/ft^3, the equivalent mass of 10 ft^3 of fiber is 24 lb or 10.89 kg. NRC evaluations of the CASA Grande program indicate that there are a significant number of cases that generate much more than 10 ft^3 of fiberglass (hundreds and up to one-thousand kg). Clarify the meaning of Figure 5.4.5 in Volume 3, which appears to imply that the probability of generating more than 10.89 kg of fiberglass is smaller than 10^{-12}, and clarify how such information is used in the CASA Grande model if at all. Clarify if the information in Figure 5.4.5 in Volume 3 also includes latent fiber.

49) For breaks that are not DEGB and are assumed to have a hemispherical ZOI, how are robust barriers treated? For example, if the break is on a pipe near the floor and occurs on the bottom of the pipe, is the potential for damage from a reflected jet accounted for?

50) While reviewing SSIB Round 1 RAI 9, the staff developed a question regarding the treatment of debris in the head loss calculation. Are the small and fine debris treated as if they have the same properties in the head loss calculation (correlation)? How is each debris size treated?

51) Follow up to SSIB Round 1 RAI 36 – The response to RAI 36 states that strainer buckling is the limiting failure criterion when compared to NPSH. It was not clear that flashing was considered as a failure mode for the strainer in the STP LAR. Please state how flashing across the strainer is evaluated by CASA since this failure mode may be more limiting than strainer buckling when the fluid temperature is high.

52) While reviewing ESGB Round 1 RAI 1b the NRC staff developed an additional question. It appears that some large breaks, many medium breaks, and all small breaks do not generate enough debris to result in a 1/16 inch bed when distributed over 3 strainer

trains. Please provide the distribution of LDFG debris mass reaching the strainers for small, medium, and large breaks separately. Please provide the amount of latent fibrous debris that reaches the strainers for each break category and if it varies, provide the distribution and methodology used to determine the amounts. Please provide the range of the mass of fine fibrous debris and small piece fibrous debris generated for each of the break categories. Please provide the range of the masses of these fiber categories that transport to the strainer.

53) While reviewing ESGB Round 1 RAI 2 the staff developed an additional question. What causes the variability in the head loss calculations performed by the correlation? For example, scenarios that contain similar debris loads may have significantly different head losses calculated. Is this realistic or are these non-physical predictions?

54) RG 1.174 states that licensees are expected to evaluate “whether sufficient safety margins would be maintained if the proposed licensing basis change were to be implemented.” The staff recognizes that safety margin cannot be characterized by a single number for a time-dependent analysis with multiple failure modes. Instead, present the equation or relationship that represents the safety margin as a function of time for each of the seven GSI-191 failure modes. For example, the safety margin with respect to strainer mechanical collapse can be represented as:

$Sm = 9.35 \text{ ft} - \Delta P(t)$

Where Sm = margin with respect to strainer mechanical collapse
$\Delta P(t)$ = differential pressure across strainer as a function of time

Describe whether CASA Grande calculates success with respect to each of the seven GSI-191 failure modes in a manner that is consistent with RG 1.174’s guidance on safety margins. Specifically, identify the failure threshold (worst allowable value) for each failure mode and state whether it is consistent with existing licensing basis calculations.

54) 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 must 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, Rev. 1) was provided in response to SNPB RAI 4. An input for this calculation is liquid volume in the RCS. 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. Justify the use of these numbers and any assumptions made. Refer to NRC approved methods as appropriate.