South Texas Project Units 1 & 2

STP Pilot Submittal for Risk-Informed Approach to Resolving GSI-191

Agenda

- Introduction
- Overview of the planned revised submittal
- Summary of additional information to be submitted
- STP responses to NRC items required for completion of staff's acceptance review
- Questions and comments

Attendees

Michael Murray	Manager, Regulatory Affairs
Steve Blossom	Manager, GSI-191 Project
Rick Grantom	Manager, Risk Management Projects
Ernie Kee	Risk Management Engineering
Wes Schulz	Engineering
Coley Chappell	Licensing
Tim Sande	Enercon
Bruce Letellier	Alion
Jeremy Tejada	University of Texas at Austin
Rodolfo Vaghetto	Texas A&M University
Kerry Howe	University of New Mexico
Don Wakefield	ABS Consulting
Steven Frantz	Morgan Lewis
Zahra Mohaghegh	University of Illinois at Champaign-Urbana

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Overview of Planned Revised Submittal

- NRC has accepted the proposal to submit a revised STP pilot application for a risk-informed approach to resolving GSI-191 by June 20, 2013.
- The revised submittal will include four exemption requests pursuant to 10 CFR 50.12 to support the proposed change to the licensing basis:
  - 50.46(b)(5), and GDC-35, GDC-38 and GDC-41, each provided by separate enclosure.
  - Impacts on other regulatory requirements addressed in the evaluations.
  - Additional information to be included is discussed later in the presentation.
- The revised submittal will include a license amendment request (LAR) pursuant to 10 CFR 50.90 for NRC approval of the proposed change to the STP Units 1 & 2 Updated Final Safety Analysis Report (UFSAR) .
  - LAR regulatory evaluation ties to exemption requests.
  - Content follows guidance of NEI 06-02.
  - No significant hazards consideration 10 CFR 50.92, and categorical exclusion evaluation for 10 CFR 51.22(c)(9).
  - Markup of the change to the UFSAR submitted for NRC approval.

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Overview of Planned Revised Submittal

- An attachment will be included that addresses the information requirements identified in the NRC acceptance review letter.
  - Describes the additional information included in the revised submittal that is responsive to each item.
  - References to information included to facilitate the staff's completion of its acceptance review.
- Additional supporting information previously referenced in the Project Summary (Volume 1) will be included as enclosures:
  - Volume 2 Probabilistic Risk Assessment (PRA)
  - Volume 3 Engineering (CASA Grande) Analysis

Revised Submittal – Outline

- Attachment to the Cover Letter
  - Responses to NRC items needed for acceptance review with references to additional information included in the revised submittal, and a summary of changes from the 1/31/2013 submittal.
- Enclosure 1
  - Generic risk-informed methodology for resolving GSI-191.
- Enclosures 2-1 through 2-4
  - STP-specific 10 CFR 50.12 exemption requests for ECCS acceptance criterion 10 CFR 50.46(b)(5), GDC-35, GDC-38, and GDC-41.
- Enclosure 3
  - 10 CFR 50.90 LAR with changes to the STP UFSAR for NRC approval.
- Enclosures 4-1 through 4-3
  - Volume 1 Project Summary, Volume 2 PRA, and Volume 3 Engineering (CASA Grande) Analysis

Volume 1 Project Summary

- Addresses the required content of a RG 1.174 application using the same section numbering scheme as in RG 1.174.
- Summarizes the generic methodology and how the risk metrics associated with the residual risk of GSI-191 are determined:
  - The overall analysis approach describing how engineering analyses are used in a risk-informed framework to support the PRA.
  - Identifies where the methods adopted for the STP approach involve deviations from those previously approved for deterministic (Option 1) resolution of GSI-191, primarily NEI 04-07.
  - Quantifies the change in risk associated with the concerns raised in GSI-191 in the as-built, as-operated plant (such as fibrous debris beds, chemical effects, in-vessel fiber loads, etc.).
- Summarizes the plant-specific implementation of the methodology.

Volume 2 PRA – Summary

- Describes the Probabilistic Risk Assessment (PRA) treatment of GSI-191 safety issues and interface with deterministic analyses
- Provides quantification of CDF and LERF risk metrics for comparison to RG 1.174 acceptance guidelines.
- For STP Units 1 & 2, the change in risk associated with GSI-191 is:
  - ~ 1.1E-8/yr (delta CDF) and ~ 8.6E-12/yr (delta LERF)
  - Far less than the threshold for Region III "Very Small Changes"
- Provides PRA uncertainty quantification.

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Volume 3 – Summary

- Volume 3 is a technical evaluation that provides a high-level description of the phenomenological portion of the overall risk-informed GSI-191 evaluation.
- Provides a detailed summary of supporting engineering analyses (CASA Grande evaluation) including:
  - Input parameters
  - Assumptions
  - Methodology
  - Analysis
  - Results
- Describes the STP Units 1 & 2 implementation of the generic methodology of the risk-informed approach (Enclosure 1) for addressing the required inputs to the plant-specific PRA model.

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Volume 3 – Summary

- Volume 3 provides summary descriptions of the STP approach:
  - Based on applying the NRC approved deterministic methods from NEI 04-07 and other NRC-approved guidance to model the inputs to the PRA.
  - Differences are identified and discussed to provide a basis for starting the NRC review of the STP pilot.
  - Sufficient detail is provided to identify STP-specific information so that licensees following the approach can identify plant-specific differences and deviations from STP, as the starting point for these subsequent reviews.

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Volume 3 – Summary

- A wide variety of input parameters are required for a GSI-191 evaluation. Volume 3 does not provide details for how these inputs were determined, but lists the input values with references to source calculations.
- Assumptions that were used in the CASA Grande evaluation are listed and justification is provided. Assumptions that were used to develop specific input parameters are documented in the source calculations.
- The methods used for the CASA Grande evaluation are described at a high level up front, and in more detail in the analysis section for each topical area.

Volume 3 – Summary

- The analysis sections include discussion and illustrations of the physical models for each topical area, along with the equations that are solved in CASA Grande. A description of how each physical model is linked together is also provided.
- The results of the CASA Grande evaluation are presented in the form of conditional probabilities of sump failure, core blockage, and boron precipitation for small, medium, and large breaks. These conditional failure probabilities are a direct input for the PRA evaluation (Volume 2) to determine CDF and LERF.

STP Responses to Acceptance Review Letter

- The following slides address the information items needed for acceptance review of the application as identified by the NRC staff in the April 1, 2013 letter.
- STP responses to each item and the associated changes that will be included in the revised submittal are summarized.

Exemption Requests

1. *For each exemption request submitted under 10 CFR 50.12, the application should include a narrative as to why the licensee believes that the special circumstances provided in 10 CFR 50.12(a)(2) is present. The licensee in its application has stated that 10 CFR 50.10(a)(2)(ii) and (iii) apply. There appears to be a typographical error and the NRC staff believes licensee meant to invoke 10 CFR 50.12(a)(2)(ii) and (iii). Please confirm this and provide adequate technical basis in support of applicability of 10 CFR 50.12(a)(2)(ii) and (iii). Also, please describe in detail how the special circumstances address 10 CFR 50.12(a).*

<u>STP Response</u>:

- The revised exemption requests will correct the typographical error and address the required information.

Exemption Requests – Summary

- No exceptions from the explicit acceptance criteria or design criteria provided in the regulatory requirements.
- The exemption requests are from the implicit requirements to use a deterministic method to demonstrate acceptable design and performance.
  - The current licensing basis deterministic method of evaluating sump performance meets the regulatory requirements, but has not been demonstrated to fully resolve GSI-191.
  - Exemption requests support the LAR-proposed change to the UFSAR that reconstitutes the licensing basis using a risk-informed method that meets the key principles of RG 1.174 and demonstrates the risk associated with GSI-191 concerns is Very Small (Region III in RG 1.174).
  - Acceptable design basis of the ECCS containment emergency sumps and suction strainers supports the long-term cooling licensing basis for ECCS acceptance criterion 10 CFR 50.46(b)(5) and the licensing basis for ECCS and CSS design requirements specified in GDC-35, GDC-38 and GDC-41.
- The current licensing basis for ECCS and CSS compliance with 10 CFR 50.46, including the accident analyses provided in UFSAR Chapter 15, and the GDC remain unchanged.

License Amendment Request

2. *The application describes a departure from the method of evaluation described in the Updated Final Safety Analysis Report (UFSAR) used in establishing the design bases in the plant's safety analysis, as defined in 10 CFR 50.59(a)(2) and proposes several draft modifications to the UFSAR. In accordance with 10 CFR 50.59(c)(2)(viii), these modifications would appear to be changes in the design and licensing basis and would require a license amendment in accordance with 10 CFR 50.90. Please explain why an amendment is not proposed to accompany this exemption, with the associated draft no significant hazards consideration. The licensee should clearly state the scope and nature of the change to the design and licensing basis.*

STP Response:

- Revised submittal will include an LAR pursuant to 10 CFR 50.90 with the proposed changes to the UFSAR for NRC approval, and a no significant hazards consideration.

License Amendment Request – Summary

- The proposed change reconstitutes the licensing basis using a risk-informed method:
  - For the long-term cooling ECCS acceptance criterion 10 CFR 50.46(b)(5), replaces the current licensing basis that applies a deterministic method for evaluating sump performance that meets the regulatory requirements, but has not been demonstrated to fully resolve GSI-191.
  - For acceptable design of the ECCS containment emergency sumps and suction strainers in support of the design criteria for ECCS and CSS in recirculation mode following postulated loss-of-coolant accidents as specified in GDC-35, GDC-38 and GDC-41.
- The proposed change resolves GSI-191 and is submitted for approval based on a risk-informed approach that meets RG 1.174 key principles.
- LAR Regulatory Evaluation discusses the exemption requests that support the proposed change to the UFSAR.
- The current licensing basis for ECCS compliance with 10 CFR 50.46, including the accident analyses provided in Chapter 15, and GDC-35, and for CSS compliance with GDC-38 and GDC-41 remain unchanged.

Environmental Review

3. *To process the proposed exemption, the NRC staff will need to conduct an environmental review. Please provide the description that will address the special circumstances supporting this review in accordance with 10 CFR 51.41 and 10 CFR 51.45.*

STP Response:

- For each exemption request, environmental considerations will include information to address the following:
  - 10 CFR 51.41 for compliance with Section 102(2) of National Environmental Policy Act (NEPA), consistent with SRP 19.2 (III.4.2) guidance for RG 1.174 applications.
  - 10 CFR 51.22(b), as referenced in 10 CFR 51.20, and categorical exclusion pursuant to 10 CFR 51.22(c)(9).
  - No significant hazards considerations address the three standards set forth in 10 CFR 50.92, "Issuance of amendment."

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Technical Specifications

4. Please describe how the proposed change will affect the Technical Specifications (TSs). Please indicate whether changes are needed to the operability requirements for the affected systems and any changes to the existing TS Action Statements that may be needed.

STP Response:

- An evaluation of the effect of the proposed change on the Technical Specifications will be included in the LAR, to include:
  - Consideration of the categories specified in 10 CFR 50.36(c).
  - Surveillance Requirements in effect that support the proposed change.
  - TS definition of Operable/Operability adequately addressing the proposed change as related to the required support function provided by the containment sumps and strainers for ECCS and CSS, and no changes are needed to operability requirements or existing TS Action Statements.
- Conforming changes to the TS Bases (for information only) will be included in the markups submitted with the LAR.

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Basis for the Proposed Change

5. *The basis for the proposed change is that the residual risk from the remaining GSI-191 issues (e.g., those not already addressed in a deterministic manner) satisfies the criteria in Regulatory Guide (RG) 1.174, Revision 2, "An Approach For Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," May 2011 (ADAMS Accession No. ML100910006). However, the application does not appear to provide sufficient detail for the NRC staff to determine whether the criteria of RG 1.174 have been met. Please describe in detail how the principles of RG 1.174 criteria regarding safety margin, defense-in-depth (DID), and change in risk are met. In particular, please include the following:*

Basis for the Proposed Change

5.a. Regarding the technical evaluation that supports the risk metrics, the Project Summary (Enclosure 4 to the application) describes numerous areas where the technical evaluation deviates from the approved guidance for addressing GSI-191. However, the application provides little or no information on how the issues were addressed. Please provide a discussion in sufficient detail to permit NRC staff review of the methods, bases, assumptions, acceptance criteria, and results. If test results are used to develop probability distributions, please describe how these distributions were determined and used in the overall risk evaluation. Please also provide the basis for the acceptance criteria chosen. The NRC staff requires additional information in the following areas:

NRC Approved GSI-191 Methods

- Methodology for GSI-191 evaluation has evolved, and NRC accepted methods are documented in various sources:
  - NEI 04-07 Volumes 1 and 2 (SER)
  - Plant-specific audit reports
    - Crystal River, Ft. Calhoun, Watts Bar, etc.
  - March 2008 guidance reports
  - Public meeting minutes
- NRC requested more information on the technical areas in the submittal that involve deviations from approved guidance (summarized in Volume 1).
- Revised submittal will describe the methods, bases, assumptions, acceptance criteria, and results for each of these areas.

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Topical Area: Debris Generation

NRC-Approved Deterministic Methods – NEI 04-07 SER	STP Risk-Informed Methods	Comparison
Use spherical or hemispherical ZOI	Use spherical or hemispherical ZOI	No difference
17D ZOI for Nukon and Thermal-Wrap	17D ZOI for Nukon and Thermal-Wrap	No difference
28.6D ZOI for Microtherm	28.6D ZOI for Microtherm	No difference
4D ZOI for qualified coatings	4D ZOI for qualified coatings	No difference
Truncate ZOI at walls	Truncate ZOI at walls	No difference
4-category size distribution for fiberglass debris including fines, small pieces, large pieces, and intact blankets	Alion proprietary 4-category size distribution methodology (consistent with guidance in SER appendices)	Alion 4-category size distribution methodology previously accepted by NRC for deterministic evaluations
100% fines for Microtherm debris	100% fines for Microtherm debris	No difference
100% fines (10 μm) for qualified coatings debris	100% fines (10 μm) for qualified coatings debris	No difference

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Topical Area: Debris Generation

NRC-Approved Deterministic Methods – NEI 04-07 SER	**STP Risk-Informed Methods**	**Comparison**
100% failure for all unqualified coatings debris	Time-dependent and partial failure of unqualified coatings based on available data.	New engineering model documented in Volume 3.
Unqualified coatings fail as 10 μm particles if the strainer is fully covered or as chips if a fiber bed would not be formed.	Unqualified coatings fail in a size distribution based on coating type and available data.	Similar methods previously accepted by NRC for deterministic evaluations
Plant-specific walkdowns required to determine latent debris quantity	STP-specific walkdown used to determine latent debris quantity	No difference
Latent debris consists of 85% dirt/dust and 15% fiber	Latent debris consists of 85% dirt/dust and 15% fiber	No difference

Topical Area: Debris Generation

5.a.1) Failure timing, failure amounts, and debris characteristics of unqualified coatings.

STP Response:

- Input parameters used for failure timing, failure amounts, and characteristics of unqualified coatings are provided in Volume 3.
- Description of the method, basis, and assumptions used to develop the unqualified coatings input parameters is provided in a plant-specific unqualified coatings calculation.
- As an example of the detailed information that will be provided in the revised submittal:

Example Response

Unqualified Coatings Type	Upper Containment Quantity (lb_m)	Lower Containment Quantity (lb_m)	Reactor Cavity Quantity (lb_m)	Total Quantity (lb_m)
Epoxy	295 (15%)	36 (2%)	1,574 (83%)	1,905
IOZ	305 (83%)	64 (17%)	0 (0%)	369
Alkyd	146 (54%)	125 (46%)	0 (0%)	271
Baked Enamel	0 (0%)	267 (100%)	0 (0%)	267
Intumescent	0 (0%)	2 (100%)	0 (0%)	2

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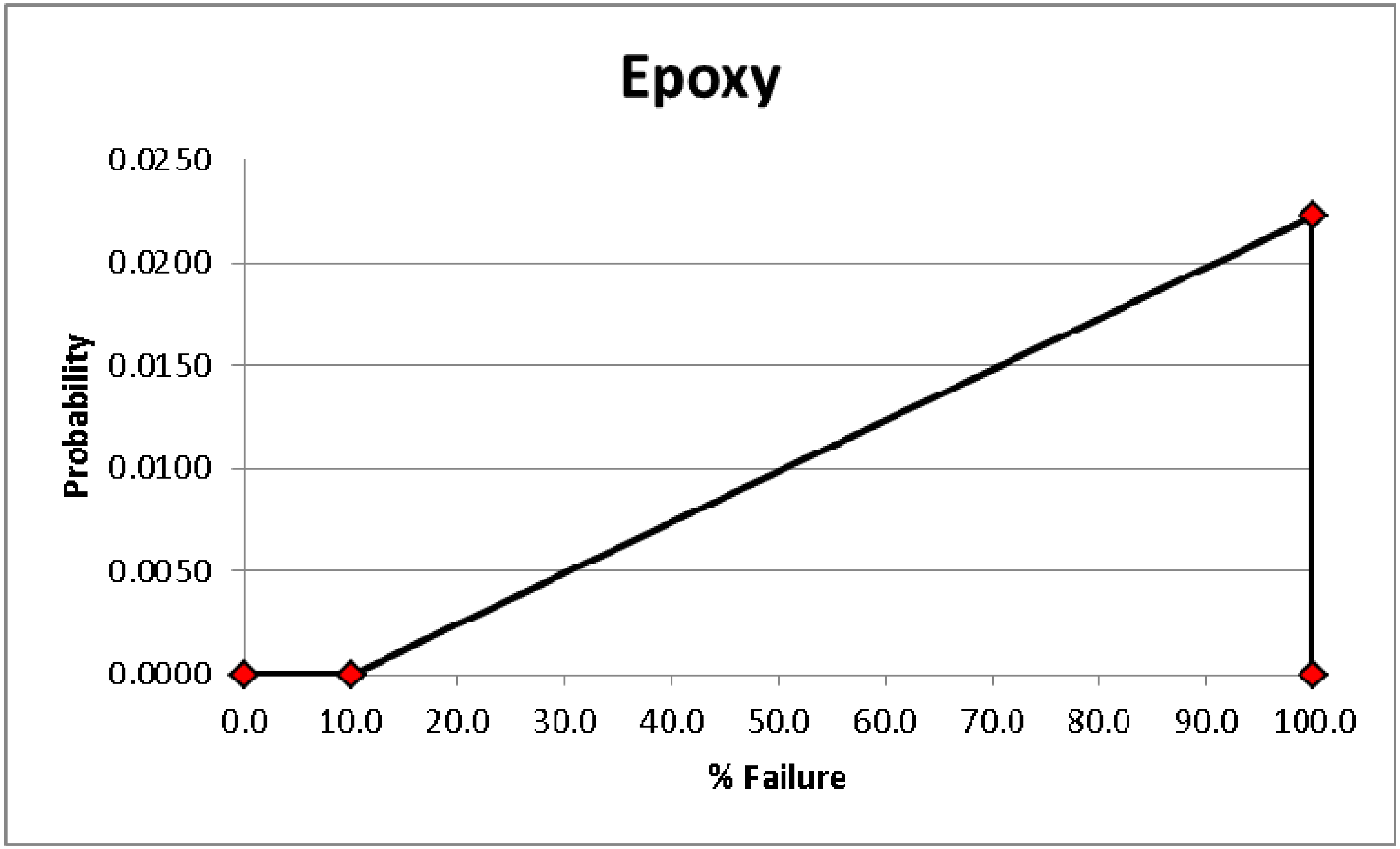
Example Response



Example Response

Time (Hours)	Time Dependent Failure
0 - 24	$0.060 \cdot F_{fail}$
24 - 48	$0.067 \cdot F_{fail}$
48 - 72	$0.054 \cdot F_{fail}$
72 - 96	$0.054 \cdot F_{fail}$
96 - 124	$0.107 \cdot F_{fail}$
124 - 148	$0.040 \cdot F_{fail}$
148 - 172	$0.047 \cdot F_{fail}$
172 - 192	$0.040 \cdot F_{fail}$
192 - 216	$0.040 \cdot F_{fail}$
216 - 240	$0.040 \cdot F_{fail}$

Example Response

Debris Type	Debris Size	Microscopic Density
Unqualified Epoxy	Fines: 6 mil particles	124 lbm/ft^3
	Fine Chips: 0.0156”×15 mil	
	Small Chips: 0.125”-0.5”×15 mil	
	Large Chips: 0.5”-2.0”×15 mil	
	Curled Chips: 0.5”-2.0”×15 mil	
Unqualified IOZ	Fines: 4 - 20 μm particles	244 lbm/ft^3
Unqualified Alkyd	Fines: 4 - 20 μm particles	207 lbm/ft^3
Unqualified Baked Enamel	Fines: 4 - 20 μm particles	93 lbm/ft^3

Topical Area: Debris Transport

NRC-Approved Deterministic Methods – NEI 04-07 SER	STP Risk-Informed Methods	Comparison
Logic tree approach to analyzing transport phases: blowdown, washdown, pool fill, recirculation, and erosion	Logic tree approach to analyzing transport phases: blowdown, washdown, pool fill, recirculation, and erosion	No difference
All large pieces and a portion of small pieces are captured when blowdown flow passes through grating.	Fines transport proportional to containment flow, grating and miscellaneous obstructions capture some small and large pieces.	Similar methods previously accepted by NRC for deterministic evaluations
100% washdown of fines, limited credit for hold-up of small pieces, and 0% washdown of large pieces through grating	100% washdown of fines. Credit for hold-up of some small piece debris on concrete floors and grating. 0% washdown of large pieces through grating.	Includes some new methodology as documented in Volume 3.
Pool fill transport to inactive cavities must be limited to 15% unless sufficient justification can be made	Pool fill transport to inactive cavities is less than 15%. Methodology is based on exponential equation with uniform mixing of fines.	Similar methods previously accepted by NRC for deterministic evaluations

Topical Area: Debris Transport

NRC-Approved Deterministic Methods – NEI 04-07 SER	STP Risk-Informed Methods	Comparison
CFD refinements are appropriate for recirculation transport, but a blanket assumption that all debris is uniformly distributed is not appropriate.	Recirculation transport based on conservative CFD simulations developed for the deterministic STP debris transport calculation. All debris was not assumed to be uniformly distributed.	Methodology for CFD modeling and recirculation transport analysis previously accepted by NRC for deterministic evaluations.
90% erosion should be used for non-transporting pieces of unjacketed fiberglass in the recirculation pool unless additional testing is performed to justify a lower fraction.	Probability distribution with a range of less than 10% erosion based on Alion testing.	Values are relatively close to the experimentally determined 10% erosion value previously accepted by the NRC for deterministic evaluations.
1% erosion of small or large pieces of fiberglass held up in upper containment.	1% erosion of small or large pieces of fiberglass held up in upper containment.	No difference.
Minimal previous analysis on time-dependent transport.	Time-dependent transport evaluated for pool fill, washdown, recirculation, and erosion.	Several aspects of the time-dependent transport are new engineering models as documented in Volume 3.

Topical Area: Debris Transport

5.a.2) Capture of small and large pieces of debris on gratings and obstructions.

STP Response:

- Methodology for debris capture on gratings and obstructions during the blowdown phase is documented in an engineering calculation based on plant-specific features (locations of grating, etc.) and applicable test data.
- Debris capture on grating and obstructions is related to the blowdown transport. Transport fractions that were used are documented in Volume 3.
- Description of the method, basis, and assumptions used to develop the blowdown transport fractions is provided in a plant-specific debris transport calculation.
- The debris capture methods have been previously accepted by the NRC, but the retention fractions on gratings and other structures are based on the drywell debris transport study (DDTS), and multiple break locations are considered.
    - Fines are transported easily and distributed according to the volume fraction of the upper containment.
    - Some of the small debris is also transported to upper containment in proportion to the volume of the compartment in which it is generated.

Topical Area: Debris Transport

5.a.3) Washdown transport holdups.

STP Response:

- Washdown transport holdups are related to the overall washdown transport; the transport fractions that were used are documented in Volume 3
- Description of the method, basis, and assumptions used to develop the washdown transport fractions is provided in a plant-specific debris transport calculation.

Topical Area: Debris Transport

5.a.4) Non-uniform debris distribution at the onset of recirculation.

STP Response:

- The debris distribution at the start of recirculation is related to the recirculation transport; the transport fractions that were used are documented in Volume 3
- Description of the method, basis, and assumptions used to develop the recirculation transport fractions is provided in a plant-specific debris transport calculation.

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Topical Area: Debris Transport

5.a.5) Time dependent transport.

STP Response:

- Time-dependent arrival of debris on the strainer is documented in Volume 3.
- Description of the method, basis, and assumptions used to determine the time-dependent transport is provided in a plant-specific debris transport calculation

Topical Area: Chemical Effects

NRC-Approved Deterministic Methods – NEI 04-07 SER	STP Risk-Informed Methods	Comparison
Corrosion and dissolution of metals and insulation in containment is a function of temperature, pH, and water volume. Accepted model is WCAP-16530-NP.	Corrosion and dissolution of metals and insulation in containment is a function of temperature, pH, water volume, and pool chemistry. New model being developed for STP conditions.	Several aspects of the corrosion and dissolution models are new engineering models as documented in Volume 3.
100% of material in solution will precipitate.	Some material in solution may not precipitate depending on the solubility limit of the precipitate.	New engineering model documented in Volume 3.
Precipitates can be simulated using the surrogate recipe provided in WCAP-16530-NP.	Precipitates are much smaller and more benign than WCAP surrogate.	New engineering model documented in Volume 3.

Topical Area: Chemical Effects

5.a.6) Chemical effects corrosion and dissolution models.

STP Response:

- Corrosion and dissolution models are part of the overall chemical effects analysis; the approach used to account for chemical effects head loss is documented in Volume 3
- New models were not developed for corrosion and dissolution, but the WCAP-16530-NP methodology was used to determine the range of potential chemical product quantities for various break scenarios as documented in a plant-specific calculation

Topical Area: Chemical Effects

5.a.7) Basis for excluding any plant materials from chemical testing.

STP Response:

- Copper, lead, carbon steel, Microtherm, alkyd coatings, and epoxy coatings were not included in the integrated tests based either on minimal exposure in the STP containment or previous testing that indicated negligible effects.

Topical Area: Chemical Effects

5.a.8) Chemical precipitation models – amount, type, head loss effect.

STP Response:

- Chemical precipitation inputs are addressed in the *5.a.6)* response.
- Head loss effects addressed as part of the 5.a.11) response.

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Topical Area: Chemical Effects

5.a.9) Disposition of chemical effects Phenomena Identification and Ranking Table open items.

STP Response:

- Methods used to address PIRT issues will be documented with the revised submittal.

Topical Area: Strainer Head Loss

NRC-Approved Deterministic Methods – NEI 04-07 SER	STP Risk-Informed Methods	Comparison
Perform plant-specific head loss testing of the bounding scenario(s) with a prototype strainer module.	Modify the NUREG/CR-6224 correlation to address old ACRS comments and STP-specific conditions so that head loss can be evaluated at the full range of scenarios.	Several aspects of the engineering models are new as documented in Volume 3.
Address chemical effects head loss using WCAP-16530-NP surrogates in prototype strainer testing.	Address chemical effects head loss with a simple bump-up factor similar to the 2011 quantification using the CHLE testing that has been performed so far to justify the conservatism.	New engineering model documented in Volume 3.
Minimum fiber quantity equivalent to 1/16 inch debris bed on the strainers is required to form a thin bed.	Minimum fiber quantity equivalent to 1/16 inch debris bed on the strainers is required to form a thin bed.	No difference
Bounding strainer head loss compared to bounding NPSH margin and bounding structural margin to determine whether the pumps or strainer would fail.	Time-dependent strainer head loss compared to time-dependent NPSH margin and bounding structural margin to determine whether the pumps or strainer would fail.	Similar engineering model as documented in Volume 3.

Topical Area: Strainer Head Loss

5.a.10) Head loss model.

STP Response:

- Basic head loss model is consistent with the NUREG/CR-6224 correlation as documented in Volume 3.
- Limited head loss testing used to help confirm that the NUREG/CR-6224 model provided reasonable predictions for STP conditions is documented in a head loss test report.

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Topical Area: Strainer Head Loss

5.a.11) Chemical effects on head loss (bump-up factor) model.

STP Response:

- Bump-up factor probability distributions that are dependent on break size were used to account for chemical effects head loss; the basis for the probability distributions is documented in Volume 3.

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Chemical Effects in STP Submittal – Overview

- In-vessel
  - WCAP-16793 (cold leg breaks)
  - Adequate flow through alternate path for all hot leg breaks and for small cold leg breaks.
- Strainer head loss
  - STP-specific testing confirmed chemical products do not form or form in small enough quantities that they are not deleterious.
  - Conservatively applied multipliers on strainer head loss:
    - 5X multiplier on conventional head loss calculation; and
    - Multiplier distributions for chemical head loss based on break size.
      - SBLOCA 2.3 mean (15.4 maximum)
      - MBLOCA 2.5 mean (18.2 maximum)
      - LBLOCA 3.0 mean (24.0 maximum)

Chemical Effects in STP Submittal – Overview

- Other testing helps support small chemical effects on strainer head loss for STP:
  - STP-specific deterministic test at Alden (2008) showed approximately 2X increase in head loss using conservative WCAP precipitates.
  - Integrated Chemical Effects Test (ICET) program Test #2, representative of the STP post accident chemistry, indicated relatively insignificant chemical effects with much large debris quantities than STP.
  - Vogtle integrated testing (VUEZ) with similar conditions to STP showed relatively insignificant chemical effects.

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Topical Area: Air Intrusion

NRC-Approved Deterministic Methods – NEI 04-07 SER	STP Risk-Informed Methods	Comparison
Release of air bubbles at the strainer calculated based on the water temperature, submergence, strainer head loss, and flow rate.	Release of air bubbles at the strainer calculated based on the water temperature, submergence, strainer head loss, and flow rate.	No difference
NPSH margin adjusted based on the void fraction at the pump inlet	NPSH margin adjusted based on the void fraction at the pump inlet	No difference
Void fraction at pumps compared to a steady-state void fraction of 2% to determine whether the pumps would fail.	Void fraction at pumps compared to a steady-state void fraction of 2% to determine whether the pumps would fail.	No difference.

Topical Area: Debris Penetration

NRC-Approved Deterministic Methods – NEI 04-07 SER	STP Risk-Informed Methods	Comparison
Perform plant-specific fiber penetration testing of the bounding scenario(s) with a prototype strainer module.	Develop a fiber penetration correlation as a function of strainer flow rate and fiber accumulation based on a series of penetration tests.	New engineering model documented in Volume 3.
100% penetration of transportable particulate and chemical precipitates.	100% penetration of transportable particulate and chemical precipitates.	No difference.

Topical Area: Debris Penetration

5.a.12) Fiber bypass amounts and amounts reaching the core for various scenarios.

STP Response:

- The methodology and model for determining time-dependent penetration and accumulation on the core is documented in Volume 3
- Testing used to develop the penetration correlation is documented in a penetration test report, and the correlation parameters are documented in a plant-specific data analysis report

Topical Area: Ex-Vessel Downstream Effects

NRC-Approved Deterministic Methods – NEI 04-07 SER	STP Risk-Informed Methods	Comparison
Evaluate ex-vessel wear and clogging based on the methodology in WCAP-16406-P	Evaluate ex-vessel wear and clogging based on the methodology in WCAP-16406-P	No difference.

Topical Area: In-Vessel Downstream Effects

NRC-Approved Deterministic Methods – NEI 04-07 SER	STP Risk-Informed Methods	Comparison
Compare fiber quantity on core to bounding 15 g/FA limit based on WCAP-16793-NP.	Use RELAP5 simulations to show that cold leg SBLOCAs and all hot leg LOCAs would not go to core damage with full blockage at the base of the core. Use WCAP-17057-P tests with conditions closer to the STP to justify an appropriate fiber limit on the core.	New engineering model documented in Volume 3.
Evaluate reduced heat transfer due to deposition on fuel rods using LOCADM software.	Evaluate reduced heat transfer due to deposition on fuel rods using LOCADM software.	No difference.

Topical Area: In-Vessel Downstream Effects

5.a.13) Fiber limits for in-vessel evaluations.

STP Response:

- Fiber limits for core blockage and boron precipitation are described in Volume 3
- Limits are based in part on thermal-hydraulic modeling documented in a plant specific report, as well as fuel head loss test results documented in WCAP-16793-NP

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Topical Area: In-Vessel Downstream Effects

5.a.14) Thermal-hydraulic analysis for in-vessel evaluations.

STP Response:

- Thermal-hydraulic results are described at a high level in Volume 3, and a detailed description of the analysis is described in plant-specific reports.

Topical Area: Boron Precipitation

NRC-Approved Deterministic Methods – NEI 04-07 SER	STP Risk-Informed Methods	Comparison
No currently accepted methodology.	Evaluate fiber accumulation on the core for cold leg breaks during cold leg injection. Assume that 7.5 g/FA of fiber is sufficient to form a debris bed that would prevent natural mixing between the core and lower plenum. Assume failure due to boron precipitation if this quantity arrives prior to hot leg switchover.	New engineering model documented in Volume 3.

Topical Area: Boron Precipitation

5.a.15) Boric acid precipitation evaluations.

STP Response:

- Methodology for addressing boric acid precipitation is described in Volume 3.

Probability Distributions

5.a.16) Methodology for determination and implementation of physical effects probability distributions.

STP Response:

- Probability distributions for each input parameter are described in Volume 3
- Description of the method, basis, and assumptions used to develop the probability distributions are provided in several different plant-specific calculations and reports.

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Defense-in-Depth

5.b. Regarding DID, please address how DID is maintained to account for scenarios that are predicted to lead to failure. One method of maintaining DID is to demonstrate that the operators can detect and mitigate inadequate flow through the recirculation strainer and inadequate core cooling. Please describe the supporting evaluations that demonstrate DID actions will be effective.

STP Response:

- The STP Units 1 & 2 approach incorporates plant modifications previously implemented to address GSI-191 concerns.
- These modifications are included in the site-specific PRA model for evaluation of the as-built and as-operated plant.

Defense-in-Depth (DID)

- Original sump screens were replaced with new advanced sump strainers designed by Performance Contracting Inc. (PCI)
  - New strainers satisfy the current licensing basis and are passive in design.
  - Maintain independence and redundancy of the ECCS and CSS sump configurations, with each train pipe inlet provided from its own sump and strainer, and no shared components between trains.
  - Surface area of each strainer train increased from ~150 sq ft to ~1800 sq ft, providing increased assurance that sump flow will not be blocked by debris and NPSH available for ECCS and CSS pumps will be maintained.
  - Diameter of screen perforations reduced from 0.25 inches to 0.095 inches (perforated plate) and complex geometry of strainer design significantly reduced the potential for downstream debris effects.

- Protective gratings for sump strainers were installed to preclude inadvertent damage to these component.

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Defense-in-Depth (DID)

- Calcium silicate insulation (Marinite) around reactor vessel nozzles has been replaced with NUKON fiberglass insulation.
  - Significant contributor to the debris loading associated with one of the worst case LOCA scenarios for strainer head loss based on previous evaluations.
  - Concern that calcium silicate can combine with the tri-sodium phosphate (TSP) pH buffer during post-LOCA conditions to form calcium phosphate precipitates which could block strainers.
  - The previous STP debris generation analysis had accounted for this chemical debris and subsequent strainer testing had acceptable results, however to fully address the concern the insulation was replaced.

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Defense-in-Depth (DID)

Operator actions to detect and mitigate inadequate flow through the recirculation strainer and inadequate core cooling utilize STP procedures and design features to maintain DID.

Inadequate Recirculation Strainer Flow

STP Emergency Operating Procedures (EOPs) provide specific steps for operators to prevent, detect, and mitigate recirculation strainer blockage:

- Guidance for restoring recirculation or for alternate cooling methods if flow blockage occurs.
- Refilling the refueling water storage tank (RWST) after verification of proper swap over to cold-leg recirculation.
- Operator training on indications of and response to strainer clogging.
- These actions are described in the STP responses to Bulletin 2003-01 and remain in effect.

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Defense-in-Depth (DID)

Inadequate Core Flow

Methods for operators to prevent, detect, and mitigate a core flow blockage condition resulting from inadequate reactor coolant system (RCS) inventory or inadequate core heat removal are provided.

- Primary detection methods include core exit thermocouples (CETs) and reactor vessel level monitoring.
  - Monitoring is initiated early in the EOPs through the Critical Safety Function Status Trees and performed continuously after completion of event diagnosis at appropriate frequency.
- Additional detection of inadequate core cooling includes monitoring of containment pressure and containment sump level, RCS subcooling, containment radiation levels (indications and alarms).
- Emergency Response Organization personnel in the Technical Support Center (TSC) or Emergency Operations Facility (EOF) will also provide oversight of plant status using these detection methods.

Defense-in-Depth (DID)

- To mitigate loss of core flow, EOP actions direct operators to restore cooling flow to the RCS:
  - Refilling the RWST.
  - Minimize break flow by cooling down and depressurizing the RCS, for example by steaming through the steam generators.
  - Aligning alternate injection paths
- Operators will inform the TSC of the condition, and the TSC will evaluate and recommend actions as necessary to restore core cooling, including:
  - Reducing injection flow rate (securing ECCS pumps) to meet the minimal heat removal requirements
  - Use of hot leg injection flow path
  - Establish alternate injection paths from sources including the Volume Control Tank (VCT)
  - Refilling the RWST using normal makeup or fire protection system
  - Restarting Reactor Coolant Pumps
  - Flood containment

Defense-in-Depth (DID)

<u>Supporting Evaluations</u>

- Training – the capabilities of the operators are evaluated through initial and continuing operator training, and the use of simulator exercises.
- Procedure implementation – STP EOPs are evaluated during the procedure development, validation, and approval. Procedures are supported by site-specific analyses, as required.
- Industry guidance – STP EOP directions are based on generic guidance provided by the Westinghouse Owners Group (WOG) Emergency Response Guidelines (ERGs), as supported by vendor analyses.

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Barriers for Release of Radioactivity

5.c. Please provide supporting evaluations that demonstrate that the barriers for the release of radioactivity will be maintained with sufficient safety margin.

STP Response:

- STP Design for Containment Heat Removal:
  - Energy released to the containment atmosphere from the postulated accidents is removed by the Containment Spray System (CS) and Reactor Containment Fan Cooler System (RCFC).
  - Three groups of RCFCs, two fans per group (six fans total).
  - Following an accident, cooling water to RCFCs is supplied by the safety grade component cooling water (CCW) system.

Barriers for Release of Radioactivity

Response to *5.c.* continued:

- Containment integrity evaluations:
  - Based on study results, two trains of RCFCs are sufficient for containment heat removal if no containment spray pumps are operating.
  - Containment integrity is maintained if all the CS pumps are secured.
  - STP design as a PWR dry containment with safety-grade fan coolers is likely to survive a core melt situation, even with a loss of the containment emergency sump (NUREG-0869, Revision 1)
- The proposed change does not impact any design or programmatic requirements for the reactor coolant pressure boundary, therefore does not affect the likelihood of a LOCA.

Treatment of Uncertainty

5.d. Please provide sufficient detail necessary to assess the treatment of uncertainty. While several known categories of uncertainty are identified (zone of influence, chemical effects, debris transport, etc.), the mechanistic models and associated parametric factors used in the analysis are not identified, nor are probability density functions for the parameters provided (Enclosure 4, Section 2.5). Please provide this information.

STP Response:

- Uncertainty associated with the various input parameters is quantified using the probability distributions for the parameters.
- Different approaches are used to develop the input parameters depending on the data that is available; these approaches are documented in several different plant-specific calculations and reports.

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Questions and Comments