Callaway Energy Center GSI-191 / GL 2004-02 Licensing Amendment Request

09/12/2019

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Nuclear Regulatory Commission
Rockville, MD

INTRODUCTION

- Callaway Energy Center Team
  - Stephanie Banker – VP of Engineering
  - Roger Wink – Manager Regulatory Affairs
  - Tom Elwood – Supervisor Regulatory Affairs & Licensing
  - Roger Andreasen – Ameren Responsible Engineer
  - Bruce Letellier – Lead Scientist
    Serco (Alion Science and Technology)
  - Luke Bockewitz – Licensing Lead
    Serco (Alion Science and Technology)

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PURPOSE OF AMENDMENT REQUEST

- Recognizing that GSI-191 is formally closed and that LAR is not a required part of GL 2004-02 response, LAR is being submitted to establish operational margin and formalize Callaway Energy Center continued commitment to recirculation sump performance

- Need for licensing submittal identified in:
  - SECY Letter 12-0093
  - GL2004-02

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OBJECTIVES OF PRE-SUBMITTAL MEETING

- Provide technical and licensing overview to NRC
- Promote common understanding
- Obtain feedback from NRC prior to formal submittal

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MEETING AGENDA

- Plant Overview and Analysis Summary
- Risk Over Deterministic (RoverD)
    - Methodology Overview
    - Sensitivity Studies
    - Strainer Testing
    - Risk Quantification
- Licensing Amendment Request Package
    - LAR Content
    - Exemption Requests
    - FSAR Changes
    - Tech Specs
- Feedback and Schedule

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Plant Overview and Analysis Summary

CALLAWAY PLANT DESCRIPTION

- Callaway Plant Description:
  - Westinghouse 4-loop
  - 193 fuel assemblies
  - Steam generator replacement with RMI
  - Nukon fiberglass on RCS and equipment
  - TSP dry buffer system
  - Unqualified coatings
  - PCI vertical stack strainers in recessed pits
    - Recent EOP change ensures small-break submergence
    - Single-train strainer area ~3300ft^2

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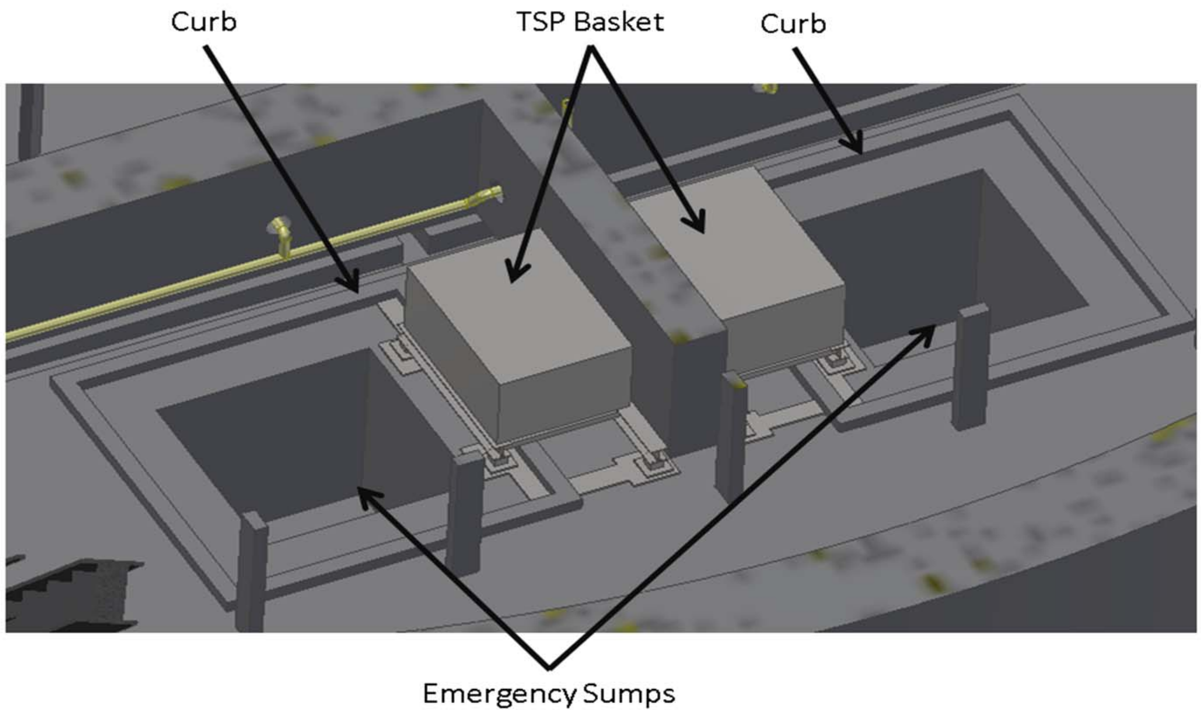
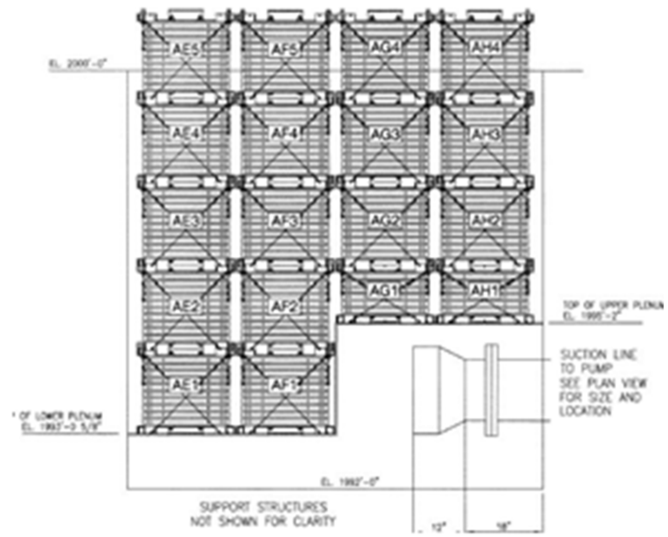
INDEPENDENT SUMP TRAINS



RECESSED STRAINER MANIFOLD

72 modules

Side View of Sump Arrangement



RESULTS SUMMARY

- Systematic aggregation of postulated LOCA breaks leads to following risk of exceeding 300 lbm fiber on a single operating strainer (capacity proven by 2016 testing)
- ALL postulated breaks include *extra* 50 lbm of fiber debris margin.

- Baseline ΔCDF = 5.37E-07 additional core damage events per calendar year
  - 25-year, Geometric-mean elicitation, continuum break, mean uncertainty
- Baseline ΔLERF = 5.37E-08 additional large early release events per calendar year

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RoverD Methodology Overview

RISK OVER DETERMINISTIC (ROVERD) REVIEW

- NUREG/CR-1829 LOCA frequencies assigned to Class-1 welds between reactor vessel and first isolation valve in proportion to pipe size and weld count
  - Preserves total annual break frequency
  - Supports both continuum and DEGB-only break assumptions
- Strainer performance success criterion defined by testing as 300 lbm fiber on one strainer with particulates and chemical products
- CASA Grande applies NEI 04-07 guidance for debris generation/transport to postulated breaks at all welds in CAD model
  - Computes fiber and particulate at the strainer for every break

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ROVERD REVIEW (CONT)

- Smallest break diameter at each weld that exceeds 300 lbm fiber at the strainer defines "D sub i small $\left(D_i^{small}\right)$ and the weld is added to "critical weld" list
- Total frequency of all breaks at a critical weld equal to or larger than D_i^{small} contribute to ΔCDF, without mitigation
- ΔLERF based on equivalence of ΔCDF/ ΔLERF = cCDF/cLERF, where conditional CDF and LERF are assuming loss of strainer flow
- ΔCDF and ΔLERF compared to RG 1.174 risk regions
  - Analysis confirms ΔCDF and ΔLERF fall within Region III

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CASA GRANDE DEBRIS GENERATION

- CASAS processes CAD model to determine debris generated from all insulation products and from qualified coatings
  - Spherical ZOI for DEGB breaks
  - Hemispherical directional ZOI for partial breaks
    - One-degree angular and 0.01-in radial search resolution
  - Reactor pressure vessel and pressurizer skirt treated as robust barriers
- Smallest break at any weld that can exceed 300 lbm of total fiber transport (including latent fiber and fiber margin) determines “D sub i small $\left(D_i^{small}\right)$ and the weld is added to “critical weld” list.

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CASA GRANDE DEBRIS GENERATION (CONT)

- Sixty (60) critical welds are identified
- Smallest critical break size is 9.145 inches (large break)

#	Weld Location Name	Smallest Break Size to Fail (inches)	Fiber Transported at Smallest Break Size (lbm)	Fiber Margin (lbm)	Contribution to Mean ΔCDF
1	WELD EBB01B-RSG-OUTLET-SC010	11.855	300.091	-0.091	1.09E-08
2	WELD 2-BB-01-3065B-WDC-002-FW2	11.795	300.354	-0.354	1.11E-08
3	WELD 2-BB-01-F206	11.495	300.096	-0.096	1.20E-08
4	WELD 2-BB-01-S204-3	11.885	300.149	-0.149	1.08E-08
5	WELD 2-BB-01-F208	11.565	300.156	-0.156	1.18E-08
6	WELD 2-BB-01-S205-4	11.125	300.025	-0.025	1.31E-08
7	WELD 2-BB-01-F207	11.525	300.048	-0.048	1.19E-08

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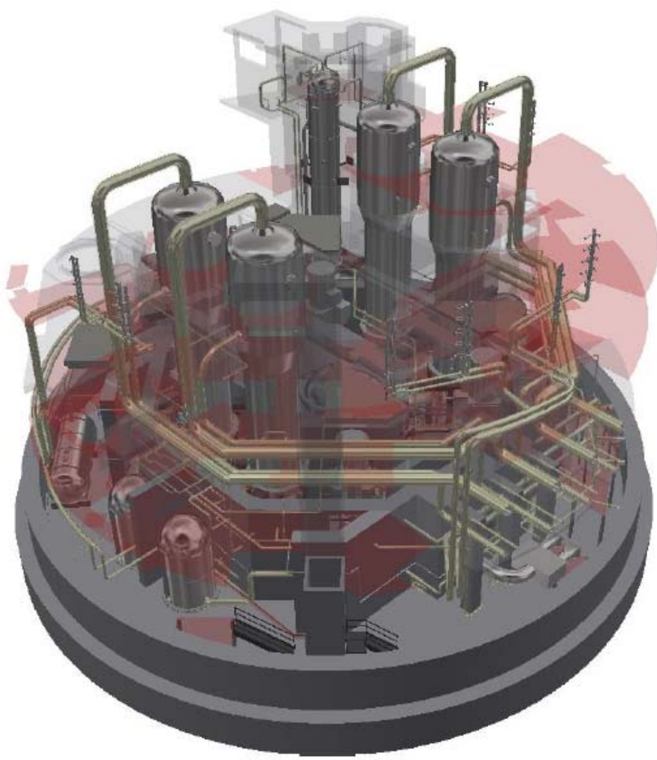
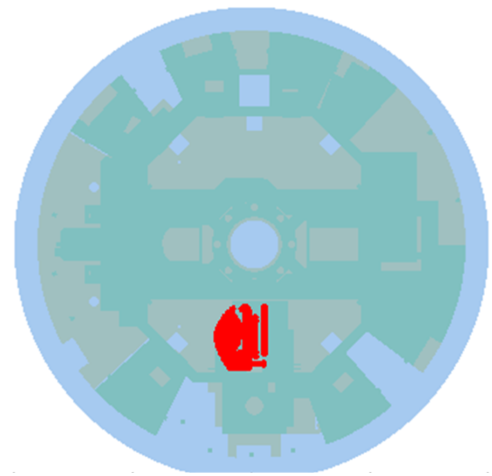
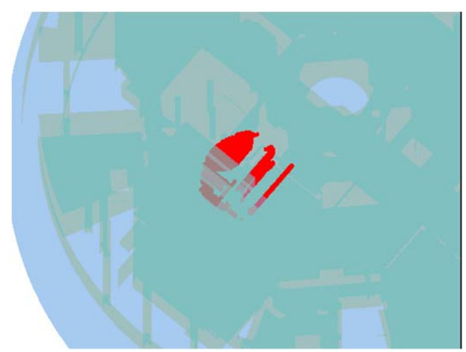
CASA GRANDE DEBRIS GENERATION EXAMPLE

- Auto process DEGB at every weld or ~100K hemispherical breaks with shadowing by robust barriers



Low-Density Fiberglass (LDFG) Debris Generated (ft^3) for 9.5" Break and 45° Angle at Weld 16-RC-1412-NSS-8





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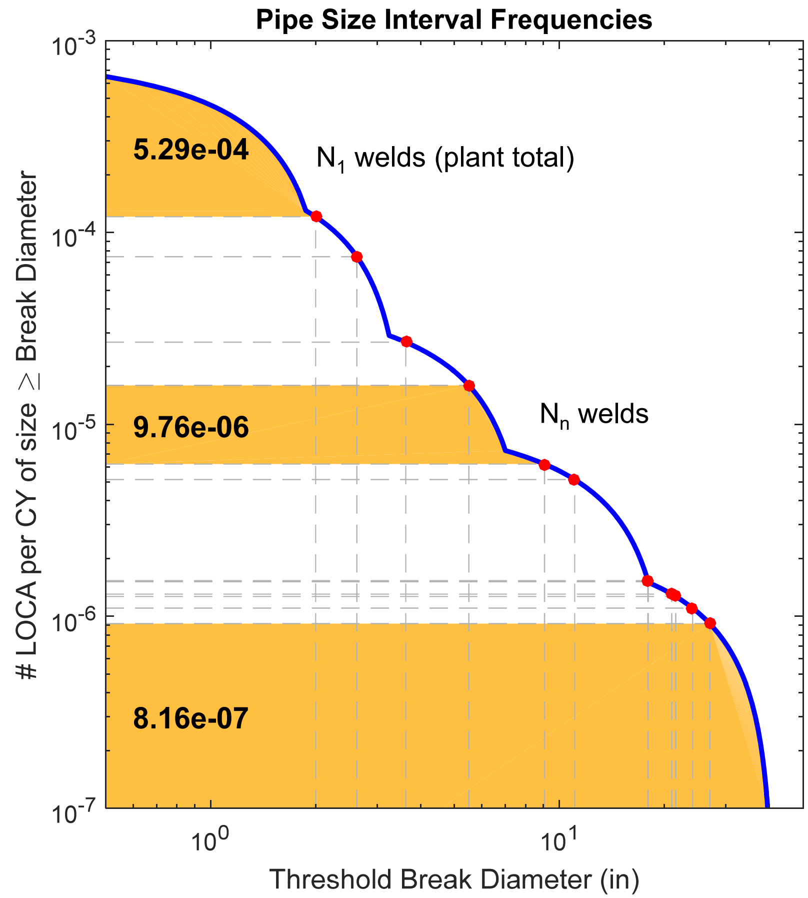
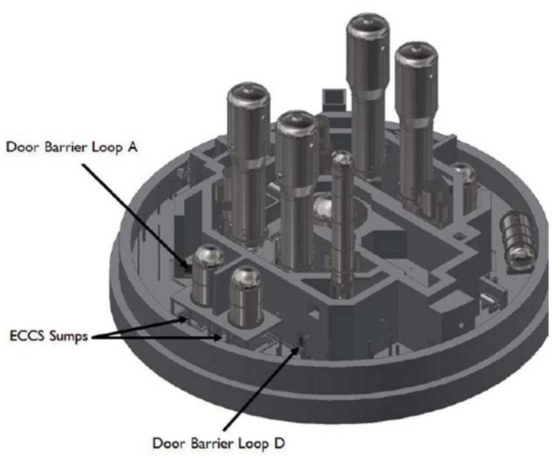
LOCA FREQUENCY ASSIGNMENT

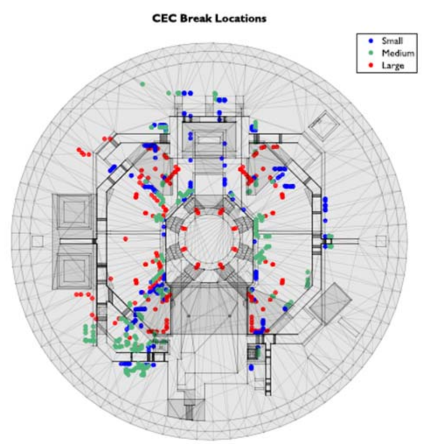
- NUREG-1829 exceedance frequency partitioned by number of welds that can incur breaks in each size interval
- Bin frequency divided by cumulative weld count in the interval gives frequency ***per weld***

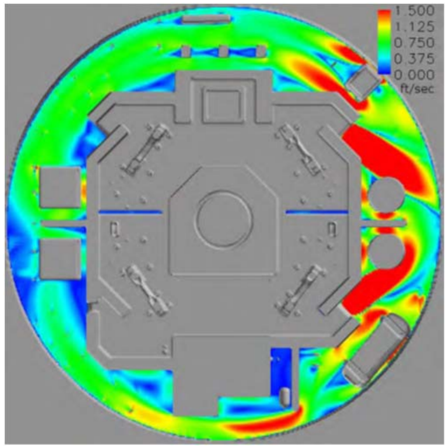


DEBRIS TRANSPORT

- NEI 04-07 guidance applied for debris generation and transport of each insulation type
  – Five stages: Blow down, Wash down, Fill up, Recirculation, Erosion
- Bounding total transport fractions for each debris type identified from <u>four</u> detailed break scenario analyses:
  – Steam Generator Compartment, Annulus, Upper Steam Generator Compartment, Lower Steam Generator Compartment







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DEBRIS SOURCE TERMS - PARTICULATE

- Callaway has some Min-K panels in reactor cavity that cannot be impinged by HELB, and stainless steel RMI that is unlikely to form transportable debris
- Particulate
  - Unqualified and Degraded (epoxy, acrylic, alkyd, IOZ, varnish) = 4370 lbm (28.5 ft3) with assumed 100% transport
  - Qualified coating is ZOI specific but can reach 1040 lbm for LLOCA DEGB
  - Latent = 85% of generic 200 lbm latent debris source term = 170 lbm with 96% transport = 163.2 lbm latent particulate in every case
  - Maximum single-break total particulate transported is 5,573 lbm (tested 5800 lbm equivalent)

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DEBRIS SOURCE TERMS – CHEMICAL

- WCAP-16530 precipitate calculator used to estimate chemical product load for bounding break scenarios

WCAP-16530 Scenario	LDFG Quantity (ft^3)
Maximum LDFG Debris Generated with Intact Blankets	761
Maximum LDFG Debris Generated without Intact Blankets*	410
Largest LDFG Debris Generated with Intact Blankets for RoverD Success Cases	273

*Used to Determine Chemical Load for CEC Strainer Testing

- Test basis significantly bounds presumed ECCS failure threshold. Test basis does not bound submerged blankets
- Last chemical test batch induced little headloss. Little value in testing absolute maximum chemical inventory

LDFG Quantity (ft^3)	Precipitate Load (lbm)			
	AlOOH	$NaAlSi_3O_8$	$Ca_3(PO_4)_2$	Total
761	0.0	472.0	102.0	574.0
410	0.0	474.0	55.0	529.0
273	15.8	399.0	37.0	451.8

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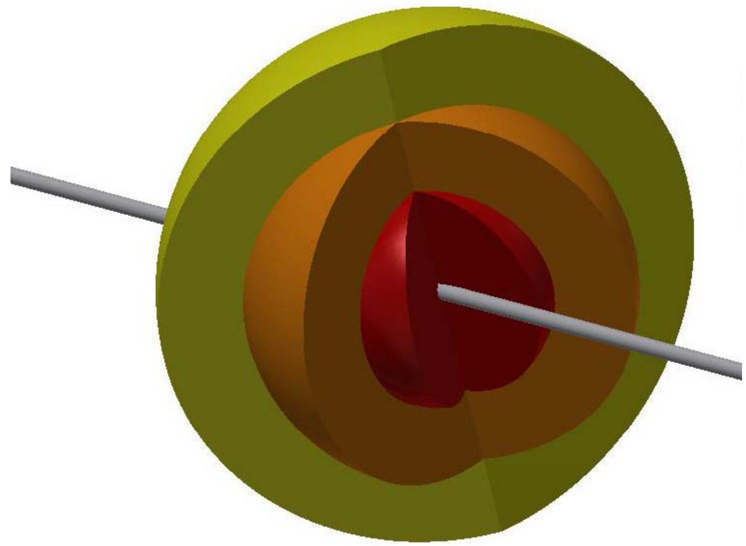
DEBRIS SOURCE TERM - FIBER

- Nukon Fiber (manufactured density 2.4 lbm/ft3)
- 300 lbm single-train performance threshold proven by 2016 testing
- Nested damage zones out to 17D

- Generic 200 lbm latent debris with 15% fiber
- Every break assigned 50 lbm of additional fiber to add explicit Safety Margin
  - Forces more breaks to exceed 300 lbm total fiber transport



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2016 Strainer Testing

TEST SERIES

- Full debris load
  - Mixed particulates and prepared fiber
  - Chemical products
  - Meets NPSH limit with up to 300 lbm of transported fiber
- Thin-bed configuration
  - Full particulates
  - Small fiber batches
  - Meets NPSH limit at maximum particulate dominated head loss
- Fiber penetration
  - Modified strainer module
  - Small fiber batches
  - Alternating downstream bag filters
  - Defines source term for downstream effects analysis

ALDEN TEST APPARATUS - PHOTOS

- Debris introduced to debris hopper (far left not shown)
- Flume transport towards strainer pit (far right)

Strainer Modules

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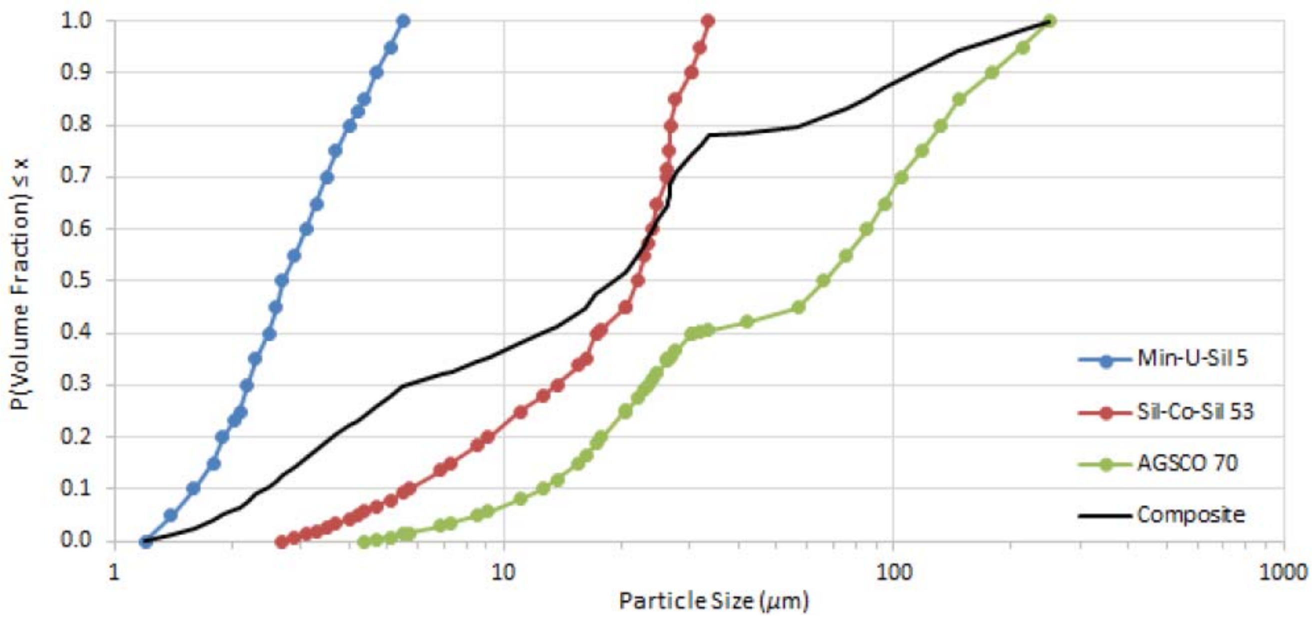
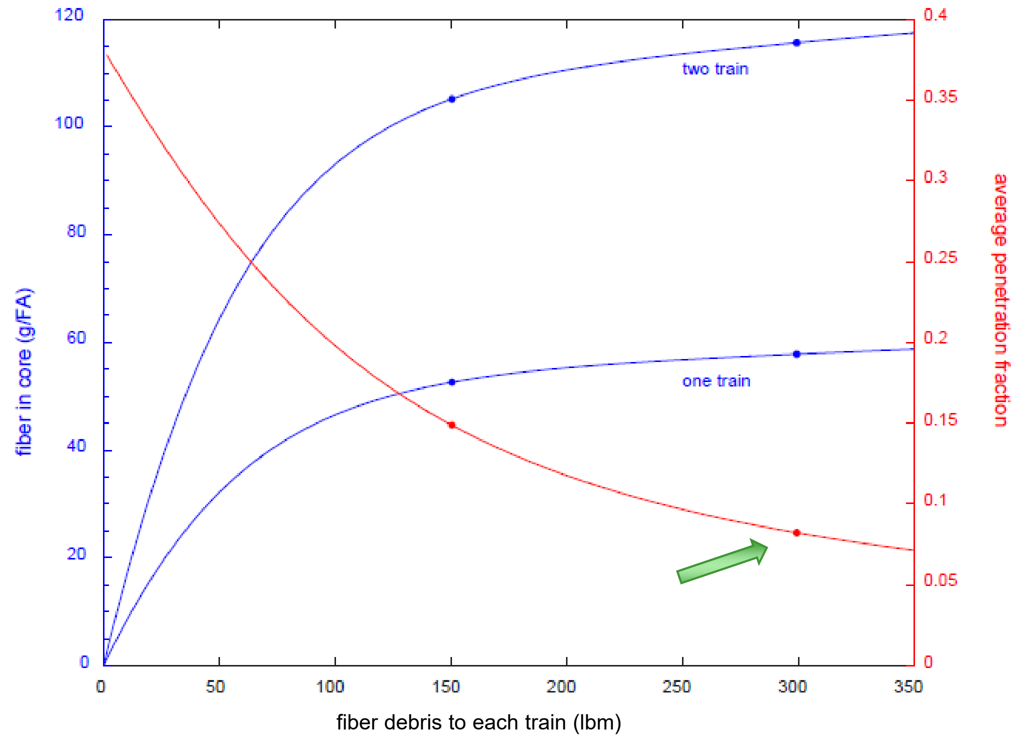
SURROGATE PARTICULATE

- Three silicate surrogates mixed for testing particulate size range



FIBER PENETRATION RESULTS

- Time-dependent bag-filter masses used to fit 4-parameter filtration model
  - Prompt penetration
  - Long-term shedding



Risk Quantification

BASELINE ΔCDF AND ΔLERF

- NUREG/CR-1829 frequencies for LOCA in Class-1 welds between vessel and first isolation valve
- Continuum break assumption
- 25-yr PWR LOCA frequencies (# / calendar year) by break size
- Geometric-mean expert elicitation aggregation
- Mean elicitation-uncertainty quantile
- ΔLERF based on ratio equivalence of ΔCDF: ΔLERF = cCDF:cLERF
  - A sensitivity assuming loss of sump flow showed cCDF:cLERF is bounded by the accepted industry CDF:LERF = (10 to 1)
  - The Callaway RoverD analysis used the bounding accepted industry CDF:LERF
- Callaway ΔCDF = 5.37E-7 events/year, ΔLERF = 5.37E-8 events/year (both in respective RG1.174 Region III)

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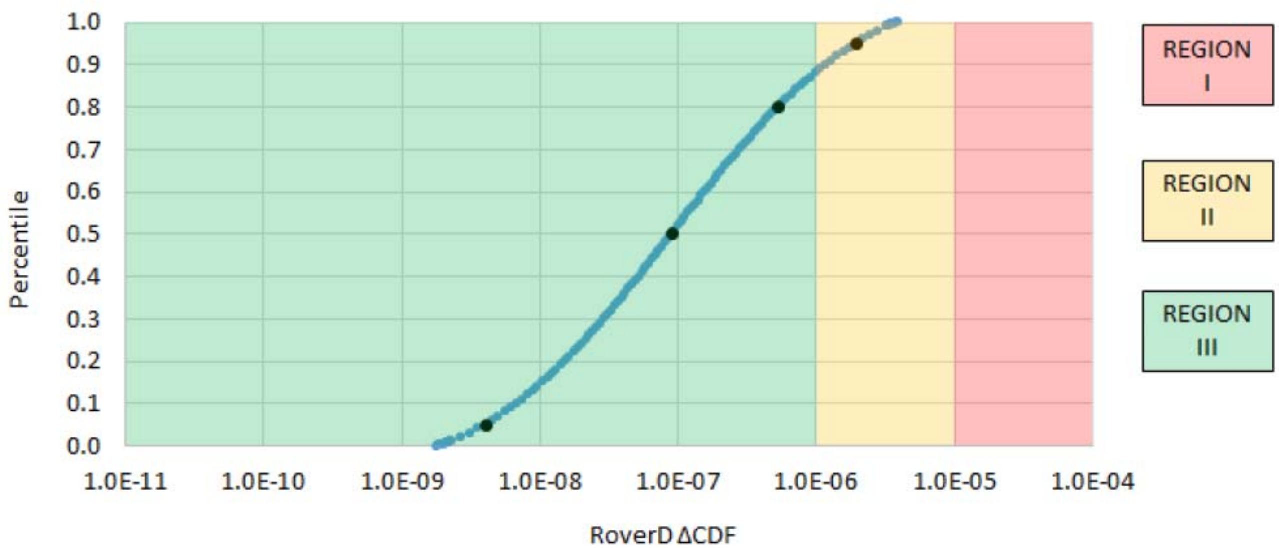
ΔCDF UNCERTAINTY

- Repeated LOCA sampling analysis for each complementary cumulative break frequency uncertainty quantile (5th, mean, 50th and 95th) gives ΔCDF risk range

Statistic	5th	50th	Mean	95th
ΔCDF (# core damage events / year)	4.01E-09	9.04E-08	5.37E-07	1.95E-06



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SENSITIVITY STUDIES

- DEGB-only break assumption
- Arithmetic-mean expert elicitation aggregation
- All elicitation-uncertainty quantiles
- 40-yr PWR LOCA frequencies (# / calendar year) by break size
- Double valve-body insulation
  - ΔCDF increased 0.56% above baseline with NO new critical welds
- ΔCDF Uncertainty

#	Plant Life	Aggregation Model	Break Model	ΔCDF Statistic			
				5th	50th	Mean	95th
0	25-Year	Geometric	Continuum	4.01E-09	9.04E-08	5.37E-07	1.95E-06
1	25-Year	Geometric	DEGB	5.52E-09	1.23E-07	6.70E-07	2.51E-06
2	25-Year	Arithmetic	Continuum	2.50E-08	5.14E-07	4.07E-06	1.29E-05
3	25-Year	Arithmetic	DEGB	3.11E-08	6.16E-07	4.73E-06	1.52E-05

SECONDARY RISK CONTRIBUTORS

PRA scenarios requiring sump recirculation that are evaluated for possible risk quantification:

- Isolable breaks beyond first isolation valve concurrent with isolation valve failure (1.11E-03 per demand)
  - Full NUREG-1829 LOCA frequency applied to separate smaller population of isolable welds
- LOCAs related to stuck-open valves or spurious valve actuation
  - Similar ZOI as small breaks, and no small or medium break critical welds
- Mechanical seal leaks
  - Similar ZOI as small breaks, and no small or medium break critical welds
- Secondary line breaks concurrent with other equipment failure leading to recirculation
  - ECCS recirculation not required by CEC license basis for Large Main Steam Line and Feedwater line breaks

None contribute significant risk compared to LOCA

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STRAINER STRUCTURAL ANALYSIS

- Joint strainer structural analysis performed by CEC and Wolf Creek assuming max head loss and max debris load as boundary conditions
- Test head loss bounded by analysis

Condition [25]	Structural Head-Loss Limit (ft) [25]	Tested Strainer Head Loss (ft) [26]
Hot, 268 °F	4.2	4.1
Cold, 175 °F	5.7	4.2

- Analyzed single-train load of 4331 lbm bounds max transport of 4303 lbm for cases that do not exceed RoverD threshold
- Note that structural analysis requires concurrent seismic acceleration

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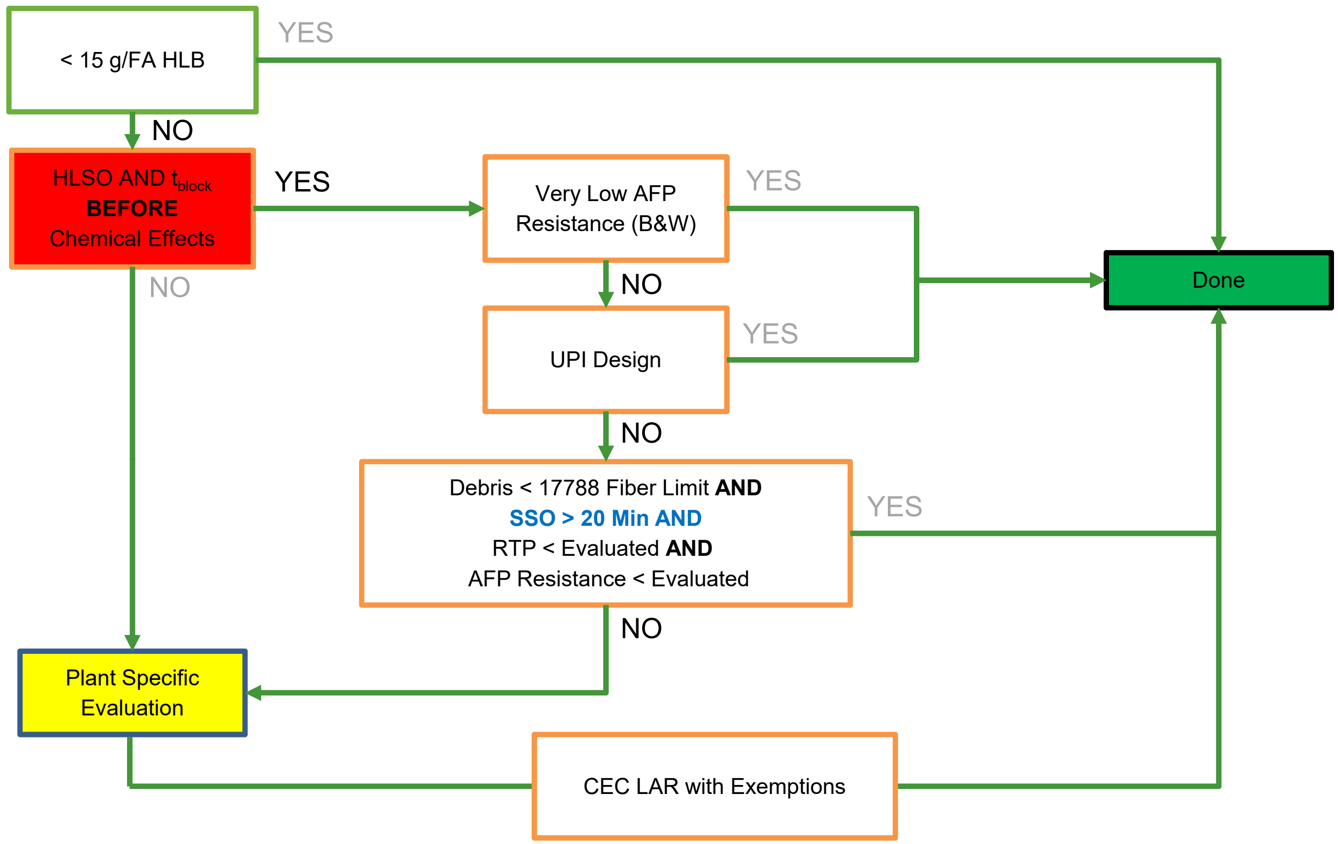
DOWNSTREAM EFFECTS SCREENING



Licensing Amendment Request Package

PREPARATION PATH

- Follow STPNOC pilot to address exemptions and technical methodology (RoverD)
  - WCAP-17788 methodology used for In-Vessel Effects
  - Strainer test performed in 2016
- Follow TSTF-567 R1 for Technical Specification changes to add Containment Sump.

LICENSING AMENDMENT REQUEST CONTENTS

- LAR Cover letter
  - Follows LAR requirements
- Enclosure 1 – Request for exemptions
  - Attachment 1-1 Request for Exemption from 10 CFR 50.46(a)(1)
  - Attachment 1-2 Request for Exemption from GDC-35
  - Attachment 1-3 Request for Exemption from GDC-38
  - Attachment 1-4 Request for Exemption from GDC-41
- Enclosure 2 - License Amendment Request
  - Attachment 2-1: List of Commitments
  - Attachment 2-2: Technical Specification Page Markups
  - Attachment 2-3: Technical Specifications Bases Page Markups (Information Only)
  - Attachment 2-4: Re-typed TS Pages
  - Attachment 2-4: CEC FSAR Page Markups (Information Only)

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LAR CONTENTS (CONT)

- Enclosure 3 - CEC Risk-Informed Approach
  - 3-1 Introduction [1.229-based]
    - Describes required inputs to the PRA model, basic structure for appropriately modeling the inputs, and performance criteria used to calculate risk
  - 3-2 Deterministic Basis-GL 2004-02
    - Addresses required content of a RG 1.174 application
  - Attachment 1L Responses to 2008 RAIs
    - Following May 2008 closure guide
  - 3-3 Risk-Informed Basis [1.174/1.229]
  - 3-4 Defense-In-Depth and Safety Margin

- Enclosure 4 - Acronyms and Definitions

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FSAR CHANGES

- Chapter 3, Section 3.1.6 - descriptions of evaluations against GDC 35, GDC 38, GDC 41

- Chapter 6, Section 6.2.1.1.3 – description of Long-term Cooling Following a LOCA
- Chapter 6, Section 6.2.2.1.2.2 – description of Containment Recirculation Sumps
- Chapter 6, Section 6.2.2.1.3 – Safety Evaluation 12
- Chapter 6, Table 6.2.2.7 – Input and Results of NPSH Analysis
- Chapter 6, Table 6.3-1 – Emergency Core Cooling System Component Parameters

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FSAR CHANGES (CONT)

- Chapter 6, Section 6.3.2.2 – description of Net Positive Suction Head
- Chapter 6, Table 6.3-13 – Containment Recirculation Sump Debris Limits
- Chapter 6, Appendix 6.3A – description of RoverD application to safety analysis

- Chapter 15, Section 15.6.5.5 – description of risk-informed assessment of debris on ECCS Sump Strainers

- Chapter 16 - Additional Technical Requirement Section Surveillance: Sump strainers will be dismantled at least every 20 years to allow for visual inspection of the strainers and sump pits

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TECHNICAL SPECIFICATION CHANGES

- Technical Specification changes
  - TS 3.5.2 ECCS – Operating: Deletion of SR 3.5.2.8
  - TS 3.5.3 ECCS – Shutdown: Deletion of reference to SR 3.5.2.8
  - TS 3.6.8 Containment Recirculation Sumps: New TS
  - TS 5.5.15 Safety Function Determination Program: Addition of clarification

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Feedback and Schedule

WRAP UP

- NRC Feedback
  - Scope of submittal,
  - LAR contents
  - Regulatory expectations

- Closing Remarks

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