NRR-PMDAPEm Resource

From: Harrison Albon [awharrison@STPEGS.COM]
Sent: Monday, August 18, 2014 7:05 PM
To: Singal, Balwant
Cc: Oesterle, Eric; Mitchell, Eliza
Subject: RE: Out-of-Office (August 18 to August 29, 2014)
Attachments: 8-20-14 NRC Meeting backup slides.pptx

Here are the backup slides in case we need them.

From: Harrison Albon
Sent: Monday, August 18, 2014 5:55 PM
To: 'Singal, Balwant'
Cc: Oesterle, Eric; Mitchell, Eliza
Subject: RE: Out-of-Office (August 18 to August 29, 2014)

Here is the main set of slides for the STP risk-informed GSI-191 meeting on 8/20/14.

Call me if you have questions.

Wayne Harrison
STP Licensing
(979) 292-6413

From: Singal, Balwant [mailto:Balwant.Singal@nrc.gov]
Sent: Thursday, August 14, 2014 2:45 PM
To: Harrison Albon
Cc: Oesterle, Eric; Mitchell, Eliza
Subject: RE: Out-of-Office (August 18 to August 29, 2014)

Wayne,

Wayne,

Please copy the following NRC staff members on your e-mail forwarding the presentation slides:

Oesterle, Eric Eric.Oesterle@nrc.gov
Mitchell, Eliza Eliza.Mitchell@nrc.gov

Thanks.

Balwant K. Singal
Senior Project Manager (Comanche Peak, STP, Diablo Canyon, and Palo Verde)
Nuclear Regulatory Commission
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Tel: (301) 415-3016
Fax: (301) 415-1222

From: Harrison Albon [mailto:awharrison@STPEGS.COM]
Sent: Thursday, August 14, 2014 12:58 PM
To: Singal, Balwant
Cc: Lyon, Fred; Blossom, Steven; Kee, Ernie
Subject: RE: Out-of-Office (August 18 to August 29, 2014)

Balwant,

You asked yesterday when we would have slides to you for the 8/20 meeting. We'll have them to you (or Fred) by COB on Monday, probably before.

Regards,
Wayne Harrison
STP Licensing
(979 292-6413

From: Singal, Balwant [mailto:Balwant.Singal@nrc.gov]
Sent: Thursday, August 14, 2014 10:30 AM
To: 'Hope, Timothy' (Timothy.Hope@luminant.com); Sterling, Lance; Harrison Albon; Carl.Stephenson@aps.com; pns3@pge.com
Cc: Lyon, Fred; Watford, Margaret; Oesterle, Eric; Markley, Michael
Subject: Out-of-Office (August 18 to August 29, 2014)

I will be out-of-office from August 18 to August 29, 2014. Please contact the following NRC staff members for Project Manager assistance:

Fred Lyon at 301-415-2296 for Comanche Peak, South Texas Project, and Diablo Canyon.
Eric Oesterle at 301-415-1014 for Palo Verde.

Thanks.

Balwant K. Singal
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Sent Date: 8/18/2014 7:05:10 PM
Received Date: 8/18/2014 7:07:08 PM
From: Harrison Albon

Created By: awharrison@STPEGS.COM

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"Singal, Balwant" <Balwant.Singal@nrc.gov>
Tracking Status: None

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Backup Slides

CASA Development Plan

- Aggressive SQA plan in place to achieve Appendix B certification
  - Alion SQA plan meets intent of IEEE standards and requirements from many plants
  - Specifically checked for STP approved software list
- Source code under configuration management
  - TortoiseSVN (windows shell to Subversion©)
  - CM plan approved
- Version 1.7 to release following V&V (Nov 1st???)
  - Changes made to answer RAIs
  - Address issue tracking reports
  - Generalize sump configuration definition
  - Auto documentation feature

CASA V&V Elements

- Software Requirements Specification
  - Functional description of capabilities
- Theory Manual
  - Reference independent from SRS for convenient updates
- Software Design Description
  - Subroutine-level architecture
- Users Guide
  - Installation process and verification
  - Example problem, definition of user input
- Verification Test Plan and Report
  - Comprehensive check of suitability/adequacy
- Issue Tracking Report (ITR) system
  - Bugzilla report and disposition (integrated with SVN)
  - Issue notification chain (Alion to users, users to NRC)

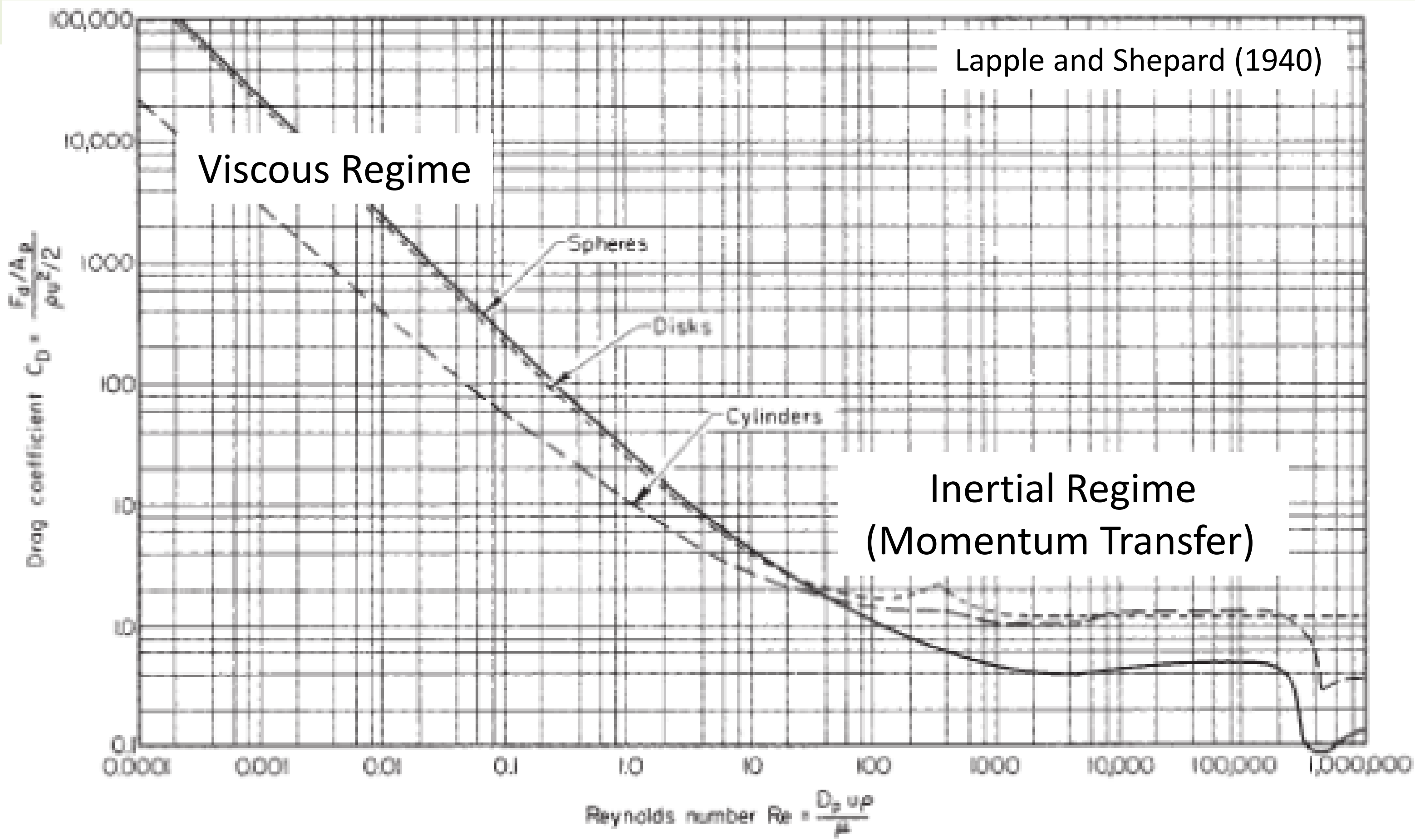
CASA V&V Activity Status

- Software Reqs Specification – final review
- Theory Manual – in preparation
- Software Design Description – final review
- Users Guide – v1.7 almost complete
- Verification Test Plan (with archive documentation)
  - Now building checklists from SRS
  - Vol 3 equation verification by independent team – >50% complete
    - Confirm printed equation
    - Confirm implementation
    - Confirm I/O and results using test routines (partial)
  - Automated Tests (dry runs complete)
    - Data Arrays, Function calls, input data checks
  - Vignette case studies – beginning
- Issue Tracking Reports
  - Populating Bugzilla archive – in progress
  - Issue disposition – in progress

Purpose of VISTA Correlation

- Independently confirms conservative application of NUREG/CR-6224
  - No change to LAR is proposed
- Addresses NRC concerns with 6224
  - Factorization of porosity (exponents of ε)
  - Uniform bed compression (now differential)
  - Limited range of test conditions (Re scaling)
  - Stratified bed configurations (case studies)

Re Scaling in Viscous/Inertial Transition



Classic experiments suggest that total hydraulic drag can be described by a low-order function of Reynolds number in the viscous/inertial transition.

VISTA Attributes

- Good agreement with HTVL test data
- Robust Reynolds number correlation confirms applicability of existing test data to STP
- Exponential drag law – (Reynolds 1883)
  - Preserves both theoretical limits (Raleigh 1892)
    - Stokes (viscous), Newton (inertial)
- "Adapts" to transition because coefficients are also fit as functions of Re
- Maximizes use of independent debris properties
- Still sensitive to bed compression/strata

VISTA Findings

- Bed configuration is the most sensitive remaining assumption
  - Uncertainty in spatial profile of porosity and surface area lead to largest discrepancy between prediction and measurement
  - Justifies STP assumption of maximum compression
- Independent confirmation of head loss for STP Reynolds flow conditions illustrates 6224 conservatism as applied
  - Maximum bed compression
  - Factor of 5 uncertainty measure

L* Approach an supporting CHL calculation

- STP CHL Correlation Objective
  - Address concerns that the conservatism in chemically-induced head loss (CHL) quantification is based on engineering judgment
  - Provide ***technical*** validation based on best available data that the chemical "bump up" is conservative

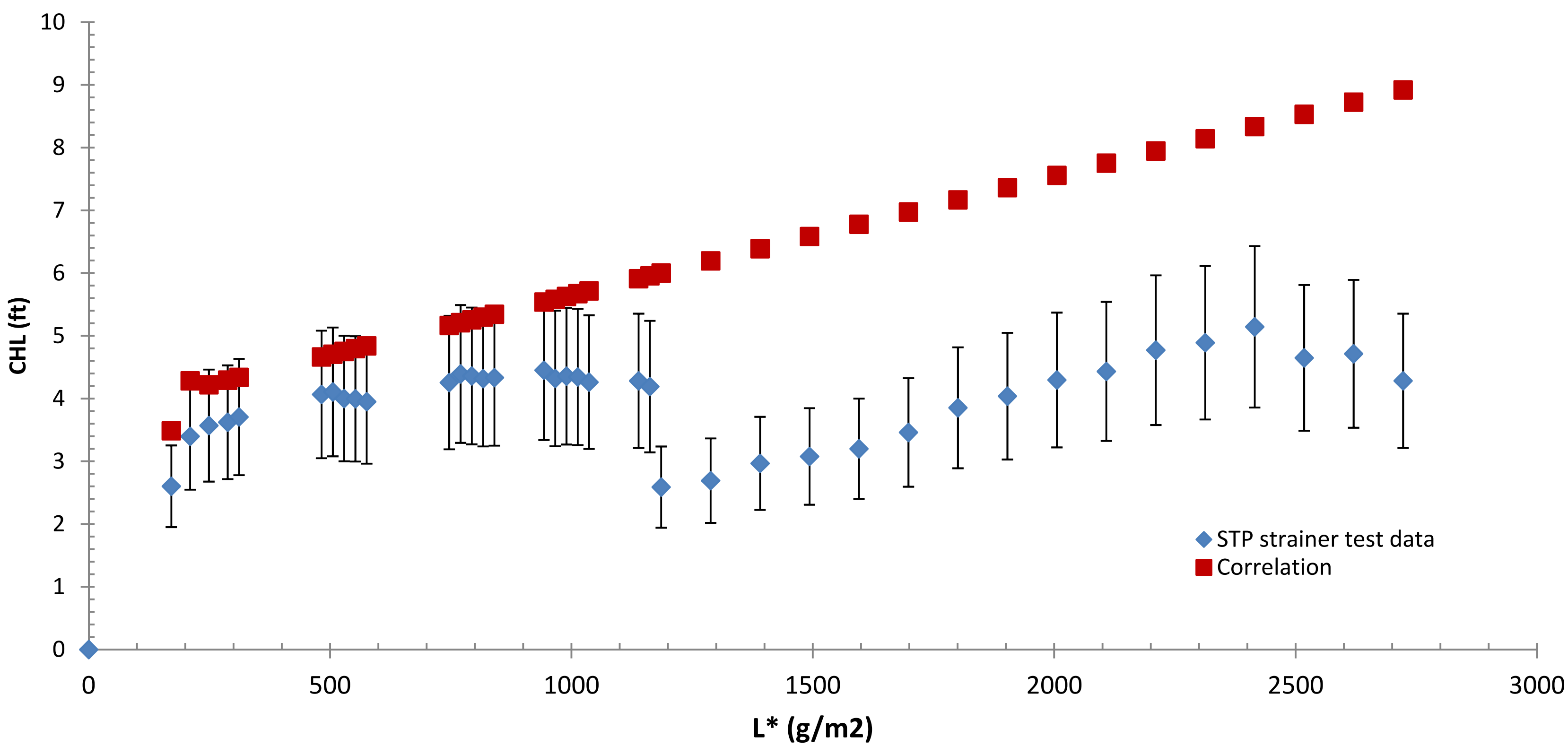
L* End Product

- Technical evaluation of "bump up" based on engineering judgment
- Provides a supplemental methodology for chemical effects quantification that improves resolution by using strainer test data and WCAP-16530-NP calculator results

L* Development

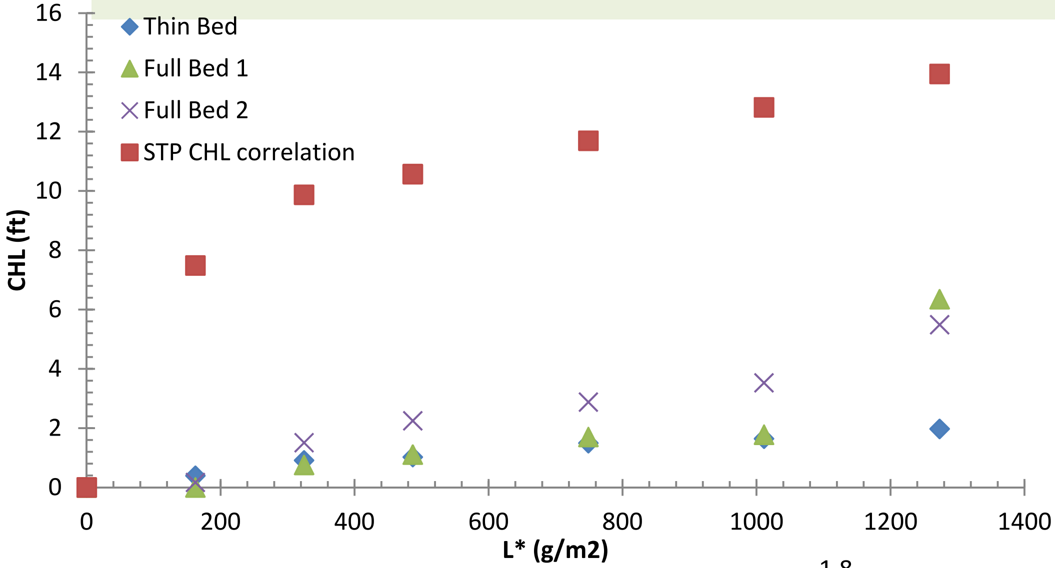
- Evaluation of both strainer and vertical head loss test
  - Concept of L* developed
    - grams of precipitate available to filter across a strainer surface area
    - Allows comparison of strainer results to vertical head loss results
    - Allows use of deterministic tools in risk informed space
- CHL investigated as a function of precipitate type
  - AlOOH CHL per gram was largest response
- Enhanced conservatism during data mining
  - Removal of declining or non-increasing head loss when chemicals are added

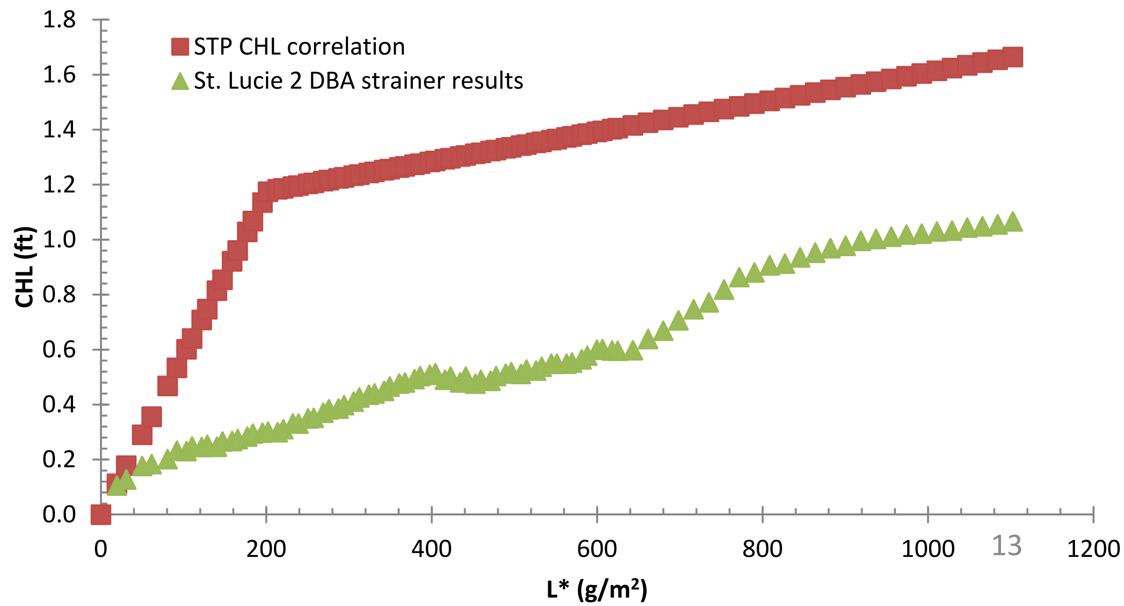
L* Correlation



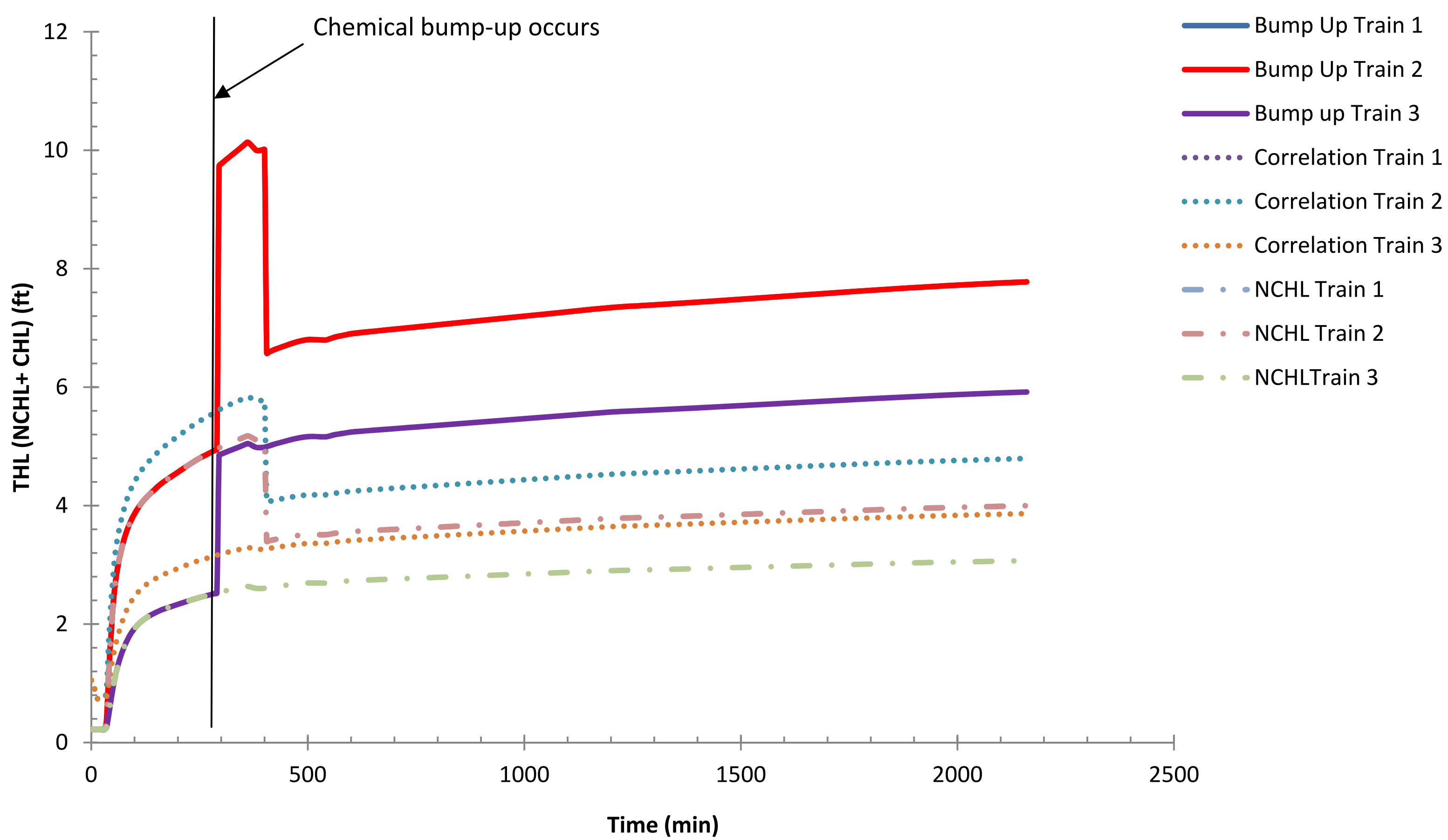
- Correlation provides conservative CHL results when compared to actual test data

L* Evaluation Compared to Strainer Tests





L* Compared to Multiplicative Chemical HL Inflation



NCHL – non-chemical head loss or conventional
CHL- chemically induced head loss
THL – total head loss

Conclusions of L* and “bump up” comparison

- Evaluation of the “bump up” approach by the supplemental CHL approach, which is derived from technical data
  - Provides supports that the “bump up” approach conservatively assesses risk
  - Identifies improvement opportunities for the bump-up approach
    - Improvements only increase resolution of total head loss quantities and does **NOT** change risk

SSIB, Head Loss: RAI 15

- The NRC staff has generally not accepted correlations for the qualification of PWR strainers for several reasons. Please, explain why the following general concerns with the use of correlations are not an issue for the STP application:

a) Correlations have not been validated for the full range of debris loads and morphologies

b) Correlations do not address nonhomogeneous debris beds

c) Correlations have not been validated for the full range of potential flow conditions and strainer geometries

d) There is significant uncertainty in the model parameters used to describe physical attributes of the constituents

SSIB, Head Loss: RAI 16

- The staff is concerned that the validation testing is not representative of the plant. Please, provide additional information:

a) If the vertical loop tests are important to the conclusions, please, provide details why the STP HTVL tests are valid, considering that similar tests in different facilities had different results

b) How was it determined that debris transported to a horizontal strainer is similar to transport to a plant strainer (with similar head loss)

c) Demonstrate that the correlation used by STP is valid for plant specific geometry and plant conditions

d) Discuss how NUREG/CR-6224 could be used to predict HL expected under conditions of STP flume tests

SSIB, Head Loss: RAI 17

- … there is little or no testing that has been conducted under conditions similar to those at STP.

a) Debris constituents in validation testing are not plant specific
b) Debris sizes in validation testing are not plant-specific
c) Little validation testing conducted at STP velocities and none validated the correlation
d) Validation testing did not include prototypical strainer geometries
e) HTVL testing did not simulate potentially important aspects of debris bed formation
f) Records from early testing not available, so conclusions from early testing must be limited.

SSIB, Head Loss: RAI 18

- Implementation of the correlation in the STP model makes specific assumptions. Justify that the assumptions and use of correlation is realistic or conservative

a) Beds are homogeneous and representative of the plant
b) Bed is assumed to accumulate with the manufactured density. Please, explain why this is valid or requantify using new density
c) Please, explain how NUREG/CR-6224 correlation compression function is applied
d) Please, explain why linear mass weighting for surface-to-volume ratio is acceptable
e) Provide technical basis for coating material packing fractions

SSIB, Invessel: RAI 37

- **Please provide the technical basis for assuming that 7.5 grams is an acceptable limit for a cold-leg break at STP when considering the potential for boric acid precipitation.**

SSIB, Invessel RAI 37 Response

- 7.5 g/FA is a “threshold of concern”
  - sharp, single-value to maintain clarity on performance metric
- Full debris deposition on the fuel for conservatism
  - no credit for barrel-to-baffle bypass fiber deposits or lower plenum mixing
- Failure at 7.5 g/FA enters the core
- Lower than 15g/FA chosen after WCAP chemical load added to fuel

APLAB RAIs

- CASA Grande – Plant Configuration: RAI 1b, 2b, 3
- HRA: RAI 3, 5
- Uncertainties: RAI 1, 2, 4, 5, 6
- Stable end state: PRA Success RAI 3c
- Use of different distributions

APLA, CASA-Plant Config: RAI 1b

- Provide technical justification for using only nominal values of time-temperature curves

APLA, CASA-Plant Config: RAI 1b Response

- Not possible to choose "conservative" profiles across entire duration of the event
- Performed additional TH analyses to support use of nominal temperature profiles

Case	Break Size (Diameter)	Working HHSI Pumps	Working LHSI Pumps	Working CS Pumps	Working Cont. Fan Coolers	Case Description
15"-9	15 inches	3	1	3	6	Dual LHSI Pump (Loops 3 & 4) Failure
15"-22a	15 inches	2	2	2	6	Single Train (Loop 4) Failure
15"-22b	15 inches	2	2	2	6	Single Train (Loop 3) Failure
15"-22a-4/6Fans	15 inches	2	2	2	4	Single Train (Loop 4) Failure (4 Cont. Fans Operating)
15"-26a	15 inches	1	2	2	6	Single Train (Loop 4) + HHSI Pump (Loop 3) Failure
15"-26b	15 inches	1	2	2	6	Single Train (Loop 3) + HHSI Pump (Loop 4) Failure
15"-43	15 inches	1	1	1	6	Dual Train (Loops 3 & 4) Failure
8"-43	8 inches	1	1	1	6	Dual Train (Loops 3 & 4) Failure

APLA, CASA-Plant Config: RAI 2b

- Provide technical justification for assuming only nominal operating conditions of flow rates and thermal hydraulic conditions

APLA, CASA-Plant Config: RAI 2b Response

- Use of nominal flow rates provides a more realistic evaluation of risk when competing factors make it difficult to define conservative conditions. APLA, CASA-Plant Config: RAI 2b
- Use of nominal values provides results that are reasonable and probable for use in a holistic, risk-informed evaluation.

APLA, CASA-Plant Config: RAI 3

- A qualitative argument is provided why a combination of pumps failing in the same train is "worse" than the same set of pumps failing in different trains.

a) Justify this assumption and clarify whether an engineering analysis was performed
b) State if this assumption always increases conditional probability of strainer failure
c) State if this assumption always increases conditional probability of in-vessel failure

APLA, CASA-Plant Config: RAI 3 Response

- A cursory engineering analysis based on proportion of total flow to each strainer provided the basis for Assumption 2b
- Effects of debris penetration were found to contradict traditional engineering judgment
- Extra parameter evaluations were performed
  - Small increase in CDF (1.5%) caused by in-vessel failures for pump failures on separate trains
  - Supplement provided with detailed statistics

APLAB, STP PRA Model-Human Reliability Analysis: RAI 3a

- Please state if CASA Grande models plant conditions that would occur if three containment spray trains were running, e.g. …
  - Sump flow rates
  - Washdown rates
  - RWST drain-down times

APLAB, STP PRA Model-Human Reliability Analysis: RAI 3a Response

- Containment spray flows only affect sump flow rate and sump flow rate dependent physical phenomena
  - Spray securement modelled as normal distribution with 20 ± 5 minute mean and STD
- RWST switchover modelled as point values with 2 containment sprays operational (most probable)
- Failed debris washdown taken from deterministic analysis with 2 sprays operational
- Statistical sampling allows for failure of manual action to secure spray pump, but this failure is not enforced

APLAB, STP PRA Model-Human Reliability Analysis: RAI 3b

- Please state if CASA Grande models plant conditions that would occur if operators fail to secure all containment spray (CS) long term e.g. …
  - Sump flow rates
  - Washdown rates
  - RWST drain-down times

APLAB, STP PRA Model-Human Reliability Analysis: RAI 3a Response

- CASA Grand did not model plant conditions that would occur if operators failed to secure CS long term.
- CASA Grande samples user-defined Post-LOCA time at which all CS are secure
- User-defined distribution was truncated a high CS securement time of 7.5 hours.
- Plant conditions not modelled for failure of long term CS securement

APLAB, STP PRA Model-Human Reliability Analysis: RAI 3c

- If either question to CS securement RAI’s is no provide technical basis, and explain how PRA meets ASME HLR-HR-G requirement to perform an assessment of post initiator human failure events using a well defied and self-consistent process that addresses scenario- specific influence on human performance

APLAB, STP PRA Model-Human Reliability Analysis: RAI 3a Response

- The PRA does include to represent failure to trip one CS pump as well as failure to trip all CS pumps later in sequence
- For the STP CASA Grande evaluation these CS securement operator action failures were not modeled
  - Failure to trip one CS pump would evenly divide debris to all strainers resulting in lower head-loss
  - This may be slightly unconservative for in-vessel effects

ESGB RAIs

- Coatings: RAI 1, 2, 6
- Chemical Effects: RAI 1

ESGB, Coatings: RAI 1

- Provide basis for the unqualified coatings epoxy distribution size.

ESGB, Coatings: RAI 1 Response

- Autoclave testing performed by K&L[1] on Comanche Peak supplied coatings chips
- Alion[2] performed characterization of chip type and size
  - Masses of chips weighed in individual size categories
  - The individual weight from each size category was divided by the total of all categories to yield mass fractions

ESGB, Coatings: RAI 1

Supporting Information

- Coatings samples were tested in two baskets, one submerged and one unsubmerged
  - Unsubmerged basket had higher mass percentage of fines and fine chips after testing
  - Chip debris that escaped both baskets was taken from autoclave floor and added to unsubmerged basket for conservatism
    - This resulted in a higher mass fraction of fines and fine chips
  - Mass fractions from unsubmerged basket were used to define failed size fractions for unqualified epoxy in STP CASA Grande evaluation

ESGB, Coatings: RAI 2

- Provide ZOI used for both epoxy and IOZ qualified coatings.

ESGB, Coatings: RAI 2 Response

- A 4D ZOI was used for both qualified zinc and IOZ coatings.

Supporting Information

- WCAP-16568[1] testing shows an average loss of about 0.1 mil at 3.68 L/D where jet directly impacts coupon (generally within 2-inch radius)
- Extrapolation of data shows zero erosion and 4.28 L/D

ESGB, Coatings: RAI 6a

- Describe what has been done to ensure that STP unqualified coatings are the same as coating used in EPRI[1] testing

ESGB, Coatings: RAI 6a Response

- Manufacture coating type is often unavailable for unqualified coatings.
- Generic coatings types at STP (i.e. epoxy, alkyd, etc.) matched with generic coatings types from the EPRI[1] study
- Generic unqualified coatings sample types labeled in EPRI[1] study were taken from multiple plants with different visual and physical characteristics

ESGB, Coatings: RAI 6b

- EPRI[1] testers stated that they made no attempt to quantify debris on the filter. Provide addition justification for using this test data to assign failure time to unqualified coatings.

ESGB, Coatings: RAI 6b Response

- Estimated failure timing of unqualified coatings was based off visual inspection of filter discoloration.
- Alkyds had the highest average detachment from testing (33.9%).
  - Alkyds tested were visually pigmented with a variety of colors (gray, silver, red, yellow, blue, blue-green)[1]
  - Alkyd failure may conservatively bias failure timing to the maximum unqualified coatings failure rate of alkyds

ESGB, Coatings: RAI 6c

- STP seeks to reduce the failure of unqualified coatings from the deterministic methodology percentage of 100% to 6%. Provide additional justification for the current failure timing analysis.

ESGB, Coatings: RAI 6c Response

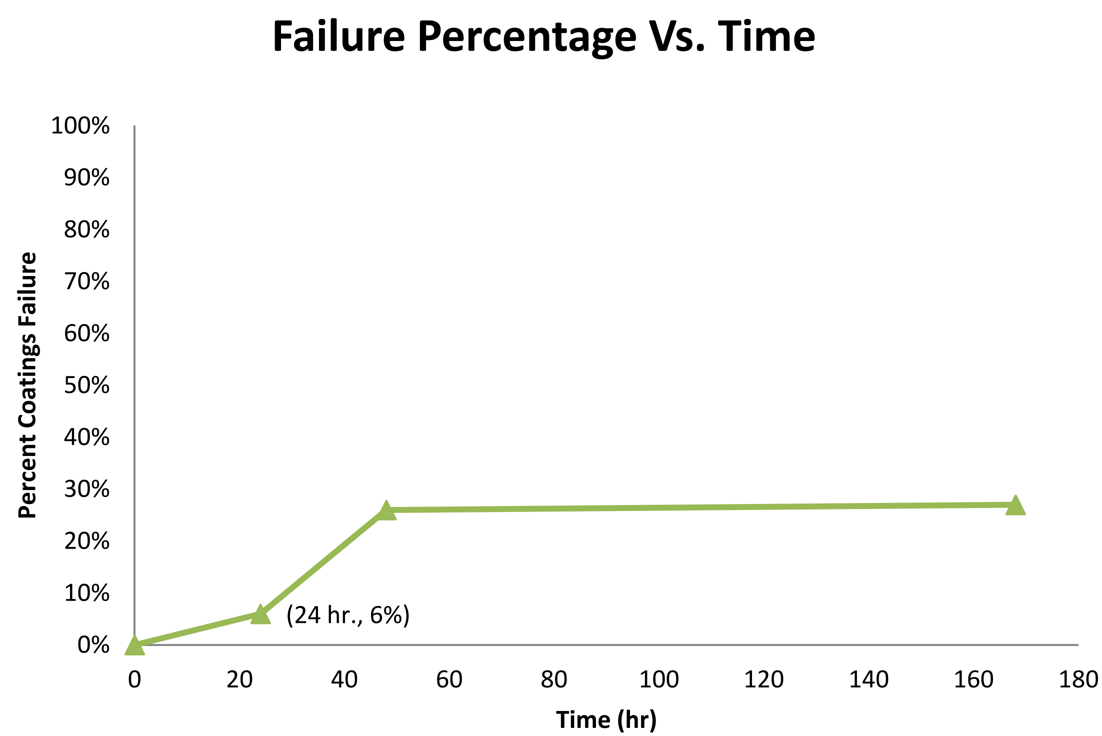
- Alkyds have greatest influence on interpretation of filter photographs because of distinctive coloration and highest average detachment
- EPRI[1] analysis states “With regard to timing of the coating failures, the filters do not demonstrate a definitive time of failure however in subjective terms it appears that much of the failure occurred in the 24- to 48- hour timeframe”

ESGB, Coatings: RAI 6c Response

- If "much of the failures" is 21% and the total average detachment is 27% for all coatings types 6% failure is found at 24 hours.

- Increasing the subjective amount of "much of the failures" to a higher percentage would yield a lower percentage of failed coatings at 24 hours than the STP assumed 6%.

- If subjective amount changed to 55% of available failure, the failed percentage at 24-hours doubles to 12%. Parametric evaluations have shown that risk is insensitive to this range of added particulate.

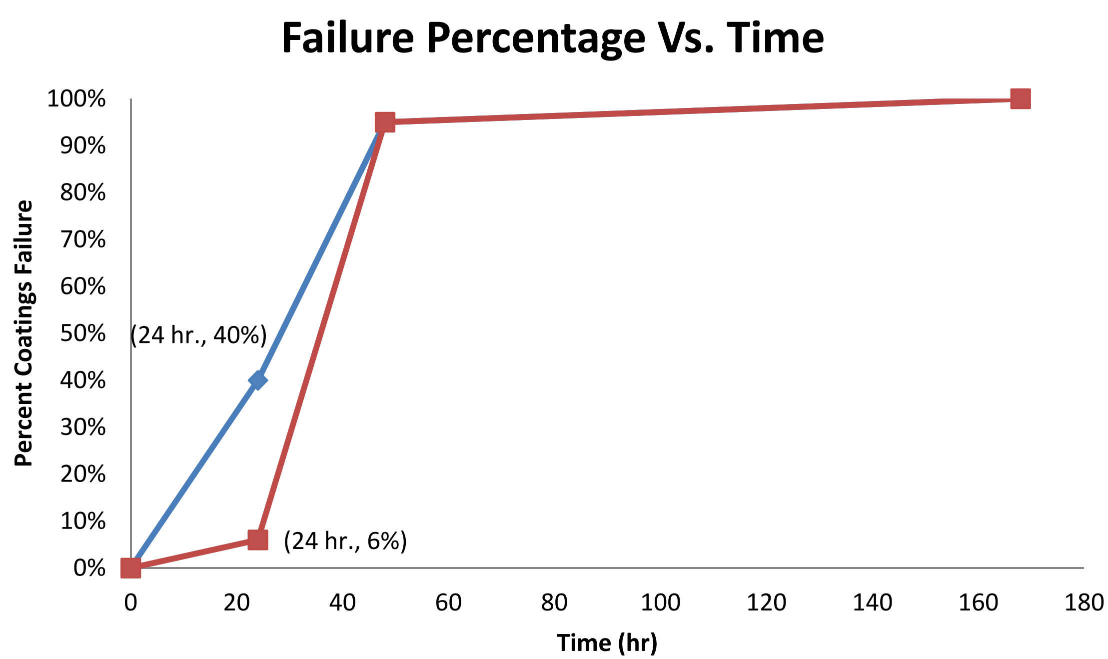


ESGB, Coatings: RAI 6c Response

- Artificially setting 100% failure over the 7 days and assuming "much of the failures" is 89% and 55% (red and blue curves respectively) with 5% residual failure (48 to 168 hours).

- Interpreting "much of the failures as 89% (red curve) yields the STP assumed 6% failure at 24 hours

- If subjective amount changed to 55% (blue curve) of available failure, the failed percentage at 24-hours is 40 %. This would contradict the observed average detachment of 27%



ESGB, Chemical Effects: RAI 1a

- **Please justify not correlating the chemical bump up factor to the conventional head loss since the same debris bed affects both values**

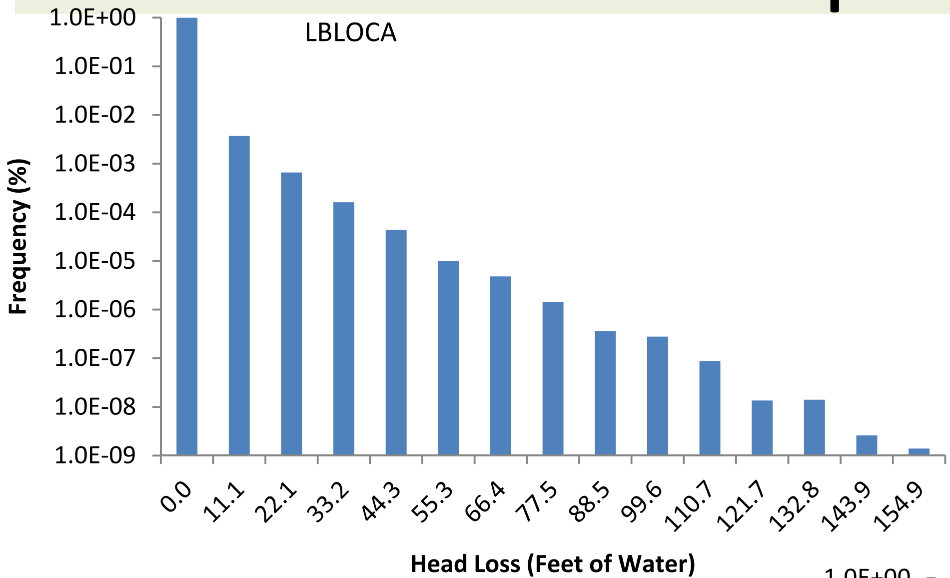
ESGB, Chemical Effects: RAI 1a Response

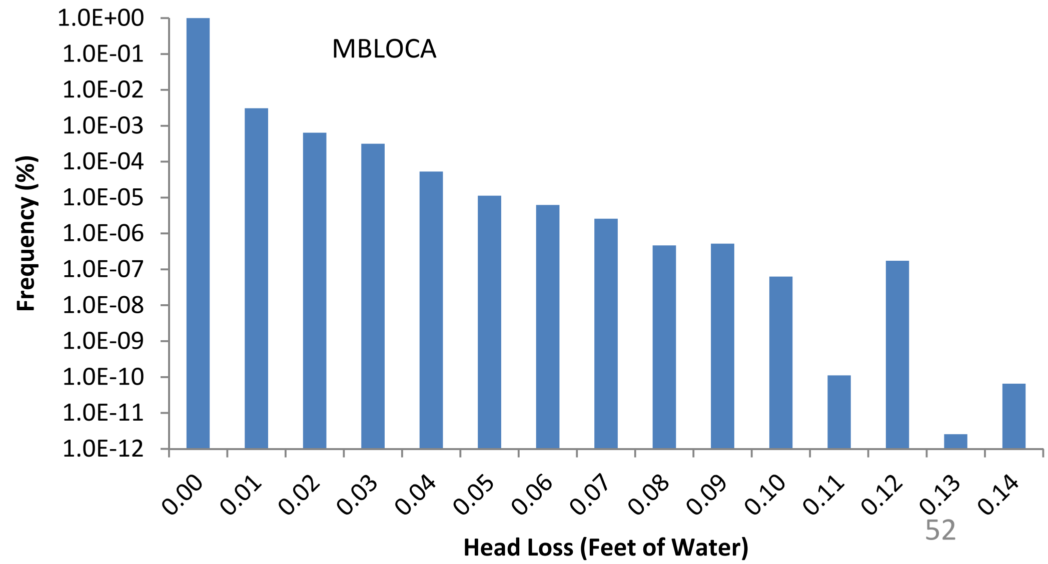
- Chemical "bump-up" factor
  - Applies maximum head loss from chemical interaction with the highest filtration debris bed
    - Based on test data (thin bed not included)
  - Conventional head loss is correlated to break size with maximum chemical interaction for increase of total head loss
  - Distributions provide opportunity for smaller breaks to have high HL
  - Simplifies the chemical and bed interaction complexity with conservatism
- Supporting calculations
  - Technical approach to support and evaluate applied "engineering judgment"
  - Allows estimation or detailed quantification of the strength and weakness of bump up approach
  - Assesses weakness of the "bump up" do not underestimate risk because of conservatisms used in generation of "bump up"

ESGB, Chemical Effects: RAI 1b

- **In order to help the staff judge the magnitude of the chemical head loss bump-up factor, please provide, by performing realizations for the existing CASA Grande model, a relative frequency plot of chemical effects for STP in terms of absolute units (e.g., feet of H_2O) for the SBLOCA [small break LOCA], MBLOCA [medium break LOCA], and LBLOCA [large break LOCA].**

ESGB, Chemical Effects: RAI 1b Response





ESGB, Chemical Effects: RAI 1c

- Please provide additional details on how the results from the Chemical Head Loss Experiment (CHLE) testing, WCAP-16530-NP, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191," calculations, and reasonable engineering judgment were used in the development of the exponential PDF. In addition, please supply the basis for choosing the exponential form of the PDF over others, e.g., Weibull"

ESGB, Chemical Effects: RAI 1c Response

- The exponential PDF was chosen:
  - Shape
  - Convenience of fitting statistics of the mean and truncated tail probability
    - Only mean is needed to fully specify distribution
- CHL testing and WCAP-16530-NP calculations were used to determine the bump-up multiplier that exist at the highest probability of the PDF
- Engineering judgment based on review of STP strainer test was used to determine a mean bump up multiplier
- The maximum values were values capable of producing a quantifiable number of chemically induced failures
  - 6.8X (SBLOCA), 8.1X (MBLOCA), and 10.7X (LBLOCA) higher than the DBA multiplicative response.

ESGB, Chemical Effects: RAI 1d

- Please provide a detailed technical basis for the mean bump up factors shown for the SBLOCA, MBLOCA, and LBLOCA. The NRC staff has observed head loss testing where the greatest chemical bump-up factors are associated with thinner beds. Please discuss why the mean bump up factor would be higher for a LBLOCA. Please explain if it is more probable that a debris bed for smaller and medium breaks (assuming the bed coverage criterion is met) would consist primarily of fiber fines that are the most readily transportable to the strainer. In general, finer fiber beds tend to lead to greater head loss

ESGB, Chemical Effects: RAI 1d Response

- Mean bump-up
  - Based on STP strainer testing of DBA bed and 30-day worst-case chemical precipitate mode
  - Conservatism applied
    - SBLOCA applies multiplier based on strainer tests
    - MBLOCA and LBLOCA increases the multiplier
- Bump up mean multipliers applied to thinner beds were confirmed higher than a DBA determined multiplier. However, sensitivity modeling required the thin bed mean to be much larger than that observed in other strainer testing
- It is not expected that small and medium break debris consists primarily of fines because
  - Every break generates the same volumetric proportions of fiber glass
  - One set of debris-size dependent transport fractions is applied for every break

APLAB HRA RAI 3

- Top Event OSI represents securing one train of Containment Spray early given three initiate; Top Event OFFS represents securing all Containment Spray later as directed by technical support center
  - (a) Does CASA Grande reflect conditions if all three Containment Spray continue to run?

    Statistical sampling of trip time does not preclude long term operation of three trains; however, this condition was not explicitly considered

APLAB HRA RAI 3, continued

(b) Does CASA Grande reflect conditions if Containment Spray is not secured in the long term?

No. While the time of tripping the pumps is sampled, truncation considerations preclude this time to go beyond 7.5 hours. Plant conditions are not modeled for the condition where operator fail to secure long-term containment spray.

APLAB HRA RAI 3, continued

(c) Provide justification if the answer to (a) or (b) is "no."

The PRA contains the necessary logic structure to represent the conditions of interest. However, no specific CASA Grande results for these conditions were available at the time of model quantification. While failure to trip one pump might lead to conservative results with respect to potential NSPH conditions due to sump screen loading (debris would be transported to two sump screens rather than three), the approach may be unconservative with respect to the filtration of debris by the sump strainers.

APLAB HRA RAI 5

- How were Casa Grande results developed to reflect combinations of success and failure of the operator actions: (1) securing one train of Containment Spray early given three trains initiate; (2) securing all trains of Containment Spray later in the event response; (3) switchover to sump recirculation; and (4) switchover to hot leg injection. How was consitency between the PRA scenario and information developed in CASA Grande assured?

APLAB HRA RAI 5, continued

- The first two actions are included in the PRA model as switches; they were included to support sensitivity analyses, if later desired
- The success or failure of the first two tasks does not impact the success or failure of the remaining two actions.
- Action 3 is required to avoid fuel damage; action 4 is only queried if action 3 was successful
- Failure of action 4 is assumed to result in fuel damage for cold leg breaks; conversely success of action 4 precludes the possibility of boron precipitation (after the time of switchover to hot leg injection), minimizing need for status of actions to be communicated between the PRA and CASA Grande

APLAB RAI 2: Arithmetic vs. Geometric Means

- **<u>RAI Statement:</u>**
  - Volume 3, Assumption 3.a (page 76 of 248) states that the geometric-mean aggregation of LOCA frequencies in NUREG-1829 is the most appropriate set of results to use for this evaluation. The basis provided is that geometric-mean aggregation produces frequency estimates that are approximately the same as the median estimates of the panelists. There is no justification about why the median estimate is preferred and emphasis on the median conflicts with the RG 1.174 guidance that the mean values be used for decision making. Furthermore, information in NUREG-1829, Section 7.6.4 shows that the use of the arithmetic mean instead of the geometric mean would increase the LOCA frequency by an order of magnitude or more for some LOCA categories and may therefore substantially increase the risk estimates. Consequently, selection of the geometric mean is a key assumption and selection of the arithmetic mean represents an alternative reasonable assumption as defined by RG 1.200. This is supported by RG 1.174, Section 2.5, which states that “the licensee should [identify] key assumptions in the PRA that impact the application.” Sensitivity studies provide important information about how some of the key assumptions affect the final results as discussed in RG 1.174 Section 2.5.3. Please provide CDF, LERF, ΔCDF, and ΔLERF using the arithmetic mean aggregation of LOCA frequencies in NUREG-1829.

APLAB RAI 2: Arithmetic vs. Geometric Means

- **<u>RAI Response:</u>**

  - Despite the above caveat NUREG-1829 contains in its Executive Summary, the body of NUREG-1829, along with the literature on combining expert opinion, makes a strong case for using GM rather than AM at least when:
    - (i) the elicited probabilities concern rare-events,
    - (ii) the opinions of the individual experts are disparate,
    - and (iii) we seek a combination rule that represents a reasonable notion of the center of the group's opinion.

Weight Required on Expert A in the Weighted GM to Achieve the AM:

5^{th}	50^{th}	95th
73.6%	72.4%	70.1%

APLAB RAI 3A, 3B, 3C: Plant Configuration

- **<u>RAI Statement:</u>**

  - Volume 3, Assumption 2b provides a qualitative argument for why a combination of pumps failing in the same train is “worse" than the same set of pumps failing in different trains.

    A) Please justify this assumption and clarify if an engineering analysis was performed in support of this assumption.

    B) Please state if this assumption always increases the conditional probability of strainer failure (i.e., is this a conservative assumption?).

    C) Please state if this assumption always increases the conditional probability of in-vessel effects.

APLAB RAI 3A, 3B, 3C: Plant Configuration

- **RAI Response:**

  - Analysis of Case 22 suggests the condition in which all pumps fail on the same train leads to the largest **sump failure** frequency.
  - For **vessel failure** frequency, three cases (Cases 22-2, 22-3, and 22-5) in which the HHSI and LHSI pumps fail on different trains result in larger frequencies than when these pumps fail on the same train.
  - The change in ΔCDF reported in Volume 2 is 2.88E-08 per year.
  - The ΔCDF obtained by replacing Case 22-1 with Case 22-3 is:

    2.88E-08 + [3.24E-02 x 1.17E-08] = 2.92E-08 per year, a 1.5% increase.

Case	Freps	Mreps	Mean Total	95% CI HW	95% CI LL	95% CI UL	CI HW % of Mean
22-1	15	301	2.542E-08	2.808E-09	2.261E-08	2.823E-08	11.05%
22-2	15	301	3.476E-08	4.738E-09	3.002E-08	3.949E-08	13.63%
22-3	15	301	3.712E-08	4.879E-09	3.224E-08	4.200E-08	13.14%
22-4	15	301	2.420E-08	2.683E-09	2.152E-08	2.688E-08	11.09%
22-5	15	301	2.089E-08	3.955E-09	1.694E-08	2.485E-08	18.93%

NUREG-1829
Related RAI's

APLAB RAI 2: Modeling LOCA Frequency & Break Size Under DEGB-Only Breaks

- **RAI Statement:**

  - NUREG-1829 states that, in general, a complete rupture of a pipe is more likely than a partial rupture. It appears, however, that STP's methodology leads to the opposite result (i.e., a rupture of a given size is more likely to be caused by a partial rupture of a large pipe than a complete rupture of a smaller pipe).

    A) Please illustrate the results of your method by comparing the frequency of partial versus complete breaks for a set of representative pipe sizes.

    B) Please describe whether the methodology described in the STP pilot is consistent with the assumption of NUREG-1829 or provide justification for an alternate approach.

APLAB RAI 2: Modeling LOCA Frequency & Break Size Under DEGB-Only Breaks

- **RAI Response:**
  - Under the implemented “continuum" model with a hybrid approach, the probability a pipe experiences a DEGB given that it has a break is 0.165.
  - Under the top-down only approach for the “continuum" model, the probability a pipe experiences a DEGB given that it has a break is 0.0746.
  - Using the NUREG-1829 frequencies without considering RI-ISI frequency information (no hybrid approach) increases the probability of a DEGB by more than a factor of 2.21.

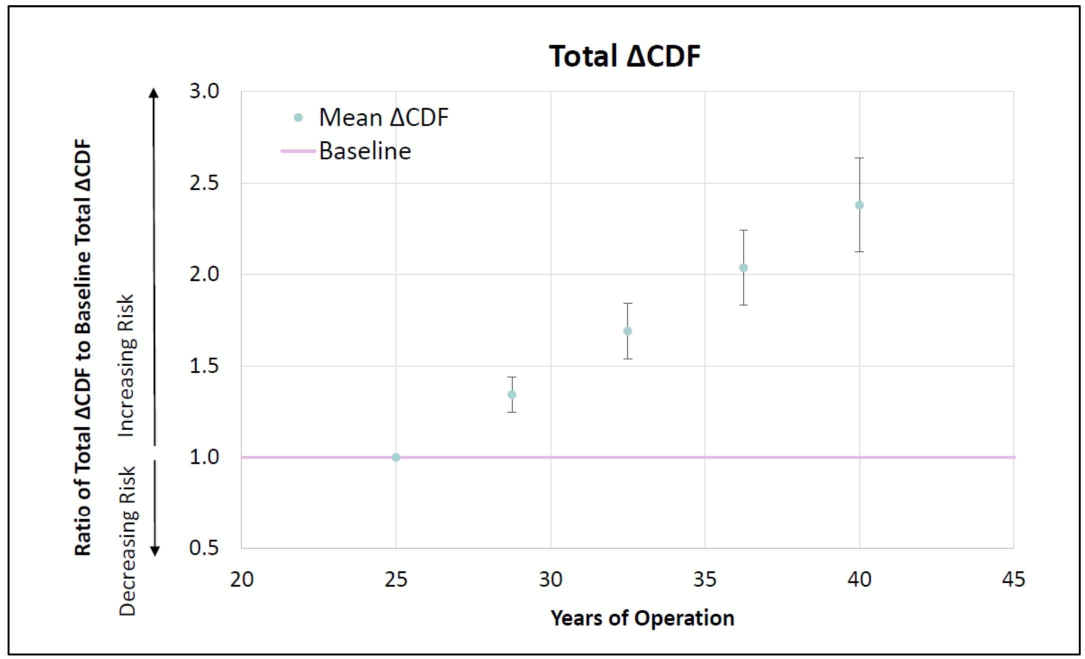
APLAB RAI 3: Justification of the Use of 25-Year Frequency Estimates

- **RAI Statement:**
  - Section 2.5.5 states that it is incumbent on the licensee to demonstrate that the choice of reasonable alternative hypotheses, adjustment factors, or modeling approximations or methods to those adopted in the PRA model would not significantly change the assessment. Also, it is assumed that the STP plants will continue to operate for more than 25 years; RG 1.174 Section 3 states that the licensee should define an implementation and monitoring program to ensure that no unexpected adverse safety degradation occurs do to the change.

    A) Please justify the use of the 25-year frequency estimates rather than the 40-year estimates provided by NUREG-1829. Provide CDF, LERF, ΔCDF, and ΔLERF using the 40-year estimates.

APLAB RAI 3: Justification of the Use of 25-Year Frequency Estimates

- **<u>RAI Response:</u>**
  - Using 40-year frequency estimates, ΔCDF increases to 6.91E-08, a factor of about 2.4.



APLAB RAI 4A: Discrepancy Between LOCA Frequency Means for Johnson Distributions & NUREG-1829

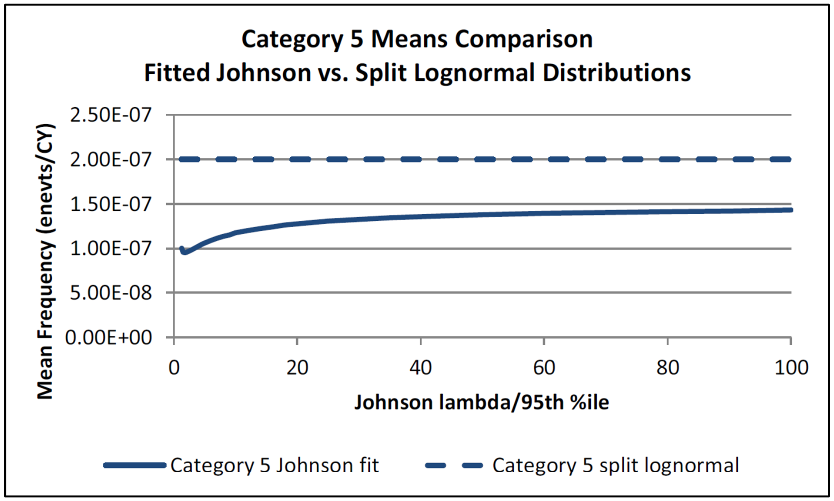
- **RAI Statement:**

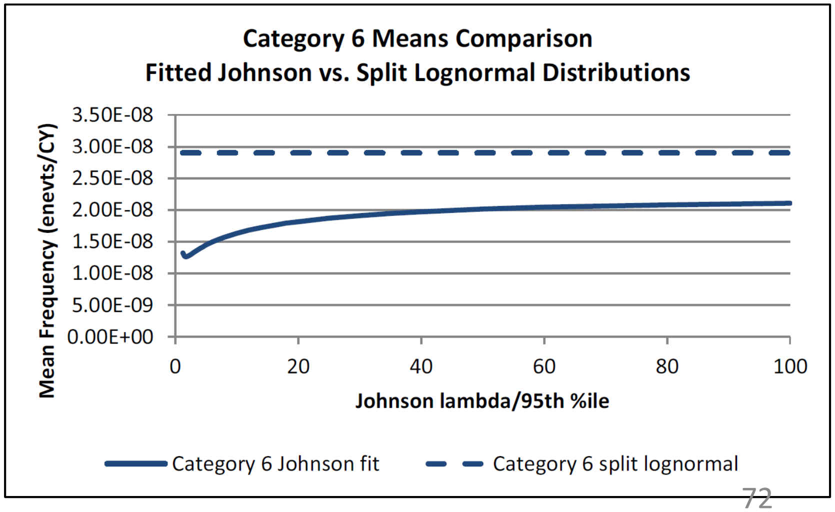
  - Typically, statistical sampling simulations will develop random variables that preserve the mean of the distribution from which the variables are sampled. STP has chosen to fit a Johnson bounded distribution that matches the expert-provided 5th, 50th, and 95th percentiles in NUREG-1829, but does not match the mean values. The properties of the distribution are such that, as fit, the mean of the fitted distribution is always less than the experts' means from the distributions in NUREG-1829.

    A) Please explain why the STP evaluation departs from the regulatory position in RG 1.174 regarding the use of mean values.

APLAB RAI 4A: Discrepancy Between LOCA Frequency Means for Johnson Distributions & NUREG-1829

- **RAI Response:**
  - Analyze means of Johnson distributions, as a function of λ.
  - x-axis: Ratio of λ to elicited 95th percentile
  - Means grow with λ, but level off for large values of λ
  - Even at a ratio of 100, the Johnson means fall short of the NUREG-1829 means, most prominently in categories 5 and 6





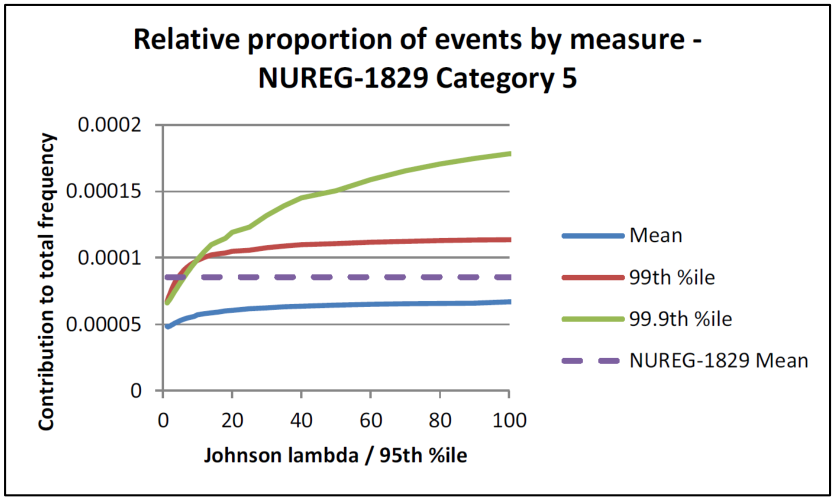
APLAB RAI 4B: Explanation of the Johnson Distribution Governing LOCA Frequency

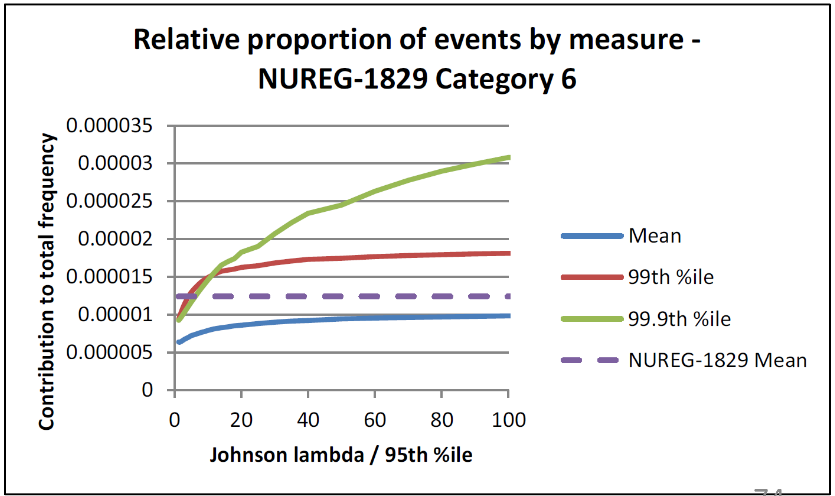
- **RAI Statement:**
  - Typically, statistical sampling simulations will develop random variables that preserve the mean of the distribution from which the variables are sampled. STP has chosen to fit a Johnson bounded distribution that matches the expert-provided 5th, 50th, and 95th percentiles in NUREG-1829, but does not match the mean values. The properties of the distribution are such that, as fit, the mean of the fitted distribution is always less than the experts' means from the distributions in NUREG-1829.

    B) The Johnson fit to 5th, 50th, and 95th percentiles is not unique. Alternative accurate fits can be constructed with arbitrary values of the scale parameter λ. The scale parameter λ defines a bound on the maximal frequencies sampled in the Monte Carlo model. By increasing the value of λ, the relative proportion of large to medium to small breaks can be altered, especially in the extrapolation range beyond the 95th percentile. Please provide a technical justification for the selection of the scale parameter λ (other selections appear possible that could change the outputs by CASA Grande).

APLAB RAI 4B: Explanation of the Johnson Distribution Governing LOCA Frequency

- **RAI Response:**
  - Using the means of the Johnson distributions as metric for relative contribution of LOCA events by category:
    - Somewhat underestimate the contribution categories 5 and 6 as compared to using the implied means from NUREG-1829,
    - Overestimate the contribution of these categories versus the implied NUREG-1829 means if we use the 99th or 99.9th percentiles and a large value for λ.
  - Fixing λ to twice the 95th percentile: Underestimate the contribution to categories 5 and 6, even using 99th or 99.0th percentiles, relative to NUREG-1829 means.





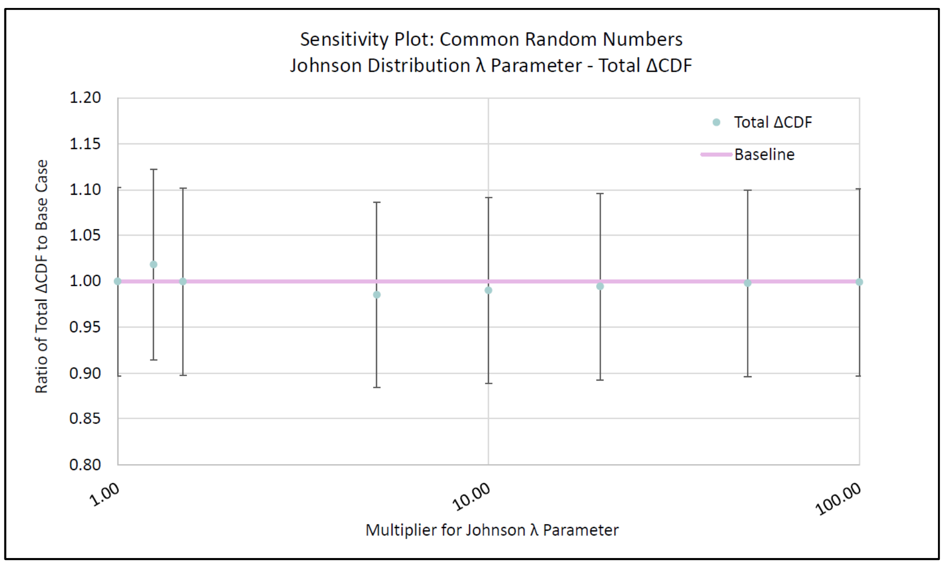
APLAB RAI 4C: Impact of Johnson Distribution Selection on CDF, LERF, ΔCDF, ΔLERF

- **<u>RAI Statement:</u>**
  - Typically, statistical sampling simulations will develop random variables that preserve the mean of the distribution from which the variables are sampled. STP has chosen to fit a Johnson bounded distribution that matches the expert-provided 5th, 50th, and 95th percentiles in NUREG-1829, but does not match the mean values. The properties of the distribution are such that, as fit, the mean of the fitted distribution is always less than the experts' means from the distributions in NUREG-1829.

    C) Please provide the maximum expected difference between the CDF, LERF, ΔCDF, and ΔLERF developed from bounded Johnson distributions that consider alternative values of the scale parameter λ, and other distributions that would preserve mean values reported in NUREG-1829. Note, in particular, that alternative bounded Johnson distributions with large values of the scale parameter λ can be built to accurately fit the NUREG-1829 5th, 50th, and 95th percentiles, and produce mean estimates closer to the NUREG-1829 values than current fits used by STP.

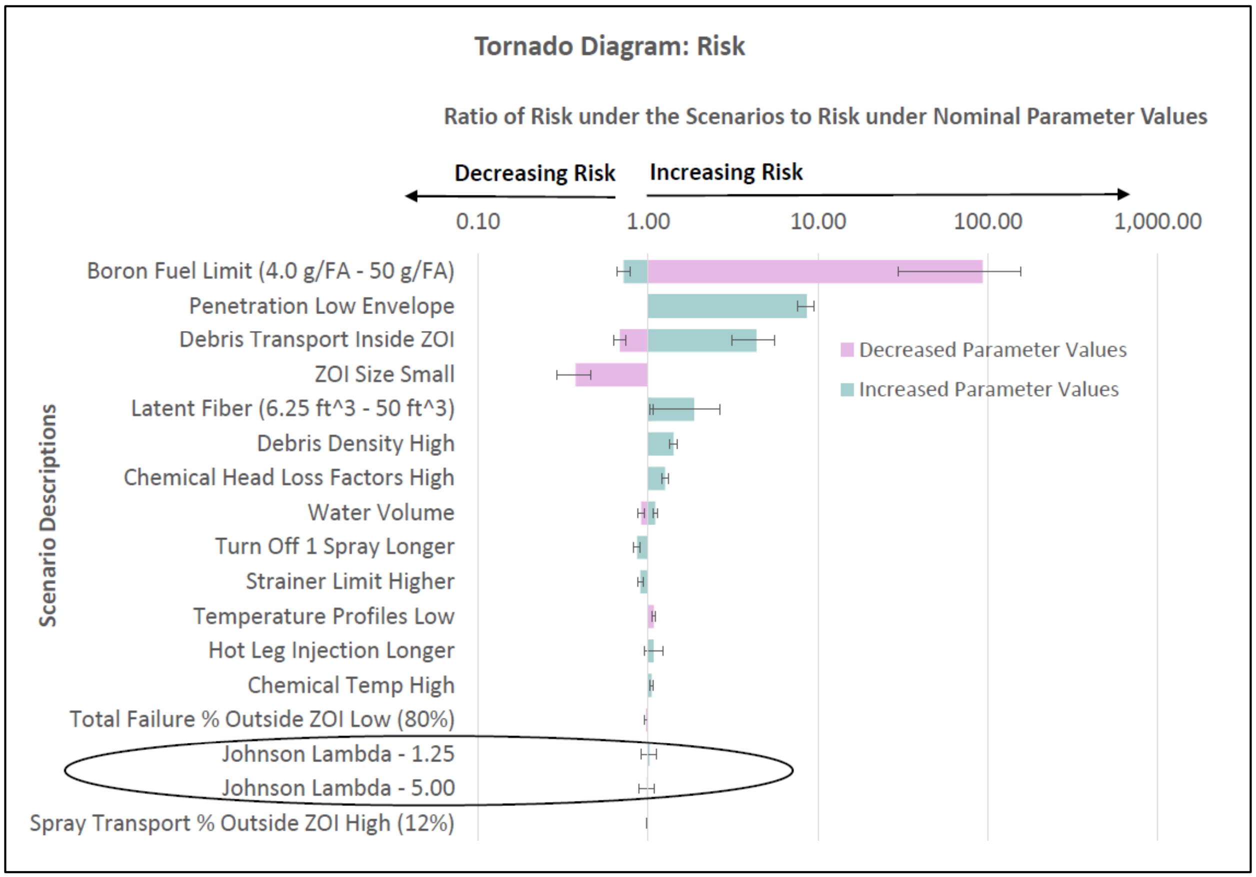
APLAB RAI 4C: Impact of Johnson Distribution Selection on CDF, LERF, ΔCDF, ΔLERF

- **<u>RAI Response:</u>**
  - Our estimates of changes in CDF, ΔCDF, LERF, and ΔLERF are modest as we range the Johnson scale parameter λ from a factor of 1.25 up to a factor of 100 times the 95th percentile of the frequencies elicited from experts in NUREG-1829. More specifically, point estimates of ΔCDF and ΔLERF increase by no more than 2% for the specific values of λ we consider here.



APLAB RAI 4C: Impact of Johnson Distribution Selection on CDF, LERF, ΔCDF, ΔLERF

- **RAI Response:**



EPNB RAI 6: Consistency of Weld Frequencies with RI-ISI Program

- **RAI Statement:**
  - By letter dated September 10, 2012, the NRC approved the risk-informed in-service inspection (RI-ISI) program for the third 10-year in-service inspection interval at STP, Units 1 and 2 (ADAMS Accession No. ML12243A343). Please discuss the following:

    A) Please state if the LOCA frequency estimates used for welds in the GSI-191 submittal are consistent with the LOCA frequency estimates used in the RI-ISI program. If the comparison is appropriate, please provide numerical examples of the comparison. If the comparison is not appropriate, please provide explanation.

    B) If the LOCA frequencies for welds are not consistent between the two analyses, (1) please identify the differences and explain why there are differences, and (2) please discuss why the LOCA frequencies proposed in the GSI-191 submittal are acceptable if they are not consistent with that of the RI-ISI program.

EPNB RAI 6: Consistency of Weld Frequencies with RI-ISI Program

- **RAI Response:**
  - The mean frequencies reported in NUREG-1829 are preserved in the mean frequencies used to compute ΔCDF. Using RI-ISI instead, these three frequencies would decrease by factors of 4.43, 15.18, and 2.27 for small, medium, and large breaks.
  - If we use only RI-ISI frequencies to construct the distribution over break size and weld case, the probability mass increases by factors of 5.03, 20.38, and 15.68 in the respective categories 4, 5, and 6.

Method / Break Size	Small	Medium	Large
NUREG-1829 Mean	1.59E-03	3.05E-04	5.20E-06
RI-ISI Point Estimate	3.59E-04	2.01E-05	2.29E-06
Ratio (NUREG/RI-ISI)	4.43	15.18	2.27

Method / Category	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5	Cat 6
Hybrid - Johnson Means	8.02E-01	1.91E-01	6.85E-03	6.82E-04	5.12E-05	7.72E-06
RI-ISI - Point Estimate	9.08E-01	6.84E-02	1.85E-02	3.43E-03	1.04E-03	1.21E-04
Ratio (RI-ISI/Hybrid)	1.13	0.36	2.70	5.03	20.38	15.68