UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001
May 9, 2000

MEMORANDUM TO: Stuart A. Richards, Director
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

FROM: Stewart N. Bailey, Project Manager, Section 2
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF APRIL 6, 2000, MEETING WITH THE BABCOCK AND WILCOX OWNERS GROUP REGARDING A RISK-INFORMED TOPICAL REPORT TO REMOVE LARGE BREAK LOSS-OF-COOLANT ACCIDENT FROM STEAM GENERATOR TUBE DESIGN CRITERIA (TAC NO. MA8609)

On April 6, 2000, the U. S. Nuclear Regulatory Commission (NRC) staff met with the Babcock and Wilcox Owners Group (B&WOG) to discuss a topical report that is currently being developed by the B&WOG. The B&WOG is made up of five utilities, Duke Energy Corporation, Entergy Operations, Inc., Florida Power Corporation, AmerGen, FirstEnergy, and a vendor, Framatome Technologies Group. The B&WOG has seven active reactors at five sites. The topical report would use risk-informed arguments to justify removing a large break loss-of-coolant accident (LBLOCA) from the design considerations of steam generator tubes.

Background

The original licensing basis for steam generator (SG) tube loads included the loads from main steam line break and loss-of-coolant accident. In 1990, however, the B&WOG misapplied the leak before break (LBB) rulemaking and the staff's safety evaluation of topical report BAW-10146, "Thermal and Dynamic Loads for LBLOCA," and determined that LBLOCA loads did not need to be considered for the design of SG tube repairs (such as rerolling the SG tubes). The staff became aware of this issue when reviewing a license amendment to allow rerolling of SG tubes at Davis Besse. During a call on March 9, 2000, the staff informed the B&WOG that (1) LBLOCAs need to be considered in the design basis, so the previously-approved amendments are based on incomplete information, and (2) licensees needed to justify the continued operation of the SGs, using the guidance in Generic Letter 91-18, "Information to Licensees Regarding Two NRC Inspection Manual Sections on Resolution of Degraded and Nonconforming Conditions and on Operability."

As part of the long term resolution of this issue, the B&WOG proposes a risk-informed topical report to exclude postulated breaks in large bore piping (e.g., the piping that has been previously approved for LBB) from the design basis for existing and replacement SGs.

Current Operability

The B&WOG discussed the operability of the SGs that are currently in service. The highest tube-to-shell temperature differences are produced by postulated breaks in the upper hot legs (large bore piping). This temperature difference causes high tensile loads on the SG tubes due to differential thermal expansion of the tubes and the shell. The B&WOG stated that the maximum temperature difference occurs at a time of low primary-to-secondary pressure difference. Due to this, and the current condition of the tubes that have been roll-repaired, this does not result in offsite dose consequences greater than currently analyzed for the plants. Further, emergency core cooling performance remains acceptable, and any postulated secondary-to-primary leakage is not a boron dilution concern. In addition, there is a very low probability of a break in the upper hot leg large bore piping. The staff believes that the licensees have a reasonable basis for continued operation while the risk-informed topical report is prepared and reviewed.

Topical Report

The topical report will follow the guidance in Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," and use the change in core damage frequency (ΔCDF) and the change in large early release frequency (ΔLERF) to evaluate risk. The B&WOG estimated a ΔCDF of $\leq$8E-10/year and a ΔLERF of $\leq$4E-11/year. This is well within the acceptable limits provided in RG 1.174. Also, the defense in depth and the safety margins are preserved by the change. The B&WOG concludes that the risk of a large bore, upper hot leg break is very small and the consequences are bounded by current analyses.

The B&WOG intends to submit the topical report by June 30, 2000, and will request NRC approval by September 29, 2000, to support outage activities at Oconee. In parallel, the B&WOG licensees will submit plant-specific license amendment requests, based in part on the risk-informed topical report, to allow use of reroll-repairs.

The staff thanked the B&WOG for the informative meeting. A list of those attending the meeting is provided as Attachment 1. The slides used by the B&WOG during the meeting, including backup slides, are provided in Attachment 2.

Project No. 693

Attachments: 1. Meeting Attendees
2. Slides

cc w/atts: See next page

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cc:
Mr. Guy G. Campbell, Chairman
B&WOG Executive Committee
Vice President - Nuclear
FirstEnergy Nuclear Operating Company
Davis-Besse Nuclear Power Station
5501 North State Rt. 2
Oak Harbor, OH 43449

Ms. Sherry L. Bernhoft, Chairman
B&WOG Steering Committee
Florida Power Corporation
Crystal River Energy Complex
15760 West Power Line St.
Crystal River, FL 34428-6708

Mr. J. J. Kelly, Manager
B&W Owners Group Services
Framatome Technologies, Inc.
P.O. Box 10935
Lynchburg, VA 24506-0935

Mr. F. McPhatter, Manager
Framatome Cogema Fuels
3315 Old Forest Road
P.O. Box 10935
Lynchburg, VA 24506-0935

Mr. R. Schomaker, Manager
Framatome Cogema Fuels
3315 Old Forest Road
P.O. Box 10935
Lynchburg, VA 24506-0935

Mr. Michael Schoppman
Licensing Manager
Framatome Technologies, Inc.
1700 Rockville Pike, Suite 525
Rockville, MD 20852-1631

MEETING WITH BABCOCK AND WILCOX OWNERS GROUP

LIST OF ATTENDEES

APRIL 6, 2000

FRAMATOME TECHNOLOGIES, INC.

Jeff Brown
Stuart Brown
Rick Edwards
Dave Firth
John Klingenfus
Stanley Levinson
Michael Schoppman

AmerGen

Richard Barley
David Distel
Richard Freeman
Oscar Limpias

DUKE ENERGY

H. Duncan Brewer
Joe Davis
B. Blake Lowery
Dewey Rochester
W. Morris Sample
Robert Sharpe

ENTERGY

Steve Bennett
Morris Byram
Richard Ellison
Darol Harrison
John Hathcote

FirstEnergy

Ken Byrd
David Gerren
Frank Kennedy
Peter Mahoney
Mark Riemer

FLORIDA POWER CORPORATION

Virgillio Esquillo
Jeff Peet

B&W CANADA

Jim Albert
Jeff Millman

NEI

Dave Modeen

NRC

Stewart Bailey
Steve Dembek
David LaBarge
Bill Bateman
Ted Sullivan
Mathew Mitchell
Carolyn Lauron
Andrea Kein
Eric Benner
Richard Lobel
Warren Lyon
Rich Barrett
Steve Long
See-Meng Wong

Risk-Informed Approach to Eliminating Breaks in Large Bore Piping from SG Design Basis

Agenda

• Introduction	Morris Sample, DPCo
• Background	Jeff Brown, FTI
• LBLOCA Description	John Klingenfus, FTI
• Generic Operability Discussion	
• RG 1.174 Submittal Summary	Duncan Brewer, DPCo.
– Overall Approach	
– Risk Assessment	
– Defense in Depth	Jeff Brown
– Safety Factors	
– Schedule	
• Closing/Summary	Morris Sample

Attachment 2

Introduction

- Objective of Meeting
  - Qualitative Operability Assessment
  - Discuss a Risk-Informed Approach to Addressing the LOCA Design Basis for B&W Steam Generators
    - » Discuss Expected Submittal Schedule
    - » Identify Any Major Open Issues to be Addressed
- Affected Plants
  - All B&WOG Plants (Generic Issue)
    - » ANO-1; CR-3; Davis Besse; Oconee-1, 2, & 3; TMI-1
  - Replacement S/G's

Background

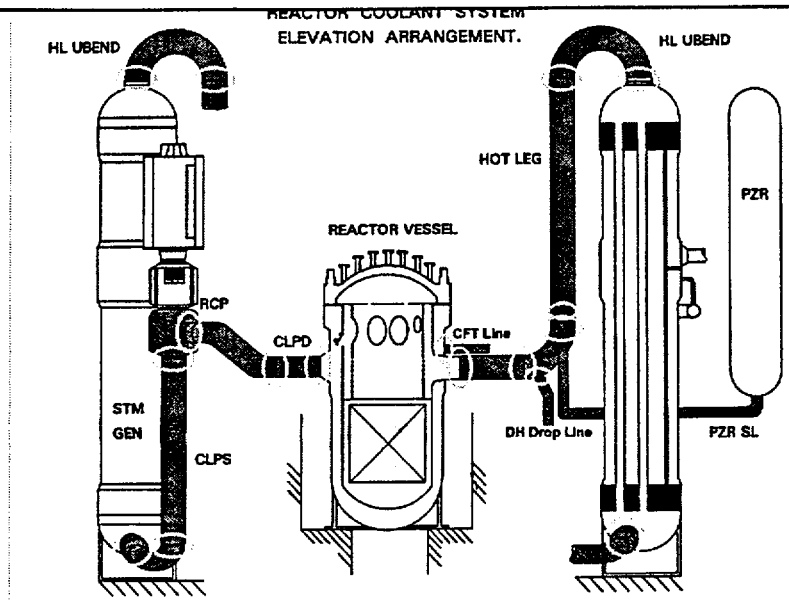
- 1970's: Original Licensing Basis for SG Tube Loads
  - BAW-10027 MSLB & LOCA Loads
- 1980: BAW-10146, Thermal and Dynamic Loads for LBLOCA
- 1985: LBB Topical Report BAW 1847-1
- 1990: LBB Credited to Exempt SG Tubes from LBLOCA Loads
- PSC 2-98: Surge Line Break Tube Loads Established
- Identified in Davis Besse Condition Report, Feb. 2000
  - LBLOCA of BAW 10027 Cited in SAR
- B&WOG, B&WOG/NRC Conference Calls 3/7 - 3/17
  - NRC Believes B&WOG Application was Not Appropriate

Proposed Resolution

- Submit Request to Exclude Postulated Breaks in Large Bore Piping From SG Design Basis for Existing and Replacement SGs.
  - Tubes
  - Repair Hardware and Processes
    - » Repair Rolls, Plugs, and Sleeves
  - Internals
  - Shell
  - Supports
- Risk-Informed Approach per Reg. Guide 1.174
- Submit and Approve for Use Prior to Fall Oconee-1 Outage

Postulated LOCA Categories

- Hypothetical LOCAs are used for:
  - Sizing Emergency Core Cooling System Flow Rates
  - Setting Core Operating Limits
  - Mass and Energy Release Rates for Containment Building Design
  - Equipment Qualification Pressure/Temperature Envelopes
  - Developing Guidance for EOPs
    - » (Basis: Pipe Breaks of Any Size or Location)
  - Component and Piping Stress Analyses
    - » (Basis SRP 3.6.2 June 87: Pipe Terminal Ends, Locations Where Cumulative Usage Factor Exceeds 0.1, and Pipe Locations Where Primary Plus Secondary Stresses Exceed 2.4 Sm.)

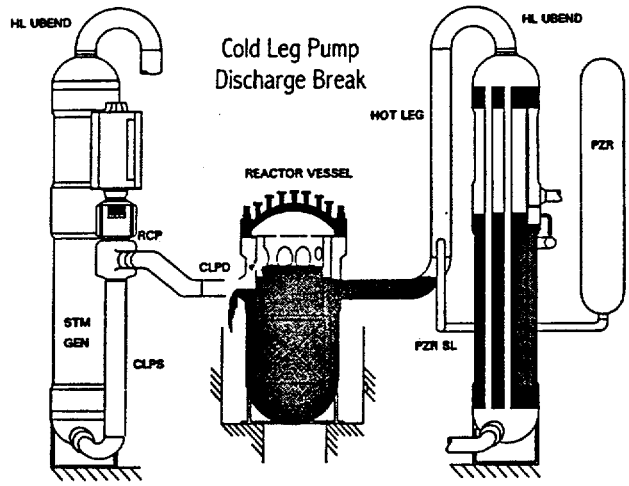


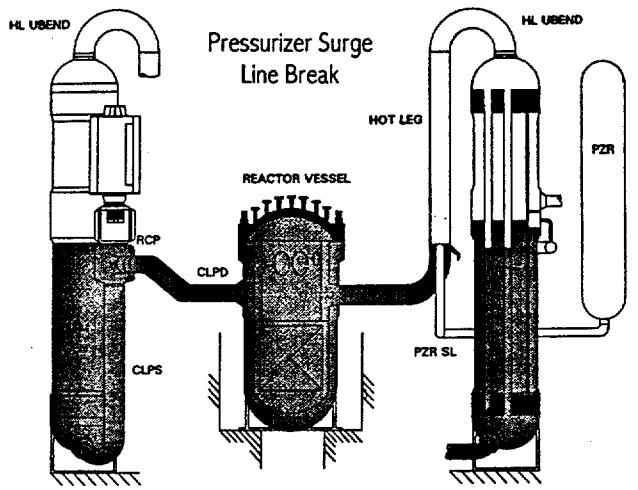
Postulated LOCA Sizes and Locations

- LOCA consequences used for stress analysis have employed deterministic fracture mechanics to define the type of break and locations defining bounding component design parameters.
- Risk-informed decisions based on LOCA size and location can also be used as a coherent and consistent process for establishing the boundary conditions used in component or design engineering analyses.

SG Tube Load LOCA Consequences

- The ECCS systems (HPI, CFT, and LPI) are sized to supply makeup flows adequate to remove the core stored energy, decay heat generation, and refill the core and vessel following a LOCA.
- Any ECCS in excess of that needed to refill the core is available to refill the RCS at a rate proportional to the excess ECCS flow rate.
- The break location and size determine the RCS refill by providing a discharge path that can limit the RCS refill levels.
  - Large CLPD breaks can limit refill to the vessel
  - Large CLPS breaks can refill the vessel, CLPD pipes, intact CLPS pipes, and a portion of the SG tubes
  - Large lower hot leg breaks limit refill to vessel, cold legs, and a portion of the SG tubes
  - Upper hot leg breaks can refill the entire RCS





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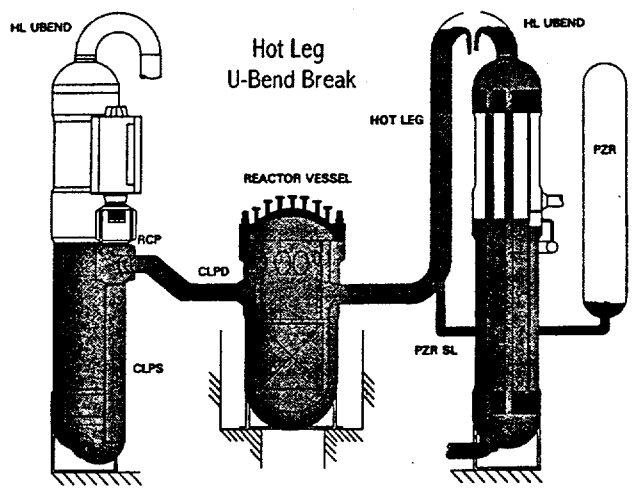

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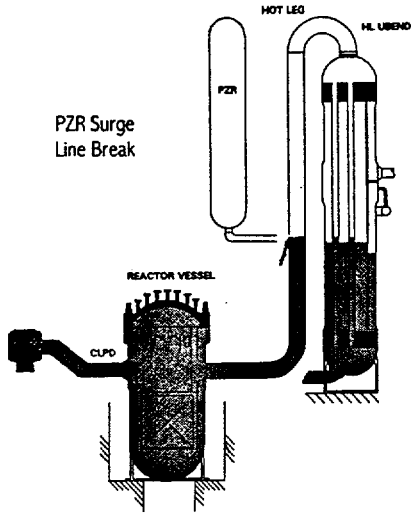
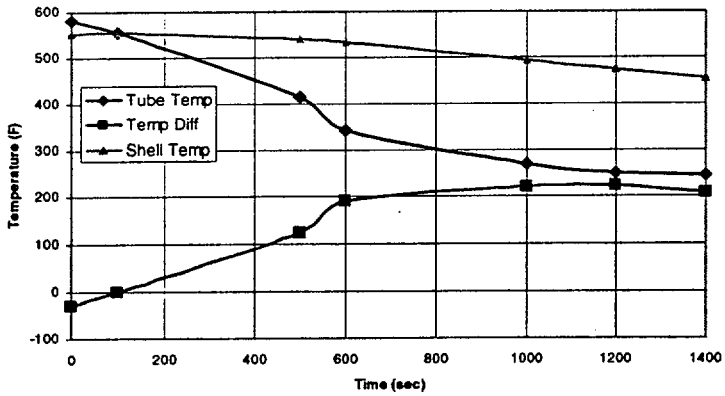
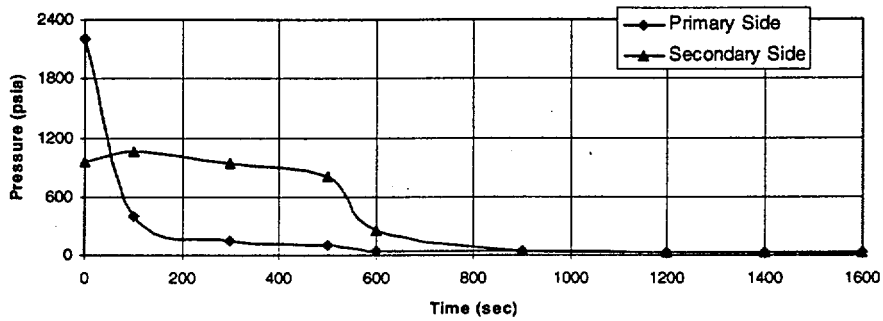
177FA Raised Loop Plant



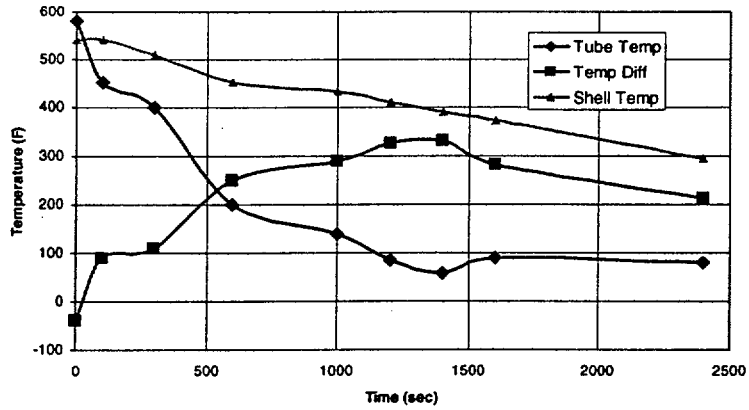
177 FA Pressurizer Surge Line Break Tube and Shell Temperatures versus Time



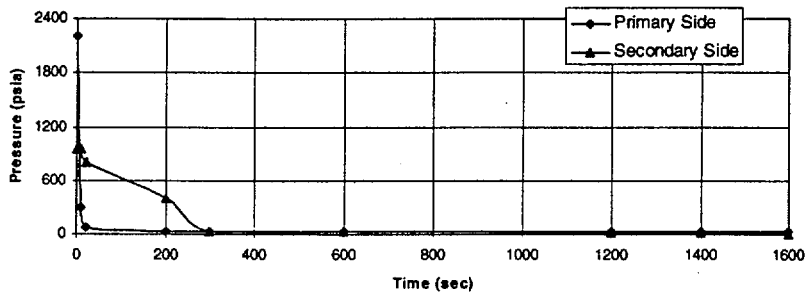
177 FA Pressurizer Surge Line Break Primary and Secondary Side Pressures vs Time



Estimated Upper Hot Leg Break Tube and Shell Temperatures versus Time



Estimated Large Hot Leg Break Primary and Secondary Side Pressures vs Time



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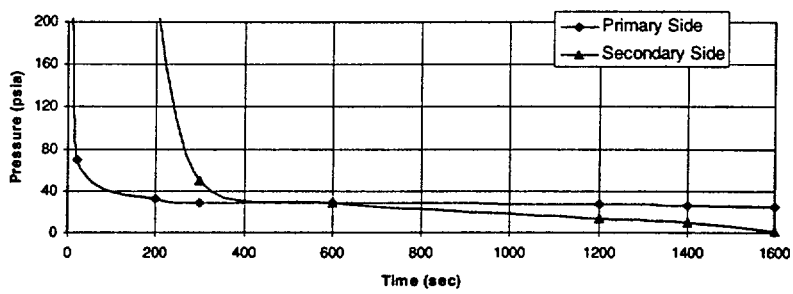

LOCA Tube Load Conclusions

- The highest tube-to-shell temperature differences are produced by postulated large bore upper hot leg breaks.
- Use of a risk-informed process will eliminate postulated large bore upper hot leg breaks from consideration.
- The attached piping breaks (i.e, previously analyzed pressurizer surge line break) can be used to define the SG design basis loads.

Generic Operability

- Time of Maximum –T Corresponds to Time of Low Primary to Secondary –P
- Current S/G Tube Conditions do not Result in Offsite Dose Consequences Greater Than Currently Analyzed Plant Specific Events
  - Based on Qualitative Assessments
- ECCS Performance Acceptable for All Break Locations
- Secondary-to-Primary Leakage Not a Boron Dilution Problem

Key Principles For Risk-Informed Licensing Basis Changes (from RG 1.174)

- Impact can be Monitored Using Performance Measurement Strategies
- Increase in CDF or Risk is Small
- Change is Consistent with Defense in Depth Philosophy
- Change Maintains Sufficient Safety Margins
- Meets Current Regulation Unless Exemption is Requested

Risk Assessment

- Two LOCA-induced SGTR Scenarios to consider:
  - Scenario #1:

    LOCA with SGTR, secondary side isolation failure, eventual loss of sump inventory through secondary side, core damage, no large early release
  - Scenario #2:

    LOCA with SGTR, failure of LP recirculation, core damage, secondary side isolation failure, large early release

Risk Assessment

- LOCA-induced SGTR, Scenario #1:
  - LOCA with SGTR, secondary side isolation failure, core damage due to eventual loss of sump inventory through secondary side
- Failures required for increase in CDF
  - LOCA
  - Break is in specific location
  - Gross SG tube pressure boundary damage
  - Secondary side isolation failure and gradual loss of inventory via MS Safeties or BOP
  - ECCS failure due to operator failure to prevent sump inventory depletion
- No increase in LERF (is not a large early release)

Risk Assessment

- LOCA-induced SGTR, Scenario #2:
  - LOCA with SGTR, CDF due to failure of LP recirculation, LERF due to SGTR and secondary side isolation failure
- No increase in CDF (already included in CDF)
- Failures required for increase in LERF:
  - LOCA
  - Break is in specific location
  - Gross SG tube pressure boundary damage
  - ECCS failure upon switchover to recirculation mode
  - Secondary side isolation failure
  - Large unscrubbed release pathway in secondary side/BOP

Initiating Event Frequency

- Break location of concern is limited to 36" ID pipe in Candy Cane above elevation of surge line
- Use INEEL method (NUREG/CR-5750) for frequency of LOCA in large pipe
  - Beliczey and Schulz Correlation (supported by LLNL, PNNL, SKI)
  - $\lambda_R = \lambda_{TW} (P_{R/TW})$
- λ_R = 8E-7/year

Consequences

- ΔCDF consequence requires loss of primary inventory
- ΔLERF consequence requires large release pathway
- Both require (unlikely) gross failure of pressure boundary
- Assume worst case
  - Conservatively assume probability of gross OTSG pressure boundary damage =1.0

Consequences (continued)

- No driving force (ΔP) for primary-to-secondary leakage through failed tubes
- ΔP reaches equilibrium
- No sustained tube leakage unless coincident failure of secondary side isolation
- Estimated secondary side isolation failure probability $\cong 0.01$

Consequences (continued)
For Sequence 1 Only

- Time to deplete primary inventory is dependent upon
  - » OTSG leak rate
  - » BOP leak rate (downstream of isolation failure)
- Operator recovery action is likely before depletion of sump inventory/core damage
- Assume conservative human error probability $\cong 0.1$

ΔCDF (Sequence #1)

Failure	
• LOCA in candy cane	• 8E-7/ year
• OTSG gross damage	• 1.0 (conservative)
• Secondary isolation fails	• 0.01
• Recovery actions fail to prevent core damage before LPR failure	• 0.1 (conservative)
	≤8E-10/year

Consequences: LERF

- LERF Sequence (Sequence #2):
  - LOCA in upper hot leg
  - Independent failure of LP recirculation
  - Core damage around time of recirculation switchover
  - LOCA-induced SGTR occurs around the same time
  - Secondary side isolation failure
  - Large unscrubbed airborne release pathway through secondary side/BOP
- Would take many tube failures to be classified as LERF
- Conservatively assume conditional probability of large release ≅ 0.1

ΔLERF (Sequence #2)

Failure	
• LOCA in candy cane	• 8E-7/ year
• OTSG gross damage	• 1.0 (conservative)
• LP Recirculation failure	• 0.05 (bounding)
• Secondary isolation fails	• 0.01
• Conditional phenomenological probability of large release	• 0.1 (conservative)
	≤ 4E-11/year

Risk Assessment Results

- According to Reg. Guide 1.174, this is "very small" risk increase
  - ΔCDF ≤ 8E-10/year
  - ΔLERF ≤ 4E-11/year
- ΔCDF/ΔLERF estimated with conservative assumptions

Defense-in-Depth

- Balance between prevention and mitigation is preserved
- System redundancy, independence, diversity is preserved
  - » Many failures must occur for large release consequence
    - LOCA with break in specific location
    - Gross SG tube pressure boundary damage
    - LP Recirculation failure
    - Secondary side isolation failure
    - Large unscrubbed release pathway in secondary side/BOP

Defense-in-Depth (Continued)

- Over-reliance on programmatic activities is avoided
  - » Tube inspection and evaluation programs are unchanged
- Defenses against Common Cause Failures are preserved
  - » No new CCFs are introduced
- Independence of barriers is not degraded
  - » Insignificant Effect Based on Low Frequency
- Defenses against human errors are preserved
  - » No changes in automatic vs. manual operation of safety systems
- Intent of GDC in Appendix A of 10CFR50 is maintained
  - » 10CFR50 compliance unaffected

SAFETY MARGINS

- For large bore hot leg breaks, the uncertainty associated with the effect on SG tubes does not significantly impact risk
  - » Risk increase is "very small" even with conservative assumption that failure of SG tube integrity is certain
- Safety margins are preserved for other events
  - » Proposal Meets Established Codes and Standards
  - » Proposal Meets Safety Analysis Acceptance Criteria
  - » Existing Deterministic Analyses are unaffected

SUBMITTAL SCHEDULE

Expected LB LOCA Resolution Schedule

- Risk-Informed Submittal — June 30, 2000
- Requested NRC Approval of Approach — Sept. 29, 2000

SUMMARY

- Not an Operability or Safety Issue
- Reasonable approach to apply RG 1.174
  - Generically applicable to all of the existing and replacement OTSG's
  - Submittal will address address five key principles for risk-informed activities
- Risk of large bore upper hot leg breaks is very small and consequences are bounded by current analysis.
- NRC concurrence is needed prior to Fall outages
  - Avoid unnecessary plugging
  - Allow use of re-roll repairs and tube ARC's under current analysis.

Qualitative Bounding Assumptions

- Maximum ΔT is approximately 350 F
- Used pressurizer surge line LOCA analysis to estimate maximum tube loads
- ΔP across the tubes is 45 psia at maximum tube load
- Axial flaws
  - Assumed freespan
  - No decrease in flaw opening area due to axial load
  - Assumed 100 percent through-wall flaw
- Circumferential flaws
  - Assumed freespan
  - Assumed 100 percent through-wall flaw
- Total leak rate calculated based on representative SG is 4-5 gpm

CURRENTLY KNOWN APPLICATIONS OF LBB AT B&W PLANTS

- SG Tube Repair Criteria
- SG Tube Repair Hardware & Processes
  - Plugs, Re-rolls, ARC's
- RV Seal Plate Analysis
- Fuel Assembly Structural Analyses
- Removal of Pipe Supports & Whip Restraints
- Removal of SG Snubbers
- Oconee Replacement SG's