xLPR Update

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Current Maintenance Activities

- Version 2.4 is wrapping up
  - Addition of stainless steel SCC crack growth
  - Stability module corrections
  - Programmatic and testing upgrades
  - “Light” version to allow more runs out of the box
  - Expected release in late Summer 2025
- Supporting NRC work on xLPR Version 3

xLPR LBB Application Status

- All publications are complete
  1. Probabilistic Assessment of Leak-Before-Break Using xLPR-Methodology Development and Technical Basis (MRP-488)
  2. Correlating Deterministic Leak-Before-Break Methodology to an Analogous Probabilistic Framework (MRP-467)
  3. Application of xLPR to Small Diameter Piping Nozzles with Dissimilar Metal Butt Welds Susceptible to Primary Water Stress Corrosion Cracking

Provided needed insights into the impact of PWSCC on LBB and is being relied upon for the high burnup fuel ALS work

Includes thorough discussion of welding residual stress applicability to the industry

Estimation of LOCA Frequencies (MRP-480)

- xLPR used to support alternative fuel licensing strategy (ALS) for high-burnup fuels
  - Evaluate probability of LOCAs as a function of line size
  - Evaluate if leakage would be detected in sufficient time prior to piping rupture
    - Demonstrating further defense in depth

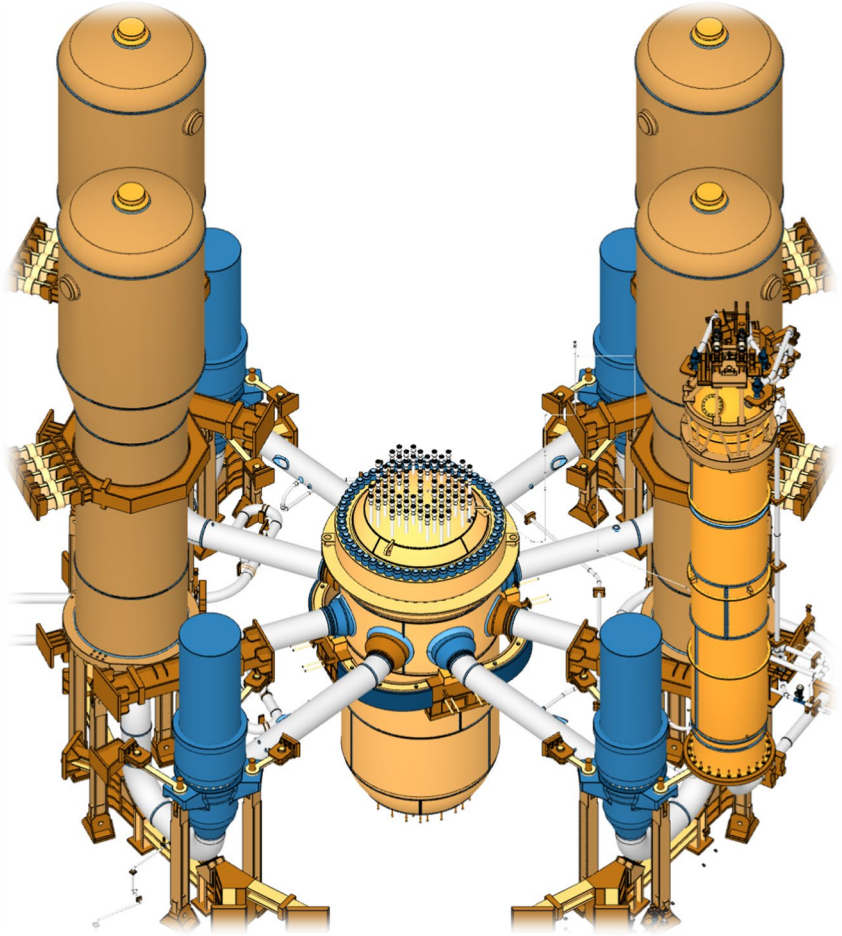
- Submitted to NRC as a Topical Report

Estimation of LOCA Frequencies (MRP-480)

- NRC audit took place the week of April 21st
  - EPRI found the audit to be useful for ensuring a more thorough understanding of MRP-480 before RAIs were issued
- RAIs have been received and EPRI is working on responses
  - A workshop will be proposed to address seismic and performance monitoring concerns

xLPR Application to Reactor Vessel Outlet Nozzle (RVON – Hot leg) Inspection Schedule

- Perform PFM evaluation of unmitigated dissimilar metal (DM) butt welds at hot leg temperatures
- Estimate the impact of the addition of one year between inspections for Code Case N-770
  - 5-year interval to a 6-year interval
- The component of interest is the Reactor Vessel Outlet Nozzle (RVON) for 7 units

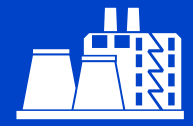


Tiered approach for analysis

01 **Fleet Analysis**
Unlikely to produce passing results but important reference run.

02 **Bounding applicable plant analysis**
Maximum temperature and maximum individual membrane and bending stress

03 **Plant specific analysis**
Use individual stresses.



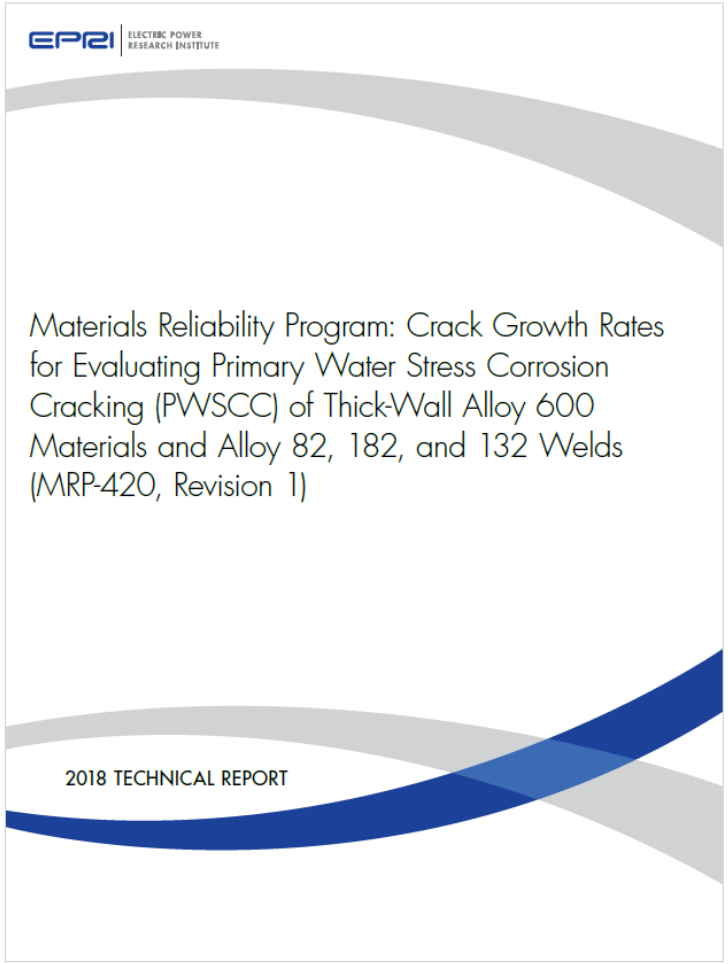
04 **Sensitivity Studies**
Exploring the impact of different input assumptions.

Fleet Analysis for reference run

Reference values for RVON from the xLPR database:

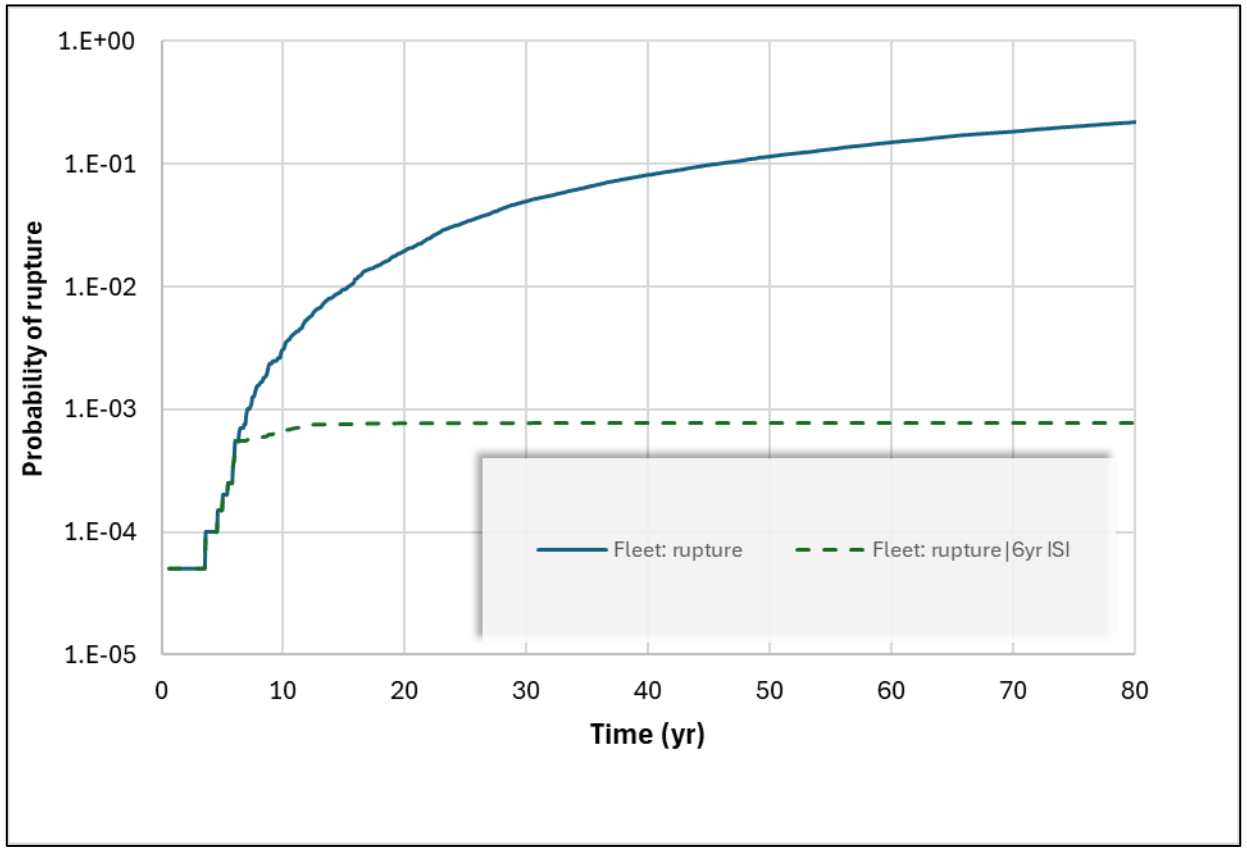
- Temperature 329.4°C
- Pressure 15.5 MPa
- Bounding stresses:
  - DW
  - Thermal
- Generic RVON WRS from xLPR database

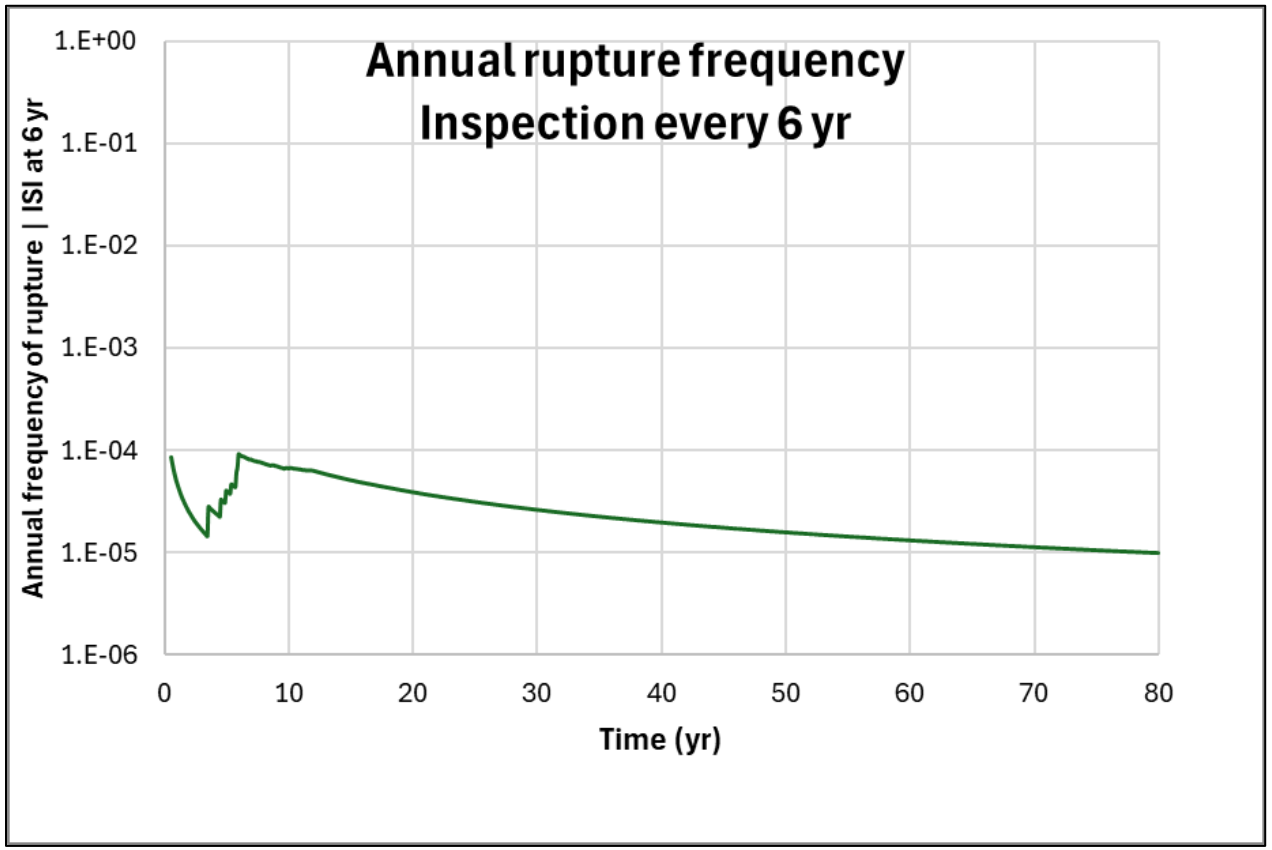
- Crack growth rate parameters based on MRP-420
- Sample size set to 20,000



RVON Fleet analysis results

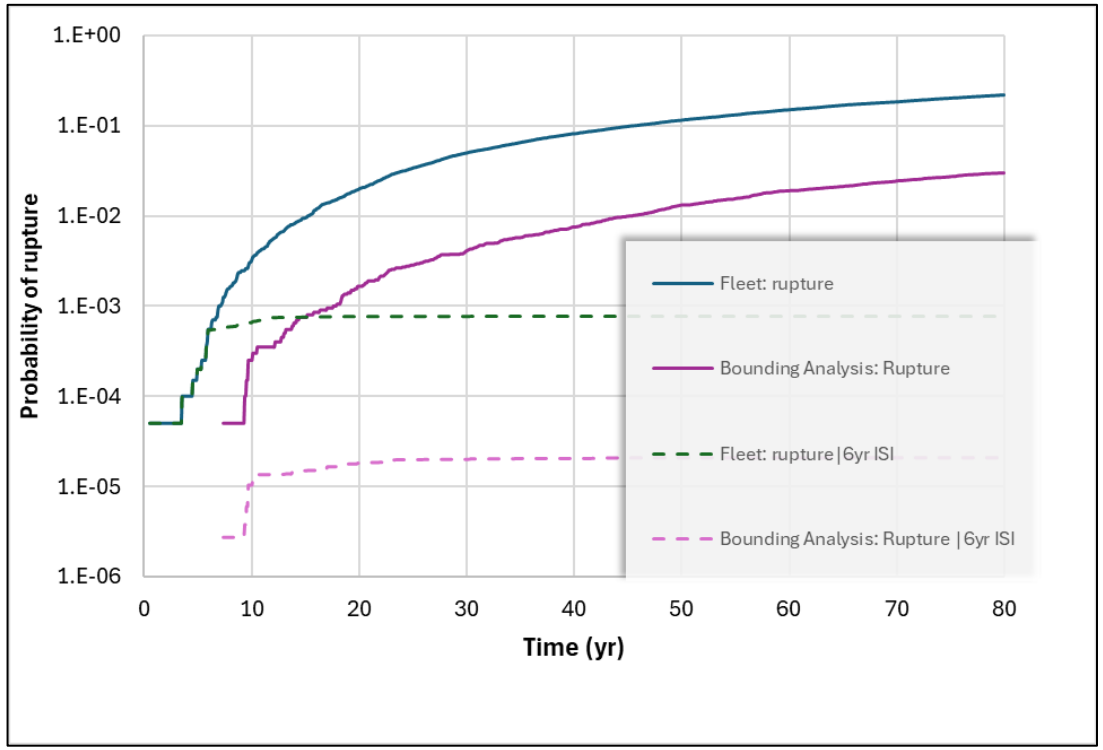
- Probability of rupture with and without ISI

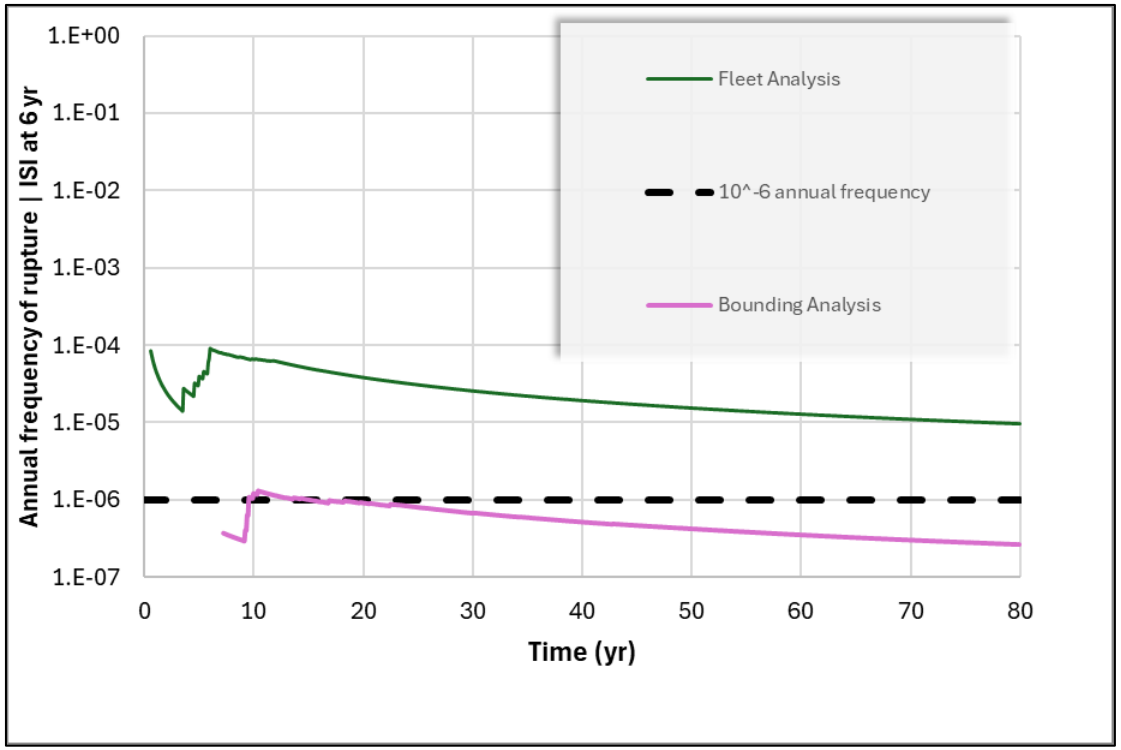




Bounding plant analysis results

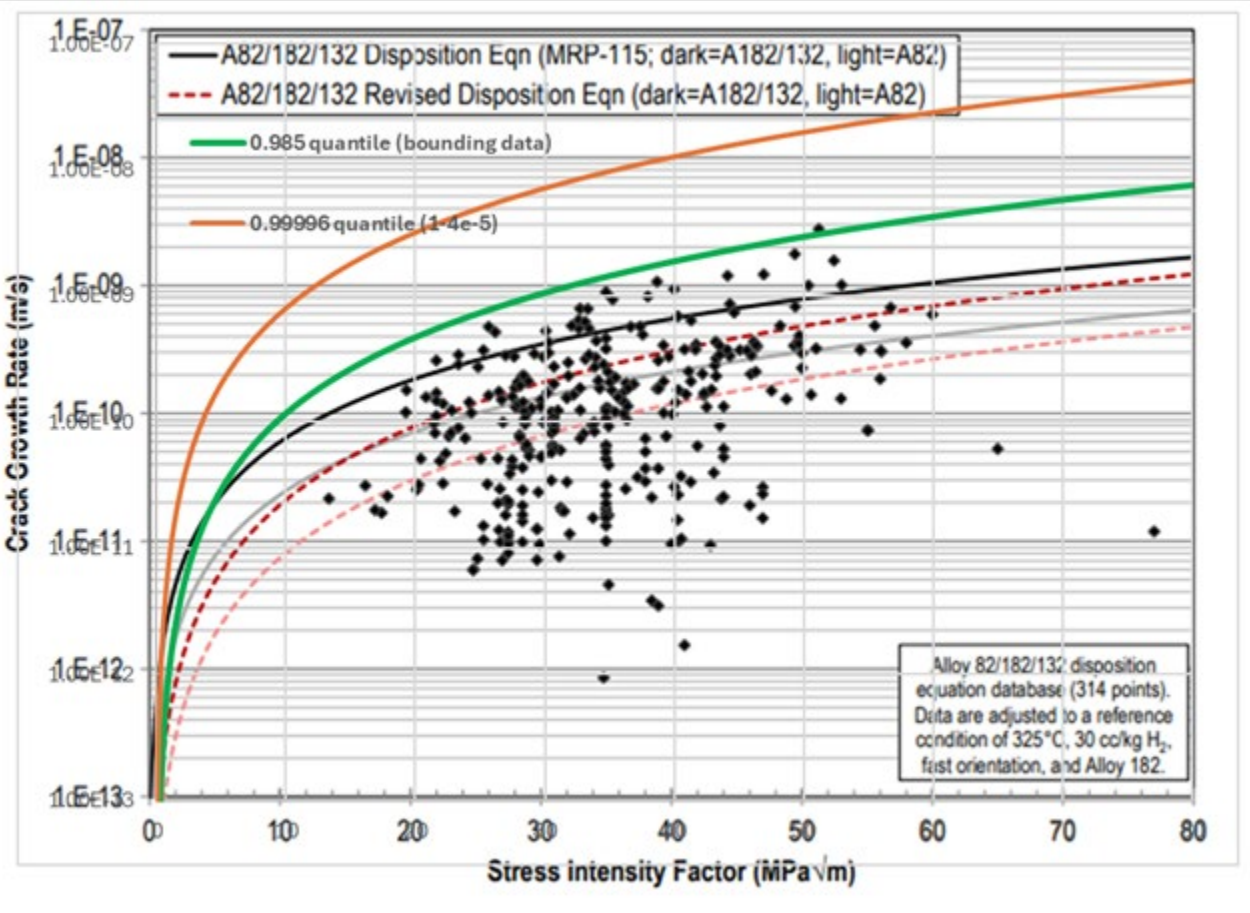
- Bounding analysis reduced probability by more than an order of magnitude
- Similar reduction on annual frequency
- But sample size still only 20,000





Conclusions and Remarks

- Analyses are ongoing
  - Initial PFM Evaluations show that the addition of one cycle between inspections would be reasonable – More Work To Do
- The results are still based on conservate assumptions such as:
  - The use of unbounded crack growth rate parameters can be very conservative when large samples are used
  - Crack initiation not accounted



Future Project: xLPR Application for Stainless Steel SCC

- Based on new available tools in xLPR v2.4, perform evaluation of potential impact of stainless steel SCC on LOCA frequencies
  - Build upon NRC LIC-504 analyses
- Significant international interest

White Paper on PFM Acceptance Criteria

Background

- PFM analysis has become an essential tool for licensees as risk-informed submittals become more prevalent
- Determination of appropriate acceptance criteria is a key component of analyses as well as regulatory review
- NRC has provided guidance on acceptance criteria for risk-informed applications in terms of core damage frequency (CDF) and large early release frequency (LERF) in RG 1.174
- Licensees have successfully leveraged PFM to demonstrate the incremental change in CDF resulting from licensing basis changes is less than 1×10^{-6}/yr
  - The 1×10^{-6}/yr criterion has been widely applied but is not the only appropriate criterion
  - Failure of components analyzed by PFM may have conditional core damage probabilities less than 1

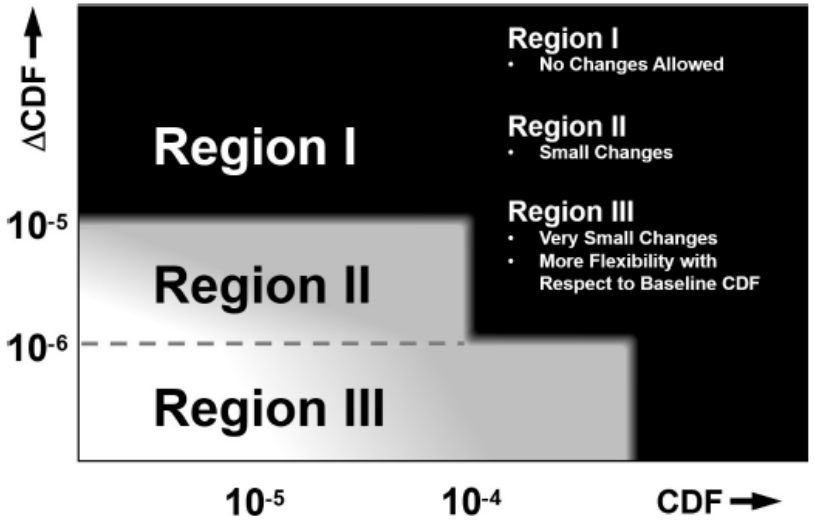


Figure 4. Acceptance guidelines* for core damage frequency

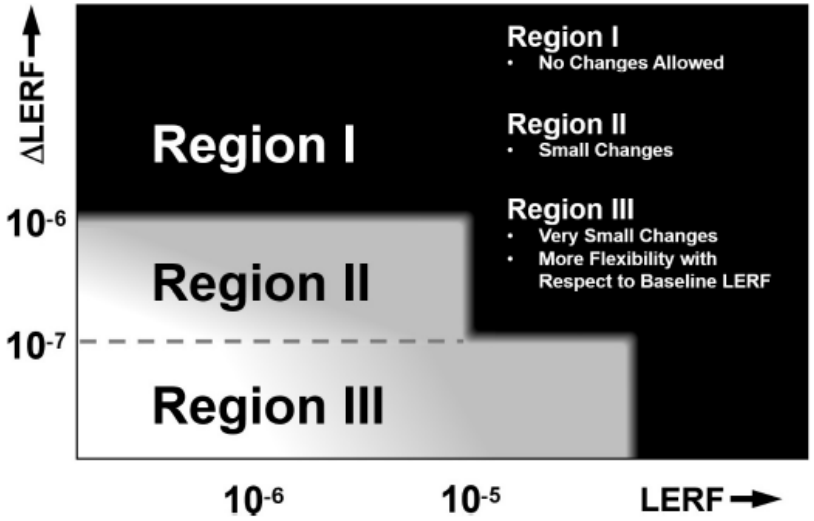


Figure 5. Acceptance guidelines* for large early release frequency

Objectives

- Review the available guidance from both the NRC and international stakeholders on appropriate acceptance criteria for PFM analyses of passive piping components
- Review the methodology for leveraging PFM to produce initiating event frequencies that can readily be applied in PRAs
- Review both U.S. and international experience with PFM analyses
  - Focus on applied acceptance criteria, basis for application, and associated the regulatory position
  - Applications include RPV PTS analysis, RI-ISI, CASS flaw tolerance, and Alloy 600/82/182 PWSCC evaluations
- Characterize the range of previously applied PFM acceptance criteria applied for various analysis outputs

White Paper Outline

- Introduction and Background
- NRC Guidance on PFM Acceptance Criteria
- International Guidance on PFM Acceptance Criteria
- Review of U.S. PFM Experience
- Review of International PFM Experience
- Conclusions

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