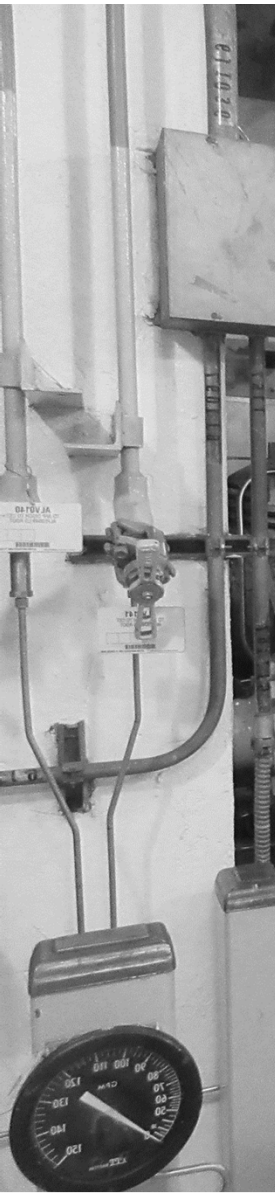

June 14, 2022

Example xLPR LOCA Frequency Estimate Compared to NUREG Expert Elicitation Results

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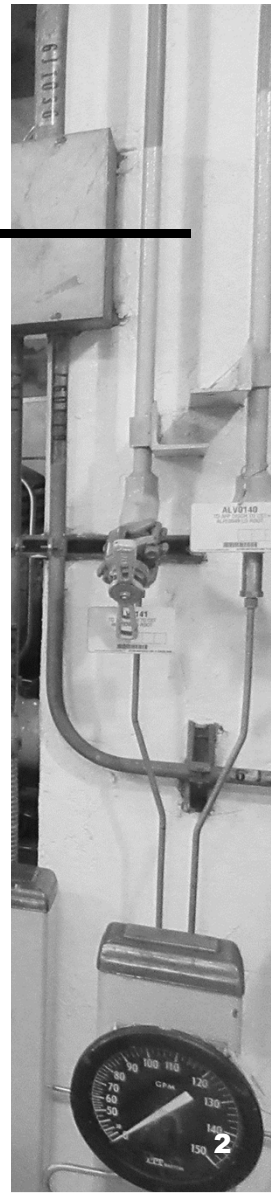
Objective and Approach

- Explore use of the Extremely Low Probability of Rupture (xLPR) probabilistic fracture mechanics code to generate loss-of-coolant accident (LOCA) frequency estimates and compare those estimates with the expert elicitation results from NUREG-1829

- Review data and assumptions from NUREG-1829
- Develop best-estimate xLPR inputs using latest data as applicable
- Generate component-level LOCA frequency estimates from xLPR simulation and compare to NUREG-1829 base case results
- Aggregate xLPR component-level estimates to arrive at system-level estimate and compare to NUREG-1829 expert elicitation results for piping system



Inputs and Modeling Assumptions

Westinghouse Reactor Pressure Vessel (RPV) Outlet Nozzle Dissimilar Metal Weld (DMW) Analysis

> Data re-used from NUREG-1829

- Component geometry
- Capacity factor (80%)
- LOCA definitions:

LOCA Category	Leak Rate (LR)	Crack Opening Area (COA)
1. Small-break (SB)	100 gpm	0.196 in^2
2. Medium-break (MB)	1,500 gpm	1.77 in^2
3. Large-break (LB)	5,000 gpm	7.07 in^2

> New data as compared to Dave Harris analysis

- Material properties (similar)
- Loads
- Initial crack size (slightly deeper)
- Leak rate detection (1 vs. 5 gpm)
- Plant operation (80 vs. 60 years)
- Welding residual stresses (included with uncertainties)
- Different inservice inspection schedule (more inspections) and probability of detection (details on Slide 11)

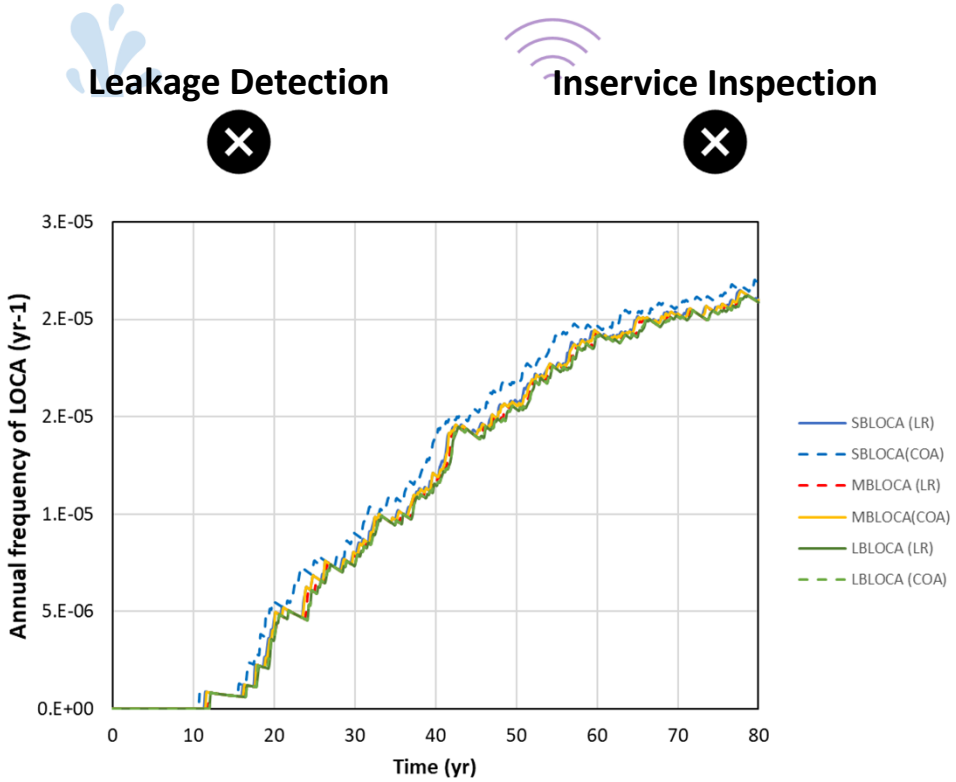
> Notable modeling assumptions

- No fatigue, only primary water stress-corrosion cracking
- Use crack initiation model
- No mechanical mitigation
- Circumferential cracks only

xLPR Westinghouse RPV Outlet Nozzle DMW LOCA Estimates

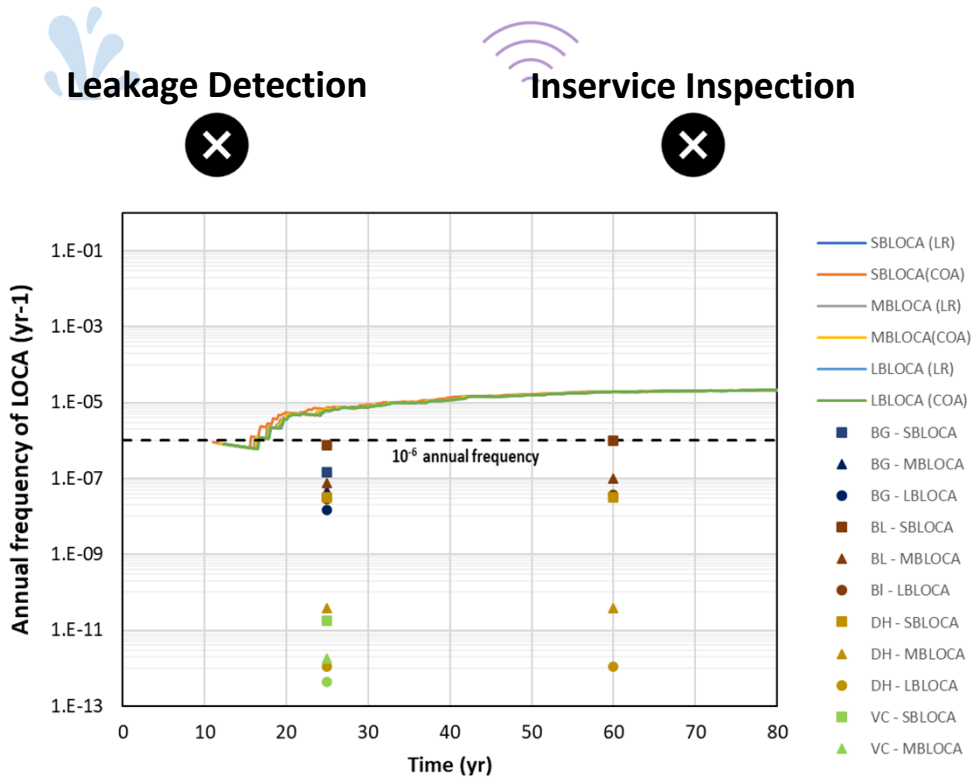
SMALL variation among SB, MB, and LB LOCA estimates

MORE variation from LOCA definition (i.e., LR vs. COA)



xLPR Results vs. NUREG-1829 PWR-1 Base Case (1 of 3)

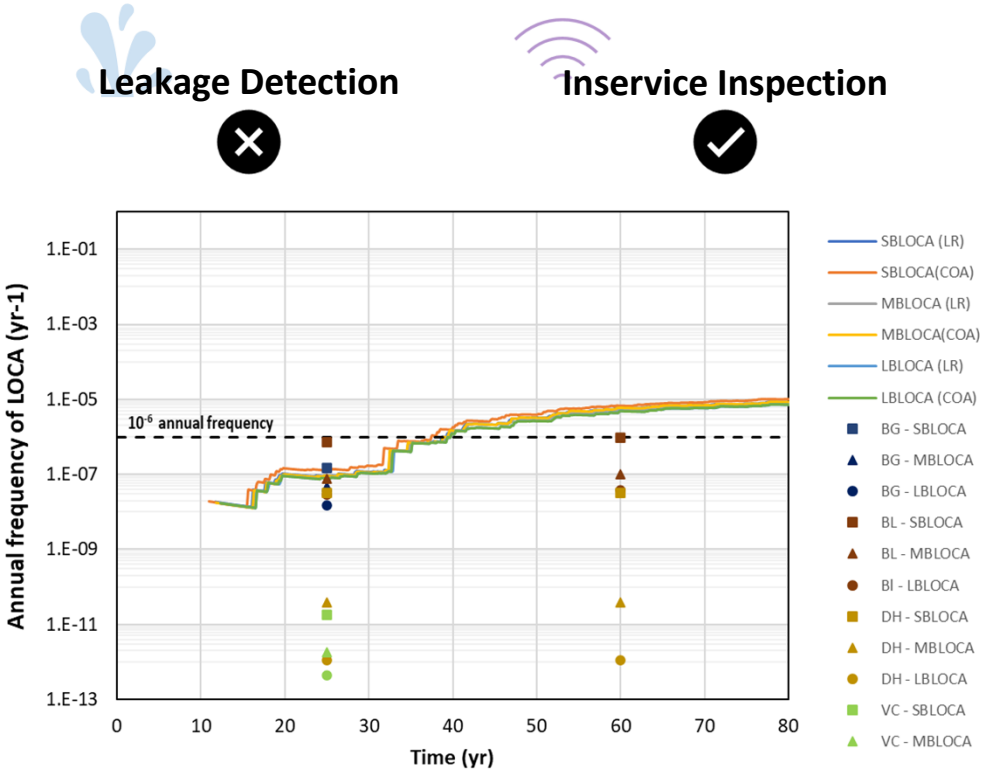
- xLPR estimates are higher, as expected
- Much more variation among NUREG-1829 estimates



xLPR Results vs. NUREG-1829 PWR-1 Base Case (2 of 3)

At **25 years**, the xLPR results are within the range of the NUREG-1829 estimates

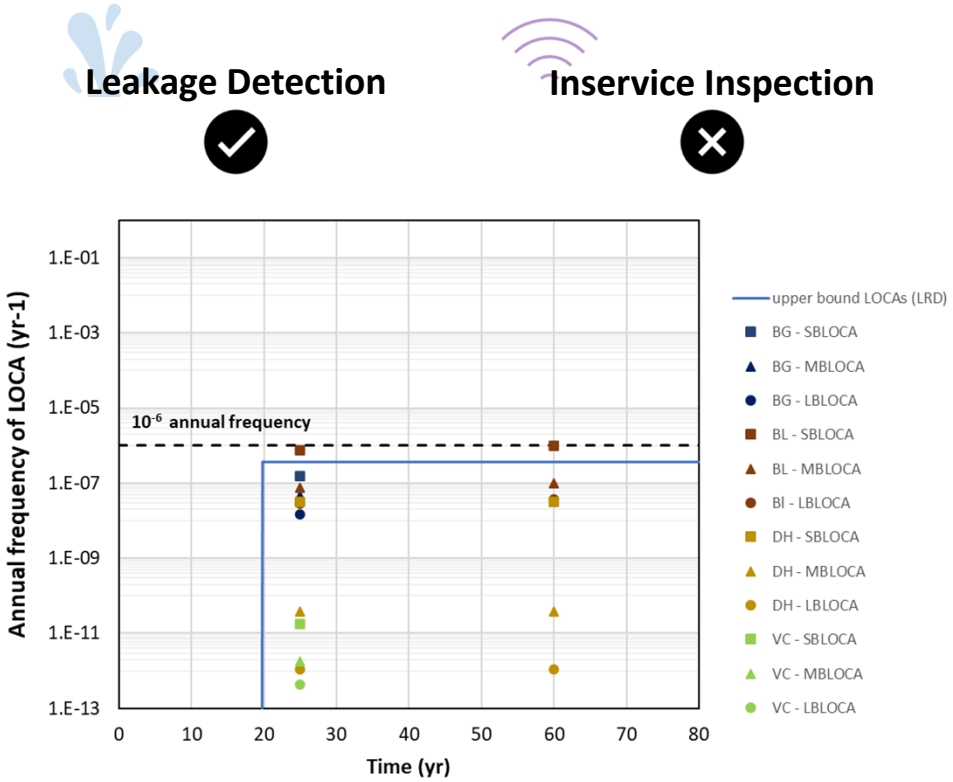
At **60 years**, the xLPR results show a higher increase relative to the NUREG-1829 estimates



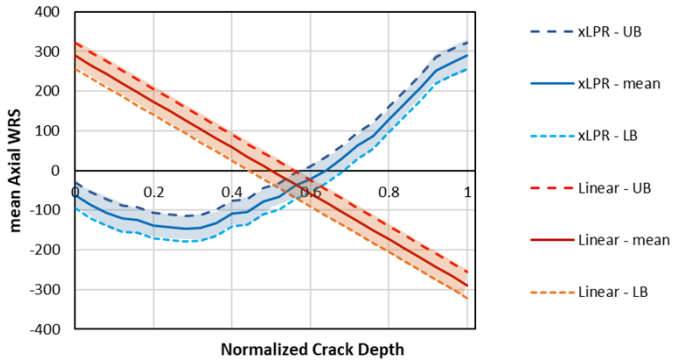
xLPR Results vs. NUREG-1829 PWR-1 Base Case (3 of 3)

NO LOCA EVENTS in xLPR simulation with a sample size of 100,000 realizations

UPPER-BOUND estimated using “rule of 3” approach consistent with NUREG/CR-7278, Section 4.3.6.4

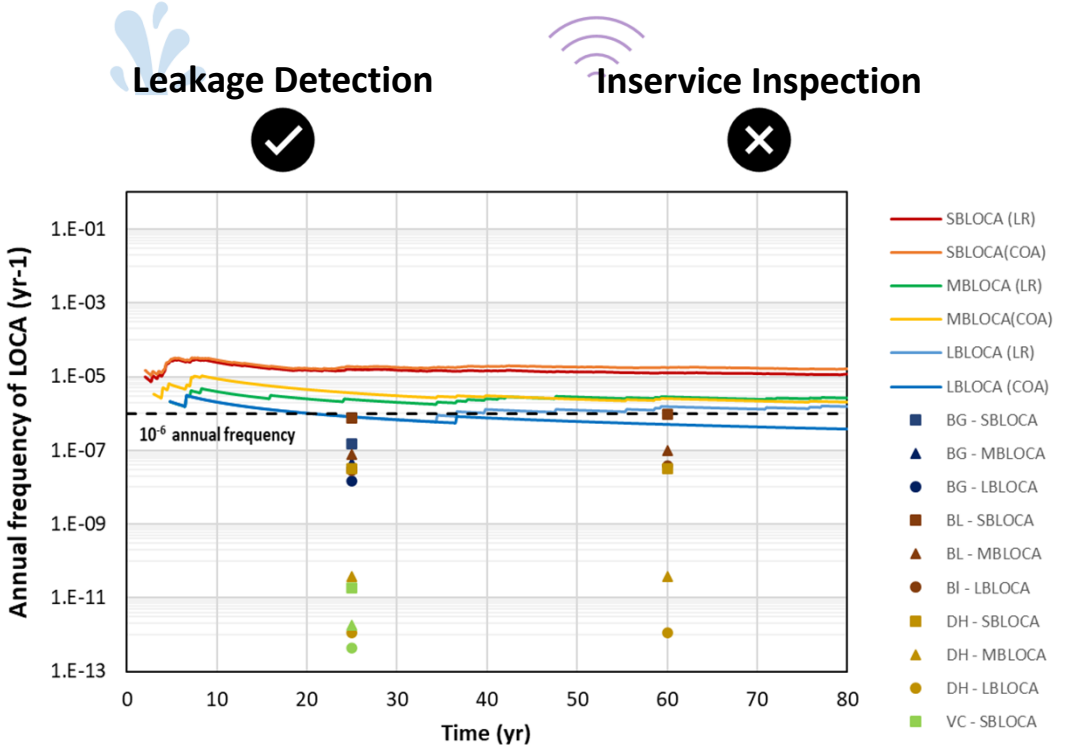


Weld Residual Stress (WRS) Sensitivity Study Results



WRS Profile Comparison

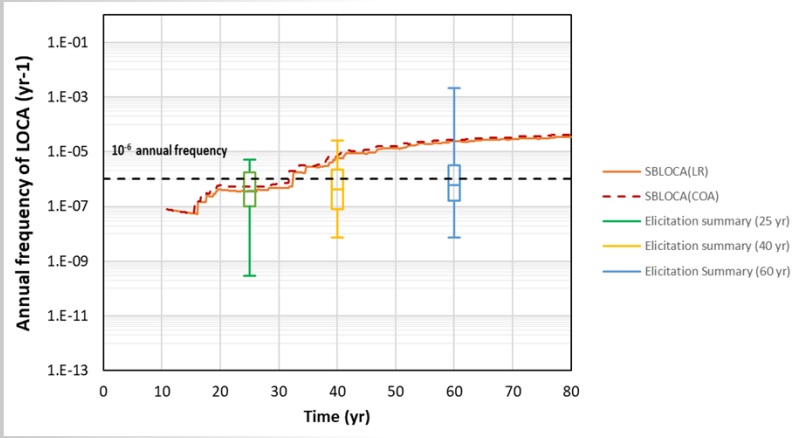
> Linear WRS profile is unrealistic



xLPR Results with Linear WRS Profile

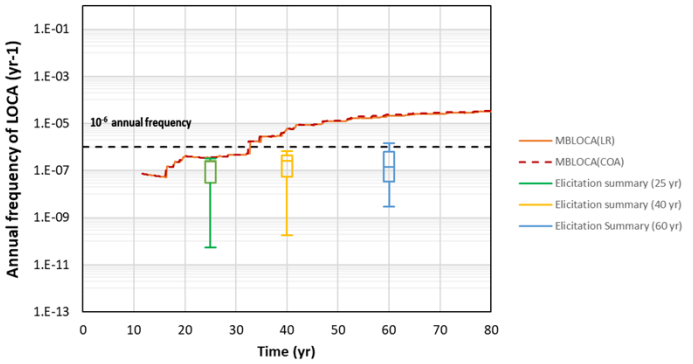
xLPR Results vs. NUREG-1829
PWR Hot Leg Expert Elicitation

Westinghouse RPV Outlet Nozzle DMW x **4**

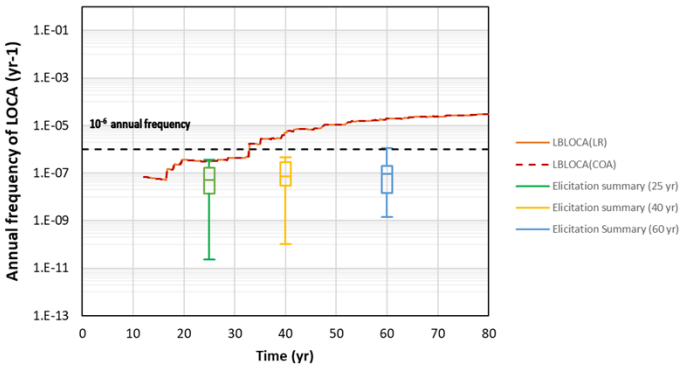


SBLOCA Results

MBLOCA Results



LBLOCA Results

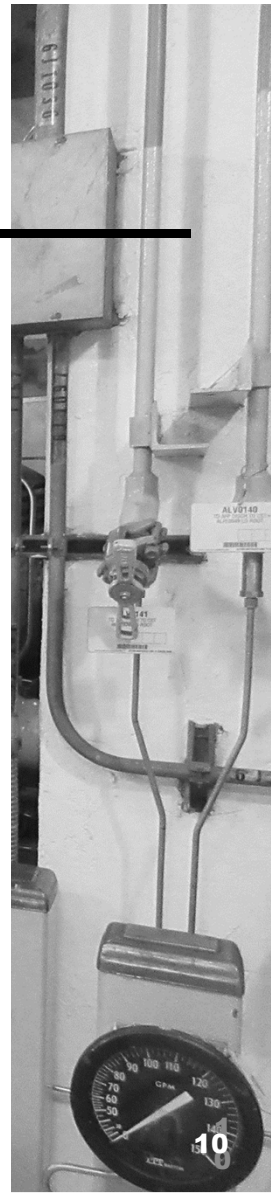


Leakage Detection ✗

Inservice Inspection ✓

Key Observations

- The xLPR code can be used to develop system- or plant-level LOCA frequency estimates using current capabilities
- The LOCA frequency estimates results are sensitive to the modeling inputs and assumptions, and these sensitivities can be studied
- Leak rate detection has a significant impact



Supporting Information - Probability of Detection Curve Comparisons