Risk-Informed Changes to § 50.46a: Large-Break LOCA Redefinition

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Risk-Informed Changes to § 50.46a

- Motivation
  - Enable licensees to reduce plant risk by optimizing safety system operation
  - Permit plant changes that insignificantly increase risk while assuring that adequate safety margins and defense-in-depth are retained
- Rulemaking Objectives
  - Develop voluntary, risk-informed alternative to the current design basis loss-of-coolant accident (LOCA) break size
  - Create broad rule that allows operational as well as design changes for existing nuclear power plants
  - Remove reactor coolant breaks with a frequency of less than 1 occurrence in every 100,000 (1E-5) reactor-years from the design basis
  - Require licensees to maintain capability to mitigate LOCAs up to the current design basis DEGB

General Approach

- Develop technical basis to support risk-informed revision of design basis break size
  - Determine passive system failure frequencies associated with normal operational service history over expected design life (60 years) using expert elicitation.
  - Ensure seismic-induced failure frequencies remain sufficiently lower than elicitation results
- Choose new design basis break size
- Specify requirements for accident mitigation beyond the new design basis break size
  - Thermal-hydraulic analysis
  - Proposed change process

Technical Basis Development

- Classical approaches
  - Operating experience: LOCA events are rare
  - Plant modeling: Number and disparity of possible failure modes is too complex to accurately model
- Expert Elicitation: Formal process for providing quantitative estimates for the frequency of physical phenomena when the required data is sparse or when the subject is too complex to adequately model
- Elicitation has been used at NRC previously.
  - Development of seismic hazard curves
  - Performance assessments for high-level radioactive waste repository
  - Determination of reactor pressure vessel flaw distributions

Expert Elicitation Approach

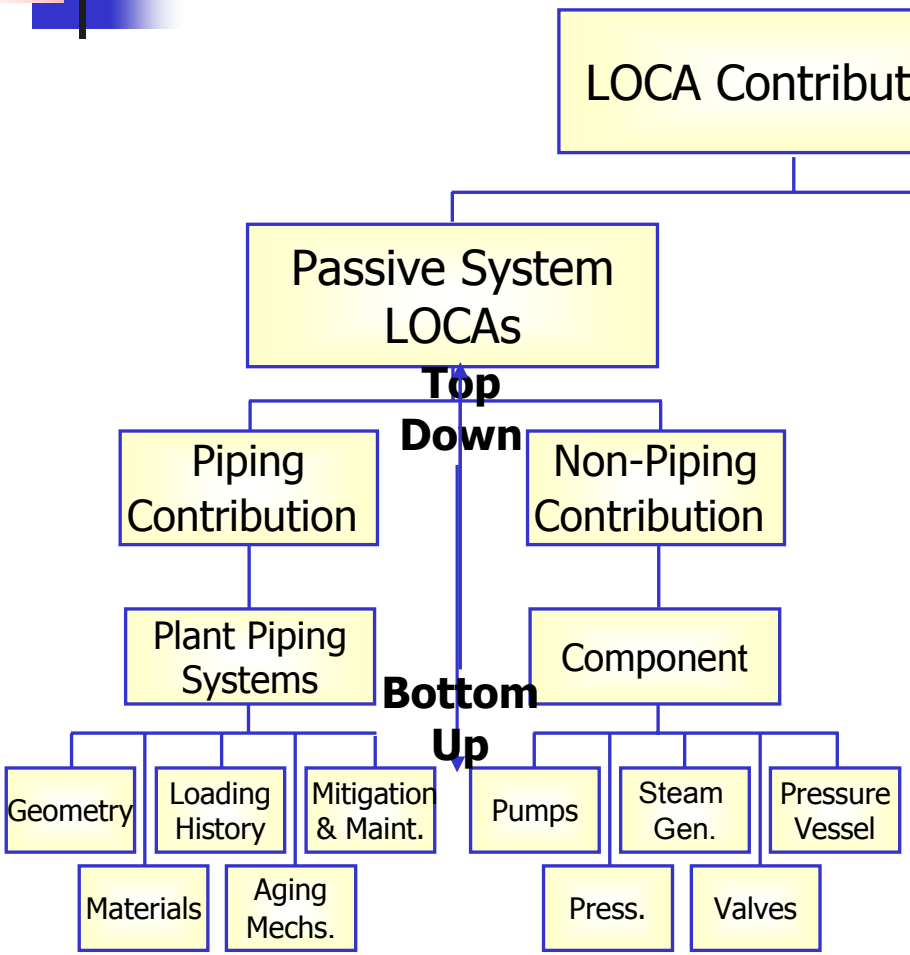
- Conduct preliminary elicitation
- Select panel and facilitation team
- Develop technical issues
- Quantify base case estimates
  - Develop quantitative estimates for well-defined piping conditions
  - Quantify non-piping precursors and targeted failure scenarios
- Formulate elicitation questions
- Conduct individual elicitations
- Analyze quantitative results and qualitative rationale
- Summarize and document results

LOCA Size Classification

- LOCA sizes based on leak rate to bin plant system response characteristics
  - First three categories similar to historical definitions (NUREG/CR-5750)
  - Three additional LB-LOCA categories added to determine larger break size trends up to DEGB
- Correlations developed to relate flow rate to effective break area
- Three time periods evaluated
  - Current (25 years of operation)
  - End of design life (40 years)
  - End of life extension (60 years)

Category	Flow Rate Threshold (gpm)	LOCA Size
1	> 100	SB
2	> 1500	MB
3	> 5000	LB
4	> 25,000	LB a
5	> 100,000	LB b
6	> 500,000	LB c

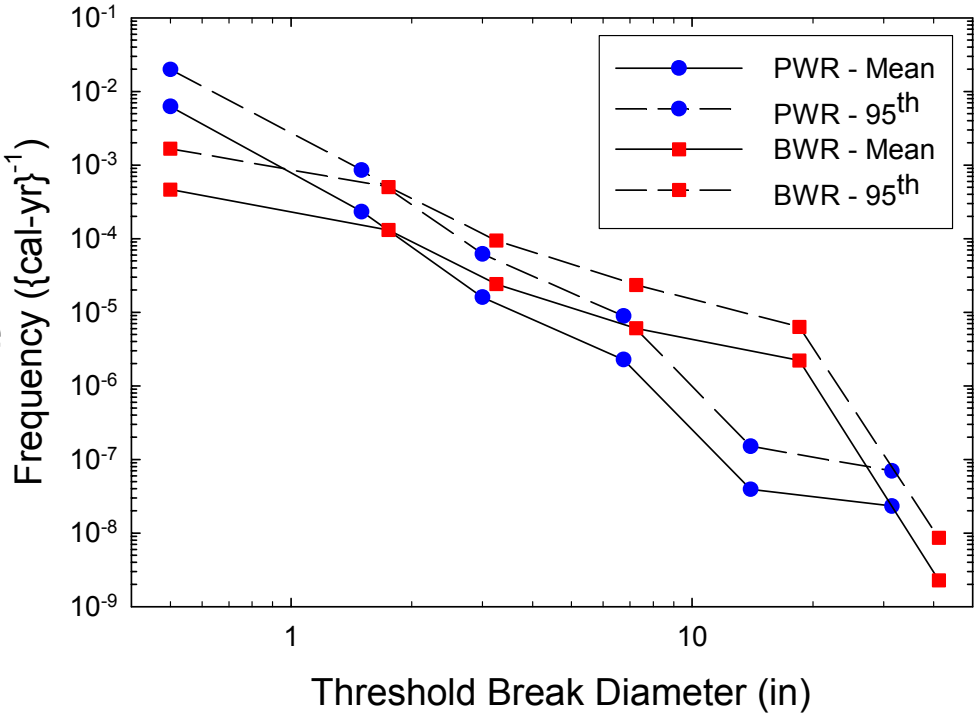
General Issue Classification



- Elicitation focused on passive system LOCAs.
- Important piping and non-piping variables identified.
- Elicitation structures supports top down and bottom up analysis.

Total LOCA Frequencies

- Boiling Water Reactors (BWRs)
  - Decreases are gradual with LOCA size
  - IGSCC is largest risk contributor
  - Only non-piping failures contribute to largest breaks
- Pressurized Water Reactors (PWRs)
  - Smallest LOCA frequencies higher due to steam generator and CRDM cont.
  - PWSCC is largest risk contributor
  - Non-piping frequency contributions important for largest LOCA sizes
- Frequencies significantly lower than WASH-1400 and comparable to NUREG/CR-5750



New Design Basis Break Size Selection Criteria

- Use expert elicitation results to determine break sizes with a frequency of 1E-5 (per reactor year) and less using 95th percentile estimates as starting point
- Increase break size to account for elicitation uncertainties and failure mechanisms not included in elicitation process (seismic loading, heavy load drop, rare water hammer loading)
- Account for other considerations (such as witnessed degradation in specific piping systems, specific pipe sizes)
- Promote regulatory stability; future break frequencies estimates not likely to change size selection
- New design basis called the Transition Break Size (TBS).

Selecting the Design Basis Break Size

- Elicitation results
  - BWR pipe sizes at 1E-05: 13 to 20 inches
  - PWR pipe sizes at 1E-05: 6 to 10 inches
- Seismic-induced failure is not significant unless large flaws present.
  - Crack depth < 40% of wall thickness ensures seismic failure frequencies less than 1E-5 (per reactor year) for most plants.
  - Induced piping failure caused by component support failure was less than 1E-6 (per reactor year) for two analyzed cases.
- TBS ultimately corresponded to the largest pipe sizes attached to the main reactor coolant loop.
  - Proposed TBS for BWRs: app. 21 inches
  - Proposed TBS for PWRs: app. 11 inches

Proposed Rule Summary

- Proposed rule divides the LOCA break size spectrum into two regions delineated by the TBS.
- Pipe breaks < TBS size
  - Analyzed by the methods, assumptions, and acceptance criteria currently used for LOCA analysis in 10 CFR 50.46
  - Evaluate single-ended break sizes up to TBS at the limiting RCS location.
- Pipe breaks > TBS size (up to DEGB)
  - Accidents can be analyzed using current 10 CFR 50.46 methods or by more realistic methods and somewhat relaxed acceptance criteria
  - Deterministic analysis assuming coincident loss of offsite power and a single additional failure is not required.
  - Mitigation capability for all LOCAs up to and including the DEGB of the largest RCS pipe shall be maintained.
  - Pending Regulatory Guide will identify detailed analysis considerations.

Proposed Rule Summary, cont.

- Change Control
  - Examine significant future changes to a facility, technical specifications, or operating procedures using risk-informed evaluation process
  - Governed by existing processes (if applicable) or by ensuring that plant changes involve acceptable changes in risk, maintain adequate defense-in-depth, and retain safety margins
  - Regulatory Guide 1.174 criteria used to determine acceptability.
- Backfit Considerations
  - The NRC will periodically evaluate LOCA frequency information. If estimated LOCA frequencies significantly increase, the TBS could be modified.
  - Licensee would need to modify or restore any previous plant changes invalidated because of a change to the TBS.

Application of Proposed Rule

- Plant designs may be no longer limited by certain acceptance criteria associated with previous DEGB analyses.
- Licensees could propose a wide scope of design or operational changes until limited by another acceptance criteria.
- Potential design or operational changes
  - Optimize containment spray designs
  - Modify core peaking factors
  - Optimize set-points on accumulators
  - Remove some accumulators from service
  - Eliminate fast starting of one or more emergency diesel generators
  - Increase power

Rulemaking Status and Schedule

- Proposed rule issued for pubic comment: November 7, 2005
- Public comment period ended: March 8, 2006
- Meetings to discuss public comments: February, June, August 2006
- Draft final rule language posted on web: October 3, 2006
- Draft Federal Register notice: October 16, 2006
- Advisory Committee on Reactor Safeguards Review: November 1, 2006
- Final rule to NRC Commission: February, 2007
- Final rule accompanying regulatory guide: Spring 2007

Risk-Informed Changes to § 50.46a: Summary

- Expert elicitation: Principal technical basis
  - Developed generic BWR and PWR LOCA frequencies vs. break size
  - Verified that seismic-induced risk contribution is not significant unless large flaws exist
- Transition break size
  - Selected to conform with elicitation results, seismic analysis, and dimensions of attached RCS piping
  - Delineates between small breaks treated using current requirements and larger breaks subject to more relaxed criteria
- Final proposed rule
  - Provides flexibility for making broad changes
  - Allows insignificant increases in plant risk and requires that adequate defense-in-depth and safety margins remain
  - Scheduled to be provided to Commission in February 2007