

***Preliminary Options for
Risk-Informing 10 CFR 50.46
and Large-Break LOCA DBA***

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References:

- Framework for Risk-Informing Regulations
 - ▶ Presented at Feb 24-25 public workshop
 - ▶ Available for review on NRC website
 - ▶ Proposes quantitative goals for four high-level defense in depth strategies

 - NUREG/CR-5750, “Rates of Initiating Events at U.S. Nuclear Power Plants: 1987 -1995”
 - ▶ Includes data and updated estimates of pipe break LOCA frequencies
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Relevant Data (NUREG/CR-5750)

- No reported medium or large NSSS pipe breaks in about 8000 worldwide reactor calendar years of operation
 - Throughwall cracks
 - ▶ PWRs
 - Dominant mechanism is thermal fatigue
 - One large (8" pipe), four medium (2" to 6" pipes)
 - ▶ BWRs
 - Dominant mechanism is intergranular stress corrosion cracking (IGSCC)
 - Most in recirculation bypass lines and riser pipe welds
 - 34 in large U.S. pipes
 - One since IGSCC mitigation efforts began in mid-1980s
 - Only 3 U.S. throughwall cracks discovered by leak detection systems while operating at power
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Estimating Large-Pipe-Break LOCA Frequencies (NUREG/CR-5750)

- Estimate through-wall crack frequency based on data
 - Adjust downward for IGSCC mitigation (BWRs)
 - Multiply by conservative estimate of probability of rupture given a through-wall crack based on
 - ▶ Technical review of information on fracture mechanics
 - ▶ Data on high-energy pipe failures and cracks
 - ▶ Assessments of pipe-break frequencies by others
 - ▶ $P_{R-TW} = \max(2.5/\text{diam}(\text{mm}), 0.01)$
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Estimated Large-Break LOCA Mean Frequencies

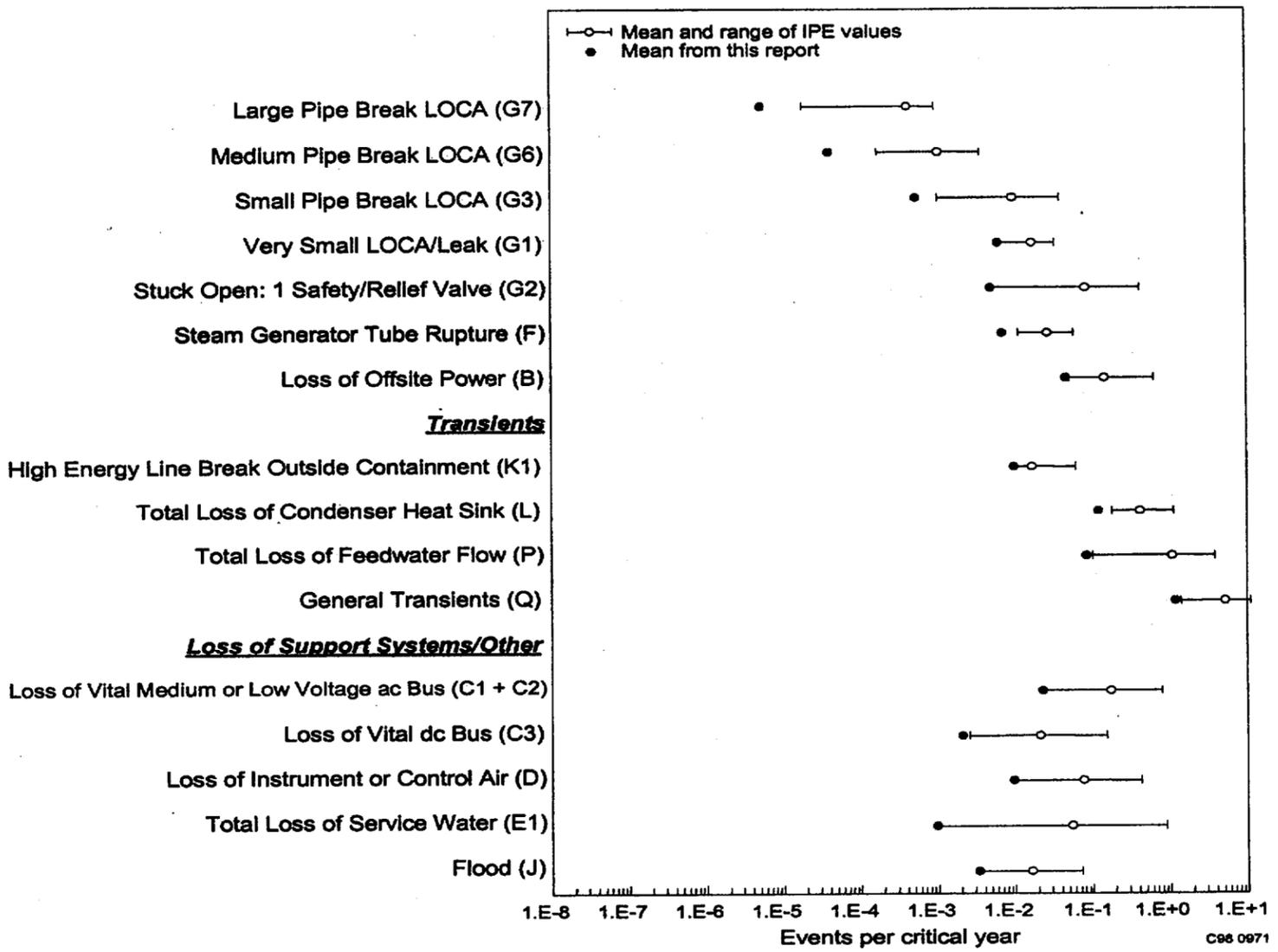
	BWR	PWR
■ WASH-1400	3e-4/yr	3e-4/yr
■ NUREG-1150	1e-4/yr	5e-4/yr
■ NUREG/CR-5750	2e-5/yr	4e-6/yr
■ Bayesian	—	2e-6/yr

NUREG/CR-5750

Large-Break LOCA Frequencies

- “Reasonable but conservative adjustment to previous estimates of pipe-break LOCA frequencies”
 - Seismic-induced LOCAs not discussed
 - NUREG/CR-5750 (page 39) suggests “an expert elicitation process could likely produce more definitive estimates” considering
 - ▶ Data
 - ▶ Fracture mechanics analyses
 - ▶ Pipe fracture experiments
 - ▶ Current operating, surveillance and maintenance practices
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NUREG/CR-5750 Figure 3-2



Preliminary Options: 50.46 and Large Break LOCA (sheet 1 of 3)

- Relax Appendix K conservatisms, e.g.
 - ▶ Use current ANS decay-heat standard
 - ▶ Replace Baker-Just oxidation model
 - ▶ Etc.
 - ▶ Revised models would have to be approved

 - Modify acceptance criteria
 - ▶ Replace high-temperature and oxidation limits with embrittlement criterion
 - ▶ Note: high-burnup fuel has more pre-existing oxidation
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Preliminary Options: 50.46 and Large Break LOCA (sheet 2 of 3)

- Make best-estimate analysis with uncertainty propagation less burdensome
 - ▶ Hybrid approaches (e.g. SECY-83-472)
 - ▶ Automate audit analyses
 - ▶ Use more efficient uncertainty analysis schemes
 - Treat break size and location probabilistically
 - ▶ Propagate this uncertainty with others
 - Relax simultaneous failure assumptions
 - ▶ Double-ended large break
 - ▶ Loss of offsite power
 - ▶ Failure of one emergency AC power train
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Preliminary Options: 50.46 and Large Break LOCA (sheet 3 of 3)

- Eliminate very large breaks as DBA initiators
 - ▶ Framework currently implies frequency would have to be demonstrably less than $1e-6/\text{yr}$
 - ▶ Might still retain as design basis event for containment
 - Risk-based definitions of AOOs and DBAs, for example (very preliminary)
 - ▶ Sequences with mean frequencies $> f_1$ should not cause significant fuel failures (AOOs)
 - ▶ Sequences with mean frequencies between f_1 and f_2 should not cause risk-significant core damage or containment failure (DBAs)
 - ▶ Sequences with mean frequencies between f_2 and f_3 should not cause a large early release
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Questions for WOG

- Feedback on preliminary options for risk-informing 50.46 and large-LOCA DBA?
 - What changes would be proposed if
 - ▶ All large pipe breaks eliminated as DBA initiators?
 - ▶ Cold and hot leg breaks eliminated as DBA initiators?
 - ▶ All breaks $>2 \text{ ft}^2$ eliminated as DBA initiators?
 - If the changes were implemented and a large LOCA occurred, what would be the probability of
 - ▶ Core melting?
 - ▶ Bottom head meltthrough?
 - ▶ Containment failure?
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