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

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

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
  - $P_{R|TW} = \max(2.5/\text{diam(mm)}), 0.01)$

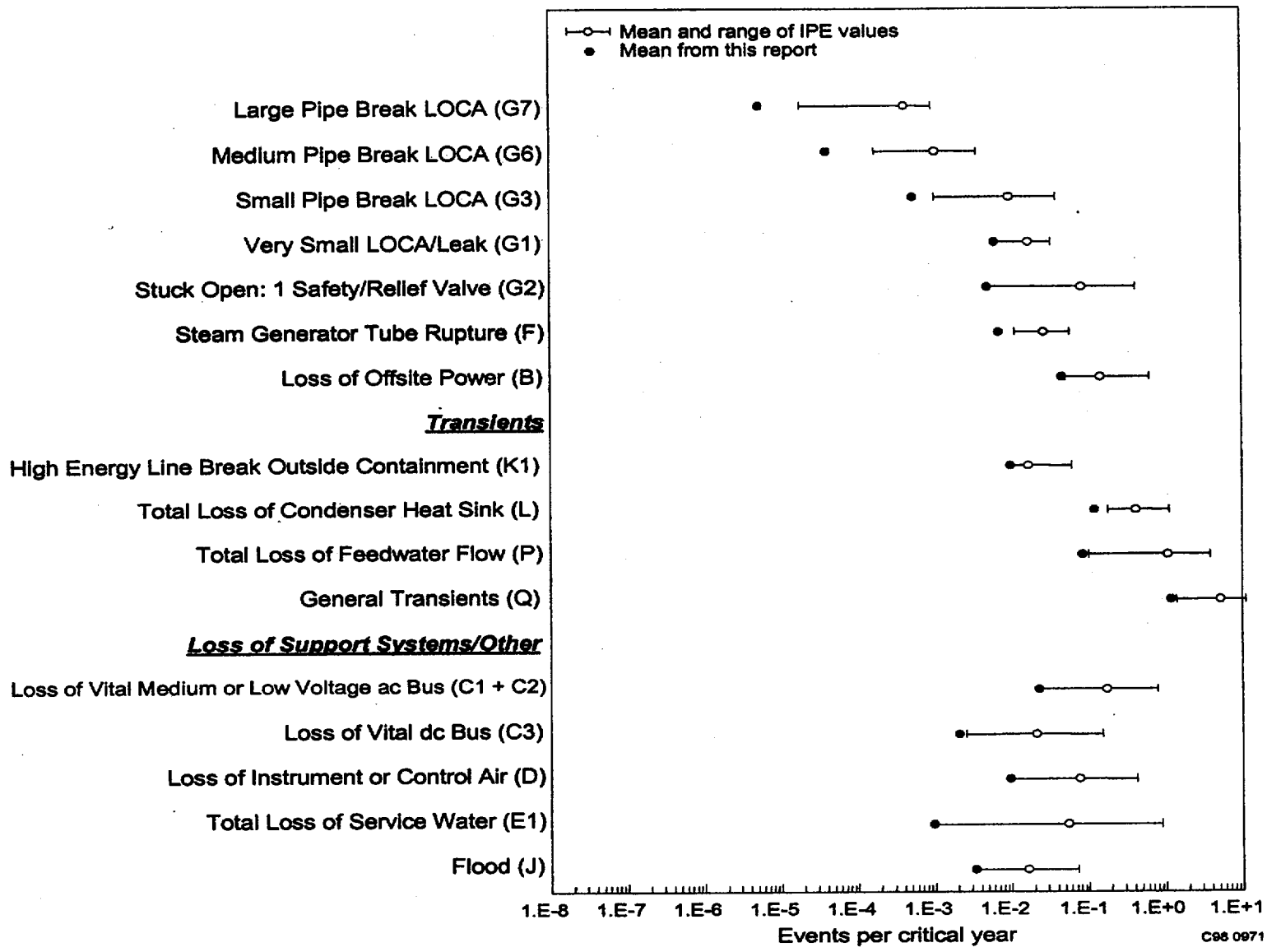
Estimated Large-Break LOCA Mean Frequencies

	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

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

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

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/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

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 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?