PROBABILITY OF LOOP Given Large LOCA

Results of Expert Elicitation Process

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NRC Meeting
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Background

Objectives for Risk-informed Changes:

- $\Delta CDF < 10^{-6}$ /yr and $\Delta LERF < 10^{-7}$ /yr acceptable (Region III of RG 1.174)

or

- Changes only affect a rare initiator $< 10^{-6}$ /yr.

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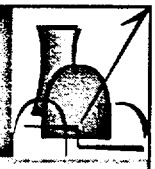
Background



- "LOOP/LOCA" can be a rare initiator for large LOCAs (LLOCA)
- "LOOP/LLOCA" is dominated by LOOP caused by LLOCA
- So, objective is:
  (LLOCA frequency) x (LOOP probability given LLOCA) < 10^{-6}/yr

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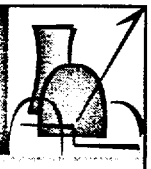
Background



No experience data applies to LOOP/LLOCA:

- No LOOP/LLOCA event has ever occurred
- LOOP given trip is 10 / 3415 = 0.003 ...
  this is a non-conservative surrogate
- LOOP given full ECCS is 1/14 = 0.07
  the failure event is not applicable
- With event removed, 0/14 yields 0.035 to 0.05
  the database is too small to be useful

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Expert Elicitation Process

Process considers event data... *and* design, operations, and electrical transient conditions

- Process based on NRC NUREGs, successful applications, and ASME PRA Standard
- Steps:
  - Discuss factors important to failure
  - Elicit individual points of view
  - Seek integration and consensus

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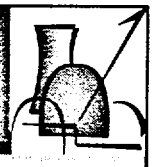
Expert Elicitation Process



Experts:

- Harvey Wyckoff, Consultant
- J. D. Wolcott, TVA Browns Ferry
- David Alstad, NMC Monticello
- Kiang Zee, ERIN Engineering
- Gerry Nicely, TVA Chattanooga
- Michael Tucker, Exelon Illinois

Facilitator:

- John Gaertner, EPRI

Observers:

- Frank Rahn, EPRI
- Adrian Heymer, NEI

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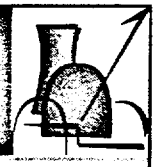
Sequence Model Quantification



1. Stable Grid
2. Successful Bus Transfer
3. Successful Pump Sequencing
4. Other Issues

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Sequence Model Quantification

1. Stable Grid

- Represented by 0.003 probability from trip data
- Differences accounted for in voltage analysis
- No adverse trends -- based on EPRI/BWROG grid contracts review

2. Successful Bus Transfer

- Represented by 0.003 probability from trip data
- Data accounts for plant design differences

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Sequence Model Quantification

3. Successful Pump Sequencing

- Latent Human Errors
  - Inaccurate voltage analysis = 0.003
  - Errors in equipment calibration = 0.003
  - Human error contribution = 0.006
- Equipment Failures
  - Relay failure = 0.0033
  - Timer failure = 0.0001
  - Common cause of coincident logic = 0.1
  - Automatic tap changer = 0.0004
  - Equipment failure contribution = 0.00083

Sequence Model Quantification

4. Other Issues

- Differences between voltage analysis and plant set-up
- Human performance quantification gives low probability -- experts disagreed
- Event in 1997 caused LOOP after trip
- Identified as an issue to be verified by plants

Probability of LOOP Given LOCA

Recommended probability:

$$P = 0.003 + 0.006 + 0.00083 = 0.00983$$

$$P = 0.01^{*}$$

* 5 percentile 0.001
95 percentile 0.03

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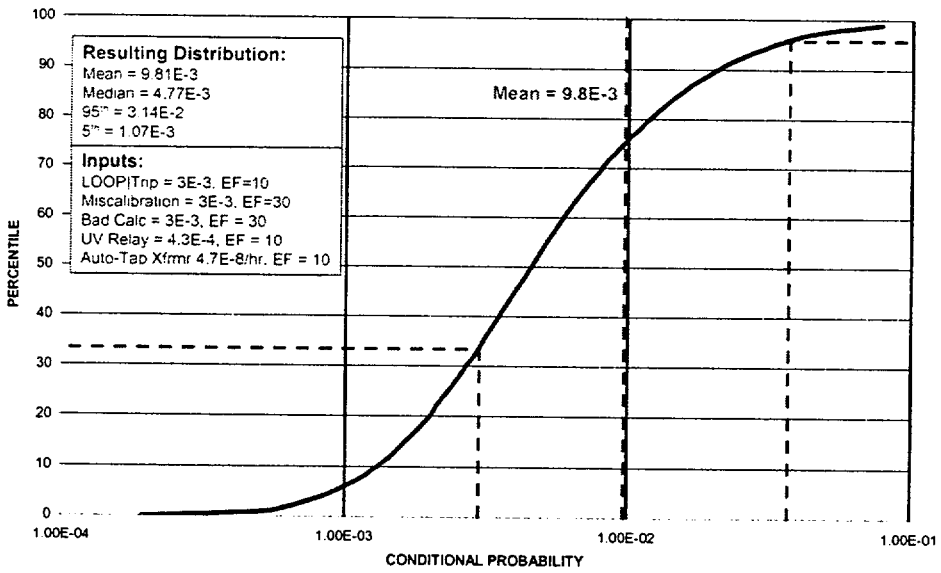
CUMULATIVE DISTRIBUTION FUNCTION FOR LOOP FOLLOWING A LOCA



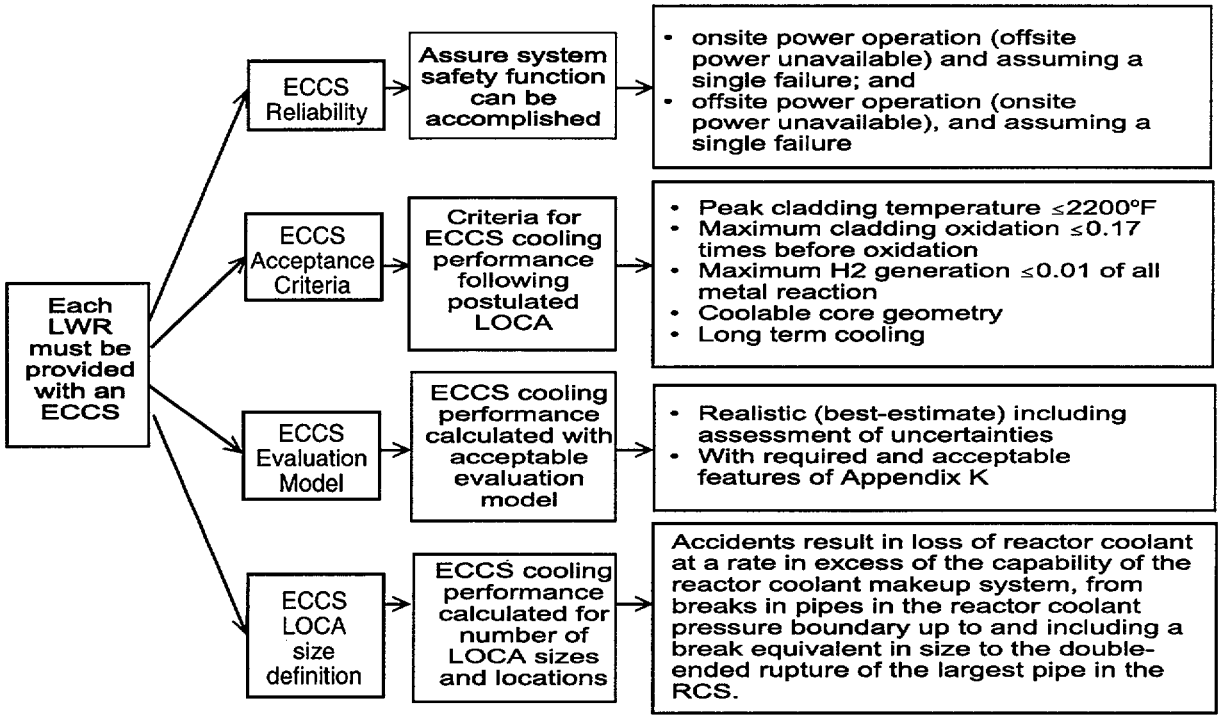
TECHNICAL WORK TO SUPPORT RULEMAKING FOR RISK-INFORMED ALTERNATIVE TO RELIABILITY REQUIREMENTS IN 50.46 (GDC 35)

Public Meeting

Alan Kuritzky
Lee Abramson
U.S. Nuclear Regulatory Commission

May 2, 2002

OVERVIEW OF 50.46 (including Appendix K and GDC 35)



RISK-INFORMED ALTERNATIVE TO GDC 35

- Ensures ECCS safety function reliability commensurate with frequency of challenge to ECCS safety function
- Permits use of more risk-informed and realistic approaches for demonstrating ECCS safety function reliability
- Example of suggested wording (modification to second paragraph of GDC 35):
  - "Suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and containment capabilities shall be provided to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure***, OR functionality shall be demonstrated by assuring an ECCS reliability commensurate with the frequency of the challenge to the ECCS such that the risk to the public health and safety is not signifcant***."

APPROACHES FOR RISK-INFORMED ALTERNATIVE TO GDC 35

- In place of loss of offsite power and additional single failure assumptions in current GDC 35, two options would be offered in a Regulatory Guide to ensure ECCS safety function reliability:

  1. Plant-specific approach where licensees, with appropriate consideration of uncertainties, demonstrate compliance with NRC-established acceptance guidelines, ***OR***

  2. Generic approach where a minimal set of ECCS equipment required to meet NRC-established acceptance guidelines would be specified by the NRC, by generic plant group.

PLANT-SPECIFIC APPROACH FOR RISK-INFORMED ALTERNATIVE TO GDC 35

- Technical work includes:
  - Establishing CDF and LERF acceptance guidelines
  - Determining acceptable LOCA frequencies
  - Develop possible method for plant-specific calculation of conditional probability of LOOP given LOCA

PLANT-SPECIFIC APPROACH FOR RISK-INFORMED ALTERNATIVE TO GDC 35 (Cont'd)

- If licensee selects plant-specific approach to risk-informed alternative, it will need to demonstrate that ECCS reliability, as is, meets acceptance guidelines
- If licensee wants to make a change at the plant, it will need to demonstrate that the change in risk still meets the acceptance guidelines
  - E.g., if licensee wants to eliminate LBLOCA-LOOP DBA, it would need to demonstrate that even if LBLOCA with coincident LOOP were to be assumed to lead directly to core damage, acceptance guidelines would still be met

GENERIC APPROACH FOR RISK-INFORMED ALTERNATIVE TO GDC 35

- Technical work includes:
  - Formulating plant groups based on based on ECCS and support system configuration
  - Performing reliability/risk calculations for representative plant for each group, to determine minimum required ECCS equipment to meet acceptance guidelines (for all initiators)
  - Determining if LOCA-LOOP is risk-insignificant on a generic basis
- List of minimum required ECCS equipment and need to consider LOCA-LOOP will likely appear in regulatory guide
- Plant equipment in excess of the minimum determined above, are candidates for design or operational changes
  - Full extent of changes allowed has yet to be determined

LOSSES OF REACTOR COOLANT (LORC)

- Includes LOCA initiating events and transient-induced (or consequential) LOCAs
- LOCA initiating events include pipe-break LOCAs and non-pipe-break LOCAs (e.g., SG manway failure)
- Causes and frequencies of transient-induced LOCAs and smaller size LOCA initiating events are well understood
- Causes and frequencies of medium and large LOCA initiating events (>~2 in.) are not as well understood
- Sources of medium/large LOCA frequencies in PRAs
  - WASH-1400/NUREG-1150
    - Based on old data, most not applicable to nuclear power plants
  - NUREG/CR-5750
    - Based on recent operating experience, some technical issues raised

LOCA FREQUENCY ESTIMATION

- Expert panel
  - RES and NRR
  - PRA, ASME Code, structural mechanics, thermo-hydraulics, piping systems, loading factors, alternative LOCA mechanisms, etc.
- Issue development meeting: April 19, 2002
- LOCA definition: An unisolable breach of the RCPB requiring ECCS initiation
- Baseline: NUREG/CR-5750, Appendix J
  - Plant population
  - Time frame: 1969-1997
  - SB, MB, LB LOCA frequencies

LOCA FREQUENCY ESTIMATION (Cont'd)

- Goal: Update baseline frequencies for next 35 years
- Identified important initiating piping systems and components along with global issues affecting LOCAs
- Elicitation questionnaire
  - Relative values only; no absolute numbers
  - Separately for BWR, PWR and SB, MB, LB LOCAs
  - Percentage change by system, components and issues
  - Compare MB to SB and LB to MB
  - Identify top 3 initiating systems or components
    - Contribution to LOCA frequency (%)
    - Contribution of non-precursor events (%)
      - e.g., no leak before break