BWR Owners' Group
Large LOCA – LOOP Safety Case

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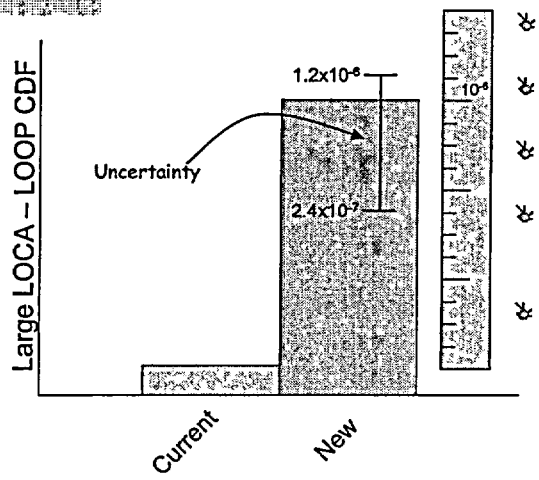
Overview

- Describe the Safety Case
- Discuss Implementation Strategies
- Quantitative Results
- Generic BWR Model
- Conclusions

LOCA – LOOP Separation
Historical Perspective

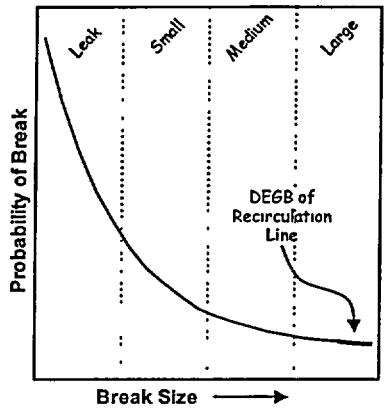


- Assume No Mitigation of Large LOCA with LOOP
- CDF is Based Only on Frequency of Event
- Increase Less than 10^{-6} per Year is Acceptable
- No Agreement on Frequency of LOCA
  - 2.4×10^{-5} to 5.2×10^{-5}
- No Agreement on Probability of LOOP
  - 0.01 to 0.024

Historical Perspective is Limited

- Does Not Address the Reasons for the Change
- Does Not Address How the Change will Be Implemented
- Does Not Provide the Full Risk Picture
- May Be Misleading on the Impact of the Change

Reason for Large LOCA – LOOP Separation

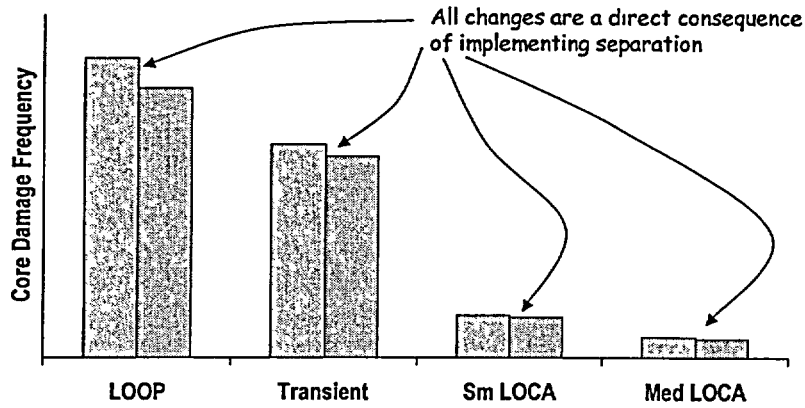


- Plants are Required to Mitigate All Breaks with On-Site Power
- Mitigating the Largest Breaks Drives Design and Operation
- Many Features Exist Only to Mitigate the DEGB of a Recirculation Line
- Design and Operation Not Optimized for More Likely Events
- Separation Will Allow Plants to Optimize Design and Operation

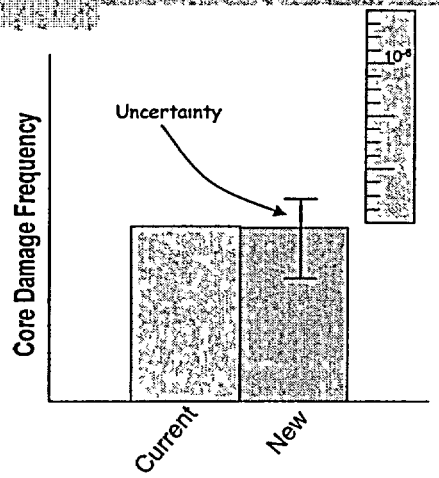
Implementation of Large LOCA – LOOP Separation

- Eliminate "Fast Start" of Diesel Generators
- Eliminate Anticipatory (LOCA) Start Signals
- Optimize the Loads Sequenced on to the Diesel Generators
- These Changes Will Reduce Risk for Many Accidents and Transients

Other Sequences Need To Be Examined

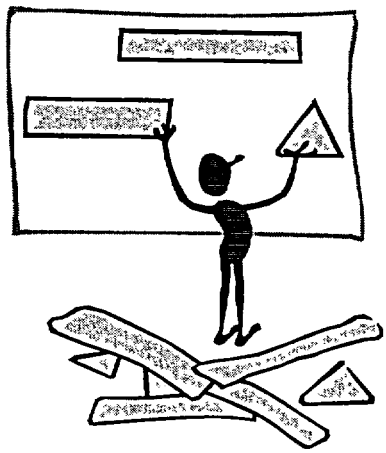


LOCA – LOOP Separation Overall Perspective



- Risk Improvements Offset or Exceed Risk Increases
- 10^{-6} Threshold is Not Challenged
- Uncertainty In Parameters Does Not Affect Decision

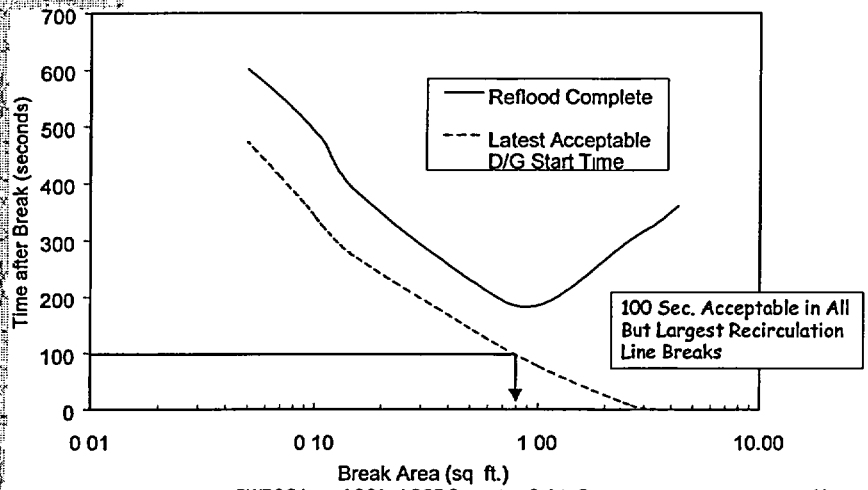
Implementation



Eliminate Fast Start of Diesels

- Consensus That Fast Starts Cause Damage
  - Existing Regs Allow Reduction of Testing
- Some Periodic Testing Still Required
- Currently, Spurious and Actual Demands are Fast Starts
- Plants Would Allow Warm Up Time for All Starts
  - Approximately 30 – 60 seconds
- Reduced Degradation
- Reduced Maintenance

Required DG Start Time



Impact of Fast Start Elimination

- Lower Diesel Generator Failure Rates
- Lower Diesel Generator Unavailability
- Decreased Mitigation Capability for a Subset of Large LOCA – LOOP Events

Optimize Load on Diesels

- Numerous High Capacity Pumps Loaded to Mitigate Largest LOCA
- Diesels Designed for This, But Little More
- Other Loads Are Desirable for More Likely Events

Suggested Optimizations

- Early Core Spray Only Needed for Largest LOCA with Additional Failures
  - Can Be Removed as a Diesel Generator Load with Negligible Impact
- Beneficial Equipment Includes:
  - Battery Chargers
  - Drywell Coolers
  - Equipment Cooling Loops

Impact of Automatically Loading Battery Charger

- Reduce Operator Burden During Events
  - No Need to Manually Restart Chargers
  - No Need to Monitor Battery Charge
  - No Need to Strip DC Loads
- Increased Margin on DC Valves
- Decreased Mitigation Capability for Largest LOCA with Certain Additional Failures

Eliminate Anticipatory Diesel Start

- Diesels Started on Any Indication of LOCA
  - Low Water Level
  - High Drywell Pressure
- Start Occurs Regardless of Bus Voltage
- Most Diesel Demands are Unnecessary
- Requires Operations Personnel to Secure
  - Running Diesel Unloaded Causes Degradation
  - Personnel Could Be Used to Respond to Event
  - Remedial Actions Necessary Following Unnecessary Start

Impact of Eliminating Anticipatory Starts

- Increased Operator Reliability During Most Accidents and Transients
- Increased Availability of DG
  - Unnecessary Starts Cause Wear
  - Remedial Actions Necessary Following All Demands
- Decreased Mitigation Capability for Largest LOCA with Consequential LOOP

Relaxed Testing

- Tests Required for All Necessary Elements
- Tests Would Be Less Challenging
  - On Equipment
  - On Operators
- Equipment Availability and Reliability would Improve

Quantification of Changes

Generic BWR Model

- Based on BWR 4 with Mark I Containment
- Single Unit
- Eliminated Plant Specific Enhancements
- Added Consequential LOOP

Generic Model Data

- Affected Failure Rates from NUREG/CR-5500
  - MOVs
  - Diesel Generators
  - ECCS Pumps
- Unavailability from 2nd Qtr 2002 ROP
  - Diesel Generators
  - HPCI
  - RCIC
  - RHR
- Initiating Events and Other Data from Base Plant

Generic Model Benchmark

- Compared Model with BWROG Member PRAs
  - Overall CDF
  - LOOP Contribution
- Three Dominant Features
  - Diesel Generator Only
  - AC Independent Low Pressure Injection
  - Black Start Capability
- Generic Model Modified to Cover All Three Configurations

Changes Examined

- Diesel Generator Unavailability & Failure Rate
- Operator Action Failure Rate
- Automatic Load of Battery Chargers
- Assumed All Large LOCA – LOOP Events Go Directly to Core Damage

Diesel Generator Changes

- Difficult to Predict Exact Reduction
- Examples:
  - 8 hr/yr Reduction of Maintenance ≈ 10% Reduction of Unavailability
  - 1 Failure in 3 yr to 1 Failure in 3.3 yr ≈ 10% Reduction of Failure Rate
- Basic Events Affected:
  - Fail to Start
  - Fail to Run
  - Common Cause

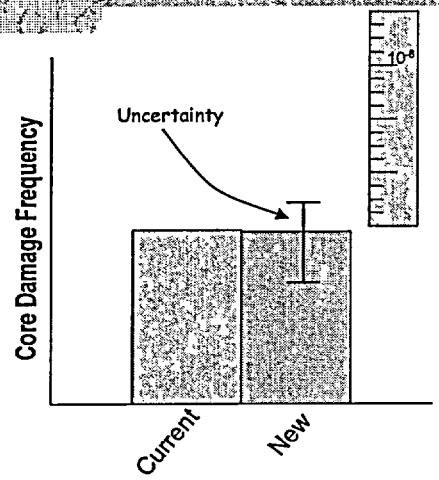
Operator Action Changes

- Also Difficult to Predict Exact Reduction
- Moderate Reduction Expected
- Basic Events Affected:
  - Operator Actions within 1st Few Hours of Initiator & Taken Outside Control Room

Battery Charger Changes

- Can Be Simulated by Setting Operator Action to Zero

LOCA – LOOP Separation Overall Perspective



- Risk Improvements Offset or Exceed Risk Increases
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Quantitative Results

- No Attempt to Postulate Reductions
- Reductions Balance Large LOCA-LOOP Increase
- Solve for Risk Neutral Offset

Configuration	CDF		Contribution			Improvement to Offset
	Overall	LOOP	Diesel Generators	Operator Actions	Reload Battery Charger	
Diesels Only	1.2E-05	7.0E-06	40 0%	35 6%	3 6%	-6 5%
AC Independent Inj	8.3E-06	3 5E-06	19 5%	50.7%	5 1%	-9 9%
Black Start Capability	5 5E-06	7.2E-07	8 6%	76 3%	7.7%	-20 1%

- Reductions Applied Evenly to All Basic Events

- Reasonable to Expect 10% Improvement
- Offset Necessary for Only Largest of Large LOCA Events
  - EPRI Estimates 18%
- All Plants Will See Risk Benefit of Changes

Quantitative Results - LERF

- P(LERF | LBLOCA) ≈ 0.01
  - Applies to Mark I
  - Mark II & III Have Lower Conditional Probability
- Driven by RPV Pressure @ Core Damage
- Driven by Water on Drywell Floor
- Neither are Affected by Changes
- Maximum LERF Increase is 10^{-8}
- DG Improvements May Reduce Probability of LERF Given Large LOCA

Conclusions

- Increased Operational Margin from Proposed Changes
- Effects of Changes Proposed Here Are Monitored by ROP
- Risk of Not Responding to the Largest Break with On-Site Power Easily Offset by Changes

Safety Case

- Requirement to Mitigate All Breaks with On-Site Power Is Not Necessary to Protect the Health and Safety of the Public
- Changes Proposed Will Improve Safety
- BWROG Recommends Moving Forward With Rulemaking
- Further Study Not Warranted
  - Large LOCA Frequency
  - Conditional Probability of LOOP