Risk-Informing 10CFR50 for Decommissioning

Industry Thoughts on a Risk-Informed Framework

NEI Decommissioning Working Group

April 13, 1999

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Outline

- Introduction - A risk-informed framework proposal
- The missing side of zirc fire analysis - initiating event probability
- If not zirc fire, what?
- What portions of 10CFR50 should be addressed

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Introduction: History

- Zircalloy fire is the only beyond design basis event considered by NRC to have any credibility for spent fuel pools
- NUREG-1353 treated the zirc fire in a risk-informed fashion - combined probabilistic and consequence analyses
- Decommissioning positions have not credited probabilistic basis, preferring instead a "zero risk" or physically unrealistic approach

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Introduction: History (cont'd)

- Calculate when zirc fire is impossible
- Adiabatic heatup (Maine Yankee)
- Commission view during 3/17 briefing
  - risk-inform decommissioning

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How Do We Risk-Inform Decommissioning?

- Combine a deterministic evaluation of consequences with a probabilistic evaluation of likelihood (e.g.):
  - Zirc fire consequences immediately after shutdown
  - Seismic initiating event probability immediately after shutdown
- Employ traditional safety benefit/cost criteria to determine if event is appropriate to consider:
  - $2000/person-rem averted
  - 10^{-6} probability cut-off

may not be most limiting initiating event.

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Proposed Decommissioning Risk-Informed Decision-Making Framework

Within the License Basis*	Beyond Design Basis**
Consequences ≥ 1 rem: Maintain full emergency plan	Probability ≥ 10^{-6}: Requirement cost ≤ $2000 x dose x probability
Consequences < 1 rem: Maintain on-site emergency plan	Probability < 10^{-6}: No requirements

Maisner says criteria used before ~~Tier~~ staff never addressed reduction of EP

* Affects emergency planning requirements

** Affects emergency planning, security, insurance and other relevant regulations

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Missing Side of Zirc Fire Analysis

Initiating Event Probability

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Risk Informed Decommissioning Emergency Planning

EPRI/NEI Project

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The Issue and the Overall Objective

- Provide Risk Informed Evidence That Inclusion of "Beyond Design Basis" Accidents, Particularly a Zircaloy Oxidation Reaction [Fire] Accident, as the Basis for Decommissioning Emergency Planning, is not Warranted

Why Employ a Risk Informed Evaluation?

- Provides Diverse and Additional Perspective on Safety Significance

What is a Risk Informed Evaluation?

- Use of Risk Assessment Technology to:
  - Determine Quantitative Risk
  - Compare Quantitative Risk to Acceptance Criteria
  - Glean Insights From the Risk Evaluation Process

Purposes

- To Provide Preliminary Results and Description of a Risk Informed Evaluation of Decommissioning Emergency Planning
- To Describe and Achieve Agreement on the Detailed Methodology for the Complete Evaluation

NUREG-1353
Regulatory Analysis for the Resolution of Generic Issue 82
"Beyond Design Basis Accidents in Spent Fuel Pools"
April 1989

" conclusion applicable today "

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NUREG-1353 Conclusions

A. "Therefore the backfit criteria [Ref. 44] that

(1) a substantial increase in the overall protection of the public health and safety is achieved , and

(2) the direct and indirect costs of implementation are justified,

are not met for any of the alternatives considered."

– to add addl systems not cost beneficial.

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NUREG-1353 Conclusions
(continued)

B. "Therefore the risk and consequences of a spent fuel pool accident appear to meet the Safety Goal Policy Statement public health objectives. They would also meet the proposed 1E-6 per reactor year large-release frequency guidelines, at least pending the definition of a 'large release' by the Commission. Therefore Alternative 1 - 'No Action' is justified.

C. comparable risk to reactor.

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NUREG-1353 Supporting Technical Documents:

- **NUREG/CR-4982 [BNL]** "Severe Accidents in Spent Fuel Pools in Support of Generic Safety Issue 82" July 1987
  - Provided the Evaluation Structure (PRA)
- **NUREG/CR-5176 [LLNL]** "Seismic Failure and Cask Drop Analyses of the Spent Fuel Pools at Two Representative Nuclear Power Plants" January 1989
  - Provided the Seismic Hazards/Fragilities

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NUREG/CR-4982 [BNL]

- Classical PRA Structure:
  - Accident Initiating Events Probability
  - Accident Event Sequence Probability
  - Consequence Evaluation
  - Risk Results [Probability X Consequence]

Table 4.7.1
Summary of SFP Accident Frequencies
from NUREG-1353 [Verbatim]

Accident Sequence	PWR Frequency		BWR Frequency	
	Best Estimate (per R-year)	Upper Bound (per R-year)	Best Estimate (per R-year)	Upper Bound (per R-year)
Structural Failures				
1. Missiles	**1.0 E-8**	**1.0 E-7**	**1.0 E-8**	**1.0 E-7**
2. Aircraft crashes	**6.0 E-9**	**2.0 E-8**	**6.0 E-9**	**2.0 E-8**
3. Heavy Load Drop	**3.1 E-8**	**3.1 E-7**	**3.1 E-8**	**3.1 E-7**
Pneumatic Seal Failures	**3.0 E-8**	**5.0 E-7**	**3.0 E-8(1)**	**5.0 E-7(1)**
Inadvertent Drainage	**1.2 E-8**	**1.0 E-7**	**1.2 E-8**	**1.0 E-7**
Loss of Cooling/Make-up	**6.0 E-8(2)**	**1.4 E-6**	**6.0 E-8(2)**	**1.4 E-6**
Total	**1.5 E-7**	**2.4 E-6**	**1.5 E-7**	**2.4 E-6**
Seismic Structural Failure	**1.8 E-6**		**6.7 E-6**	
~~Conditional Probability of Zircaloy~~ Cladding Fire Given Loss of Water (High Density Storage Racks)	**1.0**		**0.25**	

Notes: (1) BWRs do not, in general, use pneumatic refueling cavity seals, but other pneumatic seals are used in the transfer canal.
(2) Includes beyond design basis seismic induced loss of cooling and make-up.

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Frequency of Fuel Pool Accident Resulting in Spent Fuel Damage =

$$\{[(1.5E\text{-}7 + 1.8E\text{-}6) * 1.0] \quad : \text{PWR}$$

$$+ [(1.5E\text{-}7 + 6.7E\text{-}6) * 0.25]\} \quad : \text{BWR}$$

$$\div 2$$

$$= 2.0E\text{-}6$$

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Seismic Contribution to Total Initiator Frequency

$$\frac{1.8E\text{-}6}{1.5E\text{-}7 + 1.8E\text{-}6} = 92.3\% \quad : \text{PWR}$$

$$\frac{6.7E\text{-}6}{1.5E\text{-}7 + 6.7E\text{-}6} = 97.8\% \quad : \text{BWR}$$

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Seismic Structure Failure Frequencies

	PWR	BWR
NUREG-1353	1.8E-6	6.7E-6
Seismic Factor of 5 Improvement	3.6E-7	1.3E-6
Seismic Factor of 10 Improvement	1.8E-7	6.7E-7

All Other Initiators
1.5E-7

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Frequency of Fuel Pool Accident Resulting in Spent Fuel Damage

NUREG-1353	2E-6
Seismic Factor of 5 Improvement	9E-7
Seismic Factor of 10 Improvement	5E-7

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Risk Evaluation Insights

- Seismic is Dominant Contributor and When Updated With LLNL Hazard is Very Low Probability
- No Beyond Design Basis Event is Sufficiently Probable to Warrant Consideration as Basis for Decommissioning Emergency Planning
- For PWRs, Conditional Probability of Zircaloy Cladding Fire Given Loss of Water is 1.0 [Guaranteed] so That From a Risk Informed Perspective, Calculation of Cooling Time is Irrevelant → operating rx assumed fire could occur because they did not look at times greater than 90 days.

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Risk Informed Conclusions

- NUREG-1353 Results and Conclusions Were Sufficient to Resolve the Issue
- NUREG-1353 Results and Conclusions Still Valid [Unaffected by Decommissioning State]
- Major Improvement by Just Updating LLNL Seismic Hazard

Risk Informed Conclusions
(continued)

-5176 methodology.

- Inclusion of "Beyond Design Basis" Accidents, Particularly a Zircaloy Oxidation Reaction [Fire] Accident, as the Basis for Decommissioning Emergency Planning, is not Warranted

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NUREG-1353
Figures of Merit

- Estimated Frequency of Fuel Pool Accident Resulting in Spent Fuel Damage = 2E-6/year
- Seismic Contribution > 90% of Total

New Evaluation Approach

- Employ Same Methodology and Inputs as NUREG-1353
- Except Replace Seismic Hazard With Updated LLNL and EPRI Inputs
- Perform for All Sites

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Risk Informed Decommissioning Emergency Planning

EPRI/NEI Project

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Overview

- Review of LLNL/EPRI Seismic Hazard Studies
- Summarize NUREG/CR-4982 (BNL)
- Summarize NUREG/CR-5176 (LLNL)
- Present Preliminary Results of the Current Evaluation

Chronology of LLNL/EPRI Seismic Hazard Analyses

- NUREG/CR-1582 (1981)
- NUREG/CR-3756 (1984)
- EPRI PROGRAM INITIATED (1984)
- UCID-20421 (1985)
- NUREG/CR-5250 (1989)
- EPRI NP-6395-D (1989)
- NUREG-1488 (1993)

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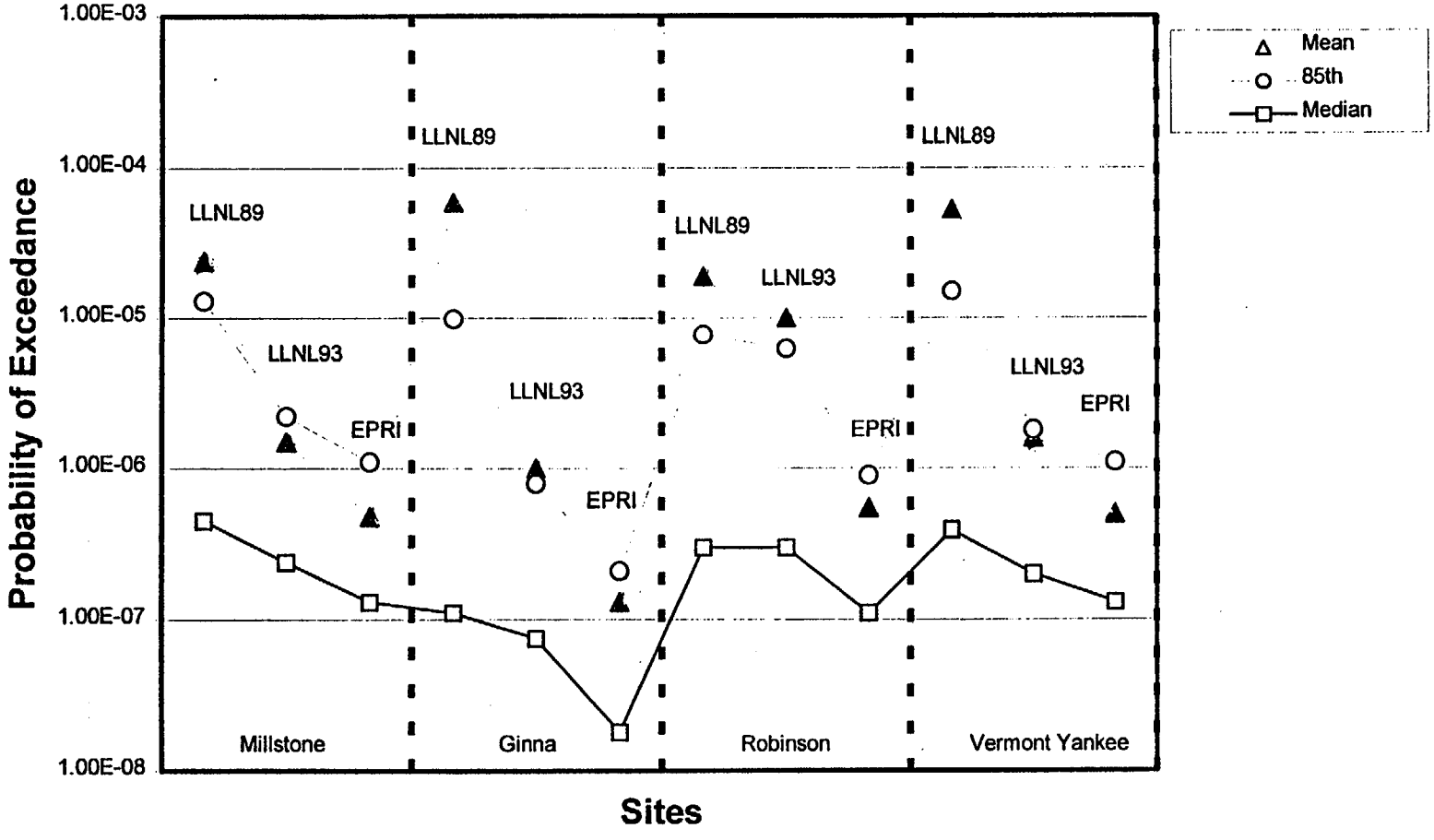
Comparison of the Probability of Exceeding 1g at 4 Sites



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NUREG/CR-4982 (BNL) - Severe Accidents in Spent Fuel Pools ... July 1987

- Seismic Hazard
  - Millstone (BWR) - UCID-20421
  - Ginna (PWR) - Synthesized
- Fragility
  - Millstone - Oyster Creek Reactor Building Used as Surrogate Median Fragility = 0.75g
  - Ginna - Zion Auxiliary Building Shear Walls Used as Surrogate Median Fragility = 1.1g

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NUREG/CR-4982 (BNL) - Severe Accidents in Spent Fuel Pools ... July 1987 (continued)

- Seismically Induced Failure Probability of SFP
  - Millstone - 2.2×10^{-5}/year
  - Ginna - 1.6×10^{-5}/year

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NUREG/CR-5176 (LLNL) - Seismic Failure and Cask Drop Analyses of the Spent Fuel Pools ... January 1989

- Seismic Hazard
  - Preliminary Results Came From LLNL
  - Hazard Assumed to be Lognormally Distributed
  - Truncation of the Hazard Distribution (99%)
  - Family of 11 Hazard Curves

NUREG/CR-5176 (LLNL) - Seismic Failure and Cask Drop Analyses of the Spent Fuel Pools ... January 1989 (continued)

- Based on Explicit Evaluation of Spent Fuel Pool Fragility

Vermont Yankee (BWR) -Median Fragility = 1.4g

Robinson (PWR) -Median Fragility = 2.0g

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NUREG/CR-5176 (LLNL) - Seismic Failure and Cask Drop Analyses of the Spent Fuel Pools ... January 1989 (continued)

- NUREG/CR-5176 Seismically Induced Failure Probability of SFP:

  Vermont Yankee - 6.7×10^{-6}/year
  Robinson - 1.8×10^{-6}/year

- These Original NUREG/CR-5176 Results Have Been Conservatively Reproduced

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Seismically Induced SFP Failure Probability Preliminary Results

	Millstone	Ginna	Robinson	Vermont
a.	2.2×10^{-5} (6×10^{-6})*	1.6×10^{-5} (4×10^{-6})*	1.8×10^{-6}	6.7×10^{-6}
b.	7×10^{-7}	2×10^{-7}	1.8×10^{-6} (d)	6×10^{-7}
c.	4×10^{-7}	$< 10^{-7}$	5×10^{-7}	2×10^{-7}

a. From NUREG/CR-4982 and NUREG/CR-5176.
b. Based on NUREG-1488 (LLNL - 1993) - seismic hazard curves.
c. Based on EPRI NP-6395-D seismic hazard curves.
d. Essentially no reduction, failure probability is already low.
* NUREG/CR-5176 methodology and LLNL89 seismic hazard.

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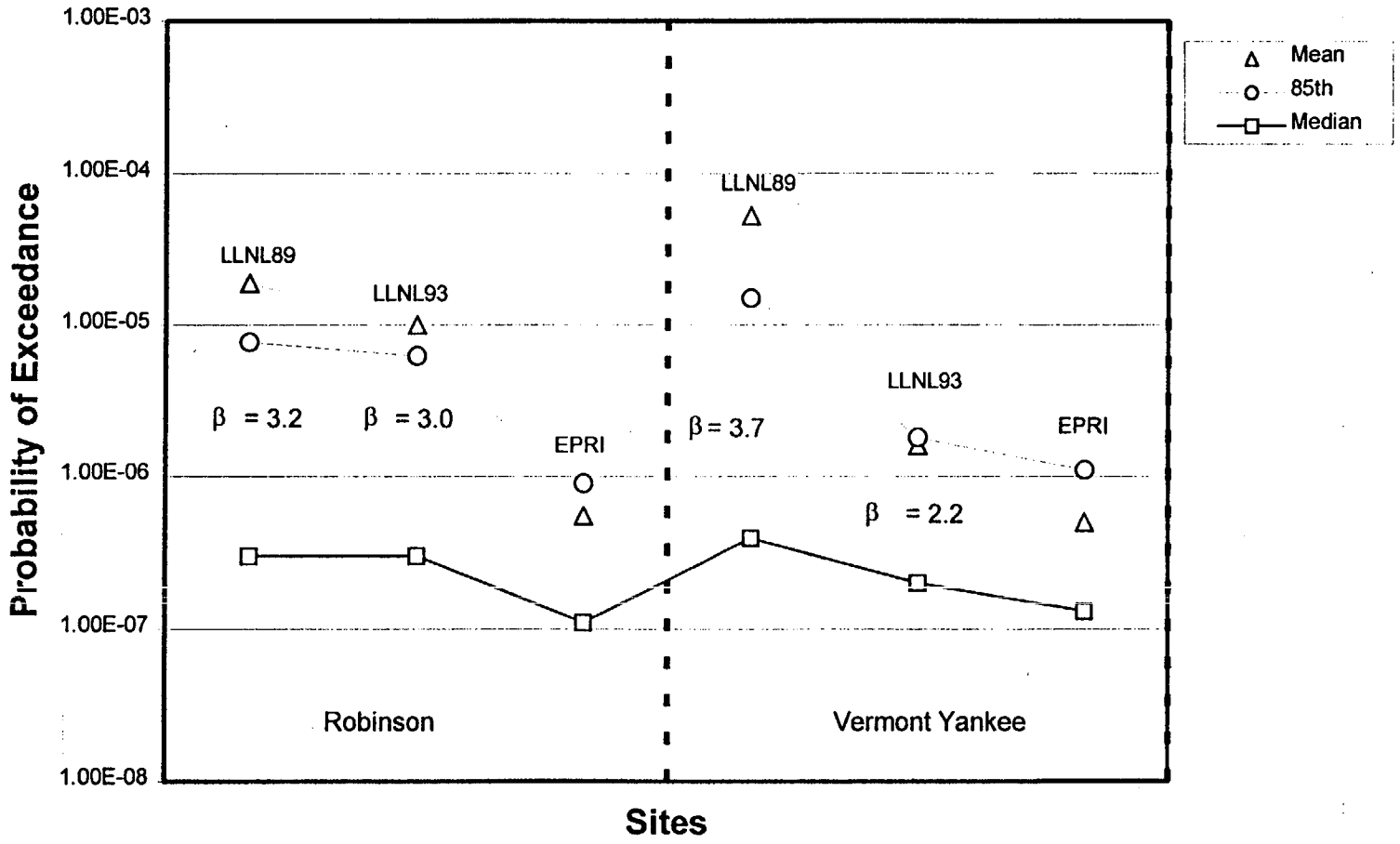
Comparison of the Probability of Exceeding 1g at 2 Sites



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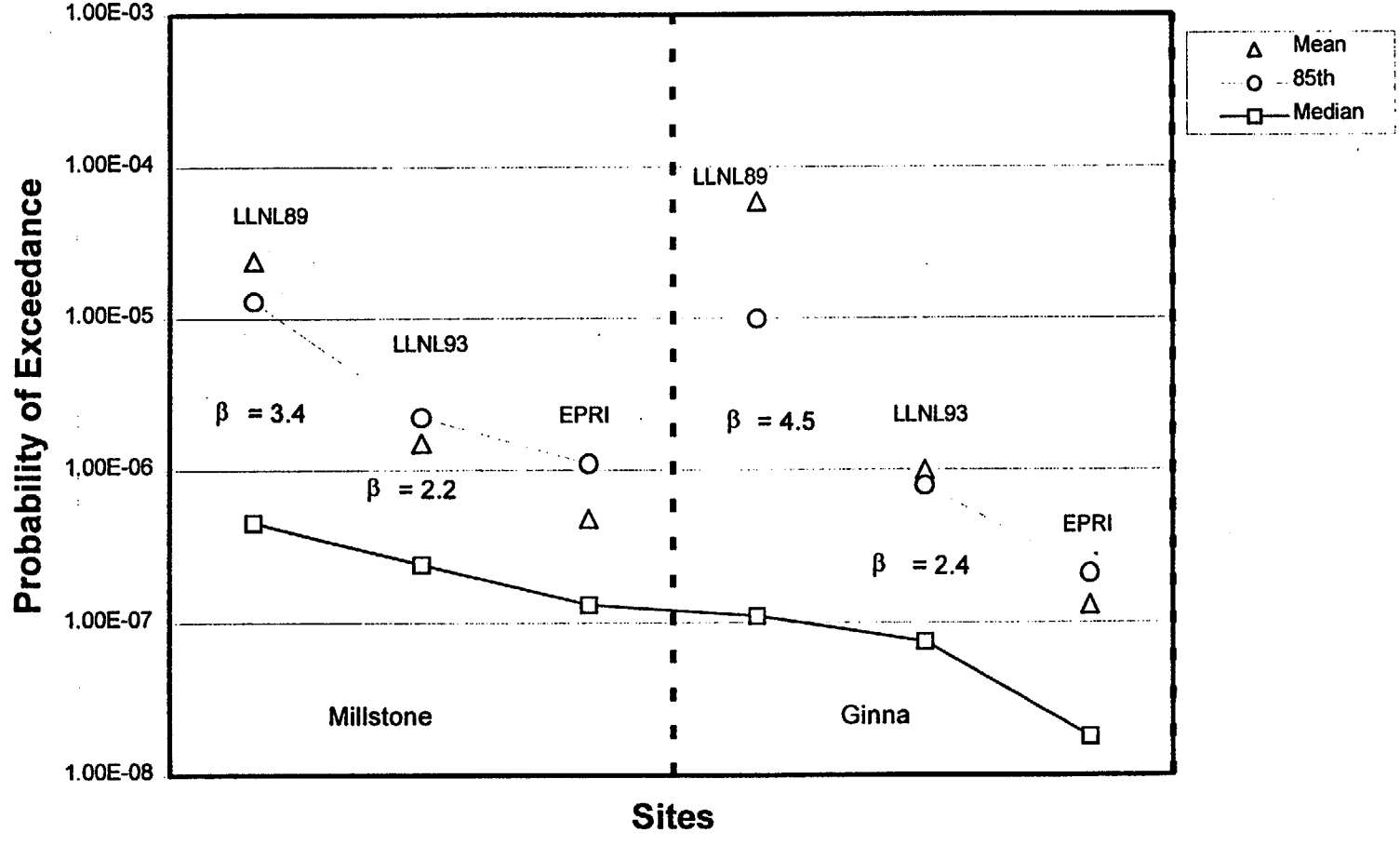
Comparison of the Probability of Exceeding 1g at 2 Sites (continued)



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Conclusions From Preliminary Results

- Application of current seismic hazard curves is appropriate
- Most plants are projected to see a reduction in the SFP failure frequency by between a factor of 5 to 10 when using the current 1993 LLNL results and greater than 10 using EPRI data.
- For the four plants analyzed a SFP failure frequency on the order of 10^{-6} results when the 1993 LLNR results are applied, and on the order of 10^{-7} when EPRI results are applied.

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If Not Zirc Fire, What?

- License basis analyses and precedents may be a fruitful starting point
  - Fuel handling analysis - fuel building ventilation tech spec } 2 mo.
  - Security devitalization
- These consider credible events and time-dependent reduced dose effects due to iodine decay

~1 month.

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Additional Thoughts

- Insurance
  - Operating plant CDF $\cong 10^{-4} - 10^{-5}$
  - Decomm. Plant risk $\cong 10^{-6} - 10^{-7}$
- Security
  - Risk may be function of fuel pool location (above- vs. in-ground)
  - Additional assurance of water makeup capability may be needed

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What Portions of 10CFR50 Should be Addressed?

- Areas to risk-inform – e.g., emergency planning, security, etc.
- Cleanup areas – e.g., station blackout, fitness for duty, etc.
- Details in handout

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Conclusion

- Risk-informing 10CFR50 for decommissioning is achievable and, perhaps, even straightforward

- NEI Decommissioning Working Group would like to continue to contribute to working sessions with the staff to develop a consensus decommissioning rulemaking package for presentation to the commission

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Decommissioning Regulations
Improvement Recommendations
April 13, 1999

Technical Specifications (10 CFR 50.36, 36a, 36b)	Case by case inconsistency difference in ops TS/Need consistent regulation. see NEI comments DG 1625 (PWR)
Emergency Planning (10 CFR 50.47, 54(q), (t), Appendix E)	Should be risk-informed.[1]
Fire Protection (10 CFR 50.48, Appendix R)	Addressed in rule see NEI comments DRG 1069
Continuation of License (10 CFR 50.51)	Addressed in rule
QA Program (10 CFR 50.54(a), Appendix B)	QA program in FSAR applies reductions in the scope that do not impact public health and safety can be made subject to NRC approval 50.54(a)(3).
Operator Requalification (10 CFR 50.54(i), 50.45, 55.59	Licensee may not reduce the scope of the program unless authorized by NRC. Requires IN stating licensed op. requirements no long apply to shutdown plants.[2]
Operator Staffing Requirements (10 CFR 50.54(k), (m))	Requires amendment request for certified fuel handler-training and retraining program.
Security Plan (10 CFR 50.54(p), Part 73)	Should be risk-informed.[1] Requires IN stating fitness for duty does not apply to shutdown plants.[2]

As noted, February 22, 1999, NRC meeting

1. High priority
2. Medium priority

Onsite Property Damage Insurance (10 CFR 50.54(w))	Should be risk informed. [1]
Changes, Test and Experiments (10 CFR 50.59)	Requires revised station procedure to conform to NRC SRM.
Loss of all AC Power (10 CFR 50.63) "station blackout"	Requires IN stating "station blackout does not apply to shutdown plants.[2]
Maintenance Effectiveness (10 CFR 50.65	Requires clarification. See NEI white paper, confine maintenance determined by spent fuel pool configuration.
Periodic UFSAR Update Requirement (10 CFR 50.71(e))	Addressed in rule.
Notification Requirements for Operating Reactors (10 CFR 50.72, 50.73)	Requires rule amendment. Rule does not address 50.73 notifications for permanently shutdown.
Training and Qualification of Nuclear Plant Personnel (10 CFR 50.120)	Requires clarification to address training for certified fuel handler. Requires IN training does not apply to shutdown plants. [2]
Material control/Accounting of Special Nuclear Material (10 CFR 70.51, 53, 74.13(a), Part 75	Addressed in rule.
Financial Protection Requirements (10 CFR 140	Should be risk informed.[1]
NRC and FEMA Fees (10 CFR 170, 171; 44 CFR 354	Requires NRC clarification - Licensee applies to withdraw from offsite exercise subject to NRC approval of 50.54(q). [2]

Environmental Protection Regulation (10 CFR 51)	Requires clarification and update based on industry experience NUREG-0586 GEIS.
Reporting and Recordkeeping (10 CFR 50.75)	Addressed in rule.
Maintenance of Records (10 CFR 50.71)	Addressed in rule.
Termination of License (10 CFR 50.82)	Modify RG 1078 (duplicate surveys not cost effective).[1] Expedite draft SRP License Termination.[1] Expedite draft regulatory guide on free release.[1] Develop guidance incremental site release.[2]
Standards for Protection Against Radiation (10 CFR Part 20, Part 50 Appendix I	Addressed in rule.
Codes and Standards (including IST/ISI) Requirements (10 CFR 50.55a(a), (f), (g))	Reduce scope to reflect shutdown condition via TS amendment.
General Design Criteria (10 CFR Part 50, Appendix A)	FSAR contains a section discussing the conformance with GDCs.

Re-evaluate NEI Submitted Comments, October 18, 1995
NRC Proposed Rule "Decommissioning of Nuclear Power Reactors"
60 Fed. Reg. 37374-July 20, 1995

Decommissioning options flexibility	(10CFR 50.82(a)(3))	Decom, SAFSTOR, or Entomb restricted/unrestricted
PSDAR content and detail	(10CFR50.82(a)(4)(i))	Synopsis, high-level summary
Public Participation hearing	(10CFR50.82(a)(4)(ii))	Exchange of information only ←
Timing prohibition of selected decommissioning activities	(10CFR50.82(a)(5))	Waive 90 day hold
Notification of variation from PSDAR	(10CFR50.82(a)(6))	Should be eliminated
Decommissioning Trust Funds	(10CFR50.82(a)(7)(i))	Use of funds for decommissioning during operations LLW, dry storage
Restrictions on timing of trust fund withdrawals	(10CFR50.82(a)(7)(ii))	Use of funds for decommissioning during operations LLW, dry storage
Approval of license termination plan	(10CFR50.82(a)(9))	
Backfitting	(10CFR50.109)	Should apply to decommissioning
Amounts of financial protection for certain reactors	(10CFR14011)	140.11(a)(4) secondary protection no longer applies