Attachment 3

OVERVIEW OF MITIGATING SYSTEMS PERFORMANCE INDEX

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August 21, 2003

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BACKGROUND

- MSPI evolved from a feasibility study of Risk-Based Performance Indicators (RBPI) in NUREG-1753
- MSPI is a highly risk-informed simplification to RBPIs that addresses recognized PI issues:
  - treatment of demand failures and fault exposure time
  - definition of unavailability and maintenance rule consistency
  - plant specific risk-informed performance thresholds
  - cascade failure treatment of cooling water support systems
- MSPI monitors risk impact of changes in performance of selected mitigating systems
  - accounts for plant specific design and performance data
  - scope consistent with current PIs: internal events (excluding internal flooding) level-1, at-power risk
  - covers unavailability and unreliability consistent with PRA modeling
  - performance thresholds consistent with basis for current PIs.

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Fundamental Expression for the MSPI

MSPI = UAI + URI

where UAI = Unavailability Index
URI = Unreliability Index

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Calculating the Change in Unreliability

$$URI = \frac{\text{delta CDF}}{\text{delta unreliability}} * \text{change in unreliability from a baseline}$$

$$URI = B(UR) * \Delta UR$$

where *B* is the Birnbaum importance

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Linearization of Unreliability

$$URI = CDF_P \sum_{j=1}^{m} \left[\frac{FV_{URcj}}{UR_{pcj}} \right]_{\max} (UR_{Bcj} - UR_{BLcj})$$

where the summation is over those active components in the system that by themselves fail a "train"

CDF_p is the plant-specific internal events, at-power core damage frequency,

FV_{URc} is the component-specific Fussell-Vesely value for unreliability,

UR_{pc} is the plant-specific PRA value of component unreliability,

UR_{Bc} is the current estimate of ("Bayesian corrected") component unreliability for the previous 12 quarters,

UR_{BLc} is the historical baseline unreliability for the component.

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MSPI Calculation and Performance Thresholds

- Based on 12 quarters rolling averages of train unavailabilities and reliability data for six systems
- Thresholds of performance consistent with NRC policy and set at
  - GREEN for change in CDF less than 1E-6/yr
  - WHITE for change of 1E-6 to 1E-5/yr
  - YELLOW for change of 1E-5 to 1E-4/yr
  - RED for change of greater than 1E-4/yr

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List of MSPI Monitored Systems

BWRs	PWRs
HPCI/HPCS (high pressure core injection/spray)	HPSI (high pressure safety injection)
RCIC (reactor core isolation cooling)	AFW (auxiliary feedwater or equivalent)
RHR (residual heat removal)	RHR
EAC (emergency AC power)	EAC
Support System Cooling (ESW + CCW)	Support System Cooling

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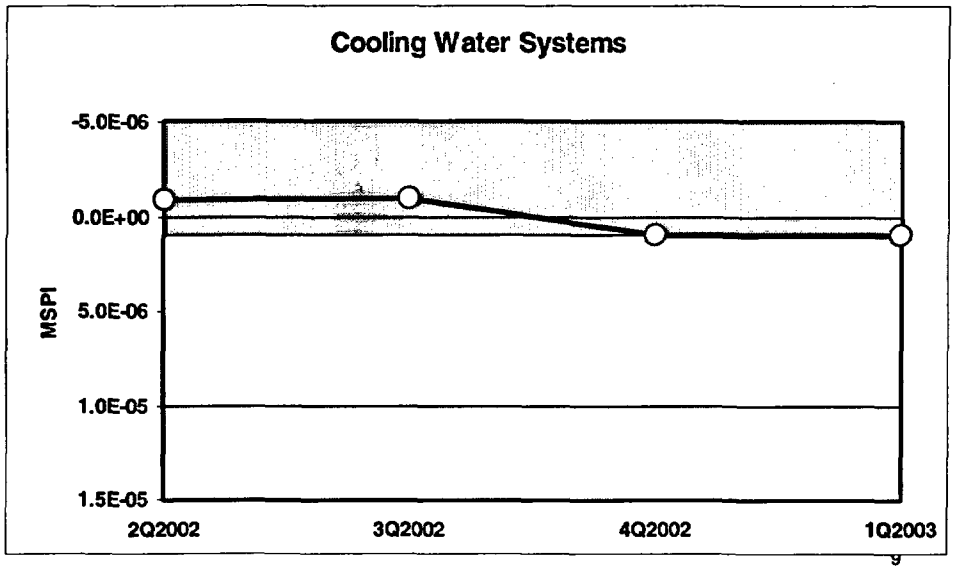
Sample Result



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MSPI PILOT OBJECTIVES

- **Exercise MSPI Guidance:**
  - **System boundary and component identification**
  - **Data collection**
  - **MSPI computation**
- **Validation and Verification:**
  - **Issue identification & special studies (Table Top)**
  - **SPAR model comparisons**
  - **Comparison to SDP (Table top)**
- **Perform Temporary Instruction Inspections**

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Status of Pilot Program

- Held July 2002 Workshop prior to Pilot implementation.
- Issued Program Guidelines in NEI 99-02 Revision and Regulatory Issue Summary in September 2002.
- Licensees collected performance data Sept 2002 through Feb 2003 and submitted to NRC on monthly basis.
- NRC Issued Temporary Instruction and performed inspections of Pilot Plant implementation.
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- Identified technical issues and have proposed modifications to approach for all issues.
- Industry performed table top of proposed approaches on August 20, 2003.
- Completed a major effort to reconcile differences in SPAR and Plant PRAs for 11 distinct models (all 20 units in Pilot).
- Preliminary research report on Pilot Program being drafted for internal NRC review, and later Public Review and Comment.

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Plants Participating in MSPI Pilot Program

Region I
Limerick 1&2
Millstone 2&3
Hope Creek
Salem 1&2

Region II
Surry 1&2

Region III
Braidwood 1&2
Prairie Island 1&2

Region IV
Palo Verde 1,2&3
San Onofre 2&3
South Texas 1&2

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Key Technical Issues

- Independent verification – significant differences between SPAR model and Plant PRA.
- One component failure resulting in system indication turning to WHITE ("Invalid Indicator").
- Large number of failures to turn system to WHITE ("Insensitive Indicator").
- Identification of system boundaries.
- Data Issues including Generic Industry Performance Data, and data collection burden.
- Treatment of Common Cause Failure contribution to Fussell-Vesely.
- Support system contribution to Fussell-Vesely.

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Independent Verification

Issues

- Replicate MSPI submittals using SPAR models.
- Expectation going into Pilot that SPAR models in good agreement with Plant PRAs.
- "High level" agreement not necessarily indicative of agreement for cut-sets at 1E-6/yr and lower.
- Importance measures of components monitored in MSPI often differed by one to two orders of magnitude, especially cooling water support systems.

Resolution

- Quality Improvement: Reconcile differences at lower cut-sets levels, and change SPAR and/or Plant PRA *where justified.*
- Major effort to enhance all 11 distinct SPAR models (20 nuclear units).

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Invalid Indicators

Issues

- **For some components with high importance measure, one component failure can result in ~ 1E-6/yr delta CDF (i.e. WHITE).**
- **Can not determine an adverse performance trend from one failure (a form of "false positive").**

Resolution

- **Use "Frontstop": Minimum number of failures within a system before performance indicator turns WHITE, *or some method that has that effect.***
- **Adapted from Risk-Informed Tech Spec initiative.**
- **Will resolve Invalid Indicator issue and substantially reduce *false positives.***

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Invalid Indicators - Preliminary Results

Licensees' Plant PRA Model	Number of Component Types with Invalid Indicators				
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Braidwood 2			2		
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Limerick 1					
Limerick 2					
Millstone 2		2	1		5
Millstone 3			1		
Palo Verde 1			2		
Palo Verde 2			2		
Palo Verde 3			2		
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Salem 2	1			1	1
San Onofre 2					
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South Texas 1					
South Texas 2					
Surry 1					
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Valid (all components within system are valid)
Invalid (one or more components are invalid)

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Insensitive Indicators

Issues

- For some components with low importance measures, may require many failures to exceed delta CDF of 1E-6/yr.
- Deterministic criteria to include sufficient number of components within system even if low importance.
- Approximately 11% of systems have at least one insensitive component.

Resolution

- Use performance and statistically-based "backstop": Maximum number of allowed failures before performance is considered "degraded" and indication is WHITE.
- Adapted from Risk-Informed Tech Specs where maximum allowed outage time ("completion time") is 30 days regardless of analysis allowing delta CDF of 5E-7/yr.

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Insensitive Indicator Study: Failures to Reach G-W Threshold (San Onofre)

System	Component	Failure Mode	Unit 2 Plant PRA Model	
			# Failures to White	FV/UR
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		FTLR	> 20	0.06
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		FTR	6	1.93
	MOV	FTO/C	1	4.46
HRS	MDP-SBY	FTS	14	1.90
		FTR	10	1.90
	TDP-AFW	FTS	7	2.45
		FTR	3	2.45
	MOV	FTO/C	11	4.32
RHR	MDP-SBY	FTS	> 20	0.02
		FTR	> 20	0.02
	MOV	FTO/C	1	7.49
SWS	MDP	FTS	5	2.61
		FTR	17	2.61
	AOV	FTO/C	5	0.51
CCW	MDP	FTS	3	4.26
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Insensitive Indicators – Preliminary Results

Licensees' Plant PRA Model	Systems with Insensitive Indicators (> 20 failures to White)				
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Identification of System Boundaries

Issues

- Numerous questions as to which MSPI system to assign particular components and sub-systems for monitoring.
- Definition of "trains" is based on number of parallel heat exchangers, pumps, or flow paths, whichever is fewer.
- Numerous design configurations which do not fit neatly into definition, especially parallel/series branch lines.

Resolution

- Submit questions for clarification to "Frequently Asked Questions" forum on the NRC web-site.
- Revise NEI 99-02 to include improved guidance.
- Conduct training and lessons-learned workshops prior to full implementation.

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Baseline Performance Data

Issue

- What time period for industry failure rate data should be used for the Prior Distribution for current performance and Baseline?
- NEI 99-02 Table 2 industry data reflect '70s, '80s, and early '90s performance. Table 2 does not reflect 1995-1997 performance.

Resolution

- Statistical trend analyses of Equipment Performance Information Exchange (EPIX), and LERs used in updated system studies, indicate generally no significant trend from 1995-2001.
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- Conclusion: Year 2000 reliability data are representative of 1995-1997 period and can be used with virtually no difference in results.

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Issues

- Average number of components to be monitored is about 50 per plant.
- Because of deterministic criteria for inclusion, some plants have large number of valves to monitor.
- Pilot Program identified some issues with estimation of demands, tabulation of data, and data entry.

Resolution

- Consolidated Data Entry program through INPO will consolidate and ease reporting.
- Use cutoff of 1E-6/yr on Birnbaum for valves to reduce number to be monitored.
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Contribution of Common-Cause to Fussell-Vesely Importance Measure

Issues

- **As noted in NUREG/CR-6819 CCF Event Insights:**
  "Proximate causes of CCF events are no different from the proximate causes of single component failures...it is reasonable to postulate that if fewer component failures occur, fewer CCF events would occur."
- **Thus, in the MSPI formulation: Should not changes in the CDF owing to changes in plant-specific unreliability from single component failures also include the effect from changes in CCF rate, given the coupling factor?**

Resolution

- **Add-in the Fussell-Vesely importance from the common cause failure for a component type in the FV/UR value for a component.**

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- **Failures of components leading to a support system initiator (e.g. loss of service water) contribute to CDF.**
- **About two-thirds of plant PRAs use fault trees to quantify initiating event frequency; the remainder use a point-estimate frequency, based on plant and/or industry experience.**
- **For a basic event, use of fault trees give higher FV than when a point-estimate frequency is simply provided.**

Resolution

- **For those models using point-estimates, if the contribution of the initiator to CDF is significant, either: (a) add support system initiator fault tree(s), or (b) use a conservative approximation to FV that includes the initiator contribution.**

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SUMMARY

- MSPI is a risk-informed performance indicator using plant-specific design configuration and equipment performance data.
- Minimum and maximum limits to the number of component failures before the component is deemed degraded (non-GREEN) will be effected (frontstop and backstop concepts).
- Numerous technical issues have arisen during the Pilot. Proposed solutions for the key issues are being assessed.
- Additional implementation issues will be addressed through the Fall '03.

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Tentative Implementation Schedule

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Attachment 4

SCRAMS WITH LOSS OF NORMAL HEAT REMOVAL

OPTION 4

- Counts scrams in which normal heat removal is unavailable during scram recovery

- Normal heat removal is available if all of the following criteria are met:

    1. At least one train of main feedwater operates as designed with no mechanical, electrical, or control logic faults

    2. At least one main steam line flow path is open

    3. At least one turbine bypass valve functions as designed

    4. Condenser vacuum is sufficient to remove decay heat

- Main feedwater pumps are recoverable if they satisfy criterion 1

- MSIVs, once closed, are not recoverable

- Cause of the scram is immaterial

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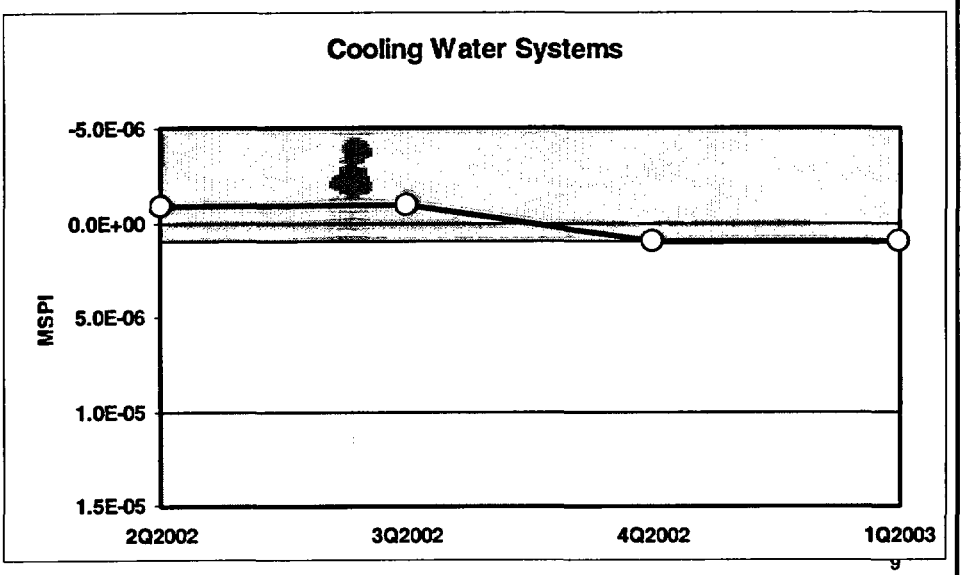

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