

**Mitigating Systems Performance Index Pilot  
Working Group Public Meeting  
January 21, 2004**

**Ongoing Research Activities**

**by**

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## **Activities**

- **Assessment of MSPI PRA Adequacy Issues**
  - **Sensitivity studies of the effect of PRA model differences on MSPI (completed)**
  - **MSPI pre-implementation checklist (next)**
- **Comparison of MSPI, SSU, and SDP results for mitigating systems of Pilot Plants**
  - **Comparison (completed)**
  - **Analysis & sensitivity studies (in-progress)**
- **Evaluation of options to account for the effect of common cause on Fussell-Vesely importance (preliminary generic multipliers derived)**

## **MSPI Sensitivity to PRA Model Differences**

- **Sensitivity performed two ways**
  - **Effect on MSPI assuming one failure more than baseline one component at a time**
  - **Effect on 4<sup>th</sup> Quarter 2002 results**
- **All significant PRA model differences grouped into three to seven change sets, FV/UR values regenerated from revised SPAR model, and MSPI requantified**

# Possible Sensitivity Study Outcomes

- **Large impact**
  - Order-of-magnitude on MSPI numerical result, and
  - Very likely to change color (e.g. WHITE to GREEN, WHITE to YELLOW, etc.)
- **Medium impact**
  - Affects first significant figure of MSPI numerical result, and change  $> 1E-7$
  - Possible change in color depending on how close to threshold
- **Low or no impact**
  - Affects second significant figure (or lower) of MSPI numerical result, or change  $< 1E-7$
  - Unlikely to or will not change color

# **MSPI Sensitivity Results**

## **Large Sensitivity Issues**

- **Braidwood: PORV success criterion (1-of-2 vs. 2-of-2 PORVs)**
- **Salem: loss of service water initiator frequency (30x lower)**
- **Millstone-2: LOCA categories and frequencies (e.g. LLOCA 14x higher, MLOCA 3x lower, SLOCA 5x higher)**

## **Plants with no Large but at least one Medium Sensitivity Issue**

- **Millstone-3: AFW & MFW basic event prob. (2x to 3x either way)**
- **Limerick: MFW/PCS basic event probability (10x lower)**
- **Hope Creek: HPCI, SWS & CCW basic event prob. (2x to 3x lower)**
- **Palo Verde: AFW basic event prob. (generally 2x to 5x lower except TDP FTR 3x higher)**
- **San Onofre: operator fails to recover offsite power (36% lower)**

## **Plants with only Small Sensitivity Issues**

- **Surry, South Texas, Prairie Island**

*77 failures - during  
46 pilot period*

# Evaluation of Pilot Plant Component Failures

(revised)

*31 failures but MSPI SDP*

## Agreement

- 8 failures where MSPI = SSU = SDP = Green
- 25 failures where MSPI = SSU = Green, no SDP findings
- 1 failure where MSPI = SDP = Green, no SSU
- 1 failure where MSPI = White (Green w Frontstop), SSU = Green, no SDP finding -

*17  
21  
5/6*

## Differences

- 1 case where three failures give MSPI = SSU = White, and SDP = Green for two
- 1 case where three failures plus later large unavailability give MSPI = White, SSU = Green, no SDP findings
- 1 case where four failures give MSPI = White (Green w Frontstop), SSU = Green, and SDP = White
- 1 case where four failures give MSPI = Green, SSU = White, and SDP = Green for one
- 1 case where five failures give MSPI = Green, SSU = White, and SDP = Green for one
- 1 failure where MSPI = Green, SSU = White, no SDP findings
- 1 failure where MSPI = Green, SSU = SDP = White

Notes: MSPI and SSU are quarterly comparisons, whereas SDP is a single event. The failures contributing to the MSPI may have occurred over several quarters. SDP findings taken from inspection reports. For all remaining failures, there was no basis for comparison since there were no SDP findings nor SSUs.

# MSPI/SSU/SDP Comparison for MSPI Failures

Plant	System	Failure	Date	MSPI		SSU				SDP		Comments
				Delta CDF (1/y) (4Q2002 Data) (note 1)	Color (note 2)	Unplanned Outage Time (h)	Fault Exposure Time (h)	Result	Color	Failure Mentioned in Inspection Report?	SDP Color Indicated in Inspection Report (note 3)	
Braidwood 1	EAC	EDG FTS	1Q2000	-9.60E-08	Green	18.3	7.4	0.40%	Green	None		
	HPI	MOV FTO/C	3Q2001	4.39E-08	Green	35.2	0	0.60%	Green	2001010	Green	SDP result from Phase 2 analysis.
	HRS	DDP FTR	2Q2001	3.84E-07	Green	0	155.9	1.50%	Green	None		MSPI using 1 FTR.
			DDP FTS	4Q2001	1.33E-06	White (Green)	0	335.8	2.30%	White	2002004	Green
		DDP FTS	1Q2002	2.28E-06	White	68.6	0	2.50%	White	2002004	Green	MSPI using 1 FTR and 2 FTS. SDP result from Phase 1 analysis.
Braidwood 2	EAC	EDG FTLR	1Q2002	-1.63E-07	Green	11.7	0	0.30%	Green	2002007	Green	SDP result from Phase 1 analysis.
	HPI	AOV FTO/C	2Q2001	-2.00E-08	Green	0	0	0.80%	Green	None		
	HRS	DDP FTR	4Q2000	1.22E-07	Green	0	8.7	0.50%	Green	None		
	RHR	MDP FTR	4Q2001	1.71E-07	Green	0	0	0.60%	Green	2001013	Green	Event occurred during process of placing shutdown cooling in service. SDP result from Phase 1 analysis.
Hope Creek	EAC	EDG FTR	2Q2000	-5.23E-07	Green	11.2	336	1.40%	Green	20010127	Green	MSPI using 1 FTR. MSPI UA contribution is -4.87E-7. SDP is from Phase 1 analysis.
		EDG FTR	4Q2001	-4.44E-07	Green	36.3	335.5	1.80%	Green	None		MSPI using 2 FTR. MSPI UA contribution is -4.87E-7.
		EDG FTR	1Q2002	-3.66E-07	Green	9.2	0	1.80%	Green	2001012	Green	MSPI using 3 FTR. MSPI UA contribution is -4.87E-7. SDP result from Phase 1 analysis.
		EDG FTR	3Q2002	-2.87E-07	Green	35.3	0	1.90%	Green	None		
		EDG FTS	4Q2002	-1.90E-07	Green	38.7	0	1.90%	Green	None		MSPI using 4 FTR and 2 FTS. MSPI UA contribution is -4.87E-7.
		EDG FTS	4Q2002	-1.90E-07	Green	40.7	0	1.90%	Green	None		MSPI using 4 FTR and 2 FTS. MSPI UA contribution is -4.87E-7.
	HPI	MOV FTO/C	3Q2000	-3.18E-07	Green	22.7	1.3	1.10%	Green	None		MSPI using 1 MOV FTO/C. MSPI UA contribution is -2.81E-7.
		MOV FTO/C	1Q2001	1.22E-07	Green	0	0	1.00%	Green	None		MSPI using 2 MOV FTO/C. MSPI UA contribution is -2.81E-7.
		MOV FTO/C	2Q2001	5.61E-07	Green	0	0	0.70%	Green	None		MSPI using 3 MOV FTO/C. MSPI UA contribution is -2.81E-7.
			(Note 4)	3Q2002	1.05E-06	White (Note 4)	0	0	1.70%	Green	None	
	HRS	TDP FTS	4Q2002	1.22E-07	Green	0	0	1.50%	Green	None		
	RHR	MOV FTO/C	1Q2000	1.71E-07	Green	14.2	0	1.10%	Green	2000007	Green	Event occurred while supporting HPCI and RCIC surveillances during startup. SDP result from Phase 1 (?) analysis.
	SWS/CCW	MDP FTR	1Q2001	4.32E-08	Green	N/A	N/A	N/A	N/A	2002002	Green	SDP result from Phase 1 (?) analysis.
Millstone 2	HPI	MOV FTO/C	1Q2000	-2.65E-07	Green	0	0	0.40%	Green	None		This failure is also listed under RHR MOV FTO/C. ROP UA hours listed under RHR.
	HRS	TDP FTS	3Q2000	-3.91E-07	Green	30.75	677.5	2.70%	White	2000011	White	SDP result from Phase 2 and Phase 3 analysis. 14-day outage assumed.
	RHR	MOV FTO/C	1Q2000	3.75E-10	Green	11.06	0	0.20%	Green	None		
	SWS/CCW	AOV FTO/C	4Q2002	3.13E-07	Green	N/A	N/A	N/A	N/A	None		
Millstone 3	HPI	MDP FTR	3Q2002	-5.64E-07	Green	0.03	0	1.10%	Green	None		MSPI using 2 MDP FTR.
		MDP FTR	3Q2002	-5.64E-07	Green	7.3	0	1.10%	Green	None		MSPI using 2 MDP FTR.
	SWS/CCW	MDP FTS	2Q2000	7.70E-08	Green	N/A	N/A	N/A	N/A	None		
Palo Verde 1	EAC	EDG FTS	2Q2002	1.10E-07	Green	27.97	15.82	0.70%	Green	None		
	HPI	MOV FTO/C	1Q2000	1.90E-09	Green	0	0	1.10%	Green	None		MSPI using 1 MOV FTO/C.
		MOV FTO/C	4Q2000	2.42E-08	Green	0	0	1.10%	Green	None		MSPI using 2 MOV FTO/C.
Palo Verde 2	HPI	MOV FTO/C	4Q2000	1.35E-08	Green	0	29.57	1.10%	Green	None		
	HRS	MDP FTS	4Q2000	3.02E-06	White (Green)	13.97	0	0.50%	Green	None		
Palo Verde 3	EAC	EDG FTR	2Q2000	8.89E-08	Green	0	0	0.50%	Green	2001004	Green	MSPI using 1 EDG FTR. SDP results from Phase 1 (?) analysis.
		EDG FTS	3Q2001	1.79E-07	Green	54.97	312.1	1.30%	Green	2001005		MSPI using 1 EDG FTR and 1 EDG FTS. Failure listed in inspection report (2001005) but no mention of SDP evaluation.
	HPI	MOV FTO/C	1Q2000	1.36E-09	Green	11.47	984.14	3.00%	White	None		MSPI using 1 MOV FTO/C. Supplemental inspection (2000012) conducted because ROP indicator changed to white. No mention of SDP evaluation.
		MOV FTO/C	4Q2001	2.38E-08	Green	0	0	0.80%	Green	None		MSPI using 2 MOV FTO/C.
Prairie Island 1	SWS/CCW	DDP FTS	2Q2002	1.66E-07	Green	N/A	N/A	N/A	N/A	None		MSPI using 2 DDP FTS.
		DDP FTS	2Q2002	1.66E-07	Green	N/A	N/A	N/A	N/A	None		MSPI using 2 DDP FTS.
		DDP FTS	3Q2002	3.52E-07	Green	N/A	N/A	N/A	N/A	None		MSPI using 3 DDP FTS.

Note 1 - For system failures occurring within a single quarter, the MSPI evaluation includes all of the failures within the quarter (plus any previous failures).

Note 2 - If the proposed front stop is applied and the resulting color is different, then the color using the front stop is presented in parentheses.

Note 3 - If blank, a green color is assumed.

Note 4 - This row was added to show that the MSPI is white using 3Q2002 data (rolling 3-year period), because of a relatively large unavailability during 3Q2002. However, the MSPI returns to green the next quarter, when the 4Q2002 data are used.

Acronyms: AOV (air-operated valve), CDF (core damage frequency), DDP (diesel-driven pump), EAC (emergency ac power), EDG (emergency diesel generator), FTLR (fail to load and run for 1 hour), FTO/C (fail to open or close), FTR (fail to run), FTS (fail to start), HPI (high pressure injection system), HRS (heat removal system), MDP (motor-driven pump), MOV (motor-operated valve), MSPI (mitigating systems performance index), RHR (residual heat removal system), ROP (reactor oversight process), SDP (significance determination process), SSU (safety system unavailability), SWS/CCW (service water system/component cooling water system), UA (unavailability)

# MSPI/SSU/SDP Comparison for MSPI Failures (cont.)

Plant	System	Failure	Date	MSPI		SSU				SDP		Comments	
				Delta CDF (1/y) (4Q2002 Data) (note 1)	Color: (note 2)	Unplanned Outage Time (h)	Fault Exposure Time (h)	Result	Color	Failure Mentioned in Inspection Report?	SDP Color: Indicated in Inspection Report (note 3)		
Prairie Island 2	EAC	EDG FTLR	1Q2000	-8.66E-09	Green	9.1	340.05	1.50%	Green	None		MSPI using 1 EDG FTLR.	
		EDG FTS	4Q2000	1.26E-07	Green	15.17	0	1.50%	Green	None		MSPI using 1 EDG FTLR and 1 EDG FTS.	
		EDG FTLR	2Q2001	2.26E-07	Green	199.42	0	1.80%	Green	2001013	Green	MSPI using 2 EDG FTLR and 1 EDG FTS. SDP result from Phase 2 analysis.	
		EDG FTS	4Q2001	3.62E-07	Green	79.87	8.78	2.30%	Green	None		MSPI using 2 EDG FTLR and 2 EDG FTS.	
Salem 1	EAC	AOV FTO/C	3Q2001	-1.90E-08	Green	13.97	390.88	1.90%	Green	None			
		EDG FTLR	3Q2002	2.84E-06	White (Green)	103.3	87.8	1.50%	Green	2002010	Green	MSPI using 3 EDG FTLR and 1 FTR.	
		EDG FTLR	3Q2002	2.84E-06	White (Green)	103.3	87.8	1.50%	Green	None		MSPI using 3 EDG FTLR and 1 FTR.	
		EDG FTLR	3Q2002	2.84E-06	White (Green)	103.3	87.8	1.50%	Green	None		MSPI using 3 EDG FTLR and 1 FTR.	
Salem 1	EAC	EDG FTR	3Q2002	2.84E-06	White (Green)	103.3	87.8	1.50%	Green	2002010	White	MSPI using 3 EDG FTLR and 1 FTR. SDP result in May 2003 letter from NRC to utility, referencing the results of a March 26 SERP workshop. EDG 1C unavailable 283 hours.	
		HPI	MDP FTR	1Q2000	-8.34E-09	Green	41.1	0	0.60%	Green	None		
		SWS/CCW	MDP FTR	2Q2000	-1.14E-07	Green	N/A	N/A	N/A	N/A	None		
		HPI	MDP FTS	1Q2000	4.20E-08	Green	11	0	0.50%	Green	None		
Salem 2	SWS/CCW	MOV FTO/C	1Q2001	-1.44E-07	Green	N/A	N/A	N/A	N/A	2000011		Inspection report 2000011 discusses failure of similar valve (21SW127) in Unit 1 on 1/24/01. For that event, the other HX was already unavailable, so both CCW HXs were unavailable. For this simultaneous outage, the SDP result of green was from a Phase 3 analysis. (Phase 2 workbooks for Salem not available at the time.) The same inspection report describes the Unit 2 failure of 22SW127 on 1/4/01, but does not mention any SDP evaluation.	
San Onofre 2	HPI	MDP FTS	3Q2000	-2.05E-08	Green	6.3	0	0.80%	Green	None			
		SWS/CCW	MDP FTR	1Q2001	-2.02E-07	Green	N/A	N/A	N/A	N/A	None		MSPI using 1 SWS MDP FTR.
			MDP FTR	4Q2001	-1.64E-07	Green	N/A	N/A	N/A	N/A	None		MSPI using 3 SWS MDP FTR.
			MDP FTR	4Q2001	-1.64E-07	Green	N/A	N/A	N/A	N/A	None		MSPI using 3 SWS MDP FTR.
			MDP FTR	1Q2002	-1.46E-07	Green	N/A	N/A	N/A	N/A	None		MSPI using 4 SWS MDP FTR.
			MDP FTR	4Q2002	-9.53E-08	Green	N/A	N/A	N/A	N/A	None		MSPI using 6 SWS MDP FTR.
			MDP FTR	4Q2002	-9.53E-08	Green	N/A	N/A	N/A	N/A	None		MSPI using 6 SWS MDP FTR.
San Onofre 3	SWS/CCW	MDP FTR	3Q2001	-4.81E-07	Green	N/A	N/A	N/A	N/A	None		MSPI using 2 SWS MDP FTR.	
			MDP FTR	3Q2001	-4.81E-07	Green	N/A	N/A	N/A	N/A	None		MSPI using 2 SWS MDP FTR.
Surry 1	EAC	EDG FTLR	3Q2000	2.00E-07	Green	83.68	0	1.50%	Green	None		MSPI using 1 EDG FTLR and 1 EDG FTR.	
		EDG FTR	3Q2000	2.00E-07	Green	83.68	0	1.50%	Green	None		MSPI using 1 EDG FTLR and 1 EDG FTR.	
		EDG FTS	4Q2001	2.96E-07	Green	0.5	237.77	2.70%	White	2001007	Green	MSPI using 1 EDG FTLR, 1 EDG FTR, and 1 EDG FTS. SDP result from Phase 1 (?) analysis.	
		EDG FTS	4Q2002	3.91E-07	Green	83.35	0	3.20%	White	None		MSPI using 1 EDG FTLR, 1 EDG FTR, and 2 EDG FTS. ROP/SSU for Unit 2 (EDG shared by both units) is 2.9% and	
Surry 2	EAC	EDG FTS	3Q2000	4.58E-08	Green	18.94	0	1.80%	Green	None		MSPI using 1 EDG FTS and 1 EDG FTLR.	
		EDG FTLR	3Q2000	4.58E-08	Green	18.94	0	1.80%	Green	None		MSPI using 1 EDG FTS and 1 EDG FTLR.	
		EDG FTLR	3Q2001	1.31E-07	Green	22.32	336.03	3.10%	White	2002008	Green	MSPI using 1 EDG FTS and 2 EDG FTLR. SDP result from Phase 1 (?) analysis.	
		EDG FTLR	4Q2001	4.00E-07	Green	133.15	0	3.20%	White	None		MSPI using 1 EDG FTS and 4 EDG FTLR.	
		EDG FTLR	4Q2001	4.00E-07	Green	133.15	0	3.20%	White	None		MSPI using 1 EDG FTS and 4 EDG FTLR.	
Surry 1/2	SWS/CCW	DDP FTR	2Q2000	<1.97E-07	Green	N/A	N/A	N/A	N/A	None		Surry 1 MSPI using 1 DDP FTR.	
		DDP FTS	3Q2000	<1.97E-07	Green	N/A	N/A	N/A	N/A	None		Surry 1 MSPI using 1 DDP FTR and 1 DDP FTS.	
		MOV FTO/C	2Q2001	<1.97E-07	Green	N/A	N/A	N/A	N/A	None		Surry 1 MSPI using 1 DDP FTR, 1 DDP FTS, and 1 MOV FTO/C.	
		DDP FTS	2Q2002	<1.97E-07	Green	N/A	N/A	N/A	N/A	None		Surry 1 MSPI using 1 DDP FTR, 2 DDP FTS, and 1 MOV FTO/C.	
		MOV FTO/C	4Q2002	1.97E-07	Green	N/A	N/A	N/A	N/A	None		Surry 1 MSPI using 1 DDP FTR, 2 DDP FTS, and 3 MOV FTO/C.	
		MOV FTO/C	4Q2002	1.97E-07	Green	N/A	N/A	N/A	N/A	None		Surry 1 MSPI using 1 DDP FTR, 2 DDP FTS, and 3 MOV FTO/C.	

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Note 2 - If the proposed front stop is applied and the resulting color is different, then the color using the front stop is presented in parentheses.

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# Preliminary Generic Multipliers on FV/UR to Address CCF

System	Component	Generic CCF Multiplier					Comments
		1.25	1.50	2.00	3.00	5.00	
EAC	EDG	2 EDGs (1/2) or 3 EDGs (2/3)	4 EDGs (1/4) with other diverse sources of power	3 EDGs (1/3)		4 EDGs (1/4) and no diverse sources of power	4 EDG case (with no diverse sources of power) includes information from SPAR Rev. 3 models for Browns Ferry 3 and Fitzpatrick.
HPI	MDP Running		With SI and CVC		With only CVC		
	MDP Standby		With SI and CVC		With only SI		
HRS	MDP Standby	2 MDPs (1/2)			3 MDPs (1/3)		
	TDP	2 TDPs and 1 MDP			3 TDPs and no MDPs		Information from SPAR Rev. 3 models for Calvert Cliffs, Davis Besse and Turkey Point used.
RHR	MDP Standby		All				
SWS	MDP Running				All		
	MDP Standby		All				
	DDP	All					
CCW	MDP Running		All				
	MDP Standby			All			
All	MOV FTO/C			All			
All	AOV FTO/C		All				

Note - Success criterion indicated in parentheses.

Note - Generic CCF multipliers obtained from SPAR resolution model results for 11 pilot plants, unless otherwise indicated.

## Effect of CCF

- Ensures more complete representation of CCF modeling
- Increase coefficients

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

- Makes positive terms more positive, and negative terms more negative
- In theory, would reduce “number-of-failures-to-WHITE,” but in practice more negative terms tend to balance more positive terms
- Analysis for Pilot indicates no case where the inclusion of CCF would have made any difference between a GREEN or WHITE in three years of results. Anticipate a marginal effect upon full implementation.

## Summary

- **Sensitivity studies of the effect of PRA model differences on MSPI results indicate that these differences are manageable. Insights from these studies will be useful in the development of pre-implementation PRA adequacy checklists.**
  - **Major differences in success criteria or initiating event frequencies from the norm have the largest impact.**
  - **Factors of 2 or 3 in basic event probability are generally of less importance.**
- **Comparisons of MSPI results with SDP and SSU identified agreements and differences, recognizing the different measures and approaches used. Further analysis of the differences is underway.**
- **Preliminary generic multipliers for the FV/UR weighting factors as an option to address CCF modeling effects have been developed. Assessment of their potential impact is ongoing.**