September 8, 2003

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SUBJECT: RESULTS OF THE FERMI NUCLEAR POWER PLANT UNIT 2 SDP PHASE 2 NOTEBOOK BENCHMARKING VISIT

During April, 2003 NRC staff and contractors visited the Detroit Edison Energy Company in Newport, MI to compare the Fermi Plant Significance Determination Process (SDP) Phase 2 notebook to the licensee's risk model results to ensure that the SDP notebook was generally conservative. The Fermi probabilistic safety assessment (PSA) did not include external initiating events therefore no sensitivity studies were performed to assess the impact of these initiators on SDP color determinations. In addition, the results from analyses using the NRC's draft Revision 3i Standardized Plant Analysis Risk (SPAR) model for Fermi were also compared with the licensee's risk model. The results of the SPAR model benchmarking effort will be documented in the next revision of the SPAR (revision 3) model documentation.

The benchmarking visit identified that there was very good correlation between the Phase 2 SDP Notebook and the licensee's PSA. The results indicate that the Fermi SDP Phase 2 notebook was conservative in comparison to the licensee's PSA. A summary of the results of comparisons of hypothetical inspection findings between SDP notebook and the licensee's PSA are as follows.

0%	Underestimates Risk Significance
77%	Match Risk Significance
16%	Overestimates Risk Significance by 1 Order of Magnitude
7%	Overestimates Risk Significance by 2 Orders of Magnitude
2%	Unable to compare with licensee's PSA.

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The Rev. 1 SDP notebook was improved as a result of the benchmarking activity. The percentage of cases that the Rev. 1 SDP notebook matched that of the updated licensee's PSA increased from 54% to 77% and the percentage of overestimates was reduced from 39% to 23%. The percentage of underestimates decreased from 7% to 0%.

During the benchmarking, some characteristics of the Fermi PSA were noted which contributed to the difference in results between the SDP notebook and the plant PSA. These characteristics include the following:

- Failure of 1 RHR pump was overestimated by two orders of magnitude by the notebook compared to the plant PRA. The color obtained based on the plant PRA is Green whereas the notebook evaluation assesses the color to be Yellow. The reason for this difference is the difference in unavailability for the RHR trains and pumps compared to the 1 multi-train credit assigned to the containment heat removal or suppression pool cooling function. In assessing the failure of 1 RHR pump in the SDP notebook, the credit for the CHR function remains at 1 multi-train system because 3 RHR pumps remain available. In the plant PRA, the unavailability for the remaining three pumps is more than two orders of magnitude lower.

- Failure of 1 RHRSW pump was overestimated by two orders of magnitude. Similar to the RHR pump discussed above, the color based on the plant PRA is Green, but the assessed color using the notebook is Yellow. The reason for this overestimation is the same as that for the RHR pump. The RHRSW system provides the heat exchange medium for the RHR heat exchanger in the suppression cooling mode. One of four RHRSW pumps is required for success. Division II of RHRSW can be crosstied to the RHR system and used as an emergency injection source to the vessel. In assessing the credit for failure of 1 RHRSW pump in the SDP notebook, the credit for the CHR function remains at 1 multi-train system equivalent to 1E-3. The unavailability of the remaining three RHRSW pumps being unavailable is more than two orders of magnitude lower.

- Failure of containment venting due to failure of the air operated damper was overestimated by two orders of magnitude. The color obtained using the SDP notebook is Red with ΔCDF impact in the 1E-3 range. The color based on the plant PRA is Yellow. Again, the reason for the difference is in the manner in which containment heat removal/suppression pool cooling (CHR/SPC) is evaluated in the notebook and the plant PRA. For failure to vent the containment, the remaining mitigation capability is the containment heat removal through suppression pool cooling. The difference in crediting suppression pool cooling between the notebook and the plant PRA results in the overestimation.

In addition to the overestimations discussed above, seven cases of overestimations by one order of magnitude were noted. Overestimations by one order of magnitude is expected because of the conservative approaches used in the SDP notebook for its use as a screening tool. No additional major differences between the plant PRA and the SDP notebook were identified as the reason for these overestimations. Difference in credit for the CHR/SPC function contribute to some of the differences along with the SDP approach for evaluation of risk significance.

The licensee's PSA staff was very knowledgeable of the plant model and provided very helpful comments during the benchmark visit.

Attachment A describes the process and results of the comparison of the Fermi SDP Phase 2 Notebook and the licensee's PSA.

Attachments: As stated

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SUMMARY REPORT ON BENCHMARKING TRIP

TO THE FERMI 2 NUCLEAR POWER PLANT

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August 2003

ATTACHMENT A

Table of Contents

List of Tables

1. INTRODUCTION

A Benchmarking of the Risk-Informed Inspection Notebook for the Fermi 2 Nuclear Power Plant was conducted during a plant site visit on April 14-16, 2003. NRC staff (R. Gibbs and M. Parker) and BNL staff (P. Samanta) participated in this Benchmarking exercise.

In preparation for the meeting, BNL staff reviewed the SDP notebook for the Fermi 2 Nuclear Power Plant and evaluated a set of hypothetical inspection findings using the Rev. 0 SDP worksheets. In addition, NRC staff provided the licensee with a copy of the meeting protocol.

The major milestones achieved during this meeting were as follows:

1. Recent modifications made to the Fermi 2 PRA were discussed for consideration in the Rev. 1 model to be prepared following benchmarking.

2. Importance measures, including the Risk Achievement Worth (RAW) for the basic events in the internal event model for average maintenance, were obtained from the licensee.

3. Benchmarking was conducted using the Rev. 0 SDP model and the revised SDP model considering the licensee's input and other modifications that were judged necessary based on comparison of the SDP model and the licensee's detailed model.

4. For cases where the color evaluated by the SDP notebook differed from that determined based on the RAW values generated by the updated licensee's PRA, results of the licensee's base case model along with specific run for the case being analyzed including the dominant minimal cutsets were reviewed to understand the reason for the differences.

The Rev. 1 version of the SDP notebook was developed considering the changes identified based on licensee input and the evaluation of the benchmarking results.

2. SUMMARY RESULTS FROM BENCHMARKING

Summary of Benchmarking Results

Benchmarking of the SDP Notebook for the Fermi 2 Nuclear Power Plant was conducted comparing the risk significance of the inspection findings obtained using the notebook with that to be obtained using the plant PRA. The benchmarking identified the hypothetical inspection findings for which the results of the evaluation using the notebook were under or overestimation compared to the plant PRA. No cases of non-conservative results or underestimation by the notebook was noted. Three cases of conservative result by two orders of magnitude (i.e., the significance obtained using the notebook is two colors higher than that to be obtained using the plant PRA) were noted. A summary of the results of the risk characterization of hypothetical inspection findings is as follows:

0% (0 of 43 cases)	Non-conservative; underestimation of risk significance (by one order of magnitude)
7% (3 of 43 cases)	Conservative; overestimation of risk significance (by two orders of magnitude)
21% (9 of 43 cases)	Conservative; overestimation of risk significance (by one order of magnitude)
72% (31 of 43 cases)	Consistent risk significance.

Detailed results of Benchmarking are summarized in Table 1. Table 1 consists of eight columns. The first two columns identify the components or the case runs. The assigned colors from the SDP Rev. 0 worksheets without incorporating any modification from the Benchmarking exercise are shown in the third column. The fourth column gives the basic event name in the plant PRA used to obtain the risk achievement worth (RAW) for the component out of service or the failed operator action. The fifth and sixth columns respectively show the licensee's internal RAW value and the color to be defined based on the RAW values from the latest PRA model. The seventh column presents the colors for the inspection findings based on the Rev. 1 version of the notebook. The Rev. 1 version of the notebook is prepared considering the revisions to the Rev. 0 version of the SDP notebook judged applicable during Benchmarking. The last column provides comments identifying the difference in results between the SDP Rev. 1 notebook and the plant PRA, and the applicable rules in obtaining the color of the inspection finding using the SDP notebook.

Table 2 presents a summary of the comparisons between the results obtained using the Fermi 2 Nuclear Power Plant notebook and the plant PRA. It also shows a comparison of the results using the Rev. 0 and Rev. 1 versions of the notebook. The results show that overestimations by the notebook were reduced and the matches were increased through revisions to the notebook implemented as a result of Benchmarking. The overestimations were reduced from 39% to 28% and the matches increased from 54% to 72%. Underestimations were eliminated.

Discussion of Non-conservative Results by the Notebook

No non-conservative results or underestimations by the notebook were noted.

Discussion of Conservative Results by the Notebook

Ten cases of overestimations or conservative results were noted during the benchmarking. Of the ten cases, three cases were overestimated by two orders of magnitude and the remaining seven cases were overestimated by one order of magnitude. Since the notebooks are designed to be screening tools and include assumptions that can result in conservative assessment, overestimation by an order of magnitude, i.e., by one color, is not unexpected. We focus on the items that are conservative by two orders of magnitude. We discuss these cases first and then provide general discussions for the conservative results by the notebook.

1. Failure of 1 RHR pump was overestimated by two orders of magnitude by the notebook compared to the plant PRA. The color obtained based on the plant PRA is Green whereas the notebook evaluation assesses the color to be Yellow. The reason for this difference is the difference in unavailability for the RHR trains and pumps compared to the 1 multi-train credit assigned to the containment heat removal or suppression pool cooling function. In assessing the failure of 1 RHR pump in the SDP notebook, the credit for the CHR function remains at 1 multi-train system because 3 RHR pumps remain available. In the plant PRA, the unavailability for the remaining three pumps is more than two orders of magnitude lower.

2. Failure of 1 RHRSW pump was overestimated by two orders of magnitude. Similar to the RHR pump discussed above, the color based on the plant PRA is Green, but the assessed color using the notebook is Yellow. The reason for this overestimation is the same as that for the RHR pump. The RHRSW system provides the heat exchange medium for the RHR heat exchanger in the suppression cooling mode. One of four RHRSW pumps is required for success. Division II of RHRSW can be crosstied to the RHR system and used as an emergency injection source to the vessel. In assessing the credit for failure of 1 RHRSW pump in the SDP notebook, the credit for the CHR function remains at 1 multi-train system equivalent to 1E-3. The unavailability of the remaining three RHRSW pumps being unavailable is more than two orders of magnitude lower.

3. Failure of containment venting due to failure of the air operated damper was overestimated by two orders of magnitude. The color obtained using the SDP notebook is Red with ΔCDF impact in the 1E-3 range. The color based on the plant PRA is Yellow. Again, the reason for the difference is in the manner in which containment heat removal/suppression pool cooling (CHR/SPC) is evaluated in the notebook and the plant PRA. For failure to vent the containment, the remaining mitigation capability is the containment heat removal through suppression pool cooling. The difference in crediting suppression pool cooling between the notebook and the plant PRA results in the overestimation.

In addition to the overestimations discussed above, nine cases of overestimations by one order of magnitude were noted. As discussed before, overestimation by one order of magnitude is expected because of the conservative approaches used in the SDP notebook for its use as a screening tool. No additional major difference between the plant PRA and the SDP notebook was identified as the reason for these overestimations. Difference in credit for the CHR/SPC function contribute to some of the differences along with the SDP approach for evaluation of risk significance.

Changes Incorporated Following Benchmarking Resulting in Updating of Benchmarking Results

Following the benchmarking, some additional changes to the notebook were addressed. The changes can be summarized as follows:

1. Credit for SBFW in the LI function was deleted where the SBFW pumps were included as part of the HPI function.

2. SORV worksheet and event tree were modified to consistently credit the CST refill function.

These changes resulted in changing the risk significance of “Failing to initiate CRD” from Green to White.

Table 1: Summary of Benchmarking Results for Fermi 2 Nuclear Power Plant

Internal Events CDF is 5.76E-6/reactor-year excluding internal flooding at a 1E-12 truncation limit
RAW thresholds are W = 1.17, Y = 2.74, R = 18.36, RR = 174.6, RRR = 1737.1 (1)

No.	Component Out of Service or Failed Operator Action	SDP Worksheet Results (Before)	Fermi 2 Nuclear Power Plant Basic Event	Fermi 2 Nuclear Power Plant RAW Ratio	Color by Fermi 2 Nuclear Power Plant RAW	SDP Worksheet Results (After)	Comments
	Component						
1.	HPCI	Y	TPTSHPCICC12_2	2.98	Y	Y	
2.	RCIC	Y	TPTSRCICCC12_1	2.68	W	Y	over (by one order of magnitude)
3.	PCS steam	Y	HEOFRCICHEOH2	1.2	W	Y	over (by one order of magnitude)
4.	PCS feed	G	Truncated	1.0	G	G	
5.	1 SBFW pump	W	MPTSSBFWCC12_1	2.44	W	W	
6.	1 SRV fto	W	VVFOSRVSF013N	1.01	G	W	over (by one order of magnitude)
7.	1 SRV ftc	Y	VVDXAOEC1OF5	1.24	W	Y	over (by one order of magnitude)
8.	1 CS pump	G	MPTSCSS1CC14_1	1.0	G	G	
9.	1 RHR pump	Y	MPFSRHR1CC14_9	1.11	G	Y	over (by two orders of magnitude)

No.	Component Out of Service or Failed Operator Action	SDP Worksheet Results (Before)	Fermi 2 Nuclear Power Plant Basic Event	Fermi 2 Nuclear Power Plant RAW Ratio	Color by Fermi 2 Nuclear Power Plant RAW	SDP Worksheet Results (After)	Comments
10.	1 RHR HX	R	HXRLRSW2B001B	21.14	R	R	
11.	1 RHRSW pump	Y	MPFSRSW2CC14_3	1.11	G	Y	over (by two orders of magnitude)
12.	1 DGSW pump	W	MPDASF12CC14_2	2.17	W	W	
13.	1 GSW pump	Y	MPRAFAQAXX15_1	1.0	G	W	over (by one order of magnitude)
14.	SLC pump	G	MPFSSLCSCC12_2	1.05	G	G	
15.	RPT 1 train	G	CLFORPTAP613D CLFORPTAP6131A	3.11	Y	Y	
16.	RPT both trains	Y	CLFORPTAP613D CLFORPTAP613A CLFORPTBP612D CLFORPTBP612B	3.11	Y	Y	
17.	1 NIAS Compressor	G	CMTSCAC2CC12_2	1.14	G	G	
18.	1 SA Compressor	W	CMTSSACSCC12_4	1.07	G	W	over (by one order of magnitude)
19.	1 EDG	W	DGFSDG12CC14_2	2.60	W	W	
20.	1 CTG	W	GTTSCTG1S069	1.75	W	W	
21.	ESF Div I Bus (Bus 64B)	Y	BSTSB64BS001B	1.95	W	Y	over (by one order of magnitude)

No.	Component Out of Service or Failed Operator Action	SDP Worksheet Results (Before)	Fermi 2 Nuclear Power Plant Basic Event	Fermi 2 Nuclear Power Plant RAW Ratio	Color by Fermi 2 Nuclear Power Plant RAW	SDP Worksheet Results (After)	Comments
22.	ESF Div II Bus (Bus 65F)	Y	BSTSB65FS001F	1.68	W	Y	over (by one order of magnitude)
23.	1 DC Bus	R	BSTSEDC1S026	1374.54	RR	RR	
24.	1 DC Battery	R	BTFDEDC1S0031	169.65	R	R	
25.	1 Battery Charger	R	BCTSEDC2S021A	1.11	G	G	Battery charger can not carry SI loads. Considering the plant's process for detecting battery charger failure, a significance of Green is assessed.
26.	1 CRD pump	W	MPTSCRDHCC12_2	1.0	G	G	
27.	1 RBCCW pump	Y	MPTSRBCWCC13_2	1.0	G	G	
28.	1 EECW pump	G	MPFSECW2CC12_2	1.05	G	G	Applicable only for LOOP and LLOCA scenarios
29.	1 EESW HX	G	HXRLECW2B001B	1.03	G	G	Applicable only for LOOP and LLOCA scenarios
30.	1 TBCCW pump	G	MPTSTBCWCC13_3	1.18	W	W	

No.	Component Out of Service or Failed Operator Action	SDP Worksheet Results (Before)	Fermi 2 Nuclear Power Plant Basic Event	Fermi 2 Nuclear Power Plant RAW Ratio	Color by Fermi 2 Nuclear Power Plant RAW	SDP Worksheet Results (After)	Comments
31.	1 emergency hotwell supply pump	W	MPFSCSTSC001B	1.01	G	G	
32.	CV valve	Y	AVFCHVNTTF407	6.26	Y	RR	over (by two orders of magnitude)
33.	RHR room coolers	G	Not modeled because of no impact	1.0	G	G	Not needed for successful operation of the pumps
34.	1 SP vacuum breakers	R	Not modeled	NA	NA	R	
	Operator Actions						
35.	Fails PCS	G	HEOFRCICHEOH2	1.2	W	W	
36.	Fails to DEP	R	HEOFRXPCHEOL6A	88.8	R	R	
37.	Fails to initiate SBFW pump	Y	HEOFSBFWHESF1	5.38	Y	Y	Not for late injection;
38.	Fails to initiate SPC	R	HEOFPCHROL6A	1521.16	RR	RR	
39.	Fails to use RHRSW as LI	Y	HERFRSW2HEXR1	1.0	G	G	
40.	Fails to initiate CRD	R	HERFCRDHHERD1	1.0	G	W	over (by one order of magnitude)

No.	Component Out of Service or Failed Operator Action	SDP Worksheet Results (Before)	Fermi 2 Nuclear Power Plant Basic Event	Fermi 2 Nuclear Power Plant RAW Ratio	Color by Fermi 2 Nuclear Power Plant RAW	SDP Worksheet Results (After)	Comments
41.	Fails to use CTG	W	HEOFCTG1HEGT1	1.69	W	W	
42.	Fails to recover offsite power (7 hours)	W	HERFOSPROG1	1.43	W	W	
43.	Fails to initiate SLC	W	HEOFSLCSHEBI2	3.46	Y	Y	
44.	Fails to INH	Y	HEOFIADSOA2	3.46	Y	Y	

Note:

1. RR signifies a CDF impact between 1E-3 and 1E-2. RRR signifies a CDF impact between 1E-2 and 1E-1.

Table 2: Comparative Summary of the Benchmarking Results

	Rev. 0 SDP Worksheets		Rev. 1 SDP Worksheets, as Modified	
	Number of Cases	**Percentage**	**Number of Cases**	**Percentage**
SDP: Non-Conservative	3	7	0	0
SDP: Conservative	(17)	(39)	(12)	(28)
by one order	10	23	9	21
by two orders	7	16	3	7
SDP: Matched	23	54	31	72
RAW values not available	1		1	
Total	44	100	44	100

Notes:

1. Prior to the onsite adjustments in the notebook, there were **17** conservative items. Of these, **7** were conservative by two orders of magnitude. After the revisions to the notebook, there were **12** conservative items. **Three** of these items were two orders of magnitude conservative.

2. Prior to the onsite adjustments in the notebook, there were **3** non-conservative items. After benchmarking and related changes to the notebook, there were **no** non-conservative items remaining.

3. PROPOSED REVISIONS TO THE REV. 0 SDP NOTEBOOK

A set of modifications were proposed for the Rev. 0 SDP notebook as a result of the site visit. These proposed modifications are driven by the licensee's revisions to the plant's PRA, better understanding of the current plant design features, revised Human Error Probabilities (HEPs), modified initiator frequencies, and the results of benchmarking.

3.1 Specific Changes to the Rev. 0 SDP Notebook for the Fermi 2 Nuclear Power Plant

The following changes were made based on the licensee's inputs and evaluations conducted as part of Benchmarking:

1. Changes to Table 1

    1. Loss of General Service Water (LGSW) initiating event was moved from Row I to Row II based on the revised plant-specific frequency.

    2. Medium LOCA (3 SORVs) was deleted from the table.

2. Changes to Table 2

    2.1 Condensate transfer was removed as a support system for HPCI, RCIC, CRD, and SBFW. The footnote was revised to clarify that condensate transfer is needed for long term success when the torus suction fails.

    2.2 It is noted that RBCCW/EECW dependency for LPCI is for MLOCA and LLOCA only. RBCCW/EECW dependency was removed for the RHR mode.

    2.3 HVAC dependency for LLOCA only was added for the CS system.

    2.4 DG HVAC was added as a support system for the EDGs. It is noted that for each EDG room 2 of 2 fans are needed.

    2.5 It is footnoted that nitrogen is used in the TBCCW, RBCCW, and EECW system surge/head tanks. A loss of nitrogen results in a reduction in the NPSH of the pumps in these cooling water systems. However, sufficient NPSH is assumed to still exist for the system to continue to operate satisfactorily.

    2.6 IAS is defined as the primary support system for containment venting. It is noted that NIAS is automatic backup to the IAS.

    2.7 It is clarified in the footnote that CTG does not supply power to Div. II.

    2.8 Footnote is added to note that loss of either division AC will result in loss of CV because of loss of valve F407.

3. Changes to Worksheets and Event Trees

3.1 Event trees and worksheets are modified to credit CST refill for long term success of high pressure injection sources. This applied to all worksheets except MLOCA, LLOCA, LOOP, and LOP2. Safety function of condensate transfer is added with 1/1 emergency hotwell supply pump or 1/3 condensate pumps (operator action=2).

3.2 Crediting SBFW pump as part of LI was modified as follows. When SBFW pumps are credited as part of the HPI, their credit in the LI function was deleted. When SBFW pumps are not credited as part of the injection function, their credit in the LI function was retained.

3.3 In SLOCA worksheet, operator action credit for using the SBFW pumps was changed to 3. Overall credit for LI was changed to 3.

3.4 In the SORV worksheet, similar to the SLOCA worksheet, credits for SBFW pumps and LI were modified.

3.5 In MLOCA worksheet, mitigation capability for LI was modified to credit use of Div. II RHRSW, but removed CRD pumps. Credit for LI changed from 1 to 3.

3.6 In the MLOCA worksheet, considering the loop selection logic, injection by RHR pumps in the LPI function was defined as “1/4 RHR pumps in 1/1 train in LPCI mode (1 train)”. Also, core spray function was defined as “1/2 CS trains with 2/2 pumps per train (1 multi-train system)”.

3.7 In the LLOCA worksheet, similar to the MLOCA worksheet, LI mitigation capability was modified to credit RHRSW pumps, but removed CRD pumps.

3.8 In the LLOCA worksheet, similar to the MLOCA worksheet, LPI function was redefined.

3.9 In the LOOP worksheet, credit for RLOOP7 was changed from 1 to 2 and a footnote is added for CTG and HPI that with the availability of CTG, SBFW can be credited with operator action credit of 3. Also, LI mitigation capability was modified to remove SBFW pumps.

3.10 In the ATWS worksheet, Containment venting (CV) is credited with associated late injection (LI). Also, credit for PCS within DEP and CHR was deleted consistent with SDP modeling approach.

3.11 In the LIA worksheet, mitigation capability for DEP was changed from 2/7 to 3/15 SRVs since N_2 is available for all 15 SRVs.

3.12 In the LGSW worksheet, similar to the LIA worksheet, mitigation capability for the DEP function was revised.

3.13 In the LOP1 worksheet, credit for SBFW pumps in the HPI function was corrected to 1/1 SBFW pump from 1/2 SBFW pumps. CV mitigation capability was defined to include recovery of offsite power or alignment of CTG with operator action credit of 2. In addition, Div I RHRSW pumps were removed from the LI function.

3.14 LOP2 worksheet and event tree were modified to include operator crosstie of the other bus with an operator action credit of 1. In addition, credit for SBFW pumps in the HPI function was corrected to 1/1 SBFW pump from 1/2 SBFW pumps.

3.2 Generic Change in IMC 0609 for Guidance to NRC Inspectors

None.

3.3 Generic Change to the SDP Notebooks

None identified.

4. DISCUSSION ON EXTERNAL EVENTS

Integrated external event PRA model was not available for the Fermi 2 Nuclear Power Plant. No evaluation was conducted for the external event risk during the Benchmarking exercise.

ATTACHMENT 1. LIST OF PARTICIPANTS

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