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SUBJECT: RESULTS OF THE DAVIS BESSE NUCLEAR POWER STATION UNIT 1 SDP PHASE 2 NOTEBOOK BENCHMARKING VISIT

During July, 2002, NRC staff and contractors visited the Davis Besse Nuclear Power Station Unit 1 compare the Davis Besse Significance Determination Process (SDP) Phase 2 notebook and licensee's risk model results to ensure that the SDP notebook was generally conservative. Since the licensee had completed analyses on the impact of some external initiators, the benchmark group performed sensitivity analyses to determine the impact of not considering external event initiators and internal flooding in the current revision of the SDP notebook. In addition, the results from analyses using the NRC's draft Revision 3i Standard Plant Analysis Risk (SPAR) model for Davis Besse were also compared with the licensee's risk model. The results of the SPAR model benchmarking effort will be documented in next revision of the SPAR (revision 3) model documentation.

The benchmarking visit identified that there was good correlation between the Phase 2 SDP Notebook and the licensee's PSA. The results indicate that the Davis Besse Phase 2 notebook was generally more conservative in comparison to the licensee's PSA. The revision 1 SDP notebook will capture 93% of the risk significance of inspection findings. A summary of the results of comparisons of hypothetical inspection findings between SDP notebook and the licensee's PSA are as follows.

7%	Notebook predicted the risk an order of magnitude less than the licensee's PSA Significance
55%	Notebook and licensee's PSA results matched within an order of magnitude
38%	Notebook predicted the risk an order of magnitude greater than the licensee's PSA.

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At Davis Besse, the CDF contribution from internal events was 1.22E-5/yr, and the CDF contribution from internal floods and tornadoes was 6.2E-6/yr. The integrated model was incomplete and only accounted for internal events, internal flood initiators, and tornadoes. Examination of these external initiators showed that the importance of three components, i.e., EDG 1-2, a shutdown Cooling heat exchanger, and a service water pump, would be raised by one order of magnitude if the flood and tornadoes were included in the risk significance determination.

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 Davis Besse SDP Phase 2 Notebook and the licensee's PSA.

Attachments: As stated

At Davis Besse, the CDF contribution from internal events was 1.22E-5/yr, and the CDF contribution from internal floods and tornadoes was 6.2E-6/yr. The integrated model was incomplete and only accounted for internal events, internal flood initiators, and tornadoes. Examination of these external initiators showed that the importance of three components, i.e., EDG 1-2, a shutdown Cooling heat exchanger, and a service water, would be raised by one order of magnitude if the flood and tornadoes were included in the risk significance determination.

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

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SUMMARY REPORT ON BENCHMARKING TRIP

TO THE DAVIS BESSE NUCLEAR POWER STATION UNIT 1

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August 2002

Attachment A

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1. INTRODUCTION

A meeting to benchmark the Davis Besse SDP Phase 2 notebook took place at the Davis Besse site on July 9-11, 2002. P. Wilson and S. Burgess from NRC, along with M.A. Azarm from BNL, and S. Beck from INEEL participated in this benchmarking exercise. This benchmarking report documents the overall results and insights from the benchmarking trip.

In preparation of the meeting, BNL staff reviewed the SDP notebook for Davis Besse, evaluated the coloring of the Rev. 0 SDP worksheets, and collected the system diagrams and information. In addition, a copy of the meeting protocol was sent to the licensee by P. Wilson of the NRC prior to the meeting.

The major milestones achieved during this meeting were as follows:

1. Obtained hard copies of the Risk Achievement Worth (RAW) values for basic events for the internal event model and full model for average maintenance. Received an Excel file containing the RAW information and the associated Delta CDFs for the basic events for both internal events and the full model.

2. Identified a target set for the basic events for the Benchmarking exercise.

3. Performed benchmarking of a subset of the target set of basic events using the Rev. 0 SDP notebook with the licensee's staff participating and providing comments on the notebooks.

4. Requested a few runs from the licensee to determine the dominant contributors to the RAW values, to compare with the contributors captured by the notebook.

5. Obtained updated HEPs used in the Davis Besse PSA.

6. Obtained descriptions of instrument air and AFW systems that should provide the details of dependencies and interconnection of the systems.

The utility staff provided extensive comments that were resolved and will be incorporated in the SDP Rev. 1 notebook.

The Rev. 0 SDP notebook for Davis Besse was updated and the sequences were solved prior to the site visit based on the current SDP generic guidelines. A total of 43 hypothetical inspection findings were examined during the site visit. Table 1 lists these items along with the associated risk significance based on the RAW values from the licensee's PSA and the SDP notebook. In one case, failure of MSIV to close (which is a PTS concern), the licensee's PSA lacked the needed modeling. In 23 out of the remaining 42 cases the SDP notebook and the licensee's PSA assigned similar colors reflecting the risk significance of the items under consideration. It should be noted that for the case of the failure of D1P battery, the licensee's

color is “Y” whereas the SDP notebook assigns a “W” color. A case run of this hypothetical inspection finding revealed that the licensee’s result is conservative and it is the manifestation of a PRA technique that is typically used to break the circular logic. This case is noted in the parentheses in Table 1 as a “match” and it would be treated as such in the remainder of the discussion. In 16 cases the SDP notebook’s color reflected a more conservative result than that of the licensee’s PSA (by one color). In the remaining three cases, the SDP notebook was suspected of underestimating the risk significance generated by the licensee’s PSA.

The summary results from benchmarking is shown in Table 2. The SDP Rev. 1 notebook when issued should provide similar or slightly more conservative results than the licensee’s PSA in 93% of the cases.

2. SUMMARY RESULTS FROM BENCHMARKING

This section provides the results of the benchmarking exercise. The results of the benchmarking analyses are summarized in Table 1. Table 1 consists of seven columns. In the first column, the out-of-service components, human actions, or recovery actions are identified for the case analyses. The second column shows the colors assigned for significance characterization from using the Rev. 0 SDP notebook. The third column shows the RAW values and the associated color determined based on the licensee's PSA for internal event initiators. The fourth column shows the assigned color that is expected to be obtained from the Rev. 1 SDP notebook when the licensee's comments are incorporated and the report is issued. The fifth column shows the results from comparison of the third and fourth columns. The results are categorized in three groups: O, M, and U which stand for Overestimated, Matched, and Underestimated, respectively. If an item in this column is categorized as "M", it indicates that the color that will be obtained from the SDP Rev. 1 notebook will match the risk significance color obtained from the current licensee's PSA model. Items categorized by "M" and "U" should also be interpreted similarly. The sixth column provides the RAW value and associated significance color based on the licensee's PSA model for both internal and external events excluding fire. It should be noted that the internal RAW values exclude flood and tornado contributions and the external RAW values do not include the contribution from fire. Finally, the last column provides the basic event name, comments for clarification of the SDP evaluation process, and the underlying reasons for any differences that might have occurred.

A total of 43 hypothetical inspection findings were examined during the site visit. Table 1 lists these items along with the associated risk significance based on the RAW values from the licensee's PSA and the SDP notebook. In one case, failure of MSIV to close (which is a PTS concern), the licensee's PSA lacked the needed modeling. In 23 out of the remaining 42 cases the SDP notebook and the licensee's PSA assigned similar colors reflecting the risk significance of the items under consideration. It should be noted that for the case of the failure of D1P battery, the licensee's color is "Y" whereas the SDP notebook assigns a "W" color. A case run of this hypothetical inspection finding revealed that the licensee's result is conservative and it is the manifestation of a PRA technique that is typically used to break the circular logic. This case is noted in the parentheses in Table 1 as a "match" and it would be treated as such in the remainder of the discussion. In 16 cases the SDP notebook's color reflected a more conservative result than that of the licensee's PSA (by one color). In the remaining three cases, the SDP notebook was suspected of underestimating the risk significance generated by the licensee PSA .

In the three cases where the SDP notebook underestimated the licensee's PSA risk significance, i.e., the backup SW pump, failure of MSSV to close after demand, and failure of D2P DC bus, the licensee conducted the appropriate case runs. Examinations of these case runs indicated that all major sequences have been identified by the SDP worksheets. The difference between the color assignments for the backup SW pump and the MSSV fail to close were attributed to round up errors caused by order of magnitude analyses in the SDP worksheets. For example, for MSSV fail to close, the SGTR worksheet is to be analyzed and it

would result in two whites. The RAW values from the licensee's PSA would indicate a border line yellow. The licensee's PSA frequency for SGTR is 7E-3 per reactor-year whereas the SDP notebook assigns this initiator to Row III.

Another case of underestimation was for DC bus D2P. The review of the case run for this case again revealed the SDP notebook covers all the major sequences in the licensee's PSA. However, the total contribution from loss of DC bus D2P in the licensee's PSA includes many low probability sequences (of the order of 1E-7) in addition to the major sequences. The summation of these lower probability sequences was the major reason for the difference in the color assignment in the SDP notebook compared to that of the licensee's PSA.

In the Rev. 1 SDP notebook, the above three cases would be noted as true underestimates and they will be identified as a footnote in Table 2 of the SDP notebook to warn the users.

A total of 16 cases were identified where the SDP notebook overestimated the licensee's PSA by one color. Reasons behind these cases of overestimation by one color are not usually investigated and they are accepted as an outcome of the conservative approaches and assumptions used in the SDP notebook. However, a preliminary examination of these cases was conducted since the number of these cases was higher than what is normally expected, and there is a need for documenting insights for B&W plants.

The cases overestimated by one color can be categorized into three groups based on the underlying causes. These three groups are discussed below:

Group 1: 1 Make up pump, 1 PSV FTO, 1 PORV FTO, HPR, and LPR to support HPR (SDC HX): The licensee's PSA assigns a recovery credit for PCS as long as the initial phase of feed and bleed through any two out of three primary bleed paths (PORV or PSVs) and makeup through makeup pumps is available. Note that for operation of HPR, success of PORV is necessary. The SDP notebook does not currently credit the long term recovery of the PCS. This same issue also affected the overestimation of PCS as both the initiator and the mitigation. Examination of Table 1 shows that failure of PCS as an initiator is a "Match," but failure of PCS as both the initiator and the mitigation is an "Over" since no credit is provided for recovery of PCS in the SDP notebook.

Group 2: Block valve FTC and PORV FTC: At Davis Besse a transient with loss of total secondary heat removal could demand both PORVs and PSVs. The licensee's PSA, therefore, accounts for failure of either PSV or PORV fail to re-close whereas the SDP notebook accounts for only failure of PORV to re-close (SORV and LEAC worksheets). The importance of PORV failure to re-close and the block valve failure to close then would be less in the licensee's PSA since some of the scenarios are covered by the failure of a PSV to stick open.

Group 3: DC bus D1P, one containment cooler, TPCW, and failure of SW spare pump: These cases are typical cases where the SDP notebook is expected to overestimate due to the conservative SDP evaluation process and simplifications in the SDP notebook.

Table 1: Summary of Benchmarking Results for Davis Besse Unit 1

**Internal Events' CDF is 1.22E-5 per reactor-year; therefore,
RAW thresholds are: W = 1.08, Y = 1.82, and R = 9.2**

**External Events excluding fire' CDF is 1.84 E-5 per reactor-year; therefore,
RAW thresholds are: W = 1.054, Y = 1.54, and R = 6.4**

Component Out-of-Service	SDP Worksheet Results (Before) (Internal only)	Internal RAW[1]	SDP Worksheet Results (After)	PSA/SDP	Internal + External RAW	Comments
HPSI Pump	Y	5.57 Y	Y	M	4.03 Y	HMM00011
Make-up pump	R	1.11 W	Y	O	1.08 W	MMBMUP11
LPI Pump	R	5.79 Y	Y	M	4.18 Y	LMM00018 C/O
TD AFW Pump 1	Y	4.31 Y	Y	M	3.88 Y	QMM0028A C/O
TD AFW Pump 2	Y	3.67 Y	Y	M	3.07 Y	QMM0032A C/O
MDAFW	Y	2.1 Y	Y	M		Case Run
Start up FW pump	W	1.09 W	W	M	1.95 Y	FMBOSUFP
EDG 1-2	Y	1.73 W	W	M	1.83 Y	EDG0012A Feeds MDAFW
EDG 1-1	W	1.58 W	W	M	1.50 W	EDG0011A
SBO DG	G/W	1.64 W	W	M	1.50 W	EDG0SBOA

Component Out-of-Service	SDP Worksheet Results (Before) (Internal only)	Internal RAW[1]	SDP Worksheet Results (After)	PSA/SDP	Internal + External RAW	Comments
Both MSIVs FTC	R	PTS Not Modeled	R	NM		
1 PSV FTO	W	G	W	O	1.01 G	
PZR PORV FTO	W	2.54 Y	R	O	2.00 Y	PRZRC2AN
Block Valve FTC	W	G	W	O	1.0 G	Case Run RHA011CE
PORV FTC	Y	W	Y	O	1.06 W	Case Run PRZRC2AT
1 CCW Pump (spare)	W	1.54 W	W	M	1.59 Y	WMM00040
1 CCW Loop (standby)	R	18.47 R	R	M	12.97 R	WMM00016
SDC HX	W	1.73 W	Y	O	1.49 Y	Assumed also loss of one train of HPR
BWST Make up Clean Water Receiver Tank	Y	1.39 W	W	M	1.26 W	LMM00030 Modified SGTR Tree
PCS Initiator Only	G/W	1.18 W	W	M	1.12 W	T2
PCS Initiator & Mitigation	W	1.34 W	Y	O	1.24 W	FMFWTRIP
AVV (SG PORV) FTO	G/W	1.01 G	W	O	1.00 G	FVV011AN C/O
MSSV FTC	G/W	2.20 Y	W	U	2.32 Y	FMM0003 2W (round up error)

Component Out-of-Service	SDP Worksheet Results (Before) (Internal only)	Internal RAW[1]	SDP Worksheet Results (After)	PSA/SDP	Internal + External RAW	Comments
Service Water Pump (Running Pump)	R	6.53 Y	Y	M		Case Run SDP Evaluation Credited Recovery
Service Water Pump (Spare Pump)	W	1.02 G	W	O	1.01 W	SMBW001
TPCW Pump	W	1.28 W	Y	O	1.18 W	PCS and SU FW Pump
DC Bus D1P Initiator + Mitigation	R	6.01 Y	R	O	4.32 Y	EBD0D1PF
DC Bus D1P Initiator	Y	2.68 Y	Y	M	2.07 Y	T17
DC Bus D2P Initiator + Mitigation	R	22.76 R	R	M	15.44 R	EB00D2PF
DC Bus D2P Initiator	Y	12.66 R	Y	U	8.71 R	T18 2Y and a W. Many sequences with low probability, otherwise the dominant sequences add up to 8.E-5
Battery D1P	R/Y Charger Cap.	5.63 Y	W	U (M)	4.24 Y	EBT001NF PSA breaks the circular logic
Battery D2P	R/Y Charger Cap.	1.53 W	Y	O	1.52 W	EBT002PF
Battery Charger D1P	Y	2.99 Y	R	O	2.31 Y	EMM0CHIP

Component Out-of-Service	SDP Worksheet Results (Before) (Internal only)	Internal RAW[1]	SDP Worksheet Results (After)	PSA/SDP	Internal + External RAW	Comments
Battery Charger D2p	Y	37.08 R	R	M	25.21 R	EMM0CH2P
Total Loss of IA	Y	1.81 (Y-W)	Y	M	1.53 (Y-W)	19TC
Operator action FB	Y	2.22 Y	Y	M	1.81 Y	ZHAMUHPE
Operator action HPR	R	2.38 Y	R	O	1.89 Y	ZHAHPRLE
Secondary Dep and Equalization DEPS and DEPP in SGTR	Y	2.16 Y	Y	M		Case Run
Late Dep. (DEPP in SGTR)	Y	1.2 W	W	M		Case Run
Emergency Boration	W	1.07 G-W	W	M	1.05 G-W	ZHABORAE
RCP Trip	R	117.50 R	R	M	79.26 R	ZHARCPCE
Backup SW pump	W	2.28 Y	W	U	1.85 Y	SMBSW002 Round up ending up to 1.08E-5
One cont. cooler unit	NM	1.0 G	W	O	1.0 G	

(1) The RAW values obtained are based on the internal event model, excluding flood.

Table 2: Comparative Summary of the Benchmarking Results

Total Number of Cases Compared = 42	SDP Notebook	
	Number of Cases	Percentage
SDP: Less Conservative	3	7
SDP: More Conservative	16	38
SDP: Matched	23	55

The summary results of the benchmarking as shown in Table 2 would indicate that the SDP Rev. 1 notebook would capture 93% of the risk significance of the inspection findings. In 7% of the cases which will be explicitly identified in the SDP Rev. 1 notebook, the risk characterization of the inspection findings would be underestimated.

3. PROPOSED REVISIONS TO 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 comments on the Rev. 0 SDP notebook, better understanding of the current plant design features, allowance for additional recovery actions, revised Human Error Probabilities (HEPs), updated frequencies of the initiating events, and the results of benchmarking.

3.1 Specific Changes to the Rev. 0 SDP Notebook for Davis Besse

The earlier version of the notebook was reviewed by the utility on May 26-27, 2000. The resolution of the utility's comments is included in the notebook. Additional comments were received during the benchmarking site visit. These comments were reviewed and incorporated into the SDP notebook to the extent possible. The following items list major comments that were incorporated.

1. Footnoted in Table 2 stating that BWST has a capacity of about 500,000 gallons.
2. Footnoted in Table 2 stating that the PORV setting is at 2450 psi and PSV is at 2500 psi, and during transients with total loss of secondary heat removal, both PORV and PSVs would be demanded.
3. Footnoted in Table 2 that operation of containment air coolers is needed for proper operation of PORVs. Also indicated that PORV is fed from Bus D2N and its size is 2-1/2 inches on the high pressure side and 3 inches on the low pressure side.
4. Footnoted in Table 2 to indicate that for operation of HPR during feed and bleed, the reactor should be depressurized; therefore, operation of the PORV to open is necessary. To avoid complexity, the SDP notebook requires 1/1 PORV and 1/2 PSVs to open for successful FB.
5. Footnoted in Table 2 that the battery chargers cannot take the SI loads.
6. Footnoted in Table 2 that the day tank capacity for EDG is 24 hours, and there are separate trains of fuel transfer powered by the associated EDG for longer term operation.
7. Footnoted in Table 2 that the day tank capacity for SBODG is 6 hours and the fuel transfer is totally manual.
8. Footnoted in Table 2 that the RCP is BJ N-9000 series.
9. Footnoted in Table 2 that the switchyard is equipped with both dedicated 125 VDC for breaker operation and 48 VDC for switchyard; therefore, recovery of offsite power after depletion of emergency batteries can be credited.
10. Generically changed 1/3 CAC to 1/2 CAC trains for support of FB.
11. In SORV, added a footnote that the PSVs could be stuck-open in transients with total loss of secondary heat removal.
12. In SGTR, redrew the event tree and redid the worksheets consistent with the licensee's input.
13. In LCCW, changed the credit for PCS to 2.
14. In LDCD1P, credited both TDAFW and resolved the sequences.

15. In LDCD1P, did not credit CS in CNT.
16. Changed LOOP1ED to LEAC and assigned it in Table 1 to Row V accounting for failures of an EDG and the SBODG. Gave a credit of 1/1 HPI train for EIHP.
17. In LOOP, added a footnote stating the frequency of LOOP is 5E-2 and failure to recover offsite power within the first hour is 0.23.

3.2 Generic Changes in IMC 0609 for Guidance to NRC Inspectors

A change in the instructions of IMC 0609 per the discussion given in subsection 3.3.1 could be potentially envisioned.

3.3 Generic Changes to the SDP Notebook

None.

3.3.1 Generic Insights for SDP Evaluation Process

Davis Besse, similar to some other U.S. plants, have support systems that are designed with two trains, each with one pump. Upon failure of the running pump, the standby pump will be automatically started. The spare pump could also be aligned if the running pump fails. If the system as a whole is not split and it is a special initiator, the following rules for SDP evaluation were examined and used in Davis Besse:

1. If the spare pump fails, increase the special initiator frequency by one order of magnitude.
2. If the running pump fails, increase the special initiator frequency by one order of magnitude.
3. If the standby pump fails, increase the special initiator frequency by two orders of magnitude.

3.3.2 Generic Insights for B&W Plants

Pending additional site visits, Davis Besse was the second B&W plant benchmarked.

4. Discussion on External Events

At Davis Besse, the CDF contribution from internal events is 1.22E-5, and the combined CDF contribution from internal floods and tornadoes is 6.2E-6. The integrated model currently is incomplete and accounts for internal events, internal flood initiators, and tornadoes. Examination of the RAW values in Table 1 shows that the importance of three components, i.e., EDG 1-2, SDC-HX, and SW pump, would be raised by one order of magnitude if the flood and tornadoes are included in the risk significance determination.

5. LIST OF PARTICIPANTS

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