July 14, 2003

MEMORANDUM TO: Stuart Richards, Chief
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FROM: Mark F. Reinhart, Chief **/RA/**
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SUBJECT: RESULTS OF THE COMANCHE PEAK STEAM ELECTRIC STATION (CPSES) SDP PHASE 2 NOTEBOOK BENCHMARKING VISIT

During December, 2002, NRC staff and contractors visited the Comanche Peak site to compare the CPSES Significance Determination Process (SDP) Phase 2 notebook and licensee's risk model results to ensure that the SDP notebook was generally conservative. The current plant probabilistic safety assessment's (PSA's) internal event core damage frequency was 2.38 E-5/reactor-year excluding internal flood events. The CPSES PSA did not include an integrated PSA model with external initiating events and therefore sensitivity studies were not performed to determine any impact of external event initiators on SDP color determinations. In addition, the results from analyses using the NRC's draft Revision 3i Standard Plant Analysis Risk (SPAR) model for CPSES 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.

In the review of the CPSES SDP notebook for the benchmark efforts, the team determined that some changes to the SDP notebook were needed to reflect how the CPSES is currently designed and operated. Thirty six hypothetical inspection findings were processed through the SDP notebook and compared with the licensee's related importance measures. Results from this effort indicated that the risk impacts modeled in the SDP notebook were less conservative by 6 percent, more conservative by 66 percent, consistently estimated by 25 percent, and 3 percent were not comparable. Of the conservative cases, 11 cases were two colors greater than the results obtained using the licensee's model. Consequently, 41 changes were made to the SDP notebook.

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Using the revised SDP notebook, the team obtained 11 percent of the cases that were less conservative, 39 percent were more conservative, 47 percent of the cases were consistent with the licensee's results, and 3 percent were not comparable. Of the conservative cases, all were one order of magnitude greater than the results obtained with the licensee's model and as such are generally consistent with the expectation that the notebooks should be slightly conservative when compared to the licensee's model. Although the revised notebook slightly increased the cases of under-estimates from two to four, the underlying reasons were well understood and were attributed to round-off differences or SDP notebook construction rule constraints.

The licensee's PSA staff had substantial knowledge of both the CPSES PSA model and conduct of plant operations. The licensee's comments greatly improved the quality and content of the SDP notebook.

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

Attachment: As stated

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Attachments: As stated

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SUMMARY REPORT ON BENCHMARKING TRIP

TO THE COMANCHE PEAK STEAM ELECTRIC STATION (CPSES),

UNITS 1 AND 2

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1 INTRODUCTION

A benchmarking meeting took place at the Comanche Peak (CP) site on December 3-5, 2002. Mr. Michael Franovich from USNRC, along with M.A. Azarm from BNL, and Mr. Scott Beck from INEEL participated in this benchmarking exercise. This benchmarking report documents the overall results and insights from the benchmarking trip.

In preparation for the meeting, BNL staff reviewed the SDP notebook for Comanche Peak, evaluated the coloring of the Rev. 0 SDP worksheets, and collected the system diagrams and information. In addition, a copy of the meeting protocol, table of the target lists, and a set of questions were sent to the licensee by Mr. Franovich prior to the meeting.

The major milestones achieved during this meeting were as follows:

1. Obtained the Risk Achievement Worth (RAW) values for basic events for the internal event model for average maintenance based on the internal event model excluding the internal flood.

2. Identified the final 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 CP PSA.

6. Obtained updated dependency information for the fluid support systems and electrical systems to facilitate evaluation of the hypothetical inspection findings as a part of the benchmarking exercise.

7. Carried out the benchmarking and on-site modifications to the SDP notebook Rev. 0 per the licensee's comments.

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 CP was updated and the sequences were solved prior to the site visit based on the current SDP generic guidelines. A total of 36 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. Both the NRC and BNL staff felt that the PSA credit for repair and recovery of the failed diesel generators and the pumps could significantly impact the RAW results from the PSA, based on the previous TER/SER on Comanche Peak PSA. The recovery of the failed component depends on the inspection finding and it will be treated separately within the worksheet evaluation. Therefore, a request was made

that the licensee generate the revised RAW values not crediting the repair and recovery actions for EDGs and the pumps. These revised RAW values were used for the purpose of benchmarking.

The summary results from benchmarking are 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 86% of the cases. In 11% of cases the SDP underestimated the PSA. The reason for two of these underestimates was attributed to round off errors. Round off errors refer to the results of a case run when the following two conditions exist:

1. The SDP notebook captures all pertinent sequences affected and identified by PSA for the specific case run (e.g. when a given component is removed from service).

2. The resulting RAW value from the PSA for the specific case run is at proximity of the assigned color threshold.

The remainder two cases of underestimates resulted from the differences between the ATWS modeling in the SDP and the licensee's PSA. All cases where the SDP underestimated the PSA were examined during the site visit and they are discussed in detail in the next section. It should be noted that there was no case where the SDP overestimated the licensee's PSA by two orders of magnitude.

2. SUMMARY RESULTS FROM BENCHMARKING

This section provides the results of the benchmarking exercise. A total of 36 hypothetical inspection findings were examined during the site visit. 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 based on the licensee's PSA for internal event initiators. The fourth column, i.e, the site color, shows the color assigned based on the licensee's RAW values. The fifth column shows the assigned colors that are expected to be obtained from the Rev. 1 SDP notebook when the licensee's comments are incorporated and the report is issued. Finally, the last column provides some comments for clarification of the SDP evaluation process, the basic event names used in PSA, and the underlying reasons for any differences that might have occurred.

This table shows that there are four cases where the SDP underestimated the licensee's color, and there is no case where the SDP overestimated the licensee's color by more than one order of magnitude. The reasons behind these four cases of underestimates are discussed below:

- PORV fail to close: This case of underestimation was determined to be as a result of a round-off error. The licensee's RAW value is 5.21 which is almost at the "Red" threshold of 5.20. The SDP determines a "Yellow" color.

- MKRWST: Makeup to RWST (MKRWST) plays an important role in SGTR scenarios. This event is captured properly in the SDP notebook and the result is consistent with the licensee's PSA. MKRWST is also credited for non-SGTR scenarios as a backup for recirculation if the injection was successful. This is the case where the SDP underestimated the color obtained from the licensee's RAW value. Further examination of this case determined that the cause is the round-off error caused by summing up a large number of minimal cutsets.

- AMSAC failure and failure of SRV to open: These two cases of underestimates resulted from the modeling assumptions in the SDP worksheet for ATWS. The SDP worksheet models mechanical failures of scram rods in the ATWS worksheet with a frequency of about 1.0E-6 per reactor-year. The licensee's PSA models both the mechanical and electrical ATWS with a frequency of 1.8E-4 per reactor-year (almost two orders of magnitude higher than the SDP frequency). The licensee's PSA, therefore, credits AMSAC as a backup to the scram system and, furthermore, requires SRVs to open in any type of ATWS initiator.

Table 2 shows the summary statistics of the benchmarking results for the Rev. 0 SDP notebook and what would be the expected results for the Rev. 1 SDP notebook. This table shows that the Rev. 1 SDP notebook has been greatly improved as a result of the benchmarking activity. The number of cases that the Rev. 1 SDP would match compared with the updated licensee's PSA has doubled, i.e., increased from 9 to 17. The number of cases where the SDP would have overestimated the PSA has been reduced from 24 to 14 with no cases of overestimations by two orders of magnitude (note that 11 cases in the Rev. 0 notebook were overestimated by two orders of magnitude). Finally, the number of underestimates has slightly increased (from 2 cases to 4 cases) but the sequence logic and the reasons behind it were well understood.

Table 1: Summary of Benchmarking Results for Comanche Peak Units 1 and 2 (36 cases)

Internal Events CDF is 2.38E-5, no flood, no EDG or pump recoveries; therefore, the RAW Thresholds are W = 1.04, Y = 1.42, and R = 5.20

Component Out-of-Service	SDP Worksheet Results (Before)	Internal RAW	Site Color	SDP Worksheet Results (After)	Comments
Accumulator	W	1.0	G	G	Not found.
EDG FTR/FTS	R	3.17/10.07	Y/R	R	EPADGGEE01FN/ EPADGGEE01NN (changed REC2 to zero and added SBO-SORV sequence to LEAC worksheet)
AFW MDP	R	1.8	Y	Y	AFBPMPMD02NN
AFW TDP FTS	R	6.22	R	R	AFCPTPTD01NN
CCW Train (pump A FTR/Pump B FTS	R	3.32/1.11 (averaged RAW, 2.215)	Y/Y	Y/Y	CCAPOPCC01FN/CCBPOPCC02NN (asymmetric modeling in PRA) CCW pumps trains rotated every 2 weeks and, therefore, each train has the same importance with RAW of approximately 2.2. Therefore, Yellow.)
PCS/MFW initiator	W	1.03	G	W	INIT-T6
CVCS CCP FTS (B pump)	Y	1.20	W	Y	CSBPMPCH02NN/ CSAPMPCH01FN
Battery Charger	Y	Not found/1.0	G	G	Solved base case only; there are two chargers per bus.
Battery	R	8.81	R	R	EPBBTTED02NN
Air Compressor FTS	Y	1.0	G	G	CWCPAPMC02NN
PORV Fail to Open	Y	1.07	W	Y	RCAVPCV456NN
PORV Fail to Close (SORV)	Y	5.21	R	Y	RCAVPCV456FF (On threshold of red/yellow by RAW.)

Component Out-of-Service	SDP Worksheet Results (Before)	Internal RAW	Site Color	SDP Worksheet Results (After)	Comments
PORV Block Valve	W	1.08	W	W	RCAVM8000AFF
1 RHR/LPSI Pump	Y	1.15	W	Y	Fail-to-run not found case run shows.
Containment Sump valve FTO 8811B	Y	1.0	G	W/G with recovery	HPR/LPR. Notebook matched when recovery action was credited for the failed valve (operator manually opens it). Licensee's model applies recovery credit.
ECCS piggyback valve 8804B	Y	1.35	W	W	HPR
RWST level transmitters CCF	R	1.26	W	R/Y with recovery	MLOCA dominated. In licensee's model, they apply a 0.1 recovery credit with operator manual swap.
One Train of SW FTR	R	13.70	R	R	SWAPOPSW01FN
One Train of SI FTR	Y	1.0	G	W	SIBPMPSI02FN
LIA	R	1.14	W	W	INIT-X8
One MSIV FTC	Y	1.01	G	Y/W	MSXVH2333AFF (notebook gets W without PTS sequence). White results from SGTR sequences.
DC Bus 1ED1	R	1.56	Y	R	INIT-X1-1ED1
ARV FTO	Y	1.0	G	W	MSXVPV2325NN (PORV 1-PV-2325 fails to open on demand).
Non 1E bus 1A3 (1B3)	W	1.01	G	W	INIT-X4-1A3 Loss of non-vital AC Bus Initiating event.
AMSAC failure	W	1.16	W	G	ESAMSACF (driven by the licensee's ATWS frequency).
1 primary SRV FTO (8010A)	W	7.89	R	W	RCCVF8010ANN, licensee models electrical and mechanical ATWS (1.8E-4 frequency per reactor-year).

Component Out-of-Service	SDP Worksheet Results (Before)	Internal RAW	Site Color	SDP Worksheet Results (After)	Comments
Operator Action					
Emergency borate	W	1.14	W	W	HILTS
FB Operator Action	W	1.87/5.26	Y/R	R	HIBFXXINITNY/HIBFXXINITNYC (conditional on loss of condensate). Note there are several basic events that are conditional on the event initiator (weighted RAW across initiator is Red).
Closure of Block Valve B (Operator Action)	W	1.08	W	W	RCAVM8000BFY
Operator action to crosstie SW to opposite unit	R	1.12	W	Y	SWXTIERECOVY
CCW crosstie	R	1.05	W	Y	CCXTIERECOVY
Equalization with HPI working	R	1.02	G	W	HIRCSDEPSG, Fail to [initiate] depressurize RCS within 5 minutes of SGTR (surrogate; however, basic event does not include other actions for SG isolation).
Equalization without HPI working	W	1.02	G	W	HIRCSDEPSG, Fail to [initiate] depressurize RCS within 5 minutes of SGTR (surrogate; however, basic event does not include other actions for SG isolation).
MKRWST	R	2.79	Y	W	HIECA11, Operator fails to use ECA-1.1 on loss of recirc capability [non-SGTR initiators].
Manual Control of AFW flow	R	5.23	R	R	AFTDMANTRTLY
RCP Trip	R	?	?	Y	Not modeled.

Table 2: Comparative Summary of Benchmarking Results

Total Number of Cases Compared	SDP Notebook Before (Rev. 0)		SDP Notebook After (Rev. 1)	
	Number of Cases (36)	**Percentage**	**Number of Cases (36)**	**Percentage**
SDP: Less Conservative	2	6	4	11
SDP: More Conservative	13 (O1)	36	14 (O1)	39
	11 (O2)	30	0 (O2)	0
SDP: Matched	9	25	17	47
not modeled	1	3	1	3

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 Comanche Peak Units 1 and 2

The earlier version of the notebook was reviewed by the utility on April 11, 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. The following items list major comments that were incorporated.

Table 1:

1. Removed LBAC and the associated worksheet.

2. Added a footnote that the loss of non-vital AC bus (LBAC) has a frequency of 1.76E-1 for 4 buses. The special initiators of interest are the losses of buses 1A3 and 1A4 which also affect the operation of TPCW. The overall initiating event for these two buses is 8.9E-2 per reactor-year and would exactly behave like TPCS. Therefore, they are subsumed under the TPCS initiator.

3. Loss of chilled water would lead to loss of CCW if not detected. Therefore, it is considered as a special initiator in the licensee's PSA. This initiator is subsumed under loss of CCW in the SDP worksheet.

4. Moved the LCCW from Row II to Row III reflecting the updated IE frequency of 2.0E-3 per reactor-year.

5. Moved loss of Station Service Water to Row I from Row III. Added a footnote saying that loss of station service water frequency is estimated at 3.93E-1. The crosstie between the units is now explicitly modeled in the SDP worksheet.

Table 2:

1. Added a footnote for AF saying that there is a service water manual backup for CST which is not currently credited in the licensee's PSA due to a large volume of CST (539,000 gallons).

2. Removed CI from CS.

3. For diesel fuel oil transfer, explicitly identified that there are two pump trains per each diesel generator. The fuel day tank per each DG is sufficient for 2.8 hours of operation.

4. Added a footnote that there are two switchyard batteries, primary/secondary, each with its own charger. The batteries are 150 ampere rating for one hour with total capacity of 270 ampere hours. They are sufficient for 8 to 10 hours operation after LOOP.

5. Added a footnote that the chargers can take SI loads; therefore, all inspection findings associated with a charger should be evaluated by increasing loss of DC initiating event frequency by one order of magnitude and solving the LOOP and LEAC worksheets as well.

6. Explicitly noted that the RCP seals are high temperature type Westinghouse seals on all pumps for both units.

7. Added a footnote saying that ARV has air backup for 30 minutes. Local control of ARVs after 30 minutes is proceduralized. The flow control valves are also equipped with air backup to keep them closed for 30 minutes avoiding the SG overfill.

8. Changed RWST to MKRWST to explicitly address the makeup function. Identified the three paths to makeup according to priority 1) from CVCS blender, primary water, 2) from spent fuel pool through the SPF transfer pumps, and 3) from the other unit. Showed the 480V AC and 125V DC as the main dependency.

9. Modified the PORV footnote saying that the nitrogen could provide up to 100 cycle-stroke sufficient for feed and bleed.

10. Explicitly showed that RHR has two drop lines.

11. Modified the footnote saying that the internal event CDF when no credit is given for recovery of the failed component is 2.38E-5 per reactor-year.

Table 3.1: TRANS

1. Changed the credit for MFW from 1 to 2 and added a footnote that MFW restoration when there is no SI signal, therefore there is no need for resetting, has a HEP value of 0.05 in PSA.

2. Where appropriate, changed the credit for MKRWST from 1 to 2 and modified the footnote showing that the PSA HEP value is 3.3 E-3 per demand. Also noted that the credit of 2 is generically assigned.

Table 3.4: SORV

1. Added an event tree for SORV.

Table 3.5: MLOCA

1. Changed the EIAC success criteria from 2/3 to 1/3 remaining accumulators.

Table 3.6: LLOCA

1. Removed the function EIHP and modified the event trees/sequences to reflect EIHP is not needed.

Table 3.8: SGTR

1. Added a function for the long term cooldown and placing SDC into operation. Noted that the HEP value in the PSA is 5E-4; therefore, a credit of 1 multi-train system is assigned.

2. Modified EQ1 and EQ2 to EQ1/ISO and EQ2/ISO. Added the closure of the SG steam admission valve and the MSIV on the faulted SG for ISO function.

3. Modified the event trees and the associated worksheet sequences.

Table 3.9: ATWS

1. Removed MFW function.

Table 3.10: MSLB

- Added a footnote referenced by the worksheet sequences 4 and 5 saying that PTS is not a concern for this plant. The surveillance results so far show that the vessel is plate, not weld limited for PTS concerns and the transition temperature is currently very low (below 100 degree F). Therefore, these sequences are not applicable.

Table 3.11: LSW

- Assigned a credit of 1 to LSW and added the cross-tie to other unit explicitly in the worksheet with a credit of 2 (HEP value in PSA is 1.0E-2).

- Added a function of CCW cross-tie if SW cross-tie was not successful.

- Added a function for aligning the fire water or demineralized water to CP cooling to ensure RCP seal integrity.

- Modified the event tree and the associated sequences in the worksheet.

Table 3.12: CCW

1. Assigned a credit of 3 instead of 2 to LCCW corresponding to IE frequency of 2.0E-3 per reactor-year.

2. Added a footnote that the room heatup for the CCP compartment would take more than 24 hours. Therefore, failure of the RCP seals is not considered since there would be plenty of time for cooldown and depressurization of primary such that even if the RCP seals fail the leakage would be small and of no concern.

Table 3.13: LOIA

1. Changed the credit for AFW from 2 to 4.

2. Added a footnote that per the licensee's comment the overfilling of the SG would only fail TDAFW. The Main Steam Lines will not fail on overfill and the CST volume is sufficient to support cooldown under the overfill scenario.

Table 3.14: LBDC

1. Changed 2/4 ARVs to ½ ARVs or 1/5 MSSVs.

2. Credit of HPI was changed to 1 multi-train system from 1 train.

3. For FB, changed the ½ PORVs to 1/1 remaining PORV.

4. Modified footnote 1 to show that the statement applies to both 1ED1 and 1ED2 buses.

Table 3.15: LBAC

1. Removed the worksheet and substituted LEAC worksheet to Table 3.15.

2. For LEAC changed the credit for EIHP from 1 train to 1 multi-train system.

3. For LEAC changed the credit for AFW to 3, i.e., 1 train and 1 ASD train.

3.2 Generic Changes in IMC 0609 for Guidance to NRC Inspectors

No changes were identified from this site visit.

3.3 Generic Changes to the SDP Notebook

None.

3.3.1 Generic Insights for SDP Evaluation Process

It would be useful to include the following information in Table 2.

- The number of drop lines for the RHR/SDC system.

- The capacity of switchyard batteries and how long after LOOP the AC can be recovered by utilizing the switchyard DC.

- To the extent possible obtain information on PTS. Is it weld limited or plate limited? What is the current NDT transient temperature?

4. DISCUSSION ON EXTERNAL EVENTS

The Comanche Peak PSA addresses the risk from internal fire and high wind/tornado quantitatively. Seismic risk is addressed through qualitative seismic margin approach. The risks associated with all other external events were judged to be small and they were screened out. The CDF associated with fire is 2.09 E-5 per reactor-year and it is estimated by using the FIVE (Fire Induced Vulnerability Evaluation) methodology. The CDF associated with high wind/tornado is 3.7E-6 per reactor-year. The RAW values for internal events could not be easily compared to those of internal plus external events since the PRA models are not currently integrated.

5. LIST OF PARTICIPANTS

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