September 10, 2003

NOTE TO: Stuart Richards, Chief
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SUBJECT: RESULTS OF THE PEACH BOTTOM ATOMIC POWER STATION UNITS 2 AND 3 SDP PHASE 2 NOTEBOOK BENCHMARKING VISIT

During December, 2002, NRC staff and contractors visited the Exelon Company office in Kennett Square, Pennsylvania to compare the Peach Bottom Significance Determination Process (SDP) Phase 2 notebook and licensee's risk model results to ensure that the SDP notebook was generally conservative. The Peach Bottom PRA did not include external initiating events so 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 Standard Plant Analysis Risk (SPAR) model for Peach Bottom were 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 good correlation between the Phase 2 SDP Notebook and the licensee's PRA. The results indicate that the Peach Bottom Phase 2 notebook was generally more conservative in comparison to the licensee's PRA. The revision 1 SDP notebook will capture 91% (results matched or overestimated the licensee's PRA by one order of magnitude) 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 PRA are as follows.

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0% Underestimates Risk Significance
43% Match Risk Significance
49% Overestimates Risk Significance by 1 Order of Magnitude
9% Overestimates Risk Significance by 2 Orders of Magnitude

The Rev-1 SDP notebook has been significantly improved as a result of the benchmarking activity. The number of under estimations dropped from 5 to 0 cases. The number of overestimations by two orders dropped from 4 to 3. However, the number of over estimations by one order of magnitude increased from 10 to 17 and the number of matches decreased slightly from 16 to 15. Comparing to the Rev. 0 version of the notebook, the main benefit from benchmarking was the elimination of non-conservative assessments by the notebook in addition to making the notebook more reflective of plant-specific features and analyses.

The licensee's PRA 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 Peach Bottom SDP Phase 2 Notebook and the licensee's PRA.

Attachments: As stated

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SUMMARY REPORT ON BENCHMARKING TRIP

TO PEACH BOTTOM ATOMIC POWER STATION

UNITS 2 AND 3

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August 2003

ATTACHMENT A

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List of Tables

1. Introduction

A benchmarking of the SDP risk-informed inspection notebook was conducted during a visit to the Exelon Corporate Headquarters in Kennett Square, PA. on December 11, 12, and 13, 2002. NRC staff (S.M. Wong and E. Cobey), supported by BNL staff (E. J. Grove and J. Higgins), participated in this benchmarking exercise.

In preparation of the visit, BNL staff reviewed the Peach Bottom Atomic Power Station, Units 2 and 3 SDP notebook and evaluated a set of hypothetical inspection findings using the Rev. 0 SDP worksheets, plant system diagrams, and information in the licensee's updated PRA. A copy of the agenda was sent to the licensee by NRC staff (S. M. Wong) prior to the meeting.

The major activities performed during the plant visit were:

1) Discussed licensee's comments on the Rev. 0 SDP notebook.

2) Obtained listings of the Risk Achievement Worth (RAW) values for basic events of the internal event PRA for average maintenance model.

3) Identified a target set of basic events for the benchmarking exercise.

4) Performed benchmarking of the Rev. 0 SDP worksheets with consideration of the licensee's proposed modifications to the SDP notebook.

5) Identified areas of discrepancies and reviewed the licensee's PRA model to determine the underlying reasons. Proposed additional changes to the SDP notebook when appropriate.

Subsequent to the benchmarking trip, revised RAWs were obtained based on the revised PRA model for the plant. Additional documentation on the accident sequence analyses were also provided by the licensee. This resulted in revisions to the SDP notebook and revised benchmarking results. Additional investigation of the differences between the notebook and the plant PRA, however, was not conducted. The revised results presented here in this report are considered more logical and consistent both for the notebook and the plant PRA compared to the results obtained at the time of the benchmarking.

2. Summary Results From Benchmarking

Summary of Benchmarking Results

Benchmarking of the SDP Notebook for the Peach Bottom Atomic Power Station was conducted comparing the risk significance of the inspection findings obtained using the notebook with that 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 overestimated compared to the plant PRA. No cases of non-conservative results (or underestimation) by the notebook were noted. Three cases of conservative results by two orders of magnitude (i.e., the significance obtained using the notebook was 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 35 cases)	Non-conservative; underestimation of risk significance (by one order of magnitude)
9% (3 of 35 cases)	Conservative; overestimation of risk significance (by two orders of magnitude)
49% (17 of 35 cases)	Conservative; overestimation of risk significance (by one order of magnitude)
43% (15 of 35 cases)	Consistent risk significance.

Detailed results of Benchmarking are summarized in Table 1. Table 1 consists of seven columns. The first column identifies 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 second column. The third 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 fourth and fifth columns respectively show the licensee's RAW value based on internal event CDF model and the color to be defined based on the RAW values. The sixth column presents the colors for the inspection findings based on the Rev. 1 version of the notebook. The Rev. 1 version of the notebook was prepared considering the revisions to the Rev. 0 version of the SDP notebook judged applicable during and following 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 Peach Bottom Atomic Power Station 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 showed that in 91% of the cases SDP notebook provided results either within an order of magnitude or conservative by one order of magnitude. In remaining 9% of the cases, the notebook resulted in assessments that are two orders of magnitude conservative compared to the plant PRA. Of the 91% of the cases, in a relatively high percentage (49%) of the cases, the notebook results were conservative by one order of magnitude. Comparing to the Rev. 0 version of the notebook, the main benefit from benchmarking was the elimination of the non-conservative assessments by the notebook in addition to making the notebook more reflective of plant-specific features and analyses.

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

Twenty cases of overestimations or conservative results were noted during the benchmarking. Of the twenty cases, three cases were overestimated by two orders of magnitude and the remaining seventeen 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. This section of the report focuses on the items that were conservative by two orders of magnitude. These cases are discussed first and then a general discussions for the conservative results follow.

1. Failure of the hard pipe vent path was overestimated by two orders of magnitude by the notebook compared to the plant PRA. Peach Bottom has multiple vent paths which were credited in the Peach Bottom PRA. However, in the SDP notebook, only the hardened vent path was credited. In the SDP evaluation, loss of the hard pipe vent path resulted in complete loss of containment venting. This difference in modeling between the notebook and the plant PRA resulted in the two orders of magnitude overestimation for the hard pipe containment vent path by the notebook.

2. Operator failing to initiate suppression pool cooling was also overestimated by two orders of magnitude. In the plant PRA, both suppression pool cooling and shutdown cooling were modeled. In the notebook, these two functions were combined in applicable cases. The notebook evaluation thus combines both the shutdown and suppression pool cooling modes whereas the PRA RAW value only provides the significance of the suppression pool cooling failure. In addition, the remaining mitigation capability related to containment venting and as discussed earlier, only the hardened vent path was credited in the notebook. These two factors contributed to the overestimation of operator failing to initiate suppression pool cooling.

3. Operator failing to initiate Standby Liquid Control (SLC) in an ATWS was also overestimated by two orders of magnitude. In the Peach Bottom PRA, multiple operator actions are modeled for initiation of SLC. In the notebook modeling, a single operator action was considered. The RAW value of the plant PRA corresponded to one of the operator actions related to initiation of SLC. A RAW value considering the failure of the different operator actions relating to SLC initiation would be the appropriate RAW value for comparison. This difference in modeling and calculation process resulted in the two orders of magnitude overestimation for this action.

In addition to the overestimations discussed above, seventeen 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. Overestimation by one order of magnitude resulted from differences in component unavailability used in the PRA verus the credits assigned in the

notebook, differing operator action and recovery credits, and SDP evaluation process (usage rule and counting process), in addition to the reasons discussed above.

Changes Incorporated Following Benchmarking Resulting in Updating of Benchmarking Results

Development of the Rev. 1 notebook involved significant changes following the benchmarking. This involved revising a number of the event trees and the corresponding worksheets, e.g., LOOP, LIA, LTBCCW, LNSW, LODCA, and LODCB events. In addition, credits for some mitigating features were modified, as applicable.

As discussed earlier, Licensee also revised the plant PRA model subsequent to the benchmarking trip. The RAWs obtained using the revised PRA model were different than the RAWs from the previous model used during benchmarking. These revised RAWs were used here. Some additional documentation was also obtained. Besides using the revised RAWs and additional documentation, no analysis was done using the revised PRA model.

Changes to the notebook following benchmarking and the use of the revised PRA model for the plant resulted in significant changes in the results presented in this report. The results, however, are more logical and consistent both for the SDP notebook and the plant PRA compared to that used during benchmarking. The results presented here can further benefit from review of the SDP notebook assumptions compared to the revised PRA and analyses of the detailed plant results where the notebook evaluations and the PRA results differ.

No separate listing of the changes made following benchmarking is presented. Changes made to the Rev. 0 version of the notebook to prepare the Rev. 1 version of the notebook is included in Section 3.1.

Table 1: Summary of Benchmarking Results for Peach Bottom Atomic Power Station, Units 2 and 3

Internal Events CDF is 4.6E-06 events/reactor-year including internal flooding [(1)]
at a 1 E-12 truncation limit
RAW thresholds are W = 1.22 , Y = 3.17 , R = 22.74, RR = 218.4

Component Out-of-Service or Failed Operator Action	SDP Work-sheet Results (Before)	Peach Bottom Basic Event	Peach Bottom RAW Ratio [(2)]	Color by Peach Bottom RAW	SDP Work-sheets Results (After)	Comments
HPCI	R	HTUOP38R2	2.26	W	Y	Over by 1 order of magnitude
RCIC	R	RTUOP36R2	2.22	W	Y	Over by 1 order of magnitude
PCS steam	R	FWRANDOM	3.98	Y	Y	
PCS feed: 1 train	G	FFWAPMTM2	1.11	G	G	
1 Condensate Pump	G	FCDALGSX2	1.01	G	G	
1 SRV fails to open	Y		Not Evaluated		Y	Comparable RAW not available
1 SRV ftc	R	P1	1.93	W	Y	Over by 1 order of magnitude
CS Pump A	G	LPMAP37S2	1.02	G	G	
LPCS Injection Valve	G	LMV012BP2	1.04	G	G	
RHR- pump A	W	DPMAP35R2	1.25	W	Y	Over by 1 order of magnitude
RHR HX A	W	DMV089AP2	1.29 [(3)]	W	Y	Over by 1 order of magnitude
1 CV valve	R	VAV029OP2	1.98	W	R	Over by 2 orders of magnitude
1 HPSW pump	G	JPMAP42R2	1.29 [(4)]	W	Y	Over by 1 order of magnitude
SLC pump	W	SPMAP40R2	1.01	G	W	Over by 1 order of magnitude
EDG 1A	W	EDGAG12R0	5.13	Y	Y	

Component Out-of-Service or Failed Operator Action	SDP Work-sheet Results (Before)	Peach Bottom Basic Event	Peach Bottom RAW Ratio [(2)]	Color by Peach Bottom RAW	SDP Work-sheets Results (After)	Comments
EDG 1B	W	EDGBG12R0	2.41	W	Y	Over by 1 order of magnitude
4 kV Bus E12	W	EBSA15XW2	16.6	Y	Y	
4 kV Bus E22	W		6.6	Y	R	Over by 1 order of magnitude
Conowingo Tie Line	W	CWGTIEXMO	1.9	W	W	
1 CRD Pump	G	MPM039AR2	1.01	G	G	
N 2 system	W	ICMAK37S2	1.0	G	G	
RBCCW pump	G	BPMAP10S2	1.19	G	G	
TBCCW Pump	G	TPMA14412	1.01	G	W	Over by 1 order of magnitude
NSW Pump	G	PPMAP04R2	1.04	G	W	Over by 1 order of magnitude
ECW Pump	G	UPM186R0	1.0	G	W	Over by 1 order of magnitude. Only LOOP & LNSW worksheets are evaluated.
ESW Pump	G	WDMAP57D WDMBP57SO	1.01	G	W	Over by 1 order of magnitude. Only LOOP & LNSW worksheets are evaluated..
DC Battery 2AD01	R	EBYD01W2	7.99	Y	Y	
DC Battery 2BD01	R		3.3	Y	Y	
DC Battery Charger	R	EBCAD03W2	3.28	Y	R	Over by 1 order of magnitude

Component Out-of-Service or Failed Operator Action	SDP Work-sheet Results (Before)	Peach Bottom Basic Event	Peach Bottom RAW Ratio [(2)]	Color by Peach Bottom RAW	SDP Work-sheets Results (After)	Comments
Failed Operator Actions						
Fails to initiate PCS/MFW	Y		Not evaluated		Y	Comparable RAW not available
DEP	R	AHUINI2H2 & AHUINITH2	Not evaluated		RR	Comparable RAW not available
RHR/HPSW crosstie	W	OHUHWINH2	1.35	W	Y	Over by 1 order of magnitude
RHR suppression cooling mode	R	DHUSPCIH2	9.97	Y	RR	Over by 2 orders of magnitude
INH for ATWS	Y	AHUNMDOH2	8.62	Y	Y	
SLC for ATWS	Y	SHUINITH2	1.03	G	Y	Over by 2 orders of magnitude
LC for ATWS	Y	OHUC201H2	1.50	W	Y	Over by 1 order of magnitude
Overfill for ATWS	W	OHUUP02H2	1.51	W	W	
CV	R	DHUWVV1H2	4.27	Y	R	Over by 1 order of magnitude

Notes:

1. Internal flooding contributed approximately 1% of the CDF and is considered negligible.

2. RAWs are based on the revised plant PRA model and were obtained following benchmarking, in July 2003.

3. Heat exchangers are not modeled in PRA. RAW for HPSW outlet valve was used.

4. RAW for HPSW pump (Basic Event JPMAP42R2) was 1.0. RAW for the outlet valve was higher. The RAW for the outlet valve was used.

Table 2: Comparative Summary of the Benchmarking Results for Peach Bottom Atomic Power Station

Cases		SDP Notebook Before (Rev. 0)		SDP Notebook After Benchmarking (Rev.1)	
		Total number of cases = 38			
		Number of Cases	Percentage	Number of Cases	Percentage
SDP: Less Conservative		5	14	0	0
SDP: More Conservative	one order	10	29	17	49
	two orders	4	11	3	9
SDP: Matched		16	46	15	43
Comparable RAW not available		3		3	

3. Proposed Revisions to the Rev. 0 SDP Notebook

Based on insights gained from the plant visit, a set of revisions is proposed for the Rev. 0 SDP notebook. The proposed revisions are based on licensee's comments on the Rev. 0 SDP notebook, better understanding of the current plant design features, consideration of additional recovery actions, use of revised Human Error Probabilities (HEPs) and initiator frequencies, and the results of benchmarking.

3.1 Specific Changes to the Rev. 0 SDP Notebook for Peach Bottom Atomic Power Station, Units 2 and 3

1. Updated initiating event frequencies in Table 1

    1.1 Loss of Train B DC Bus (LODCB), Loss of Turbine Building Closed Cooling Water (LTBCCW), and Loss of Normal Service Water (LNSW) were added to Row III.

    1.2 Loss of Instrument Air (LIA) was added to Row IV.

2. Updated Table 2 equipment, support systems, and footnotes

    2.1 For HPCI, added a footnote that one of the valves depends on 480 VAC to open. Also, dependency on unit coolers for operation longer than 10 hours was noted.

    2.2 For RCIC, dependency on unit coolers for operation longer than 10 hours was noted.

    2.3 For RHR and CS systems, a footnote was added to explain the need of ESW for motor oil and seal cooling for the pumps. It was also noted that room cooling was not required.

    2.4 For EDGs, a footnote was added to explain the sharing of the diesels between the units. EDG ventilation requirements and day tank capacities were defined.

    2.5 For the HPSW system, dependency to both 4 kV and 480 VAC was noted.

    2.6 For the CRD system, it was footnoted that RBCCW is automatic backup to TBCCW. It was also noted that IA Compressor D is only cooled by TBCCW.

    2.7 A footnote was added to state that IA system for Unit 2 and 3 can be crosstied.

    2.8 For the SLC and Nitrogen Systems, 480 VAC dependency was noted.

    2.9 A footnote was added for the condensate and RWST transfer system that they may credited for late injection even though such credits have not been given in the notebook. The plant PRA at this time does not credit this system.

2.10 HVAC was deleted since the specific HVAC dependency of HPCI, RCIC and EDG are individually addressed.

2.11 A footnote was added to note the 16" hardened pipe vent at the plant.

3. Changes to the worksheets and event trees

3.1 Operator action credit for depressurization was changed from 2 to 3 except for ATWS.

3.2 The SORV worksheet and event tree were modified to credit CRD injection following successful HPI. PCS credit in SORV was deleted.

3.3 The MLOCA worksheet and event tree were revised to credit CRD injection similar to SORV.

3.4 The LOCA Outside Containment worksheet was deleted.

3.5 In the LLOCA worksheet, credit for operator starting condensate pumps for late injection was deleted.

3.6 The LOOP worksheet and event tree were revised to take into account RHR loading in dual-unit LOOP, Manual Crosstie, and other plant-specific features that affect the progression of the event.

3.7 The combined SLC/LC function was split into separate safety functions in ATWS worksheet.

3.8 The LODCA worksheet was modified to include injection using HPSW within the LPI function.

3.9 The worksheet and event tree for LODCB were developed.

3.10 The worksheet and event tree for LIA were developed.

3.11 The worksheet and event tree for LTBCCW were developed.

3.12 The worksheet and event tree for LNSW were developed.

3.2 Generic Change in IMC 0609 for Guidance to NRC Inspectors

No specific recommendation for changes to IMC 0609 was identified as a result of this benchmarking exercise.

3.3 Generic Change to the SDP Notebook

No generic change was identified.

4. Discussion on External Events

The licensee did not have an integrated external events PRA model. No evaluation of the impact of external initiators was conducted.

5. LIST OF PARTICIPANTS

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