

August 26, 2002

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SUBJECT: RESULTS OF THE SALEM GENERATING STATION SDP PHASE 2
NOTEBOOK BENCHMARKING VISIT

During June, 2002, NRC staff and a contractor visited the Salem/Hope Creek Nuclear Stations site to compare the Salem Generating Station (SGS) Significance Determination Process (SDP) Phase 2 notebook and licensee's risk model results to ensure that the SDP notebook was generally conservative. SGS's PSA did not include external initiating events; and 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 Standard Plant Analysis Risk (SPAR) model for SGS were also compared with the licensee's risk model. The results of the SPAR model benchmarking effort will be documented in a separate a trip report to be prepared by the Office of Nuclear Regulatory Research.

In the review of the SGS SDP notebook, it was found that some changes to the SDP worksheets were needed to reflect how the plant is currently designed and operated. Thirty hypothetical inspection findings were processed through the Rev. 0 SDP notebook, and the thirty hypothetical cases were processed after changes were made to the worksheets. Results from this effort indicated that the total risk impacts modeled in the SDP notebook were underestimated by 23 percent, overestimated by 20 percent, and adequately estimated by 57 percent. The reviewers found that if eight fixes, including the development of two additional specific worksheets for loss of component cooling water and loss of control air initiators, were made to the SDP notebook, the results would be 7 percent underestimation, 7 percent overestimation, and 87 percent adequate estimation of risk impacts.

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

If you have any questions regarding this effort, please contact See-Meng Wong.

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Attachments:As stated

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DOCUMENT NAME: G:\SPSB>wong\sgs-ltr-report.wpd NRR-001

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**SUMMARY REPORT ON BENCHMARKING TRIP FOR
SALEM GENERATING STATION (SGS) UNITS 1 AND 2**

(June 3-6, 2002)

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July 2002

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1. INTRODUCTION

A benchmarking of the Risk-Informed Inspection Notebook for the Salem Generating Station (SGS) was conducted during a plant site visit on June 3-6, 2002. NRC staff (J. Trapp and S. Wong) and BNL staff (P. Samanta) participated in this Benchmarking exercise.

In preparation for the meeting, BNL staff reviewed the SDP notebook for the Salem Generating Station 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 SGS PRA were discussed for consideration in the Rev. 1 model to be prepared following benchmarking.
2. Importance measures, including the Risk Achievement Worths (RAWs) 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 model including the detailed minimal cutsets were requested from the licensee. The cutsets were reviewed to understand the reason for the differences. Applicable changes were defined for the SDP model.

Following the modifications to the SGS notebook using the results of the benchmarking exercise, 2 cases of underestimation (by one color) and 2 cases of overestimation (by one color) were noted. Additionally, in 2 other cases, differences in assumptions between the PRA and the SDP notebook resulted in differences in results (underestimation by one color). These 2 latter cases where differences in assumptions were noted are explained below. The licensee is expected to review those assumptions in the PRA. A total of 30 cases were analyzed in the benchmarking. The results obtained with the revised notebook (Rev. 1 notebook) is a significant improvement compared to the Rev. 0 version where 7 underestimates and 6 overestimates were noted. In summary, the benchmarking has identified modifications which improve the matches (similar results) from 57% to 87%, reduce overestimation from 20% to 7%, and reduce underestimation from 23% to 7%.

2. SUMMARY RESULTS FROM BENCHMARKING

This Section describes the results of the benchmarking exercise. The results are summarized in Table 1. Table 1 consists of six 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 shows the internal RAW and the fourth column shows the associated colors estimated based on the licensee's RAW values from the latest PRA model. The fifth column presents the colors for the inspection findings based on the revisions of the SDP Rev. 0 worksheets judged applicable during benchmarking. The last column provides comments explaining the differences between the SDP's and plant's PRA colors.

Table 2 presents a summary of the comparisons between the results obtained using the Salem Generating Station Notebook and the plant PRA. The results show that in 2 out of 30 cases, the notebook provides a "color" that is conservative by one order of magnitude, and in another 2 cases, the notebook provides a "color" that is non-conservative by one order of magnitude. In the remaining 26 cases, the results match, i.e., both determine the same color.

The reasons for the differences in results between the notebook and the plant PRA can be summarized as follows:

1. The underestimations obtained for "1 EDG" and the "Gas Turbine" events are considered to be related to the difference in the LOOP frequency and the EDG unavailability. The LOOP frequency for Salem is $4.1E-02$ /reactor-yr and in the notebook, it is assigned to Row II. The combined EDG unavailability due to failure to start, failure to run, and test and maintenance, is approximately $6E-02$. In the notebook, the mitigation credit for 1 EDG is 1 train, approximately $1.0E-02$. A factor of 4 difference in LOOP frequency and a factor of 6 difference in the EDG unavailability contribute to the one order of magnitude underestimation by the notebook.
2. Loss of 1 Service Water pump is overestimated by one color in the notebook. Complete loss of service water lead to core damage. The loss of 1 SW pump has negligible impact on the PRA, but in the SDP, it is assessed assuming an order of magnitude impact on the initiating event frequency leading to the overestimation.
3. Operator failure to block PORV is overestimated because the likelihood of PORV failing to close in the licensee's PRA model is approximately an order of magnitude lower compared to the likelihood estimated in the notebook.

In two aspects, PRA assumptions contributed to differences in results between the licensee's PRA model and the notebook. A comparable assumption will lead to similar results. The assumptions will be reviewed by the licensee.

1. For a main steam line break, the licensee's PRA assumes that AFW is lost. Assuming a failure of the MSIV, this assumption results in core damage if the feed and bleed operation cannot be performed. With this assumption, the impact of MSIV is higher.
2. In the ATWS modeling, the long term boration or emergency boration is assumed successful when manual rod insertion is successful. But, following electrical failure of the rods, with continued feedwater, manual rod insertion is not questioned. In this scenario, failure to emergency borate leads to core damage. This results in increased significance of the failure to emergency borate in the plant's PRA model.

**Table 1. Comparison Table for Salem Generating Station
Benchmarking**

CDF = 4.4E- 5, W = 1.02(RAW), Y = 1.23 (RAW), R = 3.28 (RAW)

No.	Basic Event Name	SDP Before	RAW	Plant CDF Color	SDP After	Comments
1.	1 MDAFW train	R (O)	1.37	Y	Y	
2.	1 TDAFW train	R (O)	2.33	Y	Y	
3.	1 PORV	Y	1.60	Y	Y	
4.	1 HPSI train	W	1.16	W	W	
5.	1 Charging train	W (U)	1.41	Y	Y	
6.	1 CHS pump	W (U)	1.25	Y	Y	
7.	1 MFW pump	G	1.0	G	G	Not modeled in the licensee's PRA. Considered minimal impact.
8.	1 Condensate pump	G	1.0	G	G	
9.	1 Accumulator	Y	2.01	Y	Y	
10.	1 RHS Pump	W (U)	3.25	Y	Y	See Note 1 below.
11.	1 BAT Pump	G	1.0	G	G	
12.	1 EDG	Y (U)	4.77	R	Y	Underestimation; differences in LOOP frequency and EDG unavailability.
13.	2 EDGs	R	23.80	R	R	
14.	Gas Turbine	W (U)	2.97	Y	W	Underestimation; differences in LOOP frequency and EDG unavailability.
15.	1 Control Air Compressor	G	1.01	G	G	
16.	1 AC Bus	R	90.17	R	R	

No.	Basic Event Name	Before	RAW	Plant CDF Color	After	Comments
17.	1 DC Bus	R	170.40	R	R	
18.	1 SW train	Y (O)	1.11	W	Y	Overestimation; Loss of SW is assumed to lead to core damage. SDP color is assessed assuming an order of magnitude impact on the IE frequency. Impact calculated in the PRA on the IE frequency is lower.
19.	1 SRV	G	1.0	G	G	
20.	1 ARV	Y			W	Not included in the plant model.
21.	1 MSIV	Y	3.4	R	Y	Underestimation; Licensee will review the model.
22.	1 Switchgear HVAC fan	Y (O)	1.06	W	W	
23.	1 CCS train	Y(U)	4.55	R	R	
24.	SBO Compressor		1.07	W	W	
Operator Actions						
25.	Feed and Bleed	Y (U)	5.57	R	R	
26.	Fail to Emergency Borate	W	1.68	Y	W	Underestimation; licensee's ATWS tree does not credit manual rod insertion in case of electrical ATWS.
27.	Fail to HPR	R	32.95	R	R	
28.	Fail to switch to RWST	Y (O)	1.08	W	W	
29.	Fail to block PORV	W (O)	1.0	G	W	Overestimation; likelihood of PORV failure to close in licensee's PRA model is lower by an order of magnitude.
30.	Remote shutdown following CAAC	W (U)	1.37	Y	Y	

1. For one of the RHR pumps (RHR Pump 11), the licensee's PRA showed higher RAW representing a "Red" significance. However, the cutsets obtained could not be explained and the licensee plans to review the results.

Table 2. Comparative Summary of the Benchmarking Results

Comparisons	Rev. 0 SDP Notebook		Following Benchmarking	
	Total Number of Cases Compared = 30			
	Number of Cases	Percentage	Number of Cases	Percentage
SDP: Less Conservative	7	23	2	6.6
SDP: More Conservative	6	20	2	6.6
SDP: Matched	17	57	26	86.7

3. PROPOSED MODIFICATIONS TO REV. 0 SDP NOTEBOOK

A set of modifications are proposed for the Rev. 0 SDP notebook as a result of the site visit. These proposed modifications are based on 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 Salem Generating Station

Several changes were identified for the Rev. 0 notebook which included adding worksheets and modification to the existing worksheets. The major changes are summarized below.

1. Table 1 was revised based on the plant-specific initiating event frequency for the special initiators.
2. Loss of control area ventilation worksheet and event tree were modified to remove credit for operator recovering the control area ventilation and use of portable fans.
3. Loss of switchgear HVAC worksheet and event tree were modified to remove credit for recovering switchgear and penetration ventilation and use of portable fans.
4. Loss of a 125 VDC Bus worksheet and event tree were modified to credit feed and bleed operation using 1 PORV and 1 charging pump.
5. Loss of control air initiator was modeled and applicable worksheet and event tree were added.
6. Loss of component cooling water initiator was modeled. Applicable worksheet and event tree were added.
7. LEAC worksheet was modified to exclude sequences that are covered in the LOOP worksheet.
8. SGTR event tree and the worksheet were modified based on the revised modeling in the the plant's PRA. In this modeling, following failure of early depressurization, late depressurization and successful shutdown RHR lead to a successful end state. No credit for RWST refill is given.

3.2 Generic Change in 0609 for Inspectors

None identified.

3.3 Generic Change to the SDP Notebook

None identified.

4. DISCUSSION ON EXTERNAL EVENTS

Integrated external event PRA model was not available for the Salem plant. No evaluation was conducted for the external event risk during the benchmarking exercise.

5. LIST OF PARTICIPANTS

See-Meng Wong	USNRC - NRR
James Trapp	USNRC - Region I
Pranab Samanta	BNL
John Lai	PSE&G
Tom Carrier	PSE&G
Bob Buell	INEEL