July 10, 2003

NOTE TO: Stuart Richards, Chief
Inspection Program Branch
Division of Inspection Program Management
Office of Nuclear Reactor Regulation

Patrick D. O'Reilly
Operating Experience Risk Applications Branch
Division of Risk Analysis and Applications
Office of Nuclear Regulatory Research

FROM: Mark F. Reinhart, Chief **/RA/** M. Caruso for
Licensing Section
Probabilistic Safety Assessment Branch
Division of Systems Safety and Analysis
Office of Nuclear Reactor Regulation

SUBJECT: RESULTS OF THE SURRY POWER STATION UNITS 1 AND 2 SDP PHASE 2 NOTEBOOK BENCHMARKING VISIT

During August, 2002, NRC staff and contractors visited the Dominion Generation company in Glen Allen, VA to compare the Surry Power Station Significance Determination Process (SDP) Phase 2 notebook and licensee's risk model results to ensure that the SDP notebook was generally conservative. The Surry PSA 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 Surry were 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 Surry Phase 2 notebook was generally more conservative in comparison to the licensee's PSA. The revision 1 SDP notebook will capture 90% 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.

5%	Underestimates Risk Significance
52%	Match Risk Significance
38%	Overestimates Risk Significance by 1 Order of Magnitude
5%	Overestimates Risk Significance by 2 Orders of Magnitude
0%	Unable to compare with licensee's PRA.

CONTACT: Peter Wilson, SPSB/DSSA/NRR
301-415-1114

The Rev-1 SDP notebook has been significantly improved as a result of the benchmarking activity. The number of cases that the Rev-1 SDP would match that of the updated licensee's PSA has increased from 12 to 20. The number of over estimations dropped from 26 to 17 cases. However, the number of underestimations did increase from no cases to two cases.

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 Surry SDP Phase 2 Notebook and the licensee's PSA.

Attachments: As stated

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

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OFFICE	SPSB	SPSB:SC	SPSB:RII
NAME	PWilson:nxh2	MReinhart	WRogers
DATE	05/19/03	05/19/03	07/10/03

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SUMMARY REPORT ON BENCHMARKING TRIP

TO DOMINION GENERATION FOR SURRY POWER STATION

UNITS 1 AND 2

Edward J. Grove

Energy Sciences and Technology Department
Brookhaven National Laboratory
Upton, NY 11973-5000

February 2003

Attachment A

Table of Contents

List of Tables

1. INTRODUCTION

A benchmarking of the Surry Power Station, Units 1 and 2 SDP risk-informed inspection notebook was conducted during a visit to the Dominion Generation headquarters in Glen Allen, VA on August 13-14, 2002. NRC staff (P. Wilson and R. Bernhard) supported by BNL staff (E. J. Grove) participated in this benchmarking exercise.

In preparation of the visit, BNL staff reviewed the Surry Power Station SDP notebook and evaluated a set of hypothetical inspection findings using the Rev. 0 SDP worksheets, plant system diagrams and information in the licensees updated PSA. A copy of the agenda was sent to the licensee by NRC staff (P. Wilson) prior to the meeting.

The major activities performed during the headquarters 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 considerations 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.

6) Mr. J. Schroeder of INEEL performed a benchmarking exercise using the revision 3i SPAR model for Surry Power Station Units 1 and 2 .

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 six column headings. In the first column, the out-of-service components (human and recovery actions) are identified for the case analyses. The second column shows the associated colors based on the Rev. 0 SDP notebook. The third column shows the RAW values based on the licensee's latest PSA model. The site color estimated based on the RAW values are shown in the fourth column. The colors assigned for significance characterization from using the Rev. 0 SDP worksheets after incorporation of the licensee's comments are shown in the fifth column. These comparative results are categorized as "Over", "Match", and "Under" standing for cases that were overestimated, matched, and underestimated. Finally, some clarifying notes and the reasons for any differences in the fourth and the fifth columns which resulted from incorporating the licensee's comments into Rev. 0 SDP notebook are noted in the sixth column. The summary statistics of the benchmarking results are provided in Table 2. This Table shows the summary results obtained through benchmarking for both the Rev. 0 SDP and the revised notebooks.

Examination of Tables 1 and 2 shows that the revised SDP notebook provided similar or slightly more conservative significance characterization than the licensee's PRA model in about 90% of the cases analyzed. There were two cases out of 39 which resulted in a less conservative color (5%). In two other cases the SDP overestimated the PSA results by two orders of magnitude (5%). The SDP Notebook over-estimated the risk importance in 18 instances (16 by one color, 2 by two colors). Such overestimations were expected due to the conservative approach used for developing and evaluating the SDP notebooks.

In three specific instances, the SDP notebook overestimated the risk importance by two colors. The overestimates were:

1) MSIV Fail to Close: The over estimation by two colors in this instance is a result of the licensees modeling which does not include PTS,

1. PORV Fail to Close: The over estimation in this case is a result of the SDP modeling process which assumes the probability of a SORV or failure of a block valve to be 1. In actuality, a probability of 0.1 is assigned in the licensee's PSA for PORVs to be demanded during an initiator.

In two cases the SDP notebook underestimated by one color. These two cases and the results of the investigation of reasons behind them are summarized below.

- 1 CCW pump fail to operate: CCW in this plant has a common header equipped by two pumps per unit, and it only supports the cooling for RCPs and the RHR pumps. The impact of a loss of CCW pump therefore, is shown to have little importance in the SDP notebook with a Green color assigned. The PSA assigns a White color mainly driven mostly by the potential for RCP seal failure post transients. No specific reason was found to describe the difference in result between the licensee's PSA and the SDP notebook. It appears that some minor differences resulting from the rounding of the mitigation credit into orders of magnitudes in the SDP notebook might have caused this.

- Failure of one battery bank: The EDGs in this plant have their own dedicated batteries, therefore the loss of an emergency battery will not directly affect the EDG operation. The loss of an emergency battery , however would still impact the loss of DC worksheet. The licensee PSA currently does not credit the feed and bleed operation as a mitigation capability during loss of DC.

Table 1: Summary of Benchmarking Results for Surry 1 and 2

Internal Events CDF is 9.5 E-06/yr (without internal flood)
RAW Thresholds are W = 1.11, Y = 2.05, and R = 11.53

Component Out Of Service or Failed Operator Action	SDP Worksheet Results (Before)	Internal RAW	Site Color	SDP Worksheet results (After)	Comments
One Accumulator	Y (over +1)	1.31	W	Y (over +1)	Check valve 1-SI-128 FTO
PORV FTO	R (over +2)	1.27	W	W (match)	1RCRV
PORV FTC	W (by CR) (match)	1.13	W	R (over +2)	Result due to SDP overestimation of a SORV
1 Block valve FTC	Y (by CR) (over +2)	Truncated	G	W (over +1)	1RCMOV-FC-535 Result due to SDP overestimation in modeling
1 MFW Pump	G (match)	1.0	G	G (match)	1FWPAT-FS-1FWP1A FTS
1 Condensate Pump	W (by CR) (over +1)	1.04	G	G (match)	1CSP1B FTS
1 Containment Spray Pump	G (match)	1.04	G	G (match)	1CSP1B FTS
1 Inside Recirculation Spray pump	Y (by CR) (over +2)	Truncated	G	G (match)	1-RS-P1A/B
1 Outside Recirculation Spray Pump	Y (by CR) (over +2)	Truncated	G	G (match)	1-RS-P2A/B
1 MD AFW pump	R (by CR) (over +2)	1.50	W	Y (over +1)	1-FW-3B
1 TD AFW pump	R (over +2)	1.32	W	Y (over +1)	1-FW-P2

Component Out Of Service or Failed Operator Action	SDP Worksheet Results (Before)	Internal RAW	Site Color	SDP Worksheet results (After)	Comments
1 RHR pump	G (match)	1.06	G	G (match)	1-RH-P-1-A/B
1 HHSI (Charging) pump	R (over +2)	1.34	W	W (match)[(1)]	1CH-P1B
1 LHSI Pump	R (over +2)	1.37	W	Y (over +1)	1-SI-P-1A FTS
1 CCW Pump	R (by CR) (over +2)	1.61	W	G (under -1)	Standby Pump 1-CC-P-1D FTS
Loss of AC Bus 1H	R (by CR) (match)	672	R	R (match)	
1 EDG	R (over +1)	2.42	Y	Y (match)	1-EE-EG-1 FTS
SBO Diesel	R (over +2)	1.58	W	W (match)	
Swing Diesel	R (over +2)	1.80	W	W (match)	
Loss of 125 VDC Bus	R (by CR) (over +1)	9.8	Y	R (over +1)	
Loss of ESGR ventilation	R (match)	13.7	R	R (match)	1-VS-4C
Loss of all Circulating Water Pumps	R (over +1)	2.90	Y	R (over +1)	T6 Loss of all CCW
1 Diesel ESW pump	G (match)	1.05	G	G (match)	
Loss of Instrument Air Compressor	R (over +3)	Truncated	G	G (match)	
Loss of Service Air	W (over +2)	Truncated	G	G (match)	TPCS
Batteries	R (over +1)	2.6	Y	W (under -1)	FEBAT TM Licensee does not model FB in loss of DC initiator. SDP notebook does.
Battery Chargers	Y (by CR) (over +2)	1.07	G	W (over +1)	1EPBCH
Loss of ESGR	R (match)	13.7	R	R (match)	
Equalization	Y (match)	2.72	Y	Y (match)	
AMSAC	G (match)	1.05	G	W (over +1)	1FWL1C-CC

Component Out Of Service or Failed Operator Action	SDP Worksheet Results (Before)	Internal RAW	Site Color	SDP Worksheet results (After)	Comments
MSIV FTC	Y (over +2)	Truncated	G	Y (over +2)	Licensee does not model PTS and SDP does
FB Operator Action	R (over +1)	3.42	Y	Y (match)	
RCSDEP	R (by CR) (over +2)	1.22	W	Y (over +1)	
SRV FTO	W (over +1)	1.06	G	W (over +1)	
CL	R (match)	703	R	R (match)	
Operator fails to initiate HL Recirculation	Y (over +1)	1.45	W	Y (over +1)	
SG Safety Valve FTO	W (over +1)	1.07	G	W (over +1)	
Operator fails to provide alt cooling to ESG room	NM	9.63	Y	R (over +1)	
SW Booster Pumps	W (match)	1.91	W	Y (over + 1)	

Notes

1. The alignment of the spare charging pump is credited as a recovery action for obtaining the match between the SDP and the PSA.

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 39	Percentage	Number of Cases 39	Percentage
SDP: Less Conservative	0	0	2	5
SDP: More Conservative	26	67	17	43
SDP: Matched	12	31	20	52
PSA: Not modeled	1	2	0	0

SDP Notebook After: Breakdown of Results

SDP Less Conservative - One Color: 2
Two Colors: 0

SDP More Conservative - One Color: 15
Two Colors: 2

3 PROPOSED REVISIONS TO REV. 0 SDP NOTEBOOK

Based on insights gained from the headquarters visit, a set of revisions is proposed for the Rev. 0 SDP notebook. The proposed revisions are based on licensee 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 Surry Power Station, Units 1 and 2

The licensee provided several comments for minor revisions to the SDP Notebook. The suggested changes dealt mainly with the initiating event frequencies, the dependency matrix, updated footnotes associated with the worksheets, and revised HEP values. These changes will be incorporated in the SDP worksheets. In addition, several major revisions that directly impacted the color assignments by the SDP evaluation were discussed with the licensee and their resolutions were identified in the meeting. The proposed revisions are discussed below:

1 Table 1 Initiating Event Likelihood

1.1 Revised designation of L1EDG to LEAC and moved from Row II to Row IV.

1.2 Added Loss of Chilled Water System to Row IV.

1.3 Added Loss of Instrument Air to Row II.

2 Table 2 Initiators and System Dependency

2.1 Clarified RCP pump seals are High Temperature O-Rings.

2.2 Clarified IA (Condenser Vacuum) as support system for MFW. Added L4KV and LDC as initiating event scenarios.

2.3 Revised “Vital Instrument Buses” to “Vital Buses” for CLS Support Systems.

2.4 Clarified that there are 2 heat exchangers for RHR Major Component.

2.5 Added SIAS as support system for LHSI Pumps. Clarified initiating event scenarios to All except ATWS and LCW.

2.6 Revised initiating events scenarios for AC Power to All.

2.7 Revised initiating events scenarios for 125 VDC to All. Clarified that electric support is provided by 480 VAC.

2.8 Added LIA as initiating event scenario for IA, combined IA and SA, deleted fire protection as support system for IA.

2.9 Revised designator for Canal Level Probes/Canal Isolation to CL, revised support system to read Vital 120 V Bus.

2.10 Added Chilled Water as an affected system.

2.11 Added Blackout Diesel Generator as Affected System.

2.12 Added Main Steam as Affected System. The applicable initiating event scenarios are MSLB, TPCS, SLOCA, SORV, LOOP, SGTR, ATWS, LCW, and LIA.

2.13 Added RCS Pressurizer Spray as Affected System.

2.14 Added footnote clarifying that each Surry unit has two 125 VDC buses. The TS battery durations are 2 hours under full load. However, assuming load shedding, a duration of 4 hours is assumed for each battery. The battery chargers can take the SI loads. Inspection findings related to the batteries should be evaluated by assuming loss of associated DC bus when offsite power is not available (i.e., LOOP and LEAC) and increasing the frequency of loss of DC initiator by one order of magnitude.

2.15 Added footnotes documenting the overestimated and underestimated scenarios identified during benchmarking.

2.16 Clarified footnote stating that CL trains will cause the isolation of 16 condenser water boxes, the start of the ESW pumps, and a turbine trip.

2.17 Clarified the initiating event scenarios for PORVs to All except LLOCA, MLOCA, LECHW, and LCW.

2.18 Clarified the initiating event scenarios for Recirculation Spray to All except ATWS, LECHW, and LCW.

2.19 Added footnote clarifying CCW system uses IA for motive power to the thermal barrier throttle valves.

2.20 Clarified that LECHW was an exception to the Initiating Events for LHSI and Consequence Limiting Safeguards Systems. Clarified that LIA was the only initiating event scenario for the service air compressors.

2.21 Deleted Footnote 6 and renumbered subsequent footnotes.

2.22 Added AMSAC as an affected system.

3 Table 3.1 TRANS Worksheet

3.1 Where applicable, revised the credit assigned to recirculation spray to 2 multi-train systems.

3.2 Revised the safety function description for EIHP to 1/2 charging pump trains or use of 1 spare charging pump (1 multi-train system) where applicable. The corresponding

footnote was revised to indicate that the spare charging pump can be aligned as a recovery action when the charging pump aligned to the bus is failed. A credit of 1 can be assigned for use of the 1 spare charging pump.

4 Table 3.3 SLOCA Worksheet

4.1 Globally revised FB safety function to Primary Heat Removal, Feed/Bleed for consistency.

5 Table 3.4 SORV Worksheet

5.1 Revised RCSDEP to read operator depressurizes and cools down RCS using 1/3 ADVs with the 1/1 remaining PORV. Revised credit for RCSDEP to 1 train from operator action = 3.

5.2 Revised FB to read operator conducts FB using the remaining 1/1 PORV (operator action = 2).

6 Table 3.6 LLOCA Worksheet

6.1 Revised RS to read Inside Recirculation Spray (IRS).

6.2 Revised worksheet and event tree to credit ORS when CS is successful.

6.3 Revised safety function for LPR to 1/2 LHSI trains auto transfer to recirculation mode.

7 Table 3.7 LOOP Worksheet

7.1 Added CL to Safety Function Needed, added new sequence LOOP-CL [5], revised event tree accordingly. Clarified that CL also included the operator closing the main condenser water box isolation valves.

7.2 Added footnote to indicate that the HEP assessed in the PRA for the operator opening the bearing cooling water isolation valves is 8.7E-4. A value of 3 is assigned.

8 Table 3.8 SGTR Worksheet

8.1 Revised designators SHR and SHR1 to AFW and AFW1 respectively. Revised AFW1 to read 2/3 AFW trains (1 multi-train system) and changed operator action for 1/3 MFW trains with 1/3 Condensate trains from 2 to 1.

8.2 Revised safety function description for RHR to operator initiates 1/2 RHR trains.

9 Table 3.9 MSLB Worksheet

9.1 Deleted safety function ISOB and replaced it with Isolation of All Steam Lines (MSIV3) - Closure of 3/3 MSIVs (1 train) and Isolation of 2/3 Steam Lines (MSIV2) - Closure of 2/2 remaining MSIVs assuming failure of MSIV3 and isolation of feedwater to the unisolated SG (1 train).

9.2 Deleted all functions and replaced with MSLB-MSIV3-STEIHP [7]; MSLB-MSIV3-AFW-RS [15]; MSLB-MSIV3-AFW-HPR [12]; MSLB-MSIV3-AFW-FB [11]; MSLB-MSIV3-EIHP-AFW [12]; MSLB-MSIV3-FWI [7], and MSLB-MSIV3-MSIV2 [7]. Revised event tree accordingly.

9.3 Added footnote stating that SLB inside containment will cause actuation of containment spray, and the affected SG cannot be isolated. A SLB outside containment and a FLB (inside or outside containment) is considered here. The blowdown of one SG, as long as the feed to it is terminated, is assumed not to cause a severe overcooling transient (no PTS concern).

9.4 Revised event tree and table to include feedwater isolation function.

10 Table 3.10 ATWS Worksheet

10.1 Revised AFW to a 1 multi-train system.

11 Table 3.11 L4KV Worksheet

11.1 Revised FB to read 1/1 PORV open for Feed/Bleed.

11.2 Revised HPR to read 1/1 charging pump train with 2 charging pumps.

11.3 Added PCS to all sequences. Revised event tree accordingly.

11.4 Added footnote to indicate that the spare charging pump is available and can be used for recovery to EIHP.

11.5 Clarified Footnote 1.

12 Table 3.12 LDC Worksheet

12.1 Added PCS to all sequences. Revised event tree accordingly. Revised description to restore PCS through 1/2 main feedwater trains and 1/3 condensate pump trains.

12.2 Added footnote to indicate that the spare charging pump is available and can be used for recovery to EIHP.

12.3 Revised Footnote 1 to indicate that a loss of a 125 VDC bus will result in loss of MFW and reactor trip; however, PCS can be restored.

12.4 Revised safety function description for RS to read 1/1 remaining inside RS train or 1/1 remaining outside RS train.

13 Table 3.13 LCW Worksheet

13.1 Revised entire worksheet. Revised safety functions as follows: Canal Isolation (CL) - Operator closes open bearing cooling water isolation valve and 1/3 ESW pumps auto start (1 multi-train system); ESR Alternate Cooling (ESRHVAC) - Operator provides alternate cooling to ESR (operator action = 1); Early Inventory, High Pressure Injection (EIHP) - 1/2 charging pump trains or use of 1 spare charging pump (1 multi-train system); and Secondary Heat Removal (AFW) - 1/2 MDAFW trains (1 multi-train system) or 1/1 TDAFW train (1 ASD train) with 1/3ADVs or 1/5 MSSVs.

13.2 Revised sequences as follows: LCW-CL-ESRHVAC [6]; LCW-CL-EIHP [8]; and LCW-CL-AFW [9]. Revised event tree accordingly.

13.3 Added footnote stating that loss of circulating water will result in falling level in intake canal and result in a trip. The operator is required to isolate major non-essential loads, and the ESW pumps will auto-start. Failure of operator to isolate the non-essential loads would result in a loss of HVAC in the switchgear room. An alternate method of room cooling could be established by opening doors. The operation of the charging pumps is required for seal injection in those scenarios where canal isolation has failed.

13.4 Added footnote stating that for events which involve failure of circulating water pumps, non-essential loads must be isolated. These loads are the condenser water boxes, bearing cooling water system, and the normal CCW flow which must be throttled down. For some failures to isolate, the operation of the diesel-driven ESW pumps may prevent depletion of canal water. However, if the water boxes are not isolated, the operation of the three pumps would not be sufficient to maintain water level. If isolation is successful, the operation of the diesel-driven ESW pumps will not be required for 24 hours. The SDP conservatively does not credit the diesel-driven ESW pumps as a means of mitigation on failure to isolate.

13.5 Added footnote clarifying that in those scenarios where canal isolation has failed, alternate cooling for emergency switchgear room is successful, the operator must maintain seal injection and proceed to a cooldown with a combination of the AFW and charging systems.

13.6 Added footnote stating the frequency for LCW is 6.66E-2 and is assigned to row II.

14 Table 3.14 LEAC Worksheet

14.1 Added footnote to indicate that the spare charging pump is available and can be used for recovery to EIHP.

14.2 Revised Table designator to LEAC.

14.3 Deleted sequences: LEAC-AFW-RS; LEAC-AFW-HPR; LEAC-AFW-FB; LEAC-AFW-EIHP; and LEAC-CL. Revised event tree accordingly.

14.4 Revised safety function for RCSDEP to 1 train credit.

15 Table 3.15 LECHW Worksheet

15.1 New Worksheet added. One safety function defined: Cooling Trunkline (HEPTRUNK) - Operator establishes trunk line for alternate cooling (operator action = 3). One sequence identified: LECHW-HEPTRUNK [7].

15.2 Added footnote stating that loss of chilled water will result in loss of cooling water to the control room, relay room, and emergency switchgear room. This would result in a reactor trip and core damage if not recovered. Per plant procedures, the operator is required to establish alternate cooling by using a trunk line.

16 Table 3.16 Loss of Instrument Air

16.1 Added footnote clarifying that loss of instrument air is equivalent to TPCS and will result in reactor trip due to MSIV closure.

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 consider external events in the PRA.

5. LIST OF PARTICIPANTS

P Wilson	NRC-NRR
C. Wong	NRC-Region II
G DeMoss	NRC-RES
Rudolph Bernhard	NRC-Region II
Walter Rogers	NRC-Region II
Edward Grove	BNL
D Bucheit	Dominion Generation
K Tuley	Dominion Generation
R. Gibbs	NRC-Region II
J. Schroeder	INEEL