April 23, 2003

MEMORANDUM TO: Cynthia A. Carpenter, 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: F. Mark Reinhart, Chief/**RA/**
Licensing Section
Probabilistic Safety Assessment Branch
Division of Systems Safety and Analysis
Office of Nuclear Reactor Regulation

SUBJECT: RESULTS OF THE CATAWBA NUCLEAR STATION SDP PHASE 2 NOTEBOOK BENCHMARKING VISIT

During June, 2002, NRC staff and contractors visited the Duke Energy corporate offices in Charlotte, North Carolina to compare the Catawba 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) Rev. 2b internal event core damage frequency (CDF) was 3.21E-5/reactor-year excluding internal flood events. The Catawba PSA did include external initiating events (e.g. fire, seismic, flood) and therefore sensitivity studies were performed to determine any 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 Catawba 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 Catawba SDP notebook for the benchmark efforts, the team determined that some changes to the SDP notebook were needed to reflect how the Catawba plant is currently designed and operated. Thirty-five 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

CONTACT: Mike Franovich, SPSB/DSSA/NRR
415-3361

conservative by 14 percent, more conservative by 43 percent, consistently estimated by 34 percent, with 9 percent not modeled. Consequently, 77 changes were made to the SDP notebook. Using the revised SDP notebook, the team obtained zero percent of the cases that were less conservative, 38 percent were more conservative, 56 percent of the cases were consistent with the licensee's results, and 9 percent not modeled. Of the conservative cases, all but two 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.

At Catawba, the CDF contribution from internal events was 3.21E-5/yr (excluding internal floods), and the CDF contribution from floods, tornadoes, seismic, and fire, and other was 2.62E-5/yr. Examination of these external initiators showed the importance of four components. These cases were:

- failure to run of emergency diesel generator (EDG) 1A,
- failure to start the standby shutdown facility (SSF) diesel generator,
- failure upon demand of the1EBA battery, and
- failure to start of the turbine-driven auxiliary feed-water (TDAFW) sump pump 1A (powered by the SSF DG during a station blackout).

Based on the licensee's model, the risk importance of these cases would be raised by one order of magnitude if the external initiators were included in the risk significance determination. However, the revised SDP notebook already characterized the 1EBA battery and TDAFW sump pump cases as one or more orders of magnitude greater than the internal events case alone. Therefore, staff use of the inspection notebook for these cases would not under-estimate the risk of both internal and external contributors when compared to the licensee's model. The Catawba SDP notebook would under-estimate the risk impact by one order of magnitude for the EDG 1A and SSF diesel generator cases.

The licensee's PSA staff had substantial knowledge of both the Catawba 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 Catawba SDP Phase 2 Notebook and the licensee's PSA.

Attachments: As stated

conservative by 14 percent, more conservative by 43 percent, consistently estimated by 34 percent, with 9 percent not modeled. Consequently, 77 changes were made to the SDP notebook. Using the revised SDP notebook, the team obtained zero percent of the cases that were less conservative, 38 percent were more conservative, 56 percent of the cases were consistent with the licensee's results, and 9 percent not modeled. Of the conservative cases, all but two 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.

At Catawba, the CDF contribution from internal events was 3.21E-5/yr (excluding internal floods), and the CDF contribution from floods, tornadoes, seismic, and fire, and other was 2.62E-5/yr. Examination of these external initiators showed the importance of four components. These cases were:

- failure to run of emergency diesel generator (EDG) 1A,
- failure to start the standby shutdown facility (SSF) diesel generator,
- failure upon demand of the1EBA battery, and
- failure to start of the turbine-driven auxiliary feed-water (TDAFW) sump pump 1A (powered by the SSF DG during a station blackout).

Based on the licensee's model, the risk importance of these cases would be raised by one order of magnitude if the external initiators were included in the risk significance determination. However, the revised SDP notebook already characterized the 1EBA battery and TDAFW sump pump cases as one or more orders of magnitude greater than the internal events case alone. Therefore, staff use of the inspection notebook for these cases would not under-estimate the risk of both internal and external contributors when compared to the licensee's model. The Catawba SDP notebook would under-estimate the risk impact by on order of magnitude for the EDG 1A and SSF diesel generator cases.

The licensee's PSA staff had substantial knowledge of both the Catawba 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 Catawba SDP Phase 2 Notebook and the licensee's PSA.

Attachments: As stated

CONTACT: Mike Franovich, SPSB/DSSA/NRR
415-3361
Accession #ML031140298 NRR-106
G://SPSB/Franovich/CatawbaBench.wpd

OFFICE	SPSB	SPSB:SC	RII
NAME	MFranovich:nyc	MReinhart	RBernhard
DATE	04/23/03	04/23/03	04/23/03

OFFICIAL RECORD COPY

SUMMARY REPORT ON BENCHMARKING TRIP

TO THE DUKE ENERGY COMPANY FOR CATAWBA NUCLEAR

STATION UNITS 1 AND 2

Mohamad A. Azarm, Gerardo Martinez-Guridi, and Edward J. Grove

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

Table of Contents

List of Tables

1. INTRODUCTION

A benchmarking of the Catawba Nuclear Station Units 1 and 2 SDP risk-informed inspection notebook was conducted during a visit to the Duke Energy headquarters in Charlotte, N.C. on June 22-26, 2002. NRC staff (M. Franovich and R. Bernhard) supported by BNL staff (M.A. Azarm and E. J. Grove) participated in this benchmarking exercise. G. Martinez-Guridi of BNL provided support after the benchmarking visit.

In preparation for the visit, BNL staff reviewed the Catawba Nuclear Station 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 PSA. A copy of the agenda was sent to the licensee by NRC staff (M. Franovich) 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 considering 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. Performed a benchmarking exercise using the revision 3i SPAR model for Catawba Nuclear Station Units 1 and 2 (by Mr. R. Buell from INEEL).

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 nine column headings. The first column is a consecutive numbering of the hypothetical findings. In the second column, the out-of-service components (human and recovery actions) are identified for the case analyses. The third column shows the associated colors based on the Rev. 0 SDP notebook. The fourth column shows the internal RAW values based on the licensee's latest PSA model. The site colors based on the internal RAW values are shown in the fifth 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 sixth column. The seventh column shows the internal events plus the external events RAW values. The site colors based on these RAW values are shown in the eighth column. Finally, the licensee's basic event name associated with each hypothetical finding and some clarifying notes are noted in the ninth column.

The summary statistics of the benchmarking results is 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 both Tables 1 and 2 show that the revised SDP notebook should provide either similar or slightly more conservative significance characterization (i.e., maximum by two colors) than the licensee's PRA model in about 94% of the cases analyzed. There was no case out of 35 that resulted in a less conservative color, and 3 cases (about 9%) were not modeled in the PRA (no RAW values found). The SDP notebook overestimated the risk importance by one color in 11 instances.

In two specific instances, the SDP notebook overestimated the risk importance by two colors:

- TDAFW sump pump 1B fails. The SDP notebook overestimates the significance of the failure of this pump mainly because it is associated with the failure of the TDAFW in three worksheets: TRN, TKC, and TIA. In these worksheets, the credit of AFW is 1 or 2 and, hence, counting the base case of the sequences in which AFW participates in these worksheets overestimates the significance of the sump pump 1B.

- Compressor D fails to start upon demand. A review of the simplified Instrument Air system drawing indicates that this compressor provides a backup to VI compressors E and F as well as to station air compressors A and B. Station Air provides a backup to Instrument Air at 76 psi, which is sufficient to support the MFW/PCS operation. In the event of failure or maintenance on one of these compressors, Instrument Air compressor D would be placed in service. Failures of several of the VI compressors E and F or of the station air compressors A and B (blockage, corrosion) would cause the loss of compressor D to become more significant. The cause of the difference between the licensee's color and the notebook's color appears to be the redundancy of the Instrument Air and Station Air systems. Rule 1.3 of the SDP evaluation rules does not account for the level of redundancy available in a plant.

In both cases, the notebook's conservative Loss of Instrument Air (LIA) worksheet influences the risk determination. The LIA worksheet limits AFW credit based on operator action to control AFW flow following depletion of backup nitrogen to the air-operated flow control valves. This

notebook modeling assumption combined with the SDP counting/usage rule contributes to the over-estimate.

The benchmarking exercise overestimated eleven cases by one color. These were: AFW MDP 1B failure to start, AFW TDP failure to start, RN pump 1A failure to start, CCP 1A fails to run, PORV 1NC32b failure to reseat, SRV failure to reseat following a transient, 125 VDC Vital I&C Power

Distribution Center 1EDE fails, failure to start of the TDAFW sump pump 1A, failure to start of both TDAFW sump pumps, loss of IA, and loss of Recirculating Water (KR) to VI compressors.

The limiting case for the loss of a 125 VDC bus is loss of power to 125 VDC bus 1EDD (or 1EDA on the other train). Loss of this bus results in loss of the MSIV solenoids and MFW isolation valve solenoids resulting in a reactor trip. However, this will not result in loss of train B control power to the 4160 essential bus, DG load sequencer, TDAFW pump or loss of two pressurizer PORVs which are supplied from another source. Therefore, upon loss of one 125 VDC vital bus, the other train's equipment can still auto-start or be manually started in the control room. The loss of one DC vital bus was not included in the SDP notebook because it is considered to be included in the worksheet for Transients (Reactor Trip).

An additional impact on these differences are possibly the result of slightly different reliability and human error probabilities used in the licensee's PRA model compared to the generic values in the SDP notebook. The licensee is presently in the process of completing Rev. 3 of the PRA which may eliminate some of these occurrences.

The importance of this benchmarking trip was demonstrated by the reduction in over and under estimations and the increase in matches.

Table 1: Summary of Benchmarking Results for Catawba Units 1 and 2

Internal Events CDF is 3.21E-5/reactor-year with 1.0E-9 truncation limit
RAW Thresholds are W = 1.03, Y = 1.31 , and R = 4.12

Internal + External Events CDF is 5.83 E-5/reactor-year
RAW Thresholds are W = 1.02 , Y = 1.17 , R = 2.72

No.	Component Out of Service or Failed Operator Action	SDP Worksheet Results (Before)	Internal RAW	Site Color	SDP Worksheet results (After)	Internal + External RAW	Internal + External Color	Comments
	Component							
1	One Accumulator fails to inject	Y (over)	1.06	W	G (match)	1.03	W	IINIACCATKF. In Rev. 3 of PRA update, the site color will drop to Green like MNS.
2	EDG 1A FTR	W (under)	1.32	Y	Y (match)	3.68	R	JDG001ADGR. EDG importance increases when turbine building flood is included (flood transformers feeding normal power to emergency 4KV buses). Licensee considering mod (wall) to reduce risk. Increase in importance for external CDF.
3	4160 V bus 1ETB unavailable	R (match)	5.0	R	R (match)	4.08	R	PAC1ETBBHM
4	AFW MDP 1B FTS	R (over)	1.17	W	Y (over)	1.07	W	FCAMDPBMPS
5	AFW TDP FTS	R (over)	1.89	Y	R (over)	1.96	Y	FCA0TDPTPS

No.	Component Out of Service or Failed Operator Action	SDP Worksheet Results (Before)	Internal RAW	Site Color	SDP Worksheet results (After)	Internal + External RAW	Internal + External Color	Comments
6	Both MDAFW pumps CCF-FTS	R (match)	37.57	R	R (match)	21.13	R	FCAMDPSCOM
7	RN (SWS) pump 1A FTS	R (over)	1.04	W	Y (over)	1.02	W	WRN001AWPS
8	Loss of SWS (RN)	R (match)	260	R	R (match)	143.5	R	T9
9	CCW Pump KC-1A1 FTR	R (match)	5.6	R	R (match)	3.53	R	KKC01A1PPR
10	Loss of MFW initiator	R (over)	1.04	W	W (match)	1.02	W	T4
11	Failure to restore main feedwater after plant trip	G (under)	3.45	Y	Y (match)	2.48	Y	TCF0001RHE
12	Failure to restore main feedwater after loss of MFW	G (under)	1.12	W	W (match)	1.06	W	TCF0002RHE
13	CCP 1A FTR	R (over)	1.4	Y	R (over)	1.22	Y	HNVCCPACPR
14	One MSIV fail to close on demand	Y (over)	Not found	G	Y (Not modeled)	Not found	G	PTS Issue.
15	PORV 1NC32b fails to reseat	W (match)	1.11	W	Y (over)	1.12	W	RNC032BPRO

No.	Component Out of Service or Failed Operator Action	SDP Worksheet Results (Before)	Internal RAW	Site Color	SDP Worksheet results (After)	Internal + External RAW	Internal + External Color	Comments
16	1 RHR Pump ND1B FTR	R (over)	2.0	Y	Y (match)	1.55	Y	LND001BLPR
17	CCF RHR (ND) pumps fail to start	R (match)	14.97	R	R (match)	8.69	R	LNDPSTRCOM
18	SSF DG FTS	R (over)	1.04	W	W (match)	1.63	Y	NSS00DGSDS. Increased importance for external CDF.
19	SSF RC makeup pump FTS	R (over)	2.86	Y	Y (match)	2.67	Y	NNV0SMPDPS
20	AMSAC Circuitry Failure	W (match)	1.05	W	W (match)	1.02	W	MAMSAC
21	One SI (NI) pump FTS (in recirculation)	Y (match)	1.08	W	W (match)	Not found	Not known	INI136BMVO. We assumed that failure of valve NI136B to open fails one SI pump in recirculation.
22	SRV fails to reseat on transient	W (under)	1.41	Y	R (over)	1.23	Y	RNCOSRVRVC. We assume it causes a MLOCA.
23	125 V dc Vital I&C Power Distribution Center 1EDE Fails	R (match)	8.03	R	R (match)	4.87	R	DDC1EDEBDF Assumes loss of 1 train of ECCS + 1 PORV
24	125V DC Battery 1EBA fails on demand	W (under)	1.52	Y	R (over)	2.95	R	DDC1EBABYF Increased importance for external CDF.

No.	Component Out of Service or Failed Operator Action	SDP Worksheet Results (Before)	Internal RAW	Site Color	SDP Worksheet results (After)	Internal + External RAW	Internal + External Color	Comments
25	TDAFW Sump Pump 1A Fails to Start	R (over)	1.06	W	Y (over)	1.5	Y	FWL01A1GPS. TDAFW pump is located in a small pit. 87 minutes to fill pit with no sump pumps under nominal AFW leakage and condensed steam from turbine exhaust. 1A sump pump only available during SBO if powered from SSF. Increased importance for external CDF.
26	TDAFW sump pump 1B FTR	R (over)	1.01	G	Y (over)	1.01	G	FWL01A2GPR
27	TDAFW sump pumps CCF FTS	R (over)	1.58	Y	R (over)	1.54	Y	FWL1ASTCOM Loss of TDAFW
28	YD system unavailable or operators fail to establish backup cooling from YD	Y (match)	1.57/ 1.58	Y	Y (match)	1.35	Y	HYDBACKDHE. YD is alternate cooling for NV pump 1A.
29	Loss of IA	R (over)	1.71	Y	R (over)	1.31	Y	T12
30	Compressor D FTS on demand	R (over)	1.01	G	Y (over)	1.0	G	AVICMPDCMS
31	Loss of Recirculating Water (KR) to VI compressors	R (over)	3.07	Y	R (over)	2.2	Y	AKRFAILDEX

No.	Component Out of Service or Failed Operator Action	SDP Worksheet Results (Before)	Internal RAW	Site Color	SDP Worksheet results (After)	Internal + External RAW	Internal + External Color	Comments
	<u>Operator Action</u>							
32	Fail to FB Operator Action	R (match)	6.48	R	R (match)	4.02	R	TFBLD01DHE
33	Operators fail to restore VI or backup Nitrogen to PORVs	R (match)	6.25	R	R (match)	3.89	R	RVIPORVDHE
34	Common cause 3 of 3 primary PORVs FTO	R (match)	5.32	R	R (match)	3.38	R	RNC33RVCOM
35	Rapid Depressuriza-tion (in SGTR)	Y (over)	Not found	G	W (Not modeled)	Not found	G	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 (35)	Percentage	Number of Cases (35)	Percentage
SDP: Less Conservative	5	14%	0	0%
SDP: More Conservative	15	43%	13	37%
SDP: Matched	13	37%	20	57%
PSA: Not modeled	2	6%	2	6%

SDP Notebook After: Breakdown of Results

SDP Less Conservative -	One Color:	0 findings
	Two Colors:	0 findings
SDP More Conservative -	One Color:	11 findings
	Two Colors:	2 findings

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'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 Catawba Nuclear 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 Revisions to Table 1: Categories of Initiating Events

- 1.1 Revised the Initiating Event Category for Loss of SW and Loss of CCW from Row III to Row IV and created separate worksheets and event trees for loss of SW and loss of CCW.

- 1.2 Moved TIA from Row I to Row II.

- 1.3 Included footnotes 2 and 3 clarifying placement of TIA and TPCS.

- 1.4 Included footnote 4 indicating that the SGTR frequency used in the licensee's PSA model is 1.16E-2/reactor-year which is more conservative than the NUREG-5750 frequency (7.8E-3/reactor-year). Therefore, SGTR is in Row II.

2 Revisions to Table 2: Initiators and System Dependency

- 2.1 Added footnote stating that the EDG day tank has sufficient capacity for a run duration of 1 hour. The fuel transfer from the main tank to the day tank is by gravity feed through one SOV with a manual bypass valve provided for each EDG.

- 2.2 Added footnote stating that there are 2 sump pumps, one of which is powered by SSF DG during an SBO. Sump/pit input includes water from the TDAFW lube oil cooler (once through cooler that dumps water to the pit). The TDAFW will operate for 87 minutes without a pit sump pump under nominal leakage and input from the TDAFW lube oil cooler. The LOOP worksheet was also modified to account for loss of the sump pump.

- 2.3 Added footnote stating that the battery chargers cannot accommodate SI loads without the batteries.

2.4 Added footnote explaining that Station Air (VS) provides a backup to Instrument Air (VI) at 76 psi, which is sufficient pressure to support the MFW/PCS operation. The VS system consists of two trains of single stage Positive Displacement (PD), flood-lubricated, rotary-screw compressors fed from the normal 600 VAC.

2.5 Added footnote clarifying that 2 out of 3 primary PORVs and all SG PORVs have backup nitrogen.

2.6 Deleted all support systems for the accumulators.

2.7 Revised the 125 VDC train designations in the Support Systems for the Essential Auxiliary Power System, and deleted reference to HVAC system.

2.8 Clarified that the EDGs have a dedicated battery. The battery is dedicated and is the only DC system for the EDGs. Also added the Fuel Transfer System (FD) as a support system.

2.9 Added the AOV steam admission valves as a major component for the AFW system. Credited the TDAFW pit sump pumps (WL) as a support system for the TDAFW pump. Revised initiating events for TDAFW pump to all except MLOCA, LLOCA, and ATWS.

2.10 Revised the major components for the CCW system to reflect two trains, each with two pumps and one heat exchanger.

2.11 Included three 50% hotwell pumps as major components for the Condensate/MFW system. Added reference to RL and AS as applicable support systems.

2.12 Deleted PDP as a major component for the NV system. Credited ESFAS, KC, and FWST as support systems for the CVCS. Added TKC as initiating event.

2.13 Deleted the HVAC system from Table 2.

2.14 Clarified that the VI major components consist of 3 air compressors, 2 operating and 1 as backup for both Units 1 and 2.

2.15 Added ESFAS and FWST systems as providing support to RHR/LPSI. Revised initiating events to include all except ATWS, TRN, and TKC.

2.16 Clarified that the RCPs use high temperature Westinghouse O-ring seals. Added footnote indicating that the SSF pump provides seal injection as a recovery action for all 4 RCPs.

2.17 Noted that ESFAS serves as a support system for RN.

2.18 Noted that ESFAS provides support for HPSI. Revised initiating events to TRANS, TPCS, SLOCA, SORV, MLOCA, LOOP, SGTR, MSLB, LEAC, and TIA.

2.19 Clarified that the SSF makeup pump is powered by the SSF DG during station blackout.

2.20 Added the TDAFW Sump Pump (WL) system. System is comprised of 2 PDP sump pumps supported by the 600 VAC and the 125 VDC support systems. The A pump is fed from the SSF DG during station blackout. Initiating events are all except MLOCA, LLOCA, and ATWS.

2.21 Added a footnote describing the overestimates.

2.22 Added AMSAC because it is used in ATWS.

2.23 Added drinking water (YD) because it is used in TRN and TKC.

2.24 The column for "Initiating event" was updated for all systems.

2.25 Added "automatic recirculation valve (pump minimum flow protection)" as a support system of AFW. Also included a footnote indicating that these "passive" three way acting valves have some very tight clearances which could make them susceptible to fouling. This becomes an important issue if there is debris in the CACSTs, USTs, or AFW system swaps suction to the raw service water system during internal or external events (the seismic source of AFW water). If the plant has raw water with many biologics and silt, the AFW pumps could dead-head if the small min-flow clearances are clogged with debris.

2.26 Updated information for the Standby Shutdown Facility (SSF):

a) There is one Diesel generator for the site. The support systems for this DG are: Normal 6.90 kVAC, Normal 600 VAC, SSF 125 VDC, SSF 120 VAC, HVAC, fuel oil and transfer pump, SSF diesel generator 24 volt NiCad battery and associated charger.

b) There are two makeup pumps (1 per reactor unit with suction from the unit's Spent Fuel Pool). One is powered by the SSF DG during SBO. The support systems for these pumps are: Normal 6.90 kVAC, Normal 600 VAC, SSF 125 VDC, SSF 120 VAC.

2.27 Clarified that there is one MSIV per steam line.

3 Table 3.1: TRANS Worksheet

3.1 Globally revised footnotes to indicate that the HEP values for FB from the PRA is 1.2E-2, and the HEP value is 4.5E-3 for switchover to recirculation.

4 Table 3.2: TPCS Worksheet

4.1 Clarified footnote to indicate that the frequency of transients with unrecoverable loss of PCS is estimated at 4.1E-2/reactor-year based on the PRA (taking into account 0.1 for failure of recovery of PCS).

4.2 Clarified AFW safety function to indicate associated steam relief through 1/1 SG PORV or 1/5 safety relief valves.

5 Table 3.3: SLOCA Worksheet

5.1 Globally revised EIHP to 1 multi-train system. Corrected FB to read 2/3 PORVs.

5.2 Added footnote to indicate that PRA considers break sizes greater than 3/8 inch and less than 2 inches as SLOCA.

6 Table 3.4: SORV Worksheet

6.1 Added footnote to indicate that the HEP value for the operator to close the block valve is estimated as 6.0E-3.

6.2 Added SORV event tree.

6.3 Clarified BLK safety function description.

7 Table 3.5: MLOCA Worksheet

7.1 Added footnote to indicate that the PRA considers break sizes from 2.0 to 5.0 inches as MLOCA.

8 Table 3.6: LLOCA Worksheet

8.1 Added footnote to indicate that the PRA considers break sizes greater than 5.0 inches as LLOCA.

9 Table 3.7: LOOP Worksheet

9.1 Added WL to Safety Functions needed (Failure of 1/1 sump pump for TDAFW pit (1 train)). Modified SSF description to indicate injection into 4/4 RCP seals. Deleted REC4 as PRA does not consider recovery in less than 4 hours.

9.2 Deleted failure sequence 4 (LOOP-EAC-REC4) since the TDAFW pumps independent of the batteries. Added new failure sequence (LOOP-EAC-WL-REC2).

9.3 Added footnote indicating that the PRA assumes SG dryout in 20-30 minutes. Therefore, it is assumed that if AC is recovered before 30 minutes, no seal leakage or SG dryout has occurred.

9.4 Added footnote stating that the PRA uses a HEP of about 8.5E-2 which is considered as an operator action with a credit of 1.

9.5 Added footnote stating that for SBO scenarios, it is assumed to take approximately 2 hours after the RCP seal LOCA, or total loss of secondary cooling, for core damage to occur. The recovery of AC power in 2 hours is based on EPRI’s curve for this plant, and a credit of 1 is given.

9.6 Revised event tree accordingly.

9.7 Clarified AFW2 safety function description to indicate steam relief through 1/1 SG PORV or 1/5 safety relief valves.

10 Table 3.8: SGTR Worksheet

10.1 Added footnotes to table stating that the operator error probability for EQ (PDS function in licensee's PRA) and PDP is 8.0E-3, and 1.2E-2 for FB. Clarified that PORV failure to re-seat and operator failure to close block valve is not included here since it was covered under SORV.

10.2 Revised event tree accordingly.

10.3 Revised EQ to read primary depressurization using pressurizer spray to equalize and terminate break flow.

10.4 Deleted footnote 5 pertaining to RCSCOOL function.

11 Table 3.9: ATWS Worksheet

11.1 Added footnote stating that neither the PRA or licensee's worksheets discuss opening of the PORV and SRVs. The favorable MTC (typically 90% of the time) is assumed.

11.2 Clarified that HPI safety function uses 1/2 boric acid transfer pumps.

12 Table 3.10 MSLB Worksheet

12.1 Modified footnote to state that the blowdown of one SG is assumed not to cause a severe overcooling transient (no PTS concern), as long as the feed to this SG is terminated. Another footnote clarified the success criteria for FB.

13 Table 3.11: TRN Worksheet

13.1 Revised scenarios (TRN-RCPT (6), TRN-SSF-NV/YD (5), TRN-TDAFW/PCS (2, 4)).

13.2 Added footnote to state the frequency of loss of RN is 1.2E-4/reactor-year. TRN will result in reactor trip due to RCP motor overheating, and the TDAFW and SSF systems are considered to be available.

13.3 Changed footnote 2 to indicate that an operator action with a credit of 1 is assigned for the operator using the SSF makeup pump to provide RCP seal injection. This was done to be consistent with the credit used in LOOP.

13.4 Revised event tree accordingly.

13.5 Clarified TDAFW/PCS safety function to include 1/2 feedwater or condensate trains (operator action = 1).

13.6 Added YD (drinking water) as backup cooling method to the 1(2)A NV pump and credited NV/YD to operator action = 2. The HEP is 1.3E-2 (HYDBACKDHE). A footnote was added with this HEP.

14 Table 3.12 (Rev. 0): T4A Worksheet (deleted).

15 Table 3.12: TKC Worksheet

15.1 Worksheet added. Loss of KC will result in similar sequences as loss of RN and has a frequency of 2.9E-4/reactor-year.

15.2 Removed part of footnote 1 saying that “seal injection will be provided by NV (which is cooled by RN) so following a successful RCP trip, no seal LOCA is expected.” NV is cooled by KC, so seal injection cannot be provided by NV after a loss of KC unless backup cooling is aligned to the NV pump 1(2) A.

15.3 Added to footnote 1 that the event tree for Loss of Component Cooling Water (TKC) is the same as that for Loss of Nuclear SW (TRN).

15.4 Changed footnote 2 to indicate that an operator action with a credit of 1 is assigned for the operator using the SSF makeup pump to provide RCP seal injection. This was done to be consistent with the credit used in LOOP.

15.5 Added YD (drinking water) as backup cooling method to the NV pump 1(2)A and credited NV/YD to operator action = 2. The HEP is 1.3E-2 (HYDBACKDHE). A footnote was added with this HEP.

16 Table 3.13: LEAC Worksheet

16.1 Renumbered to Table 3.13

16.2 Revised EIHP to 1/1 NV train (1 train) into 4/4 loops.

16.3 Deleted first three failure scenarios (LEAC-AFW-HPR; LEAC-AFW-FB; LEAC-AFW-EIHP); added new scenario LEAC-SORV-AFW-FB (7).

17 Table 3.14: TIA Worksheet

17.1 Revised footnote to indicate the frequency of loss of instrument air is 2.6E-2/reactor-year, which causes loss of FW and MSIV closure. The SG PORVs have nitrogen backup. The SG SRVs will be available for stable heat removal. The event tree for this loss is the same as the one for Transients without PCS (TPCS).

17.2 Added footnote to indicate that upon loss of instrument air, the PORVs may be fed from the nitrogen backup.

17.3 Renumbered worksheet to Table 3.14.

17.4 Revised FB to read 1/2 remaining PORVs open for Feed and Bleed because 2 of the 3 PORVs have nitrogen backup.

17.5 Revised initiating event frequency from Row I to Row II.

17.6 Added steam relief paths available for secondary heat removal.

18 Table 3.15: ISLOCA Worksheet

18.1 The initiating pathways were updated using the information provided by the licensee during benchmarking.

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 CDF from both internal and external events is 5.83E-5/reactor-year. The most significant external events include internal flood (25% of total CDF), seismic (15% of total CDF), tornado (4% of total CDF) and fire (2% of total CDF). From limited comparisons of RAW values for internal and external events, four cases were identified and noted in Table 1 that the external events made the component more important. The cases which showed an increase in importance included: failure to run of the 1A EDG, failure to start of the SSF DG, failure upon demand of the 125 VDC 1EBA battery, and failure to start of the TDAFW sump pump 1A (powered by SSF DG during an SBO). Each of these cases resulted in an increase of importance by one color when external events were considered. For the failures of the 1A EDG and 125 VDC battery, the color increased from yellow to red. Failures of the TDAFW sump pump 1A and the SSF DG resulted in a color increase from white to yellow.

The increased importance of the EDGs and SSF was due largely to the internal plant flood initiators which were primarily dominated by a turbine building flood. The plant's normal power to the 4.1 kV emergency busses were fed by transformers located in the basement of the turbine building and the transformers were susceptible to flood damage.

List of Participants
June 24-27, 2002
Charlotte, NC

Name	Affiliation
Duncan Brewer	Duke Energy
Steve Nader	Duke Energy
Mike Barrett	Duke Energy
Mike Kitlan	Duke Energy
Robert Buell	INEEL
Mike Franovich	NRC-NRR
Julius Bryant	Duke Energy
Michael Weiner	Duke Energy
Rudolph Bernhard	NRC-Region II
Tom Baumgardner	Duke Energy
Rudy Hart	Duke Energy
George Strickland	Duke Energy
Walter Rogers	NRC-Region II
Mohamad Ali Azarm	BNL
Edward Grove	BNL