September 10, 2003

NOTE TO: Stuart Richards, Chief
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FROM: Mark F. Reinhart, Chief /***RA/*** P. Wilson for
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SUBJECT: RESULTS OF THE INDIAN POINT 2 GENERATING STATION SDP PHASE 2 NOTEBOOK BENCHMARKING VISIT

During April, 2003, NRC staff and contractors visited the Offices of Entergy Northeast to compare the Significance Determination Process (SDP) Phase 2 notebook and licensee's risk model results for the Indian Point 2 Generating Station in Buchanan, NY. In addition, the results from analyses using the NRC's draft Revision 3i Standard Plant Analysis Risk (SPAR) model for Indian Point 2 were also 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 Indian Point 2 Phase 2 notebook was generally more conservative in comparison to the licensee's PSA. The revision 1 SDP notebook will capture 86.8% 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.

13.2% Underestimates Risk Significance
63.2% Match Risk Significance
13.2% Overestimates Risk Significance by 1 Order of Magnitude
10.4% Overestimates Risk Significance by 2 Orders of Magnitude

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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 Indian Point 2 SDP Phase 2 Notebook and the licensee's PSA.

Attachments: As stated

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Attachments: As stated

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Attachment A

SUMMARY REPORT ON BENCHMARKING TRIP TO THE

INDIAN POINT NUCLEAR GENERATING STATION, UNIT 2 (APRIL 1-4, 2003)

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July 2003

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1. Introduction

A benchmarking of the Indian Point Nuclear Generating Station, Unit 2 (IP2) SDP Risk-Informed Inspection Notebook was conducted during a plant site visit on April 1-4, 2003. NRC staff (R. Rasmussen, W. Schmidt, and D. Overland) supported by BNL staff (M. A. Azarm) participated in this benchmarking exercise.

In preparation for the plant site visit, BNL staff reviewed the IP2 SDP notebook and examined the earlier comments that were received from the licensee during the benchmarking site visit of the IP3 (January 29-31, 2002). The Rev. 0 SDP notebook then was updated incorporating only those licensee's comments which were considered justifiable without any need for additional information. The Rev. 0 SDP notebook was also updated to reflect the current format and the generic construction rules for the SDP notebooks. The updated SDP notebook then was used to evaluate a set of hypothetical inspection findings, utilizing the plant system diagrams and information in the licensee's updated PRA.

Prior to the meeting, a copy of the site visit agenda was sent to the licensee by NRC staff (R. Rasmussen). This was followed by additional telephone calls initiated both by NRC and the licensee to further discuss the benchmarking and the site visit process.

The major activities performed during this plant site 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 model for the average maintenance case.

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.

6. Performed a benchmarking exercise using the Revision 3i SPAR model for the IP2 (by Mr. R. Buell of INEEL).

The benchmarking exercise provided insights for significant improvement to the SDP notebook. The revised SDP notebook should provide either similar or slightly more conservative significance characterization (i.e., maximum by one color) than the licensee's PRA model in about 77% (i.e., about 13.2% underestimation) of the cases analyzed. There were a total of 9 cases (5 underestimates and 4 overestimates of 2 or more colors) out of 41 cases analyzed that required detailed examinations. The underlying causes for these cases were identified and they are discussed in the next Section of this report.

The importance of this benchmarking trip was demonstrated by a significant increase in the number of matches (from 16 to 24) and a reduction in the number of overestimations (from 14 to 9). Furthermore, the benchmarking site visit resulted in better understanding of the plant PRA, its scope, and its associated assumptions which were reflected in the resulting update of the SDP notebook (to Rev. 1 from Rev. 0).

2. Summary Results from Benchmarking

The benchmarking of the IP2 included examination of risk significance of 41 hypothetical cases of inspection findings. Five cases were underestimated. These cases were related to the failures of MDAFW, EDG22, EDG fuel transfer pumps, SRVs to open, and tripping the RCPs. Four cases that were overestimated by more than one color were related to failures of 1 or 2 MSIVs to close, one RHR train, and a battery charger. The detailed results are presented in table 1. A summary of the results of the risk characterization of hypothetical inspection findings is as follows:

13.2% (5 of 41 cases)	underestimation of risk significance
10.4% (4 of 41 cases)	overestimation of risk significance by two or more orders of magnitude
13.2% (5 of 41 cases)	overestimation by one order of magnitude
63.2% (24 of 41 cases)	consistent risk significance
Excluded (3 of 41 cases)	The licensee's PRA did not explicitly model

These summary results are shown in Table 2. The following describes the reasons behind the cases where the SDP either underestimated, or overestimated the risk significance of the hypothetical inspection findings by more than one color.

Underestimated Cases:

MDAFW: The slightly higher risk significance estimated by the licensee's PRA which is not completely accounted for by the SDP notebook is from the sequences that involved loss of bus 6A and the failure of a MDAFW pump train. The failure of bus 6A was removed as an initiator because it does not cause a reactor scram. Therefore, the risk contributions from these sequences cannot explicitly be accounted for in the SDP notebook.

EDG22 and EDG fuel transfer pump: The risk significance associated with failure of EDG22 and 1/3 of EDG fuel transfer pump trains are estimated by the SDP notebook slightly below that of the plant PRA. Review of top event cutsets indicated that both models utilized consistent logics and developed similar sequences. Therefore, round off error is identified as the main cause for this underestimate.

SRV Fail To Open (FTO): The SDP notebook modeled ATWS as a mechanical failure of the scram rods with a frequency of about 1.0 E-6 (Row VI). The plant PRA models both the electrical as well as mechanical failures of RPS with a frequency that is more than one order of magnitude larger than the SDP. The PRA also requires operation of SRVs for early pressure relief for both electrical and mechanical ATWS.

Tripping RCPs : The risk significance of the operator action to trip RCPs is modeled in LNSW and LCCW initiators both in the licensee's PRA and the SDP notebook. Review of top event cutsets indicated that both models utilized consistent logics and developed similar sequences. Therefore, round off error is identified as the main cause for this underestimate.

Overestimated Cases by more than one order of magnitude:

Battery Charger for Bus D21 or D22: Failure of the battery charger is assumed to be readily diagnosed and recovered prior to causing a bus failure. The plant PRA provides a recovery credit of about 2 orders of magnitude for failure of battery charger. The SDP notebook, however, does not credit recover in the benchmarking evaluation, therefore resulting in an overestimation by two colors. In actual inspection findings, the inspector could credit the appropriate recovery action per SDP instruction for evaluation.

1 or 2 MSIVs fail to close: The closure of MSIVs are important for both MSLB and SGTR initiators. PTS is the major concern in MSLB scenarios whereas equalization and isolation of the faulted SG is the issue in SGTR. The IP2 PRA just addresses the latter issue and does not model the PTS scenarios.

1 RHR train: A loss of a RHR train with a fault exposure of one year is assigned a yellow color by the SDP notebook and a green color by the licensee's PRA. Either 1/2 RHR trains or 1/2 recirculation trains is needed for conducting the HPR function. The combined credit for both RHR and recirculation system for HPR in SDP notebook is limited to one multi-train system due to dependencies of both systems on CCW. This limited credit is about an order of magnitude lower than the estimates in PRA. The SDP notebook also indicates that a major contributor to the risk significance of one RHR train is due to failure of HPR in SLOCA scenarios similar to licensee's PRA. The SDP assigns a direct white risk significance to this scenario. The resulting yellow color in SDP is obtain by applying the SDP counting rule to combine this direct white with several lower significance sequences. In summary, two reasons could be identified for this overestimation: (1) limiting the combined credit for RHR and recirculation system to one multi-train system, and (2) the conservative nature of the counting rule used in the SDP evaluation process.

Table 1: Summary of Benchmarking Results for Indian Point Nuclear Generating Station, Unit 2

CDF without Flooding = 1.56E-5 [1] per reactor-year

Thresholds are W = 1.06, Y = 1.64, R = 7.4

Component Out of Service	SDP Worksheet Color	IP2 RAW Ratio [2]	SDP Worksheet Modified	Comparison [3]	IP2 Basic Event and Comments
MDAFW Pump	R	R (8.06)	Y	U	Removing the loss of 6A bus is the cause, failure of one pump plus the failure of the bus 6A a dominant cutset
TDAFW Pump	R	Y (5.9)	Y	M	
Accumulator	Y	Y (3.33)	Y	M	MLOCA/LLOCA
HPSI TRAIN	W	W (1.19)	Y	O1	C/R of 5G/W (Green next to White)
RHR Pump TRAIN LPI/LPR	Y	G (1.036)	Y	O2	SLOCA/MLOCA (1 Multi-Train System vs. 2 Multi-Train Systems)
One CHG Pump	G/W	G (1.025)	G	M	
CHG Pumps all	W	G (1.025)	W	O1	
EDG 22	Y	Y (3.8)	W	U	Round Off Error
EDG 23	Y	Y (4.5)	Y	M	
EDG 21	W	Y (2.1)	Y	M	

Component Out of Service	SDP Worksheet Color	IP2 RAW Ratio [2]	SDP Worksheet Modified	Comparison [3]	IP2 Basic Event and Comments
EDG Fuel Transfer pump 1/3 trains	W	W (1.33)	G	U	Round Off Error
Both Gas Turbine	G	W (1.22)	W	M	
CCW Pump Running/standby	R	W (1.18)	W	M	
IA any of three compressors	G	G (1.0)	G	M	N2 Backup for AFW/PORV, used TPCS and added a footnote in table 2 of SDP saying it is always Green
PORV FTO	R	Y (2.84)	Y	M	
SRV FTO (ATWS)	W	Y (4.7)	W	U	ATWS Electrical Contribution
PORV FTC	Y	Y (2.16)	Y	M	
Block Valve FTC	W	W (1.2)	W	M	
PCS/MITIGATION	W	W (1.07)	W	M	MF_OPERR_M01
1 MSIV fail to close	Y	G (1.016)	Y	O2	PTS Issues Not Accounted for
2 MSIVs fail to close	R	G (1.016)	R	O3	PTS Issues Not Accounted for
Isolation of the feed to that affected SG	W	Y (2.4)	Y	M	
ADVs FTO	G/W	Y (1.92)	Y	M	CCF Driven
1 containment fan cooler	NA	G (1.05)	G	M	Fcv-21: 1.04 Fcv-22: 1.04 Fcv-23: 1.06 Fcv-24: 1.06 Fcv-25: 1.09

Component Out of Service	SDP Worksheet Color	IP2 RAW Ratio [2]	SDP Worksheet Modified	Comparison [3]	IP2 Basic Event and Comments
All Containment fan coolers	NA	Y (5.63)	Y	M	All fan coolers 5.63
125V DC Panel D21/D22	R	Y (4.5)	R	O1	Only Initiator
125V DC Panel D23/D24	R	Y (3.1)	Y	M	Did LBDC and failed one MDAFW
One Battery	Y	W (1.28)	Y	O1	Assumed Battery Chargers Can Take SI Loads
Battery Charger (ONLY FOR D21/D22)	Y	G (1.0015)	Y	O2	Charger failure will be readily diagnosed and either recovered or plant will be shut down
1 NSW pump	Y	NA	W	NA	
Loss of NSW	R	R (37.35)	R	M	
RCSDEP for LPI after SLOCA/ MLOCA (DEP2)	W	W (1.25)	W	M	
Feed and Bleed	R	Y (5.6)	Y	M	
Tripping the RCP	R	Y (4.4)	W	U	Under Round Off Errors
City water to cool charging pump	Y	Y (2.45)	Y	M	
City water or primary to SI/RHR pumps	NA	Y (12.6)	Y	M	
Primary/Secondary equalization in SGTR	Y	Y (1.81)	Y	M	
MKRWST	Y	W (1.5)	Y	O1	
Emergency Boration ATWS	W	W (1.6)	W	M	

Component Out of Service	SDP Worksheet Color	IP2 RAW Ratio [2]	SDP Worksheet Modified	Comparison [3]	IP2 Basic Event and Comments
REC2	W	NA	W	NA	
REC5	Y	NA	Y	NA	

Notes:

1. IP2 Internal event, average maintenance CDF is 1.56E-5 per reactor-year.

2. IP2 RAWs for internal events, average maintenance case.

3. 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 and the associated SDP color based on the licensee's latest PRA. The colors assigned for significance characterization from using the Rev. 1 SDP worksheets after incorporation of the licensee's comments are shown in the fourth column. The results from comparison of the significance determination from modified SDP notebook and the licensee's PRA are shown in the fifth column using the following acronyms:

   M: Reflecting consistent results from both modified SDP notebook and the licensee's PRA.
   O1,O2,O3: Indicating that the modified SDP notebook has overestimated the significance determination from the licensee's PRA by one, two, or more colors.
   U: Reflecting that the modified SDP notebook has underestimated the significance determination from the licensee's PRA by at least by one color.

   Finally, some clarifying notes, specific RAW values, and the reasons for any differences recorded in the fifth column are noted in the sixth column. The basic event names are not shown in this column since IP2 is currently using the large event tree approach which sometimes requires RAW values to be estimated using model manipulations.

Table 2: Comparative Summary of the Benchmarking Results

		SDP Worksheet		SDP Worksheet Modified	
		Number of Cases	**Percentage**	**Number of Cases**	**Percentage**
SDP: Non-Conservative		5	14.3	5	13.2
SDP: Conservative by	1 order	9	25.7	5	13.2
	2 or more orders	5	14.3	4	10.4
SDP: Matched		16	45.7	24	63.2
SDP: Not Modeled		6	-----	3	---
Total		41	100	41	100

3. Proposed Revisions to Rev. 0 SDP Notebook

Based on insights gained from the plant site visit, a set of revisions is proposed for the Rev 0 SDP notebook. The proposed revisions are based on the 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 Indian Point Unit 2

The licensee provided several comments for minor revisions to the SDP Notebook. The suggested changes mainly dealt with the dependency matrix, updated footnotes associated with the worksheets, and revised HEP values. All of 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:

Table 1:

1. Added a footnote for loss of DC saying that its IE frequency is currently estimated conservatively in IP2's PRA, resulting in its assignment to Row II. It is expected to be moved to Row III consistent with IP3's PRA in the next revision to the PRA.

2. Removed loss of Bus 6A from the initiator list since it does not lead to a reactor trip.

3. Removed LEAC and added a footnote that the plant operates with the block valve closed. The block valve would open at a slightly lower pressure setpoint than PORV; however, it requires AC to open. In LEAC, the block valve cannot open due to lack of AC which would preclude SORV sequences.

Table 2:

1. Added a footnote to Electrical Power System stating that there are two sources of DC, normal and emergency, for EDGs and all loads on 480 V emergency AC. The switching is automatic between the normal and emergency when needed.

2. Changed the major components for IAS from four station air compressors to three station air compressors.

3. Added a row for containment fan coolers with major components five fans and four coolers.

4. Stated that the primary motive power for PORVs is nitrogen accumulator with nitrogen makeup as a backup.

5. Stated that the plant's internal event CDF excluding flood is 1.56E-5 per reactor-year and including flood is 2.25E-5 per reactor-year.

Table 3.1: TRANS

1. Changed CDS to PCS to ensure use of a consistent acronym.

Table 3.3: SLOCA

1. Included injection by 2/4 accumulators to the success criteria for DEPR2 in SLOCA.

Table 3.4: SORV

1. Included injection by 2/4 accumulators to the success criteria for DEPR in SORV.

2. Credited feed and bleed, and added a footnote saying that the requirement for opening of 2/2 PORVs during feed and bleed only applies for the most limiting case when all secondary heat removal is lost instantaneously right at the time of transient. The feed and bleed is credited by using 1/1 remaining PORV during SORV consistent with the plant PRA.

Table 3.5: MLOCA

1. Did not credit normal depressurization during MLOCA. Modified the event tree crediting only rapid depressurization. Removed worksheet sequences 4 and 5, and modified others as appropriate.

2. Changed the success criteria for accumulators from 3/3 to 2/3 accumulators.

3. Did not credit rapid depressurization and use of LPI when HPI is successful but accumulator injection has failed. This scenario could be potentially a success path but it has not yet been analyzed or credited by the licensee.

Table 3.6: LLOCA

1. Changed the 14 hours to 24 hours for hot leg recirculation.

Table 3.7: LOOP

1. Removed Appendix R EDG.

2. Changed the credit for REC2 from 1 to 2. Added a footnote saying that the recovery of offsite power is 0.18 and recovery of any of the gas turbines including hardware failure is about .32 at 2 hours (0.3 at five hours).

3. Maintained a credit of 2 for REC5. Added a footnote explaining that this action is not explicitly modeled in the licensee's PRA. It could be estimated based on 0.03 generic credit for recovery of offsite power, and .3 credit for recovery of power from any of the gas turbines.

Table 3.8: SGTR

1. Added injection of 2/4 accumulators to the success criteria for rapid depressurization and changed the credit from 2 to 1.

2. Modified the event tree such that it credited DEP/LPI when HPI and EQ have failed.

Table 3.9: ATWS

1. Modified the mitigation capability for emergency boration to say “with 1/2 boric acid transfer pumps or through RWST”.

Table 3.10: MSLB

1. Removed the worksheet sequence 4 per the licensee’s feedback that PTS is not an issue in the plant if EIHP has failed.

2. Added a footnote that If the break occurs downstream to MSIV but upstream to non-return check valves, then the MSIV function should also include the failure of the non-return valves. In such cases, the credit for MSIV may be raised to 5 to account for the failure of non-return check valve.

Table 3.11: LCCW

1. Modified the LCCW event tree to illustrate that once the RCPs are tripped the operator could align city water to charging pumps (for cooling) within 30 minutes to maintain RCP seal integrity.

2. Modified the LCCW event tree to illustrate that if Seal LOCA occurs, the operator could align the city water to CCW header for cooling of SI and RHR pumps. In this case, the role of fan coolers was modeled as the only means of removing the decay heat during the HPR operation.

Table 3.12: LNSW

a) Footnoted that the loss of non-essential SW is similar to that of loss of CCW with the exception that in a portion of the time the secondary components may be cooled by the ESW.

b) The worksheet and the event trees should be similar to that of LCCW without any credit for FW/PCS as a part of SHR.

Table 3.13: LBDC

1. Removed sequence 2 and modified the event tree accordingly.

Tables 3.14/3.15: Removed both loss of 480 VAC bus 6A and LEAC worksheets.

3.2 Generic Changes in IMC 0609 for Guidance to NRC Inspectors

None.

3.3 Generic Change to the SDP Notebooks

None.

4. DISCUSSION ON EXTERNAL EVENTS

The Indian Point Unit 2 plant does not currently have an integrated model for internal and external events. The Internal CDF without external events is currently 1.56E-5 per reactor-year. The flood contribution is about 6.5E-6 per reactor year. No information is currently available for other external events beyond what was reported originally in the IPEEE document which included contributions for seismic, fire, and high wind.

Attachment 1: List of Participants

Wayne Schmidt	USNRC/Region I SRA
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