April 24, 2002

NOTE TO: Cynthia Carpenter, Chief
Inspection Program Branch
Division of Inspection Program Management
Office of Nuclear Reactor Regulation

Patrick D. O'Reilly
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FROM: Mark F. Reinhart, Chief**/Signed by M. Caruso for**
Licensing Section
Probabilistic Safety Assessment Branch
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Office of Nuclear Reactor Regulation

SUBJECT: RESULTS OF THE SAINT LUCIE UNIT 1 SDP PHASE 2 NOTEBOOK BENCHMARKING VISIT

During February, 2002, NRC staff and a contractor visited the Florida Power and Light company headquarters to compare the Saint Lucie (STL) Unit 1 Significance Determination Process (SDP) Phase 2 notebook and licensee's risk model results to ensure that the SDP notebook was generally conservative. STL Unit 1's 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 STL Unit 1 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 Research.

In the review of the STL Unit 1 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 two hypothetical inspection findings were processed through the SDP notebook. Results from this effort indicated that the total risk impacts modeled in the SDP notebook were underestimated by 9 percent, overestimated by 56 percent, and adequately estimated by 34 percent. The reviewers found that if twelve fixes were made to the SDP notebook, the results would be 0 percent underestimation and 3 percent overestimation of risk impacts.

Attachment A describes the process and results of the comparison of the STL Unit 1 SDP Phase 2 Notebook and the licensee's PSA.

If you have any questions regarding this effort, please contact Peter Wilson.

Attachments: As stated

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# SUMMARY REPORT ON BENCHMARKING TRIP

# to the St. Lucie Nuclear Power Plant, Unit 1

# (February 25-27, 2002)

**PRANAB K. SAMANTA**

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

**March 2002**

Attachment A

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# 1. Introduction

A benchmarking of the Risk-Informed Inspection Notebook for St. Lucie, Unit 1 was conducted during a plant site visit on February 25-27, 2002. NRC staff (R. Bernhard, W. Rogers and P. Wilson) and BNL staff (P. Samanta and G. Martinez-Guridi) participated in this Benchmarking exercise.

In preparation for the meeting, BNL staff reviewed the SDP notebook for St. Lucie Unit 1 and evaluated a set of hypothetical inspection findings using the Rev. 0 SDP worksheets. In addition, a copy of the meeting protocol was sent to the licensee by P. Wilson of the NRC prior to the meeting.

The major milestones achieved during this meeting were as follows:

1) Licensee's comments on the Rev. 0 SDP notebook were discussed and applicable modifications are considered in the benchmarking exercise.

2) Importance measures including the Risk Achievement Worths (RAWs) for the basic events in the internal event model for average maintenance was obtained from the licensee.

3. Benchmarking was conducted using the Rev. 0 SDP model and the revised SDP model considering the licensee inputs 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 St. Lucie Unit 1 notebook as a result of the benchmarking exercise, it is observed that no underestimation is present for the hypothetical cases studied. Only in 1 out of 32 cases, a conservative result by one color, i.e., by one order of magnitude, is observed. This is a significant improvement compared to the Rev. 0 version where some underestimates and a relatively large number of conservative results were obtained. In addition, the benchmarking exercise identified a difference in assumption between PRA and SDP notebook modeling which contributes to differences in results. This aspect will be explained in the notebook for consideration by the user of the notebook.

## 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 generated 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 and plant PRA colors.

Table 2 presents a summary of the comparisons between the results obtained using the St. Lucie, Unit 1 Notebook and the plant PRA. The results show that in 1 out of 32 cases, the notebook provides a “color” that is conservative by one order of magnitude. In the remaining 31 cases, the results match, i.e., both determine the same color.

One difference in plant modeling compared to the modeling in the SDP notebook was noted during the benchmarking. This resulted in different colors between plant PRA results and SDP notebook. But, the same color would have been obtained if the same modeling assumption would have been used. We considered those cases to have provided a match, since the same color is obtained when the same assumption is used. This applies to cases involving PORVs (both for findings on PORVs and operator failure to conduct feed and bleed), MSIVs, and operator failure to isolate the feed to the SG. In the plant PRA, it is assumed that following failure of both the MSIVs to close, core damage is avoided if feed and bleed, i.e., once-through cooling, is successful. In the SDP notebook, it is assumed that core damage will ensue when both the MSIVs fail to close. This difference in assumption results in lower importance for the MSIVs and the operator failure to isolate the feed to the SG in the plant PRA. Also, higher importance is obtained for the PORVs and the operator failure to conduct feed and bleed, i.e., once-through cooling. The assumption in the notebook is consistently made for all the Combustion Engineering (CE) and is not changed. Justification of this assumption is expected to be taken into consideration in the detailed analysis.

For the LPI train with SDC HX, notebook result is conservative by one color. This is because of the conservative approach used in approximating the impact in situations where the system redundancy is not affected by the inspection finding. Here, the delta change is approximated by counting the basecase rating of the affected sequences. In addition, sequences with ratings up to 9 was counted. Counting up to 8 would have resulted in a match for this case.

## Table 1. Comparison Table for St. Lucie, Unit 1 Benchmarking

**CDF = 1.99E-05/yr, W = 1.05 (RAW), Y = 1.5 (RAW), R = 6.03(RAW)**

| Basic Event Name | SDP Before | RAW | Plant CDF Color | SDP After | Comments |
|---|---|---|---|---|---|
| MD AFW Pump train | R | 2.61 | Y | Y | Match. |
| TD AFW Pump train | R | 2.99 | Y | Y | Match. (By counting rule; including all 8's) |
| HPSI Pump | R | 4.22 | Y | Y | Match (By counting rule; including all 8's) |
| 1 CSS train | W | 1.0 | G | G | Match |
| 1 Fan Cooler Unit | W | 1.0 | G | G | Match |
| 1 CCW pump | R | 2.68 | Y | Y | Match. A recovery credit of 1 for the spare pump was used. |
| CCW Swing Pump | W | 1.0 | G | G | Match |
| 1 Charging Pump | G | 1.0 | G | G | Match |
| 1 Condensate Pump | G | 1.0 | G | G | Match |
| 1 Feedwater Pump | G | 1.0 | G | G | Match |
| 1 EDG | R | 1.35 | W | W | Match |

| Basic Event Name | Before | RAW | Plant CDF Color | After | Comments |
|---|---|---|---|---|---|
| Both Dedicated EDGs | R | 6.38 | R | R | Match |
| 1 IA Compressor | W | 1.0 | G | G | Match |
| 1 ICW train | R | 2.68 | Y | Y | Match |
| 1 PORV | R | 11.8 | R | Y | Plant credits once-through cooling when both MSIVs fail to close. This results in higher risk-significance for the PORVs. Similar assumption in the notebooks will result in a match. |
| 2 PORVs | R | 13.1 | R | Y | Plant credits once-through cooling when both MSIVs fail to close. This results in higher risk-significance for the PORVs. Similar assumption in the notebooks will result in a match. |
| 1 TCW Train | G | 1.1 | G | G | Match |
| 1 MSIV | Y | 1.0 | G | Y | Plant credits once-through cooling when both MSIVs fail to close. If similar assumption is made, the results will match. |
| 1 SIT | G | 3.2 | Y | Y | Match |
| 1 LPSI train with HX | W | 1.025 | G | W | Conservative by one color. |
| 1 LPSI pump | W | 1.19 | W | W | Match |

| Basic Event Name | Before | RAW | Plant CDF Color | After | Comments |
|---|---|---|---|---|---|
| 1 AC Bus | R | 31.86 | R | R | Match |
| 1 DC Bus | R | 92.42 | R | R | Match. Battery charger does not have capacity to carry SI loads |
| Both MSIVs | R | 1.72 | Y | R | Plant credits once-through cooling when both MSIVs fail to close. If similar assumption is made, the results will match. |

| Basic Event Name | Before | RAW | Plant CDF Color | After | Comments |
|---|---|---|---|---|---|
| **Operator Actions** | | | | | |
| Operator failure to feed and bleed | R | 13.1 | R | Y | Plant credits once-through cooling when both MSIVs fail to close. This results in higher risk-significance for the PORVs. Similar assumption in the notebooks will result in a match. |
| Operator failure to initiate SDC | Y | 1.23 | W | W | Match |
| Operator trips RCP to prevent seal LOCA | R | 454.27 | R | R | Match |
| Operator to start MFW following trip | G | 1.26 | W | W | Match |
| Operator fails to close the block valve associated with open PORV | Y | 1.1 | W | W | Match |
| Operator fails to initiate AFW makeup | R | 1.24 | W | W | Match |
| Failure to borate in ATWS | W | 1.31 | W | W | Match. |

| Basic Event Name | Before | RAW | Plant CDF Color | After | Comments |
|---|---|---|---|---|---|
| **Operator Actions** | | | | | |
| Failure to isolate feed to the affected SG | R | 1.14 | W | R | Plant credits once-through cooling in case of failure to isolate SG. If similar assumption is made, the results will match. |

## Table 2: Comparative Summary of the Benchmarking Results

| Comparisons | Rev. 0 SDP Notebook | | Following Benchmarking | |
|---|---|---|---|---|
| | Total Number of Cases Compared = 32 | | | |
| | Number of Cases | Percentage | Number of Cases | Percentage |
| SDP: Less Conservative | 3 | 9 | 0 | 0 |
| SDP: More Conservative | 18 | 56 | 1 | 3 |
| SDP: Matched | 11 | 34 | 31 | 97 |

# 3. Proposed Modifications to Rev 0 SDP Notebook

A set of modifications were proposed for the Rev. 0 SDP notebook as a result of the site visit. These proposed modifications are driven by the licensee's comments on the Rev. 0 SDP notebook, better understanding of the current plant design features, allowance for additional recovery actions, revised Human Error Probabilities (HEPs), modified initiator frequencies, and the results of benchmarking.

## 3.1 Specific Changes to the Rev. 0 SDP Notebook for St. Lucie, Unit 1

The licensee provided comments in the Rev. 0 SDP notebook, most of these comments clarify the detail design, procedure, and operational features in the plant and they will be incorporated in the next revision of the SDP. The following comments were considered to be important for the Benchmarking exercise and were considered for color determination.

1. Loss of a DC Bus frequency was changed to 5E-04/yr resulting in its placement in Row IV from Row III.

2. In TRANS, TPCS, SGTR, MSLB, and LIA worksheets and event trees, the success criteria for feed and bleed cooling following failure of Long Term AFW Makeup and Shutdown Cooling is 1/2 PORVs. The success criteria for feed and bleed following AFW failure remains at 2/2 PORVs.

3. The full creditable mitigation capability for Containment Heat Removal (CHR) is revised to " 2/4 fan coolers or 1/2 containment spray trains with SDC heat exchangers" in all applicable worksheets.

4. Recovery of PCS is credited in the SLOCA worksheet. An operator action credit of 1 is assigned. The associated HEP is 0.35.

5. The success criteria for safety injection tanks (SIT) in the LLOCA worksheet is revised to 3/3 unaffected SITs.

6. Capability to cross-tie other unit EDG is credited with an operator action credit of 1. The associated HEP is 1.1E-2 and the equipment unavailability is 5E-02.

7. In the SGTR worksheet, SDC2 is redefined to exclude the need for HPSI trains. The event tree is modified and the previously defined HPSI function is used. Also, two separate HPR functions are defined with and without the need for long term RCS makeup and isolation of the faulted SG.

8. In the MSLB worksheet, the isolation of feed to the faulted SG (ISOF) is redefined to exclude "closure of 2/2 MSIVs (1 train)".

9. In the LDCBUS worksheet, the function "Bus Transfer (TRANSF)" is eliminated and the need for long term AFW makeup is removed from the SDC function.

10. In the LDCBUS worksheet, the full mitigation capability for CHR function is revised to “2/2 fan coolers or 1/1 containment spray train (1 multi-train system)”.

11. In the LIA worksheet, SDC is credited with an operator action=2 assuming local action in opening the SDC heat exchanger valve.

12. LOOP with one EDG available (LOOP1EDG) worksheet is deleted.

### 3.2 Generic Change in 0609 for Inspectors

Two issues can be identified for consideration in the Inspection Manual 0609

1. In evaluating inspection finding for both unit EDGs where only crosstie capability to the other unit EDG remains, all LOOP sequences may need to be evaluated. It is assumed that the crosstie would enable use of 1 bus, thus the non-SBO sequences will have reduced mitigation capability contributing to the delta CDF.

2. As noted, for LPSI train including the HX, the notebook gives a conservative estimate. Counting sequences up to the rating of 8 will result in a match. For situations where system redundancy is not lost, i.e., credits are not affected, counting up to 8 should be sufficient.

### 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 St. Lucie, Unit 1 plant. No evaluation was conducted for the external event risk during the benchmarking exercise.

# 5. List of Participants

| | |
|---|---|
| Peter Wilson | USNRC - NRR |
| Walter Rogers | USNRC - Region II |
| Rudolph Bernhard | USNRC - Region II |
| | |
| Pranab Samanta | BNL |
| Gerardo Martinez-Guridi | BNL |