April 28, 2002

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FROM: Mark F. Reinhart, Chief**/Signed by M. Caruso for**
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SUBJECT: RESULTS OF THE COLUMBIA GENERATING STATION SDP PHASE 2 NOTEBOOK BENCHMARKING VISIT

During December, 2001, NRC staff and a contractor visited the Columbia Generating Station (CGS) to compare the CGS Significance Determination Process (SDP) Phase 2 notebook and licensee's risk model results to ensure that the SDP notebook was generally conservative. CGS'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 CGS were also compared with the licensee's risk model. The results of the SPAR model benchmarking effort will be documented in a separate trip report to be prepared by the Office of Research.

In the review of the CGS SDP notebook, it was found that some changes to the SDP worksheets were needed to reflect how the plant is currently designed and operated. Forty 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 18 percent, overestimated by 40 percent, and adequately estimated by 42 percent. The reviewers found that if thirteen fixes were made to the SDP notebook, the results would be 10 percent underestimation and 42 percent overestimation of risk impacts.

Attachment A describes the process and results of the comparison of the CGS 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

Columbia Nuclear Power Plant Unit 1 (December 11-13, 2001)

J. C. Higgins

Energy Sciences and Technology Department
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December 2001

Attachment A

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1. Introduction

This report compares the NRC Risk Informed Inspection Notebook, developed by BNL, and the licensee risk model for the CGS NPP to ensure that the Notebook is generally conservative. The benchmarking was performed after the worksheets were revised to include the appropriate licensee comments and recommendations.

2. Preparation for Benchmarking

The Columbia inspection notebook was originally prepared in August, 2001. The Columbia notebook was reviewed prior to this benchmarking visit in order to identify potential changes that may be needed. A few changes were made (Section 2.1) and some areas were identified for clarification onsite (Section 2.2). Some other areas were identified for changes that will be made in Revision 1 of the notebook.

2.1 Main Changes to Notebook Prior to Onsite Visit

- Dropped credit for LDEP from LOSW worksheet since it is lost on LOSW and added clarifying note.

- Changed CV line on Table 2, last column, to indicate not to consider LOSW worksheet.

2.2 Questions for Site

a. What is the total PRA IE frequency for those transients that involve a loss of PCS?

b. Provide a discussion of the current containment venting arrangement, paths, valves, and support systems. What is the PRA HEP for operators fail to vent?

c. What is affected by a finding in the CSTS: PCS, RCIC, HPCS, LPCI? May need to adjust Table 2 for CSTS. Now has "all."

d. CAS affects PCS, CIA, CSTS, & CV. How significantly does a finding in CAS affect these systems? Revisit Table for CAS re the CSTS and CV dependency. Note that just CV would give a Yellow.

e. CIA affects PCS and SRVs. The SRV dependency would give W_{bcr}. Probably OK but may be too conservative. Check with licensee.

f. Does loss of a single SW pump (A or B) cause a loss of LPCI, RHR, LPCS EDG, RBEC or is there a cross connect?

g. What support does RCC provide to PCS? What is the effect of loss of RCC? Clarify this in Table 2. Table now shows no system with RCC as support.

h. Need to clarify the impact of loss of RBEC and update note 16 of Table 2.

The licensee provided answers to all the above questions during the site visit.

2.3 Proposed Changes to Worksheets

- Add notes to Table 2 for RHR pumps A, B, & C, and for RCC.

3. Summary Results from Benchmarking

The onsite visit was conducted by a BNL representative, an NRC headquarters PRA representative and the Region IV SRA. We met with the Columbia PRA staff for two and one half days onsite to perform the benchmarking activities.

The initial activities included reviewing with the licensee the updates made to the CGS notebook as described in Section 2.1 above, and provided an updated copy of the Notebook to CGS. We then provided CGS with the questions in Section 2.2. CGS researched the related information and provided answers to the team. CGS also gave the team a few added comments to the Notebook, which were valuable and improved the notebook. These were incorporated before beginning the benchmarking activities. Notable changes made, based on the licensee's comments and justifications, were:

Adjustment of the initiating event (IE) frequencies to those currently used in the CGS PSA and revision of Table 1 to agree with the new IE frequencies.

1. A few minor changes to Table 2.

2. Added credit to all worksheets for LDEP after successful HPCS and failure of CHR and CV.

3. On all worksheets, removed the necessity for LDEP after successful RCIC, failure of CHR and successful CV on several worksheets.

4. Changed the DEP mitigating equipment for DEP from 3/7 ADS valves to 3/18 SRVs.

5. Added Late Injection (LI) to the MLOCA worksheet and ET.

6. Changed the credit for DC load shed from 3 to 2.

7. Dropped the need to open the doors to the RCIC room for ventilation on an SBO.

8. Added a separate worksheet for LOOP with failure of one EDG.

9. Added credit for PCS on LODC1 and LODC2 worksheets.

10. Added a worksheet for loss of the control and service air (CAS) system.

11. Obtained the current detailed system description information on the CV, CAS, and CJW systems and incorporated this into the notebook.

The licensee provided updated information to the team based on the CGS PSA, Rev. 4.2, dated 6/22/01. This was supplemented by additional PSA information provided in response to team questions throughout the visit. Information included: definition of basic events, cutsets, RAW values, system design information, analysis assumptions and results, and event trees.

The team computed the break points in RAW values for the different SDP colors based upon a current PSA total internal events CDF of 2.25 E-5 events/reactor-year. The team had pre-selected a fairly large list of components and human actions, as listed in Table 1 below, that would be evaluated for the effect of having the component or human action fail. Prior to the site visit, the team developed the color corresponding to failure of each item. This list of items was modified slightly onsite. We then used the latest revised version of the notebook to develop the color corresponding to failure of each item and compared that to the color that would be implied by the items RAW value from the PSA.

In developing the colors from the notebooks, the team evaluated all sequences in each worksheet that contained the item (component or human action). A number was obtained for each re-evaluated sequence. We then used a "counting rule" to cascade lower value sequences to higher value ones as follows. For example, three sequences of value 8 (shorthand for an estimated sequence frequency of 1 E-8 events/reactor-year) were equivalent to one sequence of value 7. Likewise 3 sequences of value 7 (3-7s) were equivalent 1 sequence of value 6(1-6). Also, 3-6s were equal to 1-5, and so on. Colors were developed as follows:

Sequences of value 7, 8, and higher	Green
Sequences of value 6	White
Sequences of value 5	Yellow
Sequences of value 4 or less	Red

When the above described counting rule was needed to obtain a color rather than a direct correlation from a sequence, then in Table 1 we note that it was obtained "by the counting rule" or "bcr."

Table 2 provides a summary of the benchmarking results. The team's initial quantification of the Notebook had seven non-conservative items and 16 that were more conservative than the colors that were based on the RAW values from the licensee's PSA. The team's final quantification of the Notebook had four non-conservative items and 19 that were more conservative than the colors that were based on the RAW values from the licensee's PSA.

For two of the non-conservative findings (LPCS and 1 SRV fail to close) the team found that their importance in the licensee's model comes from internal flooding sequences. When the contribution from internal flooding is removed, then we obtain a match between the notebook and the plant PSA. More specifically, we examined the dominant cutsets containing LPCS components and SRV (FTC) and found that they were all flooding initiators that flooded ECCS equipment rooms, areas R404 & R 405. This resulted in failure of: condensate, FW, recirculation pumps, CAS, RHR A, and HPCS. It also caused turbine trip/reactor trip. When this is combined with a stuck open SRV, one can see the increase in the importance of LPCS and SRV (FTC). We have noted this in Table 2 of the Notebook.

BNL notes that this was the second BWR-5/6 plant that has had a benchmarking visit and several useful Columbia plant systems and PSA insights were obtained from the licensee. After the first BWR-6 visit to Perry, it was recommended that, a benchmarking trip should be performed at another BWR-5/6 in order to consolidate the insights and enable the production of improved SDP notebooks for all BWR-5 and 6 plants.

Table 1: Comparison of Component Sensitivity Calculations between Phase 2 Worksheets and Columbia RAWs
(CDF = 2.25 E-5; RAW splits - 1.04, 1.44, 5.44)
Truncation level 1 E-10

Item Out of Service Component	SDP Work-sheet Color	Columbia Basic Event	Colum. RAW[1] ratio	Color by Colum RAW[1]	Mod. SDP Worksheet Color	Comments
HPCS	R_{bcr}	HPSP-MD-1R2LL	5.2	Y	R_{bcr}	conserv.
EDG-3	Y	EACENG-EDG3-W2D3	3.3	Y	Y	
RCIC	W	RCIP-TD-1R2LL	3.13	Y	Y	
1 SRV fto	W_{bcr}		1	G	W	conserv.
2 SRVs fto (OVERPR)	Y	MC	1.18	W	Y	conserv
1 SRV ftc	G		2.15	Y	G	non-conserv note 1
LPCS	G	LPSP-MD-1R2LL	1.6	Y	G	non-conserv. note 1
RHR- pump A	R	RHRPMD-2AR2LL	11	R	R_{bcr}	
RHR-pump B	R	RHRPMD-2BR2LL	14	R	R_{bcr}	
RHR-pump C	G	RHRPMD-2CR2LL	1	G	G	
RHR HX	R		2.94	Y	R	conserv
1 CV valve	Y		1.03	G	W	conserv
One SLC pump	Y	SLC-PMD 1AR2XX	1.18	W	Y	conserv

Item Out of Service Component	SDP Work-sheet Color	Columbia Basic Event	Colum. RAW[1] ratio	Color by Colum RAW[1]	Mod. SDP Worksheet Color	Comments
EDG 1 or 2	Y	EACENG-EDG2-W2D2 (or 1)	4	Y	Y	note 6
4160 AC Div. 1	R		~760	R	R	
4160 AC Div. 2	R		~4000	R	R	
CIA item	W_{bcr}	SRV	1	G	W	conserv.
CAS item	---	1 CAS compressor	1.1	W	Y	conserv.
TSW item	Y	1 TSW train	1.4	W	Y	conserv.
One DW-SP vacuum breaker	W	note 8	—	—	Y	
drywell floor seal	R	'D'	111	R	R	note 8
DC-Div 1	R		42	R	R	
DC-Div 2	R		40	R	R	
DC Battery A	R	EDCB1-EB1-1W2D1	4.53	Y	R	conserv.
DC Battery B	R	EDCB1-EB1-2W2D1	2.83	Y	R	conserv.
DC charger A	R	EDCC1-EC1-1W1D1	--	--	R	
DC charger B	R	EDCC1-EC1-2W1D1	4.92	Y	R	conserv.
SW A	R		19	R	R	
SW B	R		36	R	R	
PCS	Y/G		11.6	R	Y	non-conserv. see note

Item Out of Service Component	SDP Work-sheet Color	Columbia Basic Event	Colum. RAW[1] ratio	Color by Colum RAW[1]	Mod. SDP Worksheet Color	Comments
RPT-1 train	G		--	--	G	
RPT-both trains	Y		1.13	W	Y	conserv.
all of CJW	--		13.9	R	Y	non-conserv. - note 9
Operator Actions						
DEP	R	ADSHUMNSTARTH3LT (non ATWS)	97.5	R	R	
SW cross-tie	W	RHRHUMNSWCRTIELL	2.16	Y	Y	
SLC	Y		1.14	W	Y	conserv.
CV	R	VENTFAIL	1.21	W	Y	conserv.
RLOOP3H	G	NRAC3	1	G	G	
RLOOP6H	G	NRAC6	1.72	Y	Y	
RLOOP24H	Y	NRAC24	2.27	Y	R	conserv.
DC load shed	G	RCIHUMN-LOADSHED	1.2	W	W	
INH/LC	Y	AI	1.07	W	Y	conserv.
RHR SP cooling	R	RHRHUMNSPCOOLLL	64.4	R	R	

Notes:

1. LPCS and one SRV (fail to close) were non-conservative. The cutsets were examined and the full non-conservatism was due to internal flooding sequences that are not addressed in the current notebooks.

2. Columbia RAW for internal events, average maintenance case.

3. The Delta CDF used in RAW value calculations represented the change in CDF due to the component being out of service for 1 year.

4. The subscript bcr means “by counting rule.”

5. For a component such as a pump, we examined the RAW values for the basic events both for “failure to start” and “failure to run,” and either selected the highest (more conservative) value here, or used a synthesized RAW value separated calculated by the licensee that included all failure modes.

6. For those items where the basic event column is blank either we were unable to identify a PSA modeled basic event that was equivalent or the licensee used a synthesized RAW value separated calculated that included all failure modes.

7. Regarding the evaluation of EDG Div. 1 and 2, we used newly developed SBO and LOOP/EDG worksheets. Then for the SBO worksheet we increased the SBO initiating event frequency by two orders of magnitude for the evaluation and failing any components affected by loss of the EDG.

8. For PCS, if we assume a total loss, then the color is Y, but if we just assume a degradation and reduce credit from 3 to 2, then we get a G. Further the licensee provided the team with a best estimate RAW value for PCS, but noted that they do not model PCS per se. Rather, as with most other sites, they have a much more detailed model. Also they take considerable credit for recovery of PCS components, which increases the overall importance of PCS.

9. Both the CGS PSA and the notebook model early containment control (EC) success as “Passive operation of SP: 1 of 2 vacuum breakers in 9 of 9 lines remain closed and drywell floor seal intact.” The PSA uses a fault tree to model the 18 vacuum breakers and combines this with seal reliability estimates to obtain one event (D) with one failure probability number used in the PSA. Thus with their PSA model they cannot easily obtain a RAW for one vacuum breaker, but they can obtain a RAW for the ‘D’ function. Also the Yellow for one vacuum breaker in the notebook is somewhat conservative, since it assumes that the next failure is in the same line as the one with the inspection finding.

10. Loss of CJW (jacket cooling water system) will fail 3 of 4 air compressors of the CAS system.

11. We were not able to obtain RAW values for three items (one DW-SP vacuum breaker, DC charger A, and one train of RPT). Thus, these items are in Table 1 but are not included in the summary of Table 2.

Table 2: Comparative Summary of the Benchmarking Results

	SDP Worksheet		SDP Worksheet Modified	
	Number of Cases	**Percentage**	**Number of Cases**	**Percentage**
SDP: Less Conservative	7	18	4	10
SDP: More Conservative	15	40	17	42
SDP: Matched	16	42	19	48
Total	38	100	40	100

4. Additional Proposed Modifications to SDP Worksheets

4.1 Specific Changes to the Rev 0 SDP Worksheet for CGS

A number of changes were made to the CGS worksheet. Ones made before the onsite visit are noted is Section 2 above. A number of additional changes, made during and after the plant onsite visit, are summarized in Section 3 above and are contained in the updated notebook. This update has been supplied in draft form to the NRC Region III Senior Reactor Analyst.

4.2 Generic Change in 0609 for Inspectors

Some comments on the 0609 usage rules were provided to the Region IV SRA for forwarding on to NRR as part of the 0609 comment process.

4.3 Generic Change to the SDP Worksheet

None.

5. Discussion on External Events

As analyzed by the licensee's updated PSA models, the core damage frequency estimates for internal initiators was 2.25 E-5 events/reactor-year. Columbia does not have an integrated external event PSA. The licensee noted that their IPEEE study for fire, floods, and seismic events does not have sufficient information to provide insights to potential changes in color evaluation based on consideration of external events.

6. Persons Participating

NRC:

Pete Wilson
Troy Pruett

BNL:

Jim Higgins

INEEL:

Bob Buell

Columbia NPP:

Albert Chiang
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7. References

Columbia PSA, Rev. 4.2, dated 6/22/01.