August 28, 2003

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SUBJECT: RESULTS OF THE KEWAUNEE SDP PHASE 2 NOTEBOOK BENCHMARKING VISIT

During July 2003, NRC staff and contractors visited the Kewaunee Nuclear Power Plant (KNPP) in Kewaunee, Wisconsin to compare the KNPP 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 risk assessment's (PRA's) internal event core damage frequency was 5.43E-5/reactor-year excluding internal flood events and inter-system loss of coolant accidents. The KNPP PRA did include an integrated PRA model with some external initiating events (i.e. fire initiators). Therefore sensitivity studies were performed to determine any impact of fire 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 KNPP 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 KNPP SDP notebook for the benchmark efforts, the team determined that some changes to the SDP notebook were needed to reflect how the KNPP is currently designed and operated. Thirty seven hypothetical inspection findings were processed through the SDP notebook and compared with the licensee's related importance measures. Using the revision 0 SDP notebook, the team determined that 31 percent of the cases were less conservative, 26 percent of the cases were more conservative, and 43 percent of the cases were consistent with the licensee's results. Of the conservative cases, 3 cases were two colors greater than the results obtained using the licensee's model. Consequently, 24 changes were made to the SDP notebook.

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Using the revised SDP notebook, the team determined that 8 percent of the cases were less conservative, 32 percent of the cases were more conservative, and 60 percent of the cases were consistent with the licensee's results. Of the conservative cases, all but 4 cases were one order of magnitude greater than the results obtained with the licensee's model and as such were generally consistent with the expectation that the notebooks should be slightly conservative when compared with the licensee's model.

Although the SDP notebook does not include external initiators, the team compared the SDP results against the licensee's PRA model including internal floods and internal fire. Eight cases in the benchmark target-set would increase in importance by one order of magnitude using the licensee's model. Of the eight cases, the notebook would under-estimate five cases. Those cases were unavailability of:

- motor-driven auxiliary feedwater pump 'A'
- an emergency diesel generator
- an instrument air compressor
- battery BRA-101
- a component cooling water heat exchanger

The licensee's PRA staff had substantial knowledge of both the Kewaunee PRA 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 KNPP SDP Phase 2 Notebook and the licensee's PRA.

Attachment: As stated

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SUMMARY REPORT ON BENCHMARKING TRIP TO KEWAUNEE NUCLEAR POWER PLANT

(July 15-17, 2003)

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August 2003

ATTACHMENT A

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1. INTRODUCTION

A Benchmarking of the Risk-Informed Inspection Notebook for the Kewaunee Nuclear Power Plant was conducted during a plant site visit on July 15-17, 2003. NRC staff (S. Burgess, M. Franovich, R. Perch, and M. Tschiltz) and BNL staff (P. Samanta) participated in this Benchmarking exercise.

In preparation for the meeting, BNL staff reviewed the SDP notebook for the Kewaunee Nuclear Power Plant and evaluated a set of hypothetical inspection findings using the Rev. 0 SDP worksheets. In addition, NRC staff provided the licensee with a copy of the meeting protocol.

The major milestones achieved during this meeting were as follows:

1. Recent modifications made to the Kewaunee Nuclear Power Plant PRA were discussed for consideration in the Kewaunee SDP Rev. 1 model to be prepared following benchmarking.

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

3. Benchmarking was conducted using the Rev. 0 SDP model and the revised SDP model considering the licensee’s input 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 the color generated by the updated licensee’s PRA RAW values, a judgment about the difference was made based on the detailed base case results available for the plant. Minimal cutsets evaluating the impact of the hypothetical inspection findings were reviewed to identify the reasons for the differences.

5. RAWs for the hypothetical inspection findings were also obtained using the model that included internal fire and flooding scenarios. RAWs from the internal event model and the model including fire and flooding were compared to note if the inclusion of fire and flooding resulted in an order of magnitude difference in the risk significance, i.e., whether the inclusion of fire and flooding would change the significance of the inspection finding.

The Rev. 1 version of the Kewaunee Nuclear Power Plant SDP notebook was prepared based on the revised plant PRA and lessons learned from the benchmarking at the site.

2. SUMMARY RESULTS FROM BENCHMARKING

Summary of Benchmarking Results

Benchmarking of the SDP notebook for the Kewaunee Nuclear Power Plant (KNPP) was conducted comparing the order-of-magnitude results obtained using the notebook with that obtained using the plant-specific PRA. Cases for which the SDP notebook results were underestimated or overestimated were identified. Two cases of a conservative result by three orders of magnitude (i.e., the significance obtained using the notebook was three colors higher than that obtained using the plant PRA), two cases of conservative results by two orders of magnitude, and eight cases of conservative results by one order of magnitude were noted. In addition, three cases of underestimation by one order of magnitude were noted. A summary of the results of the risk characterization of hypothetical inspection findings was as follows:

8% (3 of 37 cases)	underestimation of risk significance
5% (2 of 37 cases)	overestimation of risk significance by three orders of magnitude
5% (2 of 37 cases)	overestimation of risk significance by two orders of magnitude
22% (8 of 37 cases)	overestimation by one order of magnitude
60% (22 of 37 cases)	consistent risk significance.

Detailed results of Benchmarking are summarized in Table 1. Table 1 consists of eight columns. The first two columns identify the components/failed operator actions or the cases used for benchmarking. The assigned colors from the Rev. 0 SDP worksheets without incorporating any modification from the Benchmarking exercise are shown in the third column. The fourth column gives the basic event name in the plant PRA used to obtain the risk achievement worth (RAW) for the out-of-service component or the failed operator action. The fifth and sixth columns respectively show the licensee's internal RAW value and the color to be defined based on the RAW values from the latest PRA model. The seventh column presents the colors for the inspection findings based on the Rev. 1 version of the notebook. The Rev. 1 version of the notebook was prepared considering the revisions to the Rev. 0 version of the SDP notebook judged applicable following Benchmarking. The last column provides comments identifying the difference in results between the Rev. 1 SDP notebook and the plant PRA.

Table 2 presents a summary of the comparisons between the results obtained using the KNPP notebook and the plant PRA. It also shows a comparison of the results using the Rev. 0 and Rev. 1 versions of the notebook. The results show that in approximately 82% of cases the risk significance obtained using the Rev. 1 version of the notebook was either comparable or conservative within one order of magnitude compared to the plant PRA. The remaining 18% cases include underestimation by one order of magnitude or overestimation by more than one order of magnitude. These differences result from differences in modeling assumptions and differences in the unavailability used in the plant PRA and the generic mitigation credit used in the notebooks. The reasons for the differences are discussed further below. The results also show that benchmarking significantly improved the notebook reducing the underestimations and improving the consistency (or matches) in the results. The underestimation was reduced from 31% to 8% and the matches increased from 43% to 60%.

Kewaunee PRA Modeling and Assumptions

In comparing the risk significance of hypothetical inspection findings using the Rev. 1 notebook and the results of the plant PRA, some differences were noted between these models. The major factors that contributed to the differences in risk significance are summarized here.

1. Common-cause failure of Auxiliary Feedwater Pumps

   The Kewaunee PRA models a common-cause failure of all three of the auxiliary feedwater (AFW) pumps. Two of the pumps were motor-driven and the third pump was turbine-driven. In the notebook, a common-cause failure was assumed for the motor-driven pumps with a credit of "1 multi-train system" for both motor-driven pumps. In addition, a credit of "1 ASD train" was assigned for the turbine driven pump. The combined mitigation credit for the AFW function was 4. In the Kewaunee PRA, the common-cause failure probability of all three AFW pumps was approximately 3E-3. This resulted in an order of magnitude difference in credit for AFW pumps contributing to differences in risk significance between the notebook and the plant PRA.

2. Modeling Shutdown Cooling (SDC) in SLOCA

   The Kewaunee PRA assumed successful termination of a small LOCA following success of auxiliary feedwater (AFW), high pressure injection (HPI), and RCS cooldown and depressurization (RCSDEP). The implicit assumption was that the SDC mode will be initiated at some time. In the notebook, it was assumed that low pressure recirculation will be needed. This assumption difference also contributed to the difference in risk significance relating to operator actions and equipment involved in low pressure recirculation.

Discussion of Non-conservative Results or Underestimations by the Notebook

Three cases of underestimation or non-conservative results were noted during the Benchmarking. They relate to the TDAFW pump, TSC diesel, and operator failure to initiate feed and bleed (FB). The reasons for these underestimations are discussed below:

1. A dominant contributor for the TDAFW pump failure involves the loss of offsite power (LOOP) initiator. This scenario involves station blackout (LOOP followed by the loss of the EDGs), loss of the TDAFW, and the failure to recover offsite power within 2 hours. Differences in credit for these functions between the notebook and the plant PRA results in the underestimation. The LOOP frequency was 3.39E-2 (the notebook approximation was 1E-2), the common-cause failure probability of the EDGs was 3.01E-3 (the notebook credit corresponds to 1E-3), and the failure to recover offsite power has a probability of 3.38E-1 (the notebook credit corresponds to 1E-1). The combination of these differences result in an order of magnitude underestimation.

1. TSC diesel was underestimated because of reasons similar to that for the TDAFW pump, as discussed above. The dominant contributor involves the LOOP initiator followed by the common-cause failure of the EDGs, failure of the TSC diesel, and failure to recover offsite power within 6 hours. The difference in LOOP frequency, EDG common-cause failure probability, and the probability to recover offsite power results in an order of magnitude underestimation.

2. The risk significance of the operator failing to conduct feed and bleed was underestimated because of the difference in modeling common-cause failure of AFW pumps. As discussed earlier, because of the difference in modeling common-cause failure of AFW pumps, there was an order of magnitude difference in credit for the AFW pumps. Operators would perform primary feed and bleed following failure of the AFW pumps, and the order of magnitude difference in the credit resulted in the underestimation.

Discussion of Conservative Results by the Notebook

Twelve cases of overestimation (two cases by three colors, two cases by two colors, and eight cases by one color) were noted during Benchmarking. The reasons for these overestimations primarily relate to the differences in assumptions between the notebook and the plant PRA, differences in the PRA input data and the notebook generic credits, and the screening approach used in SDP evaluations.

An overestimation by three colors was noted for a battery charger and the operator failure to conduct low pressure recirculation (LPR). The reasons for these three orders of magnitude overestimations are discussed below.

1. In evaluating the risk significance of a battery charger using the notebook, it was assumed that the battery charger failure will lead to failure of the corresponding DC bus. At the Kewaunee plant, there was a swing charger which can be aligned but was not credited in the PRA. However, there was a procedure for aligning the charger and it was expected to be aligned within 8 hours. The failure of the DC bus due to failure of the battery charger was also expected to be identified within 24 hours and, accordingly, in the PRA model the failure of the battery charger has a low likelihood of failing the DC bus. The assumption in the SDP screening evaluation that the battery charger failure will remain undetected and will lead to failure of the corresponding DC bus resulted in the three orders of magnitude overestimation.

2. Operator failure to conduct LPR was overestimated by three orders of magnitude because of the difference in assumptions between the notebook and the plant PRA in modeling SLOCA, as discussed earlier. Requiring LPR in a SLOCA following successful depressurization when AFW and HPI functions have been successful significantly increases the significance of the LPR function.

Overestimation by two orders of magnitude was noted for two cases: 1 boric acid transfer (BAT) pump and 1 SG PORV. The reasons for these overestimations are discussed below.

1. The BAT pump was used in conducting emergency boration in an ATWS and in carrying out RWST refill. ATWS frequency in the plant PRA was an order of magnitude lower and the probability of operator failure to carry out RWST refill dominates the failure of the RWST refill function. In the notebook, a failure of one of the BAT pumps was evaluated considering the baseline credit of the sequences involving the RWST refill function which was based on the operator failure because of its dominant error probability. This, along with the difference in the ATWS frequency, resulted in the two orders of magnitude overestimation.

2. Overestimation by two orders results for one SG PORV failure because of the lack of recovery credit application in the benchmarking exercise and the SDP process of counting base case credits even when multiple redundancies were left. The plant has a procedure for manually opening the SG PORV which was not credited in the SDP evaluation. Also, 5 safety valves were available to carry out the steam relief function in case of failure of the SG PORV. Credits for the additional redundancies were limited resulting in the overestimation.

In addition, eight cases of overestimation by one order of magnitude were noted. Some of the overestimations resulted from the difference in initiating event frequency between the notebook and the plant PRA. These cases are not discussed further here.

Changes Incorporated Following Benchmarking Resulting in Updating of Benchmarking Results

No significant change was made to the notebook following benchmarking that resulted in changes to the benchmarking results.

Table 1. Summary of Benchmarking Results for Kewaunee Nuclear Power Plant

Internal Events CDF = 5.43E-5/reactor-yr, excluding internal flooding, at Truncation Level of 1E-10
RAW Thresholds are: W = 1.02, Y = 1.18, R = 2.84, RR=19.42(1)

No.	Component Out of Service or Failed Operator Action	SDP Before	Basic Event Name	RAW	Plant CDF Color	SDP After	Comments
	Component						
1.	1 Accumulator	Y	33-TK-ACC1A-RP	1.02	W	Y	over by one order of magnitude
2.	1 MDAFW pump (B)	Y	05BPM-AFW1B-PR	1.42	Y	Y	
3.	1 TDAFW pump	Y	05BPT-AFW1C-TM	2.92	R	Y	under by one order of magnitude
4.	1 CCW pump	Y	31-PM-CCW1B-PR	2.52	Y	Y	
5.	1 CCW HX	Y	31-HX-CCW1B-LK	1.42	Y	Y	
6.	1 Charging pump	W	35-PM-CHGP1B-PS	1.41	Y	Y	
7.	1 Boric Acid Transfer Pump	W	35-PM-BATPIA-PS	1.0	G	Y	over by two orders of magnitude
8.	1 HPSI pump (B)	Y	33-PM-SI1B-PR	1.41	Y	Y	
9.	1 Condensate pump	G	03-PM-CDP1A-PR (Truncated)	1.0	G	G	
10.	1 MFW pump	G	05APM-FWP1A-PR (Truncated)	1.01	G	G	
11.	1 EDG	Y	10-GE-DG1B-PR	2.94	R	R	
12.	1 IA compressor	G	01-CM-SIAC1F-PR	1.01	G	G	
13.	1 SG PORV	W		1.0	G	Y	over by two orders of magnitude
14.	1 PORV FTO	W	36-AV-PR2B-FO	1.03	W	W	
15.	1 PORV FTC	R	IE-SLO	1.56	Y	Y	RAW for SLOCA was used; that's how PRA models SORV.

No.	Component Out of Service or Failed Operator Action	SDP Before	Basic Event Name	RAW	Plant CDF Color	SDP After	Comments
16.	1 Primary SRV FTO	W	36-SV-33113-FO	1.03	W	W	
17.	1 RHR pump (A)	Y	34-PM-RHR1A-PS	1.28	Y	Y	
18.	1 RHR HX (A)	Y	34-HX-RHR1B-LK	1.08	W	Y	over by one order of magnitude
19.	1 SW pump	W	02-PM-SW1A2-PR	5.52	R	R	
20.	1 AC Bus (Bus 5)	R	39-BS-BUS5-SG (Case Run)	19.17	R	RR	over by one order of magnitude
21.	1 DC Bus (BRA-102)	R	38-BS-BRA 102-SG (Case Run)	40.56	RR	RR	
22	1 DC Bus (BRB-104)	R	38-B5-BRB 104-SG (Case Run)	7.25	R	RR	over by one order of magnitude
23.	1 battery (BRA-101)	R	38-BY-BRA 101-OP	16.53	R	R	
24.	1 Battery Charger (BRA-108)	R	38-BC-BRA 108-OP (Case Run)	1.03	W	RR	over by three orders of magnitude
25.	RHR Pump pit Fan coil Unit A	W	17-FNPMPPITA-PS	1.28	Y	Y	
26.	TSC Diesel	NA	10-GE-TSC-DG-PR	1.65	Y	W	under by one order of magnitude
27.	1 MSIV FTC	Y	06-AV-MS1A-FC	1.38	Y	R	over by one order of magnitude
28.	1 PORV Block valve FTC	Y	-	NA	NA	W	Comparable RAW not available
29	Piggyback valve RHR-299	NA	-	NA	NA	G	Comparable RAW not available
	Operator Actions						
30.	Operator fails to recover MFW	W	05A-MF2- - -HE	2.84	Y	Y	

No.	Component Out of Service or Failed Operator Action	SDP Before	Basic Event Name	RAW	Plant CDF Color	SDP After	Comments
31.	Operator fails to initiate FB	Y	36-OBF- - - HE	10.58	R	Y	under by one order of magnitude
32.	Fails HPR	R	36-2TRN-REC-HE	3.62	R	R	
33.	Operator fails to start a charging pump	W	35-CH2- - - HE	1.60	Y	R	over by one order of magnitude
34.	Fails LPR	Y	34-LR1- - - HE	1.10	W	RR	over by three orders of magnitude
35.	Fails RCSDEP in SLOCA	W	06-OC1- - - HE	1.01	G	W	over by one order of magnitude
36.	Isolation of ruptured SG	Y	06-IS2- - - HE	3.37	R	R	
37.	RCS cooldown and depressurization in SGTR	Y	06-OC3- - - HE	3.33	R	R	
38.	Refill RWST in SGTR	NA	Case Run	1.45	Y	Y	
39.	Emergency boration in ATWS	W	Case Run	1.0	G	W	over by one order of magnitude

Note:

1. RR signifies a risk impact between 1E-3 and 1E-2.

Table 2: Comparative Summary of Benchmarking Results

Comparisons		Rev. 0 SDP Notebook		Rev. 1 SDP Notebook (Following Benchmarking)	
		Total Number of Cases Comparable = 37			
		Number of Cases	Percentage	Number of Cases	Percentage
SDP: Less Conservative		11[1]	31	3	8
SDP: More Conservative	one order	8	23	8	22
	two orders	1	3	2	5
	three orders			2	5
SDP: Matched		15	43	22	60
Comparable RAW not available or not modeled in the Notebook		4		2	

Note:

1. 10 cases by one order of magnitude and 1 case by two orders of magnitude.

3. ADDITIONAL PROPOSED MODIFICATIONS TO SDP WORKSHEETS

3.1 Specific Changes to the Rev. 0 SDP Worksheets for Kewaunee

The changes made to the Kewaunee Nuclear Power Plant notebook to develop the Rev. 1 version during and after the plant onsite benchmarking visit are summarized here and are also included in the updated notebook.

<u>Changes made to the Kewaunee Nuclear Power Plant Rev. 0 Notebook to complete the Rev. 1 Notebook</u>

1. Changes to Table 1

   1.1 Loss of Component Cooling Water (LCCW) was moved from Row III to Row II based on the revised plant-specific frequency.

   1.2 Loss of one 125 VDC bus was replaced with Loss of 125 VDC BRA 102 (LDCA) and loss of 125 VDC Bus BRB 104 (LDCB) initiators. Both LDCA and LDCB were placed in Row II.

2. Changes to Table 2

   2.1 AFW dependency on SW was removed. However, it was noted that HVAC was needed for AFW pump A which in turn depends on SW.

   2.2 A footnote was added stating that HVAC requirement was for CCW Pump B only.

   2.3 A footnote was added for charging pumps to note that one AC bus supports two of the charging pumps.

   2.4 It was noted that CCW dependency for HPSI and RHR pumps was for recirculation phase only.

   2.5 TSC diesel was added as a separate row. A footnote was added to discuss the operation of the TSC diesel.

   2.6 A footnote was added to explain the alignment of the air compressors.

   2.7 A footnote was added to note that SG PORVs have backup nitrogen accumulators.

   2.8 Separate rows were added for RWST and Reactor Water Makeup Pumps.

3. Changes to the Worksheets (Table 3) and Event trees

3.1 RWST refill following failure of recirculation (HPR and/or LPR) was credited for many initiators. The applicable initiators were TRANS, TPCS, LCCW, LDCA, LDCB, SLOCA, SORV, and MSLB. In case of LCCW, HPR was lost due to the initiator. Applicable worksheets and event trees were modified.

3.2 Credit for starting the MFW in the PCS and MFW function was changed from operator action = 3 to operator action = 2 based on plant-specific HEP. In the LOIA worksheet, it was changed to operator action = 1.

3.3 LOSW worksheet and event tree were modified to include operator failure to trip the RCPs.

3.4 LCCW worksheet and event tree were modified to include high pressure injection and RWST refill to mitigation RCP seal LOCA. Revised plant analyses showed that High pressure injection pumps do not need CCW for the injection mode.

3.5 Loss of 125 VDC Bus BRA 102 (LDCA) and Loss of 125 VDC Bus BRB 104 (LDCB) worksheets were included replacing the single loss of DC Bus (LDC) worksheet.

3.6 Loss of Instrument Air (LOIA) worksheet was modified to include the bleed and feed capability. Pressurizer PORVs have backup accumulators.

3.7 SLOCA worksheet and event tree were modified to require low pressure recirculation (LPR) following success of HPI, AFW/MFW, and RCS depressurization. Plant PRA does not require LPR; it assumed success. Operator action credit for LPR was changed from 2 to 3. Also, RCSDEP mitigation capability description was clarified.

3.8 SORV worksheet and event tree were modified similar to SLOCA. In addition, credit for the block function was changed from operator action = 1 to 1 train.

3.9 MLOCA worksheet and event tree were modified to eliminate RCS depressurization. Core damage was assumed following failure of high pressure injection function in a MLOCA.

3.10 In the LLOCA worksheet, credit for LPR was changed from operator action = 2 to operator action = 3.

3.11 LOOP worksheet and event tree were modified to include the use of the TSC diesel which can support two of the charging pumps following a station blackout. The team did not credit the TSC diesel with charging pumps for reactor coolant pump (RCP) seal LOCA prevention. TSC diesel operation which charging pumps was credited for RCP seal LOCA mitigation in the station blackout (SBO) portion of the LOOP event tree. NRC position (2003) on the WOG 2000 RCP seal LOCA model was that there would be a 20 percent chance of a seal LOCA if seal cooling is not restored in approximately 15 minutes of a SBO initiator (thermal-hydraulic instability phenomena). At KNPP, the TSC diesel would automatically start; however, the charging pumps would be manually loaded in approximately one hour and therefore would not have been available to prevent a seal LOCA.

For long term loss of seal cooling, the probability of seal failure was negligible for seals that are qualified for high temperature exposure which KNPP had installed. In the SBO case, the TSC diesel and charging pump(s) extend the time to core uncovery for seal LOCA scenarios. Combined with the 9 hour estimated time to battery depletion, KNPP could withstand SBO's of longer duration (assuming successful TDAFW pump operation).

In addition, charging and CCW pumps for seal cooling were explicitly modeled following success of EDGs (SEAL function, seal LOCA prevention).

3.12 LEAC worksheet and event tree were modified to delete sequences involving successful closure of the PORVs. These sequences duplicate sequences in the LOOP worksheet. RCSDEP function mitigation capability was also revised.

3.13 SGTR worksheet and event tree were modified to require RWST refill following successful high pressure injection but failure to isolate the faulted generator or to equalize pressure. SGI function mitigation capability was revised to explicitly include the MSIV on the ruptured SG. EQ function mitigation capability was revised to include the condenser dump valves.

3.14 In the ATWS worksheet, the mitigation capability for long term shutdown through emergency boration was changed to include the RWST suction path. The AFW function mitigation capability was revised to 2/3 AFW pumps. The steam relief path through 1 of 2 SGPORVs or 1/5 safety valves for each SG was added.

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 Kewaunee Nuclear Power Plant integrated PRA model includes internal floods and internal fire. The CDF in the integrated model including fire and flooding was 2.87E-4/reactor-yr. The integrated model was used to assess whether the inclusion of the external initiators will result in increased risk significance for components or operator actions. The assessment was carried out by evaluating the RAWs for a set of components and operator actions for the model that included the fire and flood initiators and then, comparing them with the RAWs calculated previously for internal initiators.

Table 3 presents the comparisons for the same set of components and operator actions that were used for benchmarking. Obtaining RAW for some items required separate computer runs which were not conducted for the integrated model. RAW for these items were not available and are noted as “NA.”

To obtain the color for the component being out of service or the failed operator action, new thresholds were obtained. A comparison of the RAWs for the internal initiators with those obtained using fire and flood initiators showed that in eight cases the color or the risk significance would have increased by an order of magnitude if the risk contributions of external initiators were included. These items are noted in the table.

Although the KNPP SDP notebook does not include external initiators, the team compared the “SDP after” results of Table 1 against the licensee’s PRA model including internal floods and internal fire. In the eight cases noted above, the notebook would under-estimate five cases. Those cases were unavailability of:

- motor-driven AFW pump A
- an emergency diesel generator
- an instrument air compressor
- battery BRA-101
- a component cooling water heat exchanger

Table 3. Comparison of Risk Significance With and Without External Initiators at Kewaunee Nuclear Power Plant

CDF including internal flooding and fire = 2.87E-4/reactor-yr at truncation level of 1E-10
RAW Thresholds are: W=1.003, Y=1.035, R =1.35, and RR = 4.47[(1)]

No.	Component Out of Service or Failed Operator Action	Basic Event Name	SDP After (from Table 1)	Plant CDF Color for Internal Event	RAW including external initiators	Plant CDF color including external initiators	Comments
	Component						
1.	1 Accumulator	33-TK-ACC1A-RP	Y	W	NA		
2.	1 MDAFW pump (B)	05BPM-AFW1B-PR	Y	Y	1.26 (3.23 for Pump A)	Y (R for Pump A)	Risk significance increases by one order for pump A
3.	1 TDAFW pump	05BPT-AFW1C-TM	Y	R	1.41	R	
4.	1 CCW pump	31-PM-CCW1B-PR	Y	Y	2.74	R	Risk significance increases by one order
5.	1 CCW HX	31-HX-CCW1B-LK	Y	Y	2.61	R	Risk significance increases by one order
6.	1 Charging pump	35-PM-CHGP1B-PS	Y	Y	1.06	Y	
7.	1 Boric Acid Transfer Pump	35-PM-BATPIA-PS	Y	G	NA		
8.	1 HPSI pump (B)	33-PM-SI1B-PR	Y	Y	1.23	Y	
9.	1 Condensate pump	03-PM-CDP1A-PR (Truncated)	G	G	1.0	G	
10.	1 MFW pump	05APM-FWP1A-PR (Truncated)	G	G	1.0	G	
11.	1 EDG	10-GE-DG1B-PR	R	R	4.19	RR	Risk significance increases by one order
12.	1 IA compressor	01-CM-SIAC1F-PR	G	G	1.02	W	Risk significance increases by one order

No.	Component Out of Service or Failed Operator Action	Basic Event Name	SDP After (from Table 1)	Plant CDF Color for Internal Event	RAW including external initiators	Plant CDF color including external initiators	Comments
13.	1 SG PORV		Y	G	1.0	G	
14.	1 PORV FTO	36-AV-PR2B-FO	W	W	1.01	W	
15.	1 PORV FTC	IE-SLO	Y	Y	1.11	Y	
16.	1 Primary SRV FTO	36-SV-33113-FO	W	W	1.01	W	
17.	1 RHR pump (A)	34-PM-RHR1A-PS	Y	Y	1.18	Y	
18.	1 RHR HX (A)	34-HX-RHR1B-LK	Y	W	1.14	Y	Risk significance increases by one order
19.	1 SW pump	02-PM-SW1A2-PR	R	R	1.93	R	
20.	1 AC Bus (Bus 5)	39-BS-BUS5-SG (Case Run)	RR	R	NA		
21.	1 DC Bus (BRA-102)	38-BS-BRA 102-SG (Case Run)	RR	RR	NA		
22	1 DC Bus (BRB-104)	38-B5-BRB 104-SG (Case Run)	RR	R	NA		
23.	1 battery (BRA-101)	38-BY-BRA 101-OP	R	R	6.96	RR	Risk significance increases by one order
24.	1 Battery Charger (BRA-108)	38-BC-BRA 108-OP (Case Run)	RR	W	NA		
25.	RHR Pump pit Fan coil Unit A	17-FNPMPPITA-PS	Y	Y	1.06	Y	
26.	TSC Diesel	10-GE-TSC-DG-PR	W	Y	1.13	Y	
27.	1 MSIV FTC	06-AV-MS1A-FC	R	Y	NA		
28.	1 PORV Block valve FTC	-	W		NA		
29	Piggyback valve RHR-299	-	G		NA		
	Operator Actions						

No.	Component Out of Service or Failed Operator Action	Basic Event Name	SDP After (from Table 1)	Plant CDF Color for Internal Event	RAW including external initiators	Plant CDF color including external initiators	Comments
30.	Operator fails to recover MFW	05A-MF2- - -HE	Y	Y	1.35	Y	
31.	Operator fails to initiate FB	36-OBF- - - HE	Y	R	2.74	R	
32.	Fails HPR	36-2TRN-REC-HE	R	R	1.5	R	
33.	Operator fails to start a charging pump	35-CH2- - - HE	R	Y	1.11	Y	
34.	Fails LPR	34-LR1- - - HE	RR	W	1.02	W	
35.	Fails RCSDEP in SLOCA	06-OC1- - - HE	W	G	1.01	W	Risk significance increases by one order
36.	Isolation of ruptured SG	06-IS2- - - HE	R	R	1.45	R	
37.	RCS cooldown and depressurization in SGTR	06-OC3- - - HE	R	R	1.44	R	
38.	Refill RWST in SGTR	Case Run	Y	Y	1.09	Y	
39.	Emergency boration in ATWS	Case Run	W	G	NA		

Note:

1. RR signifies a risk impact between 1E-3 and 1E-3.

ATTACHMENT 1

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