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March 6, 2017

L-PI-17-007
10 CFR 50.90
10 CFR 50.48(c)

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Prairie Island Nuclear Generating Plant Units 1 and 2
Dockets 50-282 and 50-306
Renewed License Nos. DPR-42 and DPR-60

License Amendment Request to Adopt NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactors – Response to Request for Additional Information (CAC Nos. ME9734 and ME9735)

References:

1. NSPM letter, J.P. Sorensen to NRC Document Control Desk, *License Amendment Request to Adopt NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactors,* L-PI-12-089, dated September 28, 2012, ADAMS Accession No. ML12278A405.

2. NSPM letter, S. Sharp to NRC Document Control Desk, *Supplement to License Amendment Request to Adopt NFPA 805 Performance Based Standard for Fire Protection for Light Water Reactors,* L-PI-14-045, dated April 30, 2014 (ADAMS Nos. ML14125A106 and ML14125A149).

3. NRC email, T. Beltz to S. Chesnutt, *Prairie Island Nuclear Generating Plant, Units 1 and 2 - NFPA 805 Requests for Additional Information and Response Timeline (TAC Nos. ME9734 and ME9735),* dated March 30, 2015 (ADAMS Accession No. ML15089A157).

4. NSPM letter, K. Davison to NRC Document Control Desk, *License Amendment Request to Adopt NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactors – Response to Request for Additional Information,* L-PI-15-041, dated May 28, 2015 (ADAMS No. ML15153A018).

5. NSPM letter, K. Davison to NRC Document Control Desk, *License Amendment Request to Adopt NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactors – Response to Request for Additional Information – 90-Day Responses,* L-PI-15-052, dated June 19, 2015 (ADAMS No. ML15174A139).

6. NRC email, R. Kuntz to G. Eckholt, Request for Information related to Prairie Island NFPA-805 license amendment (CAC Nos. ME9374 and ME9735), dated November 18, 2016 (ADAMS No. ML16326A353).

7. NSPM letter, K. Davison to NRC Document Control Desk, *License Amendment Request to Adopt NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactors – Response to Request for Additional Information*, L-PI-16-090, dated December 14, 2016 (ADAMS No. ML16350A105).

8. NRC email, R. Kuntz to G. Eckholt, Prairie Island NFPA 805 LAR, PRA RAI 21.01, dated February 7, 2017 (ADAMS No. ML17038A513).

In Reference 1, the Northern States Power Company, a Minnesota Corporation (NSPM) doing business as Xcel Energy, requested approval from the Nuclear Regulatory Commission (NRC) to transition the fire protection licensing basis for the Prairie Island Nuclear Generating Plant (PINGP) to 10 CFR 50.48(c), National Fire Protection Association Standard 805 (NFPA 805). Supplemental information was provided in letters dated November 8, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12314A144) and December 18, 2012 (ADAMS Accession No. ML12354A464).

In Reference 2, NSPM submitted a revised Fire Probabilistic Risk Assessment (PRA) in a supplement to the subject License Amendment Request (LAR). In Reference 3, the NRC staff provided requests for additional information (RAIs) regarding this request and also provided a timeline and due dates for submitting responses within 60, 90, or 120 days after an on-site Audit that was conducted March 23-25, 2015. NSPM letter dated May 28, 2015 (Reference 4) provided responses to the 60-day RAIs and one of the 90-day RAIs (Fire Protection Engineering RAI 03). NSPM letter dated June 19, 2015 (Reference 5) provided responses to the remaining 90-day RAIs.

In Reference 6, the NRC staff provided additional RAIs on incipient detection. In Reference 7, NSPM provided responses to these RAIs. In Reference 8, the NRC staff provided a follow-up RAI on incipient detection.

Enclosure 1 to this letter provides NSPM's response to the RAI received in Reference 8. Enclosure 2 provides a licensee identified issue regarding logic errors in the Fire PRA.

This letter is submitted in accordance with 10 CFR 50.90. The additional information provided in this letter does not impact the conclusions of the No Significant Hazards Evaluation or Environmental Considerations Evaluation presented in Reference 2.

In accordance with 10 CFR 50.91, NSPM is notifying the State of Minnesota of this additional information by transmitting a copy of this letter to the designated State Official.

If there are any questions or if additional information is needed, please contact Gene Eckholt at 651-267-1742.

Summary of Commitments

This letter contains no new commitments and makes no revisions to any existing commitments.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on March 6, 2017.

Scott Northard
Site Vice President – Prairie Island Nuclear Generating Plant
Northern States Power Company – Minnesota

Enclosures (2)

cc: Administrator, Region III, USNRC
NRR Project Manager, PINGP, USNRC
Resident Inspector, PINGP, USNRC
State of Minnesota

Response to Request for Additional Information (RAI) Regarding the License Amendment Request to Adopt National Fire Protection Association (NFPA) Standard 805 at Prairie Island Nuclear Generating Plant Units 1 and 2

NRC Request

PRA RAI 21.01

In its letter dated December 14, 2016 (ADAMS Accession No. ML16350A105), the licensee responded to PRA RAI 21 and referred to the use of a refinement made to Appendix H of NUREG/CR-6850, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities, Volume 2: Detailed Methodology," (ADAMS Accession No. ML052580118) to determine cable thermal response when exposed to a heated environment, also referred to as a damage accrual method. However, the method described in the submittal does not appear to account for the effect of the preheating, or damage accrued, that would occur prior to the cable being exposed to the cable damage temperatures specified in Appendix H of NUREG/CR-6850.

For the damage accrual method used:

1. *Provide the technical basis and the verification and validation to justify its use to determine ignition and damage delays.*

2. *Discuss whether the method accounts for the effect of the preheating noted above.*

NSPM Response - PRA RAI 21.01

1. The verification and validation for justifying the use of the damage accrual method used to determine ignition and damage delays is provided as follows:

   Verification refers to the correct model programming and implementation. Three sets of exercises were performed to verify the implementation of the damage accrual method.

   Comparison to Appendix H of NUREG/CR-6850

   First, a comparison of the model results was performed against the Failure Time-Temperature and Failure Time-Heat Flux relationship tables in Appendix H of NUREG/CR-6850, assuming targets were exposed to steady state (i.e., constant) fire conditions. The results of this comparison indicated that the damage accrual method reproduced the Time to Failure results listed in the corresponding Appendix H tables in NUREG/CR-6850. Table 1 through Table 4 below show the results of running the damage accrual method with constant exposures. It should be noted that the tables in Appendix H list times to failure for a range of temperature or heat flux. For this verification, the mid-point between heat flux (Table 3 and Table 4 below) exposures was selected. As seen, the Appendix H exposure durations are reproduced.

Table 1: Test Thermoplastic Temperature Exposure

Temperature (°C)	NUREG/CR-6805 Duration (min)	Damage Accrual Method Duration (min)
205	30	30
220	25	25
230	20	20
245	15	15
260	10	10
275	8	8
290	7	7
300	6	6
315	5	5
330	4	4
345	3	3
355	2	2
370	1	1

Table 2: Test Thermoset Temperature Exposure

Temperature (°C)	NUREG/CR-6805 Duration (min)	Damage Accrual Method Duration (min)
330	28	28
335	24	24
340	20	20
345	16	16
350	13	13
360	10	10
370	9	9
380	8	8
390	7	7
400	6	6
410	5	5

Table 2: Test Thermoset Temperature Exposure

Temperature (°C)	NUREG/CR-6805 Duration (min)	Damage Accrual Method Duration (min)
430	4	4
450	3	3
470	2	2
490	1	1

Table 3: Test Thermoplastic Heat Flux Exposure

Heat Flux (kW/m^2)	NUREG/CR-6805 Duration (min)	Damage Accrual Method Duration (min)
7	19	19
9	10	10
10.5	6	6
12	4	4
15	2	2
18	1	1

Table 4: Test Thermoset Heat Flux Exposure

Heat Flux (kW/m^2)	NUREG/CR-6805 Duration (min)	Damage Accrual Method Duration (min)
12	19	19
15	12	12
17	6	6
19	1	1
21	1	1

<u>Accounting for Exposures Below the Damage Threshold</u>

The accrual method performs the damage integral computation at all times, even when the current exposure is below the minimum thresholds in Appendix H of NUREG/CR-6850. This means that if a cable is exposed long enough to ambient conditions, the results of the damage accrual method will exceed 1.0. To avoid damage predictions in these scenarios, the damage accrual method only considers a cable damaged if both the integration result is greater than 1.0 and the exposure is above the damage threshold. This is illustrated and verified in the three tables below which are screen captures from the damage accrual tool.

The first set of cases, seen in Table 5, expose the cable to a long duration heat flux and temperature exposure that never exceeds the applicable damage thresholds. Even though in both cases the numerical results exceed 1.0, no damage occurs since the cables never exceed the damage threshold.

Table 5: Result of a long duration sub-threshold exposure

Cable Type:	TP	
Damage Time (s):	No Damage	
Time	Heat Flux	Integral
(s)	(kW/m^2)	
0	5	0.000
20	5	0.015
5000	5	3.655

Cable Type:	TP	
Damage Time (s):	No Damage	
Time	Temperature	Integral
(s)	(deg C)	
0	25	0.000
20	100	0.002
5000	100	1.060

The second set of cases, seen in Table 6, also have long duration exposures below the threshold. For a brief period, the exposures cross the damage thresholds and then drop back below before the results exceed 1.0. The exposures then continue at below threshold levels. As in the first set of cases, no damage occurs as the numerical results exceed 1.0 while the exposures are below their thresholds.

Table 6: Result of a long duration sub-threshold exposure with a brief excursion over the threshold prior to a damage accrual result of 1.0

Cable Type:	TP	
Damage Time (s):	No Damage	
Time	Heat Flux	Integral
(s)	(kW/m^2)	
0	5	0.000
20	5	0.015
1000	7	0.803
1100	7	0.890
1250	5	1.011

Cable Type:	TP	
Damage Time (s):	No Damage	
Time	Temperature	Integral
(s)	(deg C)	
0	25	0.000
20	100	0.002
4500	100	0.953
4600	206	0.992
4700	200	1.046

The third set of cases, see Table 7, is similar to the second set. The difference is, here the damage accrual method result exceeds 1.0 before the exposures exceed their thresholds. Therefore, the requirement of a result of 1.0 and an exposure over the threshold is met as soon as the exposures exceed their thresholds. The results are that cable damage is predicted in both cases as soon as the exposures exceed the threshold.

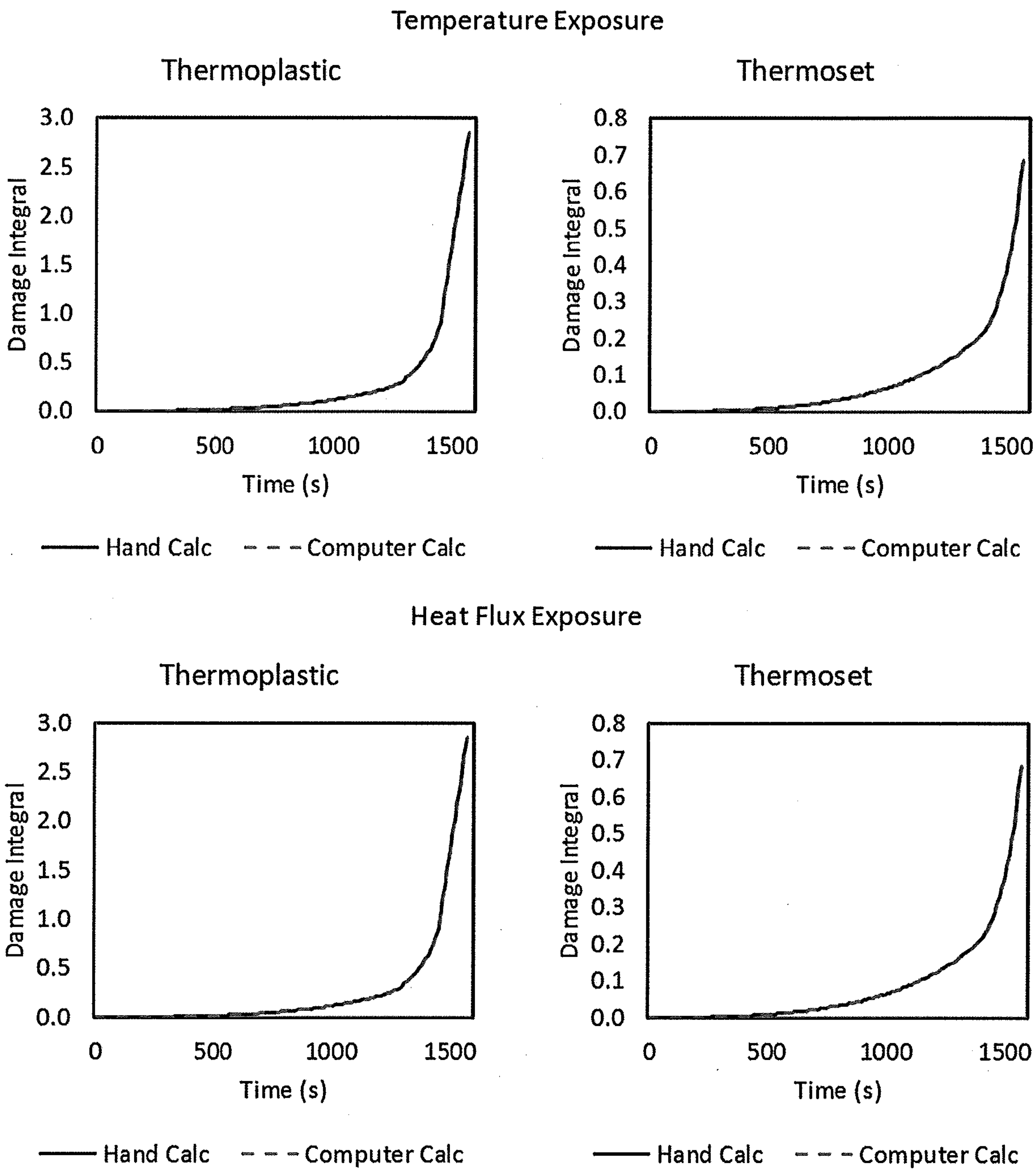
Table 7: Result of a long duration sub-threshold exposure with a brief excursion over the threshold after the accrual method result of 1.0

Cable Type:	TP		Cable Type:	TP	
Damage Time (s):	4650		Damage Time (s):	4770	
Time	Heat Flux	Integral	Time	Temperature	Integral
(s)	(kW/m^2)		(s)	(deg C)	
0	5	0.000	0	25	0.000
20	5	0.015	20	100	0.002
4500	5	3.289	4720	100	1.000
4600	5	3.363	4820	310	1.150
4700	7	3.443			

<u>Comparison of Hand and Computer Calculations</u>

In addition, the computer code was verified against hand calculations. This was done by solving the damage accrual method by hand and comparing the results with the computer implementation. Each type of cable (i.e., Thermoset or Thermoplastic) was exposed to an exponentially increasing temperature or heat flux exposure with the accrual method computed both by hand and by using the computer model. The results are shown below in Figure 1 and indicate that the model was correctly implemented.

Figure 1: Result of a exposing each cable type to an exponentially increasing temperature or heat flux.

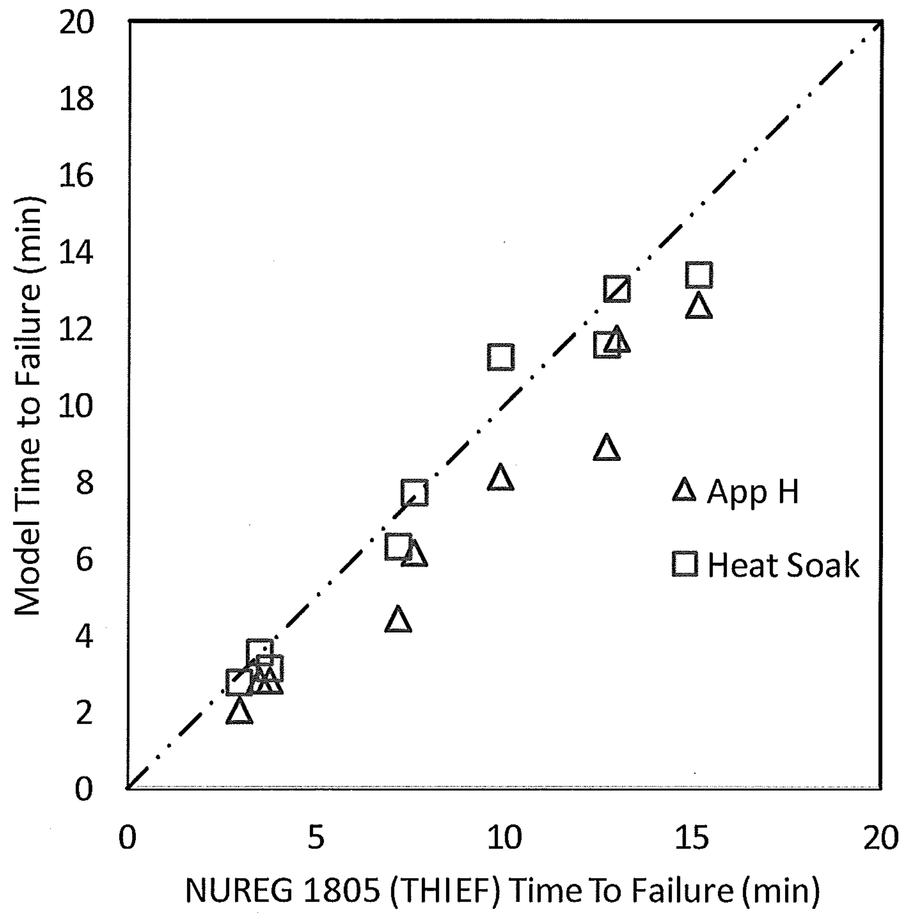


Comparison to NUREG-1805 (THIEF)

Validation refers to the evaluation of the model predictive capabilities. Validation on the damage accrual method was conducted using test data from NUREG/CR-6931. Specifically, the time dependent exposures from the tests documented in NUREG/CR-6931 were evaluated using the THIEF model in NUREG-1805, the damage accrual method, and a strict application of tables in Appendix H of

NUREG/CR-6850. Results of this are shown in Figure 2. The triangle markers, representing the strict application of Appendix H tables are under the diagonal, indicating that the THIEF model predicts longer damage times. The square markers, representing the damage accrual method, generally align with or are under the diagonal indicating good agreement with the THIEF model. As seen, the damage accrual method generally lies between THIEF and the strict application of the Appendix H tables with one outlier that is a 13 % longer time to failure than THIEF. However, since THIEF is documented as having an overall 15 % negative bias (e.g. predicts times to failures on average 15 % faster), the 13 % outlier would not result in an overall positive bias for the damage accrual method.

Figure 2: Results of the time dependent exposures from the tests documented in NUREG/CR-6931 evaluated using the THIEF model in NUREG-1805, the damage accrual method, and a strict application of tables in Appendix H of NUREG/CR-6850.



The verification and validation supporting the use of the damage accrual method to determine cable damage times demonstrates that the model is correctly implemented and agrees with predictions from the THIEF model.

2. The damage accrual method accounts for the effect of the preheating, or damage accrued, that would occur prior to the cable being exposed to the cable damage temperatures specified in Appendix H of NUREG/CR-6850 as follows: The damage accrual method assumes that a cable progresses to failure linearly with a constant exposure. Consider this in the context of Table H-6 from NUREG/CR-6850. This table states that a thermoplastic cable between 205 °C and 220 °C will be damaged in 30 minutes. The damage accrual method would, therefore, assume that every minute in that temperature range would bring the cable 1/30 = 3.33 % closer to failure. This would apply similarly for other temperature ranges. For example, every minute between 260 °C and 275 °C, which has a time to failure of 10 min, would bring the cable 1/10 = 10 % closer to failure. The damage accrual method treats this as a rate process, e.g. between 260 °C and 275 °C the rate of damage is 0.1/min. The method then integrates the damage rate, which is a function of temperature, over time. When the accrual method reaches 1.0, failure is presumed to occur.

   In developing this method, it was recognized that Tables H-5 through H-8 in NUREG/CR-6850 consider only constant exposure, they do not contain any times to failure below a threshold value. In the case of a time dependent exposure, it is possible that a cable could spend an extended period of time at elevated exposures close to but not at the threshold (i.e., a temperature exposure between ambient and the threshold for cable damage). This would preheat the cable with the expectation that failure would occur much more quickly once the exposure did rise above the threshold value. The damage accrual method accounts for this. At exposures below the threshold value, damage is assumed to accrue at a rate that would result in the same integrated exposure as the threshold value. Using Table H-8 from NUREG/CR-6850 as an example, the threshold exposure and duration is 6 kW/m^2 for 19 min or a total integrated exposure of 6 kW/m^2 x 19 min x 60 sec/min = 6840 kJ/m^2. If the exposure was only 3 kW/m^2, the damage accrual method would assume a damage time that results in the same integrated exposure or 6840 kJ/m^2 divided by 3 kW/m^2 giving a 2280 seconds (i.e., 38 min) time to failure.

   This approach can be shown to be conservative by inspection of the Appendix H tables from NUREG/CR-6850. For each table entry, the total integrated exposure at cable failure can be computed by multiplying the time to failure by the exposure given by the temperature or heat flux. The results of this show that the total integrated exposure increases as the magnitude of the heat flux or temperature decreases. As discussed above, for temperature or heat flux values below their threshold, the damage accrual method fixes the total exposure at the threshold and computes a damage time. Since the total integrated exposure actually increases with decreasing temperature or heat flux, this means the computed times to damage used in the accrual method are biased low, e.g, will predict faster times to damage. As previously discussed, to avoid the result of a cable failing after a prolonged exposure to room temperature, the damage accrual method only fails a cable if it exceeds its threshold exposure (i.e., no damage is postulated if the exposure temperature never exceeds the threshold).

Precedent

Duke Energy Progress, LLC applied the damage accrual methodology in a similar manner in the H.B. Robinson Steam Electric Plant, Unit No. 2 (HBRSEP) NFPA LAR RAI response, by letter dated July 31, 2015, ADAMs Accession No. ML15212A136. This method was discussed by NRC letter dated February 3, 2017, ADAMs Accession No. ML16337A264, which issued the HBRSEP NFPA 805 Safety Evaluation. However, in the Prairie Island Fire PRA for determining damage time for cables immersed in the hot gas layer, only the time-temperature thermal response was credited. The Prairie Island Fire PRA did not credit the thermal response for determining damage or ignition times for targets within the zone of influence.

PCD to Address Ignition Frequencies

NSPM entered an item into the PRA Change Database (PCD) to address the use of updated ignition frequencies as part of a future Fire PRA update. NSPM PRA procedures specify requirements for updates to the PRA models to incorporate updates and upgrades. This meets the RG 1.200 and ASME/ANS PRA Standard requirements for maintenance and upgrade of PRA models.

Licensee Identified Issue – Fire PRA Logic Errors

The following provides a licensee identified issue regarding logic errors in the Fire PRA.

The NFPA 805 Fire PRA model was being converted to support Maintenance Rule (a)(4) online risk assessment. During the conversion it was noted that AND-NOT gates were used in several places in the Fire PRA fault tree and some involved nested negation which may not quantify as intended in some cases.

<u>Sensitivity Study</u>

The eight Fire PRA models involving Unit 1 and Unit 2, Core Damage Frequency (CDF) and Large Early Release Frequency (LERF), Variant and Compliant cases, were re-quantified with the corrected fault tree in support of a Sensitivity Analysis. The Fire Quantification notebook was not revised. All RG 1.174 metrics for total and delta CDF and LERF remain acceptable.

	NFPA 805 PRA RAI 03 response (ML16152A046)			***Results with VEWFDS and AND-NOT Sensitivity***		
	Variant	**Compliant**	**Delta**	**Variant**	**Compliant**	**Delta**
U1 CDF	6.40E-05	5.47E-05	9.30E-06	4.86E-05	3.97E-05	8.90E-06
U1 LERF	9.90E-07	8.10E-07	1.80E-07	8.42E-07	6.79E-07	1.63E-07
U2 CDF	6.50E-05	5.93E-05	5.70E-06	6.07E-05	5.28E-05	7.90E-06
U2 LERF	9.70E-07	8.75E-07	1.10E-07	7.85E-06	7.74E-06	1.10E-07

Table 1 Results of Sensitivity Study

	Unit 1		***Unit 2***	
	CDF	***LERF***	***CDF***	***LERF***
Internal Events	2.0E-05	2.2E-07	2.0E-05	2.2E-07
Seismic	7.8E-06	Not Calculated	7.8E-06	Not Calculated
Fire	4.9E-05	8.4E-07	6.1E-05	7.9E-06
New Total	7.7E-05	1.1E-06	8.9E-05	8.1E-06
Previous Total (ML16152A046)	9.2E-05	1.2E-06	9.3E-05	1.2E-06

Table 2 Summary of Total Plant Risk

<u>Impact on NFPA 805 LAR</u>

The error correction has minimal impact on the NFPA 805 LAR:

- The identified error does not impact the deterministic (e.g., Nuclear Safety Capability Assessment, Non-power operations, Fire Protection, etc.) elements of the transition process.
- Sensitivity analyses were conducted to verify impact of selected model changes resulting from the review process. The results of the sensitivity analyses indicate the change in the risk values still produce results that meet RG 1.174 criteria.

- Although the risk values associated with the scenarios listed in the NFPA 805 LAR Attachment W (per letter dated May 24, 2016, ADAMs Accession No. ML16152A046) may be different, the conclusions remain that RG 1.174 criteria for total and delta CDF and LERF are acceptable.

Containment Isolation in non-ASD scenarios

Alternate Shutdown (ASD) is included in the Fire PRA fault tree and an ASD flag is used to switch part of the fault tree logic on and off depending on if the scenario progresses to control room abandonment and ASD or not. It was noted in the Containment Isolation logic that the logic was not correct because if ASD was false (non-ASD scenarios) then many Containment Isolation (CI) Valve failures would not propagate up to fail Containment. It was also noted that Circuit Failure Mode Likelihood Analysis (CFMLA) and hot short duration were not being applied to these Containment Isolation Air Operated Valves (AOVs). The CFMLA and hot short duration from NUREG-7150 were applied to these CI AOVs consistent with how CFMLA and hot short duration were already applied to other components in the Fire PRA model.

The majority of the Unit 2 LERF increase is due to fire damaging Train A and Train B cables for the automatic containment isolation signal. The increase in Unit 1 LERF is not as large because Train A and Train B cable routing is different. As discussed above, all RG 1.174 metrics for LERF remain acceptable.

Nested Negated Logic

AND-NOT gates were utilized in lower levels of the Fire PRA fault tree to exclude scenarios that are mutually exclusive. For example, spurious start of a pump and simultaneous failure of the required power supply was modeled with an AND-NOT gate in the system level logic. To have undesired spurious start of the pump you need to have spurious start of the pump AND-NOT failure of the required power supply. The way FTREX (quantification software) quantifies the AND-NOT gates in the fault tree is by deleting that cutset, which is acceptable when the AND-NOT gate simply negates a basic event (BE). If an AND-NOT gate has another negated gate below the negation, the Boolean logic may be correct, but the way FTREX generates cutsets may not give the intended results because once the cutset is deleted in the lowest level of the logic, it does not get un-deleted if there is another level of negation above it. The cutset has already been deleted and does not get restored. Many AND-NOT gates in the low level system fault trees were eliminated by putting the logic up at the top level Mutually Exclusive gate at the top of the fault tree.

PCD to Address Fire PRA Logic Errors

NSPM entered an item into the PRA PCD to address the Fire PRA logic errors as part of a future Fire PRA update. NSPM PRA procedures specify requirements for updates to the PRA models to incorporate updates and upgrades. This meets the RG 1.200 and ASME/ANS PRA Standard requirements for maintenance and upgrade of PRA models.

Precedent

Nine Mile Point Nuclear Station (NMPNS) addressed a similar issue with Fire PRA logic errors for NMP1 by letter dated May 23, 2014, ADAMs Accession No. ML14149A356, as part of a supplement to their NFPA 805 LAR. The scope, content and timing of the NMP-1 submittal is similar to this NSPM submittal for PINGP.