Nebraska Public Power District
Always there when you need us

50.90

NLS2013032
March 13, 2013

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

Subject: 120-Day Response to Request For Additional Information Regarding License Amendment Request To Adopt National Fire Protection Association Standard 805 Cooper Nuclear Station, Docket No. 50-298, DPR-46

Reference:
1. Letter from Lynnea E. Wilkins, U.S. Nuclear Regulatory Commission, to Brian J. O'Grady, Nebraska Public Power District, dated November 14, 2012, "Cooper Nuclear Station - Request For Additional Information Re: License Amendment Request To Adopt National Fire Protection Agency Standard NFPA 805 (TAC ME8551)"

2. Letter from Brian J. O'Grady, Nebraska Public Power District, to U.S. Nuclear Regulatory Commission, dated April 24, 2012, "License Amendment Request to Revise the Fire Protection Licensing Basis to NFPA 805 Per 10 CFR 50.48(c)" (NLS2012006)

Dear Sir or Madam:

The purpose of this letter is for the Nebraska Public Power District to provide the 120-day response to a Nuclear Regulatory Commission Request for Additional Information (Reference 1) related to the Cooper Nuclear Station (CNS) License Amendment Request to adopt National Fire Protection Association (NFPA) Standard 805 as the CNS Fire Protection licensing basis per 10 CFR 50.48(c) (Reference 2). This response is attached. There are no commitments made in this submittal.

Should you have any questions concerning this matter, please contact Todd Stevens, CNS NFPA 805 Transition Project Manager, at (402) 825-5159.

COOPER NUCLEAR STATION
P.O. Box 98 / Brownville, NE 68321-0098
***Telephone:** (402) 825-3811 / **Fax:** (402) 825-5211*
www.nppd.com

A006
NRR

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

Executed on 03/13/13
(Date)

Sincerely,

Oscar A. Limpias
Vice President - Nuclear and
Chief Nuclear Officer

OAL/wv

Attachment: 120-Day Response to Cooper Nuclear Station Request For Additional Information Regarding License Amendment Request To Adopt National Fire Protection Association Standard 805

cc: Regional Administrator w/ Attachment
USNRC - Region IV

Cooper Project Manager w/ Attachment
USNRC - NRR Project Directorate IV-1

Senior Resident Inspector w/ Attachment
USNRC - CNS

Nebraska Health and Human Services w/ Attachment
Department of Regulation and Licensure

NPG Distribution w/o Attachment

CNS Records w/ Attachment

Attachment

120-Day Response to Cooper Nuclear Station
Request For Additional Information Regarding
License Amendment Request To Adopt
National Fire Protection Association Standard 805

The Nuclear Regulatory Commission Request for Additional Information (RAI) regarding the National Fire Protection Association (NFPA) Standard 805 Transition License Amendment Request (LAR) is shown in italics. The Nebraska Public Power District (NPPD) 120-day responses to the RAI are shown in block font.

Safe Shutdown (SSD)

Request: SSD RAI 01, 02, 03, 04, 05, 06, 07, 08, and 09.

NPPD Response:

These RAIs were addressed in the 60-day and 90-day responses.

Fire Protection Engineering (FPE)

Request: FPE RAI 01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 12, 13, 14, 15, 16, 17, and 18

NPPD Response:

These RAIs were addressed in the 60-day and 90-day responses.

Probabilistic Risk Assessment (PRA)

Request: PRA RAI-01, 02, 03, 04, and 05

NPPD Response:

These RAIs were addressed in the 60-day and 90-day responses.

Request: PRA RAI-06 Non-suppression Probability

The non-suppression probability (P_{ns}) results reported in NEDC-08-041, Rev. 3 (i.e., Tables 11, 12, 13, 21, 22, and 23) used non-suppression probability values less than 0.001, contrary to NUREG/CR-6850 Attachment P. Please provide the results of a sensitivity analysis (CDF, LERF, delta (Δ) CDF, ΔLERF) using P_{ns} no lower than 1E-03.

NPPD Response:

The following tables document the revised results from Calculation NEDC 08-041 (Tables 11, 12, 13, 21, 22, and 23), replacing all non-suppression probability (P_{ns}) values less than 1.00E-03 with a set value of 1.00E-03.

Additionally, the response to Fire Modeling RAI 02d identified a calculated normalized parameter in the Main Control Room (MCR) Abandonment Fire Dynamics Simulator (FDS) fire models that was outside the validated range. As such, the FDS models were revised to bring the normalized parameter within the validated range which resulted in changes to the time to abandonment. This revision only applies to the electrical cabinet fires (Cases 2 and 5). The tables below provide the revised non-suppression probabilities based on the new abandonment times.

The following revised tables from Calculation NEDC 08-041 provide the calculated severity factors and probabilities of non-suppression for MCR Abandonment with natural ventilation:

NEDC 08-041 Table 11: Time to Abandonment Probability Analysis for Case 5 (Natural Ventilation)

Electrical Cabinets – Case 5						REVISED VALUES		
Bin	HRR [kW]	SF	Time	P_{ns}	SF·P_{ns}	Time	P_{ns}	SF·P_{ns}
2	197	1.55E-01	22.7	5.58E-04	8.65E-05	21.3	1.00E-03	1.55E-04
3	337	8.10E-02	18.7	2.09E-03	1.69E-04	16.3	4.61E-03	3.74E-04
4	475	4.70E-02	16.7	4.04E-03	1.90E-04	14.5	8.35E-03	3.93E-04
5	612	2.90E-02	15.2	6.63E-03	1.92E-04	13.3	1.24E-02	3.60E-04
6	749	1.80E-02	13.5	1.16E-02	2.09E-04	12.2	1.78E-02	3.21E-04
7	886	1.10E-02	13	1.37E-02	1.51E-04	11.7	2.10E-02	2.32E-04
8	1024	7.00E-03	12.7	1.51E-02	1.06E-04	11.0	2.65E-02	1.86E-04
9	1162	5.00E-03	12.3	1.73E-02	8.63E-05	10.5	3.13E-02	1.56E-04
10	1299	3.00E-03	11.7	2.10E-02	6.31E-05	10.2	3.45E-02	1.04E-04
11	1436	2.00E-03	11.3	2.40E-02	4.80E-05	10.0	3.69E-02	7.38E-05
12	1573	1.00E-03	11	2.65E-02	2.65E-05	9.7	4.07E-02	4.07E-05
13	1710	1.00E-03	10.8	2.83E-02	2.83E-05	9.3	4.65E-02	4.65E-05
14	1847	1.00E-03	10.5	3.13E-02	3.13E-05	10.3	3.34E-02	3.34E-05
15	2276	1.00E-03	9.83	3.90E-02	3.90E-05	9.83	3.90E-02	3.90E-05
			Total		**1.43E-03**		Total	**2.51E-03**

NEDC 08-041 Table 12: Time to Abandonment Probability Analysis for Case 2 (Natural Ventilation)

Electrical Cabinets – Case 2						REVISED VALUES		
Bin	HRR [kW]	SF	Time	P_{ns}	SF·P_{ns}	Time	P_{ns}	SF·P_{ns}
2	130	2.02E-01	22.7	5.58E-04	1.13E-04	21.3	1.00E-03	2.02E-04
3	221	1.13E-01	18.7	2.09E-03	2.36E-04	16.3	4.61E-03	5.21E-04
4	310	6.70E-02	18.7	2.09E-03	1.40E-04	16.3	4.61E-03	3.09E-04
5	400	4.10E-02	16.7	4.04E-03	1.66E-04	14.5	8.35E-03	3.43E-04
6	490	2.60E-02	15.2	6.63E-03	1.72E-04	13.3	1.24E-02	3.23E-04
7	579	1.60E-02	15.2	6.63E-03	1.06E-04	13.3	1.24E-02	1.99E-04
8	669	1.00E-02	13.5	1.16E-02	1.16E-04	12.2	1.78E-02	1.78E-04
9	759	6.00E-03	13	1.37E-02	8.22E-05	11.7	2.10E-02	1.26E-04
10	848	4.00E-03	13	1.37E-02	5.48E-05	11.7	2.10E-02	8.42E-05
11	938	3.00E-03	12.7	1.51E-02	4.54E-05	11.0	2.65E-02	7.95E-05
12	1028	2.00E-03	12.3	1.73E-02	3.45E-05	10.5	3.13E-02	6.25E-05
13	1118	1.00E-03	12.3	1.73E-02	1.73E-05	10.5	3.13E-02	3.13E-05
14	1208	1.00E-03	11.7	2.10E-02	2.10E-05	10.2	3.45E-02	3.45E-05
15	1462	1.00E-03	11	2.65E-02	2.65E-05	9.7	4.07E-02	4.07E-05
			Total		**1.33E-03**		**Total**	**2.53E-03**

NEDC 08-041 Table 13: Time to Abandonment Probability Analysis for Case 8 (Natural Ventilation)

Transient Combustibles – Case 8						REVISED VALUES	
Bin	HRR [kW]	SF	Time	P_{ns}	SF·P_{ns}	P_{ns}	SF·P_{ns}
7	238	3.50E-02	25	2.61E-04	9.14E-06	1.00E-03	3.50E-05
8	275	2.00E-02	21.7	7.76E-04	1.55E-05	1.00E-03	2.00E-05
9	312	1.20E-02	20.8	1.04E-03	1.25E-05	1.04E-03	1.25E-05
10	349	7.00E-03	19.2	1.77E-03	1.24E-05	1.77E-03	1.24E-05
11	386	4.00E-03	16.3	4.61E-03	1.84E-05	4.61E-03	1.84E-05
12	423	2.00E-03	15.2	6.63E-03	1.33E-05	6.63E-03	1.33E-05
13	460	1.00E-03	14.3	8.92E-03	8.92E-06	8.92E-03	8.92E-06
14	497	1.00E-03	13.8	1.05E-02	1.05E-05	1.05E-02	1.05E-05
15	578	1.00E-03	12.8	1.46E-02	1.46E-05	1.46E-02	1.46E-05
			Total		**1.15E-04**	**Total**	**1.46E-04**

The following revised tables from Calculation NEDC 08-041 provide the calculated severity factors and probabilities of non-suppression for MCR Abandonment with mechanical ventilation:

NEDC 08-041 Table 21: Time to Abandonment Probability Analysis for Case 5 (Mechanical Ventilation)

Electrical Cabinets – Case 5						REVISED VALUES		
Bin	HRR [kW]	SF	Time	P_{ns}	$SF \cdot P_{ns}$	Time	P_{ns}	$SF \cdot P_{ns}$
2	197	1.55E-01	N/A			24.5	1.00E-03	1.55E-04
3	337	8.10E-02	21.8	7.51E-04	6.08E-05	19.7	1.50E-03	1.22E-04
4	475	4.70E-02	18.7	2.09E-03	9.82E-05	17.2	3.43E-03	1.61E-04
5	612	2.90E-02	16.3	4.61E-03	1.34E-04	15.8	5.44E-03	1.58E-04
6	749	1.80E-02	15.2	6.63E-03	1.19E-04	15.3	6.42E-03	1.15E-04
7	886	1.10E-02	13.5	1.16E-02	1.28E-04	12.8	1.46E-02	1.61E-04
8	1024	7.00E-03	12.8	1.46E-02	1.02E-04	12.5	1.62E-02	1.13E-04
9	1162	5.00E-03	12.5	1.62E-02	8.08E-05	12.3	1.73E-02	8.63E-05
10	1299	3.00E-03	12.3	1.73E-02	5.18E-05	11.7	2.10E-02	6.31E-05
11	1436	2.00E-03	11.8	2.04E-02	4.07E-05	11.2	2.48E-02	4.96E-05
12	1573	1.00E-03	11.3	2.40E-02	2.40E-05	11.2	2.48E-02	2.48E-05
13	1710	1.00E-03	11.2	2.48E-02	2.48E-05	10.8	2.83E-02	2.83E-05
14	1847	1.00E-03	10.8	2.83E-02	2.83E-05	10.5	3.13E-02	3.13E-05
15	2276	1.00E-03	10.5	3.13E-02	3.13E-05	10.0	3.69E-02	3.69E-05
			Total		**9.24E-04**		**Total**	**1.31E-03**

NEDC 08-041 Table 22: Time to Abandonment Probability Analysis for Case 2 (Mechanical Ventilation)

Electrical Cabinets – Case 2						REVISED VALUES		
Bin	HRR [kW]	SF	Time	P_{ns}	$SF \cdot P_{ns}$	Time	P_{ns}	$SF \cdot P_{ns}$
2	130	2.02E-01	N/A			24.5	1.00E-03	2.02E-04
3	221	1.13E-01	21.8	7.51E-04	8.49E-05	19.7	1.50E-03	1.70E-04
4	310	6.70E-02	21.8	7.51E-04	5.03E-05	19.7	1.50E-03	1.01E-04
5	400	4.10E-02	18.7	2.09E-03	8.57E-05	17.2	3.43E-03	1.41E-04
6	490	2.60E-02	16.3	4.61E-03	1.20E-04	15.8	5.44E-03	1.41E-04
7	579	1.60E-02	16.3	4.61E-03	7.38E-05	15.8	5.44E-03	8.70E-05
8	669	1.00E-02	15.2	6.63E-03	6.63E-05	15.3	6.42E-03	6.42E-05
9	759	6.00E-03	13.5	1.16E-02	6.97E-05	12.8	1.46E-02	8.78E-05
10	848	4.00E-03	13.5	1.16E-02	4.65E-05	12.8	1.46E-02	5.86E-05
11	938	3.00E-03	12.8	1.46E-02	4.39E-05	12.5	1.62E-02	4.85E-05
12	1028	2.00E-03	12.5	1.62E-02	3.23E-05	12.3	1.73E-02	3.45E-05
13	1118	1.00E-03	12.5	1.62E-02	1.62E-05	12.3	1.73E-02	1.73E-05
14	1208	1.00E-03	12.3	1.73E-02	1.73E-05	11.7	2.10E-02	2.10E-05
15	1462	1.00E-03	11.3	2.40E-02	2.40E-05	11.2	2.48E-02	2.48E-05
			Total		**7.31E-04**		**Total**	**1.20E-03**

NEDC 08-041 Table 23: Time to Abandonment Probability Analysis for Case 8 (Mechanical Ventilation)

Transient Combustibles – Case 8						REVISED VALUES	
Bin	HRR [kW]	SF	Time	P_{ns}	SF·P_{ns}	P_{ns}	SF·P_{ns}
12	423	2.00E-03	22.5	5.96E-04	1.19E-06	1.00E-03	2.00E-06
13	460	1.00E-03	22.5	5.96E-04	5.96E-07	1.00E-03	1.00E-06
14	497	1.00E-03	21.3	8.86E-04	8.86E-07	1.00E-03	1.00E-06
15	578	1.00E-03	15.2	6.63E-03	6.63E-06	6.63E-03	6.63E-06
			Total		**9.31E-06**	**Total**	**1.06E-05**

The quantitative impacts on the risk measures (Core Damage Frequency (CDF), Large Early Release Frequency (LERF), ΔCDF, and ΔLERF) are minor and have no effect on conclusions. The results of a sensitivity analysis (CDF, LERF, ΔCDF, and ΔLERF) using P_{ns} no lower than 1.0E-03 and the revised non-suppression probabilities based on the new abandonment times determined in the response to Fire Modeling RAI 02d, are provided in the table below:

Risk with Base Non-Suppression Probabilities (/yr)		Risk with Revised Non-Suppression Probabilities (/yr)	
Total CDF	4.77E-05	Total CDF	4.78E-05
Total LERF	8.71E-06	Total LERF	8.83E-06
ΔCDF	-1.18E-05	ΔCDF	-1.18E-05
ΔLERF	-1.48E-05	ΔLERF	-1.48E-05

Request: PRA RAI-07, 08, 09, 10, 11a

NPPD Response:

These RAIs were addressed in the 60-day and 90-day responses.

Request: PRA 11b

Transient Fire Modeling at Pinch Points

Per Section 11.1.5.6 of NUREG/CR-6850, transient fires should at a minimum be placed in locations within the plant physical access units (PAUs) where critical targets are located, such as where CCDPs are highest for that PAU (i.e., at "pinch points"). Pinch points include locations of redundant trains or the vicinity of other potentially risk-relevant equipment, including the cabling associated with each. Transient fires should be placed at all appropriate locations in a PAU where they can threaten pinch points. Hot work should be assumed to occur in locations where hot work is a possibility, even if improbable (but not impossible), keeping in mind the same philosophy.

b. Relative to the MCR, please provide an assessment of the impact on the PRA results (CDF, LERF, ΔCDF, ΔLERF) of placing transients behind the open-back MCBs and back panels.

NPPD Response:

b. Transient fires were not postulated in the MCR Analysis (NEDC 10-001). Transient fires near the Main Control Board (MCB) and MCR electrical cabinets, whether opened back or closed back, that damage PRA targets are considered very unlikely due to the MCR layout and continuous occupancy.

An assessment of the impact to CDF, LERF, ΔCDF, and ΔLERF was performed by developing transient scenarios for potential fires located at the MCB and MCR electrical cabinet "pinch points." It was assumed for these scenarios that all PRA components in the exposed panels fail. Seven transient fire scenarios were developed.

The following table provides the impact on the PRA of this assessment:

Risk without MCR Transient Fire Scenarios (/yr)		**Risk with MCR Transient Fire Scenarios (/yr)**	
Total CDF	4.77E-05	Total CDF	4.91E-05
Total LERF	8.71E-06	Total LERF	1.00E-05
ΔCDF	-1.18E-05	ΔCDF	-1.18E-05
ΔLERF	-1.48E-05	ΔLERF	-1.48E-05

The assessment incorporated corrections made to the fire PRA model after LAR submittal for several scenarios in Fire Area TB-A and the correction of the human failure event inconsistencies discussed in the response to PRA RAI-16e. The results of this assessment indicate a small change to total CDF/LERF, and no change in delta risk.

Request: PRA RAI-12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, and 34

NPPD Response:

These RAIs were addressed in the 60-day and 90-day responses.

Radioactive Release (RR)

Request: RR RAI 01, 02, and 03

NPPD Response:

These RAIs were addressed in the 60-day and 90-day responses.

Monitoring Program

Request: Monitoring Program RAI 01, 02, 03, 04, and 05

NPPD Response:

These RAIs were addressed in the 60-day response.

Programmatic

Request: Programmatic RAI 01, 02, 03, 04, 05, 06, and 07

NPPD Response:

These RAIs were addressed in the 60-day response.

Fire Modeling

Request: Fire Modeling RAI 01 and 02a

NPPD Response:

These RAIs were addressed in the 60-day and 90-day responses.

Request: Fire Modeling RAI 02 (continued)

Section 4.5.1.2, "Fire PRA" of the Transition Report states that fire modeling was performed as part of the Fire PRA development (NFPA 805, Section 4.2.4.2). Reference is made to Attachment J, "Fire Modeling V&V," for a discussion of the verification and validation (V&V) of the fire models that were used. Furthermore, Section 4.7.3, "Compliance with Quality Requirements in Section 2.7.3 of NFPA 805," of the Transition Report states that "Calculational models and numerical methods used in support of compliance with 10 CFR 50.48(c) were verified and validated as required by Section 2.7.3.2 of NFPA 805."

Regarding the V&V of fire models:

b. *For V&V of the aforementioned algebraic models, reference is made to NUREG-1824, "Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications." Please provide technical details to demonstrate that the algebraic models have been applied within the validated range of input parameters, or to justify the application of the equations outside the validated range reported in NUREG-1824.*

NPPD Response:

b. In most cases, the Detailed Fire Modeling Workbooks have been applied within the validated range reported in NUREG-1824. In cases where the models have been applied outside the validated range reported in NUREG-1824, these have been justified as acceptable, either by qualitative analysis, or by quantitative sensitivity analysis. Technical details demonstrating the models are within range, as well as any justification of models outside the range, are documented below:

Validation of NUREG-1805 Fire Dynamics Tool (FDT) Models

The following NUREG-1805 fire models were used at Cooper Nuclear Station (CNS):

- Flame Height (Method of Heskestad)
- Plume Centerline Temperature (Method of Heskestad)
- Radiant Heat Flux (Point Source Method)
- Hot Gas Layer (Method of MQH)
- Hot Gas Layer (Method of Beyler)
- Hot Gas Layer (Method of Foot, Pagni and Alvares [FPA])
- Ceiling Jet Temperature (Method of Alpert)
- Smoke Detection Actuation Correlation (Method of Heskestad and Delichatsios)
- Fixed Temperature Heat Detection Response Time Correlation
- Sprinkler Response Time Correlation

To demonstrate that the analyses using the Detailed Fire Modeling Workbooks (based on the NUREG-1805 FDTs) were performed within the validated range of NUREG-1824, as shown in Table 2-4 and 2-5 of the aforementioned document, a discussion is provided below to analyze each relevant normalized parameter. The parameters below, where applicable, show that these models were used within the range of its validity as described in NUREG-1824, or the use of the models outside the verification and validation range is justified.

Fire Froude Number

1) Within the validated range (0.4-2.4):

   a. 211 kW Fixed Source: The calculated Fire Froude Number for a typical 211 kW fixed source electrical fire postulated at CNS using a fire diameter of 0.57 meters is 0.76. This calculated value is within the validated range of NUREG-1824.

   b. 317 kW Transient Source: The calculated Fire Froude Number for a 317 kW transient fire postulated at CNS using a fire diameter of 0.69 meters is 0.73. This calculated value is within the validated range of NUREG-1824.

2) Below the validated range (<0.4):

   a. The Fire Froude Number is predominately used to validate the use of a model to calculate plume temperatures and flame heights of a given fire scenario (NUREG-1934, "Nuclear Power Plant Fire Modeling Analysis Guidelines (NPP FIRE MAG)," November 2012, Section 2.3.7.1). For fires below the validation range, the plume temperature and flame height may be under-predicted. At CNS, fixed ignition sources using a 69 kW heat release rate (HRR), 75th percentile HRR (142 kW) transient fires, and transient fires modeled as 69 kW fires, result in Fire Froude Numbers below the validated range. Conservatisms have been identified for these cases, including the screening criteria used with respect to damage temperatures and heat fluxes (i.e., 330°C temperature damage and 11 kW/m^2 heat flux damage):

      i. 69 kW Fixed Source: A 69 kW fire with a fire area of 2.78 ft^2 yields a Fire Froude Number slightly below the validated range. To calculate a Fire Froude Number that is within the validated range, the fire area can be decreased. For a 69 kW fire, the fire area must be less than or equal to 1.89 ft^2 to be within the validated range. Decreasing the fire area to 1.89 ft^2 results in an 11% (4.1 inch) increase in the plume zone of influence (ZOI) and a 15% (4.1 inch) increase in flame height.

      To compensate for this increase, safety margin is built into the plume calculation by utilizing a 0.7 convective HRR fraction. The recommended value for convective HRR fraction is between 0.6 and 0.65 per the Society of Fire Protection Engineers (SFPE) Handbook of Fire Protection Engineering. Calculating the plume ZOI with a 0.6 convective HRR fraction using FDT 09 reduces the plume ZOI by 6.6% (2.4 inches).

      The 69 kW fixed ignition source fires that employed the plume ZOI or flame height correlations were, in all cases, transformers, motors, and small electrical panels such as distribution panels and switches containing limited quantities of cable insulation. The 69 kW fire is the 98th percentile HRR from

NUREG/CR-6850 for the transformers and motors, and the 75th percentile fire for electrical panels. This is considered a conservative HRR for these ignition sources and provides safety margin. Additional safety margin is provided in scenarios of this type by selecting the fire elevation as the top of the ignition source. This is considered conservative, since the combustion process will occur where the fuel mixes with oxygen, which is not always at the top of the highest vent. Furthermore, conservative screening damage criteria were used with respect to damage temperatures and heat fluxes (i.e., 330°C temperature damage and 11 kW/m^2 heat flux damage). The multiple sources of safety margin are significant enough to offset the possible 4.1 inch under-prediction resulting from analyzing a fire outside the validation range for the Fire Froude Number parameter.

ii. 142 kW Transient Fire: Transient fires in Fire Zones 8B, 8C, 8E, 8F, 8G and 8H, analyze a 142 kW fire with a fire area of 4.0 ft^2, which yields a Fire Froude Number slightly below the validated range. To calculate a Fire Froude Number that is within the validated range, the fire area can be decreased. For a 142 kW fire, the fire area must be less than or equal to 3.36 ft^2 to be within the validated range. Decreasing the fire area to 3.36 ft^2 results in a 4.4% (2.3 inch) increase in the plume ZOI and a 6.1% (2.4 inch) increase in flame height.

To compensate for this increase, safety margin is built into the plume calculation by utilizing a 0.7 convective HRR fraction. The recommended value for convective HRR fraction is between 0.6 and 0.65 per the SFPE Handbook of Fire Protection Engineering. Calculating the plume ZOI with a 0.6 convective HRR fraction using FDT 09 reduces the plume ZOI used in the fire modeling by 6.5% (3.4 inches). Therefore, using a convective HRR fraction of 0.7 provides 6.5% margin of safety in the output to the plume ZOI calculation, enough to compensate for an increase of 4% when the Fire Froude Number is brought into the validated range.

Additional safety margin is provided in scenarios of this type by selecting a fire elevation as 2.0 ft above the fixed floor when many transient fires occur at floor level. The safety margin with respect to fire elevation alone is sufficient to compensate for a 2.4 inch increase in plume or flame ZOI. Another item adding to the safety margin for transient fires is the use of a large bounding transient zone that assumes all targets within its ZOI are affected by a fire. Time to damage is calculated based on the most severe (closest) target. This is considered conservative, since a transient fire would actually have a much smaller ZOI and varying damage times. Further safety margin is provided by using screening criteria with respect to damage temperatures and heat fluxes (i.e., 330°C temperature damage and 11 kW/m^2 heat flux damage). The multiple sources of safety margin are significant enough to offset the possible

under-prediction of 2.4 inches resulting from analyzing a fire outside the validation range for the Fire Froude Number parameter.

iii. 69 kW Transient Source: Transient fires in Fire Zones 8A and 9A analyze a 69 kW fire with a fire area of 4.0 ft^2, which yields a Fire Froude Number slightly below the validated range. To calculate a Fire Froude Number that is within the validated range, the fire area can be decreased. For a 69 kW fire, the fire area must be less than or equal to 1.89 ft^2 to be within the validated range. Decreasing the fire area to 1.89 ft^2 results in a 27% (8.6 inch) increase in the plume ZOI and a 38% (8.6 inch) increase in flame height.

To compensate for this increase, safety margin is built into the plume calculation by utilizing a 0.7 convective HRR fraction. The recommended value for convective HRR fraction is between 0.6 and 0.65 per the SFPE Handbook of Fire Protection Engineering. Calculating the plume ZOI with a 0.6 convective HRR fraction using FDT 09 reduces the plume ZOI used in the fire modeling by 7.9% (2.5 inches).

Added safety margin is provided in scenarios of this type by selecting a fire elevation at 2.0 ft above the fixed floor when many transient fires occur at floor level. The safety margin with respect to fire elevation alone is sufficient to compensate for an 8.6 inch increase in plume or flame ZOI. Another item adding to the safety margin for transient fires is the use of a large bounding transient zone that assumes all targets within its ZOI are affected by a fire. Time to damage is calculated based on the most severe (closest) target. This is considered conservative, since a transient fire would actually have a much smaller ZOI and varying damage times. Further safety margin is provided by using screening criteria with respect to damage temperatures and heat fluxes (i.e., 330°C temperature damage and 11 kW/m^2 heat flux damage). The multiple sources of safety margin are significant enough to offset the possible under-prediction of 8.6 inches resulting from analyzing a fire outside the validation range for the Fire Froude Number parameter.

3) Above the validated range (>2.4):

a. Fires which propagate to secondary combustibles: For all fires that propagate to secondary combustibles, fire conditions are calculated assuming a nominal base area which is smaller than the area of the ignition source. This created a scenario where flames emanate from a small spot on top of the cabinet. The "base" serves as the area of the fire for the full duration of the fire scenario. This assumption results in a higher value for the Fire Froude Number than would be calculated if it were assumed that the fire burns over the actual surface area of the ignition source and associated secondary combustibles (e.g., cable trays or adjacent cabinet sections). The use of this approach results in a more severe fire plume and subsequently a conservative estimation of the ZOI for the fire conditions.

Therefore, a Fire Froude Number above the validated range leads to more conservative results.

Flame Length Relative to the Ceiling Height

The primary application of this parameter is to determine if the flame length exceeds the ceiling height. The fires at CNS are within the validated range of NUREG-1824 (0.2-1.0) or justified otherwise:

1) Below the validated range (<0.2): When the ratio of flame length relative to the ceiling height is less than 0.2, the flame length does not exceed the ceiling height. For models of this nature at CNS (i.e., small fires in fire zones with high ceilings) target impact sets are determined to fail based on plume temperatures, radiant heat, and hot gas layer (HGL) formation. These modes of failure are used in lieu of ceiling jet. The high ceiling mitigates any substantial ceiling jet from forming because, by nature of being below the validated range, a small fire is being considered:

   a. Plume temperatures and radiant heat: Failure of targets based on these criteria is considered regardless of ceiling height. Ceiling height does not factor into determining the plume or radiant heat ZOI and, therefore, use of this parameter below the validated range is justified.

   b. HGL formation: Although the HGL formation does consider ceiling height, by nature of being below the validated range, the fire being considered to calculate the ratio is not large enough to create a damaging HGL.

2) Above the validated range (>1.0): NUREG-1934, states that if the HGL temperature is not a significant source of heat flux to a target, then the significance of this parameter could decrease in the case of a target temperature calculation, provided the target distance is within the validated parameter space (i.e. not too close). For fire modeling at CNS, the HGL is not a significant source of heat flux to targets. Heat fluxes to determine target impacts are calculated using the point source model. The radiant heat flux ZOI calculated using this point source model extends horizontally further than the flame length extends horizontally on the ceiling. This ZOI calculated using the point source model was applied to determine target damage from the floor to the top of the flame. Because the horizontal ZOI calculated by the point source model extends further than the flames on the ceiling for fire scenarios at CNS, using the point source model bounds the potential for heat flux emanating from an HGL affecting a target set.

Ceiling Jet Radial Distance Relative to the Ceiling Height

Ceiling jet temperature and velocity correlations use this ratio to express the horizontal distance from a target to the plume. Most of the ratio's applications include determination of time to detection and sprinkler activation in which the ceiling jet

velocity is a sub-model in the analysis. At CNS, the Alpert ceiling jet correlation was used to calculate detection and suppression timing. Visual inspections were performed during fire modeling walkdowns to ensure that this correlation was applied for detection and suppression timing when there were no major obstructions (e.g., beam pockets, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector or sprinkler being credited.

Detection activation times were calculated for a number of fire scenarios using FDT 10 of NUREG-1805. The FDT 10 calculation uses the Alpert ceiling jet correlation in addition to a correlation that accounts for the time required for the detector to respond. The ceiling jet velocity is a sub-model in the analysis.

The ceiling jet correlation is valid for an r/H value in the range of 1.2 to 1.7 in NUREG-1824. Consistent with NUREG-1805, the "r" value is the radial distance to the detector, while "H" is the height of the ceiling above the top of the fuel source (i.e., the fire elevation). NUREG-1934 cautions that the ceiling jet application must be carefully evaluated in commercial nuclear power plants for possible obstructions near the ceiling (e.g., cable trays, HVAC ducts, piping, etc.) that may disrupt the ceiling jet and invalidate the model. Otherwise, NUREG-1934 suggests a sensitivity analysis may be performed by moving the fire location to distances that fall within the validated range. However, the guidance in NUREG-1934 acknowledges that this may not be possible in certain fire scenarios involving fixed ignition sources or critical target locations.

For detection activation, Heskestad and Delichatsios determined that an increase in temperature of 10°C (18°F) above ambient temperature corresponded to a significant enough increase in optical density to cause smoke detector activation. The method of Alpert is used to determine the temperature within the ceiling jet. The temperature to smoke obscuration correlation is discussed and detailed within Chapter 4-1 of the 4th edition of the SFPE Handbook of Fire Protection Engineering, NUREG-1805, Chapter 11, as well as NUREG-1934, Appendix B. The correlation was used within the following limitations:

- The fires analyzed are steady state.
- The forced ventilation system is not considered when calculating detection times using this method.
- Walkdowns were performed to ensure that the overhead area is not highly obstructed.
- The correlation was applied when detectors are located at or very near to ceiling. Very near to the ceiling included code compliant detectors mounted on the bottom flange of structural steel beams, where applicable. This method is not applied to detectors mounted well below the ceiling in free air.

The table below presents the ceiling jet radial distance relative to the ceiling height normalized parameter for each scenario that employs the NUREG-1805 FDT 10 detection correlation. The parameter, where applicable, shows that the correlation was

used within the range of its validity (1.2-1.7) as described in NUREG-1824, or the use of the correlation outside of the verification and validation range is justified.

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
RB	1A	CS-P-A (Large Oil)	6	22	0.3	The ratios calculated for the scenarios in Fire Zone 1A are below the validated range. However, detection activation time is not critical to the analyses. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in these scenarios and further evaluation is not required.
RB	1A	CS-P-A (Small Oil)	6	22	0.3	
RB	1A	CS-P-A (Electrical)	6	12.42	0.5	
RB	1A	RCIC-TU-TURB (Large Oil)	3	22	0.1	
RB	1A	RCIC-TU-TURB (Small Oil)	3	22	0.1	
RB	1A	RCIC-TU-TURB (Electrical)	3	16.09	0.2	
RB	1A	Transient	8	20	0.4	
RB	1B	CS-P-B (Large Oil)	6	22	0.3	The ratios calculated for the scenarios in Fire Zone 1B are below the validated range. However, detection activation time is not critical to the analyses. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in these scenarios and further evaluation is not required.
RB	1B	CS-P-B (Small Oil)	6	22	0.3	
RB	1B	CS-P-B (Electrical)	6	12.25	0.5	
RB	1D	RHR-P-B (Large Oil)	6	22	0.3	The ratios calculated for the scenarios in Fire Zone 1D are below the validated range. However, detection activation time is not critical to the analyses. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in these scenarios and further evaluation is not required.
RB	1D	RHR-P-B (Small Oil)	6	22	0.3	
RB	1D	RHR-P-B (Electrical)	6	12.42	0.5	
RB	1D	RHR-P-D (Large Oil)	6	22	0.3	
RB	1D	RHR-P-D (Small Oil)	6	22	0.3	
RB	1D	RHR-P-D (Electrical)	6	12.42	0.5	
RB	1D	Transient	8	20	0.4	
RB	1G	CRD-P-A, -B (Large Oil)	11.6	21.8	0.5	The ratios calculated for the scenarios in Fire Zone 1G are below the validated range. However, detection activation time is not critical to the analyses. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in these scenarios and further evaluation is not required.
RB	1G	CRD-P-A, -B (Small Oil)	11.6	21.8	0.5	
RB	1G	CRD-P-A, -B (Electrical)	11.6	17.9	0.6	
RB	2C	HPI-CS-RB3	16.5	20.2	0.8	The ratio calculated for Scenario HPI-CS-RB3 in Fire Zone 2C is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
RB-J	3A	EE-SWGR-4160F (15a)	6	8	0.8	Scenario EE-SWGR-4160F (15a) in Fire Zone 3A falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 6 feet and the vertical distance measuring 8 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
						of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.
RB-J	3A	EE-SWGR-4160F (15b) HEAF	6	8	0.8	The ratio calculated for Scenario EE-SWGR-4160F (15b) HEAF in Fire Zone 3A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
RB-J	3A	EE-SWGR-480F (15a)	5.33	8	0.7	The ratio calculated for Scenario EE-SWGR-480F (15a) in Fire Zone 3A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
RB-J	3A	EE-SWGR-480F (15b) HEAF	5.33	8	0.7	The ratio calculated for Scenario EE-SWGR-480F (15b) HEAF in Fire Zone 3A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
RB-J	3A	EE-XFMR-480F	5.33	8	0.7	Scenario EE-XFMR-480F in Fire Zone 3A falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 5.33 feet and the vertical distance measuring 8 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.
RB-J	3A	Transient	15	14	1.1	The transient scenarios in Fire Zone 3A fall below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, the worst case (i.e., farthest unoccupied floor area from the detector) transient fire location was used to calculate detection time. A horizontal distance (r) measuring 15 feet and a vertical distance measuring 14 feet was conservatively assumed for all transient scenarios. Considering the horizontal distance will be closer to the detector than the assumed 15 feet, the calculated time to detection is conservative for the transient scenarios. Due to proximity of the detectors to the transient fire crediting detection and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H values are slightly below the validated range.

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
RB-K	3B	EE-SWGR-4160G (15a)	6	8	0.8	*Scenario EE-SWGR-4160G (15a) in Fire Zone 3B* falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 6 feet and the vertical distance measuring 8 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.
RB-K	3B	EE-SWGR-4160G (15b) HEAF	6	8	0.8	The ratio calculated for Scenario EE-SWGR-4160G (15b) HEAF in Fire Zone 3B is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
RB-K	3B	EE-SWGR-480G (15a)	5.33	8	0.7	Scenario EE-SWGR-480G (15a) in Fire Zone 3B falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 5.33 feet and the vertical distance measuring 8 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.
RB-K	3B	EE-SWGR-480G (15b) HEAF	5.33	8	0.7	The ratio calculated for Scenario EE-SWGR-480G (15b) HEAF in Fire Zone 3B is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
RB-K	3B	EE-XFMR-480G	5.33	8	0.7	The ratio calculated for Scenario EE-XFMR-480G in Fire Zone 3B is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
RB-K	3B	Transient	15	14	1.1	The ratio calculated for the transient scenarios in Fire Zone 3B is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the transient scenarios and further evaluation is not required.

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
RB	3C	Transient	20	24	0.8	The ratios calculated for the transient scenarios in Fire Zone 3C are below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the transient scenarios and further evaluation is not required.
RB	4C	RWCU-P-PP (Large Oil)	10.8	18	0.6	The ratios calculated for the scenarios in Fire Zone 4C are below the validated range. However, detection activation time is not critical to the analyses. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in these scenarios and further evaluation is not required.
RB	4C	RWCU-P-PP (Small Oil)	10.8	18	0.6	
RB	4C	RWCU-P-PP (Electrical)	10.8	15.5	0.7	
RB	4D	RRLO-P-A1,A2,A3,B1,B2,B3 (Large Oil)	10	18	0.6	The ratios calculated for the fixed ignition source scenarios in Fire Zone 4D are below the validated range. However, detection activation time is not critical to the analyses. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in these scenarios and further evaluation is not required.
RB	4D	RRLO-P-A1,A2,A3,B1,B2,B3 (Small Oil)	10	18	0.6	
RB	4D	RRLO-P-A1,A2,A3,B1,B2,B3 (Electrical)	10	18	0.6	
RB	4D	Transient	16	16	1.0	The transient scenarios in Fire Zone 4D fall below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, the worst case (i.e., farthest unoccupied floor area from the detector) transient fire location was used to calculate detection time. A horizontal distance (r) measuring 16 feet and a vertical distance measuring 16 feet was conservatively assumed for all transient scenarios. Considering the largest horizontal distance a transient impacting FPRA components could occur is approximately 10 feet for the detector, the calculated time to detection is conservative. Due to close proximity of the detector to the transient fires crediting detection and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H values are slightly below the validated range.
RB	5B	LRP-PNL-02-184-A	8.75	4.25	2.1	The ratio calculated for Scenario LRP-PNL-02-184-A in Fire Zone 5B is above the validated range. Automatic detection timing was calculated, however, only automatic suppression timing is critical to the analysis and the smoke detection system is not credited to prevent damage to any targets in the scenario. Further evaluation is not required.
RB	5B	LRP-PNL-02-184-B	33.4	4.25	7.9	The ratio calculated for Scenario LRP-PNL-02-184-B in Fire Zone 5B is above the validated range. Automatic detection timing was calculated, however, only automatic suppression timing is critical to the analysis and the smoke detection system is not credited to prevent damage to any targets in the scenario. Further evaluation is not required.

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
RB	5B	LRP-RACK-LIR-HV-R-FP	26	6	4.3	The ratio calculated for Scenario LRP-RACK-LIR-HV-R-FP in Fire Zone 5B is above the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
RB	5B	RMV-RM-3	20	6.58	3.0	The ratio calculated for Scenario RMV-RM-3 in Fire Zone 5B is above the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
RB	5B	RRMG-GEN-MGA (Large Oil)	0	13.7	0.0	The ratios calculated for Scenario RRMG-GEN-MGA in Fire Zone 5B are below the validated range. Automatic detection timing was calculated, however, only automatic suppression timing is critical to the analysis and the smoke detection system is not credited to prevent damage to any targets in the scenario. Further evaluation is not required.
RB	5B	RRMG-GEN-MGA (Small Oil)	0	13.7	0.0	
RB	5B	RRMG-GEN-MGA (Electrical)	0	3.83	0.0	
RB	5B	RRMG-GEN-MGB (Large Oil)	8.75	12.7	0.7	The ratios calculated for Scenario RRMG-GEN-MGB in Fire Zone 5B are outside the validated range. Automatic detection timing was calculated, however, only automatic suppression timing is critical to the analysis and the smoke detection system is not credited to prevent damage to any targets in the scenario. Further evaluation is not required.
RB	5B	RRMG-GEN-MGB (Small Oil)	8.75	12.7	0.7	
RB	5B	RRMG-GEN-MGB (Electrical)	8.75	2.87	3.0	
RB	5B	Transient	16.7	23	0.7	The transient scenarios in Fire Zone 5B fall below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, the worst case (i.e., farthest unoccupied floor area from the detector) transient fire location was used to calculate detection time. A horizontal distance (r) measuring 16.7 feet and a vertical distance measuring 23 feet was conservatively assumed for all transient scenarios. Considering the horizontal distance will be closer to the detector than the assumed 16.7 feet, the calculated time to detection is conservative for the transient scenarios. Due to proximity (detection is provided directly above Transient Scenario 5) of the detector to the transient fire crediting detection and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H values are slightly below the validated range.
CB-A	7A	SA-CPSR-A (Large Oil)	20	20.25	1.0	The ratios calculated for the scenarios in Fire Zone 7A are below the validated range. However, detection activation time is not critical to the analyses. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in these scenarios and further evaluation is not required.
CB-A	7A	SA-CPSR-A (Small Oil)	20	20.25	1.0	
CB-A	7A	SA-CPSR-B (Large Oil)	20	20.25	1.0	
CB-A	7A	SA-CPSR-B (Small Oil)	20	20.25	1.0	
CB-A	7A	SA-CPSR-C (Large Oil)	20	20.25	1.0	

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
CB-A	7A	SA-CPSR-C (Small Oil)	20	20.25	1.0	
CB-A	7A	SW-P-BPA (Large Oil)	16.33	20.25	0.8	
CB-A	7A	SW-P-BPA (Small Oil)	16.33	20.25	0.8	
CB-A	7A	SW-P-BPA (Electrical)	16.33	15.17	1.1	
CB-A	7A	SW-P-BPB (Large Oil)	16.33	20.25	0.8	
CB-A	7A	SW-P-BPB (Small Oil)	16.33	20.25	0.8	
CB-A	7A	SW-P-BPB (Electrical)	16.33	15.17	1.1	
CB-A	7A	SW-P-BPC (Large Oil)	16.33	20.25	0.8	
CB-A	7A	SW-P-BPC (Small Oil)	16.33	20.25	0.8	
CB-A	7A	SW-P-BPC (Electrical)	16.33	15.17	1.1	
CB-A	7A	SW-P-BPD (Large Oil)	16.33	20.25	0.8	
CB-A	7A	SW-P-BPD (Small Oil)	16.33	20.25	0.8	
CB-A	7A	SW-P-BPD (Electrical)	16.33	15.17	1.1	
CB-A	7A	Transient	15	18	0.8	
CB-G	8A	LRP-PNL-C22	5.2	6.5	0.8	Scenario LRP-PNL-C22 in Fire Zone 8A falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 5.2 feet and the vertical distance measuring 6.5 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.
CB-C	8B	RPS-CC-RPSB	5.75	5.2	1.1	Scenario RPS-CC-RPSB in Fire Zone 8B falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 5.75 feet and the vertical distance measuring 5.2 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.
CB-C	8B	Transient	15	11	1.4	The calculated normalized parameter for this scenario is within the validated range.

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
CB-A	8C	RPS-CC-RPSA	5.75	5.2	1.1	Scenario RPS-CC-RPSA in Fire Zone 8C falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 5.75 feet and the vertical distance measuring 5.2 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.
CB-A	8C	Transient	11.3	11	1.0	The ratios calculated for the transient scenarios in Fire Zone 8C are below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the transient scenarios and further evaluation is not required.
CB-A	8D	EE-CHG-125 1C	7.6	6.1	1.2	The calculated normalized parameter for this scenario is within the validated range.
CB-A	8D	Transient	16	11	1.5	The calculated normalized parameter for this scenario is within the validated range.
CB-A-1	8E	EE-BAT-125 1A	6.58	8.75	0.8	Scenario EE-BAT-125 1A in Fire Zone 8E falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 6.58 feet and the vertical distance measuring 8.75 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.
CB-A-1	8E	EE-BAT-250 1A	8	8.75	0.9	The ratio calculated for Scenario EE-BAT-250 1A in Fire Zone 8E is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
CB-A-1	8E	EE-PNL-A	10	6.75	1.5	The calculated normalized parameter for this scenario is within the validated range.
CB-A-1	8E	EE-PNL-AA2	9	6.75	1.3	The calculated normalized parameter for this scenario is within the validated range.

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
CB-A-1	8E	EE-SW-A	11	6.08	1.8	Scenario EE-SW-A in Fire Zone 8E exceeds the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring 11 feet and the vertical distance measuring only 6.08 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly above the validated range.
CB-A-1	8E	Transient	24	11	2.2	The ratios calculated for the transient scenarios in Fire Zone 8E are above the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the transient scenarios and further evaluation is not required.
CB-B	8F	EE-BAT-125 1B Rack 1	6.58	8.75	0.8	Scenario EE-BAT-125 1B Rack 1 in Fire Zone 8F falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 6.58 feet and the vertical distance measuring 8.75 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.
CB-B	8F	EE-BAT-125 1B Rack 2	0.58	8.75	0.1	Scenario EE-BAT-125 1B Rack 2 in Fire Zone 8F falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 0.58 feet and the vertical distance measuring 8.75 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is below the validated range.
CB-B	8F	EE-BAT-250 1B Rack 1	8	8.75	0.9	The ratio calculated for Scenario EE-BAT-250 1B Rack 1 in Fire Zone 8F is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
CB-B	8F	EE-BAT-250 1B Rack 2	1	8.75	0.1	The ratio calculated for Scenario EE-BAT-250 1B Rack 2 in Fire Zone 8F is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
CB-B	8F	EE-PNL-B	10	6.75	1.5	The calculated normalized parameter for this scenario is within the validated range.
CB-B	8F	EE-PNL-BB2	9	6.75	1.3	The calculated normalized parameter for this scenario is within the validated range.
CB-B	8F	EE-SW-B	11	6.08	1.8	Scenario EE-SW-B in Fire Zone 8F exceeds the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring 11 feet and the vertical distance measuring only 6.08 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly above the validated range.
CB-B	8F	Transient	24	11	2.2	The ratios calculated for the transient scenarios in Fire Zone 8F are above the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the transient scenarios and further evaluation is not required.
CB-B	8G	EE-CHG-125 1B	5.167	6.167	0.8	Scenario EE-CHG-125 1B in Fire Zone 8G falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 5.17 feet and the vertical distance measuring 6.17 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.
CB-B	8G	EE-CHG-250 1B	6.25	6.2	1.0	Scenario EE-CHG-250 1B in Fire Zone 8G falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 6.25 feet and the vertical distance measuring 6.2 feet. Considering the close proximity of the detector to

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
						the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.
CB-B	8G	EE-SWGR-125 1B	1.75	4.2	0.4	Scenario EE-SWGR-125 1B in Fire Zone 8G falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 1.75 feet and the vertical distance measuring 4.2 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is below the validated range.
CB-B	8G	EE-SWGR-250 1B	1.75	4.2	0.4	Scenario EE-SWGR-250 1B in Fire Zone 8G falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 1.75 feet and the vertical distance measuring 4.2 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is below the validated range.
CB-B	8G	Transient	8.75	11	0.8	The ratios calculated for the transient scenarios in Fire Zone 8G are below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the transient scenarios and further evaluation is not required.
CB-A-1	8H	EE-CHG-125 1A	5.17	6.2	0.8	Scenario EE-CHG-125 1A in Fire Zone 8H falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 5.17 feet and the vertical distance measuring 6.2 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
CB-A-1	8H	EE-CHG-250 1A	6.25	6.2	1.0	Scenario EE-CHG-250 1A in Fire Zone 8H falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 6.25 feet and the vertical distance measuring 6.2 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.
CB-A-1	8H	EE-IVTR-1A	4	6.2	0.6	Scenario EE-IVTR-1A in Fire Zone 8H falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 4 feet and the vertical distance measuring 6.2 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is below the validated range.
CB-A-1	8H	EE-SWGR-125 1A	1.75	4.2	0.4	Scenario EE-SWGR-125 1A in Fire Zone 8H falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 1.75 feet and the vertical distance measuring 4.2 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is below the validated range.
CB-A-1	8H	EE-SWGR-250 1A	1.75	4.2	0.4	Scenario EE-SWGR-250 1A in Fire Zone 8H falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 1.75 feet and the vertical distance measuring 4.2 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
						configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is below the validated range.
CB-A-1	8H	Transient	8.75	11	0.8	The ratios calculated for the transient scenarios in Fire Zone 8H are below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the transient scenarios and further evaluation is not required.
CB-E	9A	EE-PNL-CPP	9	5.83	1.5	The calculated normalized parameter for this scenario is within the validated range.
CB-E	9A	EE-PNL-NBPP	8	5.83	1.4	The calculated normalized parameter for this scenario is within the validated range.
CB-E	9A	EE-PNL-RPSPP1A	4	5.83	0.7	Scenario EE-PNL-RPSPP1A in Fire Zone 9A falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 4 feet and the vertical distance measuring 5.83 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is below the validated range.
CB-E	9A	EE-PNL-RPSPP1B	10	5.83	1.7	The calculated normalized parameter for this scenario is within the validated range.
CB-E	9A	LRP-PNL-PL1	4.83	6.67	0.7	The ratio calculated for Scenario LRP-PNL-PL1 in Fire Zone 9A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
CB-E	9A	LRP-PNL-PL2	0.5	6.67	0.1	The ratio calculated for Scenario LRP-PNL-PL2 in Fire Zone 9A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
CB-E	9A	PC-CS-H2_O2I & O2II	5.92	7.33	0.8	Scenario PC-CS-H2_O2I & O2II in Fire Zone 9A falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 5.92 feet and the vertical distance measuring 7.33 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
CB-E	9A	PMIS-MUX-LNK2	12.67	7.83	1.6	The calculated normalized parameter for this scenario is within the validated range.
CB-E	9A	RFC-CC-1A & 1B	4.83	6.08	0.8	Scenario RFC-CC-1A & 1B in Fire Zone 9A falls below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, this ignition source is located in very close proximity to the credited device, with the horizontal distance (r) measuring only 4.83 feet and the vertical distance measuring 6.08 feet. Considering the close proximity of the detector to the fire and the lack of obstructions in the configuration, the use of the detector correlation in the fire model is appropriate even though the r/H value is slightly below the validated range.
CB-E	9A	SS-BAT-UPS2	14	8.75	1.6	The calculated normalized parameter for this scenario is within the validated range.
CB-E	9A	SS-IVTR-UPS2	14.58	8.75	1.7	The calculated normalized parameter for this scenario is within the validated range.
CB-E	9A	APARS BD	8.58	7.25	1.2	The calculated normalized parameter for this scenario is within the validated range.
CB-E	9A	TB-C324	9	7.83	1.1	The ratio calculated for Scenario TB-C324 in Fire Zone 9A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
CB-F	9B	Transient Scenario TS#1	5	11	0.5	The transient scenarios in Fire Zone 9B fall below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, the transient fires are located in very close proximity to the credited device, with the largest horizontal distance (r) measuring only 5 feet and the vertical distance measuring 11 feet. Considering the close proximity of the detector to the transient fires and the lack of obstructions in the configuration, the use of the detector correlation in the fire models is appropriate even though the r/H values are below the validated range.
CB-F	9B	Transient Scenario TS#2	5	11	0.5	
CB-F	9B	Transient Scenario TS#3	5	11	0.5	
TB-A	11B	CW-P-VPA (Large Oil)	2.48	20.5	0.1	The CW-P-VPA scenarios in Fire Zone 11B fall below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only
TB-A	11B	CW-P-VPA (Small Oil)	2.48	20.5	0.1	

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
TB-A	11B	CW-P-VPA (Electrical)	2.48	16	0.2	applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, CW-P-VPA is located in very close proximity to the credited device, with a horizontal distance (r) measuring only 2.48 feet and the largest vertical distance measuring 20.5 feet. Considering the close proximity of the detector to CW-P-VPA and the lack of obstructions in the configuration, the use of the detector correlation in the fire models is appropriate even though the r/H values are below the validated range.
TB-A	11B	CW-P-VPB (Large Oil)	6.58	20.5	0.3	The CW-P-VPB scenarios in Fire Zone 11B fall below the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, CW-P-VPB is located in very close proximity to the credited device, with a horizontal distance (r) measuring only 6.58 feet and the largest vertical distance measuring 20.5 feet. Considering the close proximity of the detector to CW-P-VPB and the lack of obstructions in the configuration, the use of the detector correlation in the fire models is appropriate even though the r/H values are below the validated range.
TB-A	11B	CW-P-VPB (Small Oil)	6.58	20.5	0.3	
TB-A	11B	CW-P-VPB (Electrical)	6.58	16	0.4	
NCS	13B	EE-SWGR-4160A (15a)	7.7	8	1.0	The ratios calculated for the scenarios in Fire Zone 13B are outside the validated range. However, detection activation time is not critical to the analyses. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in these scenarios and further evaluation is not required.
NCS	13B	EE-SWGR-4160A (15b) HEAF	7.7	8	1.0	
NCS	13B	EE-SWGR-4160B (15a)	1.93	8	0.2	
NCS	13B	EE-SWGR-4160B (15b) HEAF	1.93	8	0.2	
NCS	13B	EE-SWGR-4160C (15a)	11.55	8	1.4	The calculated normalized parameter for this scenario is within the validated range.
NCS	13B	EE-SWGR-4160C (15b) HEAF	11.55	8	1.4	The calculated normalized parameter for this scenario is within the validated range.
NCS	13B	EE-SWGR-4160D (15a)	8.47	8	1.1	The ratios calculated for the scenarios in Fire Zone 13B are outside the validated range. However, detection activation time is not critical to the analyses. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in these scenarios and further evaluation is not required.
NCS	13B	EE-SWGR-4160D (15b) HEAF	8.47	8	1.1	
NCS	13B	EE-SWGR-4160E (15a)	19.25	8	2.4	
NCS	13B	EE-SWGR-4160E (15b) HEAF	19.25	8	2.4	
NCS	13B	EE-SWGR-480A (15a)	3.85	8.5	0.5	
NCS	13B	EE-SWGR-480A (15b) HEAF	3.85	8.5	0.5	
NCS	13B	EE-SWGR-480B (15a)	7.7	8.5	0.9	
NCS	13B	EE-SWGR-480B (15b) HEAF	7.7	8.5	0.9	
NCS	13B	EE-XFMR-480A	3.85	8.5	0.5	
NCS	13B	EE-XMFR-480B	7.7	8.5	0.9	
NCS	13B	BAT CHRG-RECT	38.5	12	3.2	

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
NCS	13B	Transient	43	14	3.1	
TB-A	13C	Transient	24	14	1.7	The calculated normalized parameter for this scenario is within the validated range.
DG-A	14A	DG-D-1	1	14	0.1	The detection system is credited to prevent whole room damage only for the DG-D-1 (diesel/oil) scenarios. Therefore, the ceiling jet activation correlation was not used to calculate the detection activation time. The developing HGL would activate the detection system before it reached temperatures capable of causing whole room damage. The ratio calculated for Scenario DG-D-1 (Electrical) in Fire Zone 14A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-A	14A	DG-PNL-DG1 ECP	3.5	5.83	0.6	The ratio calculated for Scenario DG-PNL-DG1 ECP in Fire Zone 14A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-A	14A	DG-REL-DG1	3.5	5.67	0.6	The ratio calculated for Scenario DG-REL-DG1 in Fire Zone 14A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-A	14A	DG-VRG-DG1 (15a)	6	5.58	1.1	The ratio calculated for Scenario DG-VRG-DG1 (15a) in Fire Zone 14A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-A	14A	DG-VRG-DG1 (15b) HEAF	6	5.58	1.1	The ratio calculated for Scenario DG-VRG-DG1 (15b) HEAF in Fire Zone 14A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-A	14A	EE-SWGR-4160DG1 (15a)	5	5.58	0.9	The ratio calculated for Scenario EE-SWGR-4160DG1 (15a) in Fire Zone 14A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-A	14A	EE-SWGR-4160DG1 (15b) HEAF	6	8	0.8	The ratio calculated for Scenario EE-SWGR-4160DG1 (15b) HEAF in Fire Zone 14A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
DG-A	14A	LRP-RACK-LIR-HV-DG-A	1	8	0.1	The ratio calculated for Scenario LRP-RACK-LIR-HV-DG-A in Fire Zone 14A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-A	14A	LRP-RACK-LIR-HV-DG-C	1	8	0.1	The ratio calculated for Scenario LRP-RACK-LIR-HV-DG-C in Fire Zone 14A is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-B	14B	DG-D-2	1	14	0.1	The detection system is credited to prevent whole room damage only for the DG-D-2 (diesel/oil) scenarios. Therefore, the ceiling jet activation correlation was not used to calculate the detection activation time. The developing HGL would activate the detection system before it reached temperatures capable of causing whole room damage. The ratio calculated for Scenario DG-D-2 (Electrical) in Fire Zone 14B is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-B	14B	DG-PNL-DG2 ECP	3.5	5.83	0.6	The ratio calculated for Scenario DG-PNL-DG2 ECP in Fire Zone 14B is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-B	14B	DG-REL-DG2	3.5	5.67	0.6	The ratio calculated for Scenario DG-REL-DG2 in Fire Zone 14B is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-B	14B	DG-VRG-DG2 (15a)	6	5.58	1.1	The ratio calculated for Scenario DG-VRG-DG2 (15a) in Fire Zone 14B is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-B	14B	DG-VRG-DG2 (15b) HEAF	6	5.58	1.1	The ratio calculated for Scenario DG-VRG-DG2 (15b) HEAF in Fire Zone 14B is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-B	14B	EE-SWGR-4160DG2 (15a)	5	5.58	0.9	The ratio calculated for Scenario EE-SWGR-4160DG2 (15a) in Fire Zone 14B is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
DG-B	14B	EE-SWGR-4160DG2 (15b) HEAF	5	5.08	1.0	The ratio calculated for Scenario EE-SWGR-4160DG2 (15b) HEAF in Fire Zone 14B is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-B	14B	LRP-RACK-LIR-HV-DG-B	1	8	0.1	The ratio calculated for Scenario LRP-RACK-LIR-HV-DG-B in Fire Zone 14B is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
DG-B	14B	LRP-RACK-LIR-HV-DG-D	1	8	0.1	The ratio calculated for Scenario LRP-RACK-LIR-HV-DG-D in Fire Zone 14B is below the validated range. However, detection activation time is not critical to the analysis. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenario and further evaluation is not required.
IS-A	20A	FP-P-C (Large Oil)	20	14.8	1.4	The calculated normalized parameter for this scenario is within the validated range.
IS-A	20A	FP-P-C (Small Oil)	20	14.8	1.4	The calculated normalized parameter for this scenario is within the validated range.
IS-A	20A	FP-P-C (Electrical)	20	8.4	2.4	The ratio calculated for Scenario FP-P-C (Electrical) in Fire Zone 20A exceeds the validated range. However, detection activation time is not critical to the analysis for the electrical fire. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets for the electrical fire and further evaluation is not required.
IS-A	20A	HV-FCU-HV-IS-1A	10	7	1.4	The calculated normalized parameter for this scenario is within the validated range.
IS-A	20A	HV-FCU-HV-IS-1B	10	7	1.4	The calculated normalized parameter for this scenario is within the validated range.
IS-A	20A	LRP-PNL-S191	25	9.05	2.8	The ratios calculated for Scenarios LRP-PNL-S191 and LRP-PNL-S192 in Fire Zone 20A exceed the validated range. However, detection activation time is not critical to the analyses. Automatic detection timing was calculated, however, it is not credited to prevent damage to any targets in the scenarios and further evaluation is not required.
IS-A	20A	LRP-PNL-S192	20	9.05	2.2	
IS-A	20A	SW-P-A (Large Oil)	20	14.8	1.4	The calculated normalized parameter for this scenario is within the validated range.
IS-A	20A	SW-P-A (Small Oil)	20	14.8	1.4	The calculated normalized parameter for this scenario is within the validated range.
IS-A	20A	SW-P-A (Electrical)	20	6.3	3.2	Scenario SW-P-A (Electrical) in Fire Zone 20A exceeds the validated range. The detection system is credited to actuate the Halon system. Fire PRA target failures beyond the ignition source occur at 9.8 minutes for the electrical fire. In order for the normalized parameter to fall within the validated range, the height of the ceiling above the ignition source must be conservatively increased to 11.7 (r/H=1.7). Utilizing the revised ceiling height and FDT 10, a 105kW fire is required for smoke detection activation. The fire reaches 105kW at 8.5 minutes; therefore, time to automatic suppression is conservatively rounded up to 9.5 minutes. The Halon suppression system actuates prior to the target damage time of 9.8 minutes using

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
						the revised ceiling height and the scenario target failures and frequencies remain unchanged and valid.
IS-A	20A	SW-P-B (Large Oil)	12	14.8	0.8	The detection system is credited to prevent whole room damage only for the SW-P-B (oil) scenarios. Therefore, the developing HGL would activate the detection system before it reached temperatures capable of causing whole room damage and further evaluation is not required.
IS-A	20A	SW-P-B (Small Oil)	12	14.8	0.8	
IS-A	20A	SW-P-B (Electrical)	12	6.3	1.9	Scenario SW-P-B (Electrical) in Fire Zone 20A exceeds the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, SW-P-B is located in very close proximity to the credited device, with a horizontal distance (r) measuring 12 feet and the vertical distance measuring only 6.3 feet. Considering the close proximity of the detector to SW-P-B and the lack of obstructions in the configuration, the use of the detector correlation in the fire models is appropriate even though the r/H value exceeds the validated range.
IS-A	20A	SW-P-C (Large Oil)	12	14.8	0.8	The detection system is credited to prevent whole room damage only for the SW-P-C (oil) scenarios. Therefore, the developing HGL would activate the detection system before it reached temperatures capable of causing whole room damage and further evaluation is not required.
IS-A	20A	SW-P-C (Small Oil)	12	14.8	0.8	
IS-A	20A	SW-P-C (Electrical)	12	6.3	1.9	Scenario SW-P-C (Electrical) in Fire Zone 20A exceeds the validated range. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for detection timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the detector being credited. Additionally, SW-P-C is located in very close proximity to the credited device, with a horizontal distance (r) measuring 12 feet and the vertical distance measuring only 6.3 feet. Considering the close proximity of the detector to SW-P-C and the lack of obstructions in the configuration, the use of the detector correlation in the fire models is appropriate even though the r/H value exceeds the validated range.
IS-A	20A	SW-P-D (Large Oil)	20	14.8	1.4	The calculated normalized parameter for this scenario is within the validated range.
IS-A	20A	SW-P-D (Small Oil)	20	14.8	1.4	The calculated normalized parameter for this scenario is within the validated range.
IS-A	20A	SW-P-D (Electrical)	20	6.3	3.2	Scenario SW-P-D (Electrical) in Fire Zone 20A exceeds the validated range. The detection system is credited to actuate the Halon system. Fire PRA target failures beyond the ignition source occur at 12 minutes for the electrical fire. In order for the normalized parameter to fall within the validated range, the height of the ceiling above the ignition source must be conservatively increased to 11.7 (r/H=1.7). Utilizing the revised ceiling height and FDT 10, a 105kW fire is required for smoke detection activation. The fire reaches

Fire Compartment	Fire Zone	Ignition Source	r (ft)	H (ft)	r/H	Justification
						105kW at 8.5 minutes; therefore, time to automatic suppression is conservatively rounded up to 9.5 minutes. The Halon suppression system actuates prior to the target damage time of 9.8 minutes using the revised ceiling height and the scenario target failures and frequencies remain unchanged and valid.
IS-A	20A	Transient	17	12.8	1.3	The calculated normalized parameter for this scenario is within the validated range.

The Alpert ceiling jet correlation was also used for modeling sprinkler actuation at CNS, in addition to a correlation that accounts for the time required to heat the thermal link of the sprinkler. Refer to "Sprinkler Activation Correlation" below for detailed discussion on the use of the sprinkler activation correlation.

For other targets located in the ceiling jet, the radiant heat flux ZOI was calculated using the point source model. Using the point source model bounds the use of the ceiling jet correlation:

a. For fire zones at CNS with high ceilings: The radiant heat flux ZOI calculated using the point source model was applied to determine target damage from the floor to the top of the flame. Since the ceiling height is higher than the top of a flame, it is high enough that the ceiling jet ZOI is reduced to the approximate size of the plume radius. Within the plume radius, the plume temperatures lead to target damage.

b. For fire zones at CNS with low ceilings: The radiant heat flux ZOI calculated using this point source model extends horizontally further than the ceiling jet. This ZOI calculated using the point source model was applied to determine target damage from the floor to the ceiling. Because the horizontal ZOI calculated by the point source model extends further than the ceiling jet, the point source model is bounding.

For the following scenarios, the point source model used to calculate the radiant heat ZOI does not bound the ZOI caused by the ceiling jet. The scenarios are dispositioned as follows:

a. For the large oil fires in Fire Zones 4D, 5B, and 20A, and the large diesel fires in Fire Zones 14A and 14B, the ceiling jet radial distance relative to the ceiling height is not applicable to these fire scenarios because the fire scenarios do not consider failure to targets from the ceiling jet or radiant heat. Rather, all fire scenarios conservatively postulate whole room damage which bounds the ceiling jet and radiant heat ZOI.

Equivalence Ratio

This parameter is not applicable to fire modeling using the Detailed Fire Modeling Workbooks. The underlying consideration for this parameter is that conditions in the enclosure are not expected to be worse in a fire where the combustion process is affected

by lack of oxygen than they would be under fire conditions where the combustion process is assumed unaffected. This parameter is not applicable to fire modeling calculations using the Detailed Fire Modeling Workbooks (NUREG-1805 FDTs) because oxygen levels are not taken into account with the equations employed by these models. Therefore, the fire will not be limited by lack of oxygen.

Compartment Aspect Ratio

1) Within the validated range (0.6-5.7):

   a. Most room geometries for the fire zones at CNS where detailed fire modeling was performed are within the validated range of NUREG-1824 with respect to Compartment Aspect Ratio. For other rooms, a justification is provided below where the normalized parameter was outside of the validated range.

2) Below the validated range (<0.6):

   a. Sensitivity study: For fire zones having an aspect ratio below the validated range where detailed fire modeling was performed and whole room damage was not postulated, a sensitivity study was performed to determine the potential for HGL development with a compartment aspect ratio within the validated range. This approach is recommended by NUREG-1934. This study considered the impact of decreasing the height of the fire zones resulting in values that fall within the validation range. Reducing the height of the fire zones decreased the volume of the compartment and created more severe conditions than the actual fire zone configurations at CNS.

   b. All cables within the fire zones are of thermoset material; therefore, the target damage temperature is 330°C. The fire sizes presented in the table below were selected as the largest fire in the fire zone which did not create a HGL of 330°C in the current analysis (fires which create a HGL of 330°C in the current analysis already postulate whole room damage and bound any use of the HGL calculation tool outside of the validated range). The following fire scenarios were analyzed with aspect ratios within the validated range.

Fire Zone	Fire Size (kW)	HGL Temp - Modeled Fire Zone Dimensions (°C)	HGL Temp - Compliant Aspect Ratio (°C)
1A	772	182	184
1D	772	182	184

The results of the sensitivity study indicate that altering the fire zone geometries to bring the aspect ratio into the validation range does not cause either fire zone to reach a damaging (i.e., 330°C) HGL.

3) Above the validated range (>5.7): NUREG-1934 suggests that a large aspect ratio could lead to a misrepresentation of the HGL by the FDTs. The basis is when considering a very large room with vastly different dimensions, the HGL may not be uniformly distributed across the ceiling. Rather, hot spots can occur close to the fire scenario.

   a. Sensitivity study: For fire zones having an aspect ratio above the validated range where detailed fire modeling was performed and whole room damage was not postulated, a sensitivity study was performed to analyze the potential for HGL development in a fire zone with a compliant compartment aspect ratio. This approach is recommended by NUREG-1934. This study was done by decreasing the length or width of the fire zones to values that fall within the validation range. Reducing the length or width of the fire zones decreased the volume of the compartment and created more severe conditions than the actual fire zone configurations at CNS.

   b. All cables within the fire zones are of thermoset material; therefore, the target damage temperature is 330°C. The fire sizes presented in the table below were selected as the largest fire in the fire zone which did not create a HGL of 330°C in the current analysis (fires which create a HGL of 330°C in the current analysis already postulate whole room damage and bound any use of the HGL calculation tool outside of the validated range). The following fire scenarios were analyzed with aspect ratios within the validated range.

Fire Zone	Fire Size (kW)	HGL Temp - Modeled Fire Zone Dimensions (°C)	HGL Temp - Compliant Aspect Ratio (°C)
9A	1318	192	200
11F	317	97	139
13B	633	119	127

The results of the sensitivity study indicate that altering the fire zone geometries to bring the aspect ratios into the validation range does not cause any fire zone to reach a damaging (i.e., 330°C) HGL.

Radial Distance, *r*, relative to the Fire Diameter, *D*

Radiative heat flux was calculated using the point source radiation model found in the FDT 05.1 and FIVE fire models. Since the fire diameter is not an input to this correlation (i.e., Fuel Area set to 0 ft^2 in FDT 05.1), a sensitivity analysis is not possible and this normalized parameter is not applicable to the heat flux model used for fire modeling at CNS.

Sprinkler Activation Correlation

Sprinkler activation times were calculated for a number of fire scenarios at CNS using FDT 10 of NUREG-1805. The FDT 10 calculation uses the Alpert ceiling jet correlation in addition to a correlation that accounts for the time required to heat the thermal link of the sprinkler. The ceiling jet velocity is a sub-model in the analysis.

The ceiling jet correlation is valid for an r/H value in the range of 1.2 to 1.7 in NUREG-1824. Consistent with NUREG-1805, the "r" value is the radial distance to the sprinkler, while "H" is the height of the ceiling above the top of the fuel source (i.e., the fire elevation). NUREG-1934 cautions that the ceiling jet application must be carefully evaluated in commercial nuclear power plants for possible obstructions near the ceiling (e.g., cable trays, HVAC ducts, piping, etc.) that may disrupt the ceiling jet and invalidate the model. Otherwise, NUREG-1934 suggests a sensitivity analysis may be performed by moving the fire location to distances that fall within the validated range. However, the guidance in NUREG-1934 acknowledges that this may not be possible in certain fire scenarios involving fixed ignition sources or critical target locations.

The table below identifies each fire zone at CNS that employs the NUREG-1805 FDT 10 sprinkler activation correlation and the calculated r/H ratio for each scenario:

Fire Zone	Ignition Source	r (ft)	H (ft)	r/H
4D	RRLO-P-A1,A2,A3,B1,B2,B3 (Large Oil)	0	8.33	0
4D	RRLO-P-A1,A2,A3,B1,B2,B3 (Small Oil)	0	8.33	0
4D	RRLO-P-A1,A2,A3,B1,B2,B3 (Electrical)	0	5	0
5B	LRP-PNL-02-184-A	5	2	2.5
5B	LRP-PNL-02-184-B	9.1	2	4.55
5B	RRMG-GEN-MGA (Large Oil)	0	16	0
5B	RRMG-GEN-MGA (Small Oil)	0	16	0
5B	RRMG-GEN-MGA (Electrical)	0	6.2	0
5B	RRMG-GEN-MGB (Large Oil)	0	16	0
5B	RRMG-GEN-MGB (Small Oil)	0	16	0
5B	RRMG-GEN-MGB (Electrical)	0	6.17	0
8D	EE-CHG-125 1C	2.6	6.1	0.43
9A	EE-PNL-CPP	4	7.33	0.55
9A	EE-PNL-NBPP	4	7.33	0.55
9A	EE-PNL-RPSPP1A	6	7.33	0.82
9A	EE-PNL-RPSPP1B	5	7.33	0.68
9A	LRP-PNL-PL1	6.83	5	1.37
9A	LRP-PNL-PL2	0.5	5	0.1
9A	PC-CS-H2_O2I & O2II	5.25	6.83	0.77
9A	PMIS-MUX-LNK2	2.75	7	0.39

Fire Zone	Ignition Source	r (ft)	H (ft)	r/H
9A	RFC-CC-1A & 1B	3.33	7.58	0.44
9A	SS-BAT-UPS2	5.08	7.92	0.64
9A	SS-IVTR-UPS2	4.42	7.92	0.56
9A	APARS BD	3.17	6.42	0.49
9A	TB-C324	5	7	0.71
11B	CW-P-VPA (Large Oil)	7.75	20.5	0.38
11B	CW-P-VPB (Large Oil)	2.67	20.5	0.13

With the exception of Fire Scenario LRP-PNL-PL1 in Fire Zone 9A, all the configurations implement an r/H value outside of the validated range. The following discussions address each scenario, or set of scenarios, by either performing a sensitivity study or by providing justification for the use of the correlation outside of the validated range.

The ratios calculated for the ignition sources in Fire Zone 4D, Fire Zone 8D, and ignitions sources LRP-PNL-PL2, SS-BAT-UPS2, SS-IVTR-UPS2, and TB-C234 in Fire Zone 9A, are below the validated range. However, suppression activation time is not critical to the analyses. Automatic suppression timing was calculated, however, it is not credited to prevent damage to any targets in these scenarios and further evaluation is not required.

Fire scenarios RRMG-GEN-MGA and RRMG-GEN-MGB in Fire Zone 5B and Fire Scenarios CW-P-VPA and CW-P-VPB in Fire Zone 11B credit the automatic sprinkler systems to prevent whole room damage only. Therefore in each fire zone, the developing HGL would activate the automatic suppression system before it reached temperatures capable of causing whole room damage (330°C), and further analysis is not required.

Fire scenarios in Fire Zone 9A fall below the validated range. The guidance in NUREG-1934 does not define r/H values below the validated range as non-conservative with respect to suppression. Visual inspections were performed during fire modeling walkdowns to ensure that the ceiling jet correlation was only applied for suppression timing when there were no major obstructions (e.g., beam pockets, cable trays, HVAC ducts, piping, etc.) located in the ceiling jet between the plume and the sprinkler being credited. Additionally, these ignition sources are located in very close proximity to the sprinkler head being credited, with the largest horizontal distance (r) measuring only 6 feet and the greatest vertical distance measuring 7.6 feet. Considering the close proximity of the sprinkler to the fire, the conservatisms in the calculation and the lack of obstructions in the configurations, the use of the sprinkler correlation in these fire models is appropriate even though the r/H values are below the validated range.

Scenario LRP-PNL-02-184-A in Fire Zone 5B is above the recommended range. However, the calculated time of 2.9 minutes used in the fire model assumed a convective HRR fraction of 0.7. The Alpert Ceiling Jet correlation was verified and validated in

NUREG-1824 using the total HRR and not the convective portion. Using the total HRR, the time to suppression for this model would be 2.0 minutes. The margin provided by the additional 55 seconds to the suppression time ensures that the model is conservative. Additionally, the close proximity of the sprinkler to the fire, the conservatisms in the calculation, and the lack of obstructions in this configuration, the use of the sprinkler correlation in this fire model is appropriate even though the r/H values are not within the validated range.

Scenario LRP-PNL-02-184-B in Fire Zone 5B is above the recommended range. However, the calculated time of 3.0 minutes used in the fire model assumed a convective HRR fraction of 0.7. The Alpert Ceiling Jet correlation was verified and validated in NUREG-1824 using the total HRR and not the convective portion. Using the total HRR, the time to suppression for this model would be 2.2 minutes. The margin provided by the additional 48 seconds to the suppression time ensures that the model is conservative. Additionally, the close proximity of the sprinkler to the fire, the conservatisms in the calculation, and the lack of obstructions in this configuration, the use of the sprinkler correlation in this fire model is appropriate even though the r/H values are not within the validated range.

Gas Temperatures

The sprinkler activation time correlation used for fire modeling at CNS also includes a calculation for the time required to heat the sensing element of the suppression device from room temperature to operation temperature. Per page 3-141 of the 19th edition of the NFPA Fire Protection Handbook, it has been found that significant error for heat sensing element correlation can be found when the gas temperature does not substantially exceed the activation temperature of the heating element. In these cases, it is possible for small changes in predicted gas temperatures to result in large changes in predicted operation time. This effect may be important in the case of constant or slowly varying gas temperatures where:

$$(T_m - T_{operation})/(T_m - T_\infty) < 1/4$$

Where:

T_m = Gas temperature surrounding heat activation link

$T_{operation}$ = Activation temperature of link

T_∞ = Ambient temperature

Fire Zone	Ignition Source	T_m (°C)	$T_{operation}$ (°C)	T_∞ (°C)	$(T_m-T_{operation}) / (T_m-T_\infty)$	> 0.25
4D	RRLO-P-A1,A2,A3,B1,B2,B3 (Large Oil)	10046.8	74	40	1.00	Yes
4D	RRLO-P-A1,A2,A3,B1,B2,B3 (Small Oil)	340.98	74	40	0.89	Yes

Fire Zone	Ignition Source	T_m (°C)	$T_{operation}$ (°C)	T_∞ (°C)	$(T_m-T_{operation})/(T_m-T_\infty)$	≥ 0.25
4D	RRLO-P-A1,A2,A3,B1,B2,B3 (Electrical)	101.7	74	40	0.45	Yes
5B	LRP-PNL-02-184-A	117.5	74	40	0.56	Yes
5B	LRP-PNL-02-184-B	123	74	40	0.59	Yes
5B	RRMG-GEN-MGA (Large Oil)	15417.08	74	40	1.00	Yes
5B	RRMG-GEN-MGA (Small Oil)	141.4	74	40	0.66	Yes
5B	RRMG-GEN-MGA (Electrical)	96.5	74	40	0.40	Yes
5B	RRMG-GEN-MGB (Large Oil)	15417.08	74	40	1.00	Yes
5B	RRMG-GEN-MGB (Small Oil)	141.4	74	40	0.66	Yes
5B	RRMG-GEN-MGB (Electrical)	96.95	74	40	0.40	Yes
8D	EE-CHG-125 1C	111.65	74	29.4	0.46	Yes
9A	EE-PNL-CPP	144.46	74	25	0.59	Yes
9A	EE-PNL-NBPP	144.46	74	25	0.59	Yes
9A	EE-PNL-RPSPP1A	116.16	74	25	0.46	Yes
9A	EE-PNL-RPSPP1B	127.95	74	25	0.52	Yes
9A	LRP-PNL-PL1	101.74	74	25	0.36	Yes
9A	LRP-PNL-PL2	122.94	74	25	0.50	Yes
9A	PC-CS-H2_O2I & O2II	121.48	74	25	0.49	Yes
9A	PMIS-MUX-LNK2	95.91	74	25	0.31	Yes
9A	RFC-CC-1A & 1B	136	74	25	0.56	Yes
9A	SS-BAT-UPS2	84.02	74	25	0.17	No
9A	SS-IVTR-UPS2	89.75	74	25	0.24	No
9A	APARS BD	124.7	74	25	0.51	Yes
9A	TB-C324	92.48	74	25	0.27	Yes
11B	CW-P-VPA (Large Oil)	226.69	100	40	0.68	Yes
11B	CW-P-VPB (Large Oil)	346.62	100	40	0.80	Yes

The ratio calculated for all scenarios crediting suppression activation are within the acceptable range, with the exception of scenarios involving SS-BAT-UPS2 and SS-IVTR-UPS2. The ratio calculated for these two scenarios is slightly below the acceptable value of 0.25. Therefore, the effect of small changes in gas temperature in operation time must be considered. In the fire scenarios for SS-BAT-UPS2 and SS-IVTR-UPS2, however, suppression activation time is not critical to the analysis. Automatic suppression timing was calculated. However, it is not credited to prevent damage to any targets in these scenarios and further evaluation is not required. Considering the lack of criticality of the suppression timing and the fact that the calculated ratio is very near 0.25, the model is still considered appropriate.

Request: Fire Modeling RAI 02c, d, e, f, 03, 04, and 05

NPPD Response:

These RAIs were addressed in the 60-day and 90-day responses.