Nebraska Public Power District

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NLS2013016
February 12, 2013

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

Subject: 90-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 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 90-day response to a Nuclear Regulatory Commission (NRC) 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 provided in Attachment 1. Attachment 2 provides associated conforming changes to the License Amendment Request, which remains bounded by the original No Significant Hazards Consideration and Environmental Review. There are no additional commitments made that are not bounded by those previously made in the License Amendment Request.

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

A006
NRR

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

Executed on 2/12/13
(Date)

Sincerely,

Kenneth Higginbotham
General Manager of
Plant Operations

KH/wv

Attachments: 1. 90-Day Response to Cooper Nuclear Station Request For Additional Information Regarding License Amendment Request To Adopt National Fire Protection Association Standard 805

2. Revisions to the Cooper Nuclear Station License Amendment Request To Adopt National Fire Protection Association Standard 805 Performance-Based Standard For Fire Protection For Light Water Reactor Generating Plants

cc: Regional Administrator w/ Attachments
USNRC - Region IV

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

Senior Resident Inspector w/ Attachments
USNRC - CNS

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

NPG Distribution w/o Attachments

CNS Records w/ Attachments

Attachment 1

90-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 (NRC) 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) 90-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 response. In the response to SSD RAI 09, NPPD stated that changes to the LAR Attachment G would be provided in the 90-day response. These changes are provided in Attachment 2, Change 1.

Fire Protection Engineering (FPE)

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

NPPD Response:

These RAIs were addressed in the 60-day response.

Request: - FPE RAI 06

LAR Attachment A, Section 3.6.1, and Attachment L, Approval Request 7, requests NRC approval of deviations from NFPA 14, "Standard for the Installation of Standpipe and Hose Systems," regarding the design and installation of standpipes and hose systems. The Attachment L Acceptance Criteria Evaluation for NFPA 14, Section 322, states that the subject fire zones can be reached with a maximum of 50 feet of hose in addition to the 100 feet required by the standard. Please confirm that the hydraulic calculations for the standpipe system demonstrates acceptable pressure and flow conditions at the nozzle with the head-loss associated with 150 feet of hose.

NPPD Response:

The impact of the additional 50 feet of hose to the standard 100 feet of hose required by the NFPA 14 was evaluated in Cooper Nuclear Station (CNS) Calculation NEDC 13-002. The calculation documents that the use of an additional 50 feet of 1-1/2 inch fire hose at hose stations adjacent to Fire Zones 1F, 10B, 11L, 12B and 12F is acceptable, and within the capability of the fire protection water supply system. Pressure conditions at the nozzle of each fire hose will only be reduced by approximately 12 psi and an acceptable flow rate of 100 gpm is available at the nozzle which meets the flow rate requirements of NFPA 14.

Request: - FPE RAI 07, 08, 09, 10, 11, 12, 13, 14, 15, 16, 17, and 18

NPPD Response:

These RAIs were addressed in the 60-day response.

Probabilistic Risk Assessment (PRA)

Request: PRA RAI-01 and 02

These RAIs were addressed in the 60-day response.

Request: - PRA RAI-03 PRA Modeling of VEWFDS

LAR Attachment V, first paragraph of Section V.2, states that the very early warning fire detection system (VEWFDS) was modeled using FAQ 08-0046, with the exception that "rather than modeling the increased potential for suppressing the fire, the analysis only modeled the early detection and then applied human reliability analyses to model operator response to the early detection." As indicated, the guidance in FAQ 08-0046 is meant for determining increased probability of fire suppression, not to determine the probability of shutdown from the MCR before forced abandonment. The discussion on page V-3 indicates that two operator actions are credited. A probability of 0.01 is assigned to the failure of operators to confirm the situation locally and report back to the MCR. A probability of 0.01 is also assigned to the failure of MCR operators to respond using procedures for these panels. Attachment S (see Item S-2.4) states that crediting these actions allows for shutdown from the CR with minimal field actions and a lower CCDP (i.e., 0.0127) than if the alternate shutdown room (ASD) is modeled (0.1). However, these operator actions are not the actions defined in the FAQ-08-0046 Event Tree. Accordingly, it is not clear a probability of 0.01 is an appropriate probability for these operator failures. No HRA is presented or referenced. In light of the significant risk reduction from VEWFDS (in combination with these HEPs), please provide the basis for these operator error probabilities. As part of this basis, please include a complete description of the required operator actions and the basis for the HEPs. In addition, please clarify if the two cabinets where the VEWFDS is being installed are "sealed" cabinets per NUREG/CR-6850 and FAQ 08-0042, "Fire Propagation from Electrical Cabinets" (ADAMS Accession No. ML092110537), and, if not, please justify why the fire is not postulated to propagate to adjacent cabinets.

NPPD Response:

Installation of incipient detection and changes to procedures are planned for Panels 9-32 and 9-33. The design will meet requirements for sensitivity, equipment voltage restrictions, and fast versus slow acting devices in regard to fire growth. The system will be tested in accordance with the manufacturer's and code requirements, including sensitivity. The detection system will consist of an alarm unit that is individually assigned to each relay panel.

Alarm procedures will be developed to guide operator response to both alert and alarm events. The procedures will provide guidance for recommended actions in regard to diagnosing the cause of an alert/alarm; provide recommended compensatory measures, and identification of support resources. The alarm procedures will be designed to work in conjunction with existing operating, abnormal, and emergency response procedures.

The purpose of the incipient detection system is to provide early indication of the potential for a fire inside one of these panels. The biggest advantage to knowing that a fire could develop in one of these panels is to alert the Main Control Room (MCR) operators that MCR abandonment is not required. Absent the incipient detection, there is an increased potential for the MCR operators to implement ASD, as a fire in either of these panels would impact automatic operation of core cooling equipment and MCR instrumentation. Detailed circuit analysis demonstrated that operators can operate a train of equipment from the MCR, with some limited local manual actions, provided procedures are changed and operators are alerted to the specific location of the potential fires. In addition to installation of an incipient detection system, fire response procedures will be changed such that the MCR will be the command and control center for reaching safe and stable conditions.

The incipient detection system will provide indication in the MCR so that an operator/auxiliary operator (AO) can respond to the auxiliary relay room, confirm that the incipient detector for which panel has activated, and inform the MCR. The MCR operators can then respond in the MCR using procedures for these panels to reach safe and stable conditions.

The expected scenario, given correct response to the annunciator, is initially a normal shutdown, as all equipment would remain available for at least 60 minutes after the alarm indicating the incipient fire phase. The VEWFDS provides at least one hour of warning prior to the actual outbreak of an open flaming fire (EPRI 1019259, Supplement 1 to NUREG/CR-6850 and EPRI 1011989, Fire Probabilistic Risk Assessment Methods Enhancements). Thus, it is assumed that 60 minutes after the annunciator alarms in the MCR that the panel is damaged, and the plant trips prior to reaching shutdown conditions. Actions would be taken, as the MCR has not been abandoned and assumes maximum damage state has occurred to components within the specific panel with no propagation outside the panel.

When the annunciator actuates in the MCR, an AO is sent to verify the alarm. The MCR operators do not need to know which panel the fire is in to prepare for an orderly shutdown, but they should make preparations knowing that if the fire starts, many automatic controls are lost. An assumption is made that the operators start preparation by opening procedures, and make announcements while waiting for verification from the AO. The plant is at power with all systems available.

In 10 minutes from receipt of the annunciator, the AO reports which panel has the potential fire. It is expected that the alarm check dictates verification such that a spurious alarm is ruled out. The operators continue to prepare for an orderly shutdown, which would take several hours for completion if conditions allowed (the analysis does not credit completion of an orderly shutdown). Subsequent actions now depend upon which panel the potential fire is occurring, and each panel is considered separately as detailed below.

Panel 9-32

Panel 9-32 is the Division 1 Emergency Core Cooling System (ECCS) relay panel. At the 10 minute point, the AO reports “Potential Fire in Panel 9-32” to MCR. The plant is at power and all systems are available. For a fire contained solely in Panel 9-32, the plant may be placed in a safe and stable condition without abandonment of the MCR.

Within the first 60 minutes, the operators commenced an orderly shutdown knowing that if the fire starts in this panel, Division 2 Low Pressure systems and Safety/Relief Valves (SRV) will be the available equipment, operable manually in the MCR. With no local actions, core cooling is available after plant trip using Division 2 equipment. Thus, a success path without any additional actions due to the incipient detection alarm is known, and operators would not be diverted.

The operators would lock out the normally open 4160F-1FS breaker from the MCR. Ensuring this breaker will not close allows the 4160G Bus two sources of AC power, DG-2 and the Emergency Transformer to G bus. This MCR action significantly improves AC power reliability; however, it is not required for SSD and may be performed later.

Based on the loss of the control relays, automatic control of the High Pressure Coolant Injection (HPCI) and Reactor Core Isolation Cooling (RCIC) systems will not be available from the MCR once the fire starts, but will be available from either the ASD Panel or by local manual action, respectively.

The MCR may direct shifting motor control center (MCC)-R to an alternate power supply to prevent any time delay if the 4160F Bus is lost while providing power to MCC-R. This ensures no delay time for future control of Suppression Pool Cooling (SPC) valves from the MCR if the 4160F Bus is not recovered. Human Error Probability (HEP) for performing this shift under these conditions is 6.5E-04.

At the 60 minutes point, it is assumed Panel 9-32 is damaged with no propagation outside the panel and the plant trips prior to reaching shutdown conditions. The operators implement a prepared response to this trip. Decay heat removal is not yet needed and assumed to not have yet been established. Worst case would be core cooling by Division 2 low pressure systems with SRVs in MCR, but the expected case is core cooling with both low pressure trains available with SRVs.

At this time, lock out of 4160F-1FS breaker would be verified. Even if not accomplished, core cooling is provided by DG-2 powered low pressure systems and SRVs from MCR. If not accomplished during preparations, MCC-R is shifted to the alternate power supply, which sets up a full train of necessary equipment for long term operation prior to establishing additional means.

Actions are commenced to make the 4160F Bus available, which would make Division 1 low pressure systems available. In the "F" switchgear room the operator manually strips and aligns the 4160F Bus from the Emergency Transformer, and manually aligns necessary pumps and switchgear to provide maximum flexibility. If a Division 1 system is desired, an operator manually aligns the desired system. With the loss of the automatic relays due to a Panel 9-32 fire and potential cable damage, MCR controls may not be available for these components. These are defense-in-depth actions to provide for a full second train of power and low pressure injection. Even if Division 2 low pressure systems fail at the time of plant trip, there is at least 30 minutes to take these contingency actions.

If it is desired to restore the full complement of reactor coolant injection systems, actions can be taken to make HPCI and RCIC available. If HPCI is desired, the operator ensures MCC-R is powered from either the G or the F buses, and shifts control of HPCI to the ASD panel. Control of the plant is still available from the MCR using low pressure systems, as noted above, with additional backup of HPCI from ASD. If RCIC use is desired, the operator manually aligns the system motor-operated valves (MOV) either from their starters or via local handwheel. RCIC is reliant on the "A" DC switchgear.

There are 4 hours available in which the operators must place SPC in service. Most valves are available from MCR with the shifting of MCC-R in the preparation phase. RHR-MOV-27B, RHR-MOV-25B, and SW-MOV-MO89B will require local manual operation to ensure proper lineup for SPC. The HEP for these local manual operations of the MOVs is 1.5E-03. The HEP for then placing SPC in operation under these conditions is 2.4E-03.

The combined HEP for shifting MCC-R to alternate power, local manual operation of required MOVs, and placing SPC in operation for long term heat removal is 4.6E-03.

Panel 9-33

Panel 9-33 is the Division 2 ECCS relay panel. At the 10 minute point, the AO reports "Potential Fire in Panel 9-33" to MCR. The plant is at power and all systems are available. For a fire contained solely in Panel 9-33, the plant may be placed in a safe and stable condition without abandonment of the MCR.

Within the first 60 minutes, the operators commence an orderly shutdown knowing that if the fire starts in this panel, Division 1 low pressure systems and SRVs will be the available equipment, operable manually in the MCR. With no local actions, core cooling is available after plant trip using Division 1 equipment. Thus, a success path without any additional actions due to the incipient detection alarm is known and operators would not be diverted.

The operators would lock out the normally open 4160G-1GS breaker from the MCR. Ensuring this breaker will not close allows the 4160F Bus two sources of AC power, DG-1 and the Emergency Transformer to F bus. This MCR action significantly improves AC power reliability; however, it is not required for SSD and may be performed later.

Based on the loss of the control relays, automatic control of HPCI and RCIC will not be available from the MCR once the fire starts, but will be available from either the ASD Panel or by local manual action.

At the 60 minutes point, it is assumed Panel 9-33 is damaged with no propagation outside the panel, and the plant trips prior to reaching shutdown conditions. The operators implement a prepared response to this trip. Decay heat removal is not yet needed, and is assumed to not have yet been established. The worst case would be core cooling by Division 1 low pressure systems with SRVs in MCR, but the expected case is core cooling with both low pressure trains available with SRVs.

At this time, lock out of 4160G-1GS breaker would be verified. Even if not accomplished, core cooling is provided by DG-1 powered low pressure systems and SRVs from the MCR.

Actions are commenced to make the 4160G Bus available, which would make Division 2 low pressure systems available. In the "G" switchgear room, the operator manually strips and aligns the 4160G Bus from the Emergency Transformer, and manually aligns necessary pumps and switchgear to provide maximum flexibility. If a Division 2 system is desired, the operator manually aligns the desired system. With the loss of the automatic relays due to Panel 9-33 fire and potential cable damage, MCR controls may not be available for these components. These are defense-in-depth actions to provide for a full second train of power and low pressure injection. Even if Division 1 low pressure systems fail at plant trip, there is at least 30 minutes to take these contingency actions.

If it is desired to restore the full complement of reactor coolant injection systems, actions can be taken to make HPCI and RCIC available. If HPCI is desired, the operator ensures MCC-R is powered from either the G or the F bus, and shifts control of HPCI to the ASD panel. Control of the plant is still available from the MCR using low pressure systems, as noted above, with additional backup of HPCI from ASD. If RCIC use is desired, the operator manually aligns the system MOVs either from their starters or via local handwheel. RCIC is reliant on the "A" DC switchgear.

There are 4 hours available in which the operators must place SPC in service. Most valves are available from MCR. RHR-MOV-27A, RHR-MOV-25A, and RHR-MOV-MO66A will require manual operation to ensure proper lineup for SPC. The HEP for this manual operation of these MOVs is 1.1E-03. The HEP for then placing SPC in operation under these conditions is 2.4E-03.

The combined HEP for local manual operation of required MOVs and placing SPC in operation for long term heat removal is 3.5E-03.

Modifications

In reviewing the latching mechanism for cabinets that VEWFDS is being installed, it was noted that the Relay Panels 9-32 and 9-33 latch at the top and bottom, but not at the center handle and may not meet the criteria of a "robustly secured" cabinet per Frequently Asked Question (FAQ) 08-0042. Based on the risk significance of these panels, NPPD has decided to modify the panel doors to include additional mechanical latching around the perimeter of the panel doors, which will ensure that the doors are fully and mechanically secured, and will not create openings or gaps due to warping during an internal fire, in accordance with FAQ 08-0042.

There are five (5) additional relay panels 9-30, 9-39, 9-41, 9-42, and 9-45 located in the Auxiliary Relay Room that are of similar latch construction. Therefore, NPPD is modifying these five relay panels similar to the modification identified for the 9-32 and 9-33 panels (see Attachment 2, Change 2).

All seven (7) relay panels in the Auxiliary Relay Room (9-30, 9-32, 9-33, 9-39, 9-41, 9-42, and 9-45) are separate panels creating a double wall with air gap between the adjacent panels. Therefore, in accordance with Appendix S of NUREG/CR-6850, there is no damage to an adjacent panel. Visual inspection of the internals of the relay panels confirmed that there are no cable runs between the relay panels.

Request: - PRA RAI-04 and 05

NPPD Response:

These RAIs were addressed in the 60-day response.

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 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**	**Pns**	**SF·Pns**	**Time**	**Pns**	**SF·Pns**
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 08-041Table 12: Time to Abandonment Probability Analysis for Case 2 (Natural Ventilation)

Electrical Cabinets – Case 2						REVISED VALUES		
Bin	**HRR [kW]**	**SF**	**Time**	**Pns**	**SF·Pns**	**Time**	**Pns**	**SF·Pns**
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	Pns	SF·Pns	Pns	SF·Pns
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	Pns	SF·Pns	Time	Pns	SF·Pns
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	Pns	SF·Pns	Time	Pns	SF·Pns
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

Electrical Cabinets – Case 2						REVISED VALUES		
Bin	**HRR [kW]**	**SF**	**Time**	**Pns**	**SF·Pns**	**Time**	**Pns**	**SF·Pns**
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**	**Pns**	**SF·Pns**	**Pns**	**SF·Pns**
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 expected to be minor and have no effect on conclusions. The results of a sensitivity analysis (CDF, LERF, ΔCDF, and ΔLERF) using P_{ns} no lower than 1E-03, and the revised non-suppression probabilities based on the new abandonment times, determined in the response to Fire Modeling RAI 02d will be provided with the 120-day response, as agreed to in a conference call with the NRC on February 7, 2013.

<u>Request</u>: - PRA RAI-07, 08, 09, 10

<u>NPPD Response</u>:

These RAIs were addressed in the 60-day response.

<u>Request</u>: - PRA RAI-11 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.*

a. *Please describe how transient and hot work fires are distributed within the PAUs. In particular, identify the criteria that determine where an ignition source is placed within the PAUs. Also, if there are areas within a PAU where no transient or hot work fires are located since those areas are considered inaccessible, please describe the criteria used to define "inaccessible." Note that an inaccessible area is not the same as a location where fire is simply unlikely, even if highly improbable.*

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.*

<u>NPPD Response</u>:

a. Transient and hot work fires are distributed within the PAUs in accordance with the process described in Engineering, Planning, and Management, Inc. (EPM) Procedure EPM-DP-FP-001, "Detailed Fire Modeling," Revision 3, Section 7.6.2. To summarize:

In general, transient and hot work fires are postulated anywhere a transient fire is reasonably expected to occur. This is typically all accessible floor areas, except where precluded by design and/or operation (e.g., plant equipment). The accessible floor area of each PAU is then subdivided into one or more transient zones. The boundaries of each transient zone are chosen such that the associated fire growth and resulting damage to PRA targets (i.e., cables and equipment) can be bounded by a representative fire scenario.

In order to keep the number of locations (and therefore the number of transient scenarios) requiring separate analysis to a minimum, some PAUs have transients placed exclusively in locations where risk significant targets, or target combinations (i.e., pinch points) are located. Transient fire locations within the immediate damage range of these targets are then defined, and the transient ignition frequency apportioned to these locations only. The remainder of the floor space of the PAU is subdivided only where it is necessary to distinguish between different fire growth potentials (e.g., locations where secondary combustibles are at a low enough elevation to be ignited by the transient fire).

Transient and hot work fires are not postulated in locations within PAUs that are considered inaccessible (i.e., where precluded by design). Inaccessible areas are those that are occupied by permanent fixtures such as plant equipment, structural features, piping, and cable trays. These permanent fixtures must occupy the floor space entirely or be sufficiently low to the floor, so as to obstruct the ability to place the material in the location.

b. This RAI will be addressed in the 120-day response, as agreed to in a conference call with the NRC on February 7, 2013.

Request: - PRA RAI-12

NPPD Response:

This RAI was addressed in the 60-day response.

Request: - PRA RAI-13 Fire Ignition Frequencies from Supplement 1

Section 10 of NUREG/CR-6850, Supplement 1, states that a sensitivity analysis should be performed when using the fire ignition frequencies in the Supplement as the base case instead of the fire ignition frequencies provided in Table 6-1 of NUREG/CR-6850. Please provide the results of a sensitivity analysis of the impact of using the Table 6-1 frequencies instead of the Supplement frequencies on CDF, LERF, ΔCDF, and ΔLERF for all of those bins that are characterized by an alpha that is less than or equal to one. If the sensitivity analysis indicates that the change in risk acceptance guidelines would be exceeded using the values in Table 6-1, please justify not meeting the guidelines.

NPPD Response:

A sensitivity analysis was performed using the fire ignition frequencies provided in Table 6-1 of NUREG/CR-6850 for intra-compartment scenarios. The following table provides a comparison of the CDF, LERF, ΔCDF, and ΔLERF values using the EPRI-based ignition frequencies and the ignition frequencies from Table 6-1 of NUREG/CR-6850.

EPRI Based Ignition Frequencies (/yr)		**NUREG/CR-6850 Based Ignition Frequencies (/yr)**	
Total CDF	4.8E-05	Total CDF	1.0E-04
Total LERF	8.7E-06	Total LERF	1.7E-05
ΔCDF	-1.2E-05	ΔCDF	-2.1E-05
ΔLERF	-1.5E-05	ΔLERF	-2.7E-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 sensitivity analysis indicate that the change in risk is within acceptance guidelines.

Request: - PRA RAI-14

NPPD Response:

This RAI was addressed in the 60-day response.

Request: - PRA RAI-15 Control Power Transformer Credit

It was recently stated at the industry fire forum that the Phenomena Identification and Ranking Table Panel (PIRT) being conducted for the circuit failure tests from the DESIREE-FIRE and CAROL-FIRE tests may be eliminating the credit for Control Power Transformers (CPTs) (about a factor 2 reduction) currently allowed by Tables 10-1 and 10-3 of NUREG/CR-6850, Vol. 2, as being invalid when estimating circuit failure probabilities. Please provide a sensitivity analysis that removes this CPT credit from the PRA and provide new results that show the impact of this potential change on CDF, LERF, ΔCDF, and ΔLERF. If the sensitivity analysis indicates that the change in risk acceptance guidelines would be exceeded after eliminating CPT credit, please justify not meeting the guidelines.

NPPD Response:

A sensitivity analysis was performed by removing the CPT credit in the determination of spurious operation likelihoods from the fire PRA. The following table provides a comparison of the CDF, LERF, ΔCDF, and ΔLERF values crediting CPT and without CPT credit for the intra-compartment scenarios.

CPT Credited (/yr)		CPT Not-credited (/yr)	
Total CDF	4.8E-05	Total CDF	5.5E-05
Total LERF	8.7E-06	Total LERF	9.2E-06
ΔCDF	-1.2E-05	ΔCDF	-1.1E-05
ΔLERF	-1.5E-05	ΔLERF	-1.5E-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 sensitivity analysis indicate that the change in risk is within acceptance guidelines.

Request: - PRA RAI-16 Calculation of VFDR ΔCDF and ΔLERF

Attachment W of the LAR provides the ΔCDF and ΔLERF for the VFDRs for each of the fire areas, but the LAR does not describe either generically or specifically how ΔCDF and ΔLERF were calculated. Please describe the method(s) used to determine the changes in risk reported in the Tables in Appendix W. The description should include:

a. *A summary of PRA model additions or modifications needed to determine the reported changes in risk. If any of these model additions used data or methods not included in the fire PRA Peer Review, please describe the additions.*

b. *Identification of new operator actions (not including post MCR abandonment which are addressed elsewhere) that have been credited in the change in risk estimates. If such actions are credited, please explain how instrument failure is addressed in the HRA.*

c. *Please clarify why and how the VDFR risk estimates provided in the Fire Risk Evaluations (FRE) reports are different from the ΔCDF and ΔLERF values provided in Attachment W of the LAR for each Fire Area.*

d. *Please discuss how the FREs considered modifications, fire procedures, and RAs in the determination of risk evaluations.*

e. *LAR Table W-2 reports a negative delta risk for Fire Area RB-FN. During the audit, it was discussed that this reported Δ risk was likely in error. Please provide the revised Δ risk (CDF and LERF) for Fire Area RB-FN and any other identified corrections to Table W-2. Discuss the reason for the error in the results and whether the source of the error has potentially broader implications. If there is determined to be broader implications, please provide updated risk results where applicable.*

NPPD Response:

PRA RAI 16 a, b, c, and d were addressed in the 60-day response.

e. LAR Table W-2 reported a negative delta risk for Fire Area RB-FN. No hardware modifications are proposed for RB-FN. There is, however, a change in shutdown strategy. Currently, for a fire in Area RB-FN, operators are directed to Procedure 5.4FIRE-S/D, "Fire Induced Shutdown from Outside Control Room." The strategy for RB-FN once all NFPA 805 changes are made will be to shutdown from the MCR.

   In performing a review of the delta risk calculation, inconsistencies in modeled operator actions between current plant and the post NFPA 805 plant were identified for Fire Area RB-FN. These inconsistencies have been corrected and the RB-FN delta risk re-quantified.

   Complete risk results for Fire Area RB-FN and impact on fire risk delta CDF and LERF are provided in Attachment 2, Change 3. The delta risk is 1.59E-07/year and 5.08E-09/year for CDF and LERF respectively; and risk of recovery actions are the same values.

   Area RB-FN delta risk is a positive number, but the total delta risk remains negative.

Request: - PRA RAI-17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, and 31

NPPD Response:

These RAIs were addressed in the 60-day response.

Request: PRA RAI 32 Fire Area DW

NEDC 09-085 reports risk results (CDF/LERF) for Fire Area DW/Fire Zone Drywell. However, LAR Table W-2 does not have an entry for this fire area. Please explain this discrepancy. If the risk results for the drywell fire zone are not included in Table W-2, provide an updated table with the risk results for this fire zone/area. Please discuss whether there are any other missing fire zones/areas and, if so, provide the risk results for these areas.

NPPD Response:

The risk results (CDF/LERF) for Fire Area DW (Drywell) were not included in Table W-2 because the Drywell is inerted during "at power" operation and therefore a fire could not occur. The inclusion of the Drywell in Table W-2 would not impact the delta CDF/LERF results and conclusions. Risk results for the Fire Area DW are provided in Attachment 2, Change 3. No other fire areas were excluded from Table W-2 in the LAR.

Request: PRA RAI 33 and 34

NPPD Response:

These RAIs were addressed in the 60-day response.

Radioactive Release (RR)

Request: RR RAI 01 and 02

These RAIs were addressed in the 60-day response.

Request: RR RAI 03

Please explain the potential discrepancy between statements in the LAR, Section 4.4, Radioactive Release Performance Criteria, that the methodology used was based on guidance in NFPA 805 Task Force FAQ 09-0056 (related to meeting limitations for instantaneous release of radioactive effluents in a licensee's Technical Specifications) and the analyses and conclusions in calculation NEDC 10-062 and NEDC 11-148 which conclude that the offsite radioactive effluent releases will be limited to less than the annual dose limits of 10 CFR 20.

NPPD Response:

NEDC 10-062 and NEDC 11-148 utilized dose limits based on 10 CFR 20.1301. Review of requirements concluded that 10 CFR 20 would be conservative to the CNS Technical Specifications contained in Section 5.5.4. Calculation NEDC 11-148 Attachment T provides a comparison of 10 CFR 20 requirements to CNS Technical Specification requirements, and shows that the calculated doses are conservative with both the CNS Technical Specifications and 10 CFR 20, and meets the intent of FAQ 09-0056.

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

These RAIs were addressed in the 60-day response.

Fire Modeling

Request: Fire Modeling RAI 01

Section 4.5.1.2, "Fire PRA" of the Transition Report states that fire modeling was performed as part of the FPRA development (NFPA 805 Section 4.2.4.2). Reference is made to Attachment J, "Fire Modeling V&V [Verification and Validation]," for a discussion of the acceptability of the fire models that were used.

Regarding the acceptability of the PRA approach, methods, and data:

a. *It appears that non-cable intervening combustibles were missed in some areas of the plant. An example is the combustible insulation of the heat exchangers in fire area RB-M. Please explain how non-cable secondary combustibles were accounted for in the fire modeling analyses. In addition, please describe the criteria that were used to determine when a secondary combustible could be ignored in the zone-of-influence (ZOI) calculations. Please identify where secondary combustibles were not and should have been considered, and assess the impact on the risk of including scenarios involving the intervening combustibles in the fire modeling analyses.*

b. *Please explain why the effect of the size of the ventilation opening was not evaluated in the temperature sensitive equipment hot gas layer (HGL) study, or revise the analysis to include the ventilation opening size.*

NPPD Response:

a. EPM Procedure EPM-DP-FP-001, "Detailed Fire Modeling," requires the fire modeling analyst to quantify the fire ignition and spread associated with secondary combustibles. Detailed information regarding secondary combustibles, such as distance from the ignition source to the secondary combustible, should be collected during plant walkdowns.

This step mainly focuses on cable trays as these are the most abundant secondary combustibles in the plant. However, during plant walkdowns all secondary combustibles located in the Zone of Influence (ZOI) of the fire ignition source are identified and considered for potential fire growth and propagation. Small combustibles, such as small plastic signs, are not considered to increase the size of the fire, as this small amount of combustible loading would not significantly increase the Heat Release Rate (HRR) of the fire.

Plant walkdown notes, photographs, and videos collected during the fire modeling effort were reviewed to identify notes regarding the presence of secondary combustible materials which could impact Fire PRA (FPRA) targets. Also, as part of this reassessment of the impact of secondary combustibles, a review of Calculation NEDC 93-161, "CNS Fire Hazard Analysis Combustible Loading Calculation," was performed to identify non-cable combustible material in fire zones where detailed fire modeling was performed. This review identified several fire zones containing forms of insulation (HVAC insulation, miscellaneous fiberglass, Rubatex pipe insulation, and polyurethane foam). Plant walkdowns of these fire zones was performed, post-NRC audit, to field-verify the presence, quantity, and location of all non-cable combustible material.

A summary of the review is provided in the table below:

Fire Compartment	Fire Zone	Combustible Type	Quantity	FPRA Target Impacts
CB-A	7A	Misc. Fiberglass Insulation	50 lbs.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 7A and will not result in additional FPRA target failures.
CB-A	7A	Misc. Fiberglass	64 ft.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 7A and will not result in additional FPRA target failures.
CB-A	7A	Polyurethane Foam Insulation	264 lbs.	The polyurethane foam insulation is located on the air dryers in the fire zone. The insulation is covered with an aluminized lagging material which would significantly reduce the potential for fire spread. There are no cable trays located in Fire Zone 7A. The transient fires postulated around the air dryers result in damage to all FPRA conduit up to the ceiling, therefore, any increase in heat release rate due to the insulation would not result in the failure of additional FPRA targets.
CB-A	7A	Rubatex Pipe Insulation	44.3 lbs.	The Rubatex insulation is located on long runs of 6 inch piping in the fire zone. As the quantity of insulation is only approximately 44 lbs, there is a limited amount of insulation on a specific length of piping compared to the floor area of the fire zone. There are no cable trays routed in the fire zone. Fire propagation to the pipe insulation would not cause a significant increase in the heat release rate of the fire and therefore, no additional FPRA target failures would result.
CB-A	8C	HVAC Insulation	24 ft.	The insulation is covered with a reinforced foil faced, flame resistant kraft vapor barrier which would significantly reduce the potential for fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 8C and will not result in additional FPRA target failures.
CB-A	8D	Misc. Fiberglass	56 ft.	Although listed in NEDC 93-161, *CNS Fire Hazard Analysis Combustible Loading Calculation,* the miscellaneous fiberglass was not located in the field during walkdowns. It is assumed that the fiberglass insulation is located at the ceiling above the conduit in Fire Zone 8D. The transient fires postulated in this zone result in damage to all FPRA conduit up to the ceiling, therefore, any increase in heat release rate due to the insulation would not result in the failure of additional FPRA targets.

Fire Compartment	Fire Zone	Combustible Type	Quantity	FPRA Target Impacts
CB-A	8D	Rubatex Pipe Insulation	21 lbs.	Although listed in NEDC 93-161, *CNS Fire Hazard Analysis Combustible Loading Calculation*, the pipe insulation was not located in the field during walkdowns. It is assumed that the pipe insulation is located at the ceiling above the conduit in Fire Zone 8D. The transient fires postulated in this zone result in damage to all FPRA conduit up to the ceiling, therefore, any increase in heat release rate due to the insulation would not result in the failure of additional FPRA targets.
CB-C	8B	HVAC Insulation	21 lbs.	The insulation is covered with a reinforced foil faced, flame resistant kraft vapor barrier which would significantly reduce the potential for fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 8B and will not result in additional FPRA target failures.
CB-D	10B	Insulation	273.6 lbs.	The insulation is covered with a reinforced foil faced, flame resistant kraft vapor barrier which would significantly reduce the potential for fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 10B and will not result in additional FPRA target failures.
CB-D	10B	HVAC Insulation	504 lbs.	The insulation is covered with a reinforced foil faced, flame resistant kraft vapor barrier which would significantly reduce the potential for fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 10B and will not result in additional FPRA target failures.
CB-E	9A	Rubatex Insulation	0.8 lbs.	Fire propagation to the negligible quantity of insulation would not increase the heat release rate in Fire Zone 9A and will not result in additional FPRA target failures.
CB-F	9B	Rubatex Pipe Insulation	0.8 lbs.	Fire propagation to the negligible quantity of insulation would not increase the heat release rate in Fire Zone 9B and will not result in additional FPRA target failures.
CB-F	9B	Misc. Fiberglass Pipe Insulation	96 lbs.	The insulation is covered with a reinforced foil faced, flame resistant kraft vapor barrier which would significantly reduce the potential for fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 9B and will not result in additional FPRA target failures.
CB-G	8A	HVAC Insulation	10 lbs.	The insulation is covered with a reinforced foil faced, flame resistant kraft vapor barrier which would significantly reduce the potential for fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 8A and will not result in additional FPRA target failures.
DG-A	14A	Misc. Fiberglass	24 ft.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 14A and will not result in additional FPRA target failures.
DG-B	14B	Misc. Fiberglass	24 ft.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 14B and will not result in additional FPRA target failures.

Fire Compartment	Fire Zone	Combustible Type	Quantity	FPRA Target Impacts
IS-A	20A	Misc. Fiberglass	24 ft.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 20A and will not result in additional FPRA target failures.
NCS	13B	Misc. Fiberglass	88 ft.	The insulation is covered with a reinforced foil faced, flame resistant kraft vapor barrier which would significantly reduce the potential for fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 13B and will not result in additional FPRA target failures.
NCS	13B	Fiberglass HVAC Insulation	528 lbs.	The insulation is covered with a reinforced foil faced, flame resistant kraft vapor barrier which would significantly reduce the potential for fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 13B and will not result in additional FPRA target failures.
RB	1A	Rubatex Pipe Insulation	7.3 lbs.	Fire propagation to the negligible quantity of insulation would not increase the heat release rate in Fire Zone 1A and will not result in additional FPRA target failures.
RB	1B	Rubatex Pipe Insulation	6.5 lbs.	Fire propagation to the negligible quantity of insulation would not increase the heat release rate in Fire Zone 1B and will not result in additional FPRA target failures.
RB	1B	Misc. Fiberglass	32 ft.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 1B and will not result in additional FPRA target failures.
RB	1D	Misc. Fiberglass	64 ft.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 1D and will not result in additional FPRA target failures.
RB	1G	Rubatex Pipe Insulation	1.9 lbs.	Fire propagation to the negligible quantity of insulation would not increase the heat release rate in Fire Zone 1G and will not result in additional FPRA target failures.
RB	2A-1	Misc. Fiberglass	64 ft.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 2A-1 and will not result in additional FPRA target failures.
RB	2A-2	Misc. Fiberglass	64 ft.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 2A-2 and will not result in additional FPRA target failures.
RB	2A-3	Misc. Fiberglass	64 ft.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 2A-3 and will not result in additional FPRA target failures.
RB	2C	Rubatex Pipe Insulation	1.8 lbs.	Fire propagation to the negligible quantity of insulation would not increase the heat release rate in Fire Zone 2C and will not result in additional FPRA target failures.

Fire Compartment	Fire Zone	Combustible Type	Quantity	FPRA Target Impacts
RB	3C	Misc. Fiberglass	64 lbs.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 3C and will not result in additional FPRA target failures.
RB	3C	Rubatex Pipe Insulation	137.4 lbs.	The combustible insulation located on the ends of the heat exchangers in Fire Zone 3C has the potential to become ignited due to a floor-based transient fire and considered in the potential fire growth and propagation of the fire. The inclusion of the secondary combustible insulation could result in an increase heat release rate of the fire and increase zone of influence resulting in damage to the cable trays located directly above the heat exchangers. Transient Scenario 10 (TS#10) in Fire Zone 3C identified in the Detailed Fire Modeling Calculation NEDC 09-101 has been revised to include the additional FPRA cable tray failures.
RB	3D	Misc. Fiberglass	64 ft.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 3D and will not result in additional FPRA target failures.
RB	4A	Misc. Fiberglass	32 ft.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 4A and will not result in additional FPRA target failures.
RB	4A	Misc. Fiberglass Pipe Insulation	58 lbs.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 4A and will not result in additional FPRA target failures.
RB	4C	Misc. Fiberglass	70 lbs.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 4C and will not result in additional FPRA target failures.
RB	5B	Misc. Fiberglass	56 ft.	The insulation is covered with a reinforced foil faced, flame resistant kraft vapor barrier which would significantly reduce the potential for fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 5B and will not result in additional FPRA target failures.
RB	5B	Misc. Fiberglass HVAC Insulation	3466 lbs.	The insulation is covered with a fire retardant vapor barrier facing which would significantly reduce the potential for fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 5B and will not result in additional FPRA target failures.
TB-A	11B	Misc. Fiberglass	584 ft.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 11B and will not result in additional FPRA target failures.
TB-A	12D	Rubatex Insulation	9.9 lbs.	Fire propagation to the negligible quantity of insulation would not increase the heat release rate in Fire Zone 12D and will not result in additional FPRA target failures.

Fire Compartment	Fire Zone	Combustible Type	Quantity	FPRA Target Impacts
TB-A	13A	Misc. Fiberglass	32 ft.	The fiberglass is covered with an aluminum backing which precludes ignition of the material and fire spread. Therefore, it does not increase the heat release rate modeled in Fire Zone 13A and will not result in additional FPRA target failures.

The results of the reassessment of potential secondary combustibles, including insulation, identified that the only fire zone where Detailed Fire Modeling was performed that required additional analysis is Fire Zone 3C. The impact of these additional cable tray failures on the total calculated CDF and LERF are less than 1%. The impact on ΔCDF and ΔLERF are comparable to the results for CDF and LERF. Therefore, there is no impact on the conclusions of the fire PRA.

b. Appendix D, "Temperature Sensitive Equipment Hot Gas Layer Study," of NEDC 10-020, "Verification and Validation of Fire Modeling Tools," is being revised to consider the specific fire zones at CNS containing sensitive equipment for which detailed fire modeling was performed. Generic compartment geometries were removed from the analysis, and the study now evaluates gas layer impacts in Fire Zones 3A, 3B, 8A, 8B, 8C, 8D, 8G, 8H, 9A, and 13B. A full revision (Revision 2) of Calculation NEDC 10-020 will be completed following the 120-day response for Fire Modeling RAI 02b.

The worst-case fixed ignition source and transient fire scenarios were modeled for each fire zone to identify scenarios in which the gas layer temperatures could exceed the critical failure temperature (65°C) of sensitive equipment. For each fire zone, three ventilation conditions were considered: natural ventilation, closed compartment, and forced ventilation.

The passive ventilation openings to adjacent areas were characterized by a single standard sized (3' x 7') doorway. The fire zones under consideration typically contain multiple doors and numerous leakage paths (construction gaps, door gaps, wall penetrations, etc.) However, only one door has been modeled as the horizontal passive ventilation opening. This is a conservative approach, as adding additional passive ventilation openings would result in reduced gas layer temperatures due to entrainment of cooler ambient air. Additionally, the lower oxygen limit was set to 0%, which prevents the fire from becoming oxygen limited, thereby ensuring a worst-case fire exposure for each scenario regardless of the area of ventilation opening.

The single door is assumed open for the full duration of the simulation only for the natural ventilation scenarios. For the closed compartment and forced ventilation scenarios, the door is assumed to be closed until an operator responds to the incident (i.e. for the first 10 minutes). Ten minutes is expected to be a representative time for the fire to be detected and operators to be dispatched to the room, at which time they will open a door to provide cooling and smoke venting. Ten minutes is considered reasonable as no other passive ventilation is credited prior to that time and no additional intervention (i.e., suppression activities) is credited. Mechanical flow rates of one air change per hour are assumed for the forced ventilation scenarios.

To demonstrate that the Consolidated Model of Fire Growth and Smoke Transport (CFAST) analyses were performed within the validated range of NUREG-1824, as shown in Table 2-4 and 2-5 of NUREG-1824, the table below provides the relevant normalized parameters for the CFAST analyses. The parameters, where applicable, show that CFAST was used within the range of its validity, as described in NUREG-1824.

Normalized Parameters – Temperature Sensitive Equipment Hot Gas Layer Study (CFAST)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity statement**
Fire Froude Number	N/A	0.4 - 2.4	The Froude Number is predominately used to validate the plume temperatures and flame heights. Since the CFAST analysis was used exclusively to calculate the HGL temperatures, the item of foremost importance is the amount of energy (HRR) being released into the fire zone, and a Froude Number outside of the validated range would not invalidate the results.
Flame Length relative to Ceiling Height	N/A	0.2 - 1.0	The primary application of this parameter is to determine if the flame length exceeds the ceiling height. The concern is that for this type of configuration when the normalized parameter would be calculated as greater than one, aside from being outside of the validated range, the models for predicting this phenomenon have not been verified or validated. NUREG-1934, *Nuclear Power Plant Fire Modeling Application Guide*, states that if the hot gas layer 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). The CFAST models analyze hot gas layer development exclusively and do not calculate damage to targets within the flame height or targets which may be subjected to flame radiation, therefore, this parameter is not applicable to this analysis.
Ceiling Jet Radial Distance relative to Ceiling height	N/A	1.2 - 1.7	The primary application of this parameter is to determine target damage near the ceiling and the time to detector and sprinkler activation when using the ceiling jet correlation. The CFAST models are not used to determine the time to detection and sprinkler activation. Additionally, ceiling jet targets are not included in this analysis.

Normalized Parameters – Temperature Sensitive Equipment Hot Gas Layer Study (CFAST)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity statement**
Equivalency Ratio	N/A	0.04 - 0.6	Per NUREG-1934, 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 because the lower oxygen limit in the CFAST analysis is set to zero which means the fire will not be limited by lack of oxygen.
Compartment Aspect Ratio (Fire Zone 3A) (L)	1.9	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 3A) (W)	2.0	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio Fire Zone 3B) (L)	1.9	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 3B) (W)	2.0	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 8A) (L)	3.3	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 8A) (W)	1.7	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 8B) (L)	1.9	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 8B) (W)	1.2	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 8C) (L)	1.9	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 8C) (W)	1.3	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 8D) (L)	1.9	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 8D) (W)	1.0	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 8G) (L)	1.3	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.

Normalized Parameters – Temperature Sensitive Equipment Hot Gas Layer Study (CFAST)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity statement**
Compartment Aspect Ratio (Fire Zone 8G) (W)	1.3	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 8H) (L)	1.3	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 8H) (W)	1.3	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 9A) (L)	5.7	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 9A) (W)	5.5	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 13B) (L)	2.2	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Fire Zone 13B) (W)	5.7	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Radial Distance relative to Fire Diameter	N/A	2.2 - 5.7	This parameter is not applicable to this analysis. There are no radiant targets analyzed in the CFAST models. The hot gas layer development is the only fire effect analyzed.

The results of the CFAST simulations indicate that temperature sensitive components will not be damaged due to exposure to the gas layers at or above the damage temperature of 65°C, in any fire zone considered in the analysis. Therefore, additional damage states do not need to be considered in the Detailed Fire Modeling Reports. The fire zone-specific revision to the analysis, including setting the lower oxygen limit 0% (preventing the fire from becoming oxygen limited) ensures that the size of the ventilation opening no longer impacts the results of the temperature sensitive equipment HGL study.

Request: Fire Modeling RAI 01 (continued)

c. *In the structural steel analysis for beams in areas 13A and 20B, the flame height exceeds the elevation of the beams. Please explain why the gas temperature around the beams used in the analysis is lower than the flame temperature, or revise the analysis to reflect the flame temperature.*

d. *The fire resistance of the columns in area 13A is determined from an empirical method that is based on test data from American Society of Testing Materials (ASTM) Standard E119, "Standard Test Methods for Fire Tests of Building Construction and Materials," exposure. In the pool fire scenario that is considered in the structural steel analysis, the* *lower part of the columns are exposed to a more severe hydrocarbon fire. Please provide justification for using an empirical method that is based on ASTM E119 test data, or revise the analysis to reflect the more severe hydrocarbon fire.*

e. *Please explain how it is ensured that the model assumptions in terms of transient combustibles in a fire area or zone will not be violated during and post-transition.*

NPPD Response:

This RAI was addressed in the 60-day response.

Request: Fire Modeling RAI 01 (continued)

f. *Regarding the use of the algebraic models:*

i. *Please explain how fire location corner and wall proximity effects are accounted for in the method of McCaffrey, Quintiere, and Harkleroad for calculating HGL temperature; and in Alpert's method for calculating ceiling jet temperature.*

ii. *Please describe in detail how the time to sprinkler actuation and the time to heat and smoke detector actuation was calculated. In particular, please describe and justify any use of steady-state models to time-varying conditions.*

iii. *Please explain how the damage threshold for targets in a mixed convective/radiative environment was established. The response should also address FPRA F&O 3-9 under FSS-D1.*

iv. *Please explain how the elevation and dimensions of ignition source fires were determined. If the height and dimensions were not adjusted following ignition of secondary combustibles, justify why not.*

NPPD Response:

f.i. The following discussions provide the use of the fire location factor in the McCaffrey, Quintiere, and Harkleroad (MQH) HGL and ceiling jet ZOI calculations:

HGL – Natural Ventilation (MQH)

The following limitation applies to the MQH natural ventilation HGL calculations:

- These correlations assume that the fire is located in the center of the compartment or away from the walls. If the fire is flush with a wall or in a corner of the compartment, the MQH correlation is not valid with coefficient 6.85. The smoke layer height correlation assumes an average constant value of upper-layer density throughout the smoke-filling process.

Scenarios in which the ignition source is located within 2 feet of a wall or corner were addressed on a scenario-by-scenario basis. Justification and evaluation of this limitation and the impact on the ZOI are provided in the response to Fire Modeling RAI 03.

Ceiling Jet (Method of Alpert)

Ceiling jet temperatures are calculated using Alpert's Ceiling Jet Correlation found on Page 2-22 (Chapter 2-2) of the 4th edition of the Society of Fire Protection Engineers (SFPE) Handbook, which is as follows:

$$T_{m(jet)} = 5.38\frac{\left(\dot{Q}^{2/3} / h^{5/3}\right)}{(r/h)^{2/3}} + T_{\infty}$$

Input Parameters:

- $T_{m(jet)}$: ceiling jet temperature [K]
- h: distance above fuel surface [m]
- $\dot{Q}$: heat release rate [kW]
- r: radial distance from plume centerline to device [m]
- T_{∞}: ambient room temperature [K]

This equation was solved for "r" in order to find the critical distance from the plume for cable damage due to ceiling jet temperature. This equation is shown as follows:

$$r = h\left[\frac{5.38\dot{Q}^{2/3}}{h^{5/3}\left(T_{m(jet)} - T_{\infty}\right)}\right]^{3/2}$$

Note that this correlation is only valid for those cases in which r/h >0.18. The equation for those cases when $r/h \leq 0.18$ does not contain the variable "r," and therefore, the ceiling jet critical distance cannot be calculated.

For use in determining $\dot{Q}$ [the HRR], in the equation above, the following guidance for location factors provided by the Fire Protection Significance Determination Process (SDP) is generally accepted within the nuclear industry.

"For certain specific physical configurations, the HRR utilized in the fire plume correlation must be adjusted. In particular, close proximity of the fire ignition source to a wall or corner amplifies the effects of the plume as follows:

- For a fire in an open area (i.e., greater than 2 feet away from walls or corners) the nominal fire HRR is used,
- For the same fire next to a wall (within 2 feet), multiply the nominal HRR by two,
- For the same fire in a corner (within 2 feet from both walls), multiply the nominal HRR by four.
- Ignition sources mounted on columns will be assumed to be the same as walls."

[SDP, F7-1]

With respect to when this factor was applied, the following guidance was followed:

"a fire is considered to be "near" a wall if its outer edge is within two (2) feet of a wall, or is "near" a corner if within two feet of each of the two walls making up the corner."

[SDP, F-22]

The ceiling jet correlations provided in the Detailed Fire Modeling Workbooks utilize the guidance of the SDP by incorporating the wall (HRR x 2) and corner (HRR x 4) location factor into the HRR input to the ceiling jet ZOI calculation.

f.ii. Detection timing was determined using NUREG-1805 FDT10, "Estimating Smoke Detector Response Time." Using the physical parameters (radial distance from fire source to detector, height of ceiling above the fire source, and ambient temperature) established for the specific fire scenario, and the minimum fire size required to activate the detector, the corresponding time required for activation was calculated using FDT10. If the minimum HRR required to activate the detector was less than the critical HRR being evaluated, then detection was evaluated further (i.e., detector activation prior to FPRA target damage). Using a standard t^2 fire growth profile, the fire modeling analyst evaluated the fire growth profile against the minimum HRRs for detector activation and target damage. For electrical fires, the t^2 fire growth profile was used with the peak HRR being reached at 12 minutes (NUREG/CR-6850, Appendix G, Section G.3.1). For transient fires, the t^2 fire growth profile was used with the peak HRR in accordance with FAQ 08-0052.

The time to detector activation was adjusted by the fire modeling analyst based on the fire growth profile by manipulating the HRR in FDT10, thereby decreasing the delay to activation by increasing the HRR of the fire, while not exceeding the critical HRR under evaluation. The steady state detection model is conservatively applied to time-varying conditions by calculating the total time for detector activation as the sum of the time to activation calculated in FDT10 and the time to reach the activating HRR based on the t^2 fire growth profile. If the time to reach the critical HRR in the scenario (such as the critical HRR for target damage) is greater than the time for detector activation and any suppression delay, then detection was credited to initiate suppression in the scenario.

The time to suppression activation is dependent on the type of system under evaluation. For those systems activated by an automatic detection system, rather than directly by a sprinkler bulb or link, the time to suppression was dependent upon the time to detector activation and any delay in the delivery of the suppression (e.g., a 60-second delay for Halon delivery). For those detection-dependent systems, see the detection analysis above. For those systems requiring activation of a bulb or link (i.e., wet-pipe or pre-action systems), the sprinkler response time was determined using NUREG-1805 FDT10, "Estimating Sprinkler Response Time." The process is similar to determining detector response times.

With the physical parameters (height of ceiling above the fuel source, radial distance to the sprinkler head, ambient temperature, sprinkler Response Time Index (RTI), and activation temperature of the sprinkler) entered into FDT10, a fire size was determined that activates the sprinkler. This process requires that the fire modeling analyst establish the minimum HRR required to activate the sprinkler. If the minimum HRR required to activate the sprinkler is less than the critical HRR being evaluated, then the system was assessed further (i.e., sprinkler activation prior to FPRA target damage). The time to sprinkler activation was adjusted by the fire modeling analyst based on the fire growth profile by manipulating the HRR in FDT10; thereby decreasing the delay to activation by increasing the HRR of the fire. The fire size chosen for sprinkler activation must be less than the critical fire size that results in target damage.

Once the HRR that activates suppression was established, all values were entered and the activation time calculated by FDT10 was recorded. Using a standard t^2 fire growth profile, the time to reach the inputted HRR was calculated. The steady state suppression model is conservatively applied to time-varying conditions by adding the time to reach the activation HRR to the time to suppression calculated by FDT10, and the sum is the total sprinkler activation time. The total time to suppression is the sprinkler activation time added to the detection activation time (if applicable) and any delay to suppression delivery. If this activation time is less than the time to reach the critical HRR under evaluation (e.g., time to critical target damage), suppression is credited at this activation time. For electrical fires, the t^2 fire growth profile was used with the peak HRR being reached at 12 minutes (NUREG/CR-6850, Appendix G, Section G.3.1). For transient fires, the t^2 fire growth profile was used with the peak HRR in accordance with FAQ 08-0052.

f.iii. Although not specifically addressed in the Detailed Fire Modeling Workbooks, target failures due to combined convective and radiative failure modes are bound by the conservative methods and input parameters included in the fire modeling calculations. These conservative methods and input parameters are based upon the guidance in NUREG/CR-6850, *Fire PRA Methodology for Nuclear Power Facilities.*

The fire models were created with a substantial safety margin resulting in a conservative and a bounding ZOI. Per NEI 04-02, there is no clear definition of an adequate safety margin. However, the safety margin should be sufficient to bound the uncertainty within a particular calculation or application.

Specifically, related to the mixed convective and radiative environment, the following fire modeling input parameters are selected to develop a conservative ZOI:

- The radiant fraction utilized is 0.4. This represents a 33% increase over the normally recommended value of 0.3.
- The convective HRR fraction utilized is 0.7. The normally recommended value is between 0.6 and 0.65, and thus the use of 0.7 is conservative.

The safety margin included in the radiant heat flux ZOI and plume impingement ZOI calculated would conservatively bound any targets failures due to mixed convective and radiative exposures.

The following conservative methods and assumptions are included in the detailed fire modeling calculations which also provide safety margin related to the ZOI:

- Fire scenarios involving electrical cabinets (including the electrical split fraction of pump fires) utilize the 98th percentile HRR for the severity factor calculated out to the nearest FPRA target. This is considered conservative.

- The fire elevation in most cases is at the top of the cabinet or pump body. 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 ignition source.

- For transient fire impacts, a large bounding transient zone 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.

- Not all cable trays are filled to capacity. By assuming full, this provides conservative estimates of the contribution of cable insulation to the fire and the corresponding time to damage.

- As the fire propagates to secondary combustibles, the fire is conservatively modeled as one single fire using the fire modeling closed-form correlations. The resulting plume temperature estimates used in this analysis are therefore also conservative, since in actuality, the fire would be distributed over a large surface area, and would be less severe at the target location.

- The fire elevation for transient fires is two feet. This is considered conservative since most transient fires are expected to be below this height or even at floor level.

- Oil fires are analyzed as both unconfined and confined spills with 20-minute durations. Unconfined spills result in large HRRs, but usually burn for seconds. The oil fires have been conservatively analyzed for 20-minutes to account for the uncertainty in the oil spill size.

- High energy arcing fault scenarios are conservatively assumed to be at peak fire intensity for 20-minutes from time zero, even though the initial arcing fault is expected to consume the contents of the cabinet and burn for only a few minutes.

FPRA F&O 3-9 under FSS-D1 states:

> The combined effects of a hot gas layer and plume or radiant damage to a target are not considered in the detailed fire modeling cases. There is no specific threshold over which the detailed fire modeling tools are identified as being used outside their limits. The verification and validation (V&V) basis document for the fire model simulator specifically states that they are not valid when the hot gas layer effects are significant.

A study was conducted to analyze the effect of the HGL on plume temperatures. This study is documented in Appendix B of Calculation NEDC 10-020, "Verification and Validation of Fire Modeling Tools and Approached for Use in NFPA 805 and Fire PRA Applications." A comparison between the results of FDS simulations and NUREG-1805 FDT09, "Estimating Centerline Temperature of a Buoyant Fire Plume," revealed that there are certain configurations in which the plume and HGL interaction impacts centerline plume temperature estimates. In these specific cases, FDT09 may under-estimate plume temperatures at certain elevations. Refer to the response to Fire Modeling RAI 03 for the summary of the impact of the plume and HGL study on CNS fire scenarios.

Scenarios in which flame height exceeds compartment ceiling height were addressed on a scenario-by-scenario basis, as appropriate, in the compartment specific Detailed Fire Modeling Reports. Justification and evaluation of this limitation and the impact on ZOI is provided in the applicable individual reports and summarized in the response to Fire Modeling RAI 03.

f.iv. The height of each fixed ignition source was determined through plant walkdowns performed in accordance with EPM Procedure EPM-DP-FP-002, "Performance of Field Walkdowns." The height was selected as the highest location of the source where fire or smoke could propagate. This would typically be an opening, vent, or the top of the door of a cabinet where warping could occur. The top of the door opening was selected as the height of the electrical panels, unless the inside of the cabinet is visible through vents and the elevation of the combustible material was observed, then the fire elevation could be placed at the location of the vent openings.

Unless a detailed inspection of the cabinet internals is performed, the fire modeling selected a 20" x 20" area of the fire, since this is expected to best represent the internal cable bundles for most all cabinets, and provides a conservative characterization of the fire diameter for electrical cabinets. Using a larger size, could potentially be non-conservative (i.e., reduce flame and plume height estimates), since, even when the cabinet housing is larger, this does not necessarily translate to the configuration of combustibles within the cabinet.

The height of transient fire sources was selected as two feet based on SDP Task 2.3.4 which states that for ordinary combustibles (paper, wood, anti-contamination clothing, rags, and plastic) the fire origin is placed two feet above the floor at the center of the postulated location. The area of a transient fire was selected as two feet by two feet in order to bound a typical single plastic or metal trash can of up to 55 gallons size.

The approach for fires involving multiple combustibles was to calculate the HRR of each individual fire as a function of time, and then use the combined total HRR as the input to the algebraic models. The fire diameter used as the input to the algebraic models is equal to the fire diameter of the original source fire and remains unchanged throughout the burning duration of the fire. Conservative HRRs were determined from NUREG/CR-6850, and the rules for propagation to cable trays and fire spread rates followed the FLASH-CAT model found in NUREG/CR-7010. This approach is considered appropriate for the following reasons:

- The approach is endorsed in Section 3.2.2.2 of NUREG-1934, *Nuclear Power Plant Fire Modeling Application Guide (NPP FIRE MAG)*, Second Draft for Comment, July 2011, which states the following regarding summing individual HRRs for use in algebraic models.

  The HRR from the cable tray can be added to the HRR of the cabinet to determine a combined HRR as a function of time. This total rate can then be used in the various models as an approximation of the HRR as a function of time.

- Using the sum of all HRRs is expected to result in conservative estimation of ZOI as calculated by the algebraic models. In a realistic setting, each individual fire taken separately would create smaller ZOI than that calculated for one large, combined fire. This is in part due to the expected interference of the base fire on the plume entrainment and flame heights of the secondary combustible fires, resulting in the reduction of the effective mass burning rate of the secondary combustible fires. In addition, the obstructing fires could possibly create an environment where the fire would be oxygen limited.

- In reality, a spreading fire will have an increasingly larger fire diameter. The use of the source diameter is considered more severe for plume and flame height correlations, as the use of a small diameter results in a stronger plume and thus larger vertical ZOI values.

- Burnout was considered, however, the spread along cable trays was modeled for an 85 minute duration. NUREG/CR-7010, Section 9.2.4, states that the assumption that the fire will spread laterally until all cable is consumed is conservative, as this phenomenon was not observed in many of the multiple tray experiments. Assuming total consumption of all cables leads to conservative HRR and ZOI calculations.

Request: Fire Modeling RAI 01 (continued)

g. *Regarding the use of the Consolidated Model of Fire Growth and Smoke Transport (CFAST) in a multi-compartment analysis, please provide the input files in electronic format (*.in and *.o) for all CFAST runs that were conducted in support of this multi-compartment analysis.*

NPPD Response:

This RAI was addressed in the 60-day response.

Request: Fire Modeling RAI 01 (continued)

h. *Regarding the use of Fire Dynamics Simulator (FDS) in the MCR abandonment study:*

  i. *Please provide the input files in electronic format (*.fds) for all FDS runs that were conducted in support of the MCR abandonment time study.*

  ii. *Please provide justification for assuming an alarm set point of 8.2 percent per meter of smoke detector SD-1001 in the CSR.*

  iii. *Please provide justification for using a response time index (RTI) of 132 $m^{1/2}s^{1/2}$ for the fusible link of the dampers between the MCR and the CSR.*

NPPD Response:

h.i. The FDS input files (*.fds) for NEDC 08-041 Revision 3 were sent to the NRC in an e-mail from Bill Victor (NPPD Licensing Lead) to Leslie Fields (NRC NFPA 805 Project Manager) on February 6, 2013.

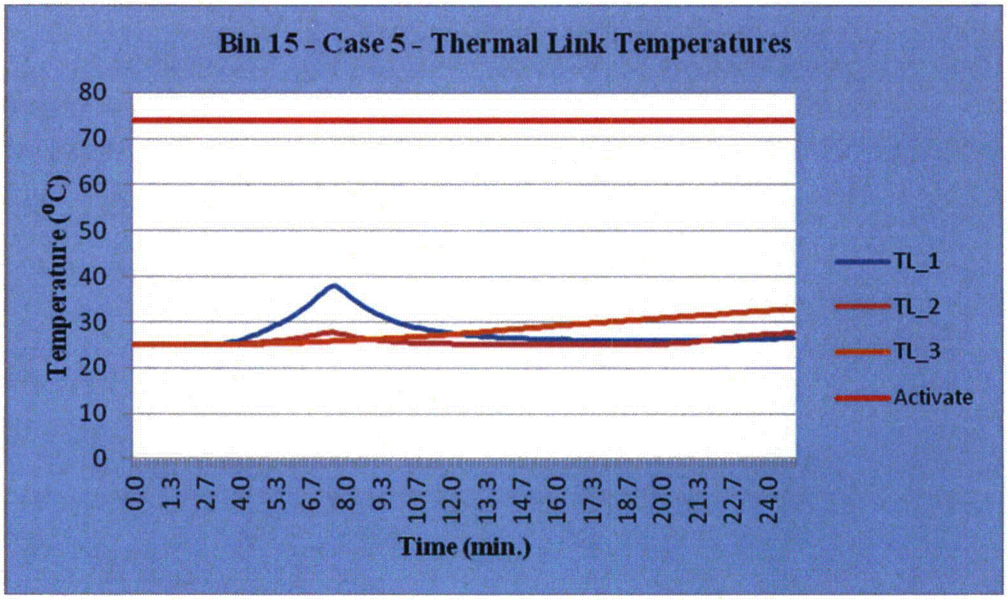
h.ii. The obscuration alarm setting for SD-1001 was programmed as 8.2%/m (2.5%/ft) using the FDS suggested Cleary Ionization Model I1. CNS documentation did not indicate the exact alarm obscuration. A review of numerous vender manuals indicated a typical alarm set point of 9.84%/m (3.0%/ft) for similar "4-wire" type duct smoke detectors. For conservatism this value was reduced to 8.2%/m (~17% reduction).

Volume 3, "Evaluation of Smoke Detector Performance," of the Fire Protection Research Foundation Report, "Validation of a Smoke Detection Performance Prediction

Methodology," states that for flaming fires with ventilation, the 80th percentile values of the obscuration level for ionization smoke detectors were 8.0 to 10.3%/ft, although it is noted that the 10.3%/ft is based on only two tests conducted at a forced ventilation rate of twelve air changes per hour. For ionization detectors, the 8.0%/ft value appears to be an appropriate guideline considering only the results from the tests with six air changes per hour. The 80th percentile values of the obscuration levels for non-flaming fires with ventilation were approximately 5.0%/ft for ionization detectors in the Naval Research Laboratory (NRL) study. Given the limited data in this area, a recommendation for establishing a guideline of only 1.0%/ft (the FDS default value) is questionable, especially in light of the difference in results obtained from experiments conducted as part of this study and the NRL study. The programmed obscuration alarm setting in the MCR Abandonment Calculation of 2.5%/ft (8.2%/m) is well below the guideline values of 8.0%/ft and 5.0%/ft for flaming and non-flaming fires, respectively, and is an appropriate and conservative value.

h.iii. The activation temperature used for the fire damper fusible links was obtained from Vendor Manual 1560 for Ruskin Model FSD31 fire dampers. The RTI, which is normally derived experimentally, is not readily available from the vendor. A best estimate RTI was selected based on engineering judgment and guidance provided in NUREG-1805, Chapter 12. The fire dampers are located in the floor of the MCR to the Cable Spreading Room and in the interconnected HVAC ductwork between the two rooms.

The maximum temperature (provided below) was reached at the damper in the duct exhausting hot gases from the MCR. This maximum temperature was less than 40°C for the maximum HRR modeled (Bin 15 of Case 5) at the time of HVAC shutdown. Fire scenarios resulting in HVAC shutdown were always initiated by activation of smoke detector SD-1001 in the Cable Spreading Room as the activation temperatures of the fire dampers were not reached for any scenario. Since the calculated temperatures were well below the activation temperature of the fire dampers, a change in RTI would not have an impact on the analysis as the HVAC shutdown would still be initiated by the smoke detector activation.



Request: Fire Modeling RAI 02

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:

a. *Attachment J of the Transition Report states that the algebraic models implemented in the FDTs and Fire Induced Vulnerability Evaluation (FIVE), Rev.1, were used to characterize flame radiation, flame height, plume temperature, ceiling jet temperature and HGL temperature. However, the FDTs and/or FIVE, Rev. 1 spreadsheets were not used to perform the calculations, but selected algebraic models from NUREG-1805, "Fire Dynamics Tools (FDT^S) Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program," and FIVE, Rev. 1, were used in a new spreadsheet (or set of spreadsheets). Please describe how this new (set of) spreadsheet(s) was verified (i.e., how was it ensured that the empirical equations and correlations were coded correctly and that the solutions are identical to those that would be obtained with the corresponding chapters in NUREG-1805 or FIVE, Rev. 1).*

NPPD Response:

This RAI was addressed in the 60-day response.

Request: Fire Modeling RAI 02 (continued)

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:

This RAI will be addressed in the 120-day response.

Request: Fire Modeling RAI 02 (continued)

c. *Please provide technical details to demonstrate that CFAST has been applied in the multi-compartment analysis for zones 7A and 8A and the sensitive equipment HGL study within the validated range of input parameters, or to justify the application of the model outside the validated range reported in NUREG-1824.*

d. *Please provide technical details to demonstrate that FDS has been applied in the MCR abandonment study and plume/HGL study within the validated range of input parameters, or to justify the application of the model outside the validated range reported in NUREG-1824.*

e. *Please provide the V&V basis for the method that models a smoke detector as a heat detector and uses a temperature increase of 10°C as the criterion for detector actuation. The response to this question should also address FPRA F&O 3-1 under FSS-D1.*

NPPD Response:

c. CFAST fire modeling was only performed for the Multi-Compartment Analysis for the impact of a fire in Fire Zone 7A on adjacent Fire Zone 7B. As shown in NEDC 10-024, CFAST fire modeling was not performed in Fire Zone 8A.

In most cases, the CFAST analyses have been utilized 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, have been documented in NEDC 10-020, "Verification and Validation of Fire Modeling Tools and Approaches for Use in NFPA 805 and Fire PRA Applications."

To demonstrate that the CFAST analysis included in NEDC 10-024, *Multi-Compartment (Zone) Analysis*, was performed within the validated range of NUREG-1824, *Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications, Final Report, April 2007*, (as shown in Table 2-4 and 2-5 of NUREG-1824), the table below presents the relevant normalized parameter. CFAST was used to determine if the Fire PRA targets in Fire Zone 7B were impacted by the large oil fire in Fire Zone 7A. The parameters, where applicable, show that CFAST was used within the range of its validity as described in NUREG-1824.

Normalized Parameters – Multi-Compartment Analysis - FZ7A HGL Impact on FZ7B (CFAST)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity statement**
Fire Froude Number	N/A	0.4 - 2.4	The Froude Number is predominately used to validate the plume temperatures and flame heights. Since the CFAST analysis was used exclusively to calculate the HGL temperature, the item of foremost importance is the amount of energy (HRR) being released into the fire zone, and a Froude Number outside of the validated range would not invalidate the results.
Flame Length relative to Ceiling Height	N/A	0.2 - 1.0	The primary application of this parameter is to determine if the flame length exceeds the ceiling height. The concern is that for this type of configuration when the normalized parameter would be calculated as greater than one, aside from being outside of the validated range, the models for predicting this phenomenon have not been verified or validated. NUREG-1934, *Nuclear Power Plant Fire Modeling Application Guide*, states that if the hot gas layer 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). The CFAST model analyzes hot gas layer development exclusively and does not calculate damage to targets within the flame height or targets which may be subjected to flame radiation, therefore, this parameter is not applicable to this analysis.
Ceiling Jet Radial Distance relative to Ceiling height	N/A	1.2 - 1.7	The primary application of this parameter is to determine target damage near the ceiling and the time to detector and sprinkler activation when using the ceiling jet correlation. This CFAST model is not used to determine the time to detection and sprinkler activation. Additionally, ceiling jet targets are not included in this analysis.
Equivalency Ratio	N/A	0.04 - 0.6	Per NUREG-1934, 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 because the lower oxygen limit in the CFAST analysis is set to 1% which means the fire will not be limited by lack of oxygen.
Compartment Aspect Ratio - Length (Fire Zone 7A)	3.0	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio - Width (Fire Zone 7A)	3.0	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.

Normalized Parameters – Multi-Compartment Analysis - FZ7A HGL Impact on FZ7B (CFAST)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity statement**
Compartment Aspect Ratio - Length (Fire Zone 7B)	1.4	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio - Width (Fire Zone 7B)	2.4	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Radial Distance relative to Fire Diameter	N/A	2.2 - 5.7	This parameter is not applicable to this analysis. There are no radiant targets analyzed in the model. The hot gas layer development is the only fire effect analyzed.

To demonstrate that the Temperature Sensitive Equipment Hot Gas Layer CFAST Analysis (Appendix D of NEDC 10-020) was performed within the validated range of NUREG-1824 (as shown in Table 2-4 and 2-5 of NUREG- 1824), the table below presents the relevant normalized parameter. The parameters, where applicable, show that CFAST was used within the range of its validity as described in NUREG-1824, or the use of CFAST outside the verification and validation range in NUREG-1824 is justified.

Normalized Parameters – Temperature Sensitive Equipment Hot Gas Layer Study (CFAST)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity statement**
Fire Froude Number	N/A	0.4 - 2.4	The Froude Number is predominately used to validate the plume temperatures and flame heights. Since the CFAST analysis was used exclusively to calculate the HGL temperatures, the item of foremost importance is the amount of energy (HRR) being released into the fire zone, and a Froude Number outside of the validated range would not invalidate the results.
Flame Length relative to Ceiling Height	N/A	0.2 - 1.0	The primary application of this parameter is to determine if the flame length exceeds the ceiling height. The concern is that for this type of configuration when the normalized parameter would be calculated as greater than one, aside from being outside of the validated range, the models for predicting this phenomenon have not been verified or validated. NUREG-1934 states that if the hot gas layer 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). The models analyze hot gas layer development exclusively and do not calculate damage to targets within the flame height or targets which may be subjected to flame radiation, therefore; this parameter is not applicable to this analysis.
Ceiling Jet Radial Distance relative to Ceiling height	N/A	1.2 - 1.7	The primary application of this parameter is to determine target damage near the ceiling and to determine the time to detector and sprinkler activation when using the ceiling jet correlation. This CFAST model is not used to determine the time to detection and sprinkler activation. Additionally, ceiling jet targets are not included in this analysis.

Normalized Parameters – Temperature Sensitive Equipment Hot Gas Layer Study (CFAST)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity statement**
Equivalency Ratio (P1)	0.5	0.04 - 0.6	The calculated normalized parameters for all of the CFAST analyses used in the Temperature Sensitive Equipment Hot Gas Layer Study (Appendix D of NEDC 10-020) are within the validation range. All of the rooms modeled in these analyses use a single ventilation opening representing the size of a typical door. Therefore, the equivalence ratio will be the same in each room for each of the four fire sizes modeled, which is within the validation range.
Equivalency Ratio (P2)	0.4	0.04 - 0.6	
Equivalency Ratio (T1)	0.1	0.04 - 0.6	
Equivalency Ratio (T2)	0.2	0.04 - 0.6	
Compartment Aspect Ratio (Configuration 1) (L)	1.4	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 1) (W)	1.5	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 2) (L)	1.8	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 2) (W)	0.8	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 3) (L)	1	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 3) (W)	1	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 4) (L)	1	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 4) (W)	1.7	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 5) (L)	2.0	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 5) (W)	1.7	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 6) (L)	2.3	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 6) (W)	2.0	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 7) (L)	2.7	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 7) (W)	2.7	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 8) (L)	4.7	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.

Normalized Parameters – Temperature Sensitive Equipment Hot Gas Layer Study (CFAST)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity statement**
Compartment Aspect Ratio (Configuration 9) (L)	5.7	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 10) (L)	3.0	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 10) (W)	3.0	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range for this configuration.
Compartment Aspect Ratio (Configuration 8) (W)	6.6	0.6 - 5.7	This parameter is above the validation range for Configurations 8 and 9. The conclusions drawn from the analysis performed in Appendix D of NEDC 10-020 were grouped for Configurations 8 and 9. Fire Zones 3A, 3B, 8A, 8B, 8C, 8D, 8G, 8H, 9A, and 13B are the only fire zones containing sensitive equipment considered in the detailed fire modeling analyses. None of these fire zones were mapped to these configurations, therefore, the conclusions established in Appendix D of NEDC 10-020 for Configurations 8 and 9 are not applicable to the fire zones containing sensitive equipment at CNS.
Compartment Aspect Ratio (Configuration 9) (W)	6.5	0.6 - 5.7	
Radial Distance relative to Fire Diameter	N/A	2.2 - 5.7	This parameter is not applicable to this analysis. There are no radiant targets analyzed in the model. The hot gas layer development is the only fire effect analyzed.

d. In most cases, the MCR Abandonment and Plume and Hot Gas Layer FDS analyses 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, have been documented in NEDC 10-020, "Verification and Validation of Fire Modeling Tools and Approaches for Use in NFPA 805 and Fire PRA Applications."

<u>Main Control Room Abandonment Analysis (FDS)</u>

To demonstrate that the MCR Forced Abandonment FDS Analyses (NEDC 08-041) was performed within the validated range of NUREG-1824 (as shown in Table 2-4 and 2-5 of NUREG-1824), the FDS models were revised to bring the Fire Froude Number within the validated range for each scenario. Revision to the models resulted in slightly early abandonment times. Refer to the response to PRA RAI 06 for the sensitivity analysis (CDF, LERF, ΔCDF, ΔLERF) using these revised abandonment times.

The table below presents the relevant normalized parameter. The parameters, where applicable, show that FDS was used within the range of its validity as described in NUREG-1824, or the use of FDS outside the verification and validation range in NUREG-1824 is justified.

Normalized Parameters – Main Control Room Forced Abandonment Analysis (FDS)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity Statement**
Fire Froude Number (Electrical Fire - Bin 1)	0.40	0.4 - 2.4	Per NUREG-1934 and NUREG-1824, the Froude Number is predominately used to validate the plume temperatures and flame heights. Plume temperatures were calculated for the electrical panel fire at LRP-PNL-9-14 to determine if and when the fire propagates to the cable tray routed above the Main Control Board. The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 2)	0.40	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 3)	0.40	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 4)	0.40	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 5)	0.40	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 6)	0.40	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 7)	0.40	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 8)	0.40	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 9)	0.40	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 10)	0.41	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 11)	0.40	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 12)	0.41	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 13)	0.41	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 14)	0.40	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Electrical Fire - Bin 15)	0.40	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.

Normalized Parameters – Main Control Room Forced Abandonment Analysis (FDS)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity Statement**
Fire Froude Number (Transient Fire - Bin 1)	0.06	0.4 - 2.4	Per NUREG-1934 and NUREG-1824, the Froude Number is predominately used to validate the plume temperatures and flame heights. Plume temperatures were calculated for the transient fires to determine if and when the fire propagates to the cable tray routed above the Main Control Board. Although the normalized parameter is below the validated range, the FDS analysis calculated temperatures well below ignition temperature of the cable tray and fire propagation to the tray was not included in the analysis. NUREG-1805 Fire Dynamics Tools FDT09 was used to confirm that the plume temperatures at the cable tray are below the critical temperature. Per NUREG-1934, a typical accidental fire has a Froude number of order 1. The Area of Combustible Fuel in FDT09 was selected as 0.03 m^2 (0.35 ft^2) in order to bring the normalized parameter to within the validated range, resulting in a Fire Froude Number equal to 1. The Bin 1 heat release rate of 22 kW results in FDT09 calculating a centerline plume temperature of 70°C at the cable tray and confirms that the plume temperature at 2.2 m (7.2 ft) above the transient fire is below the 330°C ignition temperature of the thermoset cables. Therefore, the Fire Froude Number below the validated range in the FDS analysis does not invalidate the results.
Fire Froude Number (Transient Fire - Bin 2)	0.14	0.4 - 2.4	Although the normalized parameter is below the validated range, the FDS analysis calculated temperatures well below ignition temperature of the cable tray and fire propagation to the tray was not included in the analysis. FDT09 was used to confirm that the plume temperatures at the cable tray are below the critical temperature. Per NUREG-1934, a typical accidental fire has a Froude number of order 1. The Area of Combustible Fuel in FDT09 was selected as 0.07 m^2 (0.77 ft^2) in order to bring the normalized parameter to within the validated range, resulting in a Fire Froude Number equal to 1. The Bin 2 heat release rate of 55 kW results in FDT09 calculating a centerline plume temperature of 109°C at the cable tray and confirms that the plume temperature at 2.2 m (7.2 ft) above the transient fire is below the 330°C ignition temperature of the thermoset cables. Therefore, the Fire Froude Number below the validated range in the FDS analysis does not invalidate the results.

Normalized Parameters – Main Control Room Forced Abandonment Analysis (FDS)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity Statement**
Fire Froude Number (Transient Fire - Bin 3)	0.23	0.4 - 2.4	Although the normalized parameter is below the validated range, the FDS analysis calculated temperatures well below ignition temperature of the cable tray and fire propagation to the tray was not included in the analysis. FDT09 was used to confirm that the plume temperatures at the cable tray are below the critical temperature. Per NUREG-1934, a typical accidental fire has a Froude number of order 1. The Area of Combustible Fuel in FDT09 was selected as 0.11 m^2 (1.17 ft^2) in order to bring the normalized parameter to within the validated range, resulting in a Fire Froude Number equal to 1. The Bin 3 heat release rate of 92 kW results in FDT09 calculating a centerline plume temperature of 146°C at the cable tray and confirms that the plume temperature at 2.2 m (7.2 ft) above the transient fire is below the 330°C ignition temperature of the thermoset cables. Therefore, the Fire Froude Number below the validated range in the FDS analysis does not invalidate the results.
Fire Froude Number (Transient Fire - Bin 4)	0.32	0.4 - 2.4	Although the normalized parameter is below the validated range, the FDS analysis calculated temperatures well below ignition temperature of the cable tray and fire propagation to the tray was not included in the analysis. FDT09 was used to confirm that the plume temperatures at the cable tray are below the critical temperature. Per NUREG-1934, a typical accidental fire has a Froude number of order 1. The Area of Combustible Fuel in FDT09 was selected as 0.14 m^2 (1.46 ft^2) in order to bring the normalized parameter to within the validated range, resulting in a Fire Froude Number equal to 1. The Bin 4 heat release rate of 128 kW results in FDT09 calculating a centerline plume temperature of 179°C at the cable tray and confirms that the plume temperature at 2.2 m (7.2 ft) above the transient fire is below the 330°C ignition temperature of the thermoset cables. Therefore, the Fire Froude Number below the validated range in the FDS analysis does not invalidate the results.
Fire Froude Number (Transient Fire - Bin 5)	0.41	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Transient Fire - Bin 6)	0.51	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Transient Fire - Bin 7)	0.60	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Transient Fire - Bin 8)	0.69	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Transient Fire - Bin 9)	0.78	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.

Normalized Parameters – Main Control Room Forced Abandonment Analysis (FDS)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity Statement**
Fire Froude Number (Transient Fire - Bin 10)	0.87	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Transient Fire - Bin 11)	0.97	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Transient Fire - Bin 12)	1.06	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Transient Fire - Bin 13)	1.15	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Transient Fire - Bin 14)	1.24	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Transient Fire - Bin 15)	1.45	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Electrical Fire - Bin 1)	0.50	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Electrical Fire - Bin 2)	0.71	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Electrical Fire - Bin 3)	0.82	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Electrical Fire - Bin 4)	0.91	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Electrical Fire - Bin 5)	0.98	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Electrical Fire - Bin 6)	1.04	0.2 - 1.0	The primary application of this parameter is to determine if the flame length exceeds the ceiling height. In a situation where the flame length exceeds the ceiling height, the flames will extend radially outward at the ceiling from the point of impingent, which can directly impact zone of influence calculations. Per NUREG-1934, this phenomenon is not well characterized by simple algebraic models (i.e. FDTs) or zone models (i.e. CFAST) that use plume and flame height correlations. The primary objective of the FDS models is to analyze habitably conditions in the Main Control Room. Targets subjected to flame radiation are included in the models only to determine propagation of the fire between ignition sources. The impact of this configuration is captured in the associated model calculations. Computational fluid dynamics (CFD) models (i.e. FDS) are capable of modeling flame impingement and extension at the ceiling. FDS has been validated by the National Institute of Standards and Technology (NIST) against fire
Flame Length relative to Ceiling Height (Electrical Fire - Bin 7)	1.09	0.2 - 1.0	
Flame Length relative to Ceiling Height (Electrical Fire - Bin 8)	1.14	0.2 - 1.0	
Flame Length relative to Ceiling Height (Electrical Fire - Bin 9)	1.19	0.2 - 1.0	
Flame Length relative to Ceiling Height (Electrical Fire - Bin 10)	1.23	0.2 - 1.0	
Flame Length relative to Ceiling Height (Electrical Fire - Bin 11)	1.27	0.2 - 1.0	

Normalized Parameters – Main Control Room Forced Abandonment Analysis (FDS)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity Statement**
Flame Length relative to Ceiling Height (Electrical Fire - Bin 12)	1.31	0.2 - 1.0	experiments involving fires impinging on the flat ceiling of a compartment. The measurements included in the NIST validation effort consist of heat flux to and temperatures of targets within the volume. NIST NCSTAR 1-5F and the FDS Validation Guide (NIST Special Publication 1010-5) detail the NIST fire experiments, FDS simulations, and the validation study. This phenomenon falls within the model capabilities of FDS, therefore, the model results are expected to remain valid even for the calculated normalized parameters greater than 1.0.
Flame Length relative to Ceiling Height (Electrical Fire - Bin 13)	1.34	0.2 - 1.0	
Flame Length relative to Ceiling Height (Electrical Fire - Bin 14)	1.38	0.2 - 1.0	
Flame Length relative to Ceiling Height (Electrical Fire - Bin 15)	1.48	0.2 - 1.0	
Flame Length relative to Ceiling Height (Transient Fire - Bin 1)	0.17	0.2 - 1.0	Per NUREG-1934, the primary application of this parameter is to determine if the flame length exceeds the ceiling height. The concern is that for this type of situation when the normalized parameter would be calculated as greater than one, aside from being outside of the validated range, the models for predicting this phenomenon have not been verified or validated. The 0.17 calculated normalized value shows that the flame length does not reach or exceed the ceiling height. The value below the validation range is acceptable because the analysis is not focused on the flame height with respect to target failures. There are no targets within the calculated flame height and the purpose of the model is to monitor environmental conditions within the Main Control Room which could lead to forced abandonment.
Flame Length relative to Ceiling Height (Transient Fire - Bin 2)	0.26	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Transient Fire - Bin 3)	0.32	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Transient Fire - Bin 4)	0.37	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Transient Fire - Bin 5)	0.41	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Transient Fire - Bin 6)	0.45	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Transient Fire - Bin 7)	0.48	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.

Normalized Parameters – Main Control Room Forced Abandonment Analysis (FDS)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity Statement**
Flame Length relative to Ceiling Height (Transient Fire - Bin 8)	0.51	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Transient Fire - Bin 9)	0.53	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Transient Fire - Bin 10)	0.56	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Transient Fire - Bin 11)	0.58	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Transient Fire - Bin 12)	0.61	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Transient Fire - Bin 13)	0.63	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Transient Fire - Bin 14)	0.65	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Transient Fire - Bin 15)	0.69	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Ceiling Jet Radial Distance relative to Ceiling height	N/A	1.2 - 1.7	The primary application of this parameter is to determine target damage near the ceiling and to determine the time to detector and sprinkler activation when using the ceiling jet correlation. This FDS model is not used to determine the time to detection and sprinkler activation. Additionally, ceiling jet targets are not included in this analysis.
Equivalence Ratio	N/A	0.04 - 0.6	Per NUREG-1934, 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 because gas phase flame extinction is not included in the FDS analysis via the "SUPRESSION=.FALSE." logical parameter which means the fire will not be limited by lack of oxygen.
Compartment Aspect Ratio - Length (Main Control Room)	4.38	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range.
Compartment Aspect Ratio - Width (Main Control Room)	4.13	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range.

Normalized Parameters – Main Control Room Forced Abandonment Analysis (FDS)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity Statement**
Compartment Aspect Ratio - Length (Cable Spreading Room)	3.37	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range.
Compartment Aspect Ratio - Width (Cable Spreading Room)	5.78	0.6 - 5.7	This compartment geometry consists of a large volume with a relatively low ceiling. When using a CFD model (i.e. FDS), this normalized parameter is not a significant measure of model accuracy for this scenario since the total room volume is more important than the aspect ratio. The volume of the room allows products of combustion to dissipate evenly throughout and reduces the severity of the conditions surrounding the fire. When calculating hot gas layer temperatures, aspect ratios are more important to zone models (i.e. CFAST) than computational fluid dynamics (CFD) models (i.e. FDS). In the case of a zone model, a large aspect ratio may suggest that there could be localized regions where the gasses are significantly hotter than the average (i.e. zone temperature). With a CFD model (i.e. FDS), this type of calculation falls within the model capability, and there is no reason to expect that the model is not applicable for the calculated aspect ratio, therefore, the model results are valid.
Radial Distance relative to Fire Diameter (Main Control Board Fire)	1.51	2.2 - 5.7	Per NUREG-1934, the Radial Distance Ratio is a measure of the distance from the center of the source fire at which a heat flux quantity is predicted. Radiant heat fluxes were calculated for the electrical panel fires to determine if and when the fire propagates to the open panels on the opposing inside face of the Main Control Board. Although the normalized parameter is below the validated range, the FDS analysis calculated radiant heat fluxes well below the ignition threshold of thermoset cables and fire propagation to the opposing open panel was not included in the analysis. NUREG-1805 Fire Dynamics Tools FDT05 was used to confirm that the radiant heat flux at the opposing open panel is below the critical heat flux required for ignition (11 kW/m^2) for all of the modeled electrical panel fires. The fire diameter was reduced while not altering the distance to the target. The Fuel Area in FDT05 was reduced to 1.38 m^2 (14.9 ft^2) in order to bring the normalized parameter of radial distance relative to the fire diameter to 2.2 which is within the validated range. Conservatively, the Bin 15 heat release rate of 2276 kW was selected and modeled with a Radiative Fraction of 0.4, bounding the Bin 1 through 14 electrical panel fires. FDT05 calculated a radiant heat flux of 5.58 kW/m^2 at the opposing open panel. These results confirm that the radiant heat flux at 2.9 m (9.64 ft) from the fire is well below the 11 kW/m^2 critical heat flux for the thermoset cables for all of the modeled electrical panel fires. Therefore, the Radial Distance relative to Fire Diameter normalized parameter below the validated range in the FDS analysis does not invalidate the results.

Normalized Parameters – Main Control Room Forced Abandonment Analysis (FDS)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity Statement**
Radial Distance relative to Fire Diameter (Transient Fire)	2.21	2.2 - 5.7	The calculated normalized parameter for this analysis is within the validation range.

The FDS input files (*.fds) for these revised models for draft NEDC 08-041 Revision 4 were sent to the NRC in an e-mail from Bill Victor (NPPD Licensing Lead) to Leslie Fields (NRC NFPA 805 Project Manager) on February 6, 2013.

Plume/Hot Gas Layer Interaction Study (FDS)

To demonstrate that the Plume/Hot Gas Layer Interaction Study (Appendix B of NEDC 10-020) was performed within the validated range of NUREG-1824 (as shown in Table 2-4 and 2-5 of NUREG-1824), the table below presents the relevant normalized parameter. The parameters, where applicable, show that FDS was used within the range of its validity as described in NUREG-1824, or the use of FDS outside the verification and validation range in NUREG-1824 is justified.

Normalized Parameters – Plume/Hot Gas Layer Interaction Study (FDS)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity Statement**
Fire Froude Number (Electrical Fire)	0.8	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Fire Froude Number (Transient Fire)	0.8	0.4 - 2.4	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Configuration 2 - Electrical)	0.1	0.2 - 1.0	Per NUREG-1934, the primary application of this parameter is to determine if the flame length exceeds the ceiling height. The concern is that for this type of situation when the normalized parameter would be calculated as greater than one, aside from being outside of the validated range, the models for predicting this phenomenon have not been verified or validated. The 0.1 calculated normalized value shows that the flame length does not reach or exceed the ceiling height. The value below the validation range is acceptable because the analysis is not focused on the flame height with respect to target failures. There are no targets within the flame height being analyzed and the purpose of the model is to predict plume temperatures given a hot gas layer.
Flame Length relative to Ceiling Height (Configuration 2 - Transient)	0.2	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Configuration 6 - Electrical)	0.2	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.

Normalized Parameters – Plume/Hot Gas Layer Interaction Study (FDS)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity Statement**
Flame Length relative to Ceiling Height (Configuration 6 - Transient)	0.2	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Configuration 10 - Electrical)	0.3	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Flame Length relative to Ceiling Height (Configuration 10 - Transient)	0.3	0.2 - 1.0	The calculated normalized parameter for this analysis is within the validation range.
Ceiling Jet Radial Distance relative to Ceiling height	N/A	1.2 - 1.7	The primary application of this parameter is to determine target damage near the ceiling and to determine the time to detector and sprinkler activation when using the ceiling jet correlation. This FDS model is not used to determine the time to detection and sprinkler activation. Additionally, ceiling jet targets are not included in this analysis.
Equivalence Ratio	N/A	0.04 - 0.6	Per NUREG-1934, 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 because the lower oxygen limit in the FDS analysis is set to zero which means the fire will not be limited by lack of oxygen.
Compartment Aspect Ratio (Configuration 2)	N/A	0.6 - 5.7	This normalized parameter addresses phenomena unique to compartment fires. This configuration of the analysis does not consider external walls in the model; rather, it is open to the atmosphere on all four sides. Per NUREG-1934, this parameter should not be applicable in scenarios where the enclosure conditions are not considered.
Compartment Aspect Ratio (Configuration 3)	2.1	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range.
Compartment Aspect Ratio (Configuration 4)	1.5	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range.
Compartment Aspect Ratio (Configuration 5)	1	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range.
Compartment Aspect Ratio (Configuration 6)	N/A	0.6 - 5.7	This normalized parameter addresses phenomena unique to compartment fires. This configuration of the analysis does not consider external walls in the model; rather, it is open to the atmosphere on all four sides. Per NUREG-1934, this parameter should not be applicable in scenarios where the enclosure conditions are not considered.
Compartment Aspect Ratio (Configuration 7)	2.8	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range.

Normalized Parameters – Plume/Hot Gas Layer Interaction Study (FDS)			
Quantity	**Normalized Parameter**	**Validation Range**	**Validity Statement**
Compartment Aspect Ratio (Configuration 8)	2	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range.
Compartment Aspect Ratio (Configuration 9)	1.3	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range.
Compartment Aspect Ratio (Configuration 10)	N/A	0.6 - 5.7	This normalized parameter addresses phenomena unique to compartment fires. This configuration of the analysis does not consider external walls in the model; rather, it is open to the atmosphere on all four sides. Per NUREG-1934, this parameter should not be applicable in scenarios where the enclosure conditions are not considered.
Compartment Aspect Ratio (Configuration 11)	3	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range.
Compartment Aspect Ratio (Configuration 12)	2	0.6 - 5.7	The calculated normalized parameter for this analysis is within the validation range.
Radial Distance relative to Fire Diameter	N/A	2.2 - 5.7	This parameter is not applicable to this analysis. There are no radiant targets analyzed in the FDS model. The hot gas layer development in conjunction with the plume temperatures are the only fire effects analyzed.

e. FPRA F&O 3-1 under FSS-D1 is related to the V&V basis of the smoke detection model and ensuring the temperature differential between ambient and detector actuation is set to 18°F (10°C) when the Alpert Method is employed. Calculation NEDC 10-020 includes the basis for calculating smoke detector response time which utilizes the ceiling jet temperature calculation. The ceiling jet temperature calculation is V&V'd in NUREG-1824. 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 temperature to smoke obscuration correlation is discussed and detailed in Chapter 4-1 of the 4th edition of the SFPE Handbook and also in NUREG-1805, Chapter 11. Since the correlation is documented in an authoritative publication of the SFPE Handbook and in NUREG-1805, the correlation is acceptable for use, provided that it is applied within the limits of its applicability.

Per EPM Procedure EPM-DP-FP-001, "Detailed Fire Modeling," when using FDT10 the 18°F (10°C) ceiling jet temperature rise from ambient temperature is preserved by adjusting the activation temperature of the smoke detector. The detailed fire modeling workbooks were revised after the Peer Review to ensure the temperature differential between ambient and activation is maintained at 18°F (10°C).

Request: Fire Modeling RAI 02 (continued)

f. *Please provide the V&V basis for the plume temperature equation (3.2.9) in the book by Zalosh on Industrial Fire Protection Engineering that is used in the structural steel analysis for fire zones 13A and 208.*

NPPD Response:

This RAI was addressed in the 60-day response.

Request: Fire Modeling RAI 03, 04, and 05

NPPD Response:

These RAIs were addressed in the 60-day response.

Attachment 2

Revisions to the Cooper Nuclear Station
License Amendment Request To Adopt National Fire Protection Association
Standard 805 Performance-Based Standard For
Fire Protection For Light Water Reactor Generating Plants

This attachment provides changes to the National Fire Protection Association 805 License Amendment Request based on the responses to the Requests for Additional Information (RAI) provided in Attachment 1. The changes are presented in underline/strikeout format.

1. The following Recovery Action line items on the G-1 Table are revised as follows:

Fire Area	Component	Actions
CB-A	SW-MOV-MO89B	~~Remove control power fuses for position 6C at MCC-Y and operate MO89B using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-Y by placing switch SW-SW-IS/MO-89B in isolate and open/close valve using SW-SW-CS/MO-89B and indication at panel to verify position as necessary.
CB-D	REC-MOV-695MV-ASD	~~Remove control power fuses for position 8B at MCC-R and operate 695MV using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-R by placing switch REC-SW-IS/MO-695 in isolate and close valve using REC-SW-CS/MO-695 and indication at panel to verify position as necessary.
CB-D	REC-MOV-714MV-ASD	~~Remove control power fuses for position 7C at MCC-Y and operate 714MV using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-Y by placing switch REC-SW-IS/MO-714 in isolate and close valve using REC-SW-CS/MO-714 and indication at panel to verify position as necessary.
CB-D	RHR-MOV-MO20-ASD	~~Remove control power fuses for position 3A at MCC-R and operate MO20 using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-R by placing switch RHR-SW-IS/MO-20 in isolate and close valve using RHR-SW-CS/MO-20 and indication at panel to verify position as necessary.

Fire Area	Component	Actions
CB-D	RHR-MOV-MO26B-ASD	~~Remove control power fuses for position 3C at MCC-Y and operate MO26B using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-Y by placing switch RHR-SW-IS/MO-26B in isolate and close valve using RHR-SW-CS/MO-26B and indication at panel to verify position as necessary.
CB-D	RHR-MOV-MO57-ASD	~~Remove control power fuses for position 3B at MCC-R and operate MO57 using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-R by placing switch RHR-SW-IS/MO-57 in isolate and open/close valve using RHR-SW-CS/MO-57 and indication at panel to verify position as necessary.
CB-D	RWCU-MOV-MO15	~~Remove control power fuses for position 5C at MCC-R and operate MO15 using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-R by placing switch RWCU-SW-IS/MO-15 in isolate and close valve using RWCU-SW-CS/MO-15 and indication at panel to verify position as necessary.
CB-D	SW-MOV-37MV-ASD	~~Remove control power fuses for position 7A and operate 37MV using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-Y by placing switch SW-SW-IS/MO-37 in isolate and close valve using SW-SW-CS/MO-37 and indication at panel to verify position as necessary.
CB-D	SW-MOV-651MV-ASD	~~Remove control power fuses for position 6B at MCC-Y and operate 651MV using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-Y by placing switch SW-SW-IS/MO-651 in isolate and close valve using SW-SW-CS/MO-651 and indication at panel to verify position as necessary.
CB-D	SW-MOV-887MV-ASD	~~Remove control power fuses for position 4D at MCC-RB and operate 887MV using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-RB by placing switch SW-SW-IS/MO-887 in isolate and open valve using SW-SW-CS/MO-887 and indication at panel to verify position as necessary.

Fire Area	Component	Actions
CB-D	SW-MO-889MV-ASD	~~Remove control power fuses for position 5D at MCC-RB and operate 889MV using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-RB by placing switch SW-SW-IS/MO-889 in isolate and open valve using SW-SW-CS/MO-889 and indication at panel to verify position as necessary.
CB-D	SW-MOV-MO89B-ASD	~~Remove control power fuses for position 6C at MCC-Y and operate MO89B using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-Y by placing switch SW-SW-IS/MO-89B in isolate and open/close valve using SW-SW-CS/MO-89B and indication at panel to verify position as necessary.
RB-A	SW-MOV-MO89B	~~Remove control power fuses for position 6C at MCC-Y and operate MO89B using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-Y by placing switch SW-SW-IS/MO-89B in isolate and open/close valve using SW-SW-CS/MO-89B and indication at panel to verify position as necessary.
RB-CF	SW-MOV-MO89B	~~Remove control power fuses for position 6C at MCC-Y and operate MO89B using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-Y by placing switch SW-SW-IS/MO-89B in isolate and open/close valve using SW-SW-CS/MO-89B and indication at panel to verify position as necessary.
RB-E	SW-MOV-MO89A	~~Remove control power fuses for position 8A at MCC-Q and operate MO89A using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-Q by placing switch SW-SW-IS/MO-89A in isolate and open/close valve using SW-SW-CS/MO-89A and indication at panel to verify position as necessary.
RB-J	SW-MOV-MO89B	~~Remove control power fuses for position 6C at MCC-Y and operate MO89B using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-Y by placing switch SW-SW-IS/MO-89B in isolate and open/close valve using SW-SW-CS/MO-89B and indication at panel to verify position as necessary.

Fire Area	Component	Actions
RB-K	SW-MOV-MO89A	~~Remove control power fuses for position 8A at MCC-Q and operate MO89A using the starter~~. Operate valve from panel LRP-PNL-LCP-MCC-Q by placing switch SW-SW-IS/MO-89A in isolate and open/close valve using SW-SW-CS/MO-89A and indication at panel to verify position as necessary.

Reference: Response to SSD RAI 09.

2. Attachment S, Table S-2 is revised to include this additional modification:

Table S-2 Plant Modifications Committed

Item	Rank	Problem Statement	Proposed Modification	In FPRA	Comp Measure	Risk Informed Characterization
S-2.9	High	Control Room abandonment is required along with the usage of the alternate shutdown procedures for fires in Relay Panels 9-30, 9-32, 9-33, 9-39, 9-41, 9-42, and 9-45. These panels latch on the top and bottom, but not at the center handle, and may not meet the criteria of a "robustly secured" cabinet per FAQ 08-0042.	Install additional mechanical latching around the perimeter of the panel doors of Relay Panels 9-30, 9-32, 9-33, 9-39, 9-41, 9-42, and 9-45 in the Auxiliary Relay Room (Fire Zone 8A) to provide robustly secured cabinets preventing propagation of fire outside the panels. This allows for shutdown from the Control Room with minimal field actions.	Y	Y	Risk is reduced considerably as the installation reduces the frequency of Control Room abandonment. Defense-in-depth is improved. Compensatory measure for NFPA 805: Appropriate compensatory measures will be established per CNS Procedure 0.23, as required, until the modification is implemented. Compensatory measure for 10 CFR 50 Appendix R: None. Fire Area CB-D is deterministically compliant with 10 CFR 50 Appendix R.

Reference: Response to PRA RAI 03.

3. The following line items is revised in Table W-2:

Fire Area	Fire Area Description	NFPA 805 Basis	Fire Area CDF	Fire Area LERF	VFDR(s) (Yes/No)	RA(s) (Yes/No)	Fire Risk Eval Delta CDF	Fire Risk Eval Delta LERF	Additional Risk of RAs (CDF / LERF)
DW	Drywell	4.2.3.2	1.27E-07	1.27E-07	No	No	NA	NA	NA
RB-FN	Rx Bldg 903' 6" NE Corner	4.2.4.2	~~1.84~~1.83E-06/yr	~~1.83~~1.82E-08/yr	Yes	Yes	~~1.24E-07/yr~~ 1.59E-07/yr	~~7.03E-10/yr~~ 5.08E-09/yr	~~1.24E-07/yr~~ 1.59E-07/yr ~~7.03E-10/yr~~ 5.08E-09/yr

Reference: Response to RAI PRA RAI 16e and 32.