NEXTera ENERGY POINT BEACH

August 28, 2014

NRC 2014-0054
10 CFR 50.90

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

Point Beach Nuclear Plant, Units 1 and 2
Dockets 50-266 and 50-301
Renewed License Nos. DPR-24 and DPR-27

Response (90 Day) to Request for Additional Information
License Amendment Request Associated with NFPA 805

References:
(1) NextEra Energy Point Beach, LLC, letter to NRC, dated June 26, 2013, "License Amendment Request 271, Transition to 10 CFR 50.48(c) - NFPA 805, 'Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants,' 2001 Edition" (ML131820453)
(2) NRC e-mail to NextEra Energy Point Beach, LLC, dated September 9, 2013, "Request for Supplemental Information Regarding the Acceptability of the Proposed Amendment Request" (ML13256A197)
(3) NextEra Energy Point Beach, LLC, letter to NRC, dated September 16, 2013, "License Amendment Request 271 Supplement 1 Transition to 10 CFR 50.48(c) – NFPA 805" (ML13259A273)
(4) NRC letter to NextEra Energy Point Beach, LLC, dated September 25, 2013, "Point Beach, Units 1 and 2 - Acceptance Review of Licensing Action re: License Amendment Request to Transition to NFPA 805, Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants" (ML13267A037)
(5) NRC e-mail to NextEra Energy Point Beach, LLC, dated July 8, 2014, "Point Beach Nuclear Plant, Units 1 and 2 - Final (Revised) Requests for Additional Information re: License Amendment Request Associated with NFPA 805 (TAC Nos. MF2372 and MF2373)" (ML14189A365)
(6) NextEra Energy Point Beach, LLC, letter to NRC, dated July 29, 2014, "Response (60 Day) to Request for Additional Information License Amendment Request Associated with NFPA 805" (ML14210A645)

Pursuant to 10 CFR 50.90, NextEra Energy Point Beach, LLC, (NextEra) requested to amend renewed Facility Operating Licenses DPR-24 and DPR-27 for Point Beach Nuclear Plant (PBNP), Units 1 and 2 (Reference 1 and supplemented via Reference 3). The NRC accepted the license amendment request for review in response to Reference 2, as documented in Reference 4.

The NRC Staff has determined that additional information (Reference 5) is required to complete its evaluation. The 60 Day Response was submitted in Reference 6. The Enclosure provides the NextEra response to the NRC Staff's request for additional information for the required 90 Day Response.

This letter contains no new Regulatory Commitments and no revisions to existing Regulatory Commitments.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on August 28, 2014.

Very truly yours,

NextEra Energy Point Beach, LLC

Eric McCartney
Site Vice President

Enclosure
Attachments 1 - 3

cc: Administrator, Region III, USNRC
Project Manager, Point Beach Nuclear Plant, USNRC
Resident Inspector, Point Beach Nuclear Plant, USNRC
PSCW

## ENCLOSURE

## NEXTERA ENERGY POINT BEACH, LLC
## POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

## RESPONSE (90 DAY) TO REQUEST FOR ADDITIONAL INFORMATION
## LICENSE AMENDMENT REQUEST ASSOCIATED WITH NFPA 805

Pursuant to 10 CFR 50.90, NextEra Energy Point Beach, LLC, (NextEra) requested to amend renewed Facility Operating Licenses DPR-24 and DPR-27 for Point Beach Nuclear Plant (PBNP), Units 1 and 2 (Reference 1 and supplemented via Reference 3). The NRC accepted the license amendment request for review in response to Reference 2, as documented in Reference 4.

The NRC Staff has determined that additional information (Reference 5) is required to complete its evaluation. This Enclosure provides the NextEra response to the NRC Staff's request for additional information for the 90 Day Response. Reference 6 provided the 60 Day Response to the NRC Staff's request.

### PRA RAI 02 - Internal Events PRA F&Os

*NFPA 805, Section 2.4.3.3 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a fire PRA and endorses, with exceptions and clarifications, NEI 04-02, revision 2, as providing methods acceptable to the staff for adopting a fire protection program consistent with NFPA-805. RG 1.200 describes a peer review process utilizing an associated ASME/ANS standard (currently ASME/ANS-RA-Sa-2009) as one acceptable approach for determining the technical adequacy of the PRA once acceptable consensus approaches or models have been established. The primary result of a peer review is the F&Os recorded by the peer review and the subsequent resolution of these F&Os.*

*Clarify the following dispositions to fire F&Os and SRs assessment identified in LAR Attachment U that have the potential to impact the FPRA results and do not appear to be fully resolved:*

a) *HR-D1-01 (Not Met)*

   *Screening values used to screen common-cause miscalibration errors (i.e., 1E-4 and 5E-4) are much lower than the pre-initiator and post initiator screening HEP values suggested in NUREG-1792, "Good Practices for Implementing Human Reliability Analysis."*

   *Justify these screening values or provide an estimate of the impact on the Internal Events PRA (IEPRA) and FPRA results of not performing a detailed HRA of these miscalibration errors.*

b) *QU-F5-01 (Not Met)*

   *Explain how the "flag file" setting process supporting quantification of CDF and LERF was documented to ensure accurate results in the FPRA particularly when "true" events are included.*

c) *QU-F5-01 (Not Met)*

*In the disposition to this F&O, the 2011 peer reviewer refers to Finding LE-G5-01, stating that it is not addressed by the response to QU-F5-01. This cited F&O (LE-G5-01) does not appear in LAR Attachment V.*

*If this is an F&O from the full or focused scope peer review of the IEPRA, then provide this F&O and the accompanying disposition.*

d) *LE-B1-01 (Met at CC-II)*

*It is not clear how the disposition to this F&O addresses the 2011 peer review request to justify any credited repair actions.*

*Identify and justify any repair actions credited in either the IEPRA or FPRA. (This appears to pertain to the requirement in SR LE-C3.)*

e) *LE-F3-01 (Not Met)*

*Sources of LERF modeling uncertainty (25 analysis assumptions) were identified but their potential impact on LERF was not characterized.*

*Describe the potential impact on the PRA model of the identified assumptions, and justify the use of this model for the FPRA.*

f) *QU-D7-01 (Not Met)*

*SR QU-D7 requires that the importance of components and basic events be reviewed "to determine that they make logical sense." No response to this finding is provided in LAR Attachment U, Table U-1. The licensee's analysis does not discuss a review of those results.*

*Explain what review of component and basic event importance was performed to demonstrate SR QU-D7 is met.*

**<u>NextEra Response</u>**

a) The mis-calibration error value of 5E-4 is not a screening value. Using the Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications (THERP) values for errors of commission, the probability of leaving a valve mis-aligned would be on the order of 1E-3 without recovery. Valve mis-alignment is used in place of mis-calibration, since THERP does not have mis-calibration and mis-alignment is a close approximation. With one proceduralized recovery credited and a moderate or low operator action dependency, the Human Error Probability (HEP) would be 1E-3 * 1E-1 = 1E-4. This was increased to 5E-4 to ensure no risk significant pre-initiators would be removed.

b) Flag file settings for the FPRA include flag settings from the Internal Events PRA as well as flag settings specific to the FPRA.

The “flag file” setting process supporting quantification of CDF and LERF for the Internal Events PRA flags was documented by adding the following text to Section 2.4.4, “Logic Flags” in the PRA 11.0 Quantification Notebook.

Flags were used in the Point Beach model to indicate a particular condition (e.g., “A” Steam Generator Intact) and to establish normal alignments (e.g., D-49 supplying D-53). In most cases, the flags were either set to 0.0 or 1.0. When a flag setting is set to a value between 0.0 and 1.0, the flag is being used to establish a split fraction. For example, 1 of 2 component cooling water pumps is typically running on each unit. To account for this in the model, the flag for CCW pump running is set to 0.5 and the flag for CCW pump in standby is set to 0.5. This is the way that flags are used to provide a model which represents the as-built, as-operated plant.

The potential impact on the results if the flags are not set properly is to create a model which does not accurately reflect the plant. Depending on the flag settings this can have a large or small impact on the results. For example, if the flags were set to have both component cooling water pumps running, the core damage frequency would increase.

The importance of the flags is that they enable the model to be changed to reflect changes in operating philosophy. If instead of normally operating three of six service water pumps, the plant went to normally operating two of six service water pumps the value of the flags for the service water pumps running and standby would change. No changes to the model would be required. The other importance of flag settings is that risk can easily be evaluated when equipment is set up to an alternate alignment by changing the value of the flag, rather than changing the model.

The “flag file” setting process for the flags unique to the FPRA was documented in the flag file.

The following groups of flags were added to run the FPRA:

- Mod Flag 805 Risk Reduction Mods (Flags to turn modifications on and off depending on PRA run)
- Non-Credited Fire Recovery Actions (Certain Fire Recovery Actions were not credited in the final FPRA)
- Internal Initiating Events (Internal Initiating Events not used in FPRA were set to TRUE)
- Initial Fire Flags (Fire Flag set to TRUE, No Fire Flag set to FALSE which turns on FPRA logic on at different locations in the model)
- Non-Modeled Sequences (Sets all ATWS Sequences to False since ATWS is not in FPRA)
- Sequence Events Set to True (Sets Sequences Markers to TRUE)
- Non-Credited Components (Sets basic events for components not credited in the FPRA and instrument air failure to TRUE)

c) The 2011 peer review report reference to finding LE-G5-01 in Attachment U, “Internal Events PRA Quality”, of the LAR is not correct. The original peer review combined the QU-F5 and LE-G5 elements into a single finding QU-F5-01. Thus, there is no F&O LE-G5-01 to be added to the LAR, Attachment V, "Fire PRA Quality."

The 2011 peer review report should have stated that the QU-F5-01 F&O response should have referred to issues with element LE-G5 as well. The key limitations identified in the 2011 peer review report for element LE-G5, which impact both CDF and LERF included the following:

- Maintenance Alignments: all maintenance was included in a single train (SY-A19-01). This limitation was corrected.
- Running/Standby Alignments: only one alignment was modeled (QU-F5-01 and LE-G5 reference to QU-F5-01). This limitation was corrected.

d) As stated in Section 1.6.2 and Table B-1 of PRA 12.0 (Large Early Release Frequency Notebook), repairs are not credited in the internal events PRA model. The fire PRA model was developed consistent with this approach and also does not credit any additional repairs.

e) Table A-1 in Appendix A of PRA Notebook 12.0, "LARGE EARLY RELEASE FREQUENCY (LERF) NOTEBOOK," Rev. 0, dated March 1, 2013, provides the list of 25 assumptions used in the Internal Events PRA LERF. The existing table does not include the impact of the assumptions on LERF. Notebook 12, Table A-1 of Appendix A, is modified with the table shown below which includes the impact of the assumption on LERF.

Justification for use of this model for the FPRA: The LERF accident sequences are functionally the same for internal events and external events including fires as long as the external event impacts are considered. In general, most of the assumptions are either conservative or phenomenological events that are not affected by fire. Fire impacts on cables and equipment that influence LERF have been accounted for in the fire analysis including consideration of spurious valve operations that could cause a LOCA outside containment.

| List of Assumptions and Impact on LERF | | | |
|---|---|---|---|
| **#** | **ASSUMPTION** | **SECTION** | **IMPACT ON LERF** |
| 1 | Stuck open PORV/PSV and Large RCP seal LOCA sequences have depressurization capability. However, these sequences have conservatively been assumed to have high RCS pressure in the PBNP LERF model | 2.1 (a), 4.4 | Conservative, LERF would be reduced because assuming high pressure will minimize containment pressurization time and maximize containment pressure. |
| 2 | Large LOCAs will raise the containment pressure sufficiently to trigger actuation of the containment sprays. | 2.1 (b) | Conservative. Containment spray is not credited in the PRA model. |

| List of Assumptions and Impact on LERF | | | |
|---|---|---|---|
| # | ASSUMPTION | SECTION | IMPACT ON LERF |
| 3 | Medium LOCAs are assumed to require an operator action to trigger the sprays. | 2.1 (b) | Conservative. Containment spray is not credited in the PRA model. |
| 4 | SBO events are assumed to not have the ability to provide containment heat removal or containment sprays unless power is recovered. | 2.1 (b),(d) | Realistic for SBO and conservative for recovery because containment spray and containment air recirculation are not credited in the PRA model. |
| 5 | RCS pressure is considered to be high at the time of core damage for Transient and SGTR events. | Table 2-2 | Conservative. Assuming high pressure will minimize containment pressurization time and maximize containment pressure. |
| 6 | Interfacing LOCA (V) sequences between the reactor and low pressure piping systems in the auxiliary building are assumed to occur early and have low RCS pressure at the time of core damage. | Table 2-2 | Conservative. If RCS is at high pressure when core damage occurs, this would mean LOCA was small such that RCS would not depressurize which means more time available. Low pressure versus high pressure with respect to core melt progression and impact on containment is irrelevant since interfacing system LOCA core damage frequency equals large early release frequency. |
| 7 | Steam Release Overpressure is not a credible early failure mode for a large dry containment. The only exception is for "in-vessel" recovery where CHR is treated as an uncertainty in the LER portion of the accident. See Section 4.5.1. | Table 3-1 | Realistic assumption. Per ASME-ANS RA-Sa-2009, Table 2-2.8-9, Steam Explosion for Large Dry or Sub-atmospheric, does not need to be considered for LERF contributor. Note 4 states the reason it does not need to be considered is that steam explosion challenges are of low probability for PWRs. |
| 8 | All unrecovered SGTR initiated sequences with direct path to the environment are assumed to progress to LERF. | Table 3-1 | Conservative. For SGTR events that are early high pressure melts, AFW may scrub fission products when the release is discharged 10 feet below a sub-cooled water pool. The scrubbed release may be small versus large. |
| 9 | All core damage accident class sequences in which core damage occurs at high reactor pressure, and the steam generators are dry at the time of core damage are assumed to have the potential to lead to pressure-induced SGTR. | 3.2.4 | Conservative. A PI-SGTR is only of concern if the RCS is at high pressure and a SG is depressurized to atmospheric pressure. Not all sequences have SG depressurized to atmospheric pressure. |

| List of Assumptions and Impact on LERF | | | |
|---|---|---|---|
| **#** | **ASSUMPTION** | **SECTION** | **IMPACT ON LERF** |
| 10 | Direct containment heating (DCH) is a postulated event of rapid heat transfer between finely fragmented core debris and the containment atmosphere assuming (1) the occurrence of post core melt reactor pressure vessel failure at a high pressure and (2) that high pressure melt ejection (HPME) causes extensive debris dispersal. | 3.3.1.1 | Realistic assumption. Report NUREG/CR-6338 chose an expert team which selected four specific bounding DCH scenarios with which the DCH challenge to all operating Westinghouse plants could be evaluated. A corresponding Conditional Containment Failure Probability (CCFP) was calculated for each scenario based on the predicted containment loads. To eliminate complications in modeling the various DCH scenarios, the highest CCFP of the four scenarios was chosen as a bounding containment failure probability for each plant. The bounding CCFP for PBNP from Table 7-1 of NUREG/CR-6338 was 0. |
| 11 | In-vessel steam explosions are assumed to be a negligible threat. | 3.3.3.1 | Realistic assumption. In-vessel steam explosions are not considered important for LERF for a large, dry containment such as the PBNP containment per ASME/ANS Standard Table 2-2.8-9. NUREG/CR-6595, Revision 1, considers the threat to be subsumed with other low pressure containment failure mechanisms and does not explicitly treat the mechanism. NUREG-1524 determined that in-vessel steam explosions had a very low probability of containment failure for low RCS pressure sequences and negligible for high pressure sequences. J. L. Rempe, et al., "In-Vessel Retention of Molton Corium: Lessons Learned and Outstanding Issues," also indicates that in-vessel steam explosions are very unlikely and have insufficient energy to launch the reactor head or the vessel as a rocket and damage containment. |
| 12 | This PBNP model follows the NUREG/CR-6595 conservative assumption that containment failure contribution due to ex-vessel steam explosions is bounded for all low pressure vessel failures by a factor of 0.01. | 3.3.3.2, 4.9, Table 4-1 | Realistic assumption. Per ASME-ANS RA-Sa-2009, Table 2-2.8-9, Steam Explosion for Large Dry or Sub-atmospheric, does not need to be considered for LERF contributor. Note 4 states the reason it does not need to be considered is that steam explosion challenges are of low probability for PWRs. |
| 13 | It is assumed that RWST injection is required before in-vessel recovery can be considered. | 3.4.1.1, 4.5.1 | Conservative. The RCS and accumulators provide over 6,000 ft3 of inventory. When the water level of the cavity reaches about 3400 ft3, the bottom of the vessel starts to submerge. In vessel recovery may be possible with accumulator injection only, but was not |

| List of Assumptions and Impact on LERF | | | |
|---|---|---|---|
| # | ASSUMPTION | SECTION | IMPACT ON LERF |
| | | | credited. |
| 14 | Because of uncertainties associated with retention of the debris in the vessel, a conservative potential for vessel lower head breach, notwithstanding the existence of exterior cooling of the vessel, is assumed in the quantification of the CET. This probability is estimated at 0.1 and is conditional on the transfer of the RWST volume into containment. The basic event is FAIL_EXVCOOL. | 3.4.1.2, 4.5.1 | This is judged to be reasonable assumption. Report No. FAI/ 10-354, "Point Beach MAAP4 Level II Notebook for EPU Conditions", Section 3.2 states: Subsequently, since the RPV lower head is significantly submerged in the flooded reactor cavity, MAAP4 predicts that the reactor vessel will not fail for large LOCA scenarios. This probability is estimated at 0.1 for non-SBO scenarios and 1.0 for SBO scenarios. For non-SBO scenarios, it is conditional on the transfer of the RWST volume into containment.<br><br>Unit 1 F-V for this basic event is 2.5752E-2 and RAW is 1.2318. For Unit 2, F-V is 2.275E-2 and RAW is 1.2047 from 5.02 Model LERF cutoff of 1E-14. |
| 15 | For sequences in which the vessel is not submerged, lower head penetration is assumed to occur for all accidents in which the core is uncooled. | 3.4.1.2, 4.5.1 | Realistic Assumption. Core comes through the bottom head with a probability of 1.0 if the core is not cooled and the vessel is not submerged. |
| 16 | For simplicity, it is assumed that all Steam Generator Tube Rupture (SGTR) and Interfacing Systems LOCA (ISLOCA) initiated events are containment bypass scenarios. | 4.2 | This is conservative since LERF would be reduced if scrubbing by AFW was credited or ISLOCAs credited auxiliary building room flooding. |
| 17 | Releases could be reduced to less-than-large by scrubbing. Scrubbing can be a result of feedwater available in conjunction with a SGTR core damage event, or an ISLOCA with the affected auxiliary building room flooded. However, for this evaluation, scrubbing of SGTR and ISLOCA releases has conservatively been ignored (i.e., SGTR and ISLOCA releases remain in the LERF category). | 4.2 | This is conservative since LERF would be reduced if scrubbing by AFW was credited or ISLOCAs credited auxiliary building room flooding. |
| 18 | For sequences with a failure of injection, the cavity would not be flooded. Therefore the assumption is made that these sequences will progress to vessel breach. | 4.5.2 | Conservative because containment spray is not credited for flooding. |
| 19 | The model assumes that PI-SGTR or TI-SGTR will not occur whenever the RCS is at low pressure at the time of core damage or when feedwater is available. | 4.7, 4.8 | Realistic assumption and modeling. By definition PI-SGTR occurs at high RCS pressure. |

| List of Assumptions and Impact on LERF | | | |
|---|---|---|---|
| # | ASSUMPTION | SECTION | IMPACT ON LERF |
| 20 | The insignificant amount of degradation experienced by the Point Beach replacement steam generators suggests that the PI-SGTR probability is very small. The number of tubes plugged in the PBNP SGs suggests "pristine" tube conditions. Thus, a conservative estimate of the per SG probability of a PI-SGTR would be an order of magnitude less than the NUREG-1570 value for "average" degradation, or approximately 5E-4. | "4.7, | Conservative modeling. F-V and RAW for PI-SGTR events for Unit 1 and Unit 2 are shown below:<br><br>Event Fus Ves RAW<br><br>Unit 1 PI-SGTR_NOSEAL 3.27E-03 6.7699<br>Unit 1 PI-SGTR_PORV 1.93E-06 1.0038<br>Unit 1 PI-SGTR_SEAL 1.36E-03 3.6782<br>Unit 2 PI-SGTR_NOSEAL 3.51E-03 7.195<br>Unit 2 PI-SGTR_PORV 1.72E-06 1.0034<br>Unit 2 PI-SGTR_SEAL 1.53E-03 4.0113<br><br>If tubes were pristine, values would be zero. Unit 2 LERF would go from 1.0589E-7 to 1.0536E-7. If value in cutsets increased an order of magnitude (about 5E-3) value would be 1.1070E-7. Unit 1 LERF would go from 1.0009E-7 to 9.9624E-8. If value of basic events were increased by an order of magnitude, the value would be 1.0427E-7. |
| 21 | The number of tubes plugged in the PBNP SGs suggests "pristine" tube conditions. For "pristine" SG tubes, the probability of a TI-SGTR is assumed to be 0.0 for all evaluated severe accident sequences, with the exception of RCP seal LOCA sequences where loop seal clearing and secondary side depressurization occur within the same SG loop. | 4.8,<br>Table 4-1 | Realistic modeling and assumption. Restatement of NUREG-1570, Section 5.3.2.8 for pristine tubes. For Unit 1 F-V is 1.867E-1 and RAW is 4.4248. For Unit 2, F-V is 2.3398E-1 and RAW is 5.2918 for basic event TI-SGTR. |
| 22 | For PBNP, the only non-zero early containment failure probability is CF_LOW (Low RCS Pressure @ VB) associated with the assumed possibility of an ex-vessel steam explosion. The other split faction, CF_HIGH, is zero, due to the strong PBNP containment capable of withstanding high hydrogen burn pressures. However, for conservatism, the same probability will be used for CF_HIGH as was used for CF_LOW (i.e., 0.01). | 4.9,<br>Table 4-1 | Conservative. If the possibility of an ex-vessel steam explosion is not assumed, there would not be an ex-vessel steam explosion and the LERF would decrease due to the reduced challenge to containment. |
| 23 | PBNP systems most likely to contribute to ISLOCA include RHR injection to cold leg, RHR injection to vessel and RHR suction from the RCS hot legs. Core damage is assumed on the rupture of any of these piping systems outside containment. LERF is assumed for these ISLOCA events. | 5.4 | Conservative. LERF would be reduced if mitigating systems were credited for an ISLOCA or flooding in the auxiliary building rooms mitigated release. |

| List of Assumptions and Impact on LERF | | | |
|---|---|---|---|
| # | ASSUMPTION | SECTION | IMPACT ON LERF |
| 24 | An SG with a spontaneous SGTR is assumed in the Level 1 analysis to be isolated by MSIV closure and termination of feedwater to it. Without further action the steam generator will overfill in about one hour and the safety valves will lift. One or more of these valves are assumed to then fail open following relief of water causing continued loss of RCS inventory. | 5.5 | Conservative. LERF would be reduced if there was not a spontaneous SGTR in the Level 1 analysis. LERF would also be reduced if the safety valve failure data were used instead of having one valve guaranteed to fail open. |
| 25 | The generic/assumed NUREG-1570 values for MSSV failures, MSIV leakage, etc., are retained in this analysis for estimation of PI-SGTR probabilities. As expected, PI-SGTR values are very low, its impact on LERF will be small, and use of these values will be reasonable. | Appendix C | Reasonable assumption and modeling. Values used in NUREG-1570 are reasonable and applicable to Point Beach Nuclear Plant. See Assumption 20 which looked at impact of changing PI-SGTR. |

f) Review of risk significant basic events is documented in Section 4.0, "Importance Rankings" of the Internal Events Quantification Notebook, PRA 11.0, Revision 3. A markup of LAR Attachment U is provided in Attachment 1.

## PRA RAI 08 – Main Control Board (MCB) Fire Modeling

*NFPA 805 Section 2.4.3.3 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a fire PRA and endorses, with exceptions and clarifications, NEI 04-02, revision 2, as providing methods acceptable to the staff for adopting a FPP consistent with NFPA-805. Methods that have not been determined to be acceptable by the NRC Staff require additional justification to allow the NRC Staff to complete its review of the proposed method.*

*The licensee's analysis explains that the NUREG/CR-6850 Appendix L approach was used to model MCB fires for the FPRA. In addition, the licensee's analysis explains that "minimum target sets" were selected to achieve the bounding CCDPs/conditional large early release frequencies (CLERFs) associated with fire in the MCB panels, which result in eight MCB fire scenarios (across both unit MCRs). In addition, the licensee's analysis explains that the frequencies of these scenarios incorporate "probability of target damage" values based on minimum target distances for each scenario using NUREG/CR-6850 Appendix L guidance. The NRC staff noted that none of the eight scenarios appears to involve a fire originating in panel 1C02 and affecting panel 1C01 and 1C04, even though the analysis seems to indicate that this scenario was considered. The licensee's analysis presents relatively low CCDPs for the eight MCB fire scenarios and the staff notes that it is not clear how it was determined that the scenarios selected (four per unit) bound the MCR fire risk. Explain how a "minimum target set' was identified within the MCB to determine these bounding scenarios. Given the large number of possible combinations of MCB controls that might be involved in a fire, discuss how the four scenarios chosen adequately represent or bound the risk from MCB fire.*

**<u>NextEra Response</u>**

A "minimum target set" consists of a set of controls that can fail redundant trains/systems, jeopardizing plant safe shutdown. The minimum distance between these targets was determined and additional targets within the area covered by the distance were included. The target sets selected included the following systems: charging, power operated relief valves (PORVs), component cooling, auxiliary feed water, steam generators, service water, emergency power, containment isolation, residual heat removal (RHR), safety injection (SI), and direct current (DC) power. Four scenarios per unit covered all of the sets.

The back panel of the main control board (MCB) was investigated for potential scenarios. Most of the controls were considered non-critical for the FPRA model. The exception is G-05 (gas turbine-driven generator), which has controls located on the rear of C02. Damage to both the G-05 controls and the emergency power controls on C02 could potentially jeopardize the safety of the plant through loss of emergency power. However, the controls and equipment associated with other generators and power alignment are spread throughout the entirety of the front side of C02, which would require a fire spanning nearly ten feet in length. A fire greater than seven feet in length is expected to result in abandonment, per the criteria in Section 11.5.2.11 of NUREG/CR-6850. Therefore, the severity of this fire would lead to abandonment of the main control room (MCR), which would isolate further damage to critical circuits from the control room fire. Since this extensive fire for C02 is the only credible scenario involving back panel targets that compromise plant safety, front panel fire scenarios, as developed using Appendix L of NUREG/CR-6850, are sufficient for the FPRA. Inclusion of the back panels will either lead to scenarios where the MCR is isolated by abandonment or will add an insignificant amount of risk to the current postulated scenarios.

The risk is bounded since additional scenarios would only be subsets or would only address less significant equipment. Scenario distances were limited in most cases to less than approximately seven feet in distance, fires growing a distance of seven feet or greater would be large enough to degrade the main control room habitability to the point abandonment would be required. In the cases of scenarios that were approximately seven feet or greater, the scenarios were "screened" for non-abandonment cases. This also applies to screening out the overhead of the walkway in between C01 and C02, as the separation distance is approximately six feet, which provides only one foot of offset for vertical propagation before the scenario is subjected to being an abandonment-only case.

No screening occurred for abandonment cases. Since abandonment cases use the total fire ignition frequency for MCBs and no scenarios are screened, major MCB fires are bounded by the control room abandonment analysis.

**Fire Modeling (FM) RAI 01**

*NFPA 805 Section 2.4.3.3 states that the PRA approach, methods, and data shall be acceptable to the NRC. The NRC staff noted that fire modeling comprised the following:*

- *The algebraic equations implemented in FDTs [Fire Dynamics Tools] and Fire Induced Vulnerability Evaluation, Rev. 1 (FIVE) were used to characterize flame radiation (heat flux), flame height, plume temperature, ceiling jet temperature, hot gas layer (HGL) temperature, sprinkler activation and smoke detector actuation.*

- *The FLASH-CAT model was used to calculate the fire propagation in a vertical stack of horizontal cable trays.*

- *The Consolidated Model of Fire and Smoke Transport (CFAST) was used in the HGL calculations in fire zone 552, and for the temperature sensitive equipment HGL study.*

- *Fire Dynamics Simulator (FDS) was used to assess MCR habitability, to calculate the plume temperature in fire zone 158, and in the plume/HGL interaction and temperature sensitive equipment zone of influence (ZOI) studies.*

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

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

a) *Identify whether any fire modeling tools and methods have been used in the development of the LAR that are not discussed in LAR Attachment J. One example would be a methodology used to convert damage times for targets in Appendix H of NUREG/CR-6850 to percent damage as a function of heat flux and time.*

*b) Provide information on how non-cable intervening combustibles were identified and accounted for in the fire modeling analyses.*

*c) Describe how cable trays with covers and fire-resistive wraps were treated in the fire modeling calculations in terms of ignition and fire propagation, and how the presence of holes in cable tray covers was accounted for.*

*d) The HRR of electrical cabinets throughout the plant appears to be based on the assumption that they are either Case 3 (fire limited to a single bundle of unqualified cable) or Case 4 (closed doors and fire involving multiple bundles of unqualified cable) as described in Table E-1 of NUREG/CR-6850, Vol. 2. The NRC staff notes that typically, during maintenance or measurement activities in the plant, electrical cabinet doors are opened for a certain period of time. Explain what administrative controls are in place to minimize the likelihood of fires involving such a cabinet, and describe how cabinets with temporary open doors were treated in the fire modeling analysis.*

*e) Describe the criteria that were used to decide whether a cable tray in the vicinity of an electrical cabinet will ignite following a high energy arcing fault (HEAF) event in the cabinet. Explain how the ignited area was determined and subsequent fire propagation was calculated. Describe the effect of tray covers and fire-resistant wraps on HEAF-induced cable tray ignition and subsequent fire propagation.*

*f) Specifically regarding the use of the algebraic models:*

*i. Explain how horizontal vents, and vents at or near the ceiling of the compartment were treated in the Method of Mccaffrey, Quintiere, And Harkleroad (MQH) calculations; and*

*ii. Describe in detail how the time to sprinkler activation and the time to heat and smoke detector actuation was calculated.*

*g) Specifically regarding the CFAST analysis in compartment 552GRP, discuss whether the potential damage was assessed for targets in the lower gas layer (LGL) due to the combined radiant heat flux from the HGL, heated surfaces and the flame. Describe the results of this assessment, and the damage thresholds that were used in this assessment. If a damage assessment based on radiative heat flux (or combined radiative and convective thermal exposure) was not performed, provide technical justification for the assumption that the LGL temperature damage threshold is bounding.*

*h) Specifically regarding the use of FDS in the MCR abandonment calculations:*

*i. Explain what value was used for the heat of combustion of cables in the MCR (either explicitly or implicitly through the specified fuel composition), and discuss the results of using this value in terms of conservatism of the soot generation rate;*

ii. *FDS simulations were performed with cabinet and transient fires located at four different locations. Describe the technical basis that was used for choosing these locations;*

iii. *Provide technical justification for assuming that transient fires in the MCR reach peak HRR in 8 min;*

iv. *The FDS sensitivity study indicates that placing the transient combustible outside the horseshoe against a wall or in a corner does not adversely affect control room habitability (compared to the baseline scenarios with the transient combustible remote from a wall or corner). Discuss whether this conclusion is also valid for transient wall and corner fires in the area below the acoustic tile ceiling; and,*

v. *FDS "devices" (temperature, heat flux, and optical density) were placed at different locations around the MCR. Describe the basis for choosing these locations.*

i) *Specifically regarding the multi-compartment analysis (MCA):*

i. *Describe the criteria that were used to screen multi-compartment scenarios based on the size of the exposing and exposed compartments;*

ii. *Explain how the methods described in Chapter 2 of NUREG-1805, "Fire Dynamics Tools (FDTs)," (MQH and Beyler) were used in the calculations to screen an ignition source based on insufficient HRR to generate a HGL condition in the exposing compartment;*

iii. *Explain how the size of the vents in the exposing compartments used in the MQH HGL calculations was determined, and up to what extent these vent sizes are representative of conditions in the plant; and,*

iv. *Explain how the possibility of damaging hot gases spreading to a third compartment was considered.*

**NextEra Response**

a) The solid flame radiation model (method of Shokri and Beyler) was used to calculate the radiative heat flux from a fire in the Main Control Room Analysis (P2091-2700-01) and Structural Steel Analysis (P2091-2920-02). The use of this correlation has been verified and validated in Appendix E of Report R2168-1003B-0001. Section 4.5.1.2 and Attachment J of the LAR have been revised to include the solid flame radiation model as follows:

| Calculation | Application | V&V Basis | Discussion |
|---|---|---|---|
| Radiant Heat Flux<br>(Solid Flame Model) | Calculates the horizontal separation distance, based on heat flux, to a target in order to determine the horizontal extent of the zone of influence (ZOI). | • NUREG-1805, Chapter 5, 2004<br>• NUREG-1824, Volume 3, 2007<br>• SFPE Handbook of Fire Protection Engineering, 4th edition, Chapter 3-10, Beyler, C., 2008 | • The correlation is contained in NUREG-1805, for which V&V was documented in NUREG-1824.<br>• The correlation is documented in an authoritative publication of the "SFPE Handbook of Fire Protection Engineering."<br>• The correlation has been applied within the validated range reported in NUREG-1824 or, if applied outside the validated range, the model has been justified as acceptable, either by qualitative analysis, or by quantitative sensitivity analysis. |

A markup of LAR Section 4.5.1.2 and Attachment J (Reference 1) are provided in Attachment 2. There are no additional fire modeling tools or methods used in the development of the LAR that are not identified and discussed in LAR Section 4.5.1.2 and
Attachment J.

b) EPM Procedure EPM-DP-FP-001, "Detailed Fire Modeling," requires the fire modeling analyst to quantify the fire ignition, propagation, and spread, associated with secondary combustibles. This step mainly focuses on cable trays as these are the most abundant secondary combustible in the plant. Small combustibles, such as small plastic signs, fiberglass ladders, hoses, early warning air sampling lines, eyewash and water stations, etc., are not considered to increase the size of the fire, as the 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 the presence of secondary combustible materials that could affect Fire Probabilistic Risk Assessment (FPRA) targets. As part of the assessment of the effects of non-cable secondary combustibles, a review of the Point Beach Nuclear Plant (PBNP) Fire Loading Calculation was performed to identify non-cable combustible materials in fire compartments where detailed fire modeling was performed. This review identified several fire compartments containing significant quantities of non-cable secondary combustibles (e.g., HVAC insulation, miscellaneous fiberglass, paper, etc.). Plant walkdowns for these fire compartments were performed, following the NRC LAR audit, to confirm the previous fire modeling approaches and assumptions regarding the presence, quantity, and location of non-cable combustible materials.

Based on the walkdowns, certain combustibles were screened from further analysis, as discussed below:

- Most fiberglass duct work and pipe insulation is provided with a metallic backing which preclude the ignition of the material and fire spread. Therefore, it will not increase the heat release rate, as modeled in the fire compartment, and will not affect the Fire PRA results.

Significant non-cable secondary combustibles, in fire compartments that were not screened out via walkdowns, are discussed below:

| Fire Compartment(s) | Combustible Type | Quantity | Screening Justification |
|---|---|---|---|
| FC 151 (SI Pump Room) | Polyvinyl chloride (PVC) | 23.5 lbs. | The negligible quantity of non-cable secondary combustibles (part of incidental components) are distributed throughout the large (1700 ft²) compartment. FPRA target impacts are bound by the existing peak zone of influence (ZOI) for each scenario. |
| FC 187GRP (Monitor Tank Room) | Poly(methyl methacrylate) (PMMA) | 80 lbs. | There are negligible quantities of non-cable secondary combustibles (part of incidental components) distributed throughout the large (7600 ft²) compartment. There are no locations where significant quantities of non-cable combustibles are subjected to fixed and/or transient ignition sources. FPRA target impacts are bound by the existing peak ZOI for each scenario. |
| | Office [consisting of Class A Ordinary Combustibles (typical trash contents, wood, paper, plastic, fabric, etc.)] | 36 sq. ft. | |
| | PVC | 179 lbs. | |
| | Rubber | 200 lbs. | |
| | Wood | 6.9 cu. ft. | |
| FC 237 (CCW HX & Boric Acid Tank Room) | Polyethylene | 15 lbs. | The negligible quantities of non-cable secondary combustibles (part of incidental components) are distributed throughout the large (3600 ft²) compartment. FPRA target impacts are bound by the existing peak ZOI for each scenario. |
| | PVC | 10 lbs. | |

| Fire Compartment(s) | Combustible Type | Quantity | Screening Justification |
|---|---|---|---|
| FC 245 (Electrical Equipment Room) | PVC | 40 lbs. | The negligible quantity of non-cable secondary combustibles (part of incidental components) are distributed throughout the large (3380 $ft^2$) compartment. FPRA target impacts are bound by the existing peak ZOI for each scenario. |
| FC 333GRP (North Office in Computer Room) | Class A Ordinary Combustibles (typical trash contents, wood, paper, plastic, fabric, etc.) | 3200 lbs. | The non-cable secondary combustibles are located in the office area portions of the Computer Room, which do not contain FPRA equipment or targets. Contributions from these combustibles to transient scenario ZOIs are bound by TS10 which results in whole room damage for the entire 333GRP fire compartment. |
| | Newsprint | 200 lbs. | |
| | Polyethylene | 414 lbs. | |
| | PVC | 940 lbs. | |
| | Polyurethane | 85 lbs. | |
| | Wood | 150 lbs. | |
| FC 524GRP (Containment Façade – Unit 1) | Polyethylene | 140 lbs. | All fixed ignition sources can only damage themselves and any terminating cables and will not propagate to secondary combustibles. Non-cable secondary combustibles could only be ignited by transient fires. Given the large volume (~ 3,000,000 $ft^3$) of the compartment, a transient fire propagating to secondary combustibles would not cause a damaging hot gas layer (HGL) to form. Additionally, the location and distribution of non-cable secondary combustibles are such that the existing transient scenarios and target sets are bounding. |
| | PVC | 375 lbs. | |
| | Rubber | 275 lbs. | |
| | Wood | 100 lbs. | |
| | Acetylene | 2000 cu. ft. | |

| Fire Compartment(s) | Combustible Type | Quantity | Screening Justification |
|---|---|---|---|
| FC 552GRP (Service and Circulating Water Pump Room) | PVC | 97 lbs. | There are negligible quantities of non-cable secondary combustibles (part of incidental components) distributed throughout the large (1000 ft$^2$) compartment. There are no locations where significant quantities of non-cable combustibles are subjected to fixed and/or transient ignition sources. FPRA target impacts are bound by the existing peak ZOI for each scenario. |
| | Rubber | 50 lbs. | |
| | Nylon | 30 lbs. | |
| | Polyethylene | 45 lbs. | |
| | Polyurethane | 30 lbs. | |
| | Wood | 40 lbs. | |
| FC 596 (Containment Façade - Unit 2) | PVC | 1745 lbs. | Given the large volume (~ 3,000,000 ft$^3$) of the compartment, a fire propagating to secondary combustibles would not cause a damaging hot gas layer (HGL) to form. Additionally, the location and distribution of non-cable secondary combustibles are such that the existing fixed ignition source and transient fire scenarios and target sets are bounding. |
| | Wood | 230 lbs. | |
| FC 675 and FC 676 (13.8 kV Switchgear Building) | Canvas Coverings | 50 lbs. (conservative estimate) | The location and distribution of non-cable secondary combustibles are such that the existing fixed ignition source and transient fire scenarios and target sets are bounding. |

Additionally, a potential increase to the HRR due to non-cable secondary combustibles would be bound by the following conservatisms:

- Fire scenarios involving electrical cabinets (including the electrical split fraction of pump fires) utilize the 98$^{th}$ percentile HRR for the severity factor calculated out to the nearest Fire PRA target. This is conservative because most fires will not reach the 98$^{th}$ percentile HRR.
- Not every cable tray was filled to capacity. In most cases fire modeling assumed all cable trays were filled to capacity, which provided a conservative estimate of the contribution of cable insulation to the fire and the corresponding time to damage. In some instances additional information on cable loading was used to reduce this capacity in the model, while still using conservative estimates.
- Conservative screening criteria for damage temperatures and heat fluxes were used (i.e., 205°C and 6 kW/m$^2$ for thermoplastic cables).
- Target failure was assumed to occur once the HGL temperature reached the damage temperature. No additional time delay due to thermal response was assumed.

Refer to the response to PBNP RAI FM 06.a (see 60-day RAI response – Reference NRC 2014-0043) for additional conservatisms associated with the ZOI calculations.

Based on the results of the reassessment of potential secondary combustibles and the inherent conservatisms in the fire modeling analysis, the effects from non-cable intervening combustibles on the fire modeling analysis were determined to be negligible and bound by the current analyses. Therefore, further analysis of the non-cable secondary combustibles is not required.

c) Cable trays provided with solid bottom covers were credited to delay, by 4 minutes, damage to and ignition of thermoplastic cables, based on the test results from NUREG/CR-0381, "A Preliminary Report on Fire Protection Research Program Fire barriers and Fire retardant Coatings Tests." No tests that were performed on Polyvinyl chloride [PVC (i.e., unqualified)] cable with a solid bottom tray and no coating had a time to electrical short or a time to ignition that was less than 4 minutes.

   Per Detailed Fire Modeling Report R2168-001-318, fire growth and propagation was not postulated for any fully enclosed cable trays in the Cable Spreading Room (Fire Compartment 318). These cable trays are robustly enclosed on all sides with heavy gauge steel and ½" Kaowool insulation is provided on top of the cables below the top cover, therefore, the barriers are credited to delay cable damage until after automatic suppression activation, which is slightly greater than the 4 minute delay credited for cable trays with solid bottom covers only. Attachment 5 of R2168-001-318 provides additional justification to credit a 6 minute delay in cable damage for the fully enclosed trays with Kaowool in the Cable Spreading Room. The additional justification is summarized below:

- Although a percentage of the cables in the fully enclosed trays are thermoplastic, some cables are thermoset. Thermoset cables in this arrangement are afforded a 20 minute delay to damage per NUREG/CR-0381.

- The test configuration detailed in NUREG/CR-0381 considered a propane burner located 4.75 inches below the cable tray. Walkdown information determined a majority of the bottommost cable trays in a stack are located a minimum of 16 inches above the fire elevation. For Test Number 39, a cable fault did not occur until after the first of two ignition cycles was complete.

- The cable trays in the test configuration were subjected to flame impingement as well as direct centerline plume temperatures of the initiating source for the entire duration of the test. The configuration in the Cable Spreading Room is such that the cable trays are not subjected to flame impingement until 3 minutes after ignition. Further, a majority of cable trays in the Cable Spreading Room are not located directly above an ignition source (i.e., along the centerline of the plume). Conservatively, the fire vent was assumed to be located at the top of the cabinets in the Cable Spreading Room, however, the structural features of the initiating cabinet (e.g., cabinet walls, vent characteristics, cable bracing, internal cable bundles, switches, etc.) would serve to deflect and dissipate the plume such that the cable tray would not likely be subjected to direct centerline plume temperatures for the duration of the fire scenario and the actual fire vent height would be lower.

One hour and three hour rated electrical raceway fire barrier systems (ERFBS) were credited to prevent damage and ignition of thermoplastic cables. Cable tray covers and wraps were not credited when located within the zone-of-influence (ZOI) of a high hazard event [e.g., high energy arcing faults (HEAFs)].

Credited cable tray covers and wraps were reviewed for holes by performing plant walkdowns. The plant walkdowns confirmed that all sections of cable tray covers and wraps, credited in the Fire PRA analysis to delay ignition or damage to cables, are robust and without holes. Therefore, holes in the cable tray covers and wraps were not applicable to the fire modeling analyses.

d) The assumption in the fire modeling analysis that there were no open cabinets was based on plant electrical equipment operation and electrical safety procedures and personnel expectations. Electrical equipment operation instructions require cabinet cubicle doors be closed and secured. PBNP Electrical Safety procedure requires enclosures, covers, doors, or other barriers to be properly secured at the completion of work activities. Plant procedures require that equipment is placed in a known, secure, and stable condition. Personnel are expected to report equipment problems, personnel hazards, and material condition deficiencies, following certain guidelines, when conditions cannot be immediately corrected.

The fire modeling assumptions regarding the condition of cabinet doors will be included in the monitoring program. LAR Attachment S, Table S-3 (Reference 1), describes the Implementation Items that will be completed prior to the implementation of the new NFPA 805 Fire Protection Program. A new implementation item has been added to Table S-3. The new Implementation Item reads: "Verification of the condition of electrical cabinet doors to meet Fire Modeling Assumptions will be included in the monitoring program." A markup of LAR Attachment S, Table S-3, Implementation Items (Reference 1), is included in Attachment 3.

Based on current plant procedures and requirements, and future updates to the monitoring program, open electrical cabinet doors due to maintenance or measurement activities in the plant do not invalidate the assumption used in the fire modeling analysis.

e) The guidance in NUREG/CR-6850, Appendix M was used to determine damage due to high energy arcing fault (HEAF) events. The initial zone of influence (ZOI) of the energetic phase of the HEAF in a cabinet was assumed to be five feet vertically and three feet horizontally. The zone of influence of a HEAF at a segmented bus duct transition point was calculated based on Supplement 1 to NUREG/CR-6850 [i.e., downward spread, ZOI with shape and volume of a right circular cone with sides at an angle of 15° from the vertical axis (a total enclosed solid angle of 30°)]. The total area of exposed cable trays and combustibles within the zone of influence (ZOI) of the HEAF scenario are assumed ignited at time zero. Subsequent flame spread and fire propagation calculations were performed consistent with the processes recommended by NUREG/CR-6850, "Fire PRA Methodology for Nuclear Power Facilities," and NUREG/CR-7010, "Cable Heat Release Ignition, and Spread in Tray Installations During Fire (CHRISTIFIRE) Phase 1: Horizontal Trays." The fire growth and propagation analysis was conducted using the methodology described below.

Any cable tray within the ZOI of the HEAF was assumed to be damaged and ignited at time zero. For horizontal cable trays, the horizontal cable tray flame spread rates from NUREG/CR-6850,
Section R.4.1.2, were used. The heat release rates per unit area (HRRPUA) for cables were equal to or exceeded the values recommended by NUREG/CR-7010, Section 9.2.2.

After the first cable tray in a stack of horizontal thermoplastic cable trays was assumed to ignite, the propagation of fire within the stack was assumed to occur at a rate of one tray per minute. If there was a second stack of cable trays adjacent to the first stack and located fully or at least partially immersed in the fire plume, spread to the first (i.e., lowest) tray in the second stack was assumed to occur one minute after ignition of the first tray in the first stack.

For the purpose of fire growth and propagation analysis, once the initial HEAF zone of influence has been quantified, the heat release rate probability density function for the appropriate type of vertical cabinet was selected (i.e., 211 kW). While NUREG/CR-6850 describes the door to be blown open this was not to be interpreted to mean selection of the open door vertical cabinet fire of 1002 kW. Industry experience documented in NUREG/CR-6850 and the EPRI Fire Events Database imply that the magnitude and energy produced by the HEAF would significantly consume any cabling internal to the cabinet. Since the initial combustible material is mostly consumed, the ensuing fire is expected to be limited to any secondary combustibles (trays) ignited by the HEAF. Applying the standard electrical fire size for the ensuing HRR for the source HEAF cabinet is therefore considered to be conservative. Since the mechanical force associated with the HEAF failure will cause venting in the source cabinet preventing an internal hot gas layer from forming, propagation to adjacent vertical sections was not postulated.

The modeling conservatively assumes the ensuing HEAF fire to sustain a burning duration of 20 minutes. Using a conservative burning duration to model a HEAF scenario helps to bound uncertainties inherent in modeling HEAF fires.

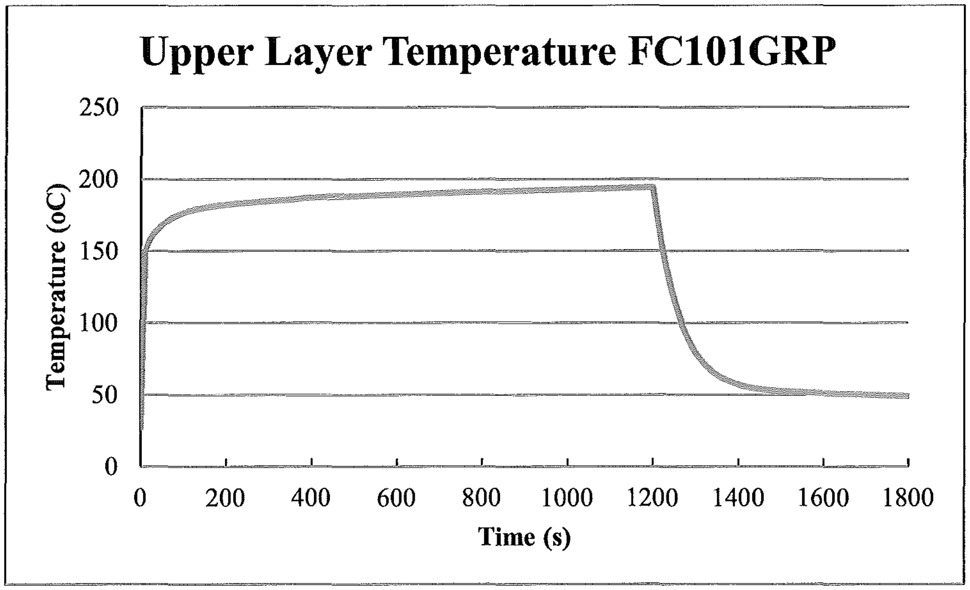
Cable tray enclosures and electrical raceway fire barrier systems (ERFBS) within the ZOI of the HEAF were assumed to be physically damaged by the initial explosion and were not credited in the analysis. The force of the HEAF is assumed to damage cable tray enclosures and fire wrap for an area equivalent to the size of the ignition source. The area of the cables exposed due to the damage will ignite at time zero. Subsequent flame spread and propagation calculations were performed as detailed above.

f)

i. When the algebraic models were implemented for hot gas layer (HGL) calculations using the Method of McCaffrey, Quintiere, and Harkleroad (MQH), horizontal vents and vents at or near the ceiling were evaluated and modeled as a single, vertical, square or rectangular wall opening [as required by Fire Dynamics Tool (FDT) 02.1 and the EPM Detailed Fire Modeling Workbook (DFMWB)]. Horizontal vents and vents at or near the ceiling were evaluated on a fire compartment by fire compartment basis and were not always included in the detailed fire modeling. In some instances, omitting these passive ventilation paths would result in overly conservative hot gas layer temperatures, therefore, the vents were incorporated into the following models for a more accurate representation of the as-built ventilation characteristics of each fire compartment:

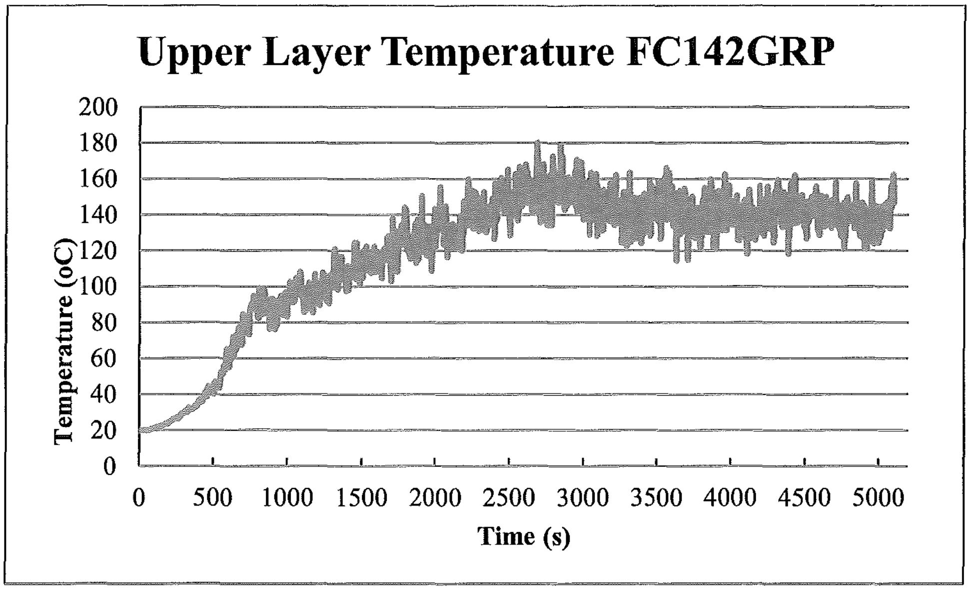
**Fire Compartment 101GRP (Valve Pit/Sump Pump Room)** has two large open horizontal vents in the ceiling in the form of an open stairwell (3.5 ft. by 10.7 ft.) and an open hatchway (6 ft. x 11 ft.), with a total open vent area of 103.5 $ft^2$. The two horizontal vents were characterized as a single vertical vent measuring 10.2 ft. by 10.2 ft. (104.0 $ft^2$). The top of the vent (11 ft.) was modeled just below the ceiling height (11.1 ft.) due to the location of the horizontal vents in the ceiling.

In order to demonstrate that this approach is acceptable, FC 101GRP was modeled in the Consolidated Model of Fire and Smoke Transport (CFAST) using the same dimensions modeled in the DFMWB. Each vent, both vertical and horizontal, was modeled individually instead of combined and the most conservative heat release rate (HRR) profile was selected from the DFMWB, including any secondary combustibles. The CFAST results for the most conservative HRR profile indicate that the upper gas layer temperature only reaches 194°C which does not result in the formation of a damaging HGL (205°C). This is consistent with the original DFMWB results and further analysis is not required. CFAST was used within the limits of applicability and the analysis was performed within the validated range of NUREG-1824. Refer to the table at the end of this response for evaluation of the relevant normalized parameters. The CFAST results are provided in the figure below.



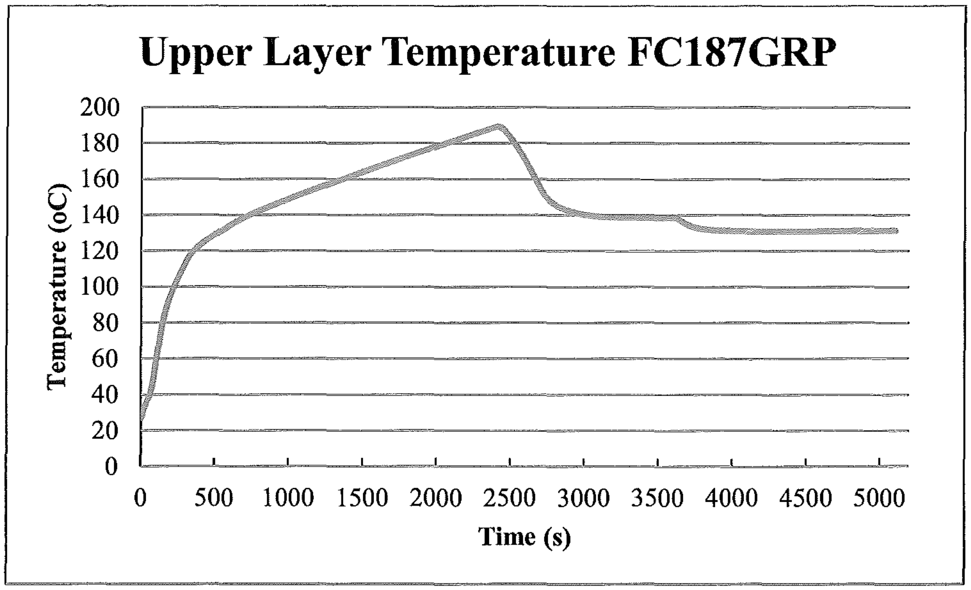

**Fire Compartment 142GRP (CCW Pump Room)** has two large open horizontal vents in the ceiling in the form of an open stairwell (13 ft. by 15 ft.) and an open hatchway (12 ft. x 15 ft.), with a total open horizontal vent area of 375 ft². The horizontal vent area was added to the vertical open vent area seven open doorways and miscellaneous open wall penetrations, totaling 345 ft²) and modeled as a single vertical vent measuring 30 ft. by 24 ft. (720 ft²). The top of the vent was modeled at ceiling height due to the location of the horizontal vents in the ceiling and the height of the open doorways and penetrations.

In order to demonstrate that this approach is acceptable, FC 142GRP was modeled in FDS using the same dimensions modeled in the DFMWB. Each vent, both vertical and horizontal, was modeled individually instead of combined and the most conservative HRR profile was selected from the DFMWB, including any secondary combustibles. The FDS results for the most conservative HRR profile indicate that the upper gas layer temperature only reaches 180°C, which does not result in the formation of a damaging HGL (205°C). This is consistent with the original DFMWB results and further analysis is not required. FDS was used within the limits of applicability and the analysis was performed within the validated range of NUREG-1824. Refer to the table at the end of this response for evaluation of the relevant normalized parameters. The FDS results are provided in the figure below.




**Fire Compartment 187GRP (Monitor Tank Room)** has one large open horizontal vent in the floor in the form of an open hatchway (11 ft. x 12 ft., 132 $ft^2$). The horizontal vent area was added to the vertical open vent area (open doorway, totaling 21 $ft^2$) and modeled as a single vertical vent measuring 7 ft. by 21.9 ft. (153 $ft^2$). The top of the vent was modeled at the height of the open doorway (7 ft.). Applying this height to the ventilation opening is conservative due to additional open doorways, stairwells, and hatchways, which were excluded from the model. Furthermore, there are no scenarios in FC 187GRP capable of generating a damaging hot gas layer.

In order to demonstrate that this approach is acceptable, FC 187GRP was modeled in CFAST using the same dimensions modeled in the DFMWB. For conservatism, only the vertical doorway vent was modeled and the most conservative HRR profile was selected from the DFMWB, including any secondary combustibles. The CFAST results for the most conservative HRR profile indicate that the upper gas layer temperature only reaches 189°C, which does not result in the formation of a damaging HGL (205°C). This is consistent with the original DFMWB results and further analysis is not required. CFAST was used within the limits of applicability and the analysis was performed within the validated range of NUREG-1824. Refer to the table at the end of this response for evaluation of the relevant normalized parameters. The CFAST results are provided in the figure below.




**Fire Compartment 237 (CCW HX & Boric Acid Tank Room, Elevation 46 ft)** was initially modeled with a single vertical vent measuring 3.5 ft. by 20.1 ft. (70.5 $ft^2$) to account for the horizontal and vertical openings present in the compartment. Further analysis of walkdown information determined that FC 237 should be modeled with a standard size open doorway (21 $ft^2$) only. Detailed Fire Modeling Report R2168-001-237 will be revised to update the ventilation opening and the fire scenarios accordingly.

| Normalized Parameters – CFAST HGL Analysis (101GRP & 187GRP) | | | | |
|---|---|---|---|---|
| Quantity | Normalized Parameter | Validation Range | In Range? | |
| Fire Froude Number | N/A | 0.4 - 2.4 | N/A | The Froude Number is predominately used to validate the plume temperatures and flame heights. Since the CFAST analyses were used exclusively to calculate HGL temperatures in the models, the item of foremost importance is the amount of energy (HRR) being released into the fire compartments, and the Froude Number outside of the validated range would not invalidate the results. |
| Flame Length relative to Ceiling Height | N/A | 0.2 - 1.0 | N/A | 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 HGL development exclusively and do not calculate target damage to targets within the flame height or targets, which may be subjected to flame radiation. Therefore, this parameter is not applicable to the analyses. |

| | | | | |
|---|---|---|---|---|
| Ceiling Jet Radial Distance relative to Ceiling height | N/A | 1.2 - 1.7 | N/A | The primary application of this parameter is to determine the temperature of targets at the ceiling, such as 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. Further, other ceiling jet targets are not included in the analyses. |
| Equivalency Ratio | N/A | 0.04 - 0.6 | N/A | The equivalence ratio is primarily a measure of the ventilation conditions of the compartment. 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 unaffected. Therefore, the lower oxygen limit in the models has conservatively been set to 0% and the equivalence ratio is not applicable to the analyses. |
| Compartment Aspect Ratio (101GRP) (L) | 2.3 | 0.6 - 5.7 | Yes | The calculated normalized parameters for the analyses are within the validation range for the configurations shown. |
| Compartment Aspect Ratio (101GRP) (W) | 5.1 | 0.6 - 5.7 | Yes | |
| Compartment Aspect Ratio (187GRP) (L) | 5.6 | 0.6 - 5.7 | Yes | The calculated normalized parameters for the analyses are within the validation range for the configurations shown. |
| Compartment Aspect Ratio (187GRP) (W) | 4.5 | 0.6 - 5.7 | Yes | |

| | | | | |
|---|---|---|---|---|
| Radial Distance relative to Fire Diameter | N/A | 2.2 - 5.7 | N/A | This parameter is not applicable to the analyses. There are no radiant targets analyzed in the models. Hot gas layer development is the only fire effect analyzed. |

| **Normalized Parameters – FDS HGL Analysis (142GRP)** | | | | |
|---|---|---|---|---|
| Quantity | Normalized Parameter | Validation Range | In Range? | Validity statement |
| Fire Froude Number | N/A | 0.4 - 2.4 | N/A | The Froude Number is predominately used to validate the plume temperatures and flame heights. Since the FDS analysis was used exclusively to calculate the HGL temperature in the model, the item of foremost importance is the amount of energy (HRR) being released into the fire compartment, and the Froude Number outside of the validated range would not invalidate the results. |

| Normalized Parameters – FDS HGL Analysis (142GRP) | | | | |
|---|---|---|---|---|
| Quantity | Normalized Parameter | Validation Range | In Range? | Validity statement |
| Flame Length relative to Ceiling Height | N/A | 0.2 - 1.0 | N/A | 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 model analyzes HGL development exclusively and does not calculate target 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 | N/A | The primary application of this parameter is to determine the temperature of targets at the ceiling, such as 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. Further, other ceiling jet targets are not included in this analysis. |
| Equivalency Ratio | 0.2 | 0.04 - 0.6 | Yes | The calculated normalized parameter for this analysis is within the validation range for the configurations shown. |
| Compartment Aspect Ratio (L) | 4.1 | 0.6 - 5.7 | Yes | The calculated normalized parameter for this |

| Normalized Parameters – FDS HGL Analysis (142GRP) | | | | |
|---|---|---|---|---|
| Quantity | Normalized Parameter | Validation Range | In Range? | Validity statement |
| Compartment Aspect Ratio (W) | 4.1 | 0.6 - 5.7 | Yes | analysis is within the validation range for the configurations shown. |
| Radial Distance relative to Fire Diameter | N/A | 2.2 - 5.7 | N/A | This parameter is not applicable to this analysis. There are no radiant targets analyzed in the model. Hot gas layer development is the only fire effect analyzed. |

ii. Detection timing was determined using NUREG-1805, *Fire Dynamics Tools,* fire model Fire Dynamics Tool FDT 10, *Estimating Smoke Detector Response Time* and *Estimating Heat 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 within one minute, the corresponding time required for activation was calculated. If the device was located too close to the ignition source to be within the validated range of the NUREG-1824 parameter for 'ceiling jet radial distance,' the radial distance was conservatively increased to force the parameter into the validated range.

If the minimum HRR required to activate the detector within one minute 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 twelve 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 Supplement 1 to NUREG/CR-6850.

The time to detector activation was determined by the fire modeling analyst by manipulating the HRR in FDT 10; thereby decreasing the delay to activation by increasing the HRR of the fire, while not exceeding the critical HRR under evaluation. Once the minimum HRR required to activate the detector within one minute was calculated using FDT 10, the time to detection was determined using the applicable $t^2$ fire growth profile for the given scenario (i.e. detection assumed to occur at the time the modeled fire reaches the HRR determined using FDT 10). 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 delay to detector activation (less than one minute), as calculated by FDT 10, was omitted for $t^2$ fire growth profiles. The FDT 10 activation time is calculated based on exposure to the inputted HRR from time zero. In using a $t^2$ fire growth profile, the detector is subject to smoke/heat exposure prior to the activation HRR. In other words, the calculated delay to detector activation is accounted for during the $t^2$ time to reach the necessary HRR, and therefore can be discounted.

For scenarios requiring the activation of two cross-zoned smoke detectors to initiate an automatic suppression system (e.g., Halon), the second detector farthest from the fire was considered when calculating time to detection. It was assumed that the detector closest to the fire will activate prior to the analyzed detector.

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 40-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 FDT 10, 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 FDT 10, a fire size was determined that activates the sprinkler within one minute. If the device was located too close to the ignition source to be within the validated range of the NUREG-1824 parameter for 'ceiling jet radial distance,' the radial distance was conservatively increased to force the parameter into the validated range.

This process requires that the fire modeling analyst establish the minimum HRR required to activate the sprinkler within one minute. If the minimum HRR required to activate the sprinkler within one minute 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 FDT 10; thereby decreasing the delay to activation by increasing the HRR of the fire. The fire size selected for sprinkler activation within one minute 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 FDT 10 was recorded. Using a standard $t^2$ fire growth profile, the time to reach the inputted HRR was calculated. 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 Supplement 1 to NUREG/CR-6850.

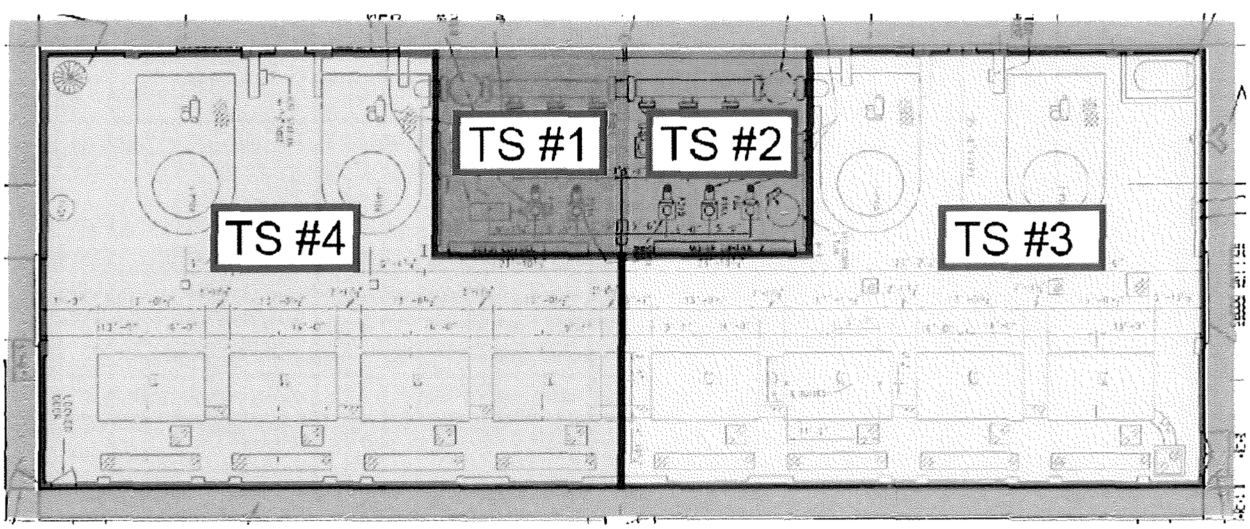
The delay to sprinkler activation (less than one minute), as calculated by FDT 10, was omitted from the total time for sprinkler activation, if a $t^2$ fire growth profile is employed. The FDT 10 activation time is calculated based on exposure to the selected HRR from time zero. In using a $t^2$ fire growth profile, the scenario provides a slow heating of the bulb or link until the critical HRR is achieved. Discounting the activation delay is justified based on this fire growth profile and the conservatisms applied to target damage (i.e., target damage is assumed once the fire reaches the critical HRR on the $t^2$ curve, without additional delay or use of the NUREG-CR/6850).

g) The singular purpose of the Consolidated *Model* of *Fire* and Smoke Transport (CFAST) analysis for the Service and Circulating Water Pump Room Fire Compartment 552GRP (provided in Attachment 5 of Detailed Fire Modeling Report R2168-001-552GRP) was to determine if a large oil fire (100% oil spill) involving one of the Circulating Water Pumps (1P-30A, 1P-30B, 2P-30A, and 2P-30B), was capable of failing all FPRA targets in the compartment via a damaging hot gas layer. Target failures via direct flame impingement, plume temperatures, radiant heating, and any combination thereof, were not screened from the analysis, and are addressed along with FPRA target impacts in Attachment 1 of Detailed Fire Modeling Report R2168-001-552GRP.

The CFAST analysis justifies the use of target failure sets limited to those targets within the line of sight of each pump. Although the lower gas layer does not exceed 205°C, FPRA target failures are assumed and accounted for due to direct flame impingement, damaging plume temperatures, radiant heating, and combined thermal exposure impacts. Attachment 1 of Detailed Fire Modeling Report R2168-001-552GRP, details the zone of influence for each pump as well as the damaged FPRA target sets. Therefore, potential damage for targets in the lower gas layer (LGL) due to the combined radiant heat flux from the HGL, heated surfaces, and the flame are addressed by the zone of influence failures in Detailed Fire Modeling Report R2168-001-552GRP.

The zone of influence for each pump is provided in Figure 1, with all targets within TS#4 failing due to a large oil fire at pump 1P-30A or 1P-30B and all targets within TS#3 failing due to a large oil fire at pump 2P-30A or 2P-30B. Target failure was conservatively assumed to fail at time zero.

**Figure 1: Zone of influence for each Circulating Water Pump**




CFAST was implemented to screen whole room damage via a hot gas layer due to the location of the FPRA targets, all of which are located at or near floor level. The Service Water Pump Room (TS#1 and TS#2 in Figure 1) shields pumps 1P-30A and 1P-30B from the zone of influence of pumps 2P-30A and 2P-30B, and vice versa. Additionally, the large oil fires are expected to occur below grade due to the presence of trenches below each pump. Therefore, the combined radiant and convective thermal exposures are bound by the failures captured by the conservative line of sight zones of influence detailed in Attachment 1 of Detailed Fire Modeling Report R2168-001-552GRP.

h)

i. Polyethylene/polyvinylchloride (PE/PVC) cabling was assumed for the Main Control Room (MCR) abandonment analysis, as these are the most common insulation materials for thermoplastic cables. As detailed in the Society of Fire Protection Engineers (SFPE) Handbook, soot yield is dependent upon combustion conditions. For pyrolysis, the soot yield value for PVC is assigned a range from 0.03 g/g (grams per gram of fuel) to 0.12 g/g, and for flaming conditions a single soot yield value of 0.12 g/g is provided. For conservatism, a soot yield value of 0.12 g/g was selected and used in the MCR analysis.

The soot yield value for PVC was conservatively assumed in the MCR abandonment analysis for transient fires, which typically involve ordinary Class A combustibles (i.e., various forms of paper and plastic products) with an aggregate soot yield value less than that of PVC cabling. Assuming a transient comprised of equal parts paper and plastic products, a representative soot yield of
0.038 g/g was calculated, for example, by averaging the soot yields of red oak (i.e., 0.015 g/g) for paper products and polyethylene (i.e., 0.060 g/g) for the plastic products. Therefore the use of a 0.12 g/g soot yield for transient fires in the analysis is conservative.

Furthermore, the MCR abandonment analysis includes additional conservatism due to Fire Dynamics Simulator (FDS) overestimation of measured smoke concentration by an average factor of 2.70.

Heat of combustion (HOC) was not specified in the MCR abandonment analysis; rather, heat release rates (HRR) were prescribed using heat release rate per unit area (HRRPUA) to replicate the growth profiles and peak heat release rate bins provided in NUREG/CR-6850, Appendices E and G. For conservatism and to prevent ventilation-limited conditions from occurring, the lower oxygen limit in FDS was set to zero.

In all MCR models, the energy released per unit mass of oxygen (EPUMO2) is used by FDS to estimate the Heat of Combustion for the fuel. The default EPUMO2 is 13,100 kJ/kg Oxygen, which is considered an accurate estimate for most hydrocarbon fuels. Along with the chemical formula for the fuel, and basic stoichiometry, FDS will use the EPUMO2 to estimate the HOC for the PVC fuel as follows:

$$C_xH_yO_zN_vOther_w + v_{O_2}O_2 \xrightarrow{yields} v_{CO_2}CO_2 + v_{H_2O}H_2O + v_{CO}CO + v_{soot}Soot + v_{N_2}N_2 + v_{H_2}H_2 + v_{other}Other$$

$$C_2H_3Cl + v_{O_2}O_2 \xrightarrow{yields} v_{CO_2}CO_2 + v_{H_2O}H_2O + v_{CO}CO + v_{soot}Soot + v_{H_2}H_2 + v_{Cl}Cl^*$$

*Chlorine is typically released as $Cl_2$ or HCl, but FDS does not recognize these byproducts and simplifies the products of combustion for "Other" atoms.

$$\boldsymbol{v_{O_2}} = v_{CO_2} + \frac{v_{co}}{2} + \frac{v_{H_2O}}{2} - \frac{z}{2} = 1.375 + 0 + \frac{3}{4} - 0 = 2.125\,mol$$

$$\boldsymbol{v_{CO_2}} = x - v_{co} - \left(1 - H_{frac}\right)v_{soot} = 2 - 0 - (1 - 0)0.625 = 1.375\,mol$$

$$\boldsymbol{v_{H_2O}} = \frac{y}{2} - \frac{H_{frac}}{2}v_{soot} - v_{H\,2} = \frac{3}{2} - 0 - 0 = 1.5\,mol$$

$$\boldsymbol{v_{CO}} = \frac{W_f}{W_{co}}y_{co} = \frac{62.5}{44} * 0 = 0$$

$$\boldsymbol{v_{H_2}} = \frac{W_f}{W_{H_2}}y_{H_2} = \frac{62.5}{2} * 0 = 0$$

$$\boldsymbol{v_{soot}} = \frac{W_f}{W_s}y_s = \frac{62.5}{12} * 0.12 = 0.625\,mol$$

$$\boldsymbol{v_{Cl}} = w = 1\,mol$$

$$\boldsymbol{W_s} = H_{frac}W_H + \left(1 - H_{frac}\right)W_c = 0 + (1 - 0) * 12 = 12\frac{g}{mol}$$

$$\boldsymbol{C_2H_3Cl + 2.125\;O_2 \xrightarrow{yields} 1.375\;CO_2 + 1.5\;H_2O + 0.625\;Soot + 1\;Cl}$$

$$\boldsymbol{\Delta H} \approx \frac{v_{O_2}W_{O_2}}{v_fW_f}EPUMO2 = \frac{2.125 * 32}{1 * 62.5}13100 = 14253\frac{kJ}{kg}\;PVC$$

By comparison, the HOC listed for PVC by SFPE is 16,400 kJ/kg PVC. In this case, the lower HOC calculated by FDS is conservative with respect to soot production and abandonment times. Since the HRR is prescribed in the FDS model, changing the HOC will alter the mass loss rate of the fuel. A lower HOC will result in a higher mass loss rate to meet the prescribed HRR. Although the soot yield is constant, more fuel is burned per unit time, producing a greater volume of soot. Therefore, since optical density drives abandonment in these models, the FDS predicted lower HOC is more conservative.

ii. Two transient and two electrical cabinet scenario locations were postulated for the Main Control Room (MCR) abandonment analysis. The locations of the fires were selected to bound a fire at any location within the room. Each electrical cabinet fire scenario location was conservatively selected such that the fire would spread to two additional cabinets, based on the methodology provided in NUREG/CR-6850, Appendix S, and thereby bound the heat release rate (HRR) of any electrical cabinet scenario. Locations for the transient fires were selected both inside and outside of the horseshoe at locations in close proximity to the main control boards and operators. Devices that measure habitability conditions were located near the fire locations to provide data to conservatively calculate when control room abandonment would be necessary.

The primary goal of the analysis was to determine the effect of the hot gas layer on habitability conditions within the MCR and, therefore, varying the location of the fires modeled in FDS would lead to similar, or potentially less severe, abandonment times. For example, transient scenarios placed farther away from the control boards would have delayed effects on the operators, and single electrical cabinet fires generate less heat and smoke than multi-cabinet fires with much higher heat release rates.

iii. Supplement 1 to NUREG/CR-6850 provides guidance on the growth profiles for transient fires. It states that a time dependent fire growth model may be appropriate for any situation where the basis of its use can be established. Three categories of transient growth profiles are provided with their respective times to peak heat release rate:

- **Common trash can fire (8 minutes).** The control room contains trash cans with the potential for transient combustibles.

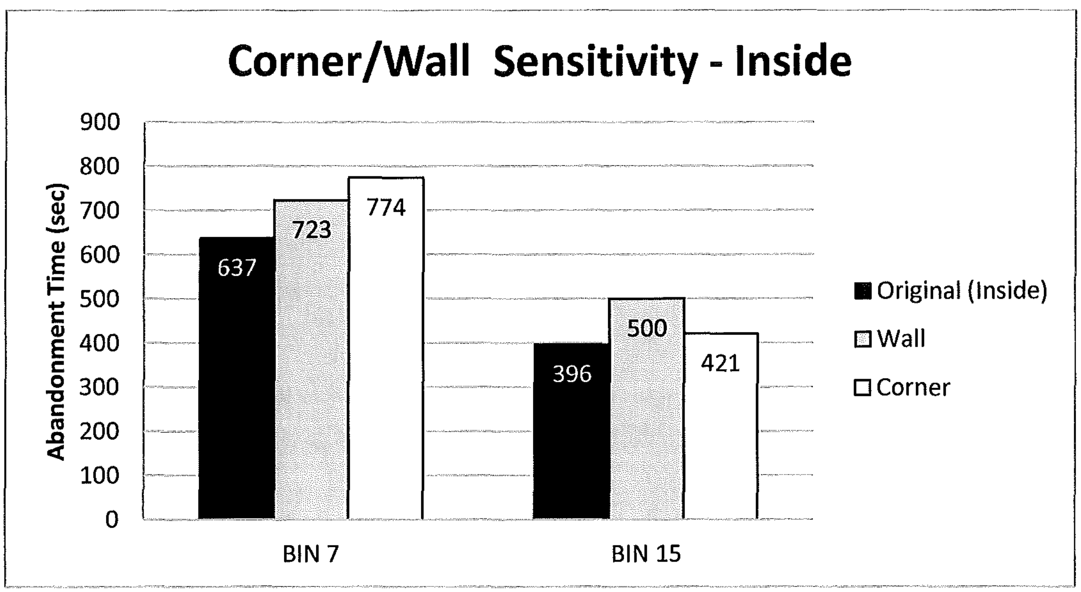
- **Common trash bag fire (2 minutes).** PBNP Administrative Procedure NP 1.9.9, *Transient Combustible Control*, requires that combustible trash be placed in metal containers fitted with metal covers and combustible trash too large to fit in metal containers shall be discarded in a proper receptacle outside of the plant. A trash bag left outside of one of the trash cans within the control room is considered unlikely, and would likely be under direct supervision of those personnel responsible for trash removal.

- **Spilled solvents/combustible liquids (0 minutes).** It is considered unlikely that the control room will contain any appreciable amount of solvents or other combustible liquids, since they are not commonly present in this plant location. For this reason, the time to peak HRR for this category of transient is not considered.

From these assumptions, the HRR growth rate for transients was determined to be that of the common trash can fire scenario, or 8 minutes. Scenarios involving fires outside a trash can or involving solvents are considered to be of sufficiently low probability that they can be ignored in the determination of the time to HRR growth.

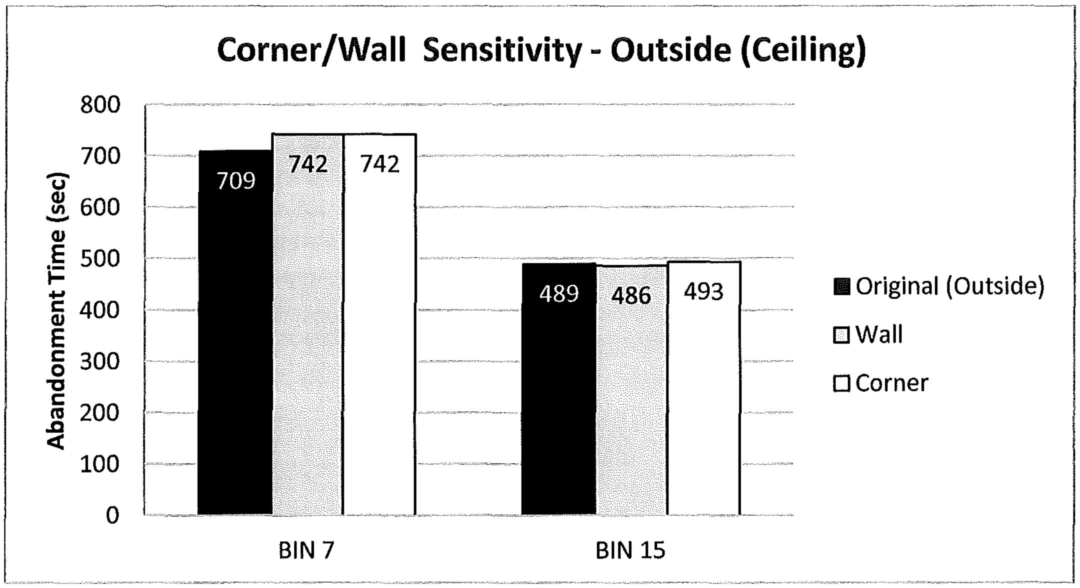
iv. The Main Control Room Analysis Notebook (P2091-2700-01) has been revised to include an additional sensitivity regarding transient placement inside the horseshoe below the acoustic tile ceiling. This sensitivity places a transient fire in both a corner and next to a wall inside the horseshoe, under the acoustic tile ceiling. The areas were selected where transient combustibles are expected to collect (i.e., a trash can next to a wall) or be overlooked (i.e., in a corner). The results of this sensitivity were compared to the original model inside the horseshoe to determine the effect on the time to abandonment.

The sensitivity results for the corner and wall placement inside the horseshoe show an overall increase in time to abandonment, therefore, the original model is conservative and bounding with respect to corner and wall fires. The original conclusion that corner and wall fires do not adversely affect optical density development of the hot gas layer and consequently control room habitability, is also valid for transient fires located below the acoustic tile ceiling within the horseshoe area. A summary of the corner and wall sensitivity results is provided below.




A sensitivity analysis was also conducted to address transient placement outside the horseshoe in areas under the acoustic tile ceiling. This sensitivity places a transient fire in the northeast corner of the compartment and along the north wall, under the acoustic tile ceiling outside of the horseshoe. The results of this sensitivity were compared to the original model outside of the horseshoe to determine the effect on the time to abandonment.

The sensitivity results for the corner and wall placement beneath the acoustic tile ceiling outside the horseshoe indicate negligible change in the abandonment time, therefore, the original model is conservative and bounding with respect to corner and wall fires. The original conclusion that corner and wall fires do not adversely affect optical density development of the hot gas layer and consequently control room habitability is also valid for transient fires located below the acoustic tile ceiling outside the horseshoe area. A summary of the corner and wall sensitivity results is provided below.




v. Devices were placed throughout the control room to monitor the effect of the hot gas layer on habitability conditions. The devices were located:

- To ensure complete coverage of the control room
- In areas that represent the most likely fire scenario points of origin
- In proximity to the expected location of the operators
- In locations where smoke was expected to accumulate (i.e., in corners and in the space between the horseshoe and the back panels)

To ensure the model's accuracy, devices to monitor temperature (i.e., thermocouple device trees) were placed vertically in three foot increments at the selected locations. The devices that were used to monitor habitability conditions (i.e., devices that monitor radiative heat flux and optical density) were placed six feet above the floor, near an operator's head. Abandonment time was assumed to occur upon reaching any of the following habitability thresholds listed in NUREG/CR-6850 as measured by a device at any location:

- The heat flux at six feet above the floor exceeds 1 $kW/m^2$ (relatively short exposure)
- The smoke layer descends below six feet from the floor, and optical density of the smoke is greater than 3.0 $m^{-1}$

- An HGL temperature of 95° Celsius (C) (200° Fahrenheit (F))

l)

i. The Multi-Compartment Analysis screens scenarios based on compartment size using two methods. One method is based on the size of the exposing compartment and the second is based on the size of the exposed compartment. A review was performed to ascertain if the exposing compartment, exposed compartment, or multiple adjacent exposed compartments is of sufficient volume to dilute the hot gas layer such that a HGL will not form in the exposed compartment. If the compartment is of sufficient volume to significantly dilute the HGL, the scenario can be screened from further analysis.

For the exposing fire compartment screening step in the Multi-Compartment Analysis, the qualitative method was based on the exposing compartment not being able to generate a hot gas layer due to its size and configuration. The only fire compartments that were screened in this step without a quantitative fire model basis are the Turbine Buildings, the Unit 1 and 2 containment buildings, and the primary auxiliary building central area (gas stripper equipment area) on elevation 44' based on the compartments having large volumes and significantly large openings and no fire being capable of generating a hot gas layer in the compartment.

For the exposed fire compartment screening step in the Multi-Compartment Analysis, the qualitative screening method was based on the exposed compartment being of sufficient volume to preclude the generation of a hot gas layer. If the exposed fire compartment volume is significant, hot gases flowing into the exposed fire compartment from the exposing fire compartment, through failed or open boundary features between the exposing and exposed fire compartments, would be diluted by the large amount of ambient air present in the exposed compartment. Therefore, the hot gas layer in the exposed compartment would be well below the temperature that would cause damage to the Fire PRA targets. Although this screening method was initially based on the volume of the exposed fire compartment, additional factors were considered such as fire type and size, and configuration of secondary combustibles. This screening method identified large volumes and open areas as having the potential for preventing a hot gas layer in the exposed fire compartment. An assessment of the nature and configuration of the fire sources and secondary combustibles in the exposing compartment with respect to openings in the exposed compartment was performed to ensure that this qualitative screening was appropriate for each MCA scenario.

The exposed fire compartments screened in the MCA as having sufficient volume/open areas to prevent the formation of a hot gas layer, and a discussion of the reasoning for this determination is provided below.

**Turbine Buildings.** The Unit 1 and 2 turbine buildings includes the turbine generators and are a large open areas spanning all elevations of the buildings.

**Diesel Generator Buildings.** The G03 diesel generator room, the G03 switchgear room, and the G04 diesel room are open to the exterior via the large air intakes.

**Areas Open to Atmosphere**. The YARDGRP is located on the building exterior which precludes the possibility of a hot gas layer.

**Circ Water Pumphouse.** The pumphouse consists of a large open volume.

**Primary Auxiliary Building.** The central area of the 8' elevation, the central area of the 26' elevation, and the central area of the 44' elevation of the PAB consist of large volumes and large open boundaries that preclude the possibility of the formation of a hot gas layer due to a fire in adjacent compartments.

**Primary Auxiliary Building Electrical Equipment Rooms.** Unit 1 and 2 electrical equipment rooms on elevation 44'-0" of the PAB consist of large volumes and high ceilings (20') which preclude the possibility of the formation of a hot gas layer.

**Primary Auxiliary Building HVAC Fan and Equipment Rooms**. The Unit 1 and 2 HVAC fan rooms in the PAB consist of large volumes with high ceilings (39'). The Unit 1 and 2 HVAC equipment rooms on elevation 44' consist of large volumes which preclude the possibility of the formation of a hot gas layer.

**Primary Auxiliary Building 44' Central (Gas Stripper) Area.** The 44' elevation central area of the PAB including the gas stripper equipment room consists of a large volume, high ceiling, and large open boundaries to adjacent compartments.

**Containment Buildings**. The elevations of the Unit 1 and 2 containment buildings consist of large volumes with openings to adjacent elevations of the building.

**Containment Façades**. The Unit 1 and 2 containment façades consists of large volumes and high ceilings.

**North Service and South Service Buildings**. The entire north and south service buildings. The large volume of the building precludes the possibility of the formation of a hot gas layer in the entire structure.

After these large, open exposed fire compartments were identified, the exposing compartments were assessed to ensure that there were no significantly large fire scenarios that were capable of generating a hot gas layer in both compartments. The assessment of the fire scenarios, including those involving secondary combustibles, in the exposing compartment determined that the high ceilings, large volumes, and open barriers of these compartments would preclude the possibility of the formation of a hot gas layer due to any fire source in an exposing fire compartment.

ii. The Beyler Method in NUREG-1805, *Fire Dynamics Tools* fire model Fire Dynamics Tool (FDT) 02.3 "Predicting Hot Gas Layer Temperature in a Room Fire with Door Closed" and the Method of McCaffrey, Quintiere, and Harkleroad (MQH) in FDT 02.1 "Predicting Hot Gas Layer Temperature and Smoke Layer Height in a Room with Natural Ventilation" of the Fire Dynamics Tools (FDTs) from NUREG-1805 were used to calculate the minimum heat release rate (HRR) required to generate a damaging hot gas layer (HGL) in the exposing compartment. In order to complete these calculations, various input parameters needed to be determined including room geometry (compartment length, width, and height), wall characteristics (interior/wall lining thickness and material), ambient air temperature, vent area (vent height, width, and distance of the top of the vent from the floor), raceway targets/cable loading, time after ignition, and the bounding initiator HRR. Using the Goal Seek analysis tool in Microsoft Excel (2007), the minimum steady state HRR that would create a damaging HGL temperature was calculated.

If the HRR required to develop a damaging HGL was greater than the 98$^{th}$ percentile HRR for the worst-case fire source of the exposing compartment and no secondary combustibles could be ignited (or were not present), then the scenario screened from the analysis. If secondary combustibles were present, the scenario screened, if the combined HRR of the initiator and applicable secondary combustibles was less than the minimum required to generate a HGL. If the 98$^{th}$ percentile HRR for the initiator was capable of developing a damaging HGL or if secondary combustibles could be involved in the bounding scenario, then the scenario did not screen and further evaluation was required.

The Beyler method is based on non-steady energy balance to a closed compartment, assuming that the compartment has sufficient leakage to prevent pressure building. This correlation has been verified and validated in NUREG-1824, which indicates the method tends to over-predict hot gas layer temperatures, producing conservative results for the analysis. This method is best applied to conventionally sized compartments, however, it is deemed acceptable for use for larger compartments evaluated in this analysis due to the inherent conservatism associated with the correlation. For irregularly shaped compartments, equivalent dimensions were calculated as recommended in NUREG-1805, which yields higher (conservative) layer temperatures than would actually be expected for the compartment. The correlation is considered valid for compartment upper layer gas temperatures up to 600$^{0}$C (1112$^{0}$F). The upper layer gas temperature threshold for this analysis is 205$^{0}$C (400$^{0}$F), well within the temperature limitation of the FDT.

The MQH method is a statistical dimensionless correlation for evaluating hot gas layer temperature within a compartment with natural ventilation conditions. This correlation has been verified and validated in NUREG-1824 and *EPM Verification and Validation of Fire Modeling Tools and Approaches for Use in NFPA 805 and Fire PRA Applications*, which indicate that the method tends to over-predict hot gas layer temperatures, producing conservative results for the MCA Analysis. This method is best applied to conventionally sized compartments. The irregularly shaped rooms were modeled with equivalent dimensions as recommended in NUREG-1805, which yields higher (conservative) layer temperatures than would actually be expected for the compartment. The correlation is considered valid for compartment upper layer gas temperatures up to 600°C (1112°F). The upper layer gas temperature threshold for this analysis is 205°C (400°F), well within the temperature limitation of the MQH method.

The validation of and the limitations and assumptions associated with the FDTs are documented in NUREG-1805, NUREG-1824, Attachment M of P2091-2900-04, and the response to FM RAI 04.a.

iii. The McCaffrey, Quintiere, Harkleroad (*MQH*) *method* hot gas layer (HGL) calculations for determining the maximum heat release rate for the screening step based on low heat release rate identified the openings from plant layout drawings and the Point Beach Fire Hazards Analysis Report. These ventilation openings range from 2 ft x 7 ft opening to an 8 ft x 8 ft opening. These ventilation openings are representative of the openings in the plant for these areas, with the exception of a few areas where a conservative (smaller than actual plant condition) opening size was utilized in the MQH calculation.

The MQH HGL calculations evaluating the combined area of the exposing and exposed fire compartments utilized a 3 ft x 7 ft standard door opening. Once the fire is detected, operators will be dispatched to the room and will open a door to provide cooling and smoke venting. Prior to this action, the single door is a representation of the various natural ventilation openings within the room (e.g., door gaps, vents, openings, etc.) because the fire compartments are connected to other areas of the plant to facilitate ventilation. This door opening is representative of the plant conditions.

The ventilation parameters for detailed fire modeling scenarios credited in the MCA are documented in Section 5.1.3 of the PBNP Detailed Fire Modeling Reports and the response to FM RAI 01.f.i.

iv. Hot gas layer (HGL) propagation past the exposed fire compartment (2nd order) was not considered in Revision 1 of the Multi-Compartment Analysis. The MCA was revised to consider the possibility of damaging HGL spreading from the exposed compartment (2nd order) to all exposed fire compartments using the following methodology.

The Third Order Analysis considered the potential for the HGL to spread to all fire compartments adjacent to the exposed compartment (2nd order). The analysis considered the barrier failure probabilities of the barrier between the 2nd and 3rd order fire compartments and also the automatic suppression in the 3rd compartment. Scenarios were screened, if the frequency of occurrence of the 3rd order scenario was less than 1.0E-08/yr.

The unscreened 2nd Order multi-compartment scenarios were evaluated to consider the potential for the hot gas layer propagation past the first exposed Fire Compartment to a third Fire Compartment. The first order is the exposing Fire Compartment, the second order is the exposed Fire Compartment, and the third order is a subsequent Fire Compartment. Therefore, propagation past the first exposed Fire Compartment was considered and referred to as the Third Order Analysis.

The Third Order Analysis frequency of occurrence ($F_{MCS}$) was generated for the remaining unscreened scenarios utilizing the Frequency of Occurrence ($F_{MCS}$) for the First | Second order combination, the barrier failure probability for the Second | Third order boundary, and the automatic suppression in the Third Order fire compartment. Crediting the 3rd order compartment suppression system can only be performed, if the system is a separate type of system than in the first and second compartments or if the first two compartments do not contain suppression systems.

The following Third Order Scenarios have a Frequency of Occurrence >1.0E-08 and need to be carried over as input to the Task 14, Fire Quantification to support the total CDF and LERF results:

| First\|Second\|Third | FMCS for 1st to 2nd Order | 3rd Order Barrier Failure Probability | Automatic Suppression in 3rd Order | FMCS of 3rd Order |
|---|---|---|---|---|
| 131 \| 113GRP \| 101GRP | 1.25E-05 | 1.00E-01 | 1.00E+00 | 1.25E-06 |
| 131 \| 113GRP \| 137 | 1.25E-05 | 1.20E-03 | 1.00E+00 | 1.50E-08 |
| 131 \| 113GRP \| 140 | 1.25E-05 | 1.20E-03 | 1.00E+00 | 1.50E-08 |
| 304S \| 318 \| 304N | 1.76E-07 | 1.00E-01 | 1.00E+00 | 1.76E-08 |
| 304S \| 318 \| 326GRP | 1.76E-07 | 1.00E-01 | 1.00E+00 | 1.76E-08 |
| 305 \| 304N \| 304S | 7.29E-07 | 2.26E-02 | 1.00E+00 | 1.65E-08 |
| 305 \| 304N \| 318 | 7.29E-07 | 1.00E-01 | 1.00E+00 | 7.29E-08 |
| 305 \| 304S \| 318 | 2.38E-07 | 1.00E-01 | 1.00E+00 | 2.38E-08 |
| 305 \| 307 \| 310 | 7.29E-07 | 1.00E-01 | 1.00E+00 | 7.29E-08 |
| 305 \| 310 \| 307 | 6.30E-06 | 1.00E-01 | 1.00E+00 | 6.30E-07 |
| 305 \| 310 \| 321 | 6.30E-06 | 1.00E-01 | 1.00E+00 | 6.30E-07 |
| 308 \| 309 \| 310 | 1.04E-06 | 1.72E-02 | 1.00E+00 | 1.79E-08 |
| 309 \| 310 \| 321 | 7.28E-07 | 1.00E-01 | 1.00E+00 | 7.28E-08 |
| 763 \| 771 \| 772 | 3.52E-05 | 1.00E-01 | 3.00E-02 | 1.06E-07 |
| 763 \| 771 \| 792GRP | 3.52E-05 | 1.00E-01 | 1.00E+00 | 3.52E-06 |

| First\|Second\|Third | FMCS for 1st to 2nd Order | 3rd Order Barrier Failure Probability | Automatic Suppression in 3rd Order | FMCS of 3rd Order |
|---|---|---|---|---|
| 772 \| 771 \| 792GRP | 1.29E-06 | 1.00E-01 | 1.00E+00 | 1.29E-07 |

**FM RAI 04**

*NFPA 805, Section 2.7.3.3, states that acceptable engineering methods and numerical models shall only be used for applications to the extent these methods have been subject to verifications and validation. These engineering methods shall only be applied within the scope, limitations, and assumptions prescribed for that method.*

*LAR Section 4.7.3 states that engineering methods and numerical models used in support of compliance with 10 CFR 50.48(c) are used and were applied appropriately as required by Section 2.7.3.3 of NFPA 805.*

*Regarding the limitations of use:*

a) *The NRC staff notes that algebraic models cannot be used outside the range of conditions covered by the experiments on which the model is based. NUREG-1805, includes a section on assumptions and limitations that provides guidance to the user in terms of proper and improper use for each FDT. There is general discussion of the limitations of use for the algebraic equations that has been utilized for hand calculations. It is not clear, however, how these limitations were applied on the individual fire areas or for the MCA. Provide a description of how the limit of applicability was determined for each fire area.*

b) *Identify uses, if any, of CFAST outside the limits of applicability of the model and for those cases, explain how the use of CFAST was justified.*

c) *Identify uses, if any, of FDS outside the limits of applicability of the model and for those cases, explain how the use of FDS was justified.*

**NextEra Response**

a) The limitations and assumptions associated with the fire modeling tools are documented in NUREG-1805, NUREG-1824, and Report R2168-1003B-0001, "*Verification and Validation of Fire Modeling Tools and Approached for Use in NFPA 805 and Fire PRA Applications.*"

   In most cases, the subject correlations have been applied within the limits of applicability reported in NUREG-1824 for the individual fire areas and for the Multi-Compartment Analysis (MCA). Cases where the models have been applied outside of the defined limits have been justified as acceptable as follows for the following correlations:

   - Flame Height (Method of Heskestad)
   - Plume Temperature (Method of Heskestad)
   - Hot Gas Layer – Natural Ventilation (McCaffrey, Quintiere, and Harkleroad – MQH)

   **Flame Height (Method of Heskestad)**

   The flame height correlation is used within the limits of its range of applicability with the exception of the fire scenarios identified below. Scenarios in which flame height exceeds compartment ceiling height are 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 zone of influence (ZOI) are summarized as follows:

The calculated flame height for the following scenarios exceeds the ceiling height of the fire compartment. However, the calculations conservatively assume a fire diameter corresponding to a Fire Froude Number of 1.0 for the calculated heat release rate (refer to Appendix E of R2168-1003B-0001). The fire growth in these scenarios results from fire propagation to adjacent electrical cabinet vertical sections, propagation to and flame spread along cable trays, or a combination of these, which would result in a fire diameter larger than the assumed and a decreased flame height. Additionally, many of the scenarios result in whole room damage or damage to all targets within line of sight of the fire, bounding the ZOI. Therefore, the calculated zone of influence is appropriate for analysis of these hazards for affected fire compartments.

**Table 1: Scenarios with Flame Height Exceeding Ceiling Height**

| Fire Compartment | Scenario |
|---|---|
| 142GRP | C-52 |
| | FACP-9 |
| | 1P-11A |
| | 2P-11A |
| | B-33 |
| | B-43 |
| | TS# 6, 7, and 8 |
| | TS# 9 and 10 |
| 151 | 1P-15A & 1P-15B |
| 156 | 1B-32 |
| | 1B313B-2B337B |
| | 2B337-1B313B |
| | 1B313A-B854B |
| | 1P-2A-Z |
| | 1P-2B-Z |

| Fire Compartment | Scenario |
|---|---|
| | 2P-2A-Z |
| | TS1 |
| | TS2 |
| | TS5 |
| | TS6 |
| | TS7 |
| 166 | 2B-32 |
| | 2N-04 |
| | B-44 |
| | HTPC |
| | TS1,10 |
| 187GRP | 1B-42 |
| | 2B-42 |
| | C-180 |
| | C-180A |
| | C-181 |
| | C-59 |
| | TS3,4,5 |
| 226 | 1-83/DY-04 |
| | 2-83/DY-04 |
| | 83/DY-0D |
| | 1DY-04 |
| | 2DY-04 |
| | DY-0D |

| Fire Compartment | Scenario |
|---|---|
| | D-04 |
| | D-108 |
| 237 | 1B-31 |
| | 2B-31 |
| 245 | 1-C40 (1AC, 1BD, 2AC, DC, Log Cab) |
| | 1C-75 |
| 246 | 1-C40 (1AC, 1BD, 2AC, DC, Log Cab) |
| 304N | C-207 |
| | D-64 |
| | Bus Duct (HEAF) |
| 304S | 1C-205 & 2C-205 |
| | D-63 |
| | Bus Duct (HEAF) |
| 305 | 1A-03 (35-37) |
| | 1A-03 (35-37) - HEAF |
| | 1A-03 (38-40) |
| | 1A-03 (38-40) - HEAF |
| | 2A-03 (41-43) |
| | 2A-03 (41-43) - HEAF |
| | 2A-03 (44-46) |
| | 2A-03 (44-46) - HEAF |
| | 1A-04 (52-54) |
| | 1A-04 (52-54) - HEAF |
| | 1A-04 (55-56) |

| Fire Compartment | Scenario |
|---|---|
| | 1A-04 (55-56) - HEAF |
| | 2A-04 (47-48) |
| | 2A-04 (47-48) - HEAF |
| | 2A-04 (49-51) |
| | 2A-04 (49-51) - HEAF |
| | 1A-05 (57-61) |
| | 1A-05 (57-61) - HEAF |
| | 1A-05 (62-66) |
| | 1A-05 (62-66) - HEAF |
| | 2A-05 (67-71) |
| | 2A-05 (67-71) - HEAF |
| | 2A-05 (72-76) |
| | 2A-05 (72-76) - HEAF |
| | D-07 |
| | D-08 |
| | D-09 |
| | D-02 |
| 308 | G-01 |
| 309 | G-02 |
| 310 | 310-HGL-K2A-OIL/-K2B-OIL/-K3A-OIL/-K3B-OIL |
| 323 | 1D-207 |
| | 2D-207 |
| 333GRP | 1C-171A |
| | 1C-171B |

| Fire Compartment | Scenario |
|---|---|
| | 2C-170 |
| | 2C-171B |
| 552GRP | P-31A, P-31B |
| | Service Water Pumps |
| | P-35A |
| | P-35B & P-35B-E |
| | Circ. Water Pumps |
| 675 | C222A |
| | C222B |
| | C222C |
| | D-52 |
| | H-02 |
| | H-02 - HEAF |
| | Bus Duct (HEAF) |
| 676 | C221A |
| | C221B |
| | C221C |
| | C221D |
| | D-51 |
| | H-01 |
| | H-01 - HEAF |
| | Bus Duct H01H02 (HEAF) |
| | Bus Duct H01H03 (HEAF) |
| 677 | C223A |

| Fire Compartment | Scenario |
|---|---|
| | C223B |
| | C223C |
| | D-53 |
| | H-03 |
| | H-03 - HEAF |
| | Bus Duct (HEAF) |
| 775GRP | G-04 (Diesel) |

**Plume Temperatures (Method of Heskestad)**

The following limitation applies to the Heskestad correlation for plume temperature:

- *The correlation will under-predict the plume temperature if the ambient temperature is at an elevated temperature. In this situation, the difference between the plume temperature and the ambient temperature will be small, the thermal plume will cool less effectively, and the correlation will subsequently underestimate the temperature.*

The correlation is used within the limits of its range of applicability with the exception of the fire scenarios identified and evaluated in Appendix B of R2168-1003B-0001. Appendix B provides a disposition for each scenario identified and discusses the plume and hot gas layer interaction impacts on the results of the fire modeling analyses.

**Hot Gas Layer – Natural Ventilation (McCaffrey, Quintiere, and Harkleroad – MQH)**

The following limitation applies to the MQH natural ventilation hot gas layer 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.*

The MQH hot gas layer correlation is used within the limits of its range of applicability with the exceptions of the fire scenarios discussed below. Scenarios for which the ignition source is located within two (2) feet of a wall or corner have been addressed on a scenario-by-scenario basis. Justification and evaluation of this limitation and the impact on the zone of influence (ZOI) are provided as follows for affected fire compartments:

The following scenarios model relatively (in comparison to the large volume of the fire compartment) low heat release rate fires located at a wall or corner. The volume of fire compartments preclude the formation of a hot gas layer (HGL) for the modeled heat release rates, generating HGL temperatures well below the thermoplastic cable target failure threshold of 205°C. Target failures are limited to the zone of influence of the fire, therefore, results of the MQH correlation are not used to determine target impacts.

**Table 2: Scenarios with Volumes Precluding HGL Formation**

| Fire Compartment | Scenario | Location Factor |
|---|---|---|
| 101GRP | TS#1-5 | 2 |
| 142GRP | C-52 | 2 |
| | FACP-9 | 2 |
| | TS#1-5, 9, 10, and 12 | 2 |
| | Propagating Transient - 2 | 2 |
| | Propagating Transient - 3 | 2 |
| 151 | Propagating Transient 2 | 2 |
| 156 | 2P-2A-Z | 2 |
| | 2P-2B-Z | 2 |
| 158 | 158-HGL-TRANS-98 | 4 |
| | 159-HGL-TRANS-98 | 4 |
| 166 | 2P-2C-Z | 2 |
| | D-31 | 2 |
| | D-41 | 4 |
| | Transient Fire 6 | 2 |
| | Transient Fire 7 | 2 |

| Fire Compartment | Scenario | Location Factor |
|---|---|---|
| 184 | 184-HGL-ELEC CABINET | 2 |
| 185 | 184-HGL-1Y-31/41 | 2 |
| 187GRP | 1B-42 | 2 |
| | 2B-42 | 2 |
| | 1BS-CV-10A | 2 |
| | 2BS-CV-10B | 2 |
| | FACP-8 | 2 |
| | TS#1, 2, & 6 | 2 |
| | TS#3, 4 & 5 | 2 |
| | TS#7, 8, 9, 10, 11, 15 & 17 | 2 |
| | TS#19-22, 26, & 31 | 2 |
| | TS#23, 25, 29 & 30 | 2 |
| | TS#24 & 28 | 2 |
| 225 | 225\|226 | 4 |
| 226 | 1-83_DY-04 | 4 |
| | 2-83_DY-04 | 2 |
| | 83_DY-0D | 2 |
| | 1DY-04 | 4 |
| | 2DY-04 | 2 |
| | DY-0D | 4 |
| | D-04 | 2 |
| | D-108 | 2 |
| | TS# 1 and 2 | 2 |
| 227 | 227\|226 | 4 |

| Fire Compartment | Scenario | Location Factor |
| --- | --- | --- |
| | 227\|228 | 4 |
| 228 | 228\|227 | 4 |
| 245 | 1C-42 | 2 |
| | PP-12 | 2 |
| 246 | 2C-42 | 2 |
| | PP-17 | 2 |
| | TS# 8 and 10 | 2 |
| 304N | 2C-144 | 2 |
| | C-715B | 2 |
| 304S | C-715A | 2 |
| 308 | K-4A | 2 |
| | K-5A | 2 |
| 309 | K-4B | 2 |
| | K-5B | 2 |
| 318 | 1C156-157, 2C166-167 | 2 |
| | 1DY-01, 2DY-02 | 2 |
| | D - Panels | 2 |
| 321 | 321\|310 | 4 |
| 323 | 1D-207 | 2 |
| | 2D-207 | 2 |
| | TS#1 and 2 | 2 |
| 324 | 1D-205 Rack 1 | 2 |
| | 2D-205 Rack 1 | 2 |
| | TS#1, 3-5 | 2 |

| Fire Compartment | Scenario | Location Factor |
|---|---|---|
| 524GRP | TS#2 and 8 | 2 |
| 596 | B-45 | 2 |
| | B-46 | 2 |
| 675 | D-49 | 2 |
| 677 | D-50 | 2 |
| 773GRP | 1B-40 | 2 |
| | D-28 | 2 |
| 777GRP | 2B-40 | 2 |
| | D-40 | 2 |

The following scenarios model fires with propagation to cable trays. The ignition source and total heat release rate (which includes the HRR contribution from secondary combustibles) is conservatively placed against a wall for the purpose of evaluating plume temperatures and propagation to cable trays. Although the ignition source is located at a wall, the ignited cable trays and ensuing flame spread will mostly occur away from the wall. Therefore, the results of the MQH correlation are considered valid and bounding for affected fire compartments. Additionally, any uncertainties associated with the hot gas layer calculations are bound by the conservative values selected for heat release rate (98th percentile), fire elevation, radiative and convective fractions, exclusion of heat loss due to heat sink (room contents), cable tray fill, etc. Refer to the response to FM RAI 06.a (see 60-day RAI response – Reference 6) for additional information related to uncertainties and safety margin.

**Table 3: Scenarios with Propagation to Cable Trays**

| Fire Compartment | Scenario | Location Factor |
|---|---|---|
| 151 | Propagating Transient 1 | 2 |
| 156 | 1B-32 | 2 |
| | 1B313B-2B337B | 2 |
| | 2B337-1B313B | 2 |
| | 1B313A-B854B | 2 |

| Fire Compartment | Scenario | Location Factor |
|---|---|---|
| | 1P-2A-Z | 2 |
| | 1P-2B-Z | 2 |
| | Transient Fire 4 | 2 |
| | Transient Fire 5 | 2 |
| | Transient Fire 6 and 7 | 2 |
| 166 | 2B-32 | 2 |
| | 2N-04 | 2 |
| | B-44 | 2 |
| | HTPC | 2 |
| | Transient Fire 1,10 | 2 |
| | Transient Fire 2,3 | 2 |
| | Transient Fire 5,8 | 2 |
| 675 | Transient TS#4, 5, 6, 7 | 2 |
| 676 | Transient TS#4, 5, 6, 7, 10 | 2 |
| 677 | Transient TS#4, 5, 6, 7, 10 | 2 |

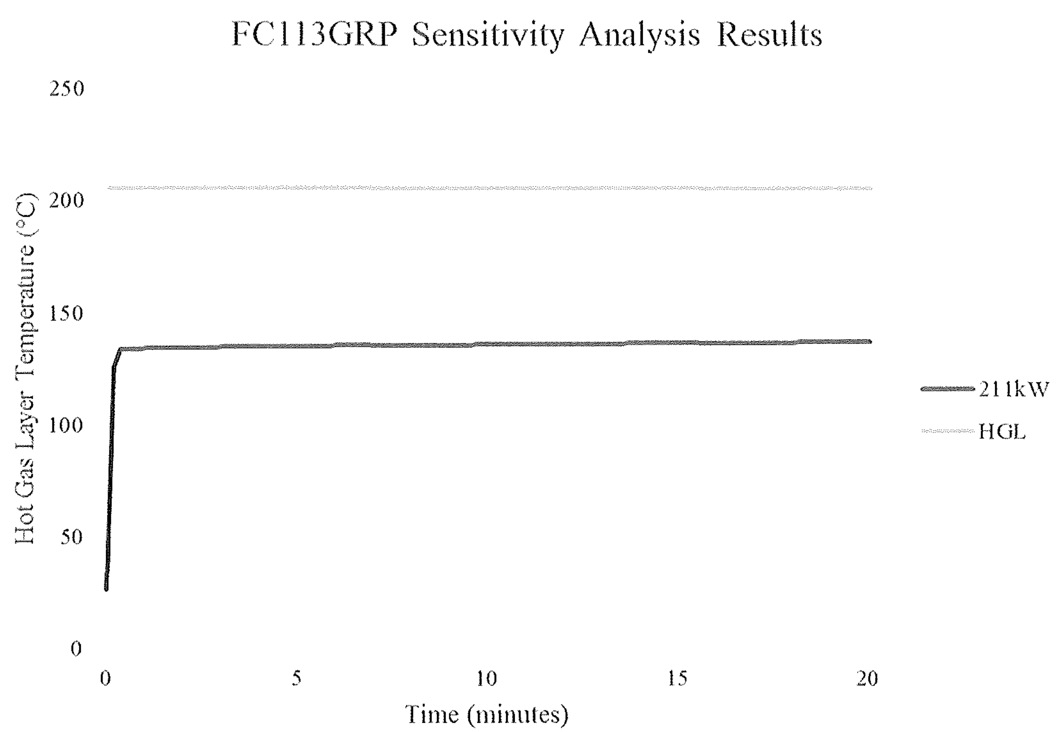
The following scenarios model fires within two feet of a wall or corner (Location Factor = 2 or 4). Sensitivity analyses were performed for these scenarios using National Institute of Standards and Technology (NIST) CFAST to determine the impact of the fire location on the calculated hot gas layer temperatures. These scenarios were modeled in CFAST using the same inputs and assumptions provided in the applicable notebooks (i.e., Compartment Analysis Notebook R2091-2900-01 or PBNP Detailed Fire Modeling Reports). The sensitivity analyses determined that the hot gas layer would not reach the thermoplastic cable target threshold temperature of 205°C or would reach 205°C at a later time than the detailed fire modeling calculations, with the fires located at a wall or corner. Therefore, the fire modeling results implementing the MQH correlation are valid and bounding for affected fire compartments.

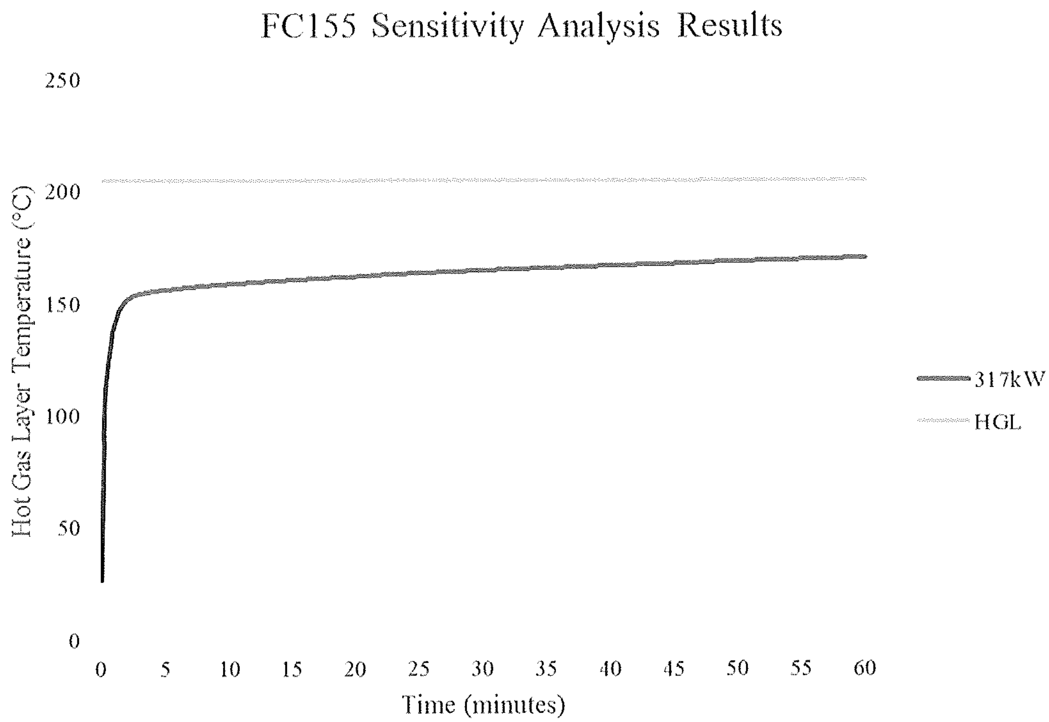
**Table 4: Scenarios Analyzed using CFAST**

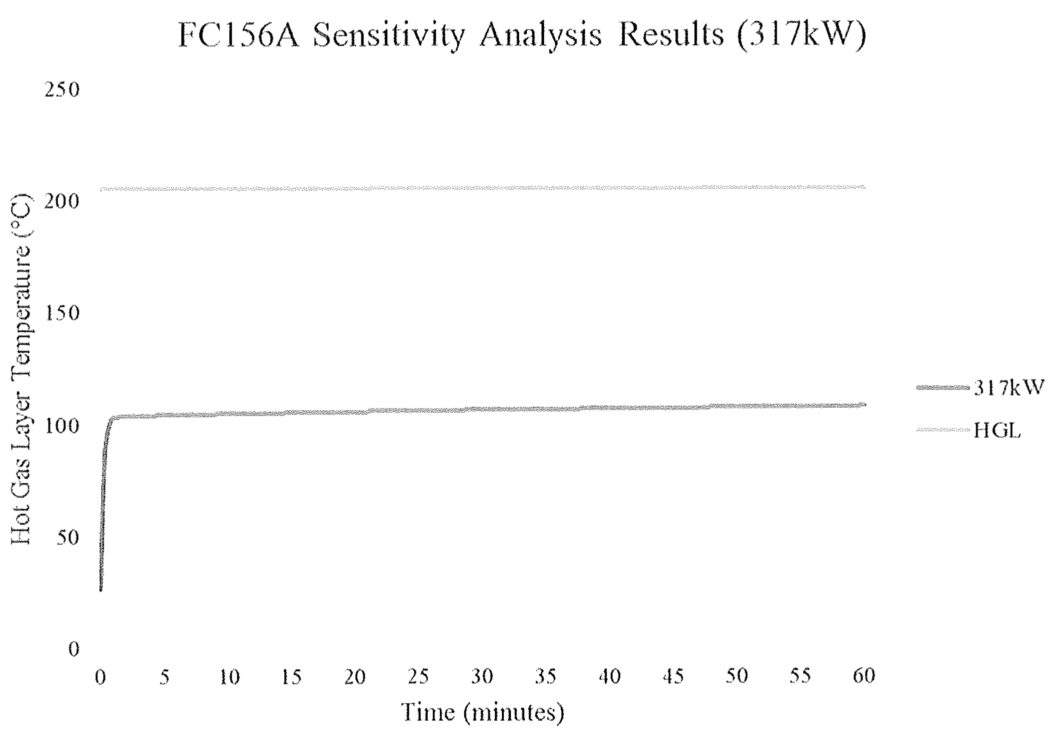
| Fire Compartment | Scenario | Location Factor |
|---|---|---|
| 113GRP | 113GRP-HGL-PUMP-MOTOR | 4 |
| 155 | 155-HGL-TRAN | 4 |
| 156A | 156A-PLUME-HGL-TRAN | 4 |
| | 156A-1N11-HGL | 4 |
| 237 | 1B-31 | 4 |
| | 2B-31 | 4 |
| 245 | PP-10 | 2 |
| | PP-11 | 2 |
| 246 | PP-15 | 2 |
| | PP-16 | 2 |
| 304N | C-207 | 2 |
| | D-64 | 2 |
| | TS#1, 3, 5, 6, 8, and 9 | 2 |
| 304S | 1C-205 & 2C-205 | 2 |
| | D-63 | 2 |
| | TS#1, 3, 4, 6, 7, 8, and 10 | 2 |
| 305 | D-09 | 2 |
| | D-01 | 2 |
| | D-02 | 2 |
| 308 | TS#4 &5 | 2 |
| 309 | TS#4, 5 & 6 | 2 |
| 524GRP | TS#1, 3, 4, 10, and 12 | 2 |

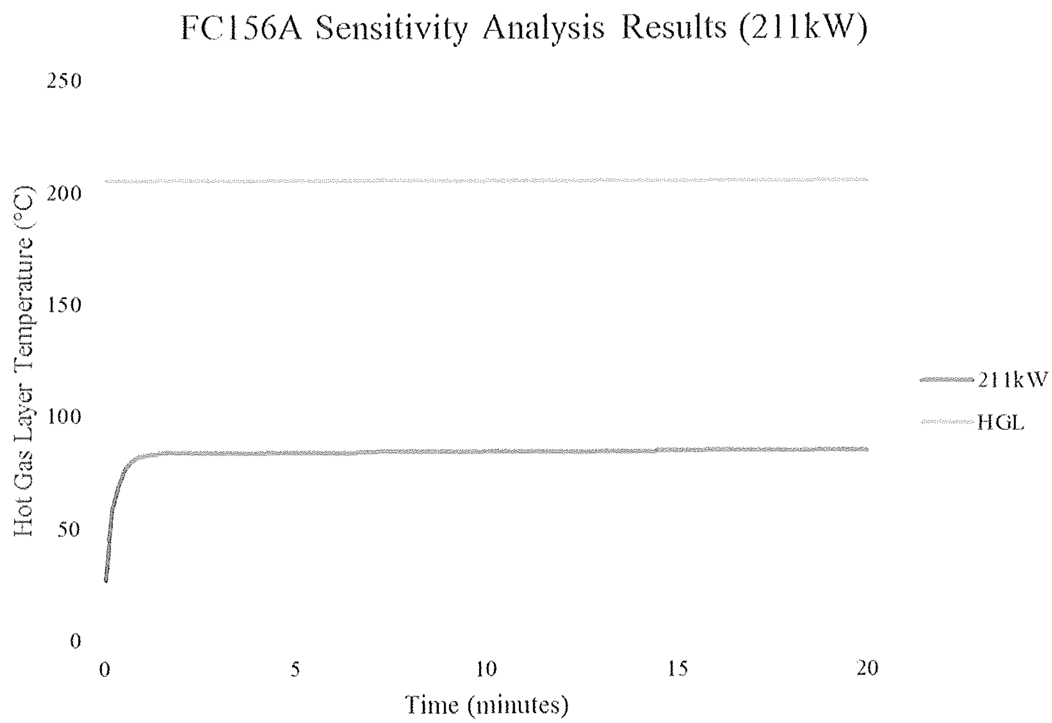
| Fire Compartment | Scenario | Location Factor |
|---|---|---|
| 675 | D-52 | 2 |
| 676 | D-51 | 2 |
| | Transient TS#1, 2, 9 | 2 |
| 677 | D-53 | 2 |

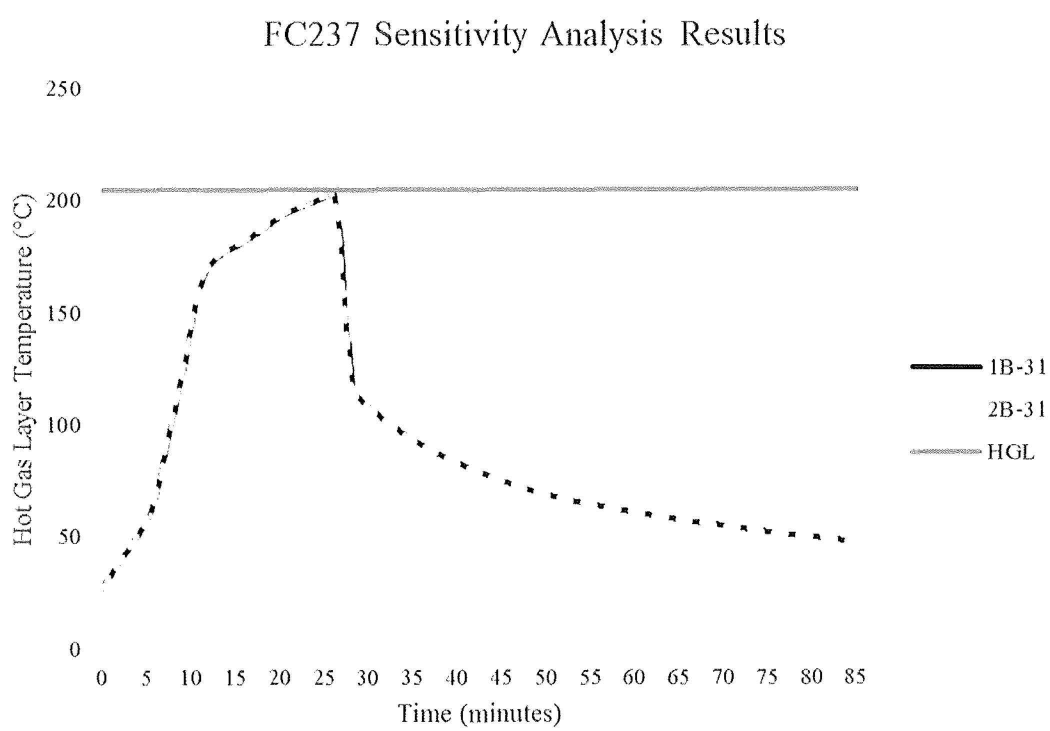
The CFAST sensitivity analyses results are summarized as follows:

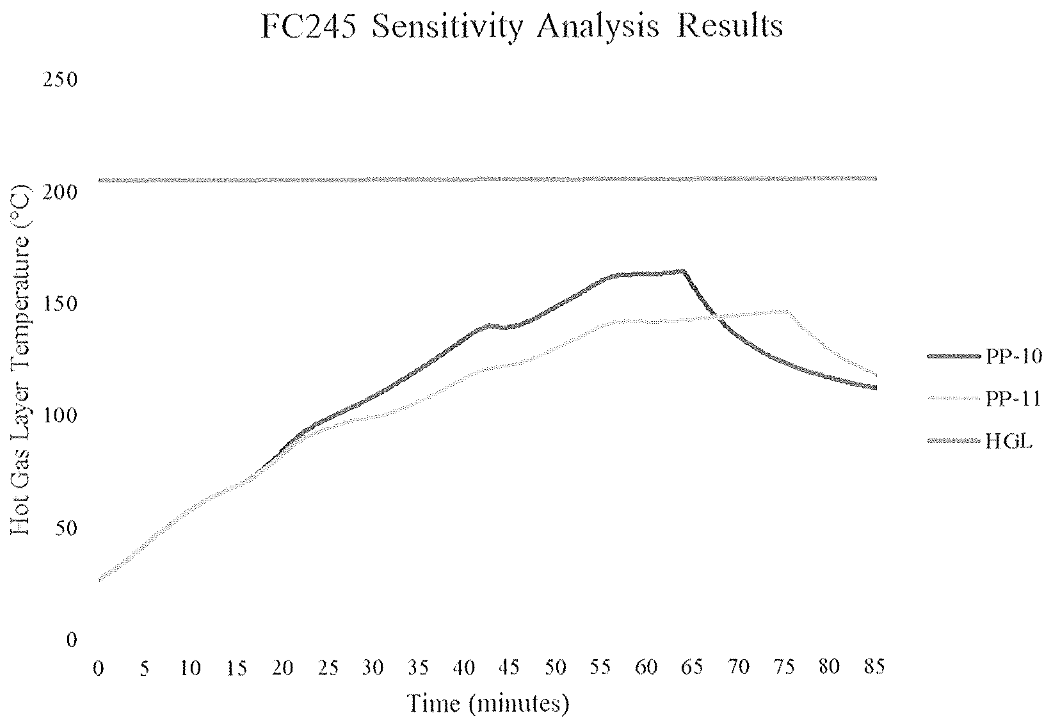


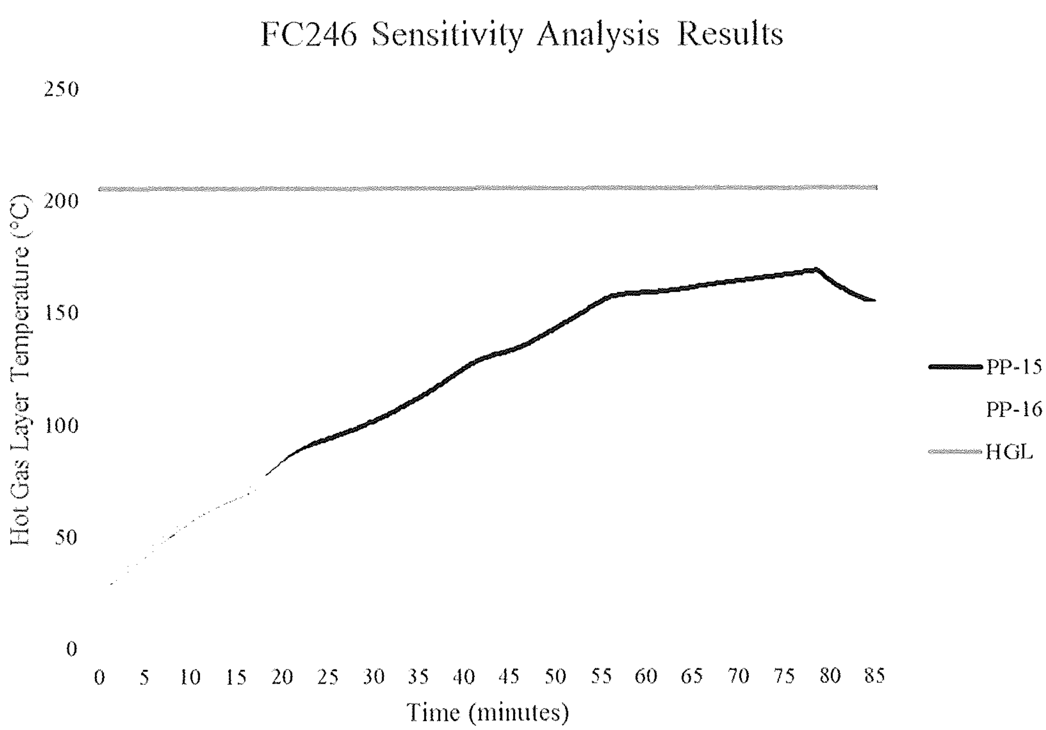

FC155 Sensitivity Analysis Results
250
200
150
100
50
0
Hot Gas Layer Temperature (°C)
0
5
10
15
20
25
30
35
40
45
50
55
60
Time (minutes)
317kW
HGL

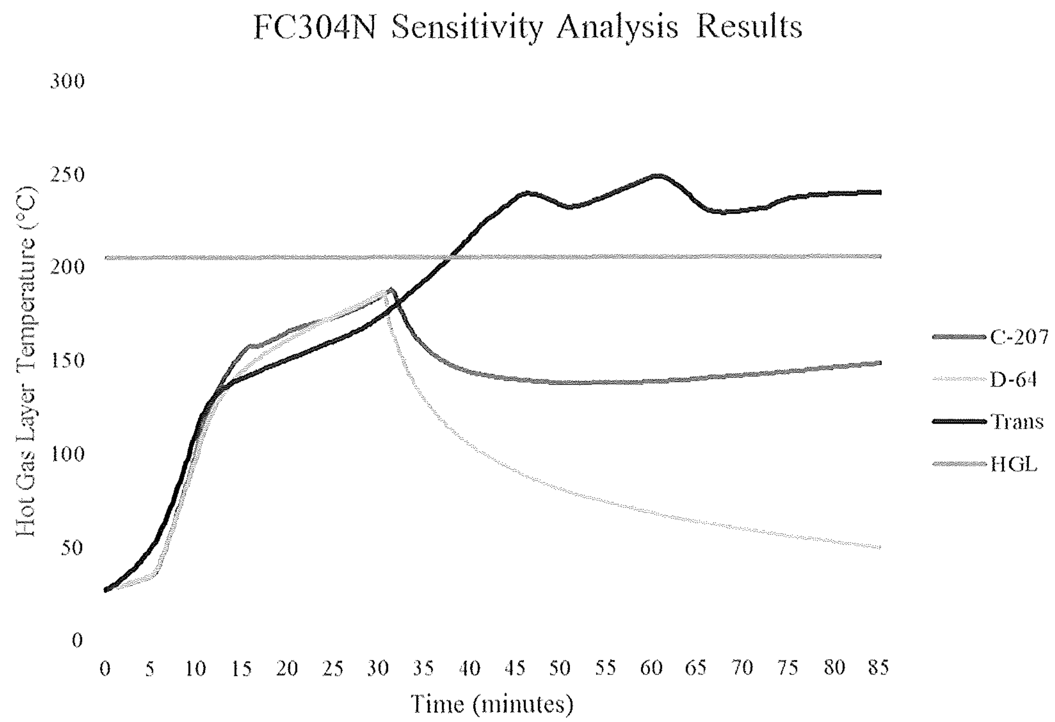

FC156A Sensitivity Analysis Results (317kW)
250
200
150
100
50
0
Hot Gas Layer Temperature (°C)
0
5
10
15
20
25
30
35
40
45
50
55
60
Time (minutes)
317kW
HGL


FC156A Sensitivity Analysis Results (211kW)
250
200
150
100
50
0
Hot Gas Layer Temperature (°C)
0
5
10
15
20
Time (minutes)
211kW
HGL

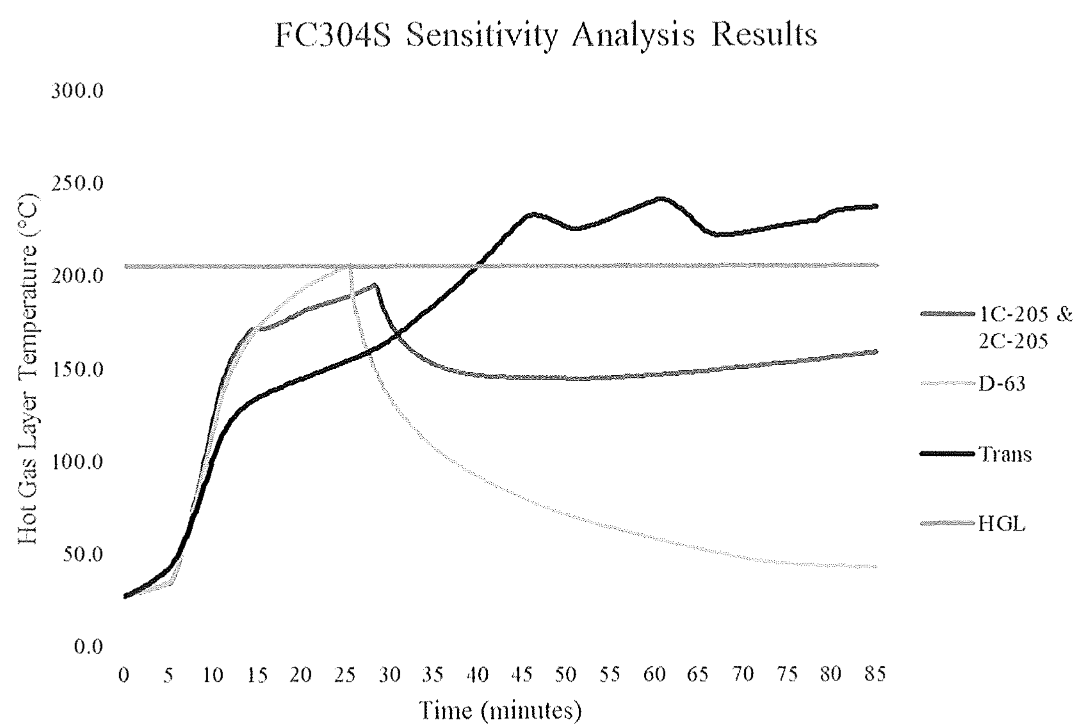

FC237 Sensitivity Analysis Results
250
200
150
100
50
0
Hot Gas Layer Temperature (°C)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Time (minutes)
1B-31
2B-31
HGL


FC245 Sensitivity Analysis Results
250
200
150
100
50
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Time (minutes)
Hot Gas Layer Temperature (°C)
PP-10
PP-11
HGL

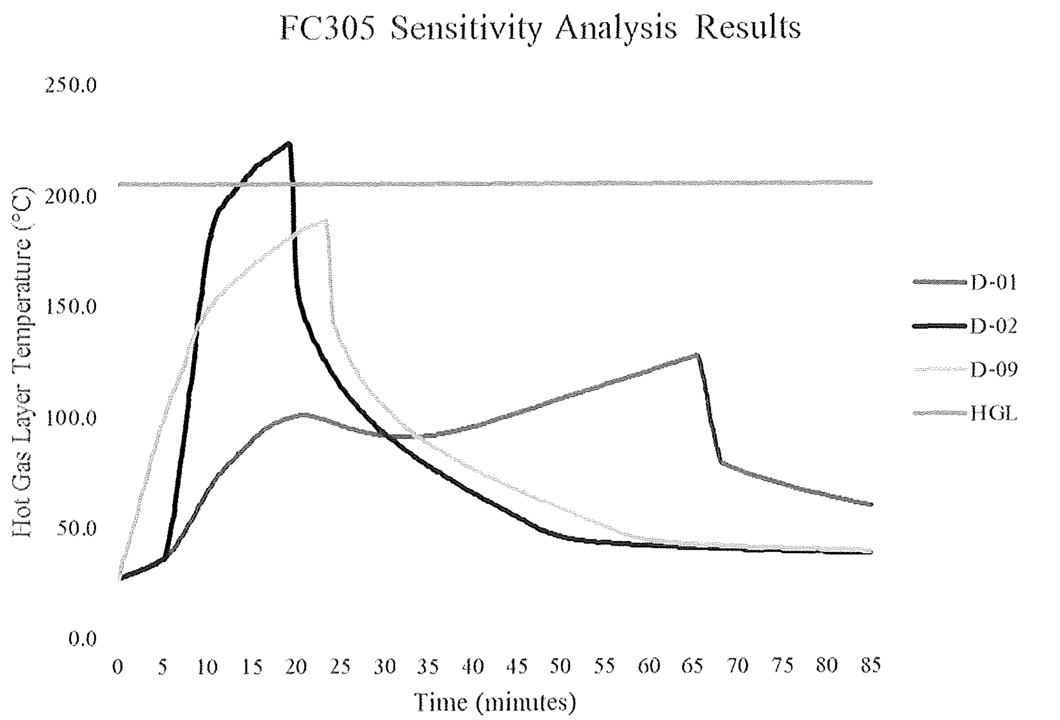

FC246 Sensitivity Analysis Results
250
200
150
100
50
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Time (minutes)
Hot Gas Layer Temperature (°C)
PP-15
PP-16
HGL

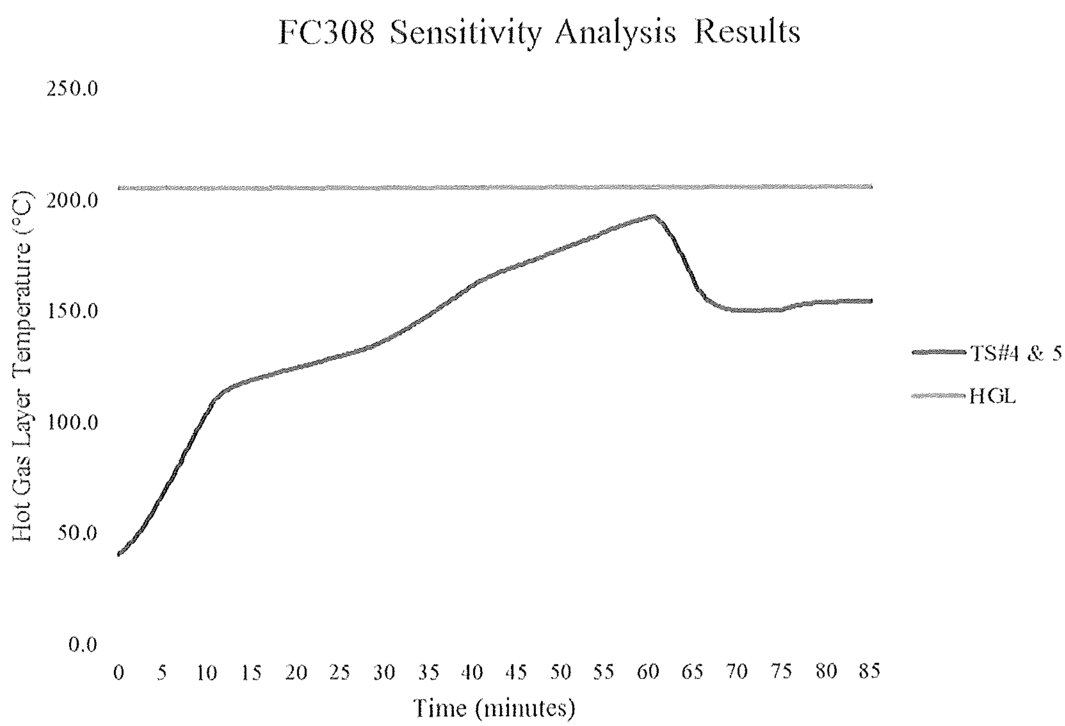


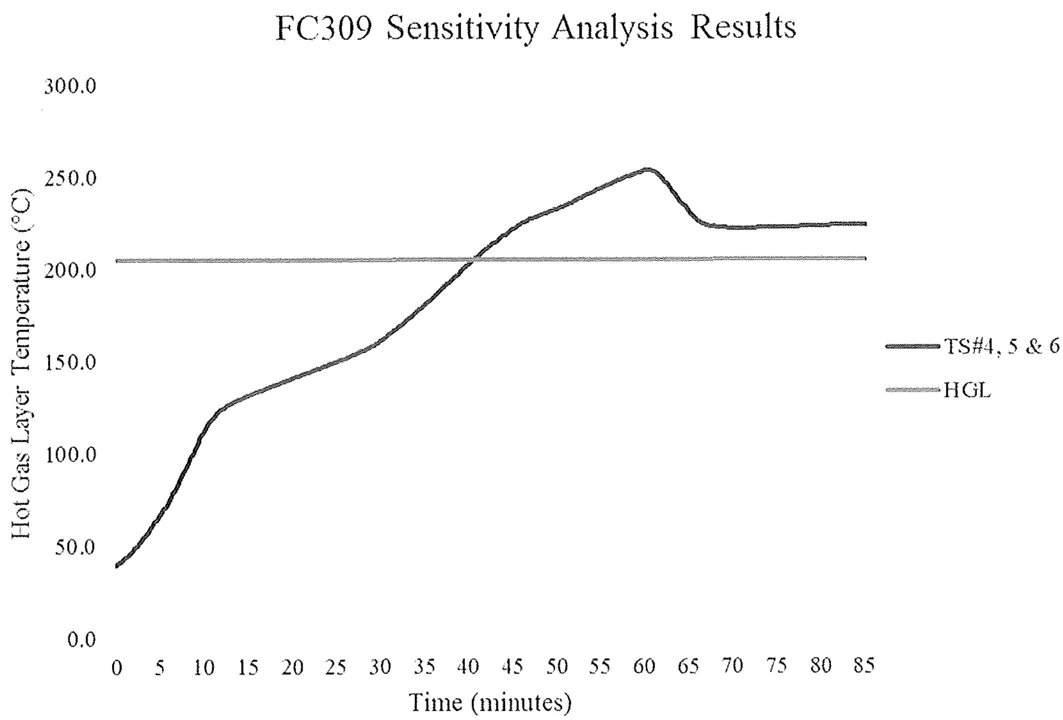
FC304N Sensitivity Analysis Results
Hot Gas Layer Temperature (°C)
300
250
200
150
100
50
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Time (minutes)
C-207
D-64
Trans
HGL

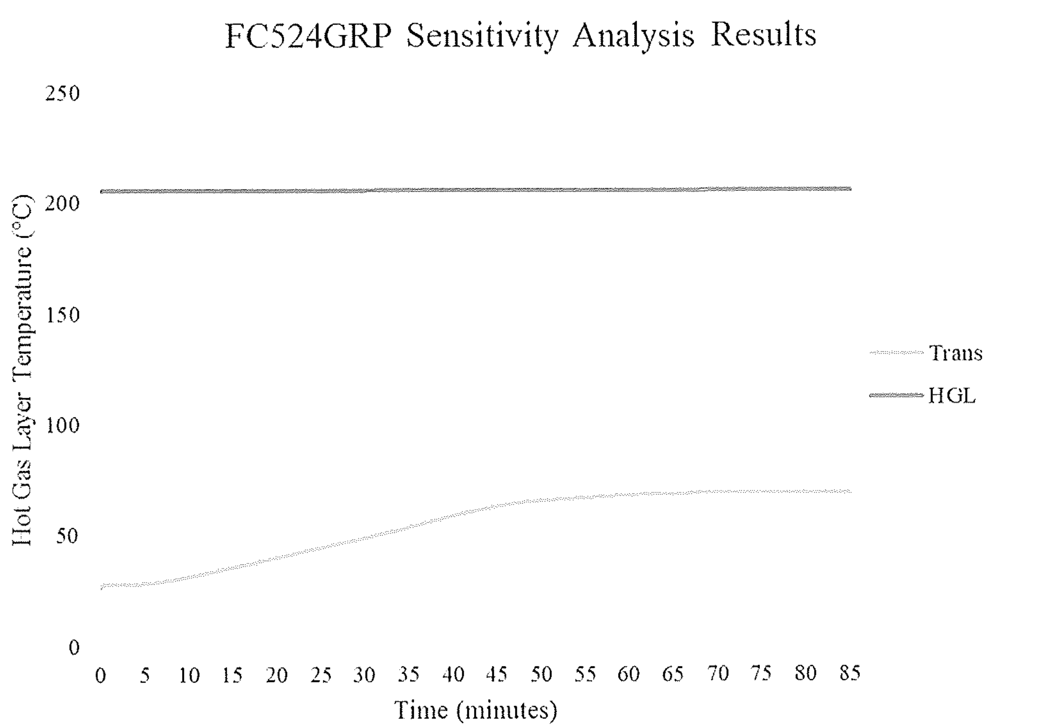



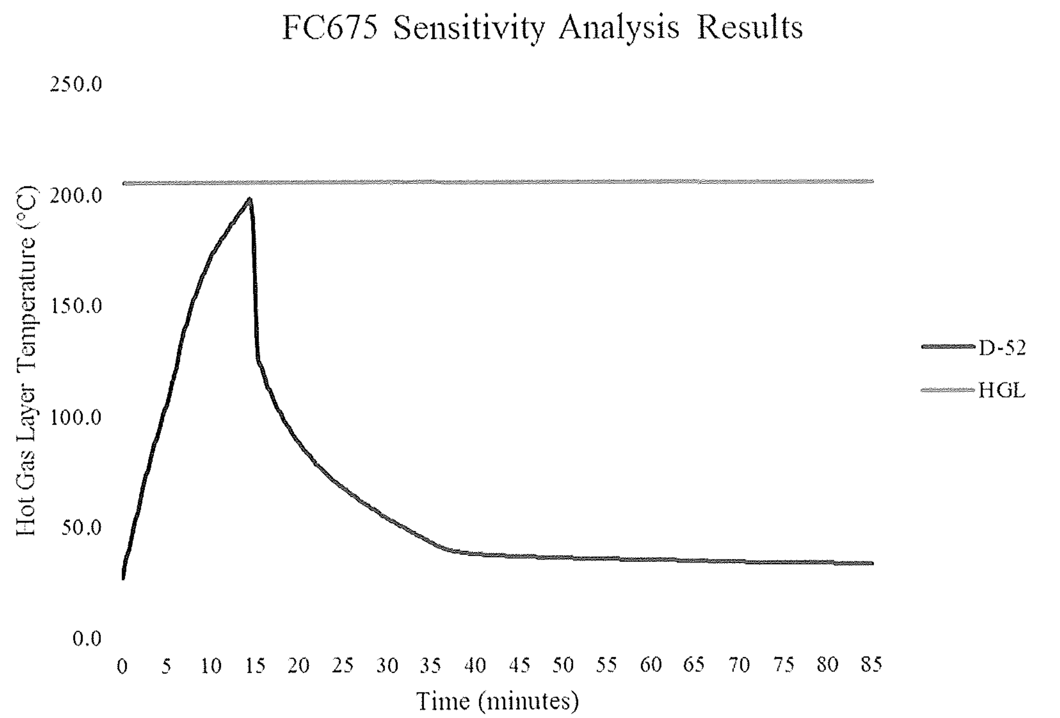
FC304S Sensitivity Analysis Results
Hot Gas Layer Temperature (°C)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Time (minutes)
1C-205 & 2C-205
D-63
Trans
HGL

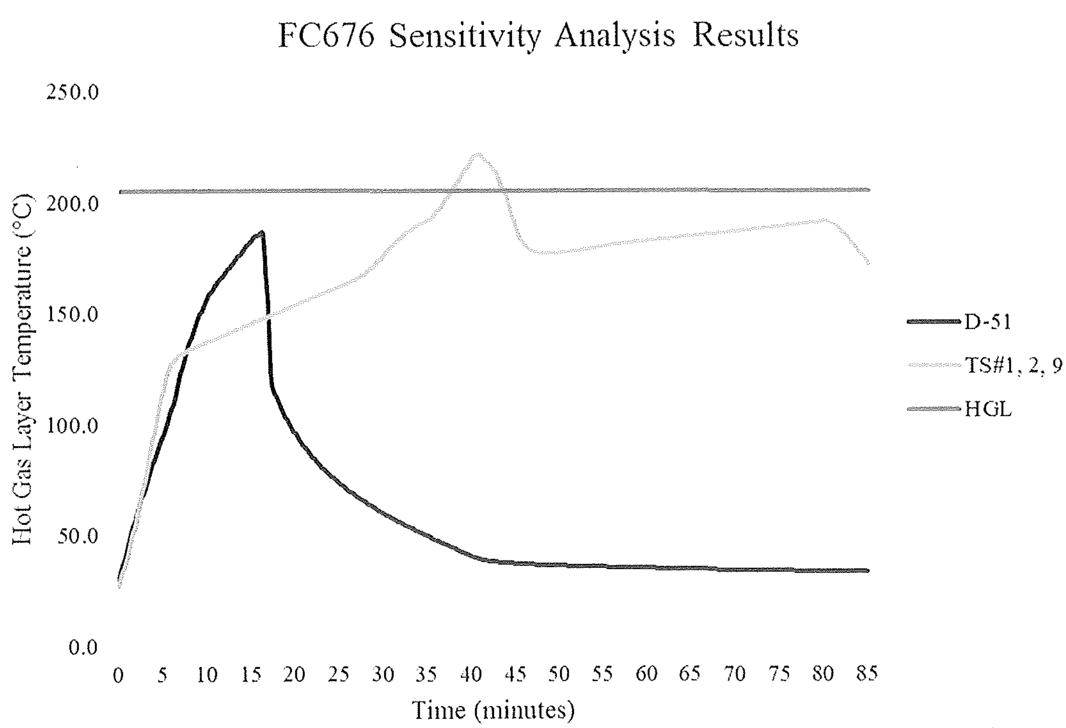

FC305 Sensitivity Analysis Results
250.0
200.0
150.0
100.0
50.0
0.0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Time (minutes)
Hot Gas Layer Temperature (°C)
D-01
D-02
D-09
HGL

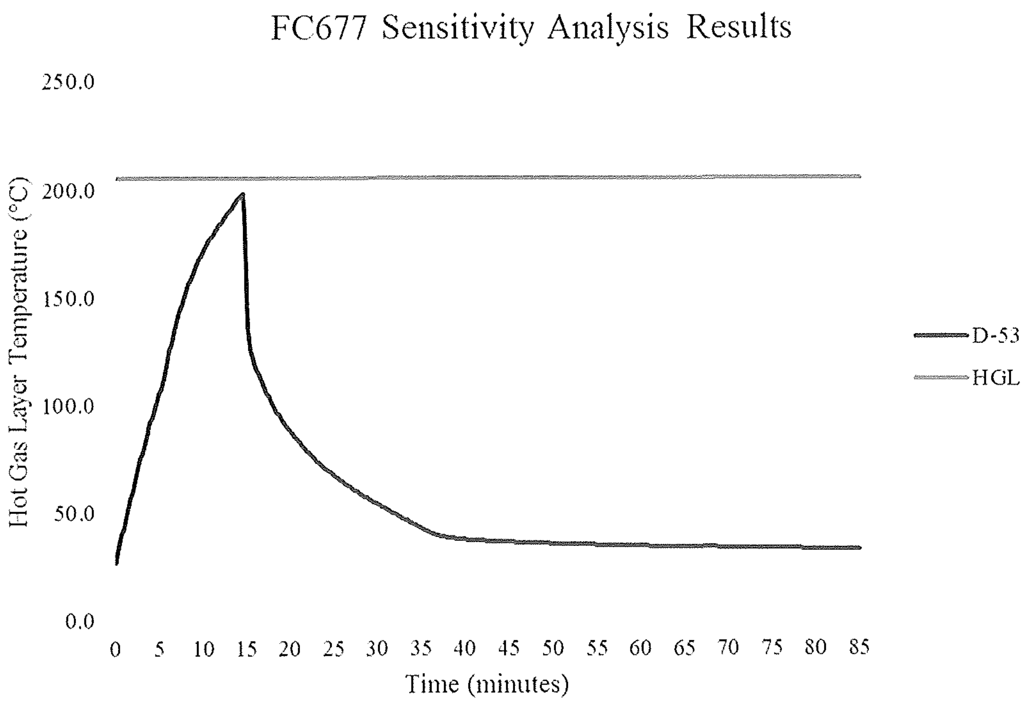

FC308 Sensitivity Analysis Results
250.0
200.0
150.0
100.0
50.0
0.0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Time (minutes)
Hot Gas Layer Temperature (°C)
TS#4 & 5
HGL


FC309 Sensitivity Analysis Results
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Hot Gas Layer Temperature (°C)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Time (minutes)
TS#4, 5 & 6
HGL


FC524GRP Sensitivity Analysis Results
250
200
150
100
50
0
Hot Gas Layer Temperature (°C)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Time (minutes)
Trans
HGL


FC675 Sensitivity Analysis Results
250.0
200.0
150.0
100.0
50.0
0.0
Hot Gas Layer Temperature (°C)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Time (minutes)
D-52
HGL


FC676 Sensitivity Analysis Results
250.0
200.0
150.0
100.0
50.0
0.0
Hot Gas Layer Temperature (°C)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Time (minutes)
D-51
TS#1, 2, 9
HGL




CFAST was used within the limits of applicability and the sensitivity analyses were performed within the validated range of NUREG-1824. The following table provides the evaluation of the relevant normalized parameters.

| **Normalized Parameters – CFAST FDT Limitations - MQH Location Factor Sensitivity Analyses** | | | | |
|---|---|---|---|---|
| Quantity | Normalized Parameter | Validation Range | In Range? | Validity statement |
| Fire Froude Number | N/A | 0.4 - 2.4 | N/A | The Froude Number is predominately used to validate the plume temperatures and flame heights. Since the CFAST analyses were used exclusively to calculate the HGL temperatures, the item of foremost importance is the amount of energy (HRR) being released into the compartment, 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 | N/A | The primary application of this parameter is to determine if the flame length exceeds the ceiling height. The concern is that when the normalized parameter is 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 HGL development exclusively and do not calculate target 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. |

| Normalized Parameters – CFAST FDT Limitations - MQH Location Factor Sensitivity Analyses | | | | |
|---|---|---|---|---|
| Quantity | Normalized Parameter | Validation Range | In Range? | Validity statement |
| Ceiling Jet Radial Distance relative to Ceiling height | N/A | 1.2 - 1.7 | N/A | The primary application of this parameter is to determine the temperature of targets at the ceiling for calculating time to detector and sprinkler activation when using the ceiling jet correlation. This CFAST models are not used to determine the time to detection and sprinkler activation. Further, other ceiling jet targets are not included in the analyses. |
| Equivalency Ratio | N/A | 0.04 - 0.6 | N/A | 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 to the analyses because the lower oxygen limit in the CFAST is set to 0% and the fires will not be limited by lack of oxygen. |
| Compartment Aspect Ratio | 0.6 – 5.7 | 0.6 - 5.7 | Yes | All of the modeled compartments fell into the validated range or the dimensions were conservatively altered to force the compartment into the validated range. |
| Radial Distance relative to Fire Diameter | N/A | 2.2 - 5.7 | N/A | 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. |

b) The Consolidated *Model* of *Fire* and Smoke Transport (CFAST) was verified and validated by NUREG-1824, *Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications*, which provides the limitations of model applicability. This analysis utilized CFAST within the limitations discussed in NUREG-1824 by conservatively following the guidance provided in model preparation. The limitations outlined in NUREG-1824 are shown below along with a basis for acceptability as applied to Appendix D of the Verification and Validation (V&V) Report R2168-1003B-0001 and Detailed Fire Modeling Report – FC 552GRP:

- **Compartments:** *CFAST is generally limited to situations where the compartment volumes are strongly stratified. However, in order to facilitate the use of the model for preliminary estimates when a more sophisticated calculation is ultimately needed, there are algorithms for corridor flow, smoke detector activation, and detailed heat conduction through solid boundaries. This model does provide for non-rectangular compartments, although the application is intended to be limited to relatively simple spaces. There is no intent to include complex geometries where a complex flow field is a driving force. For these applications, computational fluid dynamics (CFD) models are appropriate.*

  Basis for Acceptability: The dimensions of any non-rectangular compartments have been modified to conform to a rectangular compartment of an equivalent floor area. The length and width have been conservatively modeled relative to the actual compartment.

- **Gas Layers:** *There are also limitations inherent in the assumption of stratification of the gas layers. The zone model concept, by definition, implies a sharp boundary between the upper and lower layers, whereas in reality, the transition is typically over about 10% of the height of the compartment and can be larger in weakly stratified flow. For example, a burning cigarette in a normal room is not within the purview of a zone model. While it is possible to make predictions within 5% of the actual temperatures of the gas layers, this is not the optimum use of the model. It is more properly used to make estimates of fire spread (not flame spread), smoke detection and contamination, and life safety calculations.*

  Basis for Acceptability: CFAST models in this analysis were used to determine the relative gas layer temperatures for predicting target damage. Although the zone model concept predicts a sharp boundary between layers, the model provides a conservative estimate of the boundary between the upper and lower gas layers.

- **Heat Release Rate:** *There are limitations inherent in the assumptions used in application of the empirical models. As a general guideline, the heat release should not exceed about 1 $MW/m^3$. This is a limitation on the numerical routines attributable to the coupling between gas flow and heat transfer through* *boundaries (conduction, convection, and radiation). The inherent two-layer assumption is likely to break down well before this limit is reached.*

Basis for Acceptability: No CFAST model reached or exceeded these limitations.

- **Radiation:** *Because the model includes a sophisticated radiation model and ventilation algorithms, it has further use for studying building contamination through the ventilation system, as well as the stack effect and the effect of wind on air circulation in buildings.*
  Basis for Acceptability: No CFAST model utilized ventilation systems for studying building contamination or stack effect and the effect of wind on air circulation in buildings. This use of the model is not applicable to this analysis.

- **Ventilation and Leakage:** *In a single compartment, the ratio of the area of vents connecting one compartment to another to the volume of the compartment should not exceed roughly 2 $m^{-1}$. This is a limitation on the plug flow assumption for vents. An important limitation arises from the uncertainty in the scenario specification. For example, leakage in buildings is significant, and this affects flow calculations especially when wind is present and for tall buildings. These effects can overwhelm limitations on accuracy of the implementation of the model. The overall accuracy of the model is closely tied to the specificity, care, and completeness with which the data are provided.*

  Basis for Acceptability: No CFAST model reached or exceeded these limitations.

- **Thermal Properties:** *The accuracy of the model predictions is limited by how well the user can specify the thermophysical properties. For example, the fraction of fuel which ends up as soot has an important effect on the radiation absorption of the gas layer and, therefore, the relative convective versus radiative heating of the layers and walls, which in turn affects the buoyancy and flow. There is a higher level of uncertainty of the predictions if the properties of real materials and real fuels are unknown or difficult to obtain, or the physical processes of combustion, radiation, and heat transfer are more complicated than their mathematical representations in CFAST.*

  Basis for Acceptability: All thermal properties input into the CFAST model for this analysis have been conservatively estimated from the CFAST material database or from authoritative publications such as the SFPE Handbook to predict worst case results in the compartment.

To demonstrate that the CFAST analyses were performed within the applicable guidelines for nuclear power plants, the input parameters were analyzed using normalized parameters summarized in NUREG-1934. The fire modeler manually calculates and verifies that the normalized parameters are within the validated range outlined in NUREG-1934. Input parameters identified to be out of the range of applicability are conservatively modified by the fire modeler, when possible, to bring the parameter within range. In most cases, the subject correlations have been applied within the normalized parameter range reported in NUREG-1934. In cases where conservative modification is not possible and the models have been applied outside the validated range, their use has 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 or non-applicable parameters, have been provided in R2168-1003B-0001, *Verification and Validation of Fire Modeling Tools and Approaches for Use in NFPA 805 and Fire PRA Applications* and R2168-001-552GRP, *Point Beach Nuclear Plant Detailed Fire Modeling Report – Fire Compartment: 552GRP*.

c) Fire Dynamics Simulator (FDS) was verified and validated by NUREG-1824, *Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications*, which provides the limitations of model applicability. This analysis utilized FDS within the limitations discussed in NUREG-1824 by conservatively following the guidance provided in model preparation. The limitations outlined in NUREG-1824 are shown below along with a basis for acceptability as applied to the Main Control Room Analysis Notebook, Compartment Analysis Notebook, and Appendices B, C, and F of the V&V Report:

- **Low-speed flow limitation:** *The use of FDS is limited to low-speed flow with an emphasis on smoke and heat transport from fires. This assumption rules out using the model for any scenario involving flow speeds approaching the speed of sound, such as explosions, choke flow at nozzles, and detonations.*

  Basis for Acceptability: The FDS analysis does not involve flow speeds approaching the speed of sound or any explosions (Mach numbers are less than about 0.3). Flow speeds modeled are limited to low-speed flows with an emphasis on smoke and heat transport from fire.

- **Rectilinear geometry limitation:** *The efficiency of FDS is attributable to the simplicity of its rectilinear numerical grid and the use of fast, direct solvers for the pressure field. This can be a limitation in some situations where certain geometric features do not conform to the rectangular grid, although most building components do. There are techniques in FDS to lessen the effect of "sawtooth" obstructions used to represent nonrectangular objects, but these cannot be expected to produce good results if, for example, the intent of the calculation is to study boundary layer effects. For most practical large-scale simulations, the increased grid resolution afforded by the fast pressure solver offsets the approximation of a curved boundary by small rectangular grid cells.*

  Basis for Acceptability: All geometries modeled in the analysis conform to the prescribed rectangular grid.

- **Fire growth and spread limitation:** *The uncertainty of an FDS model is higher in those cases where the heat release rate is predicted rather than prescribed.*

  Basis for Acceptability: The heat release rate of the fire is prescribed in the analysis. The transport of heat and exhaust products is the principal aim of the simulation. Heat release rates are not predicted in the analysis.

- **Combustion limitation:** *FDS uses a mixture fraction combustion model that assumes that combustion is mixing-controlled, and that the reaction of fuel and* *oxygen is infinitely fast, regardless of the temperature. This assumption is most appropriate for large-scale, well ventilated fires, but not for cases in which the compartment is under-ventilated, or if a suppression agent is introduced that may inhibit the size of the fire.*

Basis for Acceptability: The analysis involves only large-scale, well-ventilated fires. Suppression agents (e.g., water mist, $CO_2$ systems, or Halon) are not utilized in the analysis and therefore the model assumption that the reaction of fuel and oxygen is infinitely fast is appropriate for this analysis.

- **Radiation limitation:** *Radiative heat transfer is included in the model via the solution of the radiation transport equation for a non-scattering gray gas, and in some limited cases using a wide band model. The equation is solved using a technique similar to finite volume methods for convective transport, thus the name given to it is the finite volume method. There are several limitations of the model. First, the absorption coefficient for the smoke-laden gas is a complex function of its composition and temperature. Because of the simplified combustion model, the chemical composition of the smoky gases, especially the soot content, can affect both the absorption and emission of thermal radiation. Second, the radiation transport is discretized via approximately 100 solid angles. For targets far away from a localized source of radiation, like a growing fire, the discretization can lead to a non-uniform distribution of the radiant energy. This can be seen in the visualization of surface temperatures, where "hot spots" show the effect of the finite number of solid angles. The problem can be lessened by the inclusion of more solid angles, but at a price of longer computing times. In most cases, the radiative flux to far-field targets is not as important as those in the near-field, where coverage by the default number of angles is much better.*

  Basis for Acceptability: The calculation of radiant heat flux from a fire to a target was verified and validated with the knowledge of the limitations in the radiation model. The radiation model analysis was utilized within the acceptable limits of the verified and validated approach.

To demonstrate that the FDS analyses were performed within the applicable guidelines for nuclear power plants, the input parameters were analyzed using normalized parameters summarized in NUREG-1934. The fire modeler manually calculates and verifies that the normalized parameters are within the validated range outlined in NUREG-1934. Input parameters identified to be out of the range of applicability are conservatively modified by the fire modeler, when possible, to bring the parameter within range. In most cases, the subject correlations have been applied within the normalized parameter range reported in NUREG-1934. In cases where conservative modification is not possible and the models have been applied outside the validated range, their use has 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 or non-applicable parameters, have been provided in R2168-1003B-0001, *Verification and Validation of Fire Modeling Tools and Approaches for Use in NFPA 805 and Fire PRA*, P2091-2700-01, *Main Control Room Analysis Notebook, and* P2091-2900-01, *Fire PRA Notebook Compartment Analysis.*

**References:**


(1) NextEra Energy Point Beach, LLC, letter to NRC, dated June 26, 2013, "License Amendment Request 271, Transition to 10 CFR 50.48(c) - NFPA 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants," 2001 Edition" (ML131820453)

(2) NRC e-mail to NextEra Energy Point Beach, LLC, dated September 9, 2013, "Request for Supplemental Information Regarding the Acceptability of the Proposed Amendment Request" (ML13256A197)

(3) NextEra Energy Point Beach, LLC, letter to NRC, dated September 16, 2013, "License Amendment Request 271 Supplement 1 Transition to 10 CFR 50.48(c) – NFPA 805" (ML13259A273)

(4) NRC letter to NextEra Energy Point Beach, LLC, dated September 25, 2013, "Point Beach, Units 1 and 2 - Acceptance Review of Licensing Action re: License Amendment Request to Transition to NFPA 805, Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants" (ML13267A037)

(5) NRC e-mail to NextEra Energy Point Beach, LLC, dated July 8, 2014, "Point Beach Nuclear Plant, Units 1and 2 - Final (Revised) Requests for Additional Information re: License Amendment Request Associated with NFPA 805 (TAC Nos. MF2372 and MF2373)" (ML14189A365)

(6) NextEra Energy Point Beach, LLC, letter to NRC, dated July 29, 2014, "Response (60 Day) to Request for Additional Information License Amendment Request Associated with NFPA 805" (ML14210A645)

# ATTACHMENT 1

# LAR UPDATES FOR

# PBNP PRA RAI 02f

(1 Page Follows)

**Table U-1 – PBNP PRA Facts and Observations**

| Category and Finding | Other Affected SRs | Peer Review Findings | Resolution | Impact on Fire PRA |
|---|---|---|---|---|
| | | contributor for one plant and not another?<br><br>While the CDF results and initiating event contributions from several plants are compared to the results from the PBNP PRA, there is no discussion of the causes for significant differences in those results. A discussion of the reasons for the differences is necessary to meet Category II/III<br><br>Provide a discussion of the reasons for significant differences in plant results. | | Review |
| | | 2011 Peer Review Finding:<br><br>No Plant response.<br><br>Section 5.4 and Tables 5.4-1 and 2 provides a high level comparison, however the description of differences in results should be enhanced (the only difference cited is the 1 hour battery life assumed for PBNP). This is a limited description that requires more detail. For example, an explanation of why loss of 4Kv is 0.0 at PBNP and not so at other plants. | 2011 Peer Review Plant Response:<br><br>On January 10, 2012 PRA analysts from PBNP, Prairie Island, Kewaunee and Ginna participated in a conference call/meeting to discuss the differences in the PRA results. The insights provided by this discussion have been added to Section 5.4 of the Quantification Notebook, 11.0. Differences now included are batteries, service water header arrangement, safety injection pumps and power uprate.<br><br>ALL issues identified in the 2011 Peer Review Findings were resolved in the PRA Model. | |
| QU-D7-01 | Not Met<br><br>Finding | 2010 Peer Review Finding:<br><br>This SR requires a review of the importance of components and basic events to determine that they make logical sense. | 2010 Peer Review Plant Response:<br><br>Review of risk significant basic events is documented in Section 4.0, "Importance Rankings" of the Quantification Notebook, PRA 11.0. | |

# ATTACHMENT 2

# LAR UPDATES FOR
# PBNP (FM) RAI 01a

(2 Pages Follow)

NUREG-1921. Attachment H provides a listing of the approved FAQs that affect the overall license transition process for PBNP. The resulting fire risk assessment model is used to support Fire Risk Evaluations during the transition process and to develop estimates of the potential change in fire related risk.

The Fire PRA was developed using the Internal Events PRA as a starting point. The Internal Events PRA was modified to model the effects of fire, both as an initiator and the subsequent potential failure modes for affected circuits or targets. The Fire PRA has been quantified using the CAFTA PRA software. The PBNP Fire PRA is documented in a series of reports and calculations associated with each NUREG/CR-6850 Fire PRA task.

An independent peer review was conducted in June 2011 that included a review of the PRA model, data, and documentation in accordance with ASME Standard ASME/ANS RA-Sa-2009, Capability Category II requirements, as well as RG 1.200, Revision 2. Focused-scope peer reviews were conducted in May 2013 and June 2013 to specifically address Fire Scenario Selection and Analysis (FSS) and Fire Risk Quantification (FQ). The FSS F&Os from the 2011 full peer review were reviewed during the focused-scope peer review and the peer review determined that they could be closed. The few items that were not completely addressed from the 2011 full peer review were captured under new findings.

No changes have been made to the Fire PRA model since completion of the May and June 2013 focused-scope peer reviews that would constitute an upgrade (based on the definition provided in ASME/ANS RA-Sa-2009). Thus, no additional focused scope peer review is required to support this LAR.

Fire PRA quality and insights are discussed in subsequent sections and in Attachments V and W, respectively.

**Fire Model Utilization in the Application**

Fire modeling was performed as part of the Fire PRA development (NFPA 805 Section 4.2.4.2). RG 1.205, Regulatory Position 4.2 and Section 5.1.2 of NEI 04-02, provide guidance to identify fire models that are acceptable to the NRC for plants implementing a risk-informed, performance-based licensing basis.

The following fire models were used:

- Flame Height (Method of Heskestad)
- Plume Centerline Temperature (Method of Heskestad)
- Radiant Heat Flux (Point Source Method)
- Radiant Heat Flux (Solid Flame Model)
- Plume Radius (Method of Heskestad)
- Hot Gas Layer (Method of McCaffrey, Quintiere, and Harkleroad)
- Hot Gas Layer (Method of Beyler)

**Table J-1 V & V Basis for Fire Models / Model Correlations Used**

| Calculation | Application | V & V Basis | Discussion |
|---|---|---|---|
| Radiant Heat Flux<br>(Solid Flame Model) | Calculates the horizontal separation distance, based on heat flux, to a target in order to determine the horizontal extent of the ZOI. | • NUREG-1805, Chapter 5. 2004<br>• NUREG-1824, Volume 3, 2007<br>• SFPE Handbook of Fire Protection Engineering, 4th edition, Chapter 3-10, Beyler, C., 2008 | • The correlation is contained in NUREG-1805, for which V&V was documented in NUREG-1824.<br>• The correlation is documented in an authoritative publication of the "SFPE Handbook of Fire Protection Engineering."<br>• The correlation has been applied within the validated range reported in NUREG-1824 or, if applied outside the validated range, the model has been justified as acceptable, either by qualitative analysis, or by quantitative sensitivity analysis. |

# ATTACHMENT 3

# LAR UPDATES FOR
# PBNP (FM) RAI 01d

(1 Page Follows)

**Table S-3 Implementation Items**

| Item | Unit | Description | LAR Section / Source |
|---|---|---|---|
| IMP-155 | 1,2 | The results of the Non-Power Operational Modes Analysis will be implemented. Technical and administrative procedures and documents that relate to non-power modes of plant operating states will be revised as needed for implementation of NFPA 805. These revisions include:<br><br>-Restriction of hot work in analysis areas during periods of increased vulnerability;<br><br>-Verification of functional detection and/or suppression in the vulnerable analysis areas;<br><br>-Limitation of transient combustible materials in analysis areas during periods of increased vulnerability;<br><br>-Plant equipment configuration changes (e.g., removing power from equipment once it is placed in its desired position);<br><br>-Provision of additional fire patrols at periodic intervals or other appropriate compensatory measures (such as surveillance cameras) during periods of increased vulnerability; and<br>-Rescheduling work to a period with lower risk or higher defense-in-depth.<br>This is being tracked by NAMS Action Request 1882226. | 4.3.2 and Attachment D |
| IMP-156 | 1,2 | A symptom-based fire procedure to address non-MCR abandonment for MCR/ CSR/ VSGR fires will be developed, to allow actions (e.g., closing PORV Block MOVs) based on plant symptoms instead of directed actions as is currently the case in AOP-10A. This is being tracked by NAMS Action Request 1882226. | 4.5 and Attachment W |
| IMP-157 | 1,2 | The fire response procedures will ensure EDG overload due to fire impact is prevented. | 4.5 and Attachment W |
| IMP-158 | 1,2 | Additional defense-in-depth measures to minimize the risk of transient fires and to ensure combustible storage in Fire Zones 250 and 251 is maintained through the utilization of enclosed shelves, or metal cabinets, or metal trash cans will be implemented. This is being tracked by NAMS Action Request 1885057. | 4.2.4 and Attachment C |
| IMP-NEW | 1,2 | Verification of the condition of electrical cabinet doors to meet Fire Modeling Assumptions will be included in the monitoring program. This is being tracked by NAMS Action Request 1882226 | 4.5 and 4.6 |