REQUEST FOR ADDITIONAL INFORMATION
LICENSE AMENDMENT REQUEST TO ADOPT
NATIONAL FIRE PROTECTION ASSOCIATION STANDARD 805
PERFORMANCE-BASED STANDARD FOR FIRE PROTECTION FOR LIGHT WATER
REACTOR GENERATING PLANTS
CALLAWAY PLANT
(TAC NO. ME7046)

Office of Nuclear Reactor Regulation
Division of Risk Assessment
Fire Protection Branch
PRA Licensing Branch

Fire Modeling RAI 01

National Fire Protection Association Standard (NFPA) 805 "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants", 2001 Edition, Section 2.7.3.2, "Verification and Validation," states: "Each calculational model or numerical method used shall be verified and validated through comparison to test results or comparison to other acceptable models."

Section 4.5.1.2 of the Transition Report of the License Amendment Request (LAR) states that a fire modeling study was performed as part of the fire probabilistic risk assessment (FPRA) development (NFPA 805, Section 4.2.4.2). During the audit, the staff noted that the fire modeling that was done in support of the LAR was in the form of a plant specific Fire Modeling Database (FMDB), called, "Transient Analysis Worksheets". The FMDB was developed in lieu of using NUREG-1805 (FDTs) or FIVE-Rev. 1.

Regarding the verification and validation of the fire models:

a. Describe how FMDB – Transient Analysis Worksheets were verified. (i.e., how was it ensured that the empirical equations/correlations were coded correctly and that the solutions are identical to those that would be obtained with the corresponding chapters in NUREG-1805, "Fire Dynamics Tools (FDT^s) Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program" or Fire Induced Vulnerability Evaluation, (FIVE), Rev.1).

b. The fire models that were used in support of the FPRA are listed in Section 4.5.1.2 of the Transition Report and reference is made to Attachment J of the Transition Report for a discussion of the acceptability of the listed fire models. For the following models it is stated in Attachment J that, "V&V was documented in NUREG-1824," and that "the correlation is used within the limits of its range of applicability."

    - Flame Height (Method of Heskestad)
    - Plume Centerline Temperature (Method of Heskestad)
    - Radiant Heat Flux (Point Source Method)
    - Hot Gas Layer (Method of MQH)
    - Hot Gas Layer (Method of Beyler)
    - Hot Gas Layer (Method of Foote, Pagni, and Alvares [FPA])
    - Hot Gas Layer (Method of Deal and Beyler)
    - Ceiling Jet Temperature (Method of Alpert)

- Smoke Detection Actuation Correlation (Method of Heskestad and Delichatsios)

The fact that a correlation is used within its range of applicability does not guarantee that it is applied within the validated range reported in NUREG-1824, “Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications”. Provide technical details to demonstrate that the correlation has been applied within the validated range or to justify the application of the correlation outside the validated range reported in NUREG-1824.

c. Attachment J of the Transition Report states that the following models are verified and validated on the basis that they are described in an authoritative publication in fire protection literature:

- Heat Detection Actuation Correlation
- Sprinkler Activation Correlation
- Corner and Wall Heat Release Rate
- Correlation for Heat Release Rates of Cables (Method of Lee)
- Correlation for Flame Spread over Horizontal Cable Trays (FLASH-CAT)

Furthermore, the Transition Report states that these models are used within their range of applicability, which does not guarantee that they are applied within the validated range. Provide technical details to demonstrate that the model has been applied within its validated range or to justify the application of the model outside its validated range.

d. Attachment J of the Transition Report states that the “Plume Radius (Method of Heskestad) model is verified and validated on the basis that it is described in an authoritative publication in the fire protection literature. Provide technical details to demonstrate that the model has been applied within its validated range or to justify the application of the model outside its validated range.

e. Attachment J of the Transition Report states that the verification and validation of the following applications of Fire Dynamics Simulator (FDS) are documented in NUREG-1824.

- Hot Gas Layer (HGL) Calculations using FDS
- Sprinkler Actuation Calculation using FDS
- Temperature Sensitive Equipment Zone of Influence Study using FDS
- Plume/Hot Gas Layer Interaction Study using FDS

Provide technical documentation that demonstrates that FDS was either used within the range of its validity as described in NUREG-1824 or that the use of FDS outside the verification and validation range in NUREG-1824 is justified.

f. Attachment J of the Transition Report states that the verification and validation of the following applications of Consolidated Model of Fire and Smoke Transport (CFAST) are documented in NUREG-1824.

- HGL Calculations using CFAST (Version 6)
- Temperature Sensitive Equipment Hot Gas Layer Study using CFAST
- Control Room Abandonment Calculation using CFAST

Provide technical documentation that demonstrates that CFAST was either used within the range of its validity as described in NUREG-1824 or that the use of CFAST outside the verification and validation range in NUREG-1824 is justified.

In addition, explain why the HGL Calculations using the CFAST calculation described on page J-6 of the Transition Report were not listed as one of the fire models utilized in the application in Section 4.5.1.2.

g. During the audit, the staff observed that part of the fire modeling performed in support of the transition to NFPA 805 is described in Engineering Planning & Management, Inc. (EPM) Report No. R1984-001-002, "Callaway Plant Verification and Validation of Fire Modeling Tools and Approaches." Appendices B, C and D of this report describe FDS and CFAST fire modeling studies of plume/HGL interaction, temperature sensitive equipment zone of influence (ZOI) and HGL effects. Provide the basis of assurance that the use of the conclusions from these studies in subsequent fire modeling analysis was within the limits of applicability.

h. Section 4.5.1.2 of the Transition Report lists 'Multi-Compartment Analysis Hot Gas Layer Analysis' as one of the fire models utilized in the application. However, there is no verification and validation basis provided for this model in Attachment J. Explain where this fire model was utilized in the application (if applicable) and provide technical details to demonstrate that the model has been applied within its validated range or to justify the application of the model outside its validated range.

i. During the audit, the staff observed that part of the fire modeling performed in support of transition NFPA 805 is described in EPM Report No. R1984-001-001, "Fire Dynamics Simulator (FDS) Analysis R0". Section C21.3.5 of this report describes how the smoke detector characteristics are prescribed based on Cleary's obscuration correlation.

   Provide the basis for verification and validation of this obscuration correlation. Provide technical documentation that demonstrates that FDS was either used within the range of its validity as described in NUREG-1824 or that the use of FDS outside the verification and validation range in NUREG-1824 is justified. In addition, explain why this particular calculation was not listed in Section 4.5.1.2 or Attachment J of the Transition Report.

j. During the audit, the staff observed that the software package Pyrosim (Version 2010.1.0928) was used to build the FDS input files. Provide technical documentation that demonstrates that Pyrosim is verified to build the input file correctly.

Fire Modeling RAI 02

NFPA 805, Section 2.7.3.5, "Uncertainty Analysis," states: "An uncertainty analysis shall be performed to provide reasonable assurance that the performance criteria have been met."

Section 4.7.3 of the Transition Report states that uncertainty analyses were performed as required by Section 2.7.3.5 of NFPA 805 and the results were considered in the context of the application.

a. Explain in detail the uncertainty analyses for fire modeling that was performed. Describe how the uncertainties of the input parameters (geometry, Heat Release Rate (HRR), Response Time Index (RTI), etc.) were determined and accounted for and substantiate the statement in Appendix J of the Transition Report that states, "…the predictions are deemed to be within the bounds of experimental uncertainty…"

b. During the audit, the staff reviewed EPM Report No. R1984-001-001, "Fire Dynamics Simulator Analysis R0". The staff noted that cable tray obstructions were omitted in the FDS fire modeling analysis for Fire Areas C-21 and C-22.

   In a typical fire risk assessment, there are completeness uncertainties in the risk contribution due to scenarios not explicitly modeled (e.g., smoke damage), model uncertainties in the assessment of those scenarios that are explicitly modeled (e.g., uncertainties in the effect of obstructions in a plume), and parameter uncertainties regarding the true values of the model parameters (e.g., the mass burning rate of the source fuel). Justify why cable tray obstructions could be omitted in the FDS fire modeling analysis for Fire Areas C-21 and C-22.

Fire Modeling RAI 03

NFPA 805, Section 2.7.3, "Quality," describes requirements for fire modeling calculations, such as acceptable models, limitations of use, validation of models, defining fire scenarios, etc. This description includes justification of model input parameters, as it is related to limitations of use and validation.

a. The staff noted that no specific discussion was found in the Transition Report, with respect to how the input for the algebraic models were established for fires that involved multiple combustibles. Explain how the input for the algebraic models was established for fires that involved multiple combustibles and justify the approach that was used.

b. The staff noted that no specific discussion was found in the Transition Report, with respect to how the input for the Consolidated Model of Fire Growth and Smoke Transport (CFAST) models was established for the Main Control Room (MCR) evacuation study. Describe the specific CFAST input parameters and provide the CFAST input files for the MCR evacuation study.

c. During the audit, the staff noted that fire modeling report R1984-001-001 "Fire Dynamic Simulator Analysis to Support Detailed Fire Modeling", Rev.0, states in several places (all Appendices) that, "The mesh size reflects the finest mesh feasibly allowable with the given computer resources." Explain why the mesh size used is within the validated range and confirm whether a grid sensitivity study was performed or justify why such a study was not performed.

d. During the audit, the staff noted that Section A11.1 of fire modeling report, R1984-001-001 discussed how the analysis performed for Fire Area C-31 was applied to Fire Area A-11 since the room dimensions for both spaces are comparable. However, this discussion does not describe how the ignition source location and the radial distance between the fire source and the sprinkler was selected.

   Explain how the assumption to use the FDS analysis for Fire Area C-31 to apply to Fire Areas A-11 and C-30 is adequate. In addition, explain how the ignition source location and secondary combustibles in Fire Areas A-11 and C-30 are considered by the analysis of Fire Area C-31.

e. During the audit, the staff noted fire modeling report R1984-001-001 states “It should be noted that NUREG 1824 did not provide verification and validation for estimating sprinkler activation times. However, the major inputs used in the determination of suppression (determination of gas temperatures) have been validated.” Based on this statement, it was not clear to the staff how the sprinkler activation time was determined. Explain how the sprinkler activation time was calculated in the FDS analysis.

f. During the audit, the staff noted that different material properties were used in the FMDB analysis as in the FDS analysis for the same fire areas (A-11, C-21, etc.). For example, in Calculation No. KC-49, the material properties used in the FDS analysis for concrete is different from that used in the FMDB and transient datasheet analysis. The thermal conductivity and density in the FMDB are 1.6 W/m-K and 2400 kg/m3 as opposed to 1.0 W/m-K and 2100 kg/m3 used in FDS. The specific heat of concrete in FDS calculations is 0.88 kJ/kg-K and in FMDB calculations are 0.75 kJ/kg-K.

   Explain the reason for the difference in material properties used in FMDB and FDS analyses. In addition, explain what effect the difference in material properties used in the analyses has on the conclusions.

g. During the audit, the staff noted that it is discussed in fire modeling report R1984-001-001, how the water discharge spray is input into FDS for each sprinkler head and there are figures in each Appendix that show water spray from an activated sprinkler. Based on this discussion, it was not clear to the staff how the sprinkler water spray characteristics were used in the FDS analysis. Explain how the sprinkler water spray characteristics were used in the FDS analysis.

h. During the audit, the staff noted that it is discussed in Section A11.3.5.1 of fire modeling report R1984-001-001, why the heat release rate profile was chosen instead of:

   1. A smaller initial fire size which, along with ignition of secondary combustibles might result in quicker sprinkler activation, or,

   2. A larger initial ignition source which would not activate sprinklers prior to ignition of secondary combustibles.

   Based on this discussion in the report, it was not clear to the staff how these assumptions were verified. Explain how the heat release rate profiles chosen were conservative for the purposes of damage assessment and sprinkler activation. In addition, apply this response to the analysis conducted for the other two cable chase fire areas (C-30 and C-31) analyzed with FDS.

i. During the audit, the staff noted that it is discussed in fire modeling report R1984-001-001 that a slice temperature file was created at ceiling level to analyze the sprinkler activation times. Based on this statement, it is not clear to the staff how the sprinkler activation time was determined (slice file output or FDS sprinkler activation algorithm). In this same section of each FDS analysis, there is a discussion about the slice file output showing that the fire ignition location does not affect the results in terms of sprinkler activation. Explain how the sprinkler activation time is determined in the FDS analysis and provide technical justification for the conclusion that the slice file output shows that fire location does not affect the sprinkler activation times.

j. During the audit, the staff noted that it is stated in Section C21.2 of fire modeling report R1984-001-001 that, “the purpose of the FDS simulation was to determine the time at which the ceiling-mounted quick-response sprinklers in this fire compartment would activate as a result of a transient fire.” However, in the paragraph that follows, it is stated that the sprinklers were given an RTI of 130 $(m\text{-}s)^{0.5}$, which is a value more typical of a standard response sprinkler. State what type of sprinklers are in the lower Cable Spreading Room (CSR) and also provide a justification for the RTI used in the analysis.

k. During the audit, the staff noted that it is stated in Section C21.3.5 of fire modeling report R1984-001-001, that standard response sprinklers are used in the CSR and therefore an RTI of 130 $(m\text{-}s)^{0.5}$ was used for the analysis. The licensee justified this value for the RTI by way of reference to NUREG 1805, “which provides a generic RTI value of 130 $(m\text{-}s)^{0.5}$ for standard response heads with a fusible link. However, in Chapter 10 of NUREG 1805, there is a note about selecting the RTI of a sprinkler element which states, “the actual RTI should be used when the value is available.” Provide justification for the RTI value chosen for this analysis and describe how that value compares with the RTI of the actual sprinklers in the CSRs. In addition, apply the response to the upper CSR (Fire Area C-22).

l. During the audit, the staff noted that it is discussed in Section C21.3.5.1 of fire modeling report R1984-001-001, why a 45 kW initiating fire was considered more conservative than a 69 kW initiating fire, in terms of sprinkler activation and ignition of secondary combustibles. It was not clear to the staff how this conservatism was verified. Explain how heat release rate profiles chosen were conservative for the purposes of damage assessment and sprinkler activation. In addition, apply this response to the analysis conducted for the other upper CSR (C-22) analyzed with FDS.

m. During the audit, the staff noted that it is stated in Section C21.4 of R1984-001-001 of fire modeling report “…is expected to result in suppression activation within 13.5 minutes. This timing directly corresponds to ignition of the third cable tray in a stack.” In Section C21.3.5.1 of the report, it was stated that, “The third cable tray ignites at 12 minutes.” This language suggests that the third cable tray ignites at the same time as sprinkler activation. Clarify what is meant by this statement and how the ignition of the third cable tray affects the sprinkler activation time.

n. During the audit, the staff noted that it is stated in Section C21.5 of fire modeling report R1984-001-001, “The modeled configuration of a transient fire in C-21 does not result in the formation of a hot gas layer before automatic suppression is actuated.” Provide technical justification for this statement. In addition, apply this response to the analysis conducted for the other upper CSR (C-22) analyzed with FDS.

o. During the audit, the staff noted that it is stated in Section C21.5 of fire modeling report R1984-001-001, “The FDS analysis results for Fire Compartment C-22 are based on the analysis performed for Fire Area C-21, the lower CSR. The C-21 analysis results for suppression activation are considered equivalent to those expected in C-22 due to their similar configurations.” However, the ceiling of C-21 is specified as approximately 25 feet and the ceiling of C-22 is specified as approximately 12 feet. Explain this difference in ceiling height and why it was not necessary to model C-22 separately.

p. During the audit, the staff reviewed Scientech Calculation 17671-010b, “Callaway NFPA 805 Fire PRA Main Control Room Fire Analysis”, and discussed the analysis with the licensee. During this discussion, it was stated that it was assumed that a fire originating in the Equipment Cabinet Area (ECA) was assumed to not be able to propagate into the MCR. Provide a basis for this assumption.

q. During the audit, the staff reviewed Scientech Calculation 17671-010b, and discussed the analysis with the licensee's staff. During this discussion, it was stated that it was assumed that there was only qualified cable in the MCR. However, Section 2 of Attachment 1 (Control Room Evacuation Study) of this calculation states that it is assumed the control room contains both qualified and unqualified cabling. Clarify whether there is unqualified cable in the control room and if so, what is the ratio of unqualified to qualified cable?

r. During the audit, the staff reviewed Scientech Calculation 17671-010b, and discussed the analysis with the licensee. In Table 1 of Attachment 1 (Control Room Evacuation Study) of Scientech Calculation 17671-010b, the modeled fire scenarios are provided. For single cabinet fires, both qualified and unqualified cabling was used in the calculation of evacuation times. However, for the multi-cabinet fire scenarios, only qualified cable was considered in the calculation of evacuation times. Explain why unqualified cable was not considered for multi-cabinet fires.

s. During the audit, the staff reviewed Scientech Calculation 17671-010b, as well as Attachment 1 (Control Room Evacuation Study). The fuel combustion properties for qualified and unqualified cable are provided in this report. The heat of combustion (HOC) for qualified and unqualified cable is given as 28.3 and 20.9 MJ/kg, respectively. It is not expected that the HOC for an unqualified cable would be lower than a qualified cable. Confirm these material values and also explain how the HOC material property is used in the analysis.

t. Provide the FDS input files for the detailed FDS fire modeling conducted as described in EPM document Nos. R1984-001-001 and R1984-001-C1, Detailed Fire Modeling Report – FDS Analysis of HDPE Pipes (Draft B).

Fire Protection Engineering RAI 01

In Attachment A of the LAR, Table B-1, on page A-25, the compliance statement for NFPA 805 Section 3.3.7.1 states “complies with clarification”. The compliance basis states: “Bulk hydrogen complies with the requirements of NFPA 50A-1973. Exceptions requiring further action are identified below”. Another compliance statement “complies with required action” is used. The compliance basis states “see implementation items identified below.” There are two implementation items associated with this requirement.

It is unclear what the clarification is and whether or not the required actions are necessary for the entire chapter 3 attribute. Clarify the use of the two-part compliance statement and what the clarification is.

Fire Protection Engineering RAI 02

In attachment A of the LAR, Table B-1, on page A-33, the compliance statement for NFPA 805 Section 3.4.1(a)(1) states “complies with clarification”. The compliance basis states “the industrial fire brigade complies with NFPA 600-2000 Edition. Exceptions requiring further action are identified below”.

It is unclear what the clarification is and whether or not the required actions are necessary for the entire chapter 3 attribute. Clarify the use of the two-part compliance statement and what the clarification is.

Fire Protection Engineering RAI 03

In attachment A of the LAR, Table B-1, on page A-37, the compliance statement for NFPA 805 Section 3.4.2 states “complies”, however implementation items are listed below. Clarify whether "complies" is the correct compliance statement with the requirements in this section or if the plant complies with required action.

Fire Protection Engineering RAI 04

In attachment A of the LAR, Table B-1, on page A-39, the compliance statements for NFPA 805 Sections 3.4.2.3 and 3.4.2.4 state “complies, with required action”, and the compliance basis states “see implementation item identified below”. It was noted that there are no implementation items identified below these two sections. Identify the required actions.

Fire Protection Engineering RAI 05

In attachment A of the LAR, Table B-1, on page A-45, the compliance statement for NFPA 805 Section 3.4.4 states “complies with clarification”. The compliance basis states “Equipment is provided for the fire brigade as required. Per visual inspection of equipment, it is in accordance with applicable NFPA codes, as documented in CAR 200902315.” However the clarification is not apparent. Identify the clarification used to support the compliance statement.

Fire Protection Engineering RAI 06

In attachment A of the LAR, Table B-1, on page A-59, the requirements of NFPA 805 Section 3.5.15 for fire hydrants and hose houses are stated. The LAR states that the exception to this section in NFPA 805 is utilized which provides a mobile means of providing hose and associated equipment in lieu of hose houses. The exception states the mobile equipment shall be equivalent to the equipment supplied by three hose houses. The compliance basis states that equipment on two mobile units is provided, but it does not specify the amount of equipment provided. Clarify the actual equipment equivalency for the mobile units.

Fire Protection Engineering RAI 07

In attachment A of the LAR, Table B-1, on page A-64, the compliance statement for NFPA 805 Section 3.6.2 states “complies with clarification”. However the clarification is not apparent. Identify the clarification used to support the compliance statement.

Fire Protection Engineering RAI 08

In attachment A of the LAR, Table B-1, on page A-66, the compliance statement for NFPA 805 Section 3.6.4 states “compliance by previous NRC approval”. The compliance basis for this element does not address the provision of this section to provide manual fire suppression in areas containing systems and components needed to perform nuclear safety functions following a safe-shutdown earthquake. Although not addressed in the LAR, 10 CFR 50.48(c)(vi) states NRC requirements for licensees that wish to apply the exception to Section 3.6.4. Describe how compliance is achieved with the requirement to provide manual fire suppression to protect nuclear safety functions in the event of a safe shutdown earthquake.

Fire Protection Engineering RAI 09

In attachment A of the LAR, Table B-1, on page A-83, the compliance statement for NFPA 805 Section 3.9.3 states “complies with clarification”. The compliance basis states that waterflow alarms annunciate on panels that connect to KC008, which is located in the control room. Similarly, in attachment A of the LAR, Table B-1, on page A-89, the compliance statement for NFPA 805 Section 3.10.2 also states “complies with clarification”. The compliance basis states that all system actuation alarms annunciate on panels that connect to KC008, which is located in the control room. Provide further discussion on these clarifications, including a description of the alarm process and how the alarming condition is communicated to the operator(s).

Fire Protection Engineering RAI 10

On December 21, 2011 there was a fire in the B emergency diesel generator (EDG) jacket water heater where the breaker for the heater did not automatically open and a fire was reported on the paint on the outside of the heater. Subsequently, the jacket water heater was determined to be non-functional and jacket water temperature dropped below the technical specification (TS) required limit and the B EDG was declared inoperable. Describe the effects (if any) this incident and any subsequent actions taken as a result of this incident, have on the NFPA 805 LAR and the transition process.

Fire Protection Engineering RAI 11

Section 4.1.2.3 and Attachment L, Approval Request 1, of the LAR describe the storage and refilling capacity of the fire protection water storage tanks to demonstrate that the requirement for two separate 300,000 gallons supplies is not adversely impacted by using the fire protection water supply for non-fire protection purposes. Describe the administrative and/or operating procedures to ensure that the minimum required fire protection water supply remains available.

Fire Protection Engineering RAI 12

Table B-1, Criteria 3.5.1(b), Fire Flow Rate of the LAR indicates that compliance with this item is not applicable. However, in Approval Request 1, compliance to this requirement, namely the 500 gpm hose stream requirement, is the basis for the request. Reconcile the discrepancy.

Fire Protection Engineering RAI 13

In attachment A of the LAR, Table B-1, on page A-91, the compliance basis for NFPA 805 Section 3.10.9 does not provide adequate detail to conclude that the possibility of secondary thermal shock damage was considered for the design of the gaseous fire suppression systems at Callaway plant. Provide additional information to justify the conclusion that Halon 1301 does not present a risk of secondary thermal shock.

Fire Protection Engineering RAI 14

NFPA 805, Section 3.9.1 requires that water-based fire suppression systems be installed in accordance with the appropriate NFPA standard. During the audit, it was observed that quick response sprinkler heads were installed in multiple cable chases, replacing the original sprinkler nozzles. Due to the piping configuration, the quick response sprinkler heads were installed at an angle relative to the ceiling, as opposed to being parallel to it; the latter of which is typical.

Plant modification item 201002877 to install the quick response sprinklers in cable chases A-11, C-30, and C-31 has been completed. Provide the basis and justification for compliance to the appropriate NFPA standard.

Fire Protection Engineering RAI 15

NFPA 805, Section 3.9.1(1) requires that the standpipe systems comply with the NFPA 14, “Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems” code of record (i.e. 1976). During the audit, the licensee indicated normal working pressures range from 150-160psi. In accordance with NFPA 14, Section 4-4.2, the pressures should not exceed 65psi for Class I connections (1.5”) and 100psi for Class II connections (2.5”). Provide a description of the system pressures at the hose connections and whether or not these pressures exceed the required values. If pressures exceed these values, provide the justification and basis for having the higher pressure(s). Include any prior approvals and any justification for meeting any other NFPA 14 requirements as necessary. Update the code conformance review calculation document as necessary.

Monitoring Program RAI 01

NFPA 805, section 2.6 “Monitoring” states that “a monitoring program shall be established to ensure that the availability and reliability of the fire protection systems and features are maintained and to assess the performance of the fire protection program in meeting the performance criteria” and that “Monitoring shall ensure that the assumptions in the engineering analysis remain valid.”

Specifically, NFPA 805, Section 2.6 states that (2.6.1) “Acceptable levels of availability, reliability, and performance shall be established.” (2.6.2) “Methods to monitor availability, reliability, and performance shall be established. The methods shall consider the plant operating experience and industry operating experience.” (2.6.3) “If the established levels of availability, reliability, or performance are not met, appropriate corrective actions to return to the established levels shall be implemented. Monitoring shall be continued to ensure that the corrective actions are effective.”

Section 4.6, “Monitoring Program” of the Transition Report states that the NFPA 805 monitoring program will be implemented “after the safety evaluation issuance as part of the fire protection program transition to NFPA 805” (Table S-3, Implementation Items, item 11-805-089 of the Transition Report).

Furthermore, the licensee has committed to comply with Frequently Asked Question (FAQ) 10-0059. The staff noted that the information provided in Section 4.6, “Monitoring Program” of the Transition Report is insufficient for the staff to complete its review of the monitoring program, and as such, is requesting that the following additional information be provided.

a. A description of the process by which systems, structures, and components (SSCs) will be identified for inclusion in the NFPA 805 monitoring program, including the approach to be applied to any fire protection SSCs that are already included within the scope of the Maintenance Rule program.

b. A description of the process that will be used to assign availability, reliability, and performance goals to SSCs within the scope of the monitoring program including the approach to be applied to any SSCs for which availability, reliability, and performance goals are not readily quantified.

c. A demonstration of how the monitoring program will address response to programmatic or training elements that fail to meet performance goals (examples include fire brigade response or performance standards and discrepancies in programmatic areas such as combustible programs).

d. A description of how the monitoring program will address fundamental fire protection program elements.

e. A description of how the guidance in EPRI Technical Report 1006756, “Fire Protection Equipment Surveillance Optimization and Maintenance Guide” will be integrated into the monitoring program.

f. A description of how periodic assessments of the monitoring program will be performed taking into account, where practical, industry wide operating experience including whether this process will include both internal and external assessments and the frequency at which these assessments will be performed.

Safe Shutdown Analysis RAI 01

NEI 00-01, “Guidance for Post-Fire Safe Shutdown Circuit Analysis”, Revision 1, Alignment - Provide a gap analysis on the differences between the alignments using NEI 00-01, Rev. 1, as the basis for transitioning the NFPA Standard 805 nuclear safety capability as indicated in NEI 04-02, “Guidance for Implementing a Risk-informed, Performance Based Fire Protection Program Under 10 CFR 50.48(c)”, versus using NEI 00-01, Revision 2, which is the current version cited in Regulatory Guide 1.205, “Risk Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants”, Rev. 1.

Safe Shutdown Analysis RAI 02

The nuclear safety capability assessment (NSCA) assumed the loss of instrument air. Explain how this was incorporated into the initial position of components for circuit analysis. Also, explain how instrument air failure was considered in the non-power operations (NPO) analysis.

Safe Shutdown Analysis RAI 03

Section 4.1.2.2 and Attachment T, Clarification Request 1 of the LAR – NUREG-0830, “Safety Evaluation Report Related to the Operation of Callaway Plant, Unit No.1," Supplement 3, states that “Some operations require cutting a control power cable at the equipment to ensure that a fault in the control room does not prevent certain equipment operation.” Explain if these operations are retained in the transition to NFPA 805. If so, explain how these were considered as variations from the deterministic requirements in the NFPA 805 analysis.

Safe Shutdown Analysis RAI 04

Section 4.1.2.2 and Attachment T, Clarification Request 2 of the LAR – Explain if there are any significant ignition sources or combustible loading in the vicinity of the subject emergency or equipment hatch that can challenge the non-rated penetrations. Explain if there has been any significant change to the room configuration since previous approval.

Safe Shutdown Analysis RAI 05

Section 4.1.2.2 and Attachment T, Clarification Request 4 of the LAR – The LAR states that “The original NRC approval was granted based on the overall design of the fire protection features in the rooms and did not specifically rely on the dike capacity.” This conflicts with other information provided in the LAR. Specify the capacity of the diesel fuel oil day tank dike system and justify if the system remains adequate with the reduced capacity of less than 100%.

Safe Shutdown Analysis RAI 06

Section 4.2.1.2 and Table B-2 of the LAR – To extend the minimum 10 hours coping time, operators must take action to recharge the nitrogen accumulators to support emergency operation of the atmospheric steam dump (ASD) valves and the turbine drive auxiliary feedwater pump (TDAFW) to steam generator (SG) flow control valves. Explain if the components and/or cables associated with this action are included in the NSCA safe shutdown (SSD) equipment list. Explain if the steps for recharging the nitrogen accumulators detailed in plant procedures are demonstrated to be feasible.

Since the actions to recharge the nitrogen accumulators are not considered recovery actions, provide a qualitative risk analysis that demonstrates that the risk of failing to perform the actions within the required time frame is low.

Should the accumulators not be recharged, explain if the TDAFW flow control valves can be locally throttled. If so, explain how these steps are proceduralized and demonstrated to be feasible.

Probabilistic Risk Assessment RAI 01

The disposition of several Facts and Observations (F&Os) for the internal events PRA model identifies that the item is resolved and thereby included in the current internal events model but not incorporated into the FPRA model. During the audit, the licensee identified that the internal events PRA model has been revised since the development of the FPRA and has undergone a focused scope peer review after the fire peer review was completed. Provide the following:

a. A description of any changes made to the internal events PRA model which are not part of the FPRA and disposition any potential impact on the FPRA results.

b. A description of the focused scope peer review and disposition any F&Os resulting from this review for their applicability to the current FPRA model.

c. A discussion of the overall impact of the changes to the internal events PRA model in terms of how the internal events risk profile has changed, that the changes would not impact the FPRA results, and that the internal events PRA model used in the FPRA development can be considered to represent the as-built and operated plant even though additional changes have subsequently been made to the internal events model.

The responses need to consider not just the FPRA results for the proposed changes which are part of the LAR, but also consider the requested self-approval after implementation of the NFPA 805 license amendment. If appropriate, in order to justify the existing model, sensitivity studies using the updated internal events conditional core damage probabilities should also be provided.

Probabilistic Risk Assessment RAI 02

The peer review description addresses the relevant internal events PRA standard, but does not identify how the RG 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities", Rev. 2, clarifications and qualifications to the standard were addressed. Indicate whether or not RG 1.200 clarifications and qualifications to the standard were considered by the peer review team, and if not, provide a self-assessment of the PRA model for the RG 1.200 clarifications and qualifications and indicate how any identified gaps were dispositioned. This also applies to the FPRA peer review, so the response should address both peer reviews.

Probabilistic Risk Assessment RAI 03

The disposition of the F&Os related to Large Early Release Frequency (LERF) refers to a separate LERF model developed for the FPRA. Provide a discussion of the peer review of this new LERF model and identify and disposition any peer review F&Os associated with this model.

Probabilistic Risk Assessment RAI 04

The resolution of a number of F&Os from the internal events review does not appear to fully address the impact of the resolution on the NFPA-805 results. Justify the proposed resolution as follows:

a. During the audit, the licensee identified that F&O SY-2 disposition should be revised to indicate that the item was addressed in the FPRA. Provide this revised disposition.

b. F&O DA-3 discusses basic events and sensitivity studies conducted. The licensee identified during the audit that this item was in fact resolved for the FPRA. Provide this revised disposition.

c. F&O IE-8 (which is cross-referenced to Supporting Requirement DA-C14) identifies recovery events in the internal events model which may not have appropriate probabilities. The disposition of this F&O states that the FPRA does not "generally" credit these recovery actions. Provide a more substantive justification that this F&O is not relevant to the FPRA.

d. F&O IE-13 relates to the age of the Inter-System Loss of Coolant Accident (ISLOCA) evaluation (and it is assumed that changes may be needed when it is updated). During the audit, the licensee identified that a revised ISLOCA evaluation was created for the FPRA and was peer reviewed. Provide a statement indicating this and provide the disposition of any F&Os from the peer review. Note that normally a FPRA peer review would not review the ISLOCA, so a statement should be provided stating that this was specifically included in the scope of the peer review for the FPRA.

e. F&O IF-D5/D5a relates to internal flooding gaps. Indicate if there are any fire-induced floods (i.e., due to spurious valve opening).

f. The licensee reported (via 10CFR50.72) the use of high density polyethylene piping in the Essential Service Water (ESW) system that was not protected by a fire barrier in fire areas C-1, D-1 and D-2, but Attachment W indicates no Variance from Deterministic Requirements (VFDR) in area C-1. Provide a discussion on how this design deficiency has been addressed and provide any required changes to the NFPA 805 LAR. This should include, as appropriate, FPRA modeling considerations, VFDR identification, and a discussion of the fire scenarios which challenge the integrity of the piping (i.e., HRR levels assumed for transient combustible ignition sources in the analyses performed to address the use of this polyethylene piping.)

Probabilistic Risk Assessment RAI 05

If changes to the FPRA model have been made subsequent to the completion of the peer review of the FPRA, provide a description of any new models or methods that have been implemented for the FPRA, including any subsequent focused scope peer reviews of the models or methods.

Probabilistic Risk Assessment RAI 06

The resolution of a number of F&Os from the FPRA review does not appear to fully address the impact of the resolution on the NFPA-805 results. Justify the proposed resolution as follows:

a. F&O ES-A1-1 - This F&O disposition identifies an "updated generic list of multiple spurious operations (MSOs)" to be considered to resolve this item. The disposition does not explicitly state the updated list was used, only that the "generic pressurized water reactor (PWR) MSO list" was reviewed. Clarify this response.

b. F&O ES-B1-1 - It is not clear to the staff what the deficiency in the FPRA model is, or if the item was resolved by making changes or by simply clarifying the underlying issue. Clarify this and discuss how it was addressed.

c. F&O ES-B2-1 - Flow diversion paths screened in the internal events PRA due to low frequency may become significant due to spurious operations. Provide a description of the method for consideration of diversion pathways which could be significant in the FPRA model due to a spurious operations failure mode.

d. F&O ES-C1-1 - The disposition is not clear as to whether a change was made to address the F&O, or if it is providing the location of the missing information which was simply not found by the peer review team (i.e., it is not a valid F&O). Provide clarification as to how the F&O was addressed.

e. F&O CS-B1-1 - The disposition is not clear as to whether a change was made to address the F&O, or if it is providing the location of the missing information which was simply not found by the peer review team (i.e., it is not a valid F&O). Provide clarification as to how the F&O was addressed.

f. F&O FSS-B01-2 - The F&O has two distinct parts. The first part is partially addressed by the evaluation of a specific cabinet in the control room which can cause a loss of heating ventilation and air conditioning (HVAC), which stated that an updated analysis considers a fire spreading to this cabinet, but the response does not specifically address a fire originating in the cabinet. The second part, the potential complexity of a fire event causing spurious safety injection (SI) and containment isolation, is not addressed in the disposition. Provide a more complete disposition of this F&O.

Probabilistic Risk Assessment RAI 07

A number of issues with the Human Reliability Analysis (HRA) need to be clarified:

a. F&O HRA-E1-1 - The F&O indicates that the human error analysis credits instrumentation not traced to assure availability. Confirm that credited instrumentation relied upon for the HRA is based on availability of instruments free from fire damage.

b. Provide the basis for assuming a screening human error probability of 0.1 for failure of successful operation at the Auxiliary Shutdown Panel (ASP) following Main Control Room (MCR) abandonment.

c. Some of the time windows cited in the Post-Fire HRA Calculation to complete a task seem very short, e.g., (1) HFE OP-OMA-FF-EGRVAB (probability = 0.13) with a "time margin" of only one out of 20 min, where the available time (20 min) is an assumption based on a hand calculation; (2) HFE OP-OMA-FF-ISOEG (probability = 0.5), with no "time margin" and an available time based on a conservative hand calculation; (3) HFE OP-OMA-FF-RCPTRP (probability = 0.29), with a "time margin" of only 0.8 out of 13 min. Note that, for this third example, ranges on various time frames based on discussions with plant personnel are cited when estimating the total time to execute (~9 min). If the upper ends of the cited ranges are assumed, this execution time becomes ~10.5 min which, when combined with the assumed 5-min delay time, exceeds the available time by ~1.5 min. Discuss whether or not (1) the methodology was reviewed in the peer review and (2) the methodology was consistently applied to all HRA. Include the results of a sensitivity evaluation if each human error probability is assumed to be 1.0 (or some other bounding value, with justification), or provide the basis for the assumed value being appropriate.

d. F&O FQ-C1-1 - The F&O identifies that the HRA dependency analysis does not consider execution dependencies for local actions for fire scenarios. This item is indicated to be closed, but the disposition is to review and disposition these dependencies in the next FPRA update. Confirm completion of this item sufficient to resolve the technical issue for the existing fire PRA used to support this application.

e. Conservatism in the current state of FPRA was cited as the basis for: (1) Considering it premature to perform a detailed dependency analysis for the fire HRA; (2) Dismissing completeness uncertainty as a current concern in fire HRA; (3) Not performing uncertainty analysis on fire risk and delta-risk. Provide either: (1) Sensitivity evaluations to address the potential impact of not explicitly addressing these issues or (2) Discussion of the plant-specific aspects of the FPRA for Callaway that constitute the basis for the cited conservatism.

f. Was a sensitivity/uncertainty analysis performed for the Fire LERF and Delta-LERF after the LERF model was ready? If so, report the results. If not, perform an analysis or justify the basis for assuring that the insights to be gained from a sensitivity/uncertainty analysis were obtained otherwise and the means of doing so.

Probabilistic Risk Assessment RAI 08

Clarify the following related to fire induced initiating events:

a. The NUREG/CR-6850, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities", apportionment method for weighting the influence factors for transient combustible ignition sources was designed to accommodate only integer values, although use of fractional values between the minimum of one and maximum of 10 (or 50 for “maintenance”) is not precluded. However, the only prescribed value below one is zero, as credit for administrative controls is considered to be already embedded in the transient fire frequencies based on the historical data. Furthermore, a physical analysis unit with a total weight of zero would appear not to meet Supporting Requirement IGN-A9 in the ASME/ANS PRA Standard. The licensee’s use of fractional values between zero and one would constitute a “deviation from 6850” for which at least a sensitivity analysis, using a minimum combined weight of one for the three influence factors, would be appropriate if any such locales have a combined weight less than one. Provide a sensitivity study that shows the impact on the total and change in fire risk of using at least one weighting factor for Low (one) rather than the “special weighting factors.”

b. In the Ignition Frequencies Calculation, it is stated that: (1) Callaway plant-specific fire history provided insufficient data for Bayesian update; (2) Generic fire frequencies are appropriate for Callaway; and (3) As a result, Bayesian update was not performed. Nonetheless, it appears that a reduced plant-specific value was used for Bin 16.2. Note that FAQ 35 (Supp. 1 of NUREG/CR-6850) states: “In calculating the fire frequencies, the number of plant reactor years is based on the entire US fleet, i.e., it has been assumed that all existing plants contribute to the bus duct fire frequency.” This means that plants such as Callaway, with a lower number of iso-phase bus ducts than “typical,” have already been, at least to some probably unquantifiable extent, implicitly included in the generic estimate. Therefore, the factor of five reduction is likely too generous. Please provide a sensitivity analysis without this factor or an alternate approach to justify the use of such a factor.

Probabilistic Risk Assessment RAI 09

Clarify the following issues related to uncertainty and sensitivity studies:

a. It was recently stated at the Nuclear Energy Institute Fire Protection Information Forum (NEI FPIF) that the Phenomena Identification and Ranking Table (PIRT) Panel being conducted for the DC circuit failure tests from the DESIREE-FIRE tests may be eliminating the credit (about a factor of two reduction) for control power transformers (CPTs) currently allowed by NUREG/CR-6850 as being invalid when estimating alternating current (AC) circuit failure probabilities. Provide a sensitivity analysis that removes this CPT credit and the resulting impact on core damage frequency (CDF), LERF, delta-CDF, and delta-LERF. Confirm that these potentially reduced probabilities based on CPT presence were not used to initially screen out components whose failure (or spurious operation) was due to fire-induced cable impacts from the subsequent analyses. Note also that assuming the presence of CPTs for control circuits in the MCR panels may be incorrect and, if so, should be removed when performing the sensitivity analysis.

b. The Uncertainty and Sensitivity Analyses Calculation indicates that sensitivity/uncertainty analyses were not performed for fire ignition frequencies (other than the bins required by FAQ 48 in Supp. 1 to NUREG/CR-6850) or cable failure mode likelihoods. Provide the results of sensitivity/uncertainty analyses for these values.

Probabilistic Risk Assessment RAI 10

FAQ 52 (NUREG/CR-6850, Supp. 1) suggests growth times from zero to peak heat release rate (HRR) of 8 min and 2 min, respectively, for common trash type fires contained vs. uncontained within plastic or metal receptacles. These are based on Tests 7 through 9 of NUREG/CR-4860, " (the reference cited by Callaway in the MCR Fire Analysis Calculation as their basis for assuming a 10-min growth time [from which Callaway specifically cites Tests 3 and 4]) and the National Institute of Standards and Technology (NIST) and Lawrence Berkeley National Laboratory (LBL) tests. Note that Tests 7 through 9 involved 5-gal and 30-gal polyethylene, unsealed trash cans containing clean cotton rags and paper, while Tests 3 and 4 involved a 2.5-gal polyethylene bucket containing "Kimwipes" and acetone. Thus, it would appear Tests 7 through 9 were more representative of the type of trash can fire to be expected in a minimal maintenance locale such as the MCR, while Tests 3 and 4, cited by the licensee as the basis for the longer growth time to maximum HRR, were more representative of the type of trash can fire to be expected in at least an occasional maintenance locale. For Tests 7 through 9, the FAQ cites times to initial peak in fire intensity of 7, 8 and 13 min, respectively, (i.e., two of the three cited tests support the recommended time of 8 min). Provide the basis for the assumption of the applicability of Tests 3 and 4, such that the longer 10-min growth time was assumed, including a quantitative estimate of the effect of assuming the appropriate shorter growth time(s).

Probabilistic Risk Assessment RAI 11

Attachment G of the LAR identifies the ASP (RP118B) as a Primary Control Station (PCS). There is then a continuation of a bulleted list which includes numerous indications and controls which are also identified as PCSs. Clarify that there are no other ex-control room locations (other than RP118B) considered as a PCS and that all the instruments and controls in the list are on RP118B. Otherwise, explain the apparent discrepancy.

Probabilistic Risk Assessment RAI 12

Area C-10 includes recovery actions to isolate Reactor Coolant System (RCS) injection flow to avoid pressurizer Power-Operated Relief Valve (PORV) challenge on pressurizer overfill. The spurious injection flowpath involves high pressure safety injection flowpath. During the audit, the licensee identified that plant-specific calculations determined that about 36 minutes are available to isolate the flowpath prior to reaching water solid conditions in the pressurizer. This time seems to be longer than reasonably expected. (The staff notes that FSAR section 15.5.1.2 states that the pressurizer is water solid following a spurious SI signal at 8.75 minutes, even assuming the operator terminates normal charging pump flow at 6 minutes.)

Provide the details of the calculation to justify that 36 minutes is available prior to water solid conditions, including assumptions related to assumed automatic pressure control response of the pressurizer spray valves and relief valves, the status of RCS letdown paths, and assumed operator responses, to justify the difference between the safety analysis of spurious SI and this scenario. In addition, provide the details of the calculation of the human error probability which describe the basis for the time available to perform the action compared to the time to access the manual valve and close it to confirm this action is feasible. The response should justify the assumptions made to bound the time, and the assumptions as to the procedural response to a spuriously open injection flowpath (i.e., is a manual actuation of Emergency Core Cooling System (ECCS) required which may further delay the recovery action).

Probabilistic Risk Assessment RAI 13

During the audit, the licensee stated that there are some fire scenarios (e.g., in Areas C-21, C-22, and C-24) where a single fire could cause spurious opening of a PORV as well as the loss of power required to close the associated block valve. Isolation of this leak path requires that operators cause the PORV to close by locally opening its direct current (DC) breaker. Discuss the fire scenarios which cause this failure mode which would require a local operator action to restore RCS integrity. The response should address the frequency of fire scenarios, a description of the scenario, the locations of the target cables in terms of physical separation between the fire source and the two targets, and the total risk reduction which would be available if this failure mode were eliminated. In addition, describe the operator recovery action in terms of its complexity, the time available to complete the action before reaching an unrecoverable condition, and in the context of each fire scenario with regards to other local recovery actions which might be required. A discussion of the risk importance of this recovery action should also be provided in terms of the change in risk if the action were assumed to be unsuccessful.

Probabilistic Risk Assessment RAI 14

In the LAR, reference is made to self approval in regard to the NFPA 805 transition results. This is incorrect as self approval thresholds do not apply for the transition aspects of the application, but rather are only applicable post-transition in evaluating plant change evaluations (i.e., at the time of the submittal the licensee has not been sanctioned by the NRC to self approve any fire-related plant changes). The licensee should revise this statement in connection with the transition risk results and indicate if revising this statement has any effect on the LAR.

Probabilistic Risk Assessment RAI 15

Table W-1 of the LAR includes in its title "95% of Calculated Fire CDF," but the table only includes approximately 58% of the Fire CDF. Provide clarification regarding the title and table and revise as appropriate.

Probabilistic Risk Assessment RAI 16

Scenarios 3801T3 and 3801T2 (upper cable spreading room transient fires) appear to involve fire-induced failure of Reactor Coolant Pump (RCP) seal cooling, Auxiliary Feedwater (AFW), and feed-and-bleed cooling resulting in core damage. The Conditional Core Damage Probability (CCDP) is stated as 0.76 indicating that some mitigative capability is available, albeit with a low probability of success. It is not clear to the staff that these scenarios have acceptable defense-in-depth given the very high CCDP. During the audit, the licensee stated that the CCDP is artificially high due to calculation methods. Discuss these scenarios in more detail including the mitigation capability that remains after fire damage and how that capability is consistent with adequate defense-in-depth. A discussion of key assumptions which impact these scenarios conservatively (if any) as well as administrative controls or other measures which reduce the likelihood of transient combustibles in the critical location should also be provided. A more accurate quantitative assessment of CCDP should be provided, or a justification as to why this is not possible.

Probabilistic Risk Assessment RAI 17

The delta-risk for fire areas A-30 and TB-1 is identified as "0.00+00" while for fire area C-35 it is identified as "epsilon". Clarify the intended difference between these table entries.

Probabilistic Risk Assessment RAI 18

The disposition of VFDRs with regards to defense-in-depth and safety margins in the LAR in Attachment C provides no technical justifications but simply states an evaluation was performed and found to be acceptable. Describe the process that was applied to evaluate the acceptability of defense-in-depth and safety margins for VFDRs. (This should be a general description of the process and criteria, not a detailed basis for each VFDR.) The description should also address how reliance upon multiple, time-critical, or complex recovery actions for a particular fire scenario is evaluated to assure there is no over reliance upon operator actions, and how the risk evaluations for recovery action probabilities consider multiple actions in a single scenario.

Probabilistic Risk Assessment RAI 19

There is no description of how the change-in-risk is estimated for the various VFDRs. Provide a description about the modeling of the cause-and-effect relationship in the PRA for each type of VFDR (e.g., cable separation issues, degraded barriers). The description should also include any key assumptions or conservatisms in these evaluations including, for example, if recovery actions are included.

Probabilistic Risk Assessment RAI 20

Provide confirmation that the use of the guidance from EPRI TR-1016735, "Fire PRA Methods Enhancements, Additions, Clarifications, and Refinements to EPRI 1011989", included any modifications of this report as incorporated into Supplement 1 of NUREG/CR-6850.

Probabilistic Risk Assessment RAI 21

The disposition for F&O PRM-B4-1 states that the fire-induced risk model report was updated to provide the bases for fire-induced initiators and non-applicability of Supporting Requirement PRM-B4. Provide these bases.

Probabilistic Risk Assessment RAI 22

The dispositions of F&Os FSS-E03-1 and UNC-A1-2, both related to Supporting Requirement FSS-E3, cite conservatism in method selection and use of data from NUREG/CR-6850 as justification for not meeting the requirement (at Capability Category II) to provide a mean value and statistical representation of uncertainty intervals for parameters used to model significant fire scenarios. Explain how the requirements of FSS-E3 are met or justify why they need not be.

Probabilistic Risk Assessment RAI 23

In some of the Fire Evaluation of Delta Risk Calculations for the various fire areas, a HRR profile for a transient combustible less than the recommended (142 kW and 317 kW at the 75th and 98th percentiles) was assumed. Provide the bases for these assumptions.