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

Fire Modeling

General Questions and Requests:

- In cases where conservative input parameters outside the validated range are used to obtain a safety margin, explain how it is ensured that this is not offset by increased model uncertainty?
- Some of the RAI responses state that specific documents on the portal (e.g. FDS Report, R1984-001-001) will be modified and corrected. It is requested that the updated documents be posted on the portal.

Fire Modeling RAI 1b - Additional Clarification Needed. To demonstrate that the models are applied within the range of applicability, the normalized parameters described in NUREG 1824 and 1934 were calculated and the calculations showed that the parameter is within the validated range or justification was provided for using a parameter value outside the validated range.

- Fire Froude Number: Explain in more detail how you determined quantitatively, the effect of using a conservative convection fraction of 0.7 on the safety margin in the plume ZOI calculation. In addition, describe the criteria that were used to judge that the margin of safety is sufficient.
- Ceiling Jet Radial Distance Relative to Ceiling Height: Provide the normalized parameter values and discuss in light of the sprinkler activation calculations.
- Compartment Aspect Ratio: Confirm that the correct damage temperature in each of the fire zones where the sensitivity analysis was conducted is in fact 330 °C and not 205 °C.

Fire Modeling RAI 1c - Additional Clarification Needed. To demonstrate that the models are applied within the range of applicability the normalized parameters described in NUREG 1824 and 1934 were calculated and either showed that the parameter is within the validated range or justification was provided for using a parameter value outside the validated range.

- Sprinkler Activation Correlation: Explain in more detail how the Ceiling Jet Distance Ratio normalized parameter was calculated. The draft response describes the r/H calculation used in the sensitivity analysis. Is the H equal to the distance between the floor and ceiling or the distance between the ignition source and the ceiling? In addition, for Fire Area A-16, explain in more detail how the ‘critical heat release rate for sprinkler activation’ was calculated in FDT 10.

Fire Modeling RAI 1e - Additional Documentation Required. Staff needs to review the report of the sensitivity study mentioned on page 11 of the draft response to confirm that it is acceptable for the Radial Distance Relative to Fire Diameter to be outside the validated range. The sensitivity analysis report needs to be posted on the portal.

Fire Modeling RAI 1f - Additional Clarification/Documentation Required.

- MCR Study: The justification for the flame length ratio normalized parameter is adequate, however, there is a confusing comment about the ACRS recently deciding that this parameter should be based not only on the flame height, but the height of the fire above the floor and that this is different from NUREG 1934. This is confusing, since the latest version of NUREG 1934 does include the base height as well as flame height in this normalized parameter. Review this last justification statement and consider whether it should be amended or stricken from the response.
- In addition, in the justification for the equivalence ratio (natural ventilation) normalized parameter being outside of the validation range for heat release rates higher than 312 kW, it is mentioned that a sensitivity study may be warranted, but none is provided in the response. Since the natural ventilation cases with the highest heat release rate bins seem to be the worst-case in terms of the calculated evacuation times, it is requested that this sensitivity study be provided.

Fire Modeling RAI 1g - Statement and Justification Needed. If the results of the studies described in Appendices B, C and D of the V&V report were used in the analyses within their limits of applicability, a statement should be provided indicating so. If not, a statement should be provided indicating why not. In addition, the plume-HGL interaction study in Appendix B is based on calculations for a single ambient temperature (70°F), heat release rate (211 kW) and fire size (physical dimensions) and height. Provide justification for drawing generalized conclusions based solely on calculations for these input parameter values.

Fire Modeling RAI 1i - Additional Justification Needed. Reference is made in the draft response to NIST GCR 07-911 for V&V of Cleary's smoke detector algorithm, which is now implemented in FDS. The validation in this NIST report is based on three sets of experiments: UL 217 Tests, Room-Corridor-Room Fire Tests and NIST 'Performance of Home Smoke Alarms' Test Validation.

i. UL 217 Tests: Page 24 of the NIST report states that the smoke (soot) yield of polystyrene was estimated as the average of the values in the literature for polystyrene and styrene. Ignoring the fact that the use of the average in itself is questionable, the SFPE Handbook gives soot yields for polystyrene and styrene as 0.135 and 0.177 g/g, respectively, leading an average of 0.156 g/g. This is approximately three times what was used in the analysis for fire area C-21.
ii. Room-Corridor-Room Fire Test Validation: These experiments consisted of pool fire experiments with a mix of 75% heptane and 25% toluene. The SFPE Handbook lists soot yields for heptane and toluene (listed directly after benzene, but the draft response indicated it was not available) as 0.037 and 0.178 g/g, respectively. The validated soot yield used in these experiments was approximately 0.072 g/g, which is a little bit higher than the value used in the C-21 analysis (0.05 g/g).
iii. NIST 'Performance of Home Smoke Alarms' Test Validation: As mentioned in the draft response, there is no validated range in this study that can be compared to the analysis in C-21.

In addition, the draft response has some discussion about the literature values of soot yield for polystyrene mattresses and gives the range of 0.056-0.227 g/g. However, the low and high limits of this range are for polyethylene and polyurethane, not polystyrene. The SFPE Handbook gives a range of soot yield for polystyrene foam of 0.18 - 0.21 g/g, which is much higher than was used in the analysis for fire area C-21. Provide additional justification for the validity of Cleary's algorithm implemented in FDS for a smoke yield of 0.05 g/g. In addition, explain how the use of a soot yield of 0.05 g/g is justified.

Fire Modeling RAI 1j - Additional Documentation Required. The draft response states that there is a discussion in the FDS report (R1984-001-001) about the verification of Pyrosim. However, Pyrosim is not mentioned in the report that is on the portal. Provide the revised FDS report on the portal that discusses Pyrosim or explain this discrepancy.

Fire Modeling RAI 2a - Additional Justification Needed. The intent of this RAI was for the licensee to discuss all of the relevant model output parameters described in Table 3-1 of NUREG 1824 (Table 4-1 of NUREG 1934), not just these three. Expand the response to include and justify (as applicable) all the relevant model output parameters described in Table 3-1 of NUREG 1824.

Fire Modeling RAI 2b - Additional Justification Needed. Provide additional explanation of why hot gas and smoke movement is not affected. During the audit walkdown, NRC staff observed numerous cable trays and other obstructions directly above and adjacent to the ignition source but still within the beam pocket. The calculations assume three cable trays stacked vertically above the fire source location. Provide a detailed explanation of why the additional obstructions are not expected to break up and delay the development of the plume/HGL necessary to activate a detector and/or sprinkler in the beam pocket. In addition, provide a description of the decision process and criteria used for omitting specific obstructions from the FDS analyses.

Fire Modeling RAI 3c - Additional Documentation Required: The draft response states that a sensitivity study was conducted for Mesh 1 in Fire Area C-1 to show that results of a 0.05-m mesh would yield the same conclusions as the 0.1-m mesh used in the original analysis. Provide the grid sensitivity study on the portal.

Fire Modeling RAI 3e - Additional Documentation Required. The Heskestad/Bill equation and part of the text appear to be missing from the non-docketed section. Provide the missing information in the response.

Fire Modeling RAI 3f - Additional Clarification Required. The licensee stated that the difference in material properties does not significantly affect the thermal inertia and therefore this difference will not affect the results of the analysis. Provide justification for the statement "… the difference in the thermal inertia values is not significant".

Fire Modeling RAI 3h - Additional Justification Needed. The licensee's approach recognizes the fact that there is a trade-off between choosing a low vs. a high heat release rate. The former delays detector and sprinkler activation but also results in less damage. To be conservative a relatively high peak heat release rate (317 kW) and a relatively slow growth rate (8 min to peak heat release rate) were used. Explain why only these two values were used and why a different set of equally plausible values would not result in greater risk.

Fire Modeling RAI 3i - Additional Documentation Required. Part of the draft response between pages 1 and 2 appears to be missing. Provide the missing information in the response.

Fire Modeling RAI 3j - Additional Justification Needed. See action for RAI 3k response below.

Fire Modeling RAI 3k - Additional Justification Needed. In the FDS analysis of fire area C-21, a sprinkler head RTI of 130$(ms)^{0.5}$ was used based on NUREG-1805. This value was justified because standard response sprinklers have an RTI of 80$(m\text{-}s)^{1/2}$ or higher and the use of 130$(m\text{-}s)^{1/2}$ is therefore conservative. The draft response refers to a NIST study, which is cited as the basis of the default values in NUREG 1805. However, the objective of that study was to compare four sprinkler activation models. Another study by the same author and published in Operation of Fire Protection Systems (special addition to the NFPA Handbook), shows that the typical range for standard response sprinkler RTIs is approximately 100-350$(m\text{-}s)^{1/2}$. Provide justification for the use of an RTI of 130$(m\text{-}s)^{1/2}$ in lieu of the more conservative values reported in the literature.

Fire Modeling RAI 3p – Additional Information Needed. The concern also included the possibility of HGL forming above the MCR cabinets, as they did not extend to the ceiling and also any other means of fire spread via the open ceiling area, not just cabinet-to-cabinet directly. Exposed cables, if any, could also be targets along which fire could propagate between the two areas.. The draft response discusses why direct cabinet-to-cabinet fire propagation is precluded, but does not discuss other potential modes of fire spread. Provide a discussion of other potential modes of fire spread in the response.