Omaha Public Power District
444 South 16th Street Mall
Omaha, NE 68102-2247

LIC-12-0120
August 24, 2012

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

References:
1. Docket No. 50-285
2. Letter from OPPD (J. A. Reinhart) to NRC (Document Control Desk), *License Amendment Request 10-07, Proposed Changes to Adopt NFPA 805, Performance-Based Standard for Fire Protection for Light Water Reactor Generating Plants (2001 Edition) at Fort Calhoun Station*, dated September 28, 2011 (LIC-11-0099) (ML112760660)
3. Letter from the NRC (L. E. Wilkins) to OPPD (David J. Bannister), *Fort Calhoun Station, Unit No.1 - Request for Additional Information Re: License Amendment Request to Adopt National Fire Protection Agency Standard NFPA 805 (TAC No. ME7244)*, dated April 26, 2012 (NRC-12-0041) (ML121040048)
4. Letter from OPPD (D. J. Bannister) to NRC (Document Control Desk), *Responses to Requests for Additional Information Re: License Amendment Request 10-07 to Adopt NFPA 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Generating Plants," 2001 Edition, at Fort Calhoun Station*, dated July 24, 2012 (LIC-12-0083)

SUBJECT: Responses to Requests for Additional Information Re: License Amendment Request 10-07 to Adopt NFPA 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Generating Plants," 2001 Edition, at Fort Calhoun Station

This letter provides the Omaha Public Power District's (OPPD's) responses to select Nuclear Regulatory Commission (NRC) requests for additional information (RAIs) transmitted in Reference 3 regarding the license amendment request (LAR) to adopt National Fire Protection Association (NFPA) 805 at the Fort Calhoun Station (FCS). Specifically, the responses to the Fire Modeling RAIs 01 c., 01 f.v.(a), and 05 e., as well as the Probabilistic Risk Assessment (PRA) RAI 01 h.i., ii., and iii., are provided in the enclosure to this letter. The remaining unanswered RAIs submitted in Reference 3 will be addressed as delineated in Table 1.

A006
NRR

In Reference 2, OPPD requested an amendment to Renewed Facility Operating License No. DPR-40 for FCS, Unit No.1, to adopt NFPA 805, Performance-Based Standard for Fire Protection for Light Water Reactor Generating Plants (2001 Edition). The NRC staff reviewed the information provided in OPPD's application and determined that additional information was required in order to complete its review. Reference 3 provides the NRC's RAIs which were received on April 26, 2012. Reference 4 provided the responses to a majority of the RAIs and a commitment schedule for submitting the remaining RAI responses.

As stated in Reference 4, OPPD will submit the remainder of the NFPA 805 transition LAR RAI responses in a separate letter to the NRC on a schedule as delineated in Table 1. [**AR 52508**]:

Table 1: Schedule for NFPA 805 Transition LAR RAI Responses Submittal

RAI Topic	RAI Number	Submittal Date
Fire Modeling	RAI 05 c.i.	September 28, 2012
Probabilistic Risk Assessment	RAI 07 a., b., and c.	September 28, 2012

In addition to the LAR supplements identified in Reference 4, OPPD will supplement the LAR to reflect the RAI response item identified in Table 2, at a time mutually agreeable between the NRC technical reviewers and OPPD project management.

Table 2 – LAR Section Impacted by the RAIs to be Updated in NFPA 805 LAR Supplement

RAI Topic	RAI Number	LAR Section to be Updated
Fire Modeling	RAI 01 f.v.(a)	Attachment S

In conclusion, consistent with Reference 4, the two regulatory commitments being made in this letter associated with the NFPA 805 Transition LAR RAI responses are provided in Table 3.

Table 3 – Regulatory Commitments

Regulatory Commitment	Commitment Due Date
OPPD will submit the remainder of the NFPA 805 transition LAR RAI responses in a separate letter to the NRC on a schedule as delineated in Table 1.	The schedule for completion is delineated in Table 1. **[AR 52508]**
In addition to the LAR supplements identified in Reference 4, OPPD will supplement the LAR to reflect the RAI response item identified in Table 2, at a time mutually agreeable between the NRC technical reviewers and OPPD project management.	The LAR supplement will be submitted at a time mutually agreeable between the NRC technical reviewers and OPPD project management. **[AR 48249]**

The enclosed RAI responses were placed on the NFPA 805 SharePoint Portal for the NRC technical reviewers to use in support of their technical review of the LAR.

If you should have any questions regarding this submittal or require additional information, please contact the Supervisor – Nuclear Licensing, Mr. Bill R. Hansher at 402-533-6894.

Sincerely,

D. J. Bannister
Site Vice President and CNO

DJB/SRM/BJVS/dll

Enclosure: Responses to Requests for Additional Information

c: E. E. Collins, Jr., NRC Regional Administrator, Region IV
L. E. Wilkins, NRC Project Manager
J. C. Kirkland, NRC Senior Resident Inspector

RESPONSES TO REQUESTS FOR ADDITIONAL INFORMATION RE: LICENSE AMENDMENT REQUEST TO ADOPT NATIONAL FIRE PROTECTION ASSOCIATION STANDARD 805, "PERFORMANCE-BASED STANDARD FOR FIRE PROTECTION FOR LIGHT WATER REACTOR GENERATING PLANTS," 2001 EDITION FORT CALHOUN STATION, UNIT NO.1 DOCKET NO. 50-285

By letter dated September 28, 2011 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML 112760660), as supplemented by letters dated December 19 and 22, 2011, and March 20, 2012 (ADAMS Accession Nos. ML 113540334, ML 11363A077, and ML 12083A147, respectively), Omaha Public Power District (OPPD, the licensee), submitted a license amendment request (LAR) to transition the fire protection licensing basis at the Fort Calhoun Station, Unit 1, from paragraph 50.48(b) of Title 10 of the *Code of Federal Regulations* (10 CFR), to 10 CFR 50.48(c), National Fire Protection Association Standard NFPA 805. Portions of the letters dated September 28 and December 22, 2011, and March 20, 2012, contain sensitive unclassified non-safeguards information (security-related and proprietary) and, accordingly, those portions have been withheld from public disclosure.

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the information provided in your application and determined that the following additional information is required in order to complete its review. The RAIs are grouped into the following technical review categories: fire modeling (FM), fire protection engineering (FPE), monitoring program (MP), programmatic, safe shutdown analysis (SSA), radioactive release (RR), and probabilistic risk assessment (PRA).

Fire Modeling RAI 01:

National Fire Protection Association Standard 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants," 2001 Edition, (NFPA 805), Section 2.4.3.3, states: "The PSA [probabilistic safety assessment] approach, methods, and data shall be acceptable to the AHJ [authority having authority] ... " The NRC staff noted that fire modeling comprised the following:

> Fire Dynamics Simulator (FDS) was used to assess the main control room (MCR) habitability and to model an air compressor oil fire scenario in Fire Area FC32 (also referred to as Room 19).
>
> 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, and hot gas layer (HGL) temperature for various ignition source types and heat release rates (HRRs).

Section 4.5.1.2, "FPRA Quality" of the Transition Report states that fire modeling was performed as part of the Fire Probabilistic Risk Assessment (FPRA) development (NFPA 805 Section 4.2.4.2). Reference is made to Attachment J, "Fire Modeling V&V," for a discussion of the acceptability of the fire models that were used. Regarding the acceptability of the Probabilistic Risk Assessment (PRA) approach, methods, and data:

c. **Please explain how the HRR of cable tray fires was calculated. Please provide justification for the use of a "characteristic length" of 1 foot instead of the cabinet length as specified in NUREG/CR-6850, "EPRI/NRC-RES, Fire PRA Methodology for Nuclear Power Facilities," page R-9, and explain (i.e., a sensitivity study to obtain a quantitative measure) the effect of this discrepancy on the ZOI and HGL calculations and target damage assessment. In addition, please provide a justification for the fact that the effect of the cable tray fire on the radius of the ZOI was not considered.**

<u>OPPD's Response to Fire Modeling RAI 01 c.</u>:

Part 1: Heat Release Rate Contribution of Cable Trays

The Heat Release Rate (HRR) contribution of cable trays was explicitly modeled for fire PRA scenarios in which the Zone-of-Influence (ZOI) was implemented. This modeling will be described for the typical example of an ignition source with a stack of trays directly above the ignition source.

The "first" tray in the stack (i.e., the tray closest to the ignition source) is assumed to ignite with a burning surface area equal to the tray width multiplied by the characteristic length of the fire scenario. This entire surface area is conservatively assumed to ignite at once, as opposed to igniting at the plume centerline and then spreading out to the characteristic length. The HRR of this burning surface area is calculated using the following equation from Section R.3 of NUREG/CR-6850:

$$\dot{Q} = 0.45(q_{BS})(A)$$

where $\dot{Q}$ is the HRR in kW, q_{BS} is the bench scale HRR (modeled as 328 kW/m^2 for FCS), and A is the burning surface area in m^2.

The fire is modeled to propagate vertically through the stack, with the following timing characteristics per Section R.2.2 of NUREG/CR-6850:

- First tray ignites when plume temperature at the tray exceeds its damage temperature (i.e., 330 degrees Celsius for thermoset cable at FCS)
- Second tray ignites four minutes after first tray
- Third tray ignites three minutes after second tray
- Fourth tray ignites two minutes after third tray
- Fifth tray ignites one minute after fourth tray

As the fire propagates to each subsequent tray, it is assumed to spread at an angle of 35 degrees per the following figure (taken from Section R.4.2 of NUREG/CR-6850):

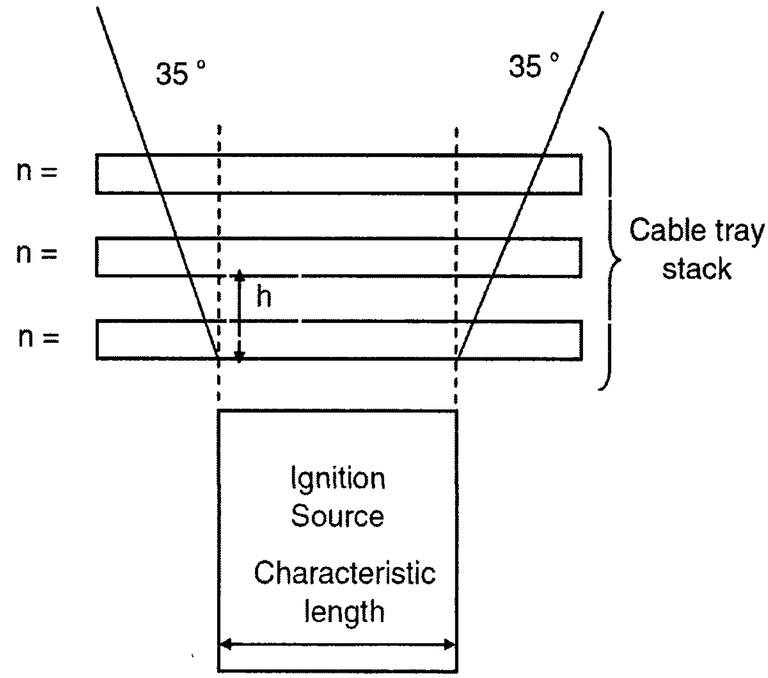

Figure R-5 from NUREG/CR-6850

As fire propagates to each tray, the tray burning surface area is calculated based on the 35-degree spread. The HRR contribution of each tray is calculated based on its burning surface area and the HRR equation presented above.

Next, an HRR decay model is applied, which assumes that each tray burns at a constant HRR calculated by the above equation until all combustible material within the impacted cable tray surface area is consumed. With an approximate combustible loading per tray, and an HRR for each tray, the rate of fuel consumption and time to burnout is calculated.

Finally, the time to ignite each tray in the stack, the HRR contribution of each tray, and the burnout time for each tray are all coupled to develop an HRR profile for the tray stack.

Part 2: Characteristic Length

The FCS fire PRA generically assumed a one foot characteristic length. This assumption carries into the cable tray HRR calculation by modeling that one foot of the first tray (i.e., lowest tray in the stack) length ignites. This ignition is modeled to occur when the plume centerline temperature at the tray height reaches the cable damage temperature.

In this particular application, use of the entire cabinet length as the characteristic length would not be realistic. This approach would involve modeling ignition of the full cable tray length above the cabinet, whereas in reality, only the portion above the flaming region (e.g., above the cabinet vent) is expected to ignite. The over-conservative nature of this approach would be magnified for switchgears, load centers, and motor control centers, which tend to be much longer than their associated vents. Because these large cabinets tend to be the most risk significant, use of the entire cabinet length would be commensurate with Capability Category I of ASME/ANS RA-Sa-2009, while the FCS fire PRA is intended to include the level of realism, especially for risk-significant scenarios, associated with Capability Category II. Furthermore, assuming the entire cabinet length as the characteristic length would be non-conservative for calculation of the severity factor, since flame height lessens and the plume temperature distribution becomes less aggressive as the characteristic length (diameter) of the fire increases. The over-conservative aspects, and the competing non-conservative aspects, of using the entire cabinet length as the characteristic length precludes the need for and value of a sensitivity study.

The entire characteristic length is conservatively assumed to ignite when the plume centerline reaches the cable damage temperature. This is conservative because, in reality, the cables at the plume centerline would ignite first and then spread (at a rate of ~0.3 mm/sec as suggested by Section R.4.1.2 of NUREG/CR-6850). This rate of spread is conservatively not credited, and the entire characteristic length is modeled to ignite instantaneously. In addition, the cables are conservatively assumed to ignite when they reach their cable damage temperature, which is lower than their ignition temperature. Finally, no credit is given to the thermal capacity of the cables in this model.

Part 3: ZOI Radius

A plant walkdown was performed April 2-6, 2012, to assess whether fire PRA targets exist outside the modeled ZOI but within the 35-degree spread of fire upward through a cable tray stack. This walkdown included all areas in which the zone of influence fire modeling approach was implemented. The walkdown did not identify any cases in which this effect required revising (adding to) the existing source-target data set.

f. Regarding the use of FDS:

v. Regarding the FDS simulation of the Fire Area FC32/Room 19:

(a) Please justify why the potential contribution from raw water pipe insulation to the HRR was not considered. Determine whether the insulation would be involved in the compressor oil scenario, and, if so, rerun FDS for this scenario accounting for the contribution of the pipe neoprene rubber insulation.

OPPD's Response to Fire Modeling RAI 01 f.v.(a):

It was judged during development of the fire PRA that the subject pipe insulation would not ignite during an instrument air compressor oil fire, and this judgment was based primarily on the pipe insulation not being located directly above or in the plume of the postulated fire. To respond to this RAI, the FDS simulation of the instrument air compressor oil fire scenario in the FC32/Room 19 has been re-run, accounting for the raw water pipe insulation, to assess its potential contribution to the scenario heat release rate and potential to damage overhead targets.

OPPD determined the insulation to be Armaflex rubberized foam. Based on material safety data sheets published by the manufacturer (Armacell), Armacell's Tubolit insulation product has a flash point of > 680 °F (360 °C).

The FDS simulation indicates that the average maximum adiabatic surface temperature of the raw water pipe insulation material is approximately 248 °F (120 °C), which is lower than the flashpoints of both the Armacell product and neoprene rubber. In each case, the fire simulation predicts that insulation material will not ignite and thus will not contribute to the overall scenario heat release rate, confirming the validity of the original assumption.

However, there is some uncertainty associated with the thermophysical properties (specifically the flashpoint) of the installed material. In addition, there is some potential for the insulation material to melt, potentially dripping to and spreading on the floor, closer to the fire location. Finally, there is uncertainty associated with the fire modeling process and simulation codes, especially given the close proximity of the insulation to the compressor oil collection trays (within a few feet).

In consideration of defense-in-depth, margin enhancement, and the potentially significant consequences if the overhead cables were to fail, OPPD plans to implement a plant modification to minimize the potential for the foam insulation to threaten overhead cables. Alternatively, OPPD may perform additional analysis to reduce uncertainty and therefore strengthen the fire modeling conclusion that the pipe insulation will not threaten overhead cables in this scenario.

This proposed modification or additional analysis will be included in the supplement to the LAR as REC-143 to the applicable Table in Attachment S. The updated LAR Attachment S will be reflected in the NFPA 805 transition LAR supplement. [**AR 48249**]

Fire Modeling RAI 05:

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, "Compliance with Quality Requirements in Section 2.7.3 of NFPA 805," 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. This is of particular interest in fire modeling and FPRA development."

Regarding the uncertainty analysis:

e. **During the audit, the NRC staff reviewed Attachment 14 to the FSSR (FC07823 and CN-RAM-10-013). The staff noted that cable tray obstructions appeared to have been omitted in the FDS fire modeling analysis for Fire Area FC32/Room 19. Please justify why cable tray obstructions were not considered in the FDS fire modeling analysis for Fire Area FC32/Room 19.**

OPPD's Response to Fire Modeling RAI 05 e.:

Excluding obstructions between the fire source and target cable trays is conservative in the case of the compressor oil fire scenario, since they are non-combustible and are not oriented in such a manner to focus the plume energy toward specific targets. When non-combustible obstructions are present in the flame or plume regions, they absorb heat from the flame/plume, and create additional turbulence that results in further entrainment and cooling of the plume. Excluding such obstructions, from the compressor fire model, results in conservative (higher) predicted target temperatures as compared to including those obstructions.

Note that the raw water pipe insulation (reference Fire Modeling RAI 01 f.v.(a)) is not considered an obstruction in this context, since it is not located in the plume between the fire source and tray targets. Nonetheless, the FDS simulation conducted to address Fire Modeling RAI 01 f.v.(a) indicates that the pipe insulation material will not ignite and will therefore not threaten overhead targets during the compressor oil fire scenario.

Probabilistic Risk Assessment RAI 01:

The FPRA peer review findings and observations (F&Os) are provided in Attachment V of the LAR. Please clarify the dispositions to the following F&Os:

h. F&O FSS-H8-01: The multi-compartment analysis (MCA) assumes 30 minutes is available for manual suppression credit prior to the fire propagating into the neighboring compartment.

i. Please summarize how fire suppression is generally included in your evaluation.

OPPD's Response to Probabilistic Risk Assessment RAI 01 h.i.:

The multi-compartment analysis credits fire suppression in three regards. First, automatic suppression (if present in the originating compartment) is credited to prevent development of a fire with the potential to propagate into the exposed compartment. Second, automatic suppression (if present in the exposed compartment) is credited to prevent fire propagation into the exposed compartment. Automatic suppression system failure probabilities are taken from NUREG/CR-6850. Finally, manual suppression is credited in the originating compartment to prevent development of a fire with the potential to cause multi-compartment propagation.

ii. Please discuss the basis for the 30-minute assumption, including the rating of barriers defining fire compartments.

OPPD's Response to Probabilistic Risk Assessment RAI 01 h.ii.:

The multi-compartment analysis has been revised in response to this RAI. This revised analysis relates the time available for fire suppression to the barrier rating (as opposed to the generic 30-minute assumption) and uses ignition source-specific suppression rates (as opposed to the average suppression rate across all ignition source types).

The time available for manual fire suppression (originally assumed to be 30 minutes) in the revised analysis is assumed to be half of the fire barrier rating. For example, if the barrier is rated for two hours, then the time available for manual suppression is assumed to be 60 minutes. While fire barrier ratings are not directly proportional to the available suppression time, this simplifying assumption is sensible for several reasons. First, the American Society for Testing and Materials (ASTM) E-119, *Fire Tests of Building Construction and Materials*, time-temperature curve to which tested barriers are exposed is generally more severe than would occur under actual fire conditions. In addition, even with random barrier failure, it will take time for significant multi-compartment propagation to occur. The fire must first grow unsuppressed to sufficient size to create the potential for multi-compartment propagation. At that point, even if a barrier has randomly failed, it will take time for significant propagation into the neighboring compartment to occur. For example, if a penetration seal fails, it presents only a small flow path for gases to escape the burning compartment. Even if an HVAC fire damper or a door fails, hot gas propagation through the duct or door and buildup in the adjacent compartment will take time.

The revised multi-compartment analysis (relating the time available for suppression to the barrier rating and use of ignition source-specific suppression rates) yields a total fire core damage frequency (CDF) and large early release frequency (LERF) of 7.17E-07 /yr and 5.92E-09 /yr, respectively. Conservatively adding these values to the variance from deterministic requirement (VFDR) ΔCDF, VFDR ΔLERF, total CDF, and total LERF values reported in each sensitivity study performed to-date, FCS remains within the Regulatory Guide (RG) 1.174, Revision 1, acceptance criteria consistent with the NFPA 805 transition LAR (Reference 1).

While the acceptance criteria are met, OPPD recognized in responding to this RAI, that the multi-compartment CDF and LERF were excluded from the CDF and LERF values reported in Reference 1. This occurred because the multi-compartment analysis is currently documented as a separate, standalone calculation, and not integrated into the base fire PRA model. OPPD plans to integrate the multi-compartment scenarios into the base fire PRA.

iii. Please provide justification for the use of the manual suppression failure probability of 0.074 using the methods described in FAQ 08-0050 or otherwise justify the estimate. Describe the results of the MCA for areas where spatial separation is credited.

<u>OPPD's Response to Probabilistic Risk Assessment RAI 01 h.iii.</u>:

The manual suppression rate (originally assumed to be 0.074) in the revised analysis is based on the ignition source(s) involved in each multi-compartment scenario. The originally assumed value was the average value over multiple bins, whereas the revised analysis uses values specific to each ignition source type. The suppression rate values are taken from NUREG/CR-6850, Supplement 1. For example, 0.025 /min is used for turbine-generator fires, 0.076 /min is used for oil fires, and 0.067 /min (average value across all ignition source bins) is used to evaluate compartments where all ignition sources were conservatively assumed capable of generating a hot gas layer (i.e., those compartments in which detailed hot gas layer calculations were conservatively not performed). The original suppression rate of 0.074 (average over all bins) is not implemented in the revised analysis.

Some degree of spatial separation between fire compartments is for FC06-3, FC20-1, and FC20-7, which all share a common stairwell. FC06-3 and FC20-1 are also exposed to each other through an open hatch in the floor of FC20-1.

However, the multi-compartment analysis does not credit spatial separation because the fire modeling performed for these compartments did not identify any fire scenarios capable of generating a hot gas layer. An April 3, 2012, walkdown of the stairwell and hatch openings also confirmed that fire propagation through these openings is unlikely due to a general lack of intervening combustibles in the vicinity of these openings. Automatic deluge systems protecting hatch and stairwell openings between FC06-3 and FC20-1 further reduce the likelihood of fire propagation between these two compartments.

References:

1. Letter from OPPD (J. A. Reinhart) to NRC (Document Control Desk), *License Amendment Request 10-07, Proposed Changes to Adopt NFPA 805, Performance-Based Standard for Fire Protection for Light Water Reactor Generating Plants (2001 Edition) at Fort Calhoun Station*, dated September 28, 2011 (LIC-11-0099) (ML112760660)

2. Letter from the NRC (L. E. Wilkins) to OPPD (David J. Bannister), *Fort Calhoun Station, Unit No.1 - Request for Additional Information Re: License Amendment Request to Adopt National Fire Protection Agency Standard NFPA 805 (TAC No. ME7244)*, dated April 26, 2012 (NRC-12-0041) (ML121040048)

3. Letter from OPPD (D. J. Bannister) to NRC (Document Control Desk), *Responses to Requests for Additional Information Re: License Amendment Request 10-07 to Adopt NFPA 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Generating Plants," 2001 Edition, at Fort Calhoun Station*, dated July 24, 2012 (LIC-12-0083)