Security-Related Information – Withhold from Public Disclosure in accordance with 10 CFR 2.390.
Portions of Enclosure 1 contain Security-Related Information. Upon removal of Attachment 1 from Enclosure 1, this letter is uncontrolled.

TVA

1101 Market Street, Chattanooga, Tennessee 37402

CNL-14-020

February 13, 2014

10 CFR 50.90
10 CFR 2.390

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

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **Response to NRC Request for Additional Information Regarding the License Amendment Request to Adopt NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants for the Browns Ferry Nuclear Plant, Units 1, 2, and 3 (TAC Nos. MF1185, MF1186, and MF1187) - Set 4**

References:

1. Letter from TVA to NRC, "License Amendment Request to Adopt NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants (2001 Edition) (Technical Specification Change TS-480)," dated March 27, 2013 (ADAMS Accession No. ML13092A393)

2. Letter from TVA to NRC, "Response to NRC Request to Supplement License Amendment Request to Adopt NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants for the Browns Ferry Nuclear Plant, Units 1, 2, and 3 (TAC Nos. MF1185, MF1186, and MF1187)," dated May 16, 2013 (ADAMS Accession No. ML13141A291)

3. Letter from NRC to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3 - Request for Additional Information Regarding License Amendment Request to Adopt National Fire Protection Association Standard 805 Performance-Based Standard for Fire Protection for Light Water Reactor Generating Plants (TAC Nos. MF1185, MF1186, and MF1187)," dated November 19, 2013 (ADAMS Accession No. ML13298A702)

4. Letter from TVA to NRC, "Response to NRC Request for Additional Information Regarding the License Amendment Request to Adopt NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants for the Browns Ferry Nuclear Plant, Units 1, 2, and 3 (TAC Nos. MF1185, MF1186, and MF1187) - Set 2," dated January 10, 2014 (ADAMS Accession No. ML1401A088)

By letter dated March 27, 2013 (Reference 1), Tennessee Valley Authority (TVA) submitted a license amendment request (LAR) for Browns Ferry Nuclear Plant (BFN), Units 1, 2, and 3, to transition to National Fire Protection Association Standard (NFPA) 805. In addition, by letter dated May 16, 2013 (Reference 2), TVA provided information to supplement the Reference 1 letter.

By letter dated November 19, 2013 (Reference 3), the Nuclear Regulatory Commission (NRC) requested additional information to support the review of the LAR. The required dates for responding to the requests for additional information (RAIs) varied from a nominal 60 days to 120 days.

Enclosure 1 provides the fourth set of TVA responses to some of the RAIs identified in the Reference 3 letter. This enclosure provides the remainder of the nominal 90 day responses that were not previously submitted, with the exception of the responses whose due dates were extended to March 15, 2014, as documented in an electronic mail (email) from the NRC to TVA, dated February 6, 2014. These nominal 90 day responses are due by February 13, 2014. Furthermore, this enclosure provides two of the nominal 120 day responses, which are due by March 15, 2014. In addition, Attachment 1 to Enclosure 1 contains security-related information and should be withheld from public disclosure under 10 CFR 2.390.

Enclosure 2 provides an updated TVA response to PRA RAI 19, Part b, which was previously responded to in the Reference 4 letter.

Enclosure 3 provides a listing of the RAIs listed in the Reference 3 letter and the actual date or the due date of the TVA response to each of the RAIs.

Consistent with the standards set forth in Title 10 of the Code of Federal Regulations (10 CFR), Part 50.92(c), TVA has determined that the additional information, as provided in this letter, does not affect the no significant hazards consideration associated with the proposed application previously provided in Reference 1.

There are no regulatory commitments contained in this submittal. Please address any questions regarding this submittal to Mr. Edward D. Schrull at (423) 751-3850.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 13th day of February 2014.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosures:

1. TVA Responses to NRC Request for Additional Information: Set 4 (nominal 90-day and 120-day)
2. Updated TVA Response to NRC Request for Additional Information PRA 19, Part b
3. Summary of BFN NFPA 805 RAI Response Dates

cc (Enclosures):

NRC Regional Administrator – Region II
NRC Senior Resident Inspector – Browns Ferry Nuclear Plant
State Health Officer, Alabama State Department of Health

ENCLOSURE 1

Tennessee Valley Authority

Browns Ferry Nuclear Plant, Units 1, 2, and 3

TVA Responses to NRC Request for Additional Information:

Set 4 (nominal 90-day and 120-day)

FM RAI 01.a

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 jurisdiction] ..." The NRC staff noted that fire modeling comprised the following:

- The algebraic equations implemented in FDTs [Fire Dynamics Tools] and Fire Induced Vulnerability Evaluation, Revision 1 (FIVE) were used to characterize flame radiation (heat flux), flame height, plume temperature, ceiling jet temperature, and hot gas layer (HGL) temperature.
- The Consolidated Model of Fire and Smoke Transport (CFAST) was used in the multi-compartment analysis (MCA), and for the temperature sensitive equipment hot gas layer study.
- Fire Dynamics Simulator (FDS) was used to assess the MCR habitability, and in the plume/hot gas layer interaction and temperature sensitive equipment ZOI studies.

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

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

a. The NRC staff identified the possibility that non-cable intervening combustibles were missed in fire areas of the plant. Provide information on how non-cable intervening combustibles were identified and accounted for in the fire modeling analyses.

RESPONSE:

The fire modeling process requires the fire modeling analyst to quantify the fire ignition and spread associated with secondary combustibles. This step mainly focuses on cable trays because these are the most abundant secondary combustibles in the plant. Small combustibles, such as small plastic signs, fiberglass ladders, early warning air sampling lines, and eyewash stations are not considered to increase the size of the fire, because this small amount of combustible loading would not significantly increase the Heat Release Rate (HRR) of the fire.

Plant walkdown notes, photographs, and videos collected during the fire modeling effort were reviewed to identify the presence of secondary combustible materials that could affect

Fire Probability Risk Assessment (PRA) targets. Also, as part of the assessment of the effects of secondary combustibles, a review of the Browns Ferry Nuclear Plant (BFN), Units 1, 2, and 3 combustible loading calculation was performed to identify non-cable combustible materials in fire compartments where detailed fire modeling was performed. This review identified several fire compartments that contained large non-cable secondary combustibles (e.g., heating, ventilation, and air conditioning (HVAC) insulation, miscellaneous fiberglass, paper). Plant walkdowns for these fire compartments were performed, following the NRC License Amendment Request (LAR) audit, to confirm the fire modeling with regard to the presence, quantity, and location of non-cable combustible materials.

Based on the various walkdowns, certain combustibles were confirmed to screen out from further analysis, as discussed below.

- The combustible loading calculation for some compartments includes paper as a significant non-cable secondary combustible. Based on walkdowns and videos during the fire modeling process, most paper is contained within closed metal storage boxes. The closed metal storage box will prevent its contents from igniting and therefore will not affect the HRR of the postulated fire. Therefore in most fire compartments, paper will not affect the Fire PRA results. Fire compartments where paper was not stored in a closed metal storage box are further discussed in the table below.
- Fiberglass duct work insulation is provided with a foil backing that helps preclude the ignition of the material and fire spread. Therefore, this insulation will not increase the HRR, as modeled in the fire compartments containing fiberglass duct work insulation, and will not affect the Fire PRA results.

Larger secondary combustibles, in areas that were not ruled out through walkdowns, are discussed below.

Fire Compartment(s)	Combustible Type	Quantity	Justification
02-04	Ready Room Office Material	140 square feet (ft^2)	The Reactor Building fire compartments have significant volumes, large amounts of cables, and relatively large fire scenarios. The non-cable intervening combustibles in these fire compartments will not significantly influence the formation of a hot gas layer or cause more than a negligible increase to the zone of influence (ZOI).
03-01 and 03-02	Paper	2000 pounds (lbs.)	
	Silflex Shielding	1000 lbs.	
03-03	Chair	1 cubic feet (ft^3)	
09	Spare Self Contained Breathing Apparatus (SCBA) Masks	60 lbs.	Based on walkdowns, the SCBA masks are not located in the ZOI of any fixed ignition source. Each transient fire scenario in this fire compartment assumes ignition of above cable trays, although most transients would not ignite the tray. The SCBA masks are not

Fire Compartment(s)	Combustible Type	Quantity	Justification
			located near the cable tray. Because the SCBA masks and the cable trays would not be ignited in the same fire scenario, the current transient analyses are bounding, and there is no effect to the results.
	Breaker Test Carts	120 lbs.	The breaker test carts located in this fire compartment contain a minimal amount of combustible material. Therefore, any increase in HRR due to ignition of the test carts would be negligible.
16-A (Main Control Room)	Drop Ceiling	90 ft^3	The polycarbonate ceiling was analyzed in a sensitivity study, which used FDS. This sensitivity study determined that ignition of the polycarbonate ceiling would not affect the results of the Main Control Room (MCR) fire modeling analysis. The results of this sensitivity study are further discussed in TVA's response to FM RAI 01i.i in this enclosure.
	Miscellaneous Paper	1800 lbs.	Based on walkdowns, stacked computer paper is located outside the horseshoe, near the printers, away from the main control boards (MCB), and near only a few fixed cabinets. The primary goal of the MCR analysis was to determine the effect of the hot gas layer on habitability conditions. The MCR fire modeling scenarios bound the inclusion of the stacked paper by igniting two adjacent cabinet sections, postulating the fires in conservative locations, as discussed in TVA's response to FM RAI 01i.viii (in the TVA letter dated December 20, 2013). Also, because the paper is located away from the MCBs, the effect on the operators would be delayed and the current fire scenarios bound the time to abandonment.
	Carpet	7000 lbs.	Based on walkdowns, there are no piles of carpet that could be affected by any fire scenario. Only the carpet on the floor, which would contribute minimally to the HRR of a fire, would be in the vicinity of any ignition source. The ignition source would also have to be located very near to the floor in order for the carpet to be ignited, which is unlikely. In addition, the carpet in the Unit 1, 2 and 3 MCRs was laboratory tested and has a critical radiant flux that exceeds the BFN adopted standard and a smoke development value that is less than the maximum allowed

Fire Compartment(s)	Combustible Type	Quantity	Justification
			rating.
	Workstations	36 ft^3 (Units 1 and 2) 1031 lbs. (Unit 3)	These workstations are not located directly adjacent to any fixed ignition source. These workstations are continuously manned, so any fire in the vicinity would be quickly detected and extinguished.
25-1	Thermo-Lag 330-1	4900 lbs.	Thermo-lag is of limited combustibility and therefore will not contribute to the HRR modeled for this fire compartment.

In addition, a potential increase to the HRR due to non-cable secondary combustibles would be offset by the following conservatisms:

- Fire scenarios involving electrical cabinets (including the electrical split fraction of pump fires) utilize the 98th percentile HRR for the severity factor calculated out to the nearest Fire PRA target. This is conservative because most fires would not reach the 98th percentile HRR.
- Not every cable tray is filled to capacity. The fire modeling analysis assumed all cable trays were filled to capacity, which provided a conservative estimate of the contribution of cable insulation to the fire and the corresponding time to damage.
- The scoping fire modeling assumed damage to all Fire PRA targets within the compartment once a cable tray was ignited.
- Conservative screening criteria for damage temperatures and heat fluxes were used (i.e., 205 degrees centigrade (°C) and 6 kiloWatts per square meter (kW/m$^{2)}$ for thermoplastic cables and 330°C and 11 kW/m^2 for thermoset cables).
- Target failure was assumed to occur once the Hot Gas Layer (HGL) temperature reached the damage temperature. No additional time delay due to thermal response was assumed.

Based on the results of the reassessment of potential secondary combustibles and the inherent conservatisms in the fire modeling analysis, the effects due to non-cable intervening combustibles on the fire modeling analysis were determined to be minimal. Therefore, the effect due to non-cable intervening combustibles on the Fire PRA is negligible.

FM RAI 01.g

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 jurisdiction] ..." The NRC staff noted that fire modeling comprised the following:

- The algebraic equations implemented in FDTs [Fire Dynamics Tools] and Fire Induced Vulnerability Evaluation, Revision 1 (FIVE) were used to characterize flame radiation (heat flux), flame height, plume temperature, ceiling jet temperature, and hot gas layer (HGL) temperature.
- The Consolidated Model of Fire and Smoke Transport (CFAST) was used in the multi-compartment analysis (MCA), and for the temperature sensitive equipment hot gas layer study.
- Fire Dynamics Simulator (FDS) was used to assess the MCR habitability, and in the plume/hot gas layer interaction and temperature sensitive equipment ZOI studies.

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

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

g. During the audit the NRC staff observed some mechanical equipment in the Unit 3 CSR. Describe whether fire scenarios involving oil from this equipment were considered in the fire modeling analyses for this fire area.

RESPONSE:

The following mechanical equipment are located in the Unit 3 cable spreading room (CSR).

- Chilled Water Pumps 3A and 3B which do not contain oil
- Control Bay Chillers 3A and 3B which contain lube oil

Because Chilled Water Pumps 3A and 3B do not contain lube oil, fires were correctly analyzed by not considering lube oil fire scenarios. The fire modeling analysis, as submitted with the LAR, determined that damage by the oil fire scenarios for Control Bay Chillers 3A and 3B would be bounded by their electrical fires. However, based on further analysis, oil fires for these ignition sources have the potential to create larger fires and therefore, the detailed fire modeling workbook will be updated with these new scenarios.

To determine the effect that these new fire scenarios would have on the Fire PRA, a sensitivity analysis was completed by evaluating these oil fire scenarios. These oil fire scenarios were evaluated following the guidance endorsed by the June 21, 2012, memo from Joseph Gitter to Biff Bradley, "Recent Fire PRA Methods Review Panel Decisions and EPRI 1022993, 'Evaluation of Peak Heat Release Rates in Electrical Cabinets Fires.'" As a conservative approach to the sensitivity analysis, both the 10% and 100% oil spill fires were assumed to damage all targets in the CSR immediately. The detailed fire modeling analysis and report will be updated to include oil fires for these ignition sources and as such, future Fire PRA quantifications will include the results from these oil fire scenarios. The revision to the LAR will be provided to the NRC after the Fire PRA is updated and additional quantification is performed in response to all the NRC RAIs.

The fire risk results of the new oil fire scenarios, with conservative target damage as described above, are provided in Table FM RAI 01.g, in Attachment 1 to this enclosure.

The results of the sensitivity analysis in Table FM RAI 01.g show that there is a slight increase in the Core Damage Frequency (CDF) and Large Early Release Frequency (LERF) for each unit. Despite the increase, BFN meets the guidance for a Region II plant with total CDF and LERF below 1E-04/reactor year (rx-yr) and 1E-05/rx-yr, respectively, for overall plant risk. BFN also meets the CDF/LERF criteria for a Region II plant, which allows a positive delta (∆)CDF of 1E-05/rx-yr and ∆LERF of 1E-06/rx-yr for acceptable risk increases.

FM RAI 01.h.iii

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 jurisdiction] ..." The NRC staff noted that fire modeling comprised the following:

- The algebraic equations implemented in FDTs [Fire Dynamics Tools] and Fire Induced Vulnerability Evaluation, Revision 1 (FIVE) were used to characterize flame radiation (heat flux), flame height, plume temperature, ceiling jet temperature, and hot gas layer (HGL) temperature.
- The Consolidated Model of Fire and Smoke Transport (CFAST) was used in the multi-compartment analysis (MCA), and for the temperature sensitive equipment hot gas layer study.
- Fire Dynamics Simulator (FDS) was used to assess the MCR habitability, and in the plume/hot gas layer interaction and temperature sensitive equipment ZOI studies.

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

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

h. Specifically regarding the use of the algebraic models:

   iii. During the audit the NRC staff observed that the assumption in the HGL calculations of a 10 x 10 ft or 3 x 7 ft natural ventilation opening may not be consistent with plant conditions. Provide technical justification for the exclusive use of the McCaffrey-Quintiere-Harkleroad method for the HGL calculations (as opposed to Beyler's method for closed compartments) and for the assumed vent dimensions.

RESPONSE:

The Beyler method was used as a conservative method to analyze some fire compartments. However, the McCaffrey-Quintiere-Harkleroad (MQH) method was used in the detailed fire modeling workbooks because it was the model that most closely matched existing plant conditions (i.e., naturally ventilated open compartments). Fire compartments at BFN were determined to be naturally ventilated based on walkdowns and analysis of plant layout drawings. As discussed above, fire compartments at BFN either have large openings to adjacent spaces not included in the fire modeling volume, or, once the fire is detected, fire brigade personnel will be dispatched to the room and are expected to open a door and perform suppression activities, which would provide the 3 feet (ft) x 7 ft opening assumed in the fire modeling analysis. Prior to this action, and because the barriers of the compartment do not realistically form an air tight seal, the size of a single door is a representation of the various natural air flow paths that exist in the compartment (e.g., door gaps, vents, openings). The time prior to fire brigade personnel opening a door to the compartment is not of foremost concern with respect to HGL development because the fire is still in the early growth phase.

The method of Beyler was not appropriate in the detailed fire modeling because fire compartments at BFN are not totally closed compartments. As noted above, ventilation flow paths exist in all fire compartments where detailed fire modeling was performed at BFN. Use of this method beyond an initial screening would provide overly conservative results because the completely closed compartment is not consistent with plant conditions.

The natural ventilation opening sizes were determined through visual inspection and the use of layout drawings. The volume used to calculate the HGL using the MQH method was the volume of the area where the fire was located. This was not always the full fire compartment volume and the fire compartment can be split into multiple rooms that are separate from each other. Most fire compartment models utilized a 3 ft x 7 ft natural ventilation opening which represents a single open door. Once the fire is detected, fire brigade personnel would be dispatched to the room and are expected to open a door and perform suppression activities, which would provide the 3 ft x 7 ft opening assumed in the fire modeling analysis.

Aside from Fire Compartment 20-E, all fire compartment models that consider anything other than a 3 ft x 7 ft door opening for the HGL calculations using the MQH method in the detailed fire modeling are located within the Reactor Building. All of these fire compartments have significant opening(s) to adjacent spaces not included in the modeled volume of the fire compartment (e.g., adjacent fire compartments, higher elevations within the same fire compartment connected by an open stairway). The table below shows the actual size of the openings to adjacent spaces for each fire compartment elevation that used a 10 ft x 10 ft opening.

Fire Compartment	**Elevation (ft)**	**Actual Size of Undampered Openings to Adjacent Fire Compartments (ft^2)**	**Note or Disposition**
01-01	519	100	Opening through 10 ft x 10 ft hatch to 565 ft elevation of 01-01.
	565	490	3 ft x 10 ft open stair to Fire Compartment 01-04 (above) and a 460 ft^2 opening to Fire Compartment 01-02 which has a 22 ft x 22 ft open hatch to above.
01-05	621	455	17 ft x 21 ft open hatch and 14 ft x 7 ft stairwell opening to Fire Compartment 01-06 (above).
02-02	519	100	Opening through 10 ft x 10 ft hatch to 565 ft elevation of 02-02.
	565	460	460 ft^2 opening to Fire Compartment 02-01 which has a 17 ft x 21 ft open hatch to above.
03-01	519	100	Opening through 10 ft x 10 ft hatch to 565 ft elevation of 03-01.
03-02	519	100	Opening through 10 ft x 10 ft hatch to 565 ft elevation of 03-02.

Fire Compartment	Elevation (ft)	Actual Size of Undampered Openings to Adjacent Fire Compartments (ft²)	Note or Disposition
03-02	565	504	11 ft x 4 ft open stair to Fire Compartment 03-03 (above) and a 460 ft^2 horizontal opening to adjacent Fire Compartment 03-01.

As shown in the above table, where HGL calculations using the MQH method were performed and used a 10 ft x 10 ft opening in the detailed fire modeling, the actual size of the undampered opening(s) to adjacent spaces is equal to or exceeds the 100 ft^2 that was considered. Using 100 ft^2 was conservative because large openings to adjacent spaces create significant flow paths, impeding HGL development. The table shows that although the 10 ft x 10 ft opening considered for HGL calculations using the MQH method in the fire modeling may not have been consistent with plant conditions, it was always more conservative by being smaller than the actual plant conditions.

For Fire Compartment 20-E, an open vent exists to an adjacent space that is not 10 ft x 10 ft. This vent was measured during walkdowns to be 5.8 ft x 4.1 ft; this area was used in the detailed fire modeling when calculating HGL temperatures using the MQH method. As such, this is consistent with plant conditions.

FM RAI 01.i.i

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 jurisdiction] ..." The NRC staff noted that fire modeling comprised the following:

- The algebraic equations implemented in FDTs [Fire Dynamics Tools] and Fire Induced Vulnerability Evaluation, Revision 1 (FIVE) were used to characterize flame radiation (heat flux), flame height, plume temperature, ceiling jet temperature, and hot gas layer (HGL) temperature.
- The Consolidated Model of Fire and Smoke Transport (CFAST) was used in the multi-compartment analysis (MCA), and for the temperature sensitive equipment hot gas layer study.
- Fire Dynamics Simulator (FDS) was used to assess the MCR habitability, and in the plume/hot gas layer interaction and temperature sensitive equipment ZOI studies.

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

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

i. Specifically regarding the use of FDS in the MCR abandonment calculations:

    i. Provide technical justification for the assumption that the polycarbonate ceiling panels in the MCR do not significantly contribute to a fire. Since the ceiling covers a very large area, there is a concern for rapid flame spread across the surface of the panels and burning droplets or lumps of melted polymer.

RESPONSE:

To demonstrate that the polycarbonate ceiling would not significantly contribute to a fire, a sensitivity analysis has been performed using the current BFN FDS models to include a ceiling tile analysis in each MCR. Based on the prescribed heat release rates, proximity to the ceiling, and confining location, the Bin 15 electrical panel fire outside of the MCR horseshoe was considered the bounding case for this analysis. In the bounding case analysis, smaller fires are less affected by the polycarbonate ceiling issue. Scenarios that did not result in abandonment in the original analysis would not be significantly affected such that abandonment is required due to the polycarbonate ceiling.

As part of the sensitivity analysis, gas phase temperature devices (i.e., thermocouples with no thermal response parameters) were modeled in the plume just below the polycarbonate ceiling to track the ceiling temperature to determine the ignition time. TVA conservatively assumed that if the plume reached the ignition temperature of polycarbonate at the elevation of the ceiling tiles, the entire tile would ignite. Solid phase temperature devices (i.e., thermocouples with thermal response parameters equal to that of the polycarbonate) were used to monitor the melting temperatures surrounding the ignition source. Based on manufacturer's data, 450°C is a conservative ignition temperature of the polycarbonate ceiling tiles.

The results of the sensitivity analysis indicate that the plume temperature reaches the polycarbonate ignition temperature before the abandonment times assumed in the NFPA 805 analyses occur. Sensitivity analysis results are provided in the following table.

Unit(s)	NFPA 805 Analysis Abandonment Time (minutes)	Sensitivity Analysis Time to Ignition Temperature (minutes)
1 and 2	6.6	6.4
3	6.2	5.5

The time between ignition of the ceiling and abandonment is the longest for Unit 3 at 0.7 minutes (i.e., worst case scenario). Because the HRR is not affected until 0.7 minutes before the NFPA 805 analysis abandonment time for any fire, ignition of the polycarbonate ceiling would not invalidate any of the NFPA 805 analysisl abandonment times. Additionally, the NFPA 805 analysis abandonment times are valid for use in the Fire PRA for the following reasons:

- As stated in the Society of Fire Protection Engineering (SFPE) Handbook, polycarbonate has an ignition temperature of 528°C. A conservative temperature of 450°C was used to predict ceiling tile ignition. If the 528°C ignition temperature were used, the Units 1 and 2 MCR and the Unit 3 MCR polycarbonate ceilings would not ignite for 6.9 minutes and 6.2 minutes, respectively. Both of these times meet or exceed the NFPA 805 analysis abandonment times.
- Gas-phase plume temperature devices with no thermal response characteristics modeled at an elevation below that of the actual ceiling tile were used to calculate ignition time. The ceiling tiles would not ignite immediately when the surrounding air temperature reached the ignition temperature due to thermal lag. The sensitivity analysis confirmed that the ignition time was conservative by modeling and analyzing solid-phase devices with polycarbonate thermo-physical properties within the FDS model; the results confirm that the ceiling tiles would not ignite until after the abandonment time. Because the sensitivity analysis using the solid-phase devices demonstrated that the ceiling tiles would not ignite before the NFPA 805 analysis abandonment times, ignition of the ceiling tiles would not affect the times to abandonment calculated in the NFPA 805 analysis.
- The sensitivity analysis shows that the ceiling tiles subject to melting and ignition temperatures are in the direct plume of the ignition source. Operators in the affected MCR are not expected to be working or standing in the direct vicinity of the fire due to the ignition source itself. Because the only tiles that could potentially ignite or melt would be those in the plume of the fire, falling burning polycarbonate ceiling tile debris could occur only within direct vicinity of the fire. Falling burning droplets or lumps of melted polymer in other areas of the affected MCR, not in the plume of the fire, are not expected.
- Flame spread across the ceiling would have little effect on the NFPA 805 analysis MCR abandonment times. The material would begin to melt away before ignition temperatures are reached in the plume. As noted in the bulleted item preceding this one, this melting would be limited to the direct vicinity of the ignition source. Additionally, flame spread tests for polycarbonate sheets show that, when in a horizontal orientation (i.e., as a ceiling tile), flame spread is minimal or unsustainable.

Therefore, a rapid flame spread across the ceiling could not reasonably occur and any potential ceiling tile fire would be limited to the area directly above the fire plume.

- To determine abandonment times, TVA conservatively assumed that the polycarbonate ceiling remains intact and prevents smoke from entering the large interstitial space (i.e., approximately 31,000 ft^3 for the Units 1 and 2 MCR and 14,300 ft^3 for the Unit 3 MCR) above the polycarbonate ceiling below the concrete slab. The results of the sensitivity analysis confirm that the ceiling tiles in the plume of the fire could melt, which would create a hole from the affected MCR into this large interstitial space above. The hole would be located directly in the plume of the fire which would allow hot gasses to flow into the large volume preventing accumulation in the operator area. This hole would also serve to ventilate the original fire in the affected MCR.
- The results of the sensitivity analysis indicate that only ceiling tiles in the plume of the fire have the potential to ignite or melt prior to MCR abandonment. Although there is uncertainty with the potential burning location of the ceiling tile material (i.e., on the ceiling or melted on the fire elevation or floor level), there are only two possibilities that could occur if the ceiling tile is ignited:

    - The ceiling tile could melt and ignite on the surface of the fire elevation or floor level. In this scenario, the ceiling tile begins to melt and starts dripping into the existing fire or the surrounding floor area. Although this would add some combustible polycarbonate fuel to the fire, it also opens a hole in the ceiling the size of the plume diameter, releasing smoke into the interstitial space above the affected MCR. The added venting would prevent the additional burning fuel from affecting the abandonment times.
    - The ceiling tile could burn at the ceiling level. In this scenario, the ceiling tile remains in place and is ignited by plume temperatures 0.7 minutes prior to abandonment. A fire of this nature would not affect the abandonment times because the combustion products would not enter the affected MCR given the location of the ceiling tile. Rather, the heat and combustion products from the ceiling tile fire would vent into the interstitial space above the affected MCR.

FM RAI 02.e

American Society of Mechanical Engineers/American Nuclear Society (ASME/ANS) Standard RA-Sa-2009, "Addenda to ASME/ANS RA-S-2008, Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessments for Nuclear Power Plant Applications," Part 4, requires damage thresholds be established to support the FPRA. Thermal impact(s) must be considered in determining the potential for thermal damage of structures, systems, and components. Appropriate temperature and critical heat flux criteria must be used in the analysis.

e. During the audit the NRC staff noted that several electrical cabinets in the auxiliary instrument rooms have Plexiglass doors with gaskets. The Plexiglass doors of two cabinets were partially open. The cabinets with Plexiglass doors appear to contain sensitive electronic equipment. Describe the damage criteria that were used for this equipment. Provide technical justification if the thresholds that were used in the fire modeling analyses are different from those recommended in Section H.2 of NUREG/CR-6850, Vol. 2.

RESPONSE:

As clarification, there are two cabinets within each auxiliary instrument room (i.e., Fire Compartments 16-K, 16-M, and 16-O) that each have a door that is made up, in part, of a plexiglass sheet attached to a metal border.

NUREG/CR-6850, Volume 2, Section H.2 recommends using 65°C and 3 kW/m^2 as the critical damage temperature and heat flux for solid state components (e.g., sensitive electronic equipment). This criteria was used as follows.

- Fire damage states for fixed ignition source scenarios that were determined to be capable of damaging Fire PRA targets beyond the source itself, were assumed to fail all targets in the fire compartment. This approach, therefore, bounds the failure of any sensitive electronic equipment, including the subject cabinets with plexiglass doors.
- Transient fire scenarios within Fire Compartments 16-K, 16-M, and 16-O were modeled as 69 kW fires. These fire scenarios do not ignite secondary combustibles and do not produce sufficient energy, by themselves, to generate a hot gas layer temperature greater than the critical damage temperature for sensitive electronic equipment as recommended by Section H.2.
- The "Temperature Sensitive Equipment Zone of Influence Study" determined that thermoset damage criteria is appropriate for use with sensitive equipment under certain conditions. The study is documented in the fire modeling analysis validation documentation and is consistent with Fire PRA Frequently Asked Question (FAQ) 13-0004. For transient fire damage by radiant heat, the analysis assumed sensitive electronic equipment would fail when the exposure environment exceeded the radiant heat flux damage criteria for thermoplastic targets, as recommended by NUREG/CR-6850, Table H-1 (i.e., 205°C or 6kW/m^2). This is conservative when compared to thermoset damage criteria as allowed by Fire PRA FAQ 13-0004.

TVA acknowledges that the plexiglass doors may not provide the same level of radiant heat shielding as required to utilize the Fire PRA FAQ 13-0004 damage criteria adjustment. Therefore, an assessment was performed to determine the effect on risk of including these panels with additional transient scenarios, using a 3 kW/m^2 critical radiant heat flux. The results of that assessment are provided below.

Three of the six cabinets with plexiglass panels (i.e., 1-PNLA-009-0038, 2-PNLA-009-0038, and 3-PNLA-009-0038) are not PRA targets and therefore have no affect on the Fire PRA results. The remaining three cabinets are very low risk. Table FM RAI 02.e in Attachment 1 to this enclosure provides the Conditional Core Damage Probability (CCDP) and Conditional Large Early Release Probability (CLERP) values associated with damaging the entire contents of the cabinets with plexiglass doors.

Using 3 kW/m^2 as radiant heat damage criteria, the subject electrical cabinets, which are PRA targets, were found to be within the ZOI of 11 transient fire scenarios. Eight of these transient fire scenarios had already captured the appropriate electrical cabinet as a damaged component.

Based on the low CCDPs and CLERPs (shown in Table FM RAI 02.e in Attachment 1), the risk increase of including these panels in three additional transient fire scenarios is insignificant and would not affect the conclusions of the Fire PRA.

FM RAI 04.a

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

LAR Section 4.7.3, "Compliance with Quality Requirements in Section 2.7.3 of NFPA 805," states that "Engineering methods and numerical models used in support of compliance with 10 CFR 50.48(c) were and are used with the same limitations and assumptions supported by the V&V for the methods as required by Section 2.7.3.3 of NFPA 805."

Regarding the limitations of use:

a. Algebraic models cannot be used outside the range of conditions covered by the experiments on which the model is based. NUREG-1805, "Fire Dynamics Tools (FDTs)," has a section on assumptions and limitations that provides guidance to the user in terms of proper and improper use for each FDT. There is general discussion of the limitations of use for the algebraic equations that has been utilized for hand calculation. It is not clear, however, how these limitations were enforced on the individual fire areas or for the multi-compartment analysis. Provide a description of how the limit of applicability was determined for each fire area.

b. Identify uses, if any, of CFAST outside the limits of applicability of the model and for those cases explain how the use of CFAST was justified. Include a list of areas, zones and scenarios for which CFAST was used to confirm HGL development.

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

RESPONSE:

Parts a and c

The fire modeler manually calculates and verifies that the normalized parameters are within the range of applicability outlined in NUREG-1824, "Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications." In addition, the fire modeling workbooks contain automatic checks for some normalized parameters to assist the fire modeler with verifying that the normalized parameters are within the range of applicability outlined in NUREG-1824. Input parameters identified to be out of the range of applicability are conservatively modified by the fire modeler, when possible, to bring the parameter within range. In most cases, the subject correlations have been applied within the validated range reported in NUREG-1824. In cases where the models have been applied outside the validated range reported in NUREG-1824, these have been justified as acceptable, either by qualitative analyses, or by quantitative sensitivity analyses. Technical details demonstrating the models are within range, as well as any justification of models outside the range, have been updated in the BFN validation documentation.

Part b

The fire modeler manually calculates and verifies that the normalized parameters are within the range of applicability outlined in NUREG-1824. Input parameters identified to be out of the range of applicability are conservatively modified by the fire modeler, when possible, to bring the parameter within range. In most cases, the subject correlations have been applied within the validated range reported in NUREG-1824. In cases where the models have been applied outside the validated range reported in NUREG-1824, these have been justified as acceptable, either by qualitative analyses, or by quantitative sensitivity analyses. Technical details demonstrating the models are within range, as well as any justification of models outside the range, have been updated in the BFN validation documentation.

The scenarios for which CFAST was used to calculate HGL temperatures, along with the applicable Fire Compartments are listed in the following table.

Fire Compartment(s)	Fire Scenario
5 and 7	Multi-Compartment Scenario 5 | 7
5 and 16-B	Multi-Compartment Scenario 5 |16-B
7 and 5	Multi-Compartment Scenario 7 | 5
16-C	Fire Compartment 16-C
16-E and 16-B	Multi-Compartment Scenario 16-E | 16-B
16-E	Intra-Compartment Scenario 16-E | 16-E
16-E and 4	Multi-Compartment Scenario 16-E | 4
16-E and 16-B	Multi-Compartment Scenario 16-E | 16-B
16-E and 16-F	Multi-Compartment Scenario 16-E | 16-F
16-E and 17	Multi-Compartment Scenario 16-E | 17
16-L and 16-K	Multi-Compartment Scenario 16-L | 16-K
16-L and 16-M	Multi-Compartment Scenario 16-L | 16-M
16-N	Fire Compartment 16-N
16-N and 8	Multi-Compartment Scenario 16-N | 8
16-N	Intra-Compartment Scenario 16-N | 16-N
16-N and 16-O	Multi-Compartment Scenario 16-N | 16-O
16-P and 16-J	Multi-Compartment Scenario 16-P | 16-J
16-P and 19	Multi-Compartment Scenario 16-P | 19
17 and 16-K	Multi-Compartment Scenario 17 | 16-K
18 and 16-M	Multi-Compartment Scenario 18 | 16-M
19 and 16-O	Multi-Compartment Scenario 19 | 16-O
5	1 (1-BDDD-281-0001A)
5	2 (1-BDDD-281-0001A)
5	3 (1-BDBB-286-0001A)
5	4 (1-BDBB-286-0001A)
5	5 (1-BDBB-286-0001A)
5	6 (0-BDAA-211-000A)
5	7 (0-BDAA-211-000A)
5	8 (0-LPNL-925-0045A)
5	9 (Transient)
9	1 (0-BDAA-211-000C)
9	2 (0-BDAA-211-000C)
9	3 (2-BDBB-268-0002A)
9	4 (2-BDBB-268-0002A)
9	5 (2-BDBB-268-0002A)
9	6 (Transient)
4	98th Percentile, 3 Section, 464 kW Cabinet Fire
4	98th Percentile Transient Fire

Fire Compartment(s)	Fire Scenario
6	98^{th} Percentile Transient Fire with Cable Tray
7, 10, 11, 14, and 15	98^{th} Percentile Transient Fire
7, 10, 11, 14, and 15	Bin 3 Transient Fire
6, 7, 10, 11, 14. and 15	Bin 4 Transient Fire
12	98^{th} Percentile 69 kW Transformer Fire with 1 Cable Tray
13	98^{th} Percentile Transient Fire
22	98^{th} Percentile 211 kW Cabinet Fire with 4 Cable Trays
20-E	98^{th} Percentile 464 kW Battery Charger Fire
22	98^{th} Percentile Transient Fire at 565 ft Elevation
22	98^{th} Percentile Transient Fire at 583 ft Elevation
22	98^{th} Percentile Transient Fire at 595 ft Elevation.
23	98^{th} Percentile Transient Fire at 565 ft Elevation.
23	98^{th} Percentile Transient Fire at 583 ft Elevation.
23	98^{th} Percentile Transient Fire at 595 ft Elevation.
24	98^{th} Percentile Transient Fire
26-A	98^{th} Percentile Transient Fire at T8
26-A	98^{th} Percentile Transient Fire at T15
26-A	98^{th} Percentile Transient Fire at Unit 1 Access

PRA RAI 01.d

Section 2.4.3.3 of NFPA 805 states that the probabilistic safety assessment (PSA is also referred to as PRA) approach, methods, and data shall be acceptable to the AHJ, which is the NRC. Regulatory Guide (RG) 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a FPP consistent with NFPA 805. RG 1.200, "An Approach For Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," describes a peer review process utilizing an associated ASME/ANS standard (currently ASME/ANS-RA-Sa-2009) as one acceptable approach for determining the technical adequacy of the PRA once acceptable consensus approaches or models have been established for evaluations that could influence the regulatory decision. The primary results of a peer review include the F&Os identified by the peer review and their subsequent resolution.

Clarify the following dispositions to fire F&Os and Supporting Requirement (SR) assessments identified in LAR Attachment V that have the potential to impact the FPRA results and do not appear to be fully resolved:

d. <u>F&O 2-38 against HRA-A2:</u>

   The disposition to this F&O states that the final fire procedures are not yet available to complete and verify the FPRA HRA. Owing to the number of modeling assumptions noted in the Post-Fire HRA report, it is unclear whether the HRA performed for the FPRA is representative of the post-transition, non-SISBO fire response procedures and unclear to what extent these procedures have been developed. Additionally, numerous other F&Os (e.g., 2-39, 2-41, 2-50, 4-3, 4-12, and 4-21) are identified as open items or remain only partially addressed due to the incompleteness of fire procedures. As a result, describe the extent to which the post-transition, non-SISBO fire response procedures have been developed as well as the degree to which they have been used to support the FPRA HRA.

RESPONSE:

The analysis to support the LAR was performed assuming use of the new methods for fire safe shutdown, including equipment and procedures. Recovery actions and attributes for new or modified equipment were developed and assumed in the modeling. These assumptions were based on initial modification scoping or knowledge of how the equipment is currently operated in fire safe shutdown and other emergency procedures. Changes to the analysis presented in the LAR are expected as fire safe shutdown procedures and modifications are developed. Subsequent development of modifications and procedures focuses on satisfying the analysis assumptions.

Although the details of procedures and equipment modifications are not finalized, TVA does not anticipate that they will differ significantly from the way systems and equipment are currently utilized and operated in fire safe shutdown and other emergency procedures. For example, the condensate and condensate booster pumps are utilized as an injection source in the symptom-based Emergency Operating Instructions (EOIs) similar to the way they will be used in the new fire safe shutdown procedures. Therefore, these changes are not expected to significantly affect risk, defense in depth or safety margin presented in the LAR.

In preparation for the LAR submittal, the recovery Human Failure Events (HFEs) included in the BFN Fire PRA utilized the most current versions of the fire response procedures available at the time. The BFN Fire Human Reliability Analysis (HRA) was based on the best understanding of the additional changes that were expected to be incorporated to support the post-transition plant and the removal of Self-Induced Station Blackout (SISBO)-related actions. The modeling assumptions were consistent with this understanding.

BFN NFPA 805 LAR Attachment S, Table S-3, Implementation Items 32 and 33 address the requirement to update both the Fire PRA and HRA analyses to reflect the effect of the finalized modifications and procedures. In the TVA response to PRA RAI 14 (in the TVA letter dated January 10, 2014), TVA changed the wording of Implementation Item 33 to state that the update to the HRA analyses will include a verification of the validity of the reported change in risk on as-built conditions after the procedure updates, modifications, and training are complete.

PRA RAI 01.e

Section 2.4.3.3 of NFPA 805 states that the probabilistic safety assessment (PSA is also referred to as PRA) approach, methods, and data shall be acceptable to the AHJ, which is the NRC. Regulatory Guide (RG) 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a FPP consistent with NFPA 805. RG 1.200, "An Approach For Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," describes a peer review process utilizing an associated ASME/ANS standard (currently ASME/ANS-RA-Sa-2009) as one acceptable approach for determining the technical adequacy of the PRA once acceptable consensus approaches or models have been established for evaluations that could influence the regulatory decision. The primary results of a peer review include the F&Os identified by the peer review and their subsequent resolution.

Clarify the following dispositions to fire F&Os and Supporting Requirement (SR) assessments identified in LAR Attachment V that have the potential to impact the FPRA results and do not appear to be fully resolved:

e. <u>F&O 2-39 against HRA-B3:</u>

   The F&O identifies the lack of human failure event (HFE) definition as a "systematic issue." The disposition indicates that the fire HRA has undergone significant enhancements since the peer review. As a result, address the following:

   i. Describe how the detailed analysis performed for the FPRA adequately addresses performance shaping factors (including cues, applicable procedures, complexity of response, training, accessibility, environment, availability of resources, special requirements, and stress), and clarify the basis used to inform these factors.
   ii. The HRA calculator files provided in Attachment D of the Post-Fire HRA report indicates that "dummy" or "pseudo" values of T_{delay} for operator actions were established to determine proper sequencing; however, this does not appear to explain the timing developed for the actions to calculate their individual human error probabilities (HEPs). Explain the basis for timing estimates (e.g., T_{SW}, T_{delay}, $T_{1/2}$, T_M, etc.) utilized in the detailed analysis individual actions.
   iii. Due to the cited lack of HFE definition, clarify how factors that influence the level of dependency between HFEs (including intervening success, manpower, shift changes, common cognition, timing between cues, time required to complete actions, stress, and location) were addressed by the dependency analysis, and clarify the basis used to inform these factors.
   iv. Explain how the above performance shaping and dependency factors are employed to address the impact of the fire on operator response.

RESPONSE:

Part i - Performance Shaping Factors

All level 1 HFEs including both recovery events and internal event actions credited for the Fire PRA were re-evaluated to consider fire conditions such as potential timing and workload differences due to the use of fire procedures. The Post-Fire HRA Report, Section 5.2, on Qualitative Analysis discusses the general effect of procedures, cues, and environment, while the details of performance shaping factor influence are shown in the Post-Fire HRA Report, Attachment D, HRA Calculator file reports. For example, complexity and workload are noted using the Calculator Execution Performance Shaping Factor (PSF) section and clarified in the PSF notes with discussions such as "Negative PSF is that this is a relatively complex action (i.e., it is not a single step or series of simple steps)," as noted in the report for HFE HFFA02114KVCRSTIE. The HRA penalized multiple procedures and high workloads where applicable. Walkthroughs/talkthroughs of HFEs were also conducted on the BFN Unit 3 simulator and notes related to these sessions are indicated in the individual HFE reports in Post-Fire HRA Report, Attachment D. Operator input was obtained to determine performance shaping factors, such as training and special tools needed, as well as whether access to the areas needed for execution actions could be significantly affected by fires.

Part ii - Action Timing

Timing was obtained through operator interviews, and Modular Accident Analysis Program (MAAP) and other Thermal-Hydraulic (TH) analysis data. These interviews or references to this data are documented in the HRA calculation.

Cognitive response times ($T_{1/2}$) were typically assigned as their non-fire affected value. HFE timing effects resulting from misleading or unclear indications were addressed by including events for the instruments in the Fire PRA model. These instruments and their associated HFEs were failed if the required instruments were affected by fire in each fire scenario. TVA assumed that the EOIs would be given top priority and any delay in implementing them would not be significant. Additionally, the HRA penalized multiple procedures and high workloads where applicable.

Total time for the action, T_{sw}, was taken from the internal events success criteria and TH analysis. T_{sw} typically was not significantly affected by a fire scenario. If the presence of a fire was known to change this timing for a specific scenario, the T_{sw} was evaluated accordingly.

Execution timing (T_m) was based on operator input.

Part iii - T_{delay} and HFE Dependencies

Because over 4,000 combinations were considered in the Fire PRA model, the Electric Power Research Institute (EPRI) HRA calculator was used to automatically compute those dependencies. The calculator utilized the assigned T_{delay} value to order the HFEs in the combination and compute their timing dependencies. Numerous actions that had many hours to complete had T_{delay} values of near zero. Based on this, the calculator would assign almost complete dependencies with other dis-similar actions that had to be performed within minutes instead of hours. In some cases it would also order the longer term action before the shorter term action. The calculator also became very cumbersome when handling this large number of combinations, which made it infeasible to use the T_{delay} override feature. To resolve this problem and get realistic ordering and timing dependency analyses, pseudo T_{delay} values were assigned for each action based on an evaluation of when the action had to be performed in the sequence in relation to other actions. This timing was based more on the time available to complete the action rather than the time the first cue was available.

Part iv - Performance Shaping and Dependency Factor Employment

PSFs attributed to fires were considered and implemented in the HRA Calculator evaluation of the Internal Event and Recovery actions. Operator input was used to support this process. TVA considers that the dependency analysis was extensive and detailed. It considered several thousand HFE combinations and utilized the HRA calculator to evaluate those dependencies.

PRA RAI 01.h

Section 2.4.3.3 of NFPA 805 states that the probabilistic safety assessment (PSA is also referred to as PRA) approach, methods, and data shall be acceptable to the AHJ, which is the NRC. Regulatory Guide (RG) 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a FPP consistent with NFPA 805. RG 1.200, "An Approach For Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," describes a peer review process utilizing an associated ASME/ANS standard (currently ASME/ANS-RA-Sa-2009) as one acceptable approach for determining the technical adequacy of the PRA once acceptable consensus approaches or models have been established for evaluations that could influence the regulatory decision. The primary results of a peer review include the F&Os identified by the peer review and their subsequent resolution.

Clarify the following dispositions to fire F&Os and Supporting Requirement (SR) assessments identified in LAR Attachment V that have the potential to impact the FPRA results and do not appear to be fully resolved:

h. <u>F&O 2-56 against FSS-F3</u>:

   The disposition to this F&O seems incomplete. Address the following:

   i. FSS-F3 requires the completion of a quantitative assessment of unscreened scenarios. Describe the basis for only performing a qualitative assessment of the CSR scenario.
   ii. The catastrophic turbine/generator (T/G) fire postulated for PAU 26A does not appear to be consistent with Table O-2 of NUREG/CR-6850. In particular, a 0.025 conditional probability is utilized; however, the frequency of the scenario is not representative of the sum of Bins 33, 34, and 35, but that of Bin 35 alone. Revise T/G scenarios to be consistent with NUREG/CR-6850 guidance, or alternatively provide a sensitivity analysis of the impact of this inconsistency on the risk results (i.e., CDF, LERF, ΔCDF and ΔLERF).
   iii. Discuss whether a severe T/G oil fire was considered for its impact on structural elements in addition to a catastrophic T/G fire.

RESPONSE:

Part i

The CSRs do not meet the conditions necessary for performing a quantitative assessment. The criteria that define the threshold for performing a quantification of fire scenarios generating structural steel damage are identified in the Fire PRA standard, ASME/ANS-RA-Sa-2009, Requirement FSS-F. The criteria require both of the following conditions:

- Exposed (i.e., unprotected) structural steel elements in the fire zone.
- The presence of ignition sources or combustibles capable of generating a "high hazard fire."

The second element of the criteria listed above is not met for the CSRs, and therefore, no quantification is necessary for fires affecting structural steel elements. That is, there is no ignition source or combustible capable of generating a high hazard fire. Specifically, fires in the CSRs are not high hazard per guidance in the Note to FSS-F1 in ASME/ANS-RA-Sa-2009, which states:

> "The prototypical fire scenario leading to failure of structural steel would be catastrophic failure of the turbine itself (e.g., a blade ejection event) and an ensuing lube-oil fire. For the lube-oil fire, the possibility of effects of pooling, the flaming oil traversing multiple levels, and spraying from continued lube-oil pump operation should be considered. However, the analysis should also consider scenarios involving other high-hazard fire sources as present in the relevant physical analysis units (e.g., oil storage tanks, hydrogen storage tanks and piping, mineral oil-filled transformers)."

The ignition sources and intervening combustibles in the CSRs consist of transients, electrical cabinets, chillers, pumps, and cable trays that do not present the typical characteristics of a "high hazard" fire as described in the ASME/ANS-RA-Sa-2009. The requirements in Supporting Requirement (SR) FSS-F3 are contingent upon selection of scenarios in SR FSS-F1. Because no scenarios were identified and selected, the requirements of FSS-F2 and FSS-F3 are not applicable to the CSRs.

Part ii

NUREG/CR-6850, Table O-2 lists the severity factor values for catastrophic turbine generator fires. These are the fires postulated to generate damage to structural steel elements generating structural collapse. As requested in the RAI, the ignition frequency for the catastrophic scenarios has been updated to be the sum of bins 33, 34, and 35 (i.e., 2.10E-03+3.23E-03+3.89E-03 = 9.22E-03). The severity factor of 0.025 was then applied with this frequency as NUREG/CR-6850, Table O-2 recommends for "T/G fires involving H_2, oil, and possibly blade ejection." The risk parameters used to calculate the ignition frequency for the scenarios in the three BFN units are:

Unit	Scenario	Ignition Frequency (IGF)	Severity Factor	Non-Suppression Probability (NSP)
1	26-A.146-TGEX-CAT	9.22E-03	2.50E-02	1.10E-01
2	26-A.490-TGEX-CAT	9.22E-03	2.50E-02	1.10E-01
3	26-A.757-TGEX-CAT	9.22E-03	2.50E-02	1.10E-01

The Fire PRA model and documentation will be updated to reflect the values in the above table. The revision to the LAR will be provided to the NRC after the Fire PRA is updated and additional quantification is performed in response to all the NRC RAIs.

The sensitivity analysis results for Fire CDF and LERF are:

Unit	Sensitivity (Plant Fire CDF)	Percent (%) Increase From Baseline	Sensitivity (Plant Fire LERF)	% Increase From Baseline	Sensitivity Delta Risk (COMP) CDF	% Increase From Baseline	Sensitivity Delta Risk (COMP) LERF	% Increase From Baseline
1	6.29E-05	0.03%	2.14E-06	0.00%	-5.59E-04	0.00%	1.91E-07	0.00%
2	6.59E-05	0.03%	1.90E-06	0.00%	-4.89E-04	0.00%	3.10E-08	0.00%
3	5.30E-05	0.09%	1.83E-06	0.00%	-5.68E-04	0.00%	1.18E-07	0.00%

In summary, the ignition frequency for the catastrophic turbine generator fires was updated to account for the sum of the generic frequencies in bins 33, 34, and 35. A sensitivity analysis was conducted to assess the effect on plant Fire CDF, LERF, ΔCDF, and ΔLERF for each of the three units. The effect in the plant fire risk value is minimal.

Part iii

The Fire PRA included the contribution of severe and catastrophic turbine generator fires. The severe turbine generator exciter, hydrogen, and oil fires all assumed a full compartment burn for the fire zone. The catastrophic turbine building fires assumed a full compartment burn and the failure of the Emergency High Pressure Makeup (EHPM) pump. The BFN Turbine Building is of concrete construction and the exposed structural elements are mostly present in the top elevation supporting the metal roof. Therefore, treatment of severe turbine generator fires not collapsing the building and generating a full compartment burn conservatively bound the risk of failing the Turbine Building. That is, a severe fire was postulated with a full compartment burn. Subsequently, a catastrophic fire additionally failing the EHPM pump was also included in the risk profile of the plant.

PRA RAI 01.p

Section 2.4.3.3 of NFPA 805 states that the probabilistic safety assessment (PSA is also referred to as PRA) approach, methods, and data shall be acceptable to the AHJ, which is the NRC. Regulatory Guide (RG) 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a FPP consistent with NFPA 805. RG 1.200, "An Approach For Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," describes a peer review process utilizing an associated ASME/ANS standard (currently ASME/ANS-RA-Sa-2009) as one acceptable approach for determining the technical adequacy of the PRA once acceptable consensus approaches or models have been established for evaluations that could influence the regulatory decision. The primary results of a peer review include the F&Os identified by the peer review and their subsequent resolution.

Clarify the following dispositions to fire F&Os and Supporting Requirement (SR) assessments identified in LAR Attachment V that have the potential to impact the FPRA results and do not appear to be fully resolved:

p. <u>F&O 5-6 against IGN-A4</u>:

The disposition notes that a review of plant-specific fire experience was performed using guidance in NUREG/CR-6850 and that only one potentially challenging fire event was identified. However, based on the at-power fire events listed in Attachment 8 of the Fire Ignition Frequency report, the basis for classifying events as non-challenging remains unclear from the descriptions provided. During the audit, the NRC staff reviewed a small sample of past events and determined that at least one of these (i.e., Problem Evaluation Report (PER) 141331) was not classified as a potentially challenging event by TVA but should have been according to the criteria in NUREG/CR-6850, Appendix C (i.e., the event identified by PER 141331 involved active intervention by non-hot-work plant personnel to suppress the fire). Lastly, a review of the "Unit/Status" column appears to only indicate two modes (i.e., power operation and shutdown); however, NUREG/CR-6850 indicates that events occurring during low-power operations, such as plant start-up, should be considered as well. Identify whether any of the fire events not classified as potentially challenging by TVA were classified in the updated EPRI fire event database (i.e., EPRI 1025284) as potentially challenging. If additional fire events were determined to be potentially challenging, discuss each of these events. Provide an assessment of the impact on the risk results provided in the LAR, Attachment W, or provide justification for why a Bayesian update is not required.

RESPONSE

A total of 69 plant specific fire events evaluated for determining if the generic ignition frequencies used in the Fire PRA require a Bayesian update are listed in the Fire Ignition Frequency Notebook, Attachment 8. The attachment includes the following information:

- Only fire events that occurred during power operations or low-power operations, such as plant start-up were included in the generic fire frequency calculations.
- Events during a refueling outage were not considered for updating generic fire ignition frequencies.

- Fire events are assumed to be at power conditions unless otherwise noted. The Unit/Status of "shutdown" does not include low-power operations or start-up. It only considers cold shutdown, refueling, and construction outages consistent with the guidance in NUREG/CR-6850, Section C.3.1.

NUREG/CR-6850, Section 6.5.2 recommends that plant specific updates are not necessary if there is no unusual fire occurrence pattern. This condition was used as the basis for determining if the generic frequencies used in the Fire PRA needed to be updated. As requested in this RAI, each of the plant specific fire events listed in the Fire Ignition Frequency Notebook, Attachment 8 was compared with the "challenging level" determination documented in EPRI 1025284, Appendix C. This Appendix summarizes the information of each fire event in EPRI's Fire Events Database (FEDB) and lists the "challenging level" determination.

- Of the 69 fire events listed in Attachment 8 of the Fire Ignition Frequency Notebook:
    - 39 fire events match the events in EPRIs FEDB.
        - Two events are classified as potentially challenging (Problem Evaluation Reports (PERs) 107306 and 75227). These are EPRI Fire ID 10576 and 10558, respectively.
        - Four events are undetermined (PERs 60700, 93601, 56024, and 134469). These are EPRI Fire ID 10555, 10582, 10585, and 50655, respectively. It should be noted that PER 134469 is not an exact match with EPRI Fire ID 50655. However, EPRI Fire ID 50655 does not have a clear description in the EPRI FEDB and suggests a smoking heater with no evidence of a flaming. The smoking event was confined to the object of origin. Furthermore, PER 134469 was a fire alarm event and no fire occurred. With the available information, there is not enough evidence to suggest a plant specific update.
        - The remaining 33 events are classified as not challenging, as described in EPRI 1025284.
    - 30 fire events are not included in the EPRI database. The 30 fire events are labeled "Not challenging" based on the criteria described in Appendix C of NUREG/CR-6850. In addition, of these 30 fire events:
        - Three occurred when the plant was at power (PERs 124788, 131112, and 141331)
        - Six occurred outside the global analysis boundary
        - 21 occurred in shutdown mode

The two potentially challenging events in the EPRI FEDB are a hydrogen fire in the switchyard or the yard and a compressor fire. These two events were judged to be potentially challenging. These fires do not suggest any plant specific pattern or ignition source vulnerable to fire warranting a plant specific update.

For the four undetermined fire events, each occurred as a result of a different type of ignition source (i.e., exposed wire, hot work, oil fire inside compressor motor, and an overheated heater). Two of the events happened during an outage, while the power level is not indicated for the other two. Two of the events resulted only in smoke, with no evidence of flaming. These fires do not suggest any plant specific pattern or ignition source vulnerability to fire warranting a plant specific update.

The specific case cited in the RAI, PER 141331, which occurred on April 1, 2008, is not listed in the EPRI Fire Events database. This event was readily suppressed, making it a non-challenging event. Although the plant worker was not the fire watch, this fire was immediately suppressed without the need of any equipment such as fire extinguishers, detection from smoke detectors, or follow up activity by plant personnel to extinguish the fire. That is, a plant worker in the immediate vicinity of the fire was able to quickly suppress it. In the case that this event would have been classified potentially challenging, it would be the only hot work fire in the plant specific collection of events, which suggests no specific pattern for BFN.

In summary, a review of the plant specific fires at BFN, including a comparison with the latest industry data documented in EPRI 1025284 suggests that no plant specific updates of the generic frequencies are necessary. This is consistent with the guidance in NUREG/CR-6850, Section 6.5.2.

PRA RAI 01.s

Section 2.4.3.3 of NFPA 805 states that the probabilistic safety assessment (PSA is also referred to as PRA) approach, methods, and data shall be acceptable to the AHJ, which is the NRC. Regulatory Guide (RG) 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a FPP consistent with NFPA 805. RG 1.200, "An Approach For Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," describes a peer review process utilizing an associated ASME/ANS standard (currently ASME/ANS-RA-Sa-2009) as one acceptable approach for determining the technical adequacy of the PRA once acceptable consensus approaches or models have been established for evaluations that could influence the regulatory decision. The primary results of a peer review include the F&Os identified by the peer review and their subsequent resolution.

Clarify the following dispositions to fire F&Os and Supporting Requirement (SR) assessments identified in LAR Attachment V that have the potential to impact the FPRA results and do not appear to be fully resolved:

s. <u>F&O 5-18 against FSS-C4 and F&O 8-3 against FSS-C1</u>:

   The disposition to F&O 5-18 appears to indicate that the risk contribution from the fraction of fires for an ignition source that do not propagate to targets beyond the ignition source was only quantified if the complement fraction of fires that do propagate result in a CDF contribution above 1.0E-07/year. However, this CDF criterion appears to differ from both the 1.0E-06/year CDF criterion noted in Attachment 2 of the Scoping Fire Modeling Scenario Report and the 1.0E-06 conditional core damage probability (CCDP) criterion stated in the disposition to F&O 8-3. Additionally, based on the disposition to F&O 8-3, it is unclear whether those ignition sources that do not result in any scenarios that propagate to secondary targets were maintained in the analysis to reflect the fire-induced failure of the ignition source itself. Describe the process for screening non-propagating fire scenarios, and justify the criteria utilized.

RESPONSE:

BFN Scoping Fire Modeling Scenario Report, Attachment 3, Section 7.6.1.1, "Verification of Screened PRA Targets," describes that in accordance with NUREG/CR-6850, Section 8.3.1, ignition sources that are Fire PRA components cannot be screened in Task 8. However, in accordance with NUREG/CR-6850, Section 8.5.3, Step 3, non-propagating fixed ignition sources can be screened out in Task 8 with further verification to confirm that the ignition source itself is not risk significant. A series of checks must be performed to determine the risk significance of the non-propagating ignition sources before they can be screened out from further analysis. The fire ignition source must first be considered for external damage. If the ignition source is a fire PRA component itself, has PRA cables that terminate at the component, or the calculated HRR is greater than the critical HRR, then the ignition source should not be screened out. For those that are candidates for screening, the initiator should be reviewed during the final quantification step (i.e., NUREG/CR-6850 task 14) to ensure that it cannot lead to a reactor trip.

BFN Scoping Fire Modeling Scenario Report, Attachment 2 details how the non-propagation fire scenarios were identified, entered into the fire scenario software, quantified, and reviewed. Any non-propagating scenarios that contained PRA targets were quantified. Non-propagating scenarios were screened out if the scenario did not contain any Fire PRA component or Fire PRA cable. BFN Scoping Fire Modeling Scenario Report, Attachment 2 only took into consideration scenarios with a high fire risk impact (1.00E-06 CDF or greater) for the propagating scenario.

The screening criteria of 1.00E-06 will be removed from BFN Scoping Fire Modeling Scenario Report, Attachment 2 and replaced with the quantitative screening criteria contained in the Task 7.7, Quantitative Risk Screening calculation that represents the screening criteria in NUREG/CR-6850 and quantitative screening (QNS) element capability category II of ASME/ANS RA-Sa-2009 with clarifications contained in RG 1.200, Revision 2. The new screening criteria is: The sum of the contribution of the screened CDF will be less than 10% of the estimated total Unit fire CDF and the sum of the contribution of the screened LERF will be less than 10% of the estimated total Unit fire LERF.

In order to satisfy the less than 10% screening criteria, additional non-propagating scenarios that were originally screened out have been identified and will be entered into SAFE-PB and quantified to include the risk contribution into the Fire PRA model.

PRA RAI 04.a

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting an FPP consistent with NFPA 805. In a letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff require additional justification to allow the NRC staff to complete its review of the proposed method.

Attachment 16 (Control Room Abandonment CCDP and LERP Calculations) of the Fire Risk Quantification report (i.e., TVA Fire PRA - Task 7.14 Fire Risk Quantification) explains that there are two shutdowns paths credited for alternate shutdown (i.e., the 25-32 panel and the emergency high pressure supplemental injection pump) and lists the HFEs credited for each path. Attachment 16 also states that failure of any of these actions is assumed to fail the shutdown path, but does not present failure probability of abandonment used in scenario analysis. Given the complexity of this analysis further describe how the HRA was performed for alternate shutdown following control room abandonment. Include in this description:

a. Identification of fire areas/compartments that credit MCR abandonment due to loss of habitability and/or loss of control or function.

RESPONSE:

The only fire area that credits MCR abandonment due to loss of habitability and/or loss of control or function is Fire Area 16. Within Fire Area 16, only fire compartments 16-A (MCRs and CSRs), 16-K (Unit 1 Auxiliary Instrument Room), 16-M (Unit 2 Auxiliary Instrument Room), and 16-O (Unit 3 Auxiliary Instrument Room) credit MCR abandonment.

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PRA RAI 04.b

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting an FPP consistent with NFPA 805. In a letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff require additional justification to allow the NRC staff to complete its review of the proposed method.

Attachment 16 (Control Room Abandonment CCDP and LERP Calculations) of the Fire Risk Quantification report (i.e., TVA Fire PRA - Task 7.14 Fire Risk Quantification) explains that there are two shutdowns paths credited for alternate shutdown (i.e., the 25-32 panel and the emergency high pressure supplemental injection pump) and lists the HFEs credited for each path. Attachment 16 also states that failure of any of these actions is assumed to fail the shutdown path, but does not present failure probability of abandonment used in scenario analysis. Given the complexity of this analysis further describe how the HRA was performed for alternate shutdown following control room abandonment. Include in this description:

b. Explanation of the logic modeled in the FPRA for crediting the alternate shutdown paths and the basis for that logic (e.g., do the two paths provide redundancy for all fires that result in abandonment scenarios?).

RESPONSE:

The logic in the Fire PRA model for crediting alternate shutdown was modeled with two paths for all MCR abandonment fire scenarios that occur in the affected fire compartments (i.e., 16-A, 16-K, 16-M, and 16-O). The first path modeled utilized Reactor Core Isolation Cooling (RCIC) and Low Pressure Coolant Injection (LPCI) for injection (i.e., inventory control) and Suppression Pool Cooling (SPC) for decay heat removal, and included the set of operator actions required to occur at the backup control panel (i.e., 25-32) and locally, and also the recovery actions (i.e., actions performed in locations other than the backup control panels) needed to ensure success. Pressure control using Safety Relief Valves (SRVs) was also required and provided. Failure of any single operator action modeled in this path resulted in the loss of this safe shutdown path. The second path was modeled as the operator actions to utilize the EHPM pump for injection (i.e., inventory control) and the hardened wetwell vent for decay heat removal. Failure of any single human action modeled in this path resulted in the loss of this safe shutdown path.

These two paths were modeled as parallel, redundant strategies for achieving alternate shutdown for all abandonment scenarios with the following exception: For scenarios that resulted in the spurious opening of SRVs, the EHPM pump path was not credited because only LPCI provides enough inventory makeup for success. In these scenarios, only the first safe shutdown path was credited.

PRA RAI 04.c

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting an FPP consistent with NFPA 805. In a letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff require additional justification to allow the NRC staff to complete its review of the proposed method.

Attachment 16 (Control Room Abandonment CCDP and LERP Calculations) of the Fire Risk Quantification report (i.e., TVA Fire PRA - Task 7.14 Fire Risk Quantification) explains that there are two shutdowns paths credited for alternate shutdown (i.e., the 25-32 panel and the emergency high pressure supplemental injection pump) and lists the HFEs credited for each path. Attachment 16 also states that failure of any of these actions is assumed to fail the shutdown path, but does not present failure probability of abandonment used in scenario analysis. Given the complexity of this analysis further describe how the HRA was performed for alternate shutdown following control room abandonment. Include in this description:

c. Explanation of the range of probabilities for properly shutting down the plant, and discussion of how they were applied in the scenario analysis.

RESPONSE:

The range of probabilities for properly shutting down the plant is based on the modeling of the HFEs associated with the two shutdown paths, and is calculated on a scenario-specific basis. The scenario-specific probabilities are calculated based on the operator actions required to perform the two alternate shutdown strategies. The scenario-specific probability variation is the result of the summation of the human error probabilities (HEPs) for the operator actions (i.e., HFEs) associated with the utilization of the backup control panel 25-32 shutdown path, with the HEPs for the local recovery actions, which is based on the scenario specific fire impacts. This makes the HEPs associated with the local recovery actions scenario-specific. The CCDPs span from 1.73E-03 to 3.51E-01. The CLERPs span from 7.84E-06 to 1.68E-03.

The probabilities were applied in the scenario analysis based on an evaluation of whether the scenario would result in MCR abandonment. This is defined and modeled in the Fire PRA as when the fire damage alone in a scenario leaves no available Nuclear Safety Capability Analysis (NSCA) safe shutdown success path. For loss of habitability scenarios, which were determined by the MCR fire modeling, abandonment was assumed to occur.

PRA RAI 04.d

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting an FPP consistent with NFPA 805. In a letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff require additional justification to allow the NRC staff to complete its review of the proposed method.

Attachment 16 (Control Room Abandonment CCDP and LERP Calculations) of the Fire Risk Quantification report (i.e., TVA Fire PRA - Task 7.14 Fire Risk Quantification) explains that there are two shutdowns paths credited for alternate shutdown (i.e., the 25-32 panel and the emergency high pressure supplemental injection pump) and lists the HFEs credited for each path. Attachment 16 also states that failure of any of these actions is assumed to fail the shutdown path, but does not present failure probability of abandonment used in scenario analysis. Given the complexity of this analysis further describe how the HRA was performed for alternate shutdown following control room abandonment. Include in this description:

d. Explain how LERF was determined for abandonment scenarios.

RESPONSE:

LERF was determined for abandonment scenarios by multiplying the frequency and CCDP of the scenario by the HEP for the event HFFA0064PCICLOSE. This event represents the operator action to vent the control air supply to containment isolation valves, which failed the containment isolation valves closed. The modification that enables this function is described in LAR Attachment S, Table S-2, Modification 93.

PRA RAI 04.e

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a FPP consistent with NFPA 805. In letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff require additional justification to allow the NRC staff to complete its review of the proposed method.

Attachment 16 (Control Room Abandonment CCDP and LERP Calculations) of the Fire Risk Quantification report (i.e., TVA Fire PRA - Task 7.14 Fire Risk Quantification) explains that there are two shutdowns paths credited for alternate shutdown (i.e., the 25-32 panel and the emergency high pressure supplemental injection pump) and lists the HFEs credited for each path. Attachment 16 also states that failure of any of these actions is assumed to fail the shutdown path, but does not present failure probability of abandonment used in scenario analysis. Given the complexity of this analysis further describe how the HRA was performed for alternate shutdown following control room abandonment. Include in this description:

e. Identification of events or conditions that prompt the decision to transfer command-and-control from the MCR. Include clarification of how the decision to abandon will be addressed by the post-transition fire procedures.

RESPONSE:

MCR abandonment decisions are based on one of two cues. The first cue is a significant reduction of MCR habitability due to the fire effects such as smoke or heat. Fire modeling is used to determine the ignition sources (initiators) and fire severities that would cue control room abandonment due to MCR habitability issues. A fire scenario and frequency is established for each MCR initiator that meets the cue criteria and abandonment is assumed for this scenario. The second cue is an MCR fire scenario that results in a loss of control. Functionality abandonment occurs when the fire damage alone in a scenario leaves no available safe shutdown success path. In these scenarios, it is assumed that operators would abandon the control room and use ex-control room alternative shutdown procedures. In order to identify those scenarios that result in this level of equipment damage, each scenario in the affected fire compartments for each unit was evaluated without crediting the EHPM pump modification. If the resulting cutsets based on review showed no safe shutdown path was available, then the use of alternative shutdown would be required. Both of these abandonment scenario types are represented in the Fire PRA model. The Fire PRA model assumed that the control room supervisor would make the decision to abandon based on observed MCR conditions or plant conditions that are similar to those discussed above.

The considerations for the decision to abandon will be addressed by the post-transition fire procedures and will be based upon Senior Reactor Operator (SRO) judgment that physical occupation is no longer feasible or the equipment needed to safely shut down the plant is not available in the particular unit's MCR. The modeling of the conditions that cue the decision to abandon will be refined once the procedure is complete, as required by LAR Attachment S, Table S-3, Implementation Item 33.

PRA RAI 04.f

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a FPP consistent with NFPA 805. In letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff require additional justification to allow the NRC staff to complete its review of the proposed method.

Attachment 16 (Control Room Abandonment CCDP and LERP Calculations) of the Fire Risk Quantification report (i.e., TVA Fire PRA - Task 7.14 Fire Risk Quantification) explains that there are two shutdowns paths credited for alternate shutdown (i.e., the 25-32 panel and the emergency high pressure supplemental injection pump) and lists the HFEs credited for each path. Attachment 16 also states that failure of any of these actions is assumed to fail the shutdown path, but does not present failure probability of abandonment used in scenario analysis. Given the complexity of this analysis further describe how the HRA was performed for alternate shutdown following control room abandonment. Include in this description:

f. Explanation of how timing was established (i.e., total time available, time until a cue is reached, manipulation time, and time for decision-making) and which fire or fires were used as the basis for the timing for both shutdown pathways. Include in the explanation the basis for any assumptions made about timing.

RESPONSE:

Two timing criteria were used to evaluate the abandonment HFEs.

The first timing criterion was the time available to establish initial Reactor Pressure Vessel (RPV) injection. This time was based on MAAP analysis. This criterion depends on whether any fire affects RPV depressurization, which affects whether initial high pressure injection can be established with either shutdown path, or whether initial low pressure injection is required which is only credited from the backup control panel safe shutdown path.

The second timing criterion was the time available to establish long term core cooling which includes decay heat removal and long term injection. This time was based on MAAP analysis and credits both safe shutdown paths. Each abandonment HFE was assumed to be dominated by the execution errors; cognitive timing was not considered.

Manipulation time for action blocks was obtained from operator input and based, in part, on validated performance times.

PRA RAI 04.g

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a FPP consistent with NFPA 805. In letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff require additional justification to allow the NRC staff to complete its review of the proposed method.

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g. Justification for using a cognitive error probability of 0.0 and a T_{delay} of 0.0 minutes for alternate-shutdown-related actions as observed in Attachment D of the Fire HRA report (i.e., TVA Fire PRA – Task 7.12 Post-Fire Human Reliability Analysis).

RESPONSE:

The cues for entry into the Compartment 16 Safe Shutdown Instruction (SSI) abandonment section were modeled as either loss of control or loss of a habitable MCR environment due to fire effects. Because of the obvious and severe nature of the abandonment cues, the PRA model assumed that the operators would abandon the MCR when these cues are present. While the operators may need to make some decisions during the cognitive stage of the abandonment actions, the need for the actions is primarily recognized by being in and following the abandonment SSI. The individual abandonment HFEs associated with the key SSI steps were dominated by the execution errors; cognitive errors and cognitive timing were not considered. Errors associated with omitting procedure steps are considered in the execution portion of the analysis.

PRA RAI 04.h

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a FPP consistent with NFPA 805. In letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff require additional justification to allow the NRC staff to complete its review of the proposed method.

Attachment 16 (Control Room Abandonment CCDP and LERP Calculations) of the Fire Risk Quantification report (i.e., TVA Fire PRA - Task 7.14 Fire Risk Quantification) explains that there are two shutdowns paths credited for alternate shutdown (i.e., the 25-32 panel and the emergency high pressure supplemental injection pump) and lists the HFEs credited for each path. Attachment 16 also states that failure of any of these actions is assumed to fail the shutdown path, but does not present failure probability of abandonment used in scenario analysis. Given the complexity of this analysis further describe how the HRA was performed for alternate shutdown following control room abandonment. Include in this description:

h. Description of how the feasibility of the operator actions supporting the two alternate shutdown pathways was assessed. Include a discussion of the potential for detrimental actions.

RESPONSE:

Each individual MCR abandonment HFE that models the backup control panel path is composed of distinct blocks of closely related execution steps in the Fire Area 16 SSI, 0-SSI-16. Although 0-SSI-16 is in draft form, its instructions are similar to the current SSIs that contain actions specific to fire in Fire Area 16 for the backup control panel shutdown path. Because the current SSI instructions are known to be feasible and there are commonalities between the current and new instructions, the HRA has assumed that the new SSI instructions will also be feasible for the backup control panel success path. However, the HRA will verify this assumption when the new SSIs are validated prior to implementation; TVA will revise the HRA as necessary. Additionally, each recovery action for the backup control panel shutdown path credited in the Fire Risk Evaluation for Fire Area 16 has been validated as feasible. For the EHPM pump path, the PRA model assumed the system will be designed such that the actions to utilize the shutdown path will be feasible. The two alternate shutdown pathways are independent in nature and no action taken on one path can adversely affect the other. This will be verified when the new SSIs are validated prior to implementation.

LAR Attachment S, Table S-3, Implementation Items 32 and 33 address the requirement to update both the Fire PRA and HRA analyses to reflect the effects of the finalized modifications and procedures, which include the Fire Area 16 SSI instructions.

PRA RAI 04.i

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a FPP consistent with NFPA 805. In letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff require additional justification to allow the NRC staff to complete its review of the proposed method.

Attachment 16 (Control Room Abandonment CCDP and LERP Calculations) of the Fire Risk Quantification report (i.e., TVA Fire PRA - Task 7.14 Fire Risk Quantification) explains that there are two shutdowns paths credited for alternate shutdown (i.e., the 25-32 panel and the emergency high pressure supplemental injection pump) and lists the HFEs credited for each path. Attachment 16 also states that failure of any of these actions is assumed to fail the shutdown path, but does not present failure probability of abandonment used in scenario analysis. Given the complexity of this analysis further describe how the HRA was performed for alternate shutdown following control room abandonment. Include in this description:

i. Justification for assuming that continuous communication and coordination will occur during implementation of the alternate shutdown procedure by the different operators at their different locations. Include consideration of actions that require taking off headsets or the unavailability of phone systems.

RESPONSE:

The current safe shutdown strategy for Fire Area 16, which utilizes the backup control panel, addresses communication and coordination by different Operators at different locations. Because continuous communication and coordination has been validated for these existing instructions and there are commonalities between the current and new SSIs, the HRA has assumed that the new SSIs will also have continuous communication and coordination. This assumption will be verified when the new SSIs are validated prior to implementation, as required by the TVA procedure change process, and the analysis will be updated as necessary. Effective radio communications are available for each fire area as outlined in a calculation entitled "Appendix R Analysis for Intraplant Communication System," based on functional testing that was performed. The communication and coordination required to implement the EHPM pump shutdown path in parallel with the backup control shutdown path was assumed to occur and will be validated using the same process.

LAR Attachment S, Table S-2, Modification 35 addresses the addition of the EHPM pump. A requirement of the design is to ensure means of communication and coordination will be provided. LAR Attachment S, Table S-3, Implementation Items 32 and 33 address the requirement to update the post-fire response procedures, and the Fire PRA and Fire HRA analyses to reflect the effects of the finalized modifications and procedures, which include the Fire Area 16 SSIs.

PRA RAI 04.j

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a FPP consistent with NFPA 805. In letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff require additional justification to allow the NRC staff to complete its review of the proposed method.

Attachment 16 (Control Room Abandonment CCDP and LERP Calculations) of the Fire Risk Quantification report (i.e., TVA Fire PRA - Task 7.14 Fire Risk Quantification) explains that there are two shutdowns paths credited for alternate shutdown (i.e., the 25-32 panel and the emergency high pressure supplemental injection pump) and lists the HFEs credited for each path. Attachment 16 also states that failure of any of these actions is assumed to fail the shutdown path, but does not present failure probability of abandonment used in scenario analysis. Given the complexity of this analysis further describe how the HRA was performed for alternate shutdown following control room abandonment. Include in this description:

j. Description of how the impact of complexity on coordination of actions and operator performance in the alternate shutdown procedure addressed, including the complexity that having two alternate shutdown paths injects.

RESPONSE:

The complexity of coordination of the two shutdown paths was minimized because of the independent nature of the two shutdown paths. The EHPM pump can inject at both high and low pressure, and in the case where SRVs may spuriously operate due to fire, only the backup control panel path utilizing LPCI is credited. In cases where pressure control is not affected, the two paths are independent for both high and low pressure injection. Coordination of multiple injection sources can occur from the backup control panel, but is not required for Fire PRA success for the two shutdown paths.

PRA RAI 04.k

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a FPP consistent with NFPA 805. In letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff require additional justification to allow the NRC staff to complete its review of the proposed method.

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k. Description of the treatment of potential dependencies between individual actions, including discussion of operator actions that can impact the actions of other operators.

RESPONSE:

For alternative shutdown, there are two independent shutdown paths credited: the backup control panel shutdown path and the EHPM pump shutdown path. The backup control panel shutdown path uses RCIC and LPCI for injection and SPC for decay heat removal. Inventory control and pressure control are also required to achieve safe shutdown with this path. For the EHPM pump path, operation of the EHPM pump assures core cooling for inventory control. Long term decay heat removal is accomplished by use of the hardened wetwell vent. The two paths are modeled as independent and utilization of one path does not have a detrimental effect on the other path because the EHPM pump can inject at both high and low pressure. Because of this assumption, dependencies between actions to initiate RCIC and LPCI and actions to initiate the EHPM pump were not considered. Long term decay heat removal can be established by either SPC or the hardened wetwell vent. Based on existing MAAP analysis, the wetwell vent is not required until 12 or more hours after the reactor scram. By this time the emergency response organization would be staffed and providing support to the operations crew. Therefore, the Fire PRA assumed there would be no dependency between these actions. For abandonment scenarios involving open SRVs, only one shutdown path utilizing Residual Heat Removal (RHR) as an initial injection source was credited. Therefore, there are no potential dependencies associated with this path.

The two alternate shutdown pathways are independent in nature and no action taken on one path can adversely affect the other. This will be verified when the new SSIs are validated prior to implementation.

LAR Attachment S, Table S-3, Implementation Items 32 and 33 address the requirement to update both the Fire PRA and HRA analyses to reflect the effects of the finalized modifications and procedures, which include the Fire Area 16 SSIs.

PRA RAI 04.l

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting an FPP consistent with NFPA 805. In a letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff require additional justification to allow the NRC staff to complete its review of the proposed method.

Attachment 16 (Control Room Abandonment CCDP and LERP Calculations) of the Fire Risk Quantification report (i.e., TVA Fire PRA - Task 7.14 Fire Risk Quantification) explains that there are two shutdowns paths credited for alternate shutdown (i.e., the 25-32 panel and the emergency high pressure supplemental injection pump) and lists the HFEs credited for each path. Attachment 16 also states that failure of any of these actions is assumed to fail the shutdown path, but does not present failure probability of abandonment used in scenario analysis. Given the complexity of this analysis further describes how the HRA was performed for alternate shutdown following control room abandonment. Include in this description:

l. Discussion of how hardware failure probabilities are addressed (See F&O 7-16).

RESPONSE:

HEPs are assumed to be significantly greater than equipment failure probabilities for the backup control shutdown path. Therefore, hardware failure probabilities for the backup control panel shutdown path were ignored in the calculation of CDF and LERF. The HEP total is approximately 0.1, which is above nominal equipment failure probabilities of the equipment used for safe shutdown. Equipment failure probabilities are included for the EHPM pump and hardened wetwell vent shutdown path.

As stated in the resolution for Facts and Observations (F&O) 7-16 in LAR Attachment V, given that the mean values of hardware failures and their associated uncertainties are small in comparison with those associated with the HFEs for MCR abandonment, this exclusion is deemed acceptable from an overall risk perspective.

PRA RAI 16

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a fire PRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a fire protection program consistent with NFPA-805. In a letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC Staff or acceptable methods that appear to have been applied differently than described require additional justification to allow the NRC staff to complete its review of the proposed method.

Section 4.1.4 of the BFN Detailed Fire Modeling Report indicates that reductions in 98th-percentile HRR of NUREG/CR-6850 for transient fires are credited. Identify all fire zones for which a reduction in the HRR below 317 kW for transient fires is credited. In addition, address the location-specific attributes and considerations, plant administrative controls, the results of a review of records related to violations of the transient combustible and hot work controls, and any other key factors used to justify a reduced HRR per the guidance endorsed by the June 21, 2012, memo from Joseph Giitter to Biff Bradley ("Recent Fire PRA Methods review Panel Decisions and EPRI 1022993, 'Evaluation of Peak Heat Release Rates in Electrical Cabinets Fires'"). If a reduced HRR cannot be justified using these guidance criteria, discuss the impact on the analysis.

RESPONSE:

Six fire compartments modeled in the Fire PRA use a reduced transient HRR for fire modeling. The transient HRR is reduced to 69kW in the following fire compartments:

- 05 (Electrical Board Room 1A and 250V Battery Rooms)
- 09 (Electrical Board Room 2A and 250V Battery Rooms)
- 16-A (CSR portions only)
- 16-K (Auxiliary Instrument Room No. 1)
- 16-M (Auxiliary Instrument Room No. 2)
- 16-O (Auxiliary Instrument Room No. 3)

LAR Attachment S, Table S-3, Implementation Item 45 states that the administrative control procedure for transient combustibles will be revised to strengthen risk and defense in depth concepts (e.g., no storage and no hot work designated areas). The TVA response to FPE RAI 09 (in the TVA letter dated January 14, 2014) discusses the administrative controls and the transient combustible controls for these fire compartments. These fire compartments are located in either the Reactor Building or the Control Building, which are both safety-related/critical areas that have strict combustible control requirements. These fire compartments are also low traffic areas which are usually unoccupied. The reduced traffic results in low probability of incidental transient combustibles; periodic housekeeping inspections are performed to control the amount of transient combustibles. The CSRs are also highly congested due to the cable tray layout, which would prevent transient combustibles from accumulating away from the entrance area.

Records identifying violations of hot work and transient combustible controls were reviewed for the period between September 2009 and December 2013. During this 52 month period, for the fire compartments using a 69kW reduced transient HRR, there were no Service Requests written for hot work control issues and four Service Requests were written for minor transient control issues, which are discussed below. The three Service Requests written in September 2013 were pre-existing conditions that were identified as a result of walkdowns primarily associated with the implementation of the commitments associated with these areas and discrepancies in the combustible loading calculation. They would not have been violations of the previous transient control procedures. None of the identified Service Requests resulted in a fire and the combustibles identified in the Service Requests would not result in a transient fire with a heat release rate exceeding 317 kW.

Service Requests Created for Transient Control Issues		
Service Request Date	**Fire Compartment**	**Description**
6/7/2013	16-A	Extension cord, sheets of absorption material and absorption rags
9/12/2013	16-A	Combustible loading calculation did not contain Spare SCBA face masks and SCBA units
9/19/2013	9	Personal Contamination Monitor staged in Electric Board Room 2A
9/25/2013	16-A	Battery chargers and cabling. These materials were removed from the combustible loading table prior to being removed from the field.

Other key factors which justify the use of a reduced HRR in these areas include:

- Large combustible liquid fires are not expected in these fire compartments because activities in the areas do not include maintenance of oil containing equipment.
- A transient fire in an area of strict combustible controls, where only small amounts of contained trash are considered possible, is judged to be no larger than the 75th percentile fire in an electrical cabinet with one bundle of qualified cable.
- The materials composing the fuel packages included in NUREG/CR-6850, Table G-7 (e.g., eucalyptus duff, one quart of acetone, 5.9 kilograms (kg) of methyl alcohol) are not representative of the typical materials expected to be located in these areas.
- A review of the transient ignition source tests in NUREG/CR-6850,Table G-7 indicates that of the type of transient fires that can be expected in these rooms (e.g., polyethylene trash can or bucket containing rags and paper) were measured at peak heat release rates of 50 kW or below.

Because only small quantities of trash in temporary containers can be expected in these fire compartments, a 69 kW peak heat release rate was determined to be appropriate to represent this quantity of combustibles. The 69 kW heat release rate bounds the small trash can fires reported in NUREG/CR-6850, Appendix G as well as the small combustibles identified in the Service Requests.

PRA RAI 17.a

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a fire PRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a fire protection program consistent with NFPA-805. In a letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff or acceptable methods that appear to have been applied differently than described require additional justification to allow the NRC staff to complete its review of the proposed method.

Describe how MCR modeling was performed. In doing so:

a. Explain the extent to which propagation of fires between adjacent cabinets in the MCR was evaluated, and provide justification for this level of treatment.

RESPONSE:

The cabinets within the control room were determined to be separated by a single wall, but the presence of wall penetrations or cables in direct contact with the separating wall could not be verified. NUREG/CR-6850, Appendix S allows assuming a 10-minute delay in fire propagation for cabinets with cables in direct contact with the wall and a 15-minute delay for cabinets without cables contacting the wall. Based on the unverified location cables within the cabinets, a delay of 10 minutes for fire propagation to adjacent cabinets was selected.

Following the methodology in NUREG/CR-6850, Appendix S, TVA assumed that fire propagation would be limited to the adjacent sections (i.e., directly next to the initiating section) only. Therefore, the maximum number of vertical sections to be affected is three (i.e., source plus one section on either side). Although there are single cabinet and double cabinet configurations within the MCRs, these scenario were not modeled as the three-cabinet scenario conservatively bounds these configurations.

PRA RAI 17.b

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a fire PRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a fire protection program consistent with NFPA-805. In a letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff or acceptable methods that appear to have been applied differently than described require additional justification to allow the NRC staff to complete its review of the proposed method.

Describe how MCR modeling was performed. In doing so:

b. Confirm the configurations of ignition sources and secondary targets/combustibles utilized to calculate MCR abandonment times appropriately bound the times for those fire scenarios not explicitly modeled.

RESPONSE:

Locations were selected both inside and outside of the MCR horseshoe for the electrical cabinet and transient fires. For the electrical fires, scenarios were conservatively selected such that the fire would spread to two additional adjacent cabinets based on the methodology of NUREG/CR-6850, Appendix S, bounding all possible electrical cabinet fire scenarios. The vertical cable tray risers exiting several of the electrical panels are enclosed and would not contribute to the total heat release rate. For transient fires, locations were conservatively selected near the main control boards in close proximity to where the operators are stationed. The fire locations were selected in order to reasonably bound a fire scenario at any location within the MCRs.

Cable trays are located in the interstitial space above the polycarbonate ceiling and could also serve as secondary combustibles. It is possible for one of the enclosed vertical cable trays exiting an electrical cabinet to subsequently ignite horizontal cable trays in the interstitial space via flame spread. However, heat and smoke released from the ignited cable trays in the interstitial space would accumulate only in the interstitial space and negligibly affect MCR abandonment times; therefore, cable tray fires have not been modeled in the FDS abandonment scenarios. Any involvement of other secondary combustibles in the area (e.g., papers, chairs) is negligible and bounded by the transient analysis, which considered all 15 heat release Bins for transient fires as provided in NUREG/CR-6850, Appendix E.

The polycarbonate ceiling has been evaluated as a secondary combustible as described in the TVA response to FM RAI 01.i.i in this enclosure. The results of the analysis determined a negligible effect on the calculated time to abandonment. The electrical and transient fires considered in the abandonment analysis have been further evaluated as described in the TVA responses to FM RAIs 01i.v and 01i.viii (in the TVA letter dated December 20, 2013) and FM RAI 01.i.vii (in the TVA letter dated January 10, 2014).

Therefore, the configuration of ignition sources and secondary targets/combustibles utilized to calculate MCR abandonment times appropriately bound times for those fire scenarios not explicitly modeled.

PRA RAI 17.c

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a fire PRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a fire protection program consistent with NFPA-805. In a letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff or acceptable methods that appear to have been applied differently than described require additional justification to allow the NRC staff to complete its review of the proposed method.

Describe how MCR modeling was performed. In doing so:

c. Provide a quantitative justification that the method utilized to apportion transient fire frequency bounds MCR risk associated with transient fires. Section 8.3 of the MCR analysis indicates that transient fire frequency was arbitrarily apportioned by the number of transient fire scenarios postulated within the MCR. This approach does not appear to address the risk significance of impacted targets (e.g., pinch points) and may underestimate MCR risk.

RESPONSE:

Transient fires were postulated to occur adjacent to all risk significant electrical cabinets and MCBs. For transient fires affecting MCBs, the target sets are similar to the target sets for the MCB scenarios. MCB scenarios were only created if they were determined to be risk significant. For transient fires affecting electrical cabinets, the target sets are similar to the electrical cabinet scenarios, except that the target set may include additional cabinets due to the transient fires being located at pinch points causing damage to multiple cabinets. To create bounding fire scenarios, the transients were placed so that the fire would damage the largest number of risk significant targets. The total transient frequencies for the MCRs were evenly apportioned to each of these risk significant transient scenarios, which ensures that potential damage from transients in the control rooms are bounded and fully characterized. Because transient fires were postulated at all risk significant targets (e.g., pinch points) and the total transient frequencies were apportioned evenly among the transient scenarios, the MCR risk is appropriately quantified.

PRA RAI 17.d

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a fire PRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a fire protection program consistent with NFPA-805. In a letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff or acceptable methods that appear to have been applied differently than described require additional justification to allow the NRC staff to complete its review of the proposed method.

Describe how MCR modeling was performed. In doing so:

d. Justify the apportionment of fire frequencies to cable trays within the MCR. Section 9.4 of the MCR analysis indicates that frequency is apportioned by tray length and not weight or combustible loading as suggested by NUREG/CR-6850.

RESPONSE:

The two types of cable fire scenarios considered in the MCRs were Bin 5, cable fires caused by welding and cutting (i.e., Bin 5 scenarios) and Bin 12, self-ignited cable fires (i.e., Bin 12 scenarios). Fire Compartment 16-A consists of the MCRs and the CSRs. With the cable tray fire frequency apportioned by tray length, the MCRs are 6.69% of the cable fire frequency for Fire Compartment 16-A. Using the cable weighting, or combustible loading, approach suggested by NUREG/CR-6850, the cable fire frequency for the MCRs are 10.1% of the total cable fire frequency of Fire Compartment 16-A. TVA acknowledges that the resulting fire ignition frequency for cable fires in the MCRs using the guidance of NUREG/CR-6850 is higher than the method TVA utilized. However, in the BFN analysis, the cable fire scenarios were divided up by unit and conservatively assumed damage to all cable trays located in that unit's MCR. The current guidance in the NRC-approved PRA FAQ 13-0005 limits damage from cable fires to the raceway of origin, not all the cable trays located in the MCRs, as was assumed in the BFN analysis. Therefore, using the methodology of failing all cables in each unit to analyze the cable fire scenarios in the MCRs is conservative and more than offsets any potential non-conservatism in the ignition frequency apportionment.

Based on historical data of cable fires in U.S. nuclear power plants, a more realistic methodology has been approved by PRA FAQ 13-0005 for self-ignited and hot work-initiated cable fires. Using the methodology in PRA FAQ 13-0005 significantly reduces the risk impact from cable fire scenarios. In addition, all cable trays were conservatively assumed to result in self-ignited cable fires, without analyzing the specific cables contained in each cable tray. Based on industry guidance, some trays do not have the potential to create self-ignited cable tray fires. For instance, self-ignited non-power cable fire scenarios do not need to be considered because of an extremely low probability of occurrence and many cable trays in the MCRs do not contain power cables. Also, based on NUREG/CR-6850, Appendix R, self-ignited cable fires should be postulated in cable trays with unqualified cables only or a mix of qualified and unqualified cables. It is likely that some cable trays within the MCRs do not contain unqualified cables and therefore self-ignited cable fires would not need to be postulated for these trays.

In conclusion, even though TVA uses a different approach for apportionment of cable tray fire frequency than is suggested in NUREG/CR-6850, the cable fire scenarios analyzed in the MCR analysis conservatively quantify the risk represented by cable fire scenarios in the MCRs.

PRA RAI 17.e

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a fire PRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a fire protection program consistent with NFPA-805. In a letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC staff or acceptable methods that appear to have been applied differently than described require additional justification to allow the NRC staff to complete its review of the proposed method.

Describe how MCR modeling was performed. In doing so:

e. Discuss how multi-unit impacts are addressed (e.g., abandonment, fire-induced failures, etc.).

RESPONSE:

Multi-unit effects were addressed in the MCR modeling as follows:

- Main Control Room Fire Scenarios – Each MCR scenario was quantified for each unit in the Fire PRA model. This ensures that no risk significant scenarios are omitted. A number of the control board scenarios have shared features such as the Unit 0 control board located in the Units 1 and 2 MCR. These MCB scenarios contain targets that affect controls for multiple units.
- Habitability Abandonment – The Units 1 and 2 control rooms make up one large room, whereas Unit 3 has its own control room. The control room abandonment times were calculated for the combined MCR for Units 1 and 2, which has a larger volume leading to longer abandonment times than Unit 3.
- Functionality Abandonment – Functionality abandonment occurs when the fire damage alone in a scenario leaves no available safe shutdown success path for the affected unit. These scenarios assumed that operators would abandon the control room and use ex-control room alternative shutdown procedures. In order to identify those scenarios which result in this level of equipment damage, each scenario in the affected fire compartments for each unit was evaluated without crediting the EHPM pump modification; if the resulting cutsets based on review showed no safe shutdown path was available then the use of alternative shutdown would be required.
- Shared Systems - There are a number of shared systems at BFN, such as plant air, raw cooling water, RHR, Service Water (SW), Emergency Equipment Cooling Water (EECW), and electrical power. These shared systems are directly modeled in the Fire PRA Computer Aided Fault Tree Analysis (CAFTA) to invoke multi-unit initiators and system failures. These events generally involve degradation or loss of support systems that are common to each unit. Therefore, the system-by-system analysis for plant-specific failures includes consideration of the effects of system degradation on the other units.

ENCLOSURE 2

Tennessee Valley Authority

Browns Ferry Nuclear Plant, Units 1, 2, and 3

Updated TVA Response to NRC Request for Additional Information PRA 19, Part b

TVA previously responded to PRA RAI 19, part b, in a letter dated January 10, 2014 (CNL 14-001). Subsequent to the submittal of the response, TVA noted an error in one of the values presented in the Table providing the risk significant fire scenarios in Fire Area (FA) 08 for the Unit 1, 2 and 3 compliant Fire PRA models. Specifically, the Ignition Frequency was listed as 6.07E-06 when it should have been 6.07E-04. The below response supersedes the previous response for PRA RAI 19, part b. The change from the previous response is shown with deleted text struck through, inserted text in bold, underline, and a revision bar to the right.

RESPONSE

Part b

Summarized below are the top few risk significant scenarios for risk significant fire areas in the compliant case. In each scenario in the compliant case, basic events associated with VFDRs on the credited train in NSCA have been removed from being failed by the fire. The core damage and large early release scenarios described here are the results of:

- Fire-induced failures (with the exception of those associated with the credited train).
- Random failures of the credited train.

The following discussion of the risk significant scenarios in FA 16 applies to BFN Units 1, 2, and 3:

Unit	**Scenario**	**IGF (Ignition Frequency)**	**CCDP (Conditional Core Damage Probability)**	**CDF (Core Damage Frequency)**
Unit 1	16-K.023-CAB-SUP	8.31E-05	9.64E-02	8.00E-06
Unit 1	16-K.024-CAB-SUP	8.31E-05	9.64E-02	8.00E-06
Unit 2	16-M.022-CAB-SUP	8.31E-05	9.64E-02	8.00E-06
Unit 2	16-M.023-CAB-SUP	8.31E-05	9.64E-02	8.00E-06
Unit 3	16-O.025-CAB-SUP	8.31E-05	9.64E-02	8.00E-06

Unit 3	16-O.024-CAB-SUP	8.31E-05	9.64E-02	8.00E-06

The risk in FA 16 is dominated by fire scenarios that are modeled as control room abandonment scenarios. The core damage risk for control room abandonment is modeled as the set of operator actions required in the main control room prior to transferring command and control to the backup control panel, and the set of actions that need to occur at the backup control panel (i.e., panel 25-32) and locally to utilize the RCIC and LPCI Systems with control of SRVs. In the compliant case, the local actions that need to occur outside of the primary control station are considered as occurring at the primary control station or to be completely successful (i.e., are not required) for safe shutdown, and do not contribute to the risk of the compliant plant.

The following discussion applies to the risk significant fire scenarios in FA 03-03 for the Unit 1, 2 and 3 compliant Fire PRA models:

Unit	**Scenario**	**IGF**	**CCDP**	**CDF**
Unit 1	03-03.4001-C	1.31E-04	1.13E-01	1.48E-05
Unit 1	03-03.3000-T-3-G-2	3.62E-05	1.13E-01	4.10E-06
Unit 2	03-03.4001-C	1.31E-04	1.13E-01	1.48E-05
Unit 2	03-03.3000-T-3-G-2	3.62E-05	1.13E-01	4.10E-06
Unit 3	03-03.4001-C	1.31E-04	1.25E-01	1.64E-05

The fire scenarios result in accident sequence GTRAN-5A, which is a general transient sequence. Accident sequence GTRAN-5A is an isolation accident (Power Conversion System not credited in the Fire PRA) with successful early high pressure injection from either the HPCI or RCIC Systems. Long term high pressure injection from the HPCI or RCIC System, or early suppression pool cooling fails, and Control Rod Drive (CRD) System fails (not credited in the Fire PRA). Manual depressurization with two SRVs at Heat Capacity Temperature Limit (HCTL) about four hours after the scram is successful and subsequent low pressure injection with either the RHR or Core Spray (CS) System fails.

In these fire scenarios, the SPC, LPCI, and CS Systems are failed due to loss of the Emergency Equipment Cooling Water (EECW) System to both RHR and CS Room Coolers. Both loops of the RHR System are failed due to a combination of fire induced and random failure of loss of power supplies to EECW pumps and failure of the pumps themselves. Of--site power is failed due to the fire; EECW Pumps A3 and C3 are failed due to the fire, and random failure to run of DG C which supplies power to EECW Pump B3 results in the loss of EECW. The loss of the EECW System results in the loss of the NSCA credited path for Units 1 (LPCI Pump 1A), 2 (LPCI Pump 2D), and 3 (LPCI Pump 3B).

Core damage is caused by loss of injection and the RPV is at low pressure.

The following discussion applies to the risk significant fire scenarios in Fire Area 03-03 for the Unit 3 compliant Fire PRA model:

Unit	**Scenario**	**IGF**	**CCDP**	**CDF**
Unit 3	03-03.022-BCHG-2	7.46E-05	1.05E-01	7.82E-06

The fire scenario results in accident sequence GTRAN-7, which is a general transient sequence. Accident sequence GTRAN-7 is an isolation accident (PCS not credited in the Fire PRA) with all high pressure injection failed immediately after scram. Depressurization with two SRVs is successful. Low pressure injection from the RHR or CS System is successful but must be initiated within 30 minutes. Suppression pool cooling fails but decay heat removal with drywell sprays or the primary containment vent is successful. Without SPC, the Primary Containment Pressure Limit is reached in approximately 10 hours. The successful vent fails the RHR and CS Systems due to inadequate net positive suction head (NPSH). Drywell (DW) spray is not successful and late (post vent) low pressure injection from the CRD System (not credited in the Fire PRA), condensate, RHRSW, SDC, CS from CST, and RHR from CST fails. Core damage is caused by loss of injection and the RPV is at low pressure.

In this fire scenario, all high pressure injection is failed due to the fire affecting the HPCI steam supply valves, HPCI instrumentation, and HPCI suction and discharge valves. The RCIC System is failed due to the fire affecting the RCIC steam supply valves and instrumentation.

SPC Loop II is failed due to the fire affecting the RHR Pump D and the fire affecting the RHRSW Pumps B1 and off-site power failure in addition to random failure of DG C power supply for RHRSW Pump B2 for RHR Heat Exchanger B cooling. The loss of RHR Heat Exchanger B cooling results in the loss of the NSCA credited LPCI path using RHR Pump 3B. SPC Loop I is failed due to the fire affecting the beakers that supply Reactor Motor Operated Valve (RMOV) Board 3D. This also results in the loss of Loop I SDC and RHRSW injection, and LPCI from CST.

The following discussion applies to the risk significant fire scenarios in FA 08 for the Unit 1, 2 and 3 compliant Fire PRA models:

Unit	**Scenario**	**IGF**	**CCDP**	**CDF**
Unit 1	08.001-CAB	6.07E-~~06~~**04**	2.90E-02	1.76E-05
Unit 2	08.001-CAB	6.07E-~~06~~**04**	3.59E-02	2.18E-05
Unit 3	08.001-CAB	6.07E-~~06~~**04**	2.77E-02	1.68E-05

The fire scenarios result in accident sequence GTRAN-5A, which is a general transient sequence. Accident sequence GTRAN-5A is an isolation accident (i.e., PCS not credited in the Fire PRA) with successful early high pressure injection from either the HPCI or RCIC System. Long term high pressure injection from the HPCI or RCIC System, or early suppression pool cooling fails, and the CRD System fails (not credited in the Fire PRA). Manual depressurization with two SRVs at HCTL about four hours after the scram is successful and subsequent low pressure injection with either the RHR or CS System fails.

In this fire scenario, Loop II of SPC, LPCI, and CS for Units 1 and 2 are failed due to the fire affecting the RHR Pumps B, D, and associated valves. Loop I for Unit 3 is lost due to the fire affecting the power from 4 kV Shutdown Board C and D to EECW Pumps B3 and D3, which supply RHR and CS Room Coolers. The credited NSCA path for Units 1 and 2 (RHR Pumps 1A and 2C) and the path for Unit 3 (RHR Pump 3B) is lost due to the loss RHR Room cooling of the credited Loop. Room cooling is failed due to a combination of fire induced and random failure. Specifically room cooling to Loop I for Units 1 (LPCI Pump 1A) and 2 (LPCI Pump 2C) and Loop II for Unit 3 (LPCI Pump 3B) is lost due to test and maintenance unavailability of EECW Pump A3 or C3 (i.e., one of the two NSCA credited and required EECW pumps).

Core damage is caused by loss of injection and the RPV is at low pressure.

ENCLOSURE 3

Tennessee Valley Authority

Browns Ferry Nuclear Plant, Units 1, 2, and 3

Summary of BFN NFPA 805 RAI Response Dates

RAI Question Number	Type of Response (days)	Actual Date of Response
Fire Protection Engineering (FPE)		
FPE 01	60	CNL-13-141 December 20, 2013
FPE 02	60	CNL-13-141 December 20, 2013
FPE 03	60	CNL-14-001 January 10, 2014
FPE 04	60	CNL-14-001 January 10, 2014
FPE 05	60	CNL-14-001 January 10, 2014
FPE 06	60	CNL-13-141 December 20, 2013

RAI Question Number	Type of Response (days)	Actual Date of Response
FPE 07	60	CNL-13-141 December 20, 2013
FPE 08	60	CNL-14-006 January 14, 2014
FPE 09	60	CNL-14-006 January 14, 2014
FPE 10	90 (extended to 120 days per electronic mail from NRC to TVA, dated February 6, 2014)	Future letter
FPE 11	90 (extended to 120 days per electronic mail from NRC to TVA, dated February 6, 2014)	Future letter
FPE 12	90 (extended to 120 days per electronic mail from NRC to TVA, dated February 6, 2014)	Future letter
FPE 13	120	Future letter
Safe Shutdown Analysis (SSA)		
SSA 01	60	CNL-13-141 December 20, 2013

RAI Question Number	Type of Response (days)	Actual Date of Response
SSA 02	60	CNL-14-006 January 14, 2014
SSA 03	60	CNL-14-006 January 14, 2014
SSA 04	60	CNL-13-141 December 20, 2013
SSA 05	60	CNL-14-001 January 10, 2014
SSA 06	60	CNL-14-006 January 14, 2014
SSA 07	60	CNL-14-001 January 10, 2014
SSA 08	60	CNL-13-141 December 20, 2013
SSA 09	60	CNL-14-006 January 14, 2014
SSA 10	60	CNL-14-006 January 14, 2014
SSA 11	60	CNL-13-141 December 20, 2013

RAI Question Number	Type of Response (days)	Actual Date of Response
SSA 12	60	CNL-13-141 December 20, 2013
SSA 13	60	CNL-14-006 January 14, 2014
SSA 14	60	CNL-13-141 December 20, 2013
SSA 15	60	CNL-14-006 January 14, 2014
Programmatic (PROG)		
PROG 01	60	CNL-13-141 December 20, 2013
PROG 02	60	CNL-13-141 December 20, 2013
Fire Modeling (FM)		
FM 01, part a	90	CNL-14-020 February 13, 2014
FM 01, part b.i	60	CNL-13-141 December 20, 2013

RAI Question Number	Type of Response (days)	Actual Date of Response
FM-01, part b.ii	60	CNL-13-141 December 20, 2013
FM-01, part b.iii	90	CNL-14-001 January 10, 2014
FM 01, part c	60	CNL-14-006 January 14, 2014
FM 01, part d.i	60	CNL-14-001 January 10, 2014
FM-01, part d.ii	90	CNL-14-001 January 10, 2014
FM 01, part e	60	CNL-13-141 December 20, 2013
FM 01, part f	60	CNL-14-001 January 10, 2014
FM 01, part g	90	CNL-14-020 February 13, 2014
FM 01, part h.i	60	CNL-14-001 January 10, 2014

RAI Question Number	Type of Response (days)	Actual Date of Response
FM 01, part h.ii	60	CNL-14-001 January 10, 2014
FM 01, part h.iii	90	CNL-14-020 February 13, 2014
FM 01, part i.i	120	CNL-14-020 February 13, 2014
FM 01, part i.ii	60	CNL-13-141 December 20, 2013
FM 01, part i.iii	90	CNL-14-001 January 10, 2014
FM 01, part i.iv	120	Future letter
FM 01, part i.v	60	CNL-13-141 December 20, 2013
FM 01, part i.vi	60	CNL-13-141 December 20, 2013
FM 01, part i.vii	90	CNL-14-001 January 10, 2014
FM 01, part i.viii	60	CNL-13-141 December 20, 2013

RAI Question Number	Type of Response (days)	Actual Date of Response
FM 01, part j.i	60	CNL-13-141 December 20, 2013
FM 01, part j.ii	90	CNL-14-001 January 10, 2014
FM 02, part a	120	Future letter
FM 02, part b	120	Future letter
FM 02, part c	60	CNL-13-141 December 20, 2013
FM 02, part d	60	CNL-13-141 December 20, 2013
FM 02, part e	90	CNL-14-020 February 13, 2014
FM 03	60	CNL-14-001 January 10, 2014
FM 04	90	CNL-14-020 February 13, 2014
FM 05	60	CNL-14-001 January 10, 2014

RAI Question Number	Type of Response (days)	Actual Date of Response
FM 06	60	CNL-14-001 January 10, 2014
Probabilistic Risk Assessment (PRA)		
PRA 01, part a	60	CNL-14-001 January 10, 2014
PRA 01, part b	60	CNL-14-006 January 14, 2014
PRA 01, part c	90	CNL-14-001 January 10, 2014
PRA 01, part d	90	CNL-14-020 February 13, 2014
PRA 01, part e	120	CNL-14-020 February 13, 2014
PRA 01, part f	120	Future letter
PRA 01, part g	60	CNL-14-001 January 10, 2014
PRA 01, part h	90	CNL-14-020 February 13, 2014

RAI Question Number	Type of Response (days)	Actual Date of Response
PRA 01, part i	60	CNL-13-141 December 20, 2013
PRA 01, part j	60	CNL-14-006 January 14, 2014
PRA 01, part k	60	CNL-14-001 January 10, 2014
PRA 01, part l	60	CNL-14-006 January 14, 2014
PRA 01, part m	60	CNL-14-001 January 10, 2014
PRA 01, part n	60	CNL-14-001 January 10, 2014
PRA 01, part o	120	Future letter
PRA 01, part p	90	CNL-14-020 February 13, 2014
PRA 01, part q	60	CNL-13-141 December 20, 2013
PRA 01, part r	60	CNL-13-141 December 20, 2013

RAI Question Number	Type of Response (days)	Actual Date of Response
PRA 01, part s	90	CNL-14-020 February 13, 2014
PRA 01, part t	60	CNL-14-001 January 10, 2014
PRA 01, part u	60	CNL-13-141 December 20, 2013
PRA 01, part v	120	Future letter
PRA 02	60	CNL-14-001 January 10, 2014
PRA 03	60	CNL-13-141 December 20, 2013
PRA 04	90	CNL-14-020 February 13, 2014
PRA 05	60 (extended to 120 days per electronic mail from NRC to TVA, dated January 9, 2014)	Future letter
PRA 06	60	CNL-14-001 January 10, 2014

RAI Question Number	Type of Response (days)	Actual Date of Response
PRA 07	60	CNL-14-006 January 14, 2014
PRA 08	60	CNL-14-001 January 10, 2014
PRA 09	60	CNL-14-001 January 10, 2014
PRA 10	90 (extended to 120 days per electronic mail from NRC to TVA, dated February 6, 2014)	Future letter
PRA 11	60	CNL-14-006 January 14, 2014
PRA 12	120	Future letter
PRA 13	60	CNL-14-006 January 14, 2014
PRA 14	60	CNL-14-001 January 10, 2014
PRA 15	90 (extended to 120 days per electronic mail from NRC to TVA, dated February 6, 2014)	Future letter

RAI Question Number	Type of Response (days)	Actual Date of Response
PRA 16	90	CNL-14-020 February 13, 2014
PRA 17	90	CNL-14-020 February 13, 2014
PRA 18	60	CNL-14-001 January 10, 2014
PRA 19	60	CNL-14-001 January 10, 2014
PRA 20	120	Future letter
PRA 21	60	CNL-14-001 January 10, 2014
PRA 22	60	CNL-13-141 December 20, 2013

RAI Question Number	Type of Response (days)	Actual Date of Response
PRA 23	60 (Part d extended to 120 days per electronic mail from NRC to TVA, dated January 9, 2014)	Parts c, f, i, and l: CNL-14-001 January 10, 2014 Parts a, b, e, g, h, j, and k: CNL-14-006 January 14, 2014 Part d: Future letter
Radioactive Release (RR)		
RR 01	60 (extended to 120 days per electronic mail from NRC to TVA, dated January 9, 2014)	Future letter
RR 02	60 (extended to 120 days per electronic mail from NRC to TVA, dated January 9, 2014)	Future letter