Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

CNL-13-141

December 20, 2013

10 CFR 50.90

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 1**

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)

A006
NRR

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 (NFPA) Standard 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 varied from 60 days to 120 days.

Enclosure 1 provides the first set of TVA responses to some of the requests for additional information (RAIs) identified in the Reference 3 letter. As stated in the Reference 3 letter, these responses are nominal 60 day responses and are due by January 14, 2014. In addition, Enclosure 2 provides a listing of all RAIs listed in the Reference 3 letter and the actual 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 20th day of December 2013.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosures:

1. TVA Responses to NRC Request for Additional Information: Set 1 (nominal 60-day)
2. 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 1 (nominal 60-day)

FPE RAI 01

License Amendment Request (LAR) (Agencywide Documents Access and Management System (ADAMS) Accession Number ML13092A392), Attachment A, Table B-1, Section 3.3.6, Roofs, indicates that testing for a Class I Factory Mutual rating is equivalent to testing for a Class A National Fire Protection Association (NFPA) 256, "Standard Methods of Fire Tests of Roof Coverings," rating. Provide technical justification for this equivalency statement.

RESPONSE:

NFPA 256 was withdrawn at the 2008 annual NFPA meeting because the material is listed in American Society for Testing and Materials (ASTM) E 108 and Underwriters Laboratories (UL) 790. ASTM E 108 specifies performance requirements for roof coverings under simulated fire originating outside the building. The Factory Mutual (FM) Approval Standard Class Number 4470, "Approval Standard for Single-Ply, Polymer-Modified Bitumen Sheet, Built-Up Roof (BUR) and Liquid Applied Roof Assemblies for use in Class 1 and Noncombustible Roof Deck Construction," specifies performance requirements for built-up roofs, which includes all components necessary for installation of the roof assembly, not just the roof coverings. The FM Approval Standard also requires the roof assembly to exhibit low fire spread both above and below the roof, unlike ASTM E 108 which only tests for fires originating outside the building. For the combustibility test above the roof assembly, the FM Approval Standard references the ASTM E 108 fire test as the test method, and places further restrictions on the flame spread test over the ASTM E 108 fire test (i.e., that the flame shall not be allowed to spread to more than two lateral edges of the exposed roof covering beyond 12 inches from the ignition source).

The FM Approval Standard 4470 fully encompasses ASTM E 108 and places further testing requirements on the full roof assembly. Therefore, FM Approval Standard 4470 is equivalent to Class A of ASTM E 108 (i.e., formerly NFPA 256).

FPE RAI 02

LAR Attachment A, Section 3.4.1(c) indicated "complies" using the exception for the incident commander and at least two brigade members having sufficient training and knowledge of nuclear safety systems to understand the effects of fire and fire suppressants on nuclear safety systems. Provide the details of the minimum "training and knowledge" the incident commander receives. For example, identify whether the incident commander will be a licensed or non-licensed operator. Describe how the incident commander is expected to function with the fire brigade.

RESPONSE:

Incident Commander Training and Knowledge

The Incident Commander (IC) is a member of the Operations Department that responds to all emergencies in the plant operating areas to evaluate and advise the Fire Brigade Leader (FBL) on firefighting activities affecting Safe Shutdown equipment and other nuclear safety systems. The IC is competent to assess the potential safety consequences of a fire and advise the control room personnel. The Fire Protection Program (FPP) requires the IC to either have an operator's license (i.e., senior operator or operator) or possess equivalent knowledge of plant nuclear safety systems. Therefore, the IC can either be a licensed operator or a non-licensed individual, depending on their qualification and training.

The IC has sufficient training in and knowledge of nuclear safety systems to understand the potential safety consequences of a fire and fire suppressants on safe shutdown equipment. The qualification of the IC is in accordance with the site specific Fire Protection Reports (FPRs).

Incident Commander Function with the Fire Brigade

The IC functions with the fire brigade in the following manner:

- Shall respond to all emergencies in plant operating areas.
- Will be involved in the establishment of a command post.
- Will be involved in the direction of the activities of the fire brigade members.
- Will coordinate support groups.
- Will evaluate and advise the FBL on firefighting activities affecting safe shutdown equipment and other plant operating equipment.
- Will keep in communications with the Shift Manager (SM) or designee to ensure they are aware of the emergency situation.
- Will direct the actions necessary per plant fire response and fire interaction procedures, including coordinating changes to ventilation system alignment through the Control Room.
- Will attend all fire drills occurring during an assigned shift.
- Will request SM to call in off-site support as needed.
- Will establish and utilize the components of the National Incident Management System when an event escalates beyond the abilities of the onsite emergency response team.

FPE RAI 06

The NRC staff noted that 1-hour rated fire wrap is used for exclusion of intervening combustibles within 20 foot separation zones. Describe how this fire protection feature was transitioned to the new risk informed, performance-based (RI/PB) fire protection program (FPP).

RESPONSE:

The instances of one-hour fire wrap (i.e., Thermo-Lag) described in the Brown's Ferry Nuclear Plant (BFN) Fire Protection Report, Volume 1, Part 3, Section 9.0.d.2 will remain in place post-transition to Title 10 of the Code of Federal Regulations (10 CFR), Part 50.48(c) NFPA 805, will be credited for separation as stated in Attachment C, Table C-1 of the LAR, and will be counted as intervening combustibles in the 20 foot separation zones. These intervening combustibles are identified in an exemption request approved by the Nuclear Regulatory Commission (NRC) in a Safety Evaluation dated March 29, 2007; this exemption will be transitioned into the NFPA 805 program as stated in the LAR Section 4.2.3 and Attachment K.

FPE RAI 07

The NRC staff noted that the plant FTP documents describe all 1-hour rated fire wrap as Thermo-Lag. Identify all the different ERFBSs (e.g., 3-M, Hemyc, etc.) in the NFPA Standard 805, "Performance-Based Standard for Fire Protection for Light-Water Reactor Electric Generating Plants" (NFPA 805), 2001 Edition, post-transition configurations.

RESPONSE:

All credited Electrical Raceway Fire Barrier Systems (ERFBS) for the post-transition plant configuration are Thermo-Lag. Table 9.3.11.H of the FPR lists the currently installed ERFBS, all of which utilize Thermo-Lag 330-1.

The current plan for the NFPA 805 transition ERFBS modifications is to utilize Thermo-Lag as the one-hour barrier for wrapping cables, conduits, and junction boxes. This includes LAR Table S-2, Modification Items 14, 17, 42, 46, 57, 65, 67, 74, 87, 91, and 92. Design Changes (DCNs) 707462 and 70492 have been issued for Modification Items 14 and 17, respectively. Both specify using Thermo-Lag 330-1 as the ERFBS.

SSA RAI 01

LAR Section 4.2.1.1 identifies that a "representative population" of motor operated valves (MOVs) was evaluated to address potential pressure boundary concerns in a technical report entitled, "NFPA 805 MOV Stall Thrust Pressure Boundary Evaluation," reviewed during the on-site audit. Explain how the failure mode was evaluated in the FPRA. Provide a list of those MOVs that may be susceptible to Information Notice (IN) 92-18, "Potential for Loss of Remote Shutdown Capability During a Control Room Fire," failure, and also may be required to be operated as a recovery action (RA). Describe the methods by which operator feasibility was resolved for those susceptible to IN 92-18 failure mode.

RESPONSE:

LAR Section 4.2.1.1 summarized the results of the relevant technical report, "NFPA 805 MOV Stall Thrust Pressure Boundary Evaluation." As stated in LAR Section 4.2.1.1, the technical report concluded that no pressure boundary failures would occur as a result of potential IN 92-18 events. Therefore, this failure mode is not modeled in the Fire Probabilistic Risk Assessment (Fire PRA).

As stated in NEI 00-01, "Guidance for Post Fire Safe Shutdown Circuit Analysis," Revision 2, Section 3.5.1.1, "A hot short in the control circuitry for an MOV can bypass the MOV protective devices, i.e., torque and limit switches. This is the condition described in NRC Information Notice 92-18. In this condition, the potential exists to damage the MOV motor and/or valve. Damage to the MOV could result in an inability to operate the MOV either remotely, using separate controls with separate power, or manually using the MOV hand wheel." For MOVs, the possibility of an IN 92-18 failure (i.e., cable damage which bypasses the motor operator torque/limit switches) was considered as part of the feasibility evaluation. Any recovery action involving the positioning of an MOV subject to such IN 92-18 cable damage in a given fire scenario was considered to be not feasible for that scenario. Therefore, no analysis credit was taken for repositioning an MOV in any fire scenario where the MOV may be subject to the IN 92-18 failure mode.

SSA RAI 04

LAR Attachment B, Table B-2, Section 3.5.2.3 "Circuit Failures Due to Hot Short," identifies that treatment of hot shorts on ungrounded circuits "aligns with intent" of Nuclear Energy Institute (NEI) 00-01, "Guidance for Post Fire Safe Shutdown Circuit Analysis," Revision 1. The LAR states that "two types of cable hot short conditions are considered to be of sufficiently low likelihood that they are not assumed credible, except for analysis involving high/low pressure interface components in accordance with NEI 00-01." These hot short exceptions are 3 phase alternating current power circuit cable-to-cable proper phase sequence faults and 2-wire ungrounded direct current (DC) circuit cable-to-cable proper polarity faults. Provide a more detailed justification for this deviation from the guidance of NEI 00-01, Rev 1.

RESPONSE:

NEI 00-01, Revision 1, Section 3.5.2.3, "Circuit Failures Due to Hot Short," provides guidance for analyzing the effects of a hot short on circuits for required safe shutdown equipment. This section includes an example of a typical ungrounded control circuit. However, Section 3.5.2.3 does not discuss the circuit failures excluded from deterministic analysis allowed in NEI 00-01, Revision 1, Appendix B. The "aligns with intent" statement in LAR Attachment B, Table B-2, Section 3.5.2.3, was made to clarify that hot short circuit failure exclusions are not discussed in Section 3.5.2.3 but, are included in NEI 00-01, Revision 1, Appendix B.

In accordance with NEI 00-01, Revision 1, Appendix B.1, "Justification for the Elimination of Multi-Conductor Hot Short Involving Power Cables," for a three-phase alternating current (AC) power cable, the potential for a fire to cause a hot short on all three phases in the proper sequence to that results in a spurious operation is highly unlikely for the following reasons:

- The aggressor cable would need to be a 3-phase power cable in the same raceway
- The aggressor cable would need to be energized
- The overcurrent protection device for the aggressor circuit would need to be set sufficiently high to ensure the valve motor starting current would not trip the breaker when the valve motor initially started running
- Both the aggressor and target power cables would need to have the cable insulation fail to hot short the three phase conductors without them shorting to each other or shorting to ground
- The aggressor cable would need to short to the target cable in the exact sequence necessary for the valve to operate to the undesired position

Similar arguments may be used to demonstrate the implausibility of consequential hot shorts on a direct current (DC) reversing motor of a motor operated valve.

- A typical reversing DC compound motor power circuit uses five conductors and must energize a series field, a shunt field, and an armature for the motor to operate. The polarity of the armature determines the direction of the motor. For this type of motor, two specific conductors of the power cable would require a hot short from an aggressor cable (of the same and correct polarity).
- A conductor-to-conductor short must occur between two other specific conductors of the power cable, in order to bypass the Open or Close contactor.
- The power fuses for the affected valve must remain intact to provide an electrical return path.
- An additional hot short of the opposite polarity would be required to cause valve operation if the power fuses were blown by the faults.

The likelihood of all of these faults occurring, without grounding (i.e., causing fuses of the aggressor, or target circuits to blow), is very low. Additionally, there are far fewer DC power cables in a plant, and even fewer, if any, continually running DC loads in the plant to serve as aggressors, making the possibility of consequential hot shorts in DC power cables for compound motors as implausible as three-phase consequential hot shorts.

NEI 00-01 Revision 2, Table B.1-0, carries forward the determination that 3-phase AC hot shorts and proper polarity DC motor hot shorts are only required to be considered for high/low pressure interfaces.

Therefore, considering hot shorts for 3-phase AC power circuit cable-to-cable proper phase sequence faults and 2-wire ungrounded DC motor power cable-to-cable proper polarity faults only for high/low pressure interfaces is justified.

RAI SSA 08.a

LAR Attachment D describes the methods and results for non-power operations (NPO) transition. Provide the following additional information:

a) At a high level, identify and describe the changes to outage management procedures, risk management tools, and any other documents resulting from incorporation of key safety functions identified as part of NFPA 805 transition for NPO for high risk periods. Include changes to any administrative procedures such as control of combustibles, hot work, fire system operability, staffing, and ignition sources.

RESPONSE:

As part of the NFPA 805 amendment implementation, Tennessee Valley Authority (TVA) will revise fleet level shutdown risk management procedures and associated site specific procedures for managing risk during non-power operations. These documents will provide departments and organizations that plan outage related work with shutdown and risk management guidance that include:

- Definition and criteria for specifying Higher Risk Evolutions (HREs).
- Identification of Key Safety Functions (KSFs) affected by fire damage or removal of credited equipment from service.
- Proposed options to reduce fire risk in those locations where fire can result in loss of one or more KSFs during HREs. These would include:
    - Pre-positioning of a component during higher risk evolutions to ensure the component is in its required position for NPO KSF success (this may also require power disabling the component to prevent spurious operation once it is placed in its desired position).
    - Restriction of hot work in areas during periods of increased vulnerability.
    - Restriction of combustible loading.
    - Restriction of transient combustible materials in areas during periods of increased vulnerability.
    - Provision of additional fire rounds at periodic intervals or other appropriate compensatory measures (such as surveillance cameras during increased vulnerability).
    - Reschedule the work to a period with a lower risk or higher Defense in Depth.
    - Housekeeping.
    - Presence of functional fire detection and suppression equipment.

The following procedures currently implement shutdown risk and the essential work planning and implementing process. These and other procedures will be revised as necessary to implement the changes and requirements as a result of the NFPA 805 approval:

NPG-SPP-07.1, "On Line Work Management"
NPG-SPP-07.2, "Outage Management"
NPG-SPP-07.3, "Work Activity Risk Management Process"

When preparing the revisions, TVA will follow the guidance of Frequently Asked Question (FAQ) 07-0040. This FAQ contains a list of acceptable measures that provide a flexible framework to prevent fires and protect against potential impacts should a fire occur, while allowing outage activities to continue.

RAI SSA 08.b

LAR Attachment D describes the methods and results for non-power operations (NPO) transition. Provide the following additional information:

b) Provide justification for not performing the NPO analysis for a fire in the MCR. In lieu of this analysis describe the provisions made in the event of a fire for the MCR during high risk evolutions. Include in this response all rooms within Fire Area 16, not just the MCR proper.

RESPONSE:

A BFN NPO analysis was performed for the main control room (MCR). The NPO analysis used a qualitative approach for the Control Bay Complex (i.e., Fire Area 16). The Control Bay Complex consists of the MCR and many additional supporting equipment rooms which collectively make one large Fire Area. The MCR is typically a pinch point for all KSFs because some portion of most of the control circuits for the KSF components pass through the main control board sections, or through the plant instrument cabinets, and are in close proximity to one another. Therefore, TVA used a qualitative approach to analyze the Control Bay Complex (i.e., Fire Area 16), and identified that Fire Area 16 is a "pinch point" for all KSFs.

In accordance with the LAR Attachment S, Table S-3, Implementation Item 26, TVA will follow the FAQ 07-0040 guidance to reduce fire risk in Fire Area 16 during HREs.

SSA RAI 11

LAR Attachment B, Table B-2, Section 3.2.1.2, "Fire Damage to Mechanical Components," identifies that fire-induced damage to mechanical components subjected to a fire is not considered credible. However, NEI 00-01, Revision 1 states that instrument tubing with brazed, soldered joints, or other heat sensitive materials should not be included in this non-failure assumption. Describe how the failure of brazed or soldered joints in a fire was considered in the NSCA.

RESPONSE:

The BFN NFPA 805 Nuclear Safety Capability Analysis aligns with the NEI 00-01 guidance regarding the susceptibility of brazed or soldered joints to fire-induced failures. The systems at BFN containing tubing/piping with brazed or soldered joints are associated with pneumatic supplies (e.g., plant control air). Plant control air system success logic within the analysis software includes logic elements representing plant control air system piping locations. These logic elements ensure that assumed fires in plant locations where plant control air piping of sufficient size is routed would result in plant control air system failure in the Nuclear Safety Capability Assessment (NSCA).

For fire areas where brazed/soldered joints in pneumatic supply tubing associated with a specific component might fail due to fire-effects, the component that directly utilizes this tubing was assumed to fail by the NSCA analysis logic due to its location within the fire area.

SSA RAI 12

LAR Attachment S, Table S-2, Items 9a through 9f, describe ten RHR valves being modified to prevent water hammer. Provide more detail of the modifications with regard to specific circuit changes and how these modifications will prevent spuriously opening the valves. Include in the description the use of insulated shield cables and how they function to protect the valve circuit.

RESPONSE:

The 10 Residual Heat Removal (RHR) system valves that are being modified to address spurious opening are:

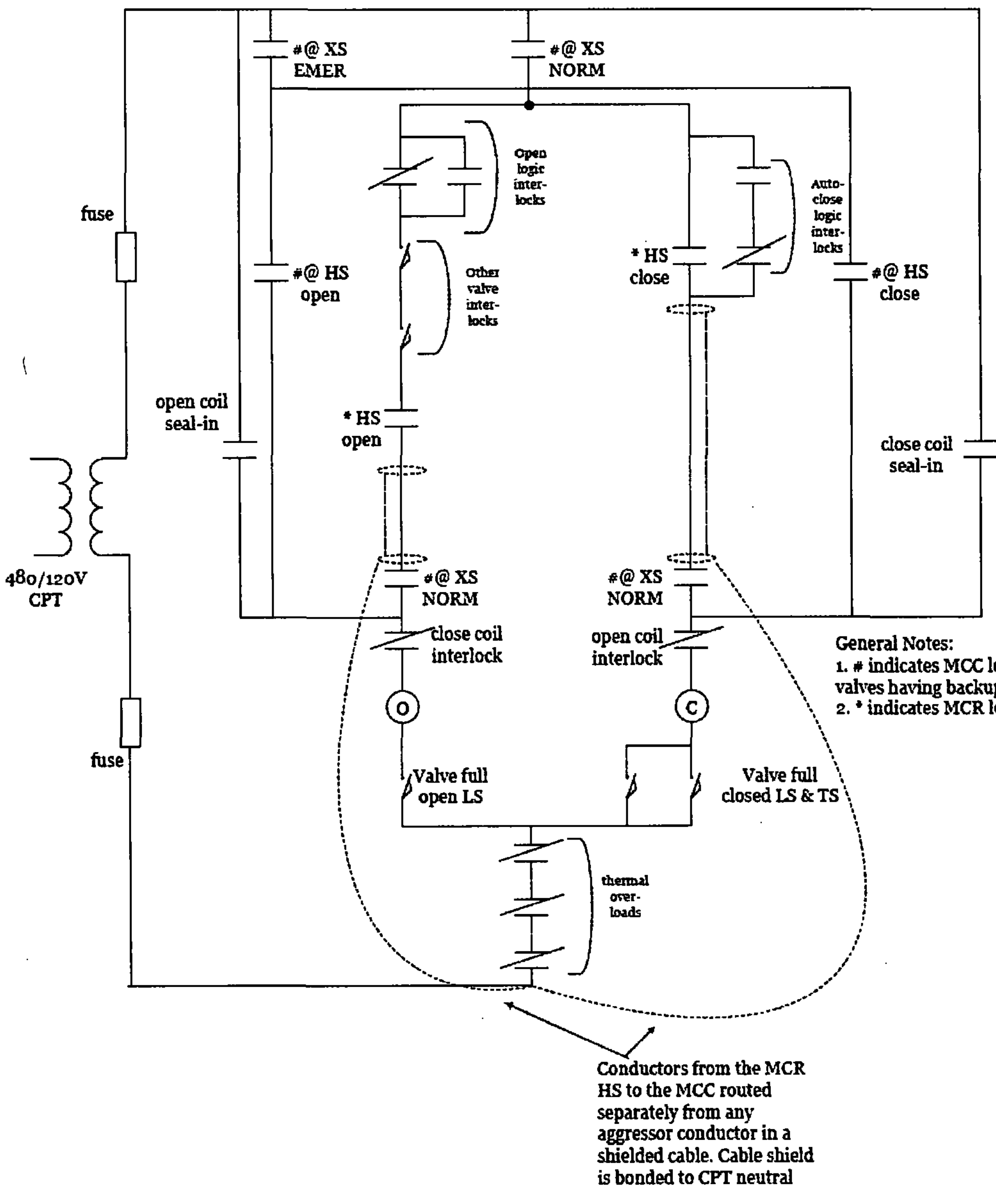
Valve Number	Valve Description
1-FCV-074-0060	RHR SYS I CONTAINMENT SPRAY OUTBD VLV
1-FCV-074-0071	RHR SYSTEM II SUPP POOL VLV
1-FCV-074-0074	RHR SYSTEM II CNTMT SPRAY OUTBD VLV
2-FCV-074-0057	RHR SYS I SUPP POOL SPRAY/TEST ISOL VLV
2-FCV-074-0060	RHR SYS I DRYWELL SPRAY OUTBD VLV
2-FCV-074-0071	RHR SYS II SUPP POOL SPRAY/TEST ISOL VLV
2-FCV-074-0074	DRYWELL SPRAY LINE OUTBOARD CONTAINMENT
3-FCV-074-0057	RHR SYS I SUPP POOL SPRAY/TEST ISOL VLV
3-FCV-074-0060	RHR SYS I CONTAINMENT SPRAY OUTBD VLV
3-FCV-074-0074	RHR SYSTEM II CNTMT SPRAY OUTBD VLV

Although the designs for these modifications are not finalized, the current plans are that the modifications will reconfigure the valves' control circuits in four major ways, as described below, to reduce the probability of fire-induced spurious opening. Each of these valves utilizes 120 volt (V) AC control power from its own ungrounded control power transformer (CPT).

- The local control station handswitches (HSs) will be removed or abandoned. This aspect of the modification eliminates a target cable vulnerability where fire-induced damage could spuriously open the valve.
- The valve position and torque switches used in the motor contactor circuit will be moved to the neutral side of the motor contactors. With the switches wired in this manner, a postulated single hot short to the limit switch (LS) or torque switch (TS) would not result in spurious opening of the valve.
- Logic relay and valve interlock contacts in the OPEN circuit will be rewired to the hot side of the MCR HS contacts. Once rewired, postulated shorts around the logic relay and interlock contacts would be prevented by the normally open MCR HS contacts from causing spurious valve operation.
- The circuit conductors between the MCR HS contacts and the motor control center (MCC) will be routed in a cable separate from any CPT hot conductors, either in a dedicated raceway or in control power cable trays limited to cables carrying no more than 30 amperes (amps). The new cable will have thermoset insulation and will have an integral, insulated braided shield. The cable shield will be bonded to the CPT neutral, such that a postulated hot short (*i.e., inter-cable or ground fault equivalent hot short*) would physically make contact with the reference grounded shield, thereby causing electrical protective device clearing, prior to contacting the target circuit conductor that could cause spurious valve operation.

The insulated braided shield will be sized so that it is protected by the CPT neutral fuse if routed in a dedicated conduit or the larger of the CPT neutral fuse or a 30 amp protection device if routed in control power cable tray. The new insulated braided shield cable will not be routed in the same fire areas where the cable carrying the valve LS/TS conductors is routed, with the exception of the MCC location fire area.

A conceptual sketch of the modified portion of the circuit design is provided below.



General Notes:
1. # indicates MCC location; @ only available for valves having backup control capability
2. * indicates MCR location

RAI SSA 14

Cable routing information being used for the FPRA is described as primarily based on the previous Appendix R safe shutdown data. Certain measures were developed that validate the accuracy of this routing information. Provide a detailed description of these processes and justification of how they were used to validate the accuracy of this data. Include in that description the efforts and scope to 'nodalize' raceways for more accurate location information. Describe how walkdown information was used to assist in this validation.

RESPONSE:

The BFN Appendix R analysis associated fire area location information directly to the Appendix R cables. The BFN Integrated Cable and Raceway Data System (ICRDS) was used to determine the raceways that a cable routes in. The Appendix R cable fire area location information was developed by identifying the cable's raceway routing on plant physical drawings and identifying the fire areas that the cable routes in via those raceways and the cable termination locations. The fire areas were then directly assigned to the Appendix R cable in the separation analysis database (SAFE). The BFN Appendix R cable fire area location information is documented in a BFN safety related calculation. For the NFPA 805 NSCA deterministic analysis, the cable fire area route information from the Appendix R data was used for cables associated with safe shutdown systems. Cables for newly credited systems were assigned to fire areas using the same Appendix R method. Utilizing the fire area assignment to cables and equipment, failures for a given fire area were evaluated for their effect on the ability to meet the NFPA 805 performance criteria.

The BFN Fire PRA only used the Appendix R cable fire area location data for full compartment burn scenarios. Otherwise, the BFN Fire PRA analysis derived the cable targets independent of the Appendix R cable fire area route information. The BFN Fire PRA fire scenarios, except full compartment burn scenarios, were developed by performing plant walkdowns. A zone of influence was determined for the fire source and then raceway and equipment targets were identified from plant walkdowns with the aid of plant physical drawings. The raceway and equipment targets were added to the SAFE database fire scenario. The SAFE software then added the appropriate cables to the scenario, based on the cable association with the raceway and equipment targets. The fire scenario analysis then failed the target cables and equipment to derive the Fire PRA basic events.

The Fire PRA scenario failures were compared to the NSCA failures for a given fire area. The expected result was that the Fire PRA scenario failures typically would be a subset of the NSCA fire area (full compartment burn) failures. In instances where this was not the case, the cable(s) causing the failure was investigated to determine the cause for the discrepancy (e.g., either the fire area assignments for the cable were incorrect or the cable was added to the fire scenario in error). This cross-comparison method of review provided a level of independent validation for both the cable fire area routing and the fire scenario modeling.

The Unit 3 tray raceways were nodalized prior to the BFN NPFA 805 project. The nodalized segmented trays in Unit 3 provided a more precise cable location footprint for the Unit 3 fire scenarios. Many tray raceways for Unit 1 and Unit 2 were not nodalized. Early in the NFPA 805 Transition Project, BFN decided to nodalize selected trays that were identified as fixed source targets in the Unit 1 or Unit 2 Reactor Building. A tray node network system was established for these trays with tray nodes established at distances of 20 feet or less. Routing information for all cables in the tray was updated to utilize the tray segments created by the node network and raceway entry/exit junction locations. Plant walkdowns were used as needed to complete this tray nodalization work. Cable route information in ICRDS was updated with the tray segment raceways and this information was also imported into the SAFE database for fire scenario use. The tray node network drawings were used by fire modelers to establish the appropriate tray segments that would be a target for the fire scenarios. The tray segment target raceways added to the fire scenario in SAFE then caused the failure of the appropriate cables contained in those tray node segments. Performing this tray nodalization work required a detailed cable route review which provided an opportunity to validate the fire area location assignment accuracy of the NFPA 805 cables, including Appendix R cables that were routed in the nodalized trays.

In conclusion, the fire modeling plant walkdowns that identified raceway fire targets for the Fire PRA enabled a cross-comparison, on a fire area basis, between the Fire PRA scenario cable failures and the set of NSCA cable failures identified in the full compartment burn analysis utilizing the cable fire area location assignment. This comparison provided a level of independent validation for both the deterministic NSCA cable fire area routing, including the Appendix R data, and the fire scenario modeling. Tray nodalization for selected cable trays provided more precise cable location information for Fire PRA scenarios, and the detailed route review performed during tray nodalization provided a separate opportunity to identify fire area location discrepancies of cables in these trays.

PROG RAI 01

Based on the NRC staff's review of the LAR and associated documentation, it was determined that the LAR did not provide the information needed for the NRC staff to evaluate what changes will be made to the FPP related training to incorporate NFPA 805 requirements.

Describe the changes that are planned to the training program to prepare the plant staff for implementing the new risk-informed, performance-based FPP as part of the NFPA 805 transition process.

RESPONSE:

The identification of the specific changes to the training program required to implement the new RI/PB FPP has not been completed. This will be performed during the implementation phase of the transition to NFPA 805. Existing TVA processes controlling program and procedure creation and revision require the consideration of necessary training to implement the associated changes. As documents are created or revised to implement the new RI/PB FPP, training needs will be evaluated and dispositioned. Specifically, TVA Procedures NPG-SPP-01.1, "Administration of Standard Programs & Processes (SPPs); Standard Department Procedures (SDPs); and Business Practices (BPs)," and NPG-SPP-01.2, "Administration of Site Technical Procedures," require procedure changes to be evaluated for the need for new or revised training. The evaluation includes:

- Assessing new or revised task(s) assigned to personnel including the training needs for these new or revised task(s)
- Determining the training approach and schedule (pre effective date, post effective date, etc.) as needed

The TVA training series of procedures provides the framework for the systematic approach to training and involves five phases. The training needs analysis phase determines the training needed and the training population. During the design and development phases, the training is catered to meet the needs of the training population. The training is then implemented based on a predetermined schedule. Following the implementation phase of the training, an evaluation phase begins to determine the effectiveness and adequacy of the training.

In addition, each procedure and process change will be evaluated during the project implementation phase using the NPG-SPP-01.1 and NPG-SPP-01.2 processes to determine the training needs. As identified in the LAR, the following processes/procedures will be revised as a result of the transition to NFPA 805, and therefore will be evaluated to the need/type of training required:

- Implementation Items 01 and 17 – revision/creation of pre-fire plans and development of standard operating procedures to support actions to prevent radioactive release.
  NOTE: Implementation Item 01.h specifically identifies the following training:
  - Each fire brigade member will be provided training to identify potential points for radioactive release and the actions that can be taken to mitigate a release. To support the training, guidance will be provided in pre-fire plans and standard operating procedures to outline these expectations and actions.
- Implementation Item 03 – creation of the NFPA 805 monitoring program.
- Implementation Items 04, 05, 11, 35, and 45 – revisions to procedure NPG-SPP-18.4.7, "Control of Transient Combustibles."

- Implementation Items 06, 43, and 45 – revision to procedure NPG-SPP-18.4.8, "Control of Ignition Sources."
- Implementation Item 07 – revisions to door inspection procedures.
- Implementation Item 11 – revisions to NPG-SPP-1.3, "Housekeeping."
- Implementation Items 12, 16, and 39 – revisions to FPDP-1, "Conduct of Fire Protection," and FPDP-4, "Fire Emergency Response," and updates to training to meet NFPA 600.
  NOTE: Implementation Item 12 specifically identifies the following training:
  - o Update training documentation to include training in accordance with NFPA 600 to all personnel who may enter the warm zones.
  - o Update training documentation to include pre-fire plan awareness as part of the training for support personnel.
- Implementation Item 13 – revisions to FPDP-2, "Administration of Prefire Plans."
- Implementation Items 14 and 15 – revisions to TPD-FBT, "Fleet Fire Brigade Training."
  NOTE: Implementation Item 14 specifically identifies the following training:
  - o Revise TPD-FBT to require fire brigade members to receive training in firefighting considerations of radioactivity and health physics on a quarterly basis.

  NOTE: Implementation Item 15 specifically identifies the following training:
  - o Revise TPD-FBT to include training for the secondary response group as to their responsibilities, potential hazards to be encountered, and interfacing with the fire brigade.
- Implementation Item 17 – revisions to battery inspection procedures.
- Implementation Item 18 revision to FP-0-000-INS005, "Quarterly Inspection of Emergency Equipment."
- Implementation Item 19 – revisions to various procedures.
- Implementation Item 21 – revisions to various surveillance procedures.
- Implementation Item 23 – fire modeling and Fire PRA qualifications.
  NOTE: Implementation Item 23 specifically identifies the following training:
  - o Position Specific Guides will be developed to identify and document required training and mentoring to ensure individuals are appropriately qualified per the requirements of NFPA 805, Section 2.7.3.4 to perform assigned work.
- Implementation Item 24 – NFPA 805 configuration control procedures.
- Implementation Item 26 – revisions to shutdown risk management procedures to implement NFPA 805 non-power operations requirements.
- Implementation Items 27, 30, and 31 – train operations on revised post-fire response procedures.
  NOTE: Implementation Items 30 and 31 specifically identify the following training:
  - o Train operators on revised post-fire response procedures.
  - o Revise training requirements for post-fire response procedures to include periodic drills.

PROG RAI 02

NFPA 805, Section 2.7.3.4, "Qualification of Users", states that cognizant personnel who use and apply engineering analysis and numerical models (e.g., fire modeling techniques) shall be competent in that field and experienced in the application of these methods as they relate to nuclear power plants, nuclear power plant fire protection, and power plant operations.

Describe how the training program will be revised to support the NFPA 805 change evaluation process, including positions that will be trained and how the training will be implemented (e.g., classroom, computer-based, reading program).

RESPONSE:

The identification of the specific changes to the training program required to implement the new change evaluation process has not been completed. This will be performed during the implementation phase of the transition to NFPA 805.

Section 4.7.2 of the BFN LAR discusses the post-transition change evaluation process. LAR Attachment S, Table S-3, Implementation Item 24 provides the following commitment:

> "For program documentation and configuration control, implement the following:
>
> - The Fire Protection Design Basis Document described in Section 2.7.1.2 of NFPA 805 and necessary supporting documentation described in Section 2.7.1.3 of NFPA 805 will be created as part of transition to 10 CFR 50.48(c) to ensure program implementation following receipt of the safety evaluation.
> - The configuration control procedures which govern fire protection related documents and databases will be revised to reflect the new NFPA 805 licensing bases requirements.
> - Several NFPA 805 document types, such as NSCA Supporting Information and Non-Power Mode NSCA Treatment, will generally require new control procedures and processes to be developed since they are new documents and databases created as a result of the transition to NFPA 805. The new procedures will be modeled after the existing processes for similar types of documents and databases. System level design basis documents will be revised to reflect the NFPA 805 role that the system components now play.
> - Configuration control of the Fire PRA model will be maintained by integrating the Fire PRA model into the existing processes used to ensure configuration control of the Internal Events PRA model."

During BFN NFPA 805 project implementation, procedures will be revised and/or created to implement the new NFPA 805 change evaluation process. This change evaluation process will be based upon FAQ 12-0061, "NFPA 805 Change Process," when it is approved. TVA Procedures NPG-SPP-01.1, "Administration of Standard Programs & Processes (SPPs); Standard Department Procedures (SDPs); and Business Practices (BPs)," and NPG-SPP-01.2, "Administration of Site Technical Procedures," require procedure changes to be evaluated for the need for new or revised training. This evaluation includes:

- Assessing new or revised task(s) assigned to personnel including the training needs for these new or revised task(s).
- Determining the training approach and schedule (pre effective date, post effective date, etc.) as needed.

The TVA training series of procedures provides the framework for the systematic approach to training and involves five phases. The training needs analysis phase determines the training needed and the training population. During the design and development phases, the training is catered to meet the needs of the training population. The training is then implemented based on predetermined schedule. Following the implementation phase of the training, an evaluation phase begins to determine the effectiveness and adequacy of the training.

During BFN NFPA 805 project implementation, this systematic approach to training will be used to develop the training for the NFPA 805 change evaluation process. The development of Task Qualification Guides for individuals involved with the change evaluation process will be required. Training to implement those Guides will be accomplished via the mentoring process.

FM RAI 01.b.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, Rev. 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 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:

b. Regarding fire propagation in cable trays:

    i. Describe how the ignition of and subsequent flame spread and fire propagation in (stacks of) horizontal cable trays and the corresponding HRR of cables were calculated.

RESPONSE:

The Scoping Fire Modeling analysis assumes that all scenarios involving ignition sources capable of igniting secondary combustibles result in a damaging hot gas layer. All targets in the fire compartment are considered damaged with a severity factor of 1.

Detailed fire modeling calculations to determine time to ignition of secondary combustibles and subsequent flame spread and fire propagation were performed consistent with the processes recommended by NUREG/CR-6850, "Fire PRA Methodology for Nuclear Power Facilities," and NUREG/CR-7010, "Cable Heat Release Ignition, and Spread in Tray Installations During Fire (CHRISTIFIRE) Phase 1: Horizontal Trays." The fire growth and propagation analysis was conducted using the methodology described below.

The time to ignition of a horizontal stack of cable trays was determined by calculating the critical heat release rate (HRR) needed to damage the first (i.e., closest) cable tray in the stack. The critical HRR was determined using FDT 09 or FDT 05.1 and the HRR was manipulated until the temperature or heat flux at the tray location reached the damage criteria. Cable trays were assumed to ignite when the fire reached the critical HRR for damage or if the cable tray was located within the flame with no additional consideration of thermal response. Cables in conduit were not considered to contribute to fire growth or spread.

To calculate the burning area, the entire width of the cable tray was assumed to ignite. The length of the tray assumed to initially ignite was determined by the length of the tray exposed to the fire.

In accordance with NUREG/CR-6850, Section R.4.2, the burning area for horizontal cable trays in a stack was determined using the empirical model for upward flame propagation assuming the angle of horizontal spread from tray level to tray level is 35 degrees to either side.

Horizontal cable tray flame spread rates from NUREG/CR 6850, Section R.4.1.2 were used. The heat release rates per unit area (HRRPUA) for cables were equal to or exceeded the values recommended by NUREG/CR-7010, Section 9.2.2.

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

For thermoset cable tray stacks, propagation of fire within the stack follows the timing outlined in NUREG/CR-6850, Section R.4.2.2.

Only fire propagation to stacks immediately adjacent to the source have been modeled, in accordance with FAQ 08-0049.

FM RAI 01.b.ii

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, Rev. 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:

b. Regarding fire propagation in cable trays:

   ii. Explain how cables with Flamemastic 77 coating and cable tray with covers were treated in the fire modeling calculations.

RESPONSE:

For self-ignited cable fires and cable fires caused by welding and cutting in the scoping fire modeling analysis, Flamemastic 77 fire protection coating was credited to delay, for 10 minutes, damage to and ignition of cables in cable trays, as allowed by NUREG/CR-6850, Section Q.2.1. The cables in the initial tray were considered damaged without delay for all self-ignited cable fires and for cable fires due to welding and cutting.

Cable trays provided with bottom covers were credited to delay, by 20 minutes, damage to and ignition of thermoset cables as allowed by NUREG/CR-6850, Section Q.2.2. Cable trays provided with bottom covers were also credited to delay, by 4 minutes, damage to and ignition of thermoplastic cables, based on test results from NUREG/CR-0381, "A Preliminary Report on Fire Protection Research Program Fire barriers and Fire retardant Coatings Tests." Fire growth and propagation was not postulated for any fully enclosed cable tray. Cable tray covers were not credited when located within the zone-of-influence (ZOI) of a high hazard event (e.g., high energy arcing faults (HEAFs)).

FM RAI 01.e

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, Rev. 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:

e. Explain if the guidance in Appendix M in NUREG 6850, Vol. 2 was used to determine the damage due to high energy arcing faults, or provide technical justification if a different approach was used. In addition, provide technical justification for the assumption that a fire following a high energy arcing fault event has a HRR of 211 kW for duration of 20 minutes, followed by a 20 minute decay.

RESPONSE:

The guidance in NUREG/CR-6850, Appendix M was used to determine the damage due to HEAFs. Fire PRA targets within the initial blast ZOI, as defined in NUREG/CR-6850, Section M.4.2, were considered damaged and/or ignited in HEAF scenarios at time zero. Cable tray enclosures and fire wrap were assumed to be physically damaged by the initial explosion and were not credited in the analysis.

The 211 kiloWatt (kW) HRR is based on the 98th percentile heat release rate of a single bundle electrical cabinet fire. It is TVA's position that this bounds the remaining contents of the cabinet after the initial HEAF event. While NUREG/CR-6850 describes the door to be "blown open," TVA did not interpret this to mean selection of the 1002 kW open door vertical cabinet fire. Industry experience documented in NUREG/CR-6850 implies that the magnitude and energy produced by the HEAF significantly consumes any cabling internal to the cabinet. Because the initial combustible material is mostly consumed, the ensuing fire is expected to be dominated by any secondary combustibles (trays) ignited by the HEAF. As stated in NUREG/CR-6850, Section M.3, "Sustained fires after the initial HEAF involve combustible materials (cable insulation, for the most part) near the cabinet."

The 20-minute burn duration used in the analysis for a typical electrical cabinet fire is a combination of the time needed to reach the peak HRR (i.e., 12 minute t^2 growth) and the time sustained at peak (i.e., 8 minutes). A 20 minute decay stage was not considered for HEAF fires. Because the combustible loading within the cabinet is mostly consumed during the initial HEAF, applying the peak HRR of a standard electrical fire for a 20-minute duration is conservative.

FM RAI 01.i.ii

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, Rev. 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:

    ii. Provide technical justification for using a soot yield of 0.12 for the cables in the MCR FDS simulations. In addition, explain what value (or values) was (were) used for the heat of combustion of cables in the MCR. Describe whether the soot yield and heat of combustion values that were used in the analysis result in conservative estimates of the soot generation rate.

RESPONSE:

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

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

Furthermore, the MCR analysis includes additional conservatism due to FDS overestimation of measured smoke concentration by an average factor of 2.70.

Heat of combustion was not specified in the MCR analysis; rather, HRRs were prescribed using HRRPUA to replicate the growth profiles and peak heat release rate bins provided in

NUREG/CR-6850, Appendices E and G. For conservatism and to prevent ventilation-limited conditions from occurring, the lower oxygen limit in FDS was set to zero.

FM RAI 01.i.v

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, Rev. 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:

   v. Provide technical justification for assuming a transient fire elevation of 1 meter above the floor, and for choosing an area so that the Froude number is within the NUREG-1824 validation range (as opposed to the actual transient size).

RESPONSE:

Transient scenarios were modeled in FDS at an elevation of 0.6 meters (m) (i.e., 2 feet (ft)), rather than 1m, above the floor. A transient fire elevation of 2 ft is conservative because most transient fires are expected to be below this height or at floor level.

For this analysis, the abandonment characteristics due to a fire, such as HGL temperature and optical density, are primarily governed by the amount of energy released and soot produced. As stated in NUREG-1934, "Nuclear Power Plant Modeling Analysis Guidelines (NPP FIRE MAG)," Section 2.3.7.1,

> "In most fire modeling tools, the fire diameter is simply used to determine HRRs or to calculate the fire plume conditions, such as the flame height or plume temperature. Considering that the HRR is "fixed" in this sensitivity study, the fire diameter may not be a relevant parameter in the analysis, with the important exception of scenarios where the fire plume conditions are relevant."

The Froude number is predominantly used to validate plume temperature and flame height. The Froude number is not important to the MCR analysis, because the MCR analysis is dependent on total heat release and soot yield (g/g) of the combustible material.

NUREG/CR-6850, Table E-9, provides the transient heat release rate distribution for 15 HRR bins. A 0.6 m by 0.6 m (i.e., 2 ft by 2 ft) area was selected for each transient scenario as a realistic and bounding characterization of a transient fuel package. While the fire could be modeled with varying sizes, the HRR of the fire would remain the same.

FM RAI 01.i.vi

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, Rev. 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, 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:

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

RESPONSE:

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

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

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

- The heat flux at six feet above the floor exceeds 1 kW/m^2 (relatively short exposure)
- The smoke layer descends below six feet from the floor, and optical density of the smoke is greater than 3.0 m^{-1} (as identified in NUREG/CR-6850 errata)
- An HGL temperature of 95° Celsius (C) (200° Fahrenheit (F))

FM RAI 01.i.viii

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, Rev. 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, 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:*

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

RESPONSE:

Two transient and two electrical cabinet scenario locations were postulated for both the Units 1 and 2 MCR and the Unit 3 MCR. The locations of the fires were selected to bound a fire at any location within the room. Each electrical cabinet fire scenario location was conservatively selected such that the fire would spread to two additional cabinets, based on the methodology provided in NUREG/CR-6850, Appendix S, and thereby bound the HRR of any electrical cabinet scenario. Locations for the transient fires were selected both inside and outside of the horseshoe at locations in close proximity to the main control boards and operators. Devices that measure habitability conditions were located near the fire locations to provide data necessary to conservatively calculate when control room abandonment would be necessary.

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

FM RAI 01.j.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:

j. Specifically regarding the MCA:

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

RESPONSE:

The Multi-Compartment Analysis (MCA) screens scenarios based on compartment size using two methods, one is based on the size of the exposing compartment and the second is based on the size of the exposed compartment.

For the exposing fire compartment screening step in the MCA, the qualitative method was based on the exposing compartment not being able to generate a hot gas layer due to its size and configuration. Only three fire compartments, 16-A, RAD, and YARD, were screened in this step without a quantitative fire model basis.

For Fire Compartment 16-A, the following rooms were screened qualitatively as exposing fires:

- Spreading Room (606.0-C3)
- Spreading Room (606.0-C5)
- Spreading Room (606.0-C7)
- Units 1 and 2 Main Control Room (617.0-C12)
- Unit 3 Main Control Room (617.0-C19)

The three cable spreading rooms (CSRs) are open to each other with a total volume of approximately 138,000 cubic feet (ft^3). Additionally, these rooms have limited fire sources and based on the significant volume of the combined rooms and lack of severe fire sources, no hot gas layer would be generated in these rooms that would spread to an adjacent compartment.

The Units 1 and 2 MCR has a volume of 90,000 ft^3 and the Unit 3 MCR has a volume of 40,000 ft^3. The MCRs are manned 24 hours a day and contain main control boards and electrical panels.

The few cable trays located within the MCRs are located beyond the ZOI of potential significant fires. Based on the volume of the MCRs, operators manning the room 24 hours, and the lack of significant fire scenarios, no hot gas layer would be generated in the MCRs that would spread to an adjacent compartment.

Fire Compartment RAD is the entire Radwaste Building. The large volume of the building precludes the possibility of the formation of a hot gas layer in the entire structure. Fire Compartment YARD is located on the building exterior and therefore is not capable of generating a hot gas layer to exposed fire compartments.

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

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

- Reactor Building. Fire compartments within the Reactor Buildings include open boundaries to adjacent fire compartments.
- Turbine Building. The Units 1, 2, and 3 Turbine Building includes the turbine generators and is a large open area spanning all elevations of the building.
- Diesel Generator Rooms. The Diesel Generator rooms consist of multiple elevations of the buildings that are open to the exterior via the large air intakes. The Diesel Generator Building corridors consist of multiple open elevations with openings between the elevations.
- Areas Open to Atmosphere. Intake Pumping Station EL 565, Control Bay Chillers, Cooling Towers and Cooling Water Channel Areas each have open boundaries to the exterior.
- Intake Pump Station. Intake Pumping Station (including EL 542 and EL 550) consist of a large open volume.
- Control Building. The main corridors of the Control Building consist of EL 593 and EL 606 with each of the corridors spanning the length of the Control Building. The Control Building Roof has open boundaries to the exterior.

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

FM RAI 02.c

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.

c. Describe how cable tray covers and conduits affect the damage thresholds that were used in the fire modeling analyses. In addition, explain how holes in cable tray covers were treated in this respect.

RESPONSE:

The damage threshold for Fire PRA target cables in conduit and cable trays were based on the damage thresholds identified in NUREG/CR-6850, Table H-1. Target damage to cables in conduit was conservatively considered to occur when the exposure environment met or exceeded the damage threshold for the cable. The conduit was not credited to delay damage to the cable.

Cable tray covers do not alter the damage thresholds of the cables, but delay the time to damage due to the shielding they provide for the cables. Cable trays provided with bottom covers were credited to delay damage to thermoset cables as allowed by NUREG/CR-6850, Section Q.2.2. Cable trays provided with bottom covers were also credited to delay damage to thermoplastic cables, based on test results from NUREG/CR-0381. Fire growth and propagation was not postulated for any fully enclosed cable trays in any fire scenario.

Plant walkdowns confirmed that there were no holes in any cable tray cover credited to delay damage to target cables. Therefore, consideration of holes in the cable tray covers was not applicable to the analysis.

FM RAI 02.d

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.

d. Explain what damage thresholds and associated time delays were used in the fire modeling analyses for cables coated with Flamemastic 77.

RESPONSE:

The damage threshold for Fire PRA target cables with cable coatings consistent to those identified in NUREG/CR-6850, Section Q.2.1 (e.g., Flamemastic 77) were based on the damage thresholds identified in NUREG/CR-6850, Table H-1 (i.e., 205°C and 6 kW/m^2 for thermoplastic cables and 330°C and 11 kW/m^2 for thermoset cables).

For certain risk significant, self-ignited cable fires and cable fires caused by welding and cutting, the cable coating was credited to delay, for 10 minutes, damage to and ignition of cables in cable trays adjacent to the initial tray. This approach aligns with the application guidance for time to damage in NUREG/CR-6850, Section Q.2.1, and is conservative with respect to the application guidance for time to ignition in NUREG/CR-6850, Section Q.2.1.

PRA RAI 01.i

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 appear to be fully resolved:

i. <u>F&O 2-57 against FSS-D7:</u>

   A disposition to this F&O does not appear to be provided. Describe the credit given in the FPRA to incipient fire detectors in panels as well as the resulting impact on fire scenario development (e.g., damage end states), and clarify the resolution to the peer review observation that incipient detection credit should be removed from transient fire scenarios. Include explanation of whether the incipient detection is used only to limit damage to targets outside the cabinet and not used to limit damage inside the cabinet where the detection would be installed. If incipient detection was used to limit damage inside the cabinets where detection would be installed, as opposed to limit damage to targets outside the cabinet, provide the impact on CDF, LERF, ΔCDF, and ΔLERF of removing the credit for this deviation from acceptable methods.

RESPONSE:

TVA considers Facts and Observations (F&O) 2-57 against Fire Selection Scenario (FSS)-D7 resolved based on the treatment of incipient fire detection systems as very early warning fire detection systems (VEWFDS) in accordance with the methodology for the in-panel incipient detection system, as described in NUREG/CR-6850, Supplement 1, Chapter 13 (FAQ 08-0046).

NUREG/CR-6850, Supplement 1, Chapter 13, provides criteria that must be met to credit incipient detection. The incipient detection in panels within the Unit 1, Unit 2, and Unit 3 Auxiliary Instrument Rooms (Fire Compartments 16-K, 16-M, and 16-O) for fixed ignition source fires met the criteria and was credited in the fire modeling analysis. As allowed by NUREG/CR-6850, Supplement 1, Chapter 13, the in-panel detectors are credited to limit damage to the source by initiating a response activity to stage appropriate trained personnel at the location, who are prepared to initiate fire suppression if an actual fire were to occur. Suppression initiated by in-panel detectors is not credited to limit damage inside the cabinet where detection is or will be installed. In addition, transient fire scenarios do not credit in-panel incipient detection to initiate suppression to limit target damage.

Because incipient detection was not used to limit damage inside the cabinet, where the detector is or will be installed, determining the effect on Core Damage Frequency (CDF), Large Early release Frequency (LERF), delta (Δ) CDF, and Δ LERF of removing the credit was not required.

PRA RAI 01.q

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 appear to be fully resolved:

q. F&O 5-10 against IGN-A7:

In regard to the specific example cited by the F&O, the ignition source's contribution to Bin 15 appears to have been adjusted from 2 to 15; however, based on a review of Attachment 4 to the Fire Ignition Frequency report, its contribution to Bin 16a appears to have remained at 2. Clarify the discrepancy between these two counts.

RESPONSE:

The count of vertical sections associated with Bin 15 for this electrical panel (480V MCC 1-BDBB-268-0001C, Reactor MOV Board 1C) was adjusted from a value of 11 to a value of 15 as a result of the second walkdown effort. The adjusted value reflects a count of four additional panels in the back of the Reactor MOV Board. Attachment 4 of the Fire PRA Ignition Frequency notebook includes a note clarifying that the count was adjusted to 15 based on walkdown observations to account for four back panels and 11 front panels.

The adjusted count value is not applicable to the HEAF (i.e., Bin 16a in NUREG/CR-6850, Supplement 1) for this ignition source. This ignition source is an MCC panel for which HEAFs are not postulated unless specific conditions are met, based on the guidance in NUREG/CR-6850, Section M.1 and FAQ 06-0017, which is included in NUREG/CR-6850, Supplement 1. In this particular case, HEAFs are only assigned to MCC vertical sections with switchgear for the load center supply to the MCC. Therefore, the Reactor MOV board is assigned a count of two for each vertical section containing supply breakers from the load centers. This approach is documented in Section 6.6 of the Fire PRA Ignition Frequency notebook.

PRA RAI 01.r

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 appear to be fully resolved:

r. <u>F&O 5-11 against IGN-A7</u>:

The disposition to this F&O notes that junction boxes were excluded as a fire ignition source. Describe the treatment of junction boxes in the FPRA as ignition sources, and clarify whether this treatment is consistent with FAQ 13-0006.

RESPONSE:

F&O 5-11 states that "more detail needed when saying boxes appear well sealed." As a possible resolution, the peer reviewers suggested that the contribution of junction box fires should be added to the Fire PRA. To resolve the F&O, the contribution of junction box fires was added to the Fire PRA as described below:

- <u>Full compartment burn scenarios.</u> These were scenarios where all the targets in the Physical Analysis Unit (PAU) were assumed to be failed by fire at the time of fire ignition. The Conditional Core Damage Probability (CCDP) for these scenarios was calculated assuming all the targets mapped to the PAU were failed by fire. The ignition frequency for these scenarios was the sum of the contribution from each of the ignition sources assigned to the PAU. The contribution of junction box fires was included in the total frequency assigned to the PAU. Specifically, in the BFN Fire PRA, the frequency contribution of Bin 18 junction boxes was combined (i.e., summed) with the frequency of Bin 12 cable run (i.e., self-ignited cable fires). Therefore, for the full compartment burn scenarios, the frequency contribution from junction boxes was accounted for in the Fire PRA.

- <u>Fire scenarios.</u> For PAUs where fire scenarios were defined, the contribution for junction box fires was accounted for as follows:

  - For selected PAUs, one scenario was added consisting of the sum of the frequency of self-ignited cable fires and junction box fires only and the failure of all the targets in the PAU. This scenario conservatively bounds the risk contribution of junction boxes as the CCDP was calculated assuming failure of all the targets assigned to the PAU.

- For the remaining PAUs (i.e., those where the conservatisms associated with failing all targets in the PAU had to be refined), the CCDP was re-calculated using the two most risk significant raceways as documented in the BFN Fire PRA Cable Tray Sensitivity evaluation. The process consisted of identifying the highest pair of risk contributing targets (i.e., raceways) in a PAU and selecting those as targets for the Junction Box scenario. This approach was consistent with FAQ 13-0006, "Modeling Junction Box Scenarios in a Fire PRA," as the damage associated with junction box fires was limited to one junction box (i.e., one target). In the BFN evaluation, the approach used is bounding because the BFN evaluation assumed junction box fires damaged two targets, not one target. The frequency calculation for these scenarios included the generic frequency apportioned to the fire zone and an ignition source weighting factor based upon the length of trays selected as target sets compared to the total length of trays in the fire PAU.

In summary, the contribution of junction box fires was included in the BFN Fire PRA. The frequency of full compartment burn scenarios included the contribution for junction box fires as apportioned to individual PAUs. For PAUs subdivided into fire scenarios, the contribution of junction box fires was accounted for by either: 1) postulating one scenario per PAU with the sum of the frequencies of self ignited cable fires and junction box fires and the CCDP associated with full room burn, or 2) postulating one scenario with a refined fire ignition frequency that included an ignition source weighting factor and the CCDP associated with the pair of top risk significant targets in the PAU.

PRA RAI 01.u

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 appear to be fully resolved:

u. F&O 5-26 against FSS-A2:

It is unclear from the disposition to this F&O whether conduits in areas without electrical cabinets, cable trays, or other secondary combustibles were considered by the scoping transient analysis. Given that damage to conduits from a transient fire could result in potential risk-significant scenarios, clarify whether such scenarios were considered by the scoping transient analysis. If not, provide the results of a sensitivity study (i.e., CDF, LERF, ΔCDF and ΔLERF) that considers conduits.

RESPONSE:

TVA has closed (i.e., resolved) F&O 5-26 against FSS-A2 because conduit damage was considered for all transient fire scenarios. However, the above disposition is not accurately conveyed in the LAR, Attachment V, Table V-7. Therefore, the following discussion supersedes the previous disposition to F&O 5-26 in the LAR, Attachment V, Table V-7.

> "For many transient fire scenarios, the scoping fire modeling analysis conservatively assumed full compartment damage. For risk significant fire compartments, the floor area of the fire compartment was divided into multiple transient zones. The Fire PRA targets, including any conduit, within each transient zone were assumed damaged.
>
> Because conduit damage was considered for all fire scenarios, a sensitivity study is not required."

PRA RAI 03

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 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.

A review of Attachment 6 indicates that very high maintenance influencing factor (50) was not applied to any PAUs. Clarify whether influencing factors were developed per the guidance in NUREG/CR-6850 as modified by FAQ 12-0064 (ADAMS Accession No. ML12346A488) and justify why the full range of influencing factors was not implemented.

RESPONSE:

Influence factors were developed based on the guidance in NUREG/CR-6850, Section 6.5.7. The LAR, Attachment V, Section V.2.3 states "The guidance in NUREG/CR-6850 was followed and no deviations were made in terms of fractional influence factors being utilized for the hot work and transient fire ignition frequency. NFPA 805 FAQ 12-0064 was not incorporated because it was released fairly late in the development of the BFN Fire PRA.". Implementation of the guidance in NUREG/CR-6850 is contained in the fire ignition frequency calculation. The TVA BFN expert panel determined that the turbine building was the only fire compartment that could have met the criteria for a Very High (i.e., 50) maintenance influence factor. However, due to the BFN focus on trip sensitive equipment, the TVA BFN expert panel determined that maintenance was not significantly higher for the turbine building fire area and the maintenance influence factor was set to High (i.e., 10).

PRA RAI 22

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 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.

Summarize the circuit analysis method(s) utilized to estimate circuit failure probabilities in the fire PRA (e.g., whether Option 1 and/or 2 in NUREG/CR-6850 were applied). If Option 2 was utilized, clarify how uncertainty was addressed.

RESPONSE:

NUREG/CR-6850, Option 2, was the circuit analysis method used to estimate circuit failure probabilities in the Fire PRA. This option was used in the circuit failure mode likelihood analysis (one of the input analyses for the Fire PRA) due to the circuit configuration of the components which are of concern. The circuit configurations were typically ungrounded or were relatively complex due to the number of interlocks, push buttons, and hand switches. A number of cables also contained more than two source and two target conductors. Based on the applicability discussion in NUREG/CR-6850, Option 2 was chosen as the best fit. The only exception was that Option 1 was utilized for the Reactor Protection System (RPS) float switches. None of the BFN circuit failure probabilities credited CPTs.

Generic uncertainty values were used for BFN circuit failure probabilities in order to propagate the overall uncertainty through the BFN Fire PRA results. An Error Factor (EF) of 2.2 was used for all circuit failure probabilities based on a review of NUREG/CR-6850, Vol. 2, Tables 10-1 through 10-5. These tables provide generic best estimate, 5%, and 95% values for various circuit failure probabilities. The median and EF was calculated for each cable type circuit failure probability provided in these tables, assuming the probabilities are log-normally distributed. It was noted that most EFs were either 2.2 or lower. The only cable type circuit failure probabilities that had an EF higher than 2.2 were armored or shielded cables; however, these have a much lower best estimate failure probability than those for other cables in these tables and those used for BFN specific cables. For most cable types, an EF of 2.2 is a best estimate value and for a few cable types, an EF of 2.2 is a bounding high value. Thus, the EF of 2.2 was considered applicable or bounding for all BFN circuit failure probabilities.

As stated in the Uncertainty and Sensitivity Analysis calculation, Monte Carlo sampling was performed to propagate parametric uncertainties through the BFN Fire PRA model to generate probability distributions for BFN Units 1, 2, and 3 fire CDF and LERF, which considered the state of knowledge correlation. This parametric uncertainty quantification included the parametric uncertainty from the circuit failure probabilities.

ENCLOSURE 2

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	Future letter
FPE 04	60	Future letter
FPE 05	60	Future letter
FPE 06	60	CNL-13-141 December 20, 2013
FPE 07	60	CNL-13-141 December 20, 2013
FPE 08	60	Future letter
FPE 09	60	Future letter
FPE 10	90	Future letter
FPE 11	90	Future letter
FPE 12	90	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	Future letter
SSA 03	60	Future letter
SSA 04	60	CNL-13-141 December 20, 2013
SSA 05	60	Future letter
SSA 06	60	Future letter
SSA 07	60	Future letter
SSA 08	60	CNL-13-141 December 20, 2013
SSA 09	60	Future letter
SSA 10	60	Future letter
SSA 11	60	CNL-13-141 December 20, 2013
SSA 12	60	CNL-13-141 December 20, 2013
SSA 13	60	Future letter
SSA 14	60	CNL-13-141 December 20, 2013
SSA 15	60	Future letter
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	Future letter
FM 01, part b.i	60	CNL-13-141

RAI Question Number	Type of Response (days)	Actual Date of Response
		December 20, 2013
FM-01, part b.ii	60	CNL-13-141 December 20, 2013
FM-01, part b.iii	90	Future letter
FM 01, part c	60	Future letter
FM 01, part d.i	60	Future letter
FM-01, part d.ii	90	Future letter
FM 01, part e	60	CNL-13-141 December 20, 2013
FM 01, part f	60	Future letter
FM 01, part g	90	Future letter
FM 01, part h.i	60	Future letter
FM 01, part h.ii	60	Future letter
FM 01, part h.iii	90	Future letter
FM 01, part i.i	120	Future letter
FM 01, part i.ii	60	CNL-13-141 December 20, 2013
FM 01, part i.iii	90	Future letter
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	Future letter
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	Future letter
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	Future letter
FM 03	60	Future letter
FM 04	90	Future letter
FM 05	60	Future letter
FM 06	60	Future letter
Probabilistic Risk Assessment (PRA)		
PRA 01, part a	60	Future letter
PRA 01, part b	60	Future letter
PRA 01, part c	90	Future letter
PRA 01, part d	90	Future letter
PRA 01, part e	120	Future letter
PRA 01, part f	120	Future letter
PRA 01, part g	60	Future letter
PRA 01, part h	90	Future letter
PRA 01, part i	60	CNL-13-141 December 20, 2013

RAI Question Number	Type of Response (days)	Actual Date of Response
PRA 01, part j	60	Future letter
PRA 01, part k	60	Future letter
PRA 01, part l	60	Future letter
PRA 01, part m	60	Future letter
PRA 01, part n	60	Future letter
PRA 01, part o	120	Future letter
PRA 01, part p	90	Future letter
PRA 01, part q	60	CNL-13-141 December 20, 2013
PRA 01, part r	60	CNL-13-141 December 20, 2013
PRA 01, part s	90	Future letter
PRA 01, part t	60	Future letter
PRA 01, part u	60	CNL-13-141 December 20, 2013
PRA 01, part v	120	Future letter
PRA 02	60	Future letter
PRA 03	60	CNL-13-141 December 20, 2013
PRA 04	90	Future letter
PRA 05	60	Future letter
PRA 06	60	Future letter
PRA 07	60	Future letter
PRA 08	60	Future letter
PRA 09	60	Future letter

RAI Question Number	Type of Response (days)	Actual Date of Response
PRA 10	90	Future letter
PRA 11	60	Future letter
PRA 12	120	Future letter
PRA 13	60	Future letter
PRA 14	60	Future letter
PRA 15	90	Future letter
PRA 16	90	Future letter
PRA 17	90	Future letter
PRA 18	60	Future letter
PRA 19	60	Future letter
PRA 20	120	Future letter
PRA 21	60	Future letter
PRA 22	60	CNL-13-141 December 20, 2013
PRA 23	60	Future letter
Radioactive Release (RR)		
RR 01	60	Future letter
RR 02	60	Future letter