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10 CFR 50.90

April 13, 2015

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2
Renewed Facility Operating License Nos. DPR-53 and DPR-69
NRC Docket Nos. 50-317 and 50-318

Subject: Request for Additional Information Regarding the National Fire Protection Association Standard 805 License Amendment Request

References:
1. Letter from G. H. Gellrich (CCNPP) to Document Control Desk (NRC), dated September 24, 2013, License Amendment Request re: Transition to 10 CFR 50.48(c) - NFPA 805 Performance Based Standard for Fire Protection
2. Letter from N. S. Morgan (NRR) to G. H. Gellrich (CCNPP), dated January 12, 2015, Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2 – Request for Additional Information Regarding the National Fire Protection Association Standard 805 License Amendment Request (TAC Nos. MF2993 and MF2994)

In Reference 1, Calvert Cliffs Nuclear Power Plant, LLC submitted a license amendment request to transition to 10 CFR 50.48(c) – NFPA 805 Performance Based Standard for Fire Protection. In Reference 2 the NRC staff requested additional information regarding this amendment request. Attachment (1) and the Enclosure provide the response to the request for additional information. The schedule for providing responses to individual questions was provided in Reference 2. Enclosure 1 contains markups of the original license amendment package pages and supersedes the previously provided pages.

The Attachment C, S and W pages in Enclosure 1 contain security-related information and are requested to be withheld from public disclosure under 10 CFR 2.390.

In addition to the responses to the requests for additional information, we are requesting more time to complete the implementation of the of the new NFPA 805 fire protection program, as described in the attached updated page for section 5.5, Transition Implementation Schedule. We are requesting an additional 6 months (180 days to 12 months) beyond the original schedule. The reason for the request is that we have made additional implementation

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commitments, as shown on Attachment S. Additionally, the response to the requests for additional information result in a change to the fire probabilistic risk assessment model, the main control room recovery actions, Attachment G and the Abnormal Operating Procedures, which require more time to implement.

Another licensee identified change is described in updated pages 46 and 47. These changes update the flowchart. We request that these changes be included in the application review.

Another licensee identified change is described in the updated pages for Attachment L for NFPA 805, Sections 2.2.1.2(1) and 3.3.5.2. We request that these changes be included in the application review.

This additional information does not change the No Significant Hazards Determination provided in Reference 1. No regulatory commitments are contained in this letter.

Should you have questions regarding this matter, please contact Mr. Larry D. Smith at (410) 495-3954.

I declare under penalty of perjury that the foregoing is true and correct. Executed on April 13, 2015.

Respectfully,

Mark D. Flaherty
Plant Manager

MDF/PSF/bjm

Attachment: (1) Request for Additional Information Regarding the National Fire Protection Association Standard 805

Enclosure 1 Updated pages

cc: NRC Project Manager, Calvert Cliffs
NRC Regional Administrator, Region I
NRC Resident Inspector, Calvert Cliffs
S. Gray, MD-DNR

ATTACHMENT (1)

REQUEST FOR ADDITIONAL INFORMATION REGARDING THE NATIONAL FIRE PROTECTION ASSOCIATION STANDARD 805

ATTACHMENT (1)

REQUEST FOR ADDITIONAL INFORMATION REGARDING THE NATIONAL FIRE PROTECTION ASSOCIATION STANDARD 805

By letter dated September 24, 2013 Calvert Cliffs Nuclear Power Plant, LLC (CCNPP), submitted a license amendment request (LAR) for Calvert Cliffs Nuclear Power Plant, Units 1 and 2 (Calvert Cliffs) to transition its fire protection licensing basis from Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.48(b) to 10 CFR 50.48(c), National Fire Protection Association Standard (NFPA) 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants," 2001 Edition. The Nuclear Regulatory Commission (NRC) staff is reviewing the application and has determined that the following additional information is needed to complete the review of the LAR:

Fire Protection Engineering (FPE) Request for Additional Information (RAI) 01:

Section 3.3.4 of NFPA 805, 2001 Edition, requires that thermal insulation materials, radiation shielding materials, ventilation duct materials, and soundproofing materials be noncombustible or limited combustible. In Attachment A, "NEI [Nuclear Energy Institute] 04-02 Table B-1 - Transition of Fundamental Fire Protection Program & Design Elements," of the LAR, the licensee stated that the plant "Complies with Clarification" on the basis that the referenced procedures, specifications, and the Combustible Loading Analysis Database control and account for the use of thermal insulation materials, radiation shielding materials, ventilation duct materials, and soundproofing materials. The licensee does not state whether these materials are specified in the documents to be noncombustible or limited combustible. Provide the following information:

a. *Clarify that the procedure(s), specifications, and database specify that thermal insulation materials, radiation shielding materials, ventilation duct materials, and soundproofing materials shall be noncombustible or limited combustible.*

b. *Clarify in the compliance bases whether thermal insulation materials, radiation shielding materials, ventilation duct materials, and soundproofing materials that are either permanently or temporarily installed in the plant are noncombustible or limited combustible.*

c. *If installed materials are not noncombustible or limited combustible, describe how these materials are accounted for and managed in the fire protection program.*

CCNPP RESPONSE FPE RAI 01:

Response provided in Reference 2.

FPE RAI 02:

Section 3.4.1(c) of NFPA 805 requires that the fire brigade leader and at least two brigade members have sufficient training and knowledge of nuclear safety systems to understand the effects of fire and fire suppressants on nuclear safety performance criteria (NSPC). In Section 1.6.4.1, "Qualifications," of NRC Regulatory Guide (RG) 1.189, "Fire Protection for Nuclear Power Plants," Revision 2, September 2009 (ADAMS Accession No. ML092580550), the NRC staff has acknowledged the following example for the fire brigade leader as sufficient:

> *The brigade leader should be competent to assess the potential safety consequences of a fire and advise control room personnel. Such competence by the brigade leader may be evidenced by possession of an operator's license or equivalent knowledge of plant systems.*

In Attachment A, the licensee stated that it complies and references Procedure SA-1-105, Fire Brigade Training, Section 4.4.A.1, which includes the NFPA 805, Section 3.4.1(c) requirement as a responsibility for the shift manager to assure the fire brigade members have the requisite training and knowledge. Provide additional detail regarding the training that is provided to the fire brigade leader and members that addresses their ability to assess the effects of fire and fire suppressants on NSPC.

CCNPP RESPONSE FPE RAI 02:

Response provided in Reference 1.

FPE RAI 03:

In the compliance bases in Attachment A for NFPA 805, Sections 3.10.1(2) and 3.10.3, the licensee refers to a required action in Attachment S, Table S-2, Item 18 of the LAR. Attachment S, Table S-2 does not include an Item 18; however, Attachment S, Table S-2, Item 17 appears to address these elements. Confirm that Attachment S, Table S-2, Item 17 is the correct reference for the implementation item or provide the correct implementation item for the Halon system actions identified in the LAR.

CCNPP RESPONSE FPE RAI 03:

Response provided in Reference 1.

FPE RAI 04:

Section 3.11.3(2), "Fire Barrier Penetrations," of NFPA 805 requires that fire dampers comply with NFPA 90A, "Standard for the Installation of Air-Conditioning and Ventilating Systems." In Attachment A, the licensee requested NRC approval for the use of a performance-based methodology described in Electric Power Research Institute (EPRI) TR-1006756, "Fire Protection Surveillance Optimization and Maintenance Guide for Fire Protection Systems and Features," to change the surveillance frequencies for fire dampers. Attachment L of the LAR, Approval Request 1, which is related to the use of performance-based methodology described in EPRI TR-1006756, only includes NFPA 805, Section 3.2.3(1), as the NFPA 805 requirement that is applicable.

Clarify if Attachment L, Approval Request 1, is also applicable to NFPA 805, Section 3.11.3(2), and revise Approval Request 1 as necessary to accommodate the additional section.

CCNPP RESPONSE FPE RAI 04:

Response provided in Reference 1.

FPE RAI 05:

In Attachment L, Approval Request 2, the licensee proposed a performance-based approach to evaluate the acceptability of unprotected cables located above the suspended ceilings for compliance with the requirements of NFPA 805, Section 3.3.5.1. Provide the following information:

a. *Provide further details that describe the extent of use of extension cords that are located above the suspended ceilings, such as number, length, size, use (e.g., types of electrical loads), and if the extension cords are for permanent or temporary use.*

b. Describe the administrative controls that are (or will be) in place to maintain the technical bases for the request (e.g., prevent/limit future placement of ignition sources and combustible materials, periodic surveillance above the ceiling, etc.).

c. Clarify the following:

i. If the Nuclear Safety Capability Assessment (NSCA) credited cables that are routed in metal conduit above the suspended ceiling need to be free from fire damage in order to support a nuclear safety function or fire risk evaluation (FRE) for a fire in the fire areas described in this request.

ii. The NSPC discussion implies fire damage will not occur because, in part, the cables are protected in metal conduit or in metal covered trays. Metal conduit and metal trays are not generally sufficient to protect cables from exposure fire damage. Provide additional discussion and/or details that provide assurance that NSCA credited cables are not susceptible to damage from extension cords or other potential fire hazards in the area above the ceiling.

d. The licensee appears to conclude that because defense-in-depth (DID) Echelon 1 is satisfied, that Echelons 2 and 3 are also satisfied. The NRC staff notes that DID is based on a balance of the three echelons. Provide additional details related to how Echelons 2 (fire detection and suppression) and 3 (safe shutdown) of the DID concept are maintained.

CCNPP RESPONSE FPE RAI 05:

05a - Extension cords are no longer located above the suspended ceiling. Administrative procedures prohibit the use of extension cords above the suspended ceiling. A reference has been added to the "Complies" compliance statement for NFPA 805, Section 3.3.5.1.

The text of Attachment L has been revised to remove discussion of extension cords as a result of this RAI response. Refer to the attached marked up pages of Attachment L.

05b - Response provided in Reference 2.

05c - Response provided in Reference 1.

05d - Per NFPA 805 Section 1.2, defense-in-depth is achieved when an adequate balance of each of these elements is provided.

- Echelon 1: Hot work controls and the lack of fixed ignition sources in the areas above the suspended ceilings will limit possibility of fires in the area.
- Echelon 2: Manual detection and CCNPP fire brigade manual suppression capability for a fire in the above-ceiling space will limit fire damage in the area.
- Echelon 3: Fire rated barriers between fire areas limit fire spread above the suspended ceiling and the VFDRs located above the suspended ceiling areas were evaluated and found acceptable in accordance with NFPA 805, Section 4.2.4.2, "Performance based approach – fire risk evaluation with simplifying deterministic assumptions."

A reasonable balance of these elements is provided; therefore, DID is achieved.

FPE RAI 06:

In Attachment L, Approval Request 3, the licensee requested the use of procedural guidance that will allow performance of welding, cutting and other hot work in sprinklered fire areas while the suppression system is impaired, as an acceptable performance-based approach to comply with NFPA 805, Section 3.3.1.3.1. Provide the following information:

a. *In the bases for the request, the licensee stated that this request is applicable to any fire area containing a sprinkler system, as identified in Attachment C, Table C-2. Discuss the bases for limiting this hot work procedure request to only fire areas that contain required fire sprinkler systems identified in Attachment C, Table C-2.*

b. *Describe the hot work administrative controls for the fire areas that contain a suppression system that is not identified as a required suppression system in Attachment C, Table C-2, and whether the administrative controls are different than those for fire areas with required fire suppression systems.*

c. *In the bases for the request, the licensee stated that permanent combustibles located within 35 feet of the work area that cannot be removed must be covered with the appropriate style of blanket. Clarify if the "appropriate style of blanket" is a listed or approved welding curtain, welding blanket, welding pad, or equivalent, as required by NFPA 51B, "Standard for Fire Prevention During Welding, Cutting, and Other Hot Work."*

d. *Describe any additional actions/controls to be used when hot work is performed in fire areas/zones where one or more sprinkler systems are impaired above and beyond those taken for any other hot work activity conducted when sprinklers are in service.*

CCNPP RESPONSE FPE RAI 06:

Response provided in Reference 1.

FPE RAI 07:

NRC endorsed guidance NEI 04-02, "Guidance for Implementing a Risk-Informed, Performance-Based Program Under 10 CFR 50.48(c)," states that, where used in Chapter 3, "power block" and "plant" refer to structures that have equipment required for nuclear plant operations, such as containment, auxiliary building, service building, control building, fuel building, radiological waste, water treatment, turbine building, and intake structure, or structures that are identified in the facility's pre-transition licensing basis.

Section 4.1.3 and Attachment I, Table I-1, "Definition of Power Block," of the LAR state that buildings that are required for nuclear plant operations (i.e., required to meet the nuclear safety or radioactive release (RAD) performance criteria identified in Sections 1.5.1 and 1.5.2 of NFPA 805) are considered within the power block. The licensee reviewed the plant for compliance with the RAD performance criteria, and the results are documented in Attachment E, which includes the following compartments as screened in for RAD review, but are not described as part of the power block in Attachment I, Table I-1:

- *Interim Resin Storage Facility (Lake Davies)*
- *Material Processing Facility*
- *Office and Training Facility*
- *Original Steam Generator Storage Facility*
- *Pre-Assembly Facility (Upper Laydown Area)*

- *Sewage Treatment Plant*
- *Unit 1 Butler Building*
- *Unit 2 Butler Building*
- *Warehouse No. 3*
- *West Road Cage*

Describe the basis for excluding these structures from the power block, based on the criteria stated in Section 4.1.3, " ... those that contain equipment required to meet the nuclear safety and RAD criteria ... ," and consequently, exclusion from the NFPA 805, Chapter 3 elements that apply to the power block.

CCNPP RESPONSE FPE RAI 07:

Response provided in Reference 2.

FPE RAI 08:

Section 3.11.1 of NFPA 805 requires that each major building within the power block be separated from the others by barriers having a designated fire resistance rating of 3 hours or by open space of at least 50 feet or space that meets the requirements of NFPA 80A, "Recommended Practice for Protection of Buildings from Exterior Fire Exposures." In Attachment A, the licensee stated that it "Complies with Clarification" and described that the North Service Building and Turbine Building are analyzed as one fire area in the NFPA 805 NSCA, and are, therefore, treated as one building from a building separation perspective. The licensee also stated that it "Complies with Use of EEEE's" with respect to excluding the 45'-0" elevation of the North Service Building from the power block. The licensee did not discuss the basis for excluding this specific elevation from the power block in Attachment I.

Provide the basis for excluding the 45'-0" elevation of the North Service Building from the power block.

CCNPP RESPONSE FPE RAI 08:

Response provided in Reference 1.

FPE RAI 09:

Section 3.4.1(a) of NFPA 805 requires that a fully staffed, trained, and equipped fire-fighting force be available at all times to control and extinguish all fires on site. In Attachment A, the licensee stated that in Section 5.5.B of Procedure SA-1-101, "If there are less than 5 brigade members notify the Control Room."

Current NRC guidance, Frequently Asked Question (FAQ) 12-0063, "Fire Brigade Make-Up" (ADAMS Accession No. ML121980572), discusses conditions where fire brigade complement may be less than the minimum for a period of time, in order to accommodate unexpected absence of on-duty shift members. Further, licensees may claim prior approval if their current technical specifications or fire protection safety evaluation addresses the issue. If prior approval has not been granted, then the licensee should seek NRC approval in the NFPA 805 LAR.

Provide additional detail on the compliance bases related to conditions when there are less than 5 fire brigade members onsite.

CCNPP RESPONSE FPE RAI 09:

Calvert Cliffs has prior approval based on current Technical Specifications Section 5.2.2 which allows for the shift crew composition, of which Fire Brigade members are, to be less than the minimum for a period of time not to exceed 2 hours in order to accommodate unexpected absence of on-duty shift crew members provided immediate action is taken to restore the shift crew composition to within the minimum requirements. The compliance basis or the LAR Attachment A, Section 3.4.1(a) has been revised to show compliance by previous NRC approval. See enclosed mark up.

FPE RAI 10:

Section 3.11.5 of NFPA 805 requires that Electrical Raceway Fire Barrier Systems (ERFBS) that are required by NFPA 805, Chapter 4, be capable of resisting the fire effects of the hazards in the area. In Attachment A, the licensee stated that there are no ERFBS credited for compliance with Chapter 4, and, therefore, there is no compliance applicable to NFPA 805, Section 3.11.5. However, in Attachment B (Attributes 3.4.1.3, 3.4.1.5, 3.4.2.2, and 3.4.2.3) the licensee described that one of the means of addressing cable impacts of fire damage is to protect the cables by an ERFBS.

a. *Clarify if there were any cable resolutions in the NSCA that credit an ERFBS to protect the affected cables to meet NFPA 805, Chapter 4. If yes, then clarify if the ERFBS are in compliance with NFPA 805, Section 3.11.5.*

CCNPP RESPONSE FPE RAI 10:

Response provided in Reference 1.

Safe Shutdown Analysis (SSA) RAI 01:

Attribute 3.2.1.2 of NEI 00-01, Revision 2, includes the assumption that exposure fire damage to manual valves and piping does not adversely impact their ability to perform their pressure boundary or safe shutdown function, and that any post-fire operation of a rising stem valve located in the fire area of concern should be well justified using an engineering evaluation. In Attachment B, the alignment bases for NEI 00-01, Attribute 3.2.1.2, states that manual valves that are repositioned for credited NFPA 805 recovery actions (RAs) are included in the NFPA 805 NSPC equipment list and are subject to assessment of feasibility.

Provide the following information:

a. *Clarify if any rising stem valves involved in an RA are subjected to fire damage.*
b. *If any of the valves in the fire area of concern being repositioned by an RA are rising stem valves, then clarify if an engineering evaluation was performed to evaluate the exposure fire damage to manual valves and piping to determine if the exposure to fire would adversely impact their ability to perform their pressure boundary or safe shutdown function. If used, describe the method and results obtained from the engineering evaluation.*

CCNPP RESPONSE SSA RAI 01:

Response provided in Reference 1.

SSA RAI 02:

Attribute 3.3.1.1.4 of NEI 00-01, Revision 2, includes criteria and assumptions for evaluating power cables for breaker coordination concerns and includes safe shutdown cables and those non-safe shutdown cables that can impact safe shutdown. In Attachment B of the LAR, the alignment bases for NEI 00-01, Attribute 3.3.1.1.4, states that the NSCA circuit identification and analysis should utilize a "building block" approach and include only, as applicable, the power cable from the NSCA component to the upstream electrical power source.

Provide the following information:

a. *Clarify if cables that supply loads not required to meet the NSPC off of the nuclear safety buses are classified as "required" cables. If non-nuclear safety cables are not included, then provide the justification for not considering the failure of non-nuclear safety cables in meeting the breaker coordination criteria for protection.*
b. *The alignment basis states that plant modifications have been identified to achieve selective coordination of breakers/fuses and identified as implementation items in Attachment S, Table S-2. Identify the specific modifications that are required to achieve the selective coordination of breakers/fuses.*

CCNPP RESPONSE SSA RAI 02:

Response provided in Reference 2.

SSA RAI 03:

Attribute 3.5.1.3 of NEI 00-01, Revision 2, includes an assumption that circuit contacts are initially positioned (i.e., open or closed) consistent with the normal mode/position of the "required for hot shutdown" equipment, and that the analyst must consider the position of the "required for hot shutdown" equipment for each specific shutdown scenario when determining the impact that fire damage to a particular circuit may have on the operation of the equipment. In LAR Attachment B, the alignment basis for Attribute 3.5.1.3 states that the circuit analysis may discount spurious operation based on a fire affected cable being routed in a dedicated conduit and the cable being protected from external sources of voltage (also taking into consideration the potential impact from ground equivalent hot shorts).

For multi-conductor cables routed in dedicated conduit, provide a description if intra-cable hot shorts (wire-to-wire shorts) are considered as a potential impact of fire damage on required position of the NSCA equipment (i.e., the function of the initial position of circuit contacts are not affected by intra-cable hot shorts).

CCNPP RESPONSE SSA RAI 03:

Response provided in Reference 2.

SSA RAI 04:

The nuclear safety goal described in NFPA 805, Section 1.3.1, is to provide reasonable assurance that a fire during any operational mode and plant configuration will not prevent the plant from achieving and maintaining the fuel in a safe and stable condition. In Section 4.2.1.2, the licensee stated that the NSCA will demonstrate that the plant can achieve and maintain safe and stable conditions for at least 12 hours with the minimum shift operating staff. After

12 hours, the Emergency Response Organization (ERO) will be available to support "safe and stable" actions to extend hot standby conditions.

a. *In Section 4.2.1.2, subsection "Methods to Maintain 'Safe and Stable' and Extend Hot Standby Conditions," of the LAR, local manual actions are described to align various systems and functions. In Item No. 8, the licensee stated that should alternating current (AC) charging sources be lost, local manual operator action may be required, and that station batteries are capable of providing a minimum of 4 hours of 125 V direct current power to their respective loads during a station blackout without AC charging sources. The licensee further stated that this time allowance credits securing 1INV1T11 in the cable spreading room (CSR) within 45 minutes. Clarify if this local manual action is credited as an RA in any fire area.*

b. *In Section 4.2.1.2, subsection "Assessment of Risk," the licensee stated that the ERO provides sufficient resources for assessment of fire damage and completion of repairs to equipment necessary to maintain hot standby for an extended period, transition to cold shutdown, or return to power operations as dictated by the plant fire event. Describe if any repair activities are necessary to maintain hot standby for an extended period (safe and stable conditions), including a detailed description of the specific repairs that would be needed, the success path(s) being restored, and the time frame required to complete the repair.*

CCNPP RESPONSE SSA RAI 04:

Response provided in Reference 2.

SSA RAI 05:

Section 2.4 of RG 1.205, "Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants," Revision 1, dated December 2009 (ADAMS Accession No. ML092730314) describes the treatment of RAs supplemented by guidance provided in NEI 04-02 and FAQ 07-0030, "Establishing Recovery Actions" (ADAMS Accession No. ML110070485). In RG 1.205, the NRC staff clarifies that operation of alternative or dedicated shutdown controls while the main control room (MCR) remains the command and control location would primarily be considered an RA because, for such scenarios, the dedicated or alternative controls are not considered primary. Attachment G of the LAR describes the primary control stations (PCS) and identifies RAs performed at the PCS in Fire Area 16 (Unit 1 CSR and 1C cable chase) and Fire Area 17 (Unit 2 CSR and 2C cable chase). Provide the following information:

a. *Clarify if the control room remains the command and control location for a fire in Fire Areas 16 and 17, and if so, discuss how the RAs at the PCS are evaluated for compliance with NFPA 805, Section 4.2.4.*

b. *In Fire Areas 16 and 17, there are RAs at the PCS that are not associated with a variance from deterministic requirement (VFDR).*

   - *For Fire Area 16, the RAs are:*

     6ICHECKRXSD1; 16ICONSERVE1; 16ISECHTR11_13; 16IADV1C43; 16I1C43CONTROL; and 16IRCSTEMP1.

- *For Fire Area 17, the RAs are:*

  17ICHECKRXSD2; 17ICONSERVE2; 17ISECHTR21_23; 17IADV2C43; 17I2C43CONTROL; and 17IRCSTEMP2.

Clarify the purpose of performing these RAs, and whether the actions are required to meet the NSPC required by NFPA 805, Section 1.5.1.

c. *In Attachment G, Table G-1 of the LAR, disposition of VFDR 16-19-1 credits RAs at the PCS to energize pressurizer backup heater banks 11 and 13; however, another non-VFDR related RA (16ISECHTR11_13) is credited to secure the pressurizer backup heater banks 11 and 13. Discuss how the contradicting RAs are evaluated in the NSCA.*

d. *In LAR Attachment G, Table G-1, RAs are credited to disposition VFDRs 16-27-1 and 17-25-2 to control atmospheric dump valve (ADV) hand valves to support control of the ADVs at the PCS locations 1C43 and 2C43, respectively. However, the RAs (16IADV1C43 and 17IADV2C43) to control the ADVs at the PCS location do not have a VFDR associated with them. Discuss the method for crediting RAs to support the VFDR disposition without crediting the RA at the PCS.*

CCNPP RESPONSE SSA RAI 05:

Response provided in Reference 2.

SSA RAI 06:

Attachment W Tables W-6 and W-7 of the LAR appear to conflict with information described in Attachment C, Table C-1, and Attachment G, Table G-2. Clarify the following discrepancies:

a. *In Attachment C, Table C-1, Fire Area 34 is identified as transitioning deterministically in Unit 2 (Section 4.2.3.2 of NFPA 805) with no VFDRs identified. However, in Attachment W, Table W-7, Fire Area 34 is identified as transitioning using performance-based methods (Section 4.2.4.2 of NFPA 805), VFDRs are identified, RAs are credited, and the risk of the RA was calculated. Clarify the correct nuclear safety compliance strategy for Fire Area 34.*

b. *In Attachment C, Table C-1, the following fire areas are identified as transitioning deterministically with no VFDRs identified. However, Attachment W, Table W-6 (for Unit 1) and Attachment W, W-7 (for Unit 2) identify that these fire areas have VFDRs identified. Further, an FRE was performed that calculated a delta core damage frequency (CDF) and delta large early release frequency (LERF) value as follows:*

   Unit 1: 2, 8, 13, 18, 18A, 22, 23, 25, 26, 27, 28, 31, 38, 40, and 2CNMT
   Unit 2: 3, 4, 6, 14, 15, 19, 19A, 21, 30, 33, 39, and 1CNMT

   For each of these fire areas, clarify the correct nuclear safety compliance strategy, and justify the bases for performing an FRE that is not discussed in the NSCA in LAR Attachment C, Table C-1, and the bases for crediting RAs that are not included in LAR Attachment G, Table G-1.

c. *In Attachment C, Table C-1, the following fire areas are identified as transitioning using performance-based methods (FRE) to meet the NSPC, and no RAs were credited (either for risk or DID). However, Attachment W, Table W-6 (for Unit 1) and Attachment W, W-7 (for Unit 2) identify these fire areas as crediting RAs and the risk of the RA was calculated:*

Unit 1: 12, 14, 15, 19A, 21, 30, 32, 33, 35, 36, 39, 1 CNMT, and IS
Unit 2: 12, 13, 18A, 20, 26, 27, 28, 32, 34, 35, 36, 40, 2CNMT and IS

For each of these fire areas, clarify the correct nuclear safety compliance strategy for these fire areas and the bases for crediting RAs that are not included in Attachment G, Table G-1.

d. In Attachment C, Table C-1, the following fire areas are identified as transitioning using deterministic methods to meet the NSPC, and no RAs were credited (either for risk or DID). However, Attachment W, Table W-6 (for Unit 1) and Attachment W, W-7 (for Unit 2) identifies these fire areas as crediting RAs and the risk of the RA was calculated:

Unit 1: 13, 18, 18A, 22, 23, 25, 26, 27, 28, and 2CNMT
Unit 2: 14, 15, 19, 19A, 21, 30, 33, 39 and 1CNMT

For each of these fire areas, clarify the correct nuclear safety compliance strategy and justify the bases for not including these RAs in Attachment G, Table G-1, if these RAs are actually credited in the NSCA.

CCNPP RESPONSE SSA RAI 06:

06a - The nuclear safety compliance strategy for Unit 2, Fire Area 34 is 4.2.3.2, deterministic. Attachment W, Table W-7 is updated (see enclosure) to identify Unit 2 compliance as 4.2.3.2 with no VFDRs or RAs.

06b - Unit 1 - Attachment C correctly identifies the compliance strategy for Unit 1 as 4.2.3.2 for Fire Areas 2, 8, 13, 18, 18A, 22, 23, 25, 26, 27, 28, 31, 38, 40, and 2CNMT. Attachment W, Table W-6 identifies these fire areas with VFDRs which contradicts the compliance strategy in Attachment C. Table W-6 is updated (see enclosure) to "No" for the "VFDRs" column for Fire Areas 2, 8, 13, 18, 18A, 22, 23, 25, 26, 27, 28, 31, 38, 40, and 2CNMT. The "Delta CDF / Delta LERF" column for these fire areas is updated to "N/A."

Unit 2 - Attachment C correctly identifies the compliance strategy for Unit 2 as 4.2.3.2 for Fire Areas 3, 4, 6, 14, 15, 19, 19A, 21, 30, 33, 39, and 1CNMT. Attachment W, Table W-7 identifies these fire areas with VFDRs which contradicts the compliance strategy in Attachment C. Table W-7 is updated (see enclosure) to "No" for the "VFDRs" column for Fire Areas 3, 4, 6, 14, 15, 19, 19A, 21, 30, 33, 39, and 1CNMT. The "Delta CDF / Delta LERF" column for these fire areas will be updated to "N/A."

06c - Attachments C and G are correct and Attachment W, Tables W-6 and W-7 are revised (see enclosure) as follows:

Unit 1 - RAs are not required for Fire Areas 12, 14, 15, 19A, 21, 30, 32, 33, 35, 36, 39, 1CNMT and IS. Table W-6 is updated to show the "Additional Risks of RAs" column for these Fire Areas as "N/A."

Unit 2 - RAs are not required for Fire Areas 12, 13, 18A, 20, 26, 27, 28, 32, 34, 35, 36, 40, 2CNMT and IS. Table W-7 is updated to show the "Additional Risks of RAs" column for these Fire Areas as "N/A."

06d - Attachments C and G are correct and Attachment W, Tables W-6 and W-7 are revised (see enclosure) as follows:

Unit 1 - RAs are not required for Fire Areas 13, 18, 18A, 22, 23, 25, 26, 27, 28, and 2CNMT. Attachment W, Table W-6 is updated to show the "Additional Risks of RAs" column for these Fire Areas as "N/A."

Unit 2 - RAs are not required for Fire Areas 14, 15, 19, 19A, 21, 30, 33, 39 and 1CNMT. Attachment W, Table W-7 will be updated to show the "Additional Risks of RAs" column for these Fire Areas as "N/A."

Attachment W, Tables W-6 and W-7 are updated (see enclosure) in accordance with this RAI. Additional changes will be included in the integrated response to PRA RAI 03.

SSA RAI 07:

Modifications were identified in Attachment S, Table S-2, that appear to resolve certain VFDR issues. However, the disposition of the certain VFDRs as summarized in Attachment C, Table C-1, do not describe whether the modification was credited or not. Provide clarification on how the modifications described below were addressed in the disposition of the VFDRs listed:

a. Attachment S, Table S-2, Item 7, involves modifying control circuits for the Pressurizer Power Operated Relief Valves (PORVs), 1(2)ERV402 and 1 (2)ERV404, to prevent the PORVs from spuriously opening. However, VFDRs 16-46-1, 24-26-1, 16-47-1, 24-27-1, 17-41-2, 24-63-2, 17-42-2, and 24-64-2 involve fire damage to cables which could result in spurious opening of the Pressurizer PORV, and the VFDR dispositions credits an RA for DID.

b. Attachment S, Table S-2, Item 8, involves modifying the control circuits for the auxiliary feed water (AFW) steam admission valves 1(2)CV4070 and 1(2)CV4071 to ensure adequate separation such that one set of valves will be available during a fire in either the CSR or switchgear rooms. However, VFDRs (16-22-1, 17-16-2, 16-26-1, and 17-26-2) involve fire damage to cables that could cause the loss of control and/or spurious operation of 1(2)CV4070 and 1(2)4071, and the VFDR dispositions credit an RA either to reduce risk (VFDRs 16-22-1 and 17-16-2) or for DID (VFDRs 16-26-1 and 17-26-2).

c. Attachment S, Table S-2, Item 11, involves modifying control circuits for the Main Steam Isolation Valves (MSIVs), 1(2)CV4043OP and 1(2)CV4048OP, to ensure at least one solenoid dump valve can be energized to close the MSIVs. However, VFDRs 16-31-1, 16-32-1, 17-23-2, and 17-24-2 involve fire damage to cables that could cause a loss of control and/or spurious operation of the associated MSIV, and the VFDR dispositions credit an RA for DID (VFDRs 16-31-1, 16-32-1, 17-23-2, and 17-24-2).

CCNPP RESPONSE SSA RAI 07:

07a - The modification identified in LAR Attachment S, Table S-2, Item 7 will not prevent the possible spurious operation of the PORVs due to a fire in Fire Areas 16, 17 or 24. The NSCA credits a recovery action for DID to ensure the PORVs are closed.

07b - The modification identified in LAR Attachment S, Table S-2, Item 8 will prevent the potential for a loss of control and/or spurious operation of the AFW Steam Admission valves as identified in VFDRs 16-22-1 and 17-16-2. LAR Attachment C, Table B-3, and LAR

Attachment S, Table S-2, will be updated to reflect this. The modification will not prevent the potential for a loss of control and/or spurious operation of the AFW Steam Admission Valves as identified in VFDRs 16-26-1 and 17-26-2. A recovery action is required for DID for these failures in Fire Areas 16 and 17.

07c - The modification identified in LAR Attachment S, Table S-2, Item 11 will prevent the potential for a loss of control and/or spurious operation of the MSIVs as identified in VFDRs 16-31-1, 16-32-1, 17-23-2 and 17-24-2. LAR Attachment C, Table B-3, and LAR Attachment S, Table S-2, will be updated to reflect this.

SSA RAI 08:

In Attachment K, Licensing Action 5, the licensee requested that a previously approved exemption, related to dedicated water curtains as being adequate to maintain the 3-hour fire rating of barriers, be transitioned to the NFPA 805 program. The licensee described the sprinkler systems located in Room 216A and Room 106 as supplying the sprinkler heads for the dedicated water curtains. In the summary of the exemption approved by the NRC in a letter dated March 15, 1984 (ADAMS Accession No. ML010430325), the licensee stated that on the Corridor No. 110 side of the hatch, a dedicated sprinkler head will be supplied from the Room No. 116 sprinkler system. However, in the Baltimore Gas & Electric Company submittal dated November 21, 1983 (ADAMS Accession No. 8311290159), the licensee stated that on the corridor No. 110 side of the hatch, a dedicated sprinkler head will be supplied from the Room No. 106 sprinkler system. The NRC staff also noted that Attachment C, Table C-1, refers to room numbers in the "Required Fire Protection System and Features," and Attachment C, Table C-2, refers to fire zones. The NRC staff also noted in the discussion for Licensing Action 1 that room numbers at the plant may have changed over time. Provide the following information:

a. *Describe if the fire zone numbers listed in Attachment C, Table C-2, are the same as the room numbers listed in the fire area summary in Attachment C, Table C-1. Describe if the room numbers in Attachment C correspond with the room numbers cited in the previous licensing actions in Attachment K.*
b. *Provide a description of the water curtain arrangement, including the sprinkler systems that supply the required sprinkler heads using the current terminology for rooms, fire areas, and/or fire zones such that the staff can fully understand the installation and how the installation is represented in the various tables in the submittal and the previous licensing actions.*

CCNPP RESPONSE SSA RAI 08:

Response provided in Reference 1.

SSA RAI 09:

In Attachment C, Table C-1, under the heading "Fire Suppression Effects on Nuclear Safety Performance Criteria," the majority of the fire areas contain the concluding statement, "Fire suppression in this fire area will not impact the ability to achieve the NSPC in accordance with NFPA 805, Sections 4.2.1 and 4.2.4.1.5." NFPA 805, Section 4.2.4.1.5, is associated with the fire modeling performance-based approach, which the licensee stated it did not use in Section 4.5.2.1 of the LAR. In addition, the suppression effects sections for several other fire areas (e.g., 18A, 20, 21, 22, 23, 35, and 36) contain the statement, "There is no suppression

effect concern for this fire area as the fire area does not contain NSCA equipment," yet the fire area contains VFDRs. Address the following:

a. *Clarify the basis for discussing the fire suppression effects for a fire modeling performance-based approach when the fire areas used a risk evaluation performance-based approach.*

b. *Provide additional discussion for those fire areas where VFDRs are identified, but the suppression effects discussion states there is no NSCA equipment in the fire area.*

CCNPP RESPONSE SSA RAI 09:

Response provided in Reference 2.

SSA RAI 10:

In Section 4.5.2.2, the licensee stated that there are no VFDRs that involved performance-based evaluations related to wrapped or embedded cables. However, in Attachment C, Table C-1, Fire Areas 18, 19, 35, 36, and TB/NSB/ACA are performance-based fire areas and credit EEEE, "ECP-13-000359 - "Generic Letter (GL) 86-10 Evaluation of Embedded Conduit in the Turbine Building and Barrier Thickness of the Floor/Ceiling Barrier between AB-4/AB-5 and 517/518," which justifies the acceptability of conduits embedded in the Turbine Building floor slab (elevation 27'), the floor/ceiling slab between stairwells AB-4 and AB-5, and the horizontal cable chases (Rooms 517 and 518). Clarify if the disposition of the VFDRs in Fire Areas 18, 19, 35, 36, and TB/NSB/ACA credit the embedment as evaluated in the EEEE.

CCNPP RESPONSE SSA RAI 10:

Response provided in Reference 2.

SSA RAI 11:

In Attachment C, Table C-1, the licensee identified Marinite boards as fire protection features that are credited for "S" (required for Chapter 4 separation criteria) and "R" (required for risk significance) to protect cables for a fire in Fire Area 1CNMT (Unit 1 Containment) and 2CNMT (Unit 2 Containment). Provide the following information:

a. *Describe the extent that Marinite boards are credited for Chapter 4 separation ("S") and for risk significance ("R") in the Unit 1 and Unit 2 Containments. In addition, describe the design and plant configuration of the Marinite boards and the nuclear safety functions that the passive fire protection features are protecting.*

b. *Provide previous NRR staff approval (if any) for the use of Marinite boards in containment to demonstrate meeting the requirements of Appendix R, Section III.G.2, which can be credited to meet the requirements of NFPA 805, Section 4.2.3.4, or evaluate acceptability using a performance-based analysis approach in accordance with NFPA 805, Section 4.2.4.*

CCNPP RESPONSE SSA RAI 11:

11a - The Marinite boards will no longer be credited to provide 20 foot separation in Unit 1 and Unit 2 Containments. Attachment C, Table C-1, is updated (see enclosure) to remove credit for the Marinite boards for Chapter 4 separation criteria in Fire Area 1CNMT and 2CNMT.

Refer to the response to part b of SSA RAI 11 for additional discussion of Chapter 4 separation criteria.

The Marinite boards are credited in the Fire PRA as a "fire break" to prevent fire spread across the east and west portions of Unit 1 and 2 containments. The Marinite boards are not credited to protect the cables inside the trays from fire damage. There are 4 trays covered in Unit 1, and 3 trays covered in Unit 2.

The design of the Marinite boards is as follows:

- A minimum of 25 feet of each cable tray (that traverses between containment east to west) is covered (top and bottom) with ½ inch Marinite XL.
- The Marinite board is banded to the trays with 3/8 inch stainless steel banding, minimum of 12 gauge steel.

Site procedures ensure the Marinite boards are inspected, in place and free from damage prior to start-up.

11b - Attachment C, Table C-1, is updated (see enclosure) to remove credit for the Marinite boards for Chapter 4 separation criteria in Fire Area 1CNMT and 2CNMT. This will result in additional VFDRs that will be evaluated for acceptability in accordance with NFPA 805, Section 4.2.4 as part of the integrated PRA response (PRA RAI 03).

SSA RAI 12:

In Attachment C, Table C-2, the licensee makes reference to "Unit 1 Containment (App-R Purposes Only)" and "Unit 2 Containment (App-R Purposes Only)," for fire protection systems and features. The fire protection systems and features are identified as required for "S" (Required for Chapter 4 Separation Criteria), "R" (Required for Risk Significance), and/or "D" (maintain an adequate balance of DID in a change evaluation or FRE).

Clarify the meaning of "Appendix-R Purposes Only" and if these fire protection systems and features are credited with respect to compliance with NFPA 805, Chapter 4.

CCNPP RESPONSE SSA RAI 12:

Response provided in Reference 1.

SSA RAI 13:

Provide the following pertaining to non-power operations (NPO) discussions provided in Section 4.3 and Attachment D:

a. *Section 4.3.2 and Attachment D state that incorporation of the recommendations from the "KSF [key safety function] pinch point" evaluations into appropriate plant procedures prior to implementation will be done to ensure the requirements of NFPA 805 are met. Identify and describe the changes to outage management procedures, risk management tools, and any other document resulting from incorporation of KSFs identified as part of NFPA 805 transition. Include changes to any administrative procedures such as "Control of Combustibles."*

b. *For those components that had not previously been analyzed in support of the at-power analysis or whose functional requirements may have been different for the non-power analysis, cable selection was performed in accordance with approved project procedures. Provide a list of the additional components and a list of those at-power components that have a different functional requirement for NPO. Describe the difference between the at-power safe shutdown function and the NPO function. Include with this list a general description by system indicating why components would be selected for NPO and not be included in the at-power analysis.*

c. *Section 4.3.1 and Attachments D and H state that the NPO analysis was performed in accordance with FAQ 07-0040, "Non-Power Operations Clarifications (ADAMS Accession No. ML082200528). However, the LAR did not provide the results of the KSF pinch point analysis. Provide a list of KSF pinch points by fire area that were identified in the NPO fire area reviews using FAQ 07-0040, including a summary level identification of unavailable paths in each fire area. Describe how these locations will be identified to the plant staff for implementation.*

d. *During NPO modes, spurious actuation of valves can have a significant impact on the ability to maintain decay heat removal and inventory control. Provide a description of any actions being credited to minimize the impact of fire-induced spurious actuations on power operated valves (e.g., air-operated valves and motor-operated valves) during NPO (e.g., pre-fire rack-out, actuation of or pinning of valves, and isolation of air supplies).*

e. *During normal outage evolutions, certain NPO credited equipment will have to be removed from service. Describe the types of compensatory actions that will be used during such equipment down-time.*

f. *The description of the NPO review for the LAR does not identify locations where KSFs are achieved via RAs or for which instrumentation not already included in the at-power analysis is needed to support RAs required to maintain safe and stable conditions. Identify those RAs and instrumentation relied upon in NPO and describe how RA feasibility is evaluated. Include in the description whether these variables have been or will be factored into operator procedures supporting these actions.*

CCNPP RESPONSE SSA RAI 13:

13a – Response provided in Reference 1.

13b – Response provided in Reference 1.

13c – Response provided in Reference 1.

13d – Response provided in Reference 2.

13e – Response provided in Reference 2.

13f – Response provided in Reference 1.

SSA RAI 14:

Describe if any RAs require the cross-tie of Unit 1 and Unit 2 systems to achieve the NSPC. Provide the following information:

a. *Describe whether these cross-connecting RAs require staff from both units. If so, describe how the feasibility analysis reflects the Unit 1 and Unit 2 staffing, communication, and operational interface.*

b. *Describe the operational impacts (by fire), if any, on the unaffected unit created by cross-tying these systems. Describe whether Technical Specification 3.0.3 is entered once the cross-tie with the opposite unit has been completed for fire safe shutdown.*

CCNPP RESPONSE SSA RAI 14:

Response provided in Reference 1.

SSA RAI 15:

In Attachment B of the LAR, the alignment basis discussion for Attribute 3.2.1.2 provides the following statement on possible fire damage to instrument air tubing that includes copper tubing with soldered joints that are susceptible to separation during a fire and could cause the loss of instrument air to components:

> *These affects were evaluated on an area basis to determine if the instrument air system pressure could be maintained. Calculation CA07971 demonstrates that the instrument air system can maintain system pressure with a 1 inch line pipe rupture.*

Calculation CA07971 states, "Evaluation of Maximum Air Line Break Size in Which Nominal Instrument Air Pressure Can Be Maintained at 50 psig." The NRC staff noted apparent discrepancies in the use and recovery of instrument air as described in Attachment C. Provide the following:

a. *Provide justification that 50 psig of instrument air pressure will not prevent instrument air operated valves from changing position.*

b. *Provide justification for limiting the size of the line to 1" soldered joints being susceptible to separation during a fire. Describe the soldered joints used in the plant instrument air system. For any soldered joints larger than 1", describe how they were treated in the NSCA and Fire Probabilistic Risk Assessment (PRA).*

c. *For several fire areas in Attachment C (such as Fire Areas 18, 19, 20, 21, and 22), the licensee stated in the method of accomplishment for the vital auxiliaries performance goal that instrument air may be recoverable from the opposite unit plant air system. However, the VFDRs associated with the fire areas (such as VFDRs 18-16-2, 19-01-1, 20-02-1, 21-02-1, and 22-05-2) state that plant air from the opposite unit cannot be used because of failure of 1CV2061 or 2CV2061, and the VFDR disposition credits an RA that involves aligning backup nitrogen to the affected unit control valves. Clarify the discrepancy between the method described in the subject fire areas for achieving the performance goal, the VFDRs that state this method is not available, and the RAs cited in LAR Attachment G for resolution of the VFDRs.*

d. *In Attachment C, the discussion of fire suppression effects on the NSPC for Fire Areas 39 and 40 addresses the impact of suppression damage to redundant instrument air compressors and the saltwater air system, and states that the AFW air accumulators can*

be charged from the nitrogen system with an RA. However, the disposition of VFDRs 39-01-1 and 40-01-2, which address fire damage to the respective unit's instrument air system, stated that the VFDR has been evaluated with no further action required. In addition, the RA to align the nitrogen system to the AFW air accumulators is not discussed in LAR Attachment G for these fire areas. Clarify the apparent discrepancy between the effects of fire damage and suppression damage on the instrument air system and salt water air compressors (SWAC) with regard to the need for an RA. If an RA is necessary to mitigate the suppression effects on the instrument air compressors and SWAC, then describe the feasibility and additional risk of the RA.

CCNPP RESPONSE SSA RAI 15:

15a - Calculation CA07971 documents that a system pressure as low as 50 psig is acceptable to maintain system operability in support of fire safe shutdown. Valves may change position at this pressure but all credited valves can only change to the desired NSCA position. Credit is not taken for the loss of instrument air pressure to place credited valves in the required NSCA position.

15b - Response provided in Reference 1.

15c - For the subject VFDRs the loss of instrument air will be mitigated by a Recovery Action to align the opposite unit plant air system. The Recovery Action to align nitrogen will not be used for these VFDRs. A markup of Attachment C and Attachment G is enclosed with this response. Attachment G will be reissued as part of the response to PRA RAI 03.

Fire Area 18 - The compliance statement in Attachment C stating that Unit 2 instrument air is RECOVERABLE from Unit 1 plant air is correct. VFDR 18-16-2 is misleading in stating that Unit 1 plant air cannot be used to mitigate the loss of the Unit 2 instrument air system because plant air can be aligned to the instrument air system with a recovery action to open 2CV2061. The recovery action identified in LAR Attachment G to mitigate this failure was to align nitrogen to the instrument air system. The VFDR statement in Attachment C is revised to clarify and Attachment G is updated to credit a recovery action to align Unit 1 plant air to the Unit 2 instrument air system (see enclosure).

Fire Area 19 - The compliance statement in Attachment C stating that Unit 1 instrument air is RECOVERABLE from Unit 2 plant air is correct. VFDR 19-01-1 is misleading by stating that Unit 2 plant air cannot be used to mitigate the loss of the Unit 1 instrument air system because plant air can be aligned to the instrument air system with a recovery action to open 1CV2061. The recovery action identified in LAR Attachment G to mitigate this failure was to align nitrogen to the instrument air system. The VFDR statement in Attachment C is revised to clarify and Attachment G is updated to credit a recovery action to align Unit 2 plant air to the Unit 1 instrument air system (see enclosure).

Fire Area 20 - The compliance statement in Attachment C stating that Unit 1 instrument air is RECOVERABLE from Unit 2 plant air is correct. VFDR 20-02-1 is misleading by stating that Unit 2 plant air cannot be used to mitigate the loss of Unit 1 instrument air system because plant air can be aligned to the instrument air system with a recovery action to open 1CV2061. The recovery action identified in LAR Attachment G to mitigate this failure was to align nitrogen to the instrument air system. The VFDR statement in Attachment C is revised to

clarify and Attachment G is updated to credit a recovery action to align Unit 2 plant air to the Unit 1 instrument air system (see enclosure).

Fire Area 21 - The compliance statement in Attachment C stating that Unit 1 instrument air is RECOVERABLE from Unit 2 plant air is correct. VFDR 21-02-1 is misleading by stating that Unit 2 plant air cannot be used to mitigate the loss of Unit 1 instrument air system because plant air can be aligned to the instrument air system with a recovery action to open 1CV2061. It has been determined that a recovery action to open 1CV2061 is required to be credited for defense-in-depth. Attachment C and Attachment G are updated (see enclosure) and the FRE for Fire Area 21 will be updated for VFDR 21-02-1 to identify the defense-in-depth recovery action to align Unit 2 plant air to the Unit 1 instrument air system.

Fire Area 22 - The compliance statement in Attachment C stating that Unit 2 instrument air is RECOVERABLE from Unit 1 plant air is correct. VFDR 22-05-2 is misleading by stating that Unit 1 plant air cannot be used to mitigate the loss of Unit 2 instrument air system because plant air can be aligned to the instrument air system with a recovery action to open 2CV2061. The recovery action identified in LAR Attachment G to mitigate this failure was to align nitrogen to the instrument air system. The VFDR statement in Attachment C is revised to clarify and Attachment G is updated to credit a recovery action to align Unit 1 plant air to the Unit 2 instrument air system (see enclosure).

15d - Unit 1 instrument air and SWAC compressors could both be lost due to the effects of fire and/or suppression in Fire Area 39. Unit 2 instrument air and SWAC compressors could both be lost due to the effects of fire and/or suppression in Fire Area 40. The NSCA analysis identifies these potential failures as documented in VFDRs 39-01-1 and 40-01-2. There is no discrepancy in the deterministic analysis between the failures for fire and/or suppression. These VFDRs were evaluated in accordance with NFPA 805, Section 4.2.4.2 and it was determined that the risk, safety margin and defense-in-depth meet the acceptance criteria of NFPA 805 Section 4.2.4 with no further action. Recovery actions are not required for these VFDRs. The suppression effects section of Attachment C for Fire Area 39 is updated to identify that Unit 2 plant air can be aligned to the Unit 1 instrument air system from the Control Room. The suppression effects section of Attachment C for Fire Area 40 is updated to identify that Unit 1 plant air can be aligned to the Unit 2 instrument air system from the Control Room (see enclosure).

SSA RAI 16:

In Attachment C, the licensee stated in the summary of vital auxiliaries for Fire Area 17B that the control room and CSR heating, ventilating, and air conditioning (HVAC) is not available without an RA and referenced VFDR 17B-01-0. However, the disposition discussion for VFDR 17B-01-0 states that no further actions are required based on the performance-based analysis for the VFDR, and no RAs required for risk or DID were identified in Attachment G. Clarify the bases for the discrepancy between the description of the vital auxiliaries' discussion and the VFDR disposition.

CCNPP RESPONSE SSA RAI 16:

Response provided in Reference 1.

SSA RAI 17:

In Attachment G, there are numerous RAs to provide portable fans for temporary cooling of switchgear rooms for Unit 1 Fire Areas 11, 16, 17, 18, and 20, and for Unit 2 Fire Areas 22, 25, 34, and yard. Plant procedures indicate the use of portable generators to power the fans if normal power is not available. Provide the following additional information:

a. Describe the location of the portable generators and the location of NSCA structures, systems, and components (SSCs), if any, in the vicinity of these location(s). In your description, include a summary of the procedure guidance for the use of portable gas generators and how the RA aligns with each of the feasibility criteria of FAQ 07-0030 (i.e., training, procedures, drills, etc.).

b. Describe the type of fuel and quantity associated with the portable generators and the availability and the location(s) of sufficient fuel sources to support maintaining safe and stable conditions for the time period required.

c. Provide justification that refueling the generators does not present a fire exposure hazard to NSCA SSCs.

d. Describe the installation of temporary power cables, connections to distribution panels, and any disruptions to fire area boundaries.

e. Describe the method (e.g., the analyzed ventilation path configuration) of providing temporary cooling when portable fans are used for these RAs.

CCNPP RESPONSE SSA RAI 17:

17a - Should the use of portable generators be required to supply power to the fans used to provide cooling to switchgear rooms, the generator will be placed outside of the Turbine Building in the Yard. The U4000 transformers, which are relied upon in the NSCA analysis, are located in the Yard approximately 50 ft. from the area where the generator will be located. The operation of the generator or refueling the generator will not impact the function or operability of the U4000 transformers based on:

1. The generator represents a minimal fire severity/load for the Yard fire area.
2. The U4000 transformers are of sufficient distance away from the portable generators to not represent a fire risk.

17b - The portable generators are fueled by gasoline. The portable generator has a 7.2 gallon capacity onboard tank. Each generator will run for 10 hours at 50% load. The load demand from the cooling fans is below 50% capacity of the generators, therefore, with two generators available per unit, a scenario that requires two rooms to be cooled via the fans will have 20 hours of run time prior to requiring refuel. Additional fuel can readily be obtained from outside sources within a 20 hour time frame thereby maintaining the ability to provide cooling for any duration that is required.

17c - Refer to SSA RAI 17a response.

17d - The use of the portable generators to supply power to the fans, via an extension cord, does not require connections to distribution panels or disrupt any fire area boundary.

17e - The analyzed ventilation path configuration is air from the Turbine Building directed into the switchgear rooms via the portable fans at the switchgear room roll up door. The roll up door is lowered down to rest on top of the fans. The personnel access door to the switchgear room is opened for the ventilation path exhaust.

RAD RAI 01:

The radioactive material (RAM) described in the CENG [Constellation Energy Nuclear Group] Calculation No. CA07953 provides a quantification of the maximum amount of RAM that may be stored in various areas. Provide information, if any, on site procedures that are (or will be) established to limit the amount of RAM in storage containers to the levels identified in the analyses (e.g., West Road Cage area, Warehouse #3, Pre-Assembly Facility, and Upper Laydown Area).

CCNPP RESPONSE RAD RAI 01:

Response provided in Reference 2.

RAD RAI 02:

Provide information, if any, on site procedures that establish operational controls to restrict the opening of storage containers in open, uncontained areas (e.g., West Road Cage area, Warehouse #3, Pre-Assembly Facility, and Upper Laydown Area).

CCNPP RESPONSE RAD RAI 02:

Response provided in Reference 2.

RAD RAI 03:

In the Upper Laydown Area, there are "sealed" Sealand containers, casks, and other containers. Describe what is meant by "sealed" (e.g., are the containers locked and access is not allowed, and do site procedures prevent the opening of these containers?). Also, describe how potential effluent will be contained based on the "sealing" of containers and concluding that there will be negligible RAD.

CCNPP RESPONSE RAD RAI 03:

Response provided in Reference 2.

RAD RAI 04:

Describe any compensatory actions that may be taken during fire suppression activities to minimize RAD (e.g., diking of liquid effluent, use of storm drain covers, radioactive monitoring, or use of other gaseous effluent controls (e.g., use of eductors, effluent filtration)).

CCNPP RESPONSE RAD RAI 04:

Response provided in Reference 2.

Fire Modeling (FM) RAI 01:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. The NRC staff noted that fire modeling comprised the following:

- *The algebraic equations implemented in Fire Dynamics Tools (FDTs) were used to characterize flame radiation (heat flux), flame height, plume temperature, ceiling jet temperature, and hot gas layer (HGL) temperature, and the latter in the multi-compartment analysis (MCA).*
- *Fire Dynamics Simulator (FDS) was used to assess MCR habitability, to calculate temperatures and heat fluxes for damage assessment to critical targets in selected compartments, calculate the flame height and how that affected certain targets, and calculate temperature rise for the purposes of estimating smoke detector activation.*
- *The Thermally-Induced Electrical Failure model, as part of FDS, was used as a secondary check on the temperature and heat flux calculations using FDS for zone of influence (ZOI) purposes.*

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

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

a. *Identify whether any fire modeling tools and methods have been used in the development of the LAR that are not discussed in Attachment J. In addition, identify any fire modeling tools and methods that are discussed in Attachment J that were not used in the fire modeling analyses performed at the plant.*

b. *It is discussed in the detailed fire modeling analysis that, "the FDTs are not setup for secondary ignition or for the effects of suppression systems on a fire scenario." This implies that secondary combustibles were not considered for any fire modeling analysis at the plant, except those using FDS.*

c. *Provide justification for ignoring the effects of flame spread and fire propagation in secondary combustibles (for example, cable trays) and the corresponding heat release rate (HRR) on the calculated ZOI and HGL temperature.*

d. *Provide information on how non-cable intervening combustibles were identified and accounted for in the fire modeling analyses.*

e. *Typically, during maintenance or measurement activities in the plant, electrical cabinet doors are opened for a certain period of time. Explain what administrative controls are in place to minimize the likelihood of fires involving such a cabinet, and describe how cabinets with temporary open doors were treated in the fire modeling analyses.*

f. *Describe the criteria that were used to decide whether a cable tray in the vicinity of an electrical cabinet will ignite following a high energy arcing fault (HEAF) event in the cabinet. Explain how the ignited area was determined and subsequent fire propagation was calculated. If applicable, describe the effect of tray covers and fire-resistant wraps on HEAF-induced cable tray ignition and subsequent fire propagation.*

g. *Provide justification for the assumed fire areas and elevations that were used in the transient ZOI calculations. Explain how the model assumptions in terms of location and HRR of transient combustibles in a fire area or zone will not be violated during and post-transition.*

h. *Explain how wall and corner effects were accounted for in the fire modeling calculations, or provide justification if these effects were not considered.*

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

   i. *It appears that the ceiling height of the MCR used in the calculations is rather high (~ 17ft.). Explain how the MCR dimensions specified in the FDS input files were established, and confirm that they are consistent with the actual dimensions of the control room. In addition, if a false ceiling is present to separate the interstitial space above the operator and back panel areas, provide justification for ignoring it in the control room abandonment calculations.*

   ii. *Explain if the doors of the MCR were assumed to be closed or open at all times, or were assumed to be open at a specified time. Discuss the impact of this assumption on the calculated abandonment times. Describe the additional leakage paths that were specified in the FDS input files, and provide the technical basis for the assumed natural vent areas.*

   iii. *The abandonment calculations consider two mechanical ventilation modes: HVAC inoperative and HVAC in smoke purge mode. Explain why the normal HVAC mode was not considered in the analysis, and why the two modes that were considered are bounding.*

   iv. *The MCR abandonment calculations for a specified ignition source appear to include FDS runs for 10 HRR bins. Appendix-E of NUREG/CR-6850, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities: Volume 1: Summary and Overview," September 2005 (ADAMS Accession No. ML052580075) uses a 15-bin discretization. Explain why only 10 bins were used, and describe how the 10-bin discretization was established.*

   v. *Describe the technical basis for choosing the location of the ignition source in the electrical cabinet and transient fire scenarios that were modeled in FDS, and confirm that locations in the operator area and the back panel area were considered for both types of ignition sources. Provide technical justification for not considering fire scenarios with the ignition source against a wall or in a corner.*

   vi. *Explain how the area and elevation of electrical cabinet and transient fires were determined, and demonstrate that the assumed areas and elevations are consistent with plant conditions or lead to conservative estimates of the abandonment times.*

   vii. *Provide justification for not considering scenarios that involve secondary combustibles in the MCR abandonment calculations.*

   viii. *Explain how the HRRs for electrical cabinets were determined and whether the values are consistent with the type(s) of cabinets present in the MCR at the plant.*

   ix. *Provide technical justification for not considering electrical cabinet fires that propagate to adjacent cabinets.*

   x. *Provide the technical basis for the material properties that were specified in FDS for the cables inside the cabinets in the MCR. Provide confirmation that the assumed soot yield and heat of combustion values (the latter either explicitly or implicitly through the specified fuel composition) lead to conservative estimates of the soot generation rate.*

xi. *Describe the transient fire growth rate(s) used in the control room abandonment calculations and provide the technical basis for the assumed time(s) to peak HRR.*

xii. *Provide the technical basis for the material properties that were specified in FDS for the transient combustibles in the MCR. Provide confirmation that the assumed soot yield and heat of combustion values (the latter either explicitly or implicitly through the specified fuel composition) lead to conservative estimates of the soot generation rate.*

xiii. *Describe the habitability conditions that were used to determine the time to MCR abandonment. FDS "devices" (temperature and optical density) were placed at a height of 6 feet and at four different locations in the MCR. Describe the basis for choosing these locations and demonstrate that these locations are either representative of where operators are expected to be, or lead to conservative abandonment time estimates. Confirm that heat flux sensors were not specified and, if so, provide technical justification for using temperature sensors as a surrogate for heat flux sensors.*

xiv. *Variations in the input parameters such as ambient temperature, soot yield of the fuel, fire base height, etc., affect the output of FDS calculations. The abandonment analyses for the MCR were performed using a single set of input parameters for each scenario. Demonstrate that the FDS calculations obtained using this set of input parameters provide conservative or bounding results. Alternatively, demonstrate that the abandonment times for a given scenario are not sensitive to variations within the uncertainty of the input parameters.*

xv. *Explain how the results of the MCR abandonment time calculations were used in the FPRA.*

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.*

ii. *Explain how the methods described in Chapter 2 of NUREG-1805, "Fire Dynamics Tools (FDTs): Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program," December 2004 (ADAMS Accession No. ML043290075) were used in the calculations to screen an ignition source based on insufficient HRR to generate a HGL condition in the exposing compartment. In addition, clarify which FDTs were used for the HGL calculations.*

iii. *In the MCA scenario analysis, explain the technical basis of modeling the ZOI as a vertical cylinder with the radius equal to 0.2 times the ceiling height in scenarios where the fire occurs near the opening between the two compartments and damages items on both sides within its ZOI.*

iv. *Some of the FDT calculations make the following assumption: "It is assumed that the forced ventilation of air flow rate is distributed among the interconnected compartments, especially corridors, based on the volume of the compartments." Provide technical justification for this assumption.*

v. *The screening process based on the ZOI specifies that if there are cable trays, conduits, or targets on the exposed side of the barrier within the ZOI, which may not*

be the same as those inside the exposing compartment, the scenario should be analyzed further. Provide details about this additional analysis.

k. Specifically regarding the use of FDS in the CSR (physical analysis units (PAUs) 306 and 302) calculations:

i. It is stated that engineering judgment is used to assess that the delay in smoke detector activation, which is associated with cross-train logic that is not possible to incorporate in FDS, would be in the range of 2 to 10 seconds. Provide technical justification for this estimate.

ii. The FDS "devices" (temperature and heat flux) were placed at different locations around the switchgear rooms. Describe the basis for choosing these locations.

iii. The analysis highlights the location of possible electrical cabinet fires that were considered. Provide technical justification for selecting these specific fire locations or demonstrate that these locations lead to bounding or conservative estimates.

iv. A number of transient fires were postulated in the CSRs, but the documentation indicates that the walkdown identified no transient combustibles and there were no storage areas for more permanent combustibles in the fire areas. Provide justification for selection of the transient fire areas and indicate if this selection is dependent on any administrative controls of transient combustibles in the CSRs.

v. The HRR used for the cabinet fires indicates that the cabinet doors were assumed to be closed. Provide justification for this assumption (e.g., on the basis of the actual plant configuration or operational condition).

vi. As stated in FM RAI 1.b, it is expected that secondary combustibles (ignition, flame spread, and cable tray fire propagation) would be part of the FDS analysis for the CSRs. Clarify how secondary combustibles were considered in the FDS analysis of the CSRs, and if they were not considered, provide justification for their omission.

l. During the walkdown of the MCR, several observations were made, which require additional information:

i. The main horseshoe and back panel cabinet configurations consist of open cabinets with a steel mesh open top with the open sides facing each other across a narrow aisle. The FDS analysis utilizes an HRR case from Appendix G of NUREG-CR 6850, which assumes closed cabinets. Provide justification for not using an HRR case applicable to open cabinets or update the analysis with the appropriate HRR.

ii. During the discussion about the open cabinets, it was also discussed that the current analysis does not consider the potential for fire spread across the aisle (i.e., within the horseshoe) from the front to back or vice versa. Provide justification for not considering this potential fire spread or update the analysis to include this scenario.

iii. During the walkdown of the MCR, several combustible items, which could be considered transient fire sources, were observed that could potentially have an HRR of greater than 317 kW. Examples include the kitchen area, the upholstered furniture in the shift manager's office and space below the shift manager's office, and photocopiers. Provide additional information that can justify that the transient fire source selected in the FDS analysis is conservative and bounding.

CCNPP RESPONSE FM RAI 01:

01a - Eight tools and methods that were not discussed in Attachment J of the LAR are used to support the RAI responses. These eight tools and methods are added to Attachment J. The verification and validation basis of these tools and methods is discussed in CCNPP's response to FM RAI 03. Nine methods and tools are discussed in FM RAI 03; however, the Smoke Detection Actuation Correlation was determined to be already included in Attachment J and no longer is an addition to Attachment J, but is updated to reflect the description in the FM RAI 03 response.

The eight tools and methods that will be added to Attachment J are:

- Plume Radius (Method of Heskestad);
- Ceiling Jet Temperature (Method of Alpert);
- Sprinkler Activation Correlation;
- Plume/Hot Gas Layer Interaction Study using Fire Dynamics Simulator (FDS);
- Temperature Sensitive Equipment Hot Gas Layer Study using Consolidated Model of Fire and Smoke Transport (CFAST);
- Correlation for Flame Spread over Horizontal Cable Trays (FLASH-CAT);
- PyroSim software package for generating FDS input files; and,
- Engineering Planning and Management (EPM) Fire Modeling Workbook (FMWB).

The method for determining the wall and corner heat release rate (HRR) described in the response to FM RAI 01h is also added to Attachment J. This method is not discussed in the response to FM RAI 03, however, the verification and validation (V&V) basis for the wall and corner method is discussed in the response to FM RAI 01h.

Four tools and methods are removed from Attachment J because they were not used in the development of the LAR. The four tools and methods that are removed from Attachment J are:

- Cable Response to Live Fire (CAROLFIRE) Thermally Induced Electrical Failure (THIEF) Model;
- Corner Flame Height (Method of Hesemi and Tokunaga);
- Wall Flame Height (Method of Delichatsios); and,
- Time to Ignition of Combustible Materials (Method of Tewarson).

Additionally, some of the tools and methods already listed in Attachment J are reorganized to make it clearer where each method and tool is used in the CCNPP Fire PRA. These changes are:

- Flame Height Impacts using FDS Version 5 (Mixture Fraction Combustion Model) will be added to the list under Main Control Room Abandonment;
- Temperature Impacts using FDS Version 5 (Large Eddy Simulation Model) will be add to the list under Main Control Room Abandonment;
- Hot Gas Layer (Method of Foote, Pagni, and Alvares or FPA) will no longer be listed under Multi-Compartment Scenarios;

- Radian Heat Flux (Point Source Method of Drysdale) will no longer be listed under Multi-Compartment Scenarios; and,
- Radiant Heat Flux (Radiant Flame Method) will no longer be listed under Multi-Compartment Scenarios.

Attachment J is updated as seen in the attached revision.

01b - CCNPP is reviewing the fire modeling analysis to ensure secondary combustibles have been included, as appropriate, in the fire scenarios for all PAUs. CCNPP is updating the models, as necessary, to include fire propagation and spread to secondary combustibles. The use of FDS to perform the fire modeling is limited to a subset of fire modeling compartments. CCNPP is utilizing the EPM Fire Modeling Workbook (FMWB) for the remainder of fire modeled areas, where an FDS analysis has not been performed.

The EPM FMWB is a tool used for fire modeling applications. The tool uses correlations from verified and validated fire models. The FMWB incorporates secondary combustibles, for fire scenarios where they are found to be within the ZOI of the primary ignition source, into the fire scenarios and calculates an expanded ZOI based on the additional heat release rate (HRR).

The use of the EPM FMWB and FDS to estimate the ignition, propagation and spread characteristics, of secondary combustibles been verified and validated as documented in CCNPP's responses to FM RAI 01a, FM RAI 03, FM RAI 04 and Attachment J.

The inclusion of secondary combustibles in the fire modeling analysis will be reflected in the updated CCNPP Fire PRA results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in the CCNPP response to PRA RAI 03, Integrated Analysis.

01c - As described in the response to FM RAI 01b, CCNPP is reviewing the fire modeling analysis to ensure secondary combustibles have been included, as appropriate, in the fire scenarios for all PAUs. CCNPP is updating the fire modeling analysis, as necessary, to include fire propagation and spread to secondary combustibles.

Fire propagation to cable trays will be updated to follow the guidance of NUREG/CR-6850 Appendix R and NUREG/CR-7010; while fire propagation to adjacent cabinets will follow the guidance of NUREG/CR-6850 Appendix S.

The fire modeling workbook (FMWB) calculates the zone of influence (ZOI) and the hot gas layer (HGL) temperature at individual time steps based on the total heat release rate of the fire. The fire modeling updates described above will incorporate the HRR contribution of secondary combustibles in the analysis and will ensure the effects of flame spread and fire propagation will be included in the updated analysis.

The inclusion of secondary combustibles in the fire modeling analysis will be reflected in the updated CCNPP Fire PRA results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in the CCNPP response to PRA RAI 03, Integrated Analysis.

01d - As part of the non-cable secondary combustibles review, walkdowns will be performed for all fire compartments where detailed fire modeling was performed. Small combustible items, such as small plastic signs, fiberglass ladders, plastic telephones, etc., are screened as negligible, as the small amount of combustible loading would not significantly increase the heat release rate (HRR) of the fire scenarios. For any PAUs with greater than negligible quantities of non-cable secondary combustibles (e.g., clothing/rags, significant quantities of miscellaneous plastic, large rubber hoses of significant length, etc.), the additional combustibles will be incorporated into the model.

The inclusion of secondary combustibles in the fire modeling analysis will be reflected in the updated CCNPP Fire PRA results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in the CCNPP response to PRA RAI 03, Integrated Analysis.

01e - The fire modeling analysis assumes that electrical cabinets with normally closed doors are maintained closed. This assumption is based on plant walkdowns and confirmed by procedures and personnel practices.

Administrative procedures, including those related to industrial/electrical safety and foreign material exclusion, require that proper housekeeping be maintained related to fire prevention and protection of equipment. Procedurally, efforts are made to ensure that electrical equipment is de-energized prior to performing work. A de-energized electrical cabinet is not considered to be a credible ignition source. Plant administrative procedures require that periodic inspections be performed to ensure electrical component doors and hardware are intact and that enclosure covers are not open, missing, or not secure. Plant administrative procedures also require that these inspections take place at the end of each shift during maintenance activities. Maintenance logs are kept to ensure equipment is returned to the "As-Found" configuration at the completion of maintenance. Also, personnel are expected to report housekeeping or material discrepancies, following the guidelines contained in the procedure.

Based on plant procedures, electrical cabinet doors are unlikely to be left open when maintenance or measurement activities are not in progress. Cabinet doors may be temporarily open; however, administrative procedures provide a reasonable assurance that the likelihood of a fire in these cabinets is minimal.

01f - The guidance in Appendix M of NUREG/CR-6850, Vol. 2 will be used to determine fire damage due to high energy arching faults (HEAFs). Fire PRA targets within the initial blast zone of influence (ZOI) (i.e., 3 feet horizontally and 5 feet vertically), as defined in Section M.4.2 of NUREG/CR-6850, will be considered damaged and/or ignited in HEAF scenarios at time zero. Cable tray enclosures and fire wrap, if determined to be located within the HEAF ZOI, will be assumed to be physically damaged by the initial explosion and will not be credited in the analysis.

The ensuing cabinet fire occurring after the HEAF event will be modeled as an electrical cabinet fire with a peak heat release rate occurring at time 0 and lasting for a duration of 40 minutes. The HRR will be the recommended 98th percentile HRR value in NUREG/CR-6850, Table G-1, for the bin 15 electrical fire originating from the same source.

The 40 minute duration of the fire scenarios bounds the total recommended timing for electrical cabinet fires in Table G-2 of NUREG/CR-6850.

The first overhead cable tray within the ZOI of the HEAF will be assumed to be damaged and ignited at time zero (i.e., at the time of the electrical fault). For horizontal cable trays, the cable tray flame spread rate and the heat release rate per unit area (HRRPUA) are determined using methods recommended by NUREG/CR-7010, Volume 1, Section 9.2.2. The total area of the exposed cable trays and combustibles within the ZOI of the HEAF scenario will be assumed ignited at time zero. Any remaining trays in a stack ignite consistent with the timing rules in Section R.4.2.2 of NUREG/CR-6850 and NUREG/CR-7010.

Fire propagation to adjacent cabinet sections was not assumed to occur. This is because the front of the cabinet is assumed to blow open by the initial energy release of the HEAF event as per guidance of Appendix M of NUREG/CR-6850, Section M.4.2. Therefore, an internal hot gas layer plenum in the cabinet is not postulated and fire spread between adjacent vertical sections of the cabinet is assumed not to occur.

Updates to the CCNPP detailed fire modeling to include HEAFs modeled as described in response to this RAI will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01g - The modeling of transient fires in the Main Control Room is discussed in CCNPP's response to FM RAI 01i.vi and the modeling of transient fires in the Cable Spreading Room is discussed in CCNPP's response to FM RAI 01k.iv. This response pertains to transient fires in all other areas where detailed fire modeling was performed.

The height of transient fire sources composed of ordinary combustibles (i.e., paper, wood, anti-contamination clothing, rags, and plastic) was selected as 2ft above the floor for most physical analysis units (PAUs). The fire origin was chosen to be 2ft above the floor at the center of the postulated location. In some PAUs, the height of transient fire sources was selected to be at floor level, with a large bounding zone of influence (ZOI) that included damage of targets to the ceiling.

Although transient fire elevations are consistent with most plant conditions, the 2ft fire elevation was selected to add conservatism. A transient fire elevation 2ft above the floor is considered conservative because many transient fires occur at floor level. Assuming the fire elevation is 2ft above the floor leads to conservatism in the plume ZOI and HGL temperatures. Assuming a large ZOI and target damage to the ceiling bounds the potential transient elevation.

Transient fires were modeled to be 4ft2 (2ft x 2ft) in area. This is considered to represent a typical fuel package (e.g., a waste basket or a small packing crate). A 98th percentile (317kW) 2ft x 2ft transient fire has a Froude number of 0.71. Per the guidance of NUREG-1824, a typical accidental fire has a Froude number of 1. Momentum driven fires, like jet flares, have relatively high values while buoyancy-driven fires (such as those involving cable insulation, lube oil, transient materials, etc.) generally have Froude numbers toward the lower end of the validation range (0.2-9.1). The transient fire area is considered reasonable based

on both the expected fuel package sizes as well as the experimental values of Froude number.

Transient fires were evaluated based on the 98th percentile heat release rate (HRR) (i.e., 317 kW) specified in NUREG/CR-6850, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities," Table G-1, except in PAUs 311, 317, 407 and 430. Refer to CCNPP's response to PRA RAI 06 for discussion of transient fire modeling in these PAUs.

The 98th percentile HRR for transient fires listed in NUREG/CR-6850, Table G-1 are based on tested fuel package configurations identified in NUREG/CR-6850, Table G-7. The configurations tested are various solid fuel packages such as cardboard, paper, plastics, cotton rags, and acetone. The model assumptions pertaining to the locations and HRRs of transient combustibles consider that fire areas or fire zones in Safety Related areas are being controlled via plant procedures which require all transients combustible material shall:

- Be constantly attended (with the exception of one-hour or less breaks);
- Be removed from the work area at the end of the shift;
- Have a Transient Combustible Permit for all of the combustible material that will be needed for the work activity; or,
- Be contained in closed metal containers with closed metal lids/openings (e.g., cabinets, tool boxes, gang boxes, metal drums, metal drums with flame tamer lids, etc.) that are in good repair.

Minor amounts of transient combustibles are allowed and exempt from the requirements above. However, minor transient combustibles are limited as follows:

- Only the amount needed to support the work should be staged/stored; and,
- The materials are to be removed from the work location at the completion of the work activity.

Examples of minor transient combustibles are temporary power cables (<100ft), ladders, absorbent pads, test equipment, wood (less than 25lbs), tool bags, rope, and lead blankets. The examples of minor transient combustibles were found to be consistent and bounded by the tested configurations in NUREG/CR-6850 Table G-7.

In non-Safety Related areas of critical buildings (e.g., the Turbine Building), strict transient combustible controls are also applied:

- Transient combustibles are limited to those materials and quantities necessary to support the work activity;
- All waste (e.g., debris, scraps, used rags, loose packing material, oil spills) resulting from the work activity is either removed from the area immediately following completion of the activity or at the end of each work shift (whichever comes first) or is placed in appropriate containers (e.g., storage cabinets, trash receptacles, etc.); and,
- General housekeeping is maintained in accordance with applicable housekeeping procedures.

Walkdowns were performed and the usage was considered when selecting the transient HRR for a given PAU. This provided assurance that the HRRs used for the transient

scenarios modeled in the CCNPP Fire PRA would be appropriate representation of any potential transient fire in the PAU.

01h - The CCNPP fire modeling calculations will account for wall and corner effects by utilizing a location factor adjustment to the heat release rate (HRR) in accordance with the criteria in Table 1:

Table 1: Location Factors Used in Detailed Fire Modeling

Configuration	Flush with surface(s)*	≤ 2 ft from surface(s)	>2 ft from surface(s)
Wall	2	1	1
Corner	4	4	1

* note: a source may not be considered flush with surface(s) if the fire point of origin of the fire is not in contact with the wall or corner.

The location factors in Table 1 will be applied for flame height, plume temperature, plume radius and ceiling jet correlations. No specific guidance is provided in NUREG/CR 6850 or subsequent FAQs on this subject; therefore, a review of the fire protection engineering literature was performed.

Section 2, Chapter 1, "Fire Plumes, Flame Height, and Air Entrainment," of the SFPE Handbook (Reference 1) references various experiments related to the effects of wall/corner on flame heights and concludes that the effects are generally reported to be small.

The experimental studies in References 2, 3, 4, 5 and 6 generally report the following for wall effects:

- Wall effects are significant when flames are in contact with a wall; fires located as little as 5 to 10 cm from a wall typically exhibit less flame attachment to the wall.
- Flame heights and thermal radiation to the wall are increased for a fire in contact with a wall. Fires removed 10 to 40 cm from a wall do not exhibit enhanced flame heights or thermal radiation to the wall.
- Flame heights for fires along a wall are similar to those predicted for a fire in the open

The experimental studies in References 2, 3, 4 and 5 generally report the following for corner effects:

- Flame heights and thermal radiation are increased for fires burning near corners. There are also moderate increases in horizontal plume growth and a reduction in upward velocity with height. As distance from a corner increases, the effects of these phenomena are decreased.
- Corner effects are more substantial when flames are in contact with the corner walls; fires located as little as 5 to 10 cm from a corner typically exhibit less flame attachment to the corner walls.
- Corner effects are more substantial than wall effects and are potentially significant even when a fire is not flush with the corner.

Based on the review of the above referenced fire protection engineering literature, it was concluded that wall effects are negligible unless the point of fire origin is in contact with the

wall. Wall effects will be addressed for a fire source that is located flush with the wall by use of a location factor, which effectively adjusts the HRR of the fire.

The fire protection engineering literature suggests that corner effects are more substantial than wall effects and that the further from a corner a fire is located, the smaller the corner effect will be. Corner effects will be addressed for a fire source that is located within two feet of a corner, by use of a location factor, which effectively adjusts the HRR of the fire. This is considered conservative and is consistent with the NRC's Fire Protection Significance Determination Process (SDP), which states, "...a fire is considered to be "near" a wall if its outer edge is within two feet of a wall, or is near a corner if within two feet of each of the two walls making up the corner" (Reference 7).

CCNPP fire modeling updates will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI-03.

References:

1. SFPE, SFPE Handbook of Fire Protection Engineering, 4th Edition, 2008
2. Mizuno, T. and Kawagoe, K., 1986, Burning Rate Of Upholstered Chairs In The Center, Alongside A Wall And In The Corner Of A Compartment. Fire Safety Science 1: 849-858
3. Williamson, R.B., Revenaugh, A. and Mowrer, F.W., 1991. Ignition Sources In Room Fire Tests And Some Implications For Flame Spread Evaluation, Fire Safety Science 3: 657-666
4. Takahashi, W., Sugawa, O., Tanaka, H. and Ohtake, M., 1997, Flame And Plume Behavior In And Near A Corner Of Walls. Fire Safety Science 5: 261-271.
5. Dougal Drysdale, An Introduction to Fire Dynamics, 3rd Edition, John Wiley & Sons, 2011
6. Shintani, Yusuke, Aramaki, Y., Harada, K., Kakae, N., Tsuchihashi, T. and Tanaka, T., 2007, The Effects Of Building Elements And Smoke Layer On Fire Spread Between Combustible Materials.
7. NRC Inspection Manual, Manual Chapter 0609 Appendix F, Fire Protection Significance Determination Process, 2013 (ML13191B312)

01i.i - The Main Control Room (MCR) dimensions used in the CCNPP Fire PRA's FDS input files are consistent with the as-built plant design, as taken from plant drawings and confirmed during walkdowns of the MCR. Varying ceiling heights are modeled, including a false ceiling. The false ceiling is modeled at a height of 13 ft (4 m) above the floor in the majority of the MCR, and the false ceiling height increases to approximately 16 ft (4.8 m) above the floor near the Shift Supervisor's Office, which is consistent with the measured ceiling height. The suspended acoustic tiles comprising the false ceiling are modeled to not allow smoke or hot gases to enter the interstitial space above unless the ventilation smoke purge mode is activated. Excluding the interstitial space reduces the overall volume in the MCR which provides more conservative hot gas layer (HGL) and optical density results.

01i.ii - The doors of the MCR were assumed to be closed for the entirety of the analysis. Modeling the doors as closed increases the hot gas layer (HGL) temperature and optical

density, and decreases the layer height above the floor since less fresh air is introduced into the room. The modeling of the door position is, therefore, conservative as it leads to shorter MCR abandonment times.

A 0.2 m tall leakage path was modeled underneath each doorway; this represents the height of one grid cell. Each door was either 1 m or 1.2 m wide, resulting in a 0.2 m^2 or 0.24 m^2 opening area per door, respectively. There were four 1.2 m wide doors and one 1 m wide door, for a total leakage area of 1.16 m^2. These were the only leakage paths provided in the MCR analysis. The leakage paths in the MCR prevent artificial over-pressurization within the compartment enclosure, and ensure the fire does not become under-ventilated. The leakage paths were modeled at the floor, so the smoke layer had to descend to floor level before any smoke was able to escape the MCR.

The total leakage area, of all doors combined, is less than the ventilation area of one standard 0.91 m x 2.1 m door. Once the fire is detected, fire brigade personnel will be dispatched to the MCR. They are expected to open a door in order to perform suppression activities; opening a door would provide a 1.91 m^2 opening. Prior to fire brigade response, the only natural ventilation will be provided by existing air flow paths in the MCR (e.g., door gaps, vents, openings, etc.) because the MCR barriers do not realistically form an air tight seal. Therefore using a total leakage area of 1.16 m^2 for the entirety of the analysis is conservative.

01i.iii - NUREG-CR/6850, Section 11.5.2.11, states two possible ventilation modes should be considered for Main Control Room (MCR) abandonment:

1. The ventilation system is turned off, causing hot gases and smoke to accumulate inside the control room; or,
2. The ventilation system is on smoke-purge mode.

These ventilation modes represent the two extremes of mechanical ventilation operability. The normal HVAC mode is conservatively bound by scenarios where the ventilation system is inoperable due to equipment failure or operator error and was not included in the analysis. With the HVAC system turned off, less fresh air is introduced into the compartment and no smoke is purged, resulting in higher hot gas layer (HGL) temperatures and optical density, and lower layer heights. This represents the worst case scenario for heat and smoke build up in the MCR. Additionally, gas-phase suppression was eliminated from the CCNPP Fire PRA's FDS models to ensure the fire would not become ventilation limited.

With the ventilation system running in smoke-purge mode, smoke and hot gases are removed from the MCR and ambient air is introduced at their maximum designed flow rates. This results in the lowest HGL temperatures and optical density, and highest HGL heights. This represents the best case scenario for heat and smoke build up in the MCR. This mode is conservatively applied in the CCNPP Fire PRA's MCR models by delaying smoke-purge activation until 20 minutes into the simulation. This accounts for the delay associated with the manual activation of the system required by operations personnel. Prior to 20 minutes, the ventilation system is conservatively assumed inoperable.

01i.iv - The CCNPP Fire PRA's Main Control Room (MCR) FDS analysis will be updated to use the 15-bin HRR discretizations in Appendix E of NUREG/CR-6850 for both electrical cabinets and transient fires.

Updates to the CCNPP Fire PRA's MCR abandonment fire modeling analysis to utilize the 15-bin discretized distribution will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01i.v - The CCNPP Fire PRA's Main Control Room (MCR) FDS fire modeling analysis will be updated to include two electrical cabinet scenarios and four transient scenarios. The locations of the fires were selected to bound a fire at any location within the control room. Electrical and transient fires were modeled in the operator area, the back panel area, and in the shift supervisor's office. 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 Appendix S of NUREG/CR-6850, and thereby bound the heat release rate (HRR) of any electrical cabinet scenario. Locations for the transient fires were selected based on walkdowns which identified areas where transient combustible were present (e.g., photocopiers) or likely to accumulate (e.g., trash cans, binders, etc.). Additionally, one transient fire placed in the back panel area was modeled against the wall to account for any potential plume temperature and hot gas layer effects due to the decreased entrainment rate.

The primary goal of the analysis was to determine the effect of the hot gas layer on habitability conditions within the MCR. 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 farther 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.

Updates to the CCNPP Fire PRA's MCR abandonment fire modeling analysis to update the scenario locations used in the MCR abandonment fire model analysis will be reflected in the updated fire risk results that will be provided to the NRC after the Fire PRA is updated and additional quantification is performed in the response to PRA RAI-03.

01i.vi - The area (2.6 m x 1.2 m) and elevation (2.6 m) of electrical cabinet fires in the MCR operator area will be updated to represent the dimensions of a typical MCB section determined by plant walkdowns. The area (2.6 m x 1.0 m) and elevation (2.6 m) of electrical cabinet fires outside of the operator area was determined by plant walkdowns and represents the dimensions of a typical MCR electrical cabinet. The fire vent in the FDS model will be placed on the vertical cabinet surface and will extend from the floor to the top of the cabinet. This vent location was established based on walkdown information of the electrical cabinets in the MCR. The majority of cabinets within the MCR have open backs with exposed cables spanning from the top to the bottom. Therefore the full height of the electrical cabinet will be used for the vent height to accurately depict plant conditions. The width of the vent will be based on the exposed width of cables in a representative cabinet section.

The area (0.6 m x 0.4 m) and elevation (0.8 m) of transient fires characterized as trash cans was determined by plant walkdowns and represents the dimensions of a large trash can located in the MCR. Since a trash can fire is the most likely transient scenario, this is consistent with plant conditions. Additionally, a transient fire height of 0.8 m is considered conservative since other transient fires in the MCR can be expected to occur at floor level.

An additional transient scenario will be modeled which is characterized as a photocopier. The area (1.2 m x 0.8 m) and elevation (1.2 m) of this scenario was determined by plant walkdowns and represents the dimensions of a typical photocopier which is consistent with plant conditions. The fire height of 1.2 m is considered conservative since other transient fires in the MCR can be expected to occur at floor level.

Updates to the CCNPP Fire PRA's MCR abandonment fire modeling analysis to incorporate the updated electrical cabinet fire area and elevation will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01i.vii - Walkdowns of the CCNPP MCR were performed for both electrical and transient ignition sources to determine if any significant secondary combustibles could impact the MCR abandonment calculations.

For electrical cabinet ignition sources, it was determined that there were no significant secondary combustibles in the MCR other than the spread to adjacent electrical cabinet vertical sections. The CCNPP Fire PRA's MCR FDS analysis will be updated to include fire propagation to adjacent vertical cabinet sections in accordance with the guidelines of NUREG/CR-6850, Appendix S. This update to the FDS analysis is detailed in the response to FM RAI 01.ix. Modeling fire propagation to three vertical sections for all electrical cabinet scenarios bounds any potential impact due to limited secondary combustibles.

Walkdowns for transient ignition sources identified locations where potential secondary combustibles existed (e.g., photocopiers, bookshelves, upholstered chairs). Additional transient scenarios will be created in FDS for these secondary combustible locations which use an increased HRR of 1000 kW. This increased HRR was determined to be bounding for the types of combustibles in the area, which accounts for any potential impact due to secondary combustibles.

Updates to the CCNPP Fire PRA's MCR abandonment fire modeling analysis to incorporate scenarios bounding secondary combustible impacts will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in the response to PRA RAI-03.

01i.viii - The CCNPP Fire PRA's Main Control Room (MCR) FDS analysis will be updated to use the Case 5 discretized HRR distribution from Table E-6 in NUREG/CR-6850 for vertical cabinets with unqualified cable, fire in more than one cable bundle and open doors.

If these updates produce overly conservative risk estimates, the NUREG/CR-6850 recommended HRR may be refined and a more appropriate peak HRR for open door

electrical cabinets will be estimated using the approach outlined in the response to FM RAI 01l.i.

Electrical cabinets with closed doors can be refined to use the appropriate discretized HRR distribution from Appendix E of NUREG/CR-6850. Additionally, panels that are confirmed to contain primarily thermoset cables (over 90% of cables/wires in the panel confirmed to be thermoset) may be refined to reflect the appropriate thermoset panel configuration HRR.

Updates to the CCNPP Fire PRA's MCR abandonment fire modeling analysis incorporating the appropriate HRRs for the electrical cabinets will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01i.ix - The CCNPP Fire PRA's Main Control Room (MCR) FDS fire modeling analysis will be updated to include spread to adjacent vertical cabinet sections.

NUREG/CR-6850, Appendix S suggests that a 10 minute delay in fire propagation can be assumed for cabinets with cables in direct contact with the wall and a 15 minute delay for cabinets without cables contacting the wall. Based on this guidance, a delay of 10 minutes for fire propagation to adjacent cabinets will be conservatively modeled.

Following the methodology in NUREG/CR-6850, Appendix S, fire propagation is limited to the adjacent cabinet (i.e., directly next to the initiating section) only. Therefore, the maximum number of cabinets to be affected is three (i.e., source plus one cabinet on either side).

The CCNPP Fire PRA's MCR FDS fire models will be developed using the 10 minute delay to adjacent vertical section spread. Only three cabinet section scenarios will be modeled which will provide conservative abandonment times since not all electrical panels in the MCR are capable of spreading to two adjacent vertical sections.

Updates to the CCNPP Fire PRA's MCR abandonment fire modeling analysis to incorporate propagation to adjacent cabinet sections will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in the response to PRA RAI-03.

01i.x - The cable material properties specified in the MCR FDS model for cables inside of the cabinets was based on XLPE cable. The soot yield (0.120 g/g) and heat of combustion (28.3 kJ/g) values were obtained from Table 3-4.16 in the SFPE Handbook. XLPE cable is representative of the primary combustible in scenarios involving fire with qualified cables. Safety-related internal wiring in the main control boards is assumed to be comprised of thermoplastic material. From Table 3-4.16 in the SFPE Handbook, the soot yield and heat of combustion values for XLPE cable are representative of thermoplastic type cables. Therefore, the XLPE soot yield and heat of combustion values specified for the MCR electrical cabinets are conservative.

The MCR abandonment analysis includes additional conservatism due to FDS overestimation of measured smoke concentration by an average factor of 2.63 when compared to experimental full-scale testing.

01i.xi - The CCNPP Fire PRA's FDS analysis for the Main Control Room (MCR) will be updated to use a revised fire growth rate for transient fires. Transient fires in the MCR analysis will use a t2 growth rate for 8 minutes until the peak heat release rate (HRR) is reached, with the fire remaining at the peak HRR for the remainder of the simulation. The discretized HRR distribution from Table E-9 in NUREG/CR-6850 is used for transient fires in the MCR analysis.

Supplement 1 to NUREG/CR-6850 provides guidance on the growth profiles for transient fires. It states that a time dependent fire growth model may be appropriate for any situation where the basis of its use can be established. Three categories of transient growth profiles are provided with their respective times to peak heat release rate:

- Common trash can fire (8 minutes). The MCR contains trash cans with the potential for transient combustibles.
- Common trash bag fire (2 minutes). CCNPP administrative procedures require that combustible trash be placed in metal containers fitted with metal covers and combustible trash too large to fit in metal containers shall be discarded in a proper receptacle outside of the plant. A trash bag being left outside of one of the approved trash cans within the MCR is considered unlikely; uncontained trash in the MCR would likely be under direct supervision of those personnel responsible for trash removal.
- Spilled solvents/combustible liquids (0 minutes). It is considered unlikely that the MCR room will contain any appreciable amount of solvents or other combustible liquids since they are not commonly present in this plant location. For this reason, the time to peak HRR for this category of transient is not considered.

Therefore, the HRR growth rate for transients was determined to be that of the common trash can fire scenario, or 8 minutes. Scenarios involving fires outside a trash can or involving solvents are considered to be of sufficiently low probability that they can be ignored in the determination of the time to HRR growth.

Updates to the CCNPP Fire PRA's MCR fire modeling analysis to incorporate revised transient fire growth rates will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01i.xii - The CCNPP Fire PRA's Main Control Room (MCR) FDS analysis will be updated to include conservative soot yield and heat of combustion values. The material properties specified in the MCR FDS model for the transient combustibles will be based on a combination of red oak wood and polyethylene. The soot yield (i.e., 0.015 g/g for red oak and 0.060 for polyethylene) and heat of combustion (i.e., 12.4 kJ/g for red oak and 38.4 kJ/g for polyethylene) values were obtained from Table 3-4.16 in the SFPE Handbook. Assuming a transient comprised of equal parts paper and plastic products, a representative soot yield of 0.038 g/g and a representative heat of combustion of

25.4 kJ/g was calculated by a weighted average of the soot yields and heats of combustion of red oak for paper products and polyethylene for plastic products.

The CCNPP Fire PRA's MCR abandonment analysis includes additional conservatism due to FDS overestimation of measured smoke concentration by an average factor of 2.63 when compared to experimental full-scale testing.

Updates to the CCNPP Fire PRA's MCR fire modeling analysis to incorporate the above soot yield and heat of combustion values will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01i.xiii - The habitability conditions used for the CCNPP Fire PRA's Main Control Room (MCR) abandonment analysis are consistent with the guidance in NUREG/CR-6850 and are as follows:

1. The heat flux at 6 feet above the floor exceeds 1 kW/m2 (relatively short exposure);
2. An upper layer temperature greater than 95°C; and,
3. The smoke layer descends below 6 feet from the floor and the optical density of smoke is less than 3.0 m-1.

The CCNPP Fire PRA's MCR FDS analysis will be updated to include additional devices to measure the habitability conditions in different locations in the MCR. Temperature, optical density, and heat flux gauges will be placed at a height of 6 feet throughout the MCR in over 25 different locations. These devices will be placed throughout the MCR to monitor the effect of the hot gas layer on habitability conditions. The devices will be located:

- To ensure complete coverage of the MCR;
- In areas representing the most likely fire scenario points of origin;
- In proximity to the expected locations of the operators; and,
- In locations where smoke is expected to accumulate (i.e., in corners and in the space between the horseshoe and the back panels).

Therefore, MCR abandonment is conservatively established if any of the habitability conditions listed above are measured by a device at any location.

Updates to the CCNPP Fire PRA's MCR fire modeling analysis to incorporate additional measurement devices and device locations will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01i.xiv - The CCNPP Fire PRA's Main Control Room (MCR) FDS analysis will be updated to ensure the fire model inputs provide conservative or bounding results. The updated fire model inputs bound the uncertainty present in the model. The conservatisms that will be used for the input parameters in the MCR analysis are detailed below:

- The ambient temperature will be modeled as 75°F. This is conservative for a climate-controlled room.

- The soot yield for electrical cabinet fires and transient fires will use conservative values as discussed in the response to FM RAI 01.x and FM RAI 01.xii, respectively.
- The fire base height for electrical cabinet fires will be equal to the height of the cabinet, as discussed in the response to FM RAI 01.vi.
- The fire base height for transient fires will be equal to the height of a large trash can (2.6 ft) found in the MCR which is discussed in the response to FM RAI 01.vi.
- Walls will be modeled as 3 foot thick concrete to minimize the heat loss to the outside environment. The material properties for concrete were selected from the PyroSim "property library" file that were obtained from NBSIR 88-3752 - ATF NIST Multi-Floor Validation. These values were reviewed using The SFPE Handbook of Fire Protection Engineering, 4th Edition, and were determined to be acceptable for use in the fire modeling analysis.
- The HVAC system will be modeled as being shut off unless the smoke-purge mode is activated at 20 minutes, as discussed in the response to FM RAI 01i.iii.

Updates to the CCNPP Fire PRA's MCR abandonment fire modeling analysis to incorporate the updated conservatisms will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01i.xv - The abandonment times calculated in the Main Control Room (MCR) analysis were used to calculate the probability of non-suppression for each scenario. The probability of non-suppression was multiplied by the severity factor for each HRR bin from the appropriate discretized distribution tables in Appendix E of NUREG/CR-6850 to calculate the abandonment probability for each scenario. The abandonment probabilities for all scenarios capable of reaching abandonment criteria were added together to get the total probability of abandonment. The total probability of abandonment was multiplied by the ignition frequency in order to calculate the overall frequency of MCR abandonment. The overall abandonment frequency was then used in the quantification task for establishing the CDF and LERF of abandonment scenarios.

01j.i - The CCNPP Fire PRA Multi-Compartment Analysis (MCA) is being updated to include the effects of fire propagation to secondary combustibles and will only exclude scenarios from further analysis based on compartment size using the size of the exposing compartment. No exposed fire compartments will be screened out of the analysis based on their size.

For the exposing fire compartments which will have undergone detailed fire modeling, the potential of forming a damaging HGL will be determined using Fire Dynamics Simulator (FDS) or the Engineering Planning and Management Fire Modeling Workbook (FMWB). For the exposing compartments, the compartment size is used in determining the heat release rate (HRR) necessary for generating a damaging hot gas layer (HGL) in each exposing compartment. This HRR will be compared with the highest HRR attainable in the compartment. The highest HRR attainable will be conservatively determined by adding the HRR from intervening combustibles, such as cable trays, to the 98th percentile values listed in Appendix G of NUREG/CR-6850 for fixed ignition sources and transient fires. Those compartments for which the highest HRR is below the HRR required to create a damaging HGL will be screened from further consideration. This is consistent with

NUREG/CR-6850, section 11.5.4.3, step 3.c, second screening for low fire load exposing compartments.

Updates to the CCNPP MCA as described in response to this RAI will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01j.ii - For the CCNPP Fire PRA Multi-Compartment Analysis (MCA) the method of McCaffrey, Quintiere, and Harkleroad (MQH) described in Chapter 2 of NUREG-1805 is used in predicting hot gas layer (HGL) temperatures in the exposing compartments. The MQH method for determining the HGL during natural ventilation is used in FDT 02.1_Temperature_NV.xls.

In order to complete these calculations, various input parameters need to be determined including room geometry (compartment length, width, and height), wall characteristics (interior/wall lining thickness and material), ambient air temperature, vent area (vent height, width, and distance of the top of the vent from the floor), and the bounding maximum heat release rate (HRR). Many of the compartments are not perfectly rectangular, so a similar rectangular compartment is considered that maintains the same floor area and volume as the original compartment and these compartment dimensions are used as the inputs in the calculations. As stated in NUREG-1805 this should produce slightly higher HGL temperatures and is therefore considered conservative.

For the fire compartments which will have undergone detailed fire modeling, the potential of forming a damaging HGL will be determined using Fire Dynamics Simulator (FDS) or the Engineering Planning and Management Fire Modeling Workbook (FMWB). For the remainder of the compartments, the method of MQH will be used to determine the minimum HRR required to generate a HGL during natural ventilation conditions and compared to the maximum possible HRR attainable from the bounding worst case fire determined as described in CCNPP's response to FM RAI 01j.i. Those compartments whose maximum HRR is below the level required to create a damaging HGL will be eliminated from further review.

Updates to the CCNPP MCA as described in response to this RAI will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01j.iii - The analysis in step 6 of the Multi-Compartment Analysis (MCA) used a ZOI of 0.2 times the ceiling height for modeling potential fires occurring near openings between two adjacent compartments. This is beyond the NUREG/CR-6850 methodology, is not needed in the analysis and will be eliminated from the MCA evaluation methodology. NUREG/CR-6850 section 11.5.4.3 states that scenarios can be removed from further analysis if a damaging hot gas layer (HGL) is not reached in the exposing compartment. This step is described in the response to FM RAI 01j.i & ii. Therefore, scenarios that would have been retained by including Step 6 in the MCA will be removed from the subsequent analysis during Step 3 of the MCA as long as a HGL is not reached.

Updates to the CCNPP MCA as described in the response to this RAI will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01j.iv - This assumption will no longer be used in the analysis. A compartment will only be screened out of the analysis if both the forced ventilation and natural ventilation will not form a damaging hot gas layer (HGL) in the exposing compartment. The results from the natural ventilation case will produce conservatively higher HGL temperatures and is the limiting factor that will determine if the compartment will be eliminated from further analysis. Therefore, only the case of natural ventilation will be evaluated.

For some compartments the natural ventilation was assumed to be 5% of the forced ventilation into the compartment. These compartments will instead use the dimensions of the openings into the room with the method of McCaffrey, Quintiere, and Harkleroad for predicting HGL temperatures as described in FM RAI 01j.i&ii.

Updates to the CCNPP MCA as described in response to this RAI will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01j.v - The screening based on the Zone of Influence (ZOI) at the boundaries between the exposing and exposed compartments will be removed from the Multi-Compartment Analysis (MCA) as discussed in FM RAI 01j.iv. Therefore, no additional analysis is required based on this criteria. Fire compartments will be evaluated as outlined in the MCA calculation, excluding the ZOI step, and will be quantified and included in the Fire PRA as applicable.

Updates to the CCNPP MCA will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01k.i - The CCNPP Fire PRA's Cable Spreading Room (CSR) FDS fire modeling analysis will be updated to utilize the modeled cross-train detection timing for determination of the time to automatic suppression.

In order to determine the cross-train detection time, the cross-train smoke detectors will be included in the FDS model as a thermocouple device. The FDS device output files will be reviewed to identify at what time each smoke detector device in the model reaches the activation criteria. The time at which the first detector in each train activates will be determined, and the automatic suppression sequence will be assumed to begin after the activation of the second cross-train detector. Therefore, representative cross-train detection activation times will be utilized for the fire modeling analysis.

Updates to the CCNPP Fire PRA's CSR fire modeling analysis to incorporate actual cross-train smoke detector activation timing will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in the response to PRA RAI-03.

01k.ii - The CCNPP Fire PRA's Cable Spreading Room (CSR) FDS analysis will be updated to include additional devices in the CSR. FDS devices will be placed in the following locations:

- Smoke detectors will be modeled as thermocouple devices in their actual locations within the CSR.
- Thermocouple and heat flux devices will be modeled near the fire source in each scenario, spaced in one foot horizontal increments in each of the 4 cardinal directions and extending from the top of the ignition source to the ceiling in one foot vertical increments. These devices will be used to determine both the temperature and radiative ZOI for the ignition source.
- A string of thermocouples located in the fire plume for the ignition source will be included in one foot vertical increments up to the ceiling to measure plume centerline temperature.
- Thermocouples will be placed at the top of each cabinet to record scenario temperatures at the component locations in order to determine if a damaging hot gas layer would reach the cabinet.

The locations of these devices will provide a detailed overview of the fire conditions throughout the CSR. The devices will be located:

- To ensure complete coverage of the CSR.
- In larger quantity and spaced closer in areas in the vicinity of the fire.
- In actual locations within the plant for smoke detectors.
- Above electrical components throughout the room.

Updates to the CCNPP Fire PRA's CSR fire modeling analysis to incorporate additional measurement devices and device locations will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

01k.iii - The CCNPP Fire PRA's Cable Spreading Room (CSR) FDS analysis will be updated to analyze electrical cabinet fire scenarios in bounding locations. Multiple fire scenarios will be considered that will provide bounding results for the other ignition sources. The following details will be taken into consideration when creating the bounding scenarios:

- The peak heat release rate (HRR) of the cabinet
- The distance to the closest secondary combustible
- The amount of secondary combustibles in the area (e.g., number of cable trays in a stack, number of cable tray stacks, etc.)
- The number of adjacent cabinet sections the fire is capable of propagating to following the guidelines of NUREG/CR-6850, Appendix S
- The location of cabinets (i.e., against a wall, in a corner)

Electrical cabinets that are not analyzed in an FDS scenario will be mapped to a bounding scenario to ensure the estimates are conservative. Relevant information will be taken from the analyzed FDS scenario such as the zone of influence (ZOI) or time to detection and suppression, which will then be used to determine the target damage and non-suppression probability for each ignition source.

Updates to the CCNPP Fire PRA's CSR fire modeling analysis to incorporate the bounding electrical fire scenarios will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in the response to PRA RAI-03.

01k.iv - The intent of the transient combustible walkdowns in the CSR was to identify any permanent storage locations of transient combustibles and determine if there were any locations where transient combustibles were likely to accumulate. Although it was indicated that there are no such permanent or accumulating storage areas, transient scenarios were still analyzed in any possible location in the CSR fire areas, including at the ceiling level with a standard peak heat release rate of 317 kW. These scenarios conservatively bound any potential procedural non-compliances of the administrative controls for transient combustibles in these areas. Therefore the transient fires analyzed in the CSR are only dependent on the administrative controls of transient combustibles already present in the CSR.

01k.v - The assumption in the fire modeling analysis that there were no open cabinets was based on plant procedures and personnel practices. Plant administrative procedures require that periodic inspections be performed to ensure electrical component doors and hardware are intact and that enclosure covers are not open, missing or not secure. Plant administrative procedures also require that these inspections take place at the end of each shift during maintenance activities. Maintenance logs are kept to ensure equipment is returned to the "As-Found" configuration at the completion of maintenance. Also, personnel are expected to report housekeeping or material discrepancies, following certain guidelines, unless the discrepancy is the result of work-in-progress.

Based on current plant procedures and requirements, electrical cabinet doors are unlikely to be left open when maintenance or measurement activities are not in progress. Therefore the assumption that there are no open cabinet doors in the CSR is valid.

01k.vi - The CCNPP Fire PRA's Cable Spreading Room (CSR) FDS analysis will be updated to include secondary combustibles.

The time to ignition of a horizontal stack of cable trays will be determined by calculating the critical HRR needed to damage the first (closest) cable tray in the stack. The critical HRR will be determined using FDT 09 and the HRR will be manipulated until the temperature at the tray location reaches the damage criteria. Heat release rates below this value will not cause ignition and will be excluded from the scenario associated with the impact on the secondary combustible. Ignition of the cable trays will be assumed to occur once the damage threshold is reached with no additional consideration of thermal response. Subsequent trays in a cable tray stack will ignite according to the timing rules in Section R.4.2.2 of NUREG/CR-6850.

To calculate the burning area, the entire width of the cable tray will be assumed to ignite. The length of the tray assumed to initially ignite will be 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 will be determined using the empirical model for upward flame propagation assuming the angle of horizontal spread between tray levels is 35 degrees from vertical on either edge of the fire at the first tray in the stack.

Horizontal cable tray flame spread rates from NUREG/CR-6850, Section R.4.1.2 will be used. The HRR per unit area for cables will be equal to the values recommended by NUREG/CR-7010, Section 9.2.2. The cable tray fires will be modeled in FDS by placing a vent on the top of each cable tray in the stack. The vent width will be equal to the width of the cable tray and the vent length will be equal to the length of the cabinet fire vent length. The area of the cable tray fires in the FDS model will remain constant. The HRR, which will be calculated outside of FDS, will be defined by a ramp function that accounts for the time to ignition and the increase in HRR due to horizontal cable tray flame spread and upward flame propagation.

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

The updated CSR FDS analysis will also include fire propagation to adjacent vertical cabinet sections. NUREG/CR-6850, Appendix S suggests that a 10 minute delay in fire propagation can be assumed for cabinets with cables in direct contact with the wall and a 15 minute delay for cabinets without cables contacting the wall. Based on this guidance, a delay of 10 minutes for fire propagation to adjacent cabinets will be conservatively assumed. The adjacent cabinet sections were modeled in FDS as a vent adjacent to the initial ignition source vent. The ignition of the adjacent vents was delayed by 10 minutes by the use of a ramp function.

Following the methodology in NUREG/CR-6850, Appendix S, fire propagation is limited to the adjacent cabinet (i.e., directly next to the initiating section) only. Therefore, the maximum number of cabinets to be affected is three (i.e., source plus one cabinet on either side).

Non-cable intervening combustibles were analyzed in the response to FM RAI 01.d, and it was determined that there are no significant non-cable intervening combustibles in the CSR.

Updates to the CCNPP Fire PRA's CSR fire modeling analysis to incorporate the effect of secondary combustibles will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in the response to PRA RAI-03.

01l.i - Response provided in Reference 2.

01l.ii - The CCNPP Fire PRA's Main Control Room FDS fire modeling analysis will be updated to include heat flux gauge devices placed against the cabinets directly across the horseshoe aisle from the initial fire location and the adjacent cabinet sections. The heat

flux gauge devices will be positioned from the floor to the top of the panel in 0.4 m increments.

The FDS device output files will be reviewed to determine if the appropriate heat flux damage criteria for the cable (i.e., 11 kW/m^2 for thermoset cable and 6 kW/m^2 for thermoplastic cable) is capable of being reached across the horseshoe aisle. If the critical radiant heat flux is reached by any of the heat flux gauges, the time at which this heat flux is reached will be determined. This time will be compared to the time at which any of the abandonment criteria is reached to determine if the fire is capable of spreading across the horseshoe aisle before MCR abandonment is postulated. If the across-aisle heat flux reaches the critical heat flux before the abandonment criteria is reached, the FDS model will be updated to include ignition of the cabinet across the aisle at the time identified.

Updates to the CCNPP Fire PRA's MCR abandonment fire modeling analysis to incorporate heat flux gauge devices across the horseshoe aisle and potential across-aisle fire spread will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in the response to PRA RAI-03.

01l.iii - The CCNPP Fire PRA's Main Control Room (MCR) FDS analysis will be updated to include an increased transient fire heat release rate (HRR) in locations where greater quantities of transient combustibles are located.

Confirmatory walkdowns for transient ignition sources have identified the locations where greater quantities of transient combustibles existed (e.g., photocopiers, bookshelves, upholstered chairs). Additional transient scenarios will be created in FDS for these transient combustible locations which will use an increased transient fire HRR of 1000 kW. This increased HRR was determined to be bounding for the types of combustibles in these locations. The severity factor will be assumed to be 1.0 for these locations and will not use a HRR probability distribution.

Updates to the CCNPP Fire PRA's MCR abandonment fire modeling analysis to incorporate transient fire scenarios with an increased HRR will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in the response to PRA RAI-03.

FM RAI 02:

The ASME/ANS Standard RA-Sa-2009, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment 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 SSCs and appropriate temperature and critical heat flux criteria must be used in the analysis.

a. *Describe how the installed cabling in the power block was characterized, specifically with regard to the critical damage threshold temperatures and critical heat fluxes for thermoset and thermoplastic cables as described in NUREG/CR-6850. If thermoplastic cables are present, explain how raceways with a mixture of thermoset and thermoplastic cables were treated in terms of damage thresholds.*

b. Explain how the damage thresholds for non-cable components (i.e., pumps, valves, electrical cabinets, etc.) were determined. Identify any non-cable components that were assigned damage thresholds different from those for thermoset and thermoplastic cables, and provide a technical justification for these damage thresholds.

c. Explain how exposed temperature-sensitive equipment was treated, and provide a technical justification for the damage criteria that were used.

CCNPP RESPONSE FM RAI 02:

02a - NUREG/CR-6850, Appendix H, provides damage and ignition criteria for both thermoset and thermoplastic cables that are typically found in nuclear power plants. The CCNPP Fire PRA applied the guidance of Appendix H in both the scoping and detailed fire modeling tasks.

A review of all plant cables was performed using the cable database and specifications (i.e., manufacturer, cable insulation/jacket material, etc.) to determine the type (i.e., thermoset or thermoplastic) of cables installed. This analysis was used to determine the appropriate thermal damage threshold for fire modeling purposes.

For those PAUs where detailed fire modeling was performed, the damage criteria of NUREG/CR-6850 Appendix H, Table H-1 was utilized. Per Appendix H of NUREG/CR-6850 the following thermal damage criteria have been used for thermoplastic targets. These criteria have also been applied to raceways containing mixed or unknown cable types:

Critical Temperature: 205°C (400°F)
Critical Heat Flux: 6 kW/m^2 (0.5 BTU/ft^2s)

For raceways and conduits known to contain only thermoset cables, the following damage criteria have been used:

Critical Temperature: 330°C (625°F)
Critical Heat Flux: 11 kW/m^2 (1.0 BTU/ft^2s)

The scoping fire modeling task used alternative target damage thresholds based on the review of all plant cables. The review determined that the majority of the plant cables are composed of silicon rubber with an asbestos braided jacket. Per NUREG/CR-6850 Table H-3, the damage failure temperature for cables with silicone rubber insulation is approximately 400°C. The review also determined that the second most common cable types are thermoset XLPE insulation with thermoset jacketing material, which has an average failure temperature of approximately 350°C. Based on the results of the review, a value of 380°C was selected as representative of performance for the general class of thermoset cables installed at CCNPP. This damage threshold was used for scoping fire modeling in areas with thermoset cables only.

A small population of cables were found to have thermoset XLPE insulation with thermoplastic PVC jacket. Since these cables have XLPE insulation, which is shown to have a higher temperature threshold than thermoplastic materials, a failure temperature of 350°C was selected for use in areas containing thermoplastic jacket cables.

In addition, the scoping fire modeling employs multiple conservatisms that contribute to ensure a bounding analysis. The conservatisms are as follows:

- Fire scenarios utilized the 98th percentile HRR
- All unscreened fire scenarios (including those with a severity factor) are mapped to whole PAU damage
- The fire elevation in most cases is at the top of the cabinet. This is considered conservative, since the combustion process will occur where the fuel mixes with oxygen, which is not always at the top of the ignition source. In addition, the guidance of FAQ 08-0043 recommends an elevation of 1ft below the top of the cabinet for electrical cabinets sealed at the top.
- The convective heat release rate fraction utilized is 0.7. The normally recommended value is between 0.6 and 0.65. Therefore the 0.7 provides additional margin over the recommended values.

Based on the use of multiple conservative elements in the model, the use of plant specific target damage thresholds in the Scoping Fire Modeling task is acceptable.

02b - Response provided in Reference 2.

02c - NUREG/CR-6850, Volume 2, Section H.2 recommends the use of 65°C and 3 kW/m^2 as the critical damage temperature and heat flux for solid state components (e.g., sensitive electronic equipment).

All CCNPP Fire PRA analyses that consider damage to sensitive electronics by hot gas layer (HGL) immersion (i.e., gas layers above 65°C engulfing the cabinet) will be consistent with the critical temperature threshold established in the NUREG/CR-6850 guidance. A study of the effect of room size on the formation of a damaging HGL will be utilized to characterize the risk of a HGL in any given area, with a more detailed analysis performed as required.

CCNPP Fire PRA analyses considering damage by radiant heat will be consistent with the guidance provided in Fire PRA FAQ 13-0004, which relies on the shielding characteristics of cabinet walls to allow the radiant damage to the zone of influence (ZOI) for thermoset cables (i.e., 11 kW/m2) to be used. The Fire PRA FAQ 13-0004 guidance can be applied to cabinets as long as the component is not mounted on the surface of the cabinet (front or back wall / door) where it would be directly exposed to the convective and/or radiant energy of an exposure fire, and where the presence of louvers or other ventilation means could expose the cabinet to damaging heat fluxes, invalidating the FAQ results. Field inspections for all cabinets containing sensitive electronics that will make use of the heat flux damage threshold of Fire PRA FAQ 13-0004 will be the basis to verify that the limitations outlined in the FAQ are not exceeded.

Additional details regarding the treatment of sensitive electronics are provided in the CCNPP response to PRA RAI 09. Updates to the fire modeling to include the application of this treatment of sensitive electronics will be incorporated in the updated fire risk results that will be provided to the NRC after the CCNPP fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

FM RAI 03:

Section 2.7.3.2 of NFPA 805 states that each calculational model or numerical method used shall be verified and validated through comparison to test results or comparison to other acceptable models.

Section 4.5.1.2 of the 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 for a discussion of the verification and validation (V&V) of the fire models that were used. Furthermore, Section 4.7.3 of the LAR states that "Calculation models and numerical methods used in support of compliance with 10 CFR 50.48(c) were verified and validated as required by Section 2.7.3.2 of NFPA 805."

For any tool or method identified in the response to FM RAI 1.a above, provide the V&V basis if not already explicitly provided in the LAR (for example, in Attachment J). Provide technical details to demonstrate that these models were applied within the validated range of input parameters, or justify the application of the model outside the validated range in the V&V basis documents.

CCNPP RESPONSE FM RAI 03:

Response provided in Reference 2.

FM RAI 04:

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

Section 4.7.3 of the LAR states that, "Engineering methods and numerical models used in support of compliance with 10 CFR 50.48(c) were applied appropriately as required by Section 2.7.3.3 of NFPA 805."

Regarding the limitations of use, the NRC staff notes that algebraic models cannot be used outside the range of conditions covered by the experiments on which the model is based. NUREG-1805 includes a section on assumptions and limitations that provides guidance to the user in terms of proper and improper use for each FDT.

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

CCNPP RESPONSE FM RAI 04:

The limitations and assumptions associated with the Fire Dynamics Simulator (FDS) and Fire Dynamics Tools (FDTs) are documented in NUREG-1934, NUREG-1824 (including Draft Supplement 1), and the CCNPP fire modeling verification and validation documentation. Using this guidance, the fire modeling analyst manually calculates and verifies that the fire modeling tools are used within the limits and ranges of applicability.

To demonstrate that the CCNPP Fire PRA FDS and FDT analyses are performed within the applicable guidelines for nuclear power plants, the fire modeling input parameters will be analyzed to determine if they are within the normalized parameter ranges summarized in

NUREG-1934 and NUREG-1824 (including Supplement 1) and the CCNPP fire modeling verification and validation documentation.

The normalized parameters that may end up outside of the validated range for the fire modeling updates will be assessed to determine if they can be quantitatively or qualitatively justified for being outside of the validated range and documented in the CCNPP fire modeling verification and validation documentation; otherwise, use of the fire modeling input parameters in question will be reevaluated. In most cases, the fire modeling input parameters identified to be out of range can be conservatively modified to bring the parameters within range as recommended by NUREG-1934 Section 2.3.7.1. When this is not possible, the fire modeling input parameters in question may be qualitatively justified through the use of conservativism and safety margin, the applicability of the normalized parameter to the model, the assumption that targets are damaged that fall outside of the validated range, or by some other appropriate means.

Technical details demonstrating that the fire models are within the validated ranges, as well as any justification of fire models outside the range or non-applicable input parameters, will be in the CCNPP fire modeling verification and validation documentation.

FM RAI 05:

Section 4.5.1.2 of the LAR states that fire modeling was performed as part of the FPRA development (NFPA 805, Section 4.2.4.2). The NRC staff notes this requires that qualified fire modeling and PRA personnel work together. Furthermore, Section 4.7.3 of the LAR states the following:

> *Cognizant personnel who use and apply engineering analysis and numerical methods in support of compliance with 10 CFR 50.48(c) are competent and experienced as required by Section 2.7.3.4 of NFPA 805.*
>
> *For personnel performing fire modeling for FPRA development and evaluation, CCNPP [Calvert Cliffs Nuclear Power Plant] develops and maintains qualification requirements for individuals assigned various tasks. Position specific guides were 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.*
>
> *Qualification cards provide evidence that Design Engineering and PRA personnel have the appropriate training and technical expertise to perform assigned work, including the use of engineering analyses and numerical models.*
>
> *Qualification requirements are contained in procedure CNG-TR-1.01-1014 (Reference 6.47). CCNPP will maintain qualification requirements for the performance of NFPA 805 related tasks. Position specific qualification cards identify and document required training and mentoring to ensure cognizant individuals are appropriately qualified to perform assigned work per the requirements of NFPA 805, Section 2.7.3.4.*

Regarding qualifications of users of engineering analyses and numerical models (i.e., fire modeling techniques):

a. *Describe the requirements to qualify personnel for performing fire modeling calculations in the NFPA 805 transition.*

b. *Describe the process for ensuring that fire modeling personnel have the appropriate qualifications not only before the transition, but also during and following the transition.*

c. *When fire modeling is performed in support of the FPRA, describe how proper communication between the fire modeling and FPRA personnel is ensured.*

CCNPP RESPONSE FM RAI 05:

05a – Response provided in Reference 1.

05b – Response provided in Reference 2.

05c – Response provided in Reference 2.

FM RAI 06:

Section 4.7.3 of the LAR states that, "Uncertainty analyses were performed as required by Section 2.7.3.5 of NFPA 805 and the results were considered in the context of the application. This is of particular interest in fire modeling and FPRA development."

Regarding the uncertainty analysis for fire modeling:

a. *Describe how the uncertainty associated with the fire model input parameters was accounted for in the fire modeling analyses.*

b. *Describe how the "model" and "completeness" uncertainties were accounted for in the fire modeling analyses.*

CCNPP RESPONSE FM RAI 06:

06a - Fire modeling was performed within the CCNPP Fire PRA utilizing codes and standards developed by the industry and NRC staff and that were verified and validated in authoritative publications such as NUREG-1824, "Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications." In general, the fire modeling was performed using conservative methods and input parameters that were based upon NUREG/CR-6850, "Fire PRA Methodology for Nuclear Power Facilities." This approach was used based upon the current state of knowledge regarding the uncertainties related to the application of the fire modeling tools and associated input parameters for specific plant configurations. A discussion of uncertainties associated with detailed fire modeling is summarized below.

The detailed fire modeling task develops a probabilistic output in the form of target failure probabilities and are subject to both aleatory (statistical) and epistemic (systematic) uncertainty.

Appendix U of NUREG/CR-6850 suggests that, to the extent possible, fire modeling parameters should be expressed as probability distributions and propagated through the analysis to arrive at target failure probability distributions. These distributions should be based on the variation of experimental results as well as the analyst's judgment. In addition, to the extent possible, more than one fire model can be applied and probabilities assigned to the outcome which describe the degree of belief that each model is the correct one.

Due to the uncertainty with each of these parameters, the fire modeling task has selected conservative values for each to provide safety margin. . Per NEI 04-02, there is no clear definition of an adequate safety margin; however, the safety margin should be sufficient to bound the uncertainty within a particular calculation or application. The CCNPP fire modeling

documentation provides a list of items that were modeled conservatively and that provide safety margin. Some examples include the following items:

- The majority of the CCNPP Fire PRA's scenarios involving electrical equipment (including the electrical split fraction of pump fires) will utilize the 98th percentile heat release rate (HRR) for the severity factor calculated out to the nearest Fire PRA target. This is considered conservative.
- The fire elevation is will usually be modeled at the top of a cabinet, pump, or motor body. This is considered conservative, since the combustion process will occur where the fuel mixes with oxygen, which is not always at the top of the ignition source. Additionally the guidance of FAQ 08-0043 recommends fires be modeled 1 ft. below the top of electrical cabinets that are sealed at the top, and reinforces that this method is conservative.
- The radiant fraction that will be utilized is 0.4. This represents a 33% safety margin over the normally recommended value of 0.3. In addition, the convective heat release rate fraction that will be utilized is 0.7. The normally recommended value is between 0.6 and 0.65, and thus the use of 0.7 is conservative.
- For most transient fire impacts, a large bounding transient zone will be used and all targets within its zone of influence (ZOI) will be affected by a fire. Time to damage will be usually calculated based on the most severe (closest) target. This was considered conservative, because a transient fire would actually have a much smaller zone of influence and varying damage times for the various heat release rate bins which make up the total heat release rate probability distribution. This approach was implemented to minimize the multitude of transient scenarios to be analyzed.
- For hot gas layer (HGL) calculations, no equipment or structural steel will be credited as a heat sink, because the closed-form correlations used do not account for heat loss to these items.
- For most scenarios, target damage will occur when the exposure environment meets or exceeds the damage threshold. No additional time delay due to thermal response will be allowed.
- In some PAUs, transient fires will be assumed to damage everything from the floor to the ceiling. This is conservative since most transient fires are not expected to have a ZOI that would reach the ceiling.
- The fire elevation for transient fires in most cases will be two feet. This is considered conservative since some transient fires occur at the floor.
- For many scenarios, automatic or manual detection and suppression will not be credited which leads to conservative results.
- Scenarios that identify the time to automatic detection and suppression will not utilize the approach of adding the HGL temperature to the ceiling jet temperature. Including the effects of a HGL would result in shorter detection and suppression times; therefore, the use of the ceiling jet correlation is considered conservative.
- All fires modeled using FDS will assume that the fire does not experience the effects of oxygen deprivation. This is a conservative assumption that enables the fire to

continuously burn in environments with oxygen levels below that required to sustain the prescribed HRR.

- The FDTs generally over-predict hot gas layer temperatures and this over-prediction is expected to lead to conservative results.
- For the non-FDS analyses, as the fire propagates to secondary combustibles, the fire will conservatively be modeled as one single fire using the fire modeling closed-form correlations. The resulting plume temperature estimates used in non-FDS analyses will, therefore, be conservative because the fire would actually be distributed over a large surface area, and would be less severe at the target location.
- For some scenarios fire propagation to the first cable tray will be estimated to be one minute. In most cases, propagation to the first cable tray would be greater than one minute; therefore, this is considered conservative.
- Not every cable tray in the plant is filled to capacity. In many cases, fire modeling will assume cable trays were filled to capacity, which provided a conservative estimate of surface area and the corresponding fire severity.

06b - NUREG-1934, "Nuclear Power Plant Fire Modeling Analysis Guidelines," Final Report dated November 2012 states that "model" uncertainties can be estimated using the processes of verification and validation. Model uncertainty is based primarily on comparisons of model predictions with experimental measurements as documented in NUREG-1824, "Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications," Final Report, dated May 2007 (including Supplement 1, Draft for Comment, dated November 2014), and other model validation studies.

All of the fire models used and listed in Attachment J of the CCNPP NFPA 805 Transition Report will be within or very near the experimental uncertainty as defined in NUREG-1824.Where applicable, all fire models listed below will be applied within the validation ranges or the use will be justified as acceptable with a subsequent analysis.

NUREG-1934 and NUREG-1824 (including Draft Supplement 1) describe how to quantify the uncertainty by calculating the probability that the actual value of a model prediction will exceed a given threshold. The bias factors and standard deviations that are used in calculating this probability for any given prediction have been determined through the comparison of model predictions with experimental measurements. The Supplement 1 Draft to NUREG-1824 includes a larger sample of experimental results for each model, so the quantitative uncertainty analysis in this RAI response uses the values for the bias factor and standard deviation of each model listed in Table 5-1 of the Supplement 1 Draft to NUREG-1824.

The bias factor for each model describes, on average, how much the model over predicts or under predicts the experimental results. The standard deviation denotes the variation at which the model predictions will over predict or under predict the experimental results. The values of each model's predictive capabilities that will be used are described below.

Hot Gas Layer (HGL) Temperature Using the Method of McCaffrey, Quintiere and Harkleroad (MQH): The uncertainty curve for the predictions of the HGL temperature in a compartment with natural ventilation using the method of MQH is characterized in

NUREG-1824 Draft Supplement 1, Table 5-1. On average, the model will over predict the HGL temperature by a bias factor of 1.17. The standard deviation for the HGL temperature predictions is 0.15. The normally over predictive nature of the method of MQH is, therefore, expected to lead to conservative results and increased safety margin.

HGL Temperature Using the Method of Foote, Pagni and Alvares (FPA): The uncertainty curve for the predictions of the HGL temperature in a compartment with forced ventilation using the method of FPA is characterized in NUREG-1824 Draft Supplement 1, Table 5-1. On average, the model will over predict the HGL temperature by a bias factor of 1.29. The standard deviation for the HGL temperature predictions is 0.32. The normally over predictive nature of the method of FPA is, therefore, expected to lead to conservative results and increased safety margin.

HGL Temperature Using the Method of Deal and Beyler (DB): The uncertainty curve for the predictions of the HGL temperature in a compartment with forced ventilation using the method of DB is characterized in NUREG-1824 Draft Supplement 1, Table 5-1. On average, the model will over predict the HGL temperature by a bias factor of 1.18. The standard deviation for the HGL temperature predictions is 0.25. The normally over predictive nature of the method of DB is, therefore, expected to lead to conservative results and increased safety margin.

HGL Temperature Using the Method of Beyler: The uncertainty curve for the predictions of the HGL temperature in a closed compartment with no ventilation using the method of Beyler is characterized in NUREG-1824 Draft Supplement 1, Table 5-1. On average, the model will over predict the HGL temperature by a bias factor of 1.04. The standard deviation for the HGL temperature predictions is 0.37. The normally over predictive nature of the method of Beyler is, therefore, expected to lead to conservative results and increased safety margin.

HGL Depth and Temperature Using Fire Dynamics Simulator (FDS): The uncertainty curve for the predictions of the HGL depth and temperature using FDS is characterized in NUREG-1824 Draft Supplement 1, Table 5-1. On average, FDS will over predict the HGL temperature in compartments with natural ventilation by a bias factor of 1.02 with a standard deviation of 0.12; in compartments with forced ventilation by a bias factor of 1.21 with a standard deviation of 0.22; and, in closed compartments with no ventilation by a bias factor of 1.20 with a standard deviation of 0.12. On average, FDS will also over predict the HGL depth by a bias factor of 1.03 with a standard deviation of 0.06. The normally over predictive nature of FDS at predicting HGL depth and temperature is, therefore, expected to lead to conservative results and increased safety margin.

HGL Temperature and Depth Using the Consolidated Model of Fire and Smoke Transport (CFAST): The uncertainty curve for the predictions of the HGL temperature and depth using CFAST is characterized in NUREG-1824 Draft Supplement 1, Table 5-1. On average, CFAST will over predict the HGL temperature in compartments with natural ventilation by a bias factor of 1.20 with a standard deviation of 0.36; in compartments with forced ventilation by a bias factor of 1.15 with a standard deviation of 0.19; and, in closed compartments with no ventilation with a listed bias factor of 1.00 and a standard deviation of 0.08. On average, CFAST will also over predict the HGL depth by a bias factor of 1.05 with a standard deviation of 0.34. The normally over predictive nature of CFAST at predicting HGL temperature and depth is, therefore, expected to lead to conservative results and increased safety margin.

Ceiling Jet Temperature Using the Alpert Correlation: The uncertainty curve for the predictions of the ceiling jet temperature using the Alpert Correlation is characterized in NUREG-1824 Draft Supplement 1, Table 5-1. On average, the model will under predict the ceiling jet temperature by a bias factor of 0.86 with a standard deviation of 0.11. The Alpert Correlation is primarily used for predicting smoke detection time and sprinkler activation time, so the under predictive nature of the method is, therefore, expected to lead to conservative results and increased safety margin.

The approach of adding the HGL temperature to the ceiling jet temperature was not used in the CCNPP fire modeling analysis. The primary application of the ceiling jet correlation in the CCNPP fire modeling analysis will be the determination of detection and suppression timing, in which the ceiling jet velocity is a sub-model in the analysis. Including the effects of an HGL would have resulted in shorter detection and suppression times; therefore, the CCNPP fire modeling approach is conservative.

Plume Temperature Using the Method of Heskestad: The uncertainty curve for the predictions of the plume centerline temperature using the method of Heskestad is characterized in NUREG-1824 Draft Supplement 1, Table 5-1. On average, the model will under predict the plume centerline temperature by a bias factor of 0.84 with a standard deviation for of 0.33.

NUREG-1824, Volume 3, Section 6.2 (Summary) states, "The FDTs model for plume temperature is based on appropriate empirical data and is physically appropriate. FDTs generally under-predicts plume temperature, outside of uncertainty, because of the effects of the hot gas layer on test measurements of plume temperature. The FDTs model is not appropriate for predicting the plume temperatures at elevations within a hot gas layer."

The method of Heskestad plume correlation for fire modeling applications will be used within the limitations provided in NUREG-1824. The effects of the plume and HGL interaction will be analyzed and documented in the CCNPP fire modeling verification and validation documentation. The method of Heskestad plume correlation will be used in accordance with the results of this analysis.

Plume Temperature Using FDS: The uncertainty curve for the predictions of the plume centerline temperature using FDS is characterized in NUREG-1824 Draft Supplement 1, Table 5-1. On average, FDS will over predict the plume centerline temperature by a bias factor of 1.20 with a standard deviation of 0.21. The normally over predictive nature of FDS at predicting the plume centerline temperature is, therefore, expected to lead to conservative results and increased safety margin.

Flame Height Using the Heskestad Flame Height Correlation: NUREG-1934 Section 4.1, Table 4-1 states, "All of the models except FDS use the Heskestad Flame Height Correlation (Heskestad, SFPE Handbook). These models were shown to be in qualitative agreement with the experimental observations, but there was not enough data to further quantify this assessment." For the flame height uncertainty, the qualitative color codes from NUREG-1824 will be used since no data is provided in NUREG-1824 Draft Supplement 1.

The predictive capability of this parameter using this method is characterized as GREEN according to NUREG-1824, Table 3-1. As stated in NUREG-1824, Volume 1, Section 2.6.2, a GREEN characterization is assigned, "If both criteria are satisfied (i.e., the model physics are appropriate for the calculation being made and the calculated relative differences are within or very near experimental uncertainty), then the V&V team concluded that the fire model prediction is accurate for the ranges of experiments in this study, and as described in Tables 2-4 and 2-5. A grade of GREEN indicates the model can be used with confidence to calculate the specific attribute. The user should recognize, however, that the accuracy of the model prediction is still somewhat uncertain and for some attributes, such as smoke concentration and room pressure, these uncertainties may be rather large. It is important to note that a grade of GREEN indicates validation only in the parameter space defined by the test series used in this study; that is, when the model is used within the ranges of the parameters defined by the experiments, it is validated."

NUREG-1824, Volume 3, Section 6.3 (Summary) states, "The FDTs model predicted flame heights consistent with visual test observations."

Smoke Concentration Using FDS: The uncertainty curve for the predictions of smoke concentration using FDS is characterized in NUREG-1824 Draft Supplement 1, Table 5-1. On average, FDS will over predict the smoke concentration by a bias factor of 2.63 with a standard deviation of 0.59.

The smoke concentration will be analyzed and used to determine the probability of Main Control Room (MCR) abandonment in the CCNPP Fire PRA following a fire scenario in the MCR. Since the smoke concentration was over-predicted for both the open-door and closed-door test configurations with the overestimation being most pronounced in the closed-door experiments, as indicated in NUREG-1824 Draft Supplement 1, the CCNPP Fire PRA's FDS smoke concentration results are considered conservative.

Radiant Heat Flux Using the Point Source Model: The uncertainty curve for the predictions of target radiant heat flux using the point source model is characterized in NUREG-1824 Draft Supplement 1, Table 5-1. On average, the point source model will over predict the radiant heat flux by a bias factor of 1.44 with a standard deviation of 0.47. The normally over predictive nature of the point source model at predicting the radiant heat flux is, therefore, expected to lead to conservative results and increased safety margin.

In addition, NUREG-1824 states that the point source model is not intended to be used for locations relatively close to the fire. In the CCNPP fire modeling analysis, targets located close to the fire will be conservatively failed within the early stages of fire growth.

Radiant Heat Flux Using FDS: The uncertainty curve for the predictions of target radiant heat flux using FDS is characterized in NUREG-1824 Draft Supplement 1, Table 5-1. On average, FDS will slightly under predict the radiant heat flux by a bias factor of 0.98 with a standard deviation of 0.25.

NUREG-1824, Volume 7, Section 6.8 states, "FDS has the appropriate radiation and solid phase models for predicting the radiative and convective heat flux to targets, assuming the targets are relatively simple in shape. FDS is capable of predicting the surface temperature of a target, assuming that its shape is relatively simple and its composition fairly uniform.

FDS predictions of heat flux and surface temperature are generally within experimental uncertainty, but there are numerous exceptions attributable to a variety of reasons. The accuracy of the predictions generally decreases as the targets move closer to, or go inside of the fire. There is not enough near-field data to challenge the model in this regard."

FDS will be used to calculate the radiant heat exposure to an electrical cabinet due to a nearby fire. For these calculations, care will be taken to ensure that FDS is used within its limitations, or justification will be provided if used outside of the limitations as described in CCNPP's response to FM RAI 04.

"Completeness" Uncertainties: "Completeness" uncertainties refer to the fact that a model may not be a complete description of the phenomena it is designed to predict. Completeness associated with fire models will be addressed in the CCNPP Fire PRA within the overall quantification process, since the Fire PRA is an integrated analysis. Fire modeling provides inputs to a broad comprehensive Fire PRA that includes modeling of electrical systems, operator actions and the plant systems and components needed to shut down the plant. One of the first steps in the fire modeling process is to identify the fire scenarios that will be analyzed. In some situations, these scenarios would require fire modeling capabilities that are not currently available, creating completeness uncertainty in the analysis. The CCNPP Fire PRA will resolve this uncertainty using the scenario definition and target mapping within the fire models to conservatively compensate for the lack of information. In all cases, conservative zones of influence (ZOI) will be used to address radiation and plume fire damage, thus ensuring that a conservative target impact set is generated for each scenario regardless of the scenario type or fire initiator.

For uncertainties specifically involved with ignoring the contents of a compartment in the non-FDS fire modeling, there are several areas of conservatism that mitigate the reduction in volume in HGL calculations. The following assumptions will be utilized within the non-FDS fire modeling to induce conservatism or reduce the impact of ignoring the contents of a compartment in the fire modeling:

- If equipment is included in HGL calculations, a large heat sink will be provided in the fire compartment, which would have generated lower HGL temperatures.
- No heat passage through fire closed doors or dampers will be considered in the HGL temperature calculations. The material properties of concrete will be applied to all exterior boundaries of the fire compartment. Realistically, the heat from the HGL would be transferred to adjacent spaces more easily by a door or fire damper, which have a higher thermal conductivity than concrete. Including these passages to adjacent compartments would have generated lower HGL temperatures.
- Although obstructions within the room could reduce the effective volume when analyzing HGL temperatures, many of these obstructions (e.g., electrical cabinets and transformers) are not totally solid obstructions. Electrical cabinets are generally not full of components on the inside (i.e., they contain large, empty spaces). These empty spaces within the electrical cabinets reduce the impact of including obstructions for HGL temperature calculations.
- The volume of some fire compartments will be reduced in the CCNPP fire modeling analysis to meet the validation range for compartment aspect ratio. For fire compartments having an aspect ratio outside the validated range where detailed fire

modeling will be performed and whole room damage is not postulated, the height, length, or width of the fire compartment will be "shortened" to values that fall within the validation range. Shortening the dimensions of the fire compartment decreases the overall volume of the compartment and creates a more severe condition. The reduction in volume in these fire compartments bounds the obstructions that were not considered.

PRA RAI 01 - Fire Event Facts and Observations:

Section 2.4.3.3 of NFPA 805 states that the probabilistic safety assessment (also referred to as PRA) approach, methods, and data shall be acceptable to the authority having jurisdiction, which is the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the NRC staff for adopting a fire protection program consistent with NFPA 805. RG 1.200 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 result of a peer review are the facts and observations (F&Os) recorded by the peer review and the subsequent resolution of these F&Os.

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

a) *PRM-83-01: The disposition to F&O PRM-83-01 appears to indicate that the FPRA was updated to address events involving a fire induced loss of MCR HVAC, which the peer review suggests has a conditional core damage probability (CCDP) of 1.0, by increasing the likelihood of functional failures in lieu of assuming their occurrence. Justify the functional failures modeled by the FPRA to address this loss of MCR HVAC. In addition, explain how the FPRA evaluates the degradation of equipment due to elevated temperatures caused by loss of HVAC as an increase in equipment failure rates, and provide a technical basis for doing so.*

b) *FSS-A5-01: This F&O states that some PAUs are further divided into "sub-PAUs" and appears to indicate that there is no explicit process for evaluating the fire spread across sub-PAU boundaries, which, as the peer review noted, are not defined by physical barriers. The disposition to this F&O, however, does not discuss such a process, and by referencing a sensitivity analysis limited to a number of "representative" PAUs, suggests that this apparent deviation from acceptable methods has not been fully addressed for all PAUs for which sub-PAUs have been defined. Explain how the fire effects across non-physical sub-PAU boundaries are identified and evaluated. Discuss how this approach is consistent with or conservatively bounds acceptable methods.*

c) *FSS-G4-01: The disposition to this F&O indicates that the MCA did not postulate a propagation scenario if doing so would require failure of a penetration seal. The licensee's analysis (C0-FSS-08) suggests that a similar approach may have also been followed for other barrier types (e.g., walls). As a result, identify each barrier type for which propagation scenarios were not postulated, and provide quantitative justification (e.g., an evaluation demonstrating that MCA scenarios involving barrier failure are low risk, even considering the risk associated with the multi-compartment fire) for not addressing propagation. As an alternative, provide updated risk results as part of the*

integrated analysis requested in PRA RAI 03, summing the generic barrier failure probabilities for each type of barrier present between communicating compartments, consistent with NUREG/CR-6850.

d) FSS-G5-01: The disposition to this F&O indicates that unreliability values were applied to all normally open, self-closing dampers and doors; however, the disposition neither provides a basis for the values applied nor mentions active elements discussed elsewhere (e.g., water curtains in F&O PP-B5-01). Summarize the types of active fire barrier elements credited in the FPRA, and provide quantitative justification for their unreliability and unavailability.

e) HRA-B2-01: The disposition to this F&O indicates that "adverse" operator actions, which include actions to de-energize electrical busses as a means to address spurious operations, are modeled in the FPRA by assuming all equipment disabled by the action is failed (i.e., the action is successful). Although the licensee's analysis (Section 2.2 of C0-HRA-001) indicates that this assumption is conservative, the basis for this conclusion is unclear if the action is taken to reduce risk. In light of this:

i. Provide justification for the assumption that modeling "adverse" actions as successful is conservative. Note that guidance in NUREG-1921 offers considerations for evaluating fault clearing strategies in the FPRA human reliability analysis (HRA).

ii. Clarify how "adverse" actions are addressed by the FPRA HRA dependency analysis, given that these actions are modeled by failing associated equipment directly within the PRA logic model.

iii. Explain the statement in Attachment G that "[n]one of the recovery actions were found to have an adverse impact on the FPRA." In doing so, clarify how "adverse" risk impact was defined. Note that FAQ 07-0030 states that "[i]f activities (recovery actions or other actions in the post-fire operational guidance) are determined to have an adverse risk impact, they should be resolved during NFPA 805 implementation via an alternate strategy that eliminates the need for the action in the NSCA."

f) CS-B1-01: The licensee's analysis (Appendix F of ECP-13-000321, "Common Power Supply and Common Enclosure Study") identifies several MCC 208/120 Volts alternating current load breakers that were not coordinated with their respective feed breakers. The disposition to this F&O indicates that these 120V panel breaker coordination issues are to be addressed by plant modification; however, Attachment S does not appear to contain such a modification. Identify the Attachment S modification(s) being credited to resolve the 120V panel breaker coordination issues identified in the disposition to this F&O.

CCNPP RESPONSE PRA RAI 01:

01a - Response provided in Reference 1.

01b - CCNPP is reviewing all Physical Analysis Units (PAUs) that utilized sub-PAUs in detailed fire modeling. The existing analysis will be revised to include ignition of secondary combustibles due to any fixed or transient source in the PAU in the model. For sub-PAUs where fire spread is possible due to intervening combustibles, the additional heat release rate (HRR) with the resulting expanded zone of influence (ZOI) as well as the physical fire spread due to the intervening combustibles will be used to evaluate and identify the potential for target damage outside of the existing sub-PAU boundaries.

In addition, all scenarios will be reviewed to ensure that, where the zone of influence (ZOI) of any fire scenario affects targets outside of the sub-PAU, target damage outside of the sub-PAU is postulated.

In postulating ignition of secondary combustibles and applying the zone of influence regardless of sub-PAU boundaries, the revised analysis will be consistent with the guidance of NUREG/CR-6850 and does not deviate from acceptable methods.

The result of this review will be quantified as part of the integrated analysis of PRA RAI 03.

01c - The CCNPP Fire PRA multi-compartment analysis (MCA) will be revised to include propagating scenarios for all barrier types, including walls containing penetrations with fire seals and solid walls, as described in Section 11.5.4 of NUREG/CR-6850. The barrier failure probability to be used will be the sum of the probabilities specified in NUREG/CR-6850, Table 11-3 which are applicable to each PAU boundary. The sum of the applicable values in Table 11-3 (for doors, dampers and wall/penetration seals) is considered to be applicable regardless of the number of such barrier configuration Types present in the barrier. The values in Table 11-3 are applied to a barrier containing these barrier configuration Types but are not multiplied by the number of individual components associated with the configuration Type. The revised MCA will be done in conjunction with the update of CCNPP FPRA analysis documentation supporting Request for Additional Information (RAI) PRA-03.

01d – Response provided in Reference 1.

01e – Response provided in Reference 1.

01f – Response provided in Reference 1.

PRA RAI 02 - Internal Event F&Os:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a fire protection program consistent with NFPA 805. RG 1.200 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. The primary results of a peer review are the F&Os recorded by the peer review and the subsequent resolution of these F&Os.

Clarify the following dispositions to internal events F&Os and SR assessments identified in Attachment U of the LAR that have the potential to impact the FPRA results and do not appear to be fully resolved:

a) 4-5: This F&O indicates that the alignment strategy assumed by the PRA for the 0C diesel generator (DG) is not appropriately justified and may be non-conservative. While the disposition to this F&O clarifies how alignment of the 0C DG is modeled in the PRA, a justification for this treatment is not provided. Provide a technical and/or procedural basis for the alignment strategy assumed in the PRA for the 0C DG, and indicate whether any operator interviews were conducted to support the analysis.

b) 6-23: This F&O indicates that some joint human error probabilities (HEPs) applied within the internal events PRA (IEPRA) may not accurately reflect the sequential timing of associated operator actions. While the disposition appears to address the specific example referenced by the F&O, it is not clear that the broader issue has been fully resolved in the fire PRA, particularly noting that the status of this F&O in Table U-1 is identified as "open."

i. Explain how the HRA methods used by the FPRA for developing HEP and joint HEP values are consistent with or conservatively bound NRC-accepted guidance in NUREG/CR-6850 or NUREG-1921. Alternatively, provide updated risk results as part of the aggregate change-in-risk analysis requested in PRAN RAI 03 applying HEP and joint HEP values developed using NRC-accepted guidance.

ii. NUREG-1921 indicates and NUREG-1792 (Table 2-1) states that joint HEP values should not be below 1.0E-05. Confirm that each joint HEP value used in the FPRA below 1.0E-05 includes its own justification that demonstrates the inapplicability of the NUREG-1792 lower value guideline. Provide an estimate of the number of these joint HEPs below 1.0E-05 and at least two different types of justification.

CCNPP RESPONSE PRA RAI 02:

Response provided in Reference 1.

PRA RAI 03 - Integrated Analysis:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. Section 2.4.4.1 of NFPA 805 further states that the change in public health risk arising from transition from the current fire protection program to an NFPA 805 based program, and all future plant changes to the program, shall be acceptable to the NRC. RG 1.174 provides quantitative guidelines on CDF and LERF, identifies acceptable changes to these frequencies that result from proposed changes to the plant's licensing basis, and describes a general framework to determine the acceptability of risk-informed changes. The NRC staff's review of the information in the LAR has identified additional information that is required to fully characterize the risk estimates.

The PRA methods currently under review in the LAR include:

- *PRA RAI 01.a regarding loss of MCR HVAC*
- *PRA RAI 01.b regarding division of PAUs into "sub-PAUs"*
- *PRA RAI 01.c regarding treatment of propagation in the MCA*
- *PRA RAI 01.d regarding unreliability and unavailability of active barriers*
- *PRA RAI 01.e regarding adverse operator actions*
- *PRA RAI 01.f regarding 120V panel breaker coordination issues*
- *PRA RAI 02.a regarding alignment of OC diesel generator*
- *PRA RAI 02.b regarding HRA methods, including sequential timing of operator actions*
- *PRA RAI 04 regarding placement of transient fires*
- *PRA RAI 05 regarding transient influence factors*
- *PRA RAI 06 regarding reduced transient HRR*
- *PRA RAI 07 regarding self-ignited cable fires and those caused by welding and cutting*
- *PRA RAI 08 regarding treatment of junction boxes*
- *PRA RAI 09 regarding treatment of sensitive electronics*

- *PRA RAI 10 regarding circuit failure probabilities*
- *PRA RAI 11 regarding counting and treatment of Bin 15 electrical cabinets*
- *PRA RAI 12 regarding treatment of HEAF*
- *PRA RAI 13 regarding MCR modeling*
- *PRA RAI 14 regarding credit for MCR abandonment actions*
- *PRA RAI 15 regarding MCR abandonment on loss of control*
- *PRA RAI 16 regarding application of the state-of-knowledge correlation (SOKC)*
- *PRA RAI 18 regarding ΔICDF, ΔLERF and additional risk of RAs*
- *PRA RAI 23 regarding other deviations from acceptable methods*

Provide the following:

a) *Results of an aggregate analysis that provide the integrated impact on the fire risk (i.e., the total transition CDF, LERF, ΔCDF, ΔLERF, and additional risk of RAs) of replacing specific methods identified above with alternative methods that are acceptable to the NRC. In this aggregate analysis, for those cases where the individual issues have a synergistic impact on the results, a simultaneous analysis must be performed. For those cases where no synergy exists, a one-at-a-time analysis may be done. For those cases that have a negligible impact, a qualitative evaluation may be done. It should be noted that this list may change depending on NRC's review of the responses to other RAIs in this document.*

b) *For each method (i.e., each bullet) above, explain how the issue will be addressed in 1) the final aggregate analysis results provided in support of the LAR, and 2) the PRA that will be used at the beginning of the self-approval of post-transition changes. In addition, provide a process to ensure that all changes will be made, that a focused-scope peer review will be performed on changes that are PRA upgrades as defined in the PRA standard, and that any findings will be resolved before self-approval of post-transition changes.*

c) *In the response, explain how RG 1.205 risk acceptance guidelines are satisfied for the aggregate analysis. Additionally, discuss the likelihood that the risk increase in any individual fire area would exceed the acceptance guidelines, and if so, why exceeding the guidelines should be acceptable. If applicable, include a description of any new modifications or operator actions being credited to reduce delta risk as well as a discussion of the associated impacts to the fire protection program.*

d) *If any unacceptable methods identified above will be retained in the PRA and will be used to estimate the change in risk of post-transition changes to support self-approval, explain how the quantification results for each future change will account for the use of these methods.*

CCNPP RESPONSE PRA RAI 03:

Final risk quantification information and license amendment request related updates will be provided after the approaches outlined in all other RAI responses are reviewed and acceptable to the NRC.

PRA RAI 04 - Transient Fire Placement at Pinch Points:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology

for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a fire protection program consistent with NFPA 805. 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.

The NRC staff could not identify in the LAR or licensee's analysis a description of how "pinch points" for transient fires were treated in the FPRA. Per NUREG/CR-6850, Section 11.5.1.6, transient fires should, at a minimum, be placed in locations within the plant PAUs where CCDPs are highest for that PAU (i.e., at "pinch points"). Pinch points include locations of redundant trains or the vicinity of other potentially risk-relevant equipment. Cable congestion is typical for areas like the CSR, so placement of transient fire at pinch points in those locations is important. Hot work should be assumed to occur in locations where hot work is possible, even if improbable, keeping in mind the same philosophy.

a) Clarify how "pinch points" were identified and modeled for general transient fires and transient fires due to hot work.

b) Describe how general transient fires and transient fires due to hot work are distributed within the PAUs at Calvert Cliffs. In particular, identify the criteria used to determine where such ignition sources are placed within the PAUs.

<u>CCNPP RESPONSE PRA RAI 04</u>:

04a - A "pinch point" focused approach is not utilized at CCNPP. Transient fires have been postulated in each PAU in the Fire PRA. The models are being reviewed to ensure that all available floor area is postulated as a possible transient ignition source location or the model will be updated. Some PAUs have been subdivided into transient zones (weighted by floor area) to refine the frequency of damage to risk significant targets. The total transient and hot work ignition frequency for each PAU is apportioned throughout the available floor area.

04b - Transient and hot work fires are distributed within the PAUs in accordance with the process described below:

In all compartments where detailed fire modeling has been performed, transient and hot work fires are postulated in all available floor areas (i.e., all accessible floor areas except where precluded by design and/or operation (e.g., plant equipment)). The accessible floor area of each PAU is then subdivided into one or more transient zones. The boundaries of each transient zone are chosen such that the associated fire growth and resulting damage to PRA targets (i.e., cables and equipment) can be bounded by a representative fire scenario (i.e., including or excluding secondary combustibles).

In order to keep the number of locations (and therefore the number of transient scenarios) requiring separate analysis to a minimum, locations with similar Fire PRA targets may be grouped into larger transient scenarios. The transient ignition frequency is then apportioned to these locations based on a geometrical factor. The remainder of the floor space of the PAU is subdivided as necessary to distinguish between different fire growth potential (e.g., locations where secondary combustibles are at a low enough elevation to be ignited by the transient fire) and Fire PRA targets. In some cases this leaves a section of the floor area with no fire growth potential beyond the initial transient source and no targets within the ZOI,

creating a transient scenario with no target damage. This ensures that all accessible floor area is accounted for in the transient analysis.

Target damage sets for any transient initiator is not limited to the targets within the floor area, but is based on the ZOI of the transient when placed anywhere within the transient floor area, including the border. The result is that some transients may damage the same targets, or have overlapping zones of influence.

PRA RAI 05 - Transient Influencing Factors:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. The 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the NRC staff for adopting a fire protection program consistent with NFPA 805. 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.

Appendix H of the LAR does not indicate that FAQ 12-0064, "Hot Work/Transient Fire Frequency Influence Factors," dated January 17, 2013 (ADAMS Accession No. ML12346A488), was used in preparation of the FPRA. According to this FAQ, transient influence factor may not be assigned a ranking value of 0, unless associated activities and/or entrance during power operation are precluded by design and/or operation. The licensee's analysis (Table C-2 of CO-IGN-001) indicates, however, that a large number of PAUs are assigned ranking values of 0 for one or more of the transient influence factors. As a result, clarify whether ranking values assigned to transient influencing factors were developed consistent with the guidance in NUREG/CR-6850 and FAQ 12-0064, in particular Section 6.5.7.2, and if not, provide justification. If justification cannot be provided, then provide treatment of transient influence factors consistent with NRC guidance in the integrated analysis provided in response to PRA RAI 03.

CCNPP RESPONSE PRA RAI 05:

The methodology of Section 6.5.7 of NUREG/CR-6850 was utilized in the development and assignment of transient fire influencing factors during preparation of the CCNPP Fire PRA. This methodology allowed for factors of 'No (0)', 'Low (1)', 'Medium (3)', 'High (10)' or 'Very High (50)' to be assigned for levels of maintenance, occupancy and storage in each physical analysis unit (PAU). This methodology allowed the use of 'No (0)' only if associated activities and/or entrance during power operation are precluded by design and/or operation. FAQ 12-0064 further reinforces that 'No (0)' can only be used in locations that are physically inaccessible during power operations.

A review of all PAUs having a transient fire influencing factor of 'No (0)' in the analysis (Table C-2 of CO-IGN-001, Fire PRA Ignition Frequency (IGN) Notebook) was performed with the following findings:

- The majority of the PAUs with 'No (0)' values were screened in Task 4 (Qualitative Screening) because either the compartment does not contain PRA components/cables, or it is comprised of a floor/wall containing PRA component raceways which are fully embedded in concrete. These qualitatively screened PAUs are excluded from further

analysis; therefore, the transient fire influencing factors of 'No (0)' that were assigned to them are appropriate and do not dilute the transient fire frequency apportionment.

- Upon review, several PAUs that had been assigned fire influencing factors of 'No (0)' were determined to not meet the requirement that activities and/or entrance during power operation are precluded by design and/or operation. The transient fire influencing factors for these PAUs will be changed to non-zero values consistent with the guidance of NUREG/CR-6850.
- PAUs 314 and 313 represent the lower 18 feet (i.e., the underwater portion) of the Unit 1 and Unit 2 spent fuel pools, respectively. These two PAUs are assigned transient fire influencing factors of 'No (0)'. Upon review, it was determined that activities in and/or entrance to these PAUs during power operation are precluded by design and/or operation; therefore, the assigned transient fire influencing factors of 'No (0)' are consistent with approved NRC guidance. PAUs 314 and 313 will be excluded from the assessment of transient fire influencing factors.

Ignition frequency updates will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI-03.

PRA RAI 06 - Reduced Transient Heat Release Rates:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the NRC staff for adopting a fire protection program consistent with NFPA 805. 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.

It appears that reductions below the NUREG/CR-6850 98th percentile HRR of 317 kilowatt (kW) for transient fires may have been credited in the FPRA. In particular, the licensee's analysis (e.g., Section 6.5.4 of Addendum 1 to CO-FSS-004) indicates that a 142 kW (75th percentile) HRR transient fire was postulated in the switchgear rooms. As a result, discuss the key factors used to justify any reduced HRR below 317 kW, per the guidance endorsed by the June 21, 2012, memo from Joseph Giitter to Biff Bradley, "Recent Fire PRA Methods Review Panel Decisions and EPRI 1022993, 'Evaluation of Peak Heat Release Rates in Electrical Cabinet Fires'" (ADAMS Accession No. ML12171A583). In doing so:

a) Identify all PAUs for which a reduction in the HRR below 317 kW for transient fires is credited.

b) For each location where a reduced HRR is credited, describe the administrative controls that justify the reduced HRR, including how location-specific attributes and considerations are addressed.

c) Provide the results of a review of records related to violations of transient combustible and hot work controls, including how this review informs the development of administrative controls credited, in part, to justify an HRR lower than 317 kW.

CCNPP RESPONSE PRA RAI 06:

06a - A reduction in the HRR below 317kW for transient fires was applied only to the Switchgear Rooms at CCNPP; PAUs 311, 317, 407 and 430. A transient HRR of 142kW was postulated in these rooms.

06b - The justification for using a 142kW as a representative transient fire in PAUs 311, 317, 407 and 430 is as follows:

- Combustible controls are enhanced in areas containing Safety Related equipment, which includes the Switchgear Rooms. All transient combustible material that is required for work in Safety Related areas shall be either
  - Constantly attended (with the exception of short, 1-hour breaks, and lunches); or
  - Removed from the work area at the end of the shift; or
  - Have a Transient Combustible Permit for all of the combustible material that will be needed for the work activity; or
  - Contained in closed metal containers with closed metal lids/openings (cabinets, tool boxes, gang boxes, metal drums, metal drums with flame tamer lids, etc.) that are in good repair.
- Minor amounts of transient combustibles are allowed in the area and exempt from the requirements above. However, minor transient combustibles are limited as follows:
  - Only the amount needed to support the work should be staged/stored
  - Materials are only allowed to be pre-staged for 72 hours or in an approved staging location
  - The materials are to be removed from the work location at the completion of the work activity.
  - Examples of minor transient combustibles are temporary power cables (<100ft), ladders, absorbent pads, test equipment, wood (less than 25 pounds), tool bags, rope, and lead blankets.
- The Switchgear Rooms are considered high risk areas and are designated as such in the plant. High risk areas are subject to additional requirements for work planning activities, including assessment of high risk fire scenarios, transient combustibles and secondary combustibles.

Based on the controls above, there is reasonable assurance that only small amounts of confined trash will be located in these rooms for any period of time. A transient fire in an area with combustible controls, where only a small amount of confined trash is considered possible, is judged to be no larger than the 75th percentile transient fire. A review of the transient ignition source tests in Table G-7 of NUREG/CR-6850 indicates that the type of transient fires which can be expected in these rooms (i.e., rags, paper towels, plastic products, methyl alcohol, etc.) were measured at peak heat release rates of 119kW or below.

06c - CCNPP performed a review of Incident Reports (IRs), for the previous 5 years (from 2009 to present). The review indicated no transient or combustible violations in PAUs 311, 317, 407 and 430. CCNPP maintains strict controls on transient combustibles via plant procedures. Combustible controls are enhanced in Safety Related areas; and the Switchgear Rooms are considered Safety Related. The current controls are sufficient to ensure the

bases outlined in part (b) to this response are not violated. No additional transient controls or transient exclusion zones are required in these areas.

PRA RAI 07 - Self-Ignited and Caused by Welding and Cutting:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the NRC 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.

Appendix H of the LAR does not indicate that FAQ 13-0005, "Cable Fires Special Cases: Self-Ignited and Caused by Welding and Cutting," dated June 26, 2013 (ADAMS Accession No. ML13322B260), was used in preparation of the FPRA. Explain whether the treatment of self-ignited fires and fires caused by welding and cutting is consistent with FAQ 13-0005, and if not, provide justification. If justification cannot be provided, then provide treatment of self-ignited fires and fires caused by welding and cutting consistent with NRC guidance in the integrated analysis provided in response to PRA RAI 03.

CCNPP RESPONSE PRA RAI 07:

Response provided in Reference 2.

PRA RAI 08 - Junction Boxes:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the NRC staff for adopting a fire protection program consistent with NFPA 805. In letter dated July 12, 2006, to NEI from Sunil Weerakkody (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.

Appendix H of the LAR does not indicate that FAQ 13-0006, "Modeling Junction Box Scenarios in an Fire PRA," dated May 6, 2013 (ADAMS Accession No. ML13149A527), was used in preparation of the FPRA. Explain whether the treatment of junction box fires is consistent with FAQ 13-0006, and if not, provide justification. If justification cannot be provided, then provide treatment of junction box fires consistent with NRC guidance in the integrated analysis provided in response to PRA RAI 03.

CCNPP RESPONSE PRA RAI 08:

Response provided in Reference 2.

PRA RAI 09 - Sensitive Electronics:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02,

Revision 2, as providing methods acceptable to the NRC staff for adopting a fire protection program consistent with NFPA 805. 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.

The NRC staff could not identify in the LAR or licensee's analysis a description of how potential fire damage to sensitive electronics was modeled. Though the treatment of sensitive electronics may be consistent with recent guidance on the modeling of sensitive electronics, Appendix H of the LAR does not cite FAQ 13-0004, "Clarifications Regarding Treatment of Sensitive Electronics," dated December 3, 2013 (ADAMS Accession No. ML13322A085), as one of the FAQ guidance documents used to support the FPRA. Describe the treatment of sensitive electronics for the FPRA and explain whether it is consistent with the guidance in FAQ 13-0004, including the caveats about configurations that can invalidate the approach (i.e., sensitive electronic mounted on the surface of cabinets and the presence of louvers or vents). If the approach is not consistent with FAQ 13-0004, justify the approach, or replace the current approach with an acceptable approach in the integrated analysis performed in response to PRA RAI 03.

CCNPP RESPONSE PRA RAI 09:

PRA credited components in compartments where detailed fire modeling is performed will be examined to determine if they meet the definition of temperature sensitive equipment as defined in Fire PRA FAQ 13-0004. The components that meet this definition will be analyzed to determine whether they may be exposed to fire conditions exceeding the damage threshold recommended by NUREG/CR-6850.

Regarding hot gas layer exposure, a temperature sensitive equipment hot gas layer study using CFAST has been performed with varying representative geometries and a range of fire sizes for both fixed and transient sources. The CFAST simulations were used to develop generic categories and will be documented in the CCNPP fire modeling verification and validation documentation. For each category, the upper gas layer and the lower gas layer were analyzed to determine if the damaging hot gases could descend to equipment level, resulting in equipment failure.

The conclusions from the temperature sensitive equipment hot gas layer study will be applied in the fire modeling analysis by correlating each modeled fire compartment to a generic category. The correlation will be made by examining the fire compartment parameters (i.e., compartment volume and ceiling height), with consideration of fire scenario characteristics (i.e., heat release rate and fire growth profile). Fire compartments with parameters within the limits of a generic category will be judged to perform similarly with respect to gas layer formation. Details regarding the application of this study will be documented on a compartment basis in the CCNPP Fire PRA Detailed Fire Modeling.

Damage to temperature sensitive plant equipment caused by radiant heat will make use of a study using Fire Dynamics Simulator (FDS) referenced in Fire PRA FAQ 13-0004. The FDS study concludes that the metal housing of temperature sensitive equipment is effective in reducing damaging heat fluxes so that the damage threshold for thermoset cables can be used. The treatment of sensitive electronics with respect to radiant heat exposure will be consistent with the guidance in Fire PRA FAQ 13-0004.

Fire PRA FAQ 13-0004 includes caveats that can invalidate the use of the thermoset heat flux damage threshold. These caveats include the presence of louvers or vents on the face of a panel, and sensitive electronics that are mounted to the surface of the cabinet. Cabinets that have exposed electronics on the cabinet face that are either test devices, electronic readouts of meters, or monitoring devices that are not critical to cabinet functionality will not be considered to violate these caveats. In addition, cabinets that contain vents on the face of the cabinet will be evaluated on a case by case basis to determine if the sensitive electronics will be shielded from the radiant exposure. This will be based on the positioning and orientation of the vents, if there is no gap in shielding that would allow radiant heat to damage sensitive components the caveats of FAQ 13-0004 are not considered to be violated. Field inspections will be conducted in fire compartments where detailed fire modeling is performed to confirm that sensitive electronic components that make use of the heat flux damage threshold of Fire PRA FAQ 13-0004 do not violate these caveats.

Updates to the fire modeling to include the application of this treatment of sensitive electronics will be incorporated in the updated fire risk results that will be provided to the NRC after the CCNPP fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

PRA RAI 10 - Conditional Probabilities of Spurious Operations:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. Section 2.4.4.1 of NFPA 805 further states that the change in public health risk arising from transition from the current fire protection program to an NFPA 805 based program, and all future plant changes to the program, shall be acceptable to the NRC. RG 1.174 provides quantitative guidelines on CDF, LERF, and identifies acceptable changes to these frequencies that result from proposed changes to the plant's licensing basis and describes a general framework to determine the acceptability of risk-informed changes. The NRC staff's review of the information in the LAR has identified additional information that is required to fully characterize the risk estimates.

Attachment V of the LAR indicates that application of circuit failure probabilities was limited to circuits without control power transformers and further clarifies that the probabilities applied yield conservative risk and delta risk estimates relative to the July 1, 2013, interim guidance (ADAMS Accession No. ML13165A214). However, new guidance on using conditional probabilities of spurious operation for control circuits was recently issued by the NRC in Section 7 of NUREG/CR-7150, Volume 2. This guidance included a) replacement of the conditional hot short probability tables in NUREG/CR-6850 for Option #1 with new circuit failure probabilities for single break and double break control circuits, b) Option #2 in NUREG/CR-6850 is not an adequate method and should not be used, c) replacement of the probability of spurious operation duration figure in FAQ 08-0051 for AC control circuits, d) aggregate values for circuit failure probabilities should be used unless it is demonstrated that a cable is only susceptible to a single failure mode, e) incorporation of the uncertainty values for the circuit failure probabilities and spurious operation duration in the SOKC for developing the mean CDF/LERF, and f) recommendations on the hot short probabilities to use for other cable configurations, including panel wiring, trunk cables, and instrument cables. Provide an assessment of the assumptions used in the Calvert Cliffs FPRA relative to the updated guidance in NUREG/CR-7150, Volume 2, specifically addressing each of the above items. If the FPRA assumptions are not bounded by the new guidance, provide a justification for each difference, or provide updated risk

results as part of the aggregate change-in-risk analysis requested in PRA RAI 03, utilizing the guidance in NUREG/CR-7150.

CCNPP RESPONSE PRA RAI 10:

The modeling of spurious operations will be updated to reflect the recently published guidance in Section 7 of NUREG/CR-7150, Volume 2. Hot short probability and hot short duration probability data will be taken from the applicable tables in Sections 4, 5 and 7 of NUREG/CR-7150, Volume 2. These revised calculations will be will be generated in conjunction with the update of CCNPP FPRA analysis documentation supporting Request for Additional Information (RAI) PRA-03.

PRA RAI 11 - Counting and Treatment of Bin 15 Electrical Cabinets:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the NRC staff for adopting a fire protection program consistent with NFPA 805. 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.

The licensee's analysis (Section 2.2.1 of C0-FSS-002) appears to indicate that the FPRA evaluates the potential for propagation of electrical cabinet fires based solely on the text in Appendix G (Section G.3.3) to NUREG/CR-6850; however, portions of this text were either clarified or disregarded in Chapter 8 of Supplement 1 of NUREG/CR-6850. In light of this observation, address the following:

a) Per Section 6.5.6 of NUREG/CR-6850, fires originating from within "well-sealed electrical cabinets that have robustly secured doors (and/or access panels) and that house only circuits below 440V" do not meet the definition of potentially challenging fires and, therefore, should be excluded from the counting process for Bin 15. By counting these cabinets as ignition sources within Bin 15, the frequencies applied to other cabinets are inappropriately reduced. Clarify that this guidance is being applied. If not, then address the impact as part of the integrated analysis performed in response to PRA RAI 03.

b) Clarify if the criteria used to evaluate whether electrical cabinets below 440V are "well sealed" are consistent with guidance in Chapter 8 of Supplement 1 of NUREG/CR-6850. If not, then address the impact as part of the integrated analysis performed in response to PRA RAI 03.

c) All cabinets having circuits of 440V or greater should be counted for purposes of Bin 15 frequency apportionment based on the guidance in Section 6.5.6 of NUREG/CR-6850. Clarify that this guidance is being applied. If not, then address the impact as part of the integrated analysis performed in response to PRA RAI 03.

d) For those cabinets that house circuits of 440V or greater, propagation of fire outside the ignition source should be evaluated based on guidance in Chapter 6 of NUREG/CR-6850, which states that "an arcing fault could compromise panel integrity (an arcing fault could burn through the panel sides, but this should not be confused with the high energy arcing fault type fires)." Describe how fire propagation outside of cabinets greater than 440V is evaluated (including those that are considered "well-sealed"). If propagation is not

evaluated, then address the impact as part of the integrated analysis performed in response to PRA RAI 03.

CCNPP RESPONSE PRA RAI 11:

11a – The guidance of Chapter 8 (Fire Propagation from Electrical Cabinets / FAQ 08-0042) of Supplement 1 of NUREG/CR-6850 has been utilized to identify well-sealed electrical cabinets that have robustly secured doors (and/or access panels) and that house only circuits below 440VAC. In some instances, however, these cabinets were included in the Bin 15 count. The inclusion of these electrical cabinets could potentially produce non-conservative estimates of the fire risk.

A confirmatory review of the electrical cabinets that were included in the Bin 15 count will be performed. Based on the accepted guidance, well-sealed electrical cabinets that have robustly secured doors (and/or access panels) and that house only circuits below 440VAC will not be counted.

Ignition frequency updates will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI-03.

11b – Response provided in Reference 2.

11c – Response provided in Reference 2.

11d – Response provided in Reference 2.

PRA RAI 12 - High Energy Arcing Faults:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the NRC staff for adopting a fire protection program consistent with NFPA 805. 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.

The NRC staff could not identify in the LAR or licensee's analysis a description of how HEAF were modeled. The licensee's analysis (e.g., Appendix B to C0-FQ-001) appears to indicate that HEAF ignition sources are combined with other ignition sources (e.g., transients) to form fire scenarios. Per Appendix P of NUREG/CR-6850, however, HEAF events and other types of fires have different non-suppression probability curves. In addition, the NRC staff's interpretation of the NUREG/CR-6850 guidance is that the growth of a fire subsequent to a HEAF event, unlike other types of fires, instantaneously starts at a non-zero HRR because of the intensity of the initial heat release from the HEAF. As a result, provide a detailed justification of the FPRA's treatment of HEAF events and the ensuing fire that includes a discussion of conservatisms and non-conservatisms relative to the accepted methods and assesses the associated impacts on the fire total and delta risk results. Alternatively, replace the current approach with an acceptable approach in the integrated analysis performed in

response to PRA RAI 03. Note that the response should address the treatment of all HEAF scenarios, including in the HGL analysis and MCA.

CCNPP RESPONSE PRA RAI 12:

CCNPP is updating the fire modeling to incorporate high energy arching fault (HEAF) scenarios that will be consistent with the method described in Appendix M of NUREG/CR-6850. This will include an instantaneous non-zero heat release rate (HRR) for the fire following the initial HEAF event and the ignition of secondary combustibles within the initial ZOI at time zero. Additional information on the ensuing fire after the HEAF event is described in FM RAI 01f.

HEAF scenarios will not be combined with other ignition sources and will be identified independently in the fire modeling. HEAF scenarios will be evaluated for the potential to create a hot gas layer (HGL) in the room. If the peak HRR for the HEAF scenario is determined to be the highest HRR obtainable in a compartment being analyzed in the Multi-Compartment Analysis (MCA) then the HEAF scenario will be used in determining if the exposing compartment is capable of generating a HGL. Where applicable, non-suppression probabilities will be applied based on the fire source.

Updates to the CCNPP detailed fire modeling to include HEAFs modeled as described in response to this RAI will be reflected in the updated fire risk results that will be provided to the NRC after the CCNPP Fire PRA is updated and additional quantification is performed in response to PRA RAI 03.

PRA RAI 13 - MCR Modeling:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. Section 2.4.4.1 of NFPA 805 further states that the change in public health risk arising from transition from the current fire protection program to an NFPA 805 based program, and all future plant changes to the program, shall be acceptable to the NRC. RG 1.174 provides quantitative guidelines on CDF, LERF, and identifies acceptable changes to these frequencies that result from proposed changes to the plant's licensing basis and describes a general framework to determine the acceptability of risk-informed changes. The NRC staff's review of the information in the LAR has identified additional information that is required to fully characterize the risk estimates.

The licensee's analysis (Section 11.1 of CO-FSS-007) appears to assume that all of the wiring inside MCR control panels is qualified, even though unqualified wiring is known to be present as well. Describe how the presence of both qualified and unqualified wiring is incorporated into the NUREG/CR-6850 Appendix L evaluation. Alternatively, provide treatment of qualification that is consistent with or bounds the actual MCR configuration in the integrated analysis provided in response to PRA RAI 03.

CCNPP RESPONSE PRA RAI 13:

CCNPP will review the Main Control Board (MCB) wiring and update the MCB analysis to appropriately address the requirements concerning the use of thermoset or thermoplastic wires within the MCB. The revised MCB analysis will be included with the revised CCNPP Fire PRA quantification that will be submitted in response to RAI PRA-03.

PRA RAI 14 - Credit for MCR Abandonment Actions:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. Section 2.4.4.1 of NFPA 805 further states that the change in public health risk arising from transition from the current fire protection program to an NFPA 805 based program, and all future plant changes to the program, shall be acceptable to the NRC. RG 1.174 provides quantitative guidelines on CDF, LERF, and identifies acceptable changes to these frequencies that result from proposed changes to the plant's licensing basis and describes a general framework to determine the acceptability of risk-informed changes. The NRC staff's review of the information in the LAR has identified additional information that is required to fully characterize the risk estimates.

Tables W-2 through W-5 of the LAR and the licensee's analysis (Section 9.0 of CO-FSS-007) appear to represent MCR abandonment on loss of habitability as a single scenario with unit specific CCDP and conditional large early release probability (CLERP) values. However, the NRC staff could not identify in the LAR or the licensee's analysis the method(s) used to obtain these values. In light of this:

- *a) Describe how MCR abandonment was modeled for loss of habitability in both the post-transition and the compliant plant. Include identification of the actions required to execute safe alternate shutdown and how they are modeled in the FPRA, including actions that must be performed before leaving the MCR. Also, include an explanation of how the CCDPs and CLERPs are estimated for fires that lead to MCR abandonment.*
- *b) Explain how the CCDPs and CLERPs estimated for fires that lead to abandonment due to loss of habitability address various possible fire-induced failures. Specifically, provide a discussion of how the following scenarios are addressed:*
  - *i. Scenarios where fire fails only a few functions aside from forcing MCR abandonment and successful alternate shutdown is straightforward;*
  - *ii. Scenarios where fire could cause some recoverable functional failures or spurious operations that complicate the shutdown, but successful alternate shutdown is likely; and,*
  - *iii. Scenarios where the fire-induced failures cause great difficulty for shutdown by failing multiple functions and/or complex spurious operations that make successful shutdown unlikely.*
- *c) Explanation of the timing considerations (i.e., total time available, time until cues are reached, manipulation time, and time for decision-making) made to characterize scenarios in Part (b). Include in the explanation the basis for any assumptions made about timing.*
- *d) Discussion of how the probability associated with failure to transfer control to the Auxiliary Shutdown Panel is taken into account in Part (b).*

CCNPP RESPONSE PRA RAI 14:

14a - Main Control Room (MCR) abandonment will be modeled on a scenario basis consistent with the MCR analysis results developed using NUREG/CR-6850 Section 11.5.2, Analysis of Fire Scenarios in the Main Control Room and Appendix L, Main Control Board Fires. The approach will ensure a delta risk between the variant and compliant plant when appropriate

Note that a final list of credited actions will not be available until completion of the integrated analysis performed in response to PRA RAI 03. However, at this time identified pre abandonment actions in the MCR include:

- Trip the Reactor;
- Trip the Main Turbine;
- Trip the Steam Generator Feed Pumps;
- Attempt to shut the Main Steam Isolation Valves (MSIV); and,
- Attempt to trip all Reactor Coolant Pumps.

Post-abandonment actions focus on decay heat removal using the Auxiliary Feedwater (AFW) system with control from the Auxiliary Safe Shutdown Panel (ASSDP). Actions identified at this time are:

- Establish and maintain AFW from the ASSDP;
- Manually close the MSIVs locally if needed;
- Start and align a diesel generator if needed;
- Align the Saltwater Air compressors (SWACs);
- Start the standby turbine driven AFW pump if needed; and,
- Start the motor driven AFW pump if needed.

A successful recovery action is required only when an existing design function fails. For example, a manual local action would be required only when the MSIVs fail to close from the MCR.

As previously stated, the post-abandonment actions are centered on establishing and maintaining AFW flow. Explicit steps for this process already exist in Abnormal Operating Procedures (AOPs). If the AOP action is distinct from the AFW flow actions (for example, the action to locally close the MSIVs or align SWACs) it is evaluated as a separate human failure event (HFE). Starting the standby turbine driven AFW pump (not an explicit AOP action at this time) addresses random failures of the running pump. See the response to RAI 14(b) for an explanation of the CCDPs and CLERPs estimation.

14b - Abandonment CCDPs and CLERPs are evaluated in the CCNPP Fire RPA in the same manner as other fire scenarios: Control flag basic events toggle abandonment specific portions of the fault tree based on the initiator; functional and HFE failures developed in the MCR analysis are set by FRANX; and, the abandonment actions described above are incorporated into their specific functions as applicable:

i. For abandonment scenarios having few or even no failed functions, operators would complete the pre-abandonment actions and establish/maintain AFW from the ASSDP. This is the least complicated and best supported case where automatic system response, vital auxiliaries, and other support are not impacted by fire.

ii. For abandonment scenarios having fire related failures that cause loss of some recoverable functional failures or spurious operations that complicate the shutdown, successful alternate shutdown is likely. These scenarios can be varied, but some of the non-AFW related actions may be required to support the use of AFW and/or maintain

support other support functions and MSO mitigation actions at the ASSDP or at other control locations (for other control locations the action would be considered a recovery action).

iii. For abandonment scenarios where the fire-induced failures cause great difficulty for shutdown by failing multiple functions and/or complex spurious operations, successful shutdown may be unlikely. In these cases, many or all of the post-abandonment actions may be needed.

A complex response will entail more operator actions, thus decreasing the likelihood of success, especially when functional dependencies require all operator actions to succeed.

14c - The timing considerations for the MCR abandonment operator actions characterized above are developed in the same manner as the operator actions in the existing fire scenarios. Specifically, actions are:

- Feasible (i.e., time available meets or exceeds the time required);
- Adjusted for impacts due to fire;
- Defined in the context of the scenario; and,
- Include a timing basis (obtained from thermal-hydraulic calculations, simulator observations and/or operator interviews).

Timing considerations for the MCR abandonment actions were developed using the EPRI HRA Calculator methodology. The total time available for the each action is defined by the success criteria in the context of the scenario.

Specific considerations for time cues include delays in responding to the cue, the time it takes to reach a step in the procedure and the elapsed time from the start of the fire until reactor trip.

The AOPs provide an established sequence of operator actions to mitigate fire impacts based on specific areas. Routine training exercises provide a timing basis for performance of these actions and confidence that the actions are feasible. These timed exercises, in addition to interviews with plant operations personnel, provide the basis for the time associated with decision making and task execution. For post-abandonment actions, travel time to a specific location is considered in the execution time.

For pre-abandonment actions, the actions for tripping the plant are typically the first actions taken upon entry into the AOPs. Based on operator interviews, these are considered to be immediate, memorized actions that the operators practice regularly as part of training or on the simulator. It is reasonable to assume that operators will have time to implement these actions as long as the required equipment is available.

A dependency analysis considering the post fire HEPs will be incorporated into the quantification model.

14d - Post abandonment, the CCNPP Fire RPA credits AFW for decay heat removal. This is consistent with the ASSDP design and existing procedural guidance. Depending on the fire

scenario, additional actions may be required to maintain vital auxiliaries and compressed air. There is no alternative post-abandonment decay heat removal strategy credited in the CCNPP Fire PRA; failure to transfer and control AFW from the ASSDP on abandonment is modeled as leading directly to core damage.

PRA RAI 15 - MCR Abandonment on Loss of Control:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. Section 2.4.4.1 of NFPA 805 further states that the change in public health risk arising from transition from the current fire protection program to an NFPA 805 based program, and all future plant changes to the program, shall be acceptable to the NRC. RG 1.174 provides quantitative guidelines on CDF, LERF, and identifies acceptable changes to these frequencies that result from proposed changes to the plant's licensing basis and describes a general framework to determine the acceptability of risk-informed changes. The NRC staff's review of the information in the LAR has identified additional information that is required to fully characterize the risk estimates.

LAR Table G-1 identifies several PCS actions for non-MCR fire areas (Fire Areas 16 and 17), which encompass, in part, the Unit 1 and Unit 2 CSRs. Additionally, the licensee's analysis (Table 6 of C0-HRA-001) appears to credit actions to transfer control from the MCR to the auxiliary shutdown panel for fires in the CSR. In light of this:

a) Clarify whether the above fire areas (or other non-MCR areas) contain fire scenarios for which primary command and control is not retained in the MCR (i.e., the MCR is abandoned), and if so, explain how this decision was reached.

b) If primary command and control is retained in the MCR, then RG 1.205 states, "Operation of dedicated or alternative shutdown controls while the MCR remains the command and control location would normally be considered a recovery action." If actions taken at the PCS are not considered RAs for scenarios in which primary command and control are retained in the MCR, assess the impact of treating such actions consistent with RG 1.205 on both the delta risk and additional risk of RAs as part of the integrated analysis performed in response to PRA RAI 03. Additionally, discuss the results of the feasibility and reliability evaluation of any new RAs in accordance with FAQ 07-0030.

c) For scenarios in which primary command and control is not retained in the MCR and is instead transferred to the PCS, the actions taken at the PCS are not RAs, and the MCR is assumed to be abandoned on loss of control (or function). Describe these scenarios, discussing how actions taken prior to and after MCR abandonment are modeled in the FPRA and its HRA. Additionally, explain the cues that result in the decision to abandon and their timing, identify the instruments being relied upon to make the abandonment decision, discuss whether the identified instruments are protected, and discuss how failure to transfer control to the PCS is taken into account.

CCNPP RESPONSE PRA RAI 15:

15a - Fires originating in areas other than the Main Control Room (MCR) are considered for abandonment based on functional loss and equipment impact (described in more detail below). A review of all fire scenarios showed that only scenarios originating in the Cable Spreading Room (CSR) result in a combination of losses that would preclude a successful shutdown from the MCR.

15b - At this time, all MCR abandonment cases assume a complete relocation of the primary control station (PCS) to the Auxiliary Safe Shutdown Panel (ASSDP) located in the 45' Switchgear Room, with one exception: For non-abandonment MCR scenarios that impact the feedwater control boards operators will use the ASSDP to control AFW while retaining primary control in the MCR.

Although the action to man the ASSDP is a new recovery action in this instance, the sequence and actions involved are well understood steps in Abnormal Operating Procedures (AOPs) and meet the FAQ 07-0030 Table B feasibility criteria. In addition, a formal reliability analysis consistent with accepted HRA practices will be developed. This operator action is considered a recovery action and will be included in the delta risk and additional risk of recovery actions.

15c - In the LAR submittal model, MCR habitability abandonment will be modeled on a scenario basis consistent with the MCR analysis results developed using NUREG/CR-6850 Section 11.5.2, Analysis of Fire Scenarios in the Main Control Room and Appendix L, Main Control Board Fires.

CSR-based MCR abandonment is determined by functional and/or equipment losses that impact AFW flow control. Specifically, immediate or impending loss of vital auxiliaries, degraded steam generator level indication and/or degraded flow control instruments will lead to MCR abandonment. Loss of the whole CSR compartment meets these conditions. For other CSR cases, the status of these instruments and their support is evaluated and the appropriate fault tree logic is applied. None of the relevant instruments or their supplies are hardened or protected from fire effects beyond normal routing practices and fire suppression coverage.

The pre- and post-abandonment actions identified at this time are described in the PRA RAI 14 – Credit for MCR Abandonment Actions response. That response also provides a discussion of HRA methodology and timing.

The AOP entry condition for MCR abandonment is a fire "that inhibits or prohibits the use of normal shutdown procedures ..." All of the non-habitability scenarios that credit abandonment would have high conditional core damage probabilities (CCDPs) without abandonment, so the abandonment scenarios are appropriate with regard to the AOP entry condition.

There is no other post-abandonment decay heat removal strategy credited in the CCNPP Fire PRA; failure to transfer and control AFW from the ASSDP on MCR abandonment is modeled as leading to core damage.

PRA RAI 16 - State-of-Knowledge Correlation:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. Section 2.4.4.1 of NFPA 805 further states that the change in public health risk arising from transition from the current fire protection program to an NFPA 805 based program, and all future plant changes to the program, shall be acceptable to the NRC. RG 1.174 provides quantitative guidelines on CDF, LERF, and identifies acceptable changes to these frequencies that result from proposed changes to the plant's licensing basis and

describes a general framework to determine the acceptability of risk-informed changes. The NRC staff's review of the information in the LAR has identified additional information that is required to fully characterize the risk estimates.

Section 4.7.3 of the LAR explains that the sources of uncertainty in the FPRA were identified, and specific parameters were analyzed, for sensitivity in support of the NFPA 805 FRE process. It is further explained that during the FRE process, the uncertainty and sensitivity associated with specific FPRA parameters were considerations in the evaluation of the change in risk relative to the applicable acceptance thresholds. Based on these explanations, it appears that the risk results presented in Attachment W of the LAR are point estimates and do not include parameter uncertainty. Explain how the SOKC was taken into account in the FPRA quantification, including fire ignition frequencies, circuit failure likelihood and hot short duration, and non-suppression probabilities. If the SOKC for these parameters was not addressed in the FPRA quantification, then include the impact of the SOKC for these parameters in the integrated analysis performed in response to PRA RAI 03.

CCNPP RESPONSE PRA RAI 16:

Response provided in Reference 1.

PRA RAI 17 - Sensitivity Analysis on FAQ 08-0048 Fire Bin Frequencies:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the NRC staff for adopting a fire protection program consistent with NFPA 805. 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.

The licensee's analysis appears to indicate that generic fire ignition frequencies were based upon those provided in Supplement 1 to NUREG/CR-6850. Chapter 10 of this supplement, however, states that a sensitivity analysis should be performed when using the fire ignition frequencies in the supplement instead of those provided in Table 6-1 of NUREG/CR-6850. As part of the response to PRA RAI 03, provide the results (i.e., CDF, LERF, ΔCDF and ΔLERF) of a sensitivity analysis that evaluates the impact of using the supplement frequencies, consistent with Chapter 10 of Supplement 1 to NUREG/CR-6850. If RG 1.174 risk acceptance guidelines are exceeded, (1) discuss which ones are exceeded, (2) describe the fire protection or related measures that will be taken to provide additional DID, and (3) discuss conservatisms in the analysis and the risk significance of these conservatisms.

CCNPP RESPONSE PRA RAI 17:

This sensitivity evaluation will be performed in conjunction with the completion of the CCNPP Fire PRA model quantification in support of the response to PRA RAI 03. The sensitivity analysis will follow the guidance of NUREG/CR-6850, Supplement 1, Chapter 10, footnote 10 which defines the scope of the sensitivity analysis as being limited to, "bins characterized by an alpha from the EPRI TR-1016735 analysis that is less than or equal to 1." Where the Regulatory Guide (RG) 1.174 risk acceptance guidelines may be exceeded, a review of available Defense-in Depth (DID) measures will be performed. Credit will be taken, where

appropriate for the DID measures as a means of offsetting the risk in areas where the RG 1.174 risk acceptance guidelines are exceeded in the NUREG/CR-6850 sensitivity analysis. The DID measures credited will be commensurate with the increase in risk that is to be offset.

PRA RAI 18 - Calculation of VFDR ΔCDF and ΔLERF:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. Section 2.4.4.1 of NFPA 805 further states that the change in public health risk arising from transition from the current fire protection program to an NFPA 805 based program, and all future plant changes to the program, shall be acceptable to the NRC. RG 1.174 provides quantitative guidelines on CDF, LERF, and identifies acceptable changes to these frequencies that result from proposed changes to the plant's licensing basis and describes a general framework to determine the acceptability of risk-informed changes. The NRC staff's review of the information in the LAR has identified additional information that is required to fully characterize the risk estimates.

Section W.2.1 of the LAR provides some description of how the change-in-risk and the additional risk of RAs associated with VFDRs is determined, but not enough detail to make the approach completely understood. As a result, provide the following:

a) *A detailed definition of both the post-transition and compliant plant models used to calculate the reported change-in-risk, including any special calculations for the MCR and other abandonment areas (if applicable). Include description of the model adjustments made to remove VFDRs from the compliant plant model, such as adding events or logic, or use of surrogate events. Also, provide an explanation of how VFDR- and non-VFDR-related modifications are addressed for both the post-transition and compliant plant models.*

b) *Justification for the assumption in the licensee's analysis (Section 8.0 of EPM Report R2215-008-024) that the risk associated with the post-transition plant model is considered equivalent to that of the compliant plant model for scenarios requiring MCR abandonment.*

c) *A description of how the reported additional risk of RAs was calculated, including any special calculations performed for the MCR and other abandonment areas (if applicable). If non-VFDR-related modifications are credited to reduce delta risk, equating the additional risk of RAs (as discussed in W.2.1) to the sum of the delta risks of the VFDRs that are resolved by crediting an RA may be non-conservative. In this case, the additional risk of these RAs should be re-calculated consistent with FAQ 07-0030 as part of the integrated analysis performed in response to PRA RAI 03.*

d) *A summary of the types of VFDRs that were identified but not modeled in the FPRA. Include any qualitative rationale for excluding these from the change-in-risk calculations.*

e) *A clarification of whether they DID RAs listed in Attachment G of the LAR are quantified in the FPRA. Also, explain whether credit for such DID RAs is necessary for the change-in-risk to be acceptable.*

CCNPP RESPONSE PRA RAI 18:

18a – Response provided in Reference 1.

18b - The MCR abandonment analysis is being revised to provide a quantified CCDP representative of the risk of each scenario consistent with the MCR analysis methodology

defined in NUREG/CR-6850 Section 11.5.2, Analysis of Fire Scenarios in the Main Control Room and Appendix L, Main Control Board Fires.

The primary control station (PCS) for these scenarios will shift to the Alternate Safe Shutdown Panels. Operator actions that support the abandonment shutdown will be identified and developed, including detailed HEPs, consistent with FAQ 07-0030 Establishing Recovery Actions.

The compliant case risk will be quantified based on adjustment of HEPs associated with non-primary control station actions to reflect an HEP consistent with an equivalent action at the primary control station (or by use of a bounding zero HEP value).

This approach will ensure a delta risk between the variant and compliant plant when appropriate and allow the calculation of additional risk associated with use of recovery actions.

The results of this update to the analysis will be submitted in conjunction with the response to PRA RAI 03.

18c – Response provided in Reference 1.

18d – Response provided in Reference 1.

18e – Response provided in Reference 1.

PRA RAI 19 - Attachment W Inconsistencies:

Several inconsistencies were noted within Attachment W as well as between its tables and those in Attachments C and G for particular fire areas. In light of this:

a) Provide clarification on the following inconsistencies, and discuss their significance to the risk results reported in Tables W-6 and W-7:

i. In Table W-6, Unit 1 Fire Areas 2, 8, 13, 18, 18A, 22, 23, 25, 26, 27, 28, 31, 38, 40, and 2CNMT are indicated as Deterministically Compliant (4.2.3.2); however, they are indicated as having VFDRs (i.e., there is a "Yes"' under the "VFDR" column and sometimes under the "RAs" column) as well as very small risk values (i.e., Fire Area 18) or epsilon for ΔCDF/ΔLERF. Similarly, in Table W-7, Unit 2 Fire Areas 3, 4, 6, 14, 15, 19, 19A, 21, 30, 33, 39, and 1CNMT are noted as Deterministically Compliant (4.2.3.2); however, they are indicated as having VFDRs and very small risk values (i.e., Fire Areas 19 and 30) or epsilon for ΔCDF/ΔLERF. Attachment C does not identify any of the above deterministic fire areas as having VFDRs. Furthermore, while for most of these fire areas the ΔCDF/ΔLERF and additional risk of RAs is reported to be epsilon, actual (very small) numerical values are reported for ΔCDF/ΔLERF for Unit 1 Fire Area 18 and for Unit 2 Fire Areas 19 and 30, and actual (very small) numerical values are reported for additional risk of RAs for Unit 1 Fire Area 23.

ii. In Table W-6, Unit 1 Fire Areas 12, 14, 15, 19A, 21, 30, 32, 33, 35, 36, 39, 1CNMT, and IS are indicated as Performance-Based (4.2.4.2) and as having an RA credited in the FPRA (i.e., there is a "Yes"' under the "RAs" column); however, no RAs are

described in the VFDR dispositions presented in Attachment C or listed in Attachment G for these areas. Similarly, Unit 2 Fire Areas 12, 13, 18A, 20, 26, 27, 28, 32, 34, 35, 36, 40, 2CNMT, and IS are indicated as Performance-Based (4.2.4.2) and identify a "Yes"' under RA; however, no RAs were described in the VFDR dispositions presented in Attachment C or listed in Attachment G for these areas. Furthermore, while for most of these fire areas the additional risk of RAs is reported to be epsilon, actual (very small) numerical values are reported for Unit 1 Fire Areas 21 and 36 and for Unit 2 Fire Area 13.

iii. *The LERF (9.49E-08/year (yr) reported in Table W-4 for scenario PAU CC-1A-C (Complete Burn of Vertical Cable Chase 1A) is greater than the total LERF (4.04E-08/yr) reported in Table W-6 for Fire Area 20 (Cable Chase 1A). For two scenarios reported in Table W-4 (PAU 230E-C and PAU 230W-C), which represent fires in Unit 1 Containment, the summation of their LERF (1.99E-07/yr) is greater than the total LERF (1.91 E-07/yr) reported in Table W-6 for Fire Area 1CNMT (Unit 1 Containment). These inconsistencies also exist between Tables W-5 and W-7 for the same scenarios in Unit 2.*

iv. *The Table W-1 Unit 1 fire LERF of 3.2E-06/(chemical reactor (rx)-yr) does not match the corresponding value reported in Table W-6. Similarly, the Table W-1 Unit 2 fire LERF of 4.4E-06/(rx-yr) does not match the corresponding value reported in Table W-7.*

b) *Describe what is meant by the use of "ε," or epsilon, in columns for Fire Area CDF/LERF, ΔCDF/ΔLERF, and additional risk of RAs. Address if epsilon is defined by a specific cut-off value(s). Also, clarify how an actual value for LERF can be reported while epsilon is reported for the corresponding CDF (i.e., Unit 1 Fire Area 24 for additional risk of RAs, Unit 2 Fire Areas 8 and 10 for CDF/LERF and Δ CDF/LERF).*

c) *Describe what is meant by the use of "N/A" in columns for Fire Area CDF/LERF, ΔCDF/ΔLERF, and additional risk of RAs. In doing so, clarify the basis for not reporting Fire Area CDF/LERF values (or epsilon) for Unit 1 and Unit 2 Fire Areas 44, AB-1, AB-3, ABFL, DGB1, DGB2, and TBFL.*

d) *Tables W-6 and W-7 include a risk reduction credit for internal events that is described in a footnote to these tables as covering random failures and internal floods. This risk reduction credit is used to offset the increase in fire risk reported in these tables. Explain how the risk reduction from internal events reported in these tables is calculated.*

CCNPP RESPONSE PRA RAI 19:

19a – Final risk quantification information and license amendment request related updates will be provided after the approaches outlined in all other RAI responses are reviewed and acceptable to the NRC.

19b – Response provided in Reference 1.

19c – Response provided in Reference 1.

19d - Final risk quantification information and license amendment request related updates will be provided after the approaches outlined in all other RAI responses are reviewed and acceptable to the NRC.

PRA RAI 20 - Implementation Item Impact on Risk Estimates:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. Section 2.4.4.1 of NFPA 805 further states that the change in public health risk arising from transition from the current fire protection program to an NFPA 805 based program, and all future plant changes to the program, shall be acceptable to the NRC. RG 1.174 provides quantitative guidelines on CDF, LERF, and identifies acceptable changes to these frequencies that result from proposed changes to the plant's licensing basis and describes a general framework to determine the acceptability of risk-informed changes. The NRC staff's review of the information in the LAR has identified additional information that is required to fully characterize the risk estimates.

Table S-3, Implementation Item 12 of the LAR commits to updating the FPRA and verifying the risk results after "risk related" plant modifications have been incorporated. However, it is unclear to which modifications the implementation item refers. Update Implementation Item 12 to reflect completion of both the Table S-2 modifications and Table S-3 implementation items before this verification.

CCNPP RESPONSE PRA RAI 20:

Response provided in Reference 1.

PRA RAI 21 - Internal Events Peer Review:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. The RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the NRC staff for adopting a fire protection program consistent with NFPA 805. The RG 1.200 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.

Attachment U of the LAR indicates that the full-scope IEPRA peer review was performed against ASME/ANS PRA Standard, RA-S-2008a. In light of this observation, if RG 1.200, Revision 2, and ASME/ANS PRA Standard, RA-Sa-2009, were not used as the basis for the peer review of the IEPRA, then discuss whether any differences between SRs were evaluated and whether they had any impact on the application.

CCNPP RESPONSE PRA RAI 21:

Response provided in Reference 1.

PRA RAI 22 - PRA Upgrades:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. The RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting an FPRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the NRC staff for adopting a fire protection program consistent with NFPA 805. The RG 1.200 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.

The LAR does not indicate whether any changes made to the IEPRA or FPRA since their most recent full-scope peer reviews are consistent with the definition of a "PRA upgrade" in ASME/ANS-RA-Sa-2009, "Standard for Level 1/Large Early Release Frequency for Nuclear Power Plant Applications," as endorsed by RG 1.200, Revision 2. In light of this, identify any such changes. If a focused-scope peer review has not been performed for the identified changes, describe what actions will be implemented to address this issue. If a focused-scope peer review has been performed, confirm whether it was done consistent with the guidance in ASME/ANS-RA-Sa-2009, as endorsed by RG 1.200, and provide any findings and their resolutions.

CCNPP RESPONSE PRA RAI 22:

Response provided in Reference 1.

PRA RAI 23 - Deviations from Acceptable Methods:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. Section 2.4.4.1 of NFPA 805 further states that the change in public health risk arising from transition from the current fire protection program to an NFPA 805 based program, and all future plant changes to the program, shall be acceptable to the NRC. The RG 1.174 provides quantitative guidelines on CDF, LERF, and identifies acceptable changes to these frequencies that result from proposed changes to the plant's licensing basis and describes a general framework to determine the acceptability of risk-informed changes. The NRC staff's review of the information in the LAR has identified additional information that is required to fully characterize the risk estimates.

Section 4.5.1.2 of the LAR states that the FPRA model uses "a methodology consistent with the guidance provided in NUREG/CR-6850 and subsequent clarifications documented in responses to NFPA 805 FAQs" and that "[n]o unreviewed methods or deviations from NUREG/CR-6850 were utilized in the FPRA model development." Indicate if any other methods were employed that deviate from other NRC-accepted guidance (e.g., subsequent clarifications documented in FAQs, interim guidance documents, etc.). If so, describe and justify any proposed method that deviates from NRC guidance, or replace the proposed method with an accepted method. Also, include the proposed method as a method "currently under review" as part of the integrated analysis in the response to PRA RAI 03.

CCNPP RESPONSE PRA RAI 23:

Response provided in Reference 1.

PRA RAI 24 - Defense-in-Depth and Safety Margin:

Section 2.4.3.3 of NFPA 805 states that the PRA approach, methods, and data shall be acceptable to the NRC. Section 2.4.4.1 of NFPA 805 further states that the change in public health risk arising from transition from the current fire protection program to an NFPA 805 based program, and all future plant changes to the program, shall be acceptable to the NRC. The RG 1.174 provides quantitative guidelines on CDF, LERF, and identifies acceptable changes to these frequencies that result from proposed changes to the plant's licensing basis and describes a general framework to determine the acceptability of risk-informed changes. The

NRC staff's review of the information in the LAR has identified additional information that is required to fully characterize the risk estimates.

LAR Section 4.5.2.2 provides a high-level description of how the impact of transition to NFPA 805 impacts DID and safety margin was reviewed, including using the criteria from Section 5.3.5 of NEI 04-02 and from RG 1.205. However, no explanation is provided of how specifically the criteria in these documents were utilized and/or applied in these assessments.

a) *Provide further explanation of the method(s) or criteria used to determine when a substantial imbalance between DID echelons existed in the FREs, and identify the types of plant improvements made in response to this assessment.*

b) *Provide further discussion of the approach in applying the NEI 04-02, "Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program Under 10 CFR 50.48(c)," Revision 2 (ADAMS Accession No. ML081130188) criteria for assessing safety margin in the FREs.*

CCNPP RESPONSE PRA RAI 24:

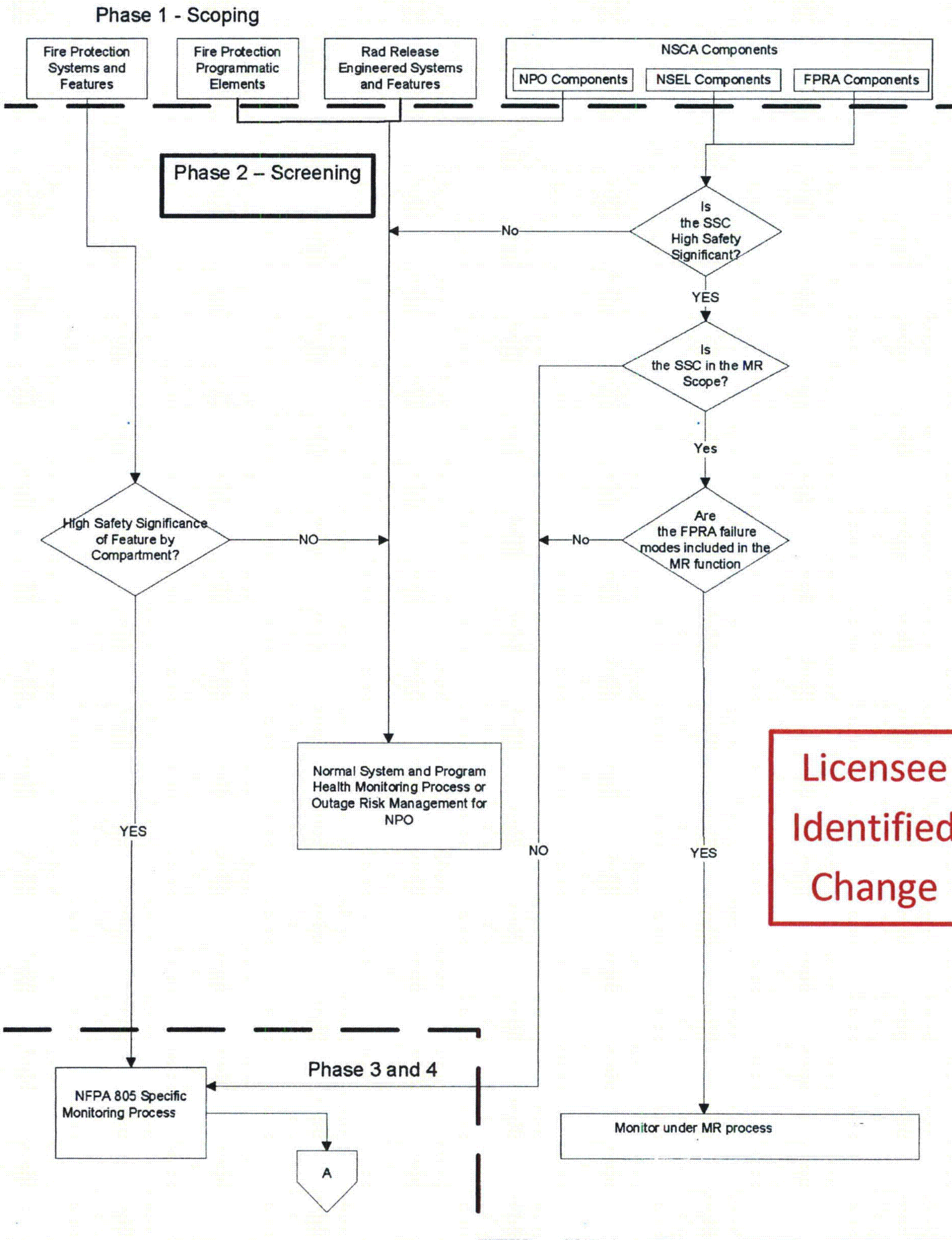
Response provided in Reference 1.

REFERENCES

1. Letter from G. H. Gellrich (Exelon Generation) to Document Control Desk (NRC), dated February 9, 2015, Request for Additional Information Regarding the National Fire Protection Association Standard 805 License Amendment Request
2. Letter from G. H. Gellrich (Exelon Generation) to Document Control Desk (NRC), dated March 11, 2015, Request for Additional Information Regarding the National Fire Protection Association Standard 805 License Amendment Request

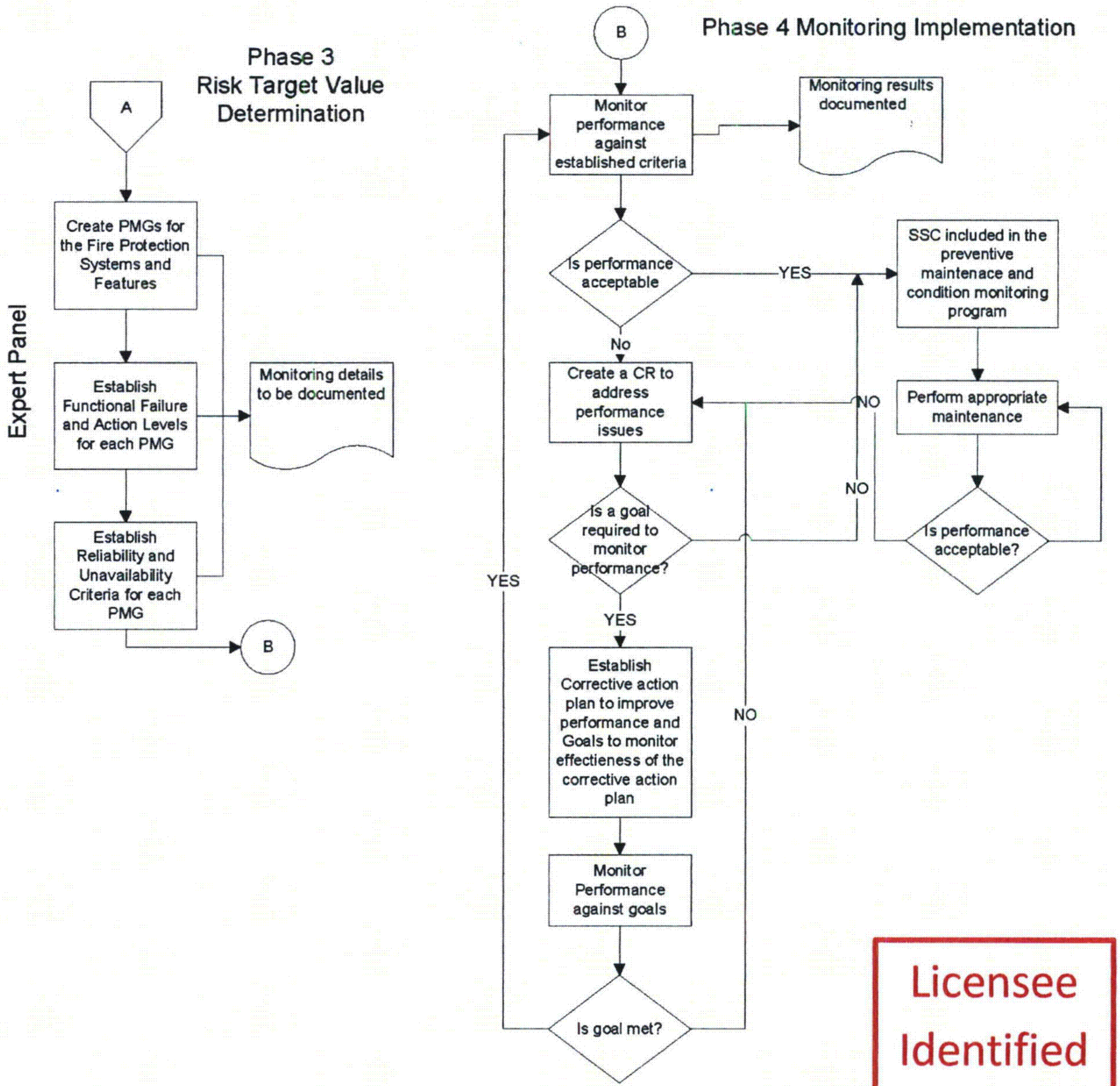
ENCLOSURE 1

UPDATED PAGES



Licensee Identified Change

Figure 4-8 – NFPA 805 Monitoring Program Flowchart (Part 1 of 2)



Licensee Identified Change

Figure 4-8 – NFPA 805 Monitoring Program Flowchart (Part 2 of 2)

51.22(c). That evaluation is discussed in Attachment R. The evaluation confirms that this LAR meets the criteria set forth in 10 CFR 51.22(c)(9) for categorical exclusion from the need for an environmental impact assessment or statement.

5.4 Revision to the UFSAR

After the approval of the LAR, in accordance with 10 CFR 50.71(e), the CCNPP UFSAR will be revised. The format and content will be consistent with NEI 04-02 FAQ 12-0062.

5.5 Transition Implementation Schedule

The following schedule for transitioning CCNPP to the new fire protection licensing basis requires NRC approval of the LAR in accordance with the following schedule:

- Implementation of new NFPA 805 fire protection program to include procedure changes, process updates, and training to affected plant personnel. This will occur ~~180 days~~ following the issuance of an approved SER from the NRC unless that date falls within a scheduled refueling outage. Then, implementation will occur 60 days after startup from that scheduled refueling outage. See Attachment S, Table S-3. Insert
- Modifications will be completed by April 30, 2018. This date assumes SER approval within two years from LAR submittal. Appropriate compensatory measures will be maintained until modifications are complete. See Attachment S, Table S-2.

12 months

Licensee Identified change

It should be noted that Implementation Item IMP-12 is associated with incorporation of the NPFA 805 modifications and the completion of this implementation item is an on-going action initiated within the 180 day timeframe for completion of implementation items but only complete after completion of modification implementation per Table S-2.

PRA RAI 20

NFPA 805 Ch. 3 Ref.	Requirements/Guidance	Compliance Statement	Compliance Basis	Reference Document	
3.3.1.2(1)	Wood used within the power block shall be listed pressure-impregnated or coated with a listed fire-retardant application. Exception: Cribbing timbers 6 in. by 6 in. (15.2 cm by 15.2 cm) or larger shall not be required to be fire-retardant treated.	Complies with Clarification	~~No Additional Clarification~~ Except as identified below, CCNPP complies with the Requirements of NFPA 805, Section 3.3.1.2(1).	NEI 04-02, Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program under 10 CFR 50.48(c), Rev. 2 / Section K.2 Procedure SA-1-100, Fire Prevention, Rev. 01800 / Attachment 1, Section A.2 and PCR-13-02460	Licensee Identified Change
		Submit for NRC Approval	Approval is requested in Attachment L to store wood in designated storage areas of the North Service Building.	None.	Licensee Identified Change
3.3.1.2(2)	Plastic sheeting materials used in the power block shall be fire-retardant types that have passed NFPA 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films, large-scale tests, or equivalent.	Complies	No Additional Clarification	NEI 04-02, Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program under 10 CFR 50.48(c), Rev. 2 / Section K.2 Procedure SA-1-100, Fire Prevention, Rev. 01800 / Attachment 1, Section A.4	
3.3.1.2(3)	Waste, debris, scrap, packing materials, or other combustibles shall be removed from an area immediately following the completion of work or at the end of the shift, whichever comes first.	Complies	No Additional Clarification	Procedure SA-1-100, Fire Prevention, Rev. 01800 / Section 5.2.A.6	

NFPA 805 Ch. 3 Ref.	Requirements/Guidance	Compliance Statement	Compliance Basis	Reference Document
3.3.5 N/A	N/A	N/A	N/A - General Statement; No Technical Requirements	N/A
3.3.5.1	Wiring above suspended ceiling shall be kept to a minimum. Where installed, electrical wiring shall be listed for plenum use, routed in armored cable, routed in metallic conduit, or routed in cable trays with solid metal top and bottom covers.	Complies	Except as identified below, CCNPP complies with no additional clarification.	Procedure CNG-FES-007, Preparation of Design Inputs and Change Impact Screen, Rev. 00017 / Attachment 3 - Section O SA-AA-129-2118, Management and Control of Temporary Power, Rev. 8 / Section 4.1.8 FPE RAI 05
		Submit for NRC Approval	Approval is requested in Attachment L for the current configuration of wiring above suspended ceilings.	None

NFPA 805 Ch. 3 Ref	Requirements/Guidance	Compliance Statement	Compliance Basis	Reference Document
3.3.5.2	Only metal tray and metal conduits shall be used for electrical raceways. Thin wall metallic tubing shall not be used for power, instrumentation, or control cables. Flexible metallic conduits shall only be used in short lengths to connect components.	**Submit for NRC Approval** Complies with Clarification	**Approval is requested in Attachment L for the current configuration and future use of thin wall metallic tubing and non-metal raceways.** Section 1.0 of drawing 61406SEC105.1SH0001 requires that ~~only~~ metal **be used for** cable trays. ~~be used for electrical raceways.~~ Drawing 61406SEC105.2SH0001~~, "Raceway Installation,"~~ Rev. 3, requires that ~~only~~ metal **be used for** conduit. ~~shall be used for electrical raceways.~~ **Drawing 61406SEC105.3SH0001 Rev. 0, requires that non-metallic conduit be used for concrete encased and underground raceways.** Section K.4 of NEI 04-02 clarifies that, where used, cable air drops of limited length (~3 feet) are considered acceptable. ~~Section P of attachment 3, "Electrical/I&C Design Considerations," of engineering standard CNG-FES007, states, "Use metal tray and metal conduits for electrical raceways. Thin wall metallic tubing shall not be used for power, instrumentation, or control cables. Flexible metallic conduits shall only be used in short lengths to connect components."~~	**None** Drawing 61406SEC1051SH0001, Raceway Installation, Rev. 1 / Section 1.0 Drawing 61406SEC105.2SH0001, Raceway Installation, Rev. 3 / Sections 1.0, 2.0, 3.0, 4.0, and 5.0 **Drawing 61406SEC105.3, Raceway Installation, Rev. 0** NEI 04-02, Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program under 10 CFR 50.48(c), Rev. 2 / Section K.4 ~~Procedure CNG-FES-007, Preparation of Design Inputs and Change Impact Screen, Rev. 00017 / Attachment 3 - Section P~~
3.3.5.3	Electric cable construction shall comply with a flame propagation test as acceptable to the AHJ.	Complies with Clarification	Section Q of attachment 3, "Electrical/I&C Design Considerations," to engineering standard CNG-FES007, requires all new, permanent cable installations to comply with the testing criteria of one of the following: IEEE 383-1974, IEEE 1202-1991, CSA (Canadian Standards Association) 22.2 No. 0.3, NFPA 262, UL 44, UL 83, UL 1581, UL 1666, or UL 1685." The tests listed above are acceptable electrical cable construction tests per FAQ 06-0022, which clarifies the cable construction tests that are acceptable to the NRC.	NRC Memorandum from Klein to AFPB File, "Close-Out of National Fire Protection Association Standard 805 Frequently Asked Question 06-0022 Electrical Cable Flame Propagation Tests", dated May 05, 2009 / All FAQ 07-0022, Acceptable Electrical Cable Construction Tests, Rev. 3 / All Procedure CNG-FES-007, Preparation of Design Inputs and Change Impact Screen, Rev. 00017 / Attachment 3 - Section Q

*

*- Licensee Identified Change

NFPA 805 Ch. 3 Ref.	Requirements/Guidance	Compliance Statement	Compliance Basis	Reference Document	
3.4.1 On-Site Fire-Fighting Capability.	All of the following requirements shall apply.	N/A	N/A - General Statement; No Technical Requirements	N/A	
3.4.1(a) On-Site Fire-Fighting Capability.	A fully staffed, trained, and equipped fire-fighting force shall be available at all times to control and extinguish all fires on site. This force shall have a minimum complement of five persons on duty and shall conform with the following NFPA standards as applicable:	Complies with Clarification	Except as identified below, CCNPP complies with the requirements of NFPA 805, Section 3.4.1(a). Section 5.1.A of Procedure SA-1-101 states that "The General Supervisor - Shift Operations shall ensure a Plant Fire Brigade of at least Five (5) qualified members, is maintained on-site at all times." Section 5.5.B of Procedure SA-1-101 states that "The Plant Fire Brigade Leader shall ensure there are a minimum of 5 Plant Fire Brigade members. If there are less than 5 brigade members, notify the Control Room." Procedure SA-1-105 contains the detailed CCNPP requirements and procedures for the training of the fire brigade members. FAQ 12-0063 clarifies that the fire brigade makeup described in this section is intended to include a five-person firefighting team in which all five members are trained and equipped to extinguish fires.	NRC Memo from Klein to AFPB File, "Close-Out of National Fire Protection Association 805 Frequently Asked Question12-0063: Fire Brigade Make-Up", dated July 31, 2012 / All FAQ 12-0063, Fire Brigade Make-Up, Rev. 1 / All Procedure SA-1-101, Fire Fighting, Rev. 00600 / Sections 5.1.A and 5.5.B Procedure SA-1-105, Fire Brigade Training, Rev. 00500 / All	FPE RAI 09
		Complies by Previous NRC Approval.	Section 5.2.2 of the CCNPP Technical Specifications states, "Shift crew composition may be less than the minimum requirement of 10 CFR 50.54(m)(2)(i), 5.2.2.a, and 5.2.2.g for a period of time not to exceed 2 hours in order to accommodate unexpected absence of on-duty shift crew members provided immediate action is taken to restore the shift crew composition to within the minimum requirements." The CCNPP Technical Specifications have been previously approved by the NRC.	CCNPP Technical Specifications, Dated February 20, 2015 / Section 5.2.2 NRC Memo from Klein to AFPB File, "Close-Out of National Fire Protection Association 805 Frequently Asked Question12- 0063: Fire Brigade Make-Up", dated July 31, 2012 / All	FPE RAI 09

Table G-1 – Recovery Actions and Activities Occurring at the Primary Control Station(s)

Fire Area	Recovery Action ID	Component Description	Action	VFDR	RA/PCS	
17	17|AFWFLOW1	TDAFWP HAND CONTROLLERS	CONTROL AFW FLOW AT 1C43	17-50-1	RISK	
18	18|2MCC214R	MCC 214R AND MCC 204R BREAKERS	LOCALLY ALIGN 2MCC214R TO 2MCC204R.	18-07-2	RISK	
18	18|2SWGR45VENT	PORTABLE FAN UNITS	INSTALL PORTABLE FANS FOR TEMPORARY UNIT 2 45' SWGR VENTILATION.	18-15-2	RISK	
18	~~18|2AFW_RECHARGE~~ 18|2IA_CROSSTIE	~~VALVES 0-N2-107, 2-IA-390~~ VALVE 2CV2061	LOCALLY REMOVE CONTROL POWER FUSES FROM CIRCUIT 7 ON 2PNL2P01 AND MANUALLY OPEN 2CV2061.	8-16-2	RISK	SSA RAI 15c
18	18|EDG2BCOOL	SERVICE WATER VALVES 2-SRW-163, 2-SRW-178, 2-SRW-176 AND 2-SRW-168	ALIGN UNIT 1 SERVICE WATER COOLING TO EDG 2B.	18-02-2	DID	
19	19|1SWGR45VENT	PORTABLE FAN UNITS	INSTALL PORTABLE FANS FOR TEMPORARY UNIT 1 45' SWGR VENTILATION.	19-05-1	RISK	
19	~~19|1AFW_RECHARGE~~ 19|1IA_CROSSTIE	~~VALVES 0-N2-105, 1-IA-182~~ VALVE 1CV2061	LOCALLY REMOVE CONTROL POWER FUSES FROM CIRCUIT 7 ON 1PNL1P01 AND MANUALLY OPEN 1CV2061.	9-01-1	RISK	SSA RAI 15c
19	19|EDG1BCOOL	SERVICE WATER VALVES 1-SRW-170, 1-CV-1645, 1-CV-1646, 1-SRW-172, 2-SRW-170, 2-CV-1645, 2-CV-1646 AND 2-SRW-172	ALIGN UNIT 2 SERVICE WATER COOLING TO EDG 1B.	19-02-1	DID	

Table G-1 – Recovery Actions and Activities Occurring at the Primary Control Station(s)

Fire Area	Recovery Action ID	Component Description	Action	VFDR	RA/PCS	
19	19|1CCW	CONTAINMENT SUPPLY HEADER ISOLATION AND RCW EVAPS COMM HDR SUPP 1	ISOLATE COMPONENT COOLING TO UNIT 1 CONTAINMENT.	19-04-1	DID	
20	20|OPEN4KVBKRS	4KV UNIT BUS 14 BREAKERS AND 0C DISCONNECT	OPEN THE FEEDER BREAKERS FOR 4KV UNIT BUS 14 BY TRIPPING BREAKERS 152-1401, 152-1403, AND 152-1414.	20-01-1	RISK	
20	20|4KVLOADS	4KV UNIT BUS 14 BREAKERS AND 0C DISCONNECT	LOCALLY STRIP 4KV UNIT BUS 14 LOAD BREAKERS IN PREPARATION FOR RECOVERY WITH 0C EDG.	20-01-1	RISK	
20	20|0CBUS14	4KV UNIT BUS 14 BREAKERS AND 0C DISCONNECT	ALIGN 0C EDG TO 4KV UNIT BUS 14 BY CLOSING DISCONNECT 189-1406 AND CLOSING BREAKER 152-1406	20-01-1	RISK	
20	20|1SWGR45VENT	PORTABLE FAN UNITS	INSTALL PORTABLE FANS FOR TEMPORARY UNIT 1 45' SWGR VENTILATION.	20-14-1 20-15-1	RISK	
20	~~20|1AFW_RECHARGE~~ 20|1IA_CROSSTIE	~~VALVES 0-N2-105, 1-IA-182~~ VALVE 1CV2061	LOCALLY REMOVE CONTROL POWER FUSES FROM CIRCUIT 7 ON 1PNL1P01 AND MANUALLY OPEN 1CV2061.	20-02-1	RISK	SSA RAI 15c
22	22|OPEN4KVBKRS	4KV UNIT BUS 24 BREAKERS AND 0C DISCONNECT	OPEN THE FEEDER BREAKERS FOR 4KV UNIT BUS 24 BY TRIPPING BREAKERS 152-2401, 152-2403, AND 152-2414.	22-01-2	RISK	
22	22|4KVLOADS	4KV UNIT BUS 24 BREAKERS AND 0C DISCONNECT	LOCALLY STRIP 4KV UNIT BUS 14 LOAD BREAKERS IN PREPARATION FOR RECOVERY WITH 0C EDG.	22-01-2	RISK	
22	22|0CBUS24	4KV UNIT BUS 24 BREAKERS AND 0C DISCONNECT	ALIGN 0C EDG TO 4KV UNIT BUS 24 BY CLOSING DISCONNECT 189-2406 AND CLOSING BREAKER 152-2406.	22-01-2	RISK	
21	21|1IA_CROSSTIE	VALVE 1CV2061	LOCALLY REMOVE CONTROL POWER FUSES FROM CIRCUIT 7 ON 1PNL1P01 AND MANUALLY OPEN 1CV2061.	21-02-1	DID	SSA RAI 15c

Table G-1 – Recovery Actions and Activities Occurring at the Primary Control Station(s)

Fire Area	Recovery Action ID	Component Description	Action	VFDR	RA/PCS
22	22|2RCPTRIP	RCP 13KV SERVICE BUS BREAKER	LOCALLY TRIP THE RCP BREAKER AT 13KV SERVICE BUS 22.	22-11-2	RISK
22	22|2ADV3938CLOSE	22 STEAM GENERATOR ADV	LOCALLY ISOLATE UNIT 2 ADV FOLLOWING FAILURE OF RRS CHANNEL IN SERVICE DURING THE FIRE WITH MANUAL VALVE 2HVMS-104.	22-06-2	RISK
22	22|2ADV3939CLOSE	21 STEAM GENERATOR ADV	LOCALLY ISOLATE UNIT 2 ADV FOLLOWING FAILURE OF RRS CHANNEL IN SERVICE DURING THE FIRE WITH MANUAL VALVE 2HVMS-101.	22-06-2	RISK
22	22|2SWGR45VENT	PORTABLE FAN UNITS	INSTALL PORTABLE FANS FOR TEMPORARY UNIT 2 45' SWGR VENTILATION.	22-17-2 22-18-2	RISK
22	~~22|2AFW_RECHARGE~~ 22|2IA_CROSSTIE	~~VALVES 0-N2-107, 2-IA-390~~ VALVE 2CV2061	LOCALLY REMOVED CONTROL POWER FUSES FROM CIRCUIT 7 ON 2PNL2P01 AND MANUALLY OPEN 2CV2061.	22-05-2	RISK SSA RAI 15c
23	23|2AFW_RECHARGE	VALVES 2-IA-302, 2-IA-303, 2-IA-314 AND 2-IA-317.	LOCALLY ALIGN UNIT 2 SWAC-22 TO THE UNIT 2 AFW VALVES PRIOR TO DEPLETION OF THE UNIT 2 AFW VALVE INSTRUMENT AIR ACCUMULATORS.	23-01-2	RISK
23	23|2RCPTRIP	RCP 13KV SERVICE BUS BREAKER	LOCALLY TRIP THE RCP BREAKER AT 13KV SERVICE BUS 22.	23-12-2	RISK
23	23|0CBUS24	4KV UNIT BUS 24 BREAKERS AND 0C DISCONNECT	ALIGN 0C EDG TO 4KV UNIT BUS 24 BY CLOSING DISCONNECT 189-2406 AND CLOSING BREAKER 152-2406.	23-01-2	RISK

Main Control Room Abandonment

Table J-1 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion
Smoke Concentration or Visibility using FDS Version 5 (Fixed Smoke Yield from Fire and Basic LES Transport Method)	Calculates the smoke concentration to estimate visibility criteria for MCR abandonment.	• NIST Special Publication 1018-5, Volume 2 • NIST Special Publication 1018-5, Volume 3 • NUREG-1824, Volume 7 • NUREG/CR-6850, Section 11	V&V of Version 5 of FDS is documented in NIST Special Publication 1018-5. The V&V of FDS specifically for Nuclear Power Plant applications has been documented in NUREG-1824. It was concluded that FDS models the smoke concentration in an appropriate manner, and tends to over-predict the smoke concentration level, which is conservative. Abandonment criterion that is more conservative than the NUREG/CR-6850 criterion is used, which is considered conservative.
Heat Flux Impacts using FDS Version 5 (Finite Volume Radiation Model)	Calculates the heat flux at various modeled locations to determine the radiant heat flux ZOI at which equipment or cables will reach damage thresholds.	• NIST Special Publication 1018-5, Volume 2 • NIST Special Publication 1018-5, Volume 3 • NUREG-1824, Volume 7 • NUREG/CR-6850, Appendix H	V&V of Version 5 of FDS is documented in NIST Special Publication 1018-5. The V&V of FDS specifically for Nuclear Power Plant applications has been documented in NUREG-1824. It was concluded that FDS models the radiant heat in an appropriate manner. In addition, the predictions of radiant heat and gas temperature were deemed to generally be within the bounds of experimental uncertainty. NUREG/CR-6850 generic screening damage criteria are used, which is considered conservative.
Flame Height Impacts using FDS Version 5 (Mixture Fraction Combustion Model)	Used to determine the ZOI at which equipment or cables will be within the flame height.	• NIST Special Publication 1018-5, Volume 2 • NIST Special Publication 1018-5, Volume 3 • NUREG-1824, Volume 7	V&V of Version 5 of FDS is documented in NIST Special Publication 1018-5. The V&V of FDS specifically for Nuclear Power Plant applications has been documented in NUREG-1824. It was concluded that FDS models the flame height in an appropriate manner. FDS was found to either correctly predict flame heights or to over predict the flame heights, which would be conservative. FM RAI 01a

Table J-1 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion	
Temperature Impacts using FDS Version 5 (Large Eddy Simulation Model)	Calculates the temperature at a specified elevation to estimate temperature criteria for MCR abandonment.	• NIST Special Publication 1018-5, Volume 2 • NIST Special Publication 1018-5, Volume 3 • NUREG-1824, Volume 7 • NUREG/CR-6850, Section 11	V&V of Version 5 of FDS is documented in NIST Special Publication 1018-5. The V&V of FDS specifically for Nuclear Power Plant applications has been documented in NUREG-1824. It was concluded that FDS models the gas temperature in an appropriate manner. In addition, FDS either predicts the hot gas layer height and temperature within the bounds of experimental uncertainty and it may over predict plume temperatures at close distances above the fire source, which would be conservative. NUREG/CR-6850 abandonment criterion is used, which is considered conservative.	FM RAI 01a
PyroSim	Used to create FDS input files.	• Calvert V&V Calculation	PyroSim software is a graphical interface used to create FDS input files. The developers of PyroSim (Thunderhead Engineering) confirmed that PyroSim is verified to build the input file correctly. A multi-level process is used to do this, including testing during development and running example problems through the software to ensure the correct input data is written and results obtained. The software is benchmarked against selected examples from NUREG-1824, "Verification & Validation of Selected Fire Models for Nuclear Power Plant Applications, Volume 7: Fire Dynamics Simulator," to ensure the input is written correctly. In addition, PyroSim has been widely used since 2006 and any discrepancies identified by users are addressed in subsequent releases of the software via a software maintenance agreement.	FM RAI 03

Multi-Compartment Scenarios

Table J-2 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion	
Hot Gas Layer (Method of McCaffrey, Quintiere, and Harkleroad or MQH)	Calculates the hot gas layer temperature for single and combination of adjacent rooms with natural ventilation.	• NUREG-1805, Chapter 2 • NUREG-1824, Volume 3 • SFPE Handbook, 4th Edition, Chapter 3	The correlation is used in the NUREG-1805 fire model, for which V&V was documented in NUREG-1824. The correlation is documented in an authoritative publication of the SFPE Handbook of Fire Protection Engineering. The correlation is used within the limits of its range of applicability.	
~~Hot Gas Layer (Method of Foote, Pagni, and Alvares or FPA)~~	~~Calculates the hot gas layer temperature for single and combination of adjacent rooms with forced ventilation.~~	~~• NUREG-1805, Chapter 2~~ ~~• NUREG-1824, Volume 3~~ ~~• SFPE Handbook, 4th Edition, Chapter 3~~	~~The correlation is used in the NUREG-1805 fire model, for which V&V was documented in NUREG-1824. The correlation is documented in an authoritative publication of the SFPE Handbook of Fire Protection Engineering. The correlation is used within the limits of its range of applicability.~~	FM RAI 01a
Pool Fire Heat Release Rate (NUREG/CR-6850)	Calculates the heat release rate of a liquid hydrocarbon fuel pool fire.	• NUREG-1805, Chapter 3 • SFPE Handbook, 4th Edition, Chapter 2 • NUREG/CR-6850, Appendix G	Correlation used is conservative since it does not use the correction factor (always less than one) based on an empirical factor and pool diameter. The formulations are provided in NUREG-1805, Chapter 3. The correlation is documented in an authoritative publication of the SFPE Handbook of Fire Protection Engineering. The correlation is used within the limits of its range of applicability.	
~~Radiant Heat Flux (Point Source Method of Drysdale)~~	~~Calculates the horizontal or radial separation distance to a target in order to determine the horizontal extent of the ZOI based on heat flux for electrical cabinets.~~	~~• NUREG-1805, Chapter 5~~ ~~• NUREG-1824, Volume 3~~ ~~• SFPE Handbook, 4th Edition, Chapter 3~~ ~~• NUREG/CR-6850, Appendix H~~	~~The correlation is used in the NUREG-1805 fire model, for which V&V was documented in NUREG-1824. The correlation is documented in an authoritative publication of the SFPE Handbook of Fire Protection Engineering. The correlation is used within the limits of its range of applicability. NUREG/CR-6850 generic screening damage criteria are used, which is considered conservative.~~	FM RAI 01a

Table J-2 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion
~~Radiant Heat Flux (Radiant Flame Method)~~	~~Calculates the horizontal or radial separation distance to a target in order to determine the horizontal extent of the ZOI based on heat flux for oil fires.~~	~~• NUREG-1805, Chapter 5~~ ~~• NUREG-1824, Volume 3~~ ~~• SFPE Handbook, 4th Edition, Chapter 3~~ ~~• NUREG/CR-6850, Appendix H~~	~~The correlation is used in the NUREG-1805 fire model, for which V&V was documented in NUREG-1824. The correlation is documented in an authoritative publication of the SFPE Handbook of Fire Protection Engineering. The correlation is used within the limits of its range of applicability. NUREG/CR-6850 generic screening damage criteria are used, which is considered conservative.~~
Corner and Wall HRR	Determines a HRR adjustment factor for fires that are proximate to a wall or corner.	• SFPE Handbook, 4th Edition, Chapter 1 • Fire Safety Science 1: 849-858 "Burning Rate Of Upholstered Chairs In The Center, Alongside A Wall And In The Corner Of A Compartment." • Fire Safety Science 3: 657-666, "Ignition Sources In Room Fire Tests And Some Implications For Flame Spread Evaluation." • Fire Safety Science 5: 261-271, "Flame And Plume Behavior In And Near A Corner Of Walls" • An Introduction to Fire Dynamics, 3rd Edition • The Effects of Building Elements and Smoke Layer on Fire Spread Between Combustible Materials. • NRC Inspection Manual, Manual Chapter 0609 Appendix F	• The HRR input to plume and ceiling jet correlations was adjusted by using a "location factor" when the fire was located either flush to a wall or within two feet of a corner. The location factor doubled the HRR for both the plume and ceiling jet correlations for a fire flush to a wall, and quadrupled it for a fire within two feet of corner. • Although not specifically verified and validated in NUREG-1824, the correlation is documented in recognized Fire Protection Engineering publications. • The correlation has been applied in a manner consistent with the referenced studies or it has been qualitatively justified as acceptable.

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Table J-2 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion
Plume Radius (Method of Heskestad)	Calculates the horizontal radius, based on temperature, of the plume at a given height. The correlation is derived from the Heskestad centerline plume correlation.	• FIVE – Revision 1, Referenced by EPRI Report 1002981, 2002 • NUREG-1824, Volume 4, 2007 • NUREG-1824, Supplement 1, Draft, 2014 • NUREG-1934, Chapter 2, 2012 • SFPE Handbook of Fire Protection Engineering, 4th Edition, Chapter 2-1, Heskestad, G., 2008	The correlation is contained in the FIVE-Rev1 fire model. The correlation is documented in an authoritative publication of the "SFPE Handbook of Fire Protection Engineering." Although not specifically verified and validated in NUREG-1824, Page 2-7 of the 4th Edition of the SFPE Handbook of Fire Protection Engineering states that the value calculated by this correlation is the point where the temperature has declined to half of the centerline plume temperature. The Heskestad centerline plume correlation is verified and validated in NUREG-1824, including the Supplement 1, Draft. The correlation will be applied within its limits of applicability and the validated range reported in NUREG-1934 and NUREG-1824 Supplement 1, Draft or, if applied outside the validated range, the model will be justified as acceptable, either by qualitative analysis, or by quantitative sensitivity analysis. The methodology for justifying application of the fire model outside the range is in accordance with methods documented in NUREG-1934.
Correlation for Flame Spread over Horizontal Cable Trays (FLASH-CAT)	Predicts the growth and spread of a fire within a vertical stack of horizontal cable trays.	• NUREG/CR-7010, Section 9, 2012 • NUREG/CR-6850, Volume 2, Appendix R, 2005	The correlation is recommended by NUREG/CR-7010 and follows guidance set forth in NUREG/CR-6850. The FLASH-CAT model is validated in NUREG/CR-7010, Section 9.2.3, through experimentally measured HRRs compared with the predictions of the FLASH-CAT model. The correlation will be applied to configurations consistent with those reported in NUREG/CR-7010 or the correlation will be qualitatively justified as acceptable.

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Table J-2 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion
Engineering Planning and Management (EPM) Fire Modeling Workbook (FMWB)	Used to calculate the zone of influence associated with fire scenarios.	• Calvert V&V Calculation	The FMWB is a collection of fire modeling correlations that are already documented in NUREG-1805 FDTs, "Fire Dynamics Tools (FDTs),:Quantitative Fire Hazard Analysis Methods for the US Nuclear Regulatory Commission Fire Protection Inspection Program," December 2004, and Fire Induced Vulnerability Evaluation (FIVE), "EPRI Fire Induced Vulnerability Evaluation Methodology", Revision 1, Referenced by EPRI Report 1002981, 2002. The fire modeling correlations within the Fire Modeling Workbook (FMWB) have been verified, by "black box" testing, to ensure that the results were identical to the verified and validated models. "Black box" testing (or functional testing) is testing that ignores the internal mechanism of a system or component and focuses solely on the outputs generated in response to selected inputs and execution conditions. The results from the FMWB were compared to those produced by the NUREG-1805 FDTs and FIVE-Rev1, when identical inputs were entered into both. Since the correlations from NUREG-1805 FDTs and FIVE, Rev1, were verified and validated in NUREG-1824, including the Supplement 1 Draft and the results match the results produced by the FMWB, the FMWB is verified and validated with respect to NUREG-1934 and NUREG-1824 Supplement 1, Draft.

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Table J-4 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion
Pool Fire Flame Height (Method of Thomas)	Calculates the flame height of a liquid hydrocarbon fuel pool fire.	• NUREG-1805, Chapter 3 • NUREG-1824, Volume 3 • SFPE Handbook, 4th Edition, Chapter 3	The correlation is used in the NUREG-1805 fire model, for which V&V was documented in NUREG-1824. The correlation is documented in an authoritative publication of the SFPE Handbook of Fire Protection Engineering. The correlation is used within the limits of its range of applicability.
~~Time to Ignition of Combustible Materials (Method of Tewarson)~~	~~Estimates the time to ignition of a target combustible material exposed to a constant radiative heat flux.~~	~~• NUREG-1805, Chapter 6~~ ~~• NUREG-1824, Volume 3~~ ~~• SFPE Handbook, 4th Edition, Chapter 3~~	~~The correlation is used in the NUREG-1805 fire model. The correlation is documented in an authoritative publication of the SFPE Handbook of Fire Protection Engineering. The correlation is used within the limits of its range of applicability.~~
~~Wall Flame Height (Method of Delichatsios)~~	~~Calculates the flame height of a liquid hydrocarbon fuel pool fire when the fuel pool is located against a wall.~~	~~• NUREG-1805, Chapter 4~~ ~~• NUREG-1824, Volume 3~~ ~~• SFPE Handbook, 4th Edition, Chapter 3~~	~~The correlation is used in the NUREG-1805 fire model. The correlation is documented in an authoritative publication of the SFPE Handbook of Fire Protection Engineering. The correlation is used within the limits of its range of applicability.~~
~~Corner Flame Height (Method of Hesemi and Tokunaga)~~	~~Calculates the flame height of a liquid hydrocarbon fuel pool fire when the fuel pool is located in a wall corner.~~	~~• NUREG-1805, Chapter 4~~ ~~• NUREG-1824, Volume 3~~ ~~• Combustion Science and Technology, Volume 40~~	~~The correlation is used in the NUREG-1805 fire model. The correlation is documented in a publication of the ASME and Combustion Science and Technology as documented in NUREG-1805. The correlation is used within the limits of its range of applicability.~~

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Table J-4 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion
Smoke Detection Actuation using FDS Version 5 (Using Temperature Criteria)	Determine temperature for smoke detection timing estimates.	• NUREG-1805, Chapter 11 • NUREG-1824, Volume 3 • NIST Special Publication 1018-5, Volume 2 • NIST Special Publication 1018-5, Volume 3 • NUREG-1824, Volume 7	The criterion used is documented in the NUREG-1805 fire model. V&V of Version 5 of FDS is documented in NIST Special Publication 1018-5. The V&V of FDS specifically for Nuclear Power Plant applications has been documented in NUREG-1824. It was concluded that FDS models the gas temperature in an appropriate manner. In addition, FDS either predicts the hot gas layer height and temperature within the bounds of experimental uncertainty and it may over predict plume temperatures at close distances above the fire source, which would be conservative.
~~Smoke Detection Actuation Correlation (Heskestad and Delichatsios)~~	~~Heskestad and Delichatsios temperature to smoke density for smoke detection timing estimates.~~	• ~~SFPE Handbook, 4th edition, Chapter 4-1, Custer R., Meacham B., and Schifiliti, R., 2008~~ • ~~SFPE Handbook, 4th Edition, Chapter 2-2, Alpert, R., 2008~~	~~The temperature to smoke density correlation is documented in an authoritative publication of the SFPE Handbook of Fire Protection Engineering. The correlation is used within the limits of its range of applicability.~~
~~Cable Response to Live Fire (CAROLFIRE) (Thermally-Induced Electrical Failure (THIEF) Model)~~	~~Calculates the temperature at various modeled locations to determine if cables will reach damage thresholds.~~	• ~~NUREG/CR-6931, Volume 3~~ • ~~NIST Special Publication 1018-5, Volume 2~~ • ~~NIST Special Publication 1018-5, Volume 3~~ • ~~NUREG-1824, Volume 7~~	~~V&V of Version 5 of FDS is documented in NIST Special Publication 1018-5. The V&V of FDS specifically for Nuclear Power Plant applications has been documented in NUREG-1824. Additionally, the THIEF model is benchmarked in NUREG/CR-6931, Section 9.2.3, through experimentally measured cable temperatures and times to failure compared with the predictions of the THIEF model, and was found to under-predict the time to failure (reaching threshold temperature) by 15 %, on average. This result was found to be realistic and is somewhat conservative. This parameter was used as a secondary check to the temperature and heat flux impacts.~~

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Table J-4 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion
Correlation for Heat Release Rates and Ignition Timing of Cable Fires (Method of Lee)	Used to correlate benchscale data to heat release rates from cable tray fires and estimate the ignition time of cable tray fires or secondary ignition of cable tray(s).	• NUREG/CR-6850, Appendix R • SFPE Handbook, 4th Edition, Chapter 3	The correlation is recommended by NUREG/CR-6850. The correlation is documented in an authoritative publication of the SFPE Handbook of Fire Protection Engineering. The correlation is used within the limits of its range of applicability.
Corner and Wall HRR	Determines a HRR adjustment factor for fires that are proximate to a wall or corner.	• SFPE Handbook, 4th Edition, Chapter 1 • Fire Safety Science 1: 849-858 "Burning Rate Of Upholstered Chairs In The Center, Alongside A Wall And In The Corner Of A Compartment." • Fire Safety Science 3: 657-666, "Ignition Sources In Room Fire Tests And Some Implications For Flame Spread Evaluation." • Fire Safety Science 5: 261-271, "Flame And Plume Behavior In And Near A Corner Of Walls" • An Introduction to Fire Dynamics, 3rd Edition • The Effects of Building Elements and Smoke Layer on Fire Spread Between Combustible Materials. • NRC Inspection Manual, Manual Chapter 0609 Appendix F	• The HRR input to plume and ceiling jet correlations was adjusted by using a "location factor" when the fire was located either flush to a wall or within two feet of a corner. The location factor doubled the HRR for both the plume and ceiling jet correlations for a fire flush to a wall, and quadrupled it for a fire within two feet of a corner. • Although not specifically verified and validated in NUREG-1824, the correlation is documented in recognized Fire Protection Engineering publications. • The correlation has been applied in a manner consistent with the referenced studies or it has been qualitatively justified as acceptable.

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Table J-4 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion
Plume Radius (Method of Heskestad)	Calculates the horizontal radius, based on temperature, of the plume at a given height. The correlation is derived from the Heskestad centerline plume correlation.	• FIVE – Revision 1, Referenced by EPRI Report 1002981, 2002 • NUREG-1824, Volume 4, 2007 • NUREG-1824, Supplement 1, Draft, 2014 • NUREG-1934, Chapter 2, 2012 • SFPE Handbook of Fire Protection Engineering, 4th Edition, Chapter 2-1, Heskestad, G., 2008	The correlation is contained in the FIVE-Rev1 fire model. The correlation is documented in an authoritative publication of the "SFPE Handbook of Fire Protection Engineering." Although not specifically verified and validated in NUREG-1824, Page 2-7 of the 4th Edition of the SFPE Handbook of Fire Protection Engineering states that the value calculated by this correlation is the point where the temperature has declined to half of the centerline plume temperature. The Heskestad centerline plume correlation is verified and validated in NUREG-1824, including the Supplement 1, Draft. The correlation will be applied within its limits of applicability and the validated range reported in NUREG-1934 and NUREG-1824 Supplement 1, Draft or, if applied outside the validated range, the model will be justified as acceptable, either by qualitative analysis, or by quantitative sensitivity analysis. The methodology for justifying application of the fire model outside the range is in accordance with methods documented in NUREG-1934.
Ceiling Jet Temperature (Method of Alpert)	Calculates the horizontal separation distance, based on temperature at the ceiling of a room, to a target in order to determine the horizontal extent of the ZOI.	• FIVE - Revision 1, Referenced by EPRI Report 1002981, 2002 • NUREG-1824, Volume 4, 2007 • NUREG-1824, Supplement 1, Draft, 2014 • NUREG-1934, Chapter 2, 2012 • SFPE Handbook of Fire Protection Engineering, 4th Edition, Chapter 2-2, Alpert, R., 2008	The correlation is used in the FIVE – Revision 1 fire model, for which V&V is documented in NUREG-1824, including the Supplement 1, Draft, 2014. The correlation is documented in an authoritative publication of the "SFPE Handbook of Fire Protection Engineering." The correlation will be applied within its limits of applicability and the validated range reported in NUREG-1934 and NUREG-1824 Supplement 1, Draft, 2014 or, if applied outside the validated range, the model will be justified as acceptable, either by qualitative analysis, or by quantitative sensitivity analysis. The methodology for justifying application of the fire model outside the range is in accordance with methods documented in NUREG-1934.

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Table J-4 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion
Smoke Detection Actuation Correlation	Estimates smoke and heat detector timing based on the Alpert ceiling jet temperature, velocity, and thermal response of sprinkler.	• NUREG-1805, Chapter 11, 2004 • NFPA Fire Protection Handbook, 19th Edition, Chapter 3-9, Budnick, E., Evans, D., and Nelson, H., 2003 • NUREG-1824, Volume 4, 2007 • NUREG-1824, Supplement 1, Draft, 2014 • NUREG-1934, Chapter 2, 2012	The smoke detection correlation is contained in NUREG-1805. The temperature to smoke density correlation is documented in an authoritative publication of the NFPA Fire Protection Handbook. The correlation V&V is documented in NUREG-1824, including the Supplement 1, Draft. The correlation will be applied within its limits of applicability and the validated range reported in NUREG-1934 and NUREG-1824 Supplement 1, Draft, 2014 or, if applied outside the validated range, the model will be justified as acceptable, either by qualitative analysis, or by quantitative sensitivity analysis. The methodology for justifying application of the fire model outside the range is in accordance with methods documented in NUREG-1934.
Sprinkler Activation Correlation	Used to estimate sprinkler actuation timing based on the Alpert ceiling jet temperature, velocity, and thermal response of sprinkler.	• NUREG-1805, Chapter 10, 2004 • NFPA Handbook, 19th Edition, Chapter 3-9, Budnick, E., Evans, D., and Nelson, H., 2003 • NUREG-1824, Volume 4, 2007 • NUREG-1824, Supplement 1, Draft, 2014	The sprinkler actuation correlation is used in the NUREG-1805 fire model. The correlation is documented in an authoritative publication of the NFPA Fire Protection Handbook. The correlation V&V is documented in NUREG-1824 Supplement 1, Draft, 2014.The correlation will be applied within the validated range reported in NUREG-1934 and NUREG-1824 Supplement 1, Draft, 2014 or will be justified as acceptable by qualitative analysis or quantitative sensitivity analysis.
Plume/Hot Gas Layer Interaction Study using FDS	Determines the point at which hot gas layer and plume interact and establish limits for plume temperature application.	• FDS Version 5 • NIST Special Publication 1018-5, Volume 2, 2010 • NIST Special Publication 1018-5, Volume 3, 2010 • NUREG-1824, Volume 7, 2007	V&V of the FDS is documented in NIST Special Publication 1018-5. The V&V of FDS specifically for Nuclear Power Plant applications is documented in NUREG-1824, including the Supplement 1, Draft, 2014.The model has been applied within its limits of applicability and the validated range reported in NUREG 1934 and NUREG-1824 Supplement 1, Draft, 2014 or, if applied outside the validated range, the model has been justified as acceptable, either by

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Table J-4 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion
		• NUREG-1824, Supplement 1, Draft, 2014 • NUREG-1934, Chapter 2, 2012 • Calvert V&V Calculation	qualitative analysis, or by quantitative sensitivity analysis. The methodology for justifying application of the fire model outside the range is in accordance with methods documented in NUREG-1934.
Temperature Sensitive Equipment Hot Gas Layer Study	Determine the upper and lower gas layer temperatures for various compartments, and the layer height, for use in assessing damage to temperature sensitive equipment.	• NIST Special Publication 1086, 2012 • CFAST Version 6 • NUREG-1824, Volume 5, 2007 • NUREG-1824, Supplement 1, Draft, 2014 • NUREG-1934, Chapter 2, 2012 • Calvert V&V Calculation	V&V of the CFAST code is documented in the NIST Special Publication 1086. The V&V of CFAST specifically for Nuclear Power Plant applications has also been documented in NUREG-1824. The models are applied within their validated range reported in NUREG-1824 Supplement 1, Draft, 2014 or have been justified as acceptable by qualitative analysis or quantitative sensitivity analysis.
Correlation for Flame Spread over Horizontal Cable Trays (FLASH-CAT)	Predicts the growth and spread of a fire within a vertical stack of horizontal cable trays.	• NUREG/CR-7010, Section 9, 2012 • NUREG/CR-6850, Volume 2, Appendix R, 2005	The correlation is recommended by NUREG/CR-7010 and follows guidance set forth in NUREG/CR-6850. The FLASH-CAT model is validated in NUREG/CR-7010, Section 9.2.3, through experimentally measured HRRs compared with the predictions of the FLASH-CAT model. The correlation will be applied to configurations consistent with those reported in NUREG/CR-7010 or the correlation will be qualitatively justified as acceptable.

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Table J-4 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion
PyroSim	Used to create FDS input files.	• Calvert V&V Calculation	PyroSim software is a graphical interface used to create FDS input files. The developers of PyroSim (Thunderhead Engineering) confirmed that PyroSim is verified to build the input file correctly. A multi-level process is used to do this, including testing during development and running example problems through the software to ensure the correct input data is written and results obtained. The software is benchmarked against selected examples from NUREG-1824, "Verification & Validation of Selected Fire Models for Nuclear Power Plant Applications, Volume 7: Fire Dynamics Simulator," to ensure the input is written correctly. In addition, PyroSim has been widely used since 2006 and any discrepancies identified by users are addressed in subsequent releases of the software via a software maintenance agreement.

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Table J-4 V & V Basis for Fire Models / Model Correlations Used

Calculation	Application	V & V Basis	Discussion
Engineering Planning and Management (EPM) Fire Modeling Workbook (FMWB)	Used to calculate the zone of influence associated with fire scenarios.	• Calvert V&V Calculation	The FMWB is a collection of fire modeling correlations that are already documented in NUREG-1805 FDTs, "Fire Dynamics Tools (FDTs),:Quantitative Fire Hazard Analysis Methods for the US Nuclear Regulatory Commission Fire Protection Inspection Program," December 2004, and Fire Induced Vulnerability Evaluation (FIVE), "EPRI Fire Induced Vulnerability Evaluation Methodology", Revision 1, Referenced by EPRI Report 1002981, 2002. The fire modeling correlations within the Fire Modeling Workbook (FMWB) have been verified, by "black box" testing, to ensure that the results were identical to the verified and validated models. "Black box" testing (or functional testing) is testing that ignores the internal mechanism of a system or component and focuses solely on the outputs generated in response to selected inputs and execution conditions. The results from the FMWB were compared to those produced by the NUREG-1805 FDTs and FIVE-Rev1, when identical inputs were entered into both. Since the correlations from NUREG-1805 FDTs and FIVE, Rev1, were verified and validated in NUREG-1824, including the Supplement 1 Draft and the results match the results produced by the FMWB, the FMWB is verified and validated with respect to NUREG-1934 and NUREG-1824 Supplement 1, Draft.

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FM RAI 01a

detection above the ceilings in these areas. ~~However, the NSCA-credited cables that are routed through these above-ceiling areas are protected by metal conduit~~ However, it is expected that the fire will be manually detected and the Control Room operators will dispatch the CCNPP fire brigade to commence manual fire suppression activities. There are limited combustibles above the ceiling; therefore, even if detection is delayed due to the presence of the suspended ceiling a challenging fire is not expected. FPE RAI 05

This variance is technically acceptable based on the following:

Based on walkdowns and above-ceiling surveys in these areas, no ignition sources were observed above the suspended ceilings ~~except for extension cords which are potentially susceptible to self-ignition~~. Exposed wiring above these ceilings was observed to be low-voltage communication and data type "network" cables which are not prone to heat-generating overload faults. No other fixed ignition sources (i.e. fans, fan motors, etc.) were observed above the ceilings. FPE RAI 05

Industry experience has shown that in the unlikely event of a self-ignited cable tray fire, the fire is not expected to spread beyond the cable tray of fire origin. The EPRI fire events database shows that self-ignitable tray fires have only led to localized failures in a small number of cables within a single raceway. No event has led to sustained open flaming fires, or damage to cables beyond the initially impacted raceway.

~~The extension cords above the ceilings in question are not bundled with cables or other combustibles, nor are they routed in cable trays. There is even less likelihood that a self-ignited extension cord fire will lead to a sustained open flaming fire, due to a lack of combustible material in the vicinity of the extension cords.~~ Other than cable insulation, ~~T~~the only other significant combustible material observed above the ceilings was ventilation duct wrap insulation. Documentation of this material identifies that the duct wrap insulation has a flame spread rating of less than 25. The duct wrap insulation will therefore not support sustained combustion or fire growth. In the unlikely event of fire originating in the exposed non-plenum cable, fire will not spread to the duct wrap insulation. FPE RAI 05

Administrative procedures limit the future installation of additional cabling above suspended ceilings and require that all future installations comply with the requirements of NFPA 805, Section 3.3.5.1. ~~Attachment 3 of CNG-FES-007(Reference 6.38) states: "Minimize wiring above suspended ceilings. Where installed, electrical wiring shall be listed for plenum use, routed in armored cable, routed in metallic conduit, or routed in cable trays with solid metal top and bottom covers." This~~Administrative procedures ~~is in place to~~ will ensure that future compliance with this NFPA 805 requirement is achieved. FPE RAI 05

Per Drawing 60739SH0001 (Reference L-2), ACA ventilation is served by one supply unit (RTU-1) and two independent exhaust units (access control exhaust fans 11 and 12).

In the Fire Area 11 portion of the ACA, supply and exhaust registers in the ceiling are ducted to and from these units, as shown in Drawing 60597 (Reference L-3). The above-ceiling space is therefore not used as an air plenum.

On the Turbine Building side of the ACA, supply registers in the ceiling are ducted to the supply unit, but some exhaust registers in the ceiling are not ducted, as shown in Drawing 60597 (Reference L-3). Exhaust air is pulled from the ceiling plenum into ducts

that lead to the Unit 2 Main Exhaust Plenum where it is exhausted by the main plant exhaust fan 21 or 22. Per Drawings 61085SH00057 (~~Referecne~~Reference L-4); 61085SH0058 (reference L-5); and 63085SH003B (Reference L-6); the ACA exhaust fans are interlocked with the Main Plant Exhaust Fans as well as the ACA supply unit RTU-1. Per Drawings 60739SH0001 (Reference L-7) and 60722SH0001 (Reference L-8), the exhaust air discharges outside and is not recycled and returned to the ACA or any other part of the building. Editorial Change

For the Auxiliary Building ventilation system, including Fire Area 24, supply and exhaust registers in the ceiling are ducted to and from air handling units as shown in Drawing 60317 (References L-9, L-10, L-11) and Drawing 60319SH0002 (Reference L-12). The above-ceiling space is therefore not used as an air plenum.

Acceptance Criteria Evaluation:

Nuclear Safety and Radiological Release Performance Criteria:

As indicated above, there are limited ignition sources above the suspended ceilings in these areas; however, per industry findings, the postulated fires should not grow beyond the cable tray (or cable~~, or extension cord~~) of origin. The combustibles above the ceilings are insufficient to support a sustained fire or fire growth and as such will not cause fire damage to nuclear safety components~~, which are protected by metal conduit and/or metal-covered trays~~. Therefore, there is no impact on the nuclear safety performance criteria. FPE RAI 05

The cables above the suspended ceilings have no impact on the radiological release performance criteria. The radiological release performance criteria are satisfied based on the determination of limiting radioactive release (Attachment E), which is not affected by the cables above the suspended ceilings that do not comply with the requirements specified in section 3.3.5.1 of NFPA 805.

Safety Margin and Defense-in-Depth:

Exposed, non-plenum-rated electrical wiring located above suspended ceilings is minimal, and is sufficiently dispersed. Industry experience has shown that cable fires are limited to the cable tray of origin. A self-ignited cable fire will not grow to a size that could cause damage to components necessary for nuclear safety capability. The NSCA credited cables that are routed above suspended ceilings were evaluated on a fire area basis to determine if their failure would result in a VFDR. NSCA cable failures that resulted in a VFDR were evaluated in accordance with NFPA 805, Section 4.2.4.2, "Performance based approach – fire risk evaluation with simplifying deterministic assumptions," and found to be acceptable. Therefore, the safety margin inherent in the analysis for the fire event has been preserved. FPE RAI 05

The three echelons of defense-in-depth are:

(1) To prevent fires from starting (combustible/hot work controls)

(2) Rapidly detect, control and extinguish fires that do occur, thereby limiting damage (fire detection systems, automatic fire suppression, manual fire suppression, pre-fire plans)

(3) Provide adequate level of fire protection for systems and structures so that a fire will not prevent essential safety functions from being performed (fire barriers, fire

rated cable, success path remains free of fire damage, recovery actions)

Per NFPA 805 Section 1.2, defense-in-depth is achieved when an adequate balance of each of these elements is provided.

~~Exposed, non-plenum rated electrical wiring and extension cords located above suspended ceilings do not significantly affect echelon 1 of the defense-in-depth concept of preventing fires from occurring. The limited quantity of this wiring above suspended ceilings will not result in open, sustained flaming and is therefore not capable of causing fire damage to components necessary for nuclear safety capability, which are protected in enclosed metal raceways. Therefore, echelons 2 and 3 of the defense-in-depth concept are also maintained. Since~~

Echelon 1: Hot work controls and the lack of fixed ignition sources in the areas above the suspended ceilings will limit possibility of fires in the area. FPE RAI 05

Echelon 2: Manual detection and CCNPP fire brigade manual suppression capability for a fire in the above-ceiling space will limit fire damage in the area.

Echelon 3: Fire rated barriers between fire areas limit fire spread above the suspended ceiling and the VFDRs located above the suspended ceiling areas were evaluated and found acceptable in accordance with NFPA 805, Section 4.2.4.2, "Performance based approach – fire risk evaluation with simplifying deterministic assumptions."

~~a~~ A reasonable balance of the elements is provided; therefore, defense-in-depth is achieved.

Conclusion:

NRC approval is requested for the existence of exposed non-plenum-rated electrical wiring above suspended ceilings. Based on the assessment above, the level of risk encountered by this configuration is acceptable. As described above, this approach is considered acceptable because it:

(A) Satisfies the performance goals, performance objectives, and performance criteria specified in NFPA 805 related to nuclear safety and radiological release;

(B) Maintains safety margins; and

(C) Maintains fire protection defense-in-depth (fire prevention, fire detection, fire suppression, mitigation, and post-fire nuclear safety capability).

Approval Request 7

NFPA 805 Section 3.3.1.2(1) states:

"Wood used within the power block shall be listed pressure-impregnated or coated with a listed fire-retardant application.

Exception: Cribbing timbers 6 in. by 6 in. (15.2 cm by 15.2 cm) or larger shall not be required to be fire-retardant treated."

The areas at CCNPP listed below contain some quantity of wood that is not in compliance with NFPA 805, Section 3.3.1.2(1). CCNPP requests NRC approval for the ability to store/use wood in the designated portions of the subject rooms as an acceptable variance from the requirements of NFPA 805 Chapter 3. The request is applicable to the designated fenced-in storage areas described below:

- Fire Area TB/NSB/ACA, Room 1101 (12' North Storage Area)
  - Fenced-in storage area between column DD/102.4 and GG/105.5 (approximately 5,500 ft^2).
- Fire Area TB/NSB/ACA. Room 1109 (Warehouse)
  - Fenced-in storage area between column DD/207.5 and GG/208.5 (approximately 1,900 ft^2).
  - Fenced-in storage area west of the freight elevator to column AA/207.5 (approximately 1,300 ft^2).

Basis for Request:

Room 1101 and 1109 are miscellaneous storage areas at CCNPP. These rooms are part of the fire area TB/NSB/ACA which encompasses the 12' and 27/31' elevations of the North Service Building and all elevations of the Turbine Building. The storage areas contain various types and quantities of combustible storage, including but not limited to rack storage (stored height does not exceed 12'). Limits on quantities of combustibles in these storage areas are administratively established by the fire protection engineer through use of the Combustible Loading Analysis Database.

The likelihood of a fire in these areas is expected to be minimal due to the limited number of fixed ignition sources in the rooms and the procedural controls on hot work and transient combustible material at CCNPP. In the event of a fire in the storage areas, wet pipe suppression is provided in the areas above the storage which has been reviewed for compliance with NFPA 13, "Standard for the Installation of Sprinkler Systems". Actuation of a water flow switch results in a fire alarm signal being transmitted to the continually-manned Control Room. Control Room operators will dispatch CCNPP's onsite fire brigade to extinguish the fire.

There are cable trays located near the ceiling of each room, approximately 24 feet above the floor and 13 feet above the maximum height of storage. There is also a series of cable risers at column FF/102.4 in Room 1101. Although a full room burn of either Room 1101 or Room 1109 is not expected, a deterministic analysis for each of these rooms was completed. Room 1109 does not contain any Nuclear Safety Capability Assessment (NSCA) targets. The deterministic analysis of Room 1101 concluded the following:

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- Backup Control Room/Cable Spreading Room Ventilation and Cooling System is impacted; however, CR/CSR HVAC remains available from redundant systems.
- Offsite power is impacted; however, power remains available to credited 4kV buses from EDGs.
- Non-safety buses are impacted; however, power remains available to credited 4kV buses.
- Steam isolations downstream of the MSIVs are impacted for both units; however, the MSIVs remain available for both units to provide SG isolation.

Based on the above discussion, the deterministic analysis demonstrated that for a fire in Room 1101 or 1109 damaging all NSCA targets, the plant would be able to achieve a safe and stable condition with a NSCA success path free of fire damage. Due to the presence of automatic suppression and the CCNPP onsite fire brigade, the fire is not expected to spread to adjacent rooms. Fire Area TB/NSB/ACA is separated by fire barriers.

Administrative procedures prohibit wood within all other portions of power block structures at CCNPP.

Acceptance Criteria Evaluation:

Nuclear Safety and Radiological Release Performance Criteria:

Although the storage of wood in the subject fenced-in areas of Room 1101 and 1109 does not comply with section 3.3.1.2(1) of NFPA 805, it will not result in a fire that will compromise the nuclear safety performance criteria of NFPA 805. Deterministic analysis has demonstrated for a fire in Room 1101 or 1109 that the plant would be able to achieve a safe and stable condition with a Nuclear Safety Capability Assessment (NSCA) success path free of fire damage.

The storage of wood in the subject fenced-in portion of Room 1101 and 1109 has no impact on the radiological release performance criteria. The radiological release performance criteria are satisfied based on the determination of limiting radioactive release (Attachment E), which is not affected by the storage of wood within the subject areas.

Safety Margin and Defense-in-Depth:

The storage of wood to a height less than 12 feet in the subject fenced-in portions of Room 1101 and 1109 is within the design capabilities of the NFPA 13 wet pipe sprinkler system and a fire will not impact nuclear safety or radioactive release performance criteria; therefore, the safety margin inherent in the analysis for the fire event has been preserved.

The three echelons of defense-in-depth are:

(1) To prevent fires from starting (combustible/hot work controls)

(2) Rapidly detect, control and extinguish fires that do occur, thereby limiting damage (fire detection systems, automatic fire suppression, manual fire suppression, pre-fire plans)

(3) Provide adequate level of fire protection for systems and structures so that a fire will not prevent essential safety functions from being performed (fire barriers, fire rated cable, success path remains free of fire damage, recovery actions)

Per NFPA 805 Section 1.2, defense-in-depth is achieved when an adequate balance of each of these elements are provided.

Echelon 1 is met by the presence of hot work controls and the limited number of fixed ignition sources in the subject areas. Echelon 2 is met by the installed automatic wet pipe sprinkler

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system and the CCNPP on-site fire brigade. Echelon 3 is met through the fire barriers separating Fire Area TB/NSB/ACA from adjacent fire areas as well as a success path remaining free of fire damage even if all cables located within each room are failed due to fire. Since a balance of the elements is provided, defense-in-depth is achieved.

Conclusion:

NRC approval is requested for the ability to store/use wood in the designated portions of Room 1101 and 1109, contrary to the requirements of Section 3.3.1.2(1) of NFPA 805, 2001 Edition. Based on the analysis above, the level of risk encountered by maintaining this current practice is acceptable, and the approach is considered acceptable because it:

(A) Satisfies the performance goals, performance objectives, and performance criteria specified in NFPA 805 related to nuclear safety and radiological release;

(B) Maintains safety margins; and

(C) Maintains fire protection defense-in-depth (fire prevention, fire detection, fire suppression, mitigation, and post-fire nuclear safety capability).

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Approval Request 8

NFPA 805 (2001) Section 3.3.5.2 states:

> *"Only metal tray and metal conduits shall be used for electrical raceways. Thin wall metallic tubing shall not be used for power, instrumentation, or control cables. Flexible metallic conduits shall only be used in short lengths to connect components."*

This approval request is applicable to the following elements of Section 3.3.5.2:

1. **Non-metallic Raceways (Conduit):** This section requires that only metal tray and metal conduits shall be used for electrical raceways. CCNPP currently uses non-metallic raceways (conduit) in concrete-embedded and underground applications.
2. **Thin Wall Metallic Tubing (EMT):** This section requires that thin-wall metallic tubing, or electrical metallic tubing (EMT), shall not be used for power, instrumentation, or control cables. CCNPP currently uses exposed EMT to route cables in various locations throughout the plant.

Basis for Request:

<u>Non-metallic Raceways (Conduit):</u>

The use of non-metallic conduit is required by CCNPP drawing/specifications (61406SEC105.3SH0001) for concrete-embedded and underground installations where metal raceways do not meet design requirements. These design applications are required where:

- corrosive conditions exist (water, chemicals, etc.) and metal conduits are subject to failure; and
- non-metallic conduit is not relied upon for grounding

Non-metallic conduits are required to be suitable for their intended use. New applications of non-metallic conduit are approved and evaluated in accordance with design procedures which include a review of fire protection program design requirements.

Non-metallic conduit designs rely on the concrete in which they are embedded and/or the ground in which they are buried to prevent:

- the failure of credited internal circuits due to an external fire; or
- the failure of credited external circuits due to an internal fire

Non-metallic conduits are not credited to be fire resistance in the NFPA-805 analysis. Non-metallic conduits are combustible; however, due to the installed locations (underground, concrete-embedded) the combustible material associated with these conduits will not contribute to fire loading. Furthermore, the current edition of NFPA 805 (2015) only prohibits non-metallic conduits in exposed electrical raceways. The use of non-metallic conduit in concrete-embedded or underground configurations is no longer prohibited.

CCNPP requests permission to use the following performance-based approach to evaluate and self-approve the use of non-metallic conduits that are neither concrete-embedded nor underground.

The conditions for approval are:

1. Environmental conditions preclude the use of metallic conduit (e.g., corrosive environments).

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2. The use of non-metallic conduit is evaluated by a qualified fire protection engineer, as defined in Generic Letter 82-21, "the fire protection engineers (or engineering consultant) should have the qualifications for membership in the Society of Fire Protection Engineers at the grade of member."
3. The evaluation shall conclude that the configuration of non-metallic conduit:
    a. Is adequate for the fire hazards in the area based on a review of the hazards, fire protection systems and features, and administrative controls;
    b. Satisfies the performance goals, performance objectives, and performance criteria specified in NFPA 805 related to nuclear safety and radiological release;
    c. Maintains safety margin; and
    d. Maintains fire protection defense-in-depth (fire prevention, fire detection, fire suppression, mitigation, and post-fire safe shutdown capability).

Thin Wall Metallic Tubing (EMT)

Article 358.10(A) of NFPA 70, National Electric Code (NEC), 2014 Edition, states, "The use of EMT shall be permitted for both exposed and concealed work." Section 3.3.5.2 of NFPA 805 was revised for consistency with NFPA 70 to remove the sentence regarding thin wall metallic tubing (reference NFPA Report on Proposals for revision to NFPA 805, 2001 Edition). This change has been retained by the current edition of NFPA 805 (2015). The revised section (now Section 5.3.8.2 in the 2015 edition) states:

> *"Only metal tray and metal conduits shall be used for exposed electrical raceways."*

The change to this code was made by the NFPA Technical Committee on Fire Protection for Nuclear Facilities. This committee is made up of experts representing varied viewpoints and interests concerning nuclear facility fire protection, through a consensus standards development process.

The basis for this approval request is:

- The NFPA 805 (2015) edition, Section 5.3.8.2, allows the use of EMT.
- EMT is non-combustible.
- The NEC permits the use of EMT in applications where it is not subject to severe physical damage.
- EMT has been installed at CCNPP since its original construction, in accordance with plant specifications/drawings, which allow for the use of EMT.
- EMT has been installed at CCNPP under design and fire protection program procedures such that technical requirements are properly met for the intended use.

Acceptance Criteria Evaluation:

Nuclear Safety and Radioactive Release Performance Criteria:

Non-metallic Raceways (Conduit)

The use of non-metallic conduit does not adversely affect nuclear safety since the materials in which the conduits are run (concrete and earth) effectively render the non-metallic conduit non-

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combustible. New installations of non-metallic conduit are evaluated in accordance with design and fire protection program procedures.

The use of non-metallic conduit in concrete-embedded and underground locations has no impact on the radioactive release performance criteria. The radioactive release review was performed based on the potential location of radiological concerns and is not dependent on the type of conduit material. The use of non-metallic conduit in concrete-embedded and underground locations does not add additional radiological materials or challenge the integrity of plant boundaries.

Thin Wall Metallic Tubing

The use of EMT in the plant does not have an adverse effect on nuclear safety. EMT is noncombustible and will not contribute to fire load. Neither non-EMT nor EMT metallic conduits are credited in NFPA 805 analyses to prevent or delay damage due to fire. Therefore, the use of EMT does not impact the nuclear safety performance criteria.

The use of EMT has no impact on the radioactive release performance criteria. The radioactive release review was performed based on the potential location of radiological concerns and is not dependent on the construction of metallic conduits. The use of EMT does not add additional radiological materials or challenge the integrity of plant boundaries.

Safety Margin and Defense-in-Depth:

Non-Metallic Raceways (Conduits)

The use of non-metallic conduit will not adversely impact the ability to meet the NFPA 805 nuclear safety or radioactive release performance criteria. While non-metallic conduit is combustible, it is embedded or buried in non-combustible materials. The use of these materials has been defined by the limitations of the analytical methods used in the development of the Fire PRA. Therefore, the inherent safety margin and conservatisms in these methods remain unchanged. The three echelons of defense-in-depth are:

1) to prevent fires from starting (combustible/hot work controls),
2) to rapidly detect, control, and extinguish fires that do occur, thereby limiting damage (fire detection systems, automatic fire suppression, manual fire suppression, pre-fire plans), and
3) to provide an adequate level of fire protection for systems and structures so that a fire will not prevent essential safety functions from being performed (fire barriers, fire-rated cable, success path remains free of fire damage, recovery actions).

Per NFPA 805 (2001)Section 1.2, defense-in-depth is achieved when an adequate balance of each of these elements is provided.

Echelon 1: Non-metallic conduit is installed in concrete-embedded and underground locations. A fire occurring in one of the cables will not spread to impact adjacent fire areas due to combustible non-metallic conduit because the conduits are embedded in, or buried under, non-combustible materials.

Echelon 2: Areas adjacent to those containing non-metallic conduit are protected by manual fire suppression functions, such as portable extinguishers and hose reel stations that are available for manual firefighting activities by the site fire brigade, to assure that if a fire was to occur that damage from the fire would be limited.

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Echelon 3: The use of non-metallic conduit does not result in compromising automatic fire suppression functions, manual fire suppression functions, or the ability to maintain a success path free of fire damage.

Therefore, the use of non-metallic conduit in concrete-embedded or underground installations does not affect the balance of echelons, 1, 2, or 3 and fire protection defense-in-depth is maintained.

Thin Wall Metallic tubing

The use of EMT will not adversely impact the ability to meet the NFPA 805 nuclear safety or radioactive release performance criteria. EMT is noncombustible due to its metallic construction and its use is allowed by the NEC. Therefore, the safety margin inherent in the analysis for the fire event has been preserved.

The three echelons of defense-in-depth are:

1) to prevent fires from starting (combustible/hot work controls),
2) to rapidly detect, control, and extinguish fires that do occur, thereby limiting damage (fire detection systems, automatic fire suppression, manual fire suppression, pre-fire plans), and
3) to provide an adequate level of fire protection for systems and structures so that a fire will not prevent essential safety functions from being performed (fire barriers, fire-rated cable, success path remains free of fire damage, recovery actions).

Per NFPA 805 (2001) Section 1.2, defense-in-depth is achieved when an adequate balance of each of these elements is provided.

Echelon 1: Administrative hot work controls and transient combustible controls are present in the areas where EMT is routed. The use of EMT is permitted by the NEC when installed in areas not subject to severe physical damage. The use of EMT will not result in additional cables being considered ignition sources.

Echelon 2: Areas where EMT is used are protected by manual fire suppression functions, such as portable extinguishers and hose reel stations that are available for manual firefighting activities by the site fire brigade, to assure that if a fire was to occur that damage from the fire would be limited.

Echelon 3: The use of EMT does not result in compromising automatic fire suppression functions, manual fire suppression function, or the ability to maintain a success path free of fire damage.

Therefore, the use of EMT does not affect the balance of echelons, 1, 2, or 3 and fire protection defense-in-depth is maintained.

Conclusion:

NRC approval is requested for the use of non-metallic conduit in concrete-embedded or underground installations; and for the use of thin-walled metallic conduit (EMT) in existing and future applications. The request also includes the ability to use the performance-based approach described herein to evaluate the use of non-metallic conduits that are neither concrete-embedded nor underground. The performance-based methods used for this analysis provide an equivalent level of fire protection to NFPA 805 (2001) Section 3.3.5.2 and:

- Satisfy the performance goals, performance objectives, and performance criteria specified in NFPA 805 related to nuclear safety and radioactive release;

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- Maintain safety margins; and
- Maintain fire protection defense-in-depth (fire prevention, fire detection, fire suppression, mitigation, and post-fire safe shutdown capability).

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