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**Jeremy G. Browning**
Vice President - Operations
Arkansas Nuclear One

2CAN111301

November 7, 2013

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

SUBJECT: Response to Request for Additional Information
Adoption of National Fire Protection Association Standard NFPA-805
Arkansas Nuclear One, Unit 2
Docket No. 50-368
License No. NPF-6

REFERENCES:

1. Entergy letter dated December 17, 2012, *License Amendment Request to Adopt NFPA-805 Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants (2001 Edition)* (2CAN121202) (ML12353A041)

2. NRC letter dated September 11, 2013, *Arkansas Nuclear One, Unit 2 – Request for Additional Information Regarding Adoption of National Fire Protection Association Standard NFPA-805* (TAC No. MF0404) (2CNA091301) (ML13235A005)

Dear Sir or Madam:

By letter dated September 11, 2013 (Reference 2), the NRC requested additional information associated with the Entergy Operations, Inc. (Entergy) request to amend the Arkansas Nuclear One, Unit 2 (ANO-2) Technical Specifications (TS) and licensing bases to comply with the requirements in 10 CFR 50.48(a), 10 CFR 50.48(c), and the guidance in Regulatory Guide (RG) 1.205, "Risk-Informed Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants." The amendment request followed Nuclear Energy Institute (NEI) 04-02, "Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program under 10 CFR 50.48(c)." This submittal described the methodology used to demonstrate compliance with, and transition to, National Fire Protection Association (NFPA) 805, and included regulatory evaluations, probabilistic risk assessment (PRA), change evaluations, proposed modifications for non-compliances, and supporting attachments.

Based on the complexity of the questions included in the Reference 2 letter, the NRC established response due-dates of 60, 90, or 120 days, from the date of the Reference 2 letter. Enclosed are responses to all questions having a 60-day response requirement. In addition, one 90-day Fire Modeling related response and four 90-day PRA related responses are included in this letter.

Changes or additional information, as detailed in this letter, with respect to the original Entergy request (Reference 1) have been reviewed and Entergy has determined that the changes do not invalidate the no significant hazards consideration included in the Reference 1 letter.

In accordance with 10 CFR 50.91(b)(1), a copy of this application is being provided to the designated Arkansas state official.

No new commitments have been identified in this letter.

If you have any questions or require additional information, please contact Stephenie Pyle at 479-858-4704.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on November 7, 2013.

Sincerely,

**ORIGINAL SIGNED BY JEREMY G. BROWNING**

JGB/dbb

Attachment: Responses to Request for Additional Information – ANO-2 Transition to NFPA-805

cc: Mr. Marc L. Dapas
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**Attachment 1 to**

**2CAN111301**

**Responses to Request for Additional Information**
**ANO-2 Transition to NFPA-805**

**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**
**ANO-2 Transition to NFPA-805**

By letter dated September 11, 2013 (Reference 2), the NRC requested additional information associated with the Entergy Operations, Inc. (Entergy) request (Reference 1) to transition the Arkansas Nuclear One, Unit 2 (ANO-2), fire protection licensing basis to National Fire Protection Association (NFPA) Standard NFPA-805, *Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants (2001 Edition)*. Included below are Entergy responses to all questions requiring a 60-day response with respect to the *request for additional information* (RAI) (Reference 2). In addition, one 90-day Fire Modeling RAI and four 90-day Probabilistic Risk Assessment (PRA) RAI responses are included in this letter. The respective question is included for convenience.

**Fire Protection Engineering (FPE)**

<u>FPE RAI 01</u>

The compliance basis in license amendment request (LAR) dated December 17, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12353A041) Attachment A, Table B-1, Element 3.3.1.2(5) refers to an Implementation Item S2-4 in LAR Attachment S that states that procedure EN-DC-161, "Control of Combustibles," will be revised to include the following:

> In accordance with NFPA 30, applicable NFPA Standards are considered to be equivalent to those NFPA Standards identified in the current license basis (CLB) for procedures and systems in the fire protection program that are transitioning to NFPA-805.

National Fire Protection Association (NFPA) 30, "Flammable and Combustible Liquids Code," does not address the current license basis for any plant. Please clarify the above statement.

*Response*

The LAR Attachment S (Item S2-4) statement is clarified as follows:

> In accordance with FAQ 06-0020, the term “applicable NFPA Standards” is considered to be equivalent to those NFPA Standards identified in the current licensing basis (CLB) for existing procedures and systems in the fire protection program that are transitioning to NFPA-805. New Fire Protection Systems would be subject to the most current code or standard.”

Entergy requests the current subject statement in the LAR be replaced with the above clarification. This revised statement will be applied to an update to procedure EN-DC-161, “Control of Combustibles,” as part of our NFPA-805 implemented process.

FPE RAI 02

LAR Attachment K includes two exemptions from Title 10 of the Code of Federal Regulations (10 CFR) Part 50, Appendix R, that are requested to be transitioned. The evaluation for transition of these previously approved licensing actions does not clearly state that the basis for the exemptions and previous approval remain valid per the guidance in Section 2.3.1 of Regulatory Guide (RG) 1.205, "Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants," and Nuclear Energy Institute (NEI) 04-02, "Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program Under 10 CFR 50.48(c)." Describe the validity of using these previously approved exemptions to meet NFPA-805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants, 2001 Edition." Please include a discussion of any changes or modifications that have been made to the plant that impact the basis for the exemptions.

*Response*

The two exemptions identified in Attachment K are associated with the Reactor Coolant Pump (RCP) lube oil collection system (Exemption 17) and the RCP oil fill line (Exemption 19). Modifications to the existing RCP lube oil collection system have been implemented since the original exemption was granted. For example, one modification installed additional oil pans to collect potential leakage with the intent to improve the effectiveness of the oil collection system. Other system improvement modifications have also been installed. The plant modification process employed at ANO is highly robust and considers impacts on the current licensing basis, such as the basis for past NRC exemption approvals. Each change is reviewed in accordance with the requirements of 10 CFR 50.59 to ensure the current plant licensing basis remains valid. As a result, the basis for the exemption approvals remains valid.

FPE RAI 03

In LAR Attachment L, Nuclear Regulation Commission (NRC) approval is requested for Arkansas Nuclear One, Unit 2 (ANO-2) applications of epoxy floor coatings that may not meet NFPA-805, Section 3.3.3, "Interior Finishes." The basis for the request states the coatings meet NFPA 101, "Life Safety Code," Class A or American Society for Testing and Materials (ASTM) E84, "Standard Test Method for Surface Burning Characteristics of Building Materials," flame spread criteria with the exception of Douchem 9400. The LAR contains no further discussion of the properties of Douchem 9400. Please provide the classification or flame spread rating for Douchem 9400, and a justification for its use at ANO-2.

*Response*

Duochem 9400 has the following properties:

| Dry Film Thickness (inches) | Flame Spread Rating |
|---|---|
| 1/8 | 31 |
| 1/4 | 57 |

Based on a review of epoxy floor coatings at ANO documented in CR-ANO-C-2008-1315 in response to Information Notice (IN) 97-02, "Combustibility of Epoxy Floor Coatings at Commercial Nuclear Power Plants," Duochem 9400 was identified to have the highest flame spread index of any floor coating used at ANO. In addition, the review concluded that the majority of the areas have a maximum dry film thickness (DFT) that is less than 1/8-inch. As stated in Enclosure 2 to NRC Generic Letter (GL) 86-10, Section 3.6.2, material with a 1/8-inch DFT and a flame spread rating less than 50 will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. This is consistent with the definition of Limited Combustible (NFPA-805, Section 1.6.36).

The request is included in Attachment L to recognize the possibility for limited areas where the floor coating DFT may approach ¼-inch due to floor smoothness variations that have not been detected. The request to utilize Duochem 9400 bounds the characteristics of other floor coatings used at ANO. In these limited areas, the flame spread rating using Duochem 9400 properties, when averaged over the area, will be less than 50.

<u>FPE RAI 04</u>

In LAR Attachment L, the following statement (or similar) is provided for Chapter 3 Elements, 3.3.3, 3.3.5.1, 3.3.5.2, and 3.3.12(1), with regard to meeting safety margin:

> These precautions and limitations on the use of these materials have been defined by the limitations of the analytical methods used in the development of the fire probabilistic risk assessment (PRA). Therefore, the inherent safety margin and conservatisms in these methods remain unchanged.

These statements are general. Please clarify how safety margin is maintained within the context of each of the subject approval requests.

*Response*

The statement regarding safety margin was intended to be a summary statement and the term "analytical methods" is a general term that refers to ignition frequency, heat released, etc.

The Fire PRA (FPRA) uses historical fires and fire tests as the basis for many inputs, such as the ignition frequencies, the heat released from a fire, how fires will spread, and the probability that a circuit will be damaged in an adverse way.

In the second quoted sentence, wording from NEI 04-02, Section 5.3.5.3, which refers to inherent safety margin present in the internal events PRA model, is extended to the FPRA methods. This extension is reasonable because NRC-accepted methods are used to perform the FPRA. Deviations are evaluated against the methods and criteria for the overall internal events PRA and FPRA model development for consistency, or confirmation of bounding treatment, to confirm that the safety margin inherent in the PRA model is preserved. If the deviation does not change the FPRA, the safety margin inherent in the FPRA is also unchanged.

Section 3.3.3: The epoxy floor coatings of the type utilized at ANO do not present a primary fire hazard, will not propagate fire from one fire area to another, and will not exacerbate the severity of a compartment fire. Thus, their presence has no impact on the analytical methods used in the FPRA to evaluate potential fire scenarios. Therefore, the inherent safety margin in these methods remains unchanged.

Section 3.3.5.1: Power and control cables comply with NFPA-805, Section 3.3.5.1. The limited amount of other wiring above suspended ceilings consists of low voltage communications/data cable, which is not susceptible to shorts that would result in a fire. LAN cable (Category 5) is a signal cable that typically runs less than 5 volts at low current (< 0.577 amps per conductor) and can also be used for telephony and video. Analog telephone lines operate at less than 100 volts at low current (20 to 50 mA typical) and include series resistance to limit current in case of shorts. Thus, their presence above suspended ceilings has no impact on the analytical methods used in the FPRA to evaluate potential fire scenarios. Therefore, the inherent safety margin in these methods remains unchanged.

Section 3.3.5.2: The material in which nonmetallic conduits are run within embedded locations is not subject to flame or heat impingement from an external source which would result in structural failure, contribution to fire load, or damage to the circuits. Also, failure of circuits within the embedded conduit resulting in a fire would not result in damage to external targets. Thus, the use of nonmetallic conduit for raceways embedded in concrete has no impact on the analytical methods used in the FPRA to evaluate potential fire scenarios. Therefore, the inherent safety margin in these methods remains unchanged.

Section 3.3.12(1): The oil mist resultant from normal operation of the RCPs does not account for an appreciable heat release rate or accumulation near potential ignition sources. The RCPs utilize de-misters and oil loss is evaluated each outage per procedure OP-1504.001, "Visual Inspection of the Unit 1 & 2 RCP's Oil Collection System."

The RCP lube oil system is capable of withstanding the safe shutdown earthquake without rupture and the oil collection system will channel random leaks to a vented, closed container, and will keep overflow oil away from potential ignition sources. Also, the RCPs are not required to achieve and maintain fire safe shutdown, nor are they credited in the FPRA. Thus, use of the existing RCP lube oil and oil collection configuration has no impact on the analytical methods used in the FPRA to evaluate potential fire scenarios. Therefore, the inherent safety margin in these methods remains unchanged.

<u>FPE RAI 05</u>

In LAR Attachment L, NRC approval is requested for oil mist resulting from normal operation of the reactor coolant pump oil collection system. The majority of the supporting discussion is associated with the previous NRC approval of the oil collection system as addressed by the existing exemptions being transitioned (see LAR Attachment K). Please provide additional technical justification addressing the following items:

a. Characterization of the misting in terms of oil quantity and location of deposition.

b. Discussion of the fire hazard associated with the oil misting and deposition locations, including proximity to equipment necessary to meet nuclear safety performance criteria.

c. What actions, if any, are taken to clean oil mist deposits from equipment surfaces (e.g., during maintenance outages)?

*Response*

a. In recent plant outages, for example, 2R22, the difference of total oil collected and oil lost was within 1 gallon (WO-52355990), which is considered insignificant. In 2R21, the difference was within 2 gallons (WO-00215465), which again is considered insignificant. This total amount of oil lost includes the loss due to misting, but no distinction is possible between the amount lost due to misting and the other losses. Should a significant quantity of oil difference be identified, then a Condition Report would be initiated to address any concerns. With regard to where misted oil may collect, the most common areas include structural steel near the motors, the outside of the motors, motor area insulation, etc. (in general anything near the motor with an apparent preference for cooler surfaces). In the past, this misting manifests itself as a thin layer of oil on the aforementioned surfaces, sometimes including small droplets.

b. Per Calc-96-R-2001-02, any oil released from the RCP Motor Lube Oil System that is not collected by the oil collection system would be expected to accumulate on, or near, the RCP motor and pump assembly. For a fire to occur, oil would need to be exposed to an ignition source or come in contact with surfaces that have temperatures in excess of the ignition temperature of the oil. Attributes which would prevent ignition of any oil accumulation in the vicinity of the RCP motor and pump assemblies include:

    - The thermal design parameters of the Reactor Coolant System (RCS) insulation are based on a maximum pipe surface temperature of 650 °F. The piping surfaces in the vicinity of the RCP motors are insulated such that lube oil leakage would only contact relatively cool surfaces (< 200 °F) of the insulation. The oil used in the RCPs is Chevron GST 32 and 68, having a flashpoint of 374 °F.
    - There are few possible sources of potential electrical ignition in close proximity to the RCPs. Electrical junctions in the area are protected with junction/splice boxes and the use of these boxes is typically required for splicing and terminating power cables. The RCPs have induction (brushless) type motors which limit the potential for the ignition of any oil drawn into the motor through the ventilation system (reference Technical Manual G080.2580).
    - Due to the misting affect, there may be a fine film of oil on components in the area of the RCP motors, which will have no adverse impact of the subject components. No accumulation of oil is expected in the webbed areas of these components, collection pans, or dripping from any of the RCP components. If an abnormal accumulation of oil is found or the integrity of the collection system is determined to be deficient, a work order is initiated to clean surfaces and documented in procedure OP-1504.001, Supplement 2 (Unit 2 Shutdown RCP Lube Oil Collection System Inspection). This inspection falls under the responsibility of System Engineering and ensures that anything more than a fine film of oil is documented, tracked by a Condition Report, and verified acceptable prior to unit startup.

c. As stated in Part b above, with regard to cleaning the surfaces identified with an oil film deposition, the cleaning is performed on a 1R (every refueling outage) schedule as a Preventive Maintenance task for the motor per procedure OP-2412.036 (Unit 2 Reactor Coolant Pump Motor Lube PM) that includes cleaning all accessible areas of each motor. If the need for cleaning of surrounding structures is identified during the performance of procedure OP-1504.001, a Condition Report is initiated and a Work Order may be written for cleanup, as deemed necessary.

FPE RAI 06

In LAR Attachment L, NRC approval is requested for deviations from NFPA-805, Section 3.5.3, regarding fire pump compliance with NFPA 20, "Standard for the Installation of Stationary Pumps for Fire Protection." The "Basis for Request" and "Conclusion" cite historic testing and experience as reason to accept the identified deviations from the code requirements. Please provide additional summary discussion of the historic testing and operating experience, as well as the current routine testing and maintenance that support the conclusions and basis for approval.

*Response*

Routine Tests

Monthly tests that demonstrate operability of the electrical (P-6A) and diesel (P-6B) fire pumps, along with quarterly vibration tests, are performed in accordance with procedure OP-1104.032, Supplements 1 and 2. The following tests are performed for both fire pumps every 18 months in accordance with OP-1104.032, Supplement 8:

- Functional and Capacity
- Shutoff Head
- 100% Capacity and Valve Setpoint
- 150% Capacity
- Controls and Alarms
- Full Actuation

Routine Maintenance Activities

The following routine maintenance activities are performed at the designated frequency:

| Maintenance Activity | Test Procedure | Frequency |
|---|---|---|
| P-6A motor oil level check | OP-1107.001<br>Supplement 7 | Bi-Weekly |
| P-6B engine and gear oil check | OP-1107.001<br>Supplement 7 | Bi-Weekly |
| P-6B Inspection | OP-1306.027 | Semi-annually<br>Annually |
| P-6B engine surveillance | OP-1307.004 | Biannually |
| P-6A & P-6B Disassembly, Inspection and Reassembly | OP-1402.062 | Corrective Maintenance<br>No Frequency |
| P-6B engine batteries (D08 and D09) and battery charger maintenance | OP-1307.001<br>Supplement 1<br>Supplement 2<br>Supplement 3 | Weekly<br>Quarterly<br>18-Month |

Based on a review of condition reports associated with fire pumps P-6A and P-6B, deficiencies such as field related components causing the auto start of a pump; inspection or corrective maintenance task deficiencies, and sub-component (such as gauges, fittings, or piping) failures were noted. However, no applicable operating experience was found that related to a failure of the electrical motor or its controller, or the diesel or the diesel engine battery bank, due to any adverse quality issue with this equipment.

The NFPA 20 code deviation does not degrade the system or equipment and has no adverse impact on the ability of the fire protection water system to perform its function.

<u>FPE RAI 07</u>

In LAR Attachment L, NRC approval is requested for non-fire protection use of the fire protection water supply system. The approval request describes the use of a temporary fire pump to supply cooling water during unit outages when the auxiliary cooling water (ACW) system is out of service. The approval request states the fire water supply system has excess capacity to supply the demands of the system to the greatest hose reel demand. Please provide additional technical justification addressing the following items:

a. Describe the configuration of the temporary fire pump, including all connections when supplying the ACW system.

b. Describe the normal fire pump configuration, alignment, and operation with the temporary pump in-service.

c. Per NFPA-805, Section 3.5.1(b), the fire water supply must be capable of providing 500 gallons per minute for manual hose streams plus the largest demand of any sprinkler or water spray system. Describe the capability to meet the NFPA-805 required demand in addition to the temporary cooling system demand.

*Response*

a. The temporary pump and its controls are installed in the ANO-1 intake structure. The pump is configured to take suction from the lake and supply water to the Fire Water System (FWS) via the FWS Test Header.

A check valve is installed at the test header to prevent reverse flow from the fire header if the temporary system should fail. A minimum flow recirculation line, which also contains a manual isolation/throttle valve, is installed in the pump discharge line. A pressure gauge is installed on the pump discharge piping for monitoring pump operation and to allow for proper discharge pressure adjustments.

A combination of flexible hose and/or temporary pipe connects the temporary pump to a section of screen wash system piping. Lake water flows through this pipe to a tee near the FWS test header at the intake structure. Once the FWS test header manifold is removed from the flanged connection, a temporary reducer/check valve assembly is installed. The pump discharge valve is installed at the abandoned screen wash blind flange, and a combination of temporary pipe and a flexible hose section is installed between the screen wash pipe tee and the temporary FWS test header reducer/check valve assembly.

Installation of the temporary pump is procedurally controlled in accordance with OP-1104.032, “Fire Protection Systems.”

In accordance with Attachment B of OP-2104.048, “Control Room Chilled Water System,” temporary cooling water may be provided to the normal Control Room Chiller, 2VCH-2A, from fire hose station 2HR-22 with a temporary isolation valve (2FS-222) connected to the hose. Water exiting the discharge of the water regulating valves for the 2VCH-2A condenser is routed outside via hose to a storm drain on the east side of the Condensate Storage Tank (CST), 2T-41B.

Temporary cooling water may also be supplied from fire hose station 2HR-74, with an installed temporary isolation valve (2FS-176), to Auxiliary Building Extension Chiller, 2VCH-3B, in accordance with Attachment D of OP-2104.027, “Auxiliary Building Extension Chilled Water System.” Water exiting the discharge of the water regulating valves for the 2VCH-3B condenser is routed outside via hose to a storm drain on the east side of the CST, 2T-41B.

b. There is no change to the configuration, alignment, or operation of the fire water pumps (P-6A and P-6B) when the temporary pump is installed. The use of the temporary pump avoids unnecessary start and run cycles on fire water pumps P-6A and P-6B.

c. NFPA-805 Section 3.5.1, Fire Water Flow Code Requirements, states:

A fire protection water supply of adequate reliability, quantity, and duration shall be provided by *one of the two* following methods. *(emphasis added)*

(a) Provide a fire protection water supply of not less than two separate 300,000 gal (1,135,500 L) supplies.

(b) Calculate the fire flow rate for two hours. This fire flow rate shall be based on 500 gpm (1892.5L/min) for manual hose streams plus the largest design demand of any sprinkler or fixed water spray system(s) in the power block as determined in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems, or NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection. The fire water supply shall be capable of delivering this design demand with the hydraulically least demanding portion of fire main loop out of service.

ANO complies with Part (a) of NFPA-805, Section 3.5.1, as reflected in the compliance basis in Attachment A of the LAR. Therefore, Part (b) is not applicable.

Nevertheless, prior to aligning any temporary loads such as cooling water for the chillers mentioned above, an evaluation is performed to ensure the temporary modification is within the capability of the fire system. The temporary modification process employed at ANO is highly robust and considers impacts on all interconnecting and, if necessary, surrounding equipment during the evaluation process. This process also requires a Process Applicability Determination (PAD) to ascertain whether an evaluation under 10 CFR 50.59 must be performed prior to establishing any temporary modification in the field.

FPE RAI 08

LAR Table 4-3 indicates that no detection or suppression is required in Fire Area K. LAR Attachment C, Fire Area K, indicates that no suppression or detection is installed, but also indicates detection is required for existing engineering equivalency evaluations. Please resolve the discrepancy.

*Response*

None of the existing engineering equivalency evaluations (EEEE) that were performed for penetration seals associated with Fire Area K require detection in Fire Zone 2020-JJ, which has no installed detection. The EEEE was referring to detection on the far side of the penetration seal in Fire Area DD (Fire Zone 2040-JJ) where detection is properly identified. Therefore, Entergy requests the subject item in the LAR be replaced with "No" under the EEEE on the "Required Fire Protection Systems and Features" for Fire Zone 2020-J (page C-169).

Table 4-3 is correct as submitted.

FPE RAI 09

Incipient detection is being installed in Fire Area B-4 (LAR Attachment S, Modification S1-10). Please provide more details regarding system design features, NFPA code(s) of record, installation, acceptance testing, set-point control, alarm response procedures and training, and routine inspection, testing, and maintenance that will be implemented to credit the new incipient detection system.

*Response*

ANO plans to provide a modification to install a Very Early Warning Fire Detection System (VEWFDS) incipient fire detection modification in the Control Element Drive Mechanism (CEDM) room. The detection system analyzes air samples from instrument and control cabinets 2C-70, 2C-71, 2C-72, 2C-73, 2C-75, 2C-80, and 2C-409 for Fire Area B-4, Fire Zone 2154-E. Fire detection signal cables are planned to be routed from the VEWFDS incipient fire detection aspirating (air sampling) detectors to the Control Room fire detection panel 2C-343-3.

The VEWFDS incipient fire detection system will meet the criteria of the new code of record NFPA 76 (2012 Edition), "Standard for the Fire Protection of Telecommunications Facilities," and follows the guidance in FAQ 08-0046, "Incipient Fire Detection Systems."

1.0 System Design Features

The incipient fire detection system is a cloud chamber aspirating detector system. The detector panel analyzes the air sample for combustion particles that are well below the wavelength of light, invisible and weightless.

The VEWFDS incipient fire detector panel has the capability to output a fault condition, alert/pre-alarm, and three fire alarm levels. The alert/pre-alarm signal set to occur prior to the flaming stage is typically referred to as "Alert" and alarm signals set to occur when the device has entered the flaming or true fire stage are called "Alarms." Control Room Operators will respond to Trouble and Alarm signals that will be transmitted to the ANO-2 Control Room fire alarm panel 2C343-3 by verifying the signal type and status at the VEWFDS detector panel.

## 1.1 Sensitivity Settings and Transport Time Criteria

In accordance with NFPA 76, minimum sensitivity settings above ambient airborne levels for the VEWFD systems installed will be documented as follows and acceptance criteria documented in a procedure:

- Alert condition acceptance criteria: Air-sampling systems = 0.2 percent per foot obscuration (effective sensitivity at each port)
- Alarm condition acceptance criteria: Air-sampling systems = 1.0 percent per foot obscuration (effective sensitivity at each port)

In accordance with NFPA 76, maximum transport time acceptance criteria, the air transport time test from the most remote port to the detection unit of an air-sampling system will not exceed 60 seconds.

## 1.2 Power Sources

The VEWFD panel will be powered from the existing 120 VAC distribution system. A battery back-up with 24-hour capacity will also be provided.

## 2.0 Alarm Response, Routine Inspection, Testing and Maintenance Procedures

Factory and site acceptance test procedures will be developed. A routine inspection, testing, and maintenance annual procedure will be developed for the VEWFDS incipient fire detection aspirating (air sampling) detection system. This will include setpoint control and alarm response meeting FAQ 08-0046 and NFPA 76 (2012 Edition) criteria.

A VEWFDS alert/pre-alarm and alarm levels response procedure will be developed for the VEWFDS incipient fire detector panel signals and address alarm response actions for each pre-alarm, alarm level, and fault condition.

A fire detection instrumentation system operating procedure will be developed and procedure OP-2203.009, "Fire Protection System Annunciator Corrective Action," will be revised to provide Trouble and Alarm response actions.

## 3.0 Vendor Post Modification Testing Support and ANO Personnel Training

Training will be provided to ANO Operations, Fire Protection Engineering, and Maintenance personnel responsible for maintaining, testing, alarm response, operating, and/or servicing the VEWFDS incipient fire detection aspirating detection system.

All software functions will be tested either prior to modification turnover to Operations or post-turnover as part of startup testing. Testing will verify correct receipt of alarm/ trouble signals and operation of signals based on VEWFDS panel programming.

In accordance with FAQ 08-0046 and NFPA 76 (2012 Edition) criteria, the system will pass the vendor's acceptance test and associated sensitivity testing, including any extended period of commissioning, prior to being placed in service.

A code compliance review will be completed with regard to NFPA 76 (2012 Edition) considering FAQ 08-0046 criteria. In addition, any preventive maintenance required by the vendor specifications will be maintained in accordance with the applicable codes, and vendor or manufacturer requirements.

FPE RAI 10

In LAR Attachment C, Fire Area G, the discussion on fire suppression effects on nuclear safety performance criteria states automatic suppression in this fire area is limited to the cable spreading room. This Fire Area includes two cable spreading rooms (CSRs). In addition, based on review of the fire risk evaluation (FRE), fire hazards analysis, and plant drawings, it appears that fire zone 2136-I and 2137-I also have water-based suppression systems. Please provide a justification for not including these systems in the suppression effects discussion in Attachment C for this fire area.

*Response*

A revision to the "Fire Suppression Activities Effect on Nuclear Safety Performance Criteria" discussion provided for Fire Area G on Page C-104, that includes Fire Zones 2136-I and 2137-I, is provided below.

> Safe and stable conditions are achieved and maintained utilizing equipment and cables outside of this fire area. Automatic suppression in this area using water is limited to the Cable Spreading (2098-L), Upper South Electrical Penetration (2137-I), and the Health Physics (2136-I) rooms. The automatic suppression in the ANO-1 Cable Spreading Room (97-R) is physically isolated from and has no impact on ANO-2. The automatic suppression system in the Core Protection Calculator (CPC) room (2098-C) and the adjoining ANO-1 Control Room are gaseous (Halon) and has no adverse impact on equipment. The flow rate of the Cable Spreading Room (2098-L) deluge system can result in ponding in other areas, but is only of concern in Fire Zone 2093-P (south Emergency Diesel Generator room). If Fire Zone 2093-P is impacted, a single train of on-site power can be impacted, but the opposite train remains unaffected. Suppression in Fire Zones 2136-I and 2137-I can result in local ponding that impacts both trains of Control Room ventilation, but the Control Room remains habitable. Fire suppression activities will therefore not adversely affect the plant's ability to achieve the nuclear safety performance criteria.

FPE RAI 11

NFPA-805, Section 3.4.1(c) specifically requires the fire brigade leader and two members to have sufficient training and knowledge of nuclear safety systems to understand the effects of fire and fire suppressants on nuclear safety performance criteria. In RG 1.189, "Fire Protection for Nuclear Power Plants," Revision 2, the staff has acknowledged the following example for the fire brigade leader as sufficient: "The brigade leader and at least two brigade members should have sufficient training in or knowledge of plant systems to understand the effects of fire and fire suppressants on safe-shutdown capability. 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."

LAR Attachment A, Table B-1, Section 3.4.1(c) indicates compliance with this requirement. The compliance basis does not specifically address the training and knowledge given these members of the fire brigade.

Please describe how the requirements of NFPA-805 Section 3.4.1(c) are met with regard to training and knowledge for the brigade leader and at least two of the brigade members.

For some period of time, the fire protection licensing basis for ANO-2 will be NFPA-805 and the licensing basis for ANO-1 will be Appendix R. During this time, the fire brigade will continue to be composed of personnel from each unit. Please describe how the different licensing bases will be addressed in the training and knowledge of fire brigade members that respond to both ANO-1 and ANO-2.

*Response*

Procedure OP-1015.007, “Fire Brigade Organization and Responsibilities,” requires that the fire brigade leader and members are trained and qualified in accordance with procedure OP-1063.020, “Fire Brigade Training Program.”

The Fire Brigade leader is from ANO-2 Operations and three fire brigade members are from ANO-1 (the unaffected unit) Operations. No individual can be placed on the Fire Brigade unless the individual has completed Initial Fire Brigade Training. The Fire Brigade leader and the Fire Brigade members are required to maintain Non-Licensed Operator (NLO) qualifications.

Procedure EN-TQ-112, “Non-Licensed Operator Training,” requires completion of plant systems training as part of the qualification program designed to give the Non-Licensed Operator an understanding of the integrated nature and design of plant systems and structures. Since both units are pressurized water reactors (PWRs) and the Fire Brigade members participate in drills on both units, the understanding of safe shutdown components is reinforced.

For the period of time when the fire protection licensing basis for ANO-2 will be NFPA-805 and the licensing basis for ANO-1 will be Appendix R, the training and qualification program will be controlled by common requirements, since NFPA-805 requirements are bounding for Appendix R with regard to Fire Brigade training requirements.

## Safe Shutdown Analysis (SSA)

Note: SSA RAI 01 and SSA RAI 05 are expected to be addressed in the 90-day RAI response.

<u>SSA RAI 02</u>

LAR Section 4.2.1.1 states the NSCA methodology was evaluated against the guidance of NEI 00-01, "Guidance for Post-Fire Safe Shutdown Circuit Analysis," Revision 1 and a gap analysis was performed to NEI 00-01, Revision 2. LAR Attachment B, Element 3.5.1.1 states in the alignment basis that for ungrounded direct current (DC) circuits, proper polarity shorts causing spurious operation were only considered credible for high-low pressure interface components. Describe how ANO-2 meets the criteria in NEI 00-01, Revision 2, Section 3.5.1.1 for evaluating proper-polarity DC faults on non-high low pressure interface components.

*Response*

Section 4.2 of the cable analysis calculation CALC-85-E-0087-24, Revision 1, provides criteria for analysis of DC circuits at ANO. The relevant criteria are:

4.2.2 All DC grounded and ungrounded circuits must consider any and all shorts, hot shorts, shorts to ground, and open circuits.

4.2.3 All ungrounded circuits (both AC and DC) will be analyzed as if the circuit is grounded. This process accounts for the possibility of the circuit experiencing a ground fault as result of the fire.

4.2.5 For ungrounded DC circuits, two hot shorts of the proper polarity (without grounding) causing spurious operation is not considered credible except for high-low pressure interface components.

Criteria 4.2.2 and 4.2.3 provide the baseline requirements and the appropriate methodology to treat DC circuits as an equivalent AC circuit containing a bonded (grounded) neutral. This approach simplifies DC circuit analysis where only one fault or hot short is necessary to result in either functional failure or spurious actuation. An assumption of a grounded system also envelopes the condition where a separate cable fails due to fire induced damage, and creates half of the path necessary for a complete circuit should a single conductor of the subject cable fail.

Criterion 4.2.5 is included to prevent elimination of spurious actuation of DC motor operated valves (MOVs) in high-low pressure applications due to the proper polarity hot short requirement. In pressure interface applications that are not high-low, spurious actuation of DC MOVs due to hot short in the power cables to the motor are excluded as non-credible. Spurious actuation of a DC MOV can only occur due to an intercable proper polarity short of both the armature and the field windings exclusive of other failures that would disable the power circuit. This is similar to a proper rotation 3-phase hot short in AC MOVs, but with the added complexity of a fourth proper polarity hot short.

<u>SSA RAI 03</u>

The Alignment Basis for LAR Attachment B, Element 3.5.1.5 [C, Likelihood of Undesired Consequences] (page B-92) states a multi-spurious operation (MSO) expert panel was assembled to determine the scenarios that could significantly impair the ability to achieve and maintain hot standby. The reference document for this element is the licensee's manual action feasibility analysis and does not address the expert panel MSO analysis. Please provide the appropriate reference that supports the alignment basis statement.

*Response*

The appropriate reference for the expert panel MSO analysis is an Engineering Report in CALC-ANO2-FP-09-00016, “ANO-2 NFPA-805 Evaluation of Multiple Spurious Operations (MSOs),” Rev. 2, with the expert panel information from 2005 provided in Attachment B of the report.

SSA RAI 04

In LAR Attachment C:

a) Fire Area G, the disposition for the variance from deterministic requirement (VFDR) G-03 identifies a recovery action (RA) for 2CV-1066-1 to isolate SG-B blowdown. This RA is not identified in the Attachment C summary for this fire area or in Attachment G.

   Please provide a revised Attachment C Summary for Fire Area G, and a revised Attachment G that includes the RA for component 2CV-1006-1.

b) Fire Area EEU, the summary lists four components under "Credited Recovery Actions."

   - 2CV-1026-2 EFW discharge valve
   - 2CV-1076-2 EFW discharge valve
   - 2EFW-5A EFW manual cross-tie valve
   - 2EFW-5B EFW manual cross-tie valve

   These components are also included in LAR Attachment G, as associated with VFDR EEU-01. However, the disposition for VFDR EEU-01 in LAR Attachment C does not include these RAs.

   Fire Area GG, the summary lists 2CV-0789-1 under "Credited Recovery Actions." This component is also included in LAR Attachment G, as associated with VFDR GG-02. However, the disposition for VFDR GG-02 in LAR Attachment C does not include this RA.

   Fire Area JJ, the summary lists 2CV-5649-1 and 2CV-5650-2 under "Credited Recovery Actions." These components are also included in LAR Attachment G, as associated with VFDR JJ-02. However, the disposition for VFDR JJ-02 in LAR Attachment C does not include discussion of these components.

   Fire Area MM, the Summary lists several components under "Credited Recovery Actions."

   - 2A-113 offsite power breaker
   - 2A-213 offsite power breaker
   - 2CV-1025-1 EFW discharge valve
   - 2CV-1036-2 EFW discharge valve
   - 2CV-1075-1 EFW discharge valve
   - 2CV-1038-2 EFW discharge valve

These components are also included in LAR Attachment G, as associated with VFDR MM-01. However, the disposition for VFDR MM-01 in LAR Attachment C does not include discussion of these components.

Fire Area SS, the Summary lists 2EFW-802 under "Credited Recovery Actions." This component is also included in LAR Attachment G, as associated with VFDR SS-01. However, the disposition for VFDR SS-01 in LAR Attachment C does not include discussion of this component.

Fire Area TT, the Summary lists 2A-309 under "Credited Recovery Actions." This component is also included in LAR Attachment G, as associated with VFDR TT-01. However, the disposition for VFDR TT-01 in LAR Attachment C does not include discussion of this component.

Provide a revised Attachment C that includes the RAs in the disposition of VFDR-EEU-01; VFDR-GG-02; VFDR-JJ-02; VFDR-MM-01; VFDR-SS-01; and VFDR TT-01.

*Response*

Note that because changes are minimal, a revised Attachment C and G are not being submitted at this time. This was communicated and accepted by the NRC in email dated October 30, 2013.

LAR Attachment C “NEI 04-02 Table B-3 Fire Area Transition”:

a) A review of the fire risk evaluation (FRE) for Fire Area G (CALC-09-E-0008-10) shows no recovery is needed for Steam Generator (SG)-B blowdown block valve 2CV-1066-1. Entergy requests the VFDR disposition statement on LAR Page C-122 for G-03(I) be replaced with “No further actions for 2CV-1066-1.” No changes are required to the risk summary provided on Pages C-115 through C-117, or to Attachment G.

b) The VFDRs listed in LAR Attachment C reflect the deterministic equipment and paths selected to achieve post fire safe and stable conditions. Based upon the assumption that all equipment and cabling is damaged within a fire area, the deterministic equipment and path is based upon available support systems. Insights from the Fire PRA, and the consideration of dominant scenarios that influence risk, indicated in some fire areas a set of equipment and paths different from the deterministic were needed. Therefore, in each of the following fire areas, the identified discrepancy has been addressed by revising the disposition statement to associate the recoveries reflected in LAR Attachment G to the Attachment C performance goal VFDR (revisions italicized).

<u>Fire Area EE-U</u>

The following revision to the disposition statement related to VFDR EEU-01 on Page C-97 resolves the identified inconsistency:

This VFDR has been evaluated 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 the EFW function maintained using 2P-7B to feed SG-A and SG-B by cross-connecting to the 2P-7A discharge piping. This is accomplished by recovery of EFW valves 2CV-1026-2, 2CV-1076-2, 2EFW-5A, and 2EFW-5B*.

Fire Area GG

The following revision to the disposition statement for VFDR GG-02 on Page C-133 addresses the identified inconsistency:

This VFDR has been evaluated 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 *the EFW function maintained by using pump 2P-7B in lieu of 2P-7A and a recovery of 2CV-0789-1 to establish a source of feedwater from the Condensate Storage Tank T-41B. Disposition of specific VFDRs are as follows:*

Fire Area JJ

The following revision to the disposition statement of VFDR JJ-02 on Page C-163 addresses the identified inconsistency:

This VFDR has been evaluated 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 *this function maintained with restoration of high pressure safety injection suction by opening 2CV-5649-1 and 2CV-5650-2. Disposition of specific VFDRs are as follows:*

Fire Area MM

The following revision to the disposition statement of VFDR MM-01 on Page C-182 addresses the identified inconsistency:

This VFDR has been evaluated 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 *this function maintained by reestablishing normal power through recoveries of breakers 2A-113 and 2A-213, and the recovery of EFW discharge valves 2CV-1025-1, 2CV-1036-2, 2CV-1075-1, and 2CV-1038-2. Disposition of specific VFDRs are as follows:*

Fire Area SS

The following revision to the disposition statement of VFDR SS-01 on page C-204 to read:

This VFDR has been evaluated 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 *this function maintained by a recovery action to open manual valve 2EFW-802, which ensures a suction source from 2T-41A and B for EFW prior to depleting the contents of T-41B. Disposition of specific VFDRs are as follows:*

Fire Area TT

The following revision to the disposition statement of VFDR TT-01 on page C-213 addresses the identified inconsistency:

This VFDR has been evaluated 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 *this function maintained by re-establishing offsite power to safety bus 2A-3 by a recovery action to close breaker 2A-309, thereby assuring power is available to EFW equipment fed from this train. Disposition of specific VFDRs are as follows:*

<u>SSA RAI 06</u>

LAR Attachment F states the licensee followed the guidance of FAQ 07-0038, "Lessons Learned on Multiple Spurious Operations," and describes the multiple spurious operations (MSO) expert panel as being conducted in 2005, and a later review the generic pressurized water reactors MSO list from NEI 00-01, Revision 2. The FAQ guidance suggests the use of the licensee's safe shutdown analysis, probabilistic risk assessment (PRA) insights, and operating experience as sources for identifying and evaluating MSOs. Describe the use of plant-specific fire PRA or NSCA analyses that were performed since the original expert panel in 2005, as well as plant operating experience, in identifying any additional MSOs or insights to existing MSOs. If these subsequent plant specific analyses have not been reviewed, please provide a basis for their exclusion.

*Response*

Engineering Report No. ANO2-FP-09-00016, Rev. 2, "ANO-2 NFPA-805 Evaluation of Multiple Spurious Operations MSOs" (available in the Entergy NFPA-805 Online Reference Portal) provides the most recent updated analyses for identifying and evaluating MSOs for ANO-2. This report was processed via EC-42126 and completed on February 19, 2013. The report describes how the guidance of FAQ 07-0038 was followed and identifies the MSOs that have been included in the ANO-2 Fire PRA model and Nuclear Safety Capability Assessment (NSCA) to support transition to NFPA-805, including the most recent industry information from the Pressurized Water Reactor Owners Group (PWROG) included in the Fire PRA model and NSCA for ANO-2. The updated MSO's since the 2005 expert panel report includes, PWR MSO 6, "Letdown Fails to Isolate and Inventory Lost to CVCS," and PWR MSO 20, "Reactor Head Vent Valves," as these were expanded in scope from the original report. The updated Engineering Report was prepared, reviewed, and approved in accordance with Entergy procedures.

<u>SSA RAI 07</u>

LAR Section 4.2.1.3 and Attachment G describe that recovery action feasibility was assessed per the methods and criteria of FAQ 07-0030, "Establishing Recovery Actions." LAR Attachment B, Element 3.4.1.4 states the process defined in FAQ 07-0030 was used to determine recovery actions. Attachment G, under "Results of Step 4," references the Fire Risk Evaluations (FREs) and CALC-85-E-0086-02, "Manual Action Feasibility and Common Results," for the feasibility assessment against the criteria of the FAQ.

The calculation referenced for the feasibility analysis addresses manual action feasibility for compliance with Appendix R and although the feasibility criteria described in the calculation appear consistent with the FAQ, the calculation does not address or reference the FAQ. Please provide the following:

a. Confirm the recovery actions necessary to meet NFPA-805 were assessed to the FAQ 07-0030 methods and the 11 feasibility criteria or provide a comparison of the feasibility criteria in CALC-85-E-0086-02 to that of the FAQ.

b. CALC-85-E-0086-02 addresses Appendix R manual actions. Confirm that the calculation addresses all the recovery actions listed in LAR Attachment G.

c. Describe the actions necessary to transition the referenced manual action analysis to one that meets NFPA-805 and Regulatory Guide 1.205.

*Response*

a. The feasibility criteria included in Section 5.0 or method of analysis in Section 6.0 of CALC-85-E-0086-02 "Manual Action Feasibility and Common Results" meet the intent of the eleven feasibility criteria of FAQ 07-0030.

<u>Criteria 1 - Demonstrations</u>

The proposed recovery actions should be verified in the field to ensure the action can be physically performed under the conditions expected during and after the fire event.

- CALC-85-E-0086-02 Section 6.2 States:

  "In order to properly evaluate each required manual action, physical walk-downs should be performed for any new manual actions not previously evaluated. The purpose of these walk downs is to ensure the criteria listed in Section 5.0 are met."

<u>Criteria 2 - Systems and Indications</u>

Consider availability of systems and indications essential to perform the recovery action.

- CALC-85-E-0086-02, Sections 5.5 & 6.2.5, provide criteria for indications needed to assure availability of essential systems and the parameters required to operate these systems. Implementation is by Attachments 4 through 38 of CALC-85-E-0086-02 that provide the individual fire area feasibilities for ANO-2 fire areas. Subsection 6.2.1.3.5 of each Attachment lists available indication for that fire area based upon circuit analysis performed within ARC software. The indication considered and evaluated for availability to support recoveries necessary for safe and stable operation are from individual instruments mounted on control room panels, from software via SPDS (Safety Parameter Display System), and select local instruments. Plant conditions monitored are:

  RCS Pressure

  Pressurizer Level

  Pressurizer Temperature

  Neutron Flux

  RCS Loop Temperature

  SG Level and Pressure

Criteria 3 - Communications

The communications system should be evaluated to determine the availability of communication, where required for coordination of recovery actions.

- CALC-85-E-0086-02, Sections 5.7 and 6.2.7, provide criteria for communications. Implementation is by procedurally directing each Operator assigned tasks outside of the Main Control Room for post fire shutdown to obtain portable radio equipment stored in the Alternate Shutdown Equipment Locker as the primary means of communications. A base station is maintained in the Control Room and in the TSC (Technical Support Center) should Control Room abandonment occur. The phone system and plant paging equipment may also be available, but not specifically credited.

  Supplement 9, “Inventory of ANO-2 Alternate Shutdown Locker” contained in ANO-2 Procedure OP-2305.016, “Remote Features Periodic Testing,” includes periodic checks of tools/equipment that are credited by post fire shutdown procedures.

Criteria 4 – Emergency Lighting

The lighting (fixed and/or portable) should be evaluated to ensure sufficient lighting is available to perform the intended action.

- CALC-85-E-0086-02, Sections 5.3.2 and 6.2.3.2, provide criteria for emergency lighting. ANO-2 is equipped with 8-hour battery-backed lighting units that illuminate access paths and equipment to be locally operated/observed necessary to perform a post fire shutdown. The paths and locations illuminated are documented on drawings FP-2309 through FP-2314. In addition to this fixed lighting, each Operator assigned tasks by post fire shutdown procedures is provided with portable handheld lighting stored in the Alternate Shutdown Equipment Locker.

Criteria 5 – Tools / Equipment

Any tools, equipment, or keys required for the action should be available and accessible. This includes consideration of SCBA and personal protective equipment if required. (This includes staged equipment for repairs).

- CALC-85-E-0086-02, Sections 5.10, 6.2.6, and 6.2.10, provide these criteria. Additional guidance and direction is provided by Section 7.2.6 which includes procedural references for special equipment and Section 7.2.10 for credited repairs. The majority of equipment, such as breakers and MOVs locally operated for post fire shutdown, are manipulated without the use of special equipment.

Criteria 6 - Procedures

Written procedures should be provided.

- CALC-85-E-0086-02, Sections 5.8 and 6.2.8, provide these criteria. Additional direction provided by Section 7.2.8 has references to the primary procedures needed to support post fire recoveries.

Criteria 7 - Staffing

Walk-through of operations guidance (modified, as necessary, based on the analysis) should be conducted to determine if adequate resources are available to perform the potential recovery actions within the time constraints (before an unrecoverable condition is reached), based on the minimum shift staffing. The use of essential personnel to perform actions should not interfere with any collateral industrial fire brigade or Control Room duties.

- CALC-85-E-0086-02, Sections 5.2 and 6.2.2, address staffing. Consideration of staffing and Criteria 9 (Time) are concurrently addressed as the staffing levels required by operating procedures are reflected in the timeline documented by Attachment 3B "Unit 2 Timelines for Manual Actions" of calculation CALC-85-E-0086-02. Operators assigned to perform shutdown duties are solely focused on their actions included in OP-2203.014 (Alternate Shutdown) or OP-2203.049 (Fires in Areas Affecting Safe Shutdown) (i.e., the Operators have no concurrent duties).

Criteria 8 – Actions in the Fire Area

When recovery actions are necessary in the fire area under consideration or require traversing through the fire area under consideration, the analysis should demonstrate that the area is tenable and that fire or fire suppressant damage will not prevent the recovery action from being performed.

- CALC-85-E-0086-02, Sections 5.3.2 and 6.2.3.2, consider environmental conditions inclusive of fire that could affect the ability of the Operator to perform the required post fire action. Evaluation of paths to access equipment considered the traverse or entry into impacted fire areas. Only recovery of MSIV (Main Steam Isolation Valve) 2CV-1010-1 in Fire Area B-2 is identified as requiring re-entry into a fire affected area. This was documented in Action 6 of Condition Report CR-ANO-C-2006-00048. Justification of this action considered the low duration (less than 5 minutes) of the fire, based upon minimal in-situ and transient combustibles, control of hot work, and the fixed ignition sources in the area. This issue and justification is captured within CALC-85-E-0086-02.

Criteria 9 – Time

Sufficient time to travel to each action location and perform the action should exist. The action should be capable of being identified and performed in the time required to support the associated shutdown function(s) such that an unrecoverable condition does not occur. Previous action locations should be considered when sequential actions are required.

- CALC-85-E-0086-02, Sections 5.1, 5.9.1, and 5.9.2, provide guidance related to the time needed to assure the plant is in a safe and stable condition. Attachment 3B, "Unit 2 Timelines for Manual Actions," of calculation CALC-85-E-0086-02 documents travel time, the time required for performance of the task, and reflects the number of personnel (Operator 1, 2, or 3) required to perform the shutdown, based upon OP-2203.049, and any time constraints.

Criteria 10 – Training

Training should be provided on the post-fire procedures and implementation of the recovery actions.

- CALC-85-E-0086-02, Sections 5.2 and 6.2.2, address training for post fire shutdown. Procedure OP-1003.014 (ANO Fire Protection Program), Section 6.4.1, states "Operations personnel shall be trained and drilled to be capable of shutting the plant down in the event of a fire either from the Control Room or an alternate method in accordance with applicable regulatory guidance or regulations."

Criteria 11 - Drills

Periodic drills that simulate the conditions to the extent practical (e.g., communications between the Control Room and field actions, the use of SCBAs if credited, the appropriate use of operator aids).

- CALC-85-E-0086-02, Sections 5.2 and 6.2.2, address training that includes drills for post fire shutdown. Refer to discussion of Criteria 10 for additional information.

b. A design input "New Recovery Action Feasibility Evaluation" included in EC-27716 performed a comparison of existing recoveries to those recoveries reflected in Attachment G of the ANO-2 LAR. This design input concluded that the only new feasible recoveries are associated with the new Auxiliary Feedwater (AFW) pump (currently in design development) with three existing manual valves (2EFW-802, 2EFW- 5A, 2EFW-5B) included for cross alignment of Emergency Feedwater (EFW) pumps.

c. CALC-85-E-0086-02 currently reflects a bounding Appendix R safe shutdown plant that includes all actions necessary to place the plant in cold shutdown and meet any Appendix R time constraints. Two analyses will replace the single Appendix R safe shutdown analysis: an NFPA-805 NSCA for safe and stable operations and an analysis for NPO (Non-Power Operations) currently documented in CALC-09-E-0008-02. As a result, the systems needed only for cold shutdown that are in the current analysis will not be part of the NFPA-805 NSCA for safe and stable operation. Equipment and actions currently needed to support time constraints for transitioning to cold shutdown will also be re-evaluated to determine if the equipment and/or actions can be eliminated. All plant modifications require consideration of the risk impact in accordance with EN-DC-128 "Fire Protection Impact Reviews."

SSA RAI 08

LAR Attachment L contains an approval request related to NFPA-805 Section 3.5.16 for non-fire protection use of the fire protection water supply system. The approval request describes the use of a temporary fire pump to supply cooling water during unit outages when the ACW system is out of service. If fire water to the ACW system must be secured in the event of a fire, what is the impact of losing this cooling capability on achieving key safety functions and meeting the nuclear safety performance criteria?

*Response*

ACW is not essential for the safe shutdown (SSD) of the plant and thus the key safety functions and nuclear safety performance criteria are not impacted upon the loss of the fire water cooling capability due to a fire event.

An example of firewater use for non-fire purposes is included in ANO-2 procedure OP-2104.030, "Auxiliary Cooling Water System Operation," which directs the installation of two temporary modifications that will utilize fire water in the place of ACW. These modifications include aligning a temporary pump to the Control Room Chilled Water System and the Auxiliary Extension Building Chilled Water System. Typically, ACW would be shutdown only for maintenance activities occurring during non-power operations. However, maintenance on either of the two normal Control Room Chillers or the two Auxiliary Building Extension Chillers can be performed during power operations. Evaluations indicate this activity is within the capability of the fire system and loss of either chiller is not of consequence. The temporary modification process employed at ANO is highly robust and considers impacts on all interconnecting and, if necessary, surrounding equipment during the evaluation process. This process also requires a Process Applicability Determination (PAD) to ascertain whether an evaluation under 10 CFR 50.59 must be performed prior to establishing any temporary modification in the field. The temporary cooling supply to the two chilled water systems described above illustrates an example of this process. Provided firewater capability remains within limits, the firewater system may be used for temporary support of other components over time (other than ACW).

In light of the above discussion, Entergy desires to modify the request in Attachment L (NFPA-805 Section 3.5.16 for non-fire protection use of the fire protection water supply system) to include use of a temporary pump during both power operations and unit outages providing firewater capability remains within limits as demonstrated through the temporary modification process.

<u>SSA RAI 09</u>

Attachment S, Modification S1-10 describes incipient detection to be installed in Fire Area B-4. Please describe if this proposed detection system is credited to initiate any operator actions for safe shutdown.

*Response*

The incipient detection will replace an existing area-wide detection system that is currently installed in Fire Area B-4 to provide greater fire detection sensitivity. As noted in the "Risk Informed Characterization" column of LAR Attachment S, Modification S1-10, "The early warning fire detection system modification in Fire Area B-4 reduces the risk of a fire induced circuit and equipment failures that could result in the loss of Control Element Drive Mechanism (CEDM) room panels 2C-70, 2C-71, 2C-72, 2C-73, 2C-75, 2C-80, and 2C-409." In addition, with respect to Modification S1-10, the LAR referenced CALC-09-E-0008-05, which states, "The NSP value in the post-transition baseline case is different from the compliant case due to crediting a modification for incipient detection." Therefore, the incipient detection is credited for reducing the non-suppression probability in this normally unmanned area, and therefore, is credited only with initiating operator action to locate the source of the potential fire to allow for action to prevent ignition. The existing procedures for safe shutdown operator actions in this area are not being changed as a result of the incipient detection modification.

**Programmatic**

Programmatic RAI 01

Based on the NRC staff's review of the LAR and during the subsequent audit, it was determined that the licensee did not adequately describe the post-transition NFPA-805 fire protection program licensing basis.

Please describe the specific documents (e.g., analysis, designs, and engineering reviews) that will comprise the post transition NFPA-805 fire protection program (FPP) licensing basis. In addition, describe whether these documents prepared to support the NFPA-805 FPP will be managed as controlled documents under the licensee's document control process.

*Response*

The NFPA-805 FPP licensing basis will be described in the following documents controlled under 10 CFR 50.36 or 10 CFR 50.59:

- ANO-2 Operating License Condition as approved in NRC Safety Evaluation
- ANO-2 Safety Analysis Report (SAR) with format and content consistent with NEI 02-04 and FAQ 12-0062 (LAR Enclosure 1, Section 5.4)
- ANO-2 Technical Requirements Manual (TRM)
- Fire Hazards / Safety Analysis

Programmatic RAI 02

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

Please describe the changes that are planned to the FPP as part of the NFPA-805 transition process specifically associated with training and identification of the positions where any such training necessary would be to support the fire protection program changes.

*Response*

The systematic approach to training as described in EN-TQ-201 will be utilized to determine which specific tasks and activities under the new FPP require training. Currently, the review determined that specific NFPA-805 generic training, which will be a combination of classroom (initial) and computer-based training (periodic requalification training) will be provided to work groups based on their use of the FPP. NFPA-805 position specific qualification cards will be issued to Fire Protection personnel. Individuals, other than the Fire Protection, may be assigned qualification cards based on the needs of their position.

<u>Programmatic RAI 03</u>

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

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

*Response*

The NFPA-805 change evaluation process will be owned by the Fire Protection staff. The systematic approach to training as described in EN-TQ-201 will be utilized to determine what training will be required and who will be required to receive the training. Current training plans include a qualification card and associated classroom training for the fire protection staff.

<u>Programmatic RAI 04</u>

LAR Section 4.7.3, "Compliance with Quality Requirements in Section 2.7.3 of NFPA-805," does not indicate whether future NFPA-805 analyses will be conducted in accordance with the requirements of NFPA-805, Section 2.7.3. Please describe whether future NFPA-805 analysis will be conducted in accordance with NFPA-805, Section 2.7.3.

*Response*

Future NFPA-805 analyses will be conducted in accordance with the requirements of NFPA-805, Section 2.7.3.

<u>Programmatic RAI 05</u>

LAR Attachment S, Table S-1, "Plant Modifications Committed" listed the proposed modifications S1-12; S1-13; S1-14; S1-16. With respect to compensatory measures currently in place, please provide a statement regarding whether or not compensatory measures have been implemented in accordance with the plant's fire protection program for the listed modifications.

*Response*

The four (4) modifications listed in the RAI are enhancements to the existing plant licensing basis that do not require additional compensatory measures from that already established in support of unrelated Appendix R deficiencies. The first two items (S1-12 and S1-13) relate to long-term room cooling needs, which are currently addressed by manual Operator actions included in procedure OP-2203.034, “Fire or Explosion.” The current manual actions provide additional cooling when needed, as it may not always be necessary. Modifications S1-12 and S1-13 will eliminate the need for these Operator actions and simplify the post-fire safe shutdown process.

The last two items (S1-14 and S1-16) are related to NFPA code inconsistencies (NFPA 50A and NFPA 10, respectively) that are not part of the current licensing basis, but will become part of the transitioning NFPA-805 licensing basis. The physical plant changes will enhance the current plant configuration under the existing licensing basis and do not require interim compensatory measures.

**Fire Modeling**

Note: The response to Fire Modeling RAI 05, a 90-day RAI, is included in this 60-day response below. Fire Modeling RAIs 01, 04, and 06 are expected to be addressed in the 120-day RAI response.

Fire Modeling RAI 02

American Society of Mechanical Engineers/American Nuclear Society (ASME/ANS) Standard RA-S-2008, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessments for Nuclear Power Plant Applications," Part 4, requires damage thresholds be established to support the Fire PRA. Thermal impact(s) must be considered in determining the potential for thermal damage of systems, structures, and components. Appropriate temperature and critical heat flux criteria must be used in the analysis. During the audit, the damage criteria used for cables, sensitive electronics and component failures due to smoke damage was discussed.

NFPA-805, Section 2.5, requires damage thresholds be established to support the performance-based approach. Thermal impact(s) must be considered in determining the potential for thermal damage of structures, systems, or components. Appropriate temperature and critical heat flux criteria must be used in the analysis.

Section 6.1 of the Fire Scenario Report states that, "Since the cables used at ANO-2 are IEEE [Institute of Electrical and Electronics Engineers]-383 qualified cables, the damage threshold for these cables specified in NUREG/CR 6850 is used in this evaluation (Safe Shutdown Cable Jacket Insulation Types at ANO [8] documents the basis for cable qualification at ANO)."

During the audit, the licensee stated that, "NUREG/CR-6850 recommends failure criteria for solid-state control components of 3 kW/m$^2$ (versus 11 kW/m$^2$ for IEEE-383 qualified cables and 6 kW/m$^2$ for non-IEEE-383 qualified cables) be used for screening purposes. However, given that the enclosure would provide protection to the sensitive internal contents from external fire effects, it is reasonable to apply the same zone of influence established for cable damage. Credit for the enclosure is judged to provide sufficient margin to allow use of the cable damage criteria for sensitive electronics."

Please provide technical justification for using cable damage thresholds for temperature sensitive equipment located inside cabinets.

*Response*

The basis for assuming cable damage thresholds for temperature sensitive equipment located inside cabinets is the protection provided by the enclosures. In general, any component that should be evaluated using the lower damage threshold specified in Section H.2 of NUREG/CR-6850 is likely to be located within a ventilated panel (cabinet) or some other robust enclosure. The presence of that robust enclosure essentially shields the component from direct radiant exposure. Consequently, the actual exposure temperature would be based on the temperature response of the enclosure to the incident heat flux and the thermal response of the air within the enclosure.

A fire modeling analysis was performed using the Fire Dynamics Simulator (FDS) to calculate the heat flux and temperatures within a metal cabinet exposed to a fire in support of FPRA FAQ 13-0004 ("Temperature Sensitive Equipment Zone of Influence Study Using FDS," 2013). The objective of the analysis was to determine whether conditions within a panel (cabinet) would remain below the damage threshold specified in Section H.2 of NUREG/CR-6850 for sensitive electronic equipment (3 kW/m$^2$ [0.26 Btu/s-ft$^2$] and 65 °C [149 °F]) when the exterior surface was subjected to a heat flux equal to or exceeding the generic screening damage threshold for thermoset cables. The specific fire that was considered had a heat release rate of 317 kW (300 Btu/s) and corresponded to the NUREG/CR-6850 98$^{th}$ percentile transient ignition source. The fire was placed such that its centerline was 1 m (3 ft) from the panel (cabinet) surface. This distance is typical of a horizontal zone of influence (ZOI) for thermoset cable targets. The FDS simulations for this analysis found that the heat flux and temperature experienced by components within the enclosure remained below that specified in Section H.2 of NUREG/CR-6850 for sensitive electronic equipment (i.e., 3 kW/m$^2$ [0.26 Btu/s-ft$^2$] and 65 °C [149 °F]), while the exterior surface heat flux exceeded the generic screening damage threshold for thermoset cables as specified in Table H-1 of NUREG/CR-6850 (i.e., 11.4 kW/m$^2$ [1.0 Btu/s-ft$^2$]). These results support the recommendation that a generic screening heat flux damage threshold for thermoset cables, as observed on the outer surface of the cabinet, can be used as a conservative surrogate for assessing the potential for thermal damage to solid-state and sensitive electronics within an electrical panel (cabinet).

The procedure used at ANO-2 is consistent with the findings associated with the FAQ 13-0004 analysis insofar as the ZOIs for thermoset cable targets are used as surrogates for the damage thresholds for temperature sensitive equipment located inside cabinets.

Fire Modeling RAI 03

NFPA-805, Section 2.7.3.2, "Verification and Validation," states: "Each calculational model or numerical method used shall be verified and validated through comparison to test results or comparison to other acceptable models."

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

Furthermore, LAR Section 4.7.3 "Compliance with Quality Requirements in Section 2.7.3 of I\IFPA-805" states "Calculational 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 I\IFPA-805."

Regarding the V&V of 'fire models:

a) It is stated on page J-2 of LAR Attachment J that "CFAST does not use a fire diameter, therefore, it is possible to specify a fire that falls within the range of Froude numbers considered in the NUREG-1824 validation documentation." Please provide confirmation that this is true for all the CFAST model calculations or justify why CFAST is appropriate for use with Froude numbers outside the validated range.

b) It is stated on page J-3 of LAR Attachment J that "[The] flame length ratio is normally met, but in the case of the largest fire sizes postulated, the flame height may reach or exceed the ceiling height. Because sprinkler actuation and thermal radiation to targets are not computed with the CFAST model, this parameter is not an applicable metric."

   Please provide a technical justification for using CFAST to model fires with flames that impinge on the ceiling.

*Response – Part a*

The zone computer model permits the selection of two plume models: McCaffrey and Heskestad. The McCaffrey plume is selected in all ANO-2 CFAST modeling since this is the plume model that was used in the NUREG-1824, Volume 5, validation of CFAST. When the McCaffrey plume is selected, the zone computer model CFAST does not use a fire diameter; thus, the determination of the appropriate fire Froude Number is based on the application of the CFAST results rather than on the fire model inputs. The fire scenarios evaluated in the ANO-2 main control room abandonment calculation (CALC-ANO2-FP-09-00013, Rev. 1) using CFAST involve electrical panels and transient ignition sources that are typical of nuclear power plants and comparable to the types of fire scenarios envisioned in the NUREG-1824, Volumes 1 and 5, validation effort. The application of the fire modeling results to ignition sources that fall within the NUREG/CR-6850 conditional probability distribution for transient and electrical panel ignition sources are also considered to be typical of those source fires used in NUREG-1824, Volumes 1 and 5, to validate the CFAST fire model.

Fire scenarios for electrical panels, transient ignition sources, and combination ignition source – cable tray configurations are currently evaluated at ANO-2 using CFAST in the following documents:

- Main control room abandonment analysis (CALC-ANO2-FP-09-00013, Rev. 1)
- Generic Fire Modeling Treatments report (Report 1SPH02902.030, Rev. 0)
- Supplement 2 to the Generic Fire Modeling Treatments report (PRA-ES-05-007, Rev. 0)
- Detailed hot gas layer evaluations in specific ANO-2 fire compartments (PRA-A2-05-011, Rev. 0)

In addition, generic hot gas layer calculations for combined ignition source – secondary combustible fire scenarios are developed in the report PRA-A2-05-018, Rev. 0, as part of the response to Fire Modeling (FM) RAI 01i and FM RAI 01j.

Electrical panel and transient ignition source fires are typical of nuclear power plants and comparable to the types of fire scenarios envisioned in the NUREG-1824, Volumes 1 and 5, validation effort. Cable tray fires are also typical of nuclear power plants, but were not specifically examined in the NUREG-1824, Volumes 1 and 5, validation effort. However, it may be shown that the treatment in CFAST yields a conservative result relative to the output parameters that are applied. Additional discussion for each ignition source class is provided in the sub-sections that follow. It is also noted the control room abandonment calculation will be updated as part of the response to FM RAIs 01a, 01b, 01c, and 01d, and will include the applicable fire Froude Number discussion provided in the sub-sections that follow.

*Closed Electrical Panels*

There is no simple or obvious way to compute a meaningful fire Froude Number for closed electrical panels (i.e., NUREG/CR-6850, Appendix E, Cases 1, 2, 3, and 4). This is because the combustion primarily occurs within the panel and the transfer of heat and mass to the surrounding enclosure occurs across the panel vents and any gaps that may exist or form during the fire. The current method for evaluating closed electrical panel fires per NUREG/CR-6850 and NUREG/CR-6850, Supplement 1, is to assume an open configuration source fire with a base height equal to the panel height or 0.3 m (1 ft) below the panel top, depending on the panel configuration. This is a conservative alternative to modeling the fire conditions within the panel and the mass and energy flows between the panel and the surroundings. When using this method to bound the mass and energy transfer across the panel boundaries and thus into the thermal plume, it is assumed that the open configuration is such that the fire diameter produces a fire Froude Number within the NUREG-1824, Volume 1, validation range. Essentially, the method for modeling closed electrical panel fires is to treat them as an open source fire that has a fire Froude Number that falls within the range considered by NUREG-1824, Volume 1.

*Transient Ignition Sources*

Transient ignition sources (NUREG/CR-6850, Appendix E, Case 8) are located in the main control room as well as in other areas of the plant. The analysis in the main control room (CALC-ANO2-FP-09-00013, Rev. 1) considers the entire transient ignition source conditional probability distribution, whereas other areas consider only the 98$^{th}$ percentile heat release rate bin and a reduced heat release rate 69 kW (65 Btu/s) heat release rate bin.

The fire Froude Number for a transient fuel package fire may be computed using the following equation per NUREG-1934:

$$\mathrm{Fr} = \frac{\dot{Q}}{\rho_\infty c_p T_\infty D^2 \sqrt{gD}} \qquad \text{(FM 03a-1)}$$

where **Fr** is the fire Froude Number, $\dot{\boldsymbol{Q}}$ is the fire heat release rate modeled (kW [Btu/s]), $\boldsymbol{\rho_\infty}$ is the density of the ambient air (kg/m$^3$ [lb/ft$^3$]), $\boldsymbol{c_p}$ is the heat capacity of the ambient air (kJ/kg-K [Btu/lb-°R]), $\boldsymbol{T_\infty}$ is the ambient air temperature (K [°R]), $\boldsymbol{g}$ is the acceleration of gravity (9.81 m/s$^2$ [32.2 ft/s$^2$]), $\boldsymbol{D}$ and is the diameter of the fire (m [ft]).

The density is inversely proportional to the temperature via the following equation:

$$\rho = \frac{352}{T} \qquad \text{(FM 03a-2)}$$

where $\boldsymbol{\rho}$ is the density (kg/m$^3$ [lb/ft$^3$]) and $\boldsymbol{T}$ is the temperature (K [°R]). In addition, the heat capacity is nearly constant over the temperature ranges applicable to the target exposure, equal to 1 kJ/kg-K (0.24 Btu/lb-°R). Consequently, Equation FM 03a-1 may be simplified to the following:

$$\mathrm{Fr} = \frac{\dot{Q}}{1102D^{2.5}} \qquad \text{(FM 03a-3)}$$

where all terms have been defined previously. In order to define a diameter for use in Equation FM 03a-3, a reasonable approximation of the area involved is necessary. When the heat release rate per unit area is known (rather than the actual fire area or diameter), the approximate fire area may be computed using the following equation:

$$A = \frac{\dot{Q}}{\dot{q}''} \qquad \text{(FM 03a-4)}$$

where $\boldsymbol{A}$ is the plan burning area of the open panel ignition source (m$^2$ [ft$^2$]), $\dot{\boldsymbol{Q}}$ is the fire heat release rate modeled (kW [Btu/s]), and $\dot{\boldsymbol{q}}''$ is the heat release rate per unit area of the burning material (kW/m$^2$ [Btu/s-ft$^2$]). The effective fire diameter may be computed assuming an axisymmetric source:

$$D = \sqrt{\frac{4A}{\pi}} \qquad \text{(FM 03a-5)}$$

where $\boldsymbol{D}$ Is the effective fire diameter (m [ft]) for use in Equation FM 03a-3 and $\boldsymbol{A}$ is the plan burning area (m$^2$ [ft$^2$]) as previously described.

The plan heat release rate per unit area range for the transient fuels varies considerably as described in Section 3-1 of the *SFPE Handbook of Fire Protection Engineering* – 3rd Edition, given the large variation in the types and arrangement of the fuel packages. The heat release rate per unit area range is about 100 – 370 kW/m$^2$ (8.8 – 32.6 Btu/s-ft$^2$) for transient materials that are loose or located in containers, based on the test considered in NUREG/CR-6850, provided the material does not contain flammable or combustible liquids. The heat release rate per unit area for loose material alone is closer to 270 – 370 kW/m$^2$ (23.8 – 32.6 Btu/s-ft$^2$) based on a sub-set of tests involving trash bags (see PRA-ES-05-006, Rev. 0). The loose material tests are applicable in the main control room abandonment calculation (CALC-ANO2-FP-09-

00013, Rev. 1), the Generic Fire Modeling Treatments report (Report 1SPH02902.030, Rev. 0), and the evaluations that consider secondary combustibles (PRA-A2-05-011, Rev. 0 and PRA-A2-05-018, Rev. 0), since explicit credit for the slower fire growth in a container is not credited. Contained transient fire scenarios will be considered in the updated main control room abandonment calculation.

The approximate fire Froude Number for the fifteen bins listed in NUREG/CR-6850, Appendix E, Case 8, for transient ignition source fires is listed in Table FM 03a-1 for loose transient fuel packages having a plan heat release rate per unit area of 270 kW/m$^2$ (23.8 Btu/s-ft$^2$) and Table FM 03a-2 for loose transient fuel packages having a plan heat release rate per unit area of 370 kW/m$^2$ (32.6 Btu/s-ft$^2$).

Table FM 03a-1
Approximate Fire Froude Number for NUREG/CR-6850, Appendix E, Case 8, (Transient Fires) - 270 kW/m$^2$ (23.8 Btu/s-ft$^2$) Plan Heat Release Rate Per Unit Area (Loose Transient Fuel Package)

| NUREG/CR-6850 Heat Release Rate Bin | Heat Release Rate (kW [Btu/s]) | Area (m$^2$ [ft$^2$]) | Diameter (m [ft]) | Fire Froude Number† |
|---|---|---|---|---|
| 1 | 22 (21) | 0.081 (0.88) | 0.32 (1.06) | **0.34** |
| 2 | 55 (52) | 0.20 (2.2) | 0.51 (1.67) | **0.27** |
| 3 | 92 (87) | 0.34 (3.7) | 0.66 (2.16) | **0.24** |
| 4 | 128 (121) | 0.47 (5.1) | 0.78 (2.55) | **0.22** |
| 5 | 165 (156) | 0.61 (6.6) | 0.88 (2.89) | **0.20** |
| 6 | 202 (191) | 0.75 (8.0) | 0.98 (3.20) | **0.19** |
| 7 | 238 (226) | 0.88 (9.5) | 1.06 (3.47) | **0.19** |
| 8 | 275 (261) | 1.02 (11.0) | 1.14 (3.73) | **0.18** |
| 9 | 312 (296) | 1.16 (12.4) | 1.22 (3.98) | **0.17** |
| 10 | 349 (331) | 1.29 (13.9) | 1.28 (4.21) | **0.17** |
| 11 | 386 (366) | 1.43 (15.4) | 1.35 (4.43) | **0.17** |
| 12 | 423 (401) | 1.57 (16.9) | 1.41 (4.63) | **0.16** |
| 13 | 460 (436) | 1.70 (18.3) | 1.47 (4.83) | **0.16** |
| 14 | 497 (471) | 1.84 (19.8) | 1.53 (5.02) | **0.16** |
| 15 | 578 (548) | 2.14 (23.0) | 1.65 (5.42) | **0.15** |

† Bold values indicate a fire Froude Number that falls below the NUREG-1824, Volume 1, validation range of 0.4 – 2.4.

Table FM 03a-2
Approximate Fire Froude Number for NUREG/CR-6850, Appendix E, Case 8,
(Transient Fires) - 370 kW/$m^2$ (32.6 Btu/s-$ft^2$) Plan Heat Release Rate Per Unit Area
(Loose Transient Fuel Package)

| NUREG/CR-6850 Heat Release Rate Bin | Heat Release Rate (kW [Btu/s]) | Area ($m^2$ [$ft^2$]) | Diameter (m [ft]) | Fire Froude Number† |
|---|---|---|---|---|
| 1 | 22 (21) | 0.059 (0.64) | 0.28 (0.90) | 0.50 |
| 2 | 55 (52) | 0.15 (1.60) | 0.44 (1.43) | 0.40 |
| 3 | 92 (87) | 0.25 (2.67) | 0.56 (1.85) | **0.35** |
| 4 | 128 (121) | 0.35 (3.72) | 0.66 (2.18) | **0.32** |
| 5 | 165 (156) | 0.45 (4.80) | 0.75 (2.47) | **0.30** |
| 6 | 202 (191) | 0.55 (5.87) | 0.83 (2.73) | **0.29** |
| 7 | 238 (226) | 0.64 (6.92) | 0.90 (2.97) | **0.28** |
| 8 | 275 (261) | 0.74 (8.0) | 0.97 (3.19) | **0.27** |
| 9 | 312 (296) | 0.84 (9.07) | 1.04 (3.40) | **0.26** |
| 10 | 349 (331) | 0.94 (10.1) | 1.10 (3.59) | **0.25** |
| 11 | 386 (366) | 1.04 (11.2) | 1.15 (3.78) | **0.25** |
| 12 | 423 (401) | 1.14 (12.3) | 1.21 (3.96) | **0.24** |
| 13 | 460 (436) | 1.24 (13.4) | 1.26 (4.13) | **0.24** |
| 14 | 497 (471) | 1.34 (14.5) | 1.31 (4.29) | **0.23** |
| 15 | 578 (548) | 1.56 (16.8) | 1.41 (4.63) | **0.22** |

† Bold values indicate a fire Froude Number that falls below the NUREG-1824, Volume 1, validation range of 0.4 – 2.4.

Similarly, the approximate fire Froude Number for the fifteen bins listed in NUREG/CR-6850, Appendix E, Case 8, for transient ignition source fires is listed in Table FM 03a-3 for contained transient fuel packages. The fire diameters for the contained transient fire scenarios are based on the typical diameters for contained transient fuel packages considered in NUREG/CR-6850, Appendix E, which range from under 0.3 m (1 ft) to about 0.69 m (2.3 ft) (see PRA-ES-05-006, Rev. 0).

Table FM 03a-3
Approximate Fire Froude Number for NUREG/CR-6850, Appendix E, Case 8, (Transient Fires) – Contained Transient Fuel Package

| NUREG/CR-6850 Heat Release Rate Bin | Heat Release Rate (kW [Btu/s]) | Fire Froude Number† | |
|---|---|---|---|
| | | Small Diameter (0.3 m [1 ft]) Container | Large Diameter (0.69 m [2.3 ft)] Container |
| 1 | 22 (21) | **0.39** | **0.05** |
| 2 | 55 (52) | 0.97 | **0.13** |
| 3 | 92 (87) | 1.63 | **0.21** |
| 4 | 128 (121) | 2.26 | **0.30** |
| 5 | 165 (156) | **2.92** | **0.38** |
| 6 | 202 (191) | **3.57** | 0.47 |
| 7 | 238 (226) | **4.21** | 0.55 |
| 8 | 275 (261) | **4.87** | 0.64 |
| 9 | 312 (296) | **5.52** | 0.72 |
| 10 | 349 (331) | **6.17** | 0.81 |
| 11 | 386 (366) | **6.83** | 0.89 |
| 12 | 423 (401) | **7.48** | 0.98 |
| 13 | 460 (436) | **8.14** | 1.06 |
| 14 | 497 (471) | **8.79** | 1.15 |
| 15 | 578 (548) | **10.23** | 1.34 |

† Bold values indicate a fire Froude Number that falls outside the NUREG-1824, Volume 1, validation range of 0.4 – 2.4.

Tables FM 03a-1 through FM 03a-3 indicate that the fire Froude Number falls below the NUREG-1824, Volume 1, fire Froude Number range of 0.4 – 2.4 in nearly all cases for the loose configuration and the low bins for the large diameter contained configuration. The fire Froude Number is high for the high bins associated with the small diameter contained configuration. In the case of the confined configuration, based on the data provided in NUREG/CR-6850, the small diameter containers (0.3 m [1 ft] diameter) produce heat release rates that correspond to Bin 1, whereas the larger diameter containers produce heat release rates that can range all heat release rate bins. This means that, in practice, the characterization of all transient fire scenarios at ANO-2 either results in a fire Froude Number that is within the NUREG-1824, Volume 1, validation range or falls below the NUREG-1824 validation range. When this occurs, the thermal plume that is expected from the ignition source fire could be wider than the range evaluated NUREG-1824, Volume 1. A wider thermal plume will have a greater entrainment rate than one associated with a similar heat release rate fire that has a smaller diameter. This means that the conditions relative to a source fire that falls within the validation range will be less severe both in terms of the concentration of combustion products and the temperature. Conversely, the hot gas layer descent time will be faster than a case that falls within the NUREG-1824, Volume 1, validation range for the Fire Froude Number. In the case of the

Generic Fire Modeling Treatments report (Report 1SPH02902.030, Rev. 0), Supplement 2 to the Generic Fire Modeling Treatments report (PRA-ES-05-007, Rev. 0), and the reports addressing the hot gas layer effects when secondary combustibles are involved (PRA-A2-05-011, Rev. 0 and PRA-A2-05-018, Rev. 0), the position of the hot gas layer is not a factor in determining the potential for target damage, so it may be asserted that conditions associated with low fire Froude Number scenarios that may arise among various transient ignition source configurations are bound by the calculation results. In the case of the main control room abandonment calculation (CALC-ANO2-FP-09-00013, Rev. 1), a low fire Froude Number may yield non-conservative results if the hot gas layer descent time is the limiting constraint, the abandonment condition is based on visibility, and the visibility is significantly greater than the abandonment threshold at the time the hot gas layer height reaches the threshold value. A review of the temporal plots provided in CALC-ANO2-FP-09-00013, Rev. 1, indicates that these conditions are generally not met for any scenario considered. In addition, a revised discussion on the fire Froude Number will be provided in the updated main control room abandonment calculation.

A number of conservative factors that would tend to increase the fire Froude Number (toward the range validated in NUREG-1824, Volumes 1 and 5) for the transients are not explicitly accounted for in the approximate calculation presented in Tables FM 03a-1 through FM 03a-3. These include the potential for the transient material to be consolidated or contained (causing most fire Froude Numbers to fall within the NUREG-1824 validation range) and for contained fires to have heat release rates that fall within intermediate heat release rate bins. Consequently, the application of the CFAST fire modeling results to transient fuel package fire scenarios at ANO-2 is considered to either fall within the NUREG-1824 validation range for the fire Froude Number or produce results that are more conservative than a comparable case that falls within the NUREG-1824 fire Froude Number validation range. Note that additional discussion on the Froude Number validation range will be provided in the updated main control room abandonment calculation.

*Cable Trays*

The last type of source fire for which CFAST is used to calculate the compartment conditions at ANO-2 involves cable tray fires (as secondary combustibles). These scenarios are currently addressed in Supplement 2 to the Generic Fire Modeling Treatments report (PRA-ES-05-007, Rev. 0) and in the hot gas layer report PRA-A2-05-011, Rev. 0, that addresses ignition source – secondary combustible configurations in specific ANO-2 enclosures. Additional ignition source – secondary combustible scenarios that involve CFAST modeling of cable tray fires are provided in Report PRA-A2-05-018, Rev. 0, in response to FM RAI 01i and FM RAI 01j.

The three documents consider the following types of cable tray fire scenarios over a one hour time interval:

- Two 0.91 m (3 ft) wide cable trays side-by-side. Cables are treated as thermoset in terms of fire spread, but have an effective heat release rate per unit area of 225 $kW/m^2$ (19.8 $Btu/s\text{-}ft^2$), which is comparable to the recommended value of 250 $kW/m^2$ (22.0 $Btu/s\text{-}ft^2$) in NUREG/CR-7010, Volume 1, for thermoplastic cable materials (PRA-ES-05-007, Rev. 0).
- One to eight 0.3 – 0.91 m (1 – 3 ft) wide cable trays arranged in a single stack. Cables are treated as thermoplastic in terms of the heat release rate and fire spread rate (PRA-A2-05-011, Rev. 0).

- One to eight 0.91 m (3 ft) wide cable trays arranged in a single stack. Cables are treated as thermoset in terms of the heat release rate and fire spread rate (Report PRA-A2-05-018, Rev. 0).

The fire Froude Number for the cable tray fire scenario is not readily computed using the methods described in NUREG-1934 due to the geometry and fire aspect ratio (i.e., the cable tray fire is a line type fire). Because a line type fire has more entrainment per unit length than an equivalent area source fire given the plume perimeter is greater, the use of an axisymmetric plume model to approximate the conditions for a line type fire is expected to be conservative when computing the temperature and smoke density. As was the case with the transient, the converse is true for the hot gas layer descent. However, the position of the hot gas layer is not a factor in determining the potential for target damage, thus it may be asserted that conditions associated with an axisymmetric equivalent area fire bound those of the line type fire for the applications at ANO-2.

A simple means of assessing whether the fire Froude Number for the cable tray fires falls within a range considered in NUREG-1824, Volume 1, is to assume the fire diameter is equal to the cable tray width for fires with a large length to width aspect ratio and to assume a diameter based on an axisymmetric area equivalent for fires with a small length to width aspect ratio. The transition from one regime to the other is not clearly defined; however, an aspect ratio greater than five is clearly a line-type fire. The use of the cable tray width in lieu of a diameter based on an axisymmetric area equivalent for fires provides an indication of the localized plume entrainment conditions of the line fire. Nevertheless, the calculation procedure would still generate an over-estimate of the effective fire Froude Number because the line fire entrainment on a unit length basis is less than area source equivalent when using the cable tray width.

Table FM 03a-04 summarizes the fire Froude Number calculation for the configuration involving two 0.91 m (3 ft) wide cable trays side-by-side assessed in PRA-ES-05-007, Rev. 0. In this calculation, the characteristic diameter of the ignition source is minimized and set equal to 0.61 m (2 ft). The table indicates that the fire Froude Number falls within the NUREG-1824, Volume 1, validation range of 0.4 – 2.4 regardless of the method used to compute the fire Froude Number.

Table FM 03a-4
Approximate Fire Froude Number for Cable Tray Source Fires Described in PRA-ES-05-007, Rev. 0

| Tray Width (m [ft]) | Number of Trays in Stack | Cable Tray Width Method | | | Axisymmetric Source Equivalent Method | | |
|---|---|---|---|---|---|---|---|
| | | Area Involved ($m^2$ [$ft^2$]) | Effective Diameter (m [ft]) | Fire Froude Number | Area Involved ($m^2$ [$ft^2$]) | Effective Diameter (m [ft]) | Fire Froude Number |
| 1.82 (0.55) | 1 | 3.31 (1.01) | 2.05 (0.63) | 0.51 | 3.93 (1.2) | 2.24 (0.68) | 0.58 |

Table FM 03a-05 summarizes the fire Froude Number calculation for the configuration involving one to eight 0.3 – 0.91 m (1 – 3 ft) wide cable trays arranged in a single stack with the cables treated as thermoplastic. The table indicates that the fire Froude Number falls within the NUREG-1824, Volume 1, validation range of 0.4 – 2.4 or is lower when the fire Froude Number is computed using the cable tray width. Conversely, the fire Froude Number for scenarios with large numbers of cable trays falls within the NUREG-1824, Volume 1, validation range of 0.4 - 2.4 or is higher when the fire Froude Number is computed using an area source equivalent diameter. However, the minimum fire size aspect ratio among all fire scenarios that have a fire Froude Number greater than 2.4 is 8.01, which indicates the appropriate method for computing the fire Froude Number is the cable tray width. As such, it is concluded that the fire Froude Number for the cable tray fire scenarios evaluated in PRA-A2-05-011, Rev. 0, falls within the NUREG-1824, Volume 1, validation range of 0.4 – 2.4 or is lower. As previously noted, if the fire Froude Number is lower than the NUREG-1824, Volume 1, validation range, the CFAST calculation method will produce a result that is more conservative than the equivalent scenario having a fire Froude Number that falls within the validated range.

Table FM 03a-5
Approximate Fire Froude Number for Cable Tray Source Fires Described in PRA-A2-05-011, Rev. 0

| Tray Width (m [ft]) | Number of Trays in Stack | Cable Tray Width Method | | | Axisymmetric Source Equivalent Method | | |
|---|---|---|---|---|---|---|---|
| | | Area Involved ($m^2$ [$ft^2$]) | Effective Diameter (m [ft]) | Fire Froude Number† | Area Involved ($m^2$ [$ft^2$]) | Effective Diameter (m [ft]) | Fire Froude Number† |
| 0.31 (0.09) | 1 | 0.10 (0.03) | 0.35 (0.11) | **0.03** | 2.18 (0.66) | 1.66 (0.51) | 0.40 |
| 0.31 (0.09) | 2 | 0.10 (0.03) | 0.35 (0.11) | **0.07** | 2.22 (0.68) | 1.68 (0.51) | 0.82 |
| 0.31 (0.09) | 3 | 0.10 (0.03) | 0.35 (0.11) | **0.10** | 2.26 (0.69) | 1.70 (0.52) | 1.25 |
| 0.31 (0.09) | 4 | 0.10 (0.03) | 0.35 (0.11) | **0.13** | 2.31 (0.70) | 1.71 (0.52) | 1.69 |
| 0.31 (0.09) | 5 | 0.10 (0.03) | 0.35 (0.11) | **0.17** | 2.35 (0.72) | 1.73 (0.53) | 2.14 |
| 0.31 (0.09) | 6 | 0.10 (0.03) | 0.35 (0.11) | **0.20** | 2.39 (0.73) | 1.75 (0.53) | **2.61** |
| 0.31 (0.09) | 7 | 0.10 (0.03) | 0.35 (0.11) | **0.23** | 2.44 (0.74) | 1.76 (0.54) | **3.08** |
| 0.31 (0.09) | 8 | 0.10 (0.03) | 0.35 (0.11) | **0.27** | 2.48 (0.76) | 1.78 (0.54) | **3.58** |
| 0.61 (0.19) | 1 | 0.37 (0.11) | 0.69 (0.21) | **0.10** | 4.28 (1.31) | 2.33 (0.71) | 0.69 |
| 0.61 (0.19) | 2 | 0.37 (0.11) | 0.69 (0.21) | **0.20** | 4.37 (1.33) | 2.36 (0.72) | 1.41 |
| 0.61 (0.19) | 3 | 0.37 (0.11) | 0.69 (0.21) | **0.29** | 4.45 (1.36) | 2.38 (0.73) | 2.14 |
| 0.61 (0.19) | 4 | 0.37 (0.11) | 0.69 (0.21) | **0.39** | 4.54 (1.38) | 2.40 (0.73) | **2.90** |
| 0.61 (0.19) | 5 | 0.37 (0.11) | 0.69 (0.21) | 0.49 | 4.62 (1.41) | 2.43 (0.74) | **3.68** |
| 0.61 (0.19) | 6 | 0.37 (0.11) | 0.69 (0.21) | 0.59 | 4.71 (1.44) | 2.45 (0.75) | **4.48** |
| 0.61 (0.19) | 7 | 0.37 (0.11) | 0.69 (0.21) | 0.69 | 4.79 (1.46) | 2.47 (0.75) | **5.30** |
| 0.61 (0.19) | 8 | 0.37 (0.11) | 0.69 (0.21) | 0.78 | 4.88 (1.49) | 2.49 (0.76) | **6.14** |
| 0.91 (0.28) | 1 | 0.83 (0.25) | 1.03 (0.31) | **0.19** | 6.39 (1.95) | 2.85 (0.87) | 0.95 |
| 0.91 (0.28) | 2 | 0.83 (0.25) | 1.03 (0.31) | **0.37** | 6.51 (1.99) | 2.88 (0.88) | 1.94 |
| 0.91 (0.28) | 3 | 0.83 (0.25) | 1.03 (0.31) | 0.56 | 6.64 (2.02) | 2.91 (0.89) | **2.95** |
| 0.91 (0.28) | 4 | 0.83 (0.25) | 1.03 (0.31) | 0.74 | 6.77 (2.06) | 2.94 (0.90) | **3.99** |
| 0.91 (0.28) | 5 | 0.83 (0.25) | 1.03 (0.31) | 0.93 | 6.90 (2.10) | 2.96 (0.90) | **5.07** |
| 0.91 (0.28) | 6 | 0.83 (0.25) | 1.03 (0.31) | 1.12 | 7.02 (2.14) | 2.99 (0.91) | **6.17** |
| 0.91 (0.28) | 7 | 0.83 (0.25) | 1.03 (0.31) | 1.30 | 7.15 (2.18) | 3.02 (0.92) | **7.30** |
| 0.91 (0.28) | 8 | 0.83 (0.25) | 1.03 (0.31) | 1.49 | 7.28 (2.22) | 3.04 (0.93) | **8.46** |

† Bold values indicate a fire Froude Number that falls outside the NUREG-1824, Volume 1, validation range of 0.4 -2.4.

Table FM 03a-06 summarizes the fire Froude Number calculation for the configuration involving one to eight 0.91 m (3 ft) wide cable trays arranged in a single stack with the cables treated as thermoset. The table indicates that the fire Froude Number falls within the NUREG-1824, Volume 1, validation range of 0.4 – 2.4 or is lower when the fire Froude Number is computed using the cable tray width. Conversely, the fire Froude Number for scenarios with large numbers of cable trays falls within the NUREG-1824, Volume 1, validation range of 0.4 – 2.4 or is higher when the fire Froude Number is computed using an area source equivalent diameter. However, the minimum fire size aspect ratio among all fire scenarios that have a fire Froude Number greater than 2.4 is 5.96, which indicates the appropriate method for computing the fire Froude Number is the cable tray width. As such, it is concluded that the fire Froude Number for the cable tray fire scenarios evaluated in Report PRA-A2-05-018, Rev. 0, falls within the NUREG-1824, Volume 1, validation range of 0.4 – 2.4 or is lower. As previously noted, if the fire Froude Number is lower than the NUREG-1824, Volume 1, validation range, the CFAST calculation method will produce a result that is more conservative than the equivalent scenario having a fire Froude Number that falls within the validated range.

Table FM 03a-6
Approximate Fire Froude Number for Cable Tray Source Fires Described in Report PRA-A2-05-018, Rev. 0

| Tray Width (m [ft]) | Number of Trays in Stack | Cable Tray Width Method | | | Axisymmetric Source Equivalent Method | | |
|---|---|---|---|---|---|---|---|
| | | Area Involved ($m^2$ [$ft^2$]) | Effective Diameter (m [ft]) | Fire Froude Number† | Area Involved ($m^2$ [$ft^2$]) | Effective Diameter (m [ft]) | Fire Froude Number† |
| 0.91 (0.28) | 1 | 0.83 (0.25) | 1.03 (0.31) | **0.11** | 2.51 (0.77) | 1.79 (0.55) | **0.27** |
| 0.91 (0.28) | 2 | 0.83 (0.25) | 1.03 (0.31) | **0.22** | 3 (0.91) | 1.95 (0.6) | 0.62 |
| 0.91 (0.28) | 3 | 0.83 (0.25) | 1.03 (0.31) | **0.33** | 3.48 (1.06) | 2.1 (0.64) | 1.06 |
| 0.91 (0.28) | 4 | 0.83 (0.25) | 1.03 (0.31) | 0.45 | 3.96 (1.21) | 2.25 (0.68) | 1.56 |
| 0.91 (0.28) | 5 | 0.83 (0.25) | 1.03 (0.31) | 0.56 | 4.45 (1.36) | 2.38 (0.73) | 2.14 |
| 0.91 (0.28) | 6 | 0.83 (0.25) | 1.03 (0.31) | 0.67 | 4.93 (1.5) | 2.51 (0.76) | **2.79** |
| 0.91 (0.28) | 7 | 0.83 (0.25) | 1.03 (0.31) | 0.78 | 5.42 (1.65) | 2.63 (0.8) | **3.51** |
| 0.91 (0.28) | 8 | 0.83 (0.25) | 1.03 (0.31) | 0.89 | 5.9 (1.8) | 2.74 (0.84) | **4.29** |

† Bold values indicate a fire Froude Number that falls outside the NUREG-1824, Volume 1, validation range of 0.4 – 2.4.

A number of conservative factors that would tend to increase the fire Froude Number (toward the range validated in NUREG-1824, Volumes 1 and 5) for the cable trays are not explicitly accounted for in the approximate calculation presented in Tables FM 03a-4 through FM 03a-6. These include the potential for the cable trays to be stacked rather than adjacent, the potential for the propagation distance to be limited due the physical dimensions of the actual cable trays for which the CFAST results are applied, and that the scenarios involving cable trays are usually coupled with electrical panels or transient ignition source fires, which would increase the fire Froude Number when viewed as a single heat source. Although CFAST does not have plume models that account for line-type fires and the fire Froude Numbers for an equivalent axisymmetric source fire are lower than the range evaluated NUREG-1824, Volume 1, the fires modeled and the temperature results predicted by CFAST are expected to bound those that would result from an actual ANO-2 configuration, since the hot gas layer height is not a factor in determining the conditions in the Generic Fire Modeling Treatments report (Report 1SPH02902.030, Rev. 0), Supplement 2 to the Generic Fire Modeling Treatments report (PRA-ES-05-007), and the reports evaluating the hot gas layer conditions are present (PRA-A2-05-011, Rev. 0 and Report PRA-A2-05-018, Rev. 0).

*Response – Part b*

The flame height to ceiling height ratio is a measure of the degree to which flames impinge on the ceiling surface. Flame impingement on a ceiling surface can affect the predictions of the ceiling jet temperature, the heat transfer to the ceiling surface, and the radiant heat flux at a specific target location. All three of these model output parameters are not used in the CFAST models developed for the ANO-2 FPRA.

The key model parameters used in the CFAST models developed for the ANO-2 FPRA are the hot gas layer temperature and, in the case of the control room abandonment calculation (CALC-ANO2-FP-09-00013, Rev. 1), the hot gas layer temperature, its height, and its composition. The hot gas layer composition and the hot gas layer height are primarily functions of the fuel properties, the entrainment into the fire plume from the lower layer, and the overall mass balance among the various forced and natural ventilation flow paths as described in NIST-SP-1026 ("CFAST – Consolidated Model of Fire Growth and Smoke Transport Technical Reference Guide"). When evaluated in a zone model, the entrainment into the hot gas layer from the lower layer is not directly affected by the flame extension under the ceiling, because per NIST-SP-1026 the entrainment occurs from the base of the fire to the interface between the hot gas layer and the lower layer. Indirect effects could arise through changes in the predicted temperature and layer density, though these are secondary effects relative to the transfer of mass from the lower layer to the upper layer and through forced and natural ventilation flow paths. In addition, the hot gas layer temperature is the only parameter that is used in developing the hot gas layer tables in the Generic Fire Modeling Treatments report (Report 1SPH02902.030, Rev. 0), Supplement 2 to the Generic Fire Modeling Treatments report (PRA-ES-05-007), Supplement 3 to the Generic Fire Modeling Treatments report (CALC-PRA-ES-05-006, Rev. 0), and the reports evaluating the hot gas layer conditions (PRA-A2-05-011, Rev. 0 and PRA-A2-05-018, Rev. 0). Specifically, there is no hot gas layer height threshold that is used to develop the hot gas layer tables in the Generic Fire Modeling Treatments report or in Supplement 2 to the Generic Fire Modeling Treatments report.

In terms of the temperature of the hot gas layer, a situation in which the flames impinge on the ceiling will result in relatively high heat fluxes from the fire to the wall boundary (see Section 2-14 of the *SFPE Handbook of Fire Protection Engineering* – 3rd Edition) as compared to areas exposed only to the hot gas layer. The CFAST models used by the ANO-2 FPRA do not use the heat transfer model between the ceiling jet and an adjacent space and, therefore, conservatively bound the hot gas layer temperature relative to a case in which the additional boundary heat losses are included. Further, there are no CFAST models used by the ANO-2 FPRA that credit or predict the detection actuation time using the ceiling jet models in CFAST or predict the target heat flux or temperature response due to flame radiation. In addition, the floor surfaces are adiabatic, so that flame radiation from the ceiling flames to the floor is conservatively retained by the hot gas layer. Although CFAST does perform the ceiling jet computation, the results are entirely superfluous to the output data that is used. This applies to the Generic Fire Modeling Treatments report (Report 1SPH02902.030, Rev. 0), Supplement 2 to the Generic Fire Modeling Treatments report (PRA-ES-05-007, Rev. 0), the reports evaluating the hot gas layer conditions when secondary combustibles are present (PRA-A2-05-011, Rev. 0 and Report PRA-A2-05-018, Rev. 0), the ignition source – secondary combustible hot gas layer conditions report (PRA-A2-05-018, Rev. 0), and the control room abandonment calculation (CALC-ANO2-FP-09-00013, Rev. 1).

It is noted that the updated main control room abandonment will include the applicable fire discussion on the flame length to ceiling height ratio provided in this RAI response.

Fire Modeling RAI 05

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

Section 4.5.1.2, "Fire PRA" of the LAR states that fire modeling was performed as part of the fire PRA development (NFPA-805 Section 4.2.4.2). This requires that qualified fire modeling and PRA personnel work together. Furthermore, Section 4.7.3, "Compliance with Quality Requirements in Section 2.7.3 of NFPA-805," of the LAR states:

> 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.
>
> During the transition to 10 CFR 50.48(c), work was performed in accordance with the quality requirements of Section 2.7.3 of NFPA-805. Personnel who used and applied engineering analysis and numerical methods (e.g., fire modeling) in support of compliance with 10 CFR 50.48(c) are competent and experienced as required by NFPA-805 Section 2.7.3.4.
>
> Post-transition, for personnel performing fire modeling or fire PRA development and evaluation, Entergy will develop and maintain qualification requirements for individuals assigned various tasks. Position Specific Guides will be developed to identify and document required training and mentoring to ensure individuals are appropriately qualified per the requirements of NFPA-805, Section 2.7.3.4, to perform assigned work (see Attachment S).

Regarding qualifications of users of engineering analyses and numerical models, please:

a) Describe what constitutes the appropriate qualifications for the staff and consulting engineers to use and apply the methods and fire modeling tools included in the engineering analyses and numerical models.

*Response*

Qualifications for fire modeling are based on the education and background for those individuals performing the fire modeling tasks. Entergy reviewed the resumes and work history of the individuals performing the fire modeling tasks and ensured that each task was performed by individuals with appropriate training in the fire modeling area being performed. The qualifications that are required for the staff and consulting engineers that use and apply these technologies depend in part on their specific assigned role on the project. In general, the qualification requirements for those who are technical leads in the preparation of technical tasks are consistent with and often exceed those articulated in NEI 07-12 for qualification of Peer Reviewers. Given the magnitude of the technical activity being performed, the technical leads are sometimes assisted by support staff. There are no specific qualifications for those in a support role as the assigned technical lead would retain overall technical responsibility for the entire body of work. The overall acceptability of the resulting body of work is established through the review and approval process of the associated analysis documentation.

b) Describe the process for ensuring the adequacy of the appropriate qualifications of the engineers and personnel performing the fire analyses and modeling activities.

*Response*

As part of the contract proposal process and prior to assigning the task, Entergy personnel reviewed the qualifications of the engineers and personnel performing the fire analyses and modeling activities as presented in their resumes. Individuals selected to perform tasks were required to have the appropriate background for these activities as described in Part a) of this response. For example, proposal evaluation and supplier selection activities are performed in accordance with the process established in EN-MP-105, which includes:

- Technical considerations
- Research and development effort
- Qualification of supplier's personnel
- Supplier's production capability
- Supplier's past performance

c) Describe the communication process between the fire modeling analysts and PRA personnel to exchange the necessary information, and any measures taken to assure fire modeling was performed adequately and will continue to be performed adequately during post-transition.

*Response*

During the preparation of the LAR, meetings were held between PRA and fire modeling staff to review the necessary fire models and to ensure the results accurately reflected the needs of the PRA model. In addition to the meetings, Fire PRA team members reviewed the documentation prior to its incorporation into the PRA model. The fire modeling results are contained in calculations, which are reviewed in accordance with the appropriate quality assurance program. These calculations were reviewed under the contractors QA program with individuals familiar with the technical aspects of the calculation. In addition, the fire modeling calculations were reviewed by individuals at Entergy who were qualified to the respective engineering processes. At Entergy, the process contained in either EN-DC-126, "Engineering Calculation Process," "EN-DC-147, "Engineering Reports," or EN-DC-149, "Acceptance of Vendor Documents," was used to perform the review of the fire modeling. Comments were provided by the appropriate Entergy individuals.

A similar process as described above will be utilized post-transition. Fire modeling will be performed as needed and reviewed by Entergy using the Entergy engineering processes reflected in EN-DC-126, “Engineering Calculation Process,” EN-DC-147, “Engineering Reports,” or EN-DC-149, “Acceptance of Vendor Documents.”

d) Describe the communication process between the consulting engineers and Entergy personnel to exchange the necessary information and any measures taken to assure the fire modeling was performed adequately and will continue to be performed adequately during post-transition.

*Response*

Please refer to the response to Part c) of this RAI.

**Radioactive Release**

Radioactive Release RAI 01

For areas where containment/confinement is relied upon:

a. Liquid

1) Describe whether the qualitative/quantitative assessment addresses capacities of sumps, tanks, transfer pumps, etc.
2) Describe whether operator actions are specified (e.g., to direct effluent flow/overflow with temporary measures (drain covers, etc)).
3) Describe any plant features that may divert the effluent flow that were not taken into account (e.g., Aux. Bld. roll-up doors).
4) Describe whether any of the sumps being relied upon, have auto pump out features (an automatic discharge/release at a certain sump level).

b. Gaseous

1) Describe whether the qualitative/quantitative assessment addresses filtering and monitoring of confined gaseous (smoke) effluent.
2) Describe whether operator actions are specified (e.g., "manual" ventilating fire areas to other ventilated areas).
3) Describe whether there are any that can bypass the planned filtered/monitored ventilation pathway that have not been accounted for.

*Response*

No quantitative assessment has been performed. This response provides a description of the overall capabilities for directing, monitoring, and processing potentially contaminated liquid and gaseous effluent from firefighting activities in lieu of a discussion of the above attributes for each specific question.

Any unforeseen circumstances where contaminated effluents may be released outside the containment/confinement area will be monitored by Radiation Protection (RP) personnel to ensure appropriate actions are taken by the Fire Brigade, Operations personnel, or others, as needed. Therefore, in areas where firefighting liquid containment/confinement is relied upon, involving contaminated effluents directed to a sump or drain system that has the capability to retain such contaminated water, no specific actions/methods were determined to be required.

The pre-fire plans provide a listing of the fire hazards, radiation hazards, hazardous materials (both in itself and products produced during combustion), physical hazards, electrical hazards, and compressed gases for each fire zone to alert the Fire Brigade members of potential hazards. Pre-fire plans also provide guidance for potential ponding and ventilation concerns. Fire Brigade members receive training in responding to fires in radiologically controlled areas (RCAs) (lesson plan ASLP-FP-CAFRS). Additionally, continuous RP support is required if the fire is in a RCA. When the fire impacts radiologically controlled material stored in the owner controlled area, but outside the RCA, OP-2203.034. “Fire or Explosion,” includes steps to direct RP personnel to monitor radiological conditions.

The ANO-2 facility is specifically designed to contain, process, and monitor radiological fluids and materials. The major designated RCA for containing materials and fluids of significant radiological concern is the ANO-2 Auxiliary Building. The Low Level Radwaste Building (LLRWB), located away from the major plant buildings, is also a designated RCA worthy of note, but does not contain the radiological material/fluids of higher radioactivity as compared to the Auxiliary Building. While capable of containing some amount of potentially contaminated water resulting from firefighting activities, any liquid release from the LLRWB will be monitored as discussed above and as discussed in response to Radioactive Release RAI 02 below. The LLRWB is also equipped with a Super Particulate Iodine and Noble Gas (SPING) monitor in support of gaseous releases via the building ventilation exhaust system, which may also be monitored locally by RP and Chemistry personnel.

The ANO-2 Auxiliary Building is designed to house systems containing radiological fluids and accommodate leaks and piping breaks. Whether from a radioactive system or firefighting activities, liquids are directed to floor drains and openings leading to below grade portions of the building where several tanks are housed for the storage, holdup, and decay of potential radioactive liquids. ANO-2 has up to 10 tanks available below grade in the Auxiliary Building (over 200,000 gallon total storage capacity), six of which are housed in “vaults” that can contain substantial amounts of liquid should tank capacities be exceeded. Should firewater reach non-sealed doors located above grade and leading to areas of the plant outside the Auxiliary Building, any liquid release would continue to be monitored and assessed as described above. Note also that the Auxiliary Building and the portions of systems housed therein which are exposed to room atmosphere are maintained in a relatively clean condition, i.e., having very low level of surface radioactivity or none at all. Therefore, potentially contaminated firewater reaching areas outside the Auxiliary Building is not likely to be of significant radiological dose consequence.

In addition to the design of the Auxiliary Building with regard to liquid containment/confinement, the Auxiliary Building, and adjacent buildings that may house lower levels of radioactive material, have installed ventilation systems with separate installed SPING monitors. Again, local monitoring by RP and Chemistry personnel is employed when SPING monitors are out of service or in areas where the potential for gaseous radiological release exist that bypass points that are monitored by installed instrumentation.

Radioactive Release RAI 02

For areas where containment/confinement is not available describe whether a quantitative assessment was performed and if so, whether the assessment credited operator actions.

a. If operator actions are credited, describe whether they are specifically addressed in the fire pre-plans and in fire brigade training materials.

*Response*

No quantitative assessment has been performed. This is based on the limited potential for radiological release from areas where containment/confinement of potentially contaminated fire-fighting activities is not available. The implementing procedures are listed below:

EN-RP-121, "Radioactive Material Control"

EN-RP-113, "Response to Contaminated Spills / Leaks"

OP-1052.030, "ANO Spill Prevention Control and Countermeasure Plan"

OP-2203.034, "Fire or Explosion"

EN-RP-121 provides requirements for handling, controlling, storing and accountability of radioactive material. All radioactive material (RAM) stored outside of a RCA is required to be identified and monitored. RAM storage outside of the RCA requires permission of a RP supervisor and must be properly contained and logged. Any potential spills or leaks, such as during a fire, are controlled by EN-RP-113 and OP-1052.030.

The pre-fire plans provide a listing of the fire hazards, radiation hazards, hazardous materials (both in itself and products produced during combustion), physical hazards, electrical hazards, and compressed gases for each fire zone to alert the Fire Brigade members of potential hazards. Pre-fire plans also provide guidance for potential ponding and ventilation concerns. Additionally, Fire Brigade members receive training in responding to fires in controlled access areas with the support of RP personnel (lesson plan ASLP-FP-CAFRS). When the fire impacts RAM stored in the owner controlled area, but outside the RCA, OP-2203.034 includes steps to direct RP personnel to monitor radiological conditions.

**Probabilistic Risk Assessment (PRA)**

Note: The response to PRA RAI 01gii, 05, 10, and 15, 90-day RAIs, are included in this 60-day response below. PRA RAIs 01d and 08 are expected to be addressed in the 90-day RAI response. PRA RAIs 01gi, 03 (results), 06 (results), 09 (results), 10 (results), 14, 16, and 17 are expected to be addressed in the 120-day RAI response.

PRA RAI 01 – Fire PRA Facts and Observations (F&Os)

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

Please clarify the following dispositions to fire F&Os and Supporting Requirement (SR) assessment identified in Attachment V of the license amendment request that have the potential to impact the fire PRA results and do not appear to be fully resolved:

a) CF-B1-01 (Finding, Not Met at CC-I/II/III)

This F&O disposition explains that the altered events table in Attachment F of the Fire Scenarios Report (PRA-A2-05-003) has been revised to correct discrepancies such as incorrect references to EC13540, "ANO-2 Cable Routing Exclusions to Support Fire PRA for NFPA-805." Review of the current FRANC tables by the NRC Staff identified the following additional apparent discrepancies.

i. The "FRANC Altered Events" table defines basic event PMV2CV052N to be "MOV 2CV-1052 FAILS TO OPEN," but states in the "Notes" column that "only 1 cable in the control room can result in spurious opening of the valve" and therefore a modification to prevent spurious opening is proposed. Please clarify what PMV2CV052N failure mode was modeled in the fire PRA and explain the inconsistency in the referenced failure mode.

ii. The "FRANC Altered Events" table "Note" column for basic event PMV201052R (MOV 2CV-1052 Transfers Open) and PMV201002R (MOV 2CV-1002 Transfers Open) references the "Note" for event PMV2CV052N (MOV 2CV-1052 Fails to Open), but these two events are not included in Attachment K List of Modifications. Clarify that protection of Conductor 1F of Cable R2 will protect for both failure modes of MOV 2CV-1052 and for MOV 2CV-1002.

Please summarize the review that was performed that provides confidence that additional discrepancies do not exist.

*Response*

i. Basic event PMV2CV052N represents “MOTOR-OPERATED VALVE 2CV-1052 FAILS TO OPEN” in the Fire PRA (FPRA). Similarly, basic event PMV2CV002N represents “MOTOR-OPERATED VALVE 2CV-1002 FAILS TO OPEN.” These events were removed from the FRANC altered events table during the review and validation described below.

ii Basic events PMV201052R and PMV201002R were also removed from the FRANC altered events table during the review and validation described below. Also, a modification to protect conductor 1F of cable R2/G2 for MOVs 2CV-1052 and 2CV-1002 is not credited in the updated baseline Fire PRA model and is not included in the list of modifications in LAR Attachment S.

A review of the altered events table has been performed resulting in deletion of the types of discrepancies cited in the findings and observations (F&O) and in the RAI. Based on this review and validation of the altered events in support of the updated baseline FPRA, these discrepancies have been eliminated from the Altered Events table. Altered Events referencing EC-13540 which remain in the updated baseline FPRA have been confirmed against the EC. Altered Events related to modifications have been confirmed against the list of modifications in LAR Attachment S.

b) CS-B1 (Suggestion, CC-I) CS-C4-01 (Finding, Not Met at CC-I/II/III)

Section 4.1 of the Component and Cable Selection report (PRA-A2-05-005) states that mapping of the PRA Basic Events is provided in Appendix A "BE Mapping/Dispositions." This appendix describes the FREVENT (Safe Shutdown List Component ID) field as providing the TAG (equipment ID) mapping to the BE, populated when the basic event is used to disable the mapped equipment. The appendix states for Disposition Codes Y3, N1, N2, or N3 this field is not used (N/A); however numerous Y3 dispositions do have the FREVENT Field. In light of these apparent discrepancies, please explain how the Disposition Codes are used to identify basic events that will be failed following each fire.

*Response*

Table 4-1 of the Component and Cable Selection report (PRA-A2-05-005) correctly describes how the basic event disposition codes are used to identify basic events (BEs) that will be failed following a fire. As indicated, the Y3 code is associated with BEs that did not have cable routing data available and that are assumed failed in all fire scenarios unless credited by exclusion. To facilitate the mapping of multiple basic events associated with a single component, a component ID (FREVENT) is provided in the TAGBE table. The component ID or BE name for each Y3 basic event is included in the FRANC UNL (unknown location) table to cause failure in all fire scenarios. The response to PRA RAI 02 explains that specific Y3 components have been excluded from failing in specific fire scenarios after confirmation that their cabling could not be impacted by the scenario. The FRANC excluded events table is used to make the scenario-specific changes.

The quoted sentence in Section 4.1 of the report incorrectly includes Y3 components in the list of dispositions that have “N/A” in the FREVENT field. The “N/A” disposition was used for N1, N2, or N3 components, but was not used for Y3 components. This sentence has been corrected.

c) FSS-A4-01 (Finding, Met at Cat-I/II/III):

Entries in Attachment A-2 of the Fire Scenario report (PRA-A2-05-003) indicate that a large number of targets were added or revised in response to this F&O. Examples from comments in the "Notes" include: "targets added during drawing review" (e.g., page 365), "Corrected entry from comparing Walkdown Data with XX2 Table on Plant Data" (e.g., page 368), "Target not identified in walkdowns, but in PDMS XX2. Target added to high congested scenarios conservatively to increase confidence level" (e.g., pages 369 to 2208), "Revised invalid ID# to match PDMS" (e.g., pages 2219 to 2222), "Added to conservatively account for PDMS match of target A4001 during database review" (e.g., page 2223), and many others. In light of the large number of changes made to the target list, please explain why the updated list of targets can now be characterized as complete. Include description of the mechanisms (e.g., walkdowns, drawing reviews and database review) that were used to achieve a final set of targets.

*Response*

A combination of walkdowns, drawing reviews, and database reviews was used to ensure the list of targets is complete. The target list at the time of the peer review was derived from the original walkdowns. Changes were made to this list of targets as described below.

1. To address the original peer review F&O, a drawing review was performed to identify raceways which were within the zone of influence but had not been identified during the walkdowns due to congestion of raceways. These additional targets are identified by reference to a “drawing review.”
2. Additional walkdowns were performed using a grid defining the location of each potential transient combustible to revise the general transient zone of influence heat release rate to 317 kW.
3. Following the additional walkdowns, the walkdown targets were reviewed to correlate them with data in the cable and raceway database (PDMS). Some changes were made since PDMS sometimes identifies the same target with multiple identifiers. Various notes are used to identify these changes.
4. Also, the targets within each fire zone in PDMS were reviewed to ensure that all targets were impacted by at least one transient fire scenario. If a target within a fire zone was not impacted by any transient scenarios, that target was conservatively included in all transient scenarios. These additional targets are annotated in the database as follows: “Target added to high congested scenarios conservatively to increase confidence level.”

This combination of walkdowns, drawing reviews, and database reviews was used to ensure the list of targets is complete.

e) FSS-B2-01 (Finding, Met at Cat-I/II/III):

The disposition to this F&O states that detailed analysis was performed to calculate conditional core damage probability (CCDP) for MCR abandonment. Table 4-1 of the Fire PRA Summary report (PRA-A2-05-004) presents a CCDP of 6.97E-2 for MCR abandonment scenario listed as "2199-G/A." It is noted that this is a lower value than the screening value of 0.1 in use at the time of the Fire PRA peer review. The Fire Area G Fire Risk Evaluation identifies four credited Recovery Actions (RAs) that appear to be the actions credited for MCR abandonment (i.e., RHF2LTDWNP, RHF2RCPSLP, QHF2P75BFP, and QHF2SGLCXP). Other RAs for Fire Area G, where the MCR is located, are identified in Attachment G of the LAR but credited for Defense in Depth only. The Fire PRA New Human Failure Events report (PRA-A2-05-002) provides detailed Human Error Probability (HEP) analysis for each of the four credited RAs. Please explain how the CCDP for MCR abandonment and alternate shutdown was calculated. Include in this explanation:

i. Identification of all the actions required to accomplish alternate shutdown including actions credited before leaving the MCR; explanation of why RAs listed for Fire Area G that appear to be abandonment actions following a fire in the MCR are not needed or credited; and justification that actions credited for MCR abandonment are sufficient to reach safe shutdown.

ii. Identification of events and conditions that prompt the decision to transfer command-and-control from the MCR to the alternate shutdown locations, and discussion of whether and how loss-of-control due to fires in the MCR or Cable Spreading Room (CSR) were modeled.

iii. Confirmation that feasibility of operator actions supporting alternate shutdown was assessed.

iv. Justification for assuming continuous communication and coordination of actions and operator performance, including consideration of the fact that there is no primary control station.

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

*Response*

The CCDP for the main control room (MCR) abandonment scenario is calculated by setting the failure probability for all operator actions to 1.0, except for the credited actions specified below, in addition to the affected/assumed circuit failures within the main control room envelope. Following implementation of the proposed modifications listed in Attachment S of the LAR, the control room abandonment CCDP is dependent upon the random failures of the reactor coolant system (RCS) boundary, random failures of the components associated with the new Auxiliary Feedwater (AFW) pump and failure of the credited recovery actions.

i. The only action credited prior to leaving the main control room is a reactor trip. Actions RHF2LTDWNP (isolate letdown by deenergizing valves) and RHF2RCPSLP (trip reactor coolant pumps (RCPs) at switchgear) are required to ensure RCS integrity is maintained and that inventory is not compromised by losses due to an open letdown path or due to an RCP seal Loss of Coolant Accident (LOCA). Action

QHF2P75BFP represents the actions associated with control and alignment of the new AFW pump at its control station. QHF2SGLCXP is not credited in the control room abandonment scenario, but is credited in other Fire Area G scenarios in which Emergency Feedwater (EFW) is available.

The PRA success criteria can be achieved through the use of secondary heat removal to provide controlled cooling that does not require RCS makeup or boration for non-LOCA sequences. Thus, the actions to preclude RCS inventory loss and maintain control of secondary heat removal via the new AFW pump are the actions required to prevent core damage for an abandonment scenario. The actions identified as defense in depth include actions for aligning the EFW system for secondary heat removal and actions required to meet the cold shutdown success criteria by maintaining RCS inventory, maintaining boration levels, and maintaining pressurizer level within the pressurizer indicating range.

ii. Transfer of command and control from the MCR to the alternate shutdown locations is based solely on MCR habitability criteria. The analysis for the non-abandonment scenarios in Fire Area G, including those in the MCR and cable spreading room, shows that these fires will result in limited damage. Loss of control due to this damage is modeled by failing the targets associated with each specific scenario.

iii. Feasibility of Operator actions supporting alternate shutdown was assessed to the 11 feasibility criteria in FAQ 07-0030 as described in the response to RAI SSA-07. Feasibility of the control of secondary heat removal via the new AFW pump is based on its isolation from plant fire areas for which it is credited. The pump and its support equipment are being designed to survive fires for which the new pump is credited and to be accessible via pathways not impacted by fires for which it is credited. The time available for establishment of AFW is addressed in the quantification of the HEP for event QHF2P75BFP in PRA-A2-05-002.

iv. Coordination of actions during post MCR abandonment shutdown will be achieved by direct communication between the Operations Shift Manager, who provides command and control, and other Operators performing actions required to support shutdown. Most manual actions, such as repositioning a valve or tripping a breaker, do not require continuous communications (e.g., an Operator repositions a valve and then communicates the completion of that action back to the Shift Manager). Also, hand-held communications equipment is procedurally mandated for Operations personnel during post-fire shutdown. Thus, the communications criterion is met for the actions required to accomplish alternate shutdown.

v. All credited actions in the FPRA had the HEPs evaluated in the dependency analysis. The associated dependency for each combination of credited actions has been incorporated into the quantification via a recovery rule file which is applied in the post-processing of the fire scenario cutsets. The methodology used for evaluating dependencies between individual actions is the same as that used in the full power internal events PRA model as described in PRA-A2-05-002 and below.

Each set of multiple interactions was examined in the context of the cutsets in which they occurred to obtain a meaningful assessment of their combined probabilities. This was done in each case by laying out a time line for the sequence of events of interest, and by considering qualitatively the factors that imply dependence or independence for the combined events. For cases in which there were more than two events, this entailed considering the level of dependence between the first two events, and then the conditional level of dependence for successive events, given that the earlier failures had occurred.

Once the qualitative levels of dependence were assessed, the corresponding quantitative characterizations were applied. The qualitative factors taken into account in assessing the level of inter-event dependence included the following:

- Events that refer to the same action were considered completely dependent. For example, in a limited number of cases, separate human interactions could have been used to reflect the failure to initiate different trains of a particular system. This is actually a single event with respect to diagnosis and decision-making.

- Interactions related by time were assessed to have a decreasing level of dependence as the time between them increased:

  - Interactions occurring close in time (i.e., within about 15 minutes) were assessed to be at least moderately dependent (other factors could lead to an assessment of high or complete dependence).

  - Low dependence was applied for interactions separated by up to about an hour for which no other factors applied.

  - Interactions separated by more than an hour were assessed to be independent, unless factors other than time suggested dependence.

Interactions that imply actions based on nearly the same cues were assessed using one level of dependence higher than that implied by the nominal time-based delineation described above. For example, two events occurring close in time and whose diagnosis would be dependent on similar cues were assessed to be highly dependent.

In some cases, a scenario might imply a successful action occurring between (in time) two events denoting failures. In these cases, the successful action may de-couple the other two interactions (i.e., zero dependence would apply). This would be the case when the interceding event is directly relevant to at least one of the two failures. If the interceding event is completely unrelated, the level of dependence was assessed to be one step lower than that which would otherwise be used.

For cases in which there are three or more human interactions, the third interaction was generally assessed to be at least moderately dependent on the first two, since each additional interaction may imply that it is more likely the operating crew has made a fundamental misdiagnosis. Subsequent interactions are likewise at least highly dependent on the preceding events. This was applied unless the multiple interactions are widely spaced in time, or later interactions are preceded by a successful action.

f) FSS-D8-01 (Finding from Table V-2, Not Met at CC-I/II/III):

The disposition of this F&O explains that the transient fire heat release modeled for the CSR was reduced to 69 kilowatts (kW) from 317 kW (i.e., the recommended 98$^{th}$ percentile transient fire from Table G-1 of the NUREG/CR 6850). Identify any other areas where the heat release rate was reduced to 69 kW from 317 kW. For fire areas where the HRR was reduced provide justification. Please include:

i. Description of the specific administrative controls that will be added to the Control of Combustible procedure (EN-DC-161), and how those controls will address the locations and types of existing and potential transient combustible material in the CSR.

ii. The results of reviewing of records related to violations of transient combustible controls and other key factors that support this reduced fire size.

*Response*

i. The NFPA-805 LAR, Attachment S, Item S2-4, provides an implementation item for a programmatic commitment associated with incorporation of the transient controls credited in the Fire PRA into the existing Entergy Control of Combustibles Procedure, EN-DC-161. This procedure specifies the following levels of control for areas where transients are not to be stored (from Attachment 9.1 of EN-DC-161):

> "Level I: A continuous fire watch shall be posted for any transient combustible left unattended in these fire zones IAW OP-1000.120."

These controls will be imposed on the following fire zones for which reduced transient heat release rates of 69 kW were applied in the FPRA (ANO-2 Fire Probabilistic Risk Assessment Fire Scenarios Report NUREG/CR-6850 Tasks 8 and 11, PRA-A2-05-003, Rev. 0, Table 8-1 and ANO-2 Revised Baseline and Sensitivity Analysis, PRA-A2-05-010, Rev. 0, Section 6.0).

| Fire Zone | Zone Description | Fire Area |
|---|---|---|
| 2109-U | Corridor and Motor Control Center | JJ |
| 2111-T | Lower South Electrical Penetration Room | EE-U |
| 2096-M | Motor Control Center | HH |
| 2098-L | Unit 2 Cable Spreading Room | G |
| 2112-BB | Lower North Electrical Penetration Room | B-3 |
| 2154-E | CEDM Equipment Room | B-4 |
| 2183-J | Upper North Electrical Penetration Room | B-3 |

ii. Attachment C of the Fire Scenarios Report documents the review of transient control non-conformances. This review identified a few minor violations at the ANO site of the zero transient zone requirements currently specified in procedure EN-DC-161. The review encompassed the time period from February 15, 2007 to September 23, 2011.

During this 4½ year period, only three violations of the combustible control program were identified for zones implementing this combustible control procedure. These instances were associated with a plastic cart, electrical wiring staged for a bus outage, and duct tape. In each of these instances a small amount of combustible material, and no transient ignition source, were involved.

The reduced fire size of 69 kW applied to these zero transient fire zones is consistent with the vast majority of transient fires identified in the EPRI Fire Events Database. The 69kW heat release rate accurately represents the credible fire size in a strictly controlled transient combustible area. The larger heat release rates for transient fires in Tables G-7 and G-8 of NUREG/CR-6850 are based on combustible quantities much greater than those permitted (or found) in ANO zero transient zones and in configurations which would not typically include an ignition source. A more typical transient fire is a temporary electrical cable providing both the ignition source and the associated combustible loading. This type of fire is better defined by the motor fire heat release rate. Therefore, the motor fire heat release rate from NUREG/CR-6850 Table E-8 was used in the evaluation of "zero transient" fire zones.

g) FSS-E2-01 (Finding, Not Met at CC-I/II/III)

The disposition to this F&O refers to a method submitted to the Electric Power Research Institute (EPRI) Fire PRA Methods Panel regarding the conditional probability of fire propagation from electrical cabinets that was rejected in a letter from NRC staff (letter from Joseph Giitter of NRC to Biff Bradley of NEI dated June 21, 2012, see ADAMS Accession No. ML12171A583). Section V.2.2 of the LAR cites a sensitivity study performed to remove credit for the electrical panel factors associated with this approach and incorporated the results of new fire modeling. In light of this, please provide:

ii. Description of the additional modeling done to remove credit for electrical panel factors. Include discussion of how fire propagation from open versus closed cabinets was performed in the sensitivity study.

*Response*

The electrical panel factors were removed in the ANO-2 sensitivity analysis cited in Section V.2.2 of the LAR [PRA-A2-05-010, ANO-2 Baseline Sensitivity Analysis], which demonstrated that the ANO-2 FPRA met the RG 1.205 requirements with the panel factors removed. The electrical panel factor was a split fraction of the fire ignition frequency which accounted for the fraction of fires in the EPRI fire events database that were suppressed before damage propagated to external targets outside the panel. The electrical panel factors were removed entirely from the FPRA analysis. Fire propagation for all vented electrical panel fire scenarios are characterized by the zone of influence generated from the *Generic Fire Modeling Treatments,* Rev. 0. No fire propagation was postulated for a robustly sealed electrical panel that satisfied the criteria of Chapter 08 (FAQ 08-0042), of Supplement 1, to NUREG/CR-6850.

As part of the sensitivity analysis, once the panel factors were removed, additional fire modeling was performed for certain fire scenarios to reduce the fire area risk. The new fire modeling is documented in PRA-A2-05-011, *Development and Timing of Hot Gas Layer (HGL) Conditions in Selected ANO-2 Fire Zones,* and described below.

1. Fire Modeling Credit for Suppression for Panel Fire Scenarios in 2109-U

   For fixed ignition source scenarios 2109-U-B/C/D/E/F/G, detailed fire modeling was performed based on the specific ignition source, heat release rate (HRR) profile, configuration of secondary combustibles, and location relative to the automatic suppression system available in Fire Zone 2109-U. The manual non-suppression probability term is calculated following the process described in Appendix P of NUREG/CR-6850 utilizing the suppression curves from Chapter 14 (FAQ 08-0050) of Supplement 1 to NUREG/CR-6850.

2. Fire Modeling Credit for Suppression and Detection in Fire Zone 2098-C

   *Section 11.0, Smoke Detector Response Timing for Fire Zone 2098-C* in PRA-A2-05-011, applies detailed fire modeling for the panels located within Fire Zone 2098-C to ensure that if the Halon suppression system actuates as designed, no damage to the cable targets above the panel will occur before the suppression system is designed to actuate. The FPRA evaluates two scenarios (with and without Halon suppression) for each panel in Fire Zone 2098-C.

3. Detailed Fire Modeling of Select Fire Compartment Interactions with Adjacent Fire Compartments Sharing a Common Boundary (Multi-Compartments Analysis MCA).

   Additional fire modeling was utilized and described in *Section 10*, *Screening of Multi-Compartment Scenarios* [PRA-A2-05-011] for evaluation of specific multi-compartment scenarios. Table 11, *List of Multi-Compartment Analysis Compartments*, in PRA A2-05-011 lists the fire zones that were evaluated.

   The four combinations of initiating (exposing) fire zones and adjacent (exposed) fire zones with the smallest total volume were evaluated in CFAST. The worst configuration of heat source and secondary combustibles was postulated in the exposing fire zone and evaluated, to determine the time to cable damage in the exposed fire zone. The exposed zone did not reach the cable damage threshold temperature in any of these worst-fire, small volume cases. The CFAST results for the small volumes were used to screen the multi-compartment combinations with larger volumes.

This fire modeling and its use in the FPRA model were peer-reviewed as part of the focused scope peer review in November 2012 (see response to PRA RAI 18).

h) HRA-A2-01 (Finding, Not Met at CC-I/II/III)

> This F&O cites ANO-2 fire PRA staff as saying that as part of NFPA transition the fire-related procedures will "be changed to make them more symptom-based and remove many of the steps currently in the procedures." It is not clear whether this intention to update the fire procedures is included as part of the Implementation Items listed in Table S-2 of the LAR. Please clarify that update of the fire-related procedures is an Implementation Item listed in Table S-2, and that the PRA will be revised to reflect the new procedures when they are completed per Implementation Item S2-9.

*Response*

Update of the fire-related procedures is captured in LAR Table S-2, Implementation Item S2-6. This implementation item envelopes all changes to plant operating procedures that direct operator actions in response to a fire, including revising the procedures to establish a more symptom-based approach with respect to fire response.

The PRA will be revised under LAR Table S-2, Implementation Item S2-9, to address all modifications and implementation items, including the procedure changes in Implementation Item S2-6. This update will be performed in accordance with Entergy fleet PSA Maintenance procedure EN-DC-151, Section 5.2, which requires that all procedure changes be incorporated in PRA updates.

i) IGN-A7-01 (Finding, Met at CC-I/II/III):

> The Fire Scenario report (PRA-A2-05-003) states (page 8756) that the floor area of Turbine Bay is 79,406 square feet. Based on this, it appears that only a very small portion (1.5%) of Turbine Bay (TB) fire frequency is assigned to transient fire scenarios as the ignition source area is assumed to be 100 sq. ft. and there are only 12 transient scenarios. Section 8.3 of the Fire Scenario report explains that in response to the F&O a revision using the actual floor area of the zone of influence was used leading to an increase in the floor area used in calculating the ignition frequency. However, it is not clear this approach significantly changed the fraction of TB fire frequency assigned to a transient fire scenario. Please explain how the transient frequency was distributed for the TB floor area and justify excluding any areas of the TB from consideration.

*Response*

Due to the size of the turbine building and the limited number of high risk related cables routed through the turbine building, a unique transient analysis was used for this fire zone. The methodology used for evaluation of the turbine building (Fire Zone 2200-MM) transient scenarios was to identify twelve areas of the room in which critical targets are located, including “pinch-points” where targets from two different safety divisions can be damaged by the same fire, as described in Attachment H of the ANO-2 Fire Probabilistic Risk Assessment Fire Scenarios Report NUREG/CR-6850 Tasks 8 and 11, PRA-A2-05-003, Rev. 0. The fraction of the transient frequency applied to each of these risk significant scenarios was the fraction of the total turbine building floor area that comprises the specific scenario.

The remainder of the transient ignition frequency was applied to a Transient Fire Base Scenario (Scenario 2200-MM/A). This scenario uses the total ignition frequency of the turbine building with a severity factor representing the fraction of the turbine building floor area that was not included in the twelve risk significant transient scenarios (a severity factor of 0.967 was used). All components with cables in the turbine building, except the critical targets impacted in the risk significant transient scenarios, were conservatively assumed to be impacted in this "transient base" scenario. This methodology ensures a bounding, but not overly conservative, assessment of the risk from transient fires in the turbine building.

In summary, no areas of the turbine building were excluded. The total ignition frequency for transients in the turbine building is accounted for between the risk significant transient scenarios and the transient fire base scenario.

j) PRM-C1-01 (Finding, Not Met at CC-I/II/III):

This F&O finds that fire PRA documentation parallel to internal events PRA documentation does not exist (e.g., initiating event, accident sequence, success criteria, system, and data notebooks). The F&O disposition contends that fire PRA models, to a large degree, are the internal events PRA models and that the differences between the models used in the fire PRA versus the internal events PRA are identified in the Component and Cable Selection report (e.g., in Appendices D, E, F, and H). Section 4.5.2 of this report states that no initiating events, accident sequences, success criteria or data analysis methods were required to incorporate fire induced failures into the internal events model. It is not clear that the fire PRA reports provides a complete basis and accounting for fire PRA modeling. Please identify where information about such modeling discussion appears in the current fire PRA documentation.

*Response*

The revisions to the full power internal events model necessary to develop the FPRA plant response model required incorporation of multiple spurious operations (MSO) within the existing internal events accident sequences. All new failure modes resulting from added MSO events were incorporated in an existing internal events sequence. Changes to the internal events model are documented in the Component and Cable Selection Report (PRA-A2-05-005) in Appendix D (Multiple Spurious Operations Expert Panel Review and Disposition of Open Items), Appendix E (Spurious ESFAS Actuation Evaluation), Appendix F (Additional Changes to Internal Events Model for Fire PRA Quantification), Appendix G (Review of Internal Events Screening of Initiators and ISLOCA/LERF Pathways), and Appendix H (Model Implementation of Proposed Plant Modifications, HRA and Model Refinements Resulting from NFPA-805 Fire Risk Evaluations). No new initiating events, accident sequences, success criteria, or data analysis methods were required for the ANO-2 FPRA. A statement documenting the completion of this review is provided in the Component and Cable Selection Report, Section 4.5.

k) UNC-A1-01 (Finding, Met at CC-I/II/III):

As indicated by the F&O disposition, the Fire PRA Uncertainty/Sensitivity Analysis report (PRA-A2-05-006) presents the results of propagation of parametric data uncertainty for basic events in the plant response model, human failure events (HFEs), non-suppression probabilities, and circuit failure mode probabilities, while Appendix D of the Fire PRA Summary report (PRA-A2-05-004) qualitatively characterizes the sensitivity of the fire PRA results to sixteen sources of uncertainty. Please:

i. Clarify the extent to which propagation of parametric uncertainty includes state-of-knowledge-correlations (SOKC) between event probabilities including fire event related parameters (e.g., spurious operation probabilities).

ii. Confirm that the CDF, LERF, ∆CDF, and ∆LERF values reported in Attachment W of the LAR are based on calculated mean values from propagation of parametric data uncertainty and SOKC.

*Response*

i. Uncertainty intervals associated with FPRA unique parameters were correlated to ensure consistency in application of the uncertainties. Type codes were created and utilized to ensure SOKC was maintained. For example, a type code was developed for each fire ignition source bin. A mean fire ignition frequency per ignition source and its associated uncertainty were assigned to each bin. This structure allowed the parametric uncertainty analysis to correlate uncertainty in the scenario ignition frequencies with uncertainty in the underlying source bin frequencies; thus, this approach avoided the inappropriate assumption that the scenario frequencies are independent of each other. This approach to the uncertainty analysis to maintain SOKC was also utilized for the other fire event related parameters: spurious operation probabilities, non-suppression probabilities, fire ignition frequencies, human failure event probabilities, and existing internal events component random failure probabilities and unavailability frequencies.

ii. The latest revision of the uncertainty quantification resulted in mean CDF values which were no more than 1.7% above and mean LERF values which were no more than 3.7% above the corresponding point estimate values of CDF and LERF. Therefore, the CDF/LERF point estimate values provided in Attachment W are considered appropriate and the resulting ΔCDF and ΔLERF values are also considered appropriate.

PRA RAI 02 – Use of Assumed Cable Routing

Section 2.4.3.3 of NFPA-805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a fire PRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a fire protection program consistent with NFPA-805. In letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02.

The documented methods accept the use of simplifications such that the routing of all cables can be avoided but the specifics of the simplification is not described. Section 4.1 of the Component and Cable Selection report (PRA-A2-05-005) identifies a disposition code for components in the fire PRA. One such designation is "Y3" which is assigned to equipment assumed failed because there is no cable routing data. Section 4.1 of the Component and Cable Selection report explains that when cable routing is not known "assumptions are made based on general layout of the plant and required dependencies". Please explain how "assumed cable routing" is determined and justify the adequacy of these assumptions for use in the fire PRA. Include in this explanation an indication of the fraction or number of cables for which routing is assumed.

*Response*

Y3 components are those without cable routing data and are assumed failed in all fire scenarios, unless credited by exclusion. Specific Y3 components have been excluded from failing in specific fire scenarios after confirmation that their cabling could not be impacted by the scenario. The FRANC excluded events table (PRA-A2-05-003 R0-EC6964, Attachment G) is used to make the scenario-specific changes. By evaluating the cable end point locations and possible routing paths between these end points based upon the layout of the plant, it was possible to show that these cables are not in adverse locations. All Y3 component exclusions are based upon documented cable routing information. An “assumed cable routing” was not determined for these cables as they remain failed in all other, non-excluded, fire scenarios. The analyses contains 227 Y3 components and 1,988 fire scenarios in which the Y3 components are assumed failed, for a total of 451,276 assumed component failures. The cable routing exclusions remove 2,757 of these failures. In summary, the ANO-2 FPRA does not assume any cable routing information for the development of the ANO-2 FPRA scenarios.

PRA RAI 03 – Use of Incipient Detection in the Control Element Drive Mechanism

Section 2.4.3.3 of NFPA-805 states that the PRA approach, methods, and data shall be acceptable to the NRC. RG 1.205 identifies NUREG/CR-6850 as documenting a methodology for conducting a fire PRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a fire protection program consistent with NFPA-805. In letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02.

Modeling of incipient detection is summarized in FAQ 08-0046, "Guidance for Modeling Non-Suppression Probability When an Incipient Fire Detection System is Installed to Monitor Electrical Cabinets" (ADAMS Accession No. ML093220426). Attachment S of the LAR identifies an Implementation Item (i.e., S1-10) that will install an incipient detection system in the control element drive mechanism (CEDM) room cabinets in Fire Area B-4 which is credited in the fire PRA. Attachment S of the LAR states that this modification reduces the risk of fire induced circuit and equipment failures that could result in loss of CEDM room panels. Explain how incipient detection is credited in the fire PRA. Please explain whether the incipient detection is used only to limit damage to targets outside the cabinet and not used to limit damage inside the cabinet where the detection would be installed. If incipient detection was used to limit damage inside the cabinets where detection would be installed, as opposed to limit damage to targets outside the cabinet, provide the impact on CDF, LERF, ΔCDF, and ΔLERF of removing this credit.

*Response*

Incipient detection is currently credited to reduce damage to cables within the associated panels as well as damage to targets beyond the panel that initiated the fire.

A review of current quantification data indicates that the impact of elimination of the credit for incipient detection for damage inside the cabinets would not result in a significant increase in total risk. Credit for the incipient detection to limit damage inside the cabinets will be removed in the risk quantification included with the updated Attachment W expected to be provided with the 120-day RAI responses.

<u>PRA RAI 04 – PRA Treatment of Dependencies between Units 1 and 2</u>

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 AHJ, which is the NRC. RG 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," 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 review of the information in the LAR has identified the following information that is required to fully characterize the risk estimates.

a) Note 1 for Table W-2 of the LAR indicates that ANO-1 specific fire areas' contribution to ANO-2 CDF/LERF were assessed and values of 6.06E-7/yr and 1.87E-8/yr respectively are provided. Please clarify how these two ANO-1 values are calculated.

b) Note 1 further indicates ANO-1 MCR and CSR are included in Fire Area G results, presumably because this fire area includes equipment from both ANO-1 and ANO-2. Is Fire Area G the only fire area that includes both ANO-1 and ANO-2 equipment? If not, please clarify the guidelines for identifying and evaluating fire areas that include equipment from both ANO-1 and ANO-2. Please discuss the extent to which the units share systems that are credited in the ANO-2 PRA.

*Response*

a) The two ANO units have different Nuclear Steam Supply System (NSSS) vendors and different construction timeframes which limit the ability to share systems. Also, the two units are adjacent, rather than intermingled, so most fire areas are associated with one unit or the other. See response to Part b) below for more information about common areas and shared systems. The risk reported for ANO-1-specific fire areas in Table W-2 is the ANO-2 CDF/LERF from fires originating in areas that are not associated with ANO-2 or are not considered common areas. Since the two units are adjacent, there is the potential that cables for shared components or ANO-2 cables with unknown routing (those on the UNL list described in the response to RAI PRA-01b) are routed through ANO-1-specific fire areas. Therefore, the risk from a fire in each of the ANO-1 specific fire areas was quantified to assess the impact of loss of cabling in these areas on ANO-2 and the results were summed to provide the values in Table W-2. These risk values were calculated with the conservative assumption that a fire in each of these areas would result in a trip of ANO-2.

b) As noted, Fire Area G contains both ANO-1 and ANO-2 fire zones; therefore, the risk to ANO-2 from fires initiating in the ANO-1 Control Room or Cable Spreading Room is included in the Fire Area G risk values in Table W-2. Other common fire areas (containing ANO-1 and ANO-2 components or containing shared components) in Table W-2 are AAC (shared alternate AC diesel), K (ANO-1 clean waste receiver tank room and ANO-2 boron holdup tank room), L (ANO-1 and ANO-2 diesel fuel tank vaults) and YD (yard – shared power transformers).

The process for evaluating the impact of fires in ANO-1 specific areas on ANO-2 is described in response to Part a) above. The common areas are evaluated in the same way as the ANO-2 specific areas. Fires from ignition sources in these areas impact ANO-2 modeled components within their zone of influence, components on the UNL list are failed in all fires unless specifically excluded, and an ANO-2 reactor trip is assumed.

As indicated previously, the systems or components shared between the two units and credited in the ANO-2 PRA are minimal. The two units share power from offsite power transformers and an alternate power supply (the alternate AC diesel) which can supply the 4.16 kV buses for either unit. The units can also share a condensate storage tank, which is one of three condensate storage tanks that can be used by ANO-2.

PRA RAI 05 – Inconsistencies and Anomalies in Tables W-1 and 2 of the LAR

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 review of the information in the LAR has identified the following information that is required to fully characterize the risk estimates.

There are a few apparent inconsistencies and anomalies in Tables W-1 and W-2 of the LAR supplement that provide the risk results, as summarized below.

a) Table W-1 provides the IF (initiating event frequency), CCDP, and CDF for the dominant scenarios. In a number of cases the CDF presented is not the product of the IF and CCDP (i.e., 2098-L/A, 2199-G-B/A, 2154-E-TN10/A, 2154-E-TN8/A, 2154-E-TN9/A, 2154-E-TN11). Please explain these apparent inconsistencies.

b) For Fire Area B-4 (CEDM equipment room) Table W-2 presents a fire CDF of 3.26E-06/yr and a ΔCDF of 2.60E-7/yr, but a fire LERF of 2.60E-7/yr and a ΔLERF of -5.17E-8/yr. This is the only Fire Area for which the CDF is a positive value and LERF is a negative value. Please explain this apparent anomaly.

c) For Fire Area 2MH03E (concrete manhole east) Table W-2 presents a low fire CDF of 9.99E-08/yr and low LERF of 2.65E-9/yr, but a large negative ΔCDF of -5.66E-6/yr and large negative ΔLERF of -1.89E-7/yr. The CDF, LERF, ΔCDF, and ΔLERF values for the other reported concrete manholes are very low. Please explain why fire risk evaluation values for Fire Area 2MH03E result in large negative CDF and LERF values.

*Response – Part a*

Table W-1 of the ANO-2 LAR provides the CDF/LERF, the associated ignition frequency, and the conditional core damage probability (CCDP) / conditional large early release fraction (CLERP) for the dominant scenarios. The other two factors which make up the CDF and LERF are non-suppression probabilities (NSP) and severity factors (SF). These factors will be included in the updated Attachment W, Table W-1, expected to be provided with the 120-day RAI responses.

*Response – Part b*

This apparent anomaly is simply due to the mathematics involved in calculating the change in risk values on an area basis. Table 1 below lists the Fire Area B-4 scenarios that have variances from deterministic requirements (VFDRs) and contribute to the delta risk calculation. It can be seen that each individual scenario follows the expected pattern of a positive ΔCDF corresponding to a positive ΔLERF, or a negative ΔCDF corresponding to a negative ΔLERF. However, in the summation of the scenarios, the total ΔCDF is positive while the total ΔLERF is negative.

Since each scenario has unique failures and containment isolation impacts, the ratio between the CDF change and the LERF change is not constant between different scenarios. As expected, some scenarios have a proportionally larger ΔCDF than ΔLERF, and some have a larger ΔLERF than ΔCDF. For instance, both the CDF and LERF decreased by less than a factor of 2 between the compliant and variant cases in scenario 2154-E-B. However, in scenario 2154-E-TN8, the CDF increased by almost a factor of 6 while LERF increased by only about a factor of 2. Thus, the difference in the ratio of the ΔCDF and the ΔLERF between scenarios is causing the summed ΔLERF to be a negative value while the summed ΔCDF is a positive value.

Table 1

FIRE AREA B-4 ΔCDF AND ΔLERF EVALUATION SUMMARY 1

| Scenario | Compliant CDF | Variant CDF | ΔCDF | Compliant LERF | Variant LERF | ΔLERF |
|---|---|---|---|---|---|---|
| 2154-E-B | 1.94E-06 | 2.26E-07 | -1.71E-06 | 5.85E-08 | 2.49E-09 | -5.60E-08 |
| 2154-E-C | 3.23E-07 | 3.78E-08 | -2.85E-07 | 9.75E-09 | 4.16E-10 | -9.33E-09 |
| 2154-E-E-NS | 3.25E-07 | 1.26E-07 | -1.99E-07 | 7.35E-09 | 1.38E-09 | -5.97E-09 |
| 2154-E-TN8 | 1.22E-07 | 7.15E-07 | 5.93E-07 | 3.69E-09 | 7.89E-09 | 4.20E-09 |
| 2154-E-TN9 | 1.22E-07 | 7.15E-07 | 5.93E-07 | 3.69E-09 | 7.89E-09 | 4.20E-09 |
| 2154-E-TN10 | 1.22E-07 | 7.15E-07 | 5.93E-07 | 3.69E-09 | 7.89E-09 | 4.20E-09 |
| 2154-E-TN11 | 3.69E-08 | 7.14E-07 | 6.77E-07 | 8.35E-10 | 7.86E-09 | 7.03E-09 |
| Area Totals | 3.00E-06 | 3.26E-06 | 2.60E-07 | 8.78E-08 | 3.61E-08 | -5.17E-08 |

1. Table 1 is an excerpt from Table 6.5-1 from the Fire Risk Evaluation, Attachment A (CALC-09-0008-05 Rev. 1). The scenarios that do not contain VFDRs and have a zero delta risk are not shown, and the CCDP/CLERP values are not shown in order to save space, since these values do not pertain to the RAI response.

*Response – Part c*

As indicated in LAR Table W-2, the three west manholes are deterministically compliant. The three east manholes contain VFDR components because fire damage to control cables may impact the Service Water (SW) swing pump 2P-4B, if pump 2P-4A is out of service. Manhole 2MH03E has a larger compliant case CDF than the other east concrete manholes (2MH01E and 2MH02E) because it also contains cables associated with offsite power.

The risk associated with 2MH03E is reduced through credit of the AFW pump modification. The compliant configuration sets the VFDR components associated with the B SW train to the respective nominal values, thereby restoring SW cooling to Emergency Diesel Generator (EDG)-1 should 2P-4A be out of service. Since offsite power is unavailable in this scenario, the compliant case risk is dependent on the availability of EDG-1 and the Alternate AC Diesel Generator (AACDG) to supply power to the vital systems for shutdown. The AFW modification, which has two separate power supplies not impacted in this scenario, reduces the failure probability for every core damage sequence in this scenario. In conclusion, the AFW pump modification adds additional redundancy to the secondary heat removal function beyond the requirements for a compliant configuration, resulting in a large negative delta risk.

<u>PRA RAI 06 – Use of Unreviewed Analysis Methods (UAMs)</u>

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

a) Section V2 of the LAR identifies several methods for which sensitivity studies were performed. Section V.3 reports that "more fully comply with the approved methods" (i.e. UAMs were removed). Other than the UAMs cited in Section V.2 of the LAR identify any other deviations from NUREG/CR-6850 or other acceptable methods (e.g., FAQs or interim guidance documents such as the June 21, 2012, letter from Joseph Giitter "Recent Fire PRA Methods Review Panel Decisions and EPRI 1022993, 'Evaluation of Peak Heat Release Rates in Electrical Cabinets Fires'" - see ADAMS Accession No. ML12171A583); please provide analyses that remove the credit obtained from these methods, and new integrated risk estimates from these analyses.

b) Section V.2 identifies several deviations from NUREG/CR-6850 and summarizes several sensitivity studies that have been performed to measure the impact of using these methods instead of the methods in NUREG/CR-6850. During the audit, ANO indicated that the PRA has been changed after the submittal (e.g., some NUREG/CR-6850 methods have been incorporated into the PRA replacing the original methods). Please identify all changes that have been made to the PRA since the submittal and indicate whether the changes have been fully incorporated in the PRA (i.e., if the PRA models and supporting documentation have been updated and, if methods are upgrades, whether the recommended focused scope peer review has been completed).

*Response*

a) The only deviation from acceptable methods other than those cited in Section V.2 of the LAR was credit for control power transformers (CPT) in the assessment of hot short probabilities. The CPT factor of two embedded in the hot short probabilities in NUREG/CR-6850 was utilized, which was acceptable at the time the LAR was submitted, but has subsequently been determined by NRC to be unacceptable. This credit has been removed, which will be reflected in the new baseline model results to be provided in the updated Attachment W. It is noted that new phenomena identification and ranking table (PIRT) results are forthcoming, but as these have not been issued or approved by NRC, the current approach taken by ANO-2 to remove the factor of two for CPT circuits complies with the NRC's currently acceptable methods.

b) The following additional model changes were implemented in the FPRA model when the unapproved analysis methods (UAMs) were removed. None of the changes involved method upgrades; therefore, no peer review was required. Nevertheless, a focused-scope peer review was conducted on the fire modeling (FSS) technical element following incorporation of these changes (see response to PRA RAI 18 for details).

   a. The fire ignition frequencies were updated from the NUREG/CR-6850 frequencies to those provided in Supplement 1 to NUREG/CR-6850 (FAQ 08-0048).

   b. A weighting factor that had been misapplied in the manholes, which impacted the transient fire ignition frequency calculation for Bin 11, was corrected.

   c. Changes to the model fault tree logic were made as listed below.

      i. Corrected logic for steam generator depressurization due to steam losses outside of the main steam isolation valves (MSIVs).

      ii. Added a basic event to the existing small-break loss of coolant accident (SBLOCA) logic to incorporate to the potential for multiple RCS high point vent valves spurious opening.

      iii. Added new logic to the gate for failure of steam supply to the turbine-driven EFW pump to assure that fire-related failures propagate correctly.

      iv. Revised the proposed AFW pump modification logic to account for separate failures of the motor operated valves that feed the separate steam generators.

   d. Incipient detection was credited in panel 2C75, in Fire Zone 2154-E, Fire Area B-4 (Scenario 2154-E-D).

   e. Fire Zones 2154-E and 2096-M have been characterized as "zero" transient combustible zones, thus reducing the transient HRR from 317 kW to 69 kW. The zone of influence has not been reduced to a HRR of 69 kW but remains consistent with a 317 kW fire in the base quantification. The smaller HRR is only credited in the manual non-suppression probability for hot gas layer screening criteria.

f. The suppression system has been credited for scenarios in Fire Zone 2098-C in lieu of the electrical panel factors.

g. Non-suppression probabilities were updated and were applied to scenarios 2109-U-B/C/D/E/F and G, based on additional fire modeling.

These changes were completed in the sensitivity analysis removing the UAMs, which is described in Section V.2 of the LAR. Thus, the changes are not reflected in the original LAR Attachment W results. These changes have been fully incorporated in the PRA model and are being included in the documentation for the new baseline model, the results of which will be provided in the updated Attachment W.

PRA RAI 07 – 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 a fire PRA and endorses, with exceptions and clarifications, NEI 04-02, Revision 2, as providing methods acceptable to the staff for adopting a fire protection program consistent with NFPA-805. In letter dated July 12, 2006, to NEI (ADAMS Accession No. ML061660105), the NRC established the ongoing FAQ process where official agency positions regarding acceptable methods can be documented until they can be included in revisions to RG 1.205 or NEI 04-02. Methods that have not been determined to be acceptable by the NRC Staff require additional justification to allow the NRC Staff to complete its review of the proposed method.

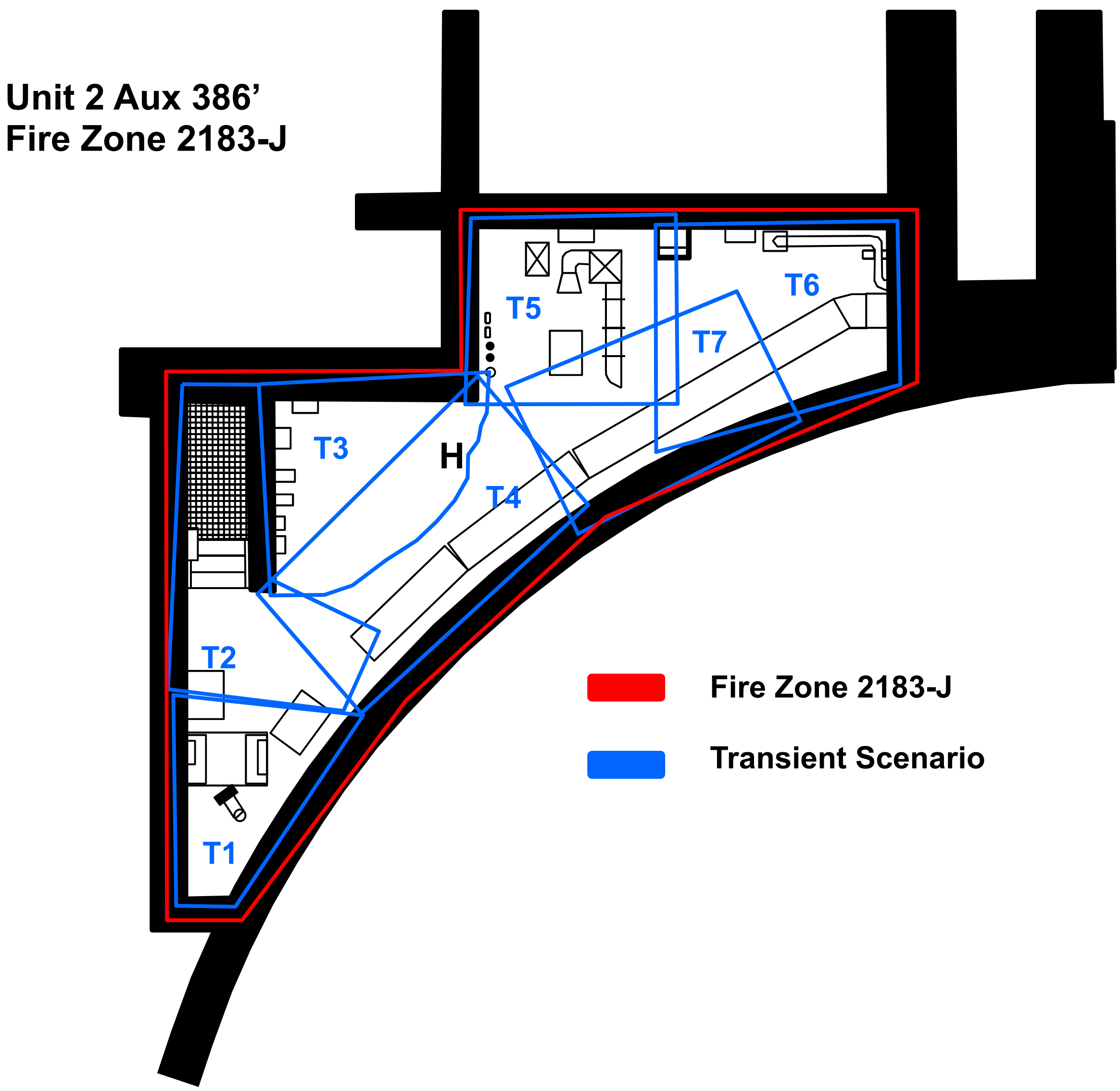
Per NUREG/CR-6850 Section 11.5.1.6, transient fires should at a minimum be placed in locations within the plant physical analysis units (PAUs) where CCDPs are highest for that PAU, i.e., at "pinch points". Pinch points include locations of redundant trains or the vicinity of other potentially risk-relevant equipment. Transient fires should be placed at all appropriate locations in a PAU where they can threaten pinch points. Hot work should be assumed to occur in locations where hot work is a possibility, even if improbable, keeping in mind the same philosophy. Please describe how transient and hot work fires are distributed within the PAUs at your plant. In particular, identify the criteria for your plant used to determine where an ignition source is placed within the PAUs.

*Response*

Transient fires are postulated at locations which may impact any plant component or raceway within a PAU, not just those locations that impact redundant trains or risk-significant equipment. See the example figure below, showing the placement of transient fires (T1 through T7) in Fire Zone 2183-J. The response to RAI PRA-01i describes transient fire placement in the turbine building, which was treated slightly differently from the other PAUs, but also includes all appropriate pinch points.

Also, as described in the response to RAI PRA-01c, all targets within a PAU are impacted by at least one transient fire. To account for overhead cable tray congestion, those targets not identified in the walkdowns of the transient zones of influence were assumed to fail in all transient fires within the PAU. Thus, transient fires are placed at all appropriate locations, including pinch points that are located within the zone of influence of a transient fire. The transient fire scenarios overlap each other, where necessary, to account for additional combinations of targets along the edge of the transient fire zone of influence.

A hot work fire is postulated for each cable tray in the plant and is assumed to impact all cables within the tray.



PRA RAI 09 – Use of Multipliers on Internal Event HEPs to Determine Fire HEPs

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

Section 4.2 of the Human Reliability Analysis (HRA) Notebook (PRA-A2-05-007) describes an approach in which multipliers are applied to HEPs that have been previously determined for the internal events PRA to calculate the increased probability of fire related HEPs. Please describe the proposed methodology. Please include discussion of how this approach is consistent with, or conservative with respect to related guidance provided in NUREG 1921, "EPRI/NRC-RES Fire Human Reliability Analysis Guidelines."

*Response*

As noted in the RAI, the proposed multiplier methodology is described in the HRA notebook (PRA-A2-05-007). The methodology is described as follows.

POST-INITIATOR (TYPE $C_P$ and $C_R$) HUMAN FAILURE EVENTS

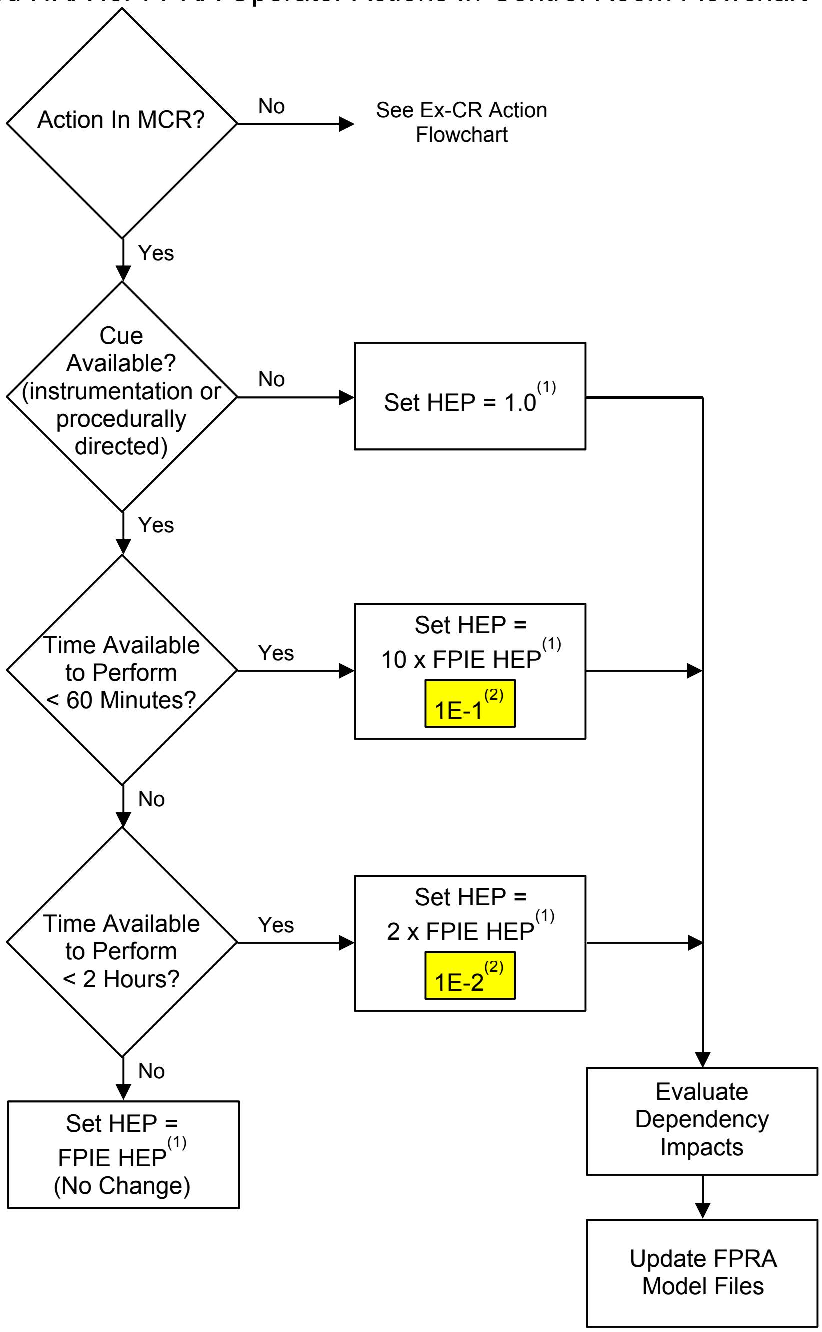
The FPRA method includes a post-fire recovery action multiplier to account for the impact of conditions created by the fire upon HFEs existing in the internal events model. The value of the multiplier varies depending on whether the action takes place inside or outside the Control Room and on the time available to perform the action. For some of the new HFEs generated to support the FPRA, the time windows, stress level, and performance shaping factors have been estimated assuming that the event is applicable to the internal events model.[1] For these events, an HRA multiplier should be applied for HFEs in the PRA internal events model.

This evaluation utilizes the flow charts provided in Figures 1 and 2 to determine the appropriate multiplier to be applied to the human error probabilities that have been previously derived by the internal events HRA methodology.

As indicated in Note 4 of the In-Control Room Flowchart (Figure 1), “actions such as immediate memorized response actions, may not require adjustment.” Actions that meet this criterion are annotated in the evaluation.

[1] New actions added for the Fire PRA were approached in two different ways. Some, in particular those associated with fire-specific procedures, were developed with the fire impacts directly included. These actions were not treated with multipliers. Others, such as standard Abnormal Operating Procedure (AOP) actions that were not included in the internal events PRA because they had no significant risk reduction benefit for internal events were added using internal events performance shaping factors (PSFs), with multipliers then applied.

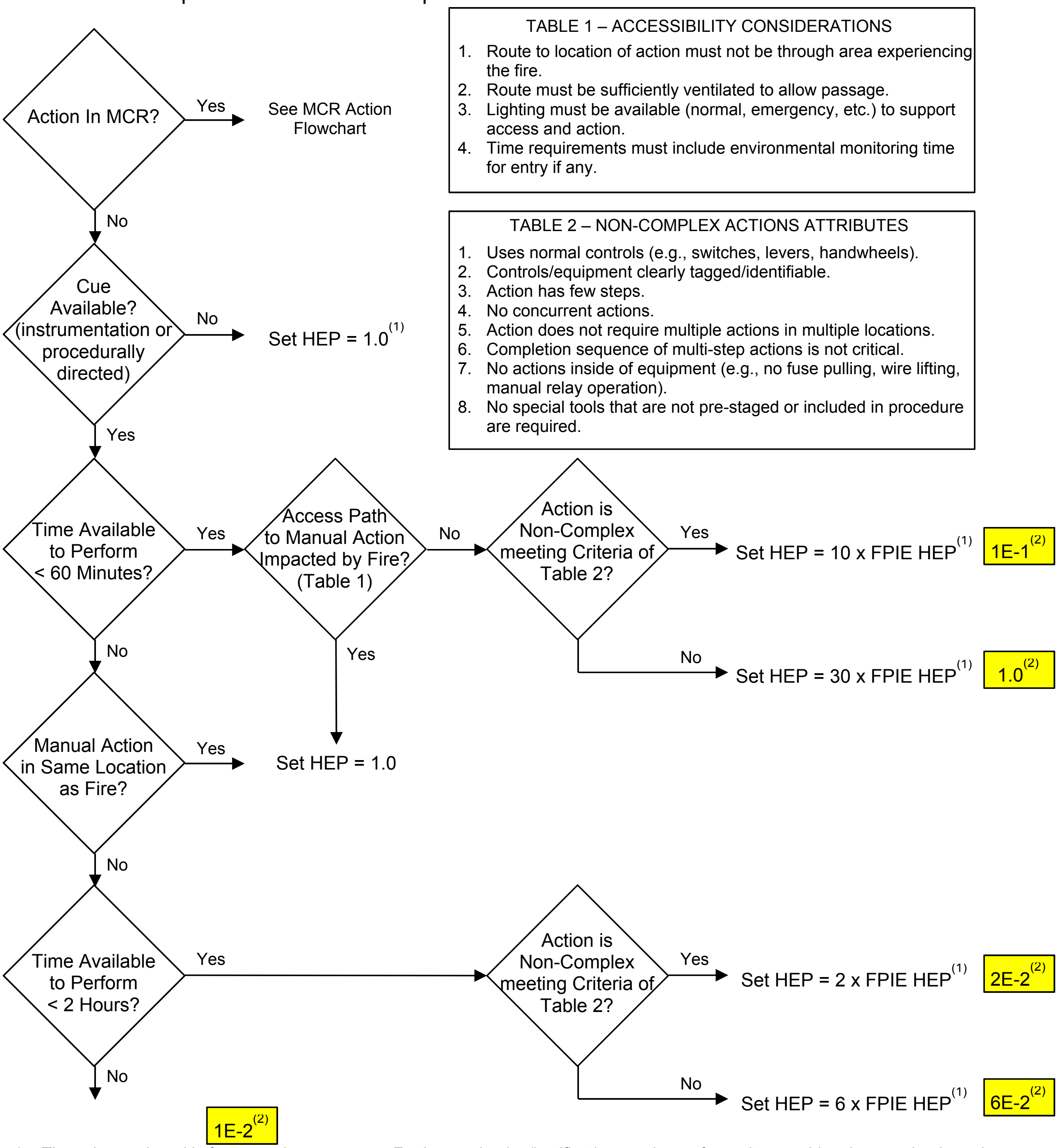
**Figure 1**
Simplified HRA for FPRA Operator Actions In-Control Room Flowchart




1. The value assigned is for screening purposes. Further evaluation/justification can be performed to provide a lower value based on specific HRA calculations.
2. Values in yellow-shaded boxes are point estimates for HEPs for undeveloped HFEs meeting the specific criteria if a procedure was to be developed.
3. This flowchart and resultant screening multipliers/values assume that a procedure exists or will be developed; for Operator actions not performed to procedure, but rather based on Operator experience, general knowledge, or rote practice, the HEP should be 1.0 with a possible reduction to not less than 0.5 with justification.
4. Some actions such as immediate memorized response actions may not require any adjustment. These should be evaluated on a case-by-case basis.
5. Caution should be exercised for actions with very short response times that are not memorized or frequently drilled. Action with short response times ($T_{SW}$ < 15 minutes) may be treated non-conservatively by over a factor of 2 by the flowchart and should be reviewed.
6. FPIE – Full Power Internal Events Model

**Figure 2**

Simplified HRA for FPRA Operator Actions Ex-Control Room Flowchart




1. The value assigned is for screening purposes. Further evaluation/justification can be performed to provide a lower value based on specific HRA calculations.
2. Values in yellow-shaded boxes are point estimates for HEPs for undeveloped HFEs meeting the specific criteria if a procedure was to be developed.
3. This flowchart and resultant screening multipliers/values assume that a procedure exists or will be developed; for Operator actions not performed to procedure, but rather based on Operator experience, general knowledge, or rote practice, the HEP should be 1.0 with a possible reduction to not less than 0.5 with justification.

ASSESSMENT OF CONSISTENCY WITH NUREG-1921

Entergy is performing a re-assessment of a selection of HFEs that were quantified using the multiplier approach with an approach that complies with the guidance in NUREG-1921. The goal of this assessment is to demonstrate that the multiplier approach would always result in a conservative estimate of the HEP relative to a detailed analysis using a NUREG-1921 approach, and would thus meet the request to discuss "how this approach is consistent with, or conservative with respect to related guidance provided in NUREG-1921, "EPRI/NRC-RES Fire Human Reliability Analysis Guidelines." The specific NUREG-1921 approach applied to support the comparison is as follows:

1.0 Internal Events HEP Modifications for Fire

If an HFE has been quantified using the HRA Toolbox approach for internal events, detailed HFE quantification for fire involves a relatively simple modification in the following areas:

- Timing
- Cue and indications impacts
- Increase in stress
- Increase in workload
- Use of multiple procedures
- For local actions, consider alternate routes, if fire impacts the normal or ideal travel path.

This approach, as presented below, meets the detailed HRA guidance in NUREG-1921.

1.2 Fire Impacts on Timing

In the Cause-Based Decision Tree Method (CBDTM) and the Human Cognitive Reliability - Operator Reliability Experiment (HCR-ORE) Method in the HRA Toolbox, timing is evaluated with the use of a timeline (illustrated conceptually in Figure 1-1[2]) and the following key time parameters which will be adjusted as indicated to account for fire impacts.

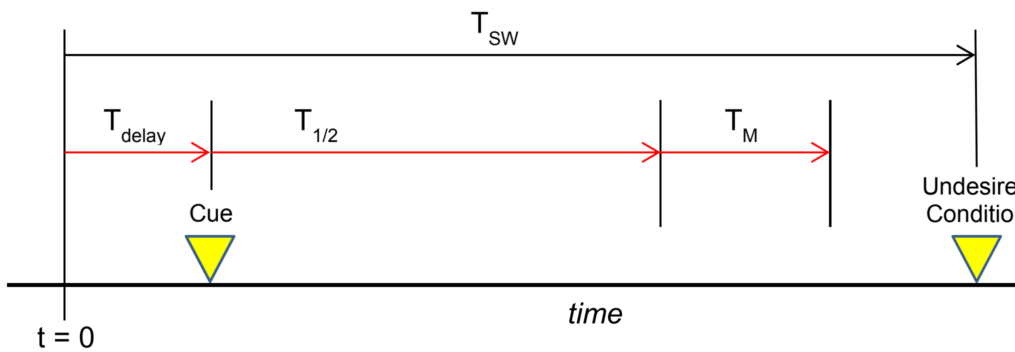
- T = 0 is considered the start of the fire. For existing internal events HFEs, T = 0 is typically reactor trip. In most cases, the FPRA assumes the fire and reactor trip coincide.
- $T_{delay}$ = Time from start of transient until cue is reached. If the cue is considered to be a procedure step, the fire may cause delays in the procedure implementation. However, 1.5 to 2 hours after the fire, the Emergency Organization is assumed to be in-place and has time to brief Operations, so fire effects are not added.

[2] Note that the figures used in this section are taken from the EPRI HRA Calculator, in order to provide a clear graphical representation of the concepts for the PSFs and adjustments. The HRA Toolbox does not use the same graphical representations, but it does implement the same quantification approaches in the same way.

- $T_{1/2}$ = If the fire impacts some, but not all of the instrumentation, $T_{1/2}$ will be increased from the internal events case to account for the time required for the Operators to assess the situation and determine which instrumentation is correct or diagnose based on secondary cues.
- $T_m$ = For MCR actions in which there is no fire in the Control Room, $T_m$ is considered to be the same for the internal events case and the fire case. For local actions, $T_m$ will account for any detours caused by the fire. $T_m$ must also account for the time needed to access and don any personnel protective equipment (PPE) and the use of tools.

The total time available for an action before a change in plant state ($T_{SW}$) and the time when a cue occurs ($T_{delay}$) are typically obtained from thermal hydraulic analyses.

*Figure 1-1 – HRA Timeline*




| | | |
|---|---|---|
| $T_{SW}$ | = | System time window |
| $T_{delay}$ | = | Time from start of transient until cue is reached |
| $T_M$ | = | Manipulation time (includes transit, tools, PPE, and executing each task) |
| $T_{1/2}$ | = | Median response time (detection, diagnosis, and decision making) |
| $T_W$ | = | Time window for cognitive response = $T_{SW} – T_{delay} – T_m$ |
| $T_W – T_{1/2}$ | = | Time available for recovery |

For existing internal events actions, the timing is adjusted (see Sections 1.2 and 1.3 below) to account for fire impacts such as:

- Delays in implementing procedures due to first implementing fire procedures
- Increases in manipulation time due to additional workload
- Increases in cognitive response time due to misleading or unclear indications
- Increases in manipulation time due to additional travel time for local actions.

## 1.2 Fire Impacts on Instrumentation

- If all instrumentation is impacted and there are no cues available for Operator diagnosis of the situation, then the HEP is set to 1.0 (meaning that the action is not considered feasible).
- Partial instrumentation impacts due to fire are modeled in CBDTM decision trees Pc-a shown in Figure 1-2 and Pc-d shown in Figure 1-3 (HEP range 1E-2 to 1.0).
- If the fire causes no impact on instrumentation, then Pc-a and Pc-d typically evaluate to “neg.” (negligible).

*Figure 1-2 – CBDTM Decision Tree Pc-a*

| pc a | Indication Available in CR | Indication Accurate | Warning or Alternative in Procedure | Training on Indication |
|---|---|---|---|---|

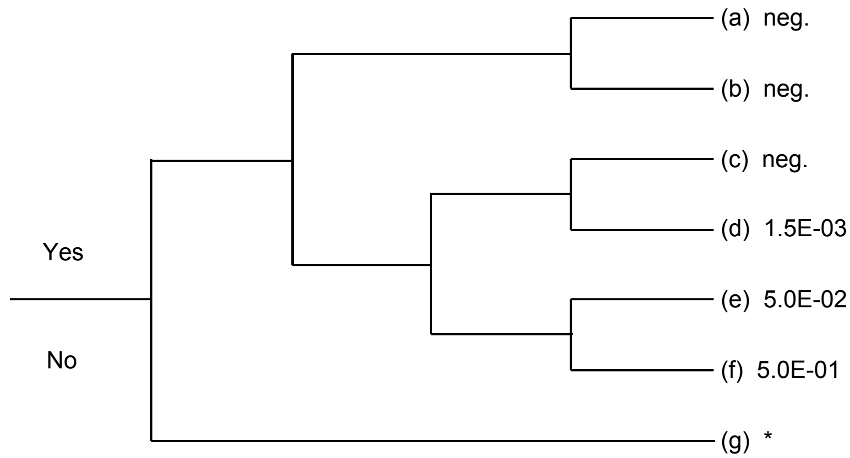
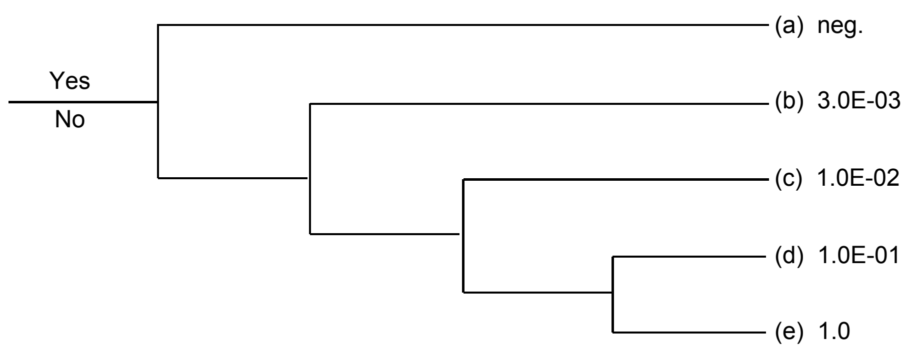



*Figure 1-3 – CBDTM Decision Tree Pc-d*

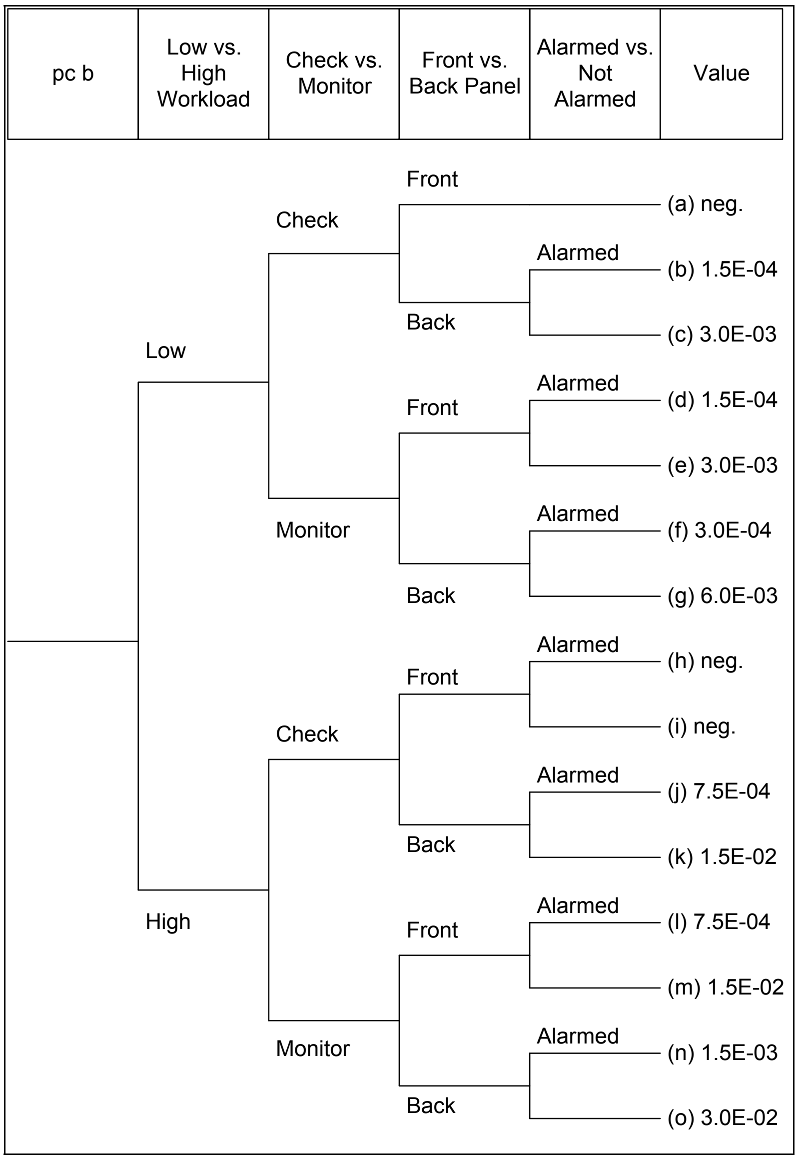
| pc d | All Cues as Stated | Warning of Differences | Specific Training | General Training | Value |
|---|---|---|---|---|---|



## 1.3 Fire Impacts on Workload

Workload impacts are modeled explicitly in CBDTM decision tree Pc-b (Figure 1-4) as part of the cognitive phase (detection and diagnosis). If fire causes an increase in workload, the branch of the decision tree for high workload is selected. There is the potential for intra-crew recovery if additional staff is available, but a higher dependency is usually set for these intra-crew recovery actions than for internal events HEPs.

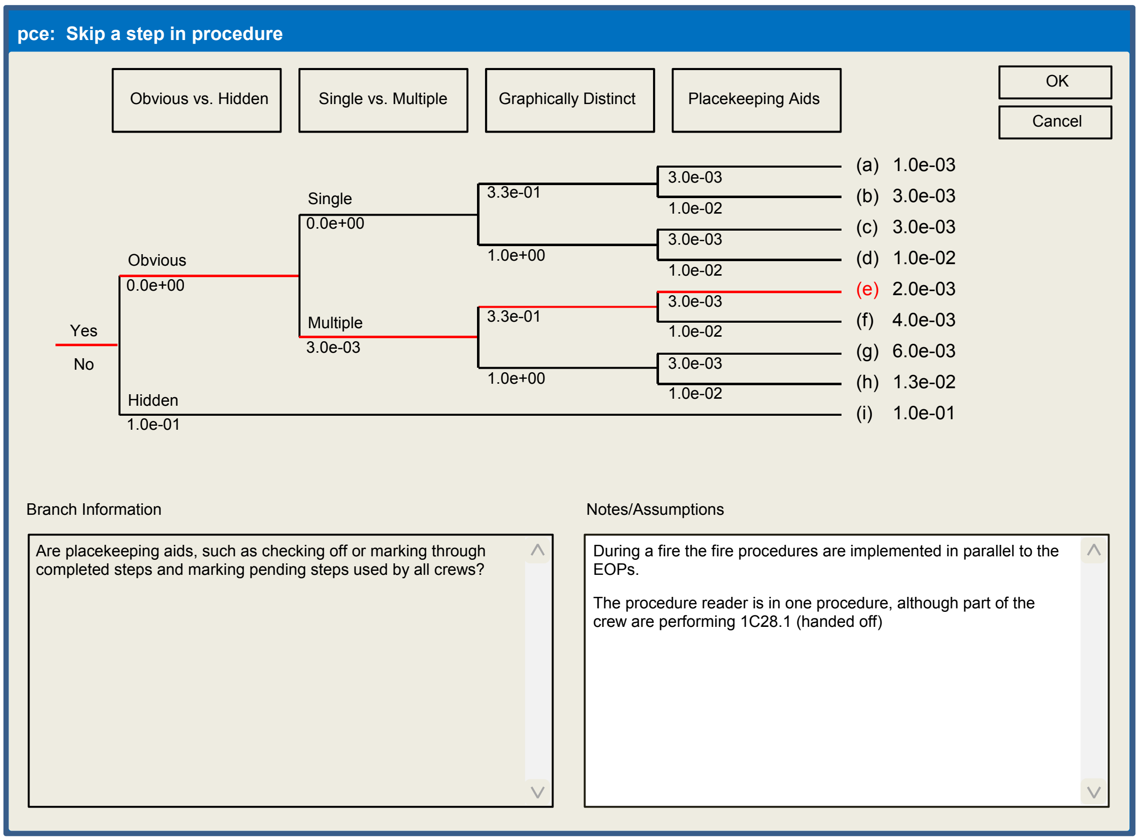
*Figure 1-4 – CBDTM Decision Tree Pc-b*



## 1.4 Fire Impacts on Procedure Usage

If emergency operating procedures (EOPs) and abnormal operating procedures (AOPs) are implemented in parallel to the fire procedures (a subset of the AOPs at ANO), then the multiple procedures branch in CBDTM decision tree Pc-e is selected (Figure 1-5). If EOPs/AOPs are not in use while fire procedures are being used, then only one procedure is credited and any time delays are accounted for in the timeline. Therefore, while a fire is likely to involve multiple procedures at ANO, any exceptions are appropriately addressed.

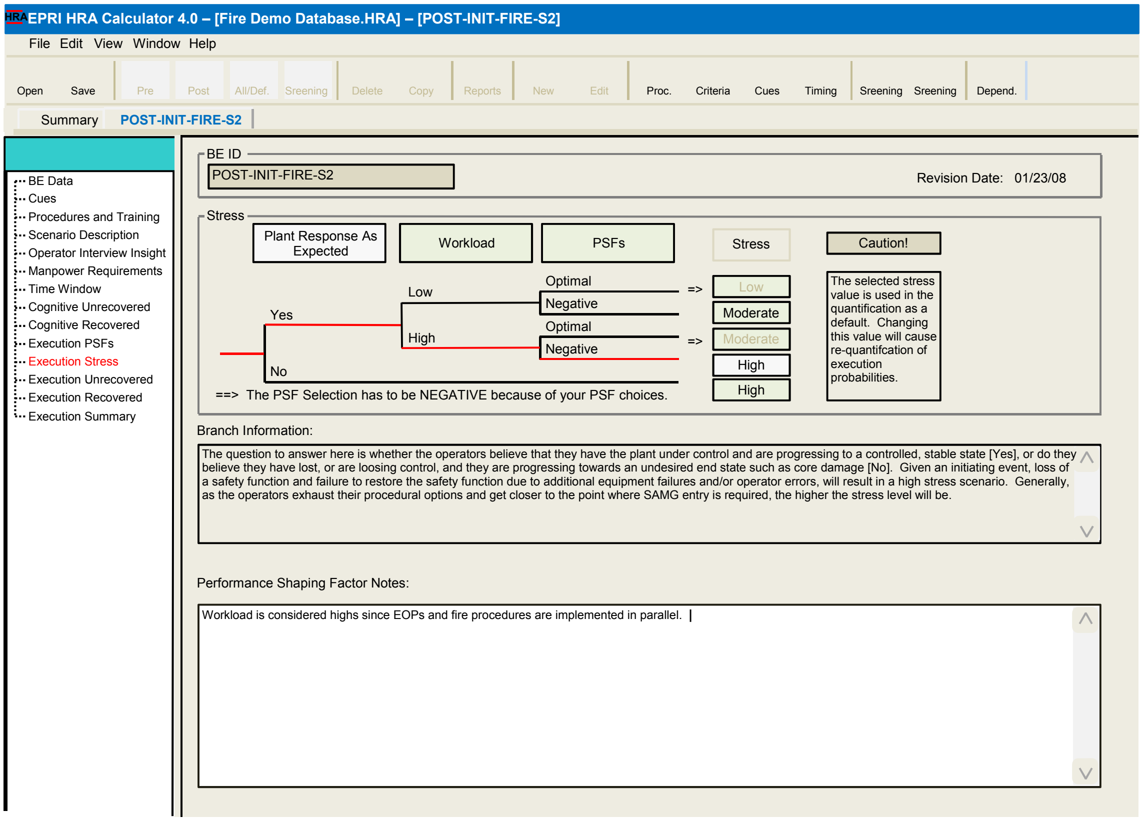
*Figure 1-5 – Multiple Procedures Branch in CBDTM Decision Tree Pc-e*




## 1.5 Fire Impacts on Execution

In the HRA Toolbox, task execution errors are addressed using THERP. For fire, if the execution stress is less than high then it is increased from the internal events case using decision tree Pc-e shown in Figure 1-6, except for Control Room actions when Operator actions occur more than 70 minutes after the fire has started, because 99% of fires are extinguished within 70 minutes per the fire event data documented in FAQ 08-0050.

*Figure 1-6 – Execution Stress in CBDTM THERP Module*




## 2.0 Ex-MCR Fire HRA modifications

In order to implement the general approach to adjusting the HEPs for fire, more specific guidance has been developed. This guidance is based on applying the principles of NUREG-1921 with considerations of plant–specific conditions, modeling, and HRA Toolbox analysis approach.

- $T_{delay}$ represents the time at which the cue is received. This time is a function of the fire and also takes into account any procedure delay caused by the fire. If implementation of the EOPs is delayed by the fire procedure, the delay time for all existing internal events HFEs would be systematically increased.
    - NUREG-1921 suggests this increase will be by the average time it would take to perform the fire procedure(s), typically about 30 minutes. In this case, $T_{delay}$ = $T_{delay}$ base case + 30 min. Depending upon $T_{SW}$, however, this can cause a very high impact to the HEP.
    - The value of the increase in $T_{delay}$ will be based on discussion with plant Operations and Training to understand how the Fire Procedures are used; many use the fire procedures in parallel, so a maximum $T_{delay}$ increase of 5 min is more justifiable. A value of less than 5 min may be applied if Operators either remain in the EOPs or are returned from the fire procedures to the EOPs quickly.

Note that because the HRA Toolbox does not include $T_{delay}$ as a specific parameter, the adjustment is made by shortening $T_{SW}$ by the amount of the increase in $T_{delay}$. This has the same effect on the quantification as reducing the $T_{delay}$.

- $T_{1/2}$: Add up to 5 additional minutes for increased diagnosis complexity due to additional MCR actions associated with fire annunciators and processing additional fire procedure tasks in parallel with EOP and AOP response.

- $T_m$: If a local (outside MCR) execution action is involved, add up to 10 minutes for challenges such as impact to travel path and/or visibility due to smoke, as appropriate to the fire scenario. Since ANO considers travel path impacts directly in the model by failing the action, no adjustment is required in this parameter.

- Cognitive Unrecovered:

  - Pc-a:

    - If HFE is considered an HFE with instruments which must be modeled in FPRA[3], account for potential instrument related confusion within the Fire HRA by selecting path (e):

      - Indications Available in CR - Yes
      - CR Indications Accurate – No
      - Warning/Alt Procedures – No
      - Training on Indications – Yes

    - If HFE is considered an HFE assessed to have adequate instrumentation diversity, account for potential instrument related impacts by selecting path (c):

      - Indications Available in CR - Yes
      - CR Indications Accurate – No
      - Warning/Alt Procedures – Yes
      - Training on Indications – Yes

    - If HFE is considered an HFE screened from fire instrumentation impact, no adverse impacts need to be modeled beyond those for internal events.

  - Pc-b: Change workload to high, assuming EOPs are implemented in parallel to the fire procedure.

[3] If FPRA model sets HFE as dependent upon instrumentation function, then HFE may fail if instruments fail due to fire and detailed Fire HRA may not be necessary. Need to coordinate with PRA model on these cases.

- o Pc-d: Changes consistent with Pc-a.
  - ▪ If HFE is considered an HFE With Instruments Which Must Be Modeled in FPRA, account for potential instrument related confusion within the Fire HRA by selecting path (c):
    - All Cues as Stated – No
    - Warning of Differences – No
    - Specific Training – Yes (unless only General Training is provided)
  - ▪ If HFE is considered an HFE Assessed to Have Adequate Instrumentation Diversity, account for potential instrument related impacts by selecting path (b):
    - All Cues as Stated – No
    - Warning of Differences – Yes
  - ▪ If HFE is considered an HFE Screened from Fire Instrumentation Impact, no adverse impacts need to be modeled beyond those for Internal Events.
- o Pc-e: Change from single to multiple procedures, assuming EOPs are implemented in parallel to the fire procedures.

- Cognitive Recovered:
  - o Change to at least moderate dependency. Note that the HRA Toolbox locks the default dependency based on consideration of other parameters, and in some cases it cannot be manually changed by adjusting the type of review credit. This is adequate for this application because, if the default dependency is deemed inappropriate, the result can be manually manipulated by other means.
  - o Credit for various levels of recovery
    - ▪ If $T_{delay}$ > shift length, shift change can be credited.
    - ▪ If $T_{SW}$ > Emergency Response Organization (ERO) activation time, ERO review can be credited.
    - ▪ If $T_{SW}$ > 15 minutes, Shift Technical Advisor (STA) review can be credited.
    - ▪ Eliminate self-review credit (if credited for internal events) if time is extremely limited, such as when the time required is equal to the time available.
    - ▪ Eliminate extra crew credit (if credited for internal events) if time is extremely limited or if the extra crew is part of fire response and thus not available for checking.
  - o During a fire, the Technical Support Center (TSC) will typically be activated within 2 hours of the start of the fire and can be credited for actions that occur later (after the TSC is activated) in the scenario.

- o Cognitive recovered credit is only added for cases where the internal events HFE credit a specific level of recovery, as it is assumed that if the level of recovery was not applicable to the internal events case it will also not be applicable to the fire case.

- Execution Stress: Change to at least Moderate stress. If the execution margin is low and the action is very complex, it may be increased to high.

3.0 In-MCR Fire HRA modifications

If the fire is in the Control Room, it could pose additional challenges to the Operators. Therefore, the following modifications are performed *in addition to* changes made for ex-MCR fire modifications previously discussed.

- $T_{1/2}$: Add 1 to 5 min (depending upon available time window) for in-MCR diagnosis complexity (distraction).

- $T_m$: Add 1 to 5 min (depending upon available time window) for in-MCR action execution challenges (potential panel impact and other distractions). No change to ex-MCR actions.[4]

- Change cognitive and execution actions from simple to complex. Execution is changed only for in-MCR actions.

- Cognitive Recovered: Change to high dependency (as recommended by HRA Calculator due to complexity) to reflect crew distraction and lessened opportunity/attention to check on other crew's actions. Within HRA Toolbox, this will be accomplished by adjusting the various recovery credits taken for internal events to account for fire effects.

- Modify (increase) the execution stress to reflect consideration of PSFs for smoke and accessibility with difficulty for in-MCR execution actions.

4.0 Implementation in NFPA-805 Model

Initial sensitivity assessments of a few of the ANO-2 HFEs using the above described NUREG-1921 approach indicates that it is unlikely to be able to demonstrate that the multiplier approach used in the ANO-2 Fire HRA "is consistent with, or conservative with respect to related guidance provided in NUREG 1921" as requested in the RAI. Therefore, the goal stated previously in this response cannot be achieved. As a result, ANO will apply the NUREG-1921 method described above to all significant HEPs using the following approach.

- FPRA importance measures will be used to identify a cut-off importance below which the HFEs are insignificant enough that, even if the HFEs would increase using the NUREG-1921 approach, the HFEs would not change the plant risk.

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[4] If the HFE includes actions performed outside the Control Room, since there is no fire outside the Control Room, there would be no impact on the performance of the Operators outside the Control Room beyond what was previously determined.

- HFEs above this cut-off will be reanalyzed using the NUREG-1921 approach presented above.

- A sensitivity study will be performed to determine if using the new values would affect the plant risk profile (CDF, LERF, ΔCDF and ΔLERF).

    - If the risk profile in not affected, the baseline PRA will not be changed.

    - If the risk profile is affected, the baseline PRA will be changed to incorporate the new HEPs.

The results will be documented in the updated Attachment W expected to be provided as part of the 120-day RAI responses.

PRA RAI 10 – Minimum Value for the Joint Probability of Multiple HFEs

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

Section 3.0, Assumption #1, of the Fire PRA Human Reliability Analysis report (PRA-A2-05-007) appears to indicate that the minimum value used for the joint probability of multiple HFEs is effectively 1 E-6. Section 6.2 of NUREG 1921 states that this "value [should] not be below ~-1 E-05 since it is typically hard to defend that other dependent failure modes that are not usually treated (e.g., random events such as even a heart attack)." Please clarify what minimum value was used for the joint probability of multiple human failure events that occur in a single cutset in the fire PRA. If 1 E-6 was used, please justify this value. Alternatively, determine the impact on CDF, LERF, ΔCDF, and ΔLERF using a minimum of 1 E-5.

*Response*

Section 6.2 of NUREG-1921 is actually quoting NUREG-1792, *Good Practices for Implementing Human Reliability Analysis*, April 2005, when it states:

> “The following is stated in NUREG-1792: … “It is suggested that the value not be below ~1E-05 since it is typically hard to defend that other dependent failure modes that are not usually treated (e.g., random events such as even a heart attack) cannot occur.”

After additional discussion of the guidance in NUREG-1792 and later guidance in EPRI 1021081, *Establishing Minimum Acceptable Values for Probabilities of Human Failure Events, Practical Guidance for Probabilistic Risk Assessment: Interim Report*, EPRI, Palo Alto, CA: 2010, Section 6.2, of NUREG-1921 finally concludes the following.

> "For fire HRA, it is recommended that the application of a lower bound follow the same guidance as was applied to the internal events PRA."

A minimum value of 1E-06 was used for the joint probability of multiple HFEs that occur in a single cutset in the ANO-2 FPRA. This minimum value is the same as that applied in the ANO-2 internal events PRA, which states, "A minimum default of 1E-6 is used for all human error combinations. The minimum default value conservatively limits the lower bound of human error probability based on the uncertainty of human errors."

Since NUREG-1921 concluded that the FPRA should follow the same guidance applied to the internal events PRA with regard to a minimum joint probability, which is the method used in the ANO-2 FPRA, the 1E-6 minimum value is justified.

Revising the minimum joint probability value from 1E-06 to 1E-05 would have little impact on the results, since the cutsets containing those joint HFEs are not top risk contributors in the ANO-2 FPRA analysis. Since the total CDF/LERF consists of the contribution from the ignition frequencies, non-suppression probabilities, and severity factors, increasing the minimum joint probability value by an order of magnitude will impact only low probability cutsets and is not expected to challenge the CDF, LERF, ΔCDF, and ΔLERF acceptance criteria associated with the NFPA-805 submittal.

Nevertheless, because a sensitivity study is being performed, as described in the response to RAI PRA 09, the study will adjust the minimum joint probability value to 1E-05 and the results will be provided in the updated Attachment W as part of the 120-day RAI responses.

<u>PRA RAI 11 – Fire-Induced Instrument Failure</u>

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

Fire-induced instrument failure should be addressed in the HRA per NUREG/CR-6850 and NUREG-1921. Please describe how fire-induced instrument failure (e.g., including no readings, off-scale readings, and incorrect/misleading readings) is addressed in the fire HRA.

*Response*

The Fire HRA analysis documented in PRA-A2-05-007 (Attachment A) includes documentation of the instruments/components that provide a cue for each HFE credited in the FPRA. An assessment of the availability of the cue is also provided. This assessment confirmed that the instrumentation providing the cue is already addressed in the fault tree logic or that the instrumentation providing the cue is included in the deterministic analysis safe shutdown equipment list as a required process monitoring instrument. If the instrumentation providing the cue is in the fault tree, its failure due to a fire will preclude credit for the associated HFE in that fire scenario. If the instrument is a safe shutdown analysis process monitoring instrument, it is available because one set of process monitoring instruments is required by and confirmed to be available on a fire area basis by the deterministic analysis.

Post-fire operating procedures provide guidance with respect to the available instrumentation for each fire area (OP-2203.049, Fires in Areas Affecting Safe Shutdown). This guidance ensures that the Operators are using only those instruments which are reliable post-fire and not those that may have no readings, or that may be off-scale, incorrect, or misleading.

Also, a simulator review was performed with Operations personnel to correlate the operational response to a fire scenario to the ANO-2 FPRA analysis (PRA-A2-05-007, Attachment B). During this review, input was obtained regarding the operational response to determine if any single instruments/annunciators resulted in an immediate Operator response prior to confirming the validity of the instrument/annunciator indication. The Operators confirmed that no actions would be initiated based on a single spurious indication/annunciator. The guidance provided in the post-fire procedures will direct the Operators to the reliable set of instrumentation to be relied upon for the post-fire mitigation strategies for each fire area.

PRA RAI 12 – Fire PRA Modeling of HVAC

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

Attachment C of the LAR identifies a number of systems for which HVAC is needed to meet its performance goal. Please describe the HVAC modeling performed to support the fire PRA and whether HVAC cable tracing and fire modeling were performed to support this modeling. Explain whether additional operator actions are needed for crediting HVAC.

*Response*

Attachment C of the ANO-2 LAR was developed based on current Appendix R criteria. As a result, the performance goals do not reflect the NFPA-805 performance goals that were refined for the transition to NFPA-805. A new analysis was performed to more accurately determine which room coolers were required, if any, for both personnel access and equipment functionality during post-fire safe shutdown conditions in a safe and stable configuration.

The assumption for all ANO-2 rooms, except the EDG and Safety Parameter Display System (SPDS) room, is that heating, ventilation, and air conditioning (HVAC) is not available for post fire shutdown. Calc-10-E-0010-05, Rev. 1, "ANO-2 Auxiliary Building Integrated Room Heat-Up Model to Support NFPA-805 Analysis," is an integrated model of the Auxiliary Building that documents acceptable environmental conditions without HVAC for safe shutdown of the unit. The calculation also documents the results of one modification that installs a passive mechanical "hold-open device" that holds open a fire door via a fusible link. In addition, the operation of one fan to lower the temperature in an electrical equipment room to acceptable levels to support unit shutdown is a function that will incorporate circuitry within the room and a logic change that will prevent fan shutdown from the Control Room. The FPRA model encompasses the impact of these configurations. The associated plant modifications are included in Attachment S (S1-12 and S1-13).

No Operator actions are necessary to credit the limited HVAC needed for post fire safe shutdown.

The FPRA and Nuclear Safety Capability Assessment (NSCA) include EDG room ventilation and the NSCA also includes SPDS room cooling.

The FPRA and NSCA analysis include room ventilation associated with the ANO-2 EDGs that is necessary for operation of these on-site sources of power. Elements included in the FPRA fault tree include power failures, exhaust fan failures, and louver failures that could result in inadequate EDG room cooling. The circuits necessary to support EDG room cooling are part of existing analysis included in the controlled database for ANO cable and raceway (PDMS). PDMS maintains mappings of fire zone / fire area associations and failure effects of each cable required to maintain functionality.

The SPDS provides post fire shutdown indication to the TSC and is included in the current NSCA. The room that contains the SPDS computer equipment has a stand-alone room cooler with power supplied from both ANO-1 and ANO-2 safety related power sources. The cables and equipment necessary to support SPDS room cooling are also included in PDMS with all mappings and associations. The SPDS instrumentation is credited for Alternate Shutdown fire areas. No cables impacting operation of this HVAC system are impacted in the Alternate Shutdown fire areas.

The current NSCA and FPRA analyses conservatively credit systems other than the EDG and SPDS room cooling systems. Updates to these analyses to eliminate credit for HVAC systems other than the EDG and SPDS room cooling systems, based on the calculation specified above, will be implemented in future revisions as necessary to facilitate configuration control for these analyses post NFPA-805 transition.

PRA RAI 13 – Smoke Damage

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

Section 6.2 of the Fire Scenario report (PRA-A2-05-003) states that only an abandonment scenario would produce smoke exposure conditions in the MCR sufficient to have negative impact on electronics not already directly affected by fire damage; high voltage components reside in enclosures that limit smoke density and that smoke removal capacity exists in areas of concern such as the switchgear rooms; and that fire within an enclosure was assumed to cause loss of function of all equipment in the enclosure, and therefore smoke effects would be bounded. Please explain how the effect of smoke on equipment was evaluated by using the guidance provided in Appendix T of NUREG/CR-6850.

*Response*

NUREG/CR-6850, Appendix T, Section T.3.1 provides the following assumptions which "should be included in the PRA assessment" of smoke damage. Each assumption is italicized followed by a statement of how the assumption was evaluated in the ANO-2 FPRA. This shows that the guidance in Appendix T of NUREG/CR-6850 was followed in the ANO-2 FPRA.

- *"The following types of components are potentially vulnerable to smoke damage:*
  - *Medium voltage electrical switching equipment (1,000 V to 15 kV), including switchgear, circuit breakers, surge arrestors, switches, etc.*
  - *High-voltage electrical power transmission equipment (above 15 kV), including transformers, switches, circuit breakers, overhead power lines, lightning arrestors, bus bars, etc.*
  - *Devices that rely on fine mechanical motion (e.g., strip chart recorders and dial indicators) where the moving parts are exposed to smoke deposition.*
  - *Unprotected printed circuit cards and electronic components."*

  The listed types of components were considered potentially vulnerable to smoke damage in the ANO-2 FPRA.

- *"Short-term smoke damage will only result from a severe smoke exposure condition.*
  - *For general compartment scenarios: Smoke exposures arising from a general compartment fire (e.g., general smoke spread within the room of fire origin or in an adjacent compartment) will not lead to short-term smoke damage, even for potentially vulnerable components."*

    General smoke spread within the room of fire origin or in an adjacent compartment was not considered to lead to short-term smoke damage in the ANO-2 FPRA.

  - *"For components housed in an individual electrical panel: Smoke damage will likely be limited to components co-located in the same electrical panel as the fire ignition source itself. Assume that, given a substantial fire in an individual electrical panel, all potentially vulnerable components within that panel will be damaged by smoke unless a specific installation feature precludes such damage (see below). Thermal damage for such components should also be considered."*

In the ANO-2 FPRA, potentially vulnerable components within the same electrical panel as the fire ignition source itself were considered to be failed by the fire (either by thermal or smoke damage). Credit for the installation features listed below was not taken for components within the same electrical panel as the fire ignition source.

– *"For components located in an interconnected bank of electrical panels: Given a substantive fire, it is reasonable to assume that dense smoke will spread, at the very least, into directly adjoining panel sections. Given a substantial fire in one section of an interconnected bank of panels, assume that potentially vulnerable components in the immediately adjoining panels will be damaged due to smoke exposure."*

In the ANO-2 FPRA, given a substantial fire in one section of an interconnected bank of panels, potentially vulnerable components within immediately adjoining panels were considered to be failed by the fire unless a specific installation feature precludes such damage (see below). Fires (which are not large enough to result in Control Room abandonment) in electrical panels in the Main Control Room are not considered substantial fires in the ANO-2 FPRA. Such fires are expected to be contained within the panel due to early fire detection and suppression by Operations personnel.

– *"For very high-voltage electrical transmission equipment: Assume that exposure to substantial quantities of smoke (e.g., from a large forest fire or from a large oil fire) will cause high-voltage transmission equipment to trip off-line."*

In the ANO-2 FPRA, very high voltage transmission equipment that could be exposed to large oil fires (i.e., off-site power transformers) was assumed to be failed by the oil fire. Large forest fires were not addressed in the ANO-2 FPRA.

– *"For components in an open main control board-type configuration: smoke exposure conditions are not expected to reach levels sufficient to cause component failures."*

The ANO-2 FPRA did not assume that components in an open main control board-type configuration would fail due to smoke exposure. The ANO-2 control room does not contain any open panels.

- *"The following features are assumed to preclude short-term smoke damage:*

– *Use of a conformal coating on a printed circuit card;"*

This feature was not credited to preclude short-term smoke damage in the ANO-2 FPRA.

– *"Hermetic encapsulation of electronic, solid state, or electromechanical devices (e.g., as is typical of a solid state relay or computer HDD unit);"*

This feature was not credited to preclude short-term smoke damage in the ANO-2 FPRA.

– *"Housing of control and indication components in a well-sealed manufacturers' housing (e.g., typical of a dial indicator, strip chart recorder with all covers in place and intact, electromechanical relays with a tight-fitting cover);"*

This feature was not credited to preclude short-term smoke damage in the ANO-2 FPRA.

– *"Housing potentially vulnerable components within an electrical chassis, so long as the chassis is reasonably well sealed, ventilation inlets into the chassis are filtered, and the fire itself remains outside the chassis;"*

This feature was not credited to preclude short-term smoke damage in the ANO-2 FPRA.

– *"Housing components in a sealed panel with a filtered local ventilation system (so long as the fire remains outside the panel); and"*

This feature was not credited to preclude short-term smoke damage in the ANO-2 FPRA.

– *"Housing components in a well-sealed and unventilated electrical panel so long as the fire remains outside the panel."*

No specific credit was taken for well-sealed and unventilated electrical panels protecting components within the panel. Fires within well-sealed and unventilated electrical panels were assumed to not cause short-term smoke or heat damage to components outside the panel or in adjacent panels. This assumption is a logical extension of this feature.

PRA RAI 15 – Calculation of VFDR ∆CDF and ∆LERF

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 review of the information in the LAR has identified the following information that is required to fully characterize the risk estimates.

Section W.2.1 of the LAR provides description of how the ∆CDF and ∆LERF for the VFDRs and how the additional risk of recovery actions for each of the fire areas were determined including a special discussion of how the MCR was assessed. The described approach is based on setting VFDR related components in the fire PRA to their random failure probability, as in the compliant case, or to "failed by the fire," as in the post transition case. However, exceptions are acknowledged of VFDRs not modeled in the fire PRA (e.g., HVAC systems) because their failure has no impact on the safety function modeled in the fire PRA. Please clarify the following:

a) Please clarify how the compliant and variant plants were modeled to determine the ∆CDF and ∆LERF for the control room abandonment scenario.

b) For exceptions described above and in Section W.2.1 explain how a system that is identified as contributing to Nuclear Safety Performance Criteria by virtue of being identified in a VFDR can have "no impact on the safety function."

c) Are there any systems not modeled in the PRA for simplicity or convenience and because not including them is conservative? Would including any of these unmodeled systems have an impact on the change in fire risk estimates?

*Response*

a) For the control room abandonment scenario, the compliant and variant plants were modeled in the same manner as described for all areas in Section W.1.2 of the LAR. The control room abandonment scenario is different from non-abandonment scenarios in Fire Area G because, in both the compliant and variant cases, Operator manual actions which would normally take place in the control room are failed. Also, the control room abandonment fire impacts all components in the control room (except those set to their random failure probability for each case as described below).

To clarify, the discussion for all areas on Pages W-3 and W-4 of LAR Section W.1.2 is made specific to the control room abandonment scenario as follows.

*Control Room Abandonment Compliant Case –*

*The control room abandonment compliant case represents the existing as-built, as-operated plant if all of the VFDRs in the control room were eliminated; in other words, if the control room was deterministically compliant. Thus, the control room abandonment compliant case was analyzed as follows.*

*The FPRA was reviewed to determine which VFDR related components are modeled. VFDR related components not modeled within the FPRA (e.g., those involving HVAC systems not required to meet PRA success criteria) were determined to have no impact on the safety functions modeled in the FPRA and thus, no contribution to CDF or LERF.*

*For the control room abandonment scenario, all of the specific VFDR related components, which if protected would eliminate the VFDR, were set to their random failure probability instead of to "failed by the fire." Setting these components to their random failure probability provides an estimate of the fire risk if individual modifications were made to protect or reroute the components, thereby eliminating the VFDRs. The other components in the FPRA model that are impacted by the fire scenario were set to "failed by the fire."*

*Recovery actions (outside control room manual actions to mitigate the direct failure of VFDRs listed in Attachment G) and inside control room manual actions were not credited in the compliant case. Non-recovery actions (manual actions to mitigate non-VFDR failures) were credited in the compliant case. This ensures that the compliant case represents the as-built, as-operated plant except for the eliminated VFDRs in the area, allowing for direct comparison with the post-transition plant model, which credits recovery actions.*

*As a rule, proposed modifications (listed in Attachment S) were not credited in the compliant case. This ensures that the compliant case represents the as-built, as-operated plant, except for the eliminated VFDRs in the area, allowing for direct comparison with the post-transition plant model, which credits the modifications. One noted exception is Modification S1-3, "Backup DC control power to switchgear 2A-1, 2A-2, 2H-1 and 2H-2," which is conservatively credited in both the compliant plant model and the post transition plant model.*

*Control Room Abandonment Post Transition Case –*

*The control room abandonment post transition case represents the plant if the recoveries listed in Attachment G and the modifications listed in Attachment S are used to protect the plant from core damage, mitigating the risk imposed by the VFDRs.*

*For the control room abandonment scenario, all of the specific VFDR related components and other components in the FPRA model were set to "failed by the fire," unless the proposed modifications removed the fire impact.*

*Recovery actions (outside control room manual actions to mitigate the direct failure of VFDRs listed in Attachment G) were credited in the post transition case. Inside control room manual actions were not credited in the post transition case. Non-recovery actions (manual actions to mitigate non-VFDR failures) were also credited in the post transition case.*

*The proposed modifications (listed in Attachment S) were credited in the post transition case by setting the appropriate basic events to their random failure probability instead of "failed by the fire." This ensures that the post transition case represents the plant following transition to NFPA-805 and allows comparison with the compliant case, which does not credit the modifications. The exception is Modification S1-3, "Backup DC control power to switchgear 2A-1, 2A-2, 2H-1 and 2H-2," which is conservatively credited in both the compliant plant model and the post transition plant model.*

In summary, the two control room abandonment cases are similar with the exception that the compliant case sets all VFDR failure events to their nominal value with no credit for recovery actions, whereas the variant case credits only the recovery actions and modifications. All the remaining failures remain the same between the variant and compliant cases.

b) The ANO-2 FPRA was developed in accordance with the requirements of Part 4 "Requirements for Fires at Power PRA" of the ASME and ANS combined PRA Standard, ASME/ANS RA-Sa-2009, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications." Consistent with those requirements, not all components required to meet the nuclear safety performance criteria need to be specifically modeled in the FPRA. Examples of these include components for maintaining inventory control for cold shutdown (CSD), pressurizer heaters to maintain level within the pressurizer, and HVAC components. These examples are discussed below:

   i. Consistent with the internal events model, CSD functions are not modeled in the FPRA. At-power PRAs are constructed on the premise that achieving and maintaining a safe, stable state through 24 hours is sufficient to support the conclusion that core damage has been prevented. Beyond that time, significant resources are available for recovery and repair of failed equipment. The additional risk attributable to the transition to CSD should be small, since the plant is already stable and additional changes in state would occur only when the necessary systems are available to support the transition. Once the plant is cold and depressurized, there are numerous options available and adequate time to respond to potential equipment failures in the long term. As a result, VFDRs associated with long-term inventory control (e.g., charging pumps) are not modeled in the FPRA. The FPRA credits the high pressure safety injection (HPSI) pumps to mitigate inventory losses within the PRA timeframe.

ii. Pressurizer heaters are listed as VFDRs because they contribute to the ability to maintain pressurizer level within the indicating range. However, as indicated in LAR Section 4.2, although their use reduces Operator burden, they are not required to provide adequate pressure control. The pressurizer heaters are not modeled in the FPRA since their loss, or spurious operation, does not lead to a core damage sequence.

iii. A discussion of the FPRA modeling of HVAC systems is provided in the response to ANO-2 PRA RAI 12.

In summary, the net effect of VFDRs related to these non-modeled components is zero in the delta risk calculations since failure, or recovery, of these components has no impact on core damage probability.

c) The systems in the FPRA model are the same systems credited in the full power internal events (FPIE) model. As described in the LAR, both models were constructed in accordance with the applicable standards and have been peer reviewed. As described for accident sequence development analysis in RG 1.200, the models include necessary and sufficient equipment (safety and non-safety) reasonably expected to be used to mitigate the initiators. Systems were not excluded from the fault trees for simplicity or convenience.

The response to RAI PRA 01b explains that, due to lack of cable routing information, some components are assumed to be failed in all fire scenarios, unless credited by exclusion. These components include the PRA-modeled components in the main feedwater, circulating water, component cooling water, and instrument air systems. The assumption that these components are failed in all fires (or almost all fires) adds a positive, conservative bias to the estimated total fire risk for the plant. However, since these systems are not credited in the NSCA, no VFDRs are associated with these systems and, therefore, these systems cannot have an impact on the change in fire risk estimates (delta risk).

PRA RAI 18 – Model Changes and Focused Scope Reviews after the Full Peer Review

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

Section V.1 of the LAR states that two focused scope peer reviews have been performed after the June 2009 full scope peer review, the first in October 2011 and a second in November 2012. A focused scope peer review only reviews a PRA against some of the elements and supporting requirements in the ASME/ANS PRA Standard. The scope of these two peer reviews is not provided. Please summarize the elements or supporting requirements reviewed during these reviews.

*Response*

The first focused scope peer review, conducted by Westinghouse Electric Company in October 2011 and documented in LTR-RAM-I-11-064, covered all 39 SRs under Fire Scenario Selection High Level Requirements (HLRs) FSS-A, FSS-C, FSS-D, FSS-E, and FSS-H. In addition, it also reviewed Ignition Frequency SRs IGN-A7 and IGN-A10.

The second focused scope peer review, conducted by Kazarians and Associates in November 2012 and documented in 5384.R02.121129, covered 37 of the 39 SRs under HLRs FSS-A, FSS-C, FSS-D, FSS-E, and FSS-H. SRs FSS-A6 and FSS-H8 were not in the scope of this peer review.

<u>PRA RAI 19 – Internal Events PRA F&Os</u>

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

Please clarify the following dispositions to fire F&Os and SR assessment identified in Attachment U of the LAR that have the potential to impact the fire PRA results and do appear to be fully resolved:

a) <u>AS-A4-01 and AS-A 10-01 (Finding, Not Met at CC-I/II/III):</u>

The full text of F&O AS-A4-01 from the internal events PRA peer review (LTR-RAM-II-08-020) says "Even though some operator actions required to achieve the identified success criteria are mentioned in portions of the initiating event analyses, these operator actions are not consistently identified and documented. Please identify all operator actions needed to achieve the success criteria for each of the key safety functions defined for modeled initiating events." Also, F&O AS-A10-01 states that operator actions are not specified in either the accident sequence descriptions or event trees. Please describe the review performed to check for treatment of operators actions required for success of accident sequences in the internal events PRA.

*Response*

The Operator actions for the ANO-2 PRA are based on the EOPs, AOPs, system Operating Procedures, and alarm response procedures. The Operator actions are determined in each system notebook (PRA-A2-01-003S11) and evaluated as part of the Human Reliability Analysis update (PRA-A2-01-003S3). In addition, the PSA model was reviewed by Plant Operations as part of the quantification expert panel review and further comments were provided by Plant Operations through the on-line risk assessments performed using the Equipment Out of Service Monitor (EOOS).

The ANO-2 event trees are functional event trees. There are few functional level manual actions that would be discussed in the Accident Sequence document. These include manually starting AFW for secondary heat removal, performing once-through cooling, and performing emergency boration for anticipated transient without scram (ATWS), as necessary.

b) AS-A5-01 (Finding, Not Met at CC-I/II/III):

> Please describe what steps were taken to develop accident sequences consistent with system design, emergency operating procedures (EOPs), and other plant response procedures. Please justify that the extent of the described effort is adequate to support the fire PRA application.

*Response*

The accident sequence event trees are developed based on the Safety Analysis Report and the EOPs. The following safety functions are addressed in the accident sequences: Reactivity Control, Electric Power, RCS and Core Heat Removal, RCS Inventory Control, RCS Pressure Control, Containment Integrity, and Containment Temperature and Pressure Control consistent with the ANO-2 Functional Recovery procedure (OP-2202.009) and the Combustion Engineering critical safety functions (CE TIS-6743). The systems that are available to provide these safety functions are based on the system success criteria for each initiating event and the instructions in the EOPs and AOPs.

The safety functions to mitigate an accident caused by a fire are the same as for non-fire accidents. The fire impacts on the accident due to spurious actions, false indications, etc., are addressed in the FPRA analysis, but would not impact the safety functions needed. A reactor trip due to a fire requires the same mitigation features as a non-fire trip. The systems and trains available change based on the fire damage, but the same core and containment functions are controlled to protect the health and safety of the public.

c) AS-B1-01 (Finding, Not Met at CC-I/II/III):

> Please describe what steps were taken to ensure that accident sequences developed for "special initiators" appropriately reflect the impact of these initiators on mitigating systems. Please justify that the extent of the described effort is adequate to support the fire PRA.

*Response*

The special initiators are included in the fault tree at the level that is needed to fail the initiator function. For instance, the initiator for loss of 4.16 KV bus 2A3 (%T12) is placed in the fault tree in the same gates as the hardware failure of 2A3. The initiator is also included in lists of transient initiators where applicable. Therefore, the loss of 2A3 initiator will fail any components or trains that are failed by the 2A3 bus (such as HPSI pump A, LPSI pump A, EFW pump 7B, SW pump A, CS pump A, 480 VAC bus 2B5, and HPSI and SW swing pumps when aligned to 2A3).

The FPRA uses the reactor trip initiator as the default initiator for FRANC quantification (PRA-A2-05-003, Rev. 0, Section 10.0). Therefore, the placement of special initiators in the fault tree does not impact the FPRA.

d) AS-B2-01 (Finding, Not Met CC-I/II/III):

Please describe what steps were taken to ensure that accident sequences adequately address dependencies in the internal events PRA. In particular, please describe how dependency between HFEs in the same cutset is evaluated. Include in this description, identification of dependencies considered (e.g., same crew, common cognition, resources, timing, and stress level), and how minimum joint HEP floors were established.

*Response*

The accident sequence analysis addresses primarily the safety functions needed to mitigate the accident. In some cases, the accident will dictate the dependencies. For instance, a large break LOCA will depressurize the primary side such that secondary cooling using feedwater will not mitigate the event.

Other dependencies, such as AC and DC power, cooling water, HVAC, and instrument air, are addressed in the system notebooks based on the failure modes of the various components.

Finally, dependence between operator actions is addressed in the quantification task. When individual cutsets include multiple operator actions, the combination of actions is evaluated and documented in Section 4.3 of the HRA report. This section of the document addresses the performance shaping factors for dependence between operator actions. The HEP floor for HRA combinations is 1.0E-6 (HRA Assumption 5). The ANO-2 quantification was performed with high screening values assigned for post-accident HRAs to allow combinations of operator actions to force unanalyzed HRA combinations to come to the top of the cutsets to be analyzed during the quantification process.

e) AS-B3-01 (Finding, Not Met at CC-I/II/III):

Please identify the assumptions made about the impact of phenomenological conditions created by accident progression on systems modeled in the accident sequences in the internal events PRA.

*Response*

WCAP-16679-P, Revision 0, Accident Sequence Phenomena Considerations (November 2006), discusses eighteen accident sequence phenomena that should be considered for a PWR. These phenomena and the ANO-2 considerations are shown below.

1. Equipment operation in beyond design basis conditions – The ANO-2 PRA model does not generally credit equipment operation beyond design basis conditions. This phenomenon primarily applies to operation of containment fan coolers for Level 1 and

Level 2 and equipment function to mitigate an Interfacing Systems LOCA (ISLOCA). ANO-2 conservatively assumes that ISLOCA leads to core damage and is a containment bypass event. The success criterion for containment heat removal for ANO-2 is based on remaining below the environmental qualification (EQ) temperature profiles for the equipment within containment.

2. Use of raw water systems as backup water supplies – The ANO-2 PRA model credits the use of Service Water (SW) as a backup supply for the EFW systems after Condensate Storage Tank (CST) depletion. The modeling of the SW system includes a high debris condition which equates to approximately 10 days per year. The impact of debris fouling of EFW valves directly is a long term failure for debris that passes through the SW filters to EFW assuming no filter plugging of SW; therefore, only failure of SW due to plugging is modeled.
3. Service Water Clogging – The ANO-2 PRA model credits the seasonal increase in debris (particularly fish runs) to address the increase in SW clogging of the traveling screens and SW pump filters for debris.
4. Containment sump debris – The ANO-2 PRA model increases the failure of sump suction valves by a factor of 100 for large and medium break LOCAs (where debris would be dislodged by the break flow and transported to the containment sump.
5. Loss of cooling to critical equipment – The ANO-2 PRA model considers pump seal cooling and room cooling to the major pumps (EFW, HPSI, LPSI, Containment Spray). Room cooling is generally required for recirculation modes. Thermal hydraulic calculations are referenced to support the modeling or exemption of pump seal cooling and room cooling for these pumps.
6. Sufficient Net Positive Suction Head (NPSH) for Emergency Core Cooling recirculation – This issue involves failure of Emergency Core Cooling System (ECCS) pumps due to loss of NPSH following a loss of containment integrity. Since the success criteria for containment pressure and temperature control is based on EQ limits, this issue would not impact CDF or LERF, but would only impact late containment failures.
7. Control Room habitability – This issue involves loss of Control Room HVAC impacting habitability during the PRA mission time. Simple actions like opening doors will keep the Control Room habitable and will not impact the PRA during the first 24 hours.
8. Local operator actions in harsh environments – For operator actions outside of the Control Room, the physical environment is addressed as part of the Operator interviews. This information is included in the performance shaping factors evaluated when evaluating the Operator action.
9. Effect of loss of station air on air-operated valves – The ANO-2 PRA model addresses the dependence of air-operated components following a loss of air. Instrument air (IA) dependence is included for valves that require air to maintain the PRA required position or change state to the PRA required position. Also, the ANO-2 model credits cross-tie to ANO-1 IA system, if necessary, to maintain air pressure.
10. Depressurized steam generators – turbine driven emergency feedwater pumps – The ANO-2 system notebook for EFW includes the following assumption: “Blowdown through the 2-inch bypass lines around the MSIV's is assumed to depressurize the steam generators to the point where EFW will automatically isolate.” Therefore, this phenomenon is addressed.

11. Overfilled steam generators – emergency feedwater availability – The ANO-2 system notebook for EFW assumes that the turbine driven EFW pump fails on overfill. The model also includes an action to manually control EFW flow to prevent overfill and includes an action (QHF2SGSBOX) to control EFW flow to prevent overfill after battery depletion.
12. Depressurize steam generators – steam generator tube integrity – The ANO-2 model considers stuck-open safety relief valves (SRVs) as a loss of RCS integrity. These events are considered as pressure-induced tube ruptures in the LERF analysis.
13. Pressurizer PORVs after core uncovery – ANO-2 does not have a power-operated relief valve (PORV). ANO-2 has a depressurization path via low-temperature overpressure (LTOP) valves and ECCS valves. These valves are not credited after core uncovery.
14. Valves closing against large pressure differentials – The ANO-2 PRA model does not credit actions to close valves to isolate ISLOCA following failures. Appendix G of PRA-A2-05-005 reviews the potential containment isolation pathways for LERF. None of these pathways credits a manual closure of containment against high pressure differentials. Finally, the ANO-2 ATWS analysis addresses RCS integrity to prevent overpressurization and for securing SRVs. Failure of either function leads directly to core damage.
15. Air/steam binding – Air/steam binding is considered the result of either a design error or a maintenance error. The aforementioned WCAP recommends that air/steam binding need not be modeled in the PRA, but should be identified as an uncertainty. Therefore, this phenomenon does not impact the PRA model.
16. Backup systems for multi-units – The ANO-2 model credits one ANO-1 system as a backup and has two systems that are shared with ANO-1. ANO-1 IA is normally cross-tied with ANO-2 IA so that either IA system can supply loads to both units. In addition, Startup Transformer 2 and the ACCDG are shared between units.
17. Containment water level – This phenomenon addresses high water levels in containment if Refueling Water Tank (RWT) refill is credited. ANO-2 does not credit RWT refill. Therefore, this phenomenon does not apply.
18. Mini-recirculation – This issue addresses ECCS pumps operating in a dead-headed mode, particularly during ATWS. The failure of the mini-flow valve to open causing dead-heading is included as a failure mode for the HPSI pumps.

f) AS-B6-01 (Finding, Not Met at CC-I/II/III):

Please describe in general how time phrased dependencies are modeled in the internal events PRA. Please include in the description how changing environmental conditions, such as room heating, are considered. Justify that the extent of the described effort is adequate to support the fire PRA.

*Response*

Time phase dependence is generally considered in the ANO-2 model for two instances. The first case is the recovery of offsite power. The loss of offsite power analysis (PRA-A2-01-003S09) performs a convolution analysis to address the time available to recover power based on battery depletion with load shedding (8 hours) or without load shedding (4 hours) and also addresses run failures to account for the fact that these failure do not necessarily occur at t=0. Since offsite power recovery is not credited in the FPRA, this use of time phasing is not applicable for fires.

The other use of time phase dependence is in the development of Human Error Probabilities. The system time window for performing the action accounts for the time when the action would be needed. For instance, the alarm to align EFW suction to an alternate source upon CST depletion would occur approximately 10 hours after accident initiation and another 2.5 hours before the tank is completely depleted. Depending on the time available and time after a fire, some of the Operator actions have been updated to support the FPRA.

g) AS-C2-01 (Finding, Not Met at CC-I/II/III):

Please describe what improvements will be made to the Accident Sequence notebook to document the process used to develop accident sequences and treat dependencies. Include in this description how the inputs, methods, and results mentioned in SR AS-C2 were considered.

*Response*

Several improvements are proposed for the Accident Sequence notebook.

1. Split the model success criteria to a separate notebook to more effectively discuss the success criteria supporting requirements. The success criteria notebook generally addresses sequence timing and system dependences.
2. Explicitly discuss operator actions for manually starting the AFW pump, aligning once through cooling, depressurization, emergency boration for ATWS, aligning hot leg injection for large break LOCA, and other accident sequence specific operator actions.
3. Add a table that shows how each transient initiator is included in the fault tree that discusses where the initiator is located in the model and what front line and support systems are impacted.
4. Discuss the loss of off-site power and station blackout events in more detail and how they are effectively addressed in the transient event tree.
5. Discuss the accident sequence phenomena from WCAP-16679 and other industry reports that are applicable to ANO-2.
6. Add the top logic fault tree that bridges the gap between the functional event trees and the system fault trees.

h) SY-A4-01 (Finding, Not Met at CC-I):

Capability Category II of SR SY-A4 requires performing walkdowns and interviews with knowledgeable plant personnel (e.g., engineering, plant operations, etc.) to confirm that the systems analysis correctly reflects the as-built, as-operated plant. Please describe what efforts were made during the systems analysis to correctly reflect the as-built, as-operated plant. Include in this description identification of any walkdowns and interviews performed specifically in support of the internal events PRA and otherwise, the extent of those efforts, and identification of what kinds of staff performed them. Please justify that the extent of the described effort is adequate to support the fire PRA.

*Response*

Walkdowns and discussions with plant engineers, plant Operations, Operations training, etc., have been conducted throughout the development of the PRA models. Many of these questions are associated with specific plant changes that might impact the PRA model, operation of certain components, verification of information in design documents, etc. Engineering, Operations, and Licensing are included in the expert panel review of PRA results to ensure that the results match the as-built, as-operated plant. While walkdowns were not documented for the system analyses, walkdowns for internal flooding and internal fires are documented. Both of these walkdowns address spatial relationships between components that are important for internal events.

The FPRA results were also reviewed to verify that the sequence of events is consistent with the as-built, as operated plant.

i) SY-B8-01 (Finding, Not Met at CC-I/II/III):

Please describe analysis performed in support of the PRA of spatial and environmental hazards that have the potential to impact multiple systems or redundant components in the same systems. Please justify that the extent of the described effort is adequate to support the fire PRA.

*Response*

Spatial hazards refer to failure of a structure, system or component (SSC) due to being in close proximity of another damaged component. The spatial hazard impacts are generally addressed in the internal flooding analysis, which reviews the impact of spray or pipe breaks on components in the local area. In addition, the FPRA addresses damage to components, cables, instruments in the zone of influence of the fire.

The environmental hazards generally impact the model through accident sequence phenomena, such as high room temperatures on loss of room cooling, pump failures on high seal temperatures or insufficient NPSH, and debris clogging of screens and heat exchangers. The impact of a loss of room cooling has been evaluated for all areas that might require room cooling during the PRA mission time. In addition, RCP, HPSI pump, and Low Pressure Safety Injection (LPSI) pump flow from the containment sump are evaluated for failure on high temperature or loss of NPSH. Finally, debris clogging of the service water intake screens and sump suction screens are evaluated for periods of higher debris.

j) HR-C2-01 (Finding, Not Met at CC-I):

Please describe the review of plant-specific and generic operating experience, including licensee event reports, to check for pre-initiators performed in support of the internal events PRA. Please justify that the extent of the described effort is adequate to support the fire PRA.

*Response*

ANO-2 condition reports since January 1, 2003 with trend codes associated with "Instrument Calibration," "Misalignment," "Mispositioned," "Mispositioned Components," and "Mispositioned Valve" were reviewed to determine if pre-initiator events should be added to the PRA model based on the actual events that have occurred. In addition, the events associated with each system were reviewed to determine if repetitive miscalibrations or mispositioning events have occurred that would increase the human error probabilities due to ineffective application of the recovery factors used in the HRA process. No new pre-initiator human actions were identified, and none of the events indicated that the human error probability would be increased due to miscalibrations or mispositioning.

Pre-initiator human actions are not impacted by the FPRA. Since the review did not add any new pre-initiator HRAs, there is no impact to the FPRA.

k) HR-D3-01 (Finding, Not Met at CC-I):

Please describe how procedures supporting human error probability assessment in the internal events PRA were reviewed and whether the review included evaluation of procedure quality (e.g., format, logical structure, ease of use, clarity, and comprehensiveness) or evaluation of administrative controls impacting the procedure (e.g., review, configuration, training, and management controls). If review of procedural quality was not performed then justify the quality of procedures used for detailed HEP assessment.

*Response*

Each HRA is evaluated against the Cause-Based Decision trees (CBDTs) described in EPRI TR-100259. These trees ensure that the performance shaping factors associated with procedural quality are explicitly addressed. In addition, the operator interviews performed for each operator action talk through the indications that will lead the operators to perform the action, the procedure steps that the operators will follow to perform the action, and the simulator and classroom training on the action.

l) HR-D6-01 (Finding, Not Met at CC-I/II/III):

Please specify the version of the HRA Toolbox Excel Spreadsheets used and describe how the conversion of median to mean values was performed. Clarify whether the HRA Toolbox Excel Spreadsheets were used for all HEP determinations or were used in combination with other software or approaches. If other approaches were also used, please describe those approaches.

*Response*

The HRA Toolbox excel worksheets do not have a specific version. For the pre-accident Operator actions (hfe_a.xls), the median to mean conversion was added below the median result. This calculation uses the error factor for a lognormal distribution.

For post-accident Operator actions, the mean probability is calculated for execution errors using the same formula using the median values and error factors from the tables in Chapter 20 of NUREG/CR-1278 to convert the execution errors to mean. This conversion is shown in cells CA12:CF67 of the worksheets in hfe_cp.xls. The equation to convert a median probability to a mean for a lognormal distribution from NUREG/CR-2728 is:

$$Mean = Median * EXP\left[\left(\frac{1}{1.645}\ln[EF]\right)^{2} / 2\right]$$

m) HR-G6-01 (Finding, Not Met at CC-I/II/III):

Please describe the consistency review performed to check the reasonableness of final HEPs in the internal events PRA given the scenario context, plant history, procedures, operational practices, and experience, and indicate whether all or just a fraction of the HEPs were reviewed. Please justify that the extent of the described effort is adequate to support the fire PRA.

*Response*

The post-accident HRA events were reviewed to verify that the values are reasonable and consistent based on the time available, the complexity of the decision-making process, and the complexity of the task. If the probability was questionable, the spreadsheets were reviewed to determine which element dominated the risk and changes were made to either correct or explain the discrepancies. In some cases, the values were compared with similar actions at similar plants. The final spreadsheets are considered consistent relative to each other.

A review of condition reports associated with Operator Error, Operating License, Operator License, and Operator Qualification did not identify any issues that would impact HEPs for any post-accident action.

The post-accident HRA evaluations for FPRA were updated based on the guidance in NUREG/CR-6850 to address impacts of a fire on Operator actions such as loss of instrumentation and increased Operator response times.

n) DA-C10-01 (Finding, Not Met at CC-I):

Please explain how surveillance test data was collected and incorporated in the internal events PRA appropriate to applicable component failure modes. If surveillance test data was not incorporated into the PRA, at a level appropriate to the failure modes then complete this work or evaluate the impact of not completing this work on the fire PRA results.

*Response*

The plant specific data used for the ANO-2 PRA are provided by the System Engineers and include successful starts, total starts, failures-to-run, run-hours, planned downtime hours, and forced down time on a monthly basis for each train important for the PRA. This data includes starts and run-hours from surveillance tests as well as any other starts and run-hours indicated in the operating logs. This data was collected for the Plant Reliability Program as an input to Maintenance Rule.

o) DA-C12-01 (Finding, Not Met at CC-I):

Please describe how the out-of-service time (i.e., unavailable time) data for maintenance of equipment components, trains, and systems was determined for the PRA and the extent to which plant operators and maintenance engineers were involved in the data collection or evaluation process.

*Response*

The data for maintenance of equipment trains and systems are provided by the associated System Engineer based on Operator logs and discussions with plant Operations. The PRA Engineer did not perform the data collection or interviews with plant Operators, but the System Engineers did perform these reviews. Note that these unavailabilities are based on actual planned and unplanned out-of-service time for the trains and systems and not estimates based on surveillance times and estimated forced maintenance times. For high-risk significant systems, the unavailability data is derived from the Maintenance Rule. For other systems, the data was provided by the System Engineers. Therefore, the data developed more accurately reflects the unavailabilities than estimates from plant staff.

p) IF-C2-01 through IF-E8-01 (Findings, many Not Met at CC-I/II/III):

For all internal flooding related entries presented in Attachment U of the LAR the dispositions state that internal flooding does not impact fire risk. It is noted that medium loss of coolant accident (LOCA) and seal LOCAs are referred to in Tables V-1 and W-1. In general, spurious actuations have the potential to cause internal flooding or spray. Please clarify whether any fire events can lead to internal flooding or spray. If flooding or spray can occur as a result of a fire event, then justify why these internal flooding F&Os cannot impact fire CDF, LERF, ΔCDF, or ΔLERF.

*Response*

Damage resulting from flooding or spray from a spuriously actuated suppression system is limited to the fire areas that contain deluge type (open-head) water systems. The containment spray system is not addressed in this response since equipment in containment potentially impacted by containment spray are designed for the containment accident environment, which would envelope the impact of the water spray environment caused by a spurious spray with a fire and/or with a limited size LOCA. Large LOCAs are not postulated in conjunction with a fire. Systems protecting the outdoor Main, Auxiliary, and Startup Transformers are also not included since these are isolated outdoor areas that do not pose a flooding concern with respect to the rest of the plant site. Fire areas with $CO_2$ or Halon deluge systems will not result in flooding or damage to equipment given the nature of the gases used. Closed-head sprinkler systems will impact only those areas where sufficient heat is generated to fuse the links associated with the sprinkler heads. This impact will be localized to the fire location and is typically limited to a small number of sprinkler heads. Spray from these sprinkler heads will be localized and is not likely to damage equipment beyond the zone of influence for the fire source. With the limited total flow associated with a small number of sprinkler heads, flooding is unlikely given the system design and floor drains provided. The ANO site includes water deluge systems in the following locations:

| Fire Zone | Description |
|---|---|
| 175-CC | Lube Oil Reservoir Room |
| 197-X | Seal Oil Unit, Lube Oil Reservoir and FW pump lube oil reservoir |
| 2200-MM | Seal Oil Unit and MFP Lube Oil Sump |
| 2109-U | Corridor to EDG room |
| 2098-L | Cable Spreading Room |
| 98-J | Corridor (368’ EL of Aux Building) |
| TKVLT | Diesel Fuel Oil Tank Vault |

The unique hazards, system actuation methods (cross zoned detection systems), system location and configuration, as well as drainage provided for these fire areas will limit the impact of spray or flooding post fire or in the event of a spurious operation. The impact on equipment required for post-fire shutdown beyond that associated with potential fire damage is highly unlikely.

q) QU-D3-01 (Suggestion, Met at CC-I):

Please provide a comparison of results with similar plants for the internal events PRA risk profile and results. Include in this assessment comparison by accident sequence frequencies, and identify any significant differences and the reasons for those differences.

*Response*

Below are tables providing a comparison between ANO-2 and Waterford 3. The first table provides a general comparison of each PSA model element. The next three tables provide a comparison of the initiating events that are common to both sites, unique to ANO-2 and unique to Waterford. The final table provides a comparison of the CDF risk for each sequence and provides a short discussion of the differences that impact results. Based on the comparison, the models are consistent and the differences are due to plant differences rather than modeling differences. Therefore, the FPRA would not be impacted by the plant differences.

<table>
<tr><th colspan="2">ANO-2 / W3 PSA Model Comparison by Element</th></tr>
<tr><th>PSA Element</th><th>Comments</th></tr>
<tr><td>General</td><td>The Waterford 3 (W3) model has recently been updated to address Peer Review Findings and incorporate latest plant specific and generic data. The ANO-2 model update process has been initiated, but will not be completed for at least 6-8 months.</td></tr>
<tr><td>Initiating Events</td><td>Comparison indicates that the differences between the ANO-2 and W3 initiators are due to plant differences. A systematic process for identifying initiators has been performed for each plant with input from plant Operators and Operator training. The tables below provide a comparison of common initiators and initiators unique to each site with a review of the differences.</td></tr>
<tr><td>Initiating Event Frequency</td><td>The W3 update is more recent and uses more recent generic frequencies (NUREG-1800 for LOCAs, NUREG/CR-6928 for non-LOCAs). ANO-2 generally uses NUREG/CR-5750 for generic frequencies.</td></tr>
<tr><td>ISLOCA Path Screening</td><td>ANO-2 and W3 both identified the LPSI lines and Shutdown Cooling (SDC) suction paths as ISLOCA paths. W3 has two separate SDC suction paths compared to one for ANO-2. All other paths screened.</td></tr>
<tr><td>Event Tree Functions and Logic</td><td>Event tree safety functions are the same.<br>General:<br>a. ANO-2 has the ability to perform once-through cooling. W3 does not.<br>b. B, U functions are reversed in the two models but does not impact results.<br>c. W3 has a separate station blackout (SBO) tree. ANO-2 includes SBO in the Transient tree.<br>Transient Tree:<br>a. W3 has a top for RCS Pressure Control, ANO-2 combines this function with RCS Pressure Boundary Integrity.<br>SGTR:<br>a. W3 credits charging pumps for inventory control<br>b. ANO-2 requires SDC for long term core cooling</td></tr>
<tr><td>LOCA Size Definitions</td><td>Success requirements for the S, M, and A LOCAs match. However, ANO-2 and W3 S and M Break size threshold differs. This appears to have no impact on analysis.</td></tr>
<tr><td>ATWS</td><td>A high level comparison of the ATWS logic indicated that the top level of the fault tree structures were similar with the following exceptions:<br>a. ANO-2 has a fault tree for the Reactor Protective System (RPS) trip system. W3 uses a point estimate for RPS trip unit failures.<br>b. Moderator Temperature Coefficients (MTCs) used for ANO-2 are generally lower than W3.</td></tr>
</table>

| ANO-2 / W3 PSA Model Comparison by Element | |
|---|---|
| **PSA Element** | **Comments** |
| Success Criteria for NSSS Systems | HPSI: identical success criteria (1 pump, 2 intact injection line)<br>LPSI: identical success criteria (1 pump, 1 intact injection line)<br>SIT: different success criteria (W3 – 3 Safety Injection Tanks (SITs) inject, each into an intact leg [consistent with CEOG LOCA standard]; ANO-2 – 2 SITs inject, each into an intact leg) |
| System Analysis | The systems modeled for ANO-2 and W3 are generally comparable. The support systems differ somewhat based on plant design (CCW at W3 vs. SW at ANO-2). Other differences are noted based on the event tree functions and logic. |
| HRA | The methodology used for HRAs is identical for ANO-2 and W3. Comparison of HEPs for similar actions between sites is difficult. For simple actions, such as tripping the RCPs or aligning HPSI hot leg injection, the HEPs are very similar. For others, such as aligning AFW pump for secondary cooling, the HEPs are different because of specific differences in performing the alignments for each site. |
| Loss of Offsite Power Recovery | Similar process and application of recoveries with the following exception:<br>a. W3 applies loss of off-site power (LOOP) recovery based on Condensate Storage Pool depletion. ANO-2 does not have an equivalent recovery. |
| Data | The W3 update is more recent and uses generic data from NUREG/CR-6928 (2010). ANO-2 uses generic data primarily from NUREG/CR 4639 with some data from NUREG/CR-4550 and other generic sources. |
| CCF | Methods for developing common cause failure (CCF) probabilities are the same. W3 uses a later version of the CCF Parameter Estimates than ANO-2. |
| Quantification | Similar quantification processes and computer codes are used to quantify the models. See the "Sequence Compare" worksheet for detailed review. |
| LERF | The LERF event tree and assumptions are similar for ANO-2 and W3. Therefore any differences are due to plant differences. |

| ANO-2 / W3 PSA Model Comparison by Element | |
|---|---|
| **PSA Element** | **Comments** |
| Documentation | The major differences between the ANO-2 and W3 documents are as follows:<br>a. W3 has developed a Success Criteria notebook. ANO-2 currently has the sequence success criteria interspersed throughout the Accident Sequence notebook. ANO-2 is planning to develop a Success Criteria notebook to ensure success criteria are more consistently documented and calculations supporting the success criteria more easily referenced.<br>b. ANO-2 uses an Access database to document the system notebooks. The database type does not easily allow for tables, such as the component dependency matrix, and figures, such as the system schematics. ANO-2 plans to move from the Access database to a more conventional document format. |

| Initiators Common to Both ANO-2 and W3 | | | | |
|---|---|---|---|---|
| **ANO-2 IE** | **ANO-2 Description** | **W3 IE** | **W3 Description** | **Frequency Comparison** |
| %RVR | Reactor Vessel Rupture <IE> | %V | Reactor Vessel Rupture Initiator | W3 uses updated frequency from NUREG-1829 which is lower. |
| %A | Large Break LOCA <IE> | %A | Large LOCA | W3 uses updated frequency from NUREG-1829 which is lower. |
| %M | Medium Break LOCA <IE> | %M | Medium LOCA | W3 uses updated frequency from NUREG-1829 which is higher. |
| %S | Small Break LOCA <IE> | %S | Small LOCA | W3 uses updated frequency from NUREG-1829 which is higher. |
| %RA, R | Steam Generator Tube Rupture on SG-A | %R | Steam Generator Tube Rupture | W3 uses updated frequency from NUREG/CR-6928 which is a factor of 2 lower. |
| %RB, R | Steam Generator Tube Rupture on SG-B | %R | Steam Generator Tube Rupture | W3 uses updated frequency from NUREG/CR-6928 which is a factor of 2 lower. |
| %T1 | Turbine Trip <IE> | %T3 | Turbine Trip (General Transient) | Plant specific frequencies used for both sites. |
| %T2 | Total loss of Feedwater Flow | %T4 | Total Loss of Feedwater flow | Bayesian update frequency used for both sites. |
| %T3 | Loss of Offsite Power <IE> | %T5 | Loss of Offsite Power | W3 frequency includes switchyard failures whereas ANO-2 has a separate %T500KV and %TST3 due to different impacts. |
| %T6 | Reactor Trip Initiating Event <IE> | %T1 | Reactor Trip (General Transient) | Plant specific frequencies used for both sites. W3 is a factor of 5 lower. |
| %T18 | Loss of Condenser Vacuum | %T2 | Loss of Condenser Vacuum | Bayesian update frequency used for both sites. W3 is a factor of 2 lower. |
| %RCP | RCP Seal LOCA | %RCP | RCP Seal LOCA | Same generic frequency used. |
| %IORV | Inadvertent Open Relief Valve | %IORV | Inadvertent open SRV | Same generic frequency used. |

| Initiators Unique to ANO-2 | | |
|---|---|---|
| **ANO-2 IE** | **Description** | **Comment** |
| %T4 | Excessive Feedwater Initiating Event <IE> | No comparable W3 IE. Excessive Main Feedwater (MFW) is included in the total loss of MFW flow for W3. |
| %T5-A | Steam / Feedwater Line Break on SG-A Side Inside MSIVs <IE> | Comparable to W3 %T6. The W3 event includes both steam lines and also feed lines inside containment. The frequency for %T6 is the same as %T5-A + %T5-B. |
| %T5-B | Steam / Feedwater Line Break on SG-B Side Inside MSIVs <IE> | |
| %T5-C | Steam Line Break outside MSIV'S <IE> | Comparable to W3 %T6OC and %T7. The W3 event also includes spurious Main Steam Isolation Valve (MSIV) closure. |
| %T7 | Total Loss of Service Water Flow <IE> | Comparable to W3 %T9. W3 Component Cooling Water (CCW) system is different from the ANO-2 Service Water (SW) system. |
| %T8 | Loss of Service Water Pump Supplying Loop I <IE> | No comparable W3 IE. Partial loss of CCW was evaluated as a special initiator, but did not qualify based on plant design. |
| %T9 | Loss of Service Water Pump Supplying Loop II <IE> | No comparable W3 IE. Partial loss of CCW was evaluated as a special initiator, but did not qualify based on plant design. |
| %T10 | Loss of DC Bus 2D01 <IE> | Comparable to W3 %TDC1. DC loads are somewhat different between W3 and ANO-2. |
| %T11 | Loss of DC Bus 2D02 <IE> | Comparable to W3 %TDC2. DC loads are somewhat different between W3 and ANO-2. |
| %T12 | Loss of AC Bus 2A3 <IE> | Comparable to W3 %TAC3. Safety-related 4.16 KV AC loads are somewhat different between W3 and ANO-2. |
| %T13 | Loss of AC Bus 2A4 <IE> | Comparable to W3 %TAC4. Safety-related 4.16 KV AC loads are somewhat different between W3 and ANO-2. |
| %T14 | Loss of AC Bus 2B5 <IE> | Comparable to W3 %TAC5. Safety-related 480 VAC loads are somewhat different between W3 and ANO-2. |
| %T15 | Loss of AC Bus 2B6 <IE> | Comparable to W3 %TAC6. Safety-related 480 VAC loads are somewhat different between W3 and ANO-2. |

| Initiators Unique to ANO-2 | | |
|---|---|---|
| **ANO-2 IE** | **Description** | **Comment** |
| %T16 | Spurious MSIS or CSAS Signal <IE> | No comparable W3 IE. Spurious Main Steam Isolation Signal (MSIS) or Containment Spray Actuation Signal (CSAS) signal will close the MSIVs and isolate CCW and Auxiliary Cooling Water (ACW) leading to the loss of MFW and Condensate pumps. Nothing similar for W3. |
| %T17 | Closure of All MSIV'S | Comparable to W3 %T6OC. The W3 event also includes Main Steam Line Break (MSLB) - outside containment. |
| %T19 | Loss of CCW Nuclear Loop | Comparable to %T9RCP and %TTCW. ANO-2 CCW nuclear loop includes Reactor Coolant Pump (RCP) seal cooling, MFW pump lube oil coolers, Condensate pump bearing coolers, Service Air compressors and aftercoolers, heater drain coolers, and other miscellaneous coolers. |
| %TA1 | Loss of 4.16KV Bus 2A-1 | Comparable to W3 %TAC1. W3 non-safety bus 3A-1 has similar loads to ANO-2 non-safety bus 2A-1, except the W3 bus also includes two RCPs. |
| %TA2 | Loss of 4.16KV Bus 2A-2 | Comparable to W3 %TAC2. W3 non-safety bus 3B-1 has similar loads to ANO-2 non-safety bus 2A-2, except the W3 bus also includes two RCPs. |
| %T500KV | Loss of 500KV Power | No comparable W3 IE. W3 switchyard failure is included in LOOP frequency, but has a different impact for ANO-2. |
| %TST3 | Loss of Start-up Transformer #3 | No comparable W3 IE. W3 has two startup transformers that are included in the loss of 6.9 KV buses. |
| %TLAKE | Loss of Lake Dardanelle | No comparable W3 IE. W3 does not take suction directly from a lake or river. |
| %TIAC | Loss of Instrument Air (IA) System Affecting both Units | No comparable W3 IE since W3 is a single unit site. |
| %TIA1 | Loss of Unit 1 IA System | No comparable W3 IE since W3 is a single unit site. |
| %TIA2 | Loss of Unit 2 IA System | Comparable to W3 %TIA. IA systems for ANO-1 and ANO-2 are normally cross-tied. |

| Initiators Unique to Waterford 3 | | |
|---|---|---|
| **W3 IE** | **Description** | **Comment** |
| %T6 | Steam Line Break / Leak Inside Containment | Comparable to ANO-2 %T5-A and %T5-B. ANO-2 separates secondary steam line / feed line failures inside containment for each Steam Generator (SG). The frequency for %T6 is the same as %T5-A + %T5-B. |
| %T6OC | Steam Line Break / Leak Outside Containment | Comparable to ANO-2 %T5-C. ANO-2 combines steam line and feed line breaks outside containment into one initiator rather than two for W3. |
| %T7 | Feedwater Line Break / Leak | |
| %T8 | Loss of Condensate System | Part of ANO-2 %T2. W3 separates condensate because W3 includes condensate for secondary cooling; ANO-2 does not. |
| %T9 | Loss of CCW | Comparable to ANO-2 %T7. ANO-2 SW system is different from the W3 CCW system. |
| %T9RCP | Loss CCW to RCP seals | Comparable to ANO-2 %T19. W3 has a CCW header to RCPs. The ANO-2 CCW nuclear loop includes RCP cooling and other loads. |
| %FWIVCC | CCF of FWIVs to remain open | No comparable ANO-2 IE. Feedwater Isolation Valves (FWIVs) are included in %T4 for ANO-2, but is considered a special initiator for W3 because it also results in AFW injection being unavailable. |
| %TIA | Loss of IA | Comparable to ANO-2 IEs %TIA2 and %TIAC. W3 plant air includes both IA and Service Air. |
| %TTCW | Loss of Turbine Cooling Water | Comparable to ANO-2 IE %T19. W3 Turbine Cooling Water (TCW) includes cooling loads similar to the ANO-2 CCW nuclear loop, but does not include RCPs. |
| %TAC1 | Loss of 6.9KV A1 | Comparable to ANO-2 %TA1. W3 6.9 KV bus 3A-1 has loads similar to ANO-2 non-safety bus 2A-1 and 2H-1. |
| %TAC2 | Loss of 6.9KV A2 | Comparable to ANO-2 %TA2. W3 6.9 KV bus 3A-2 has loads similar to ANO-2 non-safety bus 2A-2 and 2H-2. |
| %TAC3 | Loss of vital 4.16kV ac bus 3A3-S | Comparable to ANO-2 %T12. Safety-related 4.16 KV AC Loads are somewhat different between W3 and ANO-2. |
| %TAC4 | Loss of vital 4.16kV ac bus 3B3-S | Comparable to ANO-2 %T13. Safety-related 4.16 KV AC Loads are somewhat different between W3 and ANO-2. |

| Initiators Unique to Waterford 3 | | |
|---|---|---|
| **W3 IE** | **Description** | **Comment** |
| %TAC5 | Loss of 480V Bus 3A31-S | Comparable to ANO-2 %T14. Safety-related480 VAC loads are somewhat different between W3 and ANO-2. |
| %TAC6 | Loss of 480V Bus 3B31-S | Comparable to ANO-2 %T15. Safety-related 480 VAC Loads are somewhat different between W3 and ANO-2. |
| %TAC7 | Loss of 480 V Bus 3AB31-S | No comparable ANO-2 IE. Scram due to loss of AB Chargers and other pumps. ANO-2 has no similar swing bus. |
| %TAC8 | Loss of 480V MCC 3AB311-S | No comparable ANO-2 IE. Scram due to loss of AB Chargers and other pumps. ANO-2 has no similar swing bus. |
| %TDC4 | Loss of PDP 3014AB | No comparable ANO-2 IE. Loss of this 120 VAC bus causes a loss of control power to MFW and the Steam Dump and Bypass Control System (SDBCS). |
| %TDC1, 2, 3, 5 | Loss of DC Bus A, B, AB, and TGB | Comparable to ANO-2 %T10 and %T11. W3 has AB bus that ANO-2 does not have. |

| Comparison of ANO-2 and W3 results on a Sequence Basis[5] | | | | | | | |
|---|---|---|---|---|---|---|---|
| WF-3 Sequence | Description | W3 Results | | ANO-2 Sequence Name | ANO-2 Results | | Comparison of ANO-2 and W3 Cutsets |
| | | CDF | %CDF | | CDF | %CDF | |
| ATWS | Anticipated transient without scram | 1.41E-07 | 2.12% | TK | 3.76E-08 | 3.88% | CDFs are similar. The ANO-2 and W3 trees are similar. W3 MTCs are higher than ANO-2 which accounts for the difference in CDF. |
| AU | Large LOCA with SI Failure in Injection | 1.63E-09 | 0.02% | AU | 4.09E-09 | 0.42% | CDFs for ANO-2 and W3 are similar. The W3 Large LOCA frequency is smaller because it is from NUREG-1829 (more current source). Main differences are due to support system differences. |
| AX | Large LOCA with SI failure in recirculation | 1.08E-09 | 0.02% | AX | 7.73E-09 | 0.80% | CDFs for ANO-2 and W3 are similar. The W3 Large LOCA frequency is smaller because it is from NUREG-1829 (more current source). Main differences are due to support system differences. |
| ISLOCA | Interfacing system LOCA | 9.66E-10 | 0.01% | VLOCA | 1.42E-11 | 0.00% | ANO-2 and W3 model the same penetrations for ISLOCA (LPSI lines and SDC suction). W3 is higher due to restoration errors on LPSI line MOVs. ANO-2 also credited that the high/low interface for the SDC line is inside containment. |
| MU | Medium LOCA with HPSI failure in injection | 4.13E-09 | 0.06% | MU | 3.48E-10 | 0.04% | W3 has a higher CDF primarily due to the Medium LOCA frequency based on NUREG-1829 data and designated sizes. |
| MX | Medium LOCA with HPSI failure in recirculation | 2.94E-08 | 0.44% | MX | 3.59E-09 | 0.37% | W3 has a higher CDF primarily due to the Medium LOCA frequency based on NUREG-1829 data and designated sizes. |

[5] **The core damage frequencies reported are based on a 1E-13 truncation limit.**

| Comparison of ANO-2 and W3 results on a Sequence Basis[5] | | | | | | | |
|---|---|---|---|---|---|---|---|
| WF-3 Sequence | Description | W3 Results | | ANO-2 Sequence Name | ANO-2 Results | | Comparison of ANO-2 and W3 Cutsets |
| | | CDF | %CDF | | CDF | %CDF | |
| RB | SGTR with normal FW failure and EFW failure | 2.90E-09 | 0.04% | RBF, RBU, RBX | 1.64E-08 | 1.69% | ANO-2 has a higher CDF than W3 because ANO-2 SGTR procedure requires the operators to depressurize for SDC. The W3 Steam Generator Tube Rupture (SGTR) procedure does not include depressurizing to SDC entry conditions. |
| RU | SGTR with failure of RCS injection | 1.85E-08 | 0.28% | RU | 1.16E-10 | 0.01% | W3 has a higher CDF primarily because the support system failures that occur for ANO-2 in the RBF and RBX sequences, occur in RU for W3. |
| RX | SGTR with failure to depressurize | 8.97E-08 | 1.35% | RX | 8.09E-08 | 8.35% | CDFs for ANO-2 and W3 are similar, but for different reasons. ANO-2 uses SDC for long term cooling whereas W3 uses charging pumps for long term cooling. |
| SB | Small LOCA with normal FW failure and EFW failure | 8.92E-10 | 0.01% | SBF, SBX | 2.42E-09 | 0.25% | The CDF for ANO-2 is larger for the SBF scenario because the MSIVs close on a CSAS, which isolates MFW. W3 does not require MSIV isolation on this signal. |
| SU | Small LOCA with HPSI failure in injection | 1.73E-07 | 2.60% | SU | 1.85E-08 | 1.91% | W3 has a higher CDF primarily due to the Small LOCA frequency based on NUREG-1829 data and designated sizes. |
| SX | Small LOCA with HPSI failure in recirculation | 8.73E-07 | 13.14% | SX | 9.33E-08 | 9.63% | W3 has a higher CDF primarily due to the Small LOCA frequency based on NUREG-1829 data and designated sizes. |
| TB, SBO | Loss of normal feedwater with EFW failure | 4.92E-06 | 74.05% | TBF, TBX | 3.49E-07 | 36.01% | ANO-2 has a lower CDF primarily because of the ability to depressurize and perform once-through cooling using the ECCS / LTOP valves. ANO-2 also has an Alternate AC diesel to reduce the impact of SBO events. |

| Comparison of ANO-2 and W3 results on a Sequence Basis[5] | | | | | | | |
|---|---|---|---|---|---|---|---|
| WF-3 Sequence | Description | W3 Results | | ANO-2 Sequence Name | ANO-2 Results | | Comparison of ANO-2 and W3 Cutsets |
| | | CDF | %CDF | | CDF | %CDF | |
| TQB, SBORCP | RCP seal LOCA with normal FW failure and EFW failure | 1.11E-08 | 0.17% | TQBF, TQBU, TQBX | 3.05E-09 | 0.31% | ANO-2 has a lower CDF primarily because of cooling ability using the ECCS / LTOP valves. ANO-2 also has an Alternate AC diesel to reduce the impact of SBO events. |
| TQU, TPQU | RCP seal LOCA with HPSI failure in injection | 9.37E-09 | 0.14% | TQU | 3.47E-09 | 0.36% | The CDFs for ANO-2 and W3 are comparable. The differences are primarily explained by differences in support system designs. |
| TQX, TPQX | RCP seal LOCA with HPSI failure in recirculation | 3.36E-07 | 5.05% | TQX | 7.87E-08 | 8.12% | The CDFs for ANO-2 and W3 are comparable. The differences are primarily explained by differences in support system designs. |
| V | Reactor vessel rupture | 3.20E-08 | 0.48% | RVR | 2.70E-07 | 27.86% | ANO-2 uses the vessel rupture frequency from WASH-1400. W3 has updated the frequency using NUREG-1829. |
| **Overall CDF** | | **6.64E-06** | | | **9.69E-07** | | |

r) LE-D3-01 (Finding, Not Met at CC-I):

Describe how possible failures of piping segments and pump seals after the last isolation valve were modeled in the internal events PRA. Please explain how this modeling supports the evaluation of FPRA interfacing system LOCA events.

*Response*

ANO-2 conservatively assumes that low pressure piping will fail if the ISLOCA line opens to allow high pressure fluid into that low pressure pipe. This is conservative because the pipe could withstand the high pressure (despite the pipe rating). Once the low pressure piping fails outside containment, the equipment in that area will likely fail due to internal flooding or spray or high room temperatures. ECCS pumps in the other trains would likely initially function to restore reactor pressure vessel (RPV) level. However, unless the ISLOCA can be isolated, the RWT will deplete and without water in the containment sump, the ECCS pumps will no longer maintain reactor pressure vessel (RPV) level and core damage will occur.

For the FPRA, an electrical short could cause motor-operated valves (MOVs) or air-operated valves (AOVs) to spuriously open due to a fire. Each ISLOCA path consists of multiple valves before the high pressure to low pressure interface occurs. This method is consistent with the MSO report.

s) LE-E4-01 (Finding, Not Met at CC-I):

The Finding indicated that a dependency analysis had not been performed. Please indicate whether this analysis has been completed. If so, please provide a summary of the results of this analysis.

*Response*

Dependency between operator actions was performed for the pre-core damage (CD) actions, but was not performed for post-CD actions. However, ANO-2 performed a sensitivity case for the Level 2 analysis that removed any credit for post-CD actions. This sensitivity case indicates a 0.02% increase in risk with no credit for post-CD operator actions. This is documented in Echelon Calculation PRA-A2-01-003S12, Section 4.4.12. The impact of updating the HRA analysis to include dependence between pre-CD operator actions and post-CD actions is expected to be less than 0.02%.

## Additional Information/Changes

The following additional change/request associated with the original ANO-2 NFPA-805 LAR (Reference 1) is included in this 60-day RAI (Reference 2) response letter. Entergy requests this addition be considered in conjunction with the NRC's review of Attachment L, "NFPA-805 Chapter 3 Requirements for Approval (10 CFR 50.48(c)(2)(vii))." This same request will be included in the ANO-1 NFPA-805 LAR to be submitted in January 2014.

**NFPA-805 Section 3.2.3(1)**

NFPA-805, Section 3.2.3(1) states:

> *Procedures shall be established for implementation of the fire protection program. In addition to procedures that could be required by other sections of the standard, the procedures to accomplish the following shall be established: Inspection, testing, and maintenance for fire protection systems and features credited by the fire protection program.*

ANO desires the flexibility to utilize performance-based methods to establish the appropriate inspection, testing, and maintenance frequencies for fire protection systems and features required by NFPA-805. Performance-based inspection, testing, and maintenance frequencies guidance is established in Electric Power Research Institute (EPRI) Technical Report TR-1006756, *Fire Protection Equipment Surveillance Optimization and Maintenance Guide,* Final Report, July 2003.

**Basis for Request:**

NFPA-805 Section 2.6, Monitoring, requires that *"A monitoring program shall be established to ensure that the availability and reliability of the fire protection systems and features are maintained and to assess the performance of the fire protection program in meeting the performance criteria. Monitoring shall ensure that the assumptions in the engineering analysis remain valid."*

NFPA-805 Section 2.6.1, Availability, Reliability, and Performance Levels, requires that *"Acceptable levels of availability, reliability, and performance shall be established."*

NFPA-805 Section 2.6.2, Monitoring Availability, Reliability, and Performance, requires that *"Methods to monitor availability, reliability, and performance shall be established. The methods shall consider the plant operating experience and industry operating experience."*

The scope and frequency of the inspection, testing, and maintenance activities for fire protection systems and features required in the fire protection program have been established at ANO based on the previously approved Technical Specifications / Licensing Basis Documents and appropriate NFPA codes and standards. The *scope* of the aforementioned activities is determined by the required systems review identified in LAR Table 4-3, Summary of NFPA-805 Compliance Basis and Required Fire Protection Systems and Features. This request is specific to the use of EPRI TR-1006756 to establish the appropriate inspection, testing, and maintenance *frequencies* for fire protection systems and features credited by the fire protection program. As stated in EPRI TR-1006756, Section 10.1, *"The goal of a performance-based surveillance program is to adjust test and inspection frequencies commensurate with equipment performance and desired reliability."*

This goal is consistent with the stated requirements of NFPA-805, Section 2.6, Monitoring. EPRI TR-1006756 provides an accepted method to establish appropriate inspection, testing, and maintenance frequencies which ensure the required NFPA-805 availability, reliability, and performance goals are maintained.

Where a performance-based monitoring program is applied, the target tests, inspections, and maintenance will be those activities associated with the NFPA-805 required fire protection systems and features. The reliability and frequency goals associated with the NFPA-805 required fire protection systems and features will be established to ensure the assumptions in the NFPA-805 engineering analysis remain valid. Failure criterion will be established based on the required fire protection systems and features credited functions and will ensure those functions are maintained. Data collection and analysis will follow the guidance contained in EPRI TR-1006756. The failure probability will be determined based on the EPRI TR-1006756 guidance and a 95% confidence level. Performance monitoring will be performed in conjunction with the monitoring program required by NFPA-805, Section 2.6, and will ensure site specific operating experience is considered in the monitoring process. The following flowchart, Figure 10-1 of EPRI TR-1006756, identifies the basic process that will be utilized.

| **Program Framework** |
|---|
| Identify Target Tests and Inspections<br>Establish Reliability and Frequency Goals<br>Set Failure Criteria<br>Assess Licensing Impact and Other Constraints |

↓

| **Data Collection and Evaluation** |
|---|
| Establish Data Collection Guidelines<br>Collect Required Surveillance Data<br>Assemble Data in Spreadsheet or Database<br>Analyze Data to Identify Failures |

↓

| **Reliability and Uncertainty Analysis** |
|---|
| Compute Failure Probabilities<br>Compute Uncertainty Limits<br>Confirm that Reliability Supports Target Frequency |

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| **Program Implementation** |
|---|
| Modify Program Documents<br>Revise Surveillance Procedures<br>Conduct Ongoing Performance Monitoring<br>Refine and Modify Frequencies as Appropriate |

**EPRI TR-1006756 - Figure 10-1**

## Flowchart for Performance-Based Surveillance Program

ANO requests approval to use the EPRI TR-1006756 guidelines in the future as opportunities arise. ANO does not intend to revise any fire protection surveillance, test, or inspection frequencies until after transition to NFPA-805. Existing fire protection surveillance, test, and inspection procedures will remain consistent with applicable Technical Requirements Manual, Insurer, and NFPA Code requirements. ANO requests the flexibility to evaluate fire protection features using the aforementioned EPRI performance-based methods to provide evidence of equipment performance beyond that achievable under traditional prescriptive maintenance practices to ensure optimal use of resources while maintaining reliability.

**Acceptance Criteria Evaluation:**

<u>Nuclear Safety and Radiological Release Performance Criteria:</u>

The use of performance-based test frequencies established in accordance with EPRI TR-1006756 methods combined with the NFPA-805, Section 2.6, monitoring program will ensure that the availability and reliability of the fire protection systems and features are maintained at levels assumed in the NFPA-805 engineering analysis. Therefore, the use of the performance-based methods in EPRI TR-1006756 does not result in an adverse impact to Nuclear Safety Performance Criteria.

The radiological release performance criteria are satisfied based on the determination of the limiting radioactive release (refer to LAR Attachment E, NEI 04-02 Radiological Release Transition). Fire protection systems and features are credited as part of the subject evaluation. Development of performance-based test frequencies in accordance with EPRI TR-1006756 methods combined with the NFPA-805, Section 2.6, monitoring program will ensure that the availability and reliability of the fire protection systems and features are maintained at the levels assumed in the NFPA-805 engineering analysis, including assumptions supporting the Radioactive Release performance criteria. Therefore, there is no adverse impact to Radioactive Release performance criteria.

<u>Safety Margin and Defense-in-Depth:</u>

The use of performance-based test frequencies established per EPRI TR-1006756 methods combined with the NFPA-805, Section 2.6, monitoring program will ensure that the availability and reliability of the fire protection systems and features are maintained at the levels assumed in the NFPA-805 engineering analysis, including those assumptions supporting the Fire Risk Evaluation safety margin discussions. In addition, these methods do not invalidate the inherent safety margins contained in the codes and standards used for design and maintenance of fire protection systems and features. Therefore, the safety margin inherent and credited in the analysis 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), and 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).

Echelon 1 is not affected by the use of EPRI TR-1006756 methods. Use of performance-based test frequencies established in accordance with EPRI TR-1006756 combined with the NFPA-805, Section 2.6, monitoring program will ensure that the availability and reliability of the fire protection systems and features credited for defense-in-depth are maintained at the levels assumed in the NFPA-805 engineering analysis. Therefore, there is no adverse impact to echelons 2 and 3 for the defense-in-depth.

Conclusion:

NRC approval is requested to permit the use of performance-based methods contained in EPRI TR-1006756 to establish the appropriate inspection, testing, and maintenance frequencies at ANO for fire protection systems and features required by NFPA-805, where desired.

The engineering analysis performed determined that the performance-based approach utilized to evaluate a variance from the requirements of NFPA-805 Chapter 3:

- Satisfies the performance goals, performance objectives, and performance criteria specified in NFPA-805 related to nuclear safety and radiological release
- Maintains Defense in Depth (fire prevention, fire detection, fire suppression, mitigation, and post-fire safe shutdown capability)
- Maintains Safety Margin

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Summary

This letter provides the requested 60-day responses to NRC RAIs (Reference 2) associated with the ANO-2 NFPA-805 LAR dated December 17, 2012 (Reference 1). In addition, one 90-day Fire Modeling RAI and four 90-day PRA RAI responses are included in this letter. One or more of the responses require new risk values to be calculated, expected to be submitted in the 120-day RAI response letter, which will include a revised Attachment W, "Fire PRA Insights." Finally, Entergy requests a new addition to Attachment L, "NFPA-805 Chapter 3 Requirements for Approval (10 CFR 50.48(c)(2)(vii))," as described previously in this letter.

REFERENCES

1. Entergy letter dated December 17, 2012, *License Amendment Request to Adopt NFPA-805 Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants (2001 Edition)* (2CAN121202) (ML12353A041)

2. NRC letter dated September 11, 2013, *Arkansas Nuclear One, Unit 2 – Request for Additional Information Regarding Adoption of National Fire Protection Association Standard NFPA-805* (TAC No. MF0404) (2CNA091301) (ML13235A005)