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W3F1-2015-0024

April 10, 2015

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

SUBJECT: Responses to Request for Additional Information Regarding Adoption of National Fire Protection Association Standard NFPA 805 License Amendment Request (LAR) Waterford Steam Electric Station, Unit 3 (Waterford 3)
Docket No. 50-382
License No. NPF-38

REFERENCES:

1. Entergy letter W3F1-2011-0074 "License Amendment Request to Adopt NFPA 805 Performance-Based Standard for Fire Protection for Light Water Reactor Generating Plants (2001 Edition)", Waterford Steam Electric Station, Unit 3 dated November 17, 2011 [ML113220230]
2. Entergy letter W3F1-2012-0005 "Supplemental Information in Support of the NRC Acceptance Review of Waterford 3 License Amendment Request to Adopt NFPA 805, Waterford Steam Electric Station, Unit 3" dated January 26, 2012 [ML12027A049]
3. Entergy letter W3F1-2012-0064 "Response to Request for Additional Information Regarding Adoption of National Fire Protection Association Standard NFPA 805 License Amendment Request, Waterford Steam Electric Station, Unit 3" dated September 27, 2012 [ML12272A099]
4. Entergy letter W3F1-2012-0083 "90 Day Response to Request for Additional Information Regarding Adoption of National Fire Protection Association Standard NFPA 805 License Amendment Request, Waterford Steam Electric Station, Unit 3" dated October 16, 2012 [ML12290A216]
5. Entergy letter W3F1-2013-0022 "Response to 2nd Round Request for Additional Information Regarding Adoption of National Fire Protection Association Standard NFPA 805 License Amendment Request, Waterford Steam Electric Station, Unit 3" dated May 16, 2013 [ML13137A128]

6. Entergy letter W3F1-2013-0048 " Supplement to NFPA 805 License Amendment Request (LAR) Waterford Steam Electric Station, Unit 3" dated December 18, 2013 [ML13365A325]

7. NRC letter to Entergy dated February 6, 2015,"Request for Additional Information RE: License Amendment Request to Transition to National Fire Protection Association Standard 805 (TAC NO. ME7602) [ML15022A239]

Dear Sir or Madam:

By letter dated November 17, 2011, as supplemented by letters dated January 26, 2012, September 27, 2012, October 16, 2012, May 16, 2013, and December 18, 2013 (References 1 through 6 respectively), Entergy Operations, Inc. (Entergy), submitted a license amendment request (LAR) to transition its fire protection license basis at the Waterford Steam Electric Station, Unit 3, from paragraph 50.48(b) of Title 10 of the *Code of Federal Regulations* (10 CFR) to 10 CFR 50.48(c), "National Fire Protection Association Standard 805" (NFPA 805).

The LAR Supplement provided in Reference 6 represents changes to specified LAR Attachments and supporting calculations primarily as a result of performing extensive reanalysis utilizing only NRC-accepted methods. An NRC site audit was conducted the week of January 12, 2015 followed by Request for Additional Information (RAI) letter (Reference 7) received February 6, 2015. These RAIs were divided into 60, 90 and 120 day responses. Enclosure 1 contains responses to the 90 day RAIs.

There are no new regulatory commitments contained in this submittal.

If you require additional information, please contact the Regulatory Assurance Manager, John Jarrell at 504-739-6685.

I declare under penalty of perjury that the foregoing is true and correct. Executed on April 10, 2015.

Sincerely,

MRC/ajh

Enclosures: 1. 90 Day RAI Responses

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Enclosure 1 to

W3F1-2015-0024

90 Day RAI Responses
Waterford 3 NFPA 805 License Amendment Request

FPE RAI S01

60 day response

FPE RAI S02

Position C.2.3.1 of Regulatory Guide (RG) 1.205, “Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants,” Revision 1, dated December 2009 (ADAMS Accession No. ML092730314), and Section 4 of Nuclear Energy Institute (NEI) 04-02, “Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program Under 10 CFR 50.48(c),” Revision 2, dated April 2008 (ADAMS Accession No. ML081130188), provide guidance regarding transition of previously approved alternatives to NFPA 805 Chapter 3 elements. The guidance describes that the basis for previously approved elements be assessed for continued applicability and validity, including consideration of any modifications that may have altered the original basis for approval. In addition, the guidance in NEI 04-02, Figure 4-2, as repeated in the LAR, Section 4.1.1, Figure 4-1, describes the insertion of verbatim excerpts from the approval documentation in the compliance basis field (of LAR Attachment A, Table B-1). LAR, Attachment A contains several elements that cite “Complies via Previous Approval,” and although references are made to the associated NRC safety evaluations for these elements, with the exception of Element 3.6.4, 1) the licensee has not provided the applicable excerpts, 2) has not provided a statement of continued validity, and 3) does not discuss any potential impacts from plant changes over time.

Consistent with the approach used by the licensee for LAR Attachment A, Element 3.6.4, provide the compliance basis for the previously approved elements, including statements of continued applicability and validity and the impacts of plant changes over time.

Waterford 3 Response

There are six elements in LAR Attachment A, Table B-1 that cite **“Complies via Previous Approval”** in the compliance basis field, in addition to Element 3.6.4 cited in the request. For these six Elements in LAR Attachment A, Table B-1, additional compliance basis for the previously approved elements is provided below, including applicable excerpts, statements of continued applicability and validity, and the impacts of plant changes over time.

1. Element 3.5.10 Water Supply Yard Main Code Requirements
LAR Attachment A, Table B-1 contains the requested excerpts to establish the compliance basis. The underground yard fire main loop, as approved in the Waterford 3 SER Supplement 3 and FSAR Section 9.5.1.3.1.E.2(a) is still in the approved configuration. There have been no plant modifications or other changes that would invalidate the basis for approval.

2. Element 3.6.1 Standpipe and Hose Station Code Requirements
Upon review, NFPA 805 Chapter 3 Element 3.6.1 complies entirely with the use of EEEE’s. Therefore, the compliance statement “Complies via Previous Approval” and associated references for NFPA 805 Chapter 3 Element 3.6.1 are removed from Table B-1.

3. Element 3.11.2 Fire Barriers
NUREG-0787, Supplement No. 8, Section 9.5.1.3(2), dated April, 1982 states in part "*In Supplement 3 the staff stated that all access hatches in fire area boundaries are protected by 3-hour-fire-rated assemblies. By letter dated March 26, 1984, the applicant identified a number of hatches that are not fire rated. Because the effects of a fire are directed upward, the staff was concerned that a fire that occurred below the hatch would propagate through the hatchway and affect redundant shutdown-related systems on the next higher elevation. However, in the letter, the applicant committed to apply a 3-hour-fire-rated protective coating to the underside of the hatch. In addition, areas below the hatches are protected by smoke detection systems and automatic fixed suppression systems. As explained above, the active fire protection systems provide reasonable assurance that any fire would be detected and suppressed early. The 3-hour-fire-rated coating on the underside of the hatch will provide sufficient passive protection to ensure that products of combustion do not propagate upward into a vertically adjoining fire area. Therefore, these hatches represent an acceptable deviation from Section D.1(j) of Appendix A to BTP APCSB 9.5.1 and Section III.G.2.a of Appendix R to 10 CFR 50*."

The basis of NRC's approval for the hatches that are not fire rated remains unchanged. The basis for approval reflects the current plant configuration and there have been no plant modifications or other changes that would invalidate the basis for approval. Note that the floor hatch separating Fire Areas RAB 31 and RAB 39 (HC-1) is the topic of Deviation 49 in the LAR Supplement Attachment K and is not being transitioned. This boundary has been determined to be adequate for the hazard as documented in Attachment K.

4. Element 3.11.3 Fire Barrier Penetrations (2)
Enclosure 2 to W3F1-2015-0015 provided an updated compliance basis NFPA 805 Chapter 3 Element 3.11.3(2) in response to FPE RAI S05.

NUREG-0787, Supplement No. 8, Section 9.5.1.3(2), dated December, 1984 states in part "*By letter dated September 9, 1983, the applicant requested approval for a deviation from the guidelines of section D.1.j of Appendix A to BTP APCSB 9.5-1 to the extent it requires a 3-hour-fire-rated damper in HVAC duct penetrations of fire walls. The fire wall is on elevation 21 ft of the reactor auxiliary building and separates fire areas RAB-25 and RAB-32. The installation of a conventional fire damper in the duct through this wall was not possible because of obstructions from other plant structural and mechanical features. Instead, the applicant has installed 42-in.-diameter air-operated butterfly valves on either side of the fire wall. The valves are Nuclear Safety Class 3, seismic Category I, are 150 lb rated, and are designed to fail closed. Inadvertent failure will have negligible consequences on safe shutdown. The valves have been provided with thermal cutoffs, which cause the valve to close when air temperatures in the duct reach 165°F.*

The fire loading on either side of this wall is negligible. If all of the combustibles were totally consumed, a fire of less than 6 minutes as defined on the ASTM E-119 time-temperatures curve would result. Because these areas are provided with fire detectors, the staff expects any potential fire to be detected in its initial stages before a significant temperature rise or damage occurred. If hot gases from a fire should penetrate the duct, one or both of the butterfly valves would close to limit fire propagation. Because these valves are not fire rated, the staff expects some smoke and other products of combustion to spread into the adjoining area. However, they would be so diffused as to represent no significant threat to safety-related systems. The staff, therefore, *concludes that the absence of a fire damper in the duct penetration of the fire wall between RAB-25 and RAB-32 represents an acceptable deviation from Section D.1.j of BTP APCSB 9.5.1*."

Deviation request per WF3 Letter W3P84-0709 dated March 26, 1984 to the NRC provided justification for the lack of a fire damper in two HVAC penetrations through fire area boundary separating Fire Area RAB 3A (previously reported as Corridor/Vestibule) from Fire Zones RAB 8B and 8C (Fire Area RAB 8). This deviation was approved by the NRC in NUREG 0787, Supplement No.8 "Safety Evaluation Report related to the operation of Waterford Steam Electric Station, Unit No. 3", Docket No. 50-382, Section 9.5.1.3(2), dated 12/1984. In letter W3F1-91-0233, dated May 24, 1991, Waterford 3 informed the staff that it had found discrepancies between the original deviation request and the actual plant configuration. Specifically, Entergy found that (1) fire dampers are not installed in the fire area boundary as previously reported and (2) automatic fire suppression is not provided in the vestibule.

The Waterford 3 May 24, 1991 letter also provided additional information and requested reaffirmation of the NRC approval for this deviation. Additional information was requested in NRC letter (ILN93-0102) dated May 20, 1993.This additional information was provided in Waterford 3 letter W3F1-93-0083, dated December 3, 1993. The deviation was approved by the NRC in letter dated January 17, 1995 (ILN95-0017). The letter stated that the NRC staff concluded the SER (Supplement No. 8) of December 1984 remains valid and acceptable based on the justification below.

Justification:
a) Detection and suppression exist on the RAB 8 (Fire Zones RAB 8B & 8C) side of the HVAC duct penetrations which do not have fire dampers.

b) Combustible loading in RAB 3A is negligible.

c) Presence of portable fire extinguishers and standpipe hose stations ensure the ability to extinguish an exposure fire in this area in a timely manner.

The basis of NRC's approval for the HVAC duct penetrations that are not fire rated remains unchanged. The basis for approval reflects the current plant configuration and there have been no plant modifications or other changes that would invalidate the basis for approval.

5. Element 3.11.4 Through Penetration Fire Stops (a)
NUREG-0787, Supplement No. 3, Section 9.5.1.3(1), dated April 1982, states in part "*Walls and floor/ceiling assemblies separating fire areas and zones consist of 2- or 3-hour fire rated construction. In cases when the fire rating is 2 hours, the staff has evaluated the fuel loading and fire protection provided and finds the 2-hour fire rating to be acceptable. Also, the applicant has committed by letter dated December 21, 1981 to provide 3-hour fire-rated penetration seals at all penetrations of fire rated barriers. By letter dated December 21, 1981, the applicant has committed to provide test reports to demonstrate the fire resistant rating of the penetration seals. Based on staff review and the applicant's commitments, the staff concludes that the fire barriers and fire barrier penetration seals meet the guidelines of Section D.1.(j) of Appendix A to BTP ASB 9.5-1.*

NUREG-0787, Supplement No. 5, Section 9.5.1.3(1), dated June 1983, states in part "In SSER 3, the staff indicated that the applicant has committed to provide 3-hour-fire-rated penetration seals at all penetrations of fire-rated barriers and to provide test reports to demonstrate the fire resistance rating of the seals. By letter dated September 28, 1982, the applicant submitted the results of tests conducted by an independent testing laboratory that verify the materials utilized for penetration seals, in configurations representative of what is to be found throughout the plant, are capable of maintaining the integrity of a fire wall for a 3-hour period, when subjected to an American Society for Testing and Materials (ASTM) Std E-119 fire exposure. This conforms to the guidelines in Section D.1(j) of Appendix A to BTP ASB 9.5-1 and is, therefore, acceptable.

NUREG-0787, Supplement No. 8, Section 9.5.1.3(1), dated December 1984, states in part "In Supplement 3, the staff stated that the applicant had committed to provide 3-hour-fire-rated penetration seals at all penetrations of fire-rated barriers. By letter dated May 18, 1984, the applicant identified a number of concrete block walls where non-fire-rated seals were installed at the interface of the walls and floor/ceiling assemblies. The seals are composed of a fiberboard roof insulation that completely fills the 2–inch gap at the interface. The insulation is enclosed on both sides of the wall by a 3/8-inch angle iron, which is attached to the wall and the underside of the floor/ceiling assembly.

The staff was concerned that a fire on one side of the wall would propagate through the seal and damage redundant shutdown systems on the other side.

The seals are installed under the following circumstances:

- *(a) In walls that separate two fire areas that are both protected by automatic fire suppression and detection systems.*
- *(b) In stairway enclosures, where the area outside the stairway is protected by automatic fire detection and suppression systems.*
- *(c) In walls that separate fire areas in which no redundant shutdown-related systems are located.*

Because the seal assembly has not been tested to ASTM E-119, the staff does not have reasonable assurance that it will withstand the elevated temperatures expected from a fire in an unprotected area. However, if a fire was to occur under some of the circumstances noted above (Items (a) and (b)), it would be detected in its initial stages by the fire detection system and suppressed manually by the plant fire brigade before significant damage occurred. If the fire should propagate rapidly and generate a hot gas layer at the ceiling, the automatic suppression system would activate to control the fire and reduce ceiling temperatures so as not to pose a threat to the penetration seal. If significant quantities of hot gases should propagate through the seal into other areas, the fire suppression systems in those areas would activate to protect safety-related equipment.

The staff has looked at the areas in which no redundant shutdown-related systems are located (Item (c) above). These areas can be characterized as containing mostly metal tanks and piping or otherwise containing no significant quantity of combustibles or fire hazards. Consequently, the staff expects a fire in such areas to be of limited magnitude and extent and well within the capability of the plant fire brigade to extinguish using portable fire extinguishers or manual hose stations. Therefore, automatic fire suppression systems would not appreciably enhance the *existing level of safety. Nevertheless, if smoke and hot gases did penetrate the seals before the arrival of the fire brigade, there would be negligible impact on safe shutdown because these areas do not contain redundant shutdown-related systems.*

The staff, therefore, concludes that the absence of fire-rated penetration seals in those areas identified above represents an acceptable deviation from Section D.1 of Appendix A to BTP APSCB 9.5-1 and Section III.G.2 of Appendix R to 10 CFR 50. "

The basis of NRC's approval for the non-fire-rated seals remains unchanged. The basis for approval reflects the current plant configuration and there have been no plant modifications or other changes that would invalidate the basis for approval.

6. Element 3.11.4 Through Penetration Fire Stops (b)
NUREG-0787, Supplement No. 5, Section 9.5.1.3(1), dated June 1983,, states in part "*In SSER No. 3 the staff indicated that the applicant has committed to provide 3-hour-fire-rated seals at all penetrations of fire-rated barriers and to provide test reports to demonstrate the fire resistance rating of the seals. By letter dated September 28, 1982, the applicant submitted the results of tests conducted by an independent testing laboratory that verify the materials utilized for penetration seals, in configurations representative of what is to be found throughout the plant, are capable of maintaining the integrity of a fire wall for a 3-hour period, when subjected to an American Society for Testing and Materials (ASTM) Std E-119 fire exposure. This conforms to the guidelines in Section D.1(j) of Appendix A to BTP ASB 9.5-1 and is, therefore, acceptable.*

Internal conduit seals are normally located at the point where the wall is breached to prevent products by combustion from passing through the barrier via the conduit. By letter dated December 29, 1982, the applicant indicated that, because of potential for cable damage, conduit inaccessibility, and quality control considerations, certain internal fire seals will be located inside the conduit at the first available conduit opening from the penetration point on both sides of the barrier.

The staff is concerned that conduit penetrations of fire walls may be able to act as an avenue for the passage of flame and hot gases from one fire area to another. The air gap between the fire walls and the conduits will be sealed at the point of penetration. This satisfies the guidelines of Section D.1 of Appendix A to BTP ASB 9.5-1. Because the inside of the conduit will be sealed on both sides of the fire barrier at the nearest accessible point, the staff has reasonable assurance that products of combustion will not be conveyed from one side of the barrier to the other through the conduit. This represents an acceptable deviation from Section D.1 of BTP ASB 9.5-1. "

The basis of NRC's approval for the conduit internal seals remains unchanged. The basis for approval reflects current plant configuration and there have been no plant modifications or other changes that would invalidate the basis for approval.

FPE RAI S03

60 day response

FPE RAI S04

60 day response

FPE RAI S05

60 day response

SSA RAI S01

60 day response

SSA RAI S02

60 day response

SSA RAI S03

60 day response

SSA RAI S04

60 day response

SSA RAI S05

60 day response

SSA RAI S06

60 day response

FM RAI S01

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

- The algebraic equations implemented in FDTs [Fire Dynamics Tools] were used to characterize flame radiation (heat flux), flame height, plume temperature, ceiling jet temperature, and hot gas layer (HGL) temperature, the latter of which is used in the multi-compartment analysis.

- The Consolidated Model of Fire Growth and Smoke Transport (CFAST) was used to assess main control room (MCR) habitability and to calculate HGL temperature in selected multi-compartment scenarios.

LAR Section 4.5.1.2, "Fire PRA" states, in part, that "[f]ire 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 [verification and validation]," for a discussion of the acceptability of the fire models that were used.

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

a. 60 day response

b. In the updated response by letter dated June 11, 2014, to previous FM RAIs 01.m and 01.01, it is stated that secondary combustibles are considered in the revised analysis. However, it is not clear from the supporting documentation that this is the case. Clarify how this issue has been resolved in the updated analysis. Alternatively, provide justification for ignoring the effect of flame spread and fire propagation in secondary combustibles (cable trays) and the corresponding heat release rate (HRR) on the calculated zone of influence (ZOI) and HGL temperature.

c. In the updated response by letter dated June 11, 2014, to previous FM RAI 01.p, it is stated that non-cable intervening combustibles are considered in the revised analysis. However, it is not clear from the supporting documentation that this is the case. Clarify how this issue has been resolved in the updated analysis and provide information on how non-cable intervening combustibles were identified and accounted for in the fire modeling analyses.

d. 60 day response

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

f. 60 day response

g. Explain how wall and corner effects were accounted for in all of the fire modeling calculations, or provide the technical justification for not doing so.

h. Specifically, regarding the use of CFAST in the MCR abandonment calculations:

   i. 120 day response

   ii. 120 day response

   iii. The licensee indicates that for transient fires, the most conservative scenario involves an operational heating, ventilation, and air conditioning (HVAC) system. However the analysis indicates that 13 HRR bins cause abandonment with non-functional HVAC as opposed to 12 bins with functional HVAC. Also, it appears that the scenarios with operational HVAC and doors opening at 15 minutes are used to calculate the probability for control room abandonment.

   Provide the technical justification for selecting the scenarios with operating HVAC and doors opening at 15 minutes to calculate the probability for control room abandonment and explain why the cases without HVAC and doors not opening were not considered in the Fire PRA.

   iv. 60 day response

   v. 60 day response

i. Specifically, regarding the use of CFAST in the RAB 7A, 7B, 7C and 7D calculations:

   i. The soot yield, carbon monoxide (CO) yield, and radiation fraction parameters used in the CFAST analysis for both the transient fires and electrical cabinet fires are the same. Justify using the same parameters for all types of fires and also provide detail about why the values of these parameters used in the analysis are conservative or are consistent with actual plant conditions.

   ii. 120 day response

   iii. Provide the technical justification for not excluding the volume of different obstructions, such as electrical cabinets and equipment, from the overall volume used in the CFAST calculations, or demonstrate that the analysis is conservative and adequate for the stated purpose.

   iv. 60 day response

j. Specifically regarding the multi-compartment analysis (MCA):

   i. 60 day response

   ii. 60 day response

   iii. 60 day response

Waterford 3 Response

b.
The following steps were taken to evaluate the plausibility of secondary ignition of cables for the Waterford Unit 3 FPRA, and are documented in PRA-W3-05-020, "Resolution of RAI Based on Secondary Ignition". A focused walkdown was conducted to identify any potential areas where secondary ignition could occur as documented in PRA-W3-05-022 Rev 1, August 2013, "Fire PRA Walkdown Notebook". Ignition criterion for cables was established. Zones of influence (ZOIs) were established using two different types of fires: transient - 317kW/m^2; and a fixed electrical cabinet - 702 kW/m^2. These fire types are the most prevalent plant wide and are bounding for most fires. For cases where these fire types would not bound the ignition source (oil fires, HEAFs, etc.), secondary ignitions were analyzed for that specific scenario. If secondary ignition was deemed plausible, the new heat release rate (HRR) was determined from the secondary combustible(s). Using the updated HRR, a new ZOI was developed. The new ZOI was analyzed to determine if there were any additional targets present within the ZOI. If so, it was determined if these targets fail due to temperature or heat flux exposure (or even if tertiary ignition occurs). Any additional failures due to the ignition of secondary combustibles required a new scenario (or modification to the existing scenario) to determine the impact on the FPRA model. In some cases secondary ignition could occur but the failures are bounded by the original scenario, such that no additional targets were added to the FPRA model. The vast majority of cables are contained within covered cable trays or conduits; precluding them from secondary ignition. A very few areas were found where coverage was not provided due to either obstructions or tight bends in the cable tray. In some areas where many trays exist, such as the cable spreading room (RAB 1E) or the penetration rooms (RAB 5 and RAB 6), pre-action sprinkler heads are installed between trays to further reduce fire spread. These features are documented in the Fire PRA Walkdown Notebook.

c.

Secondary ignitions were evaluated in the fire PRA supporting the LAR supplement. This was demonstrated by the identified significant contributor to core damage frequency for RAB 27. As a result of this finding Waterford 3 proactively removed the source of the secondary combustibles from the associated PAU. In addition, three other fire areas were found to have potential scenarios involving secondary combustibles.

To identify non-cable intervening combustibles the fire PRA team supported by plant fire protection staff conducted several days of focused walkdowns to assess not only the potential for secondary cable ignition but also to identify any potential combustible materials that were near ignition sources. The results of the walkdown (PRA-W3-05-022, "Fire PRA Walkdown Notebook ") identified that the potential for secondary cable ignitions was small due to the prevalence of conduit and enclosed (top and bottom) trays. Cable trays that meet this criterion behave similar to conduits when a flame or heat flux is applied to them and the cables therein experience damage, but not ignition. Since cables contained inside conduits cannot provide additional ignitions to the original source fire, all cables contained within cable trays that are enclosed are not considered at risk to secondary ignition or fire propagation.

Only a few areas were found that contained secondary combustibles that could potentially contribute as a secondary ignition source. Administrative limits exist in operational procedure EN-DC-161, "Control of Combustibles". This procedure limits the total amount and locations where potential transients can be within the Waterford 3 plant; with many PAUs being designated Level 1 or Level 2 combustible control areas, which further serves to reduce the presence of potential secondary ignition materials due to long term storage in a fire area.

Using the insights and information gained from this walkdown, eight PAUs contained the potential for secondary ignition to occur. Detailed evaluations were performed to evaluate potential secondary ignitions. This activity is documented in PRA-W3-05-020, "Resolution of RAI Based on Secondary Ignition. Although only very limited potential was identified, ignition criterion for cables was established and used to evaluate the limited locations were exposed cables were identified. Combustible materials characteristics were also used to define the critical limits necessary for secondary combustion. From this the zones of influence (ZOIs) were established using two different types of fires, a 317 kW/m^2 transient fire and a 702 kW/m^2 multi-bundle electrical cabinet fire. These fire types are the most prevalent plant wide and are bounding for most fires. For cases where these fire types would not bound the ignition source (oil fires, HEAFs, etc.), secondary ignitions were analyzed during that specific scenario.

If secondary ignition is deemed plausible, the new heat release rate (HRR) is determined from the secondary combustible(s). Using the updated HRR, a new ZOI is developed. The new ZOI is analyzed to determine if there are any additional targets present within. If so, it was determined if these targets fail due to temperature or heat flux exposure (or even if tertiary ignition occurs).

Any additional failures due to the ignition of secondary combustibles required a new scenario (or modification to the existing scenario) to determine the impact on the FPRA model. In some cases a secondary ignition could occur but the failures are bounded by the original scenario, such that no additional targets were added to the FPRA model. From this assessment only two new secondary ignition scenarios were defined. One was defined for RAB 27 and the second in RAB 8. The RAB 27 scenario involved non-cable intervening combustibles and resulted in a significant increase in damage potential. The RAB 8 scenario involved secondary cable ignition due to a cabinet ignition source. The cable was vulnerable due to an area of open cable tray. However, when the conservative assumption of considering the RAB 8 source as multiple bundle cabinet rather than a single bundle cabinet (which is the actual configuration), secondary ignition was no longer a consideration

e.

High energy arcing faults (HEAFs) are evaluated for select fixed ignition source bins, as documented in PRA-W3-05-006F, "Fixed Ignition Source Zone of Influence Methods". Information from Appendix M of NUREG/CR-6850 defines the zone of influence (ZOI) for the initial blast of a HEAF fire scenario. The ZOI is considered to be 0.9 m (3 ft) radially as well as 1.5 m (5 ft) above the ignition source when considering cable tray damage (failure) and ignition of the first overhead cable tray and any cable tray(s) located horizontally to the ignition source cabinet at the time of the HEAF event. Cable trays outside of this ZOI were not assumed as initially failed or ignited by the HEAF event.

RAB6 is the only physical analysis unit (PAU) that has credited fire-resistant wrap in the Waterford 3 fire PRA. No credit is taken in the fire PRA for other existing fire-resistant wraps installed in other Waterford 3 plant locations. However, RAB 6 is not subject to HEAF consideration, therefore no credit is taken for fire-resistant wraps for the cases of HEAF events; that is, the trays are treated as if the fire-resistant wraps did not exist for all HEAF scenario evaluations. Trays with installed top and bottom covers are treated as closed trays, similar to conduit, and are failed by the HEAF event if the tray is located within the initial blast ZOI of the HEAF event as defined above. These cables are not assumed to be ignited due to the covered construction of the cable tray as enclosed trays or conduits do not readily allow fire propagation.

As documented in the Fire PRA Walkdown Notebook, PRA-W3-05-022 Rev 1, the majority of cable trays installed at Waterford 3 are covered. HEAF scenarios documented in "Fixed Ignition Source Zone of Influence Methods", PRA-W3-05-006F note that cables within the postulated HEAF ZOIs are all covered trays or conduits and therefore are not subject to secondary ignition, while other HEAF scenarios did not have cable trays or conduits within their ZOI making treatment of cable trays unnecessary for those cases.

g.

Wall and corner effects are accounted for in the fire modeling calculations and are treated with a zone of influence (ZOI) investigation similar to the ZOI investigation for other ignition source bins. The wall and corner effects are taken into account using amplification factors of two (2) for wall locations and four (4) for corner locations. The ZOI investigation arrives at a separation distance away from the fire source at which damage is no longer expected based on the target's failure criteria.

The open area ignition source ZOI distances assumes that the ignition source is located in an open area and is not located closely adjacent to a wall or a wall corner. Where an ignition source is located along a wall or in a wall corner, amplification effects of the wall(s) were taken into account which serves to increase the ZOI distances for an otherwise identical ignition source compared to the open location ZOI. These amplification factors were applied to the heat release rate (HRR) of the particular ignition source under consideration. The methodology and resultant ZOIs for the various fixed ignition source bins are presented in PRA-W3-05-006F," Fixed Ignition Source Zone of Influence Assessment Methods". The methodology and resultant ZOI for the transient ignition source bin is presented in PRA-W3-05-013, "Documentation of a Transient Fire Source Zone of Influence Using Fire Dynamic Tools (FDTs)".

For wall or corner effects of temperature plume impacts, the same ZOI determination methodology presented in PRA-W3-05-006F and PRA-W3-05-013 is used in the calculation of the wall and corner effect ZOI and uses a correlation, the Alpert-Ward method (from "Spreadsheet Templates for Fire Dynamics Calculations", September 2003), to predict the rise in the temperature plume for a fire located along a wall or in a wall corner by means of an amplification factor of two (2) for wall locations and four (4) for corner locations. The amplification factors are the same based on information in "Spreadsheet Templates for Fire Dynamics Calculations", as well as Appendix L of NUREG/CR-6850. This correlation is used in lieu of a fire dynamics tool (FDT) calculation with the temperature plume correlation from NUREG-1805 and a similar amplification factor due to stated scenario conditions for the use of the temperature plume FDT correlation having the fire source in an open area where entrainment could occur to all sides of the fire source. While a FDT calculation sheet does exist for wall and corner effects, it is limited to liquid hydrocarbon fuel fires and the estimation of flame height only, and is not applicable to a general fire of a predefined heat release rate (HRR) such as the fixed ignition sources bins assessed for the prediction of plume temperature or heat flux impacts.

For wall or corner effects of heat flux impacts, the same ZOI determination methodology presented in PRA-W3-05-006F and PRA-W3-05-013 is used in the calculation of the wall and corner effect ZOI. Neither the correlations listed in "Spreadsheet Templates for Fire Dynamics Calculations" nor the FDTs from NUREG-1805 address the specific situation of heat flux impacts for wall or wall corner ignition source locations. The FDT calculation sheet for heat flux impacts is applied for wall or wall corner ignition source locations by using the same amplifications factors of two (2) and four (4) increase in the ignition source HRR for wall or corner locations respectively, while maintaining the size of the ignition source at the same size as the open location ZOI calculations as documented in PRA-W3-05-006F and PRA-W3-05-013.

For all wall and corner effect ZOIs, the same ignition source bin bounding HRRs are used as inputs in the analyses and are taken from the presented 98^{th} percentile HRRs in NUREG/CR-6850 and are the same HRRs used in PRA-W3-05-006F and PRA-W3-05-013 for the various ignition sources.

The oil source fire scenarios, as documented in PRA-W3-05-029, "Documentation of Oil Source Zone of Influences Sizes (using FDTs)", make use of the FDT calculation sheet for liquid hydrocarbon fuel fires and the estimation of flame height for selected scenarios of flame height estimation. Only one (1) oil fire scenario is investigated for wall and corner effects, namely the 13 gallon spill in physical analysis unit (PAU) RAB 39 for the charging pumps. The 100 percent spill size for this volume could have wall or corner effects and the reported flame height in PRA-W3-05-029 is based on the FDT calculation sheet from NUREG-1805 for wall and corner effects for liquid hydrocarbon fuel fires and the estimation of flame height. Temperature plume and radiant heat flux ZOI distances for these smaller compartments of the overall RAB39 PAU already impact the PRA-related items within the respective compartment, thus expanded ZOIs are not investigated or reported. The ten percent spill size for this volume is not sufficient to warrant wall or corner effects as documented in PRA-W3-05-029.

h.iii

While thirteen HRR bins for non-functioning HVAC lead to abandonment as opposed to twelve when HVAC is functioning, all fifteen HRR bins are used to calculate the non-suppression probability (P_{NS}) for each particular scenario. When all bins are summed for transient fires in the operator area, operating HVAC has a higher SF*P_{NS} than inoperable (where SF is the fire Severity Factor); meaning it is more likely the fire will not be suppressed prior to abandonment needing to occur. This is primarily due to faster times to abandonment criteria (PRA-W3-05-026, "Evaluation of the Waterford 3 Control Room Abandonment Times"), when HVAC is operating; leading to a higher P_{NS}.

Control room abandonment timing analysis, shows that times to abandonment are fairly insensitive to the positions of the doors. For instances, for operating HVAC with doors closed versus opening at 15 minutes, there is no differences in time to abandonment. The same holds true for fire in the operator area with no HVAC operating. Only one instance occurs where the door opening at 15 minutes is not the highest (or tied for the highest) SF*P_{NS}. This occurs with a transient fire in the equipment area with doors opened all the time and the HVAC inoperable. Using this situation versus doors opening at 15 minutes would cause approximately a 3.5% increase to this scenario's contribution to risk. Though, the doors being considered open for the entire time is an unrealistic assumption and causes an insignificant increase to risk for one scenario. Therefore, control room abandonment timing with doors opening at 15 minutes was used to calculate the P_{NS} for each habitability evacuation scenario.

The opening of the doors is consistent with the Pre-fire strategy for the Main Control Room which instructs the fire brigade to open doors to allow for water to drain out of the control room. The fire brigade arrival time is estimated at 15 minutes and at least one door will need to be opened and remain open to allow for the use of hoses inside the control room proper; the available hose station is outside of the adjacent corridor.

However, the HVAC operational versus inoperable does have a noticeable effect on the SF*P_{NS}.

For these reasons three scenarios were developed for transient fires in the main control room (MCR) leading to a habitability evacuation: CRA6T, CRA7T, and CRA8T. (PRA-W3-05-028 Rev 1, "Fire PRA Main Control Room Analysis Notebook").

- CRA6T Transient fire in the operator area with HVAC operable
- CRA7T Transient fire in the operator area with HVAC inoperable.
- CRA8T Transient fire in the equipment area with HVAC inoperable.

Note that the control room abandonment timing analysis (PRA-W3-05-026) showed that regardless of the door's position for a transient fire occurring in the equipment area with an operating HVAC system, abandonment conditions are not reached within 25 minutes for any HRR bin. The SF*P_{NS} would then be 0.001 for this scenario. In lieu of modeling this separately, it was combined with the equipment area, transient fire, non-operating HVAC scenario; and the resulting scenario's SF*P_{NS} is 2.17E-3.

Further note that the control room abandonment timing analysis (PRA-W3-05-026) shows that abandonment should occur prior to the door being opened at 15 minutes. Otherwise the criteria are not reached until after 25 minutes for all transient fire HRR bins except for three:1) Inoperable

HVAC, equipment area, doors remain closed HRR bin 349 kW, 2) inoperable HVAC, equipment area, doors open at 15 minutes HRR bin 312 kW and 3) inoperable HVAC, equipment area, doors open at 15 minutes HRR bin 349 kW. This analysis shows that doors would be opened at some point during the scenario.

i.i

The soot yield and CO/CO_2 yield for the physical analysis unit (PAU) RAB 7 CFAST model are set to a single value for all scenarios to aid in not introducing excess uncertainty of changes to the yield parameters for various fuel packages. The value selected in the CFAST model, 0.01 as documented in PRA-W3-05-030, "Documentation of Fire Modeling Scenarios for WSES3 PAUs RAB 7A, 7B, 7C, and 7D Hot Gas Layers (using CFAST)", is representative for cables insulations and general plastics as fuels for the electrical cabinet scenarios and the value is bounding for the type of transient fuels expected in PAU RAB7U. Operational procedure EN-DC-161, "Control of Combustibles" limits the total amount and locations where potential transients can be within the Waterford 3 plant. RAB7 is identified as a Level 1 combustible control area (transient combustible loading is prohibited unless evaluated and approved) which further serves to reduce the presence of potential secondary ignition materials.

For various cable and plastic material types as listed in the SFPE Handbook of Fire Protection Engineering, 3rd Edition (SFPE Handbook), the CO/CO_2 yield can range from approximately 0.003 – 0.004 for various wood (cellulose) materials up to 0.007 – 0.009 for plastic types such as polyethylene (PE) or polypropylene (PP) as well as cable types such as silicon and PE or PP, all of which are present in the Waterford 3 plant.

The radiative fraction is set to a conservative or bounding value for all scenarios which also aids in not introducing excess uncertainty of changes to the radiative fraction for various fuel packages. The value selected, 0.30, is based on information taken from NIST Special Publication 1026, "CFAST-Consolidated Model of Fire Growth and Smoke Transport (Version 6) Technical Reference Guide", which states a general range for fuel sources of 0.05 to 0.40 as well as the SFPE Handbook, which notes radiative fractions in the same range. As noted in the SFPE Handbook, selection of too high a value for the radiative fraction can have a non-conservative impact on the upper layer temperature estimation, which is the focus of the CFAST study in question.

A sensitivity case investigated changes to the radiative fraction and the soot yield and CO/CO_2 yield for the CFAST model as documented in PRA-W3-05-030. In the sensitivity case, the radiative fraction is changed to 0.4 and the soot yield and CO/CO_2 yield are changed to 0.10. From PRA-W3-05-030, the maximum hot gas layer (HGL) temperatures with the alternate material properties are slightly decreased from the prior scenario results using the CFAST material properties, though by only approximately 5.0 °C for most physical analysis unit (PAU) locations, highlighting the ability of the radiative fraction value to have non-conservative impacts on the predicted results.

The sensitivity analyses provided in PRA-W3-05-030 are being updated to include sensitivity cases for radiative fraction, soot yield and CO/CO2 yield for the CFAST model for RAB 7.

i.iii

Reducing the volume of the RAB7 physical analysis unit (PAU) in the CFAST scenarios would tend to increase the predicted room temperatures, whereas the heat transfer and losses caused by the presence of these obstructions would tend to decrease the temperatures.

An additional sensitivity analysis was conducted to determine the impact on the CFAST results of deducting the volumes associated with electrical cabinets (panels) within PAU RAB7 from the overall RAB7 compartment volume in CFAST while maintaining the RAB7 compartment height as documented in PRA-W3-05-030, "Documentation of Fire Modeling Scenarios for WSES3 PAUs RAB

7A, 7B, 7C, and 7D Hot Gas Layers (using CFAST)". While the evaluation showed higher maximum hot gas layer (HGL) temperatures and increased temperatures at targets, no change in scenario impacts was noted due to the reduced compartment volumes.

The electrical cabinets (panels) are estimated to occupy approximately five to six (5 to 6) percent of the overall PAU RAB7 volume. In the sensitivity case, the overall PAU RAB7 volume is reduced by ten (10) percent while maintaining the actual height of PAU RAB7.

The results of the sensitivity show that the maximum HGL temperatures in the various compartments of the PAU RAB7 CFAST model increase by approximately fifteen (15) °C for the compartment where the fire source is located and increase by two to five (2 to 5) °C for locations further away from the fire source. Predicted target impact temperatures increased by a similar two to five (2 to 5) °C for all locations within PAU RAB7. No change in scenario impacts was noted due to either the HGL or target temperature minor increases for the sensitivity case of reduced compartment volumes.

These results demonstrate that the change in predicted impacts within the PAU RAB7 CFAST model for component or cable failures for including the cabinet volume in the calculations is small and as such, no changes to the various PAU RAB7 scenarios based on the CFAST model's predictions are required.

The additional sensitivity analyses for deducting the volume of electrical cabinets from RAB 7 volume will be included in the updated version of PRA-W3-05-030.

FM RAI S02

American Society of Mechanical Engineers/American Nuclear Society (ASME/ANS) Standard RA-Sa-2009, "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 structures, systems, and components and appropriate temperature and critical heat flux criteria must be used in the analysis.

In the updated response by letter dated June 11, 2014, to previous FM RAI 02.a, the licensee stated, in part, "[t]he design specifications for Waterford 3 cables required IEEE [Institute of Electrical and Electronics Engineers]-383 qualification. The materials of construction of the cables are consistent with thermoset performance which was the basis for the determination for the Fire PRA."

However, it appears that a damage threshold of 380 ºCentigrade (C) was used for thermoset cable, as opposed to 330 ºC, which is the NUREG/CR-6850-recommended bounding value for thermoset cable.

a. 120 day response

b. 60 day response

c. 60 day response

FM RAI S03

60 day response

FM RAI S04

NFPA 805, Section 2.7.3.3, states that acceptable engineering methods and numerical models shall only be used for applications to the extent these methods have been subject to V&V. These engineering methods shall only be applied within the scope, limitations, and assumptions prescribed for that method. The LAR, Section 4.7.3, states, in part, that “Engineering methods and numerical models used in support of compliance with 10 CFR 50.48(c) were applied appropriately as required by Section 2.7.3.3 of NFPA 805.”

a. 120 day response

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

Waterford 3 Response

b. MCR Abandonment Times CFAST V&V

The goal of the main control room (MCR) abandonment evaluation (PRA-W3-05-026) is to compute the time operators would abandon the main control room using the NUREG/CR-6850 abandonment criteria for control room fire scenarios. The abandonment times are assessed for various electronic equipment fires and for ordinary combustible fires as defined by the discretized heat release rate conditional probability distributions presented in NUREG/CR-6850. The abandonment time in the main control room is estimated by calculating the time to reach threshold values for temperature and visibility as identified by NUREG/CR-6850. The abandonment criterion for immersion temperature is based on NUREG-0700 (“Human-System Interface Design Review Guidelines”), which is more conservative than the associated NUREG/CR-6850 criteria and more consistent with an expectation that operators immersed in an elevated temperature environment will continue to perform their duties before making a successful exit.

The focus of the MCR abandonment evaluation is on the first twenty-five minutes after ignition because the non-suppression probability (NSP) decreases to 0.001 at twenty minutes per NUREG/CR-6850, Supplement 1. The abandonment calculations are performed using the zone fire model Consolidated Fire and Smoke Transport (CFAST), Version 6.1.1.

The MCR area geometry and fire parameters for the simulations fall within the model limits listed in NIST-SP-1026 (“CFAST – Consolidated Model of Fire Growth and Smoke Transport (Version 6) Technical Reference Guide, ”National Institute of Standards and Technology (NIST) Special Publication 1026”), and NIST-SP-1041 (CFAST – Consolidated Model of Fire Growth and Smoke Transport (Version 6) User’s Guide”, NIST Special Publication 1041”). Specifically, the vent area to enclosure volume ratio is less than two and the aspect ratio of the enclosures is less than five (for the true geometry). The physical input dimensions are adjusted to account for obstructions and boundary heat losses and the resulting model geometry has a length to width aspect ratio greater than five. However, the input geometry conserves the boundary area, room volume, and enclosure height. Therefore, a corridor flow model is intentionally avoided because the true geometry has an aspect ratio that is within the model limitations.

With respect to the Fire Froude Number, the only fire source that could not fall within the range considered by NUREG-1824 is the transient fuel package. The characterization of all transient fire scenarios at Waterford 3 either results in a fire Froude Number that is within the NUREG-1824, Volume 1 validation range or falls below the NUREG-1824, Volume 1 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 baseline control room abandonment CFAST, Version 6.1.1 simulations, this would only be true if the hot gas layer descent time is not the limiting constraint or, if not, there is a differential of about two or more between the hot gas layer descent time and the abandonment time. The temporal plots of the CFAST, Version 6.1.1 output provided in Appendix A of PRA-W3-05-026 show that the abandonment time for the transient fire scenarios, where predicted to be less than twenty-one minutes, is primarily determined by visibility or temperature when the hot gas layer elevation reaches 1.8 m (6.0 ft) and when considering the NUREG/CR-6850 abandonment criteria only. Accordingly, the results for the CFAST, Version 6.1.1 model are applicable or conservative relative to the validation basis provided the fire Froude Number is within the NUREG-1824, Volume 1 validated range or are lower.

Finally, as previously noted, the types of transient fuel package fires that are expected in the control room are consistent with those investigated in NUREG-1824, Volume 1 and are not expected to fall outside the range of capabilities of the CFAST, Version 6.1.1 model. Consequently, the application of the CFAST fire modeling results to transient fuel package fire scenarios at Waterford 3 is considered to either fall within the NUREG-1824, Volume 1 validation range for the fire Froude Number or produce results that are more conservative than a comparable case that falls within the NUREG-1824, Volume 1 fire Froude Number validation range.

Overall, the application of CFAST, Version 6.1.1 at Waterford 3 falls entirely within the NUREG-1824, Volume 1 V&V parameter space for applicable parameters for all times up to the predicted abandonment time or would generate a conservative result relative to a case that fall within the NUREG-1824, Volume 1 V&V parameter space.

The verification for the CFAST model is documented in Appendix D to the MCR abandonment report (PRA-W3-05-026). The validation for the CFAST model applications in the Waterford 3 MCR will also be incorporated in Appendix D in PRA-W3-05-006 and include additional validation via comparison of the model predictions against the data obtained in the control room tests documented in NUREG/CR-4527 ("An Experimental Investigation of Internally Ignited Fires in Nuclear Power Plant Control Cabinets," Volume 2).

RAB 7 CFAST V&V

NUREG-1934," Nuclear Power Plant Fire Modeling Application Guide (NPP FIRE MAG) Final Report", contains a listing of parameters with the range for that parameter that was used in the NUREG/CR-1824, "Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications, Volumes 1 through 7" study. A comparison of those parameters is presented for the CFAST modeling of RAB7 physical analysis unit (PAU) as documented in PRA-W3-05-030, "Documentation of Fire Modeling Scenarios for WSES3 PAUs RAB7A, 7B, 7C, and 7D Hot Gas Layers (using CFAST)".

Data of use in this analysis includes the heat release rate (HRR) of the various scenarios in the PRA-W3-05-030 study, either 317 kW for transient scenarios or 702 kW for electrical cabinet scenarios. Additionally, NUREG-1934 gives a correlation of $\rho_\infty T_\infty$=352 and a typical value of the heat capacity (C_p) of air at 298 K as 1.012 kJ/kg-°C. The acceleration of gravity is 9.81 m/s^2. The effective diameter (D) of all fire sources is 0.798 m using the area of the fire source as 0.5

m^2 as listed in PRA-W3-05-030. The flame height is taken from the CFAST results as 2.1 m for the electrical cabinet scenarios and as 1.2 m for the transient scenarios. The height of the base of the fire is 5 or 6 feet (1.52 to 1.83 m) for the various electrical cabinet scenarios and 0 ft (0 m) for the transient scenarios. The height of RAB7 is 10 ft (3.05 m), the length of RAB7 is 95 ft (28.96 m), and the width of RAB7 is 26 ft (7.92 m).

Below are the factors used in the analysis with description, NUREG/CR-1824 range, CFAST values and justifications.

Fire Froude Number

Given by: $\dot{Q}^* = \frac{HRR \ or \ \dot{Q}}{\rho_\infty c_p T_\infty D^2 \sqrt{gD}}$ with $\text{Effective D} = \sqrt{\frac{4A}{\pi}}$

Description: Ratio of characteristic velocities. A typical accidental fire has a Froude number of order 1. Momentum-driven fire plumes, like jet flares, have relatively high values. Buoyancy-driven fire plumes have relatively low values.

NUREG/CR-1824 V&V range: 0.4 – 2.4

CFAST model parameter value: 1.11 for cabinet scenarios, 0.50 for transient scenarios

Justification: Within the V&V range for the PAU RAB7 CFAST analysis.

Flame Length Ratio

Given by: $\frac{H_f + L_f}{H_c}$ with $\frac{L_f}{D} = 3.7\dot{Q}^{*\,2/5} - 1.02$

Description: A convenient parameter for expressing the "size" or the base height of the fire plus the length of the fire flame relative to the height of the enclosure. A value of 1 means that the flames reach the ceiling.

NUREG/CR-1824 V&V range: 0.2 – 1.0

CFAST model parameter value: 1.19 to 1.29 for cabinet scenarios, 0.39 for transient scenarios

Justification: While the cabinet scenarios exceed the NUREG/CR-1842 range, no conclusions based directly on flame height are being made in this study and the flame height was noted as extending outward on the ceiling; the temperature and velocity of the ceiling jet are not parameters of interest. Transient scenarios are within the V&V range for the PAU RAB7 CFAST analysis.

Ceiling Jet Distance Ratio

Given by: $\frac{r_{cj}}{H_c - H_f}$

Description: Ceiling jet temperature and velocity correlations use this ratio of the horizontal distance within the ceiling jet from the fire centerline relative to the enclosure height minus the height of the fire flame to express the horizontal distance from a target to plume.

NUREG/CR-1824 V&V range: 1.2 – 1.7

CFAST model parameter value: Not applicable

Justification: From NUREG-1934, this parameter is used to validate the predicted time to detector and sprinkler activation and target failure when using a ceiling jet correlation. Detection and suppression activation is not analyzed in this model. No ceiling jet targets are analyzed in this model; the temperature and velocity of the ceiling jet are not parameters of interest.

Equivalence Ratio

Given by: $\varphi = \frac{HRR\ or\ \dot{Q}}{\Delta H_{O_2} \dot{m}o_2}$

Description: The equivalence ratio relates the heat release rate (HRR) of the fire to the energy release that can be supported by the product of the heat of combustion, and mass flow rate of oxygen into the compartment. The fire is considered over- or under-ventilated based on whether φ is less than or greater than 1.0, respectively.

NUREG/CR-1824 V&V range: 0.04 – 0.6

CFAST model parameter value: Not applicable

Justification: The CFAST study assumes no ventilation is present to the overall RAB7 enclosure.

Compartment Aspect Ratio

Given by: $L/H_c \quad or \quad W/H_c$

Description: This parameter indicates the general shape of the compartment with ratios of the enclosure length to height or width to height.

NUREG/CR-1824 V&V range: 0.6 – 5.7

CFAST model parameter value: Ratios of approximately 1.10 to 3.35 for the individual compartments represented in the overall RAB7 model. For the compartments of RAB7 combined, 9.5 for the overall length of RAB7 and 2.6 for the overall width of RAB7

Justification: As discussed in NUREG-1934 when at least one of the compartment aspect ratios is large, the enclosure takes on the characteristics of a corridor. In such cases, the transport time of the combustion products and a non-uniform layer can both become significant parameters that require consideration. However, the overall RAB7 is broken into sub-areas by partial height walls and ceiling beams, with the openings above the partial height wall being further obstructed by cable trays and conduits, serving to produce compartments within the overall RAB7 PAU. These compartments are the basis for using CFAST to predict the hot gas layer (HGL) impacts within RAB7 as the RAB7 geometry is too complex for HGL predictions from the fire dynamics tools (FDTs) calculations from NUREG-1805, “Fire Dynamics Tool (FDTs): Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program”. The compartments of RAB7 in the CFAST model are within the range of NUREG/CR-1824 as stated above.

Radial Distance Ratio

Given by: $\frac{r}{D}$

Description: This ratio is the relative distance from a target to the center of the fire to the diameter of the fire source. It is important when calculating the radiative heat flux.

NUREG/CR-1824 V&V range: 2.2 – 5.7

CFAST model parameter value: Ratios of approximately 3.2 to 8.0 for the individual compartments represented in the overall RAB7 model. For the compartments of RAB7 combined, 1.6 to approximately 32.1 for the overall dimensions of RAB7.

Justification: The main parameter of interest to the RAB7 CFAST study is the HGL temperature and its position (height relative to the ceiling of the PAU) and the impact of heat flux for farther separation distances is not expected to be as restrictive as the impact of temperature due to the overall RAB7 being broken into sub-areas by partial height walls and ceiling beams, serving to produce compartments as discussed above. The model's input matches the physical layout of the room with for the division of an overall area into compartments. The important output of the CFAST runs in the HGL and this portion of the output is not significantly impacted by the somewhat higher radial distance as the heat flux impacts would be.

FM RAI S05

The LAR, Section 4.7.3, states, in part, that, "[u]ncertainty analyses were performed as required by Section 2.7.3.5 of NFPA 805 and the results were considered in the context of the application. This is of particular interest in fire modeling and Fire PRA development." The updated responses to FM RAIs 05.a & 05.b by letter dated June 11, 2014, states, "[u]ncertainty associated with specific fire modeling parameters is addressed through the use of a conservative and bounding analysis," and makes reference to several supporting documents for additional details.

Regarding the uncertainty analysis for fire modeling:

a. Describe how the uncertainty associated with the fire model input parameters was accounted for in the fire modeling analyses.
b. Describe how the "model" and "completeness" uncertainties were accounted for in the fire modeling analyses.

Waterford 3 Response

a. The uncertainty associated with fire modeling input parameters for the zone of influence (ZOI) analyses, using the fire dynamics tools (FDT) spreadsheets from NUREG-1805 "Fire Dynamics Tool (FDTs): Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program", is primarily related to the ignition source's heat release rate (HRR) as noted in NUREG/CR-1824, "Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications". Other inputs for the ZOI analyses such as ambient temperature, compartment geometry, or fire size are a more known or readily determined input with less uncertainty. As noted in the text of this RAI, FM S05, the fire modeling analyses used conservative and bounding analyses to reduce the biasing of the results due to uncertainty in the input parameters.

   As noted in PRA-W3-05-007 "Waterford 3 Fire PRA Summary Report", the true HRR for a particular fixed ignition fire source would vary on a case by case basis as the contents of the fuel source will differ from one another, however, the use of the HRRs from NUREG/CR-6850 is considered to be on the conservative or upper bound end of the possible heat release rates for such scenarios, and by using the 98th percentile HRR, any biasing of the results would be in a conservative manner. Additionally, as stated in NUREG/CR-1824, the FDT sheets are analytical calculation tools and are known to produce conservative results when compared to zone or computational fluid dynamics models. While being an approved, verified and validated fire modeling tool in NUREG/CR-1824 for fire PRA use, the FDT sheets also allow for a conservative ZOI result to be readily applied by an analyst in a consistent manner.

   The ZOI analyses for the various fixed ignition source bins are presented in PRA-W3-05-006F "Waterford 3 Fixed Ignition Source Zone of Influence Assessment Methods". The methodology and resultant ZOI for the transient ignition source bin is presented in PRA-W3-05-013 "Documentation of a Transient Fire Source Zone of Influence Using Fire Dynamic Tools (FDTs)". Similar analyses for oil source fire scenarios are documented in PRA-W3-05-029 "Documentation of Oil Source Zone of Influence Sizes (using FDTs)".

While such use is more of a scoping fire modeling approach rather than performing a PAU-specific analysis in each scenario instance with a more detailed fire modeling zone or fluid dynamics tool, applying the ZOI as determined in this report gives a useable result should the particular analysis result in an acceptable outcome. There is inherent margin in the analysis which serves to increase the acceptability of the result as the inputs and calculations were either conservative or realistic, but were not non-conservative, and the outputs of the calculations are conservative.

The uncertainty associated with more detailed fire modeling input parameters for the multi-compartment analysis (MCA) using CFAST (PRA-W3-05-005, "Waterford 3 Fire PRA Multi-Compartment Analysis and Hot Gas Layer Impact Evaluation") is primarily related to the ignition source's HRR. Other inputs for the MCA analyses such as ambient temperature, compartment geometry, or fire size are a more known or readily determined with less uncertainty. As noted in the text of this RAI, FM S05, the fire modeling analyses used conservative and bounding analyses, by using the 98th percentile HRR, to reduce the biasing of the results due to uncertainty in the input parameters.

The MCA CFAST modeling, as documented in PRA-W3-05-030 "Documentation of Fire Modeling Scenarios for WSES3 PAUs RAB 7A, 7B, 7C, and 7D Hot Gas Layers (using CFAST)", has additional input parameters such as material properties and combustion reaction properties. Material properties for the density, specific heat, conductivity, and emissivity are varied from values provided in the CFAST program, NIST Special Publication 1026, "CFAST-Consolidated Model of Fire Growth and Smoke Transport (Version 6) Technical Reference Guide" to those provided in NUREG-1934 "Nuclear Power Plant Fire Modeling Analysis Guidelines (NPP FIRE MAG)". For most parameters, there is a close match of the material properties and the material property changes do not significantly impact the sensitivity case results. Additionally, for the normal scenario analyses documented in PRA-W3-05-030, the radiative fraction is defined as 0.3, the CO/CO_2 and C/CO_2 yield as 0.01, and the H/C ratio as 0.333. For the sensitivity case, these values were defined as 0.4, 0.1, and 0.333 respectively. The base case parameters are based on material types as listed in the SFPE Handbook of Fire Protection Engineering, 3rd Edition. As discussed in RAI FM S01 part "i.i", the CO/CO_2 yield can range from approximately 0.003 – 0.004 for various wood (cellulose) materials up to 0.007 – 0.009 for plastic types such as polyethylene (PE) or polypropylene (PP) as well as cable types such as silicon and PE or PP. All of which are present in the Waterford 3 plant. The radiative fraction is set to a conservative or bounding value for all scenarios which also aids in not introducing excess uncertainty of changes to the radiative fraction for various fuel packages. The value selected, 0.30, is based on information taken from NIST Special Publication 1026, which states a general range for fuel sources of 0.05 to 0.40 as well as the SFPE Handbook of Fire Protection Engineering, 3rd Edition (SFPE Handbook), which notes radiative fractions in the same range. As noted in the SFPE Handbook, selection of too high a value for the radiative fraction can have a non-conservative impact on the upper layer temperature estimation, the focus of the CFAST study in question.

The overall effects of using the alternate radiative parameter data resulted in a notable temperature decrease only in very close proximity to the ignition source and a temperature decrease elsewhere in the RAB7 model and do not significantly impact the sensitivity case results or the hot gas layer impacts. The base case parameters are more restrictive or conservative toward the overall outcome of the scenario. PRA-W3-05-030 notes that changes to these input parameters do not significantly impact the outcome of the scenarios and that in general the modeling is not sensitive to reasonable changes, as could be expected for an uncertain input property, in the material and combustion properties.

For the CFAST modeling associated with the main control room (MCR) abandonment, uncertainty associated with specific fire modeling parameters is addressed through the use of a conservative and bounding analysis and has the results of several sensitivity cases documented in PRA-W3-05-027 ("Supplemental Fire Modeling Information in Support of Waterford 3 RAIs") to investigate the impacts of input parameters on the abandonment study. In the MCR abandonment study, the baseline fire scenarios are generally developed with the intent of skewing the assumed values conservatively.

As noted in PRA-W3-05-027, parameters for which there is little or no effect on the predicted abandonment times include the assumed boundary leakage, localized failure of the suspended ceiling in the operator area, the heat of combustion, the initial humidity, and the fire radiant fraction. In the case of the heat of combustion and fire radiant fraction, the assumed baseline values are conservative or their effect is low. Cases that have a significant effect on the abandonment time include the fire growth rate, the presence of the suspended ceiling, the fire burning regime via a nine-fold increase in the soot yield, and the assumed fire base height for certain scenarios.

The presence of the suspended ceiling sensitivity cases indicates the baseline MCR abandonment case is significantly conservative. The assumed fire base height is used to establish the baseline fire base heights to ensure conservative results. The results are shown to be sensitive to the burning regime only when the HVAC system is operational. It is further shown that the equivalence ratio under these circumstances remains well below unity (1.0) indicating that the treatment in the sensitivity case is not representative of the burning conditions that would arise and therefore not realistic. The remaining parameters show a moderate sensitivity, with some biased conservatively and others biased non-conservatively. The parameters that are biased non-conservatively include the fuel heat of combustion, the initial ambient temperature (when HVAC is inoperative), and the presence of the separation wall between the operator area and the equipment area. The heat of combustion and ambient temperature are shown to have relatively low impact to the results though the impact is non-conservative. The separation wall is present, so the sensitivity case provides a basis for ensuring that the wall is not modified in the future.

The fuel properties for the burning cables used in the CFAST MCR abandonment study are conservative compared to a sensitivity case in which the soot yield values reported in NUREG/CR-7010 ("Cable Heat Release, Ignition, and Spread in Tray Installations During Fire (CHRISTIFIRE) Volume 1: Horizontal Trays") and the abandonment criteria recommended in NUREG/CR-6850 are used. Based on the overall conservative bias associated with the parameter selections and the conservative assumptions for input parameters, the MCR abandonment study is considered conservative with respect to parameter uncertainty.

b. Fire modeling model and completeness uncertainty was not explicitly accounted for in all fire modeling evaluations or incorporated into the fire PRA directly as it is addressed through the use of a conservative and bounding analysis as noted in the FM RAI S05 text.

Model and completeness uncertainty is applicable to the ZOI calculations including hot gas layer (HGL) estimations and MCA CFAST scenario evaluations. As stated in Section 4 of NUREG-1934, model uncertainty is estimated via the processes of verification and validation (V&V); completeness uncertainty refers to the fact that a model may not be a complete description of the phenomena it is designed to predict.

NUREG/CR-6850 Section 15, step 15.5.2 provides a general outline of addressing modeling uncertainty. Model uncertainty is accounted for by selection of fire modeling tools that have been through the V&V process in NUREG/CR-1824 and further documented in NUREG-1934 and are taken as acceptable tools for fire PRA usage. The ZOI impact parameters predicted by the FDTs (plume temperature, radiant heat flux, and HGL impacts) are in general over-predicted by their calculations with the exception of plume temperature rise which is noted as slightly under-predicting its calculation as summarized in NUREG-1934 of the V&V study in NUREG/CR-1824.

The plume temperature calculation has a non-conservative bias and a relatively large standard deviation. However, the ZOI calculations did not explicitly account for the hot gas layer temperature changes and their impact on plume temperature, which are the expected source of the bias and variation as noted in Section 6.2 of NUREG-1824. The vertical plume ZOI dimension is considered to have a conservative bias embedded based on the assumed fire diameter used in its calculation as described in response to FM RAI S01 part "f" for fixed and transient ignition source bins (Enclosure 1 to W3F1-2015-0015)

From the response to FM RAI S01 part "f", when HRR per unit area (HRRPUA) is considered, a fire source must have a HRRPUA greater than 600 kW/m^2 (52.9 Btu/s-ft^2) in order to remain within the NUREG/CR-1824 validation basis fire Froude Number range. Using a fire area of 0.5 m^2 results in a HRRPUA of 300 kW / 0.5 m^2 (or 600 kW/m^2), falling within the validation range of NUREG/CR-1824 for any ignition source bin HRR equal to or greater than 300 kW. The FDTs are sensitive to the fire area used and the use of 0.5 m^2 compared to a larger area such as 1.0 m^2 serves to produce more restrictive or conservative (bounding) outputs from the FDTs by predicting higher plume temperatures at the same elevation above the fire source for a smaller fire source area as compared to a larger fire source area.

Oil ignition sources were evaluated with a fire source area determined based on the quantity of oil spilled using guidance from NUREG/CR-6850 for a spill depth also based on the quantity of oil spilled. These parameters are used to arrive at a HRR for the oil spill fire which is used in the same manner as the HRR for fixed or transient ignition sources to determine the ignition source ZOI as documented in PRA-W3-05-029. The use of the FDTs as a conservative and bounding analysis addresses the model and completeness uncertainty.

The MCA CFAST model prediction for hot gas layer impact is also noted as being over-predicted. These over-predictions, combined with the use of the conservative and bounding analyses in the use of the 98th percentile HRR serve to bias the results in a conservative manner and bound any inherent model or completeness uncertainty. Using the methods presented in Section 4.3 of NUREG-1934, the model uncertainty is determined based on the hot gas layer temperature parameter as that is the main prediction of interest to the MCA CFAST study. The hot gas layer temperatures are lower than the postulated failure criteria point thus the probability of the actual temperature exceeding the failure point is of interest.

The probability that the actual HGL temperature would exceed the failure criteria point is determined as described in Section 4.3 of NUREG-1934 and determined to be 2.37E-32 for a selected sensitivity case (where the HGL temperature prediction is 155 °C or 311 °F) to be compared to the base case (where the HGL temperature prediction is 273 °C or 523.4 °F) and 0.001006 for the base case, which are essentially zero.

For the CFAST modeling associated with the MCR abandonment as documented in PRA-W3-05-027, information from NUREG-1934 that model and completeness uncertainty are related and specific parameters that may be used to quantify both uncertainties together are provided in Table 4-1 of NUREG-1934. In cases where the abandonment times are determined exclusively from the visibility parameter, it is shown that model and completeness uncertainty are not applicable by calculating the probability that a value will be exceeded. As documented in PRA-W3-05-027, the probability that given an optical density (OD) prediction of 3 m^{-1} (0.9 ft^{-1}) that the actual value will exceed this prediction is 0.0044, which is essentially zero. For the cases in which abandonment is predicted by the 50 °C (122 °F) temperature threshold the comparison metric is the NUREG/CR-6850 temperature threshold for abandonment, or 95 °C (200 °F). The probability that the hot gas layer temperature is 95 °C (200 °F) given a prediction of 50 °C (122 °F) is also about zero.

Consequently, it is concluded that model and completeness uncertainty either would not contribute to the risk uncertainty or are bound by the conservatisms in the analysis, depending on reason by which abandonment is predicted for a given fire scenario for the CFAST fire modeling applications.

PRA RAI S01

By letter dated June 11, 2014, the responses to PRA RAI 01 and PRA RAI 21 explain that secondary ignition and subsequent fire spread beyond the initial ZOI is modeled in the updated Fire PRA, and that the resulting fire impact to secondary targets and associated change to the HRR is addressed. The response to PRA RAI 01 states that walkdowns were performed and locations of plausible secondary ignition sources were recorded. The response stated that only two PAUs were determined to require the additional analysis.

Explain the characteristics of the Waterford plant that cause such a low number of areas that require additional analysis.

Waterford 3 Response

The fire PRA walkdown, as documented in PRA-W3-05-022, “Fire PRA Walkdown Notebook”, notes that the Waterford 3 physical analysis units (PAUs) are very clean and primarily free from transient materials with very limited amounts of wood, paper, trash, clothing, or oils/fuels. Operational procedure EN-DC-161,” Control of Combustibles”, limits the total amount and locations where potential transients can be within the Waterford 3 plant with many PAUs being a Level 1 or a Level 2 area (a restricted transient combustible fire area) which further serves to reduce the presence of potential secondary ignition materials.

Additionally, from PRA-W3-05-022, exposed cables are very limited at Waterford 3 as most cables are routed in enclosed metal cable trays or in conduits. Trays with installed top and bottom covers are treated as closed trays and were found to be banded with metal strapping such that they would behave similar to a conduit. These are failed by the fire scenario if the tray is located within the ZOI of the fire source, but are not considered ignited due to the covered construction of the cable tray as enclosed trays or conduits do not readily allow fire propagation, for either thermoplastic or thermoset cables based on guidance in NUREG/CR-6850. A very few areas were found where coverage was not provided due to either obstructions or tight bends in the cable tray. These were noted when applicable by either photographic evidence or in the fire PRA walkdown text.

PRA-W3-05-020, “Resolution of RAI Based on Secondary Ignition”, noted that eight (8) PAUs were susceptible to secondary ignition concerns and were investigated further. More detailed assessment resulted in retention of two cases, as listed in the text of PRA RAI S01, which resulted in additional scenario failures for secondary ignition. The analysis for PAU scenarios that did not result in additional failures (PRA-W3-05-020) notes that in some cases the extended zone of influence (ZOI) due to secondary ignition(s) does not reach any additional targets and that in some cases the ZOI does not extend past the original fire source ZOI for secondary ignition(s) due to lower heat release rates (HRRs) of the secondary combustible as compared to the original fire source.

PRA RAI S02

60 day response

PRA RAI S03

120 day response

PRA RAI S04

120 day response

PRA RAI S05

60 day response

PRA RAI S06

60 day response

PRA RAI S07

By letter dated June 11, 2014 the responses to PRA RAI 13 and PRA RAI 45.h explain that the fire event Human Error Probabilities (HEPs) used in the Fire PRA were calculated by multiplying Internal Event HEPs by a factor of 10 to account for effects of fire on operator performance and equipment. The response to PRA RAI 45.h explains that operator actions taken outside the MCR are assumed to fail. The response to PRA RAI 45.h also states that this "methodology is different from the previous revision, which more closely resembled NUREG-1921, "EPRI/NRC-RES Fire Human Reliability Analysis Guideline," Final Report, Appendix C, (ADAMS Accession No. ML12216A104) and is considered a "more simplified approach."

The NRC staff notes that this approach is similar to the screening approaches described in Section 5.1.1 of NUREG-1921. NUREG-1921 screening approaches are similar in that for specified cases a factor of 10 times the internal event HEP could be used as a screening HEP for the corresponding fire Human Failure Events (HFE) to account for effects not covered in the internal events PRA such as fire brigade action, increased work load, and distraction. However, a number of criteria are identified in NUREG-1921 for using the screening approaches. For example, the Set 1 and Set 2 screening approaches cannot be used if there is a potential for fire damage to safe shutdown equipment that is being credited, instrumentation needed (e.g., no-readings, off-scale readings, and incorrect/misleading readings), or environmental impact that significantly impacts the MCR crew. The NRC staff notes that fire impact might preclude particular operator events from being successful by failing instrumentation needed for the action or by interfering with the operator action, and in these cases the use of the "multiplier approach" could lead to under-prediction of the HEPs associated with credited operator actions.

It is not clear how the licensee's HRA accounts for dependencies between HFEs in the same cut set. By letter dated June 11, 2014, the response to PRA RAI 13 states, in part, "[a] factor of 10 was chosen for the adjustment at the individual and combination level for actions where the probability of failure was less than 1.0E-2 and in particular combination with 1.0E-5 or lower probabilities." It is not clear what this statement means and whether the "multiplier approach" accounts for dependencies between HFEs in the same cut set.

Additionally, it is not clear whether new HFEs not used in the Internal Events PRA were added to the Fire PRA. If new HFEs were added, it is not clear how the HEPs for these HFEs are determined using the current multiplier approach. Provide the following:

a. Explain how the screening criteria discussed in Section 5.1.1 of NUREG-1921 for Sets 1 and 2 are considered. If not considered, provide further justification.

b. Explain how the HRA accounts for dependencies between HFEs in the same cut sets.

c. Explain whether or not plant procedures contain additional operator manual actions outside the control room that are currently credited in the PRA but are not listed in Table G-1 of the LAR. If so, explain why these actions are not included in Table G-1

Waterford 3 Response

a. Fire-specific human failure events (HFEs) developed to address or mitigate fire impacts were addressed in detail in the WF3 fire PRA and were not subject to the screening process. Two fire PRA specific HFEs were identified and explicitly assessed. These are the local manual trip of the RCPs (PRA-W3-05-044, "Documentation of the development of an HFE to locally trip the RCPS by de-energizing Switchgear 1A and 1B ") and the MCR abandonment (PRA-W3-05-023, "Waterford 3 MCR Abandonment HRA Analysis"). Both involve local actions within the first hour and are assessed in detail.

   For other operator actions, as defined by the guidance in NUREG/CR 6850 Task 7, the current fire PRA modeling for human actions increases the independent failure rates by a factor of 10 to address the fire impact on the bases used to define the internal event HFE values for scenarios that cannot retain their original values due to a need for fire effects.

   NUREG-1921 ("Fire Human Reliability Analysis Guidelines"), Section 5.1.1 discusses the use of this approach and identifies that for actions greater than one hour after the fire initiation that it is possible to utilize the internal events evaluation. This requires that certain criteria be met as stated in Set 2 from the NUREG 1921. A number of independent actions in the Waterford 3 model meet this criterion and no change from the internal events value is necessary.

   For those requiring adjustment due to the fire initiating event, the Set 1 and Set 2 criteria were considered. A qualitative assessment of how the operator actions originating in the internal events analysis and used in the fire PRA met these criteria is provided in Table 1. The table addresses the criteria for each operator action.

   Those that remain are MCR board actions and the following applies when looking at Set 1 and Set 2.

Table 1. Summary of Comparison of HFEs to NUREG 1921

Set 1 Criteria	
NUREG Criterion	**Assessment of Waterford 3 FPRA HFE per the Criterion**
The fire can cause an automatic plant trip or a forced and proceduralized manual trip, and the fire does not significantly damage the safe shutdown equipment being credited for the performance of the HFE, such as the equipment being used or the related indications and instrumentation, other than discussed below. This condition demonstrates that, from the safe shutdown perspective, the context is the same and the challenge of the particular fire is not significantly different (functionally or in terms of effects on equipment) from that already considered in the internal events PRA for the applicable HFE(s).	All operator actions are in series with the component logic such that if a failure occurred for required equipment the operator action is not allowed. Those few local actions occurring early in time (within one hour after fire initiated trip) are not allowed for cases where the fire is in close proximity or access is not possible due to the fire. Instrumentation and controls are directly modeled for MCR actions and the HFE is not allowed if indication is lost or MCR operation is failed. A recovery tool restriction was also added in many cases to apply the recovery only if the failure was a result of random failures.
No spurious behavior of instrumentation (e.g., false or lost indications) or spurious equipment actuations can occur in this fire beyond those with the following general characteristics: a. The spurious events are not associated with safety-related equipment and instrumentation relevant to the critical safety functions and therefore will be only minor distractions—not immediate challenges to safe shutdown. b. The operators can discern the events to be clearly attributable to the fire. c. The events do not need immediate responses or corrective actions from the crew (e.g., to prevent damage to critical safety function equipment or damage to the core) while the crew attempts to achieve safe shutdown.	Lost indication or failure of instrumentation is considered as a failure of the operator action.
One train/division of safe shutdown–related equipment and instrumentation is evaluated, based on the information available at this stage of the analysis, to be completely free of any spurious events or failures directly associated with the fire, allowing the crew to maintain the critical functions such as heat removal and RCS integrity and reach safe shutdown using the EOPs.	The model addresses the availability of equipment necessary to perform the operator action including the instrumentation and controls. If any required component or instrumentation is lost the action is not allowed for that train using the model logic.

NUREG Criterion	Assessment of Waterford 3 FPRA HFE per the Criterion
Those members of the MCR crew most directly responsible for achieving and maintaining safe shutdown (i.e., the board operators responsible for controlling and monitoring plant status and the crew supervisor responsible for reading the procedures and directing crew actions) will not have significant additional responsibilities. That is, they will be able to remain in the EOPs (as when responding to an internal event) or, if they are to follow fire procedures, those fire procedures closely resemble the EOP actions (so that the internal events PRA HFEs can still be deemed relevant for their definition and quantification). One way to demonstrate this, for instance, would be to have someone else responsible for dealing with the fire-specific response procedures and to ensure that the actions associated with those procedures do not significantly disrupt the previously mentioned MCR members' responsibilities and actions related to reaching safe shutdown. The fire-specific actions also should not divert personnel normally needed to assist the MCR crew in reaching safe shutdown.	For the credited outside control room actions, actions are handled by local operator using available procedural attachment. Operators are focused on normal plant control activities.
There is no significant environmental impact or threat to the MCR crew (e.g., no significant smoke, potential toxic gases, or loss of lighting if not already part of the internal events PRA HFE, such as for station blackout).	Scenarios with adverse environments are addressed by MCR abandonment.
There is no reason to suspect that the time available to diagnose and implement the action(s) being addressed would be significantly different from that in the internal events PRA-related scenario(s) for which the HFE(s) apply.	The timing is well defined and for those HFEs assessed the existing time considerations are appropriate.

NUREG Criterion	**Assessment of Waterford 3 FPRA HFE per the Criterion**
If any of the HFEs being modeled is a local (i.e., ex-CR) manual action originally modeled in relevant accident sequences in the internal events PRA, it should be shown that achieving the local actions will not be significantly affected by the presence of fire from an environment and accessibility perspective (e.g., no significant interference from smoke or toxic gases, either in traveling to the location of the action or in executing that action; no loss of lighting; no new high radiation threat). It should also be demonstrated that the staff assumed to conduct the action will still be available; that is, they will not be conducting other fire-related responses such as isolating electrical equipment or supporting the fire brigade. Furthermore, other conditions assumed in evaluating the corresponding internal events PRA local action (i.e., need for special tools, communication capability, and adequacy of procedures and training) should not be significantly different under fire conditions. (Note: If SCBAs are needed to carry out the local action, these Set 1 criteria are not met for that action.)	Only local actions modeled have been modeled in detail and are not subject to screening.

Set 2 Criterion	
NUREG Criterion	**Assessment of Waterford 3 FPRA HFE per the Criterion**
If all of the Set 1 conditions are met except that significant spurious electrical effects are likely to be present in one safety-related train/division (and one train/division only) of equipment and/or instrumentation important to the critical safety functions, and therefore may need some corrective responses on the part of the crew, the HFEs from similar scenarios modeled in the internal events PRA may be assigned a Set 2 screening value as long as appropriate dependencies are considered. The point of this Set 2 condition is that, in Set 1, the spurious effects are not in safety-related, critical function-related equipment and do not need any immediate response from the crew. In Set 2, the crew might have to attend and respond to the spurious activity in the affected train/division to make sure that it does not affect their ability to reach safe shutdown (e.g., causing a diversion of all injection). However, the crew would likely detect the spurious activity quickly and not be confused by it. They would still have at least one train/division of safe shutdown equipment unaffected, and they would still be likely to conduct the safe shutdown actions as indicated by the procedures without significant delays.	Any dependency related to instrumentation or spurious operation is addressed through the model logic failing the available path and precluding the ability to utilize the operator action.

b.) The assessment of dependencies maintains the same philosophy with regard to increasing the result of the dependency assessment by a factor of 10. The response to RAI PRA S05 provides more detailed discussion on the dependency assessment. Increasing the assessment by a factor of ten is appropriate based on the HRA dependency assessment method. The method utilizes the initial HFE probability as the starting point and then assesses factors for dependence between the subsequent HFEs using time as the ordering characteristic. The dependence ranges from zero to complete dependence. The fire will not alter the dependency between the actions and therefore no additional adjustments are required.

c.) The overall approach for the WF3 fire PRA with respect to ex-control room operator actions is to not consider them to be plausible as an initial screening approach (assume failed). This approach was refined for several actions by either removing the need for the action as in the case of nitrogen refill to specific accumulators or by inclusion of a refined analysis applicable for only specific PAUs as in the case for local RCP breaker trip.

During the RAI response development a single operator action (EHFMANTRNP) was identified that involved both MCR and ex-control room actions, but inappropriately binned to only MCR actions. This involved restoration following a failure of the automatic bus transfer (ABT) device when transferring from onsite to offsite power. This action has been removed from the model and the impact will be reflected in the sensitivity studies associated with PRA RAI S18.

A review of the HFEs currently credited in the fire PRA identified three HFEs that involved actions outside the control room (PRA-W3-05-007, "Waterford 3 Fire PRA Summary Report"). These are listed below in Table 2.

Table 2. Evaluation of Ex-Control Room Actions and Inclusion in Table G.1

Basic Event	Description	Disposition
QHFCSPEMPP	Failure to align CST to supply makeup to CSP during EFW operation	Long term action associated with CSP refill occurring much later than eight hours after trip. By NUREG 1921 the action can be considered the same as internal events action and is not included in Table G.1
QHFCSPWCTP	Failure to align EFW suction to WCT after CSP depletion	Long term action associated with CSP refill occurring much later than eight hours after trip. By NUREG 1921 the action can be considered the same as internal events action and is not included in Table G.1
OHFRCPTGBT	Failure to trip RCPs locally from the TGB (Switchgear 1A/1B)	Fire-specific operator action assessed using detailed modeling and is included in Table G.1.

Two of the actions, QHFCSPEMPP and QHFCSPWCTP, do not warrant inclusion in Table G.1. These actions are long term proceduralized actions necessary to ensure 24 hours of EFW inventory. They are applicable to any initiating event regardless of the presence of a fire. Since they are not impacted by the fire and are not required until well after the fire would be extinguished, NUREG-1921 would classify the HFE to be the same for internal events and fire events. Therefore, they are not fire specific and not including the events is considered to meet the intent of the NFPA 805 requirements.

One action is currently in Table G.1, OHFRCPTGBT, and was directly developed as a result of fire PRA insights (PSA-WF3-03-02, "Waterford Steam Electric Station 3 Summary of Fire PRA Driven Plant Improvements to Waterford 3 to Support Risk Optimization). A similar action existed in the prior fire-related procedures but was refined based on risk insights and the fire risk evaluation process. This is the only action that should be present in Table G-1.

PRA RAI S08

60 day response

PRA RAI S09

120 day response

PRA RAI S10

60 day response

PRA RAI S11

60 day response

PRA RAI S12

120 day response.

PRA RAI S13

By letter dated June 11, 2014, the response to PRA RAI 33 explains that though guidance to limit fire propagation from "sealed" cabinets is acknowledged, that for the Waterford Fire PRA, the licensee states, in part, "all cabinets are treated as having the ability to propagate a fire based on their resultant zone of influence impacts…." This statement seems to imply that fire propagation was considered for all electrical cabinets included in the fire frequency bin count for Bin 15 (i.e., Electrical Cabinets). In contrast to this statement, however, description of the licensee's analysis associated with fixed ignition sources states that "[c]abinet fires surrounded by only non-vented cabinets can be screened if no smoke effects are expected."

Explain how fire propagation outside of a cabinet and subsequent damage was modeled for electrical cabinets.

a. How is fire propagation outside of the cabinet modeled for electrical cabinets and motor control centers (MCCs) greater than 440 V?

b. How is fire propagation outside of well-sealed, robustly-secured cabinets modeled for electrical cabinets and MCCs greater than 440 V?

c. Is fire propagation outside of the cabinet modeled for electrical cabinets less than 440 V?

d. Are well-sealed cabinets below 440 V excluded from the counting process for Bin 15? If not, justify that this does not dilute the fire ignition frequency per cabinet leading to an underestimation of risk

Waterford 3 Response

a. No differentiation is made for electrical panels (cabinets) or motor control center (MCC) voltages in terms of allowed propagation. Each counted electrical cabinet fixed ignition source (Bin 15 as noted in the PRA RAI S13 text) greater than the 440 volt (480 volt) level is investigated using a zone of influence (ZOI) analysis for impacts and potential secondary ignition(s). The approach is consistent regardless of the cabinet's supply voltage.

   The fixed source ZOI analyses are documented in PRA-W3-05-006F ("Fixed Ignition Source Zone of Influence Assessment Methods"), which notes the ZOI impacts of the various cabinet fire scenarios to other components or cables within the physical analysis unit (PAU) for the particular cabinet. Potential secondary ignitions are analyzed and documented in PRA-W3-05-020 ("Resolution of RAI Based on Secondary Ignition"). PRA-W3-05-020 notes which PAUs have potential secondary ignition configurations, evaluates any identified potential secondary ignitions based on the fixed ignition source ZOIs taken from PRA-W3-05-006F and the presence of surrounding combustible material(s). If secondary ignition is deemed plausible, a new heat release rate (HRR) from the secondary ignition is determined using the same methods as PRA-W3-05-020, namely the NUREG-1805 ("Fire Dynamics Tool (FDTs)"), spreadsheets. Using the updated HRR, a new ZOI is then developed using the same methods as PRA-W3-05-020, namely the NUREG-1805 FDTs to determine if any additional components or cables that are present in the surrounding area fall within the new ZOI and would be expected to fail due to temperature or heat flux exposure from the secondary ignition. Any additional component or cable failures would be noted for inclusion in the overall fire scenario quantification with the original ZOI failures and ignition source failure.

b. No instances of well-sealed, robustly-secured cabinets greater than 440 volts (480 volts) were noted in the Waterford 3 fire PRA. All cabinets are subject to the same ZOI investigation as described in response item (a). Two 440 volt (480 volt) MCCs, 3B213 and 3B313-S, in PAU RAB 8 are treated as sealed (but not robustly secured) in the investigation of potential secondary ignition(s) as documented in PRA-W3-05-020; neither these MCCs nor their initial ZOI impacts are removed from the fire PRA.

c. The potential for secondary ignition(s) for all counted electrical cabinets (Bin 15) is investigated on a case-by-case basis regardless of the cabinet's input voltage and based on the ZOI impacts and surrounding environment to the particular cabinet, and if applicable, secondary ignition(s) is modeled. Two instances of secondary ignition outside of a lower than 440 volt (480 volt) cabinets are noted in PRA-W3-05-020 for multiplexors RAS2102 and RB2102 ignition sources. These cabinets are digital multiplexors. Plant Computer multiplexors have 120 volt supply voltage (Control Wiring Diagram Multiplexor Power Supply & Interface with Computer Sheets 1 through 8, 1564 B-424-2770 to -2778). These are analyzed as having potential propagation to overhead cables due to their initial ZOI analysis. The secondary ignition analysis in PRA-W3-05-020 notes there are no additional PRA-related target impacts from potential secondary ignition for cabinet RB2102 but that cabinet RAS2102 has potential additional impacts.

   It should be noted that PRA-W3-05-020 assumed all cabinets were multi-bundle heat release rate (HRR) ignition sources with no consideration for the potential of being a single-bundle ignition source for a conservative initial assessment of potential secondary ignitions. These ignition sources were later investigated in the fixed ignition source report, as documented in PRA-W3-05-006F, in a more realistic manner as single-bundle ignition source cabinets with the outcome of having no potential secondary ignition near the particular cabinets, and these ignition sources were screened from further consideration as documented in PRA-W3-05-006F.

d. Very few instances of well-sealed cabinets below 440 volts (480 volts) exist in the Waterford 3 plant; as the vast majority of cabinets are vented and are counted toward the Bin 15 total. Relay cabinets in PAU RAB7 are not vented, but are not taken as well-sealed in the fire PRA with regard to potential screening from ignition source counting nor can these cabinets be credited as being robustly secured with regard to potential screening of ignition source ZOI impacts from their surrounding environment. These relay cabinets in PAU RAB7 are counted as ignition sources and are not excluded from the overall component count for Bin 15. The number of cabinet ignition sources within PAU RAB7 is low compared to the overall number of cabinet ignition sources at the Waterford 3 site (58 counted Bin 15 sources in PAU RAB7 of nearly 900 total plant wide as documented in PRA-W3-05-001 ("Plant Partitioning, Qualitative Screening, and Ignition Frequency Development Notebook")). As such the per-cabinet ignition frequency change due to counting these cabinets is minor, and due to the cabinets not being robustly secured, the guidance for screening or inclusion from NUREG/CR-6850 is handled properly by including these cabinets in the RAB7 ignition source counts.

In comparison, the retention of the PAU RAB7 cabinets as valid ignition sources and their subsequent ZOI and hot gas layer (HGL) analyses as documented in PRA-W3-05-006F and PRA-W3-05-030 ("Documentation of Fire Modeling Scenarios for WSES3 PAUs RAB 7A, 7B, 7C, and 7D Hot Gas Layers (using CFAST)"), respectively, shows that PAU RAB7 is one of the most dominant risk contributors to the overall Waterford 3 fire PRA as documented in the "Fire PRA Summary Report ", (PRA-W3-05-007). The exclusion of these cabinets in PAU RAB7 would lower the overall risk associated with the Waterford 3 fire PRA which would be a non-conservative approach.

PRA RAI S14

60 day response

PRA RAI S15

60 day response

PRA RAI S16

By letter dated June 11, 2014, the response to PRA RAI 51 explains that the new MCA was "substantially revised" and that the current analysis does not screen out all MCA scenarios. The response and the licensee's analysis indicates that the updated MCA retains several scenarios, but do not explain the revision made to the MCA or the reason for the significantly different MCA results. Please explain the revision made to the MCA and the reasons for the significantly different MCA results.

Waterford 3 Response

The MCA was revised to align with methodology described in NUREG/CR-6850. As discussed in PRA-W3-05-005, "Fire PRA Multi-Compartment Analysis and Hot Gas Layer Impact Evaluation", the screening process utilizes a similar methodology as NUREG/CR-6850, but reorders them and includes an additional screening criterion of target damage criteria.

NUREG/CR-6850 details a process using the following steps:

Step 1.c: Exposing and exposed compartments matrix

Step 2.c: Qualitative screening

Step 3.c: Low fire load exposing compartment screening

Step 4.c: Frequency of occurrence screening

Step 5.c: CDF based screening

Step 6.c: Detailed analysis

Step 7.c: Document the analysis

The Waterford 3 MCA is performed in accordance with the following steps:

Step 1: Qualitative screening of plant buildings and other areas

Step 2: Develop compartment adjacency matrix

Step 3: Quantitative screening of retained plant areas

Step 4: Screen compartments based on hot gas layer formation

Step 5: Screen scenarios based on target damage criteria

Step 6: MCA scenario definition

Step 1 of this analysis incorporates the principles of Step 2.c in NUREG/CR-6850. Qualitative screening of plant areas is performed before building the compartment adjacency matrix to eliminate those compartments that can be screened as an exposed compartment on the bases described in NUREG/CR-6850. In addition, a compartment is qualitatively screened as an exposing compartment when the compartment does not share a common boundary with an exposed compartment that contains PRA-related equipment and/or cables.

Step 2 of this analysis incorporates the principles of Step 1.c NUREG/CR-6850. The compartment adjacency matrix only includes those exposed and exposing compartments that were not screened in Step 1 of this analysis.

Step 3 of this analysis incorporates the principles of Step 4.c and Step 5.c of NUREG/CR-6850. This screening step is a follow up to the qualitative screening that is conducted in Step 1. Step 4.c is implemented by obtaining the cumulative fixed (or transient) fire ignition frequency and multiplying it by the non-suppression probabilities (both automatic and manual per fire type) and the maximum (or limiting) barrier failure probability for a specific exposing compartment. In addition, the principles of Step 5.c are implemented by applying a maximum CCDP of 1.0 per exposing compartment. The resulting CDF allows for screening exposing compartments based on their risk significance with respect to fire ignition and maximum impacts once establishing a screening threshold. More simply, this step allows for a reduction in the amount of MCA scenarios to be analyzed by eliminating any compartment adjacency matrix combination that includes an exposing compartment that screens per this step of the analysis.

Step 4 of this analysis incorporates the principles of Section 3.c of NUREG/CR-6850. This screening step follows the quantitative screening of exposing compartments in Step 3 so that a detailed hot gas layer evaluation is only conducted for those exposing compartments where fire ignition is deemed potentially risk significant.

Step 5 of this analysis is an additional screening step that in not addressed in NUREG/CR-6850. This screening step follows the hot gas layer screening in Step 4 and interprets the results of hot gas layer formation in an exposing compartment and assesses the potential impacts in an exposed compartment. Essentially, this screening step allows for a plant specific screening of exposed compartments from the analysis on the basis that a hot gas layer that forms in any adjacent/exposing compartment must reach a target damage threshold of any target in the exposed compartment. For example, if an exposed compartment only contains thermoset cables (330 °C target damage threshold) and the exposing compartments that are adjacent only sustain a maximum hot gas layer temperature of 200 °C, any combination in the compartment adjacency matrix with that exposed compartment is screened from the analysis.

Step 6 of this analysis incorporates the principles of Step 6.c of NUREG/CR-6850. This step presents all of the exposed/exposing compartment combinations that survived the screening from the previous steps and presents them as potential MCA scenarios. These scenarios are analyzed in further detail. Some of these scenarios screened further based on the lack of potential targets within the zone of influence of the failed barrier between the exposed/exposing compartments.

PRA-W3-05-005 documents the aforementioned methodology and satisfies Step 7.c of NUREG/CR-6850.

The original analysis used unapproved methods during the screening process. This allowed for all components, and therefore scenarios, to be screened from the MCA. The updated analysis produced MCA scenarios when the prior analysis had screened them out.

PRA RAI S17

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 additional information that is required to fully characterize the risk estimates.

New guidance on using conditional probabilities of spurious operation for control circuits was issued in a letter from the NRC to NEI, "Supplemental Interim Technical Guidance on Fire-induced Circuit Failure Mode Likelihood Analysis" (ADAMS Accession Nos. ML14086A165 and ML14017A135) and in NUREG/CR-7150, Joint Assessment of Cable Damage and Quantification of Effects from Fire (JACQUE-FIRE)," Volume 2: "Expert Elicitation Exercise for Nuclear Power Plant Fire-Induced Electrical Circuit Failure" (ADAMS Accession No. ML14141A129). This guidance included: a) replacement of the conditional hot short probability tables in NUREG/CR-6850 for Option #1 (including removal of credit for Control Power Transformers (CPTs) and conduit) with new circuit failure probabilities for single break and double break control circuits, b) Option #2 in NUREG/CR-6850 is no longer an adequate method and should not be used, c) replacement of the probability of spurious operation duration figure in FAQ 08-0051 (NUREG/CR-6850 Supplement 1) for alternating current control circuits and additional guidance to address duration for direct current control circuits, d) aggregate-values for circuit failure probabilities should be used unless it is demonstrated that a cable is only susceptible to a single failure mode, e) incorporation of the uncertainty values for the circuit failure probabilities and spurious operation duration in the SOKC for developing the mean CDF/LERF, and f) recommendations on the hot short probabilities to use for other cable configurations, including panel wiring, trunk cables, and instrument cables.

Provide an assessment of the assumptions used in the Waterford Fire PRA relative to the updated guidance specifically addressing each of these items. If the Fire PRA assumptions are not bounded by the new guidance, provide justification for each of the differences or provide updated risk results as part of the integrated analysis requested in PRA RAI S18, utilizing the guidance in NUREG/CR-7150, Volume 2. Justify the proposed treatment of circuit failure probabilities during post transition for self-approval of risk-informed changes.

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Waterford 3 Response

The use of circuit failure probability was very limited in the Waterford 3 Fire PRA. Only two types of valves were assessed circuit failure probabilities. These valves were associated with the Containment Atmospheric Release system (CARS) and the Emergency Feedwater (EFW) system.

The items included in the RAI text are addressed below, followed by further explanation:

a) Option #1 utilized.

b) Option #2 not considered and no credit was taken for either duration (FAQ 08-0051) or control power transformers (CPTs). All cables where circuit failure probability was applied were of thermoset construction.

c) No credit was taken for the duration of the spurious event.

d) The value chosen for circuit failure probabilities was based on the aggregate probability value.

e) The response to PRA RAI S15 (60 Day RAI response, W3F1-2015-0015) identified the impact of implementing the SOKC terms have no significant impact on the analysis.

f) The application was limited to the following cases and no further guidance was provided. Going forward Waterford 3 will utilize NUREG/CR-7150. Implementation item S2-22 is modified to ensure the validity check of the reported change in risk subsequent to completion of all PRA-credited modifications, procedure updates, and implementation items utilizes NUREG/CR-7150 guidance.

The CARS valves are associated with the mini-purge exhaust line. The two valves assessed were CAR-200B and CAR-202B. These are dc powered solenoid operated pneumatic valves which isolate the mini-purge exhaust line (Penetration 47). The potential exists for a cable fire to introduce a spurious opening signal and unisolate the containment. An assessment of the circuit logic indicated that applying the spurious opening probability was appropriate. No credit was taken for any CPT device and the highest value found in Table 10-2 of NUREG/CR-6850 applied (0.6) for each valve based on an intra-cable short. This is documented in PRA-W3-05-043 ("Inclusion of Hot Short Conditional Probability into LERF model for CAR Isolation").

The EFW valves are EFW-228A, EFW-228B, EFW-229A, EFW-229B associated with the EFW discharge lines. These valves are dc powered solenoid operated pneumatic valves that are used to isolate the flow to the steam generators. A spurious signal could cause the valves to close isolating EFW makeup flow to the steam generators. The same circuit evaluation process was applied to the valves as described above for the control circuit and a spurious closing probability was applied as described in Section 4.2.18 of PSA-WF3-03-01, "Waterford Steam Electric Station Unit 3 Methodology for Addressing VFDRs in the Fire PRA and NFPA-805, Rev. 2". The cables are thermoset and no CPT was credited. The applied value was 0.6 for each of the four valves.

Table 4-1 from Volume 2 of NUREG/CR-7150, "Joint Assessment of Cable Damage and Quantification of Effects from Fire (JACQUE-FIRE) Volume 2: Expert Elicitation Exercise for Nuclear Power Plant Fire-Induced Electrical Circuit Failure", provides the conditional probability of spurious operation for solenoid-operated valves assuming a single break control circuit which is more conservative. For a thermoset cable the aggregate value (as suggested in the RAI, d) is 0.56 for a mean value. The value cited is within 10% of the current value utilized in the Waterford 3 Fire PRA and is lower than the current value. The inclusion of the new value would not increase the current risk contributions and the reduction is sufficiently small that it would not alter any current insights gained from the fire PRA.

The inclusion of the SOKC contribution from the information contained in Table 4-1 would not increase the total contribution above the currently utilized value for spurious operation due to fire induced cable damage.

PRA RAI S18

120 day response.

PRA RAI S19

120 day response