DPO Case File for DPO-2016-004

The following pdf represents a collection of documents associated with the submittal and disposition of a differing professional opinion (DPO) from an NRC employee involving regarding the NRC's response to the Nuclear Energy Institute (NEI) on retiring the fire protection FAQ on incipient fire detection systems (08-0046).

Management Directive (MD) 10.159, "NRC Differing Professional Opinions Program," describes the DPO Program. https://www.nrc.gov/docs/ML1513/ML15132A664.pdf

The DPO Program is a formal process that allows employees and NRC contractors to have their differing views on established, mission-related issues considered by the highest level managers in their organizations, i.e., Office Directors and Regional Administrators. The process also provides managers with an independent, multi-person review of the issue (one person chosen by the employee). After a decision is issued to an employee, he or she may appeal the decision to the Executive Director for Operations (or the Commission, for those offices that report to the Commission).

Because the disposition of a DPO represents a multi-step process, readers should view the records as a collection. In other words, reading a document in isolation will not provide the correct context for how this issue was reviewed and considered by the NRC.

It is important to note that the DPO submittal includes the personal opinions, views, and concerns by an individual NRC employee. The NRC's evaluation of the concerns and the NRC's final position are included in the DPO Decision.

The records in this collection have been reviewed and approved for public dissemination.

Document 1: DPO Submittal
Document 2: Memo Establishing DPO Panel
Document 3: DPO Panel Report
Document 4: DPO Decision

Document 1: DPO Submittal

NRC FORM 680
(09-2015)
NRCMD 10.159

U.S. NUCLEAR REGULATORY COMMISSION

DIFFERING PROFESSIONAL OPINION

DPO Case Number: DPO-2016-004

Date Received: 11/29/16

Name and Title of Submitter	Organization	Telephone Number (10 numeric digits)
Raymond HV Gallucci	NRR/DRA/APLA	(301) 415-1255
Name and Title of Supervisor	**Organization**	**Telephone Number (10 numeric digits)**
Stacey Rosenberg	NRR/DRA/APLA	(301) 415-2357

When was the prevailing staff view, existing decision or stated position established and where can it be found?

Date 11/22/2016 **Where (i.e., ADAMS ML#, if applicable):** ML16327A460

Subject of DPO

Response to July 28, 2016, Letter Regarding Retirement of National Fire Protection Association 805 Frequently Asked Question 08-0046, "Incipient Fire Detection Systems" AND Sections B and C of NCP-2016-07 (ADAMS ML16327A460)

Summary of prevailing staff view, existing decision, or stated position. (Use continuation pages or attach Word document)

Reason for DPO, potential impact on mission, and proposed alternatives. (Use continuation pages or attach Word document)

Do you believe the issue represents an immediate pubic health and safety concern?	☑ **No**	☐ **Yes, (Explain on continuation page(s) or attach Word document).**
Is the issue directly relevant to a decision pending before the Commission?	☑ **No**	☐ **Yes, Reference Document (i.e., ADAMS ML#)**

☑ **Informal discussions took place (Identify with whom and time frame of discussions)**

As this DPO is a follow-on the the unrequested response via Sections B and C of NCP-2016-017, all relevant discussions took place in the months prior to and during the submittal of that non-concurrence.

☐ **Extenuating circumstances prevented informal discussions**

Proposed panel members are (in priority order):

1. Donnie Harrison
2. Laura Kozak
3. George MacDonald

☐ **No names of potential panel members will be provided.**

When the process is complete, I would like the DPO case file: ☐ **Non-Public** ☑ **Public**

SIGNATURE OF SUBMITTER Raymond HV Gallucci **DATE** 11/29/16

SIGNATURE OF CO-SUBMITTER (If any) **DATE**

SCAN THE SIGNED AND DATED FORM (INCLUDE ANY CONTINUATION PAGES OR WORD DOCUMENTS) AND E-MAIL TO: DPOPM.Resource@nrc.gov

SIGNATURE OF DPO PROGRAM MANAGER Renée Pedersen **DATE** 12/6/16

Delete Continuation Page ☒ **DPO accepted** ☐ **DPO returned** Add Continuation Page

This DPO is a follow-up to the responses in Sections B and C of NCP-2016-017, which were not requested but nonetheless provided. As those responses failed to adequately address my concerns or evoke any change to the endorsement letter which was the subject of the non-concurrence, and the subject of this DPO, I am filing this DPO.

General Remarks:

NUREG-2180 was scheduled for final issuance several times over the past year prior to my filing the non-concurrence. However, each time, it was recalled to incorporate further revisions prompted by industry objections that insufficient credit was being offered when compared to FAQ 08-0046, which they recognized would be replaced by NUREG-2180 once it was issued. With each iteration, the credit for VEWFDS increased, until it reached what is now in the final version, discussed in the non-concurrence. Recognize that, as currently quantified, NUREG-2180 only allows credit for "enhanced suppression." Additional credit can be taken for "pre-empting the fire," although the actual quantification of this is not performed but left to the licensees. When the industry takes that additional credit, most, if not all, of the erroneous "factor of 50" from FAQ 08-0046 will be recoverable, making the rescinding of the FAQ, in no small part prompted by my intent to file a DPO if it was not rescinded independent from the issuance of NUREG-2180 (since such issuance was always "around the corner" but continued not to materialize), essentially moot. The approaches I offer in the non-concurrence already incorporate credit for fire pre-emption, so they are "complete" without the need for further manipulation by the industry. Of course, they do not approach the potential credit from the NUREG (or FAQ), which makes them unpalatable to the nuclear industry as well as to the NRC which wants NFPA 805 to finish up without further obstacles. The fact that incorporating my recommendations could place already-approved licensees for NFPA 805 into "backfit space" (see discussion in non-concurrence), not to mention stifle any remaining approvals, is untenable to the NRC. Thus, rejection of my recommendations in the non-concurrence has political motivation behind it, much more so than any technical basis for dismissal. This parallels what transpired with the original FAQ back in 2009 when the version I and my fellow engineers had nearly finalized for issuance was removed and handed over to staff more amenable to granting Harris the unreasonable amount of credit they were seeking for their transition. Technical defensibility was sacrificed for political expediency to expedite approval of the Harris pilot under NFPA 805.

The decision to retain the MCR non-suppression curve in NUREG-2180 was an unfortunate left-over from flawed and erroneous FAQ 08-0046. As the most aggressive suppression curve available at the time of the FAQ (i.e., leading to the lowest non-suppression probabilities for all fire types), it was ill-advisedly chosen to maximize the potential risk reduction from installation of VEWFDS so as to expedite Harris' transition to NFPA 805. The curve itself was developed for the entire MCR, i.e., both the front (horseshoe area) and back panel areas, where only the front is continuously occupied and in constant visual range of the operating staff. This was a likely non-conservative choice for the back panel area due to the inability to distinguish between MCR fires in the front vs. back panel areas from the original database literature, a limitation that remains today even with the updated database used in NUREG-2169. Therefore, it likely under-estimates the non-suppression probability for MCR fires in the back panel area, where there is not continuous occupation or vigilance, but rather a status similar to that for typical electrical fires in unoccupied areas of the plant, i.e., those governed by the electrical fire non-suppression curve. Even optimistically crediting the nearby presence of the operators in the front panel area, at best a non-suppression curve intermediate between that for the MCR and electrical fires would have been the most optimistic that should have been chosen in FAQ 08-0046. At that time, this curve was the welding/cutting curve, as demonstrated in Attachment 1 to the non-concurrence.

NUREG-2169 significantly reduced the credit for suppression now available for welding/cutting to the point where it is only comparable to that for electrical fires, leaving no similarly suitable curve available that is intermediate between the MCR and electrical fire curves. This prompted the NUREG-2180 analysts to develop a new curve for electrical fires where a respondent is present, essentially yielding the same credit as the original welding/cutting curve. Again,

this curve was the most optimistic that might have been allowed in NUREG-2180, not a repeat of the error from FAQ 08-0046 to allow the MCR curve again to be used. My analysis takes this approach. Both the FAQ and NUREG-2180 violate principles of PRA by assuming overly optimistic non-suppression for VEWFDS via the MCR curve rather than defaulting to a more conservative, and likely realistic, use of no better than the new electrical curve (or, in the FAQ, the comparable welding/cutting curve). As with the FAQ, this appears to be a politically-expedient, not technically-defensible, "bone" being given to the industry to again maximize the possible risk reduction credit from VEWFDS so as to not require re-evaluation of already-approved NFPA-805 licensees or hinder those currently under review from transitioning. Arguments that have been espoused since the FAQ itself, namely that "NRC needs to encourage the installation of these systems, and risk reduction credit is the best way to accomplish this," remain as flawed as ever. One does not compromise the technical validity of PRA, the basis for NFPA-805 transitions and future risk-informed applications dependent upon fire PRA, to justify encouraging a particular plant modification. That modification must stand on its own merit.

This DPO offers a chance for a much more independent review of my non-concurrence, i.e., one separate from any vested interests within NRR or RES to support the NUREG as is. As such, I strongly request that no panelist, and especially the Chair, be an NRR or RES staff member to maximize the potential for an independent review of the technical (and other) issues originally raised in the non-concurrence that carry over into the DPO.

Specific Remarks (to Sections B and C of NCP-2016-017, also attached):

1. Section C, page 1. (1). "A lack of applicable data was apparent." While this lack existed in the FAQ, there were more than sufficient data available and processed to allow for a defensible version of the FAQ as originally developed by the author of this non-concurrence and his colleagues (see Attachment 1). These data were totally disregarded by both the industry and subsequent NRC staff given control over the FAQ after it was "removed" from the original author and his colleagues. So, this statement is inaccurate. The subsequent NRC-RES DELORES-VEWFIRE program was developed to supplement the existing data which the industry and NRC disregarded.

2. Section C, page 1. (2). "Further, the methodology ... use of VEWFDS." The NCP author takes exception to the alleged "better quantification of risk benefits" in light of his objections to the non-conservative over-credit available via NUREG-2180, especially now with the additional option of "fire-pre-emption" credit returned to the process, such that as much credit as originally available in flawed FAQ 08-0046 may now be recoverable.

3. Section C, page 1. (3). "The staff decision ... to be confirmed." While this is the "official" reason, not stated is the fact that the author of the non-concurrence intended to file a DPO against the failure to have sunset FAQ 08-0046 based on the extensive results from DELORES-VEWFIRE already accumulated if the sunsetting of the FAQ continued to be "held hostage" until NRC was willing to publish NUREG-2180 despite repeated industry objections.

4. Section 3, pages 2-3. First two paragraphs under "Summary/Discussion." The first paragraph mischaracterizes my objection, suggesting that I would have considered the MCR non-suppression curve acceptable if the responder were present when the fire actually initiated. This is totally incorrect. The MCR non-suppression curve is NEVER acceptable for any fire outside the MCR, even if a responder is present (see previous discussion on pages 2-3 of DPO). The maximum creditable non-suppression curve would have been the original welding/cutting version from NUREG/CR-6850 or, in light of the reduced credit for this curve after NUREG-2169, the "new" electrical fire curve developed for the presence of responders in NUREG-2180. All this is quite clear in the non-concurrence, and the author takes exception to this mischaracterization of his objection. Second, his objection to the non-conservative, overly optimistic assumption of continuous occupation by the responder regardless of time focuses on the non-conservative, overly optimistic credit being given via the human reliability analysis portion of NUREG-2180. Despite the alleged validity of Harris' procedures cited in the second paragraph, it is well known that for the incident where an alleged 90 hours were available in advance of a VEWFDS-detected fire, the responders reset the systems multiple

times and abandoned the location when it was evident after a short time that the fire was not going to manifest itself in the near future, or if at all, contrary to the procedures. PRA is supposed to be based on realism or, when not practical, moderate conservatism. Assuming the responder stays "forever" is contradictory to both. The non-concurrence author's alternative analyses present more realistic, and moderately conservative, approaches where the responder behaves consistently with the "90-hour" Harris incident, using the results from NUREG-2180 he feels are defensible, but not the NUREG-2180 process itself.

5. Section C, pages 3-4. Last paragraph on page 3 (continue to page 4). The reviewer's failure to understand or attempt to reproduce the author's calculations in Section A points out the reason for the "surprise." The author employed THE SAME non-suppression curve for BOTH in-cabinet and area-wide VEWFDS, that being the most generous one for electrical enclosure fires with a responder present as developed in NUREG-2180. The only difference is the time available to respond and suppress, assumed by the author to be less for the area-wide vs. the in-cabinet case due to reduced "addressability" for the VEWFDS. Thus, the "small" differences in non-suppression probability (0.070 [low voltage] and 0.12 [other], for in-cabinet, vs. 0.089 [low voltage] and 0.15 [other], for area-wide) are completely consistent with variability only in the response time. NUREG-2180 non-conservatively assigns DIFFERENT non-suppression curves to these two situations, using the egregiously incorrect MCR curve for in-cabinet vs. the "new" electrical" enclosure curve for area-wide, in addition to varying the response time. This "double-counting" of credit exacerbates the non-conservative over-optimism of the NUREG-2180 results. If NUREG-2180 insisted on using different non-suppression curves, the appropriate choice would have been the "new" electrical enclosure fire curve for in-cabinet and NUREG-2169 electrical enclosure fire curve for area-wide. In fact, the author analyzed this precise case when he looked at Cases 1 through 4 from NUREG-2180 in the non-concurrence based on the "new" electrical enclosure curve. Results indicate that the increase in non-suppression probability for area-wide vs. in-cabinet could be as much as a factor of 2 using the NUREG-2180 approach - specifically compare Cases 1 (or 2) and 4 in the non-concurrence which showed in-cabinet non-suppression probability = 0.16 vs. area wide non-suppression probability = 0.31. Additionally, the author provides Attachments 1 and 2 of the non-concurrence based on the the FAQ prior to its being "removed" from the original authors and the original data available at that time. The results are completely consistent with the author's most recent analysis, as stated at the end of the non-concurrence: "The results from the paper(s) suggested reduction factors [for] ... in-cabinet VEWFDS HALVED [my emphasis] for area-wide VEWFDS ... There would appear to new be ample evidence [for} ... general guidance that limits the maximum reduction factor for non-suppression probability due to an in-cabinet VEWFDS at 5 with about half, or 3, for area-wide."

6. Section C, page 4. (4). "Additionally, potential inconsistencies ... reviews and inspections." The logic of this statement escapes the non-concurrence author. It appears to justify non-conservatism in the treatment of VEWFDS because "other PRA considerations" will offset this. This is a poor, if not indefensible, justification for accepting technical flaws in a very important aspect of fire PRA, one that has been shown to potentially dominate the risk results as per the author's analysis in the non-concurrence.

7. Section C, page 5. (5). "The staff has ... 805 licensing basis." The author performed at least a bounding analysis based on the results from eight actual NFPA-805 transitioners to show the potential effect of the non-conservative over-credit from FAQ 08-0046 could not only have rendered some of the transitions unjustified without further analysis or modification commitments, but could actually pose a potential backfit consideration. The reviewer's dismissal of this concern seems self-serving as an attempt to avoid the potential backfit issue.

8. Section C, pages 5 and 6. (6) and (8). These precisely highlight the author's objections, namely that there are EXPECTATIONS but not REQUIREMENTS associated with the replacement of the FAQ 08-0046 credit with that from NUREG-2180 or other defensible approach. The reviewer says nothing to strengthen these expectations to the level of requirements.

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Date Received

DIFFERING PROFESSIONAL OPINION
(Continued)

9. Section C, page 5. (7). "... the fire risk ... and maintained plant." It is almost comic that this statement is being used to justify the limiting of replacing FAQ 08-0046 credit with NUREG-2180, or other, when the entire NFPA-805 transition process has been based NOT on as-built and as-operated plants but exclusively on "as-will-be-built" and "as-will-be-operated" versions sometime in the future after implementation of modifications to which there have been commitments. However, given the entire NFPA-805 program has been built on EXPECTATIONS, it is not surprising that this aspect would also default to this compromise in order to enable transitions that might violate risk metrics.

10. Section C, page 6. (9). "The non-concurrence did ... for those sequences." Once again, it appears the reviewer has ignored specific calculations in the non-concurrence. As per the footnote (1) in the non-concurrence that accompanies the analysis of the potential effect on the risk metrics from the over-conservatism in erroneous FAQ 08-0046, the author specifically calculates cases where failure to have credited FAQ 08-0046 could have placed a transitioning licensee into Region I of RG 1.174 AND produced risk increases > 1E-5/yr (CDF), the threshold for investigating the potential for a backfit analysis. Also, the author did not specifically advocate a backfit, offering an option for "some sort of 'grace period' ... allowed for these plants to revise their transition, and as a result, their licensing basis, by proposing and committing to different modifications to 'recover' whatever risk reduction credit has been lost by the rescinding of the FAQ, especially in light of the FAQ's error."

Document 2: Memo Establishing DPO Panel

December 22, 2016

MEMORANDUM TO: Kenneth O'Brien, Panel Chairperson
Region III

Peter Lee, Panel Member
Office of Nuclear Security and Incident Response

Laura Kozak, Panel Member
Region III

THRU: Patricia K. Holahan, Director **/RA/**
Office of Enforcement

FROM: Renée M. Pedersen **/RA/**
Sr. Differing Professional Views Program Manager
Office of Enforcement

SUBJECT: AD HOC REVIEW PANEL - DIFFERING PROFESSIONAL OPINION ON FIRE PROTECTION FAQ ON INCIPIENT FIRE DETECTION SYSTEMS (08-0046) (DPO-2016-004)

In accordance with Management Directive (MD) 10.159, "The NRC Differing Professional Opinion Program;" and in my capacity as the Differing Professional Opinion (DPO) Program Manager; and in coordination with Patricia Holahan, Director, Office of Enforcement; Bill Dean, Director, Office of Nuclear Reactor Regulation; and the DPO submitters; you are being appointed as members of a DPO Ad Hoc Review Panel (DPO Panel) to review a DPO submitted by U.S. Nuclear Regulatory Commission (NRC) employees.

The DPO (Enclosure 1) involves concerns related to the NRC's response to NEI on retiring the fire protection FAQ on incipient fire detection systems (08-0046). The submitter previously raised concerns on this issue in NCP 2016-017. The DPO has been forwarded to Mr. Dean for consideration and issuance of a DPO Decision.

CONTACTS: Renée Pedersen, OE
(301) 415-2742

Marge Sewell, OE
(301) 415-8045

The DPO Panel has a critical role in the success of the DPO Program. Your responsibilities for conducting the independent review and documenting your conclusions in a report are addressed in the handbook for MD 10.159 in Section II.F and Section II.G, respectively. The DPO Web site also includes helpful information, including interactive flow charts, frequently asked questions, and closed DPO cases, including previous DPO Panel reports. We will also be sending you additional information that should help you implement the DPO process. Because this process is not routine, we will be meeting and communicating with all parties during the process to ensure that everyone understands the process, goals, and responsibilities. Disposition of this DPO should be considered an important and time sensitive activity. The timeliness goal for issuing a DPO Decision is 120 calendar days from the day the DPO is accepted for review. In this case, the DPO was accepted for review on December 6, 2016 and therefore, the timeliness goal for issuing this DPO Decision is April 5, 2017.

Process Milestones and Timeliness Goals for this DPO are included as Enclosure 2. The timeframes for completing process milestones are identified strictly as goals—a way of working towards reaching the DPO timeliness goal of 120 calendar days. The timeliness goal identified for your DPO task is 75 calendar days.

Although timeliness is an important DPO Program objective, the DPO Program also sets out to ensure that issues receive a thorough and independent review. The overall timeliness goal should be based on the significance and complexity of the issues and the priority of other agency work. Therefore, if you determine that your activity will exceed your 75-day timeliness goal, please send an e-mail to Mr. Dean with a copy to DPOPM.Resource@nrc.gov and include the reason for the extension request and a proposed completion date for your work. Mr. Dean can then determine if he needs to submit an extension request for a new DPO timeliness goal to the Executive Director for Operations for approval.

An important aspect of our organizational culture includes maintaining an environment that encourages, supports, and respects differing views. As such, you should exercise discretion and treat this matter appropriately. Documents should be distributed on an as-needed basis. In an effort to preserve privacy, minimize the effect on the work unit, and keep the focus on the issues; you should simply refer to the employees as the DPO submitters. Avoid conversations that could be perceived as "hallway talk" on the issue and refrain from behaviors that could be perceived as retaliatory or chilling to the DPO submitters or that could potentially create a chilled environment for others. It is appropriate for employees to discuss the details of the DPO with their co-workers as part of the evaluation; however, as with other predecisional processes, employees should not discuss details of the DPO outside the agency. If you have observed inappropriate behaviors or receive outside inquiries or requests for information, please notify me.

On an administrative note, please ensure that all DPO-related activities are charged to Activity Code ZG0007.

We appreciate your willingness to serve and your dedication to completing a thorough and objective review of this DPO. Successful resolution of the issues is important for NRC and its

stakeholders. If you have any questions or concerns, please feel free to contact me or Marge Sewell. We look forward to receiving your independent review results and recommendations.

Enclosures:
1. DPO-2016-004
2. Process Milestones and Timeliness Goals

cc: w/o Enclosures:
B. Dean, NRR
S. McDermott, NRR
D. Roberts, RIII
A. Rivera, NSIR
A. Stone, RIII
R. Gallucci, NRR
P. Holahan, OE
M. Sewell, OE

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M. Sewell, OE

ADAMS Package: ML16356A435
MEMO: ML16356A424
Enclosure 1 – ML16342C445
Enclosure 2 – ML16356A432 OE-011

OFFICE	OE: DPO/PM	OE: D
NAME	RPedersen	PHolahan
DATE	12/21/2016	12/22/2016

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Document 3: DPO Panel Report

UNITED STATES

NUCLEAR REGULATORY COMMISSION

REGION III

2443 WARRENVILLE RD. SUITE 210

LISLE, ILLINOIS 60532-4352

November 13, 2017

MEMORANDUM TO: Brian Holian, Acting Director, Office of Nuclear Reactor Regulation

FROM: Kenneth G. O'Brien, DPO Panel Chair ***/RA/***

Laura Kozak, DPO Panel Member ***/RA/***

Pete Lee, DPO Panel Member ***/RA/***

SUBJECT: AD HOC REVIEW PANEL REPORT FOR DIFFERING PROFESSIONAL OPINION 2016–004

This memorandum and attached report documents the evaluation, conclusions, and recommendations of the Ad Hoc Review Panel (Panel) tasked with reviewing Differing Professional Opinion (DPO) 2016–004 (ML1637A460). This DPO involved an Office of Nuclear Reactor Regulation response to issues raised in non-concurrence NCP-2016-017 (ML16327A460), dated November 16, 2016, entitled "Response to July 28, 2016 Letter Regarding Retirement of NFPA-805 FAQ 08-046."

The Panel conducted the review in accordance with U.S. Nuclear Regulatory Commission (NRC) Management Directive MD 10.159, "The NRC Differing Professional Opinions Program," and the scope was limited to a review of the issues identified in the DPO as clarified through a Statement of Concerns developed by the Panel and confirmed by the DPO author. The Panel evaluated the issues through interviews of knowledgeable NRC staff and a review of various documents, including agency official records.

The Panel found this review to be very challenging. The subject matter is complex and has been subject to years of NRC evaluation and research. The panel report reflects our genuine and best effort to understand the technical and regulatory issues and fairly consider the differing views. The results of the Panel's evaluation of the issues of concerns, and resulting findings and recommendations are provided in the enclosed Panel Report for your consideration.

In the course of preparing the final report, the full DPO panel could not reach a unanimous agreement on the conclusions and recommendations for issues, including supporting technical bases and rationales. Therefore, a Panel Member provided, in Appendix 2, additional conclusions, recommendations, technical bases, and rationales that were not unanimous.

In addition, statements of apparent assertions of impropriety found in the descriptions of the issues of concern in DPO were referred to the Office of Inspector General on January 30, 2016. This completes the Panel's actions on the evaluation of the DPO. Please do not hesitate to contact us if you have any questions regarding the enclosed report.

CONTACT: K. O'Brien, DPO Panel Chair

630-829-9654

Enclosures:

1. DPO Panel Report
2. Appendix 1: Statement of Concerns
3. Appendix 2: Additional Conclusions and Recommendations by a Panel Member
4. Appendix 3: Documents Reviewed
5. Appendix 4: NRC Staff Interviewed
6. Appendix 5: Interview Questions
7. Appendix 6: Discussion Topics for Determining Statement of Concerns
8. Appendix 7: Assertion of Impropriety and Communications with Office of Inspector General

cc: A. Boland, OE

R. Pedersen, OE

R. Raspa, OIG

Memo to Brian Holian from Kenneth O'Brien, et al. dated November 13, 2017

SUBJECT: AD HOC REVIEW PANEL REPORT FOR DIFFERING PROFESSIONAL OPINION 2016–004

ADAMS Accession Number ML17317A849

OFFICE	NSIR/DSP		RIII		RIII			
NAME	PLee:cl		LKozak		KO'Brien			
DATE	11/06/17		11/06/17		11/13/17			

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Differing Professional Opinion (DPO) Involving Nuclear Reactor Regulation Response

To NCP-2016-017

(DPO-2016-004)

DPO Panel Report

/RA/ 11/13/17

Kenneth O'Brien, Panel Chair

/RA/ 11/06/17

Enclosure 1

Laura Kozak, Panel Member

/RA/ 11/06/17

Pete Lee, Panel Member

November 13, 2017

Date

Introduction

On November 29, 2016, an U.S. Nuclear Regulatory Commission (NRC) staff member filed a Differing Professional Opinion (DPO) in accordance with NRC Management Directive MD 10.159, "The NRC Differing Professional Opinions Program." (ADAMS Accession No. ML163420445). The DPO involved an Office of Nuclear Reactor Regulation (NRR) response to a previous Non-Concurrence Process submittal, (NCP-2016-07; ADAMS Accession No. ML1637A460). The NCP was associated with a letter issued by NRR on November 17, 2016, "Response to July 28, 2016, Letter Regarding Retirement of National Fire Protection Association 805 Frequently Asked Question 08-0046, 'Incipient Fire Detection System'" (ADAMS Accession No. ML16253A11).

The NRC's Office of Enforcement accepted the DPO on December 6, 2016, and assigned the DPO case number DPO-2016-004. By memorandum dated December 22, 2001, (ADAMS Accession No. ML16356A424), the Office of Enforcement forwarded the DPO to the Director of NRR for consideration and issuance of a DPO decision; and established an Ad Hoc Review Panel (the Panel) to perform a review of the DPO.

On January 30, 2017, the Panel met and determined that sufficient information had been provided to permit a detailed review of the DPO issues. On February 7, 2017, the Panel met with the submitter to ensure a clear understanding of the DPO issues and to support the development of a mutually agreed upon Statement of Concerns. On April 7, 2017, the Panel reached alignment with the submitter on a Statement of Concerns associated with the DPO (Appendix 1).

The Panel evaluated the DPO concerns through review of various documents and interviews with knowledgeable NRC staff. The Panel maintained the scope of the review to the DPO concerns as confirmed through the Statement of Concerns. The results of the Panel's evaluation and findings and recommendations are documented below.

Evaluations of Concerns

Concern No. 1.a

> *The FAQ and the NUREG-2180 methodology, specifically the event tree approach in Chapter 6 to estimate non-suppression probability and the HRA developed in Chapter 10 in support of the Chapter 6 event trees, should not be used as a modeling approach for enhanced suppression (with an additional unquantified option for pre-emption) provided by VEWFDS. This approach results in overly optimistic results.*

Discussion and Evaluation

The Panel reviewed the material provided by the DPO submitter and had discussions with the DPO submitter, the authors of NUREG-2180, and other staff members involved in this technical issue. Clearly the modeling of the effectiveness of Very Early Warding Fire Detection System (VEWFDS) and the potential risk reduction is a complex topic that the NRC staff has been continuing to evaluate including conducting system testing and evaluating applicable operating experience. The Panel spent a significant amount of time reviewing the Frequently Asked Question (FAQ), the NUREG, the non-concurrence to

the endorsement letter, and the DPO submittal to understand the NUREG-2180 methods and the implications of the DPO submitters concerns.

Any method to model the reliability of VEWFDS systems and to assess the system's effectiveness in reducing fire core damage frequency will be subject to uncertainties and limitations. NUREG-2180 carefully documents assumptions, limitations, and boundary conditions that need to be understood by any end-user to apply the method in a plant specific application. It was clear to the Panel that modeling of VEWFDS could have a significant impact on the overall fire probabilistic risk assessment (PRA) results.

As documented in Appendix D of NUREG-2180, the Panel noted that there was limited operating experience with the VEWFDS in the applications being modeled. The fraction of fires that would exhibit an incipient stage and the duration of an incipient stage were estimated using the available information. Table D-2 documented seven events from the fire events database that exhibited an incipient stage of at least 30 minutes. This information was used in NUREG-2180 to estimate the time available for operator response, which then impacted the modeling of "enhanced suppression" and "pre-emption", the subjects of the DPO.

The alternate approach proposed by the DPO submitter, as understood by the Panel, used information from VEWFDS system testing. The testing showed that compared to conventional detectors, the VEWFDS systems provided some limited "bonus time" for operator response via pre-emption or enhanced suppression. This was a different approach to capturing the impact of having a system that could respond to the incipient stage of the fire event. The Panel concluded both methods, either NUREG-2180 or the alternate approach, have limitations due to the state of knowledge about the incipient stage of fires.

There are strong opinions across the Agency and industry on modeling of the impact of VEWFDS systems. An introductory section of NUREG-2180 (Section 1.2) stated:

> "Given the number of comments received on the draft interim position and the authors' discussions with knowledgeable individuals from both the industry and the regulatory arenas/sides, vastly differing views regarding these systems' performance and suitable application in fire PRA, were apparent. Notably both empirical data and operating experience in NPP [Nuclear Power Plant] applications are scarce; additionally, terminology is commonly used inconsistently. Because of these difficulties, the NRC identified a need to obtain a better understanding of these systems' performance and their operating experiences(s). Thus, the NRC began a confirmatory research program to address the objectives identified below."

Based upon the results of interviews conducted by the Panel, those individuals knowledgeable of the FAQ understood that the FAQ and its' "factor of 50 credit" in core damage frequency reduction ultimately was not supported by the associated research. Most individuals expressed a belief that NUREG-2180 was a significant improvement in the state of knowledge of the impact of VEWFDS systems on risk reduction. The authors of the NUREG emphasized to the Panel that the method described in NUREG-2180 must be used as described and that it was incumbent on licensees to ensure that they applied the method in the manner intended. The Panel did not find that any alternate approaches (i.e., the DPO submitters approach or any others) were pursued to evaluate the effectiveness of the VEWFDS systems during the conduct of the research. In fact, several individuals emphasized that the intent and

objective of the research activity, which was documented as NUREG-2180, was to confirm the FAQ and not necessarily to investigate alternate or new approaches. The DPO Panel concluded that the NRC staff's pursuit of an improvement to the existing approach, based upon an event tree model, was reasonable. Most individuals interviewed considered NUREG-2180 to be an improvement over the FAQ; acknowledged that there was limited experience using these systems in NPPs; and, crediting the systems for risk reduction. During a briefing on the NUREG to Commissioner's Assistants, NRC Office of Research estimated the reduction in core damage frequency (CDF) for VEWFDS using NUREG-2180 was a factor of 7, much less than the factor provided in applying the original FAQ.

The authors of the NUREG pointed out to the Panel that the most influential factor in the study was the characterization of the fraction of fires that exhibit an incipient stage and the duration of the incipient stage (denoted as the α factor in the NUREG-2180 event tree). The DPO Panel reviewed the report and the sensitivity studies in Chapter 12 and confirmed this point. A significant difference between the FAQ and the NUREG-2180 was this factor. The FAQ assumed that all fires exhibited an incipient stage and could be mitigated with a VEWFDS system. However the research showed that only a fraction of fires actually exhibit this stage and therefore the VEWFDS systems could only be effective in some percentage of fire events. There was limited data on fire events with incipient stages and the duration of the incipient stage could not be predicted. This was a limitation that impacted all methods for quantifying the effectiveness of these systems. In NUREG-2180, the authors reviewed the limited data available in the fire events database and generated the estimate for the alpha factor and the time estimates for the duration of the incipient stage. The alpha was modeled directly in the event tree as a branch point. The duration of the incipient stage was used in development of the human reliability in responding to the incipient alarm. In summary, the Panel members concluded that, for the fraction of fires that exhibited an incipient stage, enough time was available for responders to perform. Since only "enhanced suppression" was modeled at this time, effectively all the time from the beginning of flaming (T=0) to the damage state of interest (typically targets outside the cabinet), was then available for suppression activities by the responder. Suppression was then modeled using the main control room (MCR) non-suppression curve, given that the responder was assumed to behave similar to operators in a continuously occupied space.

Pre-empting the fire during the incipient stage by responding to VEWFDS alerts/alarms and de-energizing electrical equipment before flaming occurred was discussed in NUREG-2180 but was not modeled generically because it was a highly plant-specific strategy.

The Panel determined NUREG-2180 to be well documented with appropriate assumptions and limitations and therefore concluded that the NUREG was a reasonable approach for modeling VEWFDS systems in a fire PRA.

The Panel also reviewed the alternate approach provided by the DPO submitter in the form of published and unpublished papers and in summary e-mails to the Panel and to a wide distribution of NRC staff and managers. The Panel did not find technical flaws with the alternate approach presented. The alternate approach assumed that there was 5 to 10 minutes of "bonus time" for fire suppression and then added the bonus time to the time to damage estimate and used this total time for suppression along with the electrical fire suppression curve. The Panel did not find that the staff had considered the alternate approach and the information that it presented.

The Panel reviewed a slide presentation given as a Commission Technical Assistants Brief on September 12, 2016, on NUREG-2180. On Slide 22 of the presentation there was a table showing the CDF reduction factor for VEWFDS using the different approaches of NUREG/CR-6850, FAQ 08-0046, and NUREG-2180. The slide showed that applying NUREG-2180 resulted in a factor of 7 decrease in CDF compared to having no VEWFDS system. A factor of 7 was not very different from the factor of 5 suggested by the DPO submitter using the alternate approach. As published, the Panel did not consider that the use of NUREG-2180 would be overly optimistic. However the briefing slides also presented the results of an industry table-top pilot application of NUREG-2180 resulting in a factor of 19 to 35 reduction in CDF, without any explanation of how the pilot arrived at the much more optimistic results. Given what, on the surface, appeared to be a wide variation in results given application, it may be prudent to consider, as the DPO submitter suggested, a maximum CDF reduction factor as a practical limitation until more operational experience is gained.

Conclusion:

The Panel determined that NUREG-2180 provided a reasonable approach to estimating the enhanced suppression risk reduction of VEWFDS if applied consistent with the assumptions and limitations documented. Given limited operational experience with VEWFDS and limited knowledge and understanding of the incipient phase of fire it may be prudent to consider a maximum CDF reduction factor that can be obtained by these systems.

Concern No. 1.b

> *If the NUREG-2180 methodology is used for VEWFDS enhanced suppression modeling, the original welding/cutting non-suppression curve from NUREG/CR-6850 or the "new" electrical fire non-suppression curve developed for the presence of responders in NUREG-2180 is the maximum creditable that should be used. The MCR non-suppression curve should not be used for in plant fires.*

Discussion and Evaluation

The DPO Panel reviewed the non-suppression curves referenced in the DPO—the electrical, MCR, welding/cutting, and "new" electrical, along with the potential impact on the results in applying NUREG-2180. The selection of which curve to use is subject to judgment regarding the applicability. The DPO submitter noted that the use of the MCR curves provided the most optimistic results for the analysis outcome when compared to using any of the other curves. The Panel confirmed this point. The sensitivity analyses performed in Chapter 12 of NUREG-2180 stated that the parameter for enhanced suppression was not evaluated because its variation would have a minor effect on the end result compared to other parameters, such as the fraction of fires that have an incipient stage.

The NUREG-2180 authors provided a justification for the use of the MCR non-suppression curve that was documented in the NUREG and was addressed during the draft NUREG comment resolution process. The NUREG authors also discussed reasons why the welding/cutting non-suppression curve would not be appropriate in this application with the Panel members. The Panel concluded that no existing non-suppression curve exactly fit the application in NUREG-2180 and the impact of the selection of a non-suppression curve on the overall results of the analysis should be evaluated.

The DPO submitter strongly objected to use of the MCR curve and provided several reasons. In particular, the submitter stated that the nature of the MCR fires was different than the nature of electrical cabinet fires in the plant. The submitter also pointed out that use of the MCR curve for fires outside the MCR could be precedent setting in risk analysis. The Panel thought these were important points to consider in selecting the non-suppression curve for use.

The DPO Panel noted that the NUREG-2180 event tree contained a top event for conventional detection and suppression if enhanced suppression failed. This value would be estimated using existing guidance, including the electrical non-suppression or other applicable curves. The Panel questioned whether using the non-suppression curves in two places in the analysis, first to estimate the enhanced non-suppression probability and then to estimate the conventional non-suppression probability, was potentially "double-counting" credit for manual suppression. Recognizing that these are two distinct non-suppression efforts that were being modeled, there may be dependency between the two which does not appear to be currently addressed. It was not clear to the Panel that the way the fire suppression data was collected and analyzed, which appeared to be one suppression effort based on one fire event, supported the use of the curves as the event tree was constructed. The Panel recommends that NRC staff review further applying the non-suppression curves within the model.

Conclusion:

The Panel found that NUREG-2180 documented and justified the basis for the use of the MCR curve, including in response to questions raised during the draft NUREG comment resolution process. The Panel also concluded that no existing non-suppression curve exactly fit the application in NUREG-2180.

Recommendations:

The Panel recommends that NRC staff review further the application of non-suppression curves to the NUREG-2180 process and the impact of curve selection on the results of the analysis**.**

Concern No. 1.c

> *The HRA approach in NUREG-2180 described in Chapter 10 to estimate the Field Operator response is overly optimistic. It assumes that a responder, unable to pre-empt a fire, would remain indefinitely at the electrical enclosure as a fire watch until a fire materialized. In reality, if the responder arrived prior to fire manifestation but was unable to pre-empt the fire, the responder would remain there only for a "reasonable" time period (perhaps on the order of one hour). If the fire did not materialize, the responder would reset the VEWFDS system and abandon the location, and the entire "scenario" would begin again from scratch. Therefore, crediting the "new" electrical fire curve would only be appropriate within a limited time period for pre-emptable fires that were not pre-empted.*

Discussion and Evaluation

The Panel confirmed that the human reliability analysis (HRA) assessment for NUREG-2180 included an assumption that the responder would remain in the area, ready to suppress the fire. The assumption appeared to be based on a single plant's procedures which the NUREG authors reviewed which required

the responder to remain in the area. The HRA was clearly documented in the NUREG and the HRA results indicated that the responders' actions would be highly reliable, in that, the responders would respond and be ready to suppress a fire when it develops from essentially the time flaming initially began.

The Panel noted that limited operating experience existed with regard to licensee staff response to VEWFDS alerts/alarms, which ultimately progressed to a flaming fire. Therefore, the HRA estimates could not be compared to any significant operating experience. The NUREG was very detailed and clear that plant procedures and training must direct the immediate "drop everything" response and require the responder to remain at the location. Therefore, the Panel concluded that the HRA was consistent with the entry assumptions. The Panel also noted that the DPO submitter's concerns regarding operator response also would be valid, if a licensee's plant procedures and training were not consistent with the NUREG assumptions or operating experience indicated that the operators' response would be different from what was assumed.

Conclusions:

The Panel determined that the HRA performed for NUREG-2180 was reasonable, given the assumptions and limitations documented. If plant procedures, training, or operating experience differed from those assumed in NUREG-2180, then the HRA results may be optimistic.

Recommendation:

The Panel recommends that plant procedures, training, and operating experience relative to a licensee's planned response to VEWFDS alerts/alarms is assessed during the initial review of the license application. The Panel also recommends that inspection guidance be developed to review these attributes for licensees who install and credit VEWFDS in their fire PRAs.

Concern No.1.d

> *General guidance should be provided that limits the maximum reduction factor for non-suppression probability due to in-cabinet VEWFDS at 5 and for area-wide VEWFDS at 3. Alternate analyses provide the technical justification for these limits. The DPO submitter has provided several approaches to justify this.*

Discussion and Evaluation

Through review of NUREG-2180 and interviews with the authors of the document, the Panel determined that the authors did not consider, during development or endorsement of the NUREG, whether a maximum level of credit should be defined for the installation and use of a VEWFDS. The DPO submitter performed and provided alternate analyses, in several different ways, all of which would suggest that, given the state of current knowledge, the impact of VEWFDS on the core damage frequency would be much lower than estimated using the original FAQ methodology. Additional research, conducted in support of NUREG-2180, also confirmed that the FAQ was overly optimistic.

The outcome of modeling of the risk reduction provided by VEWFDS appeared to have a large impact on the overall fire PRA results. With limited operating experience and limited understanding of the

duration of the incipient stage of a fire, it would be important that the evaluation of the effectiveness of these system be neither overly optimistic nor overly pessimistic.

Conclusion:

The Panel found the alternate approach and the suggested limits for a maximum reduction factor to be compelling information. The Panel recommends that the staff consider the alternate analyses provided by the DPO submitter and determine whether it would be prudent for the Agency to consider a maximum reduction factor as a practical matter.

Concern No.2

> *The endorsement letter of NUREG-2180 stated that there are "expectations" that licensees update their fire PRAs to remove the modeling approach using FAQ 46 and replace it with the approach from NUREG-2180 or another defensible approach. Licensees should be "required" to perform this update. This concern is separate from the technical concerns with the FAQ and NUREG-2180 approaches to VEWFDS modeling (i.e., a change from "expectations" to "requirements" in the endorsement letter would not affect the other DPO concerns). (Note that this does not imply the DPO submitter approves of the use of NUREG-2180 in its current form, even with the wording correction from "expectations" to "requirements").*

Discussion and Evaluation

The Panel reviewed the FAQ process, as documented in a letter to the Nuclear Energy Institute (NEI) dated, July 12, 2006. The letter documented that:

"The FAQs and answers should be treated as an extension of the endorsed revision of NEI 04-02 and may be formally adopted by the NRC through a Regulatory Issue Summary (RIS) or an update of the RG [Regulatory Guide] endorsing a new revision of NEI 04-02."

Based upon the wording of this letter and from a practical standpoint, the Panel believed that licensees who used the FAQ during the National Fire Protection Association 805 license amendment process were "required" to update their fire PRAs. Licensees followed the applicable PRA standards and RG 1.200 with regard to risk-informed activities. The standards required that a licensee-controlled PRA be updated in accordance with an upgrade procedure, the details of which were not specified by Agency regulation. So the "requirement" to update the PRA was contained within the licensee's own procedures. Based upon interviews with staff involved with drafting the endorsement letter, the Panel was informed that the letter was carefully worded so as to not imply a separate NRC regulatory requirement in the letter to NEI. The Panel viewed this explanation as reasonable.

The Panel noted that the use of a RIS or other process, rather than letters to a non-NRC licensee such as NEI, to document important changes in regulatory positions, such as rescinding the FAQ and endorsing NUREG-2180 may assist in precluding future confusion with regard to NRC's regulatory positions. The Panel noted that a RIS may also be the appropriate regulatory vehicle to clarify the treatment of new data or methods in PRA updates and the risk-informed licensing basis.

Conclusions:

The Panel determined that, although the NUREG-2180 endorsement letter documented an expectation that all licensees update their PRAs; licensees were required to complete this action as a part of their internally-controlled PRA update process.

Recommendations:

The Panel recommends that the Agency consider updating RG 1.200 and issuing a RIS to formally document and communicate to all affected licensees the: (1) revised regulatory position in NUREG-2180; and, (2) the requirement for all risk-informed license amendment requests to include PRA updates in accordance with the licensee-established procedures, which conform to RG 1.200, and/or the plant-specific licensing bases.

Concern No. 3

> *NRC should consider a backfit, or designated "correction period," for plants that were licensed using the guidance of FAQ 08-0046. Even without NUREG-2180, the continued use of the FAQ would be inappropriate if the error contained within the FAQ was not corrected by the licensee prior to applying it.*

Discussion and Evaluation

The Panel determined that the issue of back-fitting was previously considered by the staff, including consultation with the Office of the General Counsel, and determined to be unnecessary. Aspects of this consideration are documented in a letter dated July 14, 2010, from S.G Burns (NRC) to E.C. Ginsberg (NEI) (ADAMS Accession No. ML101060180).

The Panel agreed that there was no basis to back-fit plants that used FAQ 08-0046, and that as a practical matter, plants licensed with a PRA analysis using the FAQ, would routinely update their PRAs using new methods and data, as required by their licensing basis. Therefore, "continued use" or reliance on the interim guidance of FAQ 08-0046 would cease as licensees updated their PRAs in accordance with current commitments and licensing bases.

Conclusions:

The Panel determined that the Agency had previously considered and concluded that a backfit was not required for licensees that transitioned to National Fire Protection Association 805 using the guidance of FAQ 08-0046.

Summary of Concerns

Management Directive 10.159 defines a differing professional opinion (DPO) as "a conscientious expression of a professional judgment that differs from the prevailing staff view, disagrees with a management decision or policy position, or takes issue with a proposed or an established agency practice involving technical, legal, or policy issues."

The DPO submitter disagrees with the endorsement of the use of NUREG-2180 as a replacement for Frequently Asked Question (FAQ) 08-0046. The FAQ provided to guidance licensees on an acceptable method to model the risk reduction impact of installing a very early warning fire detection system (VEWFDS) for in-cabinet or area-wide detection of electrical fires at nuclear power plants. The FAQ provided for a factor of 50 reduction in core damage frequency (CDF).

A number of licensees utilized the FAQ in analyses to support their transition to the National Fire Protection Association Standard 805 as a licensing basis. Subsequently, the U.S. Nuclear Regulatory Commission (NRC) withdrew endorsement of the FAQ and endorsed the guidance provided in NUREG-2180 for modeling the risk reduction impact of VEWFDS. The DPO submitter did not agree with the FAQ and disagreed with the NRC's endorsement of NUREG-2180. The DPO submitter performed alternative analyses at the time the FAQ was developed and more recently in parallel with development of NUREG-2180. The DPO submitter concluded that both the FAQ and NUREG-2180 were non-conservative and overestimated the CDF reduction allowances due to use of VEWFDS.

The Panel and DPO submitter agreed upon the following statement of concerns:

1. The modeling approach for VEWFDS in fire probabilistic risk analyses (PRAs) can impact the occurrence of an electrical enclosure fire, that would pass the threshold for inclusion as a "creditable" fire initiator in a fire PRA, via pre-emption, or the time available for fire suppression activities, if the fire cannot be pre-empted, with the latter termed "enhanced fire suppression" in NUREG-2180. The maximum CDF reduction factor crediting both pre-emption and extra time available for suppression is approximately 5, rather than a factor of 10 or more that the methodology of either the FAQ or NUREG-2180 would provide crediting only "enhanced suppression" (potentially even higher with pre-emption credit).

    a. The FAQ and the NUREG-2180 methodology, specifically the event tree approach in Chapter 6 to estimate non-suppression probability and the HRA developed in Chapter 10 in support of the Chapter 6 event trees, should not be used as a modeling approach for enhanced suppression (with an additional unquantified option for pre-emption) provided by VEWFDS. This approach results in overly optimistic results. An alternate approach using data from NUREG-2180 that accounts for pre-emption and enhanced fire suppression is recommended by the DPO submitter.

    b. If the NUREG-2180 methodology is used for VEWFDS enhanced suppression modeling, the original welding/cutting non-suppression curve from NUREG/CR-6850 or the "new" electrical fire non-suppression curve developed for the presence of responders in NUREG-

2180 is the maximum creditable that should be used. The main control room non-suppression curve should not be used for in plant fires.

c. The human reliability analysis approach in NUREG-2180 described in Chapter 10 to estimate the Field Operator response is overly optimistic. It assumes that a responder, unable to pre-empt a fire, would remain indefinitely at the electrical enclosure as a fire watch until a fire materialized. In reality, if the responder arrived prior to fire manifestation but was unable to pre-empt the fire, the responder would remain there only for a "reasonable" time period (perhaps on the order of one hour). If the fire did not materialize, the responder would reset the VEWFDS and abandon the location, and the entire "scenario" would begin again from scratch. Therefore, crediting the "new" electrical fire curve would only be appropriate within a limited time period for pre-emptable fires that were not pre-empted.

d. General guidance should be provided that limits the maximum reduction factor for non-suppression probability due to in-cabinet VEWFDS at 5 and for area-wide VEWFDS at 3. Alternate analyses provide the technical justification for these limits.3. The DPO submitter has provided several approaches to justify this.

2. The endorsement letter of NUREG-2180 stated that there are "expectations" that licensees update their fire PRAs to remove the modeling approach using FAQ 08-0046 and replace it with the approach from NUREG-2180 or another defensible approach. Licensees should be "required" to perform this update. This concern is separate from the technical concerns with the FAQ and NUREG-2180 approaches to VEWFDS modeling (i.e., a change from "expectations" to "requirements" in the endorsement letter would not affect the other DPO concerns). (Note that this does not imply the DPO submitter approves of the use of NUREG-2180 in its current form, even with the wording correction from "expectations" to "requirements").

3. NRC should consider a backfit, or designated "correction period," for plants that were licensed using the guidance of FAQ 08-0046. Even without NUREG-2180, the continued use of the FAQ would be inappropriate if the error contained within the FAQ was not corrected by the licensee prior to applying it.

Additional Analysis, Conclusions and Recommendations

1.0 Introduction

In the course of preparing the final Differing Professional Opinion (DPO) Panel Report, the full DPO Panel could not reach a unanimous agreement on the need for additional analysis, technical bases, and rationales to support the proposed conclusions and recommendations or additional conclusions and recommendations for issues within the scope of the DPO. As a result, a DPO Panel Member offered the following material to document analysis, technical bases, and rationale in support of additional conclusions and recommendations.

2.0 Evaluations of Concerns

2.1 Background

Office of Nuclear Reactor Regulation (NRR) sent a letter from J. Giitter to M. Tschiltz (ADAMS Accession No. ML16253A111), dated November 17, 2016, titled, "Response to July 28, 2016, Letter Regarding Retirement of National Fire Protection Association 805 Frequently Asked Question 08-0046, 'Incipient Fire Detection Systems,'" in response to the Nuclear Energy Institute (NEI) letters dated July 28, 2016, (ADAMS Accession No. ML16211A327), and October 27, 2016, (ADAMS Accession No. ML16302A293). These NEI letters were industry responses to the U.S. Nuclear Regulatory Commission's (NRC's) letter dated July 1, 2016, (ADAMS Accession No. ML16167A444), which states that, in light of the improved state of knowledge gained from the development of NUREG-2180, the NRC is retiring National Fire Protection Association (NFPA) 805, "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants," Frequently Asked Question (FAQ) 08-0046, "Incipient Fire Detection Systems, Guidance for Modeling Non-Suppression Probability When an Incipient Fire Detection System Is Installed to Monitor Electrical Cabinets," dated November 24, 2009, (ADAMS Accession No. ML093220426).

2.1.1 The NRC's Response to the Nuclear Energy Institute on the Retirement of FAQ 08-0046

The NRC letter from J. Giitter to M. Tschiltz, on November 17, 2016, established the current NRC staff position and guidance that address the revision of the fire protection licensing basis in which the risk assessment considers the application of a very early warning fire detection system (VEWFDS) based on the two approaches in FAQ 08-0046 and NUREG-2180. The letter states four key positions with respect to the application of the approaches that consider a VEWFDS in nuclear power plants (NPPs) that are transitioning to Title 10 of the *Code of Federal Regulations* (CFR), Part 50.48(c), which relies, in part, on Fire Probabilistic Risk Assessments (FPRAs):

(1) The purpose of the interim position in the FAQ 08-0046 closure memorandum was to provide the current staff position for developing the probability of non-suppression in fire areas that have VEWFDS installed in certain types of electrical cabinets. The NRC Interim Staff Position was that, while the approach proposed by the Electric Power Research Institute (EPRI) in EPRI Technical Report (TR) 1016735, "Fire PRA Methods Enhancements: Additions, Clarifications, and Refinements to EPRI TR 1011989," (December 2008)

provides a high-level approach to modeling VEWFDS, there are several other issues that should be addressed and conditions applied to improve accuracy/realism.

(2) To clarify our actions regarding FAQ 08-0046, the staff recognized during the development of NUREG-2180 that some assumptions used in the FAQ were not able to be confirmed. Accordingly, its continued use could cause licensees that are considering future application of FAQ 08-0046 undue difficulty in defending some of the assumptions used in the FAQ's methodology.

(3) The NRR's expectation is that future license amendment requests, fire risk evaluations supporting self-approval evaluations, or probabilistic risk assessment (PRA) maintenance and upgrades will not specifically credit the methodology provided in FAQ 08-0046. Licensees with NFPA 805 applications crediting VEWFDS and currently undergoing NRC review will be assessed on a plant-by-plant basis.

(4) Licensees that have already received a safety evaluation (for applications crediting VEWFDS using the methodology provided in FAQ 08-0046) are expected to update their risk analyses periodically with nuclear industry operating experience and new information consistent with their current licensing bases and PRA maintenance and upgrade processes outlined in the American Society of Mechanical Engineers (ASME)/American Nuclear Society (ANS) RA-Sa-2009 standard. For these licensees, the methodology provided in FAQ 08-0046 remains part of their current licensing basis until a replacement methodology becomes available. Once available, it is expected that licensees will consider and incorporate the replacement methodology consistent with their licensing bases and the PRA maintenance and upgrade process.

In addition, the FAQ 08-0046 closure letter indicates the following:

> [W]hile implementing the fire Probabilistic Risk Analysis maintenance and update process, if operating experience indicates that VEWFDS availability, reliability and effectiveness are not as high as currently modeled in the fire [probabilistic risk assessment], actions must be taken to update the analysis to reflect the new information.

If a licensee is performing a periodic or interim PRA update, performing a fire risk evaluation to support self-approval, or submitting a future risk-informed license amendment request, the staff expects it to assess the effect of new operating experience and information on its PRAs and to incorporate the change as appropriate in accordance with the guidance in RG 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," Revision 2, issued March 2009, (ADAMS Accession No. ML090410014).

2.2 Summary of Concern No. 1

The summary of this concern is as follows:

> *The modeling approach for a VEWFDS in FPRAs can affect the occurrence of an electrical enclosure fire that would pass the threshold for inclusion as a "creditable" fire initiator in FPRAs through preemption of the fire or extra time available for fire*

suppression activities if the fire cannot be preempted. NUREG-2180 refers to the latter strategy as "enhanced fire suppression." The maximum CDF reduction factor is approximately 5 for crediting both preemption and extra time available for suppression rather than a factor of 10 or more that the FAQ 08-0046 or NUREG-2180 methodology would provide for crediting only enhanced suppression (potentially even higher with preemption credit).

The overarching concern of the DPO is the potential effect that the modeling approach or method would have on the application of a VEWFDS and operator actions in the FPRA. Any method to model the reliability of VEWFDS capability for detecting fire in electrical enclosures and of operator actions for effectively suppressing a fire in reducing fire core damage frequency (CDF) will be subject to uncertainties and limitations. The method used to model should carefully document assumptions, limitations, and boundary conditions that any end user needs to understand in order to apply the method in a plant-specific application. The accuracy and realism of modeling a VEWFDS and the resulting reliability and availability of operator responses for fire suppression could significantly affect the FPRA results and the contributions of fires in electrical enclosures to the plant PRA CDF outcomes. The Panel notes that there are varying opinions across the agency and industry on modeling the effect of a VEWFDS. NUREG-2180, Section 1.2, "Need for Confirmatory Research," acknowledges this and states the following:

> Given the number of comments received on the draft interim position and the authors' discussions with knowledgeable individuals from both the industry and the regulatory arenas/sides, vastly differing views regarding these systems' performance and suitable application in fire PRA were apparent. Notably both empirical data and operating experience in NPP applications are scarce; additionally, terminology is commonly used inconsistently. Because of these difficulties, the NRC identified a need to obtain a better understanding of these systems' performance and their operating experiences(s). Thus, the NRC began a confirmatory research program to address the objectives identified below.

Based on discussions in Section 2.2.1, "Background," through Section 2.2.2, "Discussion and Evaluation," the Panel member notes that any method applied to model the applications of a VEWFDS and the resulting operator responses for fire suppression for the FPRA must be representative and account for the current states of knowledge of fire dynamics, account for and address performance and limits of the VEWFDS technology (including site-specific design and conditions), and accurately and reasonably represent site-specific preplanned plant operator actions for responding to indications of potential fires inside critical electrical enclosures. The lack of a sound and defensible technical bases and rationales as a foundation for the application of a method (e.g., NUREG-2180, DPO submitter's alternative, or others) to evaluate the FPRA can affect the validity of the results. The subsequent plant PRA, based on the fire-event-specific risk assessment, could potentially underestimate the contributions of electrical enclosure fires involving low-voltage critical safety functions to the overall plant risk. The Panel member's additional conclusions and recommendations address the overarching issues within the DPO and the need to consider the technical complexity of electrical fires and account for the limitations of methods that licensees may apply to completely and accurately assess fire scenarios and resulting risks.

2.2.1 Background

Fire Dynamics (Incipient and Self-Sustained Combustion of Fires)

The VEWFDS actively samples air within the protected environment to detect aerosol (commonly referred to as smoke) given off during the incipient stage of a fire (see Figure 2-1) from the thermal degradation of combustible material before it develops into a sustained flaming combustion of material that results in conditions that threaten high-value content or mission-critical functions.

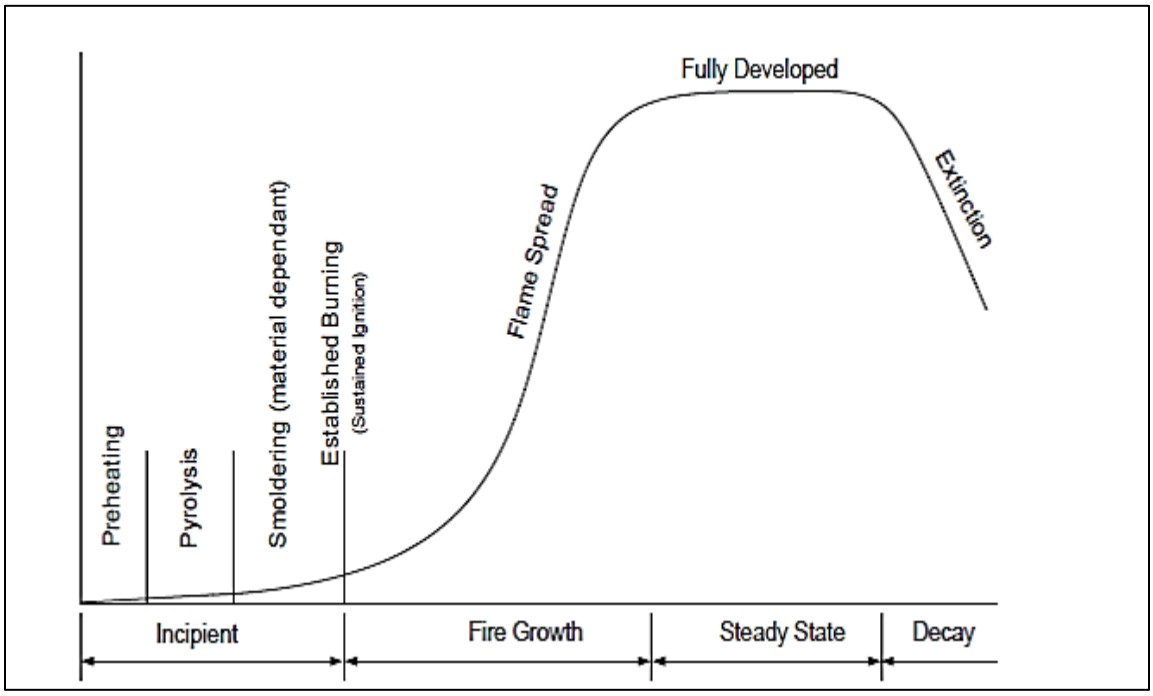

Figure 2-1 Fire stages (Source: NUREG-2180)

The progression of a typical fire consists of incipient, fire growth, steady-state, and decay stages. The incipient stage of a fire consists of preheating, pyrolysis, and smoldering (material dependent); the fire transitions to the fire-growth (a ramping heat release rate and the spread of flames), steady-state (fully developed), and decay (extinction) stages. The latter three stages characterize that portion of the fire that can be readily observable (flame and smoke) with the potential for significant consequences of smoke and heat damage. Currently available fire models and analytical tools can accurately predict portions (fractions) of the fire stages after self-sustained combustion and their effects, based on available, sound research data.

The variations of fire growth rates and rates of heat release for the self-sustained combustion stages of a fire depend on the combustible material, and they are well documented and researched in the fire protection industry outside and within the NRC. Figure 2-2 shows the various rates of fire growth that are representative of combustible and flammable material.

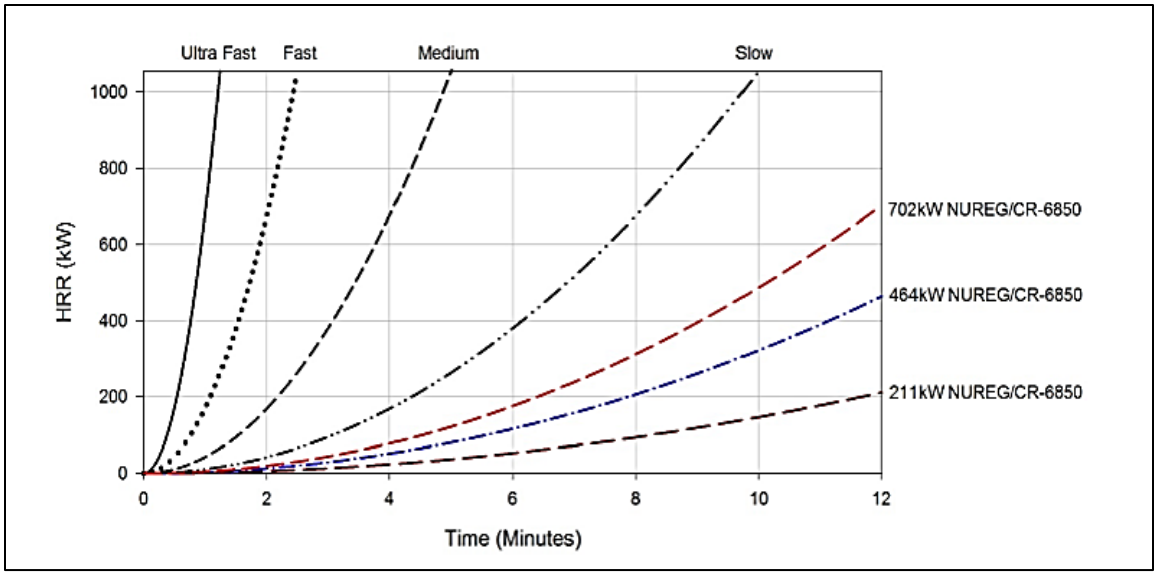

Figure 2-2 Illustration of several performance-based t-squared fire-growth profiles (incipient, steady-state, and decay stages not shown)
(Source: NUREG-2180)

The NRC's references on rates of heat release and guidance on the application of fire models and analytical tools appear in the following reports:

- NUREG-2178, "Refining and Characterizing Heat Release Rates from Electrical Enclosures During Fire (RACHELLE-FIRE)—Volume 1: Peak Heat Release Rates and Effect of Obstructed Plume," issued April 2016;
- NUREG/CR-7197, "Heat Release Rates of Electrical Enclosure Fires (HELEN-FIRE)," issued April 2016;
- NUREG/CR-6931, "Cable Response to Live Fire (CAROLFIRE)—Volume 2: Cable Fire Response Data for Fire Modeling Improvement," issued April 2008; and
- NUREG/CR-7150, "Joint Assessment of Cable Damage and Quantification of Effects from Fire (JACQUE-FIRE)," Volume 1, issued October 2012.

These references and guidance support the computer fire models and analytic tools that appear in the following reports:

- NUREG-1805, "Fire Dynamic Tools (FDTs)—Quantitative Fire Hazards Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program," issued December 2004;
- NUREG-1824, "Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications," issued May 2007; and
- NUREG-1934, "Nuclear Power Plant Fire Modeling Analysis Guidelines (NPP FIRE MAG), Final Report," issued November 2012.

These models and analytic tools predict the development of self-sustained fires and potential fire consequences and effects.

Figure 2-2 shows variation of fire-growth profiles, which are functions of the component failure, the characteristics of combustibles, and the configuration of combustibles. Similar to the variations in the rate of fire growth in the self-sustained stage, the fire-growth profiles and durations for the incipient stage can vary "dramatically" (see NFPA 921, "Guide for Fire and Explosion Investigations," issued 2014).

NUREG-2180 indicates that, in electrical enclosures, the preheating phase could start as a result of circuit, component, or interconnecting electrical conductor failure or by some other mode. Regardless of how the initial degradation begins, a source of energy that causes the preheating is necessary to initiate the potential fire scenario. Once sufficient concentrations of combustible material are present during the gasification phase, electrical energy within the electrical enclosures provides the potential ignition source to end the incipient stage. Similar to the self-sustained combustion stages of the fire, the rates of growth and durations for the incipient stage of fires vary and are not well researched. NUREG-2180, Section 8.2, "Estimating the Duration of Time Available for Operator to Respond," discusses the variability of the incipient stage of fire (e.g., preheating, pyrolysis or gasification, and smoldering) up to the self-sustained combustion or flaming fire.

In summary, the duration of electrical component incipient fire stage may vary from less than a second to hours or days and possibly even longer. NUREG-2180, Section 8.2, acknowledges the facts that there is a lack of understanding of the failure mechanisms of electrical component; a lack of knowledge of the rates of particulate generation from thermal heating and pyrolysis; and difficulties in quantifying, with any uncertainty, the phenomena that affect the rate of growth and development of incipient fires. This leads to the current state in which no agreed-upon method exists to predict the time duration from when an electrical component begins to degrade and the degrading component generates sufficient aerosol that can be detected to when self-sustained combustion, or flaming fire, occurs. The Panel member notes that these are key limitations to the application of any method that attempts to model the development of an incipient electrical enclosure fire and its detection.

Very Early Warning Fire Detection System

The VEWFDS actively draws air from the protected environment through a piping network to a particle sampling chamber (e.g., light scattering or cloud) to detect the presence of very small particles (aerosol) resulting from the pyrolysis of combustible material. The sensitivity settings of the VEWFDS provide pre-alert, alert, and alarm signals before the alarms of conventional ionization or photoelectric smoke detectors, which provide alarms under higher settings for fire detection. The incipient stage of a fire can raise the sub-micrometer (between 5x10-4 to 1x10-3) particle sizes and concentrations of aerosol sufficiently above the background levels to actuate the VEWFDS. The VEWFDS, as compared to convention smoke detection systems, is applied in an environment that requires high air-exchange rates needed for cooling electronic equipment. In the nuclear power industry, most Canadian and some U.S. NPPs currently use the VEWFDS to reduce risk by providing early warning of a fire condition.

The NFPA 72, "National Fire Alarm and Signaling Code," and NFPA 76, "Standard for Fire Protection of Telecommunication Facilities," establish the standards for the design, installation, and maintenance of a VEWFDS that provide assurance of the effectiveness of the system (i.e., reliability and availability) to

perform its intended design function of detecting fires. The NFPA 76 specifies the minimum port sensitivity above ambient airborne levels (0.2 percent and 1.0 obscuration per foot for alert and alarm conditions, respectively) for the VEWFDS to function as very early detection.

To assess (i.e., modeling the detection and suppression system's response to a fire scenario) the application of the VEWFDS to provide very early detection of an electrical component fire and to enable operator responses for fire suppression, the duration of an incipient stage must be sufficient to allow the VEWFDS to respond to the release of aerosol resulting from the pyrolysis of combustibles during the incipient stage. The overall self-sustained combustion, or flaming, stage within the electronic enclosure and the propagation of fire from the electronic enclosure must allow plant personnel (e.g., the operator, technician, and fire brigade) sufficient time to respond to the location of an alarm. The time available allows for operator to act accordingly to perform manual fire suppression before external targets are damaged.

Methods for Assessing the VEWFDS (Fire Detection) and Fire Suppression

The FAQ 08-0046, "Incipient Fire Detection System," documents an interim NRC position for quantifying the application of the VEWFDS in an FPRA to support a licensee that voluntarily transitions to NFPA 805. The FAQ 08-0046 was proposed by industry and subsequently modified and finalized (closure) on November 23, 2009. It established and retained the method for assessing the application of the VEWFDS in electric enclosures using an event tree. The FAQ 08-0046 improved on the accuracy and realism of an approach used to evaluate the application of the VEWFDS for an FPRA and was incorporated into NUREG/CR-6850, Supplement 1, and "Fire Probabilistic Risk Assessment Methods Enhancements," issued September 2010. When the NRC closed FAQ 08-0046, the NRC acknowledged in its final position that (1) there was a lack of data (empirical and operating experience in NPPs) to support the application of the VEWFDS and (2) successful operator response to the alert or alarm signals of the VEWFDS that stations a "flash watch" in the areas of electrical cabinets can successfully control a fire before it affects the adjacent target. The NRC recommended that the system issue at least a 1-hour warning before the actual outbreak of a flaming fire. Because NPPs need information about the plant applications of VEWFDSs, the NRC initiated confirmatory research to evaluate the system's effectiveness, performance, human reliability issues, response to combustion products, and design and installation configurations in support of FPRAs.

The NUREG-2180 evaluates the performance of smoke detection systems for use in NPP applications; provides results from confirmatory research that included testing and data collections, site visits, and literature reviews; and evaluates human performance and smoke detector performance as part of a fire-risk scoping study for determining the technical adequacy of FAQ 08-0046. The final version of NUREG-2180 documents the results from confirmatory research and provides technical basis for the method that supersedes the method described in the interim approach in FAQ 08-0046.

2.2.2 Discussion and Evaluation

Preempting Incipient Fire

The various methods or approaches used to assess the application of the VEWFDS and the resulting fire suppression probability for input to the plant FPRA address the second level of rapid detection and fire

suppression for defense-in-depth fire protection. The current method described in NUREG-2180 and previously in FAQ 08-0046 (as discussed in NUREG-2180, Section 6) did not consider the duration of time necessary for the incipient fire to damage to electrical components within low-voltage electrical enclosures. The method described in NUREG-2180 assumes that a fire develops from the incipient fire stage to self-sustained combustion inside the electrical enclosure, damages the contents, and potentially causes damage to adjacent critical target equipment or components in the area outside the enclosure (i.e., fire-modeled zone of influence). The resulting end states ("cabinet damage" and "fire damage outside the cabinet") are due to the lack of data and knowledge on the variability of the incipient stage of fire growth and the associated durations, which currently cannot be modeled with any certainty.

None of the methods developed and guidance established to date (e.g., EPRI TR 1018189, FAQ 08-0046, and NUREG-2180) for assessing the application of the VEWFDS provides a means of accurately modeling the incipient stage of the fire or allows for reasonable predictions of the durations of the incipient stage before the fire transitions to the self-sustained combustion stage. Conservative arguments may be made that the growth profile of the incipient fire is bounded by those profiles that are less than a slow T-square fire-growth rate (Figure 2-2). The assumption that a VEWFDS can detect the pyrolysis of combustible material during the incipient stage before the fire transitions to a self-sustained combustion range from 5 minutes to 1 hour and upwards to many hours (unsubstantiated) is uncertain and would depend on the site-specific conditions, including the physical configuration; airflow; and site-specific design, installation, and maintenance of the VEWFDS—all of which contribute to the variability in fire detection time. Currently, the incipient stage of fire growth and the associated durations of time cannot be modeled with any certainty. For this reason, there is no reasonable or sound agreement on whether a VEWFDS can detect or implement operator actions in sufficient time to preempt the transition of a fire from the incipient stage to the self-sustained combustion stage.

Methods for Assessing the Application of the VEWFDS and Fire Suppression

The EPRI TR 1016735 proposes a method for assessing VEWFDS applications. This method quantifies fire detection and suppression using an event tree with three events. The ignition frequency is adjusted to account for the VEWFDS and includes a preemptive fire suppression probability. Additional assumptions are that incipient conditions will be identified and prevented from achieving ignition for approximately 99.9 percent or more of true incipient conditions based on the control room suppression curve and 15 minutes or more of suppression time. Accordingly, this method assumes that the VEWFDS is highly capable of detecting incipient conditions and estimates a reduction in fire ignition frequency by 0.994; however, it also assumes a more limited capability of the VEWFDS and estimates a reduction in the fire ignition frequency by 0.503.

The FAQ 08-0046 proposed a method that refines the EPRI approach with the intention of improving accuracy and realism. The resulting simplified event tree represents a reduction of 0.979 to 0.984 in the non-suppression probability, depending on the addressability of the system and ignoring normal the non-suppression analysis. This method recommends and assumes that the VEWFDS provides at least 1 hour of warning before the actual outbreak of an open flaming fire.

The NUREG-2180 method further refines the event trees (see NUREG-2180, Section 6, Figure 6-4, "Basic event tree for in-cabinet smoke detection non-suppression probability estimation," and Figure 6-5, "Basic event tree area-wide smoke detection non-suppression probability estimation") that establish two end states (i.e., cabinet damage and fire damage outside the cabinet). The cabinet damage end state assumes that damage is not limited to the initiating component and that other components within the cabinet are damaged. Suppression activities, regardless of their form, are also assumed to damage the ability of components located within a cabinet to perform their intended design function. Fire damage outside the cabinet assumes that fire damage could not be limited to the initiating cabinet and that target sets outside the initiating cabinet may be damaged. This method assumes that the VEWFDS provides a 30-minute duration time for the analysis of plant operations data. The NUREG-2180, in Section 7.1, "Fractions of Fires That Have an Incipient Stages," (Page 7–3) indicates that, "Lastly, this 30-minutes quantity is used for screening events into categories to support the quantification of the 'fractions of fires that have an incipient stage,' and does not, nor should it not be used to quantify the actual incipient fire stage duration as discussed in Section 11 of this report."

The operating experience with the VEWFDS applications being modeled is limited. NUREG-2180, Appendix D, "Evaluation of Operation Experience Data," documents the existing information. The fraction of fires that exhibit an incipient stage and the duration of any incipient stage have been estimated using available information, which is very limited. Table D-2, "Summary of Incipient Stage Duration and Time Available for Operator Response," in Appendix D to NUREG-2180 lists seven events identified from the fire-events database that exhibited an incipient stage of at least 30 minutes. The NUREG-2180 used this information to estimate the time available for operator response, which then affects the modeling of enhanced suppression.

The confirmatory research for the development of NUREG-2180 testing showed that very early warning fire detectors compared to conventional (ionization and photoelectric) detectors provide some limited "bonus time" for enhanced fire suppression by operator response. This is a different approach to capturing the effect of having a system that can respond to the electrical enclosure fire event. Both methods, either the NUREG-2180 or alternate approach, have limitations because of the state of knowledge about the incipient stage of fires.

Fire Modeling Insights and Limitations on Incipient Fires

The modeling of fire development within an electrical enclosure and the subsequent propagation or thermal exposure, or both, to adjacent combustibles or critical targets, or both, can establish a timeline for the fire progression of a specific fire scenario. The fire modeling insights provide information to determine whether there is time available (i.e., opportunity) for implementing operator actions and completion of tasks that enable and perform manual fire suppression. Whether operator actions are successful or not in interrupting the progression of the fire, such actions apply to the consequences and risk assessment of targets outside the electrical enclosure (i.e., fire damage outside the cabinet). The method described in NUREG-2180 or any other methods are not sufficient or cannot be applied to assess the application of VEWFDS detection and subsequent operator actions to preempt incipient fires inside electrical enclosures. The fundamental reasons include a lack of understanding of the failure mechanisms of electrical components; a lack of knowledge of the rates of particulate generation from thermal heating and pyrolysis; and difficulties in quantifying, with any uncertainty, the phenomena that

affect the rate of growth and development of incipient fire and when sufficient pyrolysis aerosol or particles are of sufficient size and concentration to be detected. This leads to the current state in which no agreed-upon method exists to predict the time duration from when an electrical component begins to degrade and the degrading component generates sufficient aerosol that can be detected to when self-sustained combustion, or flaming fire, occurs and the slow-developing incipient fire may not be detected.

The assessment of "preempted fire"—one in which the progression of a fire within the electric enclosure is interrupted (i.e., either through operator actions or pre-engineered means)—is not an established modeling approach or the main focus of NUREG-2180. The refined event tree end states are "cabinet damage" and "fire damage outside the cabinet." Very limited information is provided in NUREG-2180, Section 6, Figure 6-6, and "Illustration of change to in-cabinet event tree for de-energization strategy," which modifies the event tree to consider operator actions to de-energize affected equipment. The NUREG-2180, Section 10.6.4, "HFE Quantification Notes for De-energization Strategy," discusses operator actions for a de-energization strategy. This guidance is intended for human reliability analysis (HRA) analysts and reviewers; it does not provide a complete illustration of the detailed site-specific HRA that would be required.

With respect to fire modeling or analysis methods or tools used to reasonably predict the pyrolysis of material for an incipient fire, the research data or available fire models or analytical tools are insufficient to predict, with any accuracy, the potential and rate of growth (which may be linear, logarithmic, or exponential profiles) for the pyrolysis of material to provide a quantitative reasonable bounding characterization of the fire development and timeline between the start (preheating) and the end (transition to self-sustained combustion) of an incipient fire. There is no readily available means to predict whether an incipient fire would transition to a flaming fire that is short or long in duration and when there would be sufficient aerosol or particulates generated in sizes and concentrations to actuate the established minimum threshold for a VEWFDS alert or alarm. For this reason, additional methods are used to determine the time necessary to detect the fire (actuation of a site-specific VEWFDS) and to determine the subsequent available time during the incipient stage of a fire in a specific electrical enclosure for the operator to complete prerequisite actions that de-energize or manually suppress an incipient fire inside an electric enclosure.

Current available guidance and research, such as experiments performed for NUREG-2180, Section 4, "Experimental Approach," and available fire models or analytical tools would not inform or provide a means of assessing specific fire scenarios to support the considerations of preempting incipient fires to support the plant-specific FPRA. The confirmatory research performed for developing the method in NUREG-2180 did not attempt to achieve a flaming combustion transition as a test end point, which was not necessary to provide a relative comparison between detector technologies. In examining the NPP in-cabinet or area wide applications of the VEWFDS, there is no technical information and no consensus opinion for characterizing the duration and the failure mechanisms of a challenging incipient fire scenario.

De-energization of Electrical Components for Preempting Incipient Fires

An assessment is conducted to determine whether the de-energizing affected component, if the strategy is not sufficiently precise to de-energize only the specific affected component that is the source of the incipient fire, could potentially lead to a loss of safety functions of more than the affected component. This condition could cause unintended outcomes that result in the loss of the entire electrical cabinet (i.e., the damage end states described in NUREG-2180), and the de-energizing equipment strategy would not preempt electrical component failures. Similarly, if the critical electrical component is the source of the incipient fire or if de-energizing affects only the electrical component that is the source of the incipient fire (i.e., affecting other components to perform their intended safety functions), the result is a loss of availability or reliability of the component's intended safety functions. In addition, for a de-energizing strategy (whether it is through manual operator actions or an engineered means of automatic de-energization) to be effective, a thorough and complete circuit analysis of as-built electronic systems and components must support the de-energizing of the specific component (or components) within the electrical enclosure before it would be feasible in achieving preemption (i.e., preventing propagation of an incipient fire to a fully developed fire) of a fire within the electrical enclosure. In addition, the de-energizing of the electrical system, subsystem, or component in itself would lead to the loss of safety functions of the systems or components, or both, and result in the end state of cabinet damage. The NUREG-2180 discusses preempting the fire inside the electrical enclosure using a strategy to de-energize electrical equipment by operators responding to VEWFDS alerts and alarms, but the strategy is not modeled generically because it is highly plant specific.

The confirmatory research and results captured in NUREG-2180, Section 5, "Experimental Results," and Section 5.9, "Evaluation of Test Results," address conceivable particle evolution scenarios that are intended to reasonably represent incipient fires for assessing the performance of various detectors to perform detection functions under experimental conditions. The confirmatory research acknowledges uncertainties and limitations of experiments to capture the most likely scenarios, along with the worst-case scenarios, that may occur. However, the durations of incipient fires for electronic components are difficult to quantify with any certainty, because the phenomena that affect the duration of the incipient stage may vary with the types of components and failure modes and thus prevent precise characterization. NUREG-2180, Section 8.2, "Estimating the Duration of Time Available for Operators To Respond," points out uncertainties in the research data on whether the incipient fire rate of growth could be potentially logarithmic or exponential or anything in between but not linear rate in growth. As a result, no reasonable method presently exists to predict the time duration from when an electrical component begins to degrade and the degrading component generates smoke to when flaming combustion commences. Therefore, a significant gap in data on the phenomena of incipient fires in general and data specific to electrical components and the absence of fire models or analytical tools for reasonably predicting the development of an incipient fire from its initiation to sustained flaming combustion do not permit the determination, with any certainty, of whether there is sufficient time from the point of detection of a fire to provide operators with the opportunity to respond and perform the necessary manual fire suppression actions to preempt incipient fires. The Panel member notes that the rate at which the incipient fire develops to a flaming fire is a significant determinant of whether operators have sufficient opportunity to complete manual fire suppression actions (e.g., completion of necessary tasks such as identifying the location of the fire and opening closed electrical panel) to interrupt the progression of a fire.

In addition, any considerations of specific VEWFDS applications for preempting incipient fire within an electrical enclosure must include the design of the VEWFDS to provide the capability of detecting the specific location of the source of incipient fire. Such a design must be in accordance with NFPA 72 and NFPA 76, listed and approved by an independent laboratory, and meet manufacturing requirements. NUREG-2180 does not sufficiently address the specific VEWFDS design necessary for ensuring the reliability and availability of the system to perform its intended detection function of providing the precise location of the source of the incipient fire and applying automatic fire suppression to a specific electronic enclosure. In addition, NUREG-2180 does not address interfacing the VEWFDS alarms with electrical systems to de-energize components based on the detailed mapping of as-built electrical circuits.

Maximum Time Available for Suppression and Resulting Risk Reduction Credit

The DPO submitter suggests that "the maximum CDF reduction factor crediting both pre-emption and extra time available for suppression is approximately 5, rather than a factor of 10 or more." This assumes that the non-suppression probability for an operator responding to an alarm fails to promptly suppress the fire quick enough to prevent damage to targets outside of the fire-originating electrical enclosure and suggests that use of the non-suppression probability established for electrical cabinet fires should be considered.

The application of the method, along with the assumptions and limitations listed in Table 12-2, "Case 1 Results—Probability of Non-Suppression," in NUREG-2180, shows reduction factors (i.e., inverse of probability of non-suppression) of between 4.6 to 9.4 for the VEWFDS and 4.9 and 5.9 for a conventional smoke detection system for in-cabinet detection. The case study shows that applying the methods in NUREG-2180 gives reduction factors ranging up to 10 (for a cloud chamber) and reduction factors of 4.6 and 6.6 (laser smoke obscurations) for the VEWFDS, which is not very different from the factor of 5 suggested by the DPO submitter using an alternate approach. The application of the method described in NUREG-2180 suggests that its application of FAQ 08-0046 would be overly optimistic.

The NUREG-2180, Section 10.4.2.2, "Determining Time Available for Operator Response in VEWFD Applications," uses cumulative probability distributions based on four detectors investigated in the confirmatory research, accounting for the uncertainty nature of the data available on the incipient stage of the fire. Using both the time-required information (developed in NUREG-2180, Section 10.4.3, "Time Required for All Operator Actions,") and the cumulative probability distributions, the duration of the time available is 30 minutes, which is approximately the maximum amount of time for the field operator to be positioned for immediate fire suppression. Previously established methods for assessing VEWFDS applications also establish available time for suppression (e.g., NUREG/CR-6850 (EPRI TR 1011989)), assume that the incipient stage has a duration of 5 minutes, and adds that duration to the time available for fire suppression. The EPRI TR 1016735 assumes that alarms will indicate incipient conditions approximately 1 hour or more before ignition occurs but adds 15 minutes of suppression time. The FAQ 08-046 recommended value assumes that the VEWFDS provides at least 1 hour of warning before the actual outbreak of an open flaming fire.

The assessments of VEWFDS applications for fire detection in electrical enclosures with installation of an in-cabinet VEWFDS for the plant-specific FPRA can affect the sequence of events for fire initiated from

low-voltage electrical components in electrical enclosure. However, the time available for manual fire suppression is scenario specific and is dependent on the fire growth inside the electrical enclosure. The potential and rate of heat release of combustible material, as-found configurations of combustible material, physical configuration of the electrical enclosure, air flow, and proximity of target equipment and components are all contributing factors on whether a bounding operator response time is less than the time to the damage of targets adjacent to the fire-originating electrical enclosure. NUREG-2178 provides the latest guidance using an event tree for modeling detection system and operator manual action response to electrical enclosure fires, which can be informed with enhanced characterization of heat release rates and research on fire plume temperature profiles generated for obstructed plumes inside electrical enclosures.

The fire inside the electrical enclosure and the subsequent fire propagation to the ignition of combustible nearby or the thermal exposure to critical target equipment and components, or both, can be modeled with reasonable certainty using readily available fire models and analytical tools. The fire modeling provides quantified information that can be applied in assessing the time available for operators to perform the prerequisite actions of manual fire suppression. The time available for operators to complete the prerequisite tasks (e.g., locate the source of the fire and the affected cabinet, access to cabinet) and perform the tasks for manual fire suppression is bounded by the time for fire development and progression to conditions that result in damage to critical target equipment and components. The modeling of specific fire scenarios should be used to determine whether there is sufficient time to implement

the operator's response for fire suppression (e.g., enhanced or conventional, or both). The time available for fire suppression is bounded (i.e., cannot be greater than) by the time for the fire (unmitigated) to completely burn out (i.e., progress through stages of fire growth, steady state, and decay).

The maximum reduction from the non-suppression probability and time suppression should be informed through fire modeling of specific scenarios. This reduction must be less than the time to the damage of critical targets and components, which is quantified through modeling both the fire inside electrical enclosure and the propagation of the fire as it damages nearby critical target equipment and components in adjacent enclosures or in the room. Regardless of the methods applied, the modeling of the specific fire scenario should provide and confirm that sufficient time is available after detection of the incipient fire for operators to perform the required tasks necessary for manual fire suppression.

2.2.3 Findings and Conclusions

The DPO Panel member additionally finds and concludes the following:

- The time available for suppression cannot be greater than the time from the self-sustained combustion stage to the decay stage of a fire and would be consider as the maximum time for suppression in determining the appropriate probability of the non-suppression of fire for the FPRA. The fire modeling of the sustained combustion stage of a fire inside the electrical enclosure after early detection (alerts and alarms from an incipient fire) and of the fire propagation to outside the fire-initiating electrical enclosure provides the upper limit to the time available for fire suppression. The time when the fire damages adjacent targets minus the plant-specific bounding required operator response time to the VEWFDS alert or alarm and the time to complete the prerequisite tasks of identifying the originating location of the fire provides the time available for suppression of the electrical enclosure fire from causing damage to nearby critical target equipment or components (i.e., within the zone of influence quantified by available fire modes and analytical tools).

- The maximum reduction factor (e.g., approximately 5, 10, or other values) affects the progression of the modeled specific fire scenario that informs the FPRA. The time available for the operators to suppress a fire in the fire-originating electrical enclosure from propagating to adjacent targets should be based on the fire modeling of the specific fire scenario.

- Crediting preemption or extra time available (e.g., enhanced manual fire suppression from VEWFDS application) for operator actions to interrupt or mitigate incipient fir cannot be established with any certainty because of a lack of knowledge on characterizing incipient fires. Fire modeling of a specific fire scenario, including the detection time, does not support or quantify specific times available for operators to respond an incipient fire and perform the necessary manual fire suppression actions. The assumption of preemption or extra available time is not justified for increased credit for reducing fire risk.

- The modeling of a fire within the electrical enclosure and the fire propagation to adjacent targets provides a quantitative timeline for a specific fire scenario. This timeline should be relied upon to inform and confirm the likelihood of operators being able to perform actions for

manual fire suppression after detection (alerts and alarm from the VEWFDS), including whether the main control room (MCR_ non-suppression probability, the electrical non-suppression probability, the NUREG-2180 new electrical non-suppression probability, or any non-suppression probability should be applied for a specific fire scenario.

- The qualitative assignment of a maximum reduction factor for the use of the VEWFDS in NPP applications may not be justified as a reasonably conservative approach for the assessment of fires involving low-voltage equipment or components in electrical enclosures. However, a method may incorporate a maximum reduction factor where detailed fire modeling supports the use of the appropriate fire-growth rate (see Figure 2-2) after the incipient stage of the fire inside the specific electrical enclosure and the time to the damage of critical targets and components outside the electrical enclosure is bounding of a maximum reduction that is appropriate and reasonable for site-specific operator actions for fire suppression. The specifics of how a fire will develop within the electrical enclosure and propagate to the adjacent targets nearby before it damages critical targets determine whether there is sufficient time available for the opportunity to perform operator actions for fire suppression.

- The accurate, complete, and realistic modeling of the relatively new VEWFDS applications at U.S. commercial NNPs is required for characterizing the potential risk profiles of fire scenarios that account for plant-specific conditions for input to the plant-specific FPRA. Caution must be applied in crediting beyond a reduction factor of 10, and any presumptions of a reduction factor should be confirmed and informed by the modeling of specific fire scenario and considerations of plant-specific conditions. The assumption that a maximum reduction factor is generically established may not be appropriate for cases in which the modeling of a specific fire scenario shows evidence that time availability is less than the required response time for operator actions or in which the time is not sufficient to enable the operator to complete required tasks necessary for performing and completing manual fire suppression. In these scenarios, a maximum factor of 10 or some other value is not appropriate.

2.2.4 Recommendations

The DPO Panel member additionally recommends the following:

- The specifics of how a fire will develop within the electrical cabinet and propagate to the adjacent targets nearby (before critical targets incur damage) should be applied in the assessment of whether there is sufficient time available for operators to perform the required actions for manual fire suppression.

- The accurate, complete, and realistic modeling of the relatively new VEWFDS applications at U.S. commercial NPPs is required for adequately characterizing the potential risk profiles of fire scenarios that account for site-specific conditions for the input to the FPRA. Caution should be applied in crediting beyond a reduction factor of 10, and any presumptions of credit should be confirmed and informed by the modeling of specific fire scenarios and consideration of plant-specific conditions.

- Neither the method in NUREG-2180 nor other methods considered or proposed to date should be applied for consideration of preempting an incipient fire within an electrical enclosure. Current data and research do not sufficiently provide assurance that the incipient fire growth rate and duration can be accurately predicated because adequate fire models or analytical tools are not readily available to characterize, with certainty, the progression of the preheating, pyrolysis, and smoldering of a fire in its incipient stage.

2.3 Summary of Concern 1.a

The summary of this concern is as follows:

> *Licensees should not use the FAQ 08-0046 and the NUREG-2180 methodology, specifically the event tree approach in NUREG-2180, Section 6, used to estimate non-suppression probability and the HRA in NUREG-2180, Section 10, to support the Chapter 6 event trees, as a modeling approach for the enhanced fire suppression (with an additional unquantified option for preemption) provided by a VEWFDS. This approach results in overly optimistic results. The DPO submitter recommends an alternate approach using data from NUREG-2180 that account for preemption and enhanced fire suppression*.

2.3.1 Background

The Panel member reviewed the material provided by the DPO submitter (i.e., the alternate approach) and had discussions with the DPO submitter, the authors of NUREG-2180, and other staff members involved in this technical issue. Based on the information gather, the modeling of the effectiveness of the VEWFDS and the potential risk reduction is clearly a complex topic with various methods of assessment, and the NRC staff had expanded significant efforts to evaluate and establish an acceptable methodology, including conducting system testing and evaluating applicable operating experience.

The industry approach, EPRI TR 1016735, addresses crediting the VEWFDS for PRA quantification. The industry approach uses an event tree to model the factor that could affect the effectiveness of the VEWFDS and operator actions to mitigate postulated fires. The event tree considers the effectiveness of plant systems and components that would be covered, the detection reliability and availability, and operator response for manual suppression and preemptive actions in limiting an incipient fire for the application of the VEWFDS.

The NEI NFPA 805 Task Force proposed FAQ 08-0046 to address VEWFDSs for FPRAs because EPRI TR 1011969 (NUREG/CR-6850) was not determined to be insufficient to consider VEWFDS on fire suppression. The EPRI published interim report EPRI TR 1016734, “Fire PRA Methods Enhancements (Additions, Clarifications, and Refinements to EPRI 10111969,” in December 2008. The NRC staff revised the event tree for an improved assessment of the VEWFDS for fire suppression. The NRC staff acknowledged that data from which the various factors can be derived and the EPRI data on duration or probability of the incipient fire were limited. The revision included considerations of additional factors where electrical components may fail quickly and not permit credit for incipient detection, duration of component degradation time to allow for a higher success potential of operator actions to mitigate or prevent fire, and human response. In June 2004, the NRC issued a draft interim position on the FAQ 08-0046 that revised the fire event tree to address the uncertainties through conditions applied to

(1) fraction of fires that has an incipient stage detection by VEWFDS, (2) detection system availability and reliability, (3) successful operator response, (4) technician response necessary for successfully preventing an incipient fire, and (5) successful fire suppression. In November 2009, the NRC issued a closed-out FAQ 08-0046 as a final interim staff position, acknowledging limited empirical data, operating experience, and vastly different views on system performances and suitable application in FPRAs. The NUREG/CR-6850, Supplement 1, incorporates the staff's interim position on a method for VEWFDS application.

The NUREG-2180 documents the assessment of the applications of smoke detection systems in NPP applications. The results are based on a confirmatory research program to evaluate the effectiveness and performance of the systems, operator responses (human factor and reliability), reliability and availability of the systems, detection systems' response to combustion products, physical and environmental effects on system responses, and design configurations. The confirmatory research supports a method applied for FPRAs and provides a technical basis and an approach for updating the interim accepted method described in FAQ 08-0046. NUREG-2180 did not propose a different method from using event trees; instead, it further enhanced the assessment with the results of the confirmatory research and consideration of the human factor and reliability analysis of operator responses.

2.3.2 Discussion and Evaluation

The FAQ 08-0046 and the NUREG-2180 methodology, specifically the event tree approach in NUREG-2180, Chapter 6, used to estimate non-suppression probability and the HRA developed in NUREG-2180, Chapter 10, in support of the Chapter 6 event trees, should not be used as a modeling approach for the enhanced suppression (with an additional unquantified option for preemption) provided by VEWFDS. This approach results in overly optimistic results.

The use of event tree is an accepted method to systematically assess hazards and risks. The method is an inductive analysis to assess the chronological sequences of events and system interactions, with considerations of time that are important in defining the progression of systems responses for fire-initiated events. The application of the event tree approach, from the industry-proposed method and the staff's final interim method in FAQ 08-0046 and NUREG-2180 to the method initially captured in EPRI TR 1016735, determine important aspects of system reliability, evaluations of sensitivity and assumptions, and identification of systems features and interfaces to model the sequences of events from the detection of a fire to the suppression systems (operator actions, engineered systems, or a combination) for the FPRA. The NUREG-2180, Section 6, estimates non-suppression probability, and NUREG-2180, Section 10, addresses HRA, which supports top events and provides a method for modeling of sequences of events where VEWFDSs are installed for fire detection and may be credited for initiating operator actions for manual fire suppression.

The HRA is the quantification of the likelihood of human errors, which can potentially contribute to the success or failure of the sequence of the events analyzed for fire scenarios that involve the crediting of VEWFDSs. The considerations of human failure events (e.g., preinitiator failures, such as adequate procedures, training, and equipment and human-induced initiated failure; alarm assessment/response and post-initiator failure, such as manual response; omission, commission, and cognition errors; and task analysis that considers performance shaping factors on error probabilities). The application in

NUREG-2180, Chapter 6, provides a method of analyzing the sequences of events to assess fire hazards and consequences in estimating success or failure (i.e., the operator's non-suppression probability). The HRA described in NUREG-2180, Chapter 10, addresses the reliability and availability of operator response parameters and conditions after the detection of a fire inside an electrical enclosure

and the manual suppression in support of the NUREG-2180, Chapter 6, and Event Trees. The overarching guidance provided for HRA is for a reference plant and the requirement that all conditions must be met for operator responses to fire suppression.

The NUREG-2180 provides the latest developed event tree for assessing VEWFDS applications for fire detection and operator actions for the FPRA, using additional information from confirmatory research. The confirmatory research and analysis included testing, the evaluation of previous data sources, human factor and reliability analysis, and the quantification of pathways (success/failures) and probability input to inform the assessment of postulate fires. The method using event trees in NUREG-2180 represents iterations of review, including stakeholder input, to characterize the physical responses to detect and suppress fires. The NUREG-2180 addresses the application of VEWFDS and conventional detection systems and the importance of detection (i.e., detection failure means no response and no fire suppression) in the sequences of events and addresses the need for adequately designed systems in accordance with NFPA 72 and NFPA 76 to ensure the availability and reliability of the detection system to perform its intended functions.

The event tree is one method that is acceptable and well suited for evaluating integrated engineered systems and operator responses that are critical to developing sequences of events as a function of time to model the various pathways for the progression of fire from the incipient stage to the fully developed and decay stages. This approach (i.e., event tree) provides results that are overly optimistic if the inputs and assumptions are overly optimistic, do not represent reasonably accurate plant-specific conditions, or account for uncertainties. As with any method applied for assessing potential hazards and consequences, the input parameters analyzed should be accurate and complete; should be supported by a sound technical basis; and, when necessary, should conservatively account for uncertainties. This overarching guidance applies to any modeling of specific fire scenario events using event trees, including modeling that quantifies fire development as a function of time. The use of event trees to characterize and assess accident sequences for the fire response of the VEWFDS and subsequent operator actions for the detection of an electrical enclosure fire in NPPs is a reasonable and an acceptable method and application for FPRAs.

The DPO submitter recommends an alternate approach using data from NUREG-2180 that accounts for preemption and enhanced fire suppression.

The NUREG-2180 provides one method that, if all limitations and conditions are met, is acceptable for assessing the applications of VEWFDSs to initiate operator responses for fire suppression and is a means of assessing the success or failure of preventing the fire from propagating in the post-incipient stage from the initiating cabinet to adjacent targets. Other methods or approaches, such as that proposed in EPRI TR 1016735 “holistic approach,” which is based on an analysis of available test results of early detection systems, qualitative considerations of effect on fire ignition frequencies and non-suppression probability, or simplified event trees (i.e., as described in the report titled, “Credit for Very Early Warning Fire Detection in Fire Probabilistic Risk Assessment,” produced by the DPO submitter and NRC staff), may be applied in the assessment for the plant-specific FPRA and overall risk reduction. The Panel member noted that before the NRC developed NUREG-2180, methods, including alternate approaches (i.e., the DPO submitter’s approach), did not include the evaluations of the performance and effectiveness of the VEWFDS because they were pursued and examined during the research phase.

Because the use of the event tree is an acceptable systematic assessment of the sequences of events from detection to operator response as a function of time, the DPO Panel member determined that it was reasonable that the NRC staff pursued an improvement to the existing approach based on the event tree instead of pursuing a new method. Because of the rigor and systematic detail considerations of factors important to assessing the detection capabilities of the VEWEFDS and the possible resulting manual operator responses for fire suppression, the method described in NUREG-2180 is an improvement over the FAQ 08-0046 method, with the acknowledgement that there is continued limited operating experience with these systems in the manner in which they are now installed in NPPs and are being credited for risk reduction. The application of the method (the updated event tree) described in NUREG-2180 provides the necessary corrections to the factor of credit to a much less (e.g., 7–10) factor provided after applying the method described in FAQ 08-0046 (e.g., 50 or greater). The NUREG-2180 documents the event tree (with the appropriate assumptions and limitations) used to model the applications of VEWFDSs and the resulting operator responses as the method that licensees and applicants should use as a tool to model plant-specific electrical enclosure fires for FPRAs.

The DPO indicates the significance of the potential credible value of the relatively new VEWFDS application at U.S. commercial NPPs to their FPRAs. The Panel member agrees with the DPO submitter that cautions must be applied to reduction factors from the applications of VEWFDSs for detection functions and the resulting operator fire suppression responses. Any presumptions of credit should be confirmed and informed by the modeling of specific fire scenarios and consideration of plant-specific conditions. Regardless of the methods applied, the modeling of the specific fire scenario should provide and confirm that sufficient time is available post-incipient fire for appropriate operator to respond and perform tasks necessary for successful manual fire suppression.

2.3.3 Findings and Conclusions

The DPO Panel member additionally finds and concludes the following:

- The use of event trees to quantitatively assess detection and operator responses for manual fire suppression applies an acceptable tool for systematically assessing and analyzing a plant's response to fire-initiating events.

- The event tree approach currently described in NUREG-2180 has evolved from the initial event tree proposed in 2008 in FAQ 08-0046 for assessing VEWFDS applications for early detection and operator response for fire risk at NPPs. The improvement of the event tree method has been informed to the extent practical by confirmatory research and has been subject to extensive review and stakeholder input. The resulting event tree, as defined in NUREG-2180, Section 6, and the consideration of HRA in assessing operator manual responses are improvements that provide a tool for the reasonable assessment of VEWFDS applications in NPPs.

- Neither the NUREG-2180 method or the method or approach considered by the DPO submitter can be readily applied for preempting an incipient fire within an electrical enclosure because current data and research do not sufficiently provide assurance, with any certainty, of how incipient fire growth potential and rates can be predicated or characterized for the time available for performing manual fire suppression before the fire transitions to self-sustained combustion—the growth stage of a fire in the electrical enclosure.

- The NUREG-2180 method does not restrict a licensee or an applicant from using other alternative approaches, including the approach described by the DPO submitter, to assess the applications of VEWFDSs for detection functions and operator responses for fire suppression for the plant-specific FPRA.

2.3.4 Recommendations

The Panel member additionally recommends the following:

- The application of the NUREG-2180 methodology using event trees to assess VEWFDS applications and subsequent fire suppression actions for FPRAs by licensees or applicants must adhere to all guidance, conditions, assumptions, and limitations as described. The method described and illustrated should not be applied as a method for addressing the preemption of incipient fire.

- The method established by the NRC in NUREG-2180 does not preclude licensees or applicants from applying other approaches, including the method recommended by the DPO submitter, for assessing the application of VEWFDS for detection functions and subsequent fire suppression or mitigation actions for the FPRA. The NRC staff should review any alternative method used with the appropriate rigor to confirm that the supporting technical basis and rationales for the assumptions and input to the risk model are representative of the fire hazards, systems, responses, and site-specific conditions for realistic FPRAs.

2.4 Summary of Concern No. 1.b

The summary of concern is as follows:

> *If the NUREG-2180 methodology is used for VEWFDS enhanced suppression modeling, the original welding/cutting non-suppression curve from NUREG/CR-6850 or the "new" electrical fire non-suppression curve developed for the presence of responders in NUREG-2180 is the maximum creditable that should be used. The MCR non-suppression curve should not be used for plant fires.*

2.4.1 Background

The NUREG-2180, Section 6, discusses the application of non-suppression probabilities, including electrical, MCR, welding/cutting, and "new" electrical non-suppression probabilities. The selection of which non-suppression probability to use is subject to judgment regarding applicability. The MCR non-suppression probability provides the most optimistic results for the outcome of the analysis when compared to the use of any of the other non-suppression probabilities. For the approach described, the sensitivity analyses in NUREG-2180, Section 12, "Quantification of Smoke Detection Performance," show that the variations of non-suppression probabilities would have a minor effect when compared to other parameters, such as the fraction of fires that have an incipient stage.

The NUREG-2180, Section 6.4, "Event Trees and Definitions of Event Headings," develops an event tree (Figure 6-4) that estimates the sequence of events for operator non-suppression probability based on the application of VEWFDSs installed inside of electrical enclosures for smoke detection. The second

event tree (NUREG-2180, Figure 6-5) represents the non-suppression probability for VEWFDSs installed in a room of electrical enclosures for area wide applications. The event trees presented in NUREG-2180, Figures 6-4 and 6-5, provide a structure to estimate the nonelectrical cabinet ignition sources. The NUREG-2180, Figure 6-6, shows how the event tree could be modified to credit a de-energization strategy. However, the use of the de-energization event tree requires scenario-specific information and, for this reason, cannot be performed under a generic approach. For this reason, the human error probabilities developed in NUREG-2180, Section 10, do not apply to the de-energization event tree.

The non-suppression probability event trees (Figures 6-4 and 6-5) have two end states: (1) cabinet damage and (2) fire damage outside the cabinet. The cabinet damage end state assumes that damage is not limited to the initiating component and that other components within the cabinet are damaged. The suppression activities, regardless of their form, are also assumed to damage the ability of components located within a cabinet to perform their intended design functions. Fire damage outside the cabinet assumes that damage could not be limited to the initiating cabinet and that target sets outside of the initiating cabinet may be damaged.

The basic events include estimations of fire phenomena, detector performance, human performance measures, and operator response for fire suppression. The basis for the development of these estimates is provided in the subsections of NUREG-2180. The detection of fire depends on detector system availability (see NUREG-2180, Section 7.2, "System Performance Measures (Availability, Reliability, and Effectiveness)"). The fraction of fires that has an incipient stage separates events that exhibit rapidly developing fires from those that exhibit longer incipient stages (see NUREG-2180, Section 7.1, "Fraction of Fires That Have an Incipient Stage"). The NUREG-2180, Section 7.2, discusses the effectiveness of the system's ability to detect low-energy (preflaming) fires for a specific installed application. The NUREG-2180, Section 10.6, "HRA Quantification," discusses the detection system's probability of effectively detecting a low-energy fire in its incipient stage, the "MCR Response" event to fire-detection system alarms, and initiation of the required operator responses and actions, including the posting of a fire watch. The enhanced suppression event represents the probability that any potential fire is suppressed before the fire can damage targets of concern (see NUREG-2180, Section 11.1, "Enhanced Fire Suppression"). The last event, "Conventional Detection/Suppression," estimates additional plant operator (such as the fire brigade) response to the probability of successfully suppressing a fire based on the failure of one of the earlier events (see NUREG-2180, Section 11.2, "Conventional Fire Suppression").

2.4.2 Discussion and Evaluation

If the NUREG-2180 methodology is used for VEWFDS enhanced suppression modeling, the original welding/cutting non-suppression curve from NUREG/CR-6850 or the "new" electrical fire non-suppression curve developed for the presence of responders in NUREG-2180 is the maximum creditable that should be used. The MCR non-suppression curve should not be used for plant fires.

NUREG-2180, Section 11.1, describes how the suppression events are modeled and states that the fire suppression time is estimated as follows:

The current approach takes credit for the fire suppression capability. This approach assumes appropriately trained personnel remain in place until the problem has been resolved. Success in this approach is ultimately judged based on the ability to suppress the fire rather than prevent it. So long as the fire is prevented from growing significantly, the adverse consequences related to a large cabinet fire, and the associated fire growth because of secondary combustibles, are prevented. Estimation of both the enhanced and conventional non-suppression probabilities necessitates the estimation of the

manual suppression time. This quantity is estimated as described in Supplement 1 to NUREG/CR-6850 (see Section 14 *Manual Non-suppression probability)*. Mathematically, the manual suppression time is estimated as:

$$T_{ms} = t_{damage} - t_{det}$$

where: t_{ms}*: time for manual suppression*

t_{damage}*: time to target damage*

t_{det}*: time to detection*

The discussion states that "the time to damage (t_{damage}) is based on scenario-specific information and fire modeling. For quantification of VEWFDS performance, the time to detection (t_{det}) should be assumed to be 0 minutes. No time should be added to the time to target damage (t_{damage}) or subtracted from the time to detection (t_{det}) to represent the advanced warning provided by the VEWFDS (detection during the incipient stage). The event tree parameters "α" and "ξ" along with the use of different manual non-suppression probabilities, as explained below, support quantification based on the performance of the VEWFDS. Adjusting the manual suppression time to account for an incipient stage time would be non-conservative and inconsistent with the method described in this report. Thus, NUREG/CR-6850 states that, "no incipient stage duration is included in the time to damage estimate due to its uncertainty in duration and that it is not expected to generate thermal conditions that threaten the integrity of other targets in the room (emphasis added)." The approach further cautions that, "if a licensee desires to obtain more credit in this process, a more detailed evaluation of de-energization strategies, including adequate and appropriate justification in the form of a detailed human reliability analysis must be performed."

The discussions for using MCR non-suppression probability (λ = 0.324) for VEWFDSs installed in electrical enclosures and for using the electrical cabinet fire non-suppression probability (λ = 0.194) for VEWFDSs installed in an area wide room application are as follows:

The "π1" factor is applicable for the in-cabinet event tree (see Figure 6-4) and represents the probability that, given **success** of the technician/field operator to respond to the VEWFD "alert," suppression has failed to limit the fire damage to the enclosure of origin. The field operator in the area of the cabinet responsible for the VEWFD system alert fails to promptly suppress the fire quickly enough to prevent damage to PRA targets outside the cabinet. The MCR curve **(λ = 0.324)** should be used for this case. This is considered to be reasonable representation given that the field operator, a trained responder, will be near the bank of cabinets where the VEWFD system alert was initiated, actively searching for the source location of the alert.

The "π2" factor is applicable for the area-wide event tree and represents the probability that, given **success** of the technician/field operator in the room responsible for the VEWFD system alert, suppression activities fail to prevent damage to PRA targets outside the cabinet. This branch path takes into account that the field operator has arrived at the room causing the VEWFD system alert, but was unable to locate the source of the condition causing the VEWFD system "alert" before the low-energy (incipient) fire progresses to a flaming condition. A newly developed non-suppression probability curve should be used with **λ = 0.194**. This value is based

upon an analysis of fire events from the Updated Fire Events Database (Ref. 63). All fires in electrical cabinets were sampled for occurrences in which personnel were present in the room of origin when a flaming condition began. The approximation for the non-suppression value to be used was then evaluated against the MCR suppression curve. Differences between the MCR and newly developed curve were sufficient to warrant a new suppression curve for this application. This is considered to be reasonable representation given that the field operator, a trained responder, will be in the room where the VEWFDS alert was initiated, actively searching for the source location of the alert.

The probability that the fire brigade or other first responders will fail to suppress the fire [Pr(Tsupp ≥ t)] is estimated with suppression probability curves developed using the suppression time data reported in Fire Effects Data Base. In EPRI 3002002936 (NUREG-2169), new non-suppression probability estimates are provided. These new estimates are used in Section 12, "Illustrative Examples." These curves were developed using U.S. Fire Event Experience through 2009 where manual suppression was involved and suppression time information was available. Suppression time was defined as the time the fire was extinguished or the time the fire was reported to have been under control by the fire brigade on scene (Ref. 45). Events, including self-extinguished fires, supervised burnouts, and fires extinguished with automatic fire suppression systems, were excluded from the curves. If the time from detection to suppression was not known, but the duration of the fire event from start to suppression was known, then the reported fire duration was used instead.

The "π" factor in the event tree represents the enhanced suppression probability. The "π" factor differs between the two event trees (in-cabinet (π 1) and area wide (π 2)). The assumptions leading up to enhanced fire suppressions are all previous sequences of successful events (i.e., VEWFDS availability, reliability, and effectiveness (β); the fraction of fires that has an incipient stage of sufficient duration (α); the system's effectiveness at detecting the incipient stage (τ); the MCR response (μ); and the field operator and technician response (ξ)).

NUREG-2180, Section 11.1, discusses the following non-suppression probabilities:

The mathematical model to derive Pr(Tsupp ≥ t) is described in NUREG/CR-6850 as follows:

The data for analysis consists of reported fire durations in commercial U.S. NPPs. These times are treated as being generated by an underlying probabilistic model. The final output of interest is the suppression curve, which gives the probability that a fire lasts longer than a specified time. If T is the random variable describing when the fire is suppressed, and λ(t) is the rate at which the fire is suppressed (possibly time-dependent), this probability of non-suppression is given by:

$$Pr(T > t) = e^{\left(-\int_0^t \lambda(S)dS\right)}$$

In this equation, λ(t) is a function of the parameters of the probabilistic model chosen for T. The simplest model for T is the exponential distribution, whose probability density function is:

$$f(t) = \lambda e^{-\lambda t}$$

In this model, λ is estimated directly and is not a function of time, giving

$$Pr(T > t) = e^{-\lambda t}$$

The non-suppression probability is calculated using the above equation, usually selecting t as the time to target damage.

Table 5-1, "Material Identification Numbers Used in Laboratory—Small-Scale Tests," in NUREG-2169, "Nuclear Power Plant Fire Ignition Frequencies and Non-Suppression Probability Estimation Using the Updated Fire Event Database: United States Fire Event Experience Through 2009," issued January 2015, revises the mean rate of fire suppression (λ) for welding fires (0.107), electrical fires (0.098), and control room fires (0.324).

The event trees described in NUREG-2180 show that the most influential factor is the characterization of the fraction of fires that is assumed or expected to exhibit an incipient stage (denoted as the alpha (α) factor in the NUREG-2180 event trees). The sensitivity analysis in NUREG-2180, Section 12.2, "Evaluation of the Event Tree Sensitivity," supports the significance because the subsequent events of the event trees will not substantially change the initial value set forth by the alpha (α) factor. This factor is a significant difference between the FAQ 08-0046 and NUREG-2180 methods. The FAQ 08-0046 method assumed that all fires exhibited an incipient stage and could be detected with a VEWFDS to initiate operator manual responses to mitigate a fire. However, the research, including the analysis of operating experiences, to confirm the FAQ 08-0046 interim method showed that only a fraction of fires may exhibit an incipient fire stage; therefore, the VEWFDS can be effective only in some percentage of fire events.

The additional information from NUREG-2180 does not address the limited data on understanding the fire dynamics for the growth rates and durations of the incipient stage of fires, and the variability of conditions necessary for the occurrence of incipient fires are not known or cannot be predicted. These limitations affect the application of any method for quantifying the applications of VEWFDSs for detection functions and subsequent manual operator actions for the suppression of fires initiated inside electrical enclosures. The fire growth inside the electrical enclosure and the effectiveness of the detection system (VEWFDS or conventional smoke detection systems) determine whether operators have adequate time to response to manually mitigate fires inside electrical enclosures.

The NUREG-2180 describes the limitations of data available in the NPP fire-events database and generated the estimate for the alpha factor and lack of data, including the time estimates for the durations, for characterizing the incipient stage of fires. The event tree directly models the alpha factor as a branch point. The early detection of fire in the electrical enclosure is considered in the preceding event for the assessment of operator response and the HRA of operator actions. The NUREG-2180 method models enhanced suppression on the assumption that the operator effectively has the time from the beginning of flaming (T = 0) to the damage end state of interest (i.e., targets outside the electrical cabinet) to perform required actions, including responding to alarms from VEWFDS, initiating operator and technician response, locating the affected electrical cabinet, and performing manual fire suppression activities. The NUREG-2180 suggests the use of the MCR non-suppression probability for the VEWFDS that provides in-cabinet fire detection based on the assumption that the operators

(e.g., responders) are available and behave similar to operators in a continuously occupied space of the MCR.

The NUREG-2180 justifies the use of the MCR non-suppression probability, along with the basis for why the welding/cutting or electrical non-suppression probabilities would not appropriate in this application of the VEWFDS for the detection and alarm of electrical enclosure fires that initiate an enhanced operator response. The DPO raises a concern on use~~s~~ of the MCR non-suppression probability for a number of reasons. In particular, the nature (i.e., conditions) of the MCR fires is different from the nature of electrical enclosure fire cabinet fires in the plant. The DPO also identified that the use of the MCR non-suppression probability for fires outside the MCR could set a precedence in risk analysis.

The DPO Panel member notes that these were important points to consider in selecting the appropriate non-suppression probability to use in the analysis of operator actions. The DPO Panel also notes that the developed non-suppression probabilities do not exactly fit the application of the approach in NUREG-2180, or other methods, and that the application of the appropriate non-suppression probability must consider the site-specific conditions, the detection and assessment limitations in the design of the VEWFDS (or conventional detectors) before initiating operator response, and the plant-specific operator responses to fires in electrical enclosures.

In addition, the NUREG-2180 event tree contains a top-event identified as “Conventional Detection/Suppression” if the preceding event, “Enhanced Suppression,” fails. For the “Conventional Detection/Suppression” event, the operator non-suppression probability would be estimated using existing guidance, including those provided by the electrical, welding/cutting, MCR, or other non-suppression probabilities that may apply. The use of the non-suppression probability, such as that of the MCR non-suppression probability, in two top events in the event tree analysis (i.e., first to estimate the enhanced non-suppression probability and then to estimate the conventional non-suppression probability) is the “double counting,” or crediting, of the MCR non-suppression probability for manual suppression. Recognizing that these are two distinct non-suppression efforts that are being modeled, the two may not be independent of one another, and the use of the MCR non-suppression probability for the second event is not appropriate to reflect the sequence of events that accounts for a second operator response. NUREG-2180 does not discuss the use of the MCR non-suppression probability for the “Conventional Detection/Suppression”; it may not be deemed appropriate.

The NUREG-2180 method for assessing the application of VEWFDSs for fire detection and the subsequent application of the MCR non-suppression probability for operator action is based on the assumption that “the field operator, a trained responder, will be near the bank of cabinets where the VEWFD system alert was initiated, actively searching for the source location of the alert.” This basis is reasonable and may apply to VEWFDS in-cabinets that are designed to provide the specific location of the electrical enclosure of fire origin and to plant-specific conditions that reasonably represent the MCR (e.g., floor area and configurations of electrical enclosures that are typical of the MCR to enable operators to successfully identify the electrical enclosure of fire origin) to enable operators to detect and perform manual suppression of the fire in electrical enclosures and to mitigate the propagation of fire to nearby critical targets.

In addition, specific fire scenarios in which a fast-developing fire occurs within the originating electrical enclosure or the VEWFDS is not effective in detecting the low-energy fire in its incipient stage could result in failure of the in-cabinet VEWFDS to provide sufficient early warning for operator response. The NUREG-2180 assumptions or basis that "the field operator, a trained responder, will be near the bank of cabinets where the VEWFD system alert was initiated, actively searching for the source location of the alert" would not be valid. Under such circumstances, the application of probabilities other than the MCR non-suppression probability may be appropriate (e.g., electrical fires, welding fires, newly developed non-suppression probability) for the specific fire scenario. These specific fire scenarios would not be representative of conditions similar to the presence of operators or conditions (i.e., number of operators and the size of the occupied area) in the MCR.

The time for operators to respond to a location indicated by the VEWFDS detection of abnormal conditions (alert or alarm) is unique. The maximum bounding time required for operator response must be less than the time for the progression of fire from within the electrical enclosure before it has begun or become sufficient in size to propagate sufficiently to cause damage to the critical targets nearby. The application of the MCR non-suppression probability for the success or failure of operator manual fire suppression must be supported and informed by modeling of the specific fire scenario that shows that operators are present in the area (i.e., occupied area) to perform manual fire suppression before the fire can propagate from within the fire-originating electrical enclosure to adjacent targets. This requires the modeling of the specific fire scenario to support and confirm that the time to the damage of adjacent targets is greater than the time required for operator responses and that time is available for operators to complete tasks necessary for manual fire suppression before the propagation of a fire that results in damage. For cases in which the modeling of the specific fire scenario shows that there is not sufficient time because of the rate of growth of the fire or the proximity of adjacent combustibles to the fire, or both, the MCR non-suppression probability value may not be appropriate. In this case, the assumption that an operator is present (i.e., occupied area) to locate and perform manual fire suppression would not be valid for such plant-specific conditions.

2.4.3 Findings and Conclusions

The DPO Panel member additional finds and concludes the following:

- The assessment needs to consider additional information to apply the MCR non-suppression probability, including whether the site-specific conditions are not sufficiently different from the conditions of the typical MCR relative to the size and number of occupants that would affect whether a fire in the electrical enclosure could propagate to an adjacent target without being observed. The ratio to the occupant per area should not be such that it no longer represents the typical MCR for which the MCR non-suppression probability was established (i.e., site-specific conditions are representative of the site conditions that the data represent).

- The modeling of the specific fire scenario (e.g., timeline for the progression of a fire) and the operator response timeline should be considered together to support the assumption that site-specific conditions for operator availability and the occupied area for fire suppression activities are similar to that of an MCR that applies the MCR non-suppression probability. Similarly, the application of operator fire suppression success or failure using the

welding/cutting non-suppression probability from NUREG/CR-6850 or another probability, such as the "new" electrical fire non-suppression probability, may be appropriate only where the modeling of the electrical enclosure fire supports the assumption that the maximum time required by the operator to respond and the plant-specific conditions represent the selected non-suppression probability.

- For plant-specific conditions in which fire modeling and specific operator responses do not support the use of the MCR non-suppression probability, other non-suppression probabilities may be justified to represent a fire that has damaged an electrical enclosure and that has the potential to propagate outside of the electrical enclosure.

2.4.4 Recommendations

The DPO Panel member additional recommends the following:

- The modeling of a specific fire scenario should be relied on to support and confirm whether the MCR non-suppression probability curve or other non-suppression probabilities (e.g., electrical, welding/cutting, "new" electrical fires) should be used.

- In modeling a specific fire scenario, if the time for a fire to damage an electrical enclosure and to propagate to adjacent targets is less than the time for operator response, the MCR non-suppression probability curve derived from operating experience data on fires in an MCR should not be used. Under these circumstances, the welding/cutting non-suppression curve from NUREG/CR-6850 or the "new" electrical fire non-suppression curve developed for the presence of responders in NUREG-2180 should be used.

2.5 Summary of Concern No. 1.c

The summary of concern is as follows:

> *The HRA approach in NUREG-2180, Chapter 10, used to estimate the field operator's response is overly optimistic. It assumes that a responder who is unable to preempt a fire would remain indefinitely at the electrical enclosure as a fire watch until a fire materialized. In reality, if the responder arrived before the fire manifested but was unable to preempt the fire, he or she would remain there only for a "reasonable" time period (perhaps on the order of 1 hour). If the fire did not materialize, the responder would reset the VEWFDS and abandon the location, and the entire "scenario" would begin again from scratch. Therefore, crediting the "new" electrical fire curve would be appropriate only within a limited time period for pre-emptable fires that were not pre-empted.*

2.5.1 Background

The HRA in NUREG-2180 assumed that the responder will remain in the area and be available to perform the tasks necessary to perform manual fire suppression. The assumption was based on plant procedures that require the responder to stay. The HRA documents the basis and assumptions for operator actions that, if implemented, will result in an operator fire suppression response that should be reliable

(i.e., trained and qualified operators will respond promptly to VEWFDS alarms and, once they are in the area of the fire alarm, will readily and reliably perform manual fire suppression activities).

Specifically, NUREG-2180, Section 10, provides a representative plant HRA quantification to support the assessment of VEWFDS applications using the event trees. The HRA applied existing HRA processes using a combination of those in NUREG-1921, "EPRI/NRC-RES Fire Human Reliability Analysis Guidelines, Final Report," issued July 2012, and in ATHEANA (A Technique for Human Event Analysis). In support of the event tree, the HRA quantification applies existing HRA methods and their associated human error probability for human failure events to address operator actions for assessing the success and failure of manual fire suppression of electrical enclosure fires. The operator "failure" in this analysis is fire damage outside of electrical cabinets (no enhanced fire suppression). Human failure events are identified using the analysis of human actions and the associated performance provided by the human factors analysis.

The HRA addresses the differences in the operator actions (MCR response, field operator response, and technician response) required for the basis event trees (in-cabinet and area wide installation of VEWFDSs) described in NUREG-2180, Section 6.4. The HRA considers timing an important criterion for each successful operator action; the operator actions must be feasible (i.e., sufficient time available for operator action as defined in NUREG-1921), and sufficient time necessary to complete actions can influence the reliability and, therefore, the failure probability of operator actions. NUREG-2180, Section 10.4, "Qualitative HRA," qualitatively analyzes the timing and input for event trees; NUREG-2180, Section 10.5, "Feasible Assessment," discusses the feasibility of an operator's action; and NUREG-2180, Section 10.6 discusses all factors (including timing) that are considered relevant to HRA quantification.

The HRA provided in NUREG-2180 is not for plant-specific installation of VEWFDSs and subsequent operator actions; instead, it is an analysis of a "representative plant" to the extent possible using real-world information that is consistent with good or best case operational practices and human factor analyses of tasks required for operator responses. The NUREG-2180, Section 10.4, indicates that the HRA for the "representative plant" is intended to represent a realistic yet fast response from MCR operators, field operators, and technicians. The NUREG-2180, Section 8, "Timing Analysis," states the following:

> The currently available timing information indicates that the time available for operator response (see Figure 8-4) can be quite short (i.e., 10 minutes or less), especially when compared to timing information regarding the time required for combined operator response, both in control room and ex-control room (see Section 10.4.3). Consequently, the qualitative analysis below also attempts to capture those factors that support a relatively fast operator response.

The HRA timing inputs developed present ranges of times that are either directly provided by plant personnel or are interpretations of more informal estimates, and the durations for the operator responses listed in Table 10-4, "Summary of Timing Inputs for Operator Actions after 'Alert' Signal," in NUREG-2180 represent the range of time estimates. Unlike traditional PRAs that use plant-specific calculations to determine the system time window, this analysis and any other similar analysis uses the timing information developed in NUREG-2180, Section 8. The HRA-specific timing inputs for a "representative plant" were developed from limited information collected through interviews with operations and fire protection personnel at NPPs that have installed VEWFDSs. NUREG-2180 indicates that the timing information from both NPPs and technician responses was not based on walk downs or demonstrations

and further states that the "HRA analysts who perform a similar analysis would need to collect their own plant-specific information for the time required for completing operator actions."

Because of limited operating experience with the application of VEWFDSs for the detection of fires inside electrical enclosures, plant operator responses, and the generic representative plant analysis in NUREG-2180, the HRA estimates cannot be considered representative of plant-specific conditions. However, a key assumption of the HRA in NUREG-2180 is that plant procedures and training must direct the immediate "drop everything" response and require the responder to remain at the location. The HRA is valid for a plant-specific operator response only if plant procedures and training are consistent with this key basis and assumptions indicated in the NUREG-2180.

2.5.2 Discussion and Evaluation

The HRA in NUREG-2180 supports a "representative plant" application of VEWFDSs for fire detection and operator responses for consideration in the FPRA. The objective of the HRA is to model operator actions—the success of which would result in successful fire suppression that would limit damage to the fire-originating electrical cabinet (i.e., cabinet is damaged) or the failure of which would result in fire damage to targets outside of the fire-originating electrical cabinet. Operator failure in the HRA is failure to provide early suppression, which leads to subsequent fire brigade actions to suppress the fire. The HRA is for a representative plant. For this reason, the analysis and results for operator actions are valid only if all the conditions, limitations, and assumptions discussed in NUREG-2180, Section 10, are met. The plant-specific application of VEWFDSs and operator actions would need a plant-specific HRA for identified operator actions (e.g., the MCR operators, a field operator, technician, fire brigade, and others) and the time available for operators to respond to actual plant-specific and as-built conditions, including the VEWFDS design for reliability and availability of detection functions and plant-specific procedures and training that support the implementation of the method describe in NUREG-2180.

The identified field operator actions in the HRA for a "representative plant" consists of principal activities of responding to the fire location, and, once at the location, the assumptions are that the operator will actively monitor the output from the incipient detector at a local panel that is present at the location and information provided by phone calls from MCR operators who are monitoring the incipient detector signal in the MCR and monitoring cabinets for any fire effects such as visible signs of smoke or burning smells. The principal activity also includes "stand at ready" to perform fire suppression at the first sign of a flaming condition inside any of the cabinets covered by the detector. The principal operator actions identified and considered are similar to the operator actions for being present and monitoring plant conditions in response to abnormal conditions (i.e., no obvious hazard is identified). The HRA approach or assumptions of required operator actions do not constitute actions beyond the normal response or required actions by operators beyond that of operators being trained and adhering to plant operating procedures (e.g., such as imposing a fire watch in a specific location of the plant).

However, where plant-specific conditions do not reflect the analyzed conditions, the expected operator response based on the HRA assumptions in NUREG-2180 for operator actions would not be realistic and could be overly optimistic. The plant-specific HRA should accurately reflect the collected plant-specific information on the times necessary for operators to complete required tasks and plant-specific conditions that affect the planned operator responses.

The assumptions that operators conduct operations in accordance with operating procedures and that they are trained accordingly is reasonable and is fundamental to the conduct of operations at NPPs. The basis and assumptions are reasonable for any safety and hazard analysis. If plant procedures state requirements for operator actions and if the basis and assumptions of the HRA described in NUREG-2180 is used, the operator responding to the fire alarm would be expected to stay within the area and essentially perform a fire watch, which is typical conduct for operator actions, but it is not extraordinary for plant operations. Operating procedures and training that require specific operator actions provide assurance of the required operator actions, including the operator remaining in the fire alarmed location to monitor the alarmed location (i.e., serve as a fire watch) as long as necessary to resolve the VEWFDS alarmed condition. The conduct of a continuous fire watch that is 1 hour or longer in duration (e.g., 8 hours, 24 hours, or 7 days) is not an unusual or extraordinary feat for the conduct of operations.

The statement above may not necessarily be representative of the assumption of a plant-specific or representative plant HRA, but it may reflect a plant-specific procedure that does not require the responding operator to remain at the fire-alarmed location as a fire watch or a plant-specific procedure that instructs the field operator to monitor and reset the VEWFDS to clear alarm conditions without a further investigation by the appropriate plant personnel (e.g., alarm technicians, system engineer) to determine and identified the cause. The NUREG-2180 method for assessing the application of VEWFDS for fire detection and fire suppression, like other safety analyses, does not address intentional acts (i.e., an operator intentionally acts contrary to the conduct of operations required in the operating procedures or acts contrary to his or her training).

There is insufficient data to accurately characterize the rate of growth and to establish with certainty the duration for the incipient stage of a fire. For this reason, operator actions for the manual suppression of a fire to preempt it inside electrical enclosures, such as the incipient stage, cannot be supported by the method described in NUREG-2180 or any other method that may be considered for an FPRA. As previously discussed in Section 2.4 of this DPO report, the modeling of the specific fire scenario should support and inform the appropriate application of the non-suppression probability currently available from the fire-event database.

2.5.3 Findings and Conclusions

The DPO Panel member additionally finds and concludes the following:

- Under the HRA assumptions for operator actions for a “representative plant” in NUREG-2180, the operator responding to the fire alarmed zone would be expected to stay within the area and essentially perform a fire watch, which is typical conduct for plant operations and does not constitute extraordinary actions by operators.

- The HRA analysts performing a similar analysis would need to collect their own plant-specific information for the time required for completing operator actions. The HRA described in NUREG-2180 is reasonable given the assumptions and limitations documented. If plant procedures, training, or operating experience differ, the results from the HRA approach in NUREG-2180 may be overly optimistic and, therefore, cannot be applied to the plant-specific HRA.

2.5.4 Recommendations

The DPO Panel member additionally recommends the following:

- Future or ongoing license amendment reviews to apply the standards in NFPA 805 to current operation licenses should include a licensing audit that examines appropriate plant procedures and training specific to operator responses for the application of VEWFDSs and any plant-specific operating experience to confirm the adequate and reasonable technical basis for resulting reduction factors for the plant-specific FPRA.

- Regulatory oversight (i.e., inspections) should include a sampling of plant procedures to ensure the implementation of operator actions for responding to VEWFDS alarmed conditions to confirm that the current licensing basis includes the technical basis and assumptions analyzed for changes to the NFPA 805. The adequacy of the design of the VEWFDS should be examined under design verification inspection.

- Regulatory oversight should include a review of the licensee's demonstrations of operator responses that account for plant-specific conditions, including those conditions that could interfere or cause delay of operator responses (e.g., high radiation, travel distance and time) and the availability of operators (e.g., back shift) to verify the realism and adequacy of planning for operator responses.

2.6 Summary of Concern No.1.d

The summary of concern is as follows:

> *General guidance to limit the maximum reduction factor for the non-suppression probability to 5 for in-cabinet VEWFDSs and 3 for area wide VEWFDSs should be provided. Alternate analyses provide the technical justification for these limits. The DPO submitter has provided several approaches to justify this.*

2.6.1 Background

A suggested approach is to replace the FAQ 08-0046 approach with a new one if any attempt is made to quantify risk-reduction credit from precluding fires or to incorporate HRA aspects. A reduction factor for VEWFDS ideally is between 4 to 6 (i.e., 5) for in-cabinet detection with capabilities of providing a specific in-cabinet location in unoccupied areas, between 2 to 3 for area wide detection, and 2 for the MCR (in-cabinet addressable to the specific cabinet).

The NUREG-2180 does not provide guidance to limit the maximum reduction factor for non-suppression curves that would apply to in-cabinet and area wide VEWFDS applications for the assessment of electrical enclosure fires.

2.6.2 Discussion and Evaluation

The DPO author suggests that "the maximum CDF reduction factor crediting both pre-emption and extra time available for suppression is approximately 5, rather than a factor of 10 or more." In addition, the maximum reduction factor for area wide VEWFDS applications should be at 3. This assumes that the non-

suppression probability for an operator responding to an alarm fails to promptly suppress the fire before it damages targets outside the fire-originating electrical enclosure and suggests that the use of the non-suppression probability established for electrical cabinet fires should be considered.

The NUREG-2180, Section 10.4.2.2, "Determining Time Available for Operator Response in VEWFDS Applications," uses cumulative probability distributions based on four detectors investigated in the confirmatory research and accounts for the uncertainty nature of the data available on the incipient stage of the fire. Using both information on the time required (developed in NURE-2180, Section 10.4.3) and the cumulative probability distributions, the duration of the time available is 30 minutes, which is approximately the maximum amount of time for positioning the field operator to perform immediate fire suppression. Previously established methods for assessing VEWFDS applications also establish time available for fire suppression activities (e.g., NUREG/CR-6850 (EPRI TR 1011989)), assuming that the incipient stage has a duration of 5 minutes and that duration is added to the time available for fire suppression. The EPRI TR 1019189, "Fire PRA Methods Enhancements—Additions, Clarifications," assumes that an alarm will indicate incipient conditions approximately 1 hour or more before ignition occurs but adds 15 minutes of suppression time. The FAQ 08-0046 recommended value assumes that the VEWFDS provides at least 1 hour of warning before the actual outbreak of an open flaming fire.

The assessment of the application of VEWFDSs for detecting fires in electrical enclosures with installation of in-cabinet VEWFDSs in FPRAs can affect the sequence of events for fires initiated by low-voltage electrical components in electrical enclosure. However, the time available for manual fire suppression is scenario specific and is dependent on the fire growth and development inside the electrical enclosure and on the propagation of the fire. The potential and rate of heat release of combustible material, the as-found configurations of combustible material, the physical configuration of the electrical enclosure, and the proximity of target equipment and components to the fire are all contributing factors on whether a given bounding operator response time is within or less than the time to the damage of targets that are adjacent to the originating fire in electrical enclosure. The NUREG-2178, Volume 1 (RACHELLE-FIRE), provides the latest guidance on methods acceptable for modeling electrical enclosure fires with enhanced characterization of heat release rates and research that informs profiles of fire-plume temperatures generated for obstructed plumes inside electrical enclosures.

The fire inside the electrical enclosure, the subsequent propagation the fire originating from the electrical enclosure, the ignition of combustible material nearby, and thermal exposure to critical target equipment and components can be modeled with reasonable certainty using readily available fire models and analytical tools. This modeling provides quantified information that can be applied in assessing the time available for prerequisite operator actions and performance of manual fire suppression. The time available for operators to respond to complete prerequisite tasks (e.g., locate the source of the fire and the effected cabinet, access the cabinet) and perform the tasks for manual fire suppression is bounded by the time for the development and progression of the fire to conditions that result in damage to critical target equipment and components. Modeling of the fire inside the electrical enclosure and propagation of the specific electrical enclosure fire scenario should be used to determine whether sufficient time is available to implement operator responses complete tasks for manual fire suppression.

The maximum reduction factor from the non-suppression probability and time suppression should be informed by modeling specific fire scenarios and should be less than the time to the damage of critical targets and components, which is quantified by modeling both the fire inside the electrical cabinet and the propagation of the fire from the cabinet to the damage of nearby critical target equipment and components.

Approaches acceptable for informed changes consist of methods that have been used in the peer-reviewed FPRA and methods that have been approved by the NRC through plant-specific license amendments. The NRC generically approved methods specifically for use in NFPA 805 risk assessments or methods that have been demonstrated to bound the risk impact. The DPO submitter's alternative approach (i.e., a more holistic approach that has very simple event trees, if any, and limited human factor analysis) may be a method that potentially demonstrates the bounding of risk impacts and leads to similar results.

The NUREG-2180 provides one method that, if all limitations and conditions are met, is acceptable for assessing the application of VEWFDSs to initiate operator responses for fire suppression. It provides a mean of assessing the success or failure of preventing fire from propagating (the post-incipient stage) from the initiating cabinet to adjacent targets. None of the methods developed and guidance established to date (e.g., EPRI TR 1018189, FAQ 08-0046, NUREG-2180) for assessing the application of VEWFDSs provides a means of modeling the incipient stage of the fire or allows for accurate predictions of the durations of the incipient stage

before the fire transitions to the self-sustained combustion (flaming) stage. The assumptions of the capability of a VEWFDS to detect combustion products from pyrolysis during the incipient stage before a fire transitions to self-sustained combustion range from 5 minutes to 1 hour or more.

Other methods or approaches, such as the holistic approach proposed in EPRI TR 1016735, which is based on an analysis of available test results of ADS, qualitative considerations of the effects of fire ignition frequencies and on non-suppression probability, or a simplified event tree (i.e., as described in the report titled, "Credit for Very Early Warning Fire Detection in Fire Probabilistic Risk Assessment," produced by the DPO submitter and various NRC staff members), may be applied in the assessment of VEWFDS applications at NPPs and input to the plant FPRA. The alternate approach suggests limits for a maximum reduction factor based on the state of current knowledge, the potential effect of VEWFDS applications and assumption of available and reliable operator actions for fire suppression on the resulting plant CDF, and overly optimistic reduction factors using the original FAQ 08-0046. The NUREG-2180 confirms that reduction factors based on the assumptions for application of VEWFDSs for fire detection and operator actions for fire suppression using the interim method described in FAQ 08-0046 were overly optimistic.

2.6.3 Findings and Conclusions

The DPO Panel member additionally finds and concludes the following:

- The outcome of the modeling of risk reduction provided by the application VEWFDS for electrical enclosure fires, fire detection, and subsequent operator response for fire suppression can have a potentially large impact on the FPRA and the fire risk contributions to the overall resulting plant CDF. With the current lack of knowledge on characterizing incipient fires and limited operating experience in applying VEWFDSs at NPPs, the evaluation of the effectiveness of VEWFDSs and the crediting of manual operator actions may not be overly optimistic nor overly pessimistic to ensure realistic FPRAs and resulting contribution of fires to the plant CDF.

- The maximum reduction from the non-suppression probability and time to fire suppression should be informed through modeling of specific fire scenarios. The reduction factor considered must be less than the time to the damage of critical targets and components, which can be quantified through modeling both the fire inside the electrical cabinet and the propagation of fire from the cabinet to the damage of nearby critical target equipment and components.

- Regardless of the assessment method applied for the application of VEWFDS for fire detection and subsequent operator actions for manual fire suppression, the modeling of the specific fire scenario should support and confirm that sufficient time is available for operator response in post-incipient fire stages.

2.6.4 Recommendations

The DPO Panel member additionally recommends the following:

- The NRC staff should establish general guidance for licensing to ensure that the assessment and results of the FPRA are complete and accurate (i.e., to ensure that reduction factors are bounded by lower and upper limits that reflect the current knowledge (or lack of knowledge thereof)); that they include incipient fires, the design of VEWFDSs, the fire development inside electrical enclosures, plant-specific operator actions, and plant conditions); and that they ensure realistic FPRA input to the overall plant PRA and resulting contributions to the plant CDF. The general guidance should address the method describe in NUREG-2180 and the alternative method describe in the DPO.

- An amendment to changes to the fire protection licensing basis that credits the application of VEWFDSs to provide a reduction factor of 10 or greater should be reviewed to ensure that the modeling of the specific fire scenario supports and informs the resulting reduction factors.

2.7 Summary of Concern No.2

The summary of concern is as follows:

> *The endorsement letter of NUREG-2180 states that there are "expectations" that licensees will update their FPRAs to remove the modeling approach using FAQ 08-0046 and replace it with the approach from NUREG-2180 or another defensible approach. Licensees should be "required" to perform this update. This concern is separate from the technical concerns with the FAQ 08-0046 and NUREG-2180 approaches to VEWFDS modeling (i.e., a change from "expectations" to "requirements" in the endorsement letter would not affect the other DPO concerns). (Note that this does not imply that the DPO submitter approves of the use of NUREG-2180 in its current form even with the correction in wording from "expectations" to "requirements.")*

2.7.1 Background

The NRC letter from J. Giitter to M. Tschiltz (ADAMS Accession No. ML1625A111), dated November 17, 2016, established the NRC staff's current positions. The guidance on these positions addresses the revision of the fire protection licensing basis for which the risk assessment considers VEWFDSs based on the two approaches in FAQ 08-0046 and NUREG-2180. The letter states the following key positions with respect to the approaches that consider VEWFDSs in NPPs that are transitioning to NFPA 805, which relies, in part, on FPRAs:

- The purpose of the interim position in the FAQ 08-0046 closure memorandum was to provide the current staff position for developing the probability of non-suppression in fire areas that have VEWFDS installed in certain types of electrical cabinets. The NRC Interim Staff Position was that, while the approach proposed by the EPRI in EPRI 1016735, "Fire PRA Methods Enhancements: Additions, Clarifications, and Refinements to EPRI 1011989," (December 2008) provides a high-level approach to modeling VEWFDS, there are several other issues that should be addressed and conditions applied to improve accuracy/realism.

- To clarify our actions regarding FAQ 08-0046, the staff recognized during the development of NUREG-2180 that some assumptions used in the FAQ were not able to be confirmed. Accordingly, its continued use could cause licensees that are considering future application of FAQ 08-0046 undue difficulty in defending some of the assumptions used in the FAQ's methodology.

- The NRR's expectation is that future license amendment requests, fire risk evaluations supporting self-approval evaluations, or PRA maintenance and upgrades will not specifically credit the methodology provided in FAQ 08-0046. Licensees with NFPA 805 applications crediting VEWFDS and currently undergoing NRC review will be assessed on a plant-by-plant basis.

- Licensees that have already received a safety evaluation (for applications crediting VEWFDS using the methodology provided in FAQ 08-0046) are expected to update their risk analyses periodically with nuclear industry operating experience and new information consistent with their current licensing bases and PRA maintenance and upgrade processes outlined in the ASME/ANS RA-Sa-2009 standard. For these licensees, the methodology provided in FAQ 08-0046 remains part of their current licensing basis until a replacement methodology becomes available. Once available, it is expected that licensees will consider and incorporate the replacement methodology consistent with their licensing bases and the PRA maintenance and upgrade process.

In addition, the FAQ 08-0046 closure letter indicates the following:

> While implementing the fire PRA maintenance and update process, if operating experience indicates that VEWFDS availability, reliability and effectiveness are not as high as currently modeled in the fire [probabilistic risk assessment], actions must be taken to update the analysis to reflect the new information.

If a licensee is performing a periodic or interim PRA update, performing a fire risk evaluation in support of self-approval, or submitting a future risk-informed license amendment request, the staff expects it to assess the impact of new operating experience and information on its PRA and incorporate the change as appropriate in accordance with Regulatory Guide 1.200, Revision 2 (ADAMS Accession No. ML090410014).

2.7.2 Discussion and Evaluation

The endorsement letter of NUREG-2180 states that there are "expectations" that licensees will update their FPRAs to remove the modeling approach using FAQ 08-0046 and replace it with the approach from NUREG-2180 or another defensible approach. Licensees should be "required" to perform this update.

The NRC letter from J. Giitter to M. Tschiltz (ADAMS Accession No. ML1625A111), dated November 17, 2016, established NRR's expectation that future license amendment requests, fire risk evaluations that support self-approval evaluations, or PRA maintenance and upgrades will not apply the method in FAQ 08-0046.

The NRC expects licensees that have already received a safety evaluation (for applications crediting VEWFDS using the methodology in FAQ 08-0046) to update their risk analyses periodically with nuclear industry operating experience and new information consistent with their current licensing bases and PRA maintenance and upgrade processes outlined in ASME/ANS RA-Sa-2009, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications," issued 2009. The NRC expects licensees to consider and incorporate the replacement methodology consistent with their licensing bases and the PRA maintenance and upgrade process. From a practical standpoint, those licensees that used the FAQ 08-0046 method during the NFPA 805 license amendment process are "required" to update their FPRAs. However, these licensees must commit to following applicable PRA standards and must conform to guidance in Regulatory Guide 1.200. The standards include a licensee-controlled PRA update and upgrade procedure. The frequency at which updates must be performed or completed is not specified and is established by licensees in their plant-specific procedures.

Licensees that are transitioning to NFPA-805 are required to commit to the NFPA 805 plant change evaluation (PCE) process to meet the requirements in NFPA 805, Section 2.2.9 and Section 2.7.2. The licensee will develop a change process that is based on guidance in Section 5.3, "Plant Change Process," and Appendix B, "Detailed Transition Assessment of Fire Protection Program," to NEI 04-02, "Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program under 10 CFR 50.48(c)," Revision 2, issued April 2008, as modified by Regulatory Position 2.2.4, "Risk Evaluations"; Regulatory Position 3.1, "Standard License Condition"; Regulatory Position 3.2, "NFPA 805 Plant Change Evaluation Process"; and Regulatory Position 4.3, "Fire Probabilistic Risk Assessment," in Regulatory Guide 1.205, "Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants." Section 4.7.2 of the license amendment request (LAR) states that the PCE process will consists of four steps: (1) define the change, (2) perform the preliminary risk screening, (3) perform the risk evaluation, and (4) evaluate the acceptance criteria. The LAR FPRA models the installation of the VEWFDS and credits its use in assessing the risk of fire areas.

The NRC's retirement of FAQ 08-0046 with NUREG-2180 recognizes that the qualitative-based (rather than quantitative-based) assumptions used in the FAQ 08-0046 could not be substantiated with comprehensive and detailed research test data and operating experiences. In the light of new information, further application of the interim guidance in FAQ 08-0046 is not defensible or cannot be justified as a reasonable performance-based or risk-informed approach for changes to the current licensing basis. Accordingly, the NRC retirement of FAQ 08-0046 addresses the inadequacy of continued use of the interim staff position in future applications in the voluntary adoption of the NFPA 805 performance-based and risk-informed approach for changes to the current licensing basis.

For licensees that have proposed changes to the current licensing basis using the FAQ 08-0046 method and that have amended their licenses and implemented the amended license requirements, the new guidance must be considered with respect to its significance to the continuance of maintaining an adequate revised licensing basis. The criteria in 10 CFR 50.59(c)(2) address whether the new and revised guidance that retired FAQ 08-0046, as applied to the amended licensing basis, would do the following:

- Result in more than a minimum increase in frequency of occurrence of a previously evaluated accident.

- Result in more than a minimum increase in the likelihood of occurrence of a malfunction of a structure, system, or component important to safety that was previously evaluated.
- Result in more than a minimum increase in the consequence of a previously evaluated accident.
- Result in more than a minimum increase in the consequences of a malfunction of a structure, system, or component important to safety that was previously evaluated.
- Create a possibility for an accident of a different type than any previously evaluated.

In light of the new and revised guidance in NUREG-2180, these criteria apply specifically to the licensee's developed FPRA using the retired FAQ 08-0046 guidance to modify its internal events PRA model. Because it captured the effects of fires using the retired FAQ 08-0046 guidance, the licensee would need to revisit the changes to its FPRA model and to the identified and scheduled plant changes for the transition to NFPA 805 for continued assurance of the adequacy of the PRA basis for the voluntary amendment to transition the current licensing basis to an 10 CFR 50.48(c) compliant (i.e., NFPA 805 performance-based and risk-informed approach) plant to the findings that (1) there is reasonable assurance that public health and safety will not be endangered by operations proposed in this manner, (2) there is reasonable assurance that such activities will be conducted in compliance with the Commission's regulations, and (3) the issue of the amendment will not be inimical to the common defense and security or to public health and safety, and (4) the issuance of the amendment is in accordance with 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," and all applicable requirements have been satisfied.

For NRC approval of the revised licensing basis for licensee changes using NFPA 805 to amend the current licensing basis, the NRC may base its approval of the proposed change on a licensee agreement to adopt new or revised guidance. However, special circumstances may arise in which new information reveals an unforeseen hazard or a substantially greater potential for the occurrence of a known hazard, such as the identification of an issue related to the requested licensing basis change that may substantially increase risk. In such circumstances, the NRC has the statutory authority to require licensee action above and beyond existing regulations and may request an analysis of the change in risk related to the requested licensing basis change to demonstrate that the level of protection necessary to avoid undue risk to public health and safety (i.e., "adequate protection") would be maintained upon approval of the requested licensing basis change. (See Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis.")

The following licensees amended their licensing bases for the 20 units listed below through 10 CFR 50.48(c) with the adoption of NFPA 805, credited a plant-specific application of in-cabinet or area wide VEWFDSs in their FPRAs, and updated their overall internal event PRAs:

- Shearon Harris NPP, Unit 1
- Virgil C. Summer Nuclear Station, Unit 1
- Cooper Nuclear Station

- Turkey Point Nuclear Generating, Units 3 and 4
- Brunswick Steam Electric Plant, Units 1 and 2
- Arkansas Nuclear One, Unit 2
- Brown Ferry Nuclear Plant, Units 1, 2, and 3
- St. Lucie Plant, Units 1 and 2
- Diablo Canyon NPP, Units 1 and 2
- H.B. Robinson Steam Electric Plant, Unit 2 (credited an area wide VEWFDS)
- Beaver Valley Power Station, Units 1 and 2
- Prairie Island Nuclear Generating Plant, Units 1 and 2

Licensees that have or are planning to implement revised licensing bases that take credit for the effectiveness of engineered VEWFDSs and the corresponding operator fire-mitigation responses, based on information other than that in NUREG-2180 in their FPRAs and the subsequent PRA models used to update the internal events, must evaluate changes using the criteria in 10 CFR 50.59, "Changes, Tests and Experiments," for adequate protection. Where required, a designation of "correction period" for plants that were licensed using the guidance of FAQ 08-0046 is reasonable, and licensees should implement appropriate compensatory measures until the evaluations are completed.

For a licensee that has transitioned to NFPA 805 and has implemented a revised licensing basis that takes credit for the effectiveness of operator fire-mitigation responses based on FAQ 08-0046, without consideration of the guidance in NUREG-2180, its FPRA and subsequently revised PRA of internal events should be reviewed using the 10 CFR 50.59 criteria and the licensee's NFPA 805 PCE process to evaluate the effects of the new information in NUREG-2180 on the amended licensing basis for the adequate assessment of fire risk in affected areas.

> The licensee that used FAQ 08-0046 as the basis for amending its licensing basis should have implemented its NFPA 805 PCE process to adequately evaluate the effect of new information in NUREG-2180 and, where necessary, should have established actions to address the reevaluation and re-baselining of previous assessments on the application of VEWFDSs and the reduction of fire risk in affected areas. A reasonable time for implementing necessary actions, including any compensatory measures necessary from the results of the preliminary screening of safety and risk significance, may receive due considerations of any appropriate enforcement discretions.

The FAQ 08-0046 process, as documented in a July 12, 2006, letter to NEI indicated that, "the FAQs and answers should be treated as an extension of the endorsed revision of NEI 04-02 and may be formally adopted by the NRC through a Regulatory Issue Summary (RIS) or an update of the [regulatory guide] endorsing a new revision of NEI 04-02."

2.7.3 Findings and Conclusions

The DPO Panel member additionally finds and concludes the following:

- The new information in NUREG-2180 for licensees that evaluates the plant risk using the guidance of FAQ 08-0046 may reveal that a substantial change to greater risks is no longer defensible and raises the potential of concerns of previously discussed and amended licensing bases to plant risks previously assumed to be acceptable.

- The retirement of FAQ 08-0046 and the new information in NUREG-2180 potentially affect the 12 NPPs that had amended their licensing bases using FAQ 08-0048 for the transition to the NFPA 805 risk-informed and performance-based alterative approach for their licensing bases. This would not affect those licensees that already considered the new information in NUREG-2180 before its final publication in December 2016.

- A licensee may rely on established plant change control processes to screen the significance of changes to the site-specific application of FAQ 08-0046 and the potential changes to risk from the new information in NUREG-2180 and to determine whether it is required to update of the overall plant PRA promptly or update it based a previously established schedule.

2.7.4 Recommendations

The DPO Panel member additionally recommends the following:

- The NRC should develop and issue an appropriate generic formal communication to licensees of the availability of NUREG-2180 guidance on assessing the application of VEWFDSs for fire detection and operator actions for fire suppression and on the retirement of FAQ 08-0048. The generic communication (e.g., a RIS or generic letter, or both) should address the need for licensees to implement its plant change control process to screen for the potential significance of changes to their FPRAs that support the amended licensing basis and to take appropriate actions to update the technical basis for the current licensing basis.

- The generic communication should address the 12 licensees that amended their licensing bases for 20 operating NPP units through the 10 CFR 50.48(c) adoption of NFPA 805 with the guidance in FAQ 08-0048 for the application of VEWFDSs in the FPRAs and update of the overall internal event PRA. The NRC should identify actions that these licensee should apply through existing plant change control processes (including NFPA 805 PCE) to evaluate the potential significance of new information and the revised method in NUREG-2180 for FPRAs using the criteria in 10 CFR 50.59.

- Regulatory oversight of the 12 licensees identified should include a review of how these licensees have adequately addressed the retirement of FAQ 08-0048 on their current licensing bases and their plans for establishing an update of their current FPRAs and required plant and system changes.

- Regulatory Guide 1.205, Regulatory Position 4.3, should incorporate NUREG-2180 to update the reference to NUREG/CR-6850/EPRI 1011989 on the use of VEWFDSs and risk assessment. Appropriate updates to NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 9.5.1.2, "Risk-Informed, Performance-Based Fire Protection Program Review Responsibilities," should reference NUREG-2180 as a method acceptable for the assessment of the application of VEWFDSs at NPPs for FPRAs. The NRC staff should consider the DPO Panel findings and recommendations in its guidance with respect to applying fire models to support and confirm the realism and accuracy of the risk assessments of specific fire scenarios that are of safety significance.

2.8 Summary of Concern No. 3

The summary of concern is as follows:

> *The NRC should consider a backfit, or a designated "correction period," for plants that were licensed using the guidance of FAQ 08-0046. Even without NUREG-2180, the continued use of FAQ 08-0046 would be inappropriate if the error contained within the FAQ was not corrected by the licensee before it was applied.*

2.8.1 Background

The regulations at 10 CFR 50.109(a)(1)and 50.109(a)(1)(iii) establish backfitting as the modification of or addition to systems, structures, components or design of a facility or the procedures or organization required in the design, construction, or operation of a facility, any of which may result from new or amended provisions in the Commission's regulations or the imposition of a regulatory staff position interpreting the Commission's regulations that is either new or different from a previously applicable staff position after the date of issuance of the operating license for facilities that have operating licenses.

The regulation at 10 CFR 50.109(a)(3) states that "except as provided in paragraph (a)(4) of this section, the Commission shall require backfitting of a facility only when it determines, based on the analysis described in paragraph (c) of this section, that there is a substantial increase in the overall protection of the public health and safety or the common defense and security to be derived from the backfit and that the direct and indirect cost of implementation for the facility are justified in view of this increase protection."

The regulation at 10 CFR 50.109(a)(4) states that "the provisions of paragraph (a)(2) and (a)(3) of this section is inapplicable and, therefore, backfit analysis is not required and the standard in paragraph (a)(3) of this section do[es] not apply when the Commission or staff, as appropriate, finds and declares, with appropriate documented evaluation for its finding, either (i) that a modification is necessary to bring a facility into compliance with a license or the rule or orders of the Commission, or into conformance with written commitments by the licensees; or (ii) that regulatory action is necessary to ensure that the facility provide[s] adequate protection to the health and safety of the public and is in accord with the common defense and security; or (iii) that the regulatory action involves defining or redefining what level of protection to the public health and safety or common defense and security should be regarded as adequate.

2.8.2 Discussion and Evaluation

The NRC should consider a backfit, or a designated "correction period," for plants that were licensed using the guidance in FAQ 08-0046.

Backfit Rule Implementation

In a letter from the S.G. Burns (NRC) to E.C. Ginsberg (NEI), dated July 14, 2010 (ADAMS Accession No. ML101060180), the Office of the General Counsel clarifies the NRC's practices in implementing the backfit rule. The Office of the General Counsel made the following statements that are pertinent to the matter or applicability of the backfit rule to licensees that have amended their current licensing bases through the voluntary adoption of the NFPA 805 performance-based and risk-informed alternative approach, which relies on the interim staff guidance in FAQ 08-0046:

- By contrast, there are guidance documents which the NRC staff intends only to be "forward fit," that is, the guidance will be applied only to: (i) future applicants; and (ii) applications from existing licensees for license amendments, requests for exemptions, and other requests for dispensation from compliance with otherwise applicable legally binding requirements (an example of such a request would be an application using an alternative under 10 CFR 50.55(a)). In these circumstances, the NRC does not consider the issuance of "forward fit" interpretive guidance to constitute "backfitting." As the NRC has stated in several different contexts, the Backfit Rule does not protect the expectations of future applicants (including licensee[s] seeking NRC permission to conduct licensed activities in a manner different than what the NRC previously approved) regarding the regulatory requirements that they must meet to obtain NRC approval. [Paragraph 2, Page 2]

- The staff has represented to us that they do not intend to impose on any current NPP licensee that the positions in the three regulatory guides you identified, absent a voluntary request from a licensee to change its licensing basis in a manner which directly implicates the safety issues addressed in those regulatory guides.2 Inasmuch as these guides are only to be "forward fit," the backfitting discussions for those regulatory guides are consistent with the Backfit Rule, and issuance of these regulatory guides do[es] not fall within the purview of "agency policy" concerning the application of the Backfit Rule to issuance of interpretive guidance.

- If a licensee voluntarily seeks to change its licensing basis (i.e., the change is initiated by the licensee to take advantage of a voluntary alternative afforded in the NRC's regulations, such as the adoption of NFPA 805 under 10 CFR 50.48(c), and is not compelled by a new or amended regulation), then the NRC may condition its approval of the proposed change upon a licensee agreement to adopt new or revised guidance. Such action will not be deemed to be backfitting if: (i) the new or revised guidance relates directly to the licensee voluntary request; and (ii) the specific subject matter of the new or revised guidance is essential considerations in [the] NRC staff's determination of the [acceptability] of the licensee's voluntary request.

Voluntarily Transition to the NFPA 805 Performance-Based and Risk-Informed Method to Change the Licensing Basis

The consideration of backfit is not necessary for NPP licensees that have voluntarily amended their licensing bases through the adoption of NFPA 805 (the alternative to complying with 10 CFR 50.48(b)) under the provisions of 10 CFR 50.48(c) and were not compelled by new or amended regulations. The following limitations apply:

- A licensee's voluntary adoption of NFPA 805 and the resulting or planned changes to its current licensing basis that are based on the adoption of new or revised guidance is not deemed to be a backfit. The revised guidance (i.e., NUREG-2180 supersedes FAQ 08-0046) relates directly to the licensee's voluntary request to amend and revise its licensing basis, and the specific subject matter of the new guidance is an essential consideration in the NRC staff's determination of the acceptability of the licensee's voluntary request.

- A licensee that voluntarily seeks to change its current licensing basis is provided limited backfit protect because the backfitting policies are not strongly implicated if the resulting changes to the current licensing basis occur through the application of guidance that is not compelled by new or amended NRC regulations.

- For licensees that voluntarily rely on FAQ 08-0046 for amending the current licensing basis, NUREG-2180 supersedes that interim guidance based on new information and the resulting systematic method for assessing and quantifying the application of VEWFDSs. Specifically, the NRC retired the FAQ 08-0064 interim staff position with a reasonably comprehensive and complete evaluation of the performance of VEWFDSs, human response, and operating experiences available to date for detecting incipient fires during the incipient stage in NPPs. Significant advanced state of knowledge based on detailed research test data and operating experiences and the increased fidelity of realistic and reasonable methods for evaluating VEWFDS performance and associated fire protection and risk applications were not available or were not considered when the staff developed its interim position in FAQ 08-0046.

- The closure of FQA08-0046 on November 23, 2009, established final interim staff guidance after internal and external stakeholder interactions, reviews, and feedbacks. For licensees that applied the guidance in FAQ 08-0046, the "Other Generation Considerations" states the following:

  > Two additional factors in a performance-based approach are the implementation of the NFPA 805 monitoring program and the fire PRA maintenance and update process. Licensees are also expected to maintain their risk analysis current with the latest information. This includes considerations of new information from nuclear industry operating experiences and external sources such as industry testing, research, data from other industries (such as the telecommunication industry), etc. While implementing the fire PRA maintenance and update process, if operating experience indicates that VEWFDS availability, reliability, and effectiveness are not as high as [those] currently modeled in the fire PRA, action must be taken to update the analysis to reflect the new information.

As indicated, above, the adoption of the method described in FAQ 08-0046 for amendments to the fire and safety licensing basis requires licensees to consider new information while implementing the fire protection program and FPRAs and to take actions necessary to update the analysis to reflect new information.

Licensee Application of FAQ 08-0046 for NFPA 805 License Amendment Requests

The NEI 04-02 provides guidance for implementing the requirements in 10 CFR 50.48(c) and describes methods for implementing, in whole or in part, a performance-based and risk-informed fire protection program. The NEI 04-02 incorporates guidance from Regulatory Guide 1.205 and approved FAQ 08-0046. For LARs that apply the VEWFDS technology, the licensee proposed the use of FAQ 08-0046 guidance for modeling non-suppression probability when a VEWFDS is installed in an electrical cabinet outside the MCR. With regard to the plant-specific treatment or technologies related to the application of the VEWFDS, the LAR establishes that the VEWFDS follows the guidance in FAQ 08-0046, and the VEWFDS is

identified in NFPA 805 LAR Attachment S, Table S-1, which includes the licensee's actions to install VEWFDS in accordance with NFPA codes, manufacturing requirements, and the guidance in FAQ 08-0046. The licensee will also develop or revise procedures related to operation, response, and maintenance.

With regard to post-implementation transition requirements for NFPA 805, the licensee commits to the NFPA 805 PCE process for meeting requirements in NFPA 805, Section 2.2.9 and Section 2.7.2. The licensee will develop a change process that is based on guidance in NEI 04-02, Section 5.3; Appendix B; Appendix I, "Plant Change Evaluation Form"; and Appendix J, "Plant Change Evaluations," as modified by Regulatory Positions 2.2.4, 3.1, 3.2, and 4.3 in Regulatory Guide 1.205. The LAR Section 4.7., states that the PCE process will consists of four steps: (1) define the change, (2) perform the preliminary risk screening, (3) perform the risk evaluation, and (4) evaluate the acceptance criteria. The LAR FPRA models the installation of the VEWFDS and credits its use in assessing the risk of fire areas.

2.8.3 Findings and Conclusions

The DPO Panel member additionally finds and concludes the following:

- The consideration of backfit is not necessary for NPP licensees that have voluntarily amended their licensing bases through the adoption of NFPA 805 (the alternative to complying with 10 CFR 50.48(b)) under the provisions of 10 CFR 50.48(c) and that were not compelled by new or amended NRC regulations.

- The continued application of FAQ 08-0046 is not defensible, regardless of the correction of errors contained in the guidance. NUREG-2180 is the new or revised guidance that establishes FPRAs that are the foundation for the update of the overall internal event PRA model for the basis of adequate protection of public health and safety. The backfit provision does not apply when the Commission finds that actions are necessary to ensure adequate protection of public health and safety.

- Licensees that have or are planning to implement a revised licensing basis that takes credit for the effectiveness of engineered VEWFDSs and the corresponding operator fire-mitigation responses, based on information other than that in NUREG-2180 for their FPRAs and the subsequent PRA models used to update internal events, must evaluate changes using the criteria in 10 CFR 50.59. Where required, a designation of "correction period" for plants that were licensed using the guidance in FAQ 08-0046 is reasonable, and licensee should implement appropriate compensatory until the evaluations are completed.

2.8.4 Recommendations

The DPO Panel member has no recommendations regarding the backfit provision because a regulatory basis requiring a backfit does not exist. A backfit is not required for licensees that voluntarily-transitioned to NFPA 805.

3.0 Summary of Additional Conclusions and Recommendations

A summary of the DPO Panel Member's additional conclusions and recommendations are as follows:

- The failure duration of an electrical component (low voltage) for incipient stage of a fire may vary from less than a second to hours or days, and possibly even longer. There is a lack of understanding of the failure mechanisms of electrical component and there is no agreed upon method to predict the time duration for incipient fire transition to self-sustained combustion stage of a fire and when electrical component generate sufficient aerosol that can be detectible.

- The post-incipient stage fire inside an electrical cabinet and potential propagation to nearby combustibles and/or critical targets can be modeled to establish the timeline for the fire progression of a specific fire scenario, with reasonable certainty using readily available fire computer models and well understood fire dynamics and researched data. The quantified timeline of fire progression provides insights on the feasibility and realism of proposed operator actions for fire suppression. The time available for operator response and tasks time for fire suppression is bounded by the time for fire development and progression to conditions that result in damage to electrical enclosure and subsequent fire damage outside of the electrical enclosure (i.e., end states of event trees) and provides the technical basis for the maximum risk reduction that is appropriate and reasonable for the FPRA.

- Neither the NUREG-2180 nor other methods can be readily applied for pre-empting of incipient fires within electrical enclosures, as current data and research do not sufficiently provide assurance of certainty of the incipient fire growth rate and duration can be predicated and there is not adequate data and fire models or analytical tools readily available to characterize, with certainty, the progression of the preheating, pyrolysis, and smoldering of the incipient stage of a fire.

- The NUREG-2180 method does not restrict a licensee or an applicant to use other alternative approaches to assess the application of VEWFDS at NPP for the FPRA. However, accurate and realism of modeling of the relative new application of VEWFDS at a NPP is required for characterizing the potential risk profiles of fire scenarios that accounts for specific plant conditions.

- The new information (i.e., NUREG-2180) for licensees that evaluated the plant risk using the guidance of FAQ 08-0046, may reveal that a substantially change to greater risk is no longer defensible and raises the potential of concerns of previously discussed and amended licensing basis to plant risk previously assumed to be acceptable. Established plant change control process may be relied-on to screen the significance of changes to site-specific application of FAQ 08-0046 and the potential changes to risk from new information in NUREG-2180 and determining whether licensee is required to update of the overall plant PRA promptly or update based a previously established schedule.

- The DPO Panel Member agrees with the DPO submitter that, based on the resulting high values of the reduction factor, applying the retired method described in FAQ 08-0046 is overly optimistic. Based on the limited knowledge of the fire dynamics at the incipient stage of fires and operational experience with VEWFDS and operator fire response, the fire modeling of specific electrical enclosure fire scenarios, considerations of plant-specific detection system design and conditions, and planned operator manual cations must confirm and inform the appropriate reduction factor that may be credited.

- The Panel Member found that NUREG-2180 provides a reasonable technical basis for the use of the MCR non-suppression probability. However, the DPO Panel Member agreed, in part, with the DPO submitter that other non-suppression probabilities (e.g., electrical, cutting/welding, new electrical, or other fires) should be used under plant-specific conditions in which fire modeling and plant-specific operator response do not support the use of the MCR non-suppression probability. The modeling of a fire must support and confirm the selected non-suppression probability, and the application must be representative of the plant-specific operator response to electrical enclosure fires.

- The Panel member found that quantification of operator actions using HRA and the analysis of "a representative plant" operator actions described in NUREG-2180 are reasonable given the documented assumptions and limitations. If plant procedures, training, or operating experience differ, the NUREG-2180 HRA results may be optimistic, as identified by the DPO submitter in the issue of concern, and would not appropriately reflect or characterize the plant-specific operator response for manual fire suppression.

- The Panel member found that the endorsement of the method described in NUREG-2180 does not restrict or preclude a licensee or an applicant from using other alternative approaches, including the approach described by the DPO submitter, to analyze the application of VEWFDSs and operator actions for the plant-specific FPRA. However, regardless of the method applied, the modeling of the specific electrical enclosure fire scenario should support and confirm that sufficient time is available for the plant-specific operator response to the post-incipient fire stage.

- The Panel member agrees that the reduction factor may be appropriate from the appropriate application of non-suppression probabilities, but the reduction factor is based on the time available for the operator to perform the required actions for fire suppression, as informed through the modeling of specific fire scenarios. The reduction factors considered should be limited to the non-suppression probability based on operator responses that are less than the time to the damage of critical targets and components, which also can be quantified through modeling of the fire inside the electrical cabinet and the propagation of fire from the cabinet to the damage of nearby critical target equipment and components.

- The DPO Panel member did not find a regulatory basis in the NRC regulations, licensing conditions, plant final safety analysis reports, NFPA 805 amendments, or NRC or industry guidance or standards that explicitly specifies a frequency required for updates to the FPRA.

The following are key additional recommendations:

- The specifics of how a fire will develop within the electrical cabinet and the propagation to the adjacent targets nearby, prior to damage of critical targets, should be applied in the assessment of whether there is sufficient time available for the opportunity to perform operator actions for fire suppression. Any presumptions of credit should be confirmed and informed by computer fire modeling of specific fire scenario and considerations of plant-specific conditions.

- Fire modeling of the specific fire scenario should be relied on to support and confirm whether MCR non-suppression probability curve should be used. Where the fire modeling of specific fire scenario for the time to cabinet damaged and the propagation of fire to adjacent target is less than time for operator response, the use of MCR non-suppression probability curve derived from operating experience data of fires in MCR should not be used and other appropriate non-suppression curves may be appropriate for use.

- The application of NUREG-2180 methodology, using event trees, is acceptable for assessing the application of VEWFDS and subsequent fire suppression for the FPRA. The application of method by licensee or applicant must adhere to all guidance, conditions, assumptions, and limitations described. Neither the NUREG-2180 nor other methods considered or proposed to date should be applied for the considerations of operator actions for fire suppression to pre-empting of incipient fire within electrical enclosures.

- The changes to the fire protection licensing basis that credits the application of VEWFDS and operator manual actions to provide a reduction risk should be review to ensure that the fire modeled specific scenario supports and informs the analyzed credited risk reduction.

- Regulatory oversight should include sampling of plant procedures implementing operator actions for responding to VEWFDS alarmed conditions to ensure flow-down of technical basis and assumptions analyzed for the NFPA 805 changes to the currently licensing basis.

- Appropriate generic communication should be developed and issued formal communications (RIS and/or Generic Letter) to NRC licensees on acceptable revised guidance (NUREG-2180) and the sunset of FAQ 08-0048. The generic communication should address the need for licensees to implement its plant change control processes for potential significance of changes and take appropriate actions to update the technical basis for licensing.

The details of the specific of additional conclusions and recommendations by the Panel member, and the supporting technical evaluations and assessment of the issue are captured in the body of this Appendix.

Documents Reviewed

DPO-2106-004

The Panel reviewed information found in, but not limited, to the following:

1. Differing Professional Opinion (DPO) No. 2016-004, "Response to July 28, 2016, Letter Regarding Retirement of National Fire Protection Association 805 Frequently Asked Question 08-0046, "Incipient Fire Detection Systems" AND Sections B and C of NCP-2016-07 (ADAMS ML16327A460)," November 29, 2016 (ADAMS Accession No. ML163420445)

2. Non-Compliance Process (NCP) No. 2016-017, Subject: Response to July 28, 2016, Letter Regarding Retirement of National Fire Protection 805 FAQ 08-0046 (ADAMS Accession No. ML16327A460)

3. NUREG 2180, "Determining the Effectiveness, Limitations, and Operator Response for Very Early Warning Fire Detection Systems in Nuclear Facilities (DELORES-VEWFIRE)," December, 2016 (ADAMS Accession No. ML16326A255)

4. NUREG-2169, "Nuclear Power Plant Fire Ignition Frequency and Non-Suppression Probability Estimation Using the Updated Fire Event Database United States Fire Event Experience Through 2009," June 2015 (ADAMS Accession No. ML15016A069)

5. Frequently Asked Question (FAQ) Number 08-0046, "Incipient Fire Detection Systems, Guidance for Modeling Non-Suppression Probability When an Incipient Fire Detection System is Installed to Monitor Electrical Cabinets," November 24, 2009 (ADAMS Accession No. ML081200291)

6. Memorandum to AFPB File from Alexander R. Klein, "Closure of National Fire Protection Association 805 Frequently Asked Question 08-0048 Revised Fire Ignition Frequencies", November 18, 2009 (ADAMS Accession No. ML093220426)

7. Emails from Ray Gallucci to DPO Panel Members (ADAMS Accession No. ML14287A454)

    a. Gallucci to Kozak, Lee, and O'Brien, FW: Draft DELORES-VEWFIRE Review and Comment, February 07, 2017 4:15:14 PM

    b. Gallucci to Kozak, Lee, and O'Brien, FW: Draft DELORES-VEWFIRE Review and Comment, February 07, 2017 4:17:19 PM, Attachment: N-VEWFDS_10_31_2014+ray.docx

    c. Gallucci to Kozak, Lee, and O'Brien, FW: Draft NUREG-2180 (DELORES-VEWFIRE) Report, February 07, 2017 2:43:35 PM, Attachment: image002.png

    d. Gallucci to Kozak, Lee, and O'Brien, FW: Draft Report DELORES-VEWFIRE for NRR Review, February 07, 2017 4:14:27 PM, Attachments: DELORES-VEWFIRE.xlsx and N-DELORES 7_31_2014+ray.pdf

    e. Gallucci to Kozak, Lee, and O'Brien, FW: Endorsing the Un-Endorsable, February 07, 2017 2:52:16 PM

f. Gallucci to Kozak, Lee, and O'Brien, FW: Follow-up Meeting on VEWFDS Draft NUREG-2180 Comments, Tuesday, February 07, 2017 2:48:13 PM, Attachments: Delores-fire.xlsx

g. Gallucci to Kozak, Lee, and O'Brien, FW: IMPENDING PUBLICATION OF DRAFT NUREG, "DETERMINING THE EFFECTIVENESS, LIMITATIONS, AND OPERA...(DELORES-VEWFIRE)," February 07, 2017 2:40:44 PM

h. Gallucci to Lee, Kozak, O'Brien, FW: IMPENDING PUBLICATION OF DRAFT NUREG, "DETERMINING THE EFFECTIVENESS, LIMITATIONS, AND OPERA...(DELORES-VEWFIRE)," February 07, 2017 2:41:38 PM

i. Gallucci to Kozak, Lee, and O'Brien, FW: IMPENDING PUBLICATION OF DRAFT NUREG, "DETERMINING THE EFFECTIVENESS, LIMITATIONS, AND OPERA...(DELORES-VEWFIRE)," February 07, 2017 2:39:39 PM

j. Gallucci to Kozak, Lee, and O'Brien, FW: IMPENDING PUBLICATION OF DRAFT NUREG, "DETERMINING THE EFFECTIVENESS, LIMITATIONS, AND OPERA...(DELORES-VEWFIRE)," February 07, 2017 2:37:53 PM

k. Gallucci to Kozak, Lee, and O'Brien, FW: NUREG-2180 Comments Disposition Meeting Outcome, February 07, 2017 2:46:00 PM, Attachment: image001.png

l. Gallucci to Kozak, Lee, and O'Brien, FW: Pre-Publications NUREG-2180, February 07, 2017 2:50:34 PM, Attachment: image001.png

m. Gallucci to Kozak, Lee, and O'Brien, FW: Pre-Publications NUREG-2180, February 07, 2017 3:07:28 PM, Attachment: image003.png

n. Gallucci to Kozak, Lee, and O'Brien, Cc: Metzger, Brian; Iqbal, Naeem, FW: The simplest explanation for VEWFDS credit, February 07, 2017 10:55:56 AM

8. Publications

a. Credit for Very Early Warning Fire Detection in Fire Probabilistic Risk Assessment, Raymond H. V. Gallucci, Naeem Iqbal, Daniel Frumkin, Brian Metzger and Harold Barrett.

b. Statistical Characterization of the Advanced Notification in Detection Time for Very Early Warning Fire Detection in Nuclear Power Plant Electrical Enclosures, Gabriel J. Taylor, Raymond H. V. Gallucci, Nicholas B. Melly, and Thomas G. Cleary

9. NRC Letter to NEI, J. Gitter to M. Tschiltz, "Response to July 28, 2016, Letter Regarding Retirement of National Fire Protection Association 805 Frequently Asked Question 08-0046, "Incipient Fire Detection System" (ADAMS Accession No. ML16253A11), dated November 17, 2016

10. Public Meeting to Discuss NUREG-2180 DELORES-VEWFIRE (ADAMS Accession No. ML16144A499)

11. Evaluation/Response to NCR-2016-017 (ADAMS Accession No. ML16327A451), dated November 16, 2016

12. NEI letter to NRC, from M.Tschiltz to J. Gitter, "RESPONSE TO JULY 28, 2016, LETTER REGARDING RETIREMENT OF NATIONAL FIRE PROTECTION ASSOCIATION 805 FREQUENTLY ASKED QUESTION 08-0046 "INCIPIENT FIRE DETECTION SYSTEMS" (ADAMS Accession No. ML16302A293), dated October 7, 2016

13. NEI letter to NRC, from M.Tschiltz to J. Gitter, "Industry Response to the July 1, 2016 Letter on Retirement of National Fire Protection Association (NFPA) Standard 805 Frequently Asked Question (FAQ) 08-0046, Incipient Fire Detection Systems," (ADAMS Accession No. ML16211A327 and ML16237A397), dated July 28, 2016

14. NRC letter to NEI from J. Gitter to M. Tschiltz, "Retirement of National Fire Protection Association 805 Frequently Asked Question 08-0046, "Incipient Fire Detection Systems" (ADAMS Accession No. ML16167A444), dated July 1, 2016

NRC Staff Interviewed

DPO-2016-004

To conduct the review, the Panel developed a potential list of staff to interview, and solicited input from the DPO submitter on staff that should be interviewed. Through the course of the interviews, additional staff were identified that should be interviewed given their potential role and knowledge of the subject DPO. The Panel interviewed the following staff:

1. Raymond H. V. Gallucci, Senior Fire PSA Engineer PRA, APLA, Division of Risk Assessment, Office of Nuclear Reactor Regulation

2. Gabriel Taylor, Sr. Fire Protection Engineer, Fire and External Hazard Analysis Branch Division of Risk Analysis, Office of Nuclear Regulatory Research

3. Susan Cooper, Human Factors and Reliability Branch, Division of Risk Analysis, Office of Nuclear Regulatory Research

4. Amy D'Agostino, Human Factors and Reliability Branch, Division of Risk Analysis, Office of Nuclear Regulatory Research

5. Nicholas B. Melly, Fire and External Hazard Analysis Branch Division of Risk Analysis Fire Research Branch, Office of Nuclear Regulatory Research

6. Brian Metzger, Fire Protection Branch, Division of Risk Assessment, Office of Nuclear Reactor Regulation

7. Naeem Iqbal, Fire Protection Branch, Division of Risk Assessment, Office of Nuclear Reactor Regulation

8. J.S. Hyslop, PRA Licensing Branch, Division of Risk Assessment, Office of Nuclear Reactor Regulation

Interview Questions

DPO-2016-004

In conducting the interviews gathering facts and technical information for evaluation of the issues of concern, the Panel used the following standard set of questions to guide the interviews and discussions. Based on the information provided by the interviewee, additional questions and topics would be discussed to ensure that the Panel members obtain sufficient understanding of relevant information to evaluate the issues of concern.

1. What was your involvement with the FAQ, the NUREG, or the endorsement letter? If no official involvement, are you familiar with the technical issues?

2. Is the original FAQ—factor of 50 reduction in CDF incorrect? Is that widely understood and accepted? Is it documented anywhere?

3. Regarding the proposed alternate approach, which suggests that the maximum reduction in CDF is a factor of 5, less than what the NUREG approach would allow.

    - Are you familiar with the proposed alternate approach?
    - Was this alternate approach, or others, considered during the NUREG development?
    - Were formal comments received offering this alternate approach?
    - If so, how were they dispositioned?

4. Was there any consideration to use an approach other than the event tree approach from the FAQ?

5. Why is the MCR non-suppression curve selected for enhanced suppression rather than the welding/cutting or electrical non-suppression curves?

6. HRA—Did you consider or how do you handle the fact that a responder may not remain in the area, but rather reset an alarm and abandon the location?

7. The DPO submitter views this as overly optimistic? Do you have a view—optimistic, realistic, or pessimistic? Can you provide the technical basis or point to technical basis that support your view, on the application of method in the FAQ 08-046, NUREG-2180, or the approach proposed by the DPO submitter.

8. Should the fact that a responder may leave the area be factored into the approach?

9. Should there be some maximum reduction factors in the guidance. The DPO submitter's alternate approach may indicate that there is a limit.

10. What is meant by the term “expectations” in the endorsement memo? Does the license amendment itself or the PRA update guidance in RG 1.200 require the licensee to update the fire PRA using the guidance in the NUREG?

11. Did the NRC consider the need for a backfit for plants that were licensed with fire PRAs that used the FAQ or the correction period, as the DPO submitter suggests?

12. Are there any other people the DPO Panel should talk to?

Discussion Topics with for Determining DPO Statements of Concern

1. Please discuss the main points of your differing opinion to help the Panel develop a concise summary of the issues. We see technical issues and process issues.

2. NUREG-2180 is 485 pages. Can you point out the specific sections that discuss the areas where you disagree? Which chapters/sections are the subject of the DPO? Where is it stated that the MCR non-suppression curve is used and the basis? Where does it describe "pre-empting the fire"?

3. Did you provide comments on the draft NUREG or did you provide your proposed method to RES? What type of review was performed and documented?

4. Who else should the DPO Panel talk to about these issues?

5. FAQ process—where is it described? Have there been other FAQs that were withdrawn? What process was followed?

6. Letter to NEI—"expectation" vs. required to update PRA to use this latest method. Discuss what the PRA standard, NFPA-805, and the licensee specific SER requires regarding PRA updates.

7. When you refer to "pre-emption" are you referring to crediting a de-energization strategy (illustrated in Figure 6-6 of NUREG-2180)? The NUREG discusses this option for in-cabinet applications but does not develop any HEPs.

Assertions of impropriety

1. "This parallels what transpired with the original FAQ back in 2009 when the version I and my fellow engineers had nearly finalized for issuance [FAQ 08-0046] was removed and handed over to staff more amenable to granting Harris the unreasonable amount of credit they were seeking for their transition [NFPA 805 amendment]." [Ref. General Remarks, 1st paragraph]

2. "*Technical defensibility was sacrificed for political expediency to expedite approval of the Harris pilot under NFPA 805*." [Ref. General Remarks, 1st paragraph]

3. "As the most aggressive suppression curve available at the time of the FAQ (leading to the lowest non-suppression probabilities for all fire types), it was ill-advisedly chosen to *maximize the potential risk reduction from installation of VEWFDS so as to expedite Harris's transition to the NFPA 805*." [Ref. General Remarks, 2nd paragraph]

4. "As with the FAQ, this [NUREG 2180] appears to be *a politically-expedient, not technically-defensible, "bone" being given to the industry to again maximize the possible risk reduction credit from VEWFDS so as to not require re-evaluation of already-approved NFPA-805 licenses or hinder those currently under review for transitioning*. Arguments that have been espoused since the FAQ itself, namely that "NRC needs to encourage the installation of these systems, and risk reduction credit is the best way to accomplish this," remain as flawed as ever. One does not *compromise the technical validity of the PRA, the basis for NFPA-805 transition* and future risk-informed applications dependent upon PRA, *to justify encouraging a particular plant modification*." [Ref. General Remarks, 3rd paragraph]

5. "These data were totally disregarded by both the industry and subsequent NRC staff given control the FAQ [FAQ 08-046] after it was "*removed" from the original author and his colleagues*. So, this statement was inaccurate. [Ref. Specific Remarks, No. 1]

6. "The reviewer's [? Need clarification] *dismissal of this concern seems self-serving as an attempt to avoid the potential backfit issue*." [Ref. Specific Remarks, No. 7] "The fact that incorporating my recommendations could *place already-approved licensee for NFPA 805 into "backfit space" (see discussion in non-concurrence), not to mention stifle any remaining approvals, is untenable to the NRC."* [Ref. General Remarks, 1st paragraph]

7. "However, given the entire NFPA-805 program has been built on EXPECTAIONS, it . . . also would default to this compromise *in order to enable transitions that might violate risk metrics*." [Ref. Specific Remarks, No. 9]

The above apparent assertions of impropriety were communicated to the NRC Office of Inspector General on January 30, 2017. See email from P. Lee (member of the DPO Panel) to R. Rossana dated Monday, January 30, 2017 at 2:25 PM.

Document 4: DPO Decision

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

February 8, 2018

MEMORANDUM TO: Raymond H. Gallucci, Senior Reliability and Risk Analyst
Division of Risk Assessment
Office of Nuclear Reactor Regulation

FROM: Brian E. Holian, Acting Director ***/RA/***
Office of Nuclear Reactor Regulation

SUBJECT: DIFFERING PROFESSIONAL OPINION REGARDING RETIREMENT OF NATIONAL FIRE PROTECTION ASSOCIATION 805 FREQUENTLY ASKED QUESTION 08-0046 (DPO-2016-004)

On November 29, 2016, in accordance with Management Directive 10.159, "The NRC Differing Professional Opinions Program," you submitted a differing professional opinion (DPO) regarding the retirement of National Fire Protection Association (NFPA) 805 FAQ 08-0046, "Incipient Fire Detection System." Specifically, your DPO raised concerns that the Frequently Asked Question (FAQ) and the NUREG-2180 methodology, specifically the event tree approach in Chapter 6 to estimate non-suppression probability and the human reliability analysis (HRA) developed in Chapter 10 in support of the Chapter 6 event trees, should not be used as a modeling approach for enhanced suppression (with an additional unquantified option for pre-emption) provided by Very Early Warning Fire Detection System (VEWFDS). The purpose of this memorandum is to respond to your DPO.

On December 22, 2016, a DPO Ad Hoc Review Panel (the Panel) was established and tasked to meet with you, review your DPO submittal, and issue a DPO report, including conclusions and recommendations to me regarding the disposition of the issues presented in your DPO. On February 7, 2017, you met with the Panel to establish a concise statement of concerns. On November 13, 2017, after reviewing the applicable documents, conducting internal interviews of relevant individuals and completing their deliberations, the Panel issued their report to me (Enclosure 1).

In order to make a decision with regard to your DPO, I reviewed your DPO submittal, the Panel's report, and your comments on the Panel report. Additionally, I held discussions with you, the Panel Chairman, the DPO Panel member that provided additional comments, and Division of Risk Assessment (DRA) management.

What follows is a summary of the Panel's findings, recommendations, and my decision.

CONTACT: Trent L. Wertz, NRR
301-415-1568

Statement of Concern

Based on a review of the DPO package, the following concerns were summarized by the Panel as your concerns:

1. The modeling approach for VEWFDS in fire probabilistic risk analyses (PRAs) can impact the occurrence of an electrical enclosure fire that would pass the threshold for inclusion as a "creditable" fire initiator in a fire PRA, via pre-emption, or the time available for fire suppression activities, if the fire cannot be pre-empted, with the latter termed "enhanced fire suppression" in NUREG-2180. The maximum CDF reduction factor crediting both pre-emption and extra time available for suppression is approximately 5, rather than a factor of 10 or more than the methodology of either the FAQ or NUREG-2180 would provide crediting only "enhanced suppression" (potentially even higher with pre-emption credit).
2.
    a. The FAQ and the NUREG-2180 methodology, specifically the event tree approach in Chapter 6 to estimate non-suppression probability and the HRA developed in Chapter 10 in support of the Chapter 6 event trees, should not be used as a modeling approach for enhanced suppression (with an additional unquantified option for pre-emption) provided by VEWFDS. This approach results in overly optimistic results. An alternate approach using data from NUREG-2180 that accounts for pre-emption and enhanced fire suppression is recommended by the DPO submitter.

    b. If the NUREG-2180 methodology is used for VEWFDS enhanced suppression modeling, the original welding/cutting non-suppression curve from NUREG/CR-6850 or the "new" electrical fire non-suppression curve developed for the presence of responders in NUREG-2180 is the maximum credit that should be used. The main control room non-suppression curve should not be used in plant fires.

    c. The human reliability analysis approach in NUREG-2180 described in Chapter 10 to estimate the Field Operator response is overly optimistic. It assumes that a responder, unable to pre-empt a fire, would remain indefinitely at the electrical enclosure as a fire watch until a fire materialized. In reality, if the responder arrived prior to fire manifestation but was unable to pre-empt the fire, the responder would remain there only for a "reasonable" time period (perhaps on the order of one hour). If the fire did not materialize, the responder would reset the VEWFDS and abandon the location, and the entire "scenario" would begin again from scratch. Therefore, crediting the "new" electrical fire curve would only be appropriate within a limited time period for pre-emptible fires that were not pre-empted.

    d. General guidance should be provided that limits the maximum reduction factor for non-suppression probability due to in-cabinet VEWFDS at 5 and for area-wide VEWFDS at 3. Alternate analyses provide the technical justification for these limits. The DPO submitter has provided several approaches to justify this.

3. The endorsement letter of NUREG-2180 stated that there are "expectations" that licensees update their fire PRAs to remove the modeling approach using FAQ 08-0046 and replace it with the approach from NUREG-2180 or another defensible approach. Licensees should be "required" to perform this update. This concern is separate from the technical concerns with the FAQ and NUREG-2180 approaches to VEWFDS modeling (i.e., a change from "expectations" to "requirements" in the endorsement letter

would not affect the other DPO concerns). (Note that this does not imply the DPO submitter approves of the use of NUREG-2180 in its current form, even with the wording correction from “expectations” to “requirements.”)

3. NRC should consider a backfit, or designated “correction period,” for plants that were licensed using the guidance of FAQ 08-0046. Even without NUREG-2180, the continued use of the FAQ would be inappropriate if the error contained within the FAQ was not corrected by the licensee prior to applying it.

DPO Panel Review

The Panel concluded the following:

1. The failure duration of an electrical component (low voltage) for incipient stage of a fire may vary from less than a second to hours or days, and possibly even longer. There is a lack of understanding of the failure mechanisms of electrical components, and there is no agreed upon method to predict the time duration for incipient fire transition to self-sustained combustion stage of a fire or for when electrical components generate sufficient aerosol that can be detectible.

2. The post-incipient stage fire inside an electrical cabinet and potential propagation to nearby combustibles and/or critical targets can be modeled to establish the timeline for the fire progression of a specific fire scenario, with reasonable certainty using readily available fire computer models and well understood fire dynamics and researched data. The quantified timeline of fire progression provides insights on the feasibility and realism of proposed operator actions for fire suppression. The time available for operator response and task times for fire suppression is bounded by the time for fire development and progression to conditions that result in damage to electrical enclosure and subsequent fire damage outside of the electrical enclosure (i.e., end states of event trees) and provides the technical basis for the maximum risk reduction that is appropriate and reasonable for the fire probabilistic risk assessment (FPRA).

3. Neither the NUREG-2180 nor other methods can be readily applied for pre-empting of incipient fires within electrical enclosures, as current data and research do not sufficiently provide assurance of certainty of the incipient fire growth rate and duration. Additionally, there is not adequate data and fire models or analytical tools readily available to characterize, with certainty, the progression of the preheating, pyrolysis, and smoldering of the incipient stage of a fire.

4. The NUREG-2180 method does not restrict a licensee or an applicant to use other alternative approaches to assess the application of VEWFDS at NPP for the FPRA. However, accurate and realistic modeling of the relative new application of VEWFDS at a NPP is required for characterizing the potential risk profiles of fire scenarios that account for specific plant conditions.

5. The new information (i.e., NUREG-2180) for licensees that evaluated the plant risk using the guidance of FAQ 08-0046 may reveal that their results are no longer defensible, which raises the question of how a plant’s licensing basis will be amended. Established plant change control process may be relied upon to screen the significance of changes to site-specific application of FAQ 08-0046 and the potential changes to risk from new

information in NUREG-2180 and determining whether licensees are required to update the overall plant PRA promptly or update based a previously established schedule.

The Panel noted that they were unable to reach unanimous agreement on the conclusions and recommendations for the issues, including supporting technical bases and rationales. A Panel member provided additional conclusions in Appendix 2 of the Panel report.

Based on their review, the Panel made the following recommendations:

1. The Panel recommends that NRC staff review further the application of non-suppression curves to the NUREG-2180 process and the impact of curve selection on the results of the analysis.

2. The Panel recommends that plant procedures, training, and operating experience relative to a licensee's planned response to VEWFDS alerts/alarms is assessed during the initial review of the license application. The Panel also recommends that inspection guidance be developed to review these attributes for licensees who install and credit VEWFDS in their fire PRAs.

3. The Panel recommends that the Agency consider updating RG 1.200 and issuing a RIS to formally document and communicate to all affected licensees the: (1) revised regulatory position in NUREG-2180; and (2) the requirement for all risk-informed license amendment requests to include PRA updates in accordance with the licensee-established procedures, which conform to RG 1.200 and/or the plant-specific licensing bases.

Director's Decision

I agree with the Panel recommendations and provide the following comments and additions to the recommendations.

Regarding Recommendations 1 and 2, you maintain that NUREG-2180 could be "manipulated by licensees to add credit for pre-emption…possibly returning it to the indefensible credit to a factor of 50 erroneously granted by FAQ 46." You clearly feel that your alternative approach developed during the drafting of NUREG-2180 was not pursued. You have requested that your alternative approach be made public. You recognize that industry would most probably not choose your method, as it gives less credit than provided in the NUREG; however, you have chosen the DPO process to ensure that your technically defensible and more conservative views be publically aired. I have attached your comments on the Panel report to my decision to accomplish that purpose, recognizing the Panel's acknowledgement of the validity of your alternate approach. The Panel's first recommendation calls for further staff review of the non-suppression curves. You request that your "strong denial of the propriety of using that for the main control room," which is paramount to the DPO, be considered. I concur and have assigned this task to DRA, NRR, to be completed by October 1, 2018.

The Panel's second recommendation is pointed at NRR's licensing process to ensure that a plant's procedures for responding to early warning fire alarms are adequately assessed during applications. Your DPO strongly objects to the idealized human response assumed in the NUREG that you believe is not borne out by actual experience. Because plant procedures and training materials may not be finalized at the time of the application, I have modified this proposed action. This action is also assigned to DRA, NRR, to assess an applicant's approach

to adequately address procedures and training. Finalized plant procedures and training for a VEWFDS may also be subject to potential future NRC inspection post-NFPA-0805 plant transition. An interim guidance memo will be completed and subsequently incorporated into the standard review plan at a future time, as appropriate. The completion date for this action is March 31, 2018.

An additional aspect of the second recommendation is to ensure that NRC's oversight process inspects key attributes for licensees who credit fire early warning systems. Both you and the Panel highlight the importance of verifying that licensees are appropriately applying credits based on plant-specific procedures. Having our oversight process evaluate implementation will ensure that NRC processes (e.g., enforcement, backfitting, if appropriate) are considered. This action is assigned to the Division of Inspection and Regional Support, NRR, with a completion date of November 1, 2018.

Regarding Recommendation 3, to consider updating RG 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," and issuing a Regulatory Issue Summary to communicate the revised positions in NUREG-2180 and the importance of including PRA updates which conform to RG 1.200, I assign this assessment to DRA (with assistance from DIRS), NRR, with a completion date of May 30, 2018 (to provide the assessment, and a project plan, as necessary).

I note that many of the six conclusions submitted by a single member of the Panel provide additional assessments of the difficulties in modeling this area and appreciate the Panel including them in its report. Aspects of these conclusions will be useful to consider as staff addresses these recommendations. Additionally, I expect that the RIS will clarify the expectation that plants should use their change control processes to update to the latest guidance on applying VEWFDS criteria. Inspection results will assist the staff in verifying proper implementation. Your concerns about proper and timely verification of assumptions used in applying credit for VEWFDS are well founded. You have logically requested that actual experimentation, preferably by industry which seeks the VEWFDS credit, is necessary to develop the preemption likelihood factor. The staff has had to rely on expert judgment to apply credit utilizing the existing knowledge base. I believe that implementing the Panel's recommendations will further consistent application in the field.

A summary of the DPO will be included in the Weekly Information Report (when the case is closed) to advise interested employees of the outcome. The package will be made publicly available since you support that action.

Thank you again for raising the issues in your DPO. I note that the review of your concerns has taken over a year. I apologize for the lengthy time it has taken. The subject area is complicated, and you have raised thoughtful concerns.

An open and thorough exploration of how we carry out our regulatory processes is essential to keeping these programs effective. Your willingness to raise concerns with your colleagues and managers and ensure that your concerns are heard and understood is admirable and vital to ensuring a healthy safety culture within the Agency.

Enclosure:
1. DPO Panel Report, dated November 13, 2017
2. Submitted Comments on Panel report

cc: R. Lorson, NRR
M. Evans, NRR
A. Boland, OE
G. Toledo, OE
M. Franovich, NRR
R. Felts, NRR
M. Johnson, OEDO
K. O'Brien, RI
L. Kozak, RIII
P. Lee, RIII

SUBJECT: DIFFERING PROFESSIONAL OPINION REGARDING RETIREMENT OF NATIONAL FIRE PROTECTION ASSOCIATION 805 FREQUENTLY ASKED QUESTION 08-0046 (DPO-2016-0004) DATED FEBRUARY 8, 2018

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RidsNrrOd
T. Wertz

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OFFICE	NRR
NAME	BHolian
DATE	2/ 8 /18

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Because of the length of the Panel Report and numerous repetitions, it is impractical to address each specific citation here, although such are provided as comments in the mark-up of the Report as an attachment. My objections to overarching themes that recur are as follows.

1. The Report concludes that my approach and that of NUREG-2180 yield similar results in terms of the maximum reduction factor available through the use of VEWFDS. What was missed by the Panel, despite my communication of this several times, is that, unlike NUREG-2180, my approach already incorporates quantitatively a maximum credit for pre-empting the fire in its "pre-fire" stage. NUREG-2180 only addresses this qualitatively, leaving any quantification as an option to the user of the approach. Therefore, my maximum reduction factor of five, which includes both pre-emption and suppression, is much more restrictive, and therefore appropriately conservative for PRA (see Item 8 below), than the suppression-only factor of seven (mistaken by the Panel – the actual factor peaks at nine under the given assumptions of the NUREG, as I showed in my DPO for Cases 1 and 2 of NUREG-2180, Chapter 12, using the main control room suppression curve) from the NUREG, which could be substantially increased with quantification of pre-emption by individual users, possibly "recovering" the erroneous factor of 50 allowed in the original FAQ. With this additional credit, the use of NUREG-2180 would be clearly even more "overly optimistic" than it currently is.[1]

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[1] Early on in the DPO process, I provided this January 30, 2017, e/mail to the Panel to help them gain a perspective on just how much credit a VEWFDS may warrant in the ideal case, as follows.

Subject: *<u>The simplest explanation for VEWFDS credit</u>*

In anticipation of the upcoming DPO conversation, here is a really simple way to view the whole issue. Assume as a base case either no detection at all or just ceiling mounted something or other, such that NO fires can be caught during the pre-flaming ("incipient") phase. Therefore, any suppression must occur only after the fire is detected and then only after flaming (or significant smoke, whatever). For simplicity, assume the response time after being subtracted from the time available for successful suppression had the fire been detected at time zero (when it started) is T. Therefore, the probability of NON-suppression is just exp(-0.098T), where the 0.098/min term is the inverse of the mean time to suppress an electrical enclosure fire (~10 min).

(1) Now, install the most effectively possible VEWFDS (in-cabinet, per-cabinet addressability, etc.). Assume half of all electrical enclosure fires are such that they are detectable during the pre-flaming phase. With perfect human response and complete pre-emption, half of all electrical enclosure "potential" fires will never occur, leaving only 50% to be detected after the pre-flaming stage, as in the case above. However, now credit the VEWFDS as providing much earlier detection for these remaining fires (remember none of these could be detected during pre-flaming [maybe grew too fast, not the "right" type of fire, whatever]) than the above case, say 10 min, such that the probability of NON-suppression (for the remaining 50% of the fires) is reduced by providing an extra 10 min, i.e., 0.5 x exp(-0.098[T+ 10]). Compared to the above case, this is a reduction by a factor of exp(-0.098T)/{0.5 x exp(-0.098[T+10])} = 2 x exp(0.98) = 5.3. Thus, for totally effective pre-emption of half of all such fires AND quicker detection/suppression (for the remaining half), the maximum reduction factor from VEWFDS is ~5.

(2) If you want to stretch and assume 75% of all these fires are detectable in the pre-flaming stage, you double the reduction factor to exp(-0.098T)/{0.25 x exp(-0.098[T+10])} = 4 x exp(0.98) = 10.7, roughly the original maximum factor of 10 from our confiscated FAQ.

A bit more. If you limit the "bonus" time for VEWFDS detection to 5 instead of 10 min (in line with NUREG/CR-6850's original intent and the original data from the Xtralis tests), the reduction factors are decreased to the following values:

(3) exp(-0.098T)/{0.5 x exp(-0.098[T+5])} = 2 x exp(0.49) = 3.3 (vs. 5.3 previously above)

(4) exp(-0.098T)/{0.25 x exp(-0.098[T+5])} = 4 x exp(0.49) = 6.5 (vs. 10.7 previously above).

2. Regarding the estimation of a "pre-emption factor" ("alpha" in NUREG-2180), the Panel fails to address that I originally recommended that a statistically defensible, experimental approach be adopted whereby a sufficient number of electrical panels be subjected to an initial electrical perturbation within a conductor so as to determine which of these potential "pre-fires" eventually evolve into actual ones. Not only would this establish potential pre-fire development times, but also would allow a defensible estimate of a pre-emption factor. The NUREG-2180 approach required subjective interpretation of a fire events database, for which the relevant information for determining such a factor was missing, or judgmental at best. While this may have been the only option available for the NUREG, it would not have been had the experimental program that led to development of this NUREG adopted my recommendation for determining the most important pre-emption factor experimentally.

3. While the Panel recognizes that there may be a large degree of subjectivity in the choice of fire suppression probability curve, it still allows use of the one for main control room fires in certain circumstances. I repeat my contention that this is never appropriate in that (1) the nature of the electrical panel fire is not the same as the for a panel fire in the main control room, precluding similar suppression timing; (2) control room personnel are not "on watch" for a fire during their normal activities, contrary to what would be the case for a first responder already present at a location as a result of a VEWFDS signal – this situation is more accurately characterized by the welding/cutting fire suppression curve for a continuous fire watch or the "new" electrical panel fire curve developed in the NUREG;[2] and (3) the presence of a first responder at the time a non-pre-empted "pre-fire" manifests itself is completely captured by application of the "bonus time" for the electrical panel fire suppression curve, as used in my alternative approach. Note that it would be double-counting to apply a "bonus time" to a suppression curve which already assumes the presence of the responder since curves of this type already incorporate such presence (e.g., welding/cutting or "new" electrical panel fire).[3] Even if the Panel feels there should be choices in the non-suppression curve, it is totally inappropriate for the NUREG baseline model to embed the most optimistic one, the main control room fire curve, thereby establishing this as the starting point for future analyses and industry extrapolations of the approach to achieve even greater reduction (likely recovering the erroneous factor of 50 in the near future with NRC accedence [only my DPO stands in the way]). No NUREG user will ever back off from use of this most optimistic curve.

4. The Panel concludes the HRA approach is representative based on one particular plant's procedures, which have been idealized and already shown in an actual event to be subject to deviation. The plant from which the procedures were drawn deviated from

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[2] This should not be misconstrued to suggest that suppression by a "first responder" should be even more optimistic than in the control room, as this is already covered by the non-suppression curves for a continuous fire watch or the "new" electrical panel fire curve. It is the nature of the control room fire that leads to the lowest non-suppression probabilities coupled with the presence of multiple potential "first responders" via the control room personnel, even if these personnel are not necessarily "on watch" in the sense of expecting a fire. Control room staff are effectively always "on watch" for any possible deviations from normal operation.

[3] The dissenting Panel member also fails to recognize the substantial effect that choice of non-suppression curve can have under the NUREG-2180 approach. As documented in the DPO, change from the overly optimistic main control room suppression curve to the next less optimistic one, the "new" electrical fire curve, can change the reduction factor three-fold, from a peak value of nine according to the Chapter 12 examples to merely three.

posting an indefinite, continuous fire watch when a potential fire was first identified by a VEWFDS, opting, not once, but twice, to reset the VEWFDS alarm and abandon the location when the pre-fire did not manifest itself. Only after the third alarm did the pre-fire manifest, roughly 90 hours after the initial. To uphold this HRA approach as "representative" when it is clearly ideal, regardless of caveats, establishes a non-conservative baseline for application by subsequent users. A more conservative (realistic, in this case) representation such as that in my approach (limited time during which responder will remain awaiting the pre-fire to manifest itself) is more appropriate for PRA (see Item 8, below). This compounds with the non-conservative main control room non-suppression curve discussed above to exacerbate the overall non-conservatism in the baseline NUREG method (see Item 9, below).

5. Regarding citing adoption of the NUREG as a replacement to the rescinded FAQ as an "expectation," clearly citing this as an "expectation" does not carry the weight of citing this as a "requirement." While the Panel goes to great length to try to equate this "expectation" with a "requirement" based on license conditions, commitments, etc., within the NFPA-805 license, and good engineering practice with regard to updating PRAs periodically as per the ASME/ANS PRA Standard, it fails to consider why not just citing this as a "requirement" in the first place would have been much clearer than resorting to these subtle, behind-the-scenes arguments for this "expectation" to be essentially a "requirement." If it truly was a "requirement" rather than an "expectation," the endorsement memo would have stated this definitively. The Panel goes to great length to skirt this simple issue in an effort to exonerate the failure of the memo to establish a "requirement" and permit leniency on the part of the licensee via an "expectation." The memo's intent was clear – "expectation," not "requirement."

6. I offered two alternatives to timing of removal of the credit for the rescinded FAQ and adoption of an alternative approach for licensees – backfit or "designated 'correction period'." Again, the Panel goes to great length to dismiss the backfit option as a path forward, but completely ignores the second option.[4] I purposely included both so as to allow for flexibility, yet the Report treats my recommendation as if it was solely one option.

7. The Report acknowledges that both the NUREG-2180 and my alternative approach are reasonable given the limitations inherent in the VEWFDS technology and current supporting data (e.g., lack of basis for a pre-emption factor). It goes on to state that "the NUREG-2180 method does not restrict a licensee or an applicant from using other alternative approaches, including the approach described by the DPO submitter." Nonetheless, while the submitter offered alternative approaches throughout the development of NUREG-2180, none were ever considered and only the NUREG-2180 approach was endorsed. This effectively establishes NUREG-2180 as NRC's endorsed approach to replace the rescinded FAQ, with no knowledge conveyed even of what the Panel itself considers a reasonable alternative, namely that provided by me. <u>Given that any recall or even modification of the endorsement of NUREG-2180 will not occur, at least the additional unveiling and endorsement of my alternative approach(es) should be made so as to place it on an equal footing as an acceptable option along with NUREG-2180, the latter's faults as enumerated herein notwithstanding.</u>

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[4] I recognize that the dissenting Panel member chose to address this second option, finding it a reasonable alternative. However, this member's view was not incorporated into the consensus Panel Report.

8. A fundamental principle of PRA is ignored throughout the Report. “When in doubt, opt for conservatism.” My approach provides bounding estimates of the maximum possible credit for use of a VEWFDS, including both pre-emption (to the extent possible given the current limitations) and suppression. It uses actual results from NUREG-2180 where appropriate. Therefore, it is a conservative approach that bounds the credit available for these systems under the current state of knowledge. NUREG-2180 incorporates several non-conservative, optimistic assumptions, in particular use of the main control room suppression curve and an idealized procedural response for the HRA, in a limited capacity, i.e., quantifying only the suppression aspect while leaving open-ended the pre-emption aspect to the user’s discretion. Yet this already yields potentially more credit than my complete approach, and this credit could very well be restored to the erroneous factor of 50 allowed by the rescinded FAQ via a licensee’s manipulation. This is totally inconsistent with how PRA should be applied in a regulatory framework.

9. For over a decade now, the nuclear industry has been complaining how fire PRA is much too conservative, citing the “compounding of conservative models” from NUREG/CR-6850 as the primary culprit. Now comes along NUREG-2180 which does the complete opposite by compounding non-conservatisms in two key areas – choice of the main control room fire non-suppression curve, exorbitantly optimistic and, therefore, non-conservative, and idealized human response, not borne out by actual experience. Both of these are embedded in NUREG-2180, including the accompanying Excel spreadsheet, as the baseline case. By doing so, the NUREG has set this optimistic case yielding the maximum reduction credit as the starting point for subsequent industry manipulations as they strive to recover the erroneous factor of 50 granted by the now rescinded FAQ. And they will be successful, given they are already starting with a peak reduction factor of nine, thanks to these compounded non-conservatisms. Already they have proposed a FAQ and “VEWFDS Credit Recovery” plans to achieve this goal, and they have not yet even tampered with the pre-emption factor, just the “enhanced suppression” aspect. I am convinced that industry will soon recover the factor of 50 reduction through their manipulations as nothing stands in their way except my DPO. The NUREG authors and reviewers, except for myself, have already shown a willingness to accede to relaxations and non-conservatisms championed by the industry in just this idealized baseline version of the NUREG. It is a short step to a modified version that recovers the erroneous factor of 50 first granted by the now rescinded FAQ.