FAQ Number	**13-0001**	**FAQ Revision**	**0c**
FAQ Title	**Clarifications on Treatment of VEWFDS to Support NFPA 805 Risk Analysis**		

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Purpose of FAQ:

The purpose of the FAQ is clarify the treatment of incipient fire detection systems in a Fire PRA Model used to support NFPA 805. Specifically the two areas addressed by this FAQ are:

- Continuously occupied locations (including within MCBs)
- Clarification on the application of FAQ 08-0046~~Area-wide in a non-continuously occupied location~~

Guidance for the treatment of such a system with respect to hardware failure rates and its relationship with the NUREG/CR-6850 / EPRI TR-1011989, Appendix P treatment of fire suppression is not currently available.

Details:

NRC document needing interpretation (include document number and title, section, paragraph, and line numbers as applicable):
None

Circumstances requiring guidance interpretation or new guidance:
New guidance

Detail contentious points if licensee and NRC have not reached consensus on the facts and circumstances:
None

Potentially relevant existing FAQ numbers:
FAQ 08-0046 (NUREG/CR-6850, Supplement 1): Incipient Fire Detection Systems
FAQ 08-0050 (NUREG/CR-6850, Supplement 1): Manual Fire Non Suppression Probability

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Response Section:

Proposed resolution of FAQ and the basis for the proposal:

INTRODUCTION

The purpose of Fire PRA FAQ 13-0001 is to provide supplemental guidance for the treatment of aspirating smoke detectors (ASD) installed as very early warning fire detectors (VEWFDs) as defined by NFPA 76 (2009) and to provide clarification to the guidance and recommendations ~~. The treatment of such a system in a fire PRA (FPRA) is described~~ in NFPA 805 FAQ 08-0046 (NUREG/CR-6850, Supplement 1). The supplemental guidance being provided in this FAQ addresses the the application of ASD installed in c~~However, based on discussions with the NRC, FAQ 08-0046 is only applicable for in-cabinet installations in locations that are not continuously occupied. The purpose of FAQ 13-0001 is to address the treatment of an ASD installed as a VEWFD for two additional applications.~~

- ~~C~~ontinuously occupied locations (including within MCBs)
- ~~Area wide in a non-continuously occupied location~~

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BACKGROUND

The current NRC interpretation of the guidance in FAQ 08-0046 is that it is only applicable to locations that are not continuously occupied. In addition, FAQ 08-0046 presents a simplified approach wherein successful response to an ASD alarm condition results in no fire propagation beyond the originating electrical cabinet (panel) but damage throughout that cabinet (panel) occurs.~~can only be credited for preventing fire propagation unless details beyond that presented in the FAQ is developed.~~ No guidance is currently available when an ASD system is installed in a continuously occupied location~~, in an area-wide application,~~ or if such a system is relied upon as part of an integrated response to prevent the occurrence of a fire.

The basis for the limited application of FAQ 08-0046 is not explicitly documented but can be inferred from the details provided in the FAQ.

- Only for locations that are not continuously occupied: The existing FPRA treatment guidance includes manual fire suppression failure probabilities in NUREG/CR-6850, Appendix P and FAQ 08-0050 (Supplement 1). This existing guidance provides credit for improved manual suppression reliability for the Main Control Room (MCR) (i.e., a continuously occupied location). In addition, the recommended treatment for the Main Control Board (MCB) in the MCR in NUREG/CR-6850, Appendix L includes credit for manual suppression. As such, there is some potential dependency between reliability of fire suppression given an ASD system versus that without such a system. Using the ASD treatment as described in FAQ 08-0046 would effectively treat it as an independent parameter and would ignore this potential dependency.
- Can only be credited for preventing fire propagation: One of the event tree nodes in FAQ 08-0046 is identified using the parameter δ, "Technician Successful in Preventing Fire in Incipient Stage." The simplified version of the event tree that was ultimately used in FAQ 08-0046 notes that this node is set to 1.0. If the simplified event tree is used and the typographical error corrected in the characterization of sequences 1 and 2, then all sequences from the event tree result in at least damage throughout the cabinet.

Comment [A1]: Not sure what error is being referred to here. Perhaps "No fire" should be replaced by "damage to component". With respect to the branching points in Figures 13-1 and 13-2, success is up and failure is down and the event tree is consistent with that.

KLZ - The first sequence is Fig 13-2 is labeled No Fire, the second sequence is labeled No Fire Damage to Targets outside Cabinet – please describe the damage characterization for these two sequences.

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DISCUSSION

The current treatment of postulated fires in the MCB is described in NUREG/CR-6850, Appendix L. Although the guidance in this Appendix is applicable only to the MCB, it provides key insights as to the treatment of fire detection and suppression. A key insight from this guidance is that the conditional probability that a fire at any location within the MCB results in damage beyond the ignition source is less than approximately 8E-3. This value is taken from Figure L-1 using d = 0 m. As described in Appendix L, this value would be multiplied by the MCB fire frequency to obtain the frequency of the specific event. The discussion in Appendix L and the development of the analysis used to generate the results shown in Figure L-1 shows that credit for manual suppression using the λ term of 0.33 from Appendix P is included.

In Section P.1.3, the following two items are noted:

> *If in-cabinet smoke detection devices are installed in the electrical cabinet postulated as the ignition source, the analyst should assume that the fire will be detected in its incipient stage. This incipient stage is assumed to have a duration of 5 minutes.*
>
> ~~*Prompt detection should be only credited when … a high sensitivity smoke detection system is installed. …*~~

The following treatment~~s~~ can therefore be considered to be within the existing methodology of NUREG/CR-6850.

- If an in-cabinet smoke detector is available in the MCB, then the Appendix L treatment can be modified to provide an additional 5 minutes for fire suppression.
- If an in-cabinet smoke detector is available in an electrical cabinet (panel), then successful suppression at 5 minutes would prevent the occurrence of a fire, be equivalent to no damage beyond the individual incipient source within the cabinet (panel), and would not require any additional procedural guidance or features such as those described in FAQ 08-0046 for the δ parameter, "Technician Successful in Preventing Fire in Incipient Stage."~~.~~

The treatment framework already described in NUREG/CR-6850 will be used to establish an 'anchor' point as part of the process of developing recommendations for the crediting of an ASD installed as a VEWFD as defined by NFPA 76 for applications beyond those addressed by FAQ 08-0046.

<u>In-Cabinet Smoke Detectors</u> – The credit available for the presence of in-cabinet smoke detectors is described in NUREG/CR-6850. Three cases are considered:

1. MCB panel in the MCR
2. Non-MCB panel in the Main Control Room
3. Electrical cabinet in a non-continuously occupied location

    1. MCB Panel in the MCR – The current guidance in NUREG/CR-6850 recommends that a FPRA treat the presence of an in-cabinet smoke detector in the MCB by considering the availability of an alarm before it would have otherwise been detected by the control room operators. The guidance states that this advance warning would occur during an assumed 5 minute incipient period. This credit in the treatment can be directly calculated using the information in Appendix L.

$$\text{From Appendix } L:$$

$$[SF \bullet P_{ns}](d) = \frac{1}{H \bullet W} \int_0^H \int_0^W SF(d,w,h) \bullet P_{ns}(d,w,h)\,dw\,dh$$

$$P_{ns}(d,w,h) = e^{-\lambda \bullet t}$$

With a traditional non-aspirating (e.g., ionization) smoke detector installed inside the MCB, the suppression term $e^{-\lambda t}$ would become $e^{-\lambda(t+5)}$. The ratio of these two factors can then be applied to the original equation from Appendix L. The net result is that a constant factor is added as shown below.

$$[SF \bullet P_{ns}](d) = \frac{1}{H \bullet W} \int_0^H \int_0^W SF(d,w,h) \bullet P_{ns}(d,w,h)\,dw\,dh \bullet \frac{e^{-\lambda \bullet (t+5)}}{e^{-\lambda \bullet t}}$$

$$[SF \bullet P_{ns}](d) = e^{-\lambda \bullet 5} \bullet \frac{1}{H \bullet W} \int_0^H \int_0^W SF(d,w,h) \bullet P_{ns}(d,w,h)\,dw\,dh$$

$$\lambda = 0.33, \text{ and therefore, } e^{-\lambda \bullet 5} = 0.19$$

This development shows that if a traditional non-aspirating smoke detector were to be installed in a MCB, application of the existing guidance in NUREG/CR-6850 would result in the factors taken from Appendix L, Figure L-1, being reduced by a factor of 0.19 (plus the random hardware failure probability for the detector).

–The only readily available guidance for the hardware failure probability for a traditional non-aspirating smoke detector is NUREG/CR-6850, Appendix P. This appendix provides a simplified bounding value of 5E-02 which is known to significantly over-estimate the failure probability. This over-estimation is evidenced by considering the failure probability of 4E-02 ~~for a CO_2~~ recommended in NUREG/CR-6850 for a CO_2 suppression system. Since many CO_2 flooding systems are actuated by cross-zoned smoke detectors, the failure of either zone of detectors would prevent system actuation. If it is assumed that the non-detector portion of the CO_2 system has the same failure probability as the detectors, then:

$P_a + P_b + P_{CO2} = 4E\text{-}02$, where P_a and P_b represent the two zones of smoke detectors and P_{CO2} represents the remainder of the CO_2 system

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Since $P_a = P_b$, and it is assumed that $P_{CO2} = P_a + P_b$, then $P_a = 1E\text{-}02$

Therefore, the random failure probability that should be used for a traditional non-aspiring smoke detector is 1E-02. This value is conservative on the basis that a relatively simple traditional non-aspiring smoke detector would reasonably be expected to have a random failure probability lower than the more complex active ASD detector which has a recommended failure probability of 1E-02 as noted in FAQ 08-0046. This value should be added to the 0.19 factor calculated earlier yielding a total value of 0.20.

~~Including hardware failure would result in this value being increased to 0.24 (0.19 + .05).~~ If instead, an ASD installed as a VEWFD were to be used instead, the associated reduction factor should be lower than 0.204. The lower value would be based on the additional time associated with the advance warning that would be appropriate given the presence of an ASD system. Although FAQ 08-0046 assumes that, an hour of warning would be available, that timing is based on the onset of open flaming. It is evident that prior to open flaming, enough smoke would be generated that it would be recognized by the MCR staff. In order to eliminate concerns related to dependencies between the detection mechanisms while still providing for a reasonable credit for the ASD system, a value less than 60 minutes should be used. As an example, the advance warning time could be increased from 5 minutes to 10 minutes (ASD system provides an additional 5 minutes of advance warning). In addition, the screening hardware failure probability of 0.01 from FAQ 08-0046 should also be included.

$$e^{-\lambda(10)} + 0.01 = e^{-0.33(10)} + 0.01 \sim 0.05$$

It is recognized that the result of this treatment is sensitive to the time duration assumed. The results of a sensitivity study as the value of this additional delay varies.

Continuously Occupied Location	
ASD Detection Credit (min.) [1]	Appendix L Adjustment Factor
0	0.20
5	0.05
10	0.02
15	0.01
20	0.01
25	0.01
30	0.01

Note 1: The time duration refers to the additional time warning provided by the ASD system as compared to a traditional non-aspirating smoke detector

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The performance of an ASD system as compared to a non-aspirating smoke detector is undergoing testing by the NRC. Preliminary test results do not provide sufficient evidence to support assigning specific guidance. In order to provide interim guidance and to ensure the treatment is bounding, a value of 0.20 is recommended until such time additional test results are available. As noted above, this value should be applied together with the parameters from Figure L-1 of NUREG/CR-6850 and represents the fraction of fire events the results in damage beyond the individual component within the MCB.

The extent of internal fire damage within the MCB should be treated using the existing guidance in Appendix L of NUREG/CR-6850.

2. Non-MCB Panel in the Main Control Room – The current guidance in NUREG/CR-6850 recommends that a FPRA treat the presence of an in-cabinet smoke detector by considering the availability of an alarm before it would have otherwise been detected by other means. The guidance states that this advance warning would occur during an assumed 5 minute incipient period. As discussed in the previous section, if an ASD installed as VEWFD were to be used instead, no additional advance warning should be credited until such time more complete test results are available.

   If the panel is located in the MCR and in the same general proximity to the MCR staff as the MCB, then a non-suppression factor of 0.20 should be used ~~.~~and represents the fraction of fire events the results in damage beyond the individual component within the electrical cabinet (panel).

   The extent of internal fire damage within a panel requires further guidance. If suppression is successful, then the fire would still be in its incipient phase and no damage beyond the individual ignition source within the enclosure should be considered. If the fire is not suppressed, then the postulated fire should be assumed to grow and be treated using the existing guidance in NUREG/CR-6850.

3. Electrical Cabinet in a Non-Continuously Occupied Location – The current guidance in NUREG/CR-6850 recommends that a FPRA treat the presence an in-cabinet smoke detector by considering the availability of an alarm before it would have otherwise been detected by other means. The guidance states that this 'advance' warning would occur during an assumed 5 minute incipient period. If the panel is in a location that is not continuously occupied, then the manual suppression characteristics documented in FAQ 08-0050 (Supplement 1) and the values in Table 14-1 should be used. As noted in the prior discussions, pending further testing results, only five minutes of advance warning should be credited if in-cabinet detection is provided (regardless of whether it is ASD or non-aspiring). The five minutes of available incipient time for electrical fires (cabinets and panels) translates to a probability of 0.60. Adding the screening hardware failure probability of 0.01 ~~from FAQ 08-0046~~ yields a non-suppression probability of 0.61 and represents the fraction of fire events the results in damage beyond the individual component within the electrical cabinet (panel). It is noted that scenario-specific adjustments to this value can be made as appropriate using the guidance in FAQ 08-0050 (Supplement 1).

   The extent of internal fire damage within a panel requires further guidance. If suppression is successful, then the fire would still be in its incipient phase and no

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damage beyond the individual ignition source within the enclosure should be considered. If the fire is not suppressed, then the postulated fire should be assumed to grow and be treated using the existing guidance in NUREG/CR-6850.