June 19, 2009

MEMORANDUM TO: AFPB File

FROM: Alexander R. Klein, Chief ***/RA/***
Fire Protection Branch
Division of Risk Assessment
Office of Nuclear Reactor Regulation

SUBJECT: PUBLIC RELEASE OF DRAFT INTERIM POSITION REGARDING NATIONAL FIRE PROTECTION ASSOCIATION 805 FREQUENTLY ASKED QUESTION 08-0050 MANUAL NON SUPPRESSION PROBABILITY

The purpose of this memorandum is to release for comment the enclosed draft interim position regarding National Fire Protection Association (NFPA) Standard 805 Frequently Asked Question (FAQ) 08-0050 to the public and the Nuclear Energy Institute NFPA 805 Task Force. Comments on the enclosed draft interim position are due by July 20, 2009. Comments should be sent to one of the contacts below.

The enclosed draft interim position was previously sent for comment under the joint U. S. Nuclear Regulatory Commission's Office of Nuclear Regulatory Research (RES) / Electric Power Research Institute Memorandum of Understanding (MOU) process. RES and the NRC's Office of Nuclear Reactor Regulation (NRR) collaborated on resolving the comments that were received from the MOU, and the enclosed position represents a joint position on this FAQ between RES and NRR.

Enclosure:
As Stated

CONTACT: Ray Gallucci, NRR/DRA
Ray,Gallucci@nrc.gov
(301) 415-1255

Charles Moulton, NRR/DRA
Charles.Moulton@nrc.gov
(301) 415-2751

MEMORANDUM TO: AFPB File

FROM: Alexander R. Klein, Chief
Fire Protection Branch
Division of Risk Assessment
Office of Nuclear Reactor Regulation

SUBJECT: PUBLIC RELEASE OF DRAFT INTERIM POSITION REGARDING NATIONAL FIRE PROTECTION ASSOCIATION 805 FREQUENTLY ASKED QUESTION 08-0050 MANUAL NON SUPPRESSION PROBABILITY

The purpose of this memorandum is to release for comment the enclosed draft interim position regarding National Fire Protection Association (NFPA) Standard 805 Frequently Asked Question (FAQ) 08-0050 to the public and the Nuclear Energy Institute NFPA 805 Task Force. Comments on the enclosed draft interim position are due by July 20, 2009. Comments should be sent to one of the contacts below.

The enclosed draft interim position was previously sent for comment under the joint U. S. Nuclear Regulatory Commission's Office of Nuclear Regulatory Research (RES) / Electric Power Research Institute Memorandum of Understanding (MOU) process. RES and the NRC's Office of Nuclear Reactor Regulation (NRR) collaborated on resolving the comments that were received from the MOU, and the enclosed position represents a joint position on this FAQ between RES and NRR.

DISTRIBUTION:

DRA r/f	AKlein	HBarrett	PLain	SWeerakkody	CMoulton	RGallucci
JHyslop	DHarrison	MSalley	NSiu	MCunningham	GParry	

ADAMS Accession No.: ML091680045 *via email

OFFICE	NRR/DRA/AFPB	NRR/DRA/AFPB	RES/DRA/FRB	NRR/DRA/APLA
NAME	RGallucci*	AKlein	MSalley*	DHarrison*
DATE	06/ 16 /09	06/ 19 /09	06/ 17 /09	06/ 15 /09

OFFICIAL RECORD COPY

FAQ 08-0050: Manual Non-Suppression Probability

Guidance on Manual Non-Suppression Probability and Adjustment for Scenario-Specific Fire Brigade Response, as per NUREG/CR-6850

Background:

Frequently Asked Questions (FAQ) 08-0050 was proposed by the Nuclear Energy Institute (NEI), through its National Fire Protection Association (NFPA) 805 Task Force, to clarify the guidance from NEI 04-02, "Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program under Title 10 of the *Code of Federal Regulations* Part 50 (10 CFR) 50.48(c)," which in turn cited guidance on manual non-suppression probability provided in NUREG/CR-6850 (EPRI 1011989), "EPRI/NRC-RES Fire Probabilistic Risk Assessment (PRA) Methodology for Nuclear Power Facilities." This guidance required the separate consideration of fire brigade response time in manual non-suppression analysis, despite its inclusion in much of the analysis. The purpose of this FAQ is to update guidance provided in NUREG/CR-6850 / EPRI TR-1011989, Appendix P, for the treatment of manual suppression and the fire brigade response. As a part of this update, a process has also been developed to adjust the non-suppression analysis for scenario-specific fire brigade responses.

In order to achieve closure of this FAQ in a timely manner, the Nuclear Regulatory Commission (NRC) developed a draft interim staff position, as discussed below. This position was developed using currently existing information, databases, and experimental results, and should not be seen as prejudicing the NRC's view of future developments in this area.

Discussion:

Introduction

The suppression time of a fire is an important factor in the determination of the likelihood of fire-induced damage to a component. This time, labeled as T_{supp} in this FAQ, is the time interval between when the fire is detected and when it is suppressed. Note that, depending upon the severity of the fire, the plant's fire brigade may be called to respond. Figure 1 shows the conceptual relationship between T_{det} (the time interval between the start of the fire and when the fire is initially detected), T_{supp}, and T_{fb}, the time from fire detection until the fire brigade begins to apply suppressant agents.[1]

[1] Note that T_{det}, T_{supp} and T_{fb} vary from fire to fire, and are treated statistically in the fire PRA.

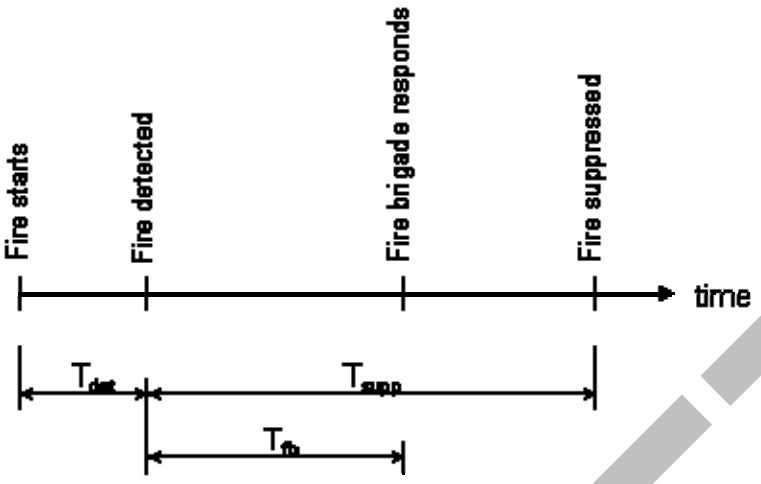

Figure 1. Conceptual relationship between fire detection time, suppression time, and fire brigade response time

As discussed in NUREG/CR-6850 - EPRI TR-1011989 (referred to in the remainder of this FAQ as NUREG/CR-6850 for brevity), the probability of non-suppression by time t, $P_{ns}(t)$, is given by

$P_{ns}(t) = Pr(T_{supp} \geq t)$

When used in computing the probability of fire-induced damage, t refers to the time available before damage to fire PRA targets occurs. Thus, in this application, t is replaced by the estimated time to damage minus the estimated time to detect the fire, i.e., $<T_{damage}> - <T_{det}>$. This difference represents the estimated time available to suppress the fire. Methods to compute $<T_{damage}>$ and $<T_{det}>$ are described in NUREG/CR-6850.

Note also that this definition of time available to suppress the fire differs from NUREG/CR-6850 in that it does not require an adjustment for T_{fb} (the fire brigade response time). That is, NUREG/CR-6850 defines the time available for manual suppression as the time to damage minus the time to detection minus the fire brigade response time, i.e., $<T_{damage}> - <T_{det}> - <T_{fb}>$. Under the revised approach, the fire brigade response time is already included in the distribution for T_{supp}, as discussed below.

Thus, the probability of fire-induced damage is given by:

$P_{damage} = P_{ns}(<T_{damage}> - <T_{det}>) = Pr(T_{supp} \geq [<T_{damage}> - <T_{det}>])$

Two complications in the development of $P_{ns}(t)$ are:

(1) available data records for actual fire events often are incomplete or ambiguous regarding the detection time, suppression time, and brigade role and response time; and
(2) NUREG/CR-6850 does not provide guidance as to how generic non-suppression probability distributions can be revised to reflect scenario-specific considerations (e.g., difficult-to-access fire locations) which can affect the fire brigade response time.

This FAQ provides clarifying and revised guidance for the estimation of $P_{ns}(t)$.

Solution

This solution addresses the probability of non-suppression for scenarios involving manual fire suppression (i.e., sequences D, E, H, I, L, and M in Figure P-1 of NUREG/CR-6850). In particular, this approach recognizes that manual suppression in these particular scenarios includes suppression activities by non-fire brigade personnel. Hence, there is some probability of manual suppression prior to arrival of the fire brigade. The solution is provided in two parts. The first part addresses cases where the fire brigade response time for the scenario being analyzed is judged to be comparable to the industry average. The second part addresses the process for making adjustments for cases where it is judged that the fire brigade response time distribution is significantly different from that underlying the events reported in the EPRI Fire Events Database.

(1) Industry-average response
Figure 2 provides revised non-suppression probability curves to be used when there are no scenario-specific factors that would tend to make the fire brigade response significantly different from the population of responses included in available data. Furthermore, the non-suppression curves are used either when (a) the fire is not suppressed by automatic fixed suppression systems[2] nor suppressed by manual actuation of a fixed suppression system (i.e., "AS" and "MF" fails leading to sequences H, I. L, and M) or (b) these failures of automatic fixed suppression systems, and their manual actuation, are preceded by a failure to promptly suppress the fire (i.e., "PS" also fails leading to sequences D and E).

(2) Scenario-specific adjustments
For cases where it is judged that the fire scenario being analyzed involves factors that will significantly affect fire brigade response (i.e., lead to a scenario-specific fire brigade response time more than 5 minutes different than the nominal fire brigade response time), the following approach may be used to estimate the impact of these factors on the probability of non-suppression.

- Identify the scenario-specific factors expected to significantly affect T_{fb} , which is composed of the time for the fire brigade to reach the fire (after the fire is initially detected) and the time for the brigade to begin applying suppressants to the fire. Consider the location, accessibility, and type of fire; the location and condition of necessary equipment (e.g., hose stations) and material; and any special features of the fire location (e.g., proximity to sensitive equipment) that could affect the fire brigade's decisions and actions.
- Document those factors judged to make the scenario unusual in comparison with fire scenarios more typical for the plant being analyzed.
- Estimate $<T_{fb\text{-}t}>$ and $<T_{fb\text{-}s}>$, the mean typical and scenario-specific fire brigade response times,[3] respectively, and document the basis (e.g., fire brigade response exercise results) for these estimates.
- Compute the probability of non-suppression as follows:

$$P_{ns}(t) = F_{ns,i}(t \cdot C_s) = \exp[-\lambda(t \cdot C_s)]$$

where $F_{ns,i}(\bullet)$ is the exponential function for the appropriate non-suppression curve from Figure

[2] Automatic systems are unavailable, fail, or are assessed as not effective against the fire scenario.

[3] Recall that T_{fb}, even for a well-specified fire scenario, is a statistical variable.

2, λ is the corresponding mean suppression rate (1/time) from Table 2 below, and C_s is a scenario-specific adjustment factor:

$$C_s = 1 - \left[\frac{\langle T_{fb-s} \rangle - \langle T_{fb-t} \rangle}{\langle T_{fb-s} \rangle + \langle T_{fb-t} \rangle} \right]$$

Basis

(1) Industry-average response

The non-suppression curves in Figure 2 and associated tabulated values in Table 1 are based on a re-analysis of the 250 manual suppression fire events addressed in NUREG/CR-6850. Suppression rates for this re-analysis are provided in Table 2. This re-analysis provides a treatment of available data for fire duration and fire suppression times that is more consistent with the conceptual framework shown in Figure 1. It recognizes that manual suppression is a continuous activity that can begin once the fire is detected, rather than rely primarily on fire brigade suppression efforts.

The non-suppression curves from NUREG/CR-6850 and from this FAQ are each based on data provided in the EPRI Fire Events Database. This data is contained in Table 3. However, NUREG/CR-6850 uses, when possible, data entered in the "suppression time" field of the database. (For those events where suppression times are not provided, NUREG/CR-6850 uses the fire duration data[4] entered in the EPRI Fire Events Database.) In this FAQ, the non-suppression curves are based on data provided in the "fire duration" field of the database[5]. The recorded fire duration is the time from fire detection to extinguishment, and generally corresponds to T_{supp} in Figure 1.

As discussed earlier, the treatment in this re-analysis avoids the need to subtract the fire brigade response time from the available time to suppress the fire when estimating the damage probability. Thus, this treatment eliminates a conservatism inherent in NUREG/CR-6850 with respect to fire brigade response times.

The non-suppression curves respond to the uncertainty in the fire duration data in a manner consistent with that used in NUREG/CR-6850. Approximately 70 manually-suppressed fire events in the EPRI Fire Events Database have duration data entered as a range (e.g. "16 to 30 minutes" or "less than 5 minutes"). For such events, all points in the range are treated as being equally likely and the midpoint of the range is used in the numerical analysis, i.e., 23 min and 2 min, respectively, for the examples.

It should be noted that the analysis underlying Figure 2 has removed four fire events treated in NUREG/CR-6850. Three incidents (1176, 1345, and 2469 impacting the Transient and Welding non-suppression curves) occurred in outside areas (2 events in a service building and 1 event in a steam generator construction area) and are outside the scope of this re-analysis. Incident 1483 (involving an oil fire) appears to be a duplicate of incident 1482 based on identical event descriptions. This event was also removed. In addition to these

[4] Fire duration and suppression time have specific database fields, and the times were taken from these fields.

[5] In a few exceptions, the duration times in the description of the event contradict the field. For those cases, the duration extracted from the event description is used in the analysis.

four removals, one event, incident 821, was transferred from the analysis of electrical fires to that of oil fires. The associated description and data are more consistent with an oil fire.

(2) Scenario-specific response

The non-suppression distributions shown in Figure 2 are derived from an analysis of events in which the fires were manually suppressed. Some (but not all) of these events were suppressed by the plant fire brigade, and so the non-suppression distributions implicitly include the fire brigade response. The purpose of the adjustment described in the Solution portion of this FAQ is to address scenarios where the fire brigade response is expected to be very different from that included in the Figure 2 curves.

Although methods are available for estimating the contribution of the fire brigade response time to the overall fire duration (taking account of the uncertainties in the available data), such methods have not yet been fully tested with current data and incorporated into software tools for fire PRA practitioners. The FAQ solution uses a simple adjustment factor, labeled C_s above, that exhibits the following, appropriate trends as $<T_{fb\text{-}s}>$ and $<T_{fb\text{-}t}>$ change.

1) If the scenario-specific fire brigade response is quicker than a typical response (i.e., $<T_{fb\text{-}s}>$ is less than $<T_{fb\text{-}t}>$) then $C_s > 1$ (i.e., the effective time available for manual suppression is increased).
2) If the scenario-specific fire brigade response is slower than a typical response (i.e., $<T_{fb\text{-}s}>$ is greater than $<T_{fb\text{-}t}>$), then $C_s < 1$ (i.e., the effective time available for manual suppression is decreased).
3) If the scenario-specific fire brigade response is the same as a typical response (i.e., $<T_{fb\text{-}s}>$ equals $<T_{fb\text{-}t}>$), then $C_s = 1$ (i.e., there is no adjustment).

(3) Correction factor

The correction factor (C_s) is not based on a first-principles analysis. Rather, the factor was derived largely on an empirical basis in order to achieve the desired behavior. The objective was to create a relatively straight-forward correction factor that adjusted the available time to reflect fire brigade responses that were either faster or slower than the typical case. Additional desirable characteristics of the adjustment include the following items:

- The magnitude of the adjustment should not be excessive for any cases. The objective for the interim position (e.g., pending additional validating research) was to allow for modest changes from generic values to reflect case-specific conditions.
- The adjustment factor should reflect that small differences in response time are generally more significant if the typical response time is small than if the typical response time is large. For example, a 5 minute difference in brigade response time is more significant to the overall fire behavior when the brigade response occurs within a 10-15 minute time frame than it is if the brigade response occurs within a 30-35 time frame.
- The adjustment factor should never be less than or equal to zero (that is, $C_s>0$ for all cases). If $C_s \leq 0$ for a given case, then no credit whatsoever would be given to manual fire suppression regardless of the time available before fire damage occurs.
- Even if the fire brigade response time exceeds the time available for suppression, the probability of non-suppression should still reflect the potential that other plant personnel may intervene and suppress the fire. This characteristic is consistent with the intent of the original FAQ.
- The correction factor should work for all practical cases without the need for additional rule sets to limit application or to correct anomalous results.

The form of the adjustment factor used derives from common temperature normalization forms used in heat transfer, especially when dealing with various conduction and convection problems where temperature differences tend to dominate the solution. This form does provide all of the desired characteristics listed above.

Recall that the correction factor is defined as follows:

$$C_s = 1 - \left[\frac{\langle T_{fb-s} \rangle - \langle T_{fb-t} \rangle}{\langle T_{fb-s} \rangle + \langle T_{fb-t} \rangle} \right]$$

The summation in the denominator may appear arbitrary, but is important because it acts to de-emphasize small changes in larger numbers and prevents the correction factor from going to zero, at least for practical applications. Other potential formulations not utilizing the summation in the denominator (e.g., normalizing using just $<T_{fb-s}>$ or $<T_{fb-t}>$) were generally found to be too volatile (yielding excessively large corrections) and tended to yield anomalous or unreasonable results for certain types of cases (e.g., yielding $C_s \leq 0$ for some cases). Other forms, such as a simple linear shift in the time available, also tended to yield anomalous results for certain types of cases requiring the application of additional rule sets to correct such cases.

The analyst may also note that the following is an equivalent numerical form for the correction factor:

$$C_s = \left[\frac{\langle T_{fb-t} \rangle}{(1/2)\left(\langle T_{fb-s} \rangle + \langle T_{fb-t} \rangle\right)} \right]$$

This alternate form illustrates that the correction factor can also be seen as the typical response time divided by average of typical and case-specific.

Insights from results

Figures 3 show a comparison of the suppression curves from this analysis and from NUREG/CR-6850. First of all, the FAQ 50 curves typically provide comparable to slightly higher non-suppression probabilities than NUREG/CR-6850. These curves are very similar since approximately ½ of the 250 suppression data entries in the database contain no entry for suppression time. Secondly, a "6850+10" curve was generated with the assumption of a 10- minute full fire brigade response. The results of this second comparison between the FAQ 50 curves and the "6850 + 10" curves demonstrate the potential degree of conservatism with the NUREG/CR-6850 approach of adding the fire brigade time to the suppression time.

Insights from database review

The re-analysis of the manual fire suppression events in the database highlighted that manual fire suppression is a more continuous process than the original NUREG/CR-6850 treatment provided. Unlike the NUREG/CR-6850 analysis which assumed that manual fire fighting was largely a function of the fire brigade, manual fire suppression activities effectively begin as soon as a fire has been detected, and if needed, confirmed. Many of the fire events are suppressed before the fire brigade arrives in full. The revised analysis is less conservative because it treats

the overall process of manual fire suppression in a more continuous manner consistent with the actual response to a fire.

Furthermore, for those cases where the database explicitly indicates that the fire brigade applied a hose stream, this database review confirmed that the duration data do not contain the time for detection. Approximately 1/3 of these events include information in the event description that allowed an independent confirmation for when the recorded duration began and ended. In those cases, the recorded duration began when the fire was detected by plant personnel, or upon indications provided by alarms or failure of equipment.

Finally, the time needed for confirmation of the fire after detection is rarely identified in fire events. A plant will generally confirm a detector actuation prior to sending out a full fire brigade to apply a hose stream. For those fires detected by fire watches or by plant personnel, confirmation may not be necessary. Note that nearly ½ of the entire 250 events in the set of suppression data identify plant personnel as the means of detection.

References:

1. Revision 0 to FAQ 08-0050, May 13, 2008, Accession No. ML081200318

2. NEI 04-02, Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program Under 10 CFR 50.48(c), Revision 1, Accession No. ML052590476

3. NFPA 805, Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants, 2001 Edition (available through the Public Document Room or NFPA)

4. Regulatory Guide 1.205, Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants, Accession No. ML061100174

5. NRC Regulatory Information Summary 2007-19, Process for Communicating Clarifications of Staff Positions Provided in Regulatory Guide 1.205 Concerning Issues Identified During The Pilot Application of National Fire Protection Association Standard 805, Accession No. ML071590227

6. NUREG/CR-6850 (EPRI 1011989), Accession Nos. ML050940183 (Vol. 1) and ML050940189 (Vol. 2)

Table 1: Updated Numerical Results for Suppression Curves

Time (min)	T/G fires	High energy arcing faults	Outdoor transformers	Flammable gas	Oil fires	Electrical fires	Transient fires	PWR containment	Welding	Control room	Cable fires	All Fires
0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	0.883	0.947	0.836	0.881	0.692	0.602	0.531	0.687	0.392	0.189	0.446	0.715
10	0.780	0.897	0.698	0.776	0.479	0.362	0.282	0.472	0.153	0.036	0.199	0.512
15	0.689	0.850	0.584	0.683	0.331	0.218	0.150	0.325	0.060	0.007	0.089	0.366
20	0.609	0.805	0.488	0.602	0.229	0.131	0.080	0.223	0.024	0.001	0.040	0.262
25	0.538	0.762	0.408	0.530	0.159	0.079	0.042	0.153	0.009	*	0.018	0.187
30	0.475	0.722	0.341	0.467	0.110	0.048	0.023	0.105	0.004	*	0.008	0.134
35	0.419	0.684	0.285	0.411	0.076	0.029	0.012	0.072	0.001	*	0.004	0.096
40	0.370	0.647	0.238	0.362	0.053	0.017	0.006	0.050	*	*	0.002	0.068
45	0.327	0.613	0.199	0.319	0.036	0.010	0.003	0.034	*	*	*	0.049
50	0.289	0.581	0.166	0.281	0.025	0.006	0.002	0.024	*	*	*	0.035
55	0.255	0.550	0.139	0.248	0.017	0.004	*	0.016	*	*	*	0.025
60	0.226	0.521	0.116	0.218	0.012	0.002	*	0.011	*	*	*	0.018
65	0.199	0.493	0.097	0.192	0.008	0.001	*	0.008	*	*	*	0.013
70	0.176	0.467	0.081	0.169	0.006	*	*	0.005	*	*	*	0.009
75	0.155	0.443	0.068	0.149	0.004	*	*	0.004	*	*	*	0.007
80	0.137	0.419	0.057	0.131	0.003	*	*	0.002	*	*	*	0.005
85	0.121	0.397	0.047	0.116	0.002	*	*	0.002	*	*	*	0.003
90	0.107	0.376	0.040	0.102	0.001	*	*	0.001	*	*	*	0.002
95	0.095	0.356	0.033	0.090	*	*	*	*	*	*	*	0.002
100	0.084	0.337	0.028	0.079	*	*	*	*	*	*	*	0.001

* A value of 1E-3 should be used

Table 2: Original & Updated Mean Suppression Rates (λ)

		Original NUREG/CR-6850		Revised Analysis	
Suppression Curve	**No. of original events/revised events**	**Original Total Suppression Time**	**Original Mean Suppression Rate [/min]**	**Revised Total Duration**	**Revised Mean Suppression Rate [/min]**
T/G fires	21/21	749	0.03	846	0.025
Control room	6/6	18	0.33	18	0.33
PWR containment	3/3	23	0.13	40	0.075
Outdoor transformers	14/14	373	0.04	390	0.036
Flammable gas	5/5	195	0.03	197	0.025
Oil fires	36/36	404	0.09	489	0.074
Cable fires	5/5	21	0.24	31	0.161
Electrical fires	114/113	942	0.12	1113	0.102
Welding fires	19/18	99	0.19	106	0.188
Transient fires	24/22	199	0.12	174	0.126
High energy arcing faults	3/3	239	0.01	276	0.011
All Fires	245[6] /246	3113	0.08	3670	0.067

[6] The "All Fires" non-suppression analysis in the original NUREG/CR-6850 excluded events from cable fire bin. Thus the total number of the events taken from individual suppression analyses in the original NUREG/CR-6850 is 250; however, the number of events used in the "All Fires" curve is only 245.

Table 3: List of Fire Events for Original and Revised Suppression Curves[7]

Incident No.	Date	Year	Mode of Operation	Suppression Curve	Fire Suppression Time (T_{supp})	
					Original NUREG/CR-6850 value [min]	Revised FAQ 50 Value [min]
398	9/7/1983	1983	Low Power Operation	Cable	2	2
510	2/1/1986	1986	Power Operation	Cable	10	10
681	3/9/1988	1988	Low Power Operation	Cable	5	15
2361	3/10/1986	1986	Power Operation	Cable	2	2
2425	3/1/2000	2000	Power Operation	Cable	2	2
485	8/24/1985	1985	Power Operation	Containment (PWR)	15	24
1041	7/11/1994	1994	Power Operation	Containment (PWR)	6	14
1488	10/21/1987	1987	Power Operation	Containment (PWR)	2	2
537	9/4/1986	1986	Low Power Operation	Control Room	1	1
659	12/30/1987	1987	Power Operation	Control Room	1	2
756	10/14/1988	1988	Low Power Operation	Control Room	1	1
928	3/1/1989	1989	Power Operation	Control Room	1	2
980	3/23/1990	1990	Undetermined	Control Room	2	2
2160	4/4/1996	1996	Low Power Operation	Control Room	10	10
238	1/24/1981	1981	Power Operation	Electrical	5	30
269	8/10/1981	1981	Power Operation	Electrical	1	1
352	11/3/1982	1982	Power Operation	Electrical	5	5
357	11/27/1982	1982	Power Operation	Electrical	2	4
388	6/19/1983	1983	Power Operation	Electrical	4	4
418	4/28/1984	1984	Low Power Operation	Electrical	10	60
469	5/2/1985	1985	Low Power Operation	Electrical	1	11
484	8/14/1985	1985	Power Operation	Electrical	15	15
490	10/11/1985	1985	Undetermined	Electrical	11	11
493	10/31/1985	1985	Power Operation	Electrical	1	1
498	12/3/1985	1985	Power Operation	Electrical	10	10
505	1/8/1986	1986	Low Power Operation	Electrical	36	36
513	2/19/1986	1986	Low Power Operation	Electrical	6	6
516	3/8/1986	1986	Low Power Operation	Electrical	6	8
518	3/22/1986	1986	Low Power Operation	Electrical	1	1
522	4/17/1986	1986	Low Power Operation	Electrical	10	10
529	6/22/1986	1986	Power Operation	Electrical	1	1
541	9/19/1986	1986	Power Operation	Electrical	5	10
544	10/14/1986	1986	Undetermined	Electrical	12	12

[7] Date, year, and mode of operation for each event are draft and have not been confirmed. This information is not relevant to the analysis, but provided as a modifier to the incident number.

Incident No.	Date	Year	Mode of Operation	Suppression Curve	Fire Suppression Time (T_{supp})	
					Original NUREG/CR -6850 value [min]	Revised FAQ 50 Value [min]
551	12/16/1986	1986	Power Operation	Electrical	1	1
557	1/31/1987	1987	Low Power Operation	Electrical	10	30
572	3/14/1987	1987	Power Operation	Electrical	3	8
608	6/17/1987	1987	Low Power Operation	Electrical	1	1
611	7/2/1987	1987	Low Power Operation	Electrical	12	12
614	7/10/1987	1987	Power Operation	Electrical	3	3
625	9/17/1987	1987	Power Operation	Electrical	1	14
642	11/4/1987	1987	Power Operation	Electrical	45	50
644	11/10/1987	1987	Undetermined	Electrical	10	10
654	12/11/1987	1987	Power Operation	Electrical	1	1
656	12/17/1987	1987	Power Operation	Electrical	25	30
665	1/19/1988	1988	Low Power Operation	Electrical	10	10
667	1/28/1988	1988	Low Power Operation	Electrical	7	7
673	2/8/1988	1988	Low Power Operation	Electrical	2	2
708	5/10/1988	1988	Low Power Operation	Electrical	3	8
726	6/11/1988	1988	Low Power Operation	Electrical	3	17
735	7/21/1988	1988	Power Operation	Electrical	2	13
745	8/17/1988	1988	Power Operation	Electrical	5	10
755	10/5/1988	1988	Power Operation	Electrical	2	3
792	7/15/1988	1988	Power Operation	Electrical	10	5
821	12/22/1990	1990	Power Operation	Electrical (to oil)	20	20
876	3/8/1992	1992	Low Power Operation	Electrical	6	6
914	11/20/1985	1985	Low Power Operation	Electrical	20	23
922	7/10/1987	1987	Power Operation	Electrical	3	3
942	3/5/1989	1989	Power Operation	Electrical	6	15
977	1/19/1990	1990	Low Power Operation	Electrical	9	9
978	1/22/1990	1990	Low Power Operation	Electrical	2	2
1034	10/15/1996	1996	Power Operation	Electrical	10	10
1053	8/19/1989	1989	Power Operation	Electrical	7	7
1097	11/15/1986	1986	Low Power Operation	Electrical	95	95
1100	4/18/1989	1989	Power Operation	Electrical	5	5
1124	10/7/1986	1986	Undetermined	Electrical	4	4
1129	2/15/1989	1989	Low Power Operation	Electrical	1	1
1133	11/7/1989	1989	Undetermined	Electrical	5	5
1135	4/6/1990	1990	Low Power Operation	Electrical	24	24
1137	6/7/1990	1990	Low Power Operation	Electrical	1	1
1139	7/9/1990	1990	Power Operation	Electrical	3	3
1141	9/10/1990	1990	Undetermined	Electrical	5	5

Incident No.	Date	Year	Mode of Operation	Suppression Curve	Fire Suppression Time (T_{supp})	
					Original NUREG/CR-6850 value [min]	Revised FAQ 50 Value [min]
1142	12/19/1994	1994	Power Operation	Electrical	10	10
1160	9/27/1991	1991	Undetermined	Electrical	5	5
1163	2/29/1992	1992	Undetermined	Electrical	5	5
1173	2/20/1994	1994	Low Power Operation	Electrical	12	12
1213	2/9/1995	1995	Power Operation	Electrical	5	5
1262	11/2/1990	1990	Low Power Operation	Electrical	3	3
1264	10/3/1991	1991	Power Operation	Electrical	1	1
1270	10/12/1992	1992	Power Operation	Electrical	1	1
1276	7/25/1993	1993	Power Operation	Electrical	35	35
1335	3/3/1992	1992	Power Operation	Electrical	7	7
1337	3/31/1989	1989	Low Power Operation	Electrical	9	9
1339	6/28/1990	1990	Low Power Operation	Electrical	29	29
1487	4/17/1987	1987	Power Operation	Electrical	2	2
1489	10/26/1987	1987	Low Power Operation	Electrical	2	2
1491	6/11/1990	1990	Low Power Operation	Electrical	2	2
1501	10/11/1994	1994	Low Power Operation	Electrical	2	2
1504	8/15/1995	1995	Low Power Operation	Electrical	10	10
1509	11/23/1998	1998	Low Power Operation	Electrical	1	1
1511	3/19/1999	1999	Power Operation	Electrical	2	2
2127	5/25/1996	1996	Undetermined	Electrical	2	2
2161	7/10/1996	1996	Low Power Operation	Electrical	2	2
2179	1/12/1994	1994	Undetermined	Electrical	22	22
2190	1/8/1997	1997	Undetermined	Electrical	45	45
2191	3/7/1994	1994	Undetermined	Electrical	2	2
2211	2/13/1997	1997	Power Operation	Electrical	10	10
2219	3/21/1996	1996	Undetermined	Electrical	2	2
2227	3/2/1997	1997	Power Operation	Electrical	2	2
2236	10/22/1997	1997	Power Operation	Electrical	10	10
2251	1/16/1998	1998	Power Operation	Electrical	10	10
2255	1/11/1993	1993	Undetermined	Electrical	2	2
2269	10/31/1994	1994	Power Operation	Electrical	2	2
2272	11/19/1995	1995	Undetermined	Electrical	10	10
2273	9/25/1995	1995	Undetermined	Electrical	2	2
2276	7/6/1995	1995	Power Operation	Electrical	10	10
2281	5/14/1998	1998	Power Operation	Electrical	10	14
2305	6/7/1998	1998	Undetermined	Electrical	2	2
2311	9/1/1999	1999	Power Operation	Electrical	2	2
2313	8/16/1999	1999	Power Operation	Electrical	2	2

Incident No.	Date	Year	Mode of Operation	Suppression Curve	Fire Suppression Time (T_{supp})	
					Original NUREG/CR-6850 value [min]	Revised FAQ 50 Value [min]
2314	8/24/1999	1999	Power Operation	Electrical	10	10
2319	5/6/1999	1999	Undetermined	Electrical	2	2
2329	11/29/1992	1992	Power Operation	Electrical	2	2
2336	8/22/1990	1990	Power Operation	Electrical	2	2
2339	10/14/2000	2000	Power Operation	Electrical	10	10
2349	7/1/1998	1998	Power Operation	Electrical	10	10
2351	8/12/1997	1997	Power Operation	Electrical	2	2
2353	10/14/1996	1996	Power Operation	Electrical	2	2
2375	2/19/1999	1999	Power Operation	Electrical	2	2
2377	10/23/2000	2000	Low Power Operation	Electrical	2	2
2378	2/25/2000	2000	Power Operation	Electrical	10	12
2387	11/18/1993	1993	Power Operation	Electrical	2	2
2416	11/5/2000	2000	Low Power Operation	Electrical	10	10
2426	5/15/2000	2000	Power Operation	Electrical	22	22
2428	8/16/2000	2000	Power Operation	Electrical	22	22
2441	12/27/2000	2000	Power Operation	Electrical	2	2
2445	10/5/1987	1987	Undetermined	Electrical	2	2
2447	8/1/1987	1987	Undetermined	Electrical	2	2
2476	1/23/1989	1989	Undetermined	Electrical	10	10
433	7/20/1984	1984	Power Operation	Flammable gas	46	46
512	2/17/1986	1986	Power Operation	Flammable gas	9	9
528	6/19/1986	1986	Low Power Operation	Flammable gas	60	72
1516	1/13/1998	1998	Power Operation	Flammable gas	20	10
2356	8/31/1992	1992	Power Operation	Flammable gas	60[8]	60
947	1/3/1989	1989	Power Operation	High Energy Arcing Faults	46	59
2175	6/10/1995	1995	Power Operation	High Energy Arcing Faults	57	76
2424	2/3/2001	2001	Power Operation	High Energy Arcing Faults	136	141
260	6/30/1981	1981	Low Power Operation	Oil	1	5
262	7/14/1981	1981	Power Operation	Oil	8	8
263	7/16/1981	1981	Power Operation	Oil	1	1
266	7/24/1981	1981	Power Operation	Oil	15	15
296	1/9/1982	1982	Low Power Operation	Oil	40	45
476	6/26/1985	1985	Power Operation	Oil	10	10
477	6/29/1985	1985	Power Operation	Oil	3	10

[8] Cited duration is 60+ minutes.

Incident No.	Date	Year	Mode of Operation	Suppression Curve	Fire Suppression Time (T_{supp})	
					Original NUREG/CR-6850 value [min]	Revised FAQ 50 Value [min]
495	11/2/1985	1985	Low Power Operation	Oil	20	23
508	1/25/1986	1986	Low Power Operation	Oil	1	1
524	5/10/1986	1986	Power Operation	Oil	9	34
535	8/13/1986	1986	Low Power Operation	Oil	3	11
559	2/8/1987	1987	Low Power Operation	Oil	4	21
566	3/1/1987	1987	Low Power Operation	Oil	25	30
662	1/8/1988	1988	Power Operation	Oil	60	60
710	5/10/1988	1988	Low Power Operation	Oil	27	27
736	7/24/1988	1988	Power Operation	Oil	15	23
737	7/29/1988	1988	Power Operation	Oil	3	7
765	11/27/1988	1988	Low Power Operation	Oil	3	3
811	4/17/1992	1992	Undetermined	Oil	1	1
824	7/13/1992	1992	Power Operation	Oil	15	15
875	5/27/1990	1990	Low Power Operation	Oil	1	1
961	8/11/1991	1991	Power Operation	Oil	11	18
1023	8/16/1993	1993	Power Operation	Oil	10	5
1108	6/6/1989	1989	Power Operation	Oil	4	4
1110	2/2/1990	1990	Power Operation	Oil	5	5
1263	3/8/1991	1991	Low Power Operation	Oil	6	6
1482	1/22/1986	1986	Power Operation	Oil	10	5
1483	3/13/1986	1986	Power Operation	Oil	10	5
1485	7/20/1986	1986	Low Power Operation	Oil	10	5
1506	2/24/1998	1998	Power Operation	Oil	2	2
1507	5/11/1998	1998	Power Operation	Oil	2	2
1514	10/9/1997	1997	Power Operation	Oil	2	2
2183	9/13/1996	1996	Undetermined	Oil	45	45
2345	11/3/2000	2000	Power Operation	Oil	2	2
2388	12/16/1993	1993	Power Operation	Oil	10	10
2422	8/24/2000	2000	Power Operation	Oil	10	10
368	2/16/1983	1983	Power Operation	Outdoor transformers	1	12
405	11/14/1983	1983	Power Operation	Outdoor transformers	40	40
407	12/23/1983	1983	Power Operation	Outdoor transformers	120	120
734	7/17/1988	1988	Power Operation	Outdoor transformers	2	2
860	9/4/1992	1992	Power Operation	Outdoor transformers	27	27

Incident No.	Date	Year	Mode of Operation	Suppression Curve	Fire Suppression Time (T_{supp})	
					Original NUREG/CR-6850 value [min]	Revised FAQ 50 Value [min]
934	4/13/1986	1986	Power Operation	Outdoor transformers	120	120
1033	6/23/1996	1996	Power Operation	Outdoor transformers	20	20
1035	1/5/1999	1999	Power Operation	Outdoor transformers	15	15
2283	6/23/1994	1994	Power Operation	Outdoor transformers	2	2
2285	10/25/1994	1994	Power Operation	Outdoor transformers	10	10
2331	7/19/1994	1994	Power Operation	Outdoor transformers	2	2
2341	8/21/2000	2000	Power Operation	Outdoor transformers	2	2
2407	10/18/2000	2000	Power Operation	Outdoor transformers	2	2
2427	9/22/2000	2000	Power Operation	Outdoor transformers	10	16
323	5/27/1982	1982	Power Operation	Transient	20	20
464	3/29/1985	1985	Undetermined	Transient	5	5
567	3/2/1987	1987	Power Operation	Transient	4	4
577	3/27/1987	1987	Power Operation	Transient	5	5
650	11/30/1987	1987	Power Operation	Transient	1	1
653	12/10/1987	1987	Power Operation	Transient	10	15
704	4/20/1988	1988	Power Operation	Transient	8	10
968	4/3/1989	1989	Undetermined	Transient	8	8
997	2/11/1992	1992	Undetermined	Transient	5	5
1050	1/1/1989	1989	Power Operation	Transient	5	5
1119	2/23/1989	1989	Power Operation	Transient	1	1
1128	3/10/1988	1988	Power Operation	Transient	10	10
1164	3/16/1992	1992	Undetermined	Transient	10	10
1171	4/13/1993	1993	Power Operation	Transient	1	1
1176	9/29/1994	1994	Power Operation	Transient (removed)	25	25
1195	8/8/1990	1990	Power Operation	Transient	1	1
1345	2/6/1990	1990	Undetermined	Transient (removed)	7	7
2253	4/1/1993	1993	Power Operation	Transient	2	2
2257	1/12/1994	1994	Undetermined	Transient	2	2
2262	7/2/1994	1994	Power Operation	Transient	45	45
2291	1/6/1993	1993	Undetermined	Transient	2	2

Incident No.	Date	Year	Mode of Operation	Suppression Curve	Fire Suppression Time (T_{supp})	
					Original NUREG/CR-6850 value [min]	Revised FAQ 50 Value [min]
2386	11/13/1993	1993	Power Operation	Transient	10	10
2393	8/9/1995	1995	Power Operation	Transient	2	2
2501	12/1/1999	1999	Power Operation	Transient	10	10
304	2/4/1982	1982	Power Operation	Turbine generator	10	20
326	6/11/1982	1982	Power Operation	Turbine generator	30	45
384	5/20/1983	1983	Power Operation	Turbine generator	18	20
401	9/19/1983	1983	Power Operation	Turbine generator	2	5
402	9/25/1983	1983	Power Operation	Turbine generator	1	1
487	9/12/1985	1985	Power Operation	Turbine generator	30	35
531	7/23/1986	1986	Power Operation	Turbine generator	3	8
554	1/2/1987	1987	Power Operation	Turbine generator	95	95
562	2/16/1987	1987	Power Operation	Turbine generator	45	45
636	10/16/1987	1987	Power Operation	Turbine generator	6	8
668	1/28/1988	1988	Power Operation	Turbine generator	217	217
809	12/23/1989	1989	Power Operation	Turbine generator	4	44
851	11/9/1991	1991	Power Operation	Turbine generator	15	15
926	1/20/1989	1989	Power Operation	Turbine generator	14	20
929	10/9/1989	1989	Power Operation	Turbine generator	160	160
940	10/2/1987	1987	Power Operation	Turbine generator	16	25
1024	12/25/1993	1993	Power Operation	Turbine generator	2	2
1042	7/29/1994	1994	Power Operation	Turbine generator	9	9
2124	6/15/1994	1994	Power Operation	Turbine generator	60[9]	60
2229	8/1/1997	1997	Power Operation	Turbine generator	10	10
2337	9/12/1991	1991	Power Operation	Turbine generator	2	2
242	2/24/1981	1981	Power Operation	Welding	2	2
257	6/3/1981	1981	Power Operation	Welding	3	3
294	12/17/1981	1981	Undetermined	Welding	0	0
319	4/14/1982	1982	Power Operation	Welding	2	2
413	2/13/1984	1984	Power Operation	Welding	0	0
474	6/14/1985	1985	Power Operation	Welding	3	5
700	4/15/1988	1988	Power Operation	Welding	10	15
751	9/27/1988	1988	Undetermined	Welding	10	10
1095	9/8/1986	1986	Power Operation	Welding	2	2
1200	9/1/1992	1992	Power Operation	Welding	1	1
1201	10/5/1992	1992	Power Operation	Welding	0	0
1231	3/9/1993	1993	Undetermined	Welding	1	1

[9] Cited duration is 60+ minutes.

Incident No.	Date	Year	Mode of Operation	Suppression Curve	Fire Suppression Time (T_{supp})	
					Original NUREG/CR-6850 value [min]	Revised FAQ 50 Value [min]
1232	1/25/1994	1994	Power Operation	Welding	0	0
1275	7/14/1993	1993	Undetermined	Welding	27	27
2126	7/22/1996	1996	Undetermined	Welding	2	2
2143	8/13/1993	1993	Undetermined	Welding	2	2
2188	3/5/1994	1994	Undetermined	Welding	2	2
2237	10/28/1997	1997	Power Operation	Welding	22	22
2469	7/14/1988	1988	Undetermined	Welding (removed)	10	10

Figure 2A: Revised Non-Suppression Curves Part A

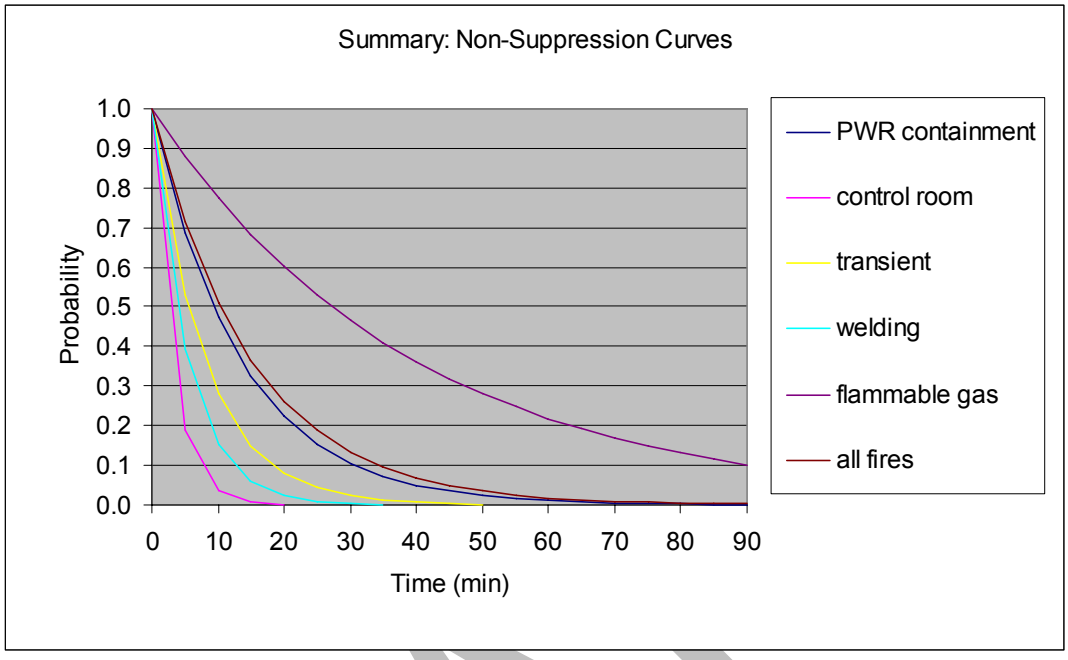

Figure 2B: Revised Non-Suppression Curves Part B

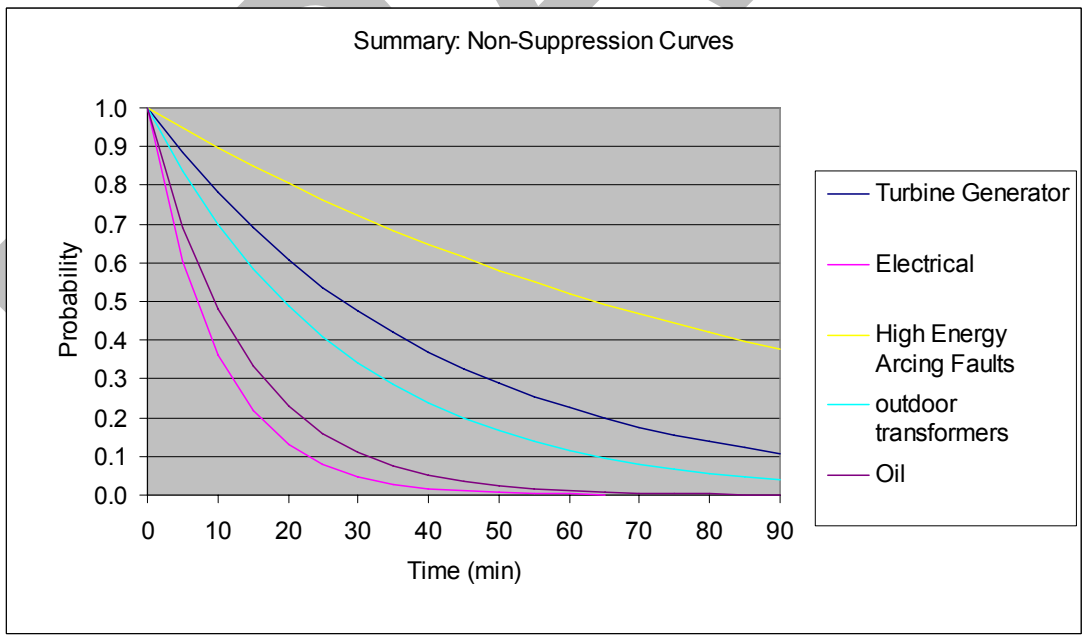

Figure 3A: Revised Non-suppression Curves for Individual Groupings

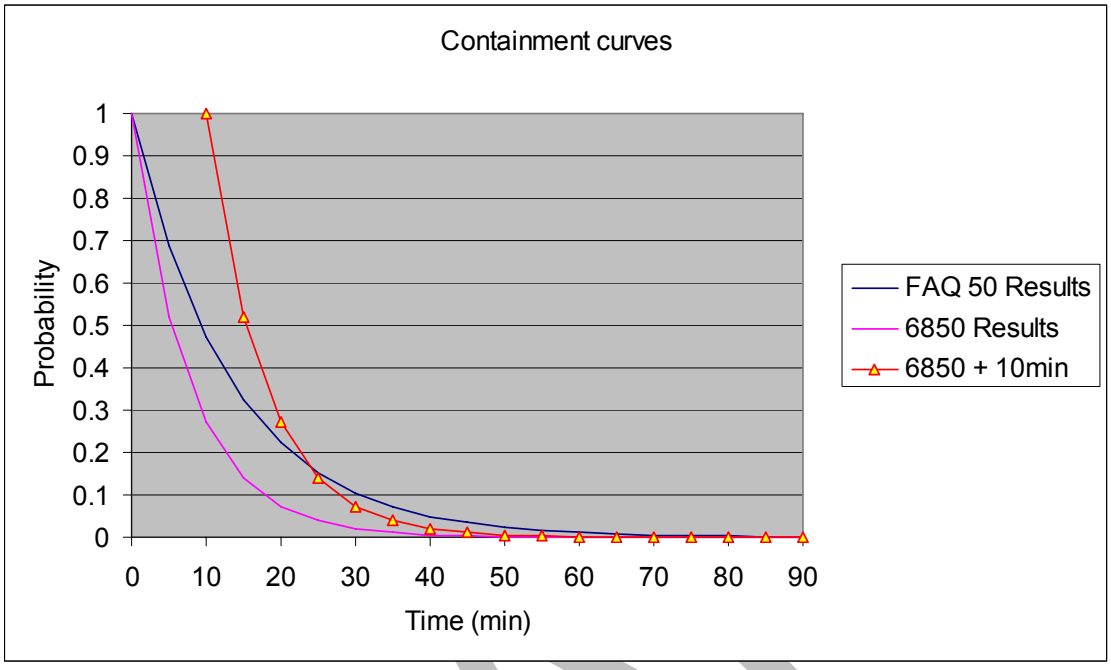

Figure 3B: Revised Non-suppression Curves for Individual Groupings

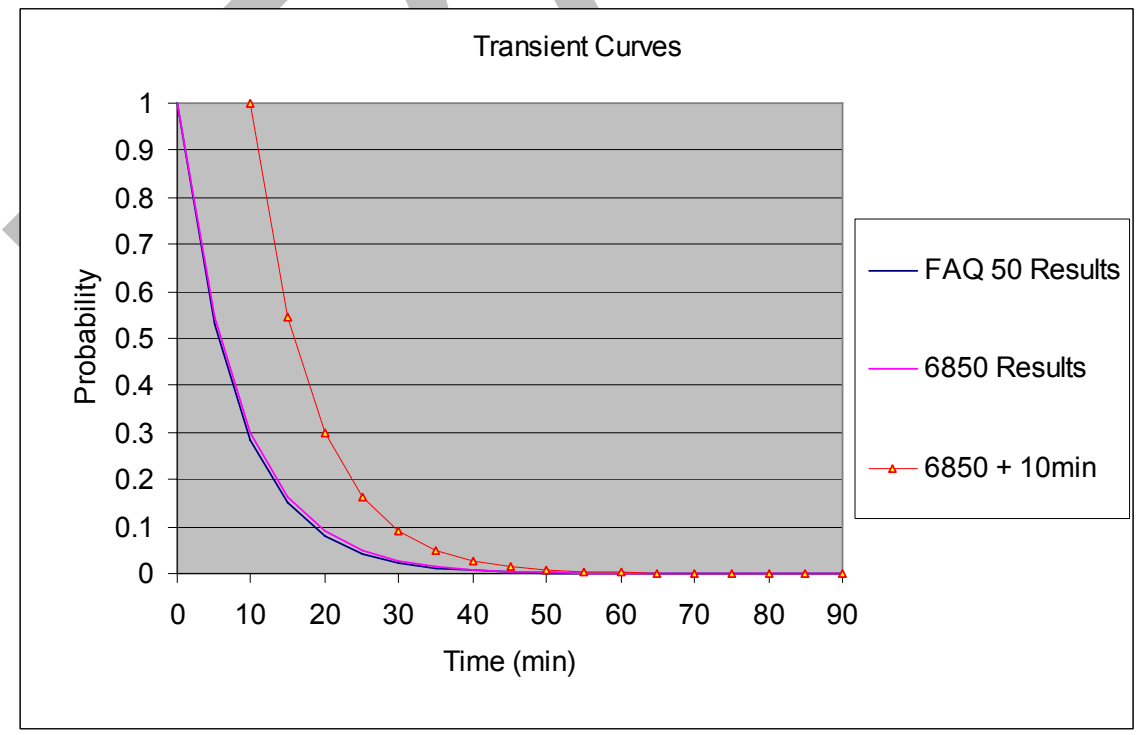

Figure 3C: Revised Non-suppression Curves for Individual Groupings

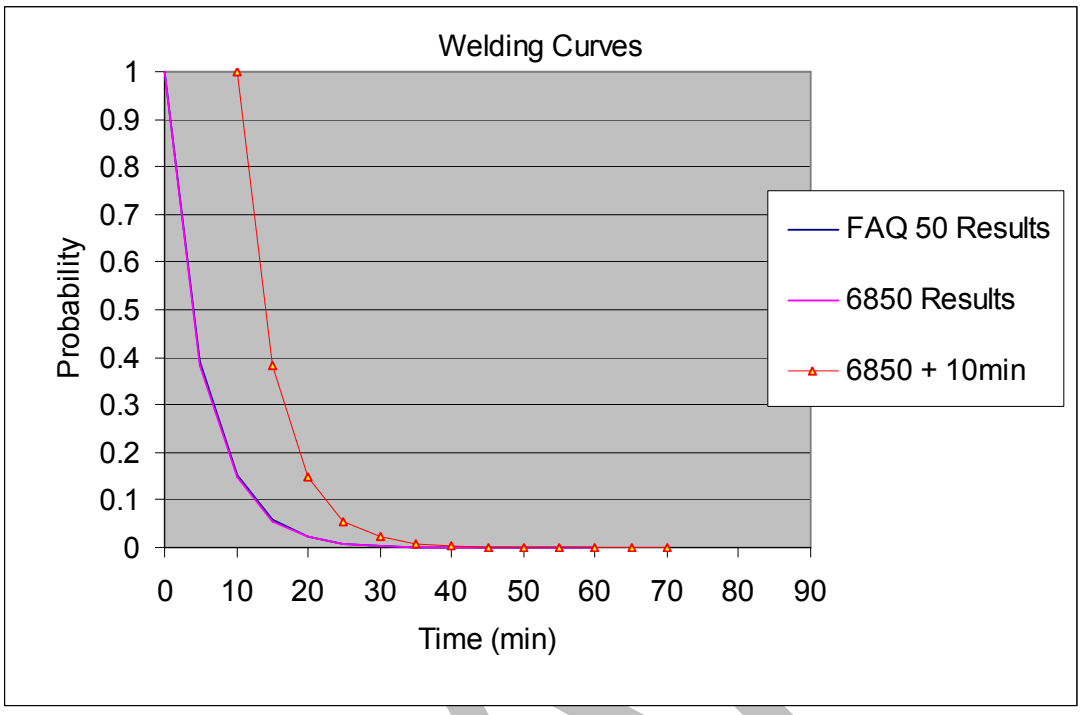

Figure 3D: Revised Non-suppression Curves for Individual Groupings

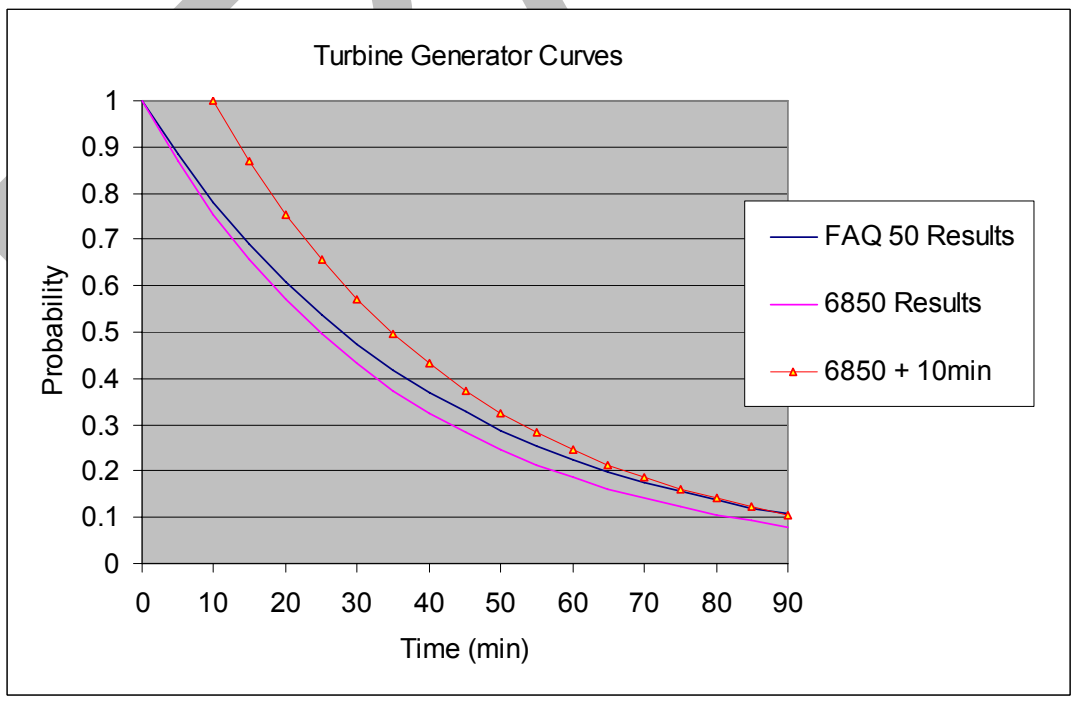

Figure 3E: Revised Non-suppression Curves for Individual Groupings

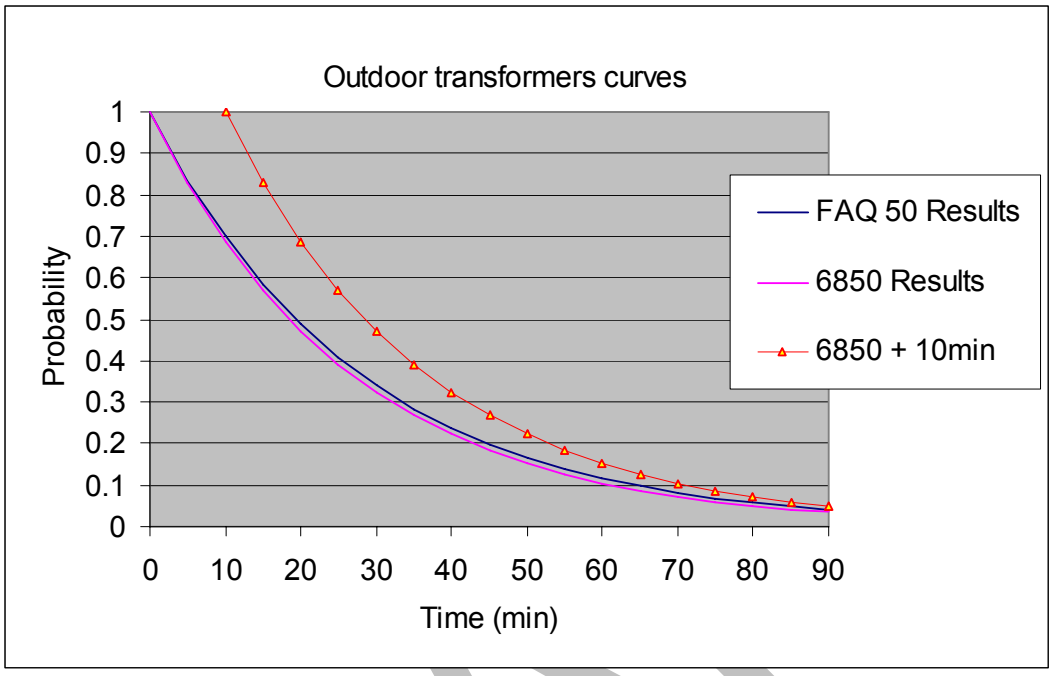

Figure 3F: Revised Non-suppression Curves for Individual Groupings

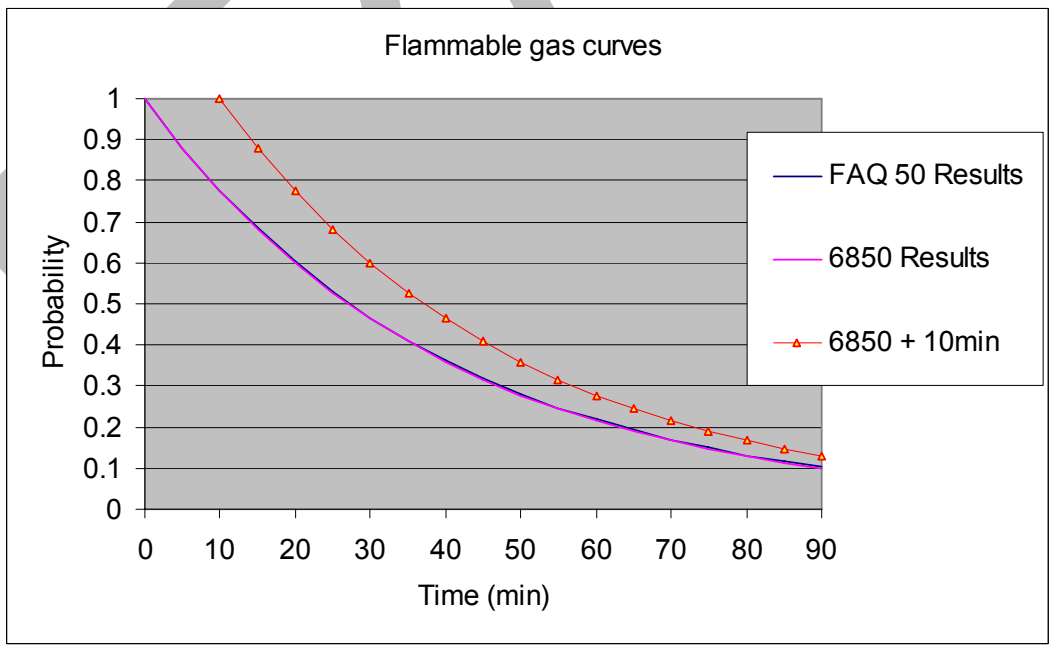

Figure 3G: Revised Non-suppression Curves for Individual Groupings

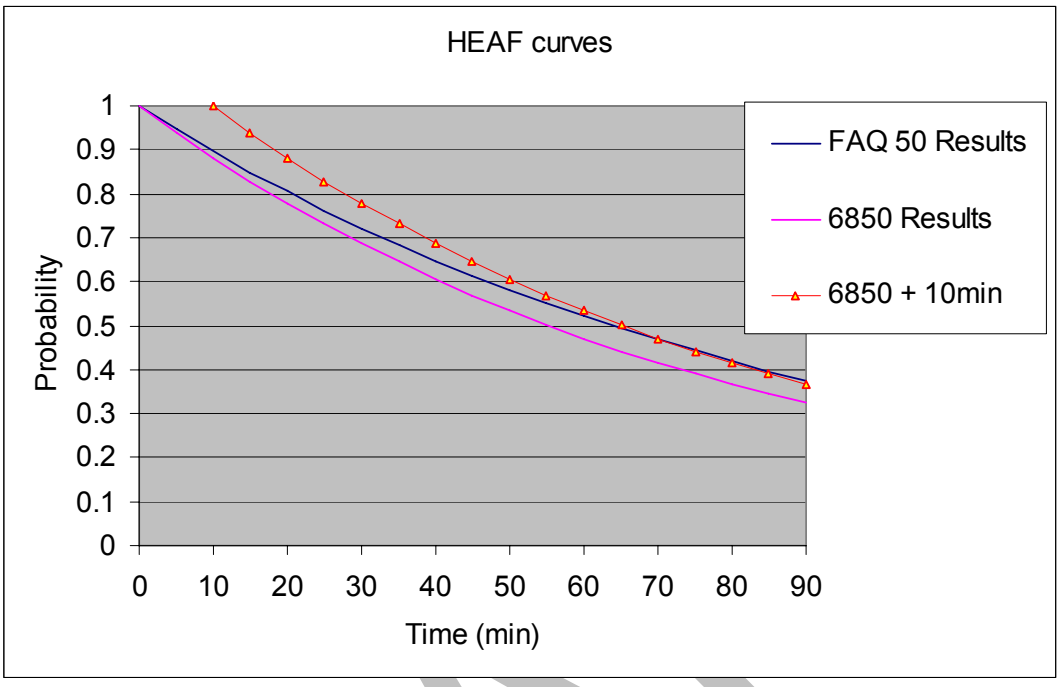

Figure 3H: Revised Non-suppression Curves for Individual Groupings

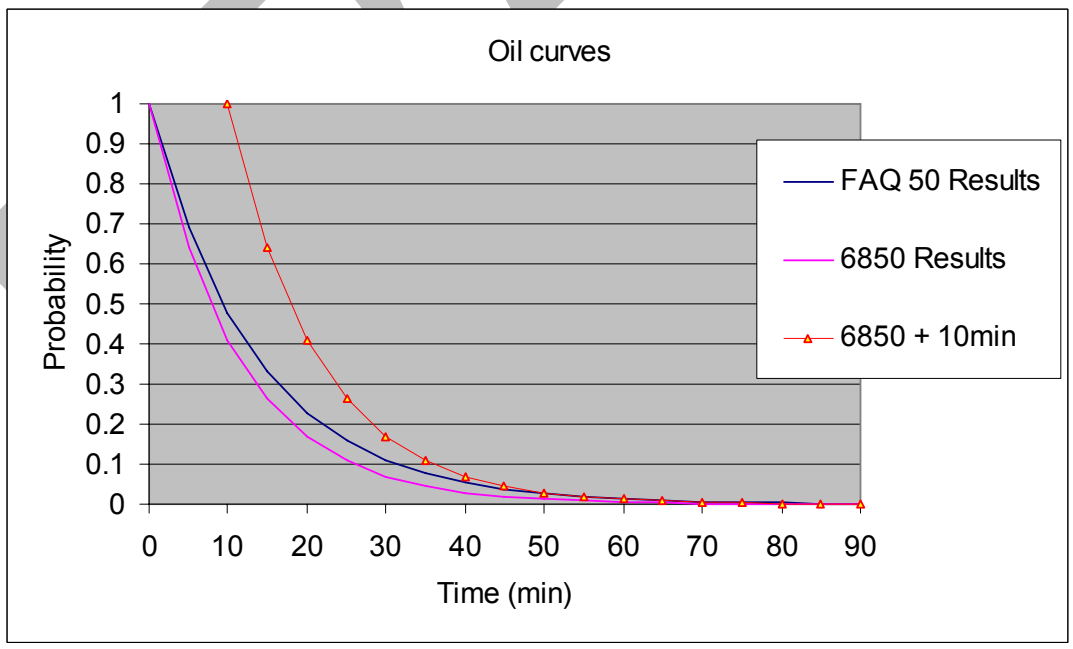

Figure 3I: Revised Non-suppression Curves for Individual Groupings

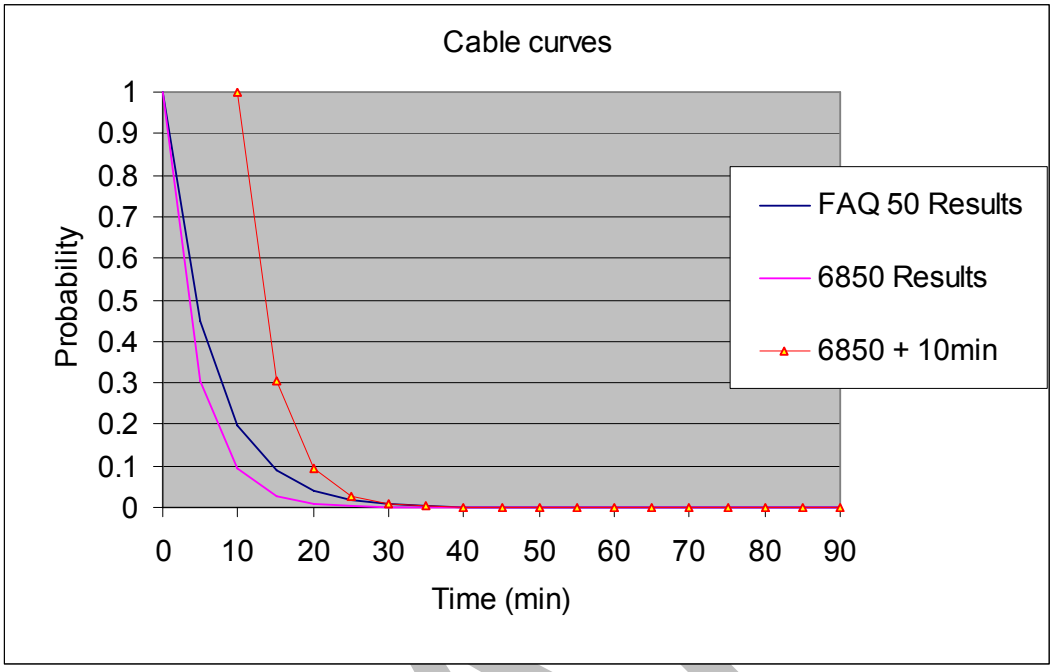

Figure 3J: Revised Non-suppression Curves for Individual Groupings

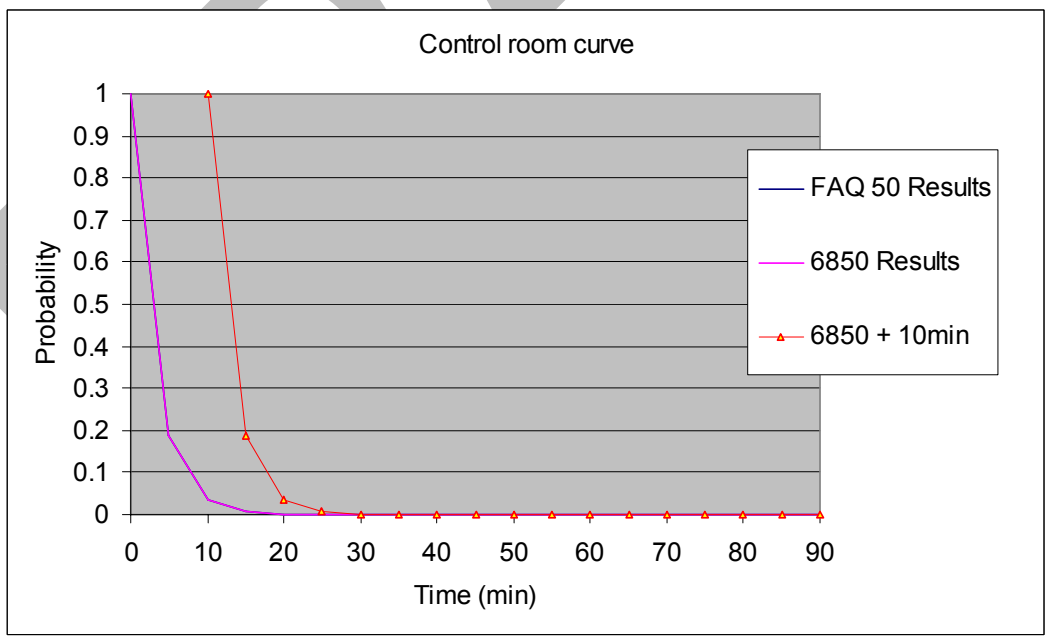

Figure 3I: Revised Non-suppression Curves for Individual Groupings

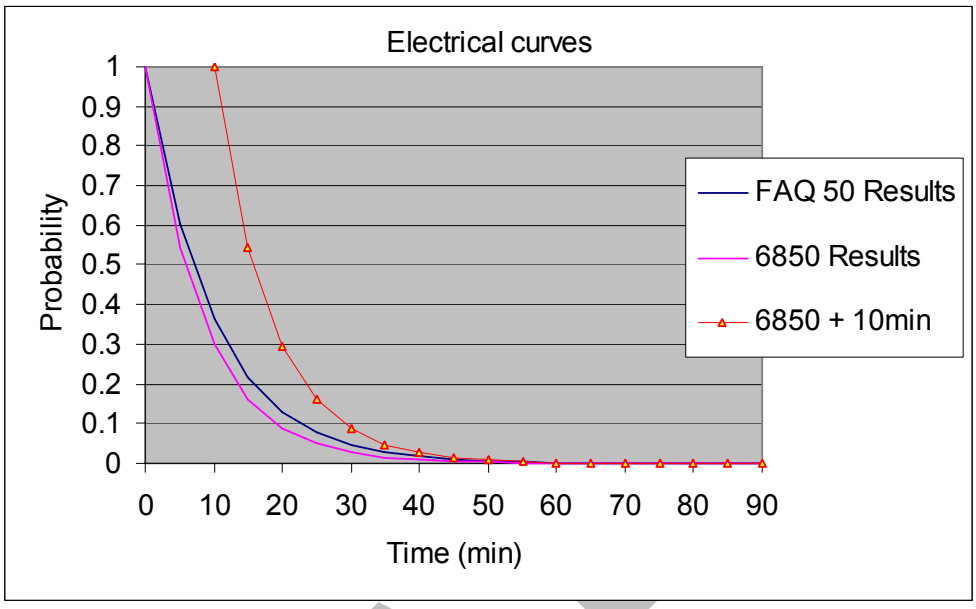

Figure 3J: Revised Non-suppression Curves for Individual Groupings