

EDO Principal Correspondence Control

FROM: DUE: / / EDO CONTROL: G20060987
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FINAL REPLY:

Marvin S. Fertel
Nuclear Energy Institute (NEI)

TO:

Reyes, EDO

FOR SIGNATURE OF : ** GRN ** CRC NO:

DESC:

ROUTING:

NRC SECY-06-0196 - Issuance of Generic Letter
2006-XX, Post-Fire Safe Shutdown Circuit Analysis,
September 11, 2006

Reyes
Virgilio
Kane
Silber
Johnson
Burns
Carpenter, OE
Baker, OIS
Cyr, OGC

DATE: 12/06/06

ASSIGNED TO: CONTACT:
NRR Dyer

SPECIAL INSTRUCTIONS OR REMARKS:

For Appropriate Action.

Template: EDO-001

E-RIDS: EDO-01



NUCLEAR ENERGY INSTITUTE

Marvin S. Fertel
SENIOR VICE PRESIDENT AND
CHIEF NUCLEAR OFFICER

October 13, 2006

Mr. Luis A. Reyes
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Mail Stop O 5 E7
Washington, DC 20555-0001

SUBJECT: NRC SECY-06-0196 – Issuance of Generic Letter 2006-XX,
Post-Fire Safe-Shutdown Circuit Analysis, September 11, 2006

PROJECT NUMBER: 689

Dear Mr. Reyes:

We appreciate the opportunity to comment on SECY-06-0196 "Issuance of Generic Letter 2006-XX Post-Fire Safe-Shutdown Circuit Analysis". This regulatory issue is critically important to the industry. Our comments are directed toward achieving consistency in past and present regulatory positions and practice. Furthermore, and most importantly, we wish to bring the issue of safe-shutdown circuit analysis spurious actuations to closure by applying a balanced approach for resolution.

Our comments address three areas:

- Staff's backfit evaluation
- Interpretation of the industry cable fire test results
- Disposition of industry comments on the draft generic letter

These areas are described further below. Additional detailed comments are provided in Enclosure 1.

Staff's Backfit Evaluation

NEI submitted comments on the proposed generic letter's regulatory analysis on September 26, 2006. One of the industry's comments was that the proposed staff position is a backfit. The proposed generic letter establishes a new staff position and requests licensees to evaluate current licensing bases against that position. As such, the burden rests with the NRC to demonstrate a quantifiable improvement in plant safety resulting from the imposition of this new position. This has not been demonstrated.

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The fundamental issue is whether the current NRC position with respect to the "one-at-a-time" direction is a new staff position, regardless of whether it may have been previously applied at one or more plants. So long as it has been applied differently at other plants and no clear direction exists either in the regulations or guidance to dictate a particular interpretation, then the selection of one of several prior staff interpretations (1) does not in itself justify adoption of the now-preferred staff position into law, and (2) does not allow a claim that the compliance exception to the backfit rule should apply. Accordingly, the current NRC preferred interpretation and the attempt to impose this now-preferred position is a backfit for any and all plants for which it has not been clearly and previously applied.

Interpretation of Cable Fire Test Results

The approach described in SECY-06-0196 relies heavily on the NRC's interpretation of the results of the EPRI/NEI tests (EPRI Technical Report: 1003326, "Characterization of Fire-Induced Cable Faults: Results of Cable Fire Testing") conducted in 2001. Page 2 of the SECY states: "...the staff and NEI concluded that the probability of fire-induced circuit failures can be relatively high and that there can be a relatively high probability of multiple spurious actuations occurring simultaneously or in rapid succession". The reference to NEI in this statement is inaccurate, as the EPRI/NEI test report includes no such statement or inference, nor has NEI stated this position.

The purpose of the EPRI/NEI testing was to determine what, if any, circuit failures would occur when cables were exposed to a severe fire resulting in cable damage. The test was designed to cause cable failures and assess possible interactions and, as such, was not necessarily representative of expected fire conditions in typical plant designs. There were 10 key observations and conclusions drawn from this testing. These are listed in their entirety in Enclosure 2. However, it is noteworthy to cite one conclusion in particular as it illustrates the indeterminate, non-generic nature of the test results:

"Given cable damage, single spurious actuations are credible and multiple spurious actuations cannot be ruled out. External cable hot shorts are also credible, but have a significantly lower probability of occurrence than do internal hot shorts. An important outcome of the tests is that no external cable hot shorts precluded a spurious actuation in thermoset cable."

We firmly believe that a careful review of all the observations and conclusions will lead to a different overall conclusion that is currently proposed by the staff.

Furthermore, applying the staff's conclusions from the EPRI/NEI testing to existing plants does not take into account the existence of an effective fire protection program and the multiple layers of defense-in-depth that exist in plant designs such as: constraints on ignition sources, control of combustible materials, installed detection and suppression systems, fire barriers, fire brigade activities, and other mitigating factors that address any and all simultaneous circuit failures. These levels of protection are designed to:

- Prevent fires from occurring
- Detect and suppress fires should they occur
- Mitigate the effects of fires
- Protect the plant by achieving safe-shutdown

All of these elements, when considered together, make it unlikely that a fire event would occur that is capable of causing cable damage and resulting circuit failures. This is supported by actual experience with plant fires.

Disposition of Industry Comments

The NRC responses to industry comments on the draft generic letter did not always address the posed question or underlying concern. Responses often replied to the comment without explaining the technical or regulatory basis for the staff position. If this issue is to be resolved, better technical bases for the staff positions are needed. This lack of responsiveness continues to be problematic with the NRC process for seeking public comment.

Concerns

The NRC's new position on spurious actuations affects the licensing basis of all plants. It should not be inferred that transitioning to NFPA 805 will address the underlying problem. A viable means to closure is needed. The following points describe the basis for our concerns:

1. Given that the results of the EPRI tests were not designed to be representative of expected fire conditions for typical plant designs, rather than requiring the industry to pursue analysis of multiple spurious actuations or plant modifications that avoid the problem, we recommend the NRC not pursue this regulatory action until additional tests have been performed that are more representative of realistic plant conditions. The NRC's Office of Research is conducting testing of cable response and failure during fire exposure under the CAROLFIRE program. We understand that the results of this research will be final in early 2007. NRC has stated the goal of this project is "to reduce uncertainty of electric cable response to fire conditions in fire models". We believe that these test results will provide additional insights that will be critically important to a resolution of this issue. We would appreciate the opportunity to peer review these test results.
2. Issuance of the generic letter would place plants in a position of performing an analysis for which no guidance has been developed. A more effective way of addressing the issues identified in the draft generic letter would be to focus on revising the methodology of NEI 00-01 "Guidance for Post-Fire Safe-Shutdown Circuit Analysis" to consider the risk of multiple spurious actuations affecting safe-shutdown. NEI is willing to work with the staff to develop a methodology acceptable to the staff for evaluating multiple spurious simultaneous faults.

3. Implementing the staff position as stated in the proposed generic letter will result in costs across the industry ranging from \$200 to \$500 million. This is based on an estimated cost per plant of between \$2 and \$5 million and does not include potential plant modifications. Due to the non-specific and unbounded nature of the circuit failure requirements provided in the proposed generic letter, there is still a high degree of uncertainty associated with this estimate. Implementation of the staff position is not justified by the low safety significance of the issue as demonstrated during several plant-specific evaluations.

Conclusion

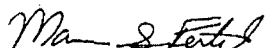
The conditional probability of spurious actuations is relatively high given a serious fire event causing cable damage, but low if all the factors affecting the potential for cable damage are considered. Calculations of CDF from multiple spurious actuations from the NEI 00-01 pilots showed that, without exception and to the best of our knowledge, multiple spurious actuations have low safety significance.

We respectfully request that the generic letter not be issued because:

- A backfit analysis has not been performed that supports the new staff position by demonstrating its safety benefit.
- A sufficient understanding of the probability and effects of multiple spurious actuations has not been developed.
- A means for analyzing multiple spurious actuations to provide reasonable assurance of safe-shutdown capability has not been developed.

We would appreciate the opportunity to work with staff to develop a resolution strategy and closure to this issue. If you have any questions, please do not hesitate to contact me at 202-739-8125; msf@nei.org or Jay Thayer at 202-739-8112; jkt@nei.org.

Sincerely,



Marvin S. Fertel

Enclosures

- c: The Honorable Edward McGaffigan, Jr., US NRC
Mr. James E. Dyer, NRR, US NRC
Mr. Michael F. Weber, NRR, US NRC
Mr. Gary M. Holahan, NRO, US NRC
Mr. James E. Lyons, NRO, US NRC
Mr. John A. Grobe, NRR, US NRC
Mr. Cornelius F. Holden, Jr., NRR, US NRC
Dr. Sunil Weerakkody, US NRC
Mr. Alexander R. Klein, US NRC
Document Control Desk

**Comments on SECY-06-0196 Issuance of Generic Letter 2006-XX,
"Post-Fire Safe-Shutdown Circuit Analysis Spurious Actuations"**

Summary

- I. The EPRI/NEI tests (EPRI Technical Report: 1003326, "Characterization of Fire-Induced Cable Faults: Results of Cable Fire Testing") did not yield results that are drastically different from the existing knowledge base available prior to the testing. In fact, it could be concluded that the results validated the positions held within the industry prior to the testing.

- II. The driving need identified by the NRC for requiring a change in the current circuit failure criteria applied in the post-fire safe-shutdown analysis is based on the information contained in the EPRI/NEI tests conducted in 2001. An independent and objective review by fire protection engineering experts of information related to this test has been unable to identify a need for the changes proposed in NRC Generic Letter 2006-XX.

A more plausible and effective way of addressing the issues identified in the EPRI/NEI tests and in NRC IN 99-17 would be to focus on revising the methodology of NEI 00-01 "Guidance for Post-Fire Safe-Shutdown Circuit Analysis" to consider the risk of multiple spurious actuations affecting safe-shutdown.

- III. The NRC recently indicated that the draft generic letter is also applicable to III.G.3 alternate shutdown fire areas. This appears to be a significant scope change occurring after the public comment period for the proposed generic letter.

Information supporting the above comments is provided in the following pages.

I. The EPRI/NEI tests (EPRI Technical Report: 1003326, "Characterization of Fire-Induced Cable Faults: Results of Cable Fire Testing") did not yield results that are drastically different from the existing knowledge base available prior to the testing.

The following four examples from the cable tests support industry's current approach to fire-induced circuit failure analysis.

- A.) Addressing cable faults one-at-a-time vs. multiple simultaneous actuations
- B.) Addressing cable faults for all conductors in each safe-shutdown cable
- C.) Duration and timing of the hot short causing a spurious actuation
- D.) Affect of testing on prior information about temperature related cable degradation

A discussion of how these examples support the industry's approach is presented below.

A.) Addressing cable faults one-at-a-time vs. multiple simultaneous actuations

The EPRI/NEI testing provides no positive indication that multiple spurious actuations affecting multiple redundant trains is possible given the current nuclear power plant designs and regulatory requirements for divisional separation and electrical separation based on Regulatory Guide 1.75.

The results of the expert elicitation conducted in support of the cable testing conclude that the effects of hot shorts leading to spurious actuations cannot be ignored. This conclusion is also echoed in the EPRI Report providing the testing results. The EPRI Report providing the results of the cable testing, however, also concludes that the predominant factor in determining cable fault mode is proximity. "Opportunity" must exist for two conductors to short together. Given the current regulatory requirements for divisional separation and electrical separation based on Regulatory Guide 1.75, proximity of cables for redundant trains should preclude the negative effect of multiple spurious actuations at the component and system level.

What the testing showed was that conductors within a common cable or in a common cable tray could be affected simultaneously. Regulations preclude conductors for redundant trains from being run within a common cable or cable tray. Given that the current requirements apply the same criteria to all safe-shutdown cables in the fire area, the current requirements are extremely conservative relative to the "proximity" findings of the EPRI/NEI testing.

B.) Addressing cable faults for all conductors in each safe-shutdown cable

The EPRI/NEI testing provided information suggesting that industry's current approach for analyzing post-fire safe-shutdown is conservative.

- First, no cases involving open circuits were identified during the test. The current approach requires that open circuits be postulated for each conductor in each safe-shutdown cable on the required safe-shutdown path in the fire area.
- Secondly, the testing indicated hot shorting in cables in conduit was deemed to be unlikely. The current approach requires the postulation of a hot short on each conductor in each safe-shutdown cable regardless of the raceway type.
- Finally, in the testing inter-cable hot shorts were found to be highly unlikely. The current approach requires the postulation of inter-cable hot shorts.

C.) Duration and timing of the hot short causing a spurious actuation

The EPRI/NEI testing has shown that the approach to evaluating fire-induced circuit failures employed in the current guidance is conservative.

Based on the testing, multi-conductor cables are more likely to short cable-to-cable than to ground. The industry's current approach addresses postulating a hot short on each conductor in each safe-shutdown cable. Given that redundant train functions are not included within the same cable, not combining the effects of these hot shorts is not viewed as a non-conservatism.

Based on the testing, when intra-cable conductor-to-conductor shorts happen they take approximately 15 to 30 minutes to occur and they last between four seconds and four minutes. This aspect of the testing renders the criterion in the current approach (the assumption of a hot short lasting until an action is taken to isolate the fault) to be conservative. This aspect of the testing also validates the assumption made by some licensees that time is available to take an action to mitigate the effect of a potential spurious actuation.

D.) Affect of testing on prior information about temperature related cable degradation

The testing confirmed that the degradation threshold temperature for thermoplastic cable was approximately 400°F and approximately 700°F for thermoset cable. This is consistent with the previous test results, particularly the oven aging tests conducted at Sandia National Laboratories (SNL) years ago.

II. The driving need identified by the NRC for requiring a change in the current circuit failure criteria applied in the post-fire safe-shutdown analysis is based on the information contained in the EPRI/NEI tests conducted in 2001.

SECY-06-0196 discusses the results of the EPRI/NEI testing performed in 2001 and uses the results of this testing as a primary basis justifying the need for the generic letter. The last sentence in the Background Section of the SECY on page 2 reads as follows:

“Based on the test results, the staff and NEI concluded that the probability of fire-induced circuit failures can be relatively high and that there can be a relatively high probability of multiple spurious actuations occurring simultaneously or in rapid succession.”

A review of the documentation prepared in support of the EPRI/NEI testing does not support this conclusion. Examples from three documents that were prepared in support of the testing are provided below:

A.) EPRI Report 1006961, “Spurious Actuation of Electrical Circuits Due to Cable Fires: Results of an Expert Elicitation”

Review of the Facts:

1. On page B-22, Expert Dr. Frederick W. Mowrer, Ph. D., P.E., provides the following conclusion:

“In summary, it appears that these test results are consistent, to a large extent, with previous work on cable damageability, particularly the oven aging tests conducted at SNL years ago. By this, I mean that it appears that 400°F is the approximate degradation temperature of the thermoplastic cable used in these experiments and 700°F is the approximate degradation temperature of the thermoset cables used in these experiments. Beyond these degradation temperatures, the potential for the loss of insulation resistance and consequent electrical activity is likely to depend on a number of factors that are difficult to characterize based on the 18 tests conducted for this project.”

2. On page B-32 and 33, Expert Steven P. Nowlen states:

“Overall, the likelihood of spurious actuation given failure was found to be somewhat higher than I might have assumed prior to conduct of the tests, It should also be observed that in estimating the likelihood of spurious operation, I have not explicitly considered issues of timing and duration. For example, if the industry tests report relay “chatter” I counted this as a spurious actuation. Also,

given a circuit lock-in, I also counted this as an actuation regardless of how long the actuation held. In practice, some consideration will need to be given to the timing and duration of the hot shorts in order to get an accurate estimate of risk implications.”

3. On page B-67 and 68, Expert Dr. R. Brady Williamson provides the following:

“... I have had a difficult time understanding what the data means in these fire tests. The arbitrary use of different door opening heights was one of the features that have made the analysis of the data so difficult. The actual fire scenarios created in each experiment are not well documented. There are, however, several conclusions that I can make from my analysis of the information...”

Dr. Williamson’s best estimate of the probability of a false actuation given a fire is: (1) for thermoset cable – 10^{-3} ; (2) for thermoplastic cable – 10^{-1} .

Analysis of the Facts:

Based on the conclusions provided by independent evaluation by industry experts, the EPRI/NEI tests did not yield results that are drastically different from the existing knowledge base available prior to the testing. In fact, it could be concluded that the results validated the positions held prior to the testing.

B.) NUREG/CR-6776, Cable Insulation Resistance Measurements Made During Cable Fire Tests

Review of the Facts:

1. On page 87, Section 7.1: “The duration of the hot shorts observed ranged from a few seconds to 4 minutes.”
2. On page 89, section 7.1: “No cases involving open circuit cable failures were observed. These results are consistent with the findings of the SNL letter report in that open circuit failures have only been observed in cases involving cables energized with a high energy (voltage and/or current) power source, and then only after repeated short-to-ground failures and arcing.”
3. On page 89, Section 7.1: “If cables routed in conduit are excluded (tests 8 and 18), the IR data results are roughly consistent with these earlier findings and, in general, indicate a high likelihood that, if failure occurs, multi-conductor cables will short internally before shorting to an external ground.”
4. On page 89, Section 7.1: “The data provides strong indications that the routing of cables in conduit tends to substantially reduce the likelihood of hot shorts (either intra- or inter-cable).”

5. On page 90, Section 7.2.1.1: "Thermoset cables tended to short-to-ground more frequently than thermoplastic cables."

Analysis of the Facts:

An independent evaluation of the facts by expert elicitation concludes the following:

- The likelihood of occurrence of a hot short is a function of many variables.
- Inter-cable hot shorts in thermoset cables and for cables in conduits are not likely.
- Multi-conductor cables are more likely to short conductor-to-conductor than to short-to-ground as a first failure mode.
- Hot shorts in multi-conductor thermoplastic cables are more likely than in thermoset cables.

C.) EPRI Report 1003326. "Characterization of Fire-Induced Circuit Failures"

Review of the Facts:

1. On page 14-3, Section 14.4:

"The proximity of conductors to each other is the predominant influence factor in determining fault mode. 'Opportunity' must exist for two conductors to short together."

2. On page 14-4, Section 14.4:

"Definitive predictions of fire-induced circuit failure outcomes is not viable."

"Cables do not fail immediately. The average time to failure exceeded 30 minutes for thermoset and armored cable and 15 minutes for thermoplastic cable. ...Preplanned high value actions have a high probability of success and should reduce both likelihood and consequence of serious fire. Similarly, early preemptive action for high risk spurious actuation components will significantly reduce the risk posed by these components."

"Spurious actuations are a transient and finite event; ultimately circuit conditions will degrade to a point that a ground fault develops and de-energizes the source conductor. Postulating that spurious actuations will last indefinitely in the absence of intervening action appears unrealistic. Probability calculations for thermoset cable indicate that over 96% of all spurious actuations will terminate within 10 minutes."

Analysis of the Facts:

An independent evaluation of the facts by expert elicitation concludes the following:

- It is possible for multiple hot shorts resulting in multiple spurious actuations to occur at the same time as a result of the same localized fire. For this to occur, the conductor of concern for causing each spurious actuation must be in close proximity. Whether or not these multiple spurious actuations have a combined adverse impact on post-fire safe-shutdown is a function of whether or not the cables are associated with plant equipment that could provide the necessary combined effect. Divisional separation and electrical separation meeting the requirements of Regulatory Guide 1.75 may be sufficient to preclude these types of combined adverse interactions.
- Even if the conductors of concern are in the same area in close proximity, for a thermoset cable it will take approximately 30 minutes for the necessary damage to occur. Preplanned actions to mitigate the effects of this spurious actuation would be effective in mitigating the effects on post-fire safe-shutdown. In areas with low fire hazards, it is unlikely that damaging conditions could be reached, since the fuel available would not support a thermal challenge to the cables like that experienced in the EPRI/NEI tests. In areas with high fire hazards, the automatic suppression and brigade would both have to fail for the damage sequence experienced in the EPRI/NEI testing to be credible.

Conclusion

Based on the conclusions provided above, the EPRI/NEI tests did not yield results that are drastically different from the existing knowledge base available prior to the testing. In fact, it could be concluded that the information that could be considered new did more to relax criteria previously applied in a post-fire safe-shutdown analysis than to suggest that new and more stringent criteria are required.

III. The NRC recently indicated that the draft generic letter is also applicable to III.G.3 alternate shutdown fire areas. This appears to be a significant scope change occurring after the public comment period for the proposed generic letter.

Initially, industry understood that the Draft Generic Letter 2006-XX "Post-Fire Safe-Shutdown Circuit Analysis Spurious Actuations" applies only to Appendix R III.G.2, redundant shutdown areas. This determination was based on the following:

A.) The draft generic letter reference to the Generic Letter 86-10 Question 5.3.10 discussion that safe-shutdown should not be affected by any one single spurious signal, and the fact that the draft generic letter identifies that this approach is only allowed for alternate shutdown capability.

B.) The fact that by not refuting the following "any and all one-at-a-time" comment for alternate shutdown areas (extracted from Enclosure 2 to SECY-06-0196), the NRC is effectively acknowledging "any and all one-at-a-time" as an acceptable approach for alternate shutdown areas.

Comment:

Entergy Operations Comment E1, STARS Comment S9 - The NRC appears to be prescribing inconsistent safe-shutdown criteria with respect to spurious circuit actuations. What is the technical justification for allowing the "any and all one-at-a-time" interpretation for alternative safe-shutdown areas (III.G.3) but not for non-alternative safe-shutdown areas (III.G.2)? A fire can not tell if the area is an alternative or non-alternative safe-shutdown area.

Staff Response:

III.G.2 is held to a different standard than III.G.3. III.G.2 protection is the first line of defense in a fire (for plants without III.G.1 protection). III.G.3 protection is a fallback arrangement for protection that does not fully comply with III.G.2 requirements.

C.) The "Applicable Regulatory Requirements" section of the draft generic letter specifically identifies and discusses III.G.2, but it does not identify or discuss III.G.3 applicability.

However, in a recent oral communication with a licensee, the NRC indicated that the draft generic letter is also applicable to III.G.3 alternate shutdown fire areas. Based on the above discussion, this appears to be a significant scope change occurring after the

public comment period for the proposed generic letter. This is especially significant since the III.L performance parameters can't be satisfied if the following analysis approach (identified in the proposed generic letter) must be utilized for III.G.3 areas:

"Licensees should assume that the fire may effect all unprotected cables and equipment within the fire area simultaneously and address all cable and equipment impacts affecting the required safe-shutdown path in the fire area."

A III.G.3 fire area does not provide the level of fire protection as a III.G.2 fire area. In applying the same multiple spurious analysis criteria for both III.G.2 and III.G.3 fire areas, it appears the staff is, for all practical purposes, eliminating III.G.3 fire areas, as literal compliance to the letter would necessitate that III.G.3 fire areas be separated in accordance with III.G.2 requirements. This is not practical, commensurate with risk, or cost beneficial.

In summary, if the staff intends for the proposed generic letter to apply to III.G.3 areas, then this approach needs to be supported by the staff's backfit analysis and the letter needs to clearly state such. In any case, the staff needs to clearly identify the parameters that are to be applied for III.G.3 areas. Not only is this specific issue important if the draft generic letter moves forward as written, it emphasizes the need for consistency between regulatory written and oral clarifications.

EPRI / NEI Tests Observations and Conclusions

The key observations and conclusions from the EPRI/NEI test performed in 2001 are in section 14.4 of the associated EPRI Technical Report: 1003326, "Characterization of Fire-Induced Cable Faults: Results of Cable Fire Testing". This information is quoted in its entirety below.

14.4 Key Observations and Conclusions

General observations and conclusions are listed below. However, a full appreciation of the test results cannot be obtained without a more detailed review of the information presented in Sections 11 and 12.

1. Given cable damage, single spurious actuations are credible and multiple spurious actuations cannot be ruled out. External cable hot shorts are also credible, but have a significantly lower probability of occurrence than do internal shorts. An important outcome of the tests is that no external cable hot shorts produced a spurious actuation in thermoset cable.
2. Given that a hot short occurs in a multi-conductor cable, it is highly probable (over 80%) that multiple target conductors will be affected (i.e., multiple simultaneous dependent hot shorts).
3. The proximity of conductors to each other is the predominant influence factor in determining fault mode. "Opportunity" must exist for two conductors to short together.
4. No open circuit faults occurred during the Test Program. Open circuits do not appear to be a credible primary cable failure mode for fire-induced faults.
5. A minimum credible fault threshold impedance did not prove viable - many shorts exhibited a near zero fault resistance.
6. Statistical characterization of fire-induced cable failures is achievable. General trends are predictable and primary influence factors are understood. However, probability estimates still carry a relatively high uncertainty.
7. Definitive predictions of fire-induced circuit failure outcomes is not viable:
 - The specific behavior and characteristics of any one fault cannot be predicted with full certainty
 - Failure mode is a function of localized conditions and subtle aspects of geometry and configuration
 - A full understanding of the fault dynamics and interdependencies is beyond the current state of knowledge

8. The dominant influence factors for the likelihood of spurious actuation are:
 - Cable type
 - Power supply characteristics
 - Tray fill
 - Conductor connection pattern

9. Cables do not fail immediately. The average time to failure exceeded 30 minutes for thermoset and armored cable and 15 minutes for thermoplastic cable. These statistics are meaningful and important to real world application of the test results. The time frames show that early action in a fire is highly likely to be affective at accomplishing the desired function. Preplanned high value actions have a high provability of success and should reduce both likelihood and consequence of serious fires. Similarly, early preemptive action for high risk spurious actuation components will significantly reduce the risk posed by these components.

10. Spurious actuations are a transient and finite event; ultimately circuit conditions will degrade to a point that a ground fault develops and de-energizes the source conductor. Postulating that spurious actuations will last indefinitely in the absence of intervening action appears unrealistic. Probability calculations for thermoset cable indicate that over 96% of all spurious actuations will terminate within 10 minutes. This probability estimate carries an uncertainty of approximately 7% at the 95% confidence level.