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December 14,1999

Mr. John Hannon
Chief, Plant Systems Branch
Division of Safety Systems and Analysis
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: Industry Integrated Methods for Addressing Circuit Failure Issues

PROJECT NUMBER: 689

Dear Mr. Hannon:

At your request, enclosed is a copy of the current draft outline of a risk-informed industry method for addressing the issue of fire-induced circuit failures (hot shorts, shorts to ground, or open circuits). Attached to this draft is a description of three generic tasks still in progress that are central to completion of the industry method. Both the enclosure and attachment are provided in draft form for NRC staff review in advance of our meeting on December 20. By having these advance copies, it is our hope that we can have a more focused discussion on the merits of the industry proposals.

As you know, this topic has remained a difficult regulatory issue between the US nuclear industry and the NRC for several years. At issue are two questions:

- Under current regulations, must plants postulate the effects of combined fire-induced circuit failures or is it acceptable to address each individually?
- Under current regulations, must plants postulate potential equipment damage from fire-induced spurious actuation of valves or pumps, e.g., Information Notice 92-18 failure modes?

The BWR Owners Group and the NEI Circuit Failures Issue Task Force developed deterministic and probabilistic approaches, respectively, to resolving the issue. EPRI is supporting the NEI task force by developing circuit failure characterization criteria. These three efforts are being integrated into the risk-informed method

Attachment 2

noted above in the hope of establishing a more rational, safety-focused, and effective approach toward issue resolution.

It is not our intent to broaden this method to all aspects of safe shutdown circuit analysis. Rather, it is narrowly focused on identifying a resource-efficient course of action if the answer to the two questions above is *yes*. Neither NRC nor industry desire to repeat the large expenditure of resources on this aspect of plant fire protection regulation as had been our collective experience in the past. Consequently, the focus on a risk-informed solution is paramount.

These enclosures should be considered outlines rather than full descriptions of the methods, and should be considered works in progress. Further work is required to fully support the method. They do not represent a final statement of industry positions, but rather a substantive description of a suggested industry approach. We are anxious, as is the NRC, to resolve the differing views between NRC and industry on this matter.

We request that you review these documents in the same spirit that industry reviewed NRC drafts of the Fire Protection Risk Significant Screening Method and the baseline inspection procedures over the past several months – as working documents subject to further optimization through comment. We have already planned additional work in the near future to further develop the method, but having your feedback first would help us achieve an acceptable outcome.

Please call me at 202-739-8084 if you have questions prior to our meeting on December 20.

Sincerely,

David J. Modeen

FAE/
Enclosure

c: Mr. Steven K. West, NRC

Industry Method for Addressing IN 92-18 Failure Modes and Multiple Spurious Actuations

Please provide any comments to Fred Emerson at fae@nei.org or 202-739-8086.

I. INTRODUCTION

Difficulties in interpreting NRC requirements and regulatory guidance, along with numerous variations in plant design, have resulted in plant-specific post-fire safe shutdown analysis approaches. Some of these approaches are based on long-held industry interpretations of regulations which differ from the staff interpretations expressed in their letter to NEI of March 11, 1997.

As the industry moves forward, a greater emphasis is being placed on risk-informed methodologies such as those used in the on-line maintenance and outage risk management areas. NRC has indicated its receptivity to a risk-informed industry proposal for resolving the circuit failures issues. Industry is therefore proposing this risk-informed approach for addressing circuit failures issues, which integrates the deterministic approach proposed by the BWR Owner's Group on November 15, 1999, with circuit failure characterization and probabilistic elements developed by the NEI Circuit Failures Issue Task Force.

II. OBJECTIVE

This document presents a method for determining the safety significance of concurrent spurious actuations, and potential fire-induced circuit failure modes indicated in Information Notice 92-18. If the user determines that additional measures are needed to prevent or mitigate the consequences of the spurious actuations, this method can also be used to ensure the cost-effectiveness of these measures.

This method, including the documentation of its use and any additional measures taken to address its results, should constitute an acceptable method for resolving these circuit failures issues.

III. METHOD

General Description

This screening method evaluates the likelihood and consequences of concurrent spurious actuations, and fire-induced spurious actuations that could result in valve failure modes as described in IN 92-18 (which can result in irrecoverable damage to valves because of bypassing valve motor protective devices). The criterion for determining risk significance is whether the increase in core damage frequency (Δ CDF) for each component (or component pair) is less than the Regulatory Guide 1.174 guideline of 1E-6 per reactor year. The analysis involves a phased approach which successively multiplies the previously calculated risk factors by new ones at each phase, and compares the Δ CDF against the 1E-6 criterion. This allows the option of stopping the analysis at any phase where the Δ CDF or probabilistic contributors thereto have been determined to be "insignificant" because they are less than 1E-6 per reactor year.

It should be noted that a Δ CDF of 1E-6 per reactor year establishes a lower bound for truncating both analyses and needs for further action. Regulatory Guide 1.174, Figure 3, "Acceptance Guideline for Core Damage Frequency," also illustrates the concept of relative risk measure; that is, the Δ CDF of importance is based on the baseline CDF. The larger the baseline, the less significant is a Δ CDF of 1E-6.

Before any component or component pair is screened out, SM (safety margins) and DID (defense-in-depth) degradations are considered in accordance with Regulatory Guide 1.174. The SM and DID evaluation guidance currently being developed for NFPA 805 may also be useful.

If, when all evaluation phases are completed, the Δ CDF remains greater than or equal to 1E-6 per reactor year, further actions to address the results of the analysis will be evaluated. The complexity of possible corrective measures can be kept to a minimum by defining the additional risk reduction needed to render the Δ CDF less than 1E-6 per reactor year. As an example, if a potential spurious actuation has been determined to have a Δ CDF of 1E-5 per reactor year after completing the screening process, a corrective action which applies an additional reduction factor of at least 10 would result in an acceptable configuration.

These screening steps are provided generally in the order of ease of analysis and robustness of acceptable methods, but they may be conducted in any order of the factors noted below.

The probabilistic formula used for this analysis follows. The factors listed below are considered to be independent.

$$\Delta \text{CDF} = F_f * P_{SA} * P_{DS} * P_M * P_{CCD} \text{ (per reactor-year)}$$

F_f = fire frequency
P_{SA} = probability of spurious actuations
P_{DS} = probability that detection and automatic suppression will not control the fire
P_M = probability of failure of manual suppression to control the fire
P_{CCD} = conditional probability of core damage given fire-induced spurious actuations

The focus of the assessment methodology contained within this document for IN 92-18 type failures is the Control Room. This is the area of the plant with the largest population of circuits from both divisions in the closest proximity to each other. As such, if this area can be demonstrated to have low safety significance, then the remaining plant areas could be considered to be less of a concern.

Additionally, any modifications performed on Control Room circuits to alleviate IN 92-18 issues will not eliminate them, but will rather relocate them to an alternate location in the plant. By demonstrating that the Control Room fire area is a low safety significance area, justification would exist for allowing the concern for this condition to be, to a large extent, conglomerated within the Control Room fire area. By keeping the potential for this concern within the Control Room, the continuous manning and strict control of combustibles currently applicable to the Control Room will provide positive measures for helping to prevent any occurrence of the condition.

Step-By-Step Analysis

Selection

This selection process builds on prior deterministic circuit analysis work. Configurations are defined in this selection step for both BWR and PWR plants. Industry expects to provide additional considerations for PWR plants in the BWROG guidance document or reflect them in the NEI guidance document which incorporates this method.

1. Select target components (or combinations of two components for multiple spurious actuation evaluations) which could impact safe shutdown to be evaluated. This first step limits consideration of multiple spurious actuation evaluations to pairs with immediate and direct consequences comparable to high/low pressure interface failures. Potential circuit failures affecting these safe shutdown target components may have been considered in previous circuit analyses, but perhaps not for IN 92-18 or multiple spurious actuation concerns. Only one component at a time needs to be considered for IN 92-18 evaluations.

2. Apply the BWROG method to selection of safe shutdown equipment, their associated target cables, and the physical location of target cables. These steps are accomplished by completing steps 3.1.3.1 through 3.4.2.5 of the BWROG guidance document for the components and fire areas in question.

3. For IN 92-18 evaluations, determine the type of actuator for these valves. Bistable relays require only a momentary signal to drive the valve open or closed; other types require a sustained signal. If bistable relays are not employed in the control circuitry, determine the length of time it takes for the valve to open or close given an actuation signal.

4. If potential circuit failures in any of these target conductors are addressed by the deterministic mitigation techniques in the BWROG guidance, then no further analysis is needed.

   Screen One

   The purpose of Screen One is to quickly and qualitatively determine the safety significance of the component failure(s) in question, regardless of the likelihood of occurrence. This significance results from the adverse failure mode of this component(s). The method outlined below is one way to do this.

5. Use Table 1 to qualitatively determine the risk significance of a postulated fire capable of causing these failure modes. The qualitative criteria used for the screening are based on an event tree analysis of bounding quantitative estimates of the parameters in the probabilistic formula above, considering plant specific features. The criteria for risk significance are based on Reg Guide 1.174 guidance.

   The numbers in Table 1 represent the number of risk reducing activities (represented by parameters of the probabilistic formula) that would need to be deterministically credited for evaluated components in order to screen out that component(s) from further analysis. Several examples:

   a. If for evaluated components the fire frequency (F_f) is qualitatively judged to be low and the circuit failure modes probability (P_{CF}) is judged to be low, no further screening is required. Explained in another way, the combination of a low fire frequency and a low circuit failures probability given a damaging fire makes it very unlikely that spurious actuation(s) will result.

   b. If for evaluated components the fire frequency (F_f) is qualitatively judged to be medium and the circuit failures probability (P_{CF}) is judged to be high, the components can be screened out as risk insignificant if at least two other reducing factors (such as automatic detection and suppression and manual suppression) can be credited deterministically as effective. Explained in another way, a medium fire frequency and a high circuit failures probability given a damaging fire will require at least two other mitigating factors (such as automatic detection and suppression, and protected safe shutdown equipment) to be credited deterministically to prevent the spurious actuation(s).

c. If for evaluated components the fire frequency (F_f) is qualitatively judged to be high and the circuit failures probability (P_{CF}) is judged to be high, the remainder of this probabilistic screening analysis must proceed at least to Screen Two in order to screen out the component. Explained in another way, if both the fire frequency and the circuit failures probability given a damaging fire are high, one cannot rule out spurious actuation(s) at this stage without detailed probabilistic analysis.

Screen Two

The purpose of Screen Two is to screen out potential spurious actuations based on fire frequency times a spurious actuation conditional probability, the former derived from generic data or plant-specific data. The spurious actuation conditional probability will be derived from hot short probabilities, which will in turn be available from the generic Delphi process described in the attachment, and assume a fire size based on a conservatively realistic evaluation of combustibles and initiators (no fire modeling). The spurious actuation probabilities therefore reflect this conservative fire size, which may or may not be large enough to cause significant damage to cable insulation.

6. Determine the characteristics (combustible types and potential initiators) of the fire areas where the target conductors are located.

7. Using the fire hazards analysis, determine a reasonable and conservative fire size, duration, and energy level (without using detailed fire modeling codes) in the vicinity of the components. This involves consideration of fixed and transient combustibles and ignition sources.

8. Using fire initiator data, determine the frequency of this fire (F_f).

Steps 9-11 address the determination of a spurious actuation probability P_{SA}

9. Obtain a circuit failure probability given a damaging fire (P_{CF}) from the results of the generic Delphi process described earlier.

10. For the fire determined in Step 7, determine a fire size parameter (P_E) from the results of the generic Delphi process described earlier. This parameter reflects the fact that below some energy threshold the likelihood of insulation damage is

very small.

11. Calculate the probability of spurious actuation(s) (P_{SA}) given a fire of the size determined in Step 7. The formula is:

$$P_{SA} = P_E * P_{CF}$$

This formula states that the probability of a spurious actuation depends on both the probability of damage before a fire reaches a certain severity threshold and the probability of hot shorts given a damaging fire.

12. If F_f * P_{SA} < 1E-6, screen this component from further review if SM and DID considerations permit.

<u>Screen Three</u>

The purpose of Screen Three is to credit the capability of the automatic detection and suppression systems for restraining the fire before it reaches damaging proportions.

13. Determine whether automatic detection and suppression capabilities available in the area are adequate to restrain the fire. This evaluation should consider the characterization of the area, type of the fire (fire with significant smoke generating capability before generating a lot of heat versus other fires), features of the detection and suppression equipment available in the area and the time available before fire severity reaches unacceptable levels.

14. Calculate the probability that automatic detection and suppression systems do not prevent undesirable consequences to the cables (P_{DS}), using established fire PSA techniques for automatic detection and suppression systems. These techniques are described in EPRI documents such as NSAC-179L, the FIVE method, and the PRA guide.

15. If F_f * P_{SA} * P_{DS} < 1E-6, screen from further review if SM and DID considerations permit.

<u>Screen Four</u>

The purpose of Screen Four is to apply the probability that manual suppression will not control the fire before it reaches damaging proportions. Manual suppression is considered effective if it is timely and uses the correct techniques and suppressants for the fire in question. This calculation will consider the dependency between automatic and manual suppression.

16. Using the results of Step 13, calculate the probability that manual suppression fails to extinguish the fire before cable damage thresholds are reached (P_M)

17. If F_f * P_{SA} * P_{DS} * P_M < 1E-6, screen from further review if SM and DID considerations permit.

Screen Five

When Screen Four is complete, one has calculated the probability of a spurious actuation which could result in irrecoverable valve damage. The purpose of Screen Five is to determine the conditional core damage probability given the spurious actuation(s) have occurred.

This analysis may be performed in two steps using the internal events PSA: (1) Determine the CCDP (conditional core damage probability) crediting only safe shutdown systems; (2) determine the CCDP for all available mitigation systems, some of which may not have been credited in safe shutdown analyses. This evaluation may be performed to determine the incremental risk reduction benefit provided by systems or equipment not previously credited for safe shutdown, to mitigate the unacceptable consequences of the spurious actuation. Note that if potential circuit failures in the target conductors are not addressed by the deterministic mitigation techniques in the BWROG guidance (see Step 3), then further analysis to address the value of potential recovery actions may be useful.

18. Using an internal events PSA analysis, determine the CCDP (P_{CCD1}) of the failure mode of concern for the target component(s) and other safe shutdown components damaged by a fire. This is done by assigning a failure probability of 1.0 for these damaged components that are in the PSA, using the area fire frequency as the initiating event and an appropriate event tree. This analysis does not quantify the size or extent of the fire, except that it is confined to the fire area in question, and does not credit components beyond those identified in the safe shutdown analysis.

19. If F_f * P_{HS} * P_{DS} * P_M * P_{CCD1} < 1E-6, screen from further review if SM and DID considerations permit

20. Using conventional circuit analysis practices (see Reference 5), determine whether systems not previously credited, and are capable of mitigating the consequences of the spurious actuation, have components or cables located outside the fire area. The configuration management of this alternate equipment needs to be addressed.

21. Similar to step 18, using the internal events PSA, calculate the conditional core damage probability P_{CCD2} that this alternate equipment is not available.

22. If $F_f * P_{HS} * P_{DS} * P_M * P_{CCD2} < 1E\text{-}6$, screen from further review if SM and DID considerations permit

Screen Six

The purpose of Screen Six is to use fire modeling techniques to recalculate F_f for a realistic fire.

23. Using accepted fire modeling techniques, determine the probability that a fire size, duration, and location sufficient to cause target conductor insulation damage will not develop.

24. Modify F_f using this probability to calculate a more accurate fire frequency

25. If $F_f * P_{HS} * P_{DS} * P_M * P_{CCD} < 1E\text{-}6$, screen from further review if SM and DID considerations permit. Note that P_{CCD} could either be P_{CCD1} or P_{CCD2} depending on at what stage of the analysis Screen 6 is performed.

Corrective Action

If, when all evaluation phases are completed, the Δ CDF remains greater than or equal to 1E-6 per reactor year, further actions to address the results of the analysis will be evaluated. The complexity of possible corrective measures can be kept to a minimum by defining the additional risk reduction needed to render the Δ CDF less than 1E-6 per reactor year. As an example, if a potential spurious actuation has been determined to have a Δ CDF of 1E-5 per reactor year after completing the screening process, a corrective action which applies an additional reduction factor of at least 10 would result in an acceptable configuration. Any regulatory reporting should be in accordance with existing regulations.

Documentation

The accurate and comprehensive documentation and preservation of documentation of this process is essential to the maintenance of a manageable and auditable Appendix R or BTP 9.5.1 (whichever is applicable) program. Appendix B criteria contained within 10CFR 50 specify the basic documentation requirements while the fire-related regulations contain more detail-specific expectations which will enable the licensee to maintain a compliant program and the NRC inspectors' ability to verify compliance over the life of the nuclear unit.

REFERENCES:

1. Appendix R to 10 CFR 50
2. Branch Technical Position 9.5.1
3. NRC Generic Letter 86-10
4. NRC Information Noticc 92-18
5. GE-NE-T43-0002-00-02, Rev 0 (BWROG Generic Guidancc for Post-Fire Safe Shutdown Analysis)
6. NFPA 805 Draft 7.0
7. EPRI reports, numbers to be supplied

Table 1

Screen One

	Fire Frequency		
Probability of Circuit Failures	**H**	**M**	**L**
H	Analyze	3	2
M	3	2	1
L	2	1	OK

Attachment 1

Generic Activities to Support Industry Method for Resolving Fire-Induced Circuit Failures Issues

Industry recommends that three generic activities be carried out in the next six to nine months to support the use of the industry circuit failure resolution method, which is described separately:

- Develop guidance for use of Table 1 in Screen One
- Develop quantitative probabilities for circuit failure modes given a damaging fire
- Develop quantitative parameter values for the likelihood of cable damage for fires below the threshold where damage might normally be expected

Guidance for Use of Table 1

Table 1 is used in Screen One to qualitatively determine the risk significance of a postulated fire capable of causing spurious actuations, and the need for additional screening. The values in this table are based on a preliminary event tree involving conservative values for the probabilistic elements in the Δ CDF equation above. Industry plans to develop the supporting event tree and Table 1 further, and plans to request feedback from NRC.

Probabilities of Circuit Failure Modes

Industry is currently developing criteria to characterize qualitatively the likelihood of circuit failure modes including hot shorts, shorts to ground, open circuits, and other failure modes which may be relevant. Industry recommends developing these characterization criteria into a spectrum of quantitative probabilities for these circuit failure modes (**P_{CF}**) to address expected plant equipment and conditions. This would done using a modified Delphi process performed one time by a body of experts representing combinations of regulatory, industry, and independent views, as well as PSA and circuit analysis expertise. This work would make use of available and relevant test results (some of these tests are still being planned) and operating experience. The **P_{CF}** values resulting from this process would be used in the analysis method described separately.

The characterization criteria and the Delphi process may consider such factors as:

- Cable construction (including grounding and number of conductors in each cable) and insulation materials

- Voltage type and magnitude and available fault current

- Need for sustained versus momentary hot shorts to achieve device actuation
- Proximity of hot short sources to targets and compatibility of voltages
- Suspected leakage currents and current necessary to actuate components
- Sequence or timing of failure modes

Results from individual plant analyses of circuit failure probabilities will also be considered where available.

Fire Size Parameter

Industry also recommends using this Delphi process to determine a fire size parameter **P_E** for use in the method below. This parameter reflects the fact that below some fire severity threshold the likelihood of insulation damage is very small. Based on preliminary conclusions from test results, **P_E** might range from a very small value for fires with severity of less than 20,000 BTU/hr up to 1.0 for fires with severity greater than 70,000 BTU/hr. The fire severity levels noted here are based on fires impinging directly on the cable; fires with greater severity may have the same effect if only a portion of the heat is applied directly to the cable and the rest to other room locations.

An Industry Approach to the Resolution of Fire-Induced Circuit Failure Issues

Fred Emerson
NEI
December 20, 1999

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Acknowledgements

- BWR Owners Group
- NEI Fire Protection Working Group
- NEI Circuit Failures Issue Task Force
- EPRI

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Objectives for This Meeting

- NRC acceptance that this industry proposal has sufficient merit to
  - Extend EGM 98-002 moratorium on enforcement action
  - Delay NRC decision on generic regulatory resolution activities until method completed and applied
  - Allow industry to complete method
  - Continue to work out final resolution pathway acceptable to industry and NRC

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Attachment 3

Objectives of Industry Method

- Resolve circuit failures issues
- Address identified NRC issues
- Achieve industry goals

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Resolve Issues

- Complete all generic issue resolution activities by fourth quarter 2000

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Identified NRC Issues

- Combined equipment impacts resulting from concurrent circuit failures
  - Two series/parallel valves
  - Two spurious instrument signals
  - Pump running without minimum flow
- Criteria for performing manual actions and repairs
- IN 92-18 failure modes

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Achieve Industry Objectives

- Base issue resolution on safety significance, not on licensing arguments
- Generically resolve issues where possible
- Provide consistent and accepted method for addressing plant-specific issues
- Integrate conventional circuit analysis and failure experience with risk insights

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Industry Method

- Integrates
  - BWROG circuit analysis guidance
  - EPRI circuit failure characterization
  - NEI probabilistic analysis
- Eliminates need for NRC to address different industry methods
- Provides licensees with consistent and acceptable approach

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Application

- Intended plant use of this method
  - If plant has known circuit analysis issues
  - If plant has not addressed circuit analysis issues fully
- Use of method not intended
  - To re-examine existing circuit analysis
  - If plant's method of addressing circuit analysis issues has been accepted by the NRC

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BWROG Guidance

- Provides consistent guidance for conducting circuit analysis in body of guidance document
- Addresses related issues in appendices
- Concludes that multiple spurious actuations and IN 92-18 issues not sufficiently risk significant to warrant analysis guidance
- Agrees to consider further action if NEI Circuit Failures Issue Task Force determines these issues to be risk significant
- Submitted to NRC on November 15

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EPRI Circuit Failure Characterization

- Supporting NEI Circuit Failures Issue Task Force
- Providing technical basis for industry-defined circuit failure mode conclusions on
  - Hot shorts
  - Shorts to ground, open circuits, other faults
  - Multiple high impedance faults

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Characterization Analysis Parameters

- Circuit type
- Fire hazard
- Fire exposure
- Heat transfer
- Insulation characteristics
- Insulation damage mechanisms

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Characterization Analysis Parameters

- Cable failure modes
- Electric faults
- Protective device characteristics
- Actuation device characteristics including actuation threshold values

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Characterization Analysis Output

- Outline of CF characterization criteria
- FMEA addressing
  - 8 failure modes within a cable
  - 7 failure modes cable-to-cable
- Estimated leakage resistance in damaged insulation
- Pickup/dropout voltage calculations for commonly used electrical devices

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EPRI Circuit Failure Characterization

- Preliminary views
  - Electrical resistance of fire-damaged insulation high enough to prevent many spurious actuations
  - High impedance faults improbable for nuclear plants
- Characterization criteria complete March 2000

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Integrated Industry Approach

- Industry method for circuit analysis integrates
  - Deterministic methods from BWROG guidance supplemented with PWR considerations
  - Cable failure characterization
  - Probabilistic elements for fire initiation, growth, mitigation and plant recovery options

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Pilot Evaluation Goals

- Help plants focus evaluations in productive areas
- Support NRC evaluation of plant-specific issues (SDP)
- Provide insights which allow some potential failure modes to be screened out generically

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Generic Actions to Support Method

- Develop guidance for use of Table 1, Screen One
- Develop quantitative circuit failure probabilities from circuit failure characterization criteria
  - Modified Delphi process using panel of industry and regulatory experts
- Develop quantitative parameter values for likelihood of cable damage for fires below normal damage threshold

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Summary of Method

- Component and circuit selection
- Six screening steps addressing elements of CDF change
- Actions to address results of screening
- Documentation

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Selection

- Multiple spurious actuations
  - Select pairs of components whose concurrent spurious actuation could have immediate and direct consequences comparable to hi/lo pressure interface failures
  - Review cables/circuits in all fire areas where the cables for both components are located
- IN 92-18
  - Focus initial review on single components affected by control room fires
    - Industry develop review criteria for fires outside control room
    - Plants review other fire areas as appropriate
- Use BWROG guidance

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Screening Equation

Δ CDF = $F_f * P_{SA} * P_{DS} * P_M * P_{CCD}$ (per reactor-year)

- F_f = fire frequency
- P_{SA} = probability of spurious actuations given substantial insulation damage
- P_{DS} = probability that detection and automatic suppression will not control the fire
- P_M - probability of failure of manual suppression to control the fire
- P_{CCD} = conditional probability of core damage given fire-induced spurious actuations

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Screen One

- Qualitative review to determine safety significance
  - Select fire frequency (high, medium, or low)
  - Select circuit failure probability (high, medium, or low)
  - Use Table 1 to determine how many deterministic risk reduction factors must be credited to screen out component(s) from further review

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Screen One

Table 1

Probability of Circuit Failures	Fire Frequency: High	Medium	Low
High	Analyze	3	2
Medium	3	2	1
Low	2	1	OK

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Screen Two

- Postulate reasonable but conservative fire size using fire hazards analysis
- Determine fire frequency F_f
- Determine circuit failure probability P_{SA}
  - Determine P_{CF} (circuit failures probability)
  - Determine P_E (fire size parameter)
  - $P_{SA} = P_{CF} * P_E$
- Δ CDF = $F_f * P_{SA} < 1E\text{-}6$?
  - If so, screen out if SM (safety margins) and DID (defense-in-depth) considerations permit

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Screen Three

- Determine whether adequate detection and automatic suppression capabilities available
- Calculate probability P_{DS} that detection and suppression do not prevent undesirable consequences
- Δ CDF = $F_f * P_{SA} * P_{DS} < 1E-6$?
  - If so, screen out if SM and DID considerations permit

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Screen Four

- Calculate probability that manual suppression fails to extinguish fire prior to cable damage (P_M)
- Δ CDF = $F_f * P_{SA} * P_{DS} * P_M < 1E-6$?
  - If so, screen out if SM and DID considerations permit

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Screen Five

- Determine conditional core damage probability for damage to safe shutdown components P_{CCD1}
- Δ CDF = $F_f * P_{SA} * P_{DS} * P_M * P_{CCD1} < 1E-6$?
  - If so, screen out if SM and DID considerations permit

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Screen Five (cont'd)

- Determine conditional core damage probability considering availability of alternate equipment (P_{CCD2})
- Δ CDF = $F_f * P_{SA} * P_{DS} * P_M * P_{CCD2} < 1E\text{-}6$?
  - If so, screen out if SM and DID considerations permit

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Screen Six

- Use accepted fire modeling techniques to refine F_f
- Δ CDF = $F_f * P_{SA} * P_{DS} * P_M * P_{CCD} < 1E\text{-}6$?
  - If so, screen out if SM and DID considerations permit

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Further Plant Actions

- Evaluate further actions to address results of screening analyses
- Document analysis

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Proposed Resolution Pathway

- 1st Quarter 2000
  - NRC extend moratorium on circuit failures enforcement actions to allow full method development
  - EPRI and NEI complete circuit failure characterization criteria
  - NRC and BWROG resolve issues with BWROG guidance
  - BWROG and NEI address applicability to PWRs
  - NRC and NEI resolve remaining issues with industry method
  - NEI draft guideline for use of industry method

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Proposed Resolution Pathway

- 2nd Quarter 2000
  - NRC, NEI and BWROG complete resolution of issues
  - NRC issue SER on BWROG guidance
  - EPRI and RES complete any confirmatory testing/research
  - EPRI and NEI revise circuit failure characterization as needed

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Proposed Resolution Pathway

- 3rd Quarter 2000
  - NEI conduct pilot evaluations of industry method
  - Implement Delphi process to develop circuit failure probabilities and fire size parameters

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Proposed Resolution Pathway

- 4th Quarter 2000
  - NEI and NRC resolve issues for NEI guideline
  - NRC agrees that NEI guideline is acceptable method for resolving circuit analysis issues
  - NRC issues any revised inspection and enforcement guidance
  - NEI guidance available for industry use
  - Generic circuit failures issues closed

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Summary

- Industry integrates BWROG guidance, EPRI circuit failure characterization, and probabilistic fire analysis
- Guidance available for plants with known issues or where analysis is incomplete
- Recommended actions aimed at resolution of circuit failures issues by 4th quarter 2000

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NRC Staff and NEI Meeting on Circuit Analysis
Summary of Topics Covered and Agreements Reached

- NEI and the Electric Power Research Institute (EPRI, developer of circuit failure characteristics input for the NEI methodology) intend to use the BWROG deterministic circuit failure analysis methodology at selected points within the NEI risk-based methodology without direct integration. Essentially, licensee use of the two methodologies will be complementary, but the two methodologies will not necessarily be integrated into one document.

- As with the BWROG deterministic methodology (recently submitted to the staff for review), the outlined NEI risk-based methodology appears applicable to both PWRs and BWRs.

- NEI expects that its final methodology will screen out multiple high impedance faults (MHIFs) and certain valve actuator faults.

- The NEI methodology will address pairs of spurious actuations and fire-induced valve actuator damage (as described in Information Notice 92-18). NEI believes that the BWROG has, in its recently submitted document, addressed the issue of multiple electrical faults per fire.

- A number of clarification comments regarding the outlined NEI risk-based methodology were made during the meeting:

    - All attendees agreed that the background criteria for the two entry values of Table 1 of Attachment 2 (fire frequency and probability of circuit failures) will need development work, and that information developed in the future by RES could be used to provide some support. However, the RES representatives stated that their program plan for analyzing fire frequency versus fire severity (not circuit failure probability) would not be ready until September 2000, and the staff expressed unease with tying the resolution of this "operational" issue to the completion of NRC research activities. NEI will not necessarily await completion of NRC research before completing the development of Table 1.

    - All attendees agreed that the engineering work necessary to develop the "Pccd2" conditional core damage probability (the probability of survival and functioning of non-designated and unanalyzed post-fire safe shutdown equipment and cables) would be significant, depending on the availability of safe shutdown analysis information (e.g. cable routing and locations) for the equipment not previously credited.

    - Fire location is a characteristic of fire size in Screen 2 of NEI's methodology.

    - Although on Slide 24 of Attachment 3 it appeared that all circuit failures lead to spurious actuations, the NEI methodology's probability factor for severe fire effects operates to reduce the likelihood of spurious actuations based on an assessment of fire sizes and circuit failure probabilities.

- The criteria for detection and suppression effectiveness is to be a decision based on fire protection engineering principles.

- The NEI representatives stated that their position in Attachment 2 that only control room fires need to be analyzed for IN 92-18 effects has been changed. Therefore, the next version of the NEI methodology will additionally address change in core damage frequency (delta CDF) for fires outside the control room as appropriate based on by plant-specific configurations.

- The answer to the question "when does the fire damage stop?" is inherent in the methodology's fire size determination.