FAQ Number	**08-0047**	**FAQ Revision**	**1**
FAQ Title	**Spurious Operation Probability**		

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Purpose of FAQ:

The purpose of this FAQ is to provide additional guidance on the determination of Circuit Failure Probabilities for components with multiple electrical cables within a fire area or compartment.

Is this Interpretation of guidance? Yes / No

Proposed new guidance not in NEI 04-02? Yes / No

Details:

NEI 04-02 guidance needing interpretation (include section, paragraph, and line numbers as applicable):

N/A

Circumstances requiring guidance interpretation or new guidance:

Lessons learned from pilot review of the Fire PRA Standard indicate confusing guidance within NUREG/CR-6850 (EPRI TR-1011989) on the determination of circuit failure probabilities (spurious operation probabilities) for components with multiple cables within a fire area.

During the pilots, it was noticed that circuit analysts were basically assuming many cables within a fire area could cause a spurious operation independently of the other cables affected by the same fire. However, under certain conditions, when the first cable is damaged (either from spurious operation or blowing the fuse in the circuit), the damage to the other cables does not affect the outcome, i.e. the likelihood of a spurious actuation of the component is not increased.

Particularly, spurious actuation from the second cable contributes to increased spurious actuation probability of the component when the second cable has a separate power supply. NUREG/CR-6850 doesn't provide guidance for looking at

the independence or dependence of cable failures, and the FAQ information below is developed to provide this guidance.

Detail contentious points if licensee and NRC have not reached consensus on the facts and circumstances:

None.

Potentially relevant existing FAQ numbers:

None

Response Section:

Proposed resolution of FAQ and the basis for the proposal:

A potential issue has been identified that could lead to the development of highly conservative estimates of the conditional probability of spurious actuations in cases where a given fire scenario may lead to the failure of more than one cable capable of inducing the spurious actuation. In particular, NUREG/CR-6850, EPRI TR 1011989, contains a specific statement as follows:

> "When more than one cable can cause the component failure mode of concern, and those cables are within the boundary of influence for the scenario under investigation, the probability estimates associated with all affected cables should be considered when deriving a failure estimate for the component. In general, the probabilities should be combined as an "Exclusive Or" function, as shown: *(with corresponding equation)*"

This statement appears twice in Chapter 10; namely Section 10.5.3.1, page 10-9, bullet list item #3 (top of page) and Section 10.5.3.1, page 10-11, bullet list item #4.

This treatment assumes that the cable failures and corresponding circuit responses are independent. However, in various cases, the cable failures and the potential for specific circuit effects will not, in fact, be independent. In such cases, use of the "exclusive or" combinatorial approach would over-estimate the overall spurious actuation likelihood. Clarification of this guidance is needed.

<u>Background</u>

One key consideration with respect to interpreting and clarifying the cited guidance is the manner in which the available test data were evaluated in the generation of the current estimates of spurious actuation likelihood. In that

evaluation (e.g., see the expert panel report, EPRI TR 1006961), circuit faults given cable failure were classified as either “spurious actuation” or “fuse blow.” That is, the panel did not explicitly consider potential intermediate modes of cable faulting, but looked at effectively the “bottom line” question; namely, did the cable’s failure lead to a spurious operation prior to loss of circuit power, or did circuit power trip prior to observation of a spurious actuation?

To illustrate the potential for misapplication of the existing guidance, consider a case where either of two cables in the same fire area might cause spurious actuation of a motor operated valve. This situation is not uncommon for areas such as MCC or switchgear rooms where one control cable runs from the control room to the switchgear or MCC, and a second control cable runs from the switchgear or MCC to the valve itself. In such cases, it is often possible to induce a spurious actuation due to faults in either cable. For this type of circuit, both of the control cables would typically be powered by a common control power transformer, likely located in the switchgear or MCC itself.

If any fire scenario in the room could fail both cables, then application of the passage cited above would imply that the total probability of spurious actuation would be based on combining the two individual values. Taking 0.3 as an example of a typical spurious actuation conditional probability value (given cable failure), the combined probability would be (0.3+0.3-(0.3*0.3)) or 0.51.

However, for this particular case, the actual spurious actuation behavior would be driven entirely by the first cable failure (regardless of which of the two cables actually fails first). Once the first cable fails, only two results are possible in the context of the spurious actuation likelihood values. Either a spurious actuation would occur, or a fuse-blow failure would de-energize the circuit prior to spurious actuation. In either case, failure of the second cable is irrelevant. In particular, for this type of case, a fuse blow failure induced by the first cable failure would also de-energize the second cable. Thus the second cable would be unable to induce a spurious actuation lacking the necessary control power energized source. Hence for this case, the correct spurious actuation likelihood would be that associated with the first cable to fail, or 0.3.

In order for the “exclusive or” combinatorial approach to be appropriate, the different cables would need to be *independently* capable of actuating the component of interest. This might, for example, be the case when a single valve is controlled by more than one control circuit, each with its own independent power supply. For example, a pump outlet valve would typically be controlled by one circuit associated with operation of the pump itself, but might also be controlled by a second independent circuit if, for example, closure of the valve was necessary to the successful operation of another plant system (e.g., to prevent backflow through the pump given re-orientation of the plant flow configuration). Another example of this independence test would be an air-

operated valve that is controlled by two or more separate solenoid valves. The valve is controlled mechanically through the porting of air to/from the AOV actuator, which can be controlled by one or more SOVs. These SOVs may be provided with independent electrical circuits and cables. Since each solenoid/electrical circuit can independently cause the valve to actuate, the probability for spurious operation is the mathematic sum of the independent hot short probabilities (a blown fuse in the first solenoid circuit does not prevent a spurious actuation from a hot short in the second SOV circuit).

However, in most cases, the circuit failure probability for a single cable should be used rather than adding the failure probability for each cable. A general exception, in addition to the specific examples above, is as follows:

- Target Cables that are powered from a separate/alternate power supply, typically powering a relay or other separate device, where a ground fault (single or multiple ground fault) or blown fuse would not affect the primary circuit, should be considered separately. These circuits, referred to as either auxiliary or “off-scheme” circuits, often times provide automatic operation of the component from an instrument/control circuit. Failure of these circuits would not, in general, prevent operation of the component through either operator action or by spurious operation of the circuit.

The following guidance is recommended for determination of the circuit failure probability for both initial screening and detailed FPRA analysis. The guidance applies for both intercable and intracable failures:

Initial Circuit Failure Probability Determination:

1) For components with no auxiliary or off-scheme circuits (powered from a separate power supply), the circuit failure probability is assigned based on the limiting (highest) circuit failure probability for the cables within the fire area/compartment.
2) For Components with auxiliary or off-scheme circuits, the circuit failure probability is based on the sum of the a) limiting (highest) circuit failure probability for the primary circuit and b) limiting (highest) circuit failure probability for the auxiliary/off-scheme circuit. The individual circuit failure probabilities should be combined using the Exclusive Or method.
3) If circuit analysis has not been performed to determine if auxiliary or off-scheme circuits are present for the component, then the circuit failure probability is assigned based on an Exclusive Or sum of the two highest circuit failure probabilities for the component cables.

The Auxiliary or off-scheme circuits would not include a second/alternate power supply. Components with separate power supplies are not affected by hot shorts

in the separate supply, since the required electrical separation requires isolation from the main supply. Therefore, only a single cable from an auxiliary or off-scheme circuit contributes to the increased spurious actuation probability. For example, if a swing pump can be powered from both A train and B train, hot shorts on the B train should not affect pump operation when the pump is physically connected to the A train power supply. The detailed circuit analysis should include this consideration when determining cables and circuits that can affect component operation.

Detailed FPRA Circuit Failure Probability Determination

Once a detailed fire scenario analysis is performed, where detailed circuit routing has been determined, the location of each circuit can be accounted for in the FPRA. In this case, the cable initially damaged determines the circuit failure probability. If the primary and auxiliary/off-scheme circuit cable are contained within the same cable tray or are estimated to be damaged at the same time, the guidance above for initial circuit failure probability determination would apply. For other circuits, the following can be used:

1) If the primary circuit cable is damaged first, then the circuit failure probability is assigned based on the initial cable damaged.
2) If the auxiliary or off-scheme cable is damaged first, then the circuit failure probability for the component is determined from the Exclusive Or sum of circuit failure probabilities for a) the initial auxiliary/off-scheme circuit cable damaged, and b) the initial primary circuit cable damaged.

Detailed circuit analysis and cable routing for the component should be performed to confirm application of the above guidance. When component circuits are determined to be unique, adjustments to the above guidance may be needed. For example, if spurious operation of a component requires circuit failures in two cables, then the model would need to be adjusted to account for damage to each of the various combinations of cables within the fire scenario. For example, if spurious operation of a component requires circuit failures from two target cables, then the model would need to be adjusted to account for the required damage to the set and be treated appropriately within the screening or detailed model. Another example would be if the component contained two independent auxiliary/off-scheme circuits, both powered from separate power supplies. In this example, the initial spurious operation probability assigned would be a sum of the three circuit failure probabilities, and the detailed analysis could include consideration for the location and damage time for each of the cables. Finally, if failure of the auxiliary/off-scheme circuit prevents spurious operation of the component, then the off-scheme circuit would be treated as if it was a primary circuit and the component circuit failure probability (initially assigned) would be based on the limiting (highest) circuit failure probability.

Summary

It is recommended that the “exclusive or” combinatorial approach for spurious actuation probabilities should only be applied in cases where multiple cables can cause the undesired component effect *and the postulated cable failure modes and effects are found to be independent*. In cases where the cables of concern are dependent, the likelihood of spurious actuation should be determined by the first cable failure only. If the spurious actuation probability is different for the different cables of concern (e.g., due to differences in the cable or routing configuration), the analysis can either determine which cable would likely fail first for the given scenario, or simply bound the individual cable values.

If appropriate, provide proposed rewording of guidance for inclusion in the next
Revision:

Revised NEI 04-02 per the above guidance.