February 26, 2004

NOTE TO: FILE

FROM: Raymond HV Gallucci, SPLB/DSSA/NRR **/RA/**

SUBJECT: RISK SCREENING TOOL FOR ASSOCIATED CIRCUITS - RECORD OF TELEPHONE CALL, FEBRUARY 26, 2004

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OTHER PARTICIPANTS: Dennis Henneke (Duke Energy)
Fred Emerson (NEI)
Steve Nowlen (Sandia)

SPLB staff conducted a phone conference with contractor (Sandia) and industry (Duke Energy and NEI) representatives on February 26, 2004, to discuss the proposed screening matrix for associated circuits fire SDP (attached). The consensus resulted that there still may be too much conservatism in the matrix to allow realistic screening. Potential sources of this conservatism include: (1) taking no credit for the frequency of a realistic fire vs. that for a fully-involved zone; (2) taking no credit for two independent, spurious actuations; (3) overestimating the CCDP by at least a factor of 10; and (4) taking no credit for circuits which may pass through only a few zones, such that the 1E-7/yr screening threshold may be too severe. NEI and industry suggested that realistic scenarios be examined with the matrix, similar to that done in their pilot studies for NEI 00-01, to determine what amount of screening would result. To facilitate this, NEI agreed to resend their reports on the NEI 00-01 pilot studies to SPLB. SPLB also plans to subject Regional URIs on associated circuits to both the screening matrix and fire SDP, which should provide additional insight. SPLB will modify the matrix as appropriate and resubmit for discussion.

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# Fire Induced Circuit Failure Analysis Screening Criteria

PURPOSE:

To provide screening criteria for plant wide fire induced circuit analysis findings.

BACKGROUND:

The NRC staff is revising the fire protection significance determination process (FP-SDP) developed for the reactor oversight process. Some findings in an individual fire area, specifically fire induced circuit failure findings, possibly affect multiple fire areas. As such, the FP-SDP may require several analyses to capture the risk of a circuit failure fully. Consequently, many circuit findings require Phase 3 type analysis by the FP-SDP. This could impose an undue burden to inspectors and other stakeholders who must determine the risk significance of circuit failure findings. The revised FP-SDP analyzes each fire area separately. We intend this screening tool to alleviate difficulty in analyzing fire induced circuit failure.

PROCEDURE:

Table 1 - Screening Criteria requires four factors. These four factors are, fire frequency (F), probability of spurious actuation (P), suppression availability, and means to mitigate core damage represented by conditional core damage probability (CCDP).

Fire Frequency - Use generic area fire frequency value from FP-SDP (Table 5.1.4). We may refine the fire frequency using the FP-SDP component based fire frequency worksheet or reliable licensee fire area frequency, if available. Up to date statistical methods must be used in any fire frequency refinements.

Probability of Spurious Actuation - Use probability of spurious actuation value from FP-SDP (Table 5.2.16).

Suppression Availability - Automatic water based or gaseous fire suppression systems installed and maintained according to applicable standards are creditable as automatic suppression. With a fully trained and dedicated fire brigade, a properly installed and maintained early warning detection system or a continuous fire watch are creditable as manual suppression.

Conditional Core Damage Probability - When hot shutdown is achievable even with spurious operations, a CCDP value of 0.01 is designated. If hot shutdown is not achievable but core damage is avoidable, a CCDP of 0.1 is designated.

| **Table 1 -**<br>**NRC Screening Criteria** | | **Fire frequency (F)** | | |
|---|---|---|---|---|
| | | **HIGH**<br>**≥3E-2/yr** | **MEDIUM**<br>**<3E-2/yr to 3E-3/yr** | **LOW**<br>**<3E-3/yr** |
| **Probability of spurious actuation of component combinations (P)** | **HIGH**<br>**≥3E-1** | Do not screen | Do not screen | Do not screen |
| | **MEDIUM**<br>**<3E-1 to 3E-2** | Do not screen | Do not screen | Screen to green only with automatic suppression and hot shutdown achievable |
| | **LOW**<br>**<3E-2** | Do not screen | Screen to green only with automatic suppression and hot shutdown achievable | Screen to green with (1) automatic suppression; or (2) manual suppression and hot shutdown achievable |

EXAMPLES: Using the criteria above the following scenarios will typically screen:

Scenario 1

| | |
|---|---|
| • Cable Spreading Room with cables only or Cable Vault and Tunnel with cables only (F=LOW),<br>• Automatic suppression,<br>• Intercable thermoplastic interactions or armored cable (P=MEDIUM), and<br>• Hot shutdown achievable | SCREEN |

Scenario 2

| | |
|---|---|
| • Cable Spreading Room cables only or Cable Vault and Tunnel cables only (F=LOW),<br>• Automatic suppression, and<br>• Intercable thermoset interactions (P=LOW) | SCREEN |

Scenario 3

| | |
|---|---|
| • Cable Spreading Room w/equipment or Cable Vault and Tunnel w/equipment, control room or switchgear room (F=MEDIUM),<br>• Automatic suppression,<br>• Intercable thermoset interactions (P=LOW), and<br>• Hot shutdown achievable | SCREEN |

Scenario 4

| | |
|---|---|
| • Cable Spreading Room with cables only or Cable Vault and Tunnel with cables only (F=LOW),<br>• Detection or fire watch with manual suppression,<br>• Intercable thermoset interactions (P=LOW), and<br>• Hot shutdown achievable | SCREEN |

CIRCUIT ANALYSIS SCREENING CRITERIA BASES DISCUSSION:

Fire Frequency (F)

Table 8.A.5, "Generic Fire Frequencies," from Draft A of the *EPRI/NRC-RES Fire Risk Re-quantification and Fire PRA Upgrade*, September 2003, lists the mean fire frequencies at power by plant location and ignition source. The mean fire frequencies range from a minimum of ~0.001/yr (Battery Room) to maximum of ~0.06/yr (Turbine Building). Considering uncertainties (somewhat reflected in the two-sided 90% confidence bounds in EPRI/NRC-RES Table 8.A.5, and by suggesting a 95% upper bound roughly three times the corresponding mean value), we developed the following ranges:

- 0.03/yr $\leq$ HIGH
- 0.003/yr $\leq$ MEDIUM < 0.03/yr
- LOW < 0.003/yr

We increased the lower cutoff from the NEI proposal to make the classifications relevant to the minimum mean fire frequency from EPRI/NRC-RES Table 8.A.5.

Probability of Spurious Actuations (P)

NEI 00-01, *Guidance for Post-Fire Safe Shutdown Analysis*, Rev. 0, May 2003, suggests best-estimate probabilities in Table 4-4, "Summary of the Probabilities of Spurious Actuations". These probabilities range from a minimum of 0.01 (thermoset inter-cable) to maximum of 0.6 (multi-conductor intra-cable). Considering uncertainties (reflected in the high confidence range in NEI-00-01 Table 4-4), we developed the following ranges for spurious actuation:

- 0.3 $\leq$ HIGH $\leq$ 1
- 0.03 $\leq$ MEDIUM < 0.3
- LOW < 0.03

The bounds for the spurious actuation ranges also reflect relevancy to the minimum probabilities and maintain step increases by one order of magnitude.

Joint frequencies for Pairings of F and P (F * P)

Multiplying F and P over their respective ranges yields the following maxima (F * P):

| | | **Fire frequency (F)** | | |
|---|---|---|---|---|
| | | **0.03/yr $\leq$ HIGH** | **0.003/yr $\leq$ MEDIUM < 0.03/yr** | **LOW < 0.003/yr** |
| **Probability of spurious actuation of component combinations (P)** | **0.3 $\leq$ HIGH $\leq$ 1** | $\geq$0.03/yr | <0.03/yr | <0.003/yr |
| | **0.03 $\leq$ MEDIUM < 0.3** | >0.009/yr | <0.009/yr | <9E-4/yr |
| | **LOW < 0.03** | >9E-4/yr | <9E-4/yr | <9E-5/yr |

Additional Considerations: Fire Suppression and Conditional Probability of Avoiding Core Damage

The F * P pairings represent the frequency of a fire-induced spurious actuation of a component combination. Core damage will occur only if, 1) the fire is not suppressed before inducing the spurious actuation, and 2) other non-fire related contingencies, including human actions and equipment operation, are unsuccessful. Thus, for core damage to occur, there must also be failure to suppress the fire prior to the spurious actuations (S) and failure to avoid core damage via non-fire means, represented by the conditional core damage probability (CCDP), or C.

Fire Suppression (S)

We give credit for either automatic or manual fire suppression (including detection by automatic or manual means). Automatic suppression is more reliable than manual, giving a non-suppression probability of 0.01 for automatic suppression and 0.1 for manual. If we can credit automatic suppression, then we will not credit manual suppression. Similarly, we will only credit manual suppression if we cannot credit automatic suppression. Finally, we will credit manual suppression only where early warning detection is effective and is supplemented by dedicated fire brigade response. Thus, the product F * P will be reduced by a factor of either 0.01 (if automatic suppression is creditable) or 0.1 (if automatic suppression is not creditable, but manual is).[a] We will never credit the combination of both types of suppression, implying a reduction by 0.001. Thus, the maximum reduction the product F * P can achieve through consideration of fire suppression is 0.01.

CCDP (C)

Plants should have one safe shutdown contingency for each credible fire. There may also be one fire-independent combination of human actions and equipment operation to prevent core damage. Failure to avoid core damage would result only from the failure of all safe shutdown contingencies, the cumulative probability of which is the CCDP for that specific unsuppressed fire-induced spurious actuation(s). If the plant can achieve hot shutdown despite the unsuppressed fire-induced spurious actuation(s), then the CCDP is relatively low suggesting a value of 0.01. The probability of 0.01 represents the random failure probability of a single train of hardware. If the plant cannot achieve hot shutdown because of the unsuppressed fire-induced spurious actuation(s), but the plant can avoid core damage through fire-independent combinations of human actions and equipment operation, then a CCDP ranging from 0.01 (multiple independent straightforward scenarios available) to 0.1 (few, or quite complex, independent scenarios available) is given. For screening purposes, we should assume the 0.1 value in all cases where the evaluation suggests a value >0.01. The higher probability of 0.1 represents failures associated with human actions. A minimum value for screening for CCDP is 0.1, since it is assumed the plant personnel could avoid core damage even in the event of a sever ifre where none of the fire protection features could be credited. See NUREG/CR-6738, *Risk Method Insights Gained for Fire Incidents*, September 2001, for several examples where non-proceduralized actions by plant personnel averted core damage during severe fires. Thus, for screening purposes, the maximum reduction in the product F * P * S that we can achieve through consideration of CCDP is 0.01. A value of 0.01 will be achieved by having normal

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[a] If neither is creditable (e.g., no automatic suppression system and the timing/location/nature/intensity of fire precludes manual suppression), there will be no reduction in the product F * P.

system availability that is not affected by the fire scenario, such as offsite power and feedwater. If an alternate shutdown system is available which can mitigate spurious operation, a credit of 0.01 can be used for feasible evolutions or evolutions with adequate time and margin. Use the value of 0.1 for more complex evolutions.

Four-Factor Frequency of Core Damage (F * P * S * C)

The maximum core damage frequencies (CDFs) that result from assuming the maximum credits for S and C (0.01 each, or a joint credit of 1E-4) for the F * P pairings are as follows:

| | | **Fire frequency (F)** | | |
|---|---|---|---|---|
| | | **0.03/yr ≤ HIGH** | **0.003/yr ≤ MEDIUM < 0.03/yr** | **LOW < 0.003/yr** |
| **Probability of spurious actuation of component combinations (P)** | **0.3 ≤ HIGH ≤ 1** | ≥3E-6/yr | <3E-6/yr | <3E-7/yr |
| | **0.03 ≤ MEDIUM < 0.3** | >9E-7/yr (~ >1E-6/yr) | <9E-7/yr (~ <1E-6/yr) | <9E-8/yr (~ <1E-7/yr) |
| | **LOW < 0.03** | >9E-8/yr (~ >1E-7/yr) | <9E-8/yr (~ <1E-7/yr) | <9E-9/yr (~ <1E-8/yr) |

NEI-00-01 states that "criteria for risk significance are . . . consistent with Regulatory Guide 1.174 guidance." In their plant-specific risk significance screening, NEI states that "the criteria for determining that component combinations are not risk significant are as follows:

- If the change in core damage frequency (ΔCDF) for each component combination for any fire area is less than 1E-7 per reactor year, AND
- If the ΔCDF for each component combination is less than 1E-6 per reactor year for the plant, i.e., sum of ΔCDF for all fire areas where circuits for the component combinations (circuits for all) are routed, AND
- If the ΔCDF for each fire area is less than 1E-6 per reactor year for the plant, i.e., the sum of ΔCDF for all combinations of circuits in the fire area."

Of these three criteria, the most stringent is the first requiring the ΔCDF to be <1E-7/yr. Since we expect this screening criterion to be conservative, 1E-7/yr is the appropriate criterion to apply to the Four-Factor Frequency of Core Damage.[b] In the table above, none of the shaded boxes satisfy this criterion exclusively, while the unshaded boxes may satisfy this criterion in certain cases. Restricting the values for fire suppression (S) and CCDP (C) as follows, the cases where this criterion is satisfied are shown in the table below. These correspond to the cases where preliminary screening to green can be assumed successful.

Fire Suppression (S)
- None fully creditable = 1
- Only manual fully creditable= 0.1
- Automatic fully creditable = 0.01

[b] For this preliminary screening ΔCDF is conservatively approximated by CDF itself.

CCDP (C)

- 0.1 (hot shutdown not achievable, but core damage avoidable)
- 0.01 (hot shutdown achievable)

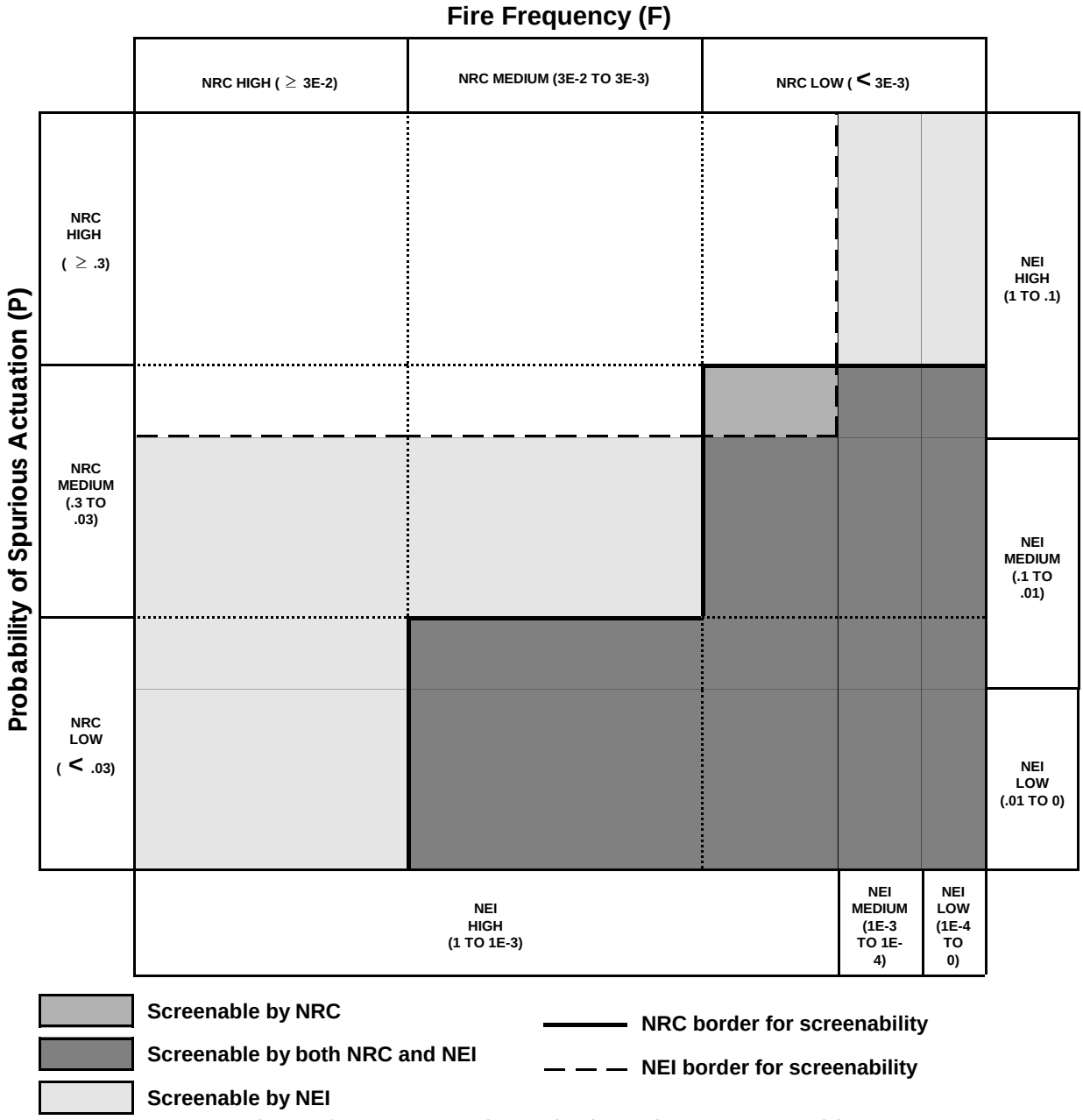
| | | Fire frequency (F) | | |
|---|---|---|---|---|
| | | **HIGH** | **MEDIUM** | **LOW** |
| **Probability of spurious actuation of component combinations (P)** | **HIGH** | Do not screen | Do not screen | Do not screen |
| | **MEDIUM** | Do not screen | Do not screen | Screen to green only with automatic suppression and hot shutdown achievable |
| | **LOW** | Do not screen | Screen to green only with automatic suppression and hot shutdown achievable | Screen to green with (1) automatic suppression or (2) manual suppression and hot shutdown achievable |

Thus, screening at this preliminary stage is not possible if either F or P is HIGH. The case is also not screenable where F and P are both MEDIUM. Screening is only possible if either F or P is LOW and the other is MEDIUM or LOW.

Comparison of NRC Screening Criteria and NEI 00-01 Table 4-1

The NRC screening criteria used NEI 00-01 Table 4-1 as a conceptual basis. The table on the next page illustrates the numerical differences between values applied by the NRC screening criteria and those used by screening criteria outlined in NEI 00-01 Table 4-1. We can attribute these differences to:

- Assigning more relevant, data representative boundaries for classifying fire frequency,
- Adjusting the numeric values of P to attain F*P values that are close to 1E-x as possible, and
- Establishing 9E-4/yr as the screening threshold for the F*P values after consideration of CCDP.

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