[redacted] response the C-Factor Value that will be used in the Spurious Operation Duration Estimation

1.0 Introduction

A review was performed in response for the request for a possible C-Factor modification of the Spurious Operation Estimates calculated in the Expert Panel process. Two areas of review were performed to look for influences that may affect the duration in the actual plant versus the tested configuration. These areas included a) Areas discussed in Table 3-1 of NUREG/CR-2170 (PIRT Panel that provided recommendations to the PRA Expert Panel), and b) other factors not discussed by the PIRT. Additionally, the consideration the impact on higher uncertainty based on the above issues is considered.

In the analysis below, the following is assumed based on the original duration values submitted to the technical integration team:

Assumptions:

1) Duration curves were provided as Weibull curves, and are assumed to be mean value curves.
2) Duration curve uncertainty values provided included uncertainty values based on the statistic uncertainty, without additional modification for qualitative issues (which are considered below).

Finally; the TI team discussed the possible use of a floor value (minimum duration value) based on FAQ 08-051. The report below provides a recommended value for this, based on additional considerations.

2.0 PIRT Panel influencing factors:

Table 3-1 of NUREG/CR-2170 provides a low, medium and high ranking for factors that may affect the hot short duration. Those that are ranked as high include the following:

1) Fire Exposure Condition
2) Cable Routing (Panel wiring)
3) Breaker/Fuse size (Time-Current) Characteristics.
4) Wiring Configuration
5) Latching versus non-Latching Device

Each is discussed below, with regard to the duration analysis provided by D. Henneke (since the final consensus approach was not provided as a part of the above question.

Fire Exposure condition was analyzed for the input to the final results. As such, it is already accounted for in the results. Yes, exposure conditions affect duration. However, what is not accounted for is whether the typical fire or the risk is dominated by larger or smaller fires.

Although smaller fires are more likely (lower exposure), these are also more likely suppressed before cable damage occurs or before large amounts of cable damage occurs. A quick review of several Fire PRAs indicated that the risk is dominated by larger and quicker growing fires. As such, a C less than 1.0 would be indicated when considering fire exposure from a Fire PRA condition. However, the scenarios involving fire duration were not reviewed, since the duration information has not been included in the FPRAs (no approved approach).

Panel wiring is an issue with duration, having both negative and positive impacts. For some circuits, an 8-conductor wire might include only 2-4 conductors going into a single panel (e.g., to a control switch). Removal of some of the circuits (e.g., the lighting circuit) could result in a longer duration. On the other hand, the removal of the outer jacket and bundling of multiple circuits and conductors would generally result in quicker shorting between circuits and a shorter duration. Without detailed analysis, it is difficult to determine whether there is a greater than or less than C influence for this issue. As a result, no change to C is recommended based on this issue.

Breaker/Fuse size is reviewed and included in the analysis. As such, no additional consideration is given here.

Wiring configuration is similar to panel wiring, with additional consideration for number of conductors and other similar factors. Given the testing included typical circuits, including various circuit designs, the influence for non-standard design circuits is not expected to have a great impact here. Additionally, the non-standard circuits could have either a greater than 1.0 C factor or less than 1.0 C factor.

Latching versus non-Latching designs is included in the MOV analysis provided.

Overall; the above discussion would result in a C = 1.0.

3.0 Other Influencing Factors

A few influencing factors are not included above, but are possible impacts to the overall risk for spurious operation duration. These include:

1) Suppression during a spurious operation (or fire extinguished during spurious operation).
2) Circuits designed to spuriously operated, such as actuation circuits.

Suppression can have both positive and negative impacts on duration. If suppression occurred when the spurious operation was occurring, the spurious operation could remain. As was shown in testing, the spurious operation clears when additional cable damage occurs and multiple conductors short together to blow the component fuse. On the positive side, the suppression itself could cause the short to ground and fuse blow. Overall, the negative side (C>1.0) is likely a stronger influence. However, it is consider small due to the low likelihood of a simultaneous spurious operation (short duration), following a relatively long duration fire (typical damage time > 30 mins), and suppression during this time. Overall, this suppression would occur less than 1% of the time during the spurious operation (using average values only). So a C = 1.01 would be recommended. However, it can also be incorporated by including this 1% value in the floor or minimum value for the duration curves.

During the discussion on this issue, it was mentioned by another proponent that there were something like 3 tests where the spurious operation continued, and the test was stopped without clearing the fuse. A review was performed to confirm this. Only one such test was found; Penlight #38, SOV-2. In this example, there was a conduit in a penlight tray (not surrounded by other cables), where the spurious operation did not clear before the test was stopped. This spurious operation lasted around 22 minutes, following a slow time to damage or around 20 minutes. It is not expected that the penlight tests would represent the typical cable configurations in the plant. However, the configuration of a single cable in a conduit could be seen in the plant; but likely with less than 1% of the overall cables in the plant (for most plants). As such, the 1% value above for suppression (or fire stopping) during the spurious operation seems reasonable.

In addition to the above, another factor is considered. Circuits designed to spuriously operation, when grounded, are often times identified during a circuit analysis or Fire PRA. For example, during the performance of circuit analysis for circuits traveling between the MCC and the ASP, the circuits were designed without indicating lights. The indicating lights are generally what cause the fuse to blow. When analyzed, these not only had a high probability of hot short, but also were likely long duration events. However, given the FPRA guidance and deterministic analysis in NEI 00-01 is to assume the spurious operation will occur with a probability of 1.0, without clearing, this issue does not affect the final results for duration analyzed by each expert. However, the issue does impact uncertainty and a potential floor value used. Since it would be an error to apply a spurious operation probability and duration in the PRA to components that would spuriously operate given a short to ground; a screening value is recommended of 0.01 to be added to the floor value to account for this issue.

Overall, a floor value of 0.02 is recommended to account for suppression of the fire during the spurious operation or a circuit design such that a fuse blow does not occur when the conductors melt together in a cable.

3.1 Uncertainty on the Minimum Probability for Exceeding Duration X

With a minimum level for the spurious operation duration curve of 0.02 recommended above, it was requested to provide the 5th and 95th values, and 25th and 75th values.

During the testing, 1 test was terminated where the spurious operation had not yet cleared. Since the test was stopped, it is uncertain as to whether the spurious operation would have cleared given the fire damage would have continued, or (for example) if the fire conditions would have worsened. Given one in 22 ungrounded DC conduit tests could have continued indefinitely; this gives an estimate of 0.045 for the upper bound for the floor level, which is determined to be the 95th percentile. Using this as an approximate for the general uncertainty for the floor value (rounded to 0.05), the following is recommended:

5th = 0.002
25th = 0.005
Median = 0.02
75th = 0.03
95th = 0.05

4.0 Additional considerations for Uncertainty

The PIRT report includes other factors that may impact spurious operation duration, many of which are ranked as low or medium impact. Considering these, and the above discussion; even if the average duration is not impacted, the uncertainty bounds for the duration curves should be impacted. Statistically, increased uncertainty results in no change in the median value/curve, but an increase in the mean value/curve.

The Weibull++ software was used for the duration analysis provided to the TI team. This software does not provide any method for re-calculating the mean curve based on adjusting the uncertainty. As a result, engineering judgment is used to estimate the increase in the mean.

In reviewing the duration data, the uncertainty bounds are relatively small. For a given duration, the uncertainty for the probability has an approximate range/error factor of 1.5. Even doubling the EF to 3.0 does not greatly increase the ratio of mean/median (of course this depends on the assumed distribution).

Given the factors not included in the calculated distribution for duration are not rated as high by the PIRT, and the other factors discussed above are not estimated to have an extremely large impact on the overall results, it is likely the uncertainty bounds accounting for all of these issues would not be greatly different than the statistically calculated bounds. An increase in the bounds is assumed (engineering judgment) to be around or less than a factor of 2 for the equivalent EF for a given point on the distribution. This is calculated to provide an increase in the estimated mean of approximately 1.2. As a result of this estimated increase, a C factor of 1.2 is recommended.

4.1 <u>Uncertainty associated with the C Factor</u>

The uncertainty for the Revised Duration curve (base curve adjusted for the C factor) can be adjusted based on the application of an S factor. The Proponents for this analysis were requested to develop an estimate of the uncertainty for the Final duration curve (not including the minimum or floor value).

In reviewing the duration data analyzed using Weibull ++ (see separate D. Henneke duration analysis), the worst case curve recommended for the duration estimates was based on Grounded AC, TP cable, HGL/Plume combined. This curve was estimated to have a Beta of 0.97 and Eta of 150. This worst-case curve was compared with the 95th value curves provided for this assessment and was found to match the 95th percentile curve for an S = 2, C = 1.4. Therefore, an S = 2 is recommended.

5.0 Summary

Overall, the largest influencing factors identified above are the possible suppression, wiring configurations (panel wires), and fire exposures. When considering the FPRA results, since simultaneous suppression and spurious operation is a low probability (less than 1% of the time), the most important fire PRA scenarios are larger fires, and during of spurious operations for circuits within panels have an undetermined impact; no change to the C value is recommended. However, when accounting for the increased uncertainty, an increase of C is recommended. Additionally, the issues identified result in a recommended minimum value for both AC and DC circuits.

Here are the recommendations from the above analysis:

1) A recommended increase in the duration curve using a C value of 1.2 is recommended to account for the increased uncertainty when considering other factors not included in the testing or possibly present in the plant.
2) A recommended "S" value of 2 is recommended, based on the 95th percentile curve for S = 2, C = 1.4 matching the Worst-Case duration curve analyzed in the D. Henneke duration evaluation.
3) A minimum probability for exceeding duration (t) for both AC and DC circuits is recommended as 0.02. This accounts for several aspects, including possible suppression during spurious operation, possible unique circuit designs where long term spurious operation is likely, and other factors. The recommended uncertainty bounds (5th and 95th) recommended is as follows, based on the low number of long duration spurious operation events in the testing, and engineering judgment:
    - 5th = 0.002
    - 25th = 0.005
    - Median = 0.02
    - 75th = 0.03
    - 95th = 0.05