MCC Treatment White Paper

The treatment of postulated fires originating at motor control centers (MCCs) should follow the guidance in NUREG/CR-6850 as modified by FAQ 08-0042 (see NUREG/CR-6850 Supplement 1 Section 8). The guidance provided in FAQ 08-0042 identifies two attributes to be considered. Those two attributes are the adequacy of the sealing of openings and the robustness of the door attachments. FAQ 08-0042 provides criteria and discussions to address these issues. However, questions have arisen regarding the behavior and risk implications if MCCs operating at 440VAC or higher were to be treated as capable of propagating a fire to external targets. These questions are based on wording in Chapter 6 of NUREG/CR-6850 that states that panels housing circuit voltages of 440V or higher should be counted because an arcing fault could compromise panel integrity.

In order to address this, additional details and methodological treatment are necessary beyond that already published in NUREG/CR-6850 or the Supplement. A simplified approach is proposed as an interim treatment pending completion of ongoing industry and NRC research activities. This simplified approach involves the consideration of two factors.

$$F = F_E \times F_B$$

Where F = fraction of fires originating from an MCC that damages external targets

F_E = fraction of MCC fires that are energetic enough to breach the MCC enclosure

F_B = fraction of MCC fires that damage targets above the MCC based on fire modeling (SF)

Given that a fire has occurred at an MCC, it is not realistic nor appropriate to assume that all such events would be capable of breaching the MCC. In order to address this consideration, it is necessary to consider empirical evidence from industry fire events. This work was previously completed, and there is an available report prepared by an independent panel that can be used [(1)]. The NRC formal response to the panel report did not identify any technical flaw or error in the document [(2)].Based on the assessment from this work, a fire frequency modification factor (F_E) of 0.181 can be used to treat the fraction of MCC fire events that are assumed to be capable of breaching an MCC. Given that a postulated fire scenario has breached an MCC, fire modeling can then be applied to treat the fire scenario. The fire modeling should rely on already established methods, treatments, and data as provided in NUREG-1824 and Appendix E of NUREG/CR-6850.

A simplified and bounding fire model for thermoplastic cable targets can be used to illustrate the integration of fire modeling results to obtain the value of F_B. This simplified treatment was developed using the plume centerline temperature correlation from NUREG-1805 and the NUREG/CR-6850, Appendix E, Table E-4 heat release rate probability distribution applicable to an MCC (per NUREG/CR-6850, Appendix G, p. G-25, including Figures G-6 and

G-7). The fire is treated with a characteristic surface area of 3 ft^2 (based on an MCC cubicle stack characteristic dimensions of 1.5 ft wide by 2 ft deep) with a cable tray target assumed to be located 6" above the top of the MCC. The MCC was assumed to be configured with four equal sized cubicles in each stack each 18 inches tall. The fire in each cubicle was assumed to be located at the horizontal centerline of the cubicle. The fire in the first cubicle was assumed to be located at a distance of 1.75 ft below the cable tray (6" between top of MCC and cable tray, 6" wireway at the top of the MCC and 9" distance from top of the cubicle to the center of the cubicle). Each subsequent cubicle fire was assumed to be 18" below the location of the fire of the cubicle above it. The resulting spacings between each of the 4 MCC cubicles and the cable tray were 1.75 ft, 3.25 ft, 4.75 ft, and 6.25 ft.

This resulted in four cases to be evaluated for the MCC stack. For each assumed cubicle fire, the required heat release rate (HRR) to cause the plume centerline temperature at the cable tray location to be equal to the thermoplastic cable damage temperature (205 ^{o}C) was determined. The severity factor associated with the HRR was then determined using the Gamma distribution parameters of 1.6 and 41.5 for alpha and beta, respectively, from NUREG/CR-6850, Table E-1. This calculation was done as a steady state analysis with no credit for fire growth, decay, suppression, or time to damage.

This simplified treatment determined the fraction of postulated fires that could create centerline plume temperatures equal to or greater than 205 ^{o}C. This was repeated for each of the assumed cubicle fires. Each successive case increased the spacing between the postulated MCC cubicle fire and the postulated cable tray target above the MCC based on the dimensions noted earlier (18 inches greater than the spacing for the cubicle above). The results are summarized below.

MCC Cubicle Position	Spacing to Tray	Critical HRR	SF [1]	SF_{crit} [2]
Topmost Cubicle	1.75 ft	19 kW	0.153	0.847
2nd Cubicle	3.25 ft	44 kW	0.418	0.582
3rd Cubicle	4.75 ft	83 kW	0.711	0.289
Bottom Cubicle	6.25 ft	137 kW	0.902	0.098

Note 1 SF is the fraction of postulated fires that have an intensity less than the critical HRR

Note 2 SF_{crit} is the fraction of postulated fires that could damage the target and is taken as being equal to 1 – SF

The resulting four severity factor values were then each weighted by 0.25 to reflect the equal likelihood of fire occurrence and then summed to obtain an aggregate effective severity factor for the entire MCC stack. The resulting aggregate severity factor, F_B, was calculated to be 0.45 and represents the fraction of MCC fires that could damage the overhead target located 6 inches above the top given that it had already breached the MCC.

This 0.45 severity factor is then combined with the previously calculated 0.181 term to yield a value for F of 0.081.

It is noted that other combinations MCC and target characterizations could exist. These combinations are:

- MCC contains non-qualified cables and targets are thermoset
- MCC contains qualified cables and targets are thermoplastic
- MCC contains qualified cables and targets are thermoset

The analysis presented earlier that yielded the 0.45 factor was repeated for the three combinations above. For the case where the MCC contains qualified cables, the NUREG/CR-6850, Appendix E, Table E-2 heat release rate probability distribution was used instead of that provided in Table E-4. For thermoset targets, a damage threshold of 330 ^{o}C was used instead of 205 ^{o}C applicable for thermoplastic targets. All other terms and inputs remained unchanged.

The resulting factors and integration with the multiplier noted above are provided below.

Combination	F_E	F_B	F_E x F_B
Non-Qualified in MCC – TP target	0.181	0.45	0.081
Non-Qualified in MCC – TS target		0.27	0.049
Qualified in MCC – TP target		0.33	0.060
Qualified in MCC – TS target		0.19	0.034

The conservative and bounding values above can be generically applied based on the plant specific combination of the wiring characterization within the MCC (qualified vs. non-qualified) are the target cable characterization (TS vs. TP). When applied, the fraction of fires that are assumed to have breached the MCC should be assumed to have damaged the first overhead cable tray. Because this simplified analysis does not consider timing, no credit for fire suppression should be taken unless separately addressed by additional analyses not addressed or discussed herein. In the absence of such further analyses, it should be assumed that target damage occurs with no delay. Further vertical and horizontal fire propagation should be considered using existing guidance including any applicable credit for fire suppression based on the available timing. If manual fire suppression is credited, the applicable suppression rate term is the same as that which would have been applicable for electrical cabinet fires.

This FAQ does not prohibit or otherwise preclude the use of accepted fire modeling methods to take advantage of actual target spacing when greater than 6 inches. For example, if for a particular installation the nearest overhead target is 2 feet from the top of the MCC instead of 6 inches, the resulting values would be 0.045, 0.018, 0.031, and 0.013 instead of 0.081, 0.049, 0.060, and 0.034, respectively.

REFERENCES

1. B. Bradley, NEI to D. Harrison, NRC, Recent Fire PRA Methods Review Panel Decision: Treatment of Electrical Cabinets, June 4, 2012

2. J. Giitter, NRC to B. Bradley, Recent Fire PRA Methods Review Panel Decisions and EPRI 1022993, "Evaluation of Peak Heat Release Rates in Electrical Cabinet Fires", June 21, 2012, ML12171A583