REDUCE ARC FLASH ENERGIES BY REDUCING FUSE AMPERE RATING

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I. THRESHOLD CURRENT AND INCIDENT ENERGY CALCULATIONS

Current-limiting fuses can limit arc flash incident energy to low values provided that the arcing fault current exceeds the fuse's threshold current. Threshold current is defined as the lowest prospective rms symmetrical current at which the fuse will clear in less than 1/2 electrical cycle. By clearing in less than 1/2 cycle, the fuse limits both the peak instantaneous current (I_p) and the rms current (I_{rms}) as seen in Figure 1. For a more in depth explanation of current limitation, refer to Mersen Arc Flash Note 2—Reducing Arc Energies with Current-Limiting Fuses.

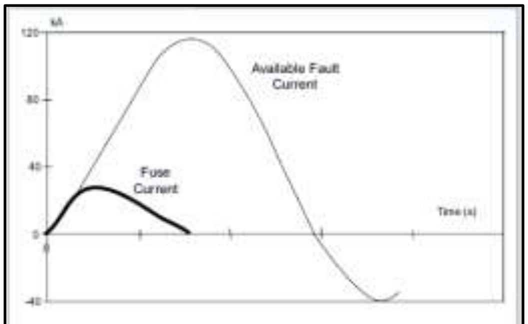

Figure 1. Fuse Current Limitation

As discussed in Arc Flash Note 2, the amount of incident energy generated by an arc flash event is determined to a large degree by the magnitude of the current (I_{rms}) and the duration (t) of the fault. A current-limiting fuse that reduces Irms and t during an arcing event will significantly reduce incident energy. However, if the arcing fault current is less than the fuse's threshold current, the fuse will limit t but not I_{rms} and the incident energy will be higher and depend on the clearing time of the fuse.

Within the same fuse class, current-limiting fuses that have lower ampere ratings will have lower threshold currents. This wider range of current-limiting operation can be used to reduce arc flash energy in applications where available fault currents are low relative to the existing fuse's threshold value.

Because of the variability of arcing fault currents and the difficulty in accurately calculating bolted fault currents, IEEE 1584™2002, Guide for Performing Arc Flash Hazard Calculations recommends that incident energy calculations be conducted using both the calculated arcing fault current from your study and 85% of that value. The lower fault current value can actually yield higher energies if it creates a situation in which the fuse is operating at less than its threshold current. In these cases, the higher incident energy calculation should be used in your arc flash hazard analysis.

For circuits of 600 volts and less, arcing fault current can be significantly lower than the bolted fault value. NFPA 70E states that at 480 volts, arcing fault current could be as little as 38% of the bolted fault value. To best represent incident energy levels for current-limiting fuses, fuse manufacturers have undertaken extensive arc fault testing with their fuses.

Fuse performance for arc flash is determined in accordance with IEEE 1584 guidelines for arc in a box testing with vertical electrodes. In these tests, the prospective bolted fault current is first determined with a calibration test conducted with a shorting bar across the phases in the test box. The arc fault is then created by replacing the shorting bar with a fine wire and initiating the test. The incident energy from the resultant arc fault is measured with calorimeters. Due to the added impedance of the arc and the current-limiting effects of the fuses the arcing fault current is less than the bolted fault value determined during circuit calibration. After a sufficient number of tests are performed to establish an acceptable confidence level for the results, the fuse manufacturer publishes its test results based upon the bolted fault values. See Figure 2 for a plot of incident energy versus bolted fault current for A4BQ Class L fuses.

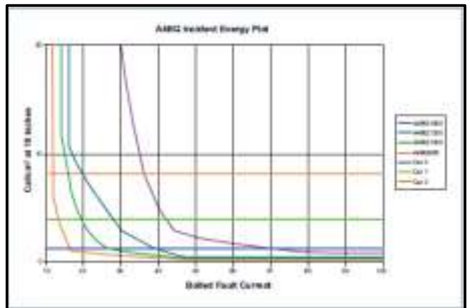

Figure 2: Incident energy chart for ABQ fuses. See Arc Flash Note 2 for proper use.

The following example illustrates a case in which a fuse of the same fuse class but with a lower current rating (and lower threshold) can significantly reduce arc flash incident energy.

EXAMPLE

Situation. In the application depicted in , the feed to MCC1 is protected by three A4BQ1600 Class L fuses. A load study indicates that the maximum load on MCC1 is 760 amperes, and the short circuit study predicts an available fault current of 32kA.

From our incident energy graph (Figure 2) we see that the projected incident energy for arc faults within the MCC would be approximately 14 cal/cm^2 for an 18 inch working distance. This requires PPE appropriate for NFPA 70E's Hazard/Risk Category 3. The company's electrical safety plan requires that Category 2 and higher hazards be evaluated for potential hazard reduction by engineering.

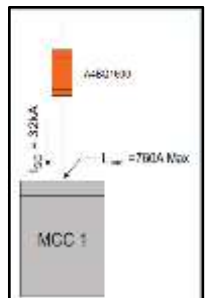

Figure 3: Single Line Diagram

Solution. The plant electrical engineer reviews the load study and short circuit study values for MCC1 to verify their accuracy and concludes that he can replace the 1600 ampere fuses with A4BQ fuses of a lower ampere rating. After consulting with the fuse manufacturer, the engineer considers ampere ratings as low as 800A since Class L fuses are suitable for 100% operation.

The incident energy graph for A4BQ fuses (Figure 2) is then considered. With a bolted fault current of 32kA, the expected incident energy is 2.5 cal/cm^2 for the A4BQ1200 and 0.5 cal/cm^2 for the A4BQ800.

The engineer now has a decision to make. Although the 2.5 cal/cm^2 energy level for the 1200 ampere fuse may be acceptable, another calculation at 85% of the bolted fault current — 27kA — yields an expected incident energy for the A4BQ1200 of 4.0 cal/cm^2. It is clear that the 1200 ampere fuse would be operating near its threshold at these fault levels and that incident energies would be significantly higher if actual bolted fault levels are less than calculated.

In contrast, the A4BQ800 fuse has a predicted incident energy of only 0.5 cal/cm^2 with a bolted fault current of 32kA, and 0.6 cal/cm^2 at the 85% value. The A4BQ800 provides expected incident energy of less than 1.2 cal/cm^2 for bolted fault current values as low as 16kA. Since the maximum load is 760 amperes and it is unlikely that all loads will be "On" at the same time in this application, the engineer selects the A4BQ800 fuses feeling that this is the safest way to mitigate the arc flash hazard. The PPE requirement for workers who must access this MCC in an energized state is reduced from Category 3 to

Category 0. This dramatic incident energy reduction can minimize the possibility of worker injury. With the A4BQ Class L fuse's one-way interchangeable design (see photo above) the change is simple and requires no special hardware.

II. FUSING RECOMMENDATIONS FOR MOTOR CONTROL CENTERS WITH CONSIDERATION FOR ARC FLASH MITIGATION

Specifying a fused Motor Control Center (MCC) can yield the benefits of low incident energy, Type 2 "No Damage" protection of starters and selective coordination for overloads and short circuits. Consider the following to ensure optimal overcurrent protection.

- Consider available fault current when specifying the fusible mains. Select the ampere rating of main fuses so that the incident energy calculations on the bus and buckets yield an incident energy of less than 1.2 cal/cm^2. Use data such as that in Figure 2. For example, selection of an A4BQ800 would yield a calculation of 1.2 cal/cm^2 for bolted fault currents as low as 16kA.
- Select branch fuses per starter manufacturers Type 2 tables. For new MCCs, specify AJT (Class J) fuses for branch circuit protection. For NEMA- and IEC– style starters, these fuses provide "No Damage" protection against fault currents up to 100,000A. For existing MCCs, upgrade the branch circuit protection to A6D (Class RK1) fuses.
- Specify the ampere rating of the main fuses to be at least twice that of largest branch. With Amp-Trap 2000® products, full selective coordination will be achieved within the MCC for fault currents as high as 200,000A as long as the ampere rating of the main fuses is at least twice that of the largest branch circuit fuse.