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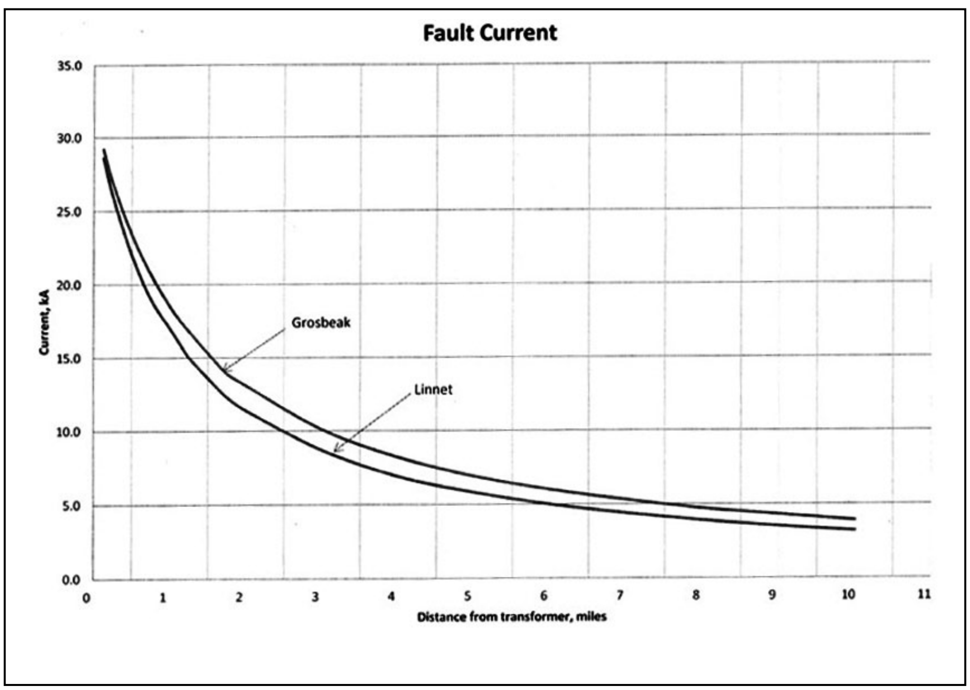
Fault Current versus Distance

Background: A major utility noted that they were having far more splice failures on their 34.5 kV distribution lines within a few miles of the substation than they were toward the end of their circuits. The primary reason is the available system fault current diminishes with distance from the sources.
In an attempt to quantify this, representative fault current calculations were made on a “typical” 34.5 kV circuit. I’ll call it “typical” because no circuit details or transformer nameplate data were available. We do know that the utility uses both 336.4 kcmil (Linnet) and 636 kcmil (Grosbeak) ACSR conductors on their 34.5 kV circuits and it is assumed that both are loaded to their 75°C maximum operating temperatures. The transformer used for these calculations was arbitrarily selected as 34.5 kV, 95.0 MVA, X/R=5.0, 5%Z (which may or may not be representative of the actual transformer).

Short circuit studies normally begin with a line diagram showing all loads and potential sources of fault current. (During a symmetrical fault, induction motors will contribute only during the asymmetric portion of fault current but synchronous motors may contribute 4 – 6 times their full load current to all fault locations). Capacitors may also be a factor under some conditions. Protective devices are not normally included in the line diagram.

Worst case short circuits are normally based on bolted 3 phase fault conditions in which all three phases are “bolted” together to obtain a zero impedance fault. This results in maximum thermal and mechanical stress in the system and typically assumes infinitely available fault current from the primary source.

In this case, we are only interested in the available short circuit current at the location of a line splice versus distance from the transformer, based entirely on the conductor resistance, reactance, and voltage at the fault (splice) location. Following are the graphical results of point-to-point analysis of both conductors from 1/8 mile to 10 miles from the transformer.



Conclusions: While this exercise may or may not be truly representative of a particular utility system, it does illustrate fault current magnitude relative to distance from a transformer source, regardless of the transformer type and location. In this case, fault currents are higher on the larger Grosbeak conductor because its total impedance is less than that of Linnet.

Although the slopes and magnitudes would change for other source and conductor combinations, the results would be similar.

Degraded, high resistance splices, connectors, damaged conductors, etc. would be less able to withstand the higher fault currents both electrically and mechanically so it would be expected that failure rates would also reduce with distance.

Waymon P. Goch
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