C35 Direct Observations of Arcing Through Char in Copper Wires

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After attending this presentation, attendees will understand the significance of the extent of melting in arced wires

This presentation will impact the forensic community and/or humanity by assisting in fire cause and origin determinations.

One of the consequences of a 110 or 220 volt electrical circuit being energized during a fire is that a local melting of the wires can occur. This can be produced either by a direct contact of wires between themselves or the grounded conduit, or, if the insulation that isolates the wires decomposes to enhance the electrical conductivity, the subsequent separation of the intermediary to produce a parting arc. The thermal decomposition of PVC insulation, for example, is well known to lead to the formation of distinctive regions of melting in what are otherwise relatively intact thermally annealed and oxidized copper wires. However, the general presence of this local melting cannot be broadly interpreted as a sign of electrical activity because the temperatures reached during structure fires are in some instances capable of melting copper directly. The determination of whether local melting should be interpreted as a sign of thermal or electrical activity in copper wires is typically based upon the subjective determination of the distinction of globules verses arc beads and the nature of the demarcation between the re-solidified regions (NFPA 921). The combination of the high melting point and thermal conductivity of copper means that a fairly extensive region of melting has to result from thermal damage from a fire because if only small regions are exposed to temperatures close to the melting point the substantial dissipation of heat through the wire will preclude any local melting. This is not the case for an electrical arc where the temperatures in an air gap that is created between the wires cannot be so effectively dissipated. Although the extent of melting due to the rapid increase in current in an arc between metal contacts should be fairly consistent, this may not extend to the case of arcing through char, where one might anticipate contributions from the precursory activity associated with lower excursions of current limited by the resistance of the connecting pathway. The extent of the melting and vaporizing of the wire that occurs in this case will be determined by the behavior of the resistance afforded by the residual insulation, so one might expect to see a variation in the degree of damage related to the rate at which the heating of the insulation occurs. Since the decomposition of the insulation can also contribute to the thermal loading, there may be a practical limit to the extent of the local regions of melting and so examining the extent of the melted region of copper wire may actually permit distinction between regions of wire melted by electrical activity versus thermal activity. .

In this paper the authors shall report the results of a series of experiments at different temperatures and different current densities that were used to determine the consequence of electrical arcing to copper wiring associated with the decomposition of PVC insulation. Energized circuits, containing wires of various gauges, were limited by a 15 amp breaker and exposed to temperatures that are capable of decomposing the insulation. The time to achieve a parting arc and the tripping of the circuit breaker as well as the extent of the melting that occurred was determined as a function of the temperature and wire gauge. These were then compared to the temperatures necessary to induce melting in specific lengths of the same copper wiring from which the authors were able to deduce the minimum size of the melted region produced in the absence of electrical activity.

Reference:

NFPA Guide for fire and explosion Investigations. National Fire Protection Association, Quincy Mass.

Electrical, Arc, Fire

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