Considerations on Arcing as a Fire Cause

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It has been concluded in this study that the evidence of arcing is not a sufficient reason to blame electricity as the cause of fire.

IN TWO recent articles\(^1\)\(^2\), the significance of arcing as related to fire investigations was discussed. It was shown that an arc is difficult to start under household conditions. In case an arc is started, it is likely to be unstable and either extinguish itself or degenerate in a short-circuit and open the protective device. Under fire environment however, an arc is most likely to occur and does a lot of damage including the melting of conductors over some length or even the conduit. It was concluded that the evidence of arcing is no sufficient reason to blame electricity as the cause of fire. In fact, in most fires of some intensity, arcings occur in many places including around the area of origin. Then the fire investigator has to find which of these is the cause — if indeed one of them is the cause. This is a difficult question and there is no simple answer.

Many fire investigators are satisfied if they find arcings in a cable close to the point of origin of a fire. They conclude that this was the cause. Since in a house there are electrical wiring, extension cords, fixtures, and appliances almost everywhere, one often observes arcing close to the point of origin. This explains why electricity is so often blamed as the cause of fire without any further evidence. This article presents further experimental evidence to help the fire investigator who is faced with arcing evidence.

Arcing Due to Heat

If a cable is put in a fire environment, arcing will usually occur. In a fire well in progress, the time to arcing is about one minute for extension cords, five minutes for a braided non-metallic sheathed cable, three minutes for

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plastic sheathed cables, and around ten minutes for a metallic tubing. These times should be taken as indicative only; they can vary by a factor of two under apparently similar conditions. The source of heat is immaterial. It can be due to high ambient heat such as that encountered in an oven. It can also be due to the self-heating of a cable under a heavy overload sustained for a long time.

Different cables were overloaded while a voltage of 125 volts was maintained between the conductors. The experiments lasted until the insulation was destroyed and arcing occurred between the conductors, and the time to arcing was measured. Figure 1 shows this time as a function of the current for three different cases. Note that the NEC® states that a 14/2 cable should not carry more than 12 amperes and should be protected by a 15-ampere fuse or breaker. These curves show clearly that arcing, at least in the short term, is possible only under gross overloading. A 100-ampere breaker was used for most of these tests. A 15- or even a 30-ampere fuse would not have permitted these overloads. It is seen that the time to arcing increases at a steep rate when the current is diminished. The arcing probability decreases to zero at the lower currents or temperatures.

In many of these tests, a thermocouple was installed under the sheathing. For the braided type of cable, arcing occurred at temperatures between 300 and 550 °C (typically 400 °C). For the plastic-sheathed type, arcing occurred at temperatures between 150 and 250 °C (typically 200 °C). These temperatures should be taken as indicative only, since the thermocouple had a tendency to move because of the softening of the insulation. Therefore, in many cases, the temperature measured may not have been the highest possible. Under these operating conditions, a great amount of smoke was generated, and in some of the tests, arcing occurred after the conductors were red hot and the insulation was pyrolized to a considerable extent.

These tests were also conducted with metallic-sheathed cable and different types of extension cords. It would be too long to report on all of these. The general shape of the current-time relationship is shown in Figure 1. The conclusion of all of these tests is that arcing is possible within a few hours, only if the current is at least three times higher than normal and if the cable is not thermally insulated. In case of very good thermal insulation, the current would have to be about two times normal values. These tests were also conducted with the voltage applied between the live and the ground conductor. The same time to arcing was obtained but with a current about 10 percent smaller.

These tests lasted for only a few days at the most for each case. One may wonder at the results if these tests were conducted for years. Firstly, in a few cases, these tests were conducted with 30-year-old wiring. Sometimes, the insulation was so brittle that the cable had to be manipulated gently otherwise it would have fallen apart. With these cables, the results did not differ from those obtained with new cables. Secondly, one can compare the curves in Figure 1 with that for the ignition or degradation of wood at high