Vehicle Short Circuit Fires and Their Prevention

By FREDERICK F. FRANKLIN

According to NFPA statistics, nearly as many vehicle fires (447,500) occur in this country as do building fires (745,000) (Fire Journal, Sept. 1989). Besides smoking and arson, short circuits and flammable liquid leaks are the two primary causes of vehicle fires. Although gasoline is typically the flammable liquid involved, power steering fluid, transmission fluid, oil or ethylene glycol coolant can occasionally be the cause. Most short circuit fires and gasoline leaks can be easily prevented.

In 1983, General Motors (GM) was experiencing ongoing problems with its electric door lock switches. These switches were short circuiting and causing fires. To demonstrate the problem, GM conducted simulations. A Nov. 22, 1983 letter from M.D. Osterhoff of Fisher Body to B.R. Wanlass stated, "The door lock switch is powered by a battery feed line that is protected by a 20-ampere fuse. Misalignment of the conductor and/or improper assembly of the base to escutcheon may cause the conductor blade to contact the plated plastic escutcheon, causing a 'high resistance' short in the switch. This situation is sufficient to draw enough current and produce enough heat to start a fire and still not blow the 20-ampere fuse. Fisher Body Electrical Lab was able to simulate this situation and cause an armrest fire on May 7, 1983."

Those who have investigated vehicle fires know that 20-ampere fuses do not prevent short circuit fires in vehicle wiring, for the reason clearly stated by Osterhoff. The arc is not a dead short, but rather a relatively "high-resistance" arc. In simulations conducted by an independent firm, this resistance has been determined to be in the general range of 0.5 to 1.0 ohm, which results in arcing currents in the range of 12 to 24 amperes.

At 24 amperes, a 20-ampere fuse may take several minutes to pop—enough time to cause a fire. To prove that arcs will continue that long, the firm videotaped an arc that lasted well over 60 seconds. The arc finally melts both 16-gauge conductors apart, yet it never pops a 20-ampere vehicle fuse.

It was determined following numerous experiments that vehicle short circuit fires could be prevented. Figure 1 illustrates a typical vehicle fuse time-current curve. Based on this graph, it is difficult to detect much difference between a 20-ampere fuse and a 10-ampere fuse. A different configuration of this graph (Figure 2), however, illustrates that at most arcing currents, a 10-ampere fuse pops hundreds of times faster than a 20-ampere fuse.
The heating energy delivered to the arc is proportional to the opening time of the fuse. Figure 2 shows the energy allowed into an arc by each size before it pops, as a function of the current that the short circuit arc draws. Between 15 and 28 amperes of arcing current, a 20-ampere fuse allows hundreds of times more heating energy into an arc than a 10-ampere fuse. Likewise, a 10-ampere fuse allows hundreds of times more energy into an arc between 7 and 13 amperes than a 5-ampere fuse.

Reducing the heating energy (opening time) by hundreds of times reduces the probability of fire by a like amount. Therefore, effective short circuit protection can be accomplished by using smaller fuses.

Beginning in 1988, the author shared this information with various automobile and truck manufacturers. Some reward for these efforts was realized during 1991. George Ferrell, manager of technical services for Littelfuse, which manufactures most vehicle fuses, indicated that GM must be listening based on the way it was utilizing fuses in the new Saturn automobile.

Photos A and B show Saturn fuse panels, while photo C shows the fuse panel from a 1988 Oldsmobile 98. As the pictures indicate, the Saturn uses mostly 5-, 7.5- and 10-ampere fuses; the Oldsmobile used mostly larger fuses. In addition, the Saturn uses many more circuits so that individual fuse ratings can be smaller. The Saturn uses 38 fuses compared to 15 in the 1988 Oldsmobile.

The author believes near-perfect protection could be obtained by using all 5-ampere fuses wired in tandem; however, this solution would be more difficult and more expensive. Apparently, GM has decided that using mostly 5-, 7.5- and 10-ampere fuses is adequate protection for most short circuit arcs. In another positive move, the Saturn uses 30-ampere fuses in place of fusible links. Also, no circuit breakers are visible (Franklin 42+).

**RESIDENTIAL AND VEHICLE ARCS**

It is interesting to note that both 120 volts A.C. residential arcs and vehicle wiring arcs have the same general range of electrical resistance—0.5 to 1.0 ohm (Franklin 42+). Since vehicle voltage (12 volts D.C.) is 10 times less than household voltage, from the formula:

\[ P = \frac{V^2}{R} \]

the power delivered to a vehicle arc is roughly 100 times less than a residential arc. However, the vehicle arc lasts 100 times longer than a residential one; therefore, the total energy delivered to the arcs is about the same.

\[ E = P \times t \]
\[ \text{Joules} = \text{Watts} \times \text{Seconds} \]

The 20,000 watts of electrical power delivered to a household arc melts copper so quickly that tens of copper globules 1/16-inch in diameter at over 2,500° F fly off in all directions, some landing up to six feet away.

Vehicle arcs are different. They are usually a very intense, localized white hot spot about 1/8-inch in diameter. In the author's opinion, both types of arcs can directly ignite electrical wiring insulation and/or plastic. Because vehicle short circuit arcing power is so much less, often no copper will remain on the wiring where the short circuit occurred. This has been confirmed in in-
As Photo A (above) and B (right) show, the Saturn uses mostly 5-, 7.5- and 10-ampere fuses, while the 1988 Oldsmobile (Photo C, below) used mostly larger fuses. In addition, the Saturn uses 38 fuses—compared to 15 in the Oldsmobile.

vestigations of several vehicle fires that produced limited damage.

The latent short circuit defect placed in vehicle wiring at the time of vehicle manufacture can cause an arcing fire at any time from one-half hour to years later (Franklin 35+). An independent firm investigated three separate vehicle fires at the same manufacturing plant. All three fires occurred after the cars were placed on semi-truck carriers located outside the plant.

Gasoline leaks can also cause vehicle fires. Most leaks occur at the short sections of neoprene rubber hoses inserted into the fuel line at the engine and fuel tank to dampen vibrations. Loose metal tubing connections rarely cause such fires. However, because these rubber sections are completely consumed during a fire, those without extensive experience may have difficulty determining the fire's cause.

Both short circuit and fuel leak fires can occur while the vehicle is being driven. Typically, if a fire occurs within a few minutes of stopping or exiting a vehicle, a fuel leak is the likely cause. While the vehicle is moving, wind blows fuel away from the leak, thus preventing a fire. Once the vehicle stops, however, fuel collects in a pool and is then ignited by hot engine parts.

If the fire occurs more than 30 minutes after parking the vehicle (and smoking or arson are not involved), it is usually a short circuit fire. With a cold engine, nothing else can produce enough heating energy to ignite a fire.

Replacing rubber hose sections with a coiled, expandable metal line, like those used in brake line tubing, and reducing the size of fuses would likely prevent most accidental vehicle fires. In addition, eliminating these fires could enhance arson investigation.

REFERENCES


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