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*FIRE SAFETY*

## Know As Arcs—In-Line & Wet-Wire Electrical Fires

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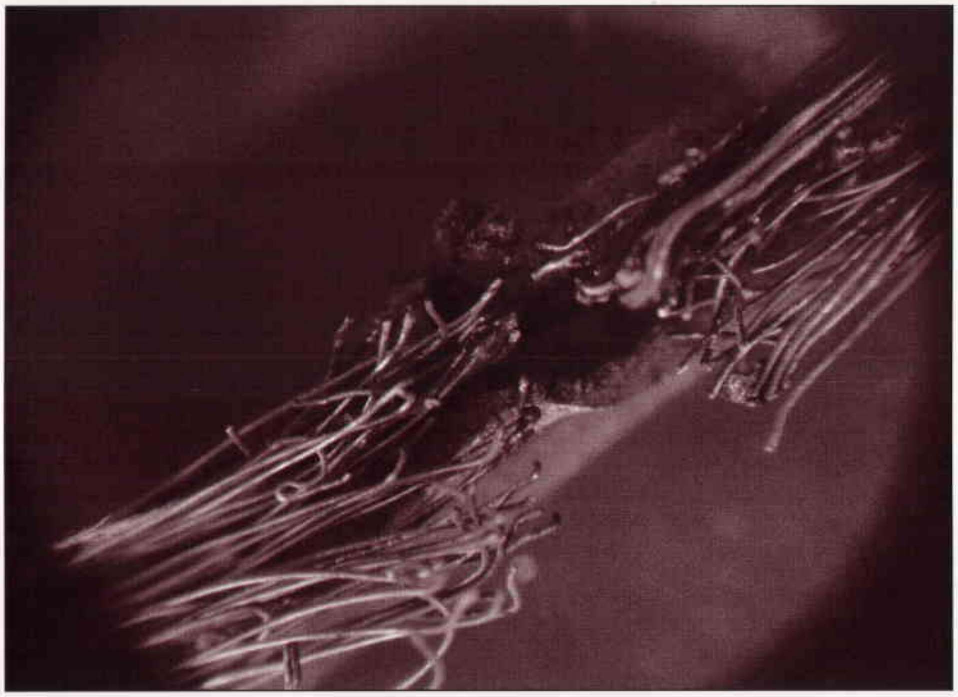

*Copper Cord After In-Line Arcing*

### Introduction

This bulletin presents information on two electrical ignition sources which are not well covered in the fire investigation literature: In-Line Arcing and Wet-Wire Arc-Tracking. Both these phenomena can occur on 115 volt circuits. Circuit breakers or fuses cannot protect against In-Line Arcing and may not protect against Wet-Wire Arc-Tracking.

### In-Line Arcing – A Case Study

Ignitions can occur as a result of arcing along a stranded conductor with broken strands. When a conductor with broken strands moves as a result of handling, exposure to vibration, or other force, current flow through broken strands is disrupted and an arc occurs. This is also possible when the movement causes contact among the broken strands. Repeated arcing can melt the wires, damage the conductor insulation and eject molten metal. In-line arcing can also occur with solid conductors and at connections; these are not discussed in this bulletin.

A fire was started by the cord of an electric iron. The cause of this fire was certain because the ignition was witnessed and the fires on the floor and ironing board were quickly extinguished. The cord suffered no fire damage so it could be examined in detail without the damage being masked by fire or environmental exposure.

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The cord, pictured on Page 1, was a two conductor, 18 gauge, copper stranded wire cord with HTN insulation on a 1200 watt electric iron. The failure occurred at the point the cord entered a flexible strain reliever attached to the body of the iron. The only visible exterior damage was a small hole in the insulation on one of the conductors and a lack of visible copper wire when looking into the cord from the hole. The entire stranded copper conductor had melted away for about one quarter inch leaving what appeared as tunnels in the insulation in both directions from the point of insulation failure. The insulation around the second conductor and between the two conductors was undamaged.

Removal of the insulation around the severed conductor revealed molten globules of copper had flowed into the strands and were intermingled with the strands away from the point of failure. Most of the ends of the strands exhibited clean breaks although some had tapered or beaded ends. Removal of the electrical insulation around the second and parallel conductor revealed the electrical wires were all intact. There were no broken strands nor other damage to the second conductor.

This incident demonstrates that in-line arcing can occur and start a fire. Also, the flow of current through the wire is limited by the connected load; in this case a 1200 watt iron which would pass 10 amps at 120 volts. The current flow can never get so large as to trip a circuit breaker as long as the connected load does not overload the circuit.

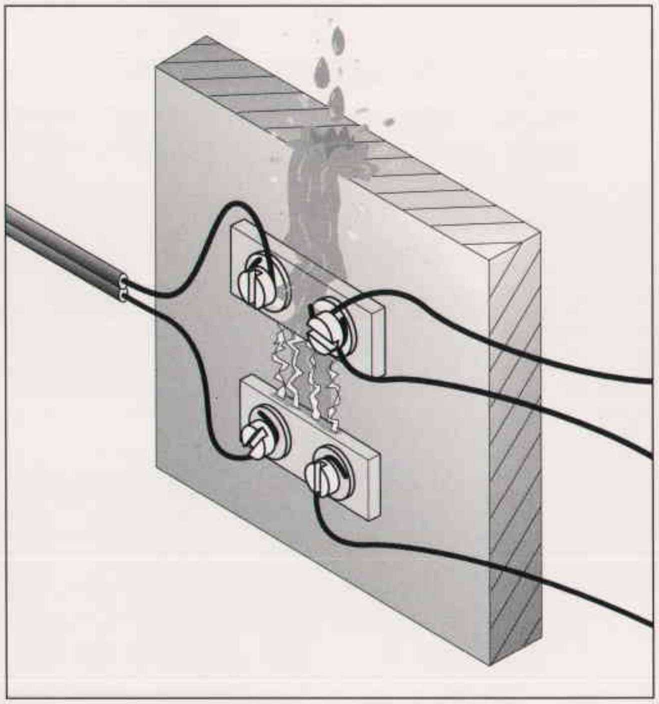
The example identifies some of the failure characteristics important to the fire investigator; imagine how much of this evidence could be masked by fire damage.

## Wet-Wire Arc-Tracking

Arc-tracking is normally associated with high voltage circuits rather than the common voltages encountered in residential and small commercial buildings. The wet-wire arc-tracking phenomenon occurs when a conductive liquid drops onto an insulating surface and the liquid bridges between two exposed electrical connections at different voltage potentials. This effectively creates a high resistance short circuit. Electrical arcing through the liquid generates heat, evaporates the liquid and slightly degrades the surface of the insulation. When the liquid evaporates, the arcing stops. A residue will be left on the insulating surface from solids that had been dissolved in the liquid. The next dropping of liquid repeats the process but the current flow will be slightly higher because the residue will be dissolved in the liquid and the insulating surface will have been degraded. This cycle is repeated until eventually the current flow is sufficient to ignite the degraded insulation. It may take hundreds of cycles before ignition occurs. The more conductive the liquid the fewer cycles required before a fire starts.

One of the first experimental investigations into low voltage wet-wire arc-tracking was conducted by the U.S. Navy because electrical flashover fires were being encountered on carrier based aircraft which were exposed to saltwater spray. These tests demonstrated that wet-wire arc-tracking was a viable ignition source even at 110 volts.[1]

In 1983 the National Transportation Safety Board investigated an Air Canada DC-9 fire that reportedly started in the lavatory. [2] The NTSB never officially determined the cause of that aircraft fire but many blamed it on a carelessly discarded cigarette even though such an ignition source previously had been shown not to be viable. After that fire, the Federal Aviation Administration (FAA) required installation of smoke detectors in airplane lavatories and reemphasized the ban on smoking in lavatories.



*Wet-Wire Arc-Tracking*

Four years later the FAA conducted tests to see if liquid from a leaking toilet could cause wet-wire arc-tracking.[3] The FAA tests showed that wet-wire arc-tracking fires could be caused by leaking toilets; these would start fires in concealed lavatory spaces not protected by the required smoke detectors. By the time such fires would be detected it would probably be too late to control them. The Navy and FAA tests and other analyses raise doubts as to the accuracy of the Air Canada and other aircraft lavatory fire cause determinations.[4]

The Navy and FAA tests were limited to aircraft type wire insulations. Later tests conducted by Triodyne Fire and Explosion Engineers showed wet-wire arc-tracking could occur with common PVC wire insulation and with molded PVC connector housings in 120 volt circuits. None of the testing performed by Triodyne Fire and Explosion Engineers tripped the 20 amp breaker protecting the circuit before starting a fire. These insulation fires were generally small and probably would not spread unless other exposed combustibles were nearby. Experimental data on the susceptibility of various types of insulation to wet-wire arc-tracking is incomplete and scenario specific tests are often necessary to evaluate this phenomenon as a probable ignition source.

## References: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