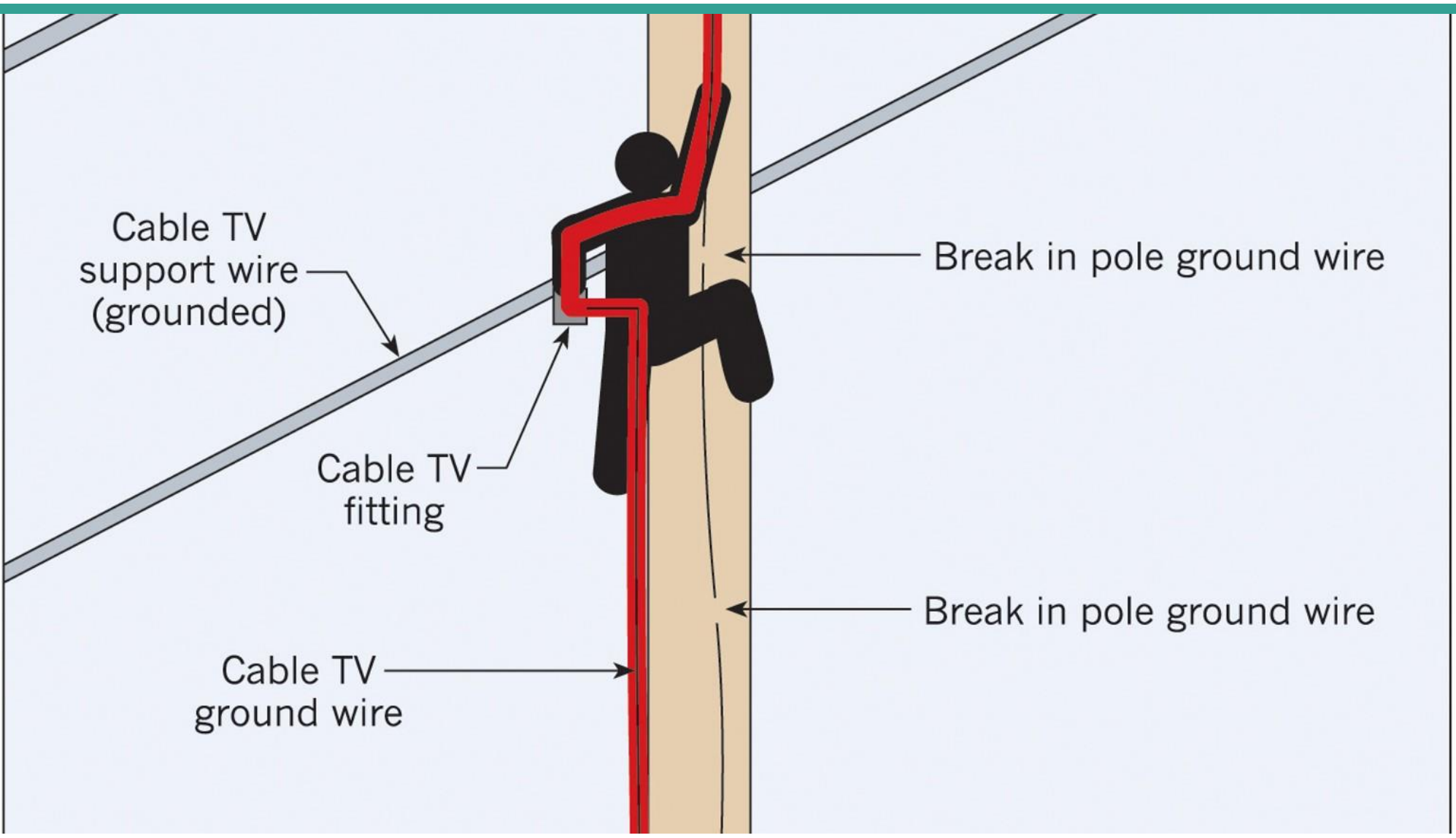

SAFETY > SHOCK & ELECTROCUTION

The Case of the Deadly Ground Wire

Current “jumping” across live phase conductor to severed ground wire on utility pole leads to fatality

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It's no secret that the electric company, phone company, and cable TV company all frequently share space on the same utility poles. National Electric Safety Code (NESC) rules control the location and spacing between these cables to ensure the safety of workers when they perform their respective services.

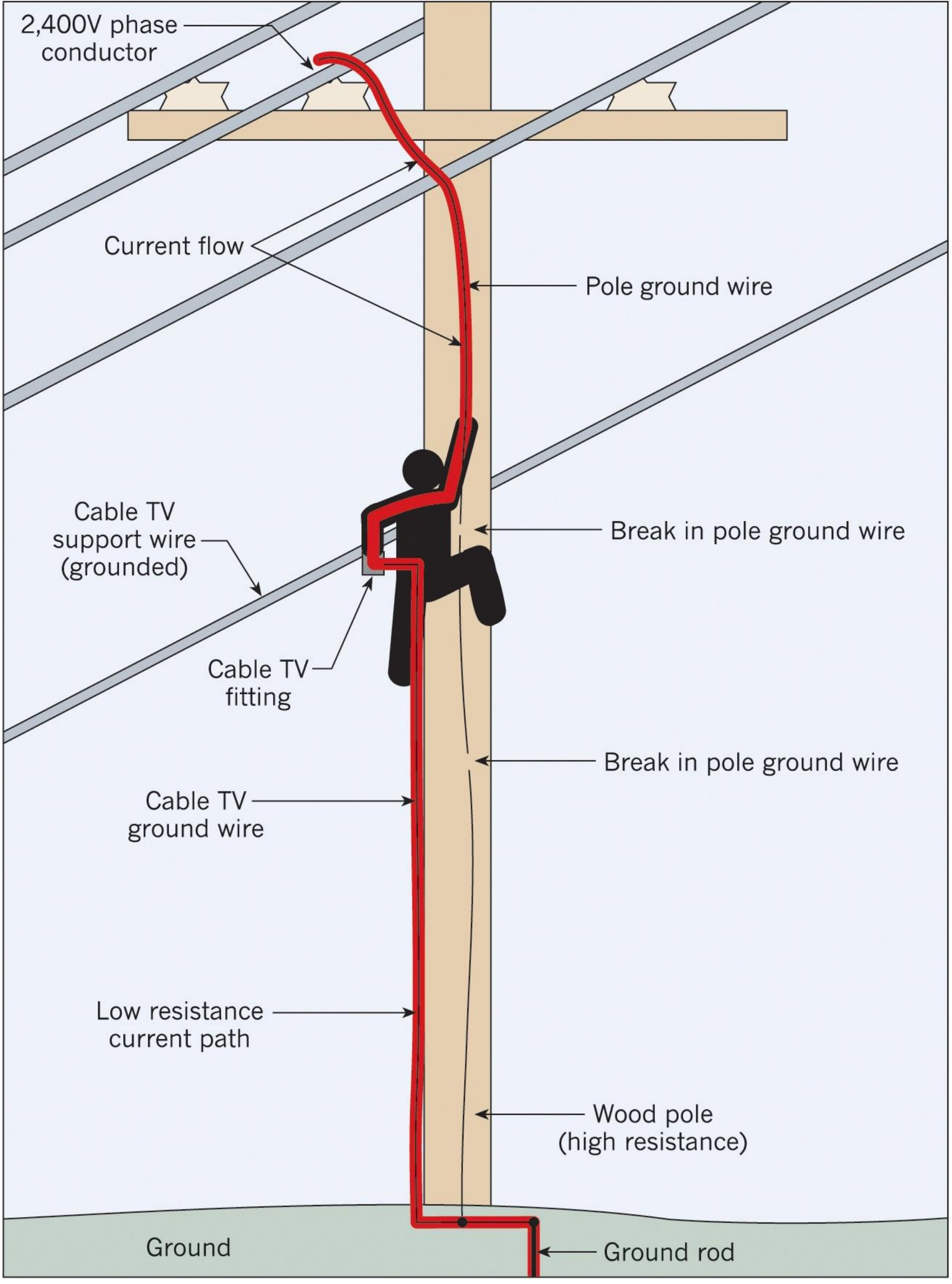
Frequently, the electric utility installs a bare ground wire or static wire on the pole top to protect its power circuits from lightning strikes. This wire is grounded by running a wire from the pole top wire to a ground rod driven into the earth at the base of the pole.

Unfortunately in this case, poor electrical housekeeping on the part of the municipal utility ultimately led to the death of one unsuspecting TV cable technician, who attempted to perform routine maintenance on a cable TV fitting attached to his company's portion of the pole.

The Scene

The setting of this tragic accident occurred at an electric utility pole, similar to the one depicted in the **Figure** below. The technician was standing near the top of a ladder (the ladder is not shown so you can more clearly see the current path). On the left side of the pole, you see a cable TV wire and fitting attached to a grounded steel support wire. The fiberglass

ladder was leaning against the wood pole. Even if a person stood on the top rung of the ladder, he would still be clear of the electric utility power conductors at the top of the pole.


2,400V phase conductor
Current flow
Pole ground wire
Cable TV support wire (grounded)
Break in pole ground wire
Cable TV fitting
Break in pole ground wire
Cable TV ground wire
Low resistance current path
Wood pole (high resistance)
Ground
Ground rod

The heavy red line depicts the current path that ultimately killed a cable television technician.

The Accident

Notified that there was a problem with a filter in the cable TV fitting, a cable technician dispatched to the site, climbed the ladder, and attempted to troubleshoot the situation. During this work, he was well clear of any energized electrical wires supported by the pole. When he experienced difficulty in removing the filter, however, he yelled down to his co-worker for a pair of pliers. While on his way to the truck to retrieve the pliers, the co-worker momentarily looked back, only to see the technician falling to the ground.

Pronounced dead by a doctor at the scene due to “massive head and brain injuries secondary to accidental electrocution,” the technician had burn marks on both of his hands — with the right hand showing more severe damage than the left. The doctor also noted that the victim’s body was positioned northwest of the utility pole and that the fiberglass ladder was resting against the west side of the pole.

The Investigation

I was contacted by an attorney retained by the technician’s family (plaintiff) to investigate the accident and give my expert opinion on the cause of his death. Because my involvement occurred many months after the accident, a site visit would not have been of much use. Fortunately for me, the local police and OSHA had taken multiple photographs at the accident scene. I was able to combine these photos with depositions of witnesses and measurements/observations by utility personnel to reconstruct the accident.

Examination of the Pole

An examination of the wood pole by electric utility personnel revealed that a ground wire ran up the east side of the pole from the ground level. However, as the investigating utility electrician followed the ground wire up the pole, he realized it had been cut in two places — 6 ft and 10 ft above ground level — and that the top portion of the wire was hanging in mid air (less than ¼ in. away from the 2,400V phase conductor at the top of the pole).

At the time of his inspection, the electrician noted current was “jumping across” from the live phase conductor to the end of the ground wire. He measured approximately 880V between the ground wire on the pole and the steel wire supporting the TV cable. He concluded that the energized phase conductor had induced the 880V on the ground wire due to its close proximity. In addition, he noted the steel wire supporting the TV cable and fitting registered 0V — as it should have, due to the fact that it was grounded.

A comparison of the location and routing of the ground wire on this pole with the ground wire configuration of a standard pole revealed that someone at the electric utility had removed the static wire connection at the top of this pole to make room for an additional phase circuit.

However, the timing of this event remained unknown.

Similar Non-Fatal Experience

After digging deeper into the details, I discovered that an electric utility electrician, who had been working on the same pole previously, had reported receiving a shock from one of the rungs of his ladder earlier that year. He had placed his ladder against the east side of the pole, which could have easily placed one of the rungs in contact with the inadvertently energized ground wire on the pole. Although he immediately notified his supervisor of this experience, for whatever reason, this electric shock event was not reported verbally or in writing to anyone in management at the municipal electric utility. It was also found that there was no detailed follow-up on this event to determine the real source of the shock.

Further investigation into this matter revealed the supervisor to whom the electrician reported the shock to (and even the electrician himself) assumed the shock had come from disconnected service drops hanging on the sides of the pole. The municipal electric utility was in the process of converting the overhead service drops to underground feeds and had cut the service drops free with what it considered sufficient clearance above grade. Although the electric utility taped up the dangling service drops following the shock event, no one performed a detailed inspection of all the connections on this pole. Had a detailed inspection been performed at this time, the close proximity of the disconnected ground wire to the 2,400V phase conductor would have easily revealed itself, preventing the fatal accident.

There is also no evidence to suggest that the municipal electric utility inspected all of its poles to ensure a similar situation did not exist elsewhere in its service territory. Based on the information provided by the deposed, there did not appear to be any well-established procedure for recording such incidents, conducting follow-up investigations to determine the root cause of the incident, or making provisions to prevent a recurrence.

Accident Reconstruction

Based on the evidence, I came up with the following conclusions regarding how the accident played out. The cable TV technician climbed up his fiberglass ladder, which was resting against the west side of the electric utility pole, to remove the filter from the TV cable fitting supported from the pole. Because the fitting was above the end of the ladder, he would have had to reach up and out to work on it. He most likely steadied himself against the pole by reaching around it with one hand as he reached out with his other hand to the TV cable fitting to remove the filter. When he had difficulty removing the filter, he probably reached further around the pole to better steady himself. It was at this point that he must have made contact with the energized ground wire, which carried some voltage (880V or higher, depending on how close the loose ground wire at the top of the pole was to the energized phase conductor).

The pattern of burns on the victim's hand were consistent with placing the hand at almost a 45° angle with the vertical against the pole covering the ground wire, as one would do to steady oneself. This would have placed his upper body in the current path between the energized ground wire and the grounded cable TV support cable. The passage of current through his body either caused his death or caused him to fall to his death (see Electrical Circuit Phenomena on page 10). The location of his body, as found on the ground at the base of the pole, was consistent with him leaning out (to the north) to work on the cable fitting. An examination of the deceased's hands showed no evidence that he had attempted to break his fall, indicating that he was either dead or unconscious prior to hitting the ground.

The Outcome

The cause of the accident was attributed to poor housekeeping by the municipal electric utility, as was evidenced by the hanging, disconnected (but apparently still energized) service drops on this pole — not to mention the manner in which the ground wire had been cut and not removed

(or at least secured properly) to ensure it would not contact energized conductors at the top of the pole. Although no specific financial details were divulged, the case did settle out of court in favor of the technician's family.

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SIDEBAR: Electrical Circuit Phenomena

Because the ground wire was not connected to ground and cut in two places, the connection between the end of the ground wire above the cut section and the ground was through the wood pole. The dry wood (the weather was dry at the time of the accident) in the pole presented a high resistance to electric current so that very little current flowed via this path. In other words, not enough current flowed to cause the protective devices that protected the power circuit to trip and interrupt the current. Thus, the arc between the phase conductor and the ground wire could have continued indefinitely. Had the ground wire not been cut in two places, it would have provided a safe path to ground and should have tripped protective devices.

As shown in the first **Figure** above, when the victim contacted the energized ground wire above the cut sections and the grounded cable support wire at the same time, the current flowed into his hand touching the energized ground wire, through his body, out his other hand to the cable TV support cable, and then through the cable TV ground wire to ground. The burn marks on his hands confirmed this path.

The resistance of the human body for electrical safety purposes is considered to be about 1,000 ohms, according to IEEE Std 80-2000. Before the switch is closed in the above circuit, simulating a person contacting the energized ground wire while being grounded through the cable TV support cable, the voltage across the resistance representing the wood pole is about 880V, as measured by the electric utility. When the switch is closed, the body resistance shorts out the wood pole resistance, because it is so much smaller in value, which allows current to flow through the body. When this happens, the voltage across the body resistance will drop from whatever the open-circuit voltage on the ground wire was (880V or higher) to a lower value due to the higher current flow from the source through the body resistance (see **Figure**

below). It only takes about 70mA to 300mA of current to kill a human. Thus, it only takes about 70V to 300V to cause a potentially fatal current to flow in the body.

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