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RESEARCH ARTICLE

Two Case Studies: Real-life fatal burn case including smoke inhalation and fatal high-voltage electrical burn

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Abstract

Electrical burns are one of the most serious injuries one can receive. It is one of the most important causes of disability and mortality throughout the world. The World Health Organization (WHO) reported an estimated total of 3,700 deaths caused by accidental fires in the United States in the year 2002. The United States Fire Administration (USFA) stated that electrical fires in homes claim the lives of 485 Americans each year and injure 2,305 more. Here, two real-life fatal electrical burn cases were presented and investigated with regards to reasons for death and fire. The first case involves smoke inhalation. The second case involves fatal high-voltage electrical burn.

INTRODUCTION

Case 1: Man redecorates kitchen and dies in fire.

An 84 years old man decided to redecorate the kitchen by hiring a contractor to rip out the kitchen cabinets, stove, refrigerator, and put in everything new. After the contractor had finished the job, all looked good and worked perfectly. Three months later, there was smoke in the kitchen. The man smelled the smoke and went to get a small extinguisher he had. The fire was contained to a small corner of the kitchen where the new cabinets started from the wall. It could have been easily contained. But the man was 84 and frail. He could not release the safety latch on the fire extinguisher. It was still on stove when the fire department arrived.

The man then rushed as quickly as possible to his bedroom on the second floor. He called the fire department, and they arrived in about 5 minutes. However, the smoke from the fire was quickly traveling upstairs. When the firemen arrived, the man was passed out on his bedroom floor. He was certified dead later at the hospital.

The fire damage was small. It was caused by the refrigerator wire under the cabinets, directly below the microwave oven, which sat in the corner. See Fig. 1(a). However, the owner died of smoke inhalation.

Fig. 1: (a) The kitchen after the fire. Fire extinguisher on top of stove is un-used. (b) Fridge wire (long straight wire) was found as the point of ignition for the kitchen fire.

Investigation and Discussion: The fire itself was small. One row of wall cabinets was damaged. A microwave oven underneath the cabinets was lost. The refrigerator was slightly blackened but functional, except for the cord leading to it. See Figure 1(a). The investigation found that a #12 gauge wire was run under the cabinets to the refrigerator. See Fig. 1(b). Typically, the fridge drew 10 amps. The wire could safely carry 20 amps. Yet, the cord was the site of the ignition of the fire. How can the cord have gotten hot enough to ignite a fire when the current was only half the rated maximum? Or to put this another way, how could the cord heat up enough to cause the fire when the heat generated was only ¼ of the rated safe maximum?

The cord started the fire due to the phenomenon of pyrolysis. The term pyrolysis has several definitions, especially in the subject of chemistry. For our purposes, it means a "slow burn". We are used to thinking of the flashpoint of burning. For paper and most wood and wood products, ignition is at 451 degrees Fahrenheit. Temperatures under this value are considered too cool to burn or too cool to ignite a burn. In pyrolysis, a high temperature (but lower than the ignition temperature) heats up the material, and in the process it makes it more easily combustible by breaking down its structure. The process can go on for hours or weeks or even months. At some point the wood will ignite, and the temperature of ignition is lower than the normal value (451 F). When the wire was run from the far wall to the refrigerator, the kitchen cabinets were placed directly on top of them. This is sloppy carpentry on the part of the contractor, since it required extra steps in leveling the cabinets. The cabinets essentially flattened the copper wire. But apart from the sloppy carpentry, there was the additional problem of heat buildup. The wire made intimate contact with the base of the wood cabinet. Over time, this wood came closer to the ignition point. After 3 months the wood ignited into a fire.

Protocols involve the use of the NEC (National Electric Code) to define safe procedures for the implementation of even the simplest electric circuit. It should be pointed out that the NEC has a rule regarding the contact of cabinets and wire run in this fashion [2, 3]. The contractor must "notch" the bottom base of the wood cabinets. The wire can then run under the cabinets with a layer of free air surrounding it. Any heat built up can then be easily dispersed, even in areas where air flow is stagnant.

Some of the electrical fires are caused by electrical system failures and appliance defects, but many more are caused by the misuse and poor maintenance of electrical appliances, incorrectly installed wiring, and overloaded circuits and extension cords. Home electrical wiring causes twice as many avoidable fires as electrical appliances. People exposed to an indoor fire often suffer from smoke inhalation and die because of the toxic effects of carbon monoxide (CO) and combustion products in the air. The mortality rate from smoke inhalation among burn victims is 0-10% among those without burns [1].

It is clear that even non-contact electric burns are both common and frightening in their effects. Education of the people has been suggested as a way of reducing morbidity and mortality. A safe circuit becomes very dangerous over time.

Case 2: Real-life fatal high-voltage electrical burn

An 80 years old man lives on a 2 acre estate outside of New York City. He is in the process of selling his house. He calls an electrician to come to his house because the power is out. When the electrician arrives, the man is not home, but his house is open. There is a guest house in back of the main house. It is locked but the electrician can clearly see no one inside. He does see smoke several hundred yards away coming from the woods. The weather is cold and damp, and there is a layer of snow on the ground, so there is no danger of a forest fire. The electrician calls the police.

The police/fire/first-aid crews find the homeowner or what is left of him. He is on his property in the woods, one hundred yards from the house. He is burned so badly that most of his bones are showing. Positive identification can only be made later from dental records. There is a 5,000 volt power line broken but lying on top of the man. See Fig. 2(a). Before the rescue crew can approach, they must tell the power company to kill power to the line. There is a series of poles (aka telephone poles or power poles) from the main road. They are on the owner's estate leading through the woods to the guest house and from there to the main house.

Figure 2: (a) Body of the man burned by 5000 Volt power line falling on him. (b) Fallen tree with broken power lines and stretched cable lines.

Investigation and Discussion: Analysis of the accident itself is bizarre. At one point, the police consider a charge of murder. According to one accusation, someone killed the man (maybe hit him on the head) and then dragged his lifeless body to the woods. But then, the murderer must climb up and cut the power line such that it lands on the body. It is well known by OSHA and other safety agencies [8] that the safe distance from a 5,000 volt source is 10 feet. If you get closer than 10 feet and if you are somehow grounded, then electricity can arc through the air and into your body. If a murderer tried to cut the power line, he would die before he got close enough to touch it.

Another theory is that the owner (who was over 80 years old) decided to go out for a walk around his property. However, the woods surrounding his property were not cleared. There was debris everywhere to the point that one had to climb over stumps and brush and fallen trees. It was not a pleasant walk even for a young man. So, even if he decided to go for this stroll, how could he be standing under the precise point where the power line would snap and land on him?

There was one theory that seemed to make the most sense, given the bizarre circumstances and the lack of hard evidence. A tree breaks and falls on the power line. The power line is accompanied by several other wires, including a phone wire and another wire from the cable TV company. A tree is weakened by disease and age and falls. It lands on the power bundle. But the wires do not break. They support the tree. There is a break in the junction box from the tension of the tree on the wires. The house loses power. The homeowner calls the electrician. While waiting, the homeowner sees smoke in the woods. He goes to investigate. Even though the tree is supported by the wires, the power wire is broken at the junction box and at that point there would be sparking and smoke as the live line made erratic connections to ground. The owner gets close to get a better look. At that point the power wire snaps. In the fashion of a whip it springs out and lands on the homeowner. Note: the two low power cables (phone/cable TV) did not snap. They just stretched more and more as the full weight of the tree came to rest on them. They were still connected from pole to pole (though bowed in the center) when the rescue team arrived. See Fig.2(b). The homeowner may have been electrocuted as well as burned. There is no way to tell. The outer body was so badly burned, that death could have been by electrocution or burning or both. Fig. 2b shows the fallen tree, the snapped power wire, and the overly stretched TV/phone wires.

The question remains: whose fault is it? The cause of this accident was the tree falling. What does the law say about this? Surprisingly, there is no national law codified into a document like the NEC which explains the responsibility for the trees near a power line. There are, however, laws in almost every state in US governing the position and shape of trees near a power line. There are many dozens of pertinent references for the laws governing trees near a power line in every state and many counties and cities. Since this accident happened in New York State, it was governed by the laws of New York State. These stated that it was the power company's job to maintain safety protecting the public from loss of life, property and natural resources by fire. The power company had to warn errant homeowners about their trees proximity to a power line. If the home owner took no action, the power companies could turn off electricity to a home, even if the electricity was deemed necessary for some emergency situation in the home. Alternatively, the power company could trim the trees on the owner's property and force him to pay the bill for this service. Although the homeowner owned the trees, they effectively belonged to the power company.

Some of the electrical fires are caused by power lines. Electricity makes its journey to the customer over power lines. The voltage at which electricity is generated varies depending on the installation. This voltage is boosted by step-up transformers at the generating plant to the high voltage required for transmission over long distances. The transmission voltages in common use are 36 kV to 500 kV. It is then transmitted over power lines to centrally located transmission and distribution substations. Distribution voltages commonly in use are 2.4 kV to 35 kV. Distribution circuits supply transformers which reduce the voltage so that it can be utilized by the customer. The secondary voltages which are normally supplied to the customer are 120 volts to 480 volts. The forensic medicine records of 291 cases of death caused by high-voltage current for a 41-year-long period (1965–2006) were examined in retrospect. The victims' average age was 36.19 years [4].

Electrical power presents an unusual hazard which brings about a mutual concern on the part of Local, State, Federal fire protection agencies and the electric utilities for making the transmission and distribution of electrical power as fire safe as possible. Fire protection agencies in their regulatory roles are concerned with public safety, loss and damage to natural resources and watershed as well as the costs of fire suppression. The electric utilities, both publicly and privately owned, are concerned with minimizing potential electrical fire hazards and minimizing interruptions of service to their customers. The purpose of the presented paper is to prevent electrical fires by providing and discussing a case report. There are very limited case reports in the literature regarding the electrical burns. Most of these reports are focused on the medical treatment of the electrical burns instead of the reasons of the accidents. [5, 6, 7].

Fatal high-voltage injuries (FHVI > or 1000 V) present a problem which has not been studied enough in the context of interaction between the human body and electricity as a technical, anthropogenic and natural phenomenon.

Snow and winds may cause trees to sway into power lines, break off limbs or fall into power lines. Arcing usually accompanies such faults. Clearance requirements around electrical poles and towers are necessary to prevent such fatal accidents. The removal or trimming of trees, or portions of trees, that are dead, decaying, rotten, or diseased and which may fall into or onto the line and trees leaning toward the line is important to prevent possible danger.

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Conflict of interest statement

None.

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