H38 Paschen's Law and Electrical Burns

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Learning Overview: The goal of this presentation is to acquaint attendees with Paschen's Law and what effect it has on the development of high-voltage electrical burns.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by assisting attendees in being able to better reconstruct high-voltage electrical deaths.

The paper by Wright and Davis that was published by the *Journal of Forensic Sciences* in 1980 (The Investigation of Electrical Deaths: A Report of 220 Fatalities) is one of the seminal papers that the forensic pathologist refers to when investigating a possible death by electrical means.[1] In their paper, the authors show that about 95% of persons who have become engaged with high voltage have some type of thermal lesion present.

Further to the point, the authors state (regarding high voltage) that "even momentary contact is associated with burning."[1] This statement is invariably true. What the authors fail to realize or explain is that burning does not at all require a continuous metallic or semi-conducting current path for a burn to occur. In other words, there is another mechanism that creates thermal lesions other than that of ohmic heating from electrical current flow through the cutaneous surfaces.

The laws of electrical engineering include a law developed by Friedrich Paschen in 1889. The law describes the size (distance) in differing gaseous media for the gas (air) to ionize and begin to conduct electrical current. In normal air, and with voltages of about 7,500 volts RMS (a common power line voltage), electrical current can "jump" or arc a distance of about 35cm (14"). During the arcing process, temperatures of between 5,000°F and 10,000ºF are developed, with much of the thermal injury creating thermal burns on the skin in the event a human body is so exposed.

Testing by this study on freshly harvested porcine legs (ethically obtained from a meat market) demonstrate the arcing phenomenon. This study used various sized high-voltage transformers electrically powering a metal grid (electrode) separated from an oppositely charged porcine leg. After power was applied, burning was seen to occur even though an air gap existed between the grid (electrode) and the porcine flesh. Moreover, using current-limited transformers and open-shutter photography, the current path through open air can be seen to move, creating a pattern that does not necessarily match the shape of the electrode that is being excited.

This research demonstrates that electrical burns from high-voltage source energy do not require that there be direct electrode-to-skin contact for burns to occur. For purposes of this presentation, the remote presentation will allow for actual live testing to take place from the lab, demonstrating the veracity of the material being presented. Different dwell (exposure) times will be presented, showing the development of burns almost instantaneously, as well as the propensity of the ionized path to "wander," creating a pattern that does not always mirror the shape of the electrode.

Finally, the Wright/Davis paper made attempts at explaining the difference between *power* and *energy* when analyzing electrical burns.[1] The present study will explain the differences between the two and will explain the corrections necessary to make the prior paper accurate in terms of thermodynamics and heat transfer.

Reference(s):

1. R. K. Wright and Joseph Davis. The Investigation of Electrical Deaths: A Report of 220 Fatalities. *Journal of Forensic Sciences,* Vol. 25, No. 3, July 1980, pp. 514-521.

Electrocution, Arc, Burn