

the electrical digest

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FORENSIC ELECTRICAL ENGINEERING ELECTROCUTIONS-LOW VOLTAGE

Forensic - belonging to, used in, or suitable to courts of judicature ...

(Webster's New Collegiate Dictionary)

Man has suffered from electrical injuries and burns since he first ventured outside his cave during a thunderstorm. In historical times, the earliest known accident from man-made electricity was recorded in 1745 when two physicists in Holland were killed when they unintentionally discharged a Leyden Jar—the original form of capacitor. The first industrial accident was to a stage carpenter in Lyons, France, when he was killed by touching a 250 V power supply. In North America, accidental electrocutions date back to the 1890s.

In modern times, the incidence of electrocutions is about five to seven per million of the population. Today, electrical burns represent one of the more unusual types of injury in North America. The true incidence of electrical accidents will never be known since only deaths or hospitalized cases are recorded. Over a 20 year period, about 100 people per year were electrocuted across North America due to various causes.

This issue of Electrical Digest will discuss electrocutions and accidents due to contact with low voltage power supplies of 600 V and less. High Voltage electrocutions will be covered in more detail in a later issue.

The human body can be considered as an electrolytic solution having a relatively low resistance to current flow, although the various tissues of the body can have significantly different resistance values. For example, dry or callused skin has up to twenty times the resistance of moist, sweating skin.

The degree of injury depends upon the voltage, current, contact surface area, and path of current. Death is virtually instantaneous if the current is high enough. However, burn marks are only found in cases where high energy absorption has occurred in the tissue for a period of five to ten seconds or more. Thus 55 percent of all low voltage electrocutions leave no burn marks on the body since the time is so short and the energy level is too low.

An increasing number of accidents are due to the use of electrical appliances and products. These invariably lead to substantial product litigation. The courts must then decide if a defective product or improper procedure caused the injury or electrocution based upon the findings of an expert witness.

A recent litigation case illustrates the work of the forensic electrical engineer.

An electrician was electrocuted when he accidentally grasped live test clips connected to a 440 V system. The plaintiff alleged that the insulating boots on the clips were defective. The manufacturer of the boots called upon the services of a forensic electrical engineering specialist who was able to show that defects could not have produced the burn marks on the deceased. His opinions were reinforced by tests on animal tissue simulating the accident. As a result, the claim for \$2 million was settled out of court for a considerably lower sum.



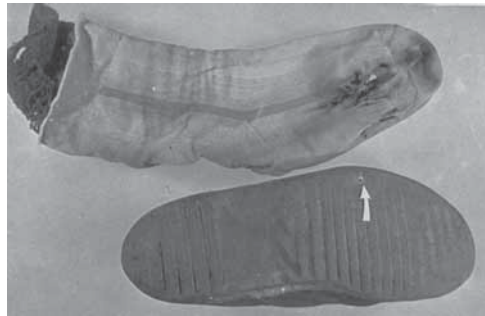
After touching a live 600 V cable, this electrician fell to his death from the top of a ladder. The photographs show the entrance burns on his right thumb and the exit burn on his left hand.



This electrician died a few minutes after touching the live contacts of a 600 V switch. The photographs show the entrance burn in his fingers and the exit burn on his forearm.



Child electrocuted by contact with a frayed extension cord.



Burns to the foot of a worker caused by a high voltage contact which penetrated the sole of his boot.

In his investigations, the forensic engineer takes into consideration every possible piece of evidence surrounding the accident. These might include eye witness accounts of the victim's movements before and during the accident, his cries of pain, the markings of the entry and exit burns and other skin damage. The alleged faulty equipment and the electrical system itself must be tested and analyzed to determine how contact was made with the live parts. Microscopic analysis of the skin might reveal the characteristic markings that are peculiar to electrocutions as opposed to burns from conventional heat sources.

Some deaths have been caused by the massive arcs resulting from short circuits. Invariably, the victims are severely burnt by the expulsion of hot gases and vapourized metal without having come in direct contact with the live parts.

The flow of electricity through the body produces numerous effects depending upon the circumstances. Muscular contractions have been so strong in some cases that bones have been fractured.

Perhaps the most characteristic effect of electrocution on the body is necrosis-literally "death of tissue" which is caused by overheating (cooking) of the flesh and/or bone. Non-fatal electrocutions often necessitate the amputation of the affected limbs many weeks after the accident because the body was unable to heal itself and recover from the damage.

The various medical problems arising from electrocutions that may cause immediate or subsequent death include:

- necrosis of muscle tissue, blood vessels, nerves, etc.
- bone fractures
- progressive thrombosis
- delayed haemorrhage
- gangrene
- emotional detachment
- unconsciousness
- impairment of mental functions
- permanent neurological injury
- electrical eye cataracts
- kidney failure
- gastro-intestinal complications
- anemia

The following case histories from official records illustrate typical accident situations involving low voltage power supplies:

Case I

A woman was electrocuted by the washing machine in her basement due to a faulty ground connection. Burns were found on her hand and finger.

Case II

A man was found in his basement workshop slumped over a lamp on his bench. The lamp was connected to the power supply via an extension cord. There were burns on his chest and hands.

Case III

Frayed insulation and a broken ground connection on the metal conduit of an irrigation pump installation caused the death of a farmer. His feet were wet and his left foot, hand and left side of his face were burned.

Case IV

A farm labourer was killed when he touched the wires of a pump motor in a storage barn. The original three phase motor had been replaced by a single phase motor but the third wire had not been insulated. His clothing and the floor of the barn were wet. The burn marks were on the palm of the hand holding the wire.

Case V

A small boy was burned when he grasped the exposed elements of an electric heater which his brother plugged into the outlet socket. He was unable to let go until the plug was removed.

The effects of electricity on the body

1 mA	-threshold for electricity flowing between the hands
6-10mA	-no let go level
20-50 mA	-asphyxia (suffocation), but heart still beating
50-200mA	-ventricular fibrillation (uncontrolled heart beat)
200 mA-4A	-thoracic muscle constriction (heart beat stops)
4-7 A	-legal electrocution, temperature of the body rise to 48°C and that of the brain to 58°C