Electric Shock – it's the Current that Kills

Naively, it would seem that a shock of 10 kV would be more deadly than 100 V. This is not necessarily so! Individuals have been electrocuted by appliances using ordinary house currents at 110 V and by electrical equipment in industry using as little as 42 V direct current. The real measure of a shock's intensity lies in the amount of current forced through the body, not in the voltage. Any electrical device used on a house wiring circuit can, under certain conditions, transmit a fatal current.

From Ohm's law we know

$$I = \frac{V}{R}$$

The resistance of the human body varies so greatly it is impossible to state that one voltage is "dangerous" and another is "safe." The actual resistance of the body varies with the wetness of the skin at the points of contact. Skin resistance may range from 1000 Ω (ohms) for wet skin to over $500,000$ Ω for dry skin. However, if the skin is broken through or burned away, the body presents no more than 500-Ω resistance to the current.

The path through the body has much to do with the shock danger. A current passing from finger to elbow through the arm may produce only a painful shock, but the same current passing from hand to hand or from hand to foot may well be fatal. The practice of using only one hand (keeping one hand in your pocket) while working on high-voltage circuits and of standing or sitting on an insulating material is a good safety habit.

The Physiological Effect of Electric Shock

Electric current damages the body in three ways:

1. it interferes with proper functioning of the nervous system and heart
2. it subjects the body to intense heat
3. it causes the muscles to contract.

Figure A.1 shows the physiological effect of various currents. Note that voltage is not a consideration. Although it takes a voltage to make the current flow, the amount of current will vary, depending on the body resistance between the points of contact.

As shown in the chart, shock is relatively more severe as the current rises. At values as low 20 mA, breathing becomes labored, finally ceasing completely even at values below 75 mA. As the current approaches 100 mA, ventricular fibrillation of the heart occurs — an uncoordinated twitching of the walls of the heart's ventricles. Above 200 mA, the muscular contractions are so severe that the heart is forcibly clamped during the shock. This clamping protects the heart from going into ventricular fibrillation, and the victim's chances for survival are good.

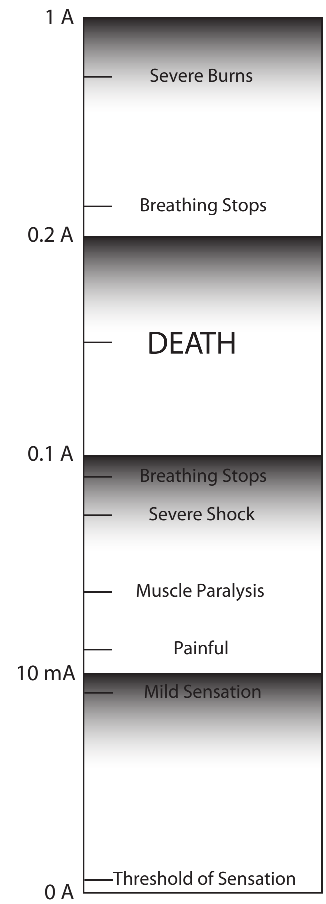

Figure A.1 Common injuries at different currents

AC is four to five times more dangerous than DC, because it stimulates sweating that lowers the skin's resistance. Along that line, it is important to note that the body's resistance goes down rapidly with continued contact. Induced sweating and the burning away of the skin oils and even the skin itself account for this. That's why it's extremely important to free the victim from contact with the current as quickly as possible before the climbing current reaches the fibrillation-inducing level. The frequency of the AC has a lot of influence over the severity of the shock. Unfortunately, 60 Hz (the frequency used in the lab) is in the most harmful range — as little as 25 V can kill. On the other hand, people have withstood 40 kV at a frequency of 1 MHz or so without fatal effects.

A very small current can produce a lethal electric shock. Any current over 10 mA will result in serious shock.

Summary

Voltage is not a reliable indication of danger, because the body's resistance varies so widely it's impossible to predict how much current will be made to flow through the body by a given voltage. The current range of 100− 200 mA is particularly dangerous, because it is almost certain to result in lethal ventricular fibrillation.

Victims of high-voltage shock usually respond better to artificial respiration than do victims ofl ow-voltage shock, probably because the higher voltage and current clamps the heart and hence prevents fibrillation. AC is more dangerous than DC, and low frequencies are more dangerous than high frequencies. Skin resistance decreases when the skin is wet or when the skin area in contact with voltage source increases. It also decreases rapidly with continued exposure to electric current.

Prevention is the best medicine for electric shock. That means having a healthy respect for all voltage, always following safety procedures when working on electrical equipment.

In case a person does suffer a severe shock, it is important to free him from the current as quickly as can be done safely and to apply artificial respiration immediately. The difference of a few seconds in starting this may spell life or death to the victim. Keep up the artificial respiration until advised otherwise by a medical authority.

References:

1. Electronics World, p. 50, December 1965

2. Tektronix Service Scope, No. 35, December 1965, The Fatal Current