When people die of electric shocks, what kills them – current or voltage?

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It is the current through the heart region that causes most deaths from electric shock. The effect depends on duration of exposure and also varies between individuals. The frequency of mains power – around 50 or 60 hertz – is very dangerous, and currents of only a few tens of milliamps at such a frequency can cause the heart to fibrillate. It pulses at a much higher rate than normal and fails to pump blood to the brain; death follows in a few minutes.

Because the body has electrical resistance, the current flowing in it depends on the voltage. It also depends on the dampness of the skin and where on the body the current enters and leaves. It is therefore very difficult to come up with a safe voltage for all circumstances. This is being attempted at the moment by the International Electrotechnical Committee (IEC) working group on electric shock, but the number of variables makes simple recommendations difficult.

There are other mechanisms that can cause death from electric shock. One of these is muscular contraction. If a current passes through the chest it can inhibit breathing and lead to asphyxia. A current in the head can affect the respiratory centre in the brain, again leading to asphyxia. Once more it is current, rather than voltage, that is the critical factor.

Most people who receive an electric shock survive. This is not because they are particularly strong but because there is usually some factor that reduces the current, such as resistance from clothing or shoes, or the length of the shock. An earth-leakage circuit breaker (also called a residual current device or ground-fault circuit interrupter), often touted as a panacea, is useful to shorten the duration of a shock but does not prevent the shock occurring in the first place.

In short, it is a function of current and time that kills.

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Damage from an electric shock varies with current. However, except in the case of superconductors, voltage is needed to

drive this current so the distinction is a little artificial. If the resistance of the human body were constant then voltage would be an equally valid yardstick. But the resistance varies according to a number of factors.

For example, dry skin offers an electrical resistance of 500,000 ohms. Yet wet skin reduces this to 1000 ohms – only double the resistance of salty water. So being soaked to the skin leaves us more vulnerable to harm.

The path of the current is critical. This is why standing on insulating material and doing electrical work with one hand behind your back, so that an earthed current will not pass across your chest but down to your feet, reduces the chance that a current will pass through your heart. The heart can stop if current passes through it, and we can suffer severe burns as electrical energy is converted to heat.

Alternating current is said to be four or five times as dangerous as direct current, because it induces more severe muscular contractions. It also stimulates sweating, which lowers the skin's resistance, increasing the current passing through the person. Sixty cycles a second happens to be the most harmful range.

Thomas Edison tried to take advantage of this fact when, in 1886, New York state established a committee to replace hanging with a more humane form of execution. He employed Harold Brown to invent the electric chair, powered by the alternating current that was favoured by his rivals in the race to commercialise electricity distribution. If it were used to kill criminals, Edison hoped that potential customers would shun alternating current in favour of the direct-current system he had developed. Sadly for Edison, this interesting piece of marketing turned out to be unsuccessful because AC proved to be cheaper and can be stepped up to higher voltages to be transported more efficiently over great distances.

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Electricity kills by delivering energy where it is not wanted. Energy is the product of voltage, current and time. It could be lethal when delivered as low as 100 microamps at a few volts if sent directly to the heart, or about 30 milliamps at a few hundred volts from one hand to another. In both cases the problem arises if the shock disorganises the electrical activity of the heart to make the ventricles fibrillate. Of course, the solution to this problem is to deliver another shock, from a defibrillator, if you have one handy.

Electrical energy can kill you in other ways. The electric chair appears to kill by asphyxiation, because it causes uncontrolled contraction of the muscles of respiration. It also cooks its victims a bit, but does not seem to reliably produce either ventricular fibrillation or rapid loss of consciousness from current through the brain. In other circumstances, large currents that pass through the body without causing instant death can cause horrible, deep burns. These can, of course, kill you more slowly. Finally, a high-voltage discharge can set fire to your clothes or blow you off the electricity pylon you might be working on, either of which can be fatal.

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