

Effect	DC(mA)	AC (60Hz, mA)	AC (10 kHz, mA)	
Slight sensation on hand -----		0.6	0.35	
Perception threshold -----		3.5	0.7	8
Shock--not painful, muscular control not lost -----		6	1.2	11
Shock--painful, muscular control not lost -----		41	6	37
Shock--painful, let-go threshold -----		51	10.5	50
Shock--painful and severe, muscular contractions, breathing difficult ---		60	15	63
Shock--possible ventricular fibrillation effect from 3-second shocks ----		500	100	

Ohm's Law

$I = E / R$ $R = \text{resistance in ohms}$
 $E = I \times R$ $E = \text{voltage in volts (for AC, use RMS volts, not peak volts)}$
 $R = E / I$ $I = \text{current in amps}$

Calculation of Joules

$E = CV^2 / 2$ $E = \text{energy in watt seconds or joules}$
 $C = \text{capacitor charge in farads}$
 $V = \text{volts}$

example: capacitor of 300uF charged to 300V has an energy of 13.5 joules $(.0003 \times 300 \times 300 / 2)$

Electrical conversions:

1mF = .001F (pronounced millifarad)
 1uF = .000001F (pronounced microfarad)
 1 nF = .000000001F (pronounced nanofarad)
 1k Ohm = 1000 Ohms (pronounced kilohm)
 1M Ohm = 1,000,000 Ohms (pronounced megohm)

Resources:

www.erostek.com
http://www.taser.com/facts/medical_info.htm - Discusses medical effects of taser energy
www.taser.com
www.emedicine.com - excellent search reference for everything medical. Requires free signup.
<http://www.emedicinehealth.com/articles/10873-6.asp> - This talks about how to operate an automatic external defibrillator.

CURRENT AND THE HUMAN BODY

The human body essentially acts as a resistor at 60 Hz. Minimum resistance of the body, between the major extremities, has been generally defined as 500 ohms. The chief initial current-limiting factor is the surface or contact resistance, which varies between different parts of the body and between individuals. Dry skin resistance varies from 100 to 300,000 ohm-cm². Wet skin has only 1% of the resistance of dry skin. If shock current flows for a few seconds, blisters develop which further decrease surface resistance.

The voltage necessary to produce shock current depends on contact resistance and total circuit impedance. When contact resistance is low, commercial 120V AC is lethal. High voltage contact resistance is not a factor, since voltages in excess of 240V AC puncture the skin upon contact. Under this condition only the internal body resistance limits the shock current.

Frequency. Body impedance at 60 Hz is essentially resistive. As the frequency increases, body impedance begins to act as a resistor-capacitor network and becomes non-linear. At about 50 kHz body impedance may decrease more than 50%, and contact resistance is negligible. Frequency also affects perception, let-go, and fibrillation currents. A current of 7mA at 5kHz is required to produce tingling. Between 100 to 200 kHz perception changes from tingling to heat. At 5kHz let-go current increases threefold over the 60 kHz value. The current required to cause fibrillation also increases at higher frequencies.

Perception current. Perception or reaction current is that level of alternating current that produces a slight tingling sensation. The startling effect from this sensation could produce involuntary muscular reaction that might cause injury. Laboratory tests show that the lowest perceivable current at 60 Hz varies in different individuals. Less than 1% can sense current levels as low as 0.3 mA. However, the mean value of perception current in men is about 1.1 mA. The mean perception level for women is about 0.7 mA. These levels do not damage human tissue. As a result, perception current has been established at 0.5 mA.

Let-go-current. Let-go current is the maximum current at which an individual grasping a conductor can release it by using muscles directly affected by the current. Let-go current, averaging about 16 mA for men and 10.5 mA for women, also does not damage human tissue.

Lethal currents begin at only slightly higher levels than let-go currents. When a current in excess of 18 mA flows through the chest cavity, the chest muscles contract to stop breathing. Maintained current flow results in loss of consciousness and, eventually, death. Ventricular fibrillation is another potentially lethal result of shock in which the heart ceases its rhythmical pumping action, and instead, feebly quivers to effectively stop blood circulation. The heart rarely recovers spontaneously from this condition. Extrapolations from data compiled from experiments on animals show that current levels necessary for producing fibrillation in humans depend on shock duration, body weight, current-flow path, flow duration, and current magnitude. It is generally believed that the heart of a normal adult is likely to fibrillate when a shock current in milliamperes exceeds $116/t^{0.5}$, where t is shock duration in seconds.

Note that 90% of shock energy is lost passing from skin to heart and back to skin.

Shock current that greatly exceeds the level necessary to produce fibrillation may completely stop the heart action, seriously burn body tissues, damage the nervous system, and stop breathing--all potentially lethal conditions.