ELECTRICAL SHOCK

The following data was compiled by the National Safety Council, and the Pacific Telephone and Telegraph Company.

TYPE OR RESISTANCE	RESISTANCE VALUES
Dry Skin	100,000 to 600,000 ohms
Wet Skin	1000 ohms
INTERNAL BODY	
Hand to foot	400 to 600 ohms
Ear-to-ear	100 ohms

For example, with 120 volts and a skin resistance plus internal resistance totaling 1200 ohms, the result would be a current of 100 milliamperes.

That much current is definitely enough to cause death.

The following data makes a very clear and self-explanatory summary of the effects of various currents through the human body:

SAFE CURRENT VALUES

1 ma.	Causes no sensation -- not felt
1 to 8 ma.	Sensation of shock, but not painful; individual can release contact at will, as muscular control is not lost.

UNSAFE CURRENT VALUES

8 to 15 ma.	Painful shock; individual can let go at will. Control is not lost.
15 to 20 ma.	Painful shock; muscular control of adjacent muscles lost. Cannot let go.
20 to 70 ma.	Painful shock; severe muscular contractions with breathing extremely difficult.
100 to 200 ma.	Painful shock; causing VENTRICULAR FIBRILLATION of the heart. This is "irregular twitching of the wall of the ventrical of the heart". It is a fatal heart condition, FOR WHICH THERE IS NO KNOWN REMEDY OR RESUSCITATION. IT MEANS D E A T H !
200 ma. or over	Severe burns, severe muscular contractions, so severe that chest muscular reaction clamps the heart and stops it for duration of the shock. This reaction prevents ventricular fibrillation. Artificial respiration should be administered immediately and in most cases the victim can be revived.
REMEMBER THIS:	Current is the killing factor in electrical shock. The voltage is only important in that it determines how much current will flow through a given body resistance.

S W I T C H T O S A F E T Y

Electric Shock Effects

The effects of an electrical current on a human body are principally determined by the magnitude of current and duration of shock. Current is determined by the open circuit voltage of the source and total path resistance (including internal source resistance) and human body resistance. In power circuits, internal source resistance is usually negligible in comparison with that of the body. In such cases, the voltage level, V, is the important factor in determining if a shock hazard exists. At commercial frequencies of 50-60 Hz and voltages of 120-140 volts, the contact resistance of the body primarily determines the amount of current that flows through the body. This resistance may decrease as much as a factor of 100 between a completely dry and a wet condition. It is conservatively estimated that the resistance of the skin is usually somewhere between 500 and 1500 ohms.

An electric current through the body can produce varying effects, including death, depending upon the magnitude of current.[1] For example, the perception current is the smallest current that might cause an involuntary reaction and produce an accident as a secondary effect. A shock current greater than the reaction current produces an increasingly severe muscular reaction.

Above a certain level, the shock victim becomes unable to release the conductor. The maximum current at which a person can still release the conductor by using the muscles directly stimulated by that current is called the *let-go* current. Shock currents above the *let-go* level cause contraction of chest muscles and impair or stop breathing. If the current is interrupted quickly enough, breathing will resume. At still higher levels, electric shock currents can cause ventricular fibrillation. This condition usually results in stoppage of heart action.

Various current levels for 60 Hz and dc are summarized in Table 1. At frequencies above 300 Hz, the current levels required to produce the above effects begin to increase due to skin effect. For example, the perception current is approximately 100 mA at 70 kHz. Above 100-200 kHz, the sensation of shock changes from tingling to heat. It is believed that heat or burns are the only effects of shock above these frequencies.

Table 1—Summary of Effects of Shock[2]

Alternating Current (60 Hz)	Direct Currents	Effects
(mA)	(mA)	
0.5-1	0-4	Perception
1-3	4-15	Surprise (Reaction Current)
3-21	15-80	Reflex Action (*let-go* Current)
21-40	80-160	Muscular Inhibition
40-100	160-300	Respiratory Block
Over 100	Over 300	Usually Fatal

References

1. Dalziel, C.F., *Electric Shock Hazard,* IEEE Spectrum, Vol. 9, No. 2, February 1972, pp. 41-50.
2. Standard General Requirements for Electronic Equipment, Requirement 1, MIL-STD-454C, 15 October 1970.