Additional Learning Material

Electric Shocks and Protection

Introduction

An electric shock is the *physiological* effect of an electric current through the human body. When a current exceeding 30 mA passes through human body, the person concerned is in serious danger if the current is not interrupted in short time. The fundamentals of protection against electric shock is detailed in the document IEC 61140. Standards distinguish two kinds of dangerous contact, *Direct contact* and *Indirect contact*.

- **Direct contact** refers to a person coming into contact with a conductor which is live in normal circumstances.
- **Indirect contact** refers to a person coming into contact with any part of a electric circuit which is not normally live, but has become live due to an accidental insulation failure or some other fault.

Physiological Effects	Current (mA)			
	Direct Current		AC 60Hz	
	Men	Women	Men	Women
No sensation on hand	1	0.6	0.4	0.3
Slight tingling (perception threshold)	5.2	3.5	1.1	0.7
Shock (not painful)	9	6	1.8	1.2
Painful shock- but muscular control not lost	62	41	9	6
Painful shock- Let go threshold	76	51	16	10.5
Painful and severe shock- muscular contractions	90	60	23	15
Possible ventricular fibrillation from short shocks				
(a) Shock duration 0.03s	1300	1300	1000	1000
(b) Shock duration 3.0s	500	500	100	100
(c) Almost certain ventricular fibrillation				
(if duration exceeds one heart beat interval)	1375	1375	275	275

Table 1: Physiological effect of current in human body [1]

	Millijoules
Maximum primary shock energy	50,000
More conservative value (IEEE)	25,000
'Unpleasant' shock energy	250
Minimum shock energy	0.5-1.5
Perception threshold	0.12

Table 2: Typical electrical shock energy effects [1]

In 60Hz systems the current that can possibly lead to a ventricular fibrillation is calculated from Dalziel's Electrocution formula [1],

$$I = \frac{0.615}{\sqrt{t}}$$

where, t is in range from 8.3 ms to 5 s. The current that will flow through the body depends on the body resistance, effective grounding resistance of the body and the open circuit voltage at the point where the individual touches the conductor.

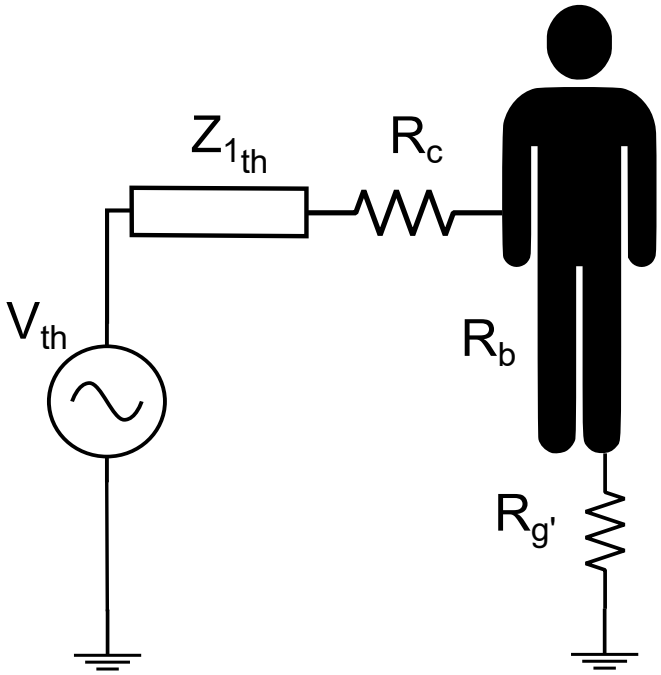

Figure 1: Equivalent circuit for estimating the current in a body contacting a grounded "incidental" line.

$$Z_m = R_{body} + R_{contact} + R_{ground}$$
$$R_c = R_{contact} \approx 500\,\Omega$$
$$R_b = R_{body} \approx 1000\,\Omega$$
$$R_g = R_{ground} \approx 600\Omega$$

Protection against Direct Contact

- Protection by the insulation of live parts
- Protection by means of barriers or enclosures in cabinets, assemblies, control panels and distribution boards
- Additional measure of protection against the hazards of direct contact is provided by use of residual current operating device, which operate at 30 mA or less, and are referred to as RCDs of high sensitivity

[1] C. F. Dalziel and W. R. Lece, "Lethal Electric Current," IEEE Spectrum 6, 44-57 (February, 1969); also, C. F. Dalziel, IEEE Spectrum 9, 41-55 (February, 1972)

Protection against Indirect Contact

Standards have identified two levels of protection against indirect contacts

- *Level I*: Earthing of all exposed-conductive-parts of electrical equipment in the installation and constitution of an equipotential bonding network
- *Level II*: Automatic disconnection of supply in the case of a fault

Protective Earthing

Protective earthing requires all exposed and conductive parts to be connected to a protective conductor which in turn is connected to the main earthing terminal. By doing so the body of the electrical equipment is brought to the same potential as earth, and this prevents flow of leakage current (if any) through body of an operator in case he/she touches the equipment accidentally.

REFERENCES

- Schneider Electric,"Protection against electric shocks"
- Legrand, "Electrical hazards and protecting persons"
- Walter L. Weeks, "Transmission and Distribution of Electrical Energy"

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