Protection Against Electric Shock

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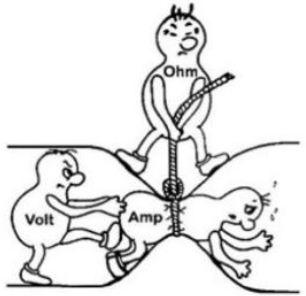
Ohm's law
El. Current (I) [Amp]
El. Voltage (U) [Volt]
El. Resistance (R) [Ohm]



What is Electric Shock?

Physical stimulation that occurs when an **electric current** flows through the human body

Important factors:

- The **magnitude** of the current
- The **resistance** of the body
- The **duration** of the current
- (The path it takes in the human body, the frequency of the electrical supply)

Touch Voltage

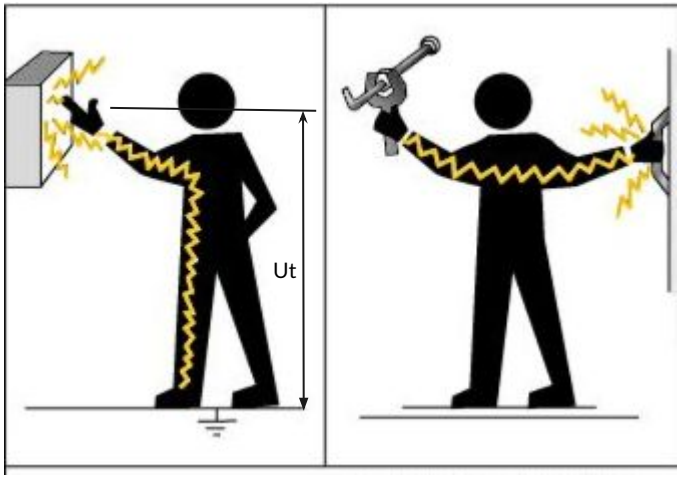
Touch potential (touch voltage, **Ut**) is difference between the ground potential (or surface on which a person is standing) and live part (e.g. bare wire) or cover of faulty equipment.

Approximate effect of electric current **I** (AC)
< 1 mA - generally no reaction
< 8 mA - no dangerous effect
15 - 25 mA- muscle contractions, breathing difficulties
> 60 mA - probability of cardiac arrest, respiratory arrest, severe burns

Approximate **resistance** (impedance) of human body 2000 Ω (Ohms) **plus** contact resistance (touch resistance, etc.) = **R**

I = U/R (Ohm's law) => Approximate **limits** of touch voltage U (depending on environment)

Environment	Touch voltage - AC	Touch voltage - DC
normal, damp	50V	120V
dangerous, wet	12V	25V



Fundamentals of Electric Shock Protection

Protection must be provided under **normal conditions** and in conditions of **single fault** (e.g. insulation fault, cover mechanical fault).

Protection = Basic protection + Under fault protection

Under normal condition - Basic protection:

Protective Measures: Basic protection prevent contact with live parts, such **protection by the insulation** of live parts and **protection by means of barriers or enclosures** (covers).

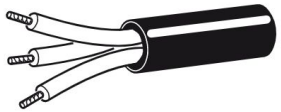
Under fault condition:

Protective Measures: **Supplementary insulation, protective equipotential bonding, automatic disconnection of the supply**, simple separation, non-conductive environment, etc.

… and additional protection

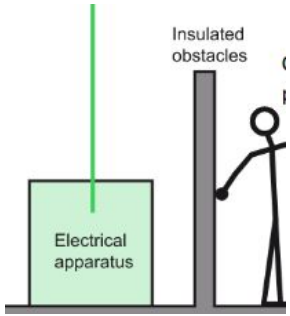
Basic protection - protective measures

Basic Insulation

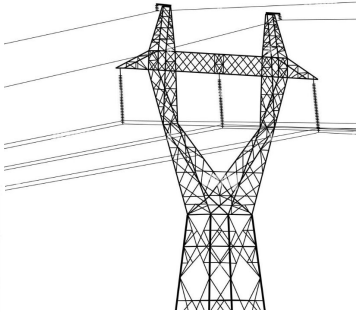


Protective barriers or enclosures

Obstacle



Placing out of reach

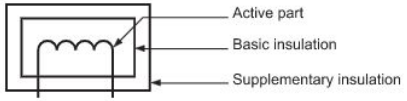


Limitation of voltage…

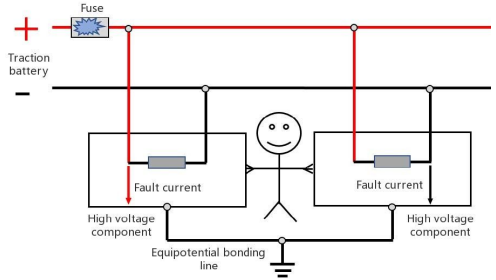
Environment	Touch voltage - AC	Touch voltage - DC
normal, damp	50V	120V
dangerous, wet	12V	25V

Under fault condition protective measures

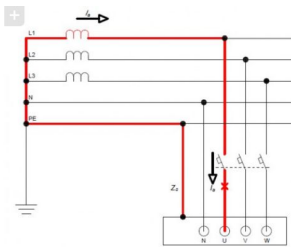
Supplementary insulation



Protective equipotential bonding



Automatic disconnection of the supply (fuse, breaker)



Simple separation (Isolation transformer)

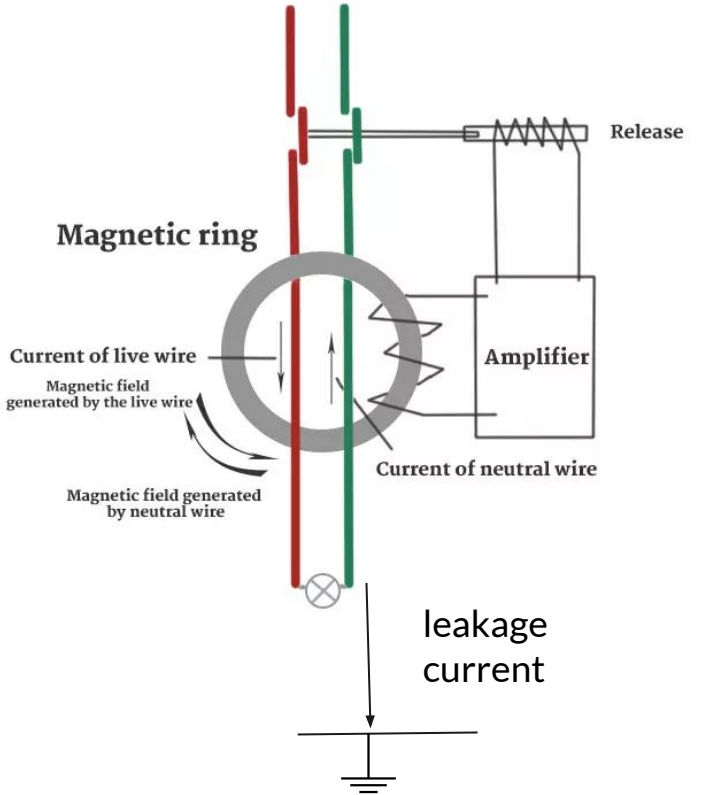
Non-conductive environment, etc.

Additional Protection

Residual-current circuit breaker

Electrical **safety device** that breaks an electrical circuit **with leakage current to ground.**

Detection of small leakage currents (typically 5–30 mA) and quick disconnection (<30 milliseconds) provides **additional** protection to protect damage of electrical appliance and users of electrical appliance from serious electric shock.



Current Range And Its Effects

Current	Effects
1mA	Barely perceptible
1-3mA	Perception threshold (most cases)
3-9mA	Painful sensation
9-25mA	Muscular contraction (can't let go)
25-60mA	Respiratory paralysis (may be fatal)
60mA or more	Ventricular fibrillation (probably fatal)
4 A or more	Heart paralysis (probably fatal)
5 A or more	Tissue burning (fatal if vital organ)

Types of injuries:
Burns
Electrical shock (cardiac, respiratory, neurological)
Falls