SAFE HOUSE WIRING

Safe action bring lasting satisfaction.....

सुरक्षित कार्रवाई स्थायी संतुष्टि लाती है .....

By

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FIE(India), Quality

Er Arun Raj
Safety

BSES
BSES Yamuna Power Limited

Contents

- Safety
  - Concept of Safety
  - Statistics of Electrical accidents
- Wiring
  - Preferred conductor material & tech comparison
  - Sizing of wires
  - Fire safe wires for house wiring
- Electrical Fittings
  - Layout planning
  - Selection of Electrical fittings
- Protection
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  - Protecting tools

Cont .....

Contents Cont.....

- Safe distribution
  - Design of distribution boards
  - Switches design
- Earthing
  - Importance of earthing
  - Legal requirement
  - Effects of current in humanbody

Concept of safety

house wiring …….

Concept of safety

- Why safety required in house wiring ?
  - Electricity is hazardous
    - Fire
    - Life danger
  - Invisible
  - We want 24x7 power
  - We want it in all parts of the house
  - We want it all the time when we are at home
  - We want it even we are not in home

- How accident caused
  - Unsafe condition
  - Unsafe Act

- How can we achieve safety
  - Removal of Unsafe condition and unsafe act.

Electrical accident Stastics

- Electrocution
  - 21% of national fatal rate (2014)
  - 10200 fatal accidents, 364 injury (2015)
  - 30-35% fires are of electrical origin
  - 8% fatal accidents in factories

- It’s a national loss

Hazards

- Hazards in house wiring
  - Over loading
  - Short circuit
  - Insulation failure
  - Ageing
  - Heating of wire
  - Lack of cooling / heat dissipation
  - External damage
  - Rat / other bite

- How to over come all this hazards??
  - Wire
  - Switch
  - Protection

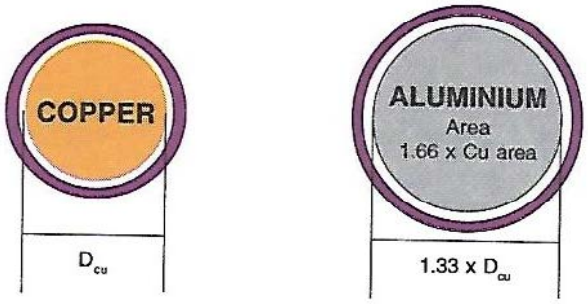
WIRE

Conductor material

- What conduction material to be selected?
  - Aluminium
  - Copper
  - Silver
  - Gold
- How to select the conducting material?
  - Cost
  - Use full Life
  - Maintenance
  - Safety

Properties of wire

- Electrical conductivity (विद्युत चालकता)
  - vidyut chaalakata
  - Resistance increases with length
  - Resistance inversely proportional to area.
  - Aluminium conductivity is only 60% of copper
  - The weight of aluminium becomes 50% and the volume becomes 166%



- Electrical Resistivity (विधुतीय प्रतिरोधकर्ता)
  - vidhuteey pratirodhakarta
  - Higher the resistance, higher the heating & temperature rise.
  - Lower resistivity is prefered
  - To have same resistance in aluminium cable, higher area of 66% is required

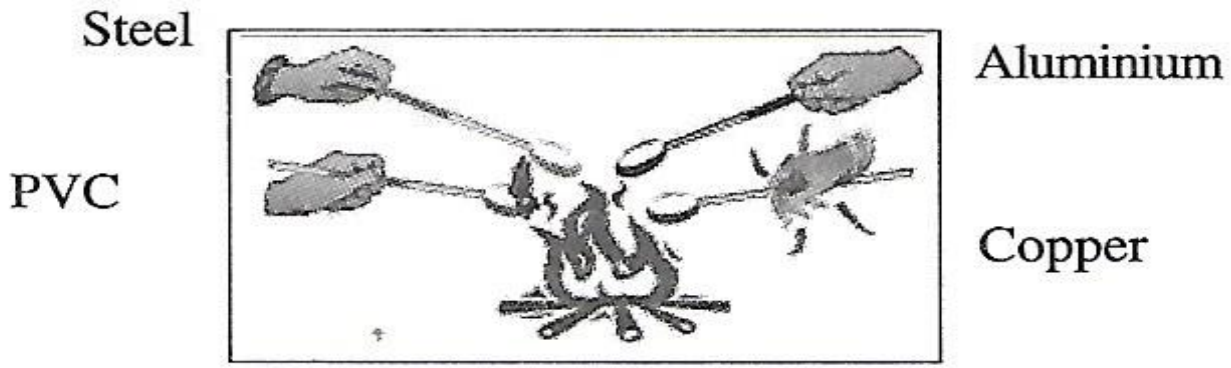
Use min 1.5 sq mm aluminium instead of 1 sq mm cu

Use min 2.5 sq mm aluminium instead of 1.5 sq mm cu

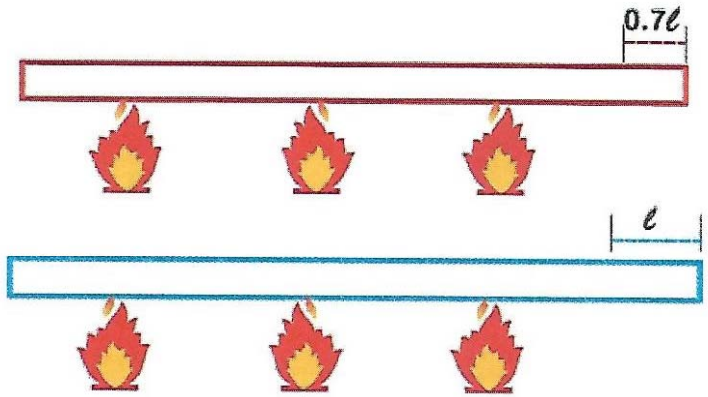
Use min 4 sq mm aluminium instead of 2.5 sq mm cu

Use min 6 sq mm aluminium instead of 4 sq mm cu

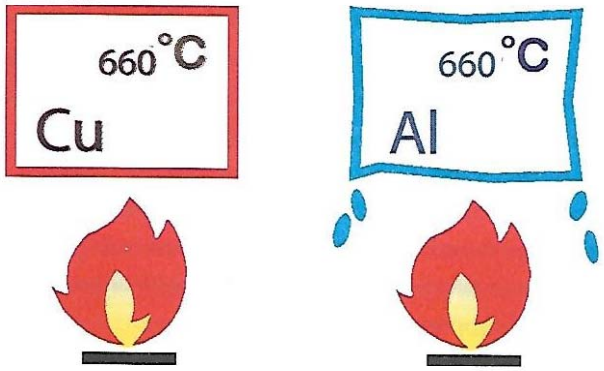
- Thermal Conductivity: (ऊष्मीय चालकता)
  - ooshmeey chaalakata
  - Important property for short circuit
  - Cu is having good S.C and hot spot resistance
  - Ampere capacity reduces / de reating due to lac of cooling
    - PVC & steel conduits



- Co efficient of linear expansion (रैखिक विस्तार)
  - 1 m of cable expands when heated to 1 deg C.
  - At full load cable temperature is 60 -70 deg C.
  - Expansion & contraction reduces the insulation life.



- Melting point (गलन तापमान)
  - pighalane ka taapamaan /Galan taapamaan
  - Defects in cable results in S.C
  - Fault current in range of 3000 – 6000 A.
  - 2.5 to 30 mili sec is the time duration.
  - If the temp reaches melting point and if cable melts it lead to fire and disaster



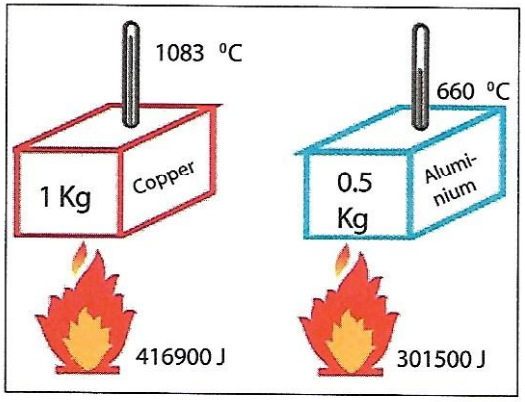
- Specific Heat (विशिष्ट ताप)

  - vishisht taap

  – Heat req to raise the 1kg conductor to 1 deg C.

  – Cu is slightly less than Al , but cu has 2 times weight compared to Al of same rating, due to high density)

  – Together with higher conductivity Cu reduces temp rise in c[illegible]nd faults.



Reason for poor performance of Al

- Aluminium is much less flexible than copper and also has less tensile strength. Chance of Breaks on sharp bends is very high.

- Terminations are mostly “Grab-screw” in switches, plugs or sockets (pressure joints). Al has a tendency of flow under pressure. It reduces contact area, which increases resistance of contact.
- Plug and socket terminations made of copper alloys like brass & phosphor bronze. Increase corrosion.
- Lead to terminal corrosion and higher contact resistance.
- Al surface form oxide immediately come in contact with air, and the oxide is bad conductor. Require petroleum jelly

Property of copper over aluminium

Property	Copper (C101)	Aluminium (1350)	Units
Electrical Conductivity (annealed)	101	61	% IACS
Electrical Resistivity (annealed)	1.7224	2.83	μ-Ohms cm
Temperature coefficient of Resistance (annealed)	0.0039	0.004	/°C
Thermal Conductivity @ 20°C	397	230	W/mk
Coefficient of Expansion	17×10^{-6}	23×10^{-6}	/°C
Tensile Strength (annealed)	200-250	50-60	N/ mm^2
Tensile Strength (Half-hard)	260-300	85-100	N/ mm^2
0.2% Proof Stress (annealed)	50-55	20-30	N/ mm^2
0.2% Proof Stress (half-hard)	170-200	85-100	N/ mm^2
Elastic Modulus	116-130	70	KN/ mm^2
Specific Heat	385	900	J/kg K
Density	8.91	2.70	G/cm^3
Electrical Resistivity (Volume) @ 20°C	0.017241	0.0283	Ohm mm^2/m
Melting Point	1083	660	°C
Elongation	30-50	8 (min)	%

Conductor selection

- Parameters considered
  - Type of conductor
    - CU with IS 694 (part1), 99.97 % electrolyte grade.
    - 3 layer insulation cables for fire resistance property (HRFR)
    - Insulation melting pt 100 deg C
  - Colour code of wire
    - Black – Neutral
    - Green – Ground
    - R, Y, B – Phase

Cable sizing

- Parameters considered (phase and Neutral)
  - Type of conductor
  - Length of the cable
  - Load Calculation
    - Continuous, momentary
  - Rated current
  - Short circuit current
  - Cooling factor (type of conduit)
  - De rating factor

Motor starting

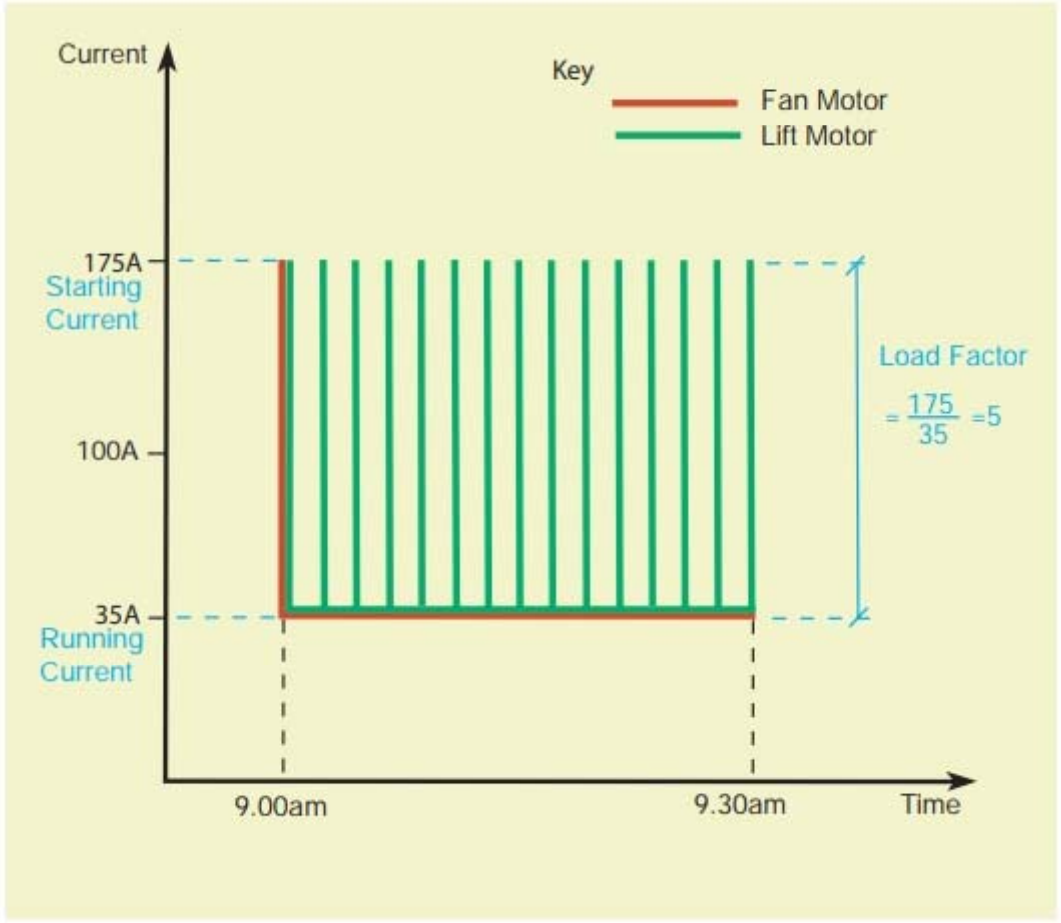


Figure C 3.1 Starting and running currents of lift motor and fan motor between 9.00 am and 9.30 am.

Continuous current

current of the lift motor, however, needs consideration, as there are 15 starting occasions in 30 min. If the starting time was 30 s, the duty cycle would be

$$\frac{0.5 \times 15}{30} = 0.25$$

indicating that the motor was in starting mode for 25% of its time. From this information, the heating effect of the duty cycle can be calculated using the fact that the heating effect is proportional to I^2Rt. Thus, the equivalent continuous current is

$$I_{\text{equivalent}} = \sqrt{i_1^2 R_1 t_1 + i_2^2 R_2 t_2} = \sqrt{35^2 \times 0.75 + 175^2 \times 0.25} = 93\,\text{A}$$

This result demonstrates the significance of duty cycle of the cyclic lift motor load compared with the steady load of the fan. The lift motor supply would need to be rated at 100 A, and the fan motor supply at 50 A (for the lift motor running current of 35 A). It should be noted that in practice the lift motor starting current will not be on for 30 s, this figure being exaggerated to emphasize the point.

Current carrying capacity

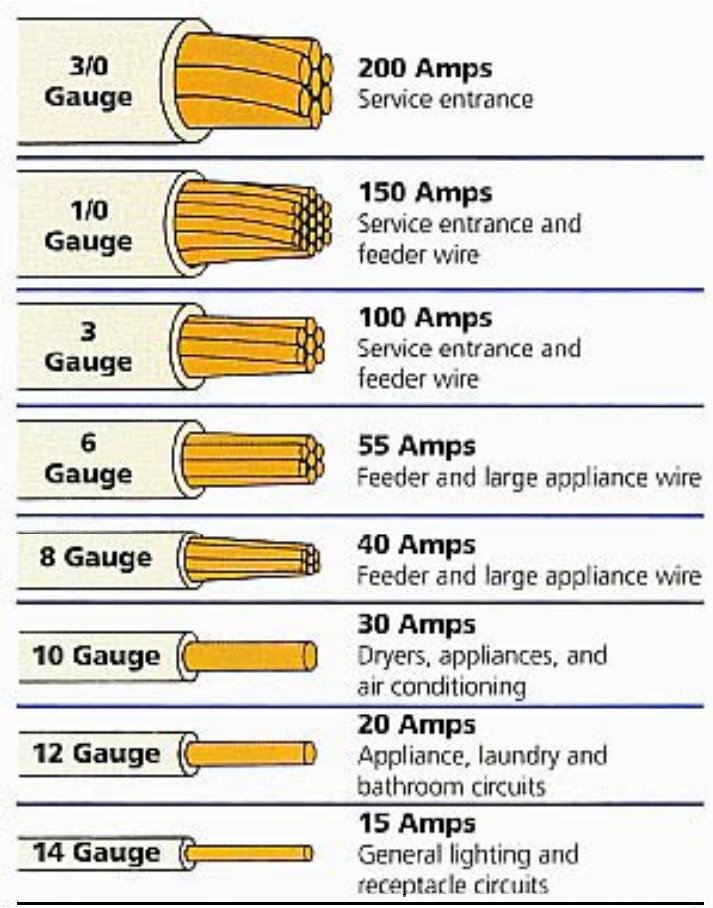
Installation reference method		Conductor cross-sectional area (mm^2)						
		1.0	1.5	2.5	4	6	10	16
C	Clipped direct	16	20	27	37	47	64	85
B	Enclosed in conduit or trunking on a wall, etc	13	16.5	23	30	38	52	69
	(from Table 4D2A of BS 7671)							
100	In contact with plasterboard ceiling or joists covered by thermal insulation not exceeding 100 mm	13	16	21	27	34	45	57
102	In a stud wall with thermal insulation with cable touching the wall	13	16	21	27	35	47	63
A	Enclosed in conduit in an insulated wall	11.5	14.5	20	26	32	44	57
101	In contact with plasterboard ceiling or joists ceiling covered by thermal insulation exceeding 100 mm	10.5	13	17	22	27	36	46
103	Surrounded by thermal insulation including in a stud wall with thermal	8	10	13.5	17.5	23.5	32	42.5

Cable sizes

Cu Vs Al cable

Table 1 - Service Wire Gauge Versus Amperage		
Copper	Aluminum	Amperage
10	8	30
6	6	60
6	4	70
4	2	100
2	1/0	125
1/0	2/0	150
2/0	4/0	200

Cu cable gauge

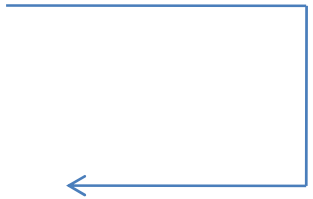


Cable sizing

- Prefer large size cable
  - More size than the required ampere
  - Large Cross section reduces resistance
  - Economical factor of large size cables
- Safe design
  - Maximum design current in circuit
  - Continuous current rating of MCB/fuse

Must Be below

  - Tripping current of the fuse
  - Continuous current rating of cable
  - Short duration capacity of cable



Must Be below

(1.45 times of normal current)

Economics of large size cable

Factor	Cable size : 1.5 sq mm	Cable size: 2.5 sq mm
1.5 tonne A/C		
Load (power input)W	2050	2050
Running current A	9.5	9.5
Distance , m	25	25
Resistance at 20 deg C (ohm/km)	12.10	7.41
Resistance at 65 deg C (ohm/km)	14.278	8.30 at 50 deg C
I2R loss for 25m at 65 deg C (W)	32.2	18.52 13.52 saving
Use: No of hrs use: 8 hrs / day No of hrs use per yr: 180 No of hrs used: 1440 hr Savings in energy: 19.5 kWh	Commercial Unit rate: 8 rs energy saved: 156 rs Cost recovered: 6 months	Domestic Unit rate: 4 rs Value of energy saved: 78 rs Cost recovered: 1 yr

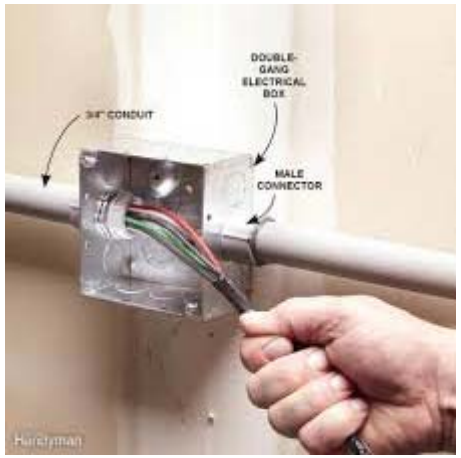
Electrical Fittings

Selection

Conduits

- Conduit wiring advantages
  - Good protection against fire
  - Prevent damages to the wire
  - Life is very long
  - Good appearance
- Disadvantage
  - Internal fires can damage cable insulation
- Types of conduits
  - PVC pipe
  - GI pipe

Conduit wiring



Normal switches Vs Modular switches

- ISI marked
  - Polycarbonate with fire resistance
  - Dust proof, high melting pt, flame retardent
  - Noise proof during On/OFF
  - Less pressure to operate
  - Luminous, Anchor, etc

- Modular switches
  - Safety features of modular switches
    - Spark shield
    - Fire retardant
    - Shuttered socket
    - Long life

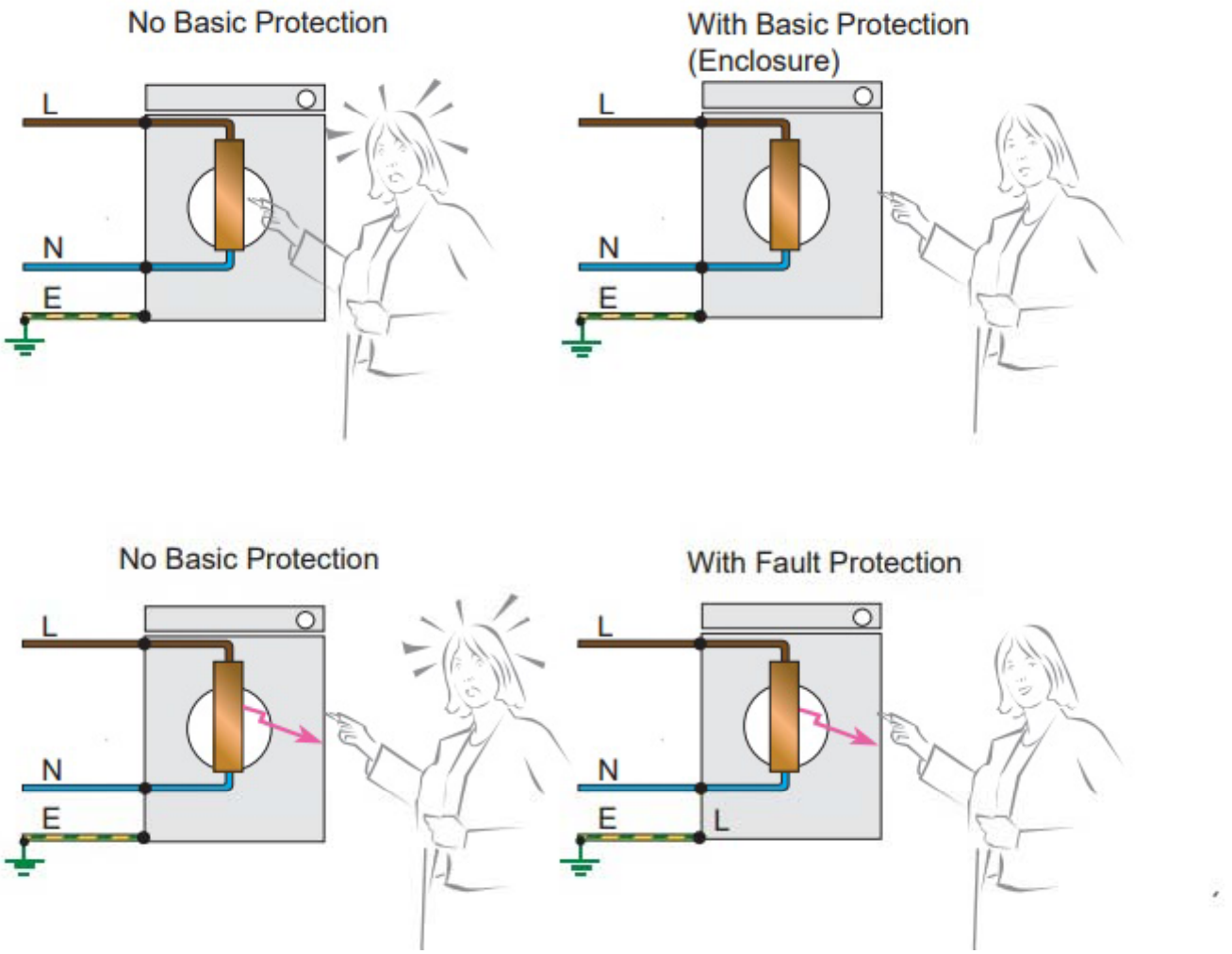
Safe electrical fittings

- Use ISI marked electrical fittings
- Use fire retardant property
- Always use 3 /6 pin sockets with shatters
- Connect the earth wire to the earth termination of socket
- Ensure the connection of phase to the switches
- Planning of switch board locations
- Selection of no of sockets required and its locations.
- Consider the factor of over loading of sockets
- Avoid twisted laying of cable in conduit
- Avoid sharp edges in conduit joints

Protection

House wiring…..

Basic protection



Protection

- Types of protection required
  - Earth fault
  - Short circuit
  - Over current
  - Shock protection

Protection equipments

- Types of protection equipments
  - Fuse wire
    - Wires
    - Cadridge
  - MCBs
  - MCCB
  - ELCB/RCCB

Fuse wire

- Low melting point
- Low loss
- High conductivity
- Low deterioration
- Low cost

Metal	Melting Point in Celsius	Specific Resistance	Value of Fuse constant k for d in mm
Silver	980	16	-
Tin	240	112	12.8
Zinc	419	60	-
Lead	328	210	10.8
Copper	1090	17	80
Aluminium	665	28	59

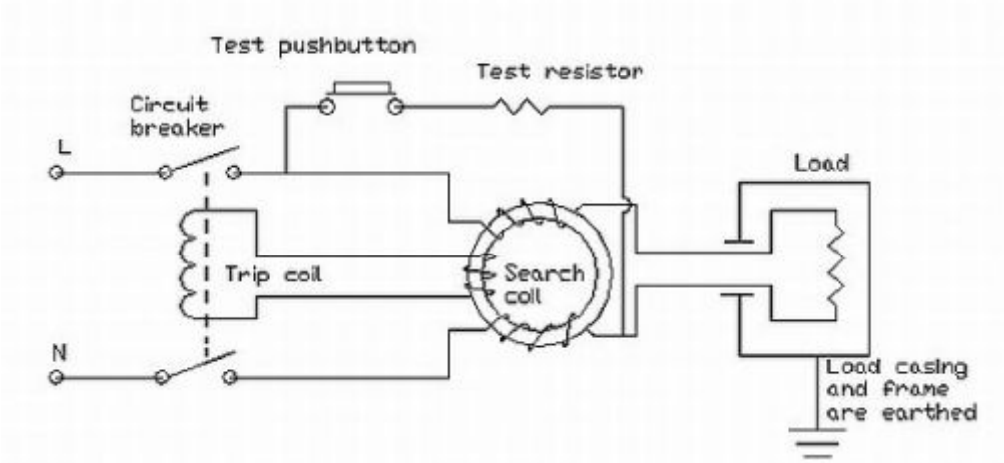
Circuit breaker

- MCB (miniature circuit breaker)
  - Only over current protection
  - Tripping setting can not be adjustable
  - Up to 100A

- MCCB
  - Earth fault and over current protection
  - Tripping setting can be adjustable
  - Up to 1000A

RCCB / ELCB

- Residual current circuit breaker
- Earth leakage circuit breaker
- Rating available
  - 30mA
  - 100mA
  - 200mA

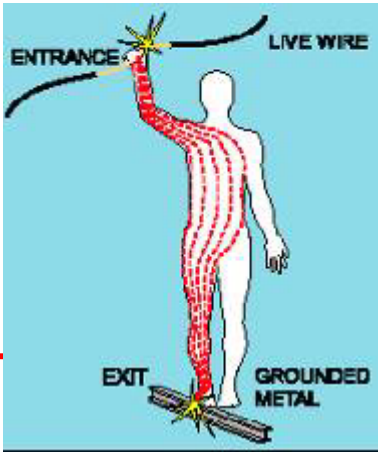


Effect of electric current

CEA:

Severity of the Shock

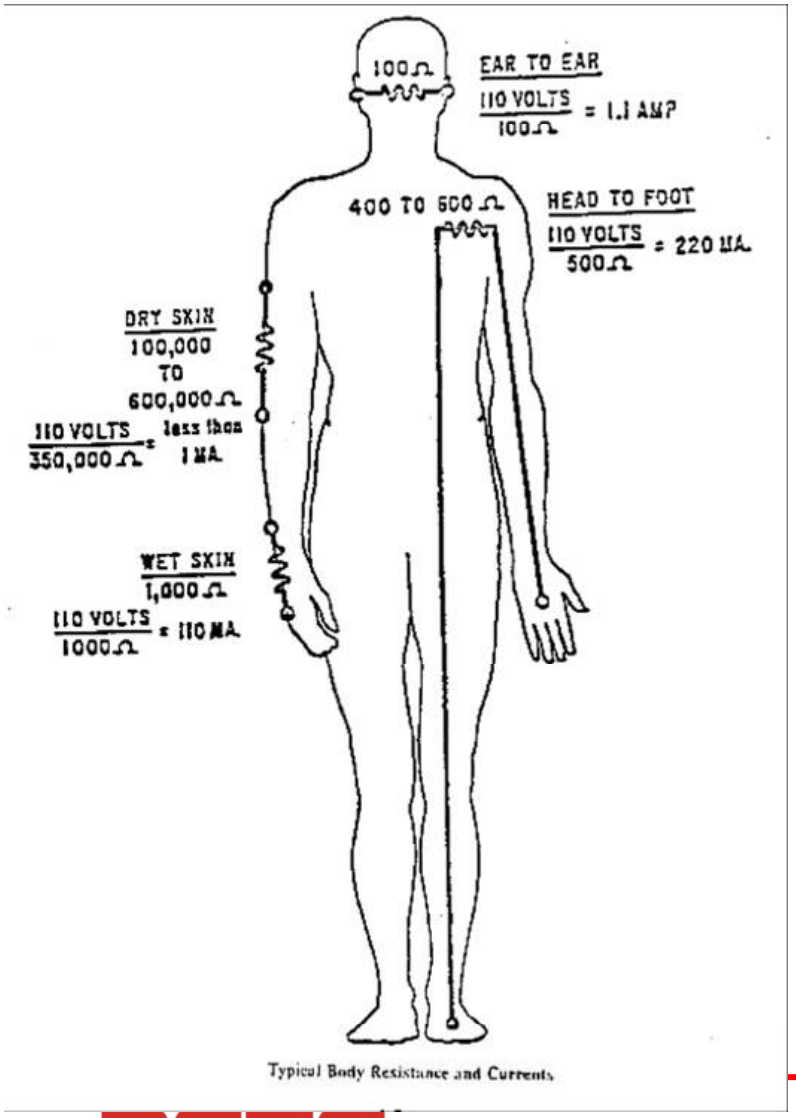
- Severity of the Shock depends on:
  - Amount of current
    - Determined by voltage and resistance to flow
  - Path through the body
  - Duration of flow through the body
  - Other factors such as general health and individual differences.



Effects of Current Flow

- More than 3 milliamps (ma): painful shock
- More than 10 ma: muscle contraction
- More than 20 ma: considered severe shock
- More than 30 ma: lung paralysis - usually temporary
- More than 50 ma: possible ventricular fibrillation (usually fatal)
- 100 ma to 4 amps: certain ventricular fibrillation (fatal)
- Over 4 amps: heart paralysis; severe burns

Using a 120 volt circuit and resistance for wet & dry skin:



Typical Body Resistance and Currents

E=IR: Voltage=Current x Resistance
(Volts) (Amps) (Ohms)

So: I=E/R

Dry Skin =220/100,000=.0022 amps
=2.2ma flowing through body to ground

Wet skin =220/1000=.220 amps
=220ma flowing through body to ground

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Remember: 1 Amp = 1000 milliamps

Arc Flash and Arc Blasts

- Arc Flash:
  - Burns due to exposure to high temperature of 35,000F.
  - Last for only few mili seconds. (20 milisec /cycle)
  - Breaker operation in 3 cycle
  - Suffer second and third degree burns.
  - Some times Fatal Burns
  - Molten metal
- Arc Blast:
  - Pressure Wave
  - Heat
  - Molten metal
  - Destruction of structures and life

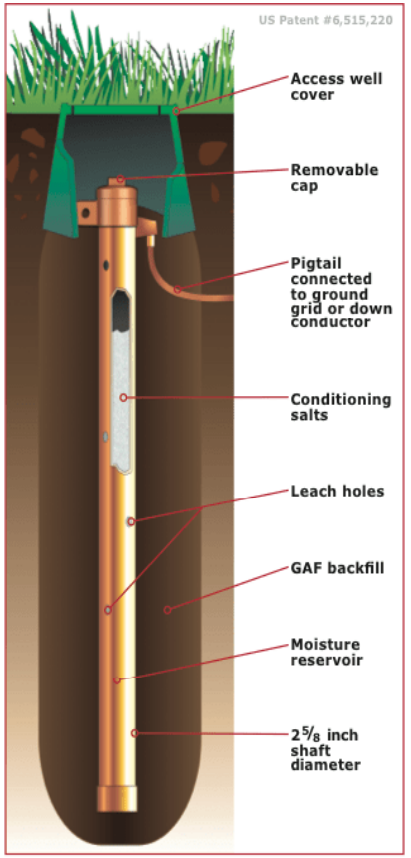
Arc Blast

- Cause
  - Short Circuit caused by working on energized equipment
    - Dropped Tool
  - Occurs in milliseconds
  - Temp: 30,000 degrees
  - Air expands very violently
    - 15 tons of pressure

EARTHING SYSTEM

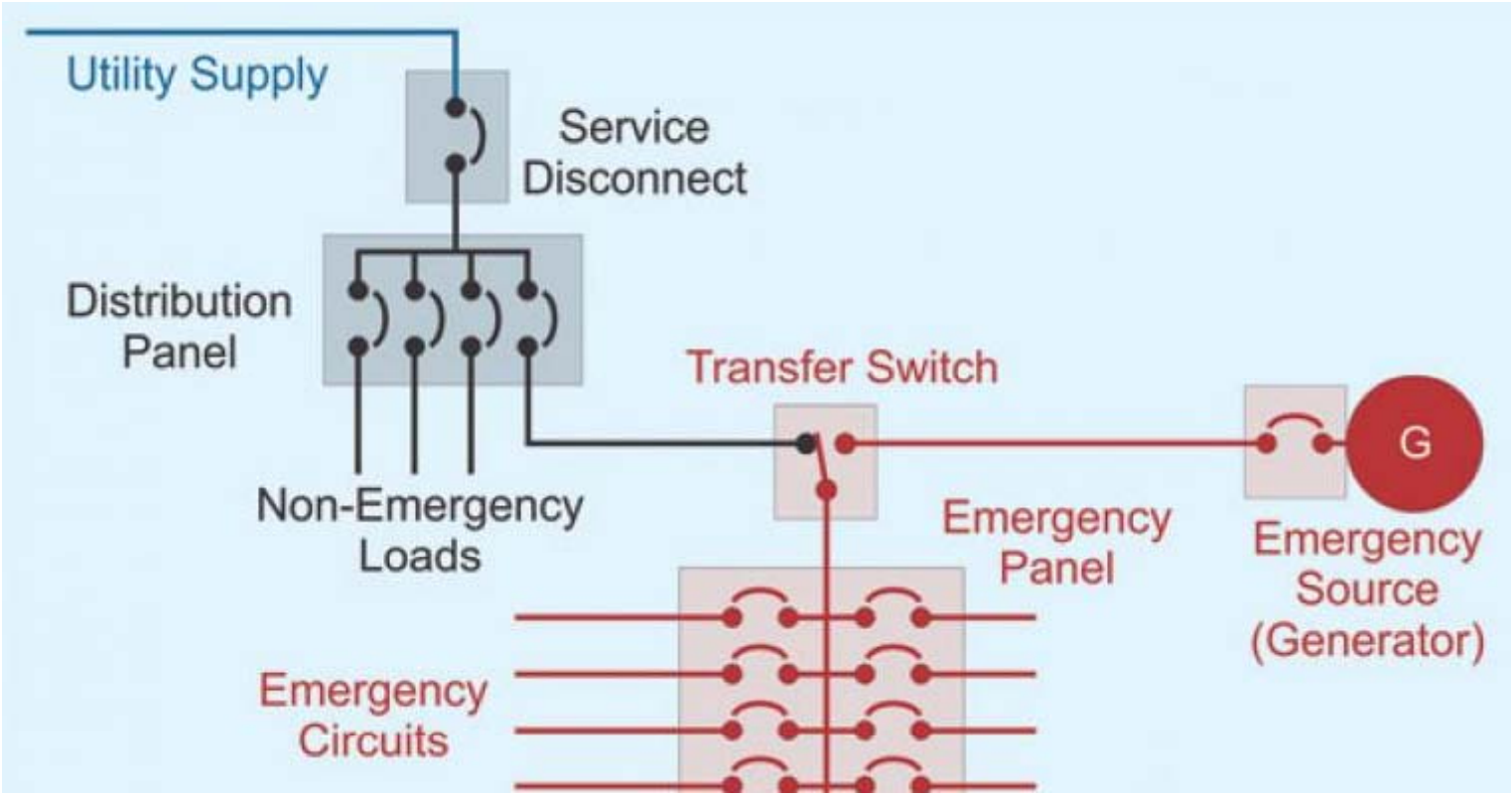
Earthing

- Make a separate earth pit for each house
- Do not use water line or other lines as earthing
- Do not use shared earthing among houses.
- Sizing of earth wire.
- Type of earth wires
- Colour code for earth wire
- Importance of earth wire.

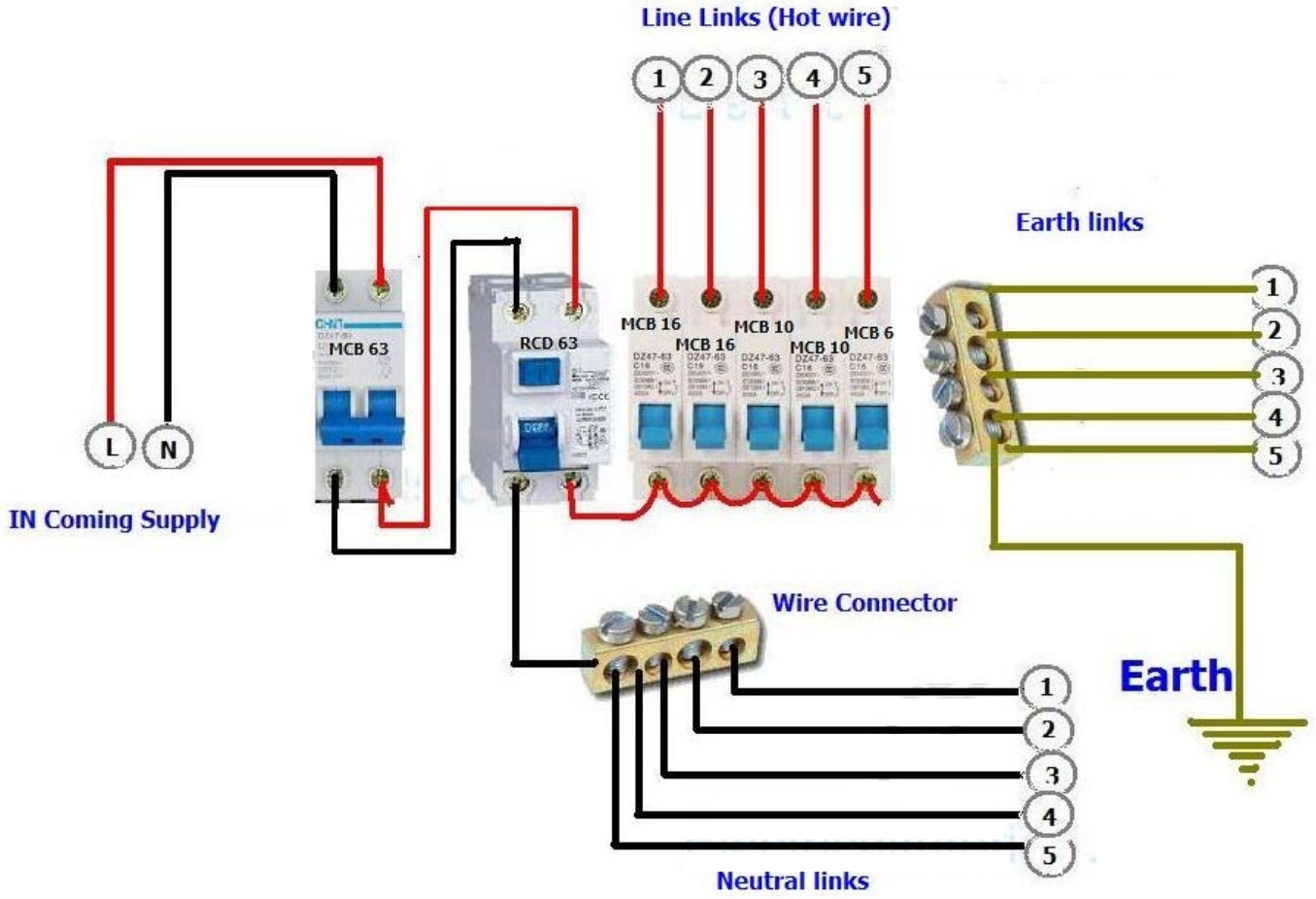


SAFE DISTRIBUTION SYSTEM

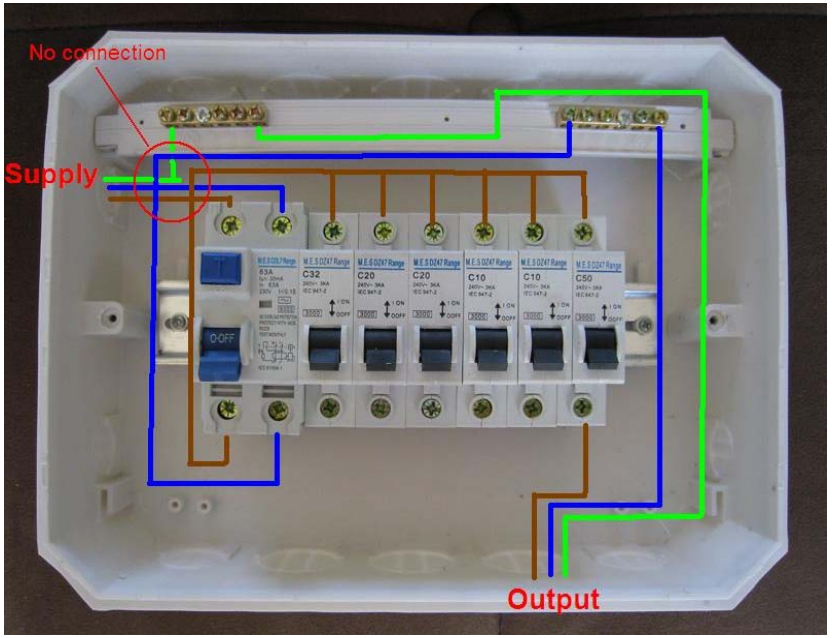
Safe Distribution Circuit

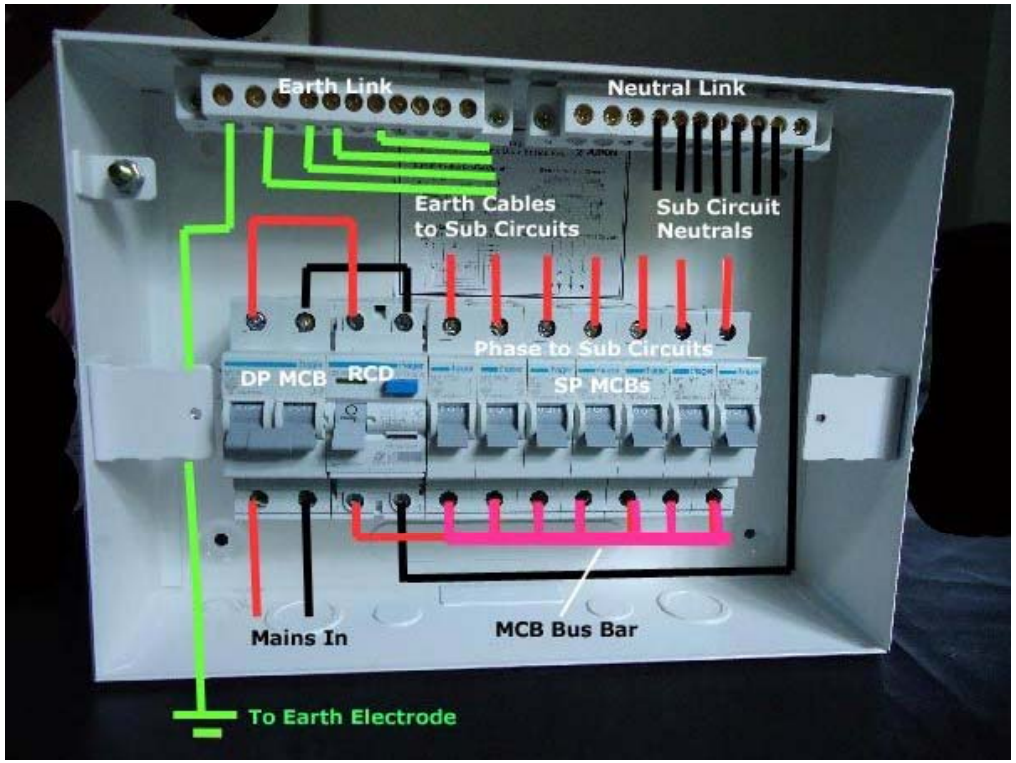


RCD Wiring Installation In Distribution

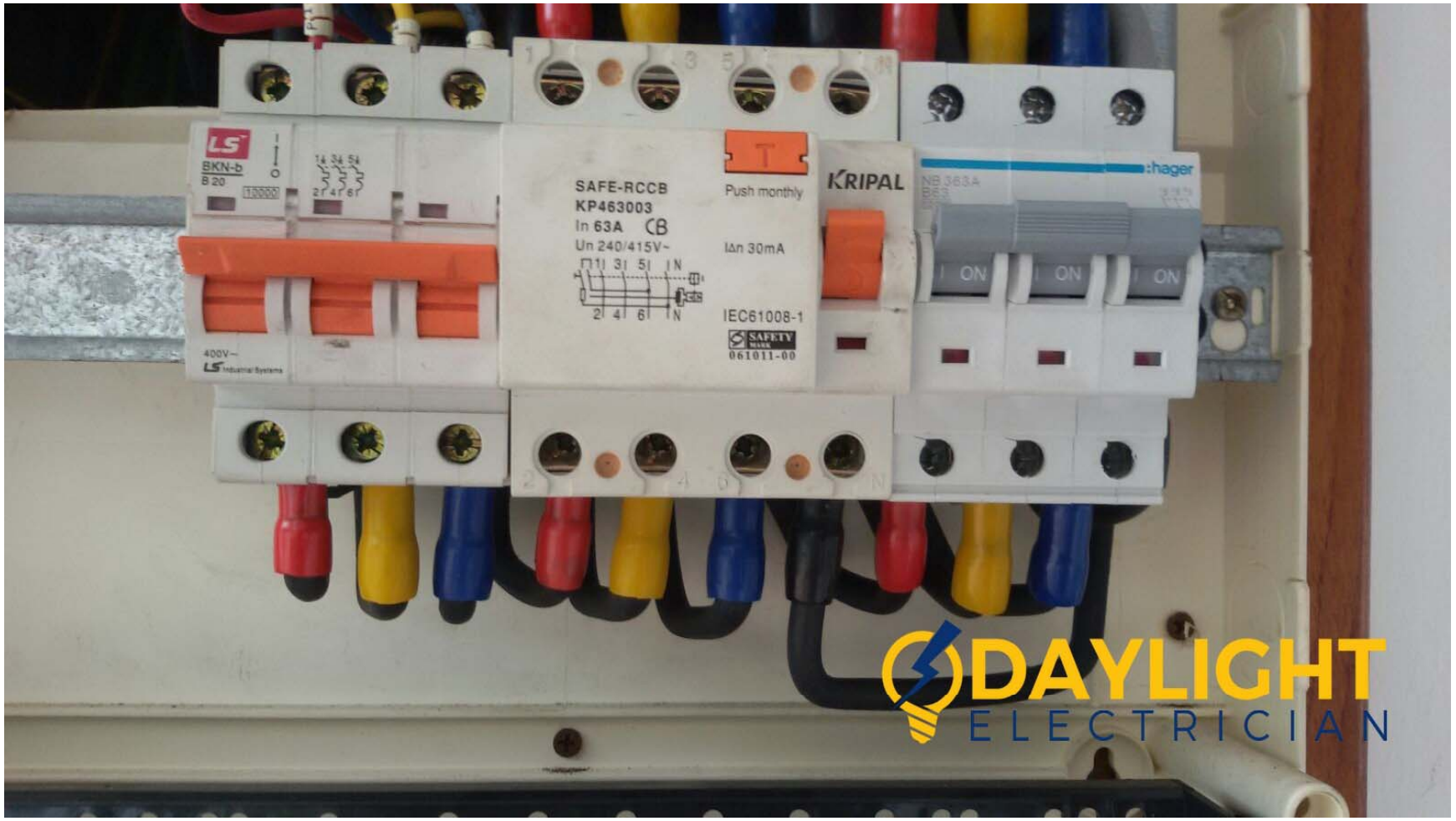


Distribution boards



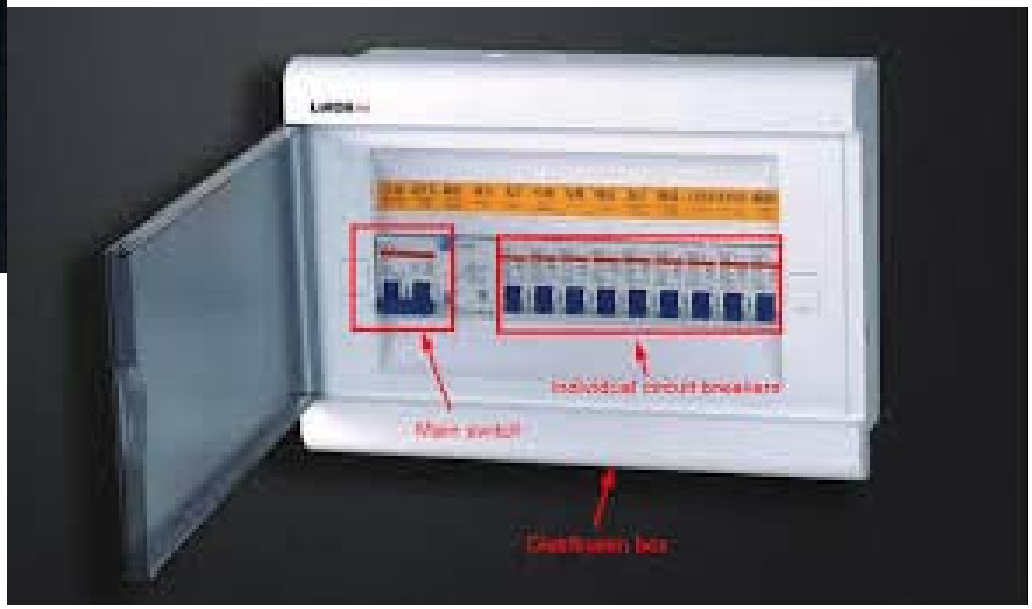


Termination insulation and taging



Tagging

1. Marking of Main switch and individual switches
2. Tagging of individual circuits by name / nomenclature



LEGAL REQUIREMENTS

LEGAL REQUIREMENTS

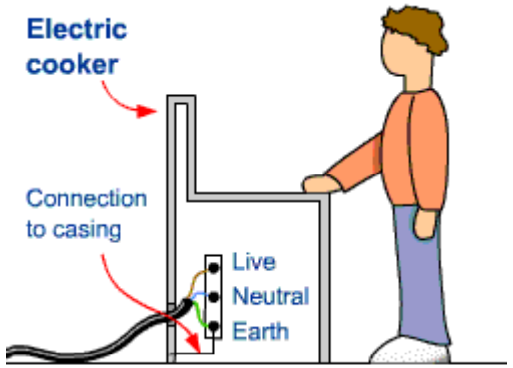
- Install ELCB (Earth Leakage Circuit Breaker)/ RCCB (Residual current circuit breakers) of 30mA rating for domestic connection and 100mA rating for commercial connection.
- Make use of proper capacity fuse wire, Miniature Circuit Breaker (MCB) as well as ELCB/RCCB.
- Install the MCB of correct rating as per the rating of the wire and gadgets. Over rated MCBs will not give protection.
- Always use double break MCB.
- Use double insulated power tools

LEGAL REQUIREMENTS

- Only competent person and authorized person is allowed to work in electrical connections. No person is allowed to work in live electrical lines.

- Use ISI standard wires for the internal house wirings. Avoid joints , give adequate mechanical support to the wires.

- Every electrical installations (Including factory registered under factories act) where more than 250kW of load is connected the owner of the premises or the management shall designate a Electrical Safety officer.



Protection fuse

- Use the correct size and ISI make of fuse. Incompatibility will cause excess current to flow in electrical appliances and house wiring. This can damage electrical appliances and can also lead to fire.

- Never replace a burn-out fuse with other materials.

- Use only 3-pin plug points for heavy appliances like - refrigerator, mixer, iron, wet grinder, washing machine, etc. and ensure it is properly earthed.

- During load addition inside the house, verify the capacity and condition of the internal wiring

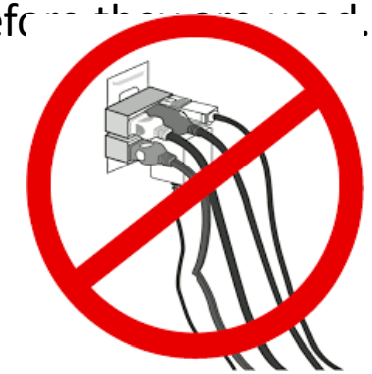
ELECTRICAL SAFETY

- **Planning of sockets & future use.**
- Extension cords should be used only when necessary and for temporary use only. It is not a substitute for the permanent or fixed wiring.

- Keep all electrical cord away from areas where they may be pinched, such as off the floor, out of walkways, and out of doorways. When possible, move the electrical appliances closer to the outlet.

- The extension cord should never be stapled or nailed to the surface.
- Do not use any appliances or extension cord that shows signs of damaged insulation or exposed wiring. To ensure safe operation, all electrical equipment should be visually inspected before they are used.

- Avoid "octopus connections".

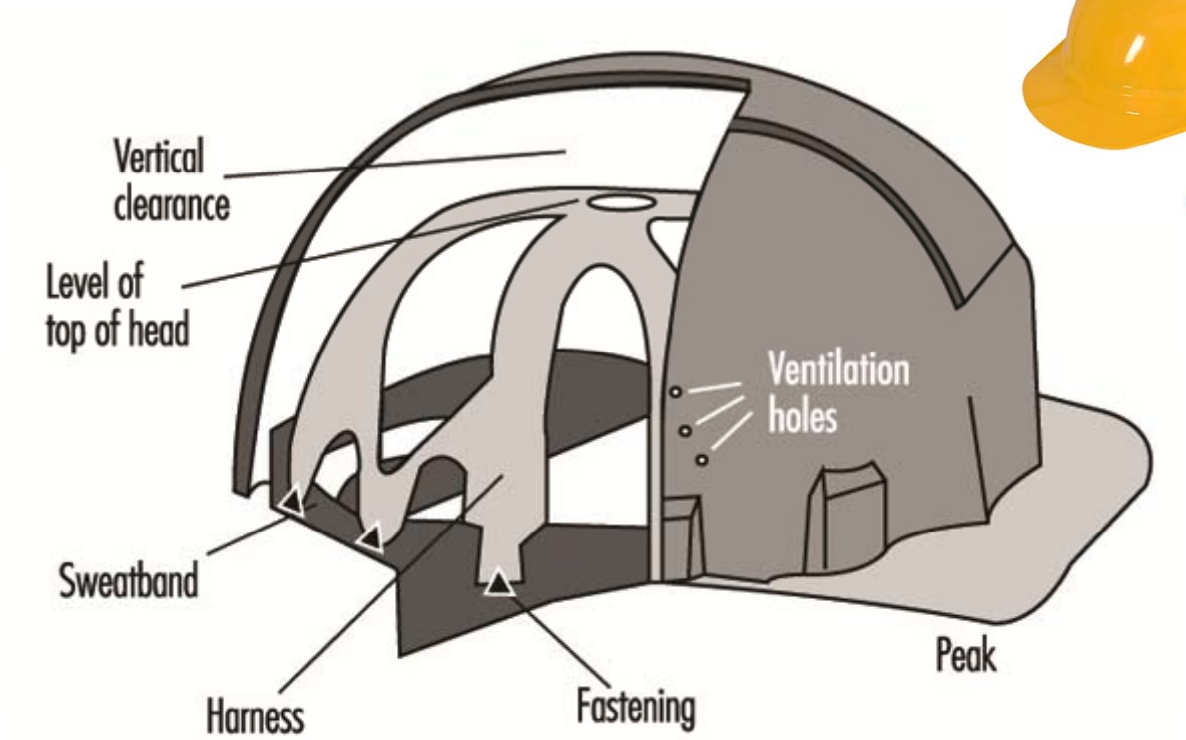


PPEs - Personal protective Equipments

CEA:

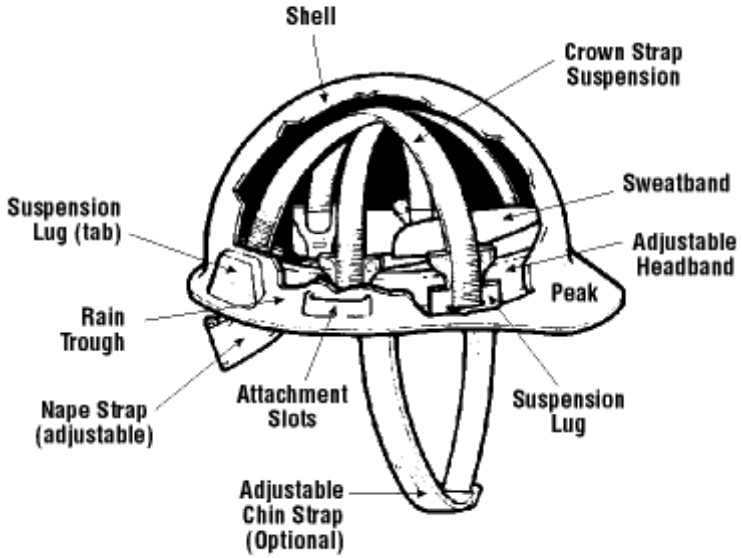
PPEs

1. Safety helmet / hard hat – Head protection
2. Safety Goggles – Eye protection
3. Electrical insulating hand gloves
4. Safety shoe
5. Full body harness
6. Arc protection face shield
7. Arc protection suit.


Vertical clearance
Level of top of head
Ventilation holes
Sweatband
Harness
Fastening
Peak


V-Design ABS shell
6 Ventilation holes
Ratchet adjustment headband
replaceable sweatband
Ear Muff and face shield adaptable
Rain channel
4 points webbing suspension

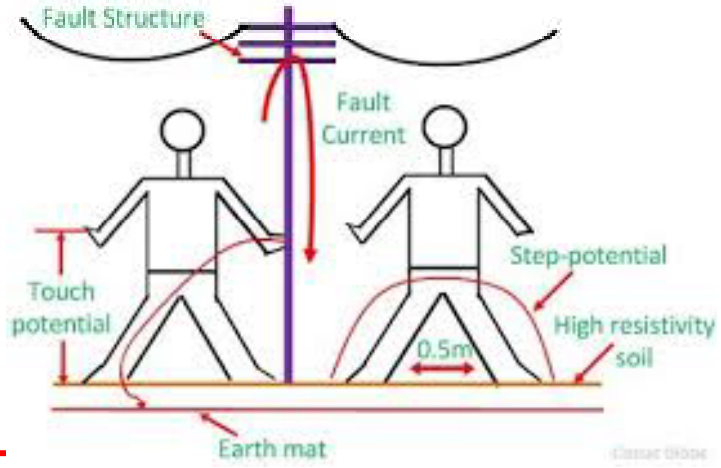
Hard Hat


Shell
Crown Strap Suspension
Sweatband
Suspension Lug (tab)
Adjustable Headband
Peak
Rain Trough
Nape Strap (adjustable)
Attachment Slots
Suspension Lug
Adjustable Chin Strap (Optional)


FAIL

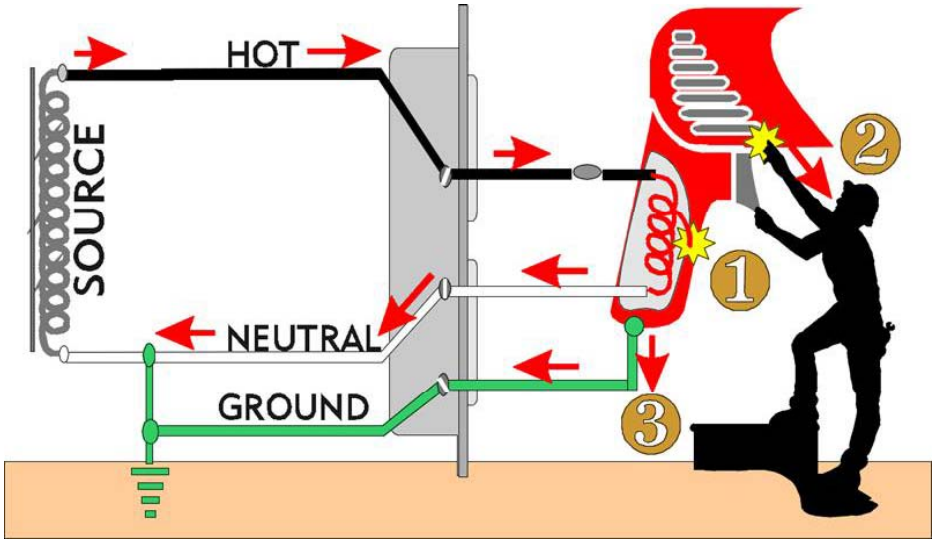
Electrical Hand goves

Class -0 (up to 1kV)
Class – I (up to 6 kV)
Class – II (up to 12kV)
Class – III (up to 22kV)
Class – IV (up to 36kV)



Shocks Occur in Three Ways

- Contact with both conductors
- Contact with one conductor and ground
- With a tool: contact with “hot” metal part and ground (1), (2) & (3)



Electrical Safety Shoe

- Public safety
  - ELCB
  - Awareness

- Employee
  - Tool talk / Safety talks
  - Training
  - Importance
  - Ill effects

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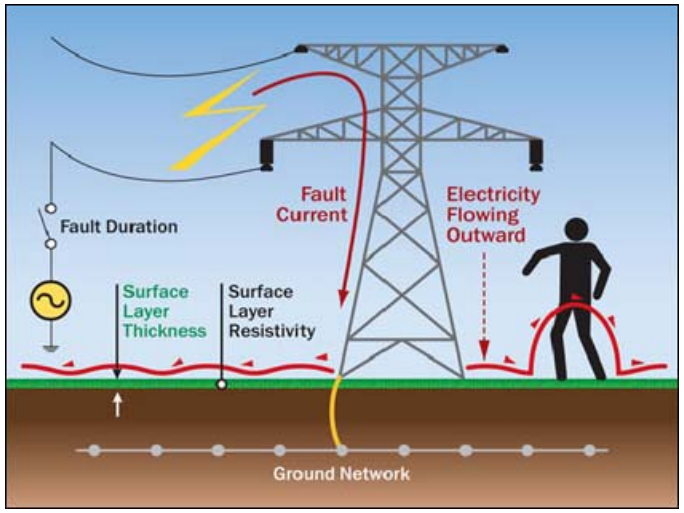
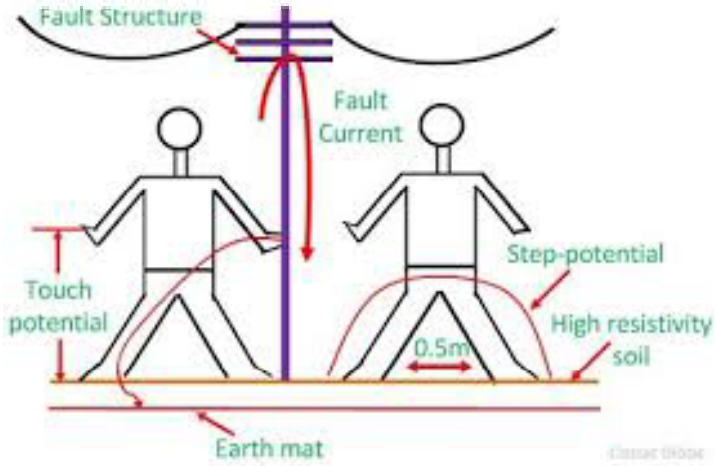
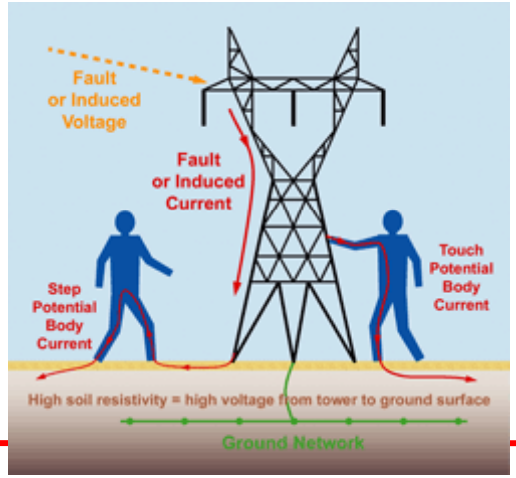
CURRENT LEAKAGE







Safety –

- PPEs
- Proper Tools
- Proper Testing Equipment

Safety –Proper Tools, Testing Equipment

- Continuity Screw Driver/Tester
- Screw Driver 4 Head/2 Head
- Pliers
- Side Cutter
- Wire stripper
- Measurement Tape
- Testing Holder
- Hexa blade
- Hammer Heavey/ Light
- Chisel
- Gunia ,Sumi ,round punch
- Cutter /Pencil
- Drill Machine & Bits max13 mm
- Hammer Machine Bit Max 32 mm different length
- Continuity tester
- Multi meter,Meggar
- Grinder Machine 4”
- Cutter


Staple Gun
Heat Gun
Crimping Tool
Wire Strippers
Precision Cutter
Soldering Gun
Adjustable Wrench
Diagonal Cutting Pliers
Multimeter w/leads
Jewelers Screwdriver Set
Needlenose Pliers
Scissors
Hobby Knife
Assorted Screwdrivers

CEA Regulation

33. Precautions against leakage before connection: -

1) The supplier shall not connect with his works the installation or apparatus on the premises of any applicant for supply unless he is reasonably satisfied that the connection will not at the time of making the connection cause a leakage from that installation or apparatus of a magnitude detrimental to safety which shall be checked by measuring the installation resistance as under,-

(i) all equipments shall have the insulation resistance (IR) value as stipulated in the relevant Indian Standards;

(ii) on application of 500 V DC between each live conductor and earth for a period of one minute the insulation resistance of installation and equipment of voltage not exceeding 650 V shall be at least 1 MEGA OHM or as specified in the relevant Indian Standard;

CEA Regulation

(iii) on application of 2.5 kV-DC between each live conductor and earth for a period of one minute, the insulation resistance, of installation and equipment of voltage exceeding 650 V but not exceeding 33 kV shall be at least 5 MEGA OHM or as specified in the relevant Indian Standard.

(2) If the supplier declines to make a connection under the provisions of sub regulation

(1) he shall convey to the applicant, the reasons in writing for so declining.