Indian Electricity rule:

General safety precaution:

Rule 29: Construction, Installation, protection, operation and maintainance of electric supply lines and apparatus

* The material and apparatus used shall conform to the relevant specifications of Bureau of indian Standards, where such specifications have already been mentioned.

* Human, animal and property safety must be maintained and apparatus

* All electric supply lines must have sufficient rating for power, insulation and estimated fault current and of sufficient mechanical strength

Rule 30: service lines and apparatus on consumer's premises

(i) The supplier shall ensure that all electric supply lines, wires, fittings and apparatus belonging to him are in a safe condition on a consumer premises, and the supplier shall take due precaution to avoid danger arising on such premises from supply lines.

(ii) The consumer shall, also take precaution for the safe custody of the equipment on his premises belonging to the supplier.

Rule 31 : Cut-out consumer premises

The supplier shall provide a suitable cut-out in each line. A cut out is a appliance which can automatically interrupt the flow of energy through any conductor when the current rise above the predetermined amount. ~~and shall also include~~

Rule 32 : Identification of earthed and earthed neutral conductor and position of switches and cut-out therein.

Rule 33 : Earthed terminal on consumer premises

* The supplier shall provide and maintain on the consumer's premises for the consumer's use a suitable earthed terminal in an accessible position

* Consumer shall take all reasonable precaution to prevent mechanical damage to the earthed terminal

* The supplier may recover from the consumer the cost of installation of such earthed terminal.

34 : Accessibility of bare conductor :

where bare conductors are used in a building the owner of such conductors shall

(a) Ensure that they are inaccessible

(b) Take necessary steps as consider by the inspector

35 : Caution notice : There should be a clearly visible caution notice in Hindi and the local langu of the district of a type approved by the inspector on every motor, generator, transformer, etc all supports of lines, provided if a generator, motor & transformer is within an enclosure, one notice affixed to the said enclosure shall be sufficient for the purpose

* It is also called warning notice.

Rule 36 ⟹ Handling of electric supply lines apparatus :

* Before any electric conductor or apparatus is handled adequate precaution shall be taken by earthing or by other suitable means.
* No person shall work on any live electric supply line or apparatus and no person shall assist such person on such work unless he/she is authorised in that behalf, and take the safety measure approved by the inspector.

Rule 40 : street box

* shall not contain gas pipes, precaution should be taken to prevent influx of water or gas
* supply line forming part of different systems pass through same street box shall be readily distinguishable.
* All street box should be regularly inspected.
* The box can only be open by means of a key

Rule 41 : Distinction of circuit of different voltage

* The owner of every generating station, sub-station, junction box or pillar in which there are many circuits or apparatus, intended for operation at different voltages, shall readily distinguishable from one another.

Rule 43 : Provision applicable to protective equipment:

* fire buckets filled with clean dry sand and ready for immediate use for extinguishing fires, in addition to fire extinguisher, suitable for dealing with electric fires should be kept in all generating station, sub-station.

* first aid boxes should be provided and maintained in every generating station, sub-station etc.
* A person who are trained in first-aid treatment shall available during working hours.

Rule 44 : Instruction for restoration of persons suffering from electric shock :

* Instructions in English, Hindi and the local language of the districts for the restoration of person suffering from electric shock, shall be affixed by the owner in a conspicuous place in every generating station, sub-station, etc in accordance with the factory act, 1948.

Rule 45 : precautions to be adopted by consumers, owners, Electrical contractors, Electrical workmen and Suppliers

Rule 46 :

periodical inspection and testing of consumer's installation

* Installation should be periodically inspected not exceed five years either by the Inspector or by the Suppliers
* The fees for such inspection and test shall be determined by the central or the state government
* In the event of the failure of any consumer to pay the fees on or before the date specified the consumer shall be liable to be disconnected under the direction of inspector
* However such disconnection by the supplier shall not be made without giving to the consumer seven clear days notice in writing of his intention to do so.

General condition relating to supply and use of energy :-

Rule 47 ⇒ Testing a consumer's installation :

Upon receipt of an application for a new or additional supply of energy, the supplier shall inspect and test the applicant's installation.

* If the result of inspection suggest modification to installation, the applicant should make such modification to make the installation safe.

low voltage → 250V

medium → 650V

High voltage → 33KV

EHV → above 33 kV, 66KV, 110 KV, 220kV, 400kV

Rule 48: precautions against leakage before connecting

* The leakage current should not exceed $\frac{1}{5000}$ x (load current) or (maximum current)

Rule 48: Leakage on consumer's premises:

If the inspector or the supplier has reason to believe that there is an leakage in the system which likely to cause danger, they may give the consumer reasonable notice in writing that he desires to inspect and test the consumer installation

* The supplier may, and if directed to do so by the inspector, shall discontinue the supply of energy to the installation but only after giving to the consumer forty-eight hours notice in writing of disconnection of supply and shall not commence the supply until he or the inspector is satisfied that the cause of leakage has been removed.

Rule 50 : Supply to consumers :

* The supplier shall not commence or continue to give supply of energy to any consumer unless :

(a) a suitable linked switch or a circuit breaker of requisite capacity to carry and break the current is placed as near as possible to, so as to easily operated to completely isolate the supply to the installation

(b) A suitable linked switch or a circuit breaker of requisite capacity to carry and break the full load current is inserted on the secondary side of a t/f, in case of high or extra high voltage installation.

* The supply of energy to each motor or other apparatus is controlled by a suitable linked switch or a circuit breaker of requisite capacity placed in such a position as to be adjecent to the motor or other apparatus readily accessible to and easily operated by the person in charge and so connected in circuit that by its means an supply of energy can be cut-off from the motor or apparatus.

* all insulating material used should have sufficient mechanical strength, and maintain its insulating property under different working condition of temp, and moisture.

* Adequate precaution are taken to ensure that no live part are so exposed to cause danger.

Rule 51 : provision applicable to medium, High or extra high voltage installation :

* All conductors (other than those of overhead lines) shall be completely enclosed in mechanically strong metal casing or metallic covering which is electrically and mechanically ~~continuous~~ protected against mechanical damage

* : All metal work enclosing, supporting or associated with the installation should be earth.

Rule 52 : Appeal to inspector in regard to defects

Rule 53 : cost of inspection and test of consumer's installation

The cost of the first inspection and the test of consumer's installation carried out in shall be borne by the supplier and the cost of every subsequent inspection and test shall be borne by the consumer.

Rule 54 : Declared voltage of supply to consumer

The declared voltage should not vary more than 5% in case of low or medium voltage or more than 12½% in the case of high or extra-high voltage.

Rule 55 : Declared frequency of supply to consumer

The supply frequency shall not vary more than 3%.

Rule 56 : sealing of meters and cut-outs

A supplier may affix one or more seals to any cut-out and to any meter, placed upon a consumer premise in accordance with section 26, and no person other that the supplier shall break any such seal.

Rule 57 : meters, maximum demand indicators and other apparatus on consumer's premises. ->

* The error do not exceed 3% above or below the absolute accuracy at all loads
* supplier shall examine, test and regulate all meters
* Every supplier shall maintain a register, showing the date of the last test the error recorded at the time of the test, date of installation etc.

Rule 58 : point of commencement of supply :

* At the outgoing terminals of the cut-out inserted by the supplier in each conductor of every service line other than earthed on earthed neutral.

Rule 59 : Precaution against failure of supply : (Notice of failure)

Supplier shall take all responsible precaution to avoid any accidental interruption of supply and also to avoid danger to the public or to any employee when engaged on any operation during installation or repair work.

Electric supply lines, systems and apparatus for low and medium voltage :

Rule 60 : Test for the resistance of insulation :

Where any electrical supply line for use at low or medium voltage has been disconnected from a system for the purpose of addition or repair, such electric supply line shall not be reconnected to the system until the supplier or the owner has applied the test prescribed under rule 98

Rule 61 : Connection with earth :

The neutral conductor of a three-phase four-wire system shall be earthed by not less than two separate and distinct connections with the earth both at the generating station and at the substation

* Cables external conductor shall be earthed by two separate and distinct connection with earth.

* The connection with earth may include a link by means of which the connection may be temporarily interrupted for the purpose of testing or for locating a fault.

* In a direct current three-wire system the middle conductor shall be earthed at the generating station only, and the current from the middle conductor to earth shall be continuously recorded by means of a recording ammeter and if at any time the current exceeds one thousand part of the maximum supply current, immediate steps shall be taken to improve the insulation of the system.

* The middle conductor is earthed by means of a circuit breaker with a resistance connected in parallel, the resistance shall not exceed 100hms and on opening of the C.B. immediate steps shall be taken to improve the insulation of the system, and the C.B. shall be reclosed as soon as possible

* The resistance shall be used as a protection for the ammeters

* In case of a.c. system there shall not be inserted in the connection with earth any impedance cut out or circuit breaker.

* The frame of every generator, stationary motor, metallic parts of all transformer shall be earthed by the owner by two separate and distinct connection with earth.

* All earthing systems belongs to the supplier shall be tested for resistance on dry day during the dry season not less than once every two years.

Rule 62: system at medium voltage: where a medium voltage system is employed the voltage between earth and any conductor forming part of the system shall not, under normal condition exceed true voltage

Electric supply lines, systems and apparatus for high and extra high voltage :⇒

63 : approval by the inspector :

Before supply of extra high voltage to a person, the supplier shall ensure that the high or extra-high voltage electric supply lines or apparatus belonging to him are placed in position properly joined and duly completed and examined.

* The owner of any high or extra high voltage installation who make any addition or alternation to his installation shall not connect to the supply his apparatus or electric supply lines unless approved by the inspector

64 : Use of energy at high and extra-high voltage :

(1) All conductors and apparatus intended for use at high or extra-high voltage and situated on the premises of the consumer are inaccessible except to an authorised person and all operation in connection with the said conductors and apparatus are carried out only by authorised person.

(11) The consumer has provided and agrees to maintain a separate building or a locked weather-proof and fire proof enclosure of agreed design and location to which the supplier shall at all time have access, for the purpose of housing high or extra high voltage apparatus and metering equipment.

* All pole type sub-station are constructed and maintain in accordance with rule 69.

* cable trenches inside sub-station and switch station containing cable shall be filled with sand, pebbles or similar non-inflammable materials

65: Voltage tests:

① High and extra high voltage electric supply lines and apparatus of the supplier shall not be connected unless the tests provided by the indian standards institution is performed.

* If the normal working voltage does not exceed 1000V, the testing voltage shall be 2000volts.

* If the normal working voltage exceed 1000 volt but does not exceed 11,000 volt the testing voltage shall be double the normal working voltage.

* If the normal working voltage exceed 11,000 volt, the testing voltage shall be normal working voltage plus 10,000 volt.

* The supplier shall duly record the result of every test made under this rule.

66: Metal sheathed electric supply lines: precaution against excess leakage

* conductor shall be enclosed in metal sheathing which shall be electrically continuous and connected with earth

* In the event of failure of insulation occering between one conductor and the metal sheathing at any point along an electric supply line as aforsaid, the impedance of the relevant circuit shall be such that ceerrent resulting from such feilure shall not be less than twice the value of the ceerrent for which a suitable cut-out of adequate capacity or other suitable overhead protectin device has been set to operate.

Rule 67: connection with earth

The neetral point shall be earthed by not less than two separate and distinct connection with earth each having its own electrode at the generating station and at the sub-station.

* In the event of appreciable harmonic current flowing in the neutral connection so as to cause interference with communication circuits the generator or transformer neutral shall be earthed through a suitable impedance.

* In the case of system comprising electric supply lines having concentric cables, the external conductor shall be the one to be connected with earth.

Rule 68: General condition as to transformation and control of energy:

Sub-station and switch-station shall preferably be erected above ground, but where necessarily constructed underground, due provision for ventilation and drainage shall be made.

* Sub-station be effectively protected by fencing not less than 8ft in height, so as to prevent access to the electric supply lines and apparatus therein by an unauthorised person.

Rule 69: Pole-type sub-station:

Where platform type construction is used for a pole type sub-station and sufficient space for a person to stand on the platform is provided.

Rule 70: Condensers > suitable provision shall be made for immediate and automatic discharge of every static condenser on disconnection of supply.

overhead lines

Rule 73 : material and strength :

All conductors of over-head lines shall have a breaking strength of not less than 317.51 Kg (700 lbs)

Rule 74 : JOINTS : Joints shall be mechanically and electrically secure under the condition of operation. The ultimate strength of joint not less than 95% of that of the conductor and electrical conductivity not less than conductor.

75 : maximum stress : factor of safety

factor of safety expresses how much stronger a system is than it needs to be for an intended load.

many systems are internally built much stronger than needed for normal usage to allow for emergency situation, unexpected load, misuse etc.

Buildings commonly use a factor of safety of 2 for each structural building, pressure vessels use 3-5 for automobile use 3, and aircraft → 1.2 to 3.0.

Inf * The minimum factor of safety for supports based on crippling load shall be

(i) metal supports ⟶ 2.0
(ii) concrete support ⟶ 2.5
(iii) wood supports ⟶ 3.5

The minimum factor of safety for stay wires, guard wires or bearer wire shall be 2.5 based on the ultimate tensile strength.

I: clearance above ground of the lowest conductor

(i) Low & medium voltage lines → 19ft (5.791m)
(ii) High voltage lines → 20ft (6.096m)

Service line erected across a street line

(i) low and medium voltage → 18ft
(ii) High voltage line → 19ft

Erected along a street line.

II: clearance bet^n conductors and trolly wires:

No conductor of an overhead line crossing a tramway or trolley bus route using trolly wires shall have less than the following clearance above any trolly wire.

(a) Low and medium voltage → 4ft
(b) High voltage upto 11,000Volt → 6ft
(c) above 11,000 → 8ft.
(d) Extra high voltage → 10ft.

* Insulated conductor → 2ft

Rule-18: Clearance from buildings of low and medium voltage lines and service lines:

* vertical Clearance of 8 feet from the highest point

* when the line passes adjecent to the building, a horizontal clearance of 4 feet from a nearest point.

Rule 79: clearance from buildings of high and extra-high voltage line:

vertical clearance

(a) upto 33KV ⟶ 12ft

(b) for extra high voltage line 12ft plus 1 foot for every additional 33KV.

horizontal clearance

upto 11KV ⟶ 4ft

above 11KV ⟶ 6ft

upto ~~below~~ 33KV

for extra-high voltage line 6ft plus 1 foot for every additional 33KV.

Rule 80: conductors at different voltages on same support:

methode of construction and the clearance b/n the conductors shall be approved by the inspector.

Rule 84: maximum interval between supports:

overhead lines carrying low or medium voltage conductors, the interval shall not exceed 67 meters.

Rule 86: Lines crossing or approaching each other:

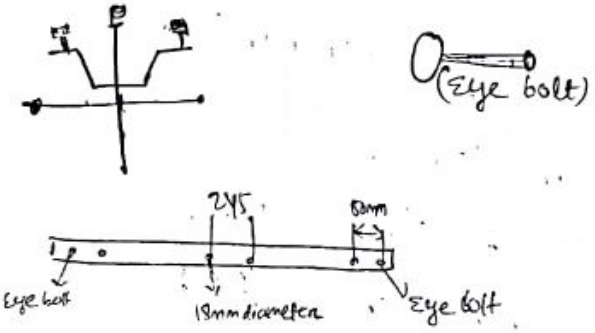
The owner of the line which was last erected shall so protect it as to guard against the possibility of its coming into contact with the other overhead line.

Rule 87 : Guarding :-

* Every guard wire shall be connected to earth at each point at which its Electrical continuity is break.

* Every guard wire shall have an actual breaking strength of not less than 635 Kg and if made of iron or steel, shall be galvanised.

* Every guard wire shall have sufficient current carrying capacity.



* where there is only one trolly wire, two guard-wire shall be erected

Rule 88: No service line shall be taken off from an overhead line except at a point of support.

Rule 89: Earthing

All metal supports of overhead lines and metallic fittings attached shall be permanently and efficiently earthed.

† Each stay wire shall be similarly earthed unless an insulator has been fixed in it at a height not less than 3.048 meter (10 ft) from the ground.

Q: safety and protective devices:
use of guarding wire and protection from unauthorised person assending using a ladder on special appliance.

Q: protection against lightning:
By using lightning arrestor to divert lightning to ground.

—x—

* high voltage equipment insulation resistance → 1 MΩ
* Frequency variation allowed → 3%
* IE rule section 44 → penalty for interference with meter (1956)
* switches always put in phase wire
* There is no switch/cut-out in neutral
* outer body of equipment always should be grounded
* Branch circuit must not feed more than 10 point.
* what is the maximum number of lighting points that can be connected in a circuit. 10
* what is the maximum load that can be connected in a circuit connecting only lighting point 800 watt

House wiring
- light & fan
- power circuit geaser, Iron,

* How many outlet are permitted in a power circuit 5 point
* what is the maximum load is permitted in a power circuit 3000 watt
* what is the value of earthing resistance of large power station 0.5 Ω
* what is the value of earthing resistance of small sub-station 2 ohm

* what is the earthing resistance of nedicem sub-station 1 ohm

* what is the diameter of the GI pipe through which the earth wire needs to be taken out 13 mm.

* what type of earthing is used by transmission lines Strip earthing.

* what is the dimension of the copper strip used for for the strip earthing 25mmX4mm

* which type of earthing is also called as fire earthing
  Ans → Rod earthing.

* material used for continuous bus bar → Aluminium.

* for motor installation, all equipment used in power wiring shall be of iron clad.

* what is the factor of safety used for current rating in a power installation 2.

* The leakage current must not be more than 1/5000 of maximum supply current

* Earth resistance according to IE
  * large power station → 0.5 ohm
  * extra high voltage station → 1 ohm
  * small sub-station 33KV → 2 ohm
  * Distribution transformer → 5 ohm
  * Tower foot resistance → 10 ohm,
    Others → 8 ohms
  * Earth continuity conductor → 10 Ohm

* check earth resistance once in a year during dry season
* High voltage and EHV installation should earth at 2 different place
* Cable Armour should be earthed at 2 different place.
* Earth leakage protection should be provided above 5KW.
* Breaking strength of wire - 350kg.
* max. no. of joints in span - 02.

Light and fan circuit
- > maximum 10 point
- > max. load - 800W
- > Copper wire - 1mm
- > Aluminium wire - 1.5mm

Power circuit
- max. point → 2
- copper wire → 1.5mm
- Aluminium wire → 2mm

* All plug should be 3 pin plug
* for Earthing use
  - > copper wire → 14 SWG
  - > Aluminium wire → 8 SWG

Earthing and wiring:
* A wire placed on the top of a transmission line ground wire
* The conductor by means of which the body of an equipment is connected to the earth is known as Earth continuity conductor
* which of the following types of wiring is preferred for workshop lighting? (Safety is required)
  Ans → Concealed conduit wiring
* supplier fuse is connected just after the energy meter.

* In a 3-pin plug → Two pins are of the same size but third one is thicker and longer

* 'Danger 440" → Caution notice

* The aluminium conductors of size 1/1.40mm is used for a subcircuit in domestic wiring

* The copper " " " 1/1.11 mm is used for a subcircuit in domestic wiring

* copper conductors are generally used for transmission line because it has longer life and high conductivity.

* what is the minimum permissible size of the earth continuity conductor?
  Ans → cu → 3 mm²
  G.I/steel → 6mm²

* aluminium is light weight

* Transmission line used plate earthing, also large power station

* rocky area → strip earthing
* pipe earthing → small installation
* sandy soil → rod earthing

* GI pipe diameter → 13 mm

* which of the following is a internal wiring
  cleats, conduit, CTS wiring

* Batten wiring → CTS / TRS or PVC all are.

* maximum distance b/w two successive cleat → 0.6m

* what should be the minimum depth of trench from the ground level for cables carrying a voltage b/w 3.3 kV and 11kV
  Ans → 0.9 m

HV cables (22kV to 33kV)
1.05m

LV cables
0.75m

* cable at road crossing
1m

} under ground cable distance from ground level

* Highly skilled labour is required in Conduit wiring
* Resistivity of earth sharply increases when moisture falls below 10%
* methods of measuring earth resistance
  - > Four point method
  - > 3 point method
  - > 2 point method
* methode to reduce earth resistivity
  - * Increase moisture content of soil → by adding water
  - * Salt like cuso4 / magnesium sulphate, sodium chloride
  - * bentonite clay / coke powder etc.
* loop earth wire shall not be less than (# 14 swg / 2.9 mm²) not less than one half the size of installation conductors
* The earth pit should not be located near roads, rail tracks, pavemen
* 3φ, 4 wire cables, the cross-sectional area of neutral is half the phase conductor
* 1φ → Neutral and line wire same size.
* acid and alkali stored area → TRS wiring should be used
* ~~Earthing voltage~~
* Eath electrod from building → 1.5 m //

* The acceptable value of ground resistance to domestic → 1 Ohm

* flexible wire is not used for cement factory
(due to high temp. they can melt)

* The another name of neutral earthing is system earthing.

* Electronic circuit symbol:

* classification of electrical equipment : IS : 9409-1980

* step voltage: The potential difference (P.D) between two points on the earth's surface separated by a distance of 1 meter.

* General requirement of earthing
→ 32, 51, 61, 62, 67, 69, 88(2) and 90.

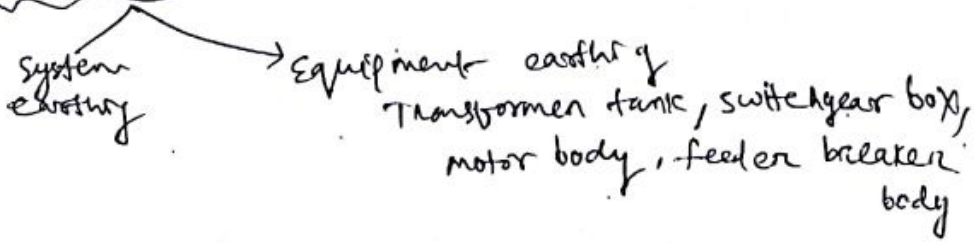
* NaCl, $CaCl_2$, Na_2CO_3, $CuSO_4$ → Artificial agent

* Earthing rod 1m in diameter, 30 cm deep

* copper, iron on mild steel → ordinary condⁿ.

* copper electrode on copper clad / zinc coated iron electrode

* classification of Earthing



33KV S.S ⟶ 2ohm

Types of earthing

Plate type * cast iron plate of size 600mm X 600mm X 6.3mm thick plate is being used as earth plate

* This is being connected with hot dip GI main Earth strip of size 50mm breadth X 6mm thick X 2.5 meter long by means of nut, bolts and washers.

* The earth plate is back filled and covered with earthing material (mixture of charcoal and salt) by 150mm from all side.

* PVC pipe of 2.5 meter long is also provided in the earth pit for watering purpose

List of electricity organization in india :

central government:

Administrative bodies

* ministry of power →
* central electricity authority → formulates plans for the development of electricity system
* central electricity regulatory commission → electricity tariffs, transperent policies, & power generating companies.
* Bureau of energy efficiency → develop program which will increase the conservation and efficient use of energy.

* ministry of power → Raj Kumar singh
* oversees rural electrification projects
* during P.V. Narasimha rao govt → It became ministry of power prior to that it is a department under ministry of power, coal, and renewable energy. came
* In 2012, the ministry of power inaugurated the smart grid project in puducherry

* CEA: construction of electrical plants, electric lines and connectivity to the grid, installation and operation of meters and safety and grid standards
* It facilitates exchange of power within the country from surplus to deficit regions and with neighbouring countries for mutual benefits
* CEA responsibility also include data collection

Field organisations

* Nuclear power corporation of india (NPCIL)
  is a PSU in mumbai, administrated by Department of Atomic Energy.
  production output → 38,336 mwh (FY18)

↓ Subsidiaries

- → NalCo power
- → Indianoil (74%)
- → Anushakti vidhyut Nigam Limited (51%)
- → L&T Steels and Heavy forging (26%)

Nuclear plants

Total 22

- * Tarapur, MH → 160 mw → Boiling water reactor
- * " MH → 160 mw → "
- 2006 * " MH → 540 mw → pressurised heavy water reactor
- * Rawatbhata, Rajasthan → 100 mw, 1973
- Chittorgarh dist * Kalpakam, T.N → 220 mw
- Town in Kanchipuram dist * Narora (town in Bulandshahr), U.P → 220 mw
- * Kakrapar, Gujarat → 220
- * Kaiga, near river Kali, in Karnataka
- * Kudankulam, T.N → 1000 mw → (2013)
  → water-water energetic reactor
  ↑ pressurised reactor series
- * Kudankulam, TN → 10000 mw (2016)
  ↓ Town in Tirunelveli dist

power grid corporation of india :

H.Q → Gurugram (Haryana), India and is mainly engaged in transmission of power, power grid trasmit 50% of the total power generated in india.

NHPC limited

National hydroelectric power corporation is an indian hydropower generation company

NTPC limited : national thermal power corporation limited

→ 57,356 mw

→ 16.1% of total national capacity

Today (28) → coal based

* singrauli super thermal power station → U.P → 2000mw
* NTPC korba → chattishgarh
* Farakka super thermal → west bengal → 2,100 mw
* vindhyachal super → M.P → 4760
* Rihand → U.P → 3000 mw
* Talcher super thermal → odisha → 3000
* Feroze gandhi → U.P → 1550
* Badarpur Thermal → Delhi → 705
* Darlipali super thermal → odisha → 1600
* LARA super thermal → Chattishgarh → 4000 mw
* Solapur super thermal → maharashtra

Gas-based thermal

(7) Anta (Rajasthan), Dadri (U.P), Kayamkulam (Kerala), Faridabad (Haryana) → state ~~project~~

Solar photovoltaic power plants of NTPC

* Dadri solar pv → U.P → 5 mw
* Port Blair solar pv → Andaman Nicoba → 5 mw
* Talcher kaniha → odisha → 10 mw
* Faridabad solar pv → Haryana → 5 mw

* wind power by NTPC

NTPC → 50 mw → wind power project at Rajnol in gujarat state

* Damodar vally corporation (DVC) indian govt. organisation in the Damodar River area of W.B. and Jharkhand operate both thermal and hydel power stati.

* Neyveli Lignite corporation limited → fossil fuel mining sector
mines at Neyveli of T.N
(Town)

Government of odisha (OPGCL)

> only thermal power generating company owned by odisha
> It owns and operate 2 units of 210 mw power plant at Banharpali in Jharsuguda dist.
> Talcher → 3000 MW → kaniha

Odisha Electricity regulatory commission

PSU of government of odisha established under the orissa Electricity reform act 1995,

Subsidiaries
→ wesco → distribution and retail supply business
→ nesco (North eastern electricity supply company
→ Central Electricity supply utility of odisha (CESU)
→ southco

OPTCL

Gridco corporation of odisha is a subsidiary of odisha Electricity regulatory commission which deal with transmission, distribution

WESCO is a subsidiary of GridCO.

↓

Sundargarh, Jharsuguda, Sambalpur, Deogarh, Bargarh, Bonaigarh, Balangir, Nuapada. The corporate office is in burla.

NESCO → Balasore, mayurbhanj, Keonjhar, Jajpur, Bhadrak

Hydroplant in odisha

* Hirakud Hydro
* Chiplima hydro electric
* Balimela, malkangiri dist, sileru river tributary of sabari river → tributary of godavari → source mahendra
* Rengali
* upper kolab
* machkund Hydro

odisha top company

* neelachal ispat nigam Limited
* gupta power infrastructure ltd → cable, conductors, wire rods etc optical fibre
* Gridco → transmission
* Balasore Alloys ltd → ferro alloys
* NCL → coal and bitumin
* National aluminium company limited → NALCO → HQ → BBSR → main unit Damanjodi, Nalconagar
* paradeep phosphate ltd → Fertilizers production

* HindALCO is a aluminium and copper manufacturing company is a subsidiary of Aditya birla group (metal industry), the → mumbai
* conglomerate → multiple business company → fertilizers, insulators, financial, metal service, telecom etc, textile, cement
* power plant → Hirakud captive power plant → thermal power plant → 450MW
  → Aditya captive power plant → 900MW

* Milk mantra → Agricultural dairy products based in odisha
  brands → milkymoo, moo shake
  * famous for its packagery called "trilak"

* Bhusan power and steel → 2640mw → Angul
* Jindal power ltd → Barbil (Kendujhar dist) → Iron city → pellets
  → Tensa, (Sundergarh) → Iron ore
  → steel plant, Angul
* Tata power →
* visa power ltd
* L & T

* Tata power → electricity utility company → India's largest integrated company generate, transmit, distribute
  ↓
  Sir Jamsetji Tata
  ↓
  1st president of indian olympic association

* Tata power → gobara ghati, odisha, Jajpur.

Systems of wiring:

The types of internal wiring usually employed in our country are

(i) Cleat wiring
(ii) Wooden casing and capping wiring
(iii) CTS or TRS or PVC sheathed wiring
(iv) Lead sheathed or metal sheathed wiring
(v) Conduit wiring
    (a) surface or open type
    (b) Recessed or concealed or underground type.

Cleat wiring:

* Cables used are either VIR or PVC type.
* cables are held by porcelain cleats, The cleats are made in two halves, one base and the other cap. The base is grooved to accomodate the cables and the cap is put over it and the whole is then screwed on wooden plugs
* The screws used are of size 38-40mm.
* The cleats are of three types one groove, two groove and three groove to accomodate one, two and three cables respectively
* For low voltage installation (upto 250V), Cleats shall be of such dimension that cables shall not be less than 2.5cm apart for branch circuit and less than 4 cm apart. for submains.
* In order to ensure longer life to cleat wiring system cleats should be usually used at intervals of 30cm and in no case more than 60 cm.
* Nowadays plastic cleats and cable ties are used

Advantages:

> cheap
> Installation is easy
> Dismantlement is also easy

Disadvantage:

> Not good looking
> temporary in nature in dry places
> VIR (vulcanized india rubber) insulation can be damaged by smoke and oil.

Field of application:> For temporary installations in dry places. This is also used where appearance is not so important and cost is the main consideration. not suitable for domestic premises.

precaution:-

> proper types of cleats should be used i.e. one way cleats should be used to carry one wire, two way cleats should be used to carry two wires and so on.
> In do case two wires should be accommodated in one groove of porcelain cleats.
> cables should not be rein near water pipes, gas pipes and etc.

Wooden casing and capping wiring ⇒

> The cables used in this type of wiring are either PVC or VIR or any other approved insulated cables

> The cables are carried through the wooden casing enclosures.

> The casing consist of V-shaped grooves (usually two hold the cables of opposite polarity in different grooves) and is covered at the top by means of rectangular strip of wood, known as capping of same width as that of casing.

> The capping is screwed to the casing by means of 13mmX4mm wooden screws fixed at every 15cm on the centre fillet.

× To protect the casing against white ants it is varnished

* Two or three cables of same polarity may be seen in one groove and in no case the cable of opposite polarity should be seen in the same groove.

Advantage :

> Cheap in cost as compained to lead sheathed and conduit wiring system.

> Easy to install and rewire.

> It provide good insulation as conductors are good distance apart.

> Easy to inspect by opening the capping.

Disadvantage:

① Even being coated with paint or varnish, is not damp-proof so can't be used in damp places.

② Since there is a risk of fire, it can't be used where there is a

Field of application:

* Suitable for low voltage domestic installation in dry places and where there is no risk of fire hazard.

* Due to increased cost of teak wood, the wooden casing and capping are becoming obsolete and PVC casing and capping are being used.

CTS or TRS wiring (Also called batten wiring)

Cable used may be single core, twin core or three core TRS cable with circular shape. These cables are chemical proof, water proof, steam proof but are slightly affected by lubricating oils. TRS stands for tough rubber sheath and CTS stands for cab tyre sheath)

* Usually a hard rubber cover is used to protect the cable from external damage. This type of cable is commonly used in open wiring system.

* It is suitable where acids and alkalis are likely to be present

* The cables are carried on teak wood perfectly straight and well varnished teak wood batten of thickness not less than 13 mm. The varnish is applied on all four sides of the batten.

(a) The wires are fixed on the batten by means of tinned brass/aluminium link clips already fixed on the batten with small nails before laying wires.

(b) * The link clips should be fixed at an interval of 15cm in case of vertical runs of batten and 10 cm in case of horizontal runs

(c) * The width of batten depends on number and size of cables to be carried on it. The minimum width of batten is 13mm for two wires.

(d) * In domestic wiring batten normally used 13 / 19 / 25 mm wide. (↓ 2 wires, ↓ 3 wires, ↓ 4 wires)

(e) * The wiring must be painted with two coats of oil-less non-cracking paints as specified in IS 732.

(f)

* Size of batten (width X Thickness)	Number and size of link clips required	number of wires of size 1/1.40 mm dia, single core, aluminium conductor that can be laid
(13mm X 13mm)	(1 X 38mm)	(2)
19mm X 13mm	1 X 50mm	3

Advantage :

(i) Easy to install, thus labour charges will be less

(ii) Fault location and fault removal is easy as the wires are visible.

(iii) Good appearance compain to clead wiring

(iv) withstand action of most chemicals such as acids and alkalis

Disadvantage :- (i) Insulation may damage if exposed to sun or rain.

(ii) Batten wiring is not suitable in damp walls, because the damp walls are likely to damage the wood.

(iii) There is risk of fire.

(iv) Appearance is not that good as compained to conduit wiring

Lead sheathed or metal sheathed wiring :

The cables used are insulated wires / TRS on PVC/VIR with an outer covering of sheath of lead-aluminium alloy containg about 95% lead . .

* This metal sheath gives protection to the cable from mechanical injury, dampness and atmospheric corrosion .
* The whole lead covering is made connected to earth at the point of entry to protect against leakage current .
* The maximum thickness of lead covering may not exceed 1 or 1.5 mm .
* The metal sheath provides toughness and gives protection to the cable against mechanical injury, dampness and atmospheric corrosion . Hence metal sheathed or lead sheathed cables may be used on places exposed to sun, rain and other damp situation .
* The lead sheathed cables should be run on well seasoned and straight teak wood batten of thickness not less than 13 mm

(a), (b), (c), (d), (e), (f) points of CTS on TRS wiring copied .

Advantage : (i) It can be used in places exposed to sun or rain, provided no joint is exposed.
(ii) It can also be used in damp situation .
(iii) it may have comparatively a longer life as compained to CTS wiring
(iv) it gives a fairly good look

Disadvantages:

> costly compared to its wiring
> If proper earthing is not done and insulation is damaged, the metal sheath becomes alive.

* Conduit wiring system:

All wires are enclosed in steel pipe known as conduit. This metal is annealed to permit easy bending.
* The conduit is coated from outside for protection against corrosion.
* steel tube coated with enamel is termed as black conduit
* when its surface is galvanized it is termed as galvanized conduit.

There are three types of conduit wiring:

(a) concealed conduit wiring.
(b) surface conduit wiring.
(c) flexible conduit wiring.

(a) Concealed conduit wiring:

The conduits are embedded along walls or ceiling in plaster at the time of construction. The wires are pulled into the conduits by means of steel wire of size 18 SWG. The conduit should be electrically and mechanically continuous and connected to earth at suitable place through earth wire.

Ordinary conduit pipe of light gauge and black enamel is preferred for concealed system for house wiring.

Galvanised iron pipe is preferred for surface conduit wiring.

Surface conduit wiring:

The conduit in surface conduit wiring is placed on the surface of the wall and held with the help of conduit saddles. This system of wiring preferred in industrial wiring. In damp situation, the conduit can be spaced from the wall by means of small wooden spacers below the conduits around its length at regular interval.

The conduit size is stated in terms of its outside diameter. The minimum size of conduit is 12.7 mm which is not commonly used as it carry limited number of wires. The next size is 15 mm, 20 mm and 25 mm which are commonly used for house wiring system. The conduits of diameter 30 mm and above are used for carrying wires to electric motors for power wiring etc.

(c) Flexible conduit wiring: The flexible conduit pipe is a pipe which can bend on twist without the change in its diameter. The purpose is to provide mechanical protection to cables.

PVC conduit pipes are also available now and are increasingly being employed in place of steel conduits. PVC conduits are cheaper in cost and the labour time saved may be as much as 25% compared to the time taken in installing steel conduit. PVC conduits is not used in location prone to fire hazards.

Advantage: > protection against mechanical damage
> complete protection against fire
> waterproof.
> It's life is long.
> Replacement of defective wiring is easy.

Disadvantage: > It is very costly
> Experienced and highly skilled labourer is required.

- field of application ⇒

> places where important document are kept such as record room.

> residential and public building where appearance is prime thing

conduit accessories and fittings :

① conduit couplers

conduits as per required length may not be available but are available in lengths of 3 to 4 metres. couplers are used to joint two lengths of conduit. The conduit of standard length is available with threading on both side on outer side. The similar threading are made in couplers on inner side so that both thread ends of the conduit to be coupled are screwed in the coupler, if shorter length of conduit is required then it may be cut off with a hecksaw, roughness removed and then thread with a die.

② conduit bends

for normal bend, the radius of the bend should be at least six times the internal diameter of the conduit

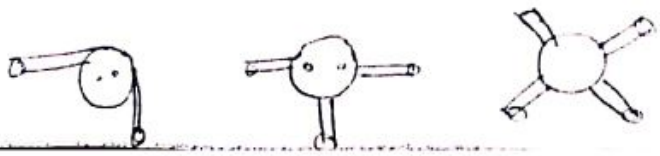
③ conduit Elbows :

It will provide 90° bend to the conduit

④ Inspection bend : used in surface conduit wiring where inspection of wires at corners is necessary at regular intervals.

⑤ terminal box :

The connection terminates in the box for onward connection to the lamp or fan or other electrical point.



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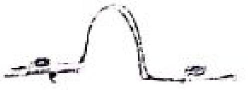
Saddle: The conduct must be rigidly held with the wall. It has two holes for fixing it with the wall on both sides.



chapter 2 Q.1) Wiring materials and accessories : ①

wires and cables :

Single wire, may be bare or covered with insulation is known as wire and several wires stranded together is known as a cable.

But in practice bare conductors, whether single or stranded together are termed as wires and conductors covered with insulation are termed as cables.

The cable consist of three parts

(a) The conductor or core

(b) The insulation or dielectric

(c) The protective covering for protection of insulation from mechanical damage

Conductor materials used in cables:

The function of conductor, usually known as core, in a cable is to carry electric current. copper and aluminium are the materials used as conductor in power and lighting cables.

① copper : Though silver is the best conductor but due to its higher cost it is rarely used. The next best conductor is copper. It is cheaper comparatively.

The electrical conductivity of copper is comparatively high. The resistivity of pure copper at 20°C is 1.786×10^{-8} Ω-m.

* It is mechanically strong, hard, exterenely tough, durable and ductile (can be drown to thin wire)
* It is highly resistive to corrosion, oxidation and pitting
* It can withstand dampness and high temperature.

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* It can be easily soldered and welded.
* The specific weight of copper is 8900 kg/m³ at 20°C.
* It's melting point is 1083°C.
* Hard drawn copper conductors ~~are~~ have very high tensile strength (40 kg/mm²), used as overhead wires mainly in bare form.
* Annealed copper conductors are comparatively soft and most suitable for indoor and outdoor wires.

② Aluminium:

Aluminium is frequently used in place of copper for bare electric cable used for long distance power distribution.

* Electrical conductivity of aluminium is about 60% of that of copper.
* resistivity being 2.87×10^{-8} Ω-m at 20°C.
* so for same resistance for a given length, the aluminium required will be 1.61 times of that of copper in volume and 1.26 times of that of copper in diameter.
* The only application of aluminium cable for wiring in building is for the "continuous bus-bar" system of distribution.

iv) Insulating materials:

The conductor is covered with insulating materials so that it may prevent leakage of current from the conductor i.e. the insulating material should be extremely high resistive to the flow of electric current through it.

The insulating materials used in electric cables must possesses the following properties

(a) High resistivity.
(b) High flexibility.
(c) High dielectric strength.
(d) Non-inflammbility.
(e) Non-hygroscopic (Having little or no tendency to absorb moisture)
(f) Highly resistive to moisture, acids or alkalies.
(g) Capacity to withstand high rupturing voltages and high temperature without much deterioration.

The various types of cable insulating material used are:

(1) Rubber

Rubber may be natural or synthetic. Its relative permittivity is between 2 and 3 and its dielectric strength is 30KV/mm. Though it possesses high insulating qualities but it absorb moisture readily, softens when heated to a temperature of 60° ~~or~~ 70°C, swells under the action of mineral oils and ages when exposed to light, hence pure rubber can't be used as insulating material.

(2) Vulcanized India rubber: It does not absorb moisture from the atmosphere, water proof when new and remain so for a number of years. The main drawback with VIR is that owing to sulphur content it attacks copper and, therefore in cables using VIR insulation the copper conductor is tinned before providing the insulation sometimes a layer of pure ~~copper~~ rubber is also given on the conductor to protect it from sulphation.

(3) Impregnated paper : It is quite cheap, has low capacitance, high dielectric strength (30 KV/mm) and high insulation resistivity (order of $10^5 \Omega$-m).
The main advantage of paper insulation over VIR insulation is that it is superior in heat conductivity and is capable to withstand higher temp. without deterioration. The only disadvantage with paper insulated cable is that it is hygroscopic and even if it is impregnated with compound, it absorb moisture, which lowers its insulation resistance. That is why paper insulated cable are always provided with some sort of protective covering and are never less sealed.
Paper insulated cables are rarely used nowadays as PVC and XLPE insulated cables are predominantly used. ↳ cross-linked polyethylene

(4) Polyvinyl chloride (PVC) : It is a synthetic compound. It is inert to oxygen and almost inert to oils and to many alkalies and acids and therefore, its use is preferred over VIR in extreme environment such as in cement factory or chemical factory. The mechanical property of PVC are not good as those of rubber.
* Usually employed for low and medium voltage domestic and industrial lights and power installations. It is low in cost compare to other.

(5) * Silk and cotton : This is used in low voltage cables. The conductor may have a single layer or double layer covering depending upon the requirement of service.
* Silk or cotton covered wires are usually used for instruments and motor windings.

Mechanical protection:

As all the insulating materials used in the manufactun of cables are mechanically weak, they require some form of protection against mechanical injury. Power cables are provided with two layers of steel tape. With regards to ordinary main cables, an aluminium sheathing is used.

(6) Enamel insulation.

It is a very fine quality insulation. wires of enamel coating are used for instrument and motor winding. Enamel insulatin is liable to crack.

(7) varnished cambric: (Empire tape)

It is varnish coated and impregnated cotton cloth. The Cambric is lapped in the form of a tape on the conductor and its surfaces are coated with petroleum jelly compound to give easy sliding of the surfaces. such cables require protective covering like lead sheath because it is hygroscopic

(8) gutta-percha: It's properties are similar to rubber but it becomes soft at about 65°C. It is non-hygroscopic but can't withstand even medium voltages. Its use is limited to telephone and telegraphic cables.

Types of cables used in internal wiring:

Acc^n to conductor material used in cables, these may be divided into two classes known as coppor conductor cables and aluminium conductor cables

Acc^n to the number of cores, the cable consist of, the cables may be divided into classes known as single core cables, twin core cables, three core cables, two core with ECC (Earth continuity conductor) cables etc.

According to voltage grading the cables may be divided into two classes (a). 250/440 volt cables

(b) 650/1100 volt cables.

Acc^{n} to type of insulation the cables are of the following types:

(a) Vulcanized indian rubber (VIR) insulated cable
(b) Tough rubber sheathed (TRS) or cab tyre sheathed cables
(c) Lead sheathed cables
(d) polyvinyl chloride cables
(e) weatherproof cables
(f) flexible cords and cables
(g) XLPE cables

(a) Vulcanised indian rubber cables :-

Tinned copper conductor covered with a layer of VIR insulation. over the rubber insulation cotton tape sheated covering is provided with moisture resistant compound bitumin wax or some other insulating material for making the cables moisture proof. The thickness of rubber insulation depends upon the voltage grade for which the cable is require

The copper conductor is tinned to provide protection against corrosion due to presence of trace of sulphur / zinc oxide and other mineral ingradient in the VIR.

(b) Tough rubber sheathed cables : These cables are available in 250/440 volt and 650/1100 volt grades and used in CTS wiring. TRS cable is nothing but a vulcanized rubber insulated conductor with an outer protective covering of tough rubber, which provides additional insulation and protection against wear and tear. These cables are waterproof, hence can be used in wet conditions. These cables are available as single core, circular twin core, circular three core with an EFC. The cores are insulated from each other and covered with a common sheathing.

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③ Lead sheathed cables

These cables are available in 240/415 volt grade. The lead sheathed cable is a vulcanised rubber insulated conductor covered with a continuous sheath of lead. The lead sheath provide very good protection against the absorption of moisteere and sufficient protection against mechanical injury and so can be used without casing or conduit system.

④ Polyvinyl chloride insulated cables

These cables are available in 250/440 volt and 650/1100 volt grades and are used in casing-capping, batten and conduit wiring system. since pvc is harder than rubber, pvc cable does not require cotton taping and braiding over it for mechanical and moisteere protection.

pvc coated wires gives smaller diameter of cable and therefore more number of wires can be accommodated in the conduit of a given size in comparison to VIR or CTS wires.

⑤ Weather proof cables : These cables are used for outdoor wiring and for power supply or industrial supply These cables are either pvc insulated or vulcanised rubber insulated conductors being suitably taped, braided and then compounded with weather resisting material. These cables are available in 240/415 volt and 650/1100 volt grades. These cables are not affected by heat or sun or rain.

Although TRS cables can be used for outdoor purpose but due to their higher cost, wheather proof cables are generally used for outdoor services.

(6) Flexible cord and cables :-

The flexible cords consist of wires silk/cotton/plastic covered. plastic cover is popular as it is available in different pleasing colours. flexible cords have tinned copper conductors. Flexibility and strength is obtained by using conductors having larger number of strands. These must not be used in fixed wiring.

Current rating of copper conductor single core cable :

Nominal area in mm²	Number and diameter of wire in mm	single phase a.c (amp)	three phase a.c (amp)
1	1/1.12	5	5
1.5	3/0.737	10	10
2.5	3/1.06	15	13
4.0	7/0.737	20	15
6.0	7/1.06	28	25
8	7/1.12	36	32
10	7/1.40	43	34

copper conductor flexible cord :

Number and diameter in mm	Nominal area in mm²	current rating: circular type	current rating: twin-twisted type
14/0.193	0.387	2	2
23/0.193	0.645	4	3
40/0.193	1.017	7	5
70/0.193	1.936	13	10
110/0.193	3.043	18	15

⑦ XLPE cables :

PVC and XLPE cables are built of insulation made of polymers. polymers are substances consisting of long macro molecules built up of small molecules or groups of molecules as repeated units. These are divided into homopolymers and copolymers. Homopolymers are built by reaction of identical monomers. copolymers are built up of at least two different kinds of monomers.

Homopolymers → PVC, polyethylene, polypropylene

Copolymers → polyamide → nylone
polyesters

HOOC — R — COOH

made by reaction of a dicarboxylic acid with a diamine.

Advantage of PVC cable over other type :

① Non-hygroscopic insulation almost unaffected by moisture
② Excellent fire resisting qualities
③ good ageing characteristics

Advantage of XLPE cables over PVC and all other.

* higher current rating
* Longer service life
* Low dielectric loss
* crack resistance increased
* Can withstand 130°C for short time.

Cable specification code :

Aluminium Conductor → A
XLPE insulation → 2X
Round steel wire → W
PVC outer sheath → Y

(10)

multi strand cables :

① multi-strand cables are more flexible and durable and therefore, can be handled conveniently.

② The surface area of multi strand cable is more as compared to the surface area of equivalent single solid conductor, so heat radiating capacity being proportional to the surface area is more

③ Skin effect is better as the conductors are tubular, specially in case of high frequency

* The number of strands in stranded cable must be 3, 7, 19, 37, 61, 91 and so on in order to obtain a circular contour.

* The section of a 3-strand cable is a three circles touching one another, the centres of which are the corners of an equilateral triangle.

* A 7 strand cable has one central wire with 6 wires surrounding it.

* The 19 strand cable has another 12 wires surrounding the 7-strands; the 37-strand cable has another 18 wires surrounding the 19-strands and so on. It is seen that each layer of wires has always 6 more wires in it than the layer beneath it.

* The various conductors are spiralled round the central conductor and when there is more than one layer, alternate layers are spiralled in opposite directions. This is to prevent "bird caging" when the conductor is bent.

* Since the length of each spiralled conductor (11) is greater than the central strand and the current flows along the various conductors, resistance is increased (11)

* The nominal cross section is the area of the X-section of one conductor in a plane perpendicular to its length multiplied by the number of conductors.

* The size of a cable can be given by a designation giving number of strands and gauge number of each strand. For example a cable having 3 strands each of gauge 20 SWG may be referred as 3/20. Numerator indicates the number of strands employed and denominator indicates the gauge number of each strand.

The size of cables, may also be given in terms of number of strands and diameter of each strand in mm. For example a cable having 19 strands, each strand of diameter 1.12 mm may be referred as 19/1.12 mm.

* The cable size is often denoted in terms of total cross-sectional area of the core instead of number and diameter of strands. As 19/1.12 mm cable has a cross section of 19.35 mm^2 so this cable is often referred to as a 19.35 mm^2 cable.

* Stranded wire will always have a slightly larger overall diameter than a solid wire due to gaps present between

Voltage grading of cables:

This specifies the safe voltage which the insulation of the cable can withstand. The cables employed for domestic wiring are graded as 650/1100 V

General Specification of Cables (12)

(i) Size of the cable in metric system (e.g 19/2.24, 7/1.70, 7/2.24, 7/2.50 etc) giving the number of strands used and diameter of each strand,

(ii) Types of conductor used in cables (copper, aluminium)

(iii) Number of cores that cable consists of e.g single core, twin core, three core, twin core with ECC etc.

(iv) Voltage grade (240/415 V or 650/1100 V grade)

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main switch and distribution boards :

As per indian electricity rule 50 a suitable linked switch (a switch operating simultaneously on phase or line and neutral) is to be provided immediately after the meter board. This rule also state a suitable cutout must be provided just after the linked switch to protect the circuit against excessive current.

* switch fuse is a combined unit and is known as an iron clad switch, being made of iron. It may be double pole for controlling single phase two wire circuits or triple pole for controlling three phase, 3-wire circuits or triple pole with neutral link for controlling 3 phase, 4 wire circuits. The respective switches are known as double pole iron clad (DPIC), triple pole iron clad (TPIC) and triple pole with neutral link iron clad (TPNIC) switches.

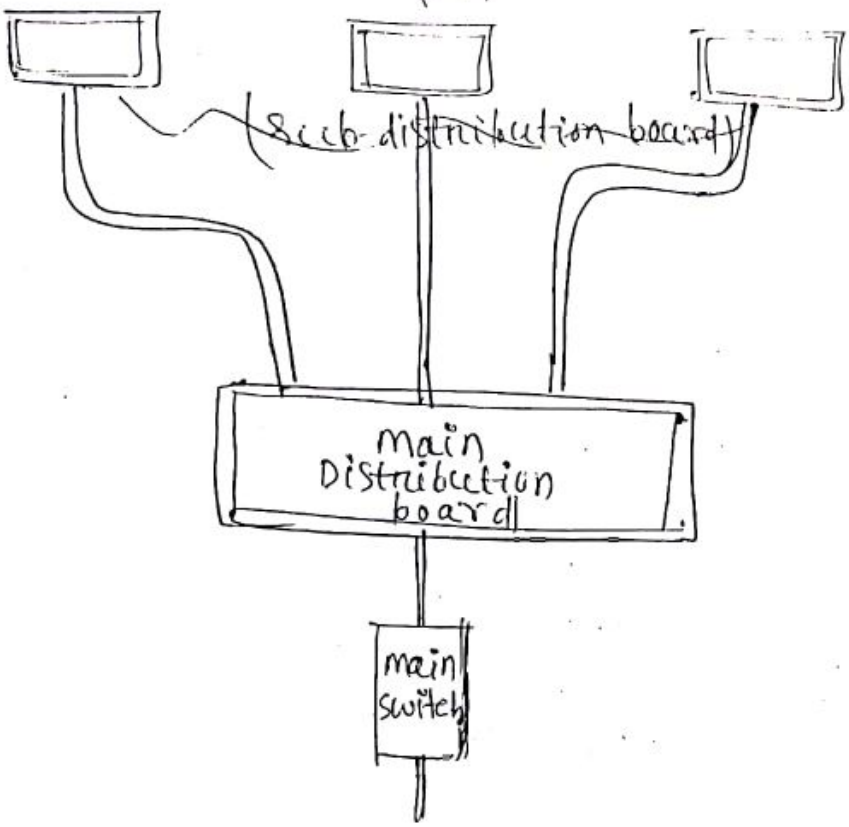
since no fuse is to be provided in neutral (Rule 32) where provision is made for fuse in both the wires, one fuse carrier is fernished with fuse element and other with a thick copper wire.

* For two-wire DC circuit or single phase A.C. circuits: 240V, 16A, DPIC switch fuse of any make approved by IS.

* For three $ wire DC circuit 500V, 32A (63/100) Is approved TPIC switch fuse.

* For three phase balanced load circuit (415V, 32A) Is approved TPIC switch fuse.

(14)

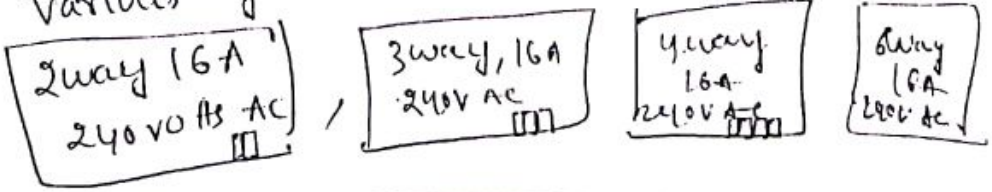


Distribution board:

is an assembly of parts, including circuit breakers, arranged for distribution of electrical energy to various circuits or to the other distribution boards known as submain distribution boards. The boards are usually metal cased in sheet steel or hard wood-cased in oak or teak. The door may be solid or glassy/glazed. The earthing terminal and locking must be provided.

* The number of ways depends upon the circuits or sub-circuits to be fed.
* Separate distribution fuse box should be provided for light and power circuits.

Various types of fuse boards



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Specification of fuse board (15) (15)

for medium size residential building

6 way, 16A, 240V ICDB of any make approved by Is.

For motor installation:

6 way, 415 V, 300A, Triple pole with neutral link ICDB of any make approved by Is

* Fuse board or distribution board must have a locking arrangement.

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Definations :

(1) Ampere :

A solution of silver nitrate ($AgNO_3$) in water is used. The steady state current that deposits silver at a rate of 0.001118 gram per second from the soln is taken as the unit of current and is called one ampere.

(2) Accessible : within physical reach without the use of any appliance or special effort.

(3) Apparatus : means electrical apparatus includes all machines, fitting accessories. Eg - motor, Transformer etc.

(4) Bare : Not covered with insulating material.

(5) Cable : wires refers to single conductor where as cable refers to two or more conductors each provided with its own insulation ~~jacket~~ packed together

(6) Circuit : It is an arrangement of conductor for the purpose of transfer of energy.

(7) Circuit breaker : A device capable of making and breaking the circuit under all condition, so designed as to break the current automatically under abnormal condition.

(8) Conductor : Any wire, cable, bar, used for conducting energy.

(9) conduit : rigid or flexible metalic tubing, mechanically strong and fire resisting tube in which a cable or cables may be drawn for the purpose of affording them mechanical protection.

cut-out : means any appliance for automatically interrupting the transmission of energy through any conductor when the current rise above a pre-determined amount, and shall also include fusible cut-out.

Danger : means danger to health or danger to life from electric shock, burn to person or property

Dead :- means at earth potential and disconnected from any live systems

Earthed : means connected with the earth to provide immediate discharge of energy without danger.

live : Electrically charged

span : Horizontal distance between two adjacent supporting point of an overhead conductor

street box : A totally enclosed box structure either above or below ground containing apparatus for transforming, switching, controlling energy flow

switch : manually operated device for opening and closing or for changing the connection of a circuit.

switch gear : Denotes switches, breakers, cutouts and other apparatus used for operation, regulation and control of circuits.

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Volt: Unit of electro-motive force and is the electric pressure which when steadily applied to a conductor which resistance is one Ohm will produce a current of one ampere.

voltage: Difference of electrical potential measured in volts between any two conductor

Low voltage → voltage does not exceed 250 volts

medium voltage → voltage does not exceed 650 volts

High voltage → " " " " 33KV under normal condition.

Extra high → voltage exceed 33KV under normal condition.

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(16) Conduits:

In general conduits can be classified as:

(i) Light gauge steel-plain (screwed) conduit
(ii) Heavy gauge steel screwed conduit
(iii) flexible conduit
(iv) pvc conduit.

(i) Light gauge steel conduit:

Used on the surface especially in connection with special grip fittings. It is available with an external diameter of 12mm, 16mm, 19mm, 25mm, 31mm, 38 mm, 50 mm.

* fittings are of the pressed steel lug grip type which clamp the conduit on the tightening of the lug screws.

* Electrical continuity can be obtained by removing enamel coating from the conduit ends

* These are cheapest and quickest of the conduit installation but should be used where location is dry and there is little likelihood of mechanical damage.

(ii) Heavy gauge screwed steel conduit:

It is expensive but provide permanent installation with a maximum protection for the cables. The joints into fittings are by means of screw thread which provide good mechanical strength and electrical continuity.

* There are two types of heavy gauge conduit; welded and solid drawn. Both types can be obtained with enamelled surface (Black/silver grey) or rust proofed by either galvanizing or sheradizing.

by coating zinc

(b) These are available in approximate 3 meter lengths and are threaded at the two ends. The threads are usually tapered (Thickness reduce towards one end) and are provided with a coupling on one side. These can be joined together to form one continuous run.

Flexible steel conduit: Consist of light gauge galvanized steel strip spirally wound and interlocked, so as to form a tube. It is made in sizes from 19mm to 50 mm internal diameter, and in two grades non-watertight and watertight. It is provided with an exterior covering of corrugated sleeving.

The flexible conduits are available in a length up to 250 meters, so no coupling is required and hence no threading. since the conduit are flexible and are easily bent, no elbow is required. For connecting the flexible conduit to ordinary conduit special brass adaptors are used screwed and soldered.

one of the most common used of flexible metal conduit is for protecting the final connections to motors. The flexibility of conduit permits any necessary movement of the motor.

* It has the additional advantage of reducing the transmission of vibration. However the flexible conduit is costlier than the rigid conduit.

PVC conduit: This type of conduit has wide application in internal wiring because it is light in weight, shockproof, anttitermite, self fixing, and fire resistant, acid, alkali and corrosion resistant having high insulation value and dielectric strength.

Such conduits can be used for surface or concealed type wiring, conduits may be joined by the screwed or plane type couplers (socket) depending upon

conduits are of screwed type or plain type. In long reen of conduits, inspection type couplers are provided.

* spacing shall be at every 60 cm, instead of 1m in case of metalic conduits.

* such conduits are particularly useful in installation where the problem of corrosion is serveriane.

Conduit accessories and fittings:

* Conduit couplers: conduit is available in length from 3 meters to 5 meters and for straight reers of greater length, couplers are used to join two lengths of conduits. The length of screwed conduit are always threaded at both ends on outer side. The threads on conduits are usually tapered. If shorter length are required then they must be cut off with a hacksaw, and threaded with a die. one coupler is supplied free of cost with each length of conduit by manufacturer. The couplers are thread on its inner surface.

Another method of coupling of light gauge conduit is by means of grip coupler. The ends of conduits are placed in the grip coupler and screwes tightened.

flexible conduits are coupled by means of similar grip couplings having two or more screws.

(19) For coupling a flexible conduit to the rigid conduit a combined coupling is used. The coupler employed for this purpose has threaded hole on one side to receive threaded end of the rigid conduit and has a large hole to receive the flexible conduit on the other side

Bends, Elbows and Tees:

Bends: are usually used for change in direction of conduit. These should never be sharp. For normal bend, the radius of the bend should be atleast six time the internal diameter of the conduit. A bender is used to bend conduit

Elbows: Are used where sudden right turn is required. It provide 90° bend to the conduit. The ends of the Elbows are threaded from inside to receive conduit ends with it.

Tees: It is a pipe fitting which is T-shaped having two outlets, at 90° to the connection to the mainline.

Conduit bushing: These are used when the rigid conduit enters the conduit box. These are used to prevent cable from being cut by the edges. These are made either from malleable iron or steel. These are of two types male and female. male bushes are provided threads on their upper surface and female bushes are provided threads on their inner surface.

Conduit reducers: Are used when size of conduit changes. It has both male and female thread.

Fixing of conduit:

clips are used for fixing the conduit on bricks wall saddles are used for fixing when clips can't provide enough hold.

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Conduit boxes :

These are used for both surface conduit wiring and concealed conduit wiring. These serve the following purpose

> For proving connection to light, fan, and other points. They conduit boxes serving this purpose are known as outlet boxes because conduit terminates at these boxes. These boxes may have entry either from side or from back or from both sides.

> for pulling of cables in to the conduits. The boxes serving this purpose are known as inspection boxes on account of removal covers provide facility for drawing of cables.

> For housing junction of cables. The conduit box serving this purpose are known as junction box.

* wooden boxes are not permitted for switches in conduit wiring, when the thickness of the wall is not enough to permit use of deep boxes, use of shallow iron boxes may be made. The disadvantage of shallow iron box is that less space is available for wiring.

different types of junction box available are

> terminal junction.
> two way junction.
> Three way junction.
> Four way " .

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(2) Saddle : The conduit must be rigidly held with the wall and minimum damage is done to the walls. It has two holes for fixing it with wall on both side. The conduit is held within its curved surface

Clip : It is very similar to the saddle with the difference that only one row of fixing holes in the wall required. its grip may not be as firm as that of saddle.

Advantage and disadvantage of conduit wiring system :

Advantages :

> It provide complete protection against fire due to short circuits
> It provide protection against mechanical injury to cable.
> replacement of defective wire within the switch board is easy.
> It looks beautiful.

Disadvantage :

> It is very costly
> Highly skilled workmanship is required

Lighting accessories and fittings:

Switches: A switch is used in an electric circuit as a device for making or breaking the electric circuit in a convenient way i.e. by the simple motion of a knob or handle to connect together or disconnect two terminals

Acc^n to the type of base material they are classified as porcelain or bakelite switch.

Acc^n to colour of base they are either white or black or brown.

Acc^n to operation required they are classified as one-way switches, two way switches, double pole switches, two way centre off switches..

(*) **one way switches:** The switch is always connected in series with the point (lamp, fan or socket outlet to be controlled). The switches usually available are for use upto 250 volt and 5 or 6A: If either of the two is increased, the switch may get damaged due to sparking. They are having 2 terminals.

* **two way switches:** The switch of this type consist of four terminals, two of them being short circuited inside the switch. The switch of this type is usually used for stair case wiring or circuit where one point is to be controlled from two different places.

* **two-way centre off switches:** In the centre it becomes off. Such switches are used when two lamps are to be operated alternately.

* **Double pole main switches:** This is a combination of two one way switches which can be operated simultaneously as the on-off terminals of both the switches are connected together by a handle made of bakelite. It is used for supply voltage of 250 volts and load of less than 5 amp, if it exceed DPIC switch is used

(v) push button switches: such switches are used for controlling the electric bells; when the knob is pressed, the circuit is completed and bell rings and as soon as the knob is left, circuit becomes open.

(vi) Table lamp switches: This is a small on-off switch which is commonly used in table lamps.

switches are of two types known as (a) surface switches (tumbler switch) and (b) flush switches (concealed switch)

Tumbler switches: These switches are directly fixed on the surface of the wall. Such switches project out of the surface of the wall and are in common use.

surface switches are available in round and oblong base. Round base switches are cheap and in common use. oblong surface switches are good in appearance, but being costly rarely used.

(b) flush switch: These switches are fixed to the wall and do not project out. These switches are used where high quality performance and appearance are required. These switches are enclosed in an iron box recessed into the wall.

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The specification for controlling 240 V lamp are given below:

6A, 240V, single way, bakelite base, round shape, black colour, tumbler switches of any make approved by IS.

ceiling rose: used to connect the pendant lamps, fans or fluorescent tubes to installation through flexible plastic or silk covered wire. It consist of two parts known as base and cover. The base may be of bakelite or porcelain and is fitted with two or more terminal plates separated from each other by a porcelain or bakelite bridge.

socket outlets: socket outlets are used to supply electrical connection wherever required for electrical appliance such as TV, radio, table lamp, table fans, irons, etc.

socket outlet are of two types. Two pin and three pin type. Two pin socket outlet has insulated base with two terminals where two pin can be easily inserted. These pins are used for 6 amp rating.

Three pin socket outlet has got three hollow terminal in which three pin can easily be inserted but not loosely two holes, being of same size, are meant for phase and neutral whereas third one which is bigger comparatively is meant for earth connection. 3 pin socket outlets are also of two types ① 6A for table fan, table lamp, TV, and 16A for power circuit as heater, geyser, iron etc.

plugs: plugs are used to collect the supply from the socket outlets for electrical ~~appliation~~ appliances such as table lamp, fan, stove, iron, heater etc. These are of two types two-pin and three pin type. Three pin type plug consists of three pin usually made from brass. The cover and base may be of bakelite or of rubber or ever material

(25)
Lamp holders :- The function is to support the lamp. These are designed for quick removal and replacement of lamp.

Acc^{n} to size of the lamp holders are of three type (i) Bayonet cap (BC)
(ii) Medium Edison Screw (ES)
(iii) Goliath Edition Screw

for ordinary tungsten filament lamp upto 200 watt the lamp caps and thus the lamp holder are bayonet cap ; upto 300 watts the caps are Edison screw and above 300 watt they are goliath edition screw.

Lamp holders may be either of brass or bakelite type with porcelain interior. Brass holders are more durable but may give shock if connections are poor. Bakelite holders are not durable, but they are safer.

The lamp holder may also be classified into
(a) batten holders
(b) pendant holder
(c) Angle holder
(d) slanting holder
(e) Bracket holder
(f) water tight bracket holder
(g) miniature lamp holder.

(4) Batten holders: used when the lamp is to be fitted to the roof or to the wall and they are directly fitted either to batten or to wooden board.

* pendant or cord grip holder: is used when the lamp is to be suspended from a flexible cord. such a lamp holder is hanged vertically downward from the ceiling with the flexible cord, one end of which makes electrical connection with the ceiling rose and other with the lamp holder/lamp.

* Angle holders: These lamp holder are used when the lamps are to be fixed up directly on the wall and to give light at an angle.

* watertight bracket holders

such lamp holders are provided with tubular glasses fixed with watertight cover. such lamp holders are used outside the houses and for street lighting where there is no cover to save the bulb from falling of water over it.

Bracket holders: These lamps are used to give direct light in the room or above a particular place. These can't be fixed on the roof or made to hang, usually these are fixed on the wall.

Slanting holders: used for lamps to be fixed on advertising boards, floodlight (used to illuminate outdoor playing field), etc. Such lamp holders are used along with shades so that light is concentrated on the material displayed and does not trouble the viewers.

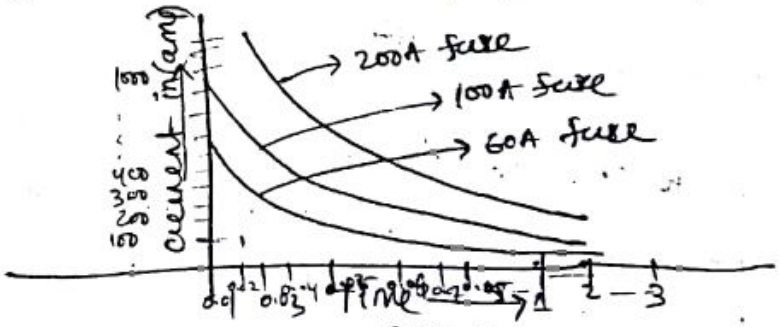
Miniature lamp holder: for small night bulb, also used for decorating bulb.

Specification of holders: 15A, 240V, bakelite, bayonet type, bracket lamp holder of any make approved by ISI.

Fuse: It is a device used for interrupting an electrical circuit under short circuit, or excessive overlo

* The action of a fuse is based upon the heating effect of the electric current. In normal operating conditions, when the current flowing through the circuit is within safe limits, the heat developed in the fuse element carrying this current is readily dissipated into the surrounding air, and therefore, fuse element remains at a temperature below its melting point. However, when some fault, such as short circuit occurs or overload occur the current exceeds the limiting value, the heat generated due to this excessive current can't be dissipated fast enou and the fusable element gets heated, melts and breaks the circuit. It thus protects a machine or apparatus or an installation from damage due to excessive current.

* The time for blowing out of fuse depends upon the magnitude of the excessive current, larger the current the more rapidly the fuse will blow i.e. the fuse has inverse time-current characteristic



Essentially, a fuse consists of a fusible element (wire) in the form of a metal conductor of specially selected small cross-sectional area, a case or cartridge to hold the fusible element, and in some cases, provided with a means to aid arc extinction The part which actually melts and opens the circuit is known as fuse element. The elec. appliance need to be protected from overcurrent is connected in series with the fuse.

fuse has the following advantages and disadvantages

Advantages:

(i) It is the cheapest form of protection available.

(ii) It needs no maintenance.

(iii) Its operation is inherently automatic

(iv) It interrupts enormous short circuit current without noise, flame, gas or smoke.

(v) The minimum time of operation can be made much smaller than that with the circuit breaker.

(vi) Its inverse time-current characteristic enables its use for overload protection.

Disadvantage:

(i) considerable time is lost in rewiring or replacing a fuse after operation.

The function of fuse wire is (i) to carry the normal working current safely without heating and to break the circuit when the current exceeds the limiting current.

fuse element material:

The material used for fuse elements must be of low melting point, low ohmic loss, high conductivity (low resistivity), low cost, and free from deterioration. Tin, lead or zinc are most preferable fuse element.

No material posses all the desirable characteristic [291] for instance lead has low melting point but it has high specific resistance and it is liable to oxidation. similarly copper has high conductivity and low cost but oxidises rapidly. Thus a compromise is required to be made in the selection of material for a fuse element.

The material commonly used for fuse elements are tin, lead, silver, copper, zinc, aluminium and alloy of lead and tin. An alloy of lead and tin (lead 37% + tin 63%) is used for small current rating fuses (say not beyond 15A) beyond 15A rating circuits copper wire fuses are employed copper suffer from the disadvantage that premature melting of the wire may occur. tin is added as a protective cover for the protection of copper against oxidation.

The present trend is to use silver as fuse element owing to its following advantages

(i) It does not get oxidised

(ii) High conductivity

(iii) The transition from melting to vaporisation is nearly instantaneous.

Either copper or lead-tin alloy is mostly used as an ordinary fuse wire.

metal	melting point (°c)	Specific resistance (Ωm)
silver	980	16
tin	240	112
zinc	419	60
lead	328	210

(30)

Necessity of fuse in an electric circuit :

If no fuse is provided in the circuit then a dangerous situation would be created on developing of faults such as overload, short circuit or earth faults.

In case of overload, short circuit and heavy earth faults a heavy current will continue to flow through the conducting apparatus, due to continuous flow of heavy current through the cables or wires or apparatus etc these will get heated up and so get damaged. The fire may also break out.

If the fuse is provided on neutral wire in place of live wire, then in abnormal conditions though the fuse will blow out but the lamp or other apparatus still remain connected to the live wire and in case some leakage some trouble will arise and cause a considerable damage.

If fuses of same capacity are provided on the phase wire and neutral wire, then in case of short circuit fault, one of them will blow out first. If the fuse on neutral wire blows out first the fuse in phase line remain intact and faulty apparatus still remain connected to live. If some person comes in contact with the faulty apparatus he/she is liable to get electric shock.

So fuse is provided only in phase or live pole never on neutral pole.

Types of fuses :

(i) Supply main fuse : This fuse is provided by the supplier and is fixed just after the service meter and sealed by him. The seal can be broken only by authorized person of the supply authority in case of blowing out of fuse for the purpose of replacement. The rating of the supply main fuse will be as per load current of the consumer.

(ii) consumer main fuse : This is another fuse of rating slightly less than that of supply main fuse provided by the supplier and placed after the consumer main switch. In case of exceeding of current than normal current consumer fuse, which can be replaced by him, may blow and supply main fuse may remain intact

(iii) Sub-circuit fuse :
A separate fuse is provided for each branch circuit and is known as sub circuit or branch circuit fuse.

(iv) point fuse :
In good quality indoor wiring of buildings every light and plug point is provided with its individual fuse known as point fuse.

Some important defination :

current rating : It is defined as the rms value of the current which the fuse wire can carry continuously without deterioration, and with temp. rise within specified limits.

Fusing current:

It is defined as the minimum value of current at which the fuse element or fuse wire melts, its value is more than the current rating of the fuse element.

Fusing current depends on various factor.

(i) Types of material used

(ii) The X-sectional area i.e. whether round or rectangular

(iii) length of conductor

(iv) Diameter of wire

Number of wires	fusing current (amp)
1	1 amp
2	1.667
3	2.25

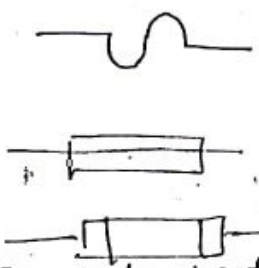
* fusing factor: The ratio of minimum fusing current and the current rating of fuse element is known as fusing factor and it is always greater than unity.

for a standard cartridge fuses fusing factor is equal to 1.45.

* Breaking capacity / Rupturing capacity

Is the current that a fuse can able to interrupt without being destroyed

Symbol :



IEEE standard

(IEC standard)

Table lamp

230V / 40W

$I = P/V$

$= \frac{40}{230} = 0.17\ A$

Toaster

800W / 230V

$\frac{800}{230} = 3.48\ A$

Determination of size of fuse wire :

The factors responsible for determining the size of fuse wire in an installation are

(i) maximum current rating of the circuit

(ii) current rating of the smallest cable in the

for an ordinary lighting sub-circuit wired with 1/1.12mm or 3/0.736 mm cable a fuse wire of 21 SWG, tin-lead alloy (having current carrying rating of 5 amp) is used.

for a power circuit (say 2 kW) wired with 8 SWG ← 7/0.736 mm cable (having current carrying capacity of 15 amp) for 240 volt supply, fuse wire used of current rating 2000/240V = 8.33 amp ~~not~~ not of 15 amp i.e. 29 or 30 SWG not 25 SWG.

* The size of the fuse must be decided acc to the rating of the cable and not acc to total load of the circuit.

* If cable of higher size is used in order to keep the voltage drop in the circuit within permissible limits, then the size of the fuse must be decided

as per circuit load and not according to rating of cable.

SWG	diameter in mm	current rating (amp)	Fusing current
40	0.122	1.5	3
39	0.132	2.5	4
38	0.152	3	5
37	0.173	3.5	6
36	0.193	4.5	7
35	0.213	5	8
30	0.315	8.5	13
29	0.355	10	16

VVIMP

Fuse unit :

The various types of fuse unit available are

(i) Round type fuse unit
(ii) Kit-kat type fuse unit
(iii) cartridge type fuse unit
(iv) HRC (High rupturing capacity) fuse
(v) Semiconductor fuse unit.

Round type fuse unit : This type of fuse unit consists of a porcelain or bakelite box and two separated wire terminals for holding the fuse wire between them.

Disadvantage (i) During replacement one need to off the main switch
(ii) Appreciable arcing takes place at the instant of blowing off fuse

They are available in 1A, 2A, 3A, 5A, 7A, 10A, 13A etc ratings.

3. Rewirable or Kit-Kat type base:

It consist of a porcelain base carrying the fixed contacts to which the incoming and outgoing live or phase wires are connected and a porcelain fuse carrier holding the fuse element, consisting of one or more strands of fuse wire.

* The fuse carrier is a separate part and can be taken out or inserted in the base without risk, even without opening the main switch.

* If fuse holder or carrier gets damaged during use, it may be replaced without replacing the complete unit.

* The fuse wire may be of lead, tinned copper, aluminium or an alloy of tin-lead. The actual fusing current will be about twice the rated current.

Standard ratings are 6, 16, 32, 63, 100 A etc.

Advantage → Easy removal or replacement without any danger of coming into contact with a live part and negligible replacement cost.

Disadvantages → > Unreliable operation
> Slow speed of operation → arcing time is more as no means are employed to extinguish the arc that blows after the fuse melt.

(3) Cartridge type fuse :- Totally enclosed type fuse unit. It consist of a bulb or tube shape insulating container and sealed at its ends with metallic cap known as cartridge enclosing the fuse element, and filled up with powder or granular materials known as filler like sand, calcium carbonate, quartz etc. The powder in the fuse cartridge cools and condenses the vapour and quenches the arc thereby interrupting the flow of current.

* It provides complete security against fire risk.
* Since it is totally enclosed it will not be possible to rewire and therefore, the whole unit will have to be replaced, once it blows out.
* The filling powder provides good insulating path and helps to extinguish the arc at the time of blowing up of fuse.
* This type of fuse available upto 660V and the current rating upto 800A.

High rupturing capacity fuse (HRC)/Link type fuse

(a) cartridge type HRC fuse

In that type of fuse, the fuse wire or element can carry short circuit heavy current for a known time period. During this time if the fault get removed then it does not blow off. otherwise, it blows off or melts. The enclosure of HRC fuse is either of glass or some other chemical compound. This enclosure is sufficiently airtight to avoid the affect of atmos

* The ceramic enclosure having metal end cap at both heads, to which fusible silver wire gets welded. There is a space within the enclosure, surrounding the fuse wire completely filled with a filling powder

* This fuse is reliable and inverse time characteristic

* when the over rated current flows through the fuse element of high rupturing capacity fuse the element is melted and vaporized. The filling powder is of such nature that the chemical reaction between the silver vapour and the filling powder forms a high resistance substance which is helpful in quenching the arc.

Tetra chloride type HRC fuse: It essentially consist of a glass tube filled with carbon tetrachloride solution and sealed at both ends with brass caps. mostly used for transformer protection. Inside the tube a high resistance fuse wire is sealed at one end of the glass tube and the other end of the fuse wire is held by a strong phosphor bronze spiral spring fixed to the other end of the glass tube. On short circuit or over load, the high resistance fuse wire melts and the arc produced is extinguished by carbon tetrachloride vapour.

Semiconductor fuse: These are very fast acting fuses for protection of thyristor and other electronic circuit.

Automotive fuse

used to protect the wiring and electrical equipments for vehicles. Generally rated for circuits of higher than 32 volts direct current. They are also called blade type fuse

(3.8)

Earthing conductor : It is of high conductivity copper and is either stranded, flat strips, circular or rectangular bar. It is protected against mechanical injury. Bare conductor is protected against corrosion. Galvanised solid iron or steel wire or rod or any other suitable approved material can be used provided the conductivity is not less than the copper earthing conductor.

Earthing system

Earthing means connections of the neutral point of a supply system or the non-current carrying parts of electrical apparatus, such as metalic framework, metalic covering of cables, earth terminal of socket outlet etc to the general mass of earth in such a manner that at all time an immediate discharge of electrical energy takes places without danger.

Earthing is provided to avoid electric shock to the human beings and to avoid risk of fire due to earth leakage current through unwanted path.

In an electric installation, if a metallic part of an electric appliance comes in direct contact with a bare or live wire (that may be due to failure of insulation) the metal being a good conductor of electricity is charged and static charge on it will accumulate. Now if any person comes in direct contact with this charged metalic part, he will get a severe shock. But if the metalic parts of the appliance are earthed, the charge will be transferred to the earth immediately, as the metalic part comes in direct contact with a bare or live wire. And as the discharge takes place to earth, the impedance of the path of the current is low, a large amount of current flows to earth, the instant, the current exceeds the limiting value, the fuse provided in the circuit will blow off and cut off the appliance from supply. Thus earthing of metalic parts of electrical equipment and appliance provides safety.

(40)

IS specifications regarding earthing of electrical installation:

(i) Distance from earth electrode:

An earthing electrode shall not be situated within a distance of 1.5 m from the building whose installation system is being earthed.

(ii) Size of the earth continuity conductor:

* The conductor by means of which the metal body of an equipment or appliance is connected to the earth, is known as earth continuity conductor (ECC).
* The cross section of earth continuity conductor should not be either less than $2.7\ mm^2$ (14 SWG).

(iii) Resistance of earth:

The earth resistance should be low enough to cause flow of current sufficient to operate the protective relays or blow fuses, in the event of an earth fault. The value of earth resistance does not remain constant but changes with the weather, as it depends upon the moisture content of the soil, and is maximum during dry season.

large power station → 0.5 Ω

major power station → 1 Ω

small substation → 2 Ω

In all other cases → 5 Ω maximum

Earth Continuity inside an installation i.e. from the earth plate to any point in the installation → 1 Ω

In case the earth resistance exceeds the permissible value, then in the event of earth fault, the fault current may not reach a sufficient value to operate the protective equipment (such as fuses or relays) and dangerous condition may arises.

* The earth wire and earth electrode will be of same material.
* Earth wire shall be taken through GI pipe of 13 mm diameter bor at least 30 cm length above and below ground surface to protect it against mechanical damage
* All the earth wire run along the various sub-circuits shall be terminated and looped firmly at the main board and from main board the main earth wire shall be taken to the earth electrode. The earth wire used for sub-circuit should not less than 2.9 mm^2 (14 SWG) or half the size of the sub-circuit conductor.
* The earthing electrode shall be placed vertically inside the earth pit so that it may be in contact with all the different earth layer.

Points to be earthed:

Acc^n to IE rules and IEE Regulation

(i) Earth pin of 3-pin lighting plug socket should permanently and effectively earthed.

(ii) All metal casing or metalic covering should be connected to earth.

(iii) frame of every generator, motor and metalic parts of a transformer should be earthed

(iv) The neutral conductor of a 3-phase, 4-wire system should be earthed.

(v) Transmission line towers, poles carrying overhead conductors should be earthed, stay wires should be earthed

Factors influencing earth resistance :

* condition of soil
* Temperature of soil
* moisture content of soil
* size and spacing of earth electrode
* Depth, at which the electrode is embedded.
* material of conductor
* quality of coal dust and charcoal in the earth electrode pit.

Methode of reducing earth resistance of the system :

The earth resistance can be considerably reduced by digging around the earth electrode to a depth of 1.5 m or 2 meter, cleaning the surface of earth plate or pipe of all rust and then filling with charcoal soaked in salt solution.

In summer season the pouring of fresh salt water (copper sulphate soln in case of copper plate earthing) through pipe over all the coal bed will reduce the earth resistance.

The additional steps for reducing the earth resistance of the system are increasing of plate area, increasing of pit depth and increasing of number of electrode in parallel.

Earth Electrode

Any coire, pipe, rod or metal plate embedded in earth for the purpose of making an effective connection with the general mass of earth is known as earth electrode.

Earthing lead

The coire which connect earth wire of apparatus to be earthed to the earth electrode is known as earthing lead.

Acc^{n} to ISI specification

* Copper wire of size not less than 8 SWG (12.9 mm^2) and not more than 64 mm^2 are used for earthing in case of small installation
* 14 SWG copper wire for domestic installation.
* Or half of the installation conductor size.

* The cross section of earthing lead, as a general rule, should not be less than half of the section of the main supply feeding the installation.

Methods of Earthing:

① Strip or wire earthing:

In this system of earthing, strip electrodes of cross section not less than 25 mm × 1.6 mm if of copper and 25 mm × 4 mm if of galvanised iron or steel are buried in horizontal trenches of minimum depth 0.5 meter.

If round conductors are used, their cross-sectional area shall not be smaller than 3 mm^2 if of copper and 6 mm^2 if of galvanised iron or steel. The length of strip shall not be less than 15 meter. If Cond^{n} require use of more than one strip, they shall be laid either

in parallel trenches or in radial trenches.
This type of earthing is used at places which have rocky soil earth bed because at such places excavation work of plate earthing is difficult.

(2) Rod earthing: In this system of earthing, 12.5 mm diameter solid rods of copper or 16mm diameter solid rods of galvanised iron or steel or hollow section 25mm GI pipes of length not less than 2.5 meters are driven vertically into the earth either manually or by pneumatic hammer. In order to increase the length of electrodes under the ground, which is sometimes necessary to reduce the earth resistance to desired value, more than one rod sections are hammered one above the other.

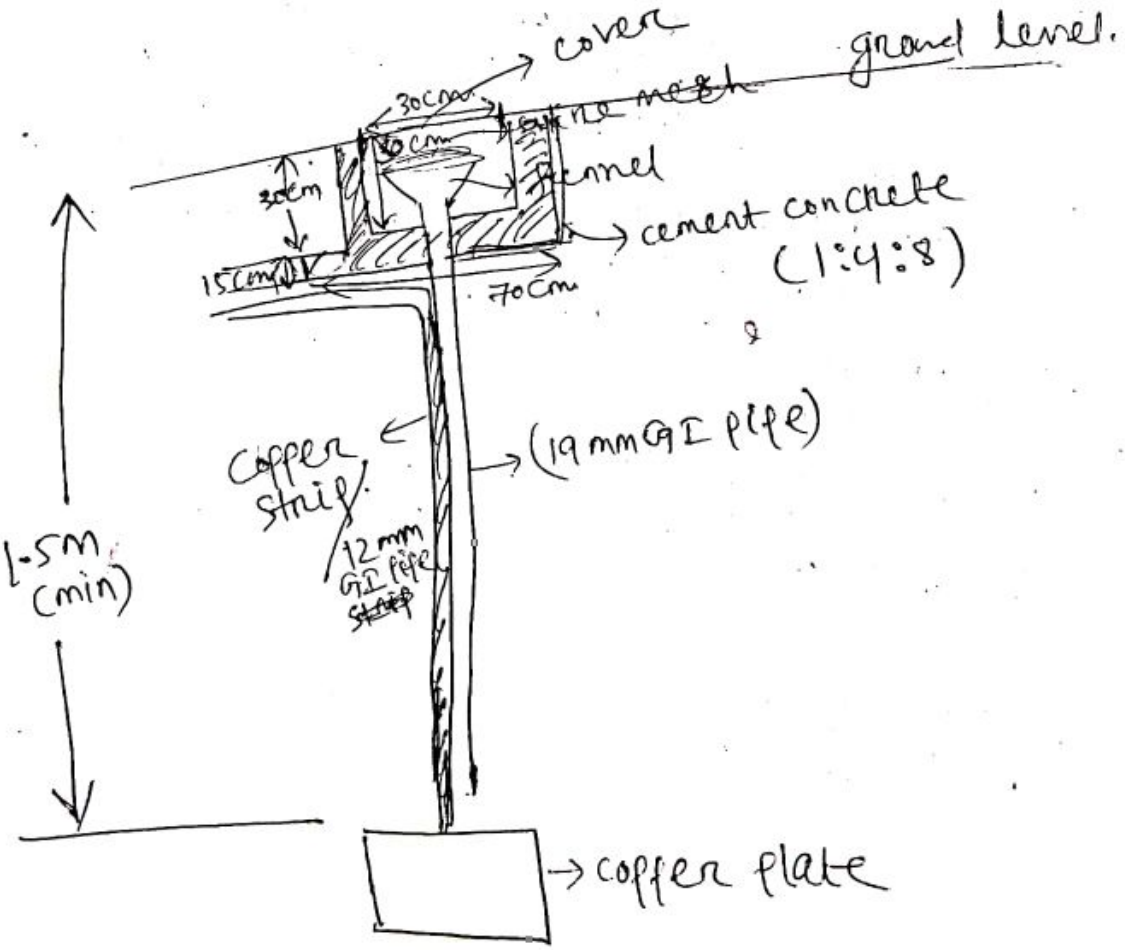
* This system of earthing is suitable for areas which are sandy in character. This system of earthing is very cheap as no excavation work involved.

(3) pipe earthing:
A galvanised steel and perforated pipe of approved length and diameter is placed upright in a permanently wet soil. The size of the pipe depends upon the current to be carried and type of soil. Usually the pipe used for this purpose is of diameter 38/40mm and 2.5 meter in length for ordinary soil and of greater length for dry and rocky soil. The pipe is placed at a depth of 3.75 meter (minimum)

* The pipe (145) at the bottom is surrounded by broken pieces of coke or charcoal for a distance of about 15 cm around the pipe for which in general 5 kg salt and 5-8 kg charcoal is used.
* Generally alternate layer of coal and salt are used to increase the effective area of the earth and to decrease the earth resistance respectively.
* Another pipe of 19mm diameter and minimum length of 1.25 meter is connected at the top of GI pipe through reducing socket.

Plate earthing: In plate earthing an earthing plate either of copper of dimension 60cm x 60cm x 3mm or of galvanised iron of dimension 60 cm x 60cm x 6mm is buried into the ground. The earth plate is embedded in alternate layers of coal and salt for a minimum thickness of 15 cm. The earth wire (GI wire) is securely bolted to an earth plate with the help of a bolt, nut and washer made of material of that of earth plate. The plate is placed vertical at a depth not less than 3 meters from ground level.

Specification of earth plate:
60cm x 60cm x 3mm high conductivity copper plate fitted with copper lug, bolt, nut and washer. The plate shall have reasonably clean and smooth surface, free from scratches, porosity, black oxide any other defects.



(4-5)

Effects of electric current on human body :

The maximum current at which the subject is still capable of releasing a conductor by using muscle directly stimulated by the current is called 'let go current'.

The 'let go current' could be taken approximately 9mA and 6mA for men and women respectively.

At current levels higher than the "let go current" the subject loses ability to control his own muscle action and he is unable to release his grip on the electrical conductor. Such current are very painful and hard to bear. This type of accident is called "hold on type" accident, and is caused by current in the range 20-100 mA. These current may also cause physical injury due to powerful contraction of the skeletal muscles, however, the heart and respiratory function usually continue because of uniform spread of current through the trunk of the body.

At about 100mA and above the heart ceases, pumping action stops and the pulse disappears.

At very high current of the order of 6A and above, there is a danger of temporary respiratory paralysis and also of serious burns. However, if the shock duration is of only a very few seconds there is a possibility of heart reverting to the normal rhythmic action.

It has been found experimentally that the safe value of current in amperes which a human body can tolerate is given as :

$$I = \frac{9}{t} \text{ mA for } t > 3 \text{ sec}$$

Determination of size of Earth wire and Earth plate for domestic and motor installation :

Earth plate is not required for domestic or low voltage installation. GI or copper wire of 8 SWG will be required to run from main distribution board to various sub-main distribution boards.

* from submain distribution board copper wire of 14 SWG will be required to run to three pin socket outlet and connected to their earth sleeve.

* In case of domestic installation supplier is required to provide and maintain a separate earthed terminal.
* In case of motor installations consumer is to provide his own earthing system. The size of earth wire and earth plate used will depend on rating of the motor for which it is to be used. The conductor used for earthing purpose should not be less than 14 SWG, and the copper earth wire should not be of size lesser than half of the largest current carrying conductor. GI wire may also be used but its conductivity is not lesser than that of copper conductor.

upto 10hp — wire		Electrode	
Size of earth wire		Size of Earth Electrode	
copper	GI	copper	GI
8	8	60 X 60 X 3mm	60cm X 60cm X 6mm
Above 10 HP and upto 15HP		-do-	-do-
copper	GI		
8	6		

materials required for GI pipe earthing (pg)

(1) 38 mm diameter GI pipe ⟶ 2.5 m

(2) 19 mm " " " for watering ⟶ 1.5 m

(3) 13 mm " GI pipe ⟶ 4 meter

(4) 6 SWG GI wire ⟶ 12 m, 1.2 kg

(5) GI lugs ⟶ 2 number

(6) 10 mm diameter 32 mm long GI bolt and nuts → 2

(7) 16 mm diameter 40 mm long GI bolt and washer → 2

(8) 13 mm diameter GI bends ⟶ 1

(9) 30 cm square cast iron frame

(10) 30 cm square cast iron cover

(11) funnel with wire mesh → 1

(12) charcoal ⟶ 10 kg

(13) common salt ⟶ 10 kg.

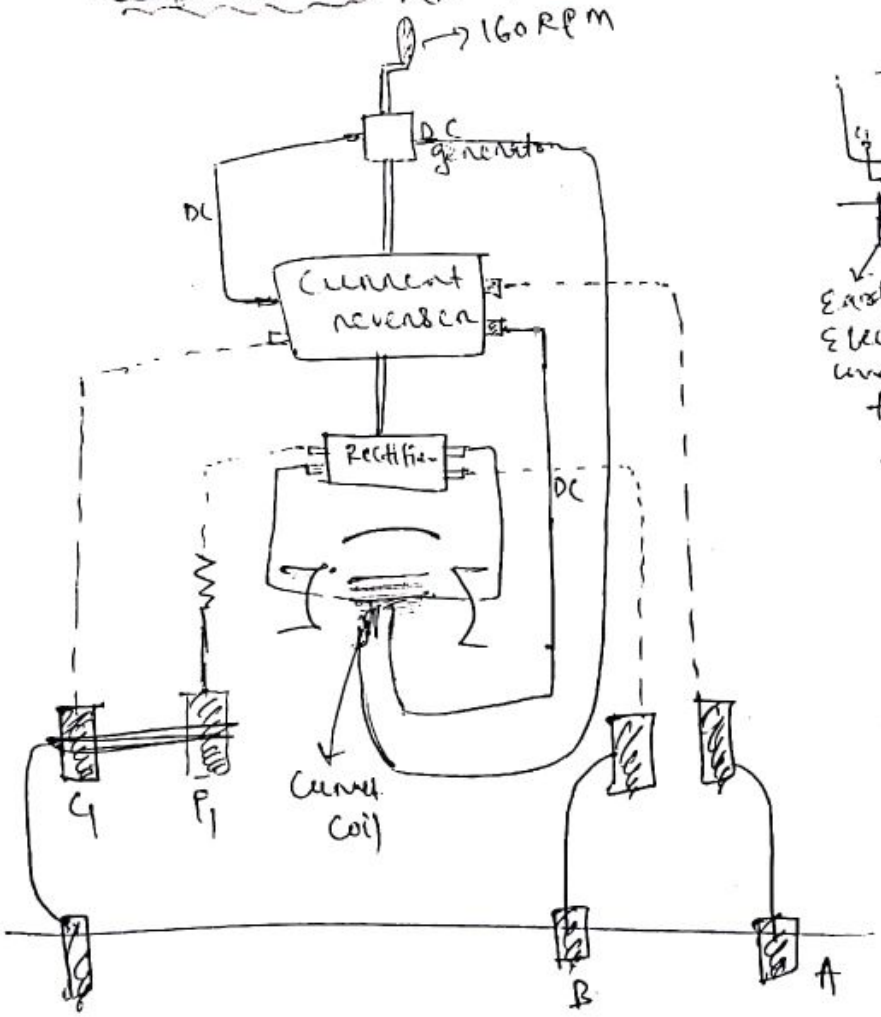
(14) cement concrete 1:4:8 → 0.15 m^3

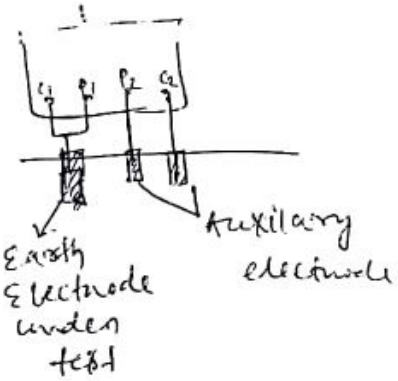
Specification of Earth wire and Earth plate:

Specification of copper earth plate: 60cm X 60cm X 3mm high conductivity copper plate fitted with copper lug, bolt nut and washer. The plate should be reasonably clean, smooth, free from scratches, porosity, black oxide and any other defect.

Earth wire for 50 HP (37 kw) motor: 2 SWG hard drawn bare copper (HDBC) wire.

Measurement of (50) Earth resistance :





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Aspects of good lighting services :

* Good lighting is necessary for all buildings for promoting work and other activities, for safety of people, and for decoration, and creating a pleasing environment for sense of wellbeing.

Types of lighting scheme :

The interior lighting scheme may be classified as

(i) direct lighting (ii) semi-direct lighting
(iii) semi-indirect lighting (iv) indirect lighting
(v) general lighting.

(1) Direct lighting ⇒

* In this lighting scheme more than 90% of total light flux is made to fall directly on the working plane with the help of deep reflectors.
* It causes hard shadows and glare
* It is mainly used for industrial and general outdoor lighting.

(2) semi-direct lighting :

In this lighting scheme 60 to 90% of the total light flux is made to fall downwards directly with the help of semi-direct reflectors, remaining light is used to illuminate the ceiling and walls.

* Such a lighting scheme is best suited to rooms with high ceilings where a high level of

uniformly distributed illumination is desirable.

Direct lighting:

* more than 90% of total light flux is thrown upward to the ceiling for reflection by using inverted reflectors. The ceiling act as a light source, and the glare is reduced to minimum.
* The resulting illumination is softer and more diffused
* The shadows are less visible and the appearance of the room is more improved.
* It is used for decoration purposes in cinemas, theaters, hotels etc

Semi-indirect lighting →

In this lighting scheme 60 to 90% of total light flux is thrown upward to the ceiling for reflection and the rest reaches the working plane. This lighting scheme is with soft shadows and glare free. mainly used for indoor light decoration purposes.

General lighting ⇒

In this scheme lamps made of diffusing glass are used which give nearly equal illumination in all direction

Design of lighting scheme :

The lighting scheme should be such that it may provide (a) adequate illumination
(b) uniform distribution of light
(c) provide light of suitable colour
(d) Avoide glare and hard shadows as far as possible.

The following factors are required to be considered while designing the lighting scheme:

Illumination level :

sufficient illumination is the basic requirement to see our surroundings.

Degree of illumination, to give necessary brightness to the objects depends upon (a) The size of the object to be seen and its distance from the observer, greater the distance of the object from observer and smaller the size of the object, greater will be the illumination required for its proper perception.

* greater the contrast between the colour of the object and its back ground, greater will be the illumination required to distinguish the object properly.
* object require longer time to be seen are more illuminated than those for casual work
* moving objects require more illumination than those for stationary object.

Location	Illumination level in (LUX)
Entrance, hall	100
Living room	300
Dining room	150
Bedroom	300
Kitchen	200
Bathroom	100
workshop	200
Study	300
garage	70
sewing	700

(Illumination level required, as per ISI, in various parts of a building is ~~given~~ written above)

② Uniformity of Illumination:

The human eye adjust itself automatically to the brightness within the field of vision. If there is a lack of uniformity, pupil or iris of the eye has to adjust more frequently and thus fatigue is caused to the eye and productivity is reduced.

Colour of light: The appearance of the body colour entirely depends upon the colour of the incident light. In general the composition of the light should be such that the colour appears natural

Shadows:
Complete absence of shadows altogether is not an ideal condition of lighting installations. A certain amount of shadow is desirable in artificial lighting as it helps to give shape to the solid objects and makes them easily recognised. object illuminated by shadowless light appear flat and uninteresting and it is difficult for the eye to form a correct judgement of the shape of an object. However in drawing offices where we need to see the flat surfaces, shadowless light is essential. Shadows can be avoided by using large number of small luminaries mounted at a height not less than 2.5 meter and by using indirect lighting system.

glare: It is the difficulty of seeing in the presence of bright light such as direct or reflected sunlight. It can be minimised by using adjustible lighting, wear polarized lenses etc.

mounting height: In case of direct lighting, in rooms of large floor area, the luminaries should be mounted as close to the ceiling as possible. Lowering them not only make illumination less uniform, but will also bring them more into the field of vision, thus increasing the glare.

* In general there should be a minimum clearance of 2.5 meter between the luminaries and the floor.

Spacing of luminaries:

In the case of tungsten lamps, the ratio of spacing to height should be 0.6.

In case of indirect lighting it is a good practice to aim horizontal spacing equal to the height of ceiling above the working plane

Colour of surrounding walls: The illumination in any room depends upon the light reflected from the wall and ceilings. white walls and ceiling reflect more light as compared to coloured ones.

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Public lighting installation :

* Is needed for proper illumination of a variety of traffic routes and city centres.
* The guidelines are given by International commission on illumination.

* Road classification

Group	Description
A → A_1 (Subgroup)	main roads, important routes,
A → A_2 (Subgroup)	main city street, arterial roads etc urban road
B → B_1 (Subgroup)	shopping streets, local traffic
B → B_2 (subgroup)	comparatively light traffic
C	residential and unclassified roads
D	Grade Elevated junction, bridges, elevated road
E	Town area
F	Roads with special requirement like aerodrome, railways,
G	Tunnel (underground roads)

Aim of public lighting installation :-

Aim of public lighting along main road, bridges and flyovers (A, B, D) is to permit users of the roads at night to move about with greatest possible safety and comfort so that the traffic capacity of the road at night is as much equal to that planned for daytime as possible.

Roads in residential area

The aim of public lighting along roads in residential area (Group C) is to provide light along the stretch of carriageway and footpath for safety and comfort of road users mainly the pedestrians. consideration has to be given to ensure that the lighting is soft and does not cause glare.

Airports :- Lighting is done to ensure pilot visibility so mistake while landing can be avoided.

Railways :- The driver of the railway is required to observe a number of signal along the tracks in the course of his work, none of the street lamp cause either glare to the driver or is mistaken by the driver for track signals.

Quality of public lighting is decided by

(a) Level of illumination for adequate visibility

(b) uniformity of luminance for visual comfort

(c) Limitation of glare to avoid visual discomfort

Selection of equipment:

is guided by following consideration

(a) Luminous flux

(b) Economy

(c) colour characteristic

The source normally used in public lighting are (a) Incandescent lamp

(B) mixed incandescent lamp

(c) high pressure mercury vapour lamp

(d) Sodium vapour high pressure lamp

Lighting installation in Group A and B roads

Average level of illumination on road in lux	Group A1	Group A2	Group B1	Group B2
	30	15	8	4
mounting height in m	9-10	9-10	7.5-9	7.5-9

Incandescent lamp :- used for residential streets where initial cost is to be kept low. They are not usually employed in traffic routes.

mercury vapour lamps (mv) :- Higher luminous efficiency and longer life than ~~mixed~~ incandescent lamps.

fluorescent lamp → used where colour appearance are important.

sodium vapour lamp → used where colour appearence is not important and they are suitable under foggy condition.

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Street Lighting:

Objective of street lighting are

* To make traffic and obstructions on the road clearly visible to promote safety
* To make the street more attractive

The principles for street lighting are different from that of interior lighting. There are no walls and ceiling which reflect light, hence only direct lighting scheme can be employed and hard shadows and high contrast can't be avoided.

* High level of illumination is not necessary, as no need to continuously look at nearby objects.
* glare must be avoided.

Two general principles are usually employed in the design of street lighting installations,

(a) Diffusion principle

(b) Specular reflection principle

Diffusion principle:

> Lamps fitted with suitable reflectors are used. The reflectors are so designed that they may direct the light downward and spread as uniformly as possible over the road surface.

> In order to avoid glare the reflectors are made to have a cut-off of between 30° to 45° so that the filament is not visible except from underneath it.

* The illumination at any point on the road surface is calculated by applying point to point or inverse-square law method.

* the road illuminated from two lamps the resulting illumination is the sum of the illuminations due to each lamp.

Specular reflection principle

> In this case the reflectors are curved upward so that the light is thrown on the road at a very large angle of incidence.

> It is observed that a motorist requires to see objects about 30 meters away. Thus in fig. The observer is shown about 30 meters from the objects much of the light from the lamp L3 is not reflected towards the observer, where as most of the light from lamp L1 and L2 is reflected towards him. Thus the object will appear silhouetted.

> The requirement of pedestrian also fulfilled as some light from the lamps falls directly downwards.

> This method of street lighting is only used for straight section of the road.

> This method is more Economical compared to diffused method

> It produces glare for the motorist.

* Illumination level for street lighting and mounting height.

Normal spacing for standard lamps is 50 meters with a mounting height of 8 meters. In class A installation i.e in important shopping centres and road junctions, illumination level of 30 lumen/m^2 is required

Types of lamps for street lighting:

mercury vapour and sodium discharge lamps have been found to have certain advantages for street lighting purposes. The most important of these is the lower power consumption

General rules for wiring:

> The conductor used is to be of such a size that it may carry load current safely.

> Every sub-circuit is to be connected to a distribution fuse board.

> Every line (phase) is to be protected by a fuse of suitable rating.

> A switch board is to be installed so that its bottom lies 1.25 meter above the floor.

> All plug and socket outlets are to be 3-pin type, the appropriate pin of socket being connected permanently to the earthing system.

> only 3pin, 5A socket outlets are to be used in all light and fan sub-circuits. and only 3pin, 15A socket outlet are to be used in all power sub-circuits. All socket outlets are to be controlled by individual switches, which are to be located immediately adjacent to it.

* Socket outlets are installed either 25 cm or 1.30 m above the floor level as desired.

* NO socket outlet is to be provided in the bathroom at a height less than 1.30 meters.

* All incandescent lamps, unless otherwise required, are to be hung at a height of 2.5 meters above the floor level.

* All ceiling fans are to be hung 2.75 meters above the floor.

* Each subcircuit is not to have more than a total of 10 points of light, fans and socket outlet

* load on each sub-circuit restricted to 800 watts

* If a separate circuit is installed for fans only the number of fans in that circuit is not to exceed 10.

* The load on each power sub-circuit is to be normally restricted to 3,000 watts In no case more than two socket outlets are to be in one power sub-circuit.

* NO fuse or switch is to be provided in earthed conductor.

* Each subcircuit is to be protected against excessive current by fuse or automatic circuit breaker.

Determination of number of points: (light, fan, socket-outlets)

The number of light point required is determined as per size of the room, illumination level required and the luminous efficiency of the lamp to be used.

Fan size in mm	Type	Air delivery in m^3/minute
900	capacitor ac	140
1200 mm	capacitor ac	215
1400 mm	"	270
1500 mm	"	300

* The number of fan points is determined as per (length, width and height) of the room and the size of the fan used.

* Number of socket outlet recommended is given below

Location	Number of 5A socket	Number of 15A socket
Bedroom	2 to 3	1
Living room	2 to 3	2
Kitchen	1	2
Dining-room	2	1
Garage	1	1
a.c		1
Bathroom	1	1
refrigerator		1

Determination of total load :→

(i) fluorescent lamp (choke type) 50 w (40w+10w)

(ii) Incandescent lamp, fans → 60 w

(iii) 5A socket outlets → 60 watt

(iv) power socket outlet → 1000 watt

Determination of number of sub-circuit:

Number of sub-circuit decided by number of points to be used and total load to be connected to the supply system.

* In one light and fan sub circuit maximum load that can be connected is 800 watt, and the maximum number of points, which can be wired is 10

* In one power sub-circuit the maximum load that can be normally connected is 3000 watt and the number of socket outlet, which can be provided is 2.

Determination of rating of main switch and distribution board ⟹

* The current rating of the main switch is decided as per the total current carried by the circuit.

* Rating of the distribution board is decided as per the number of sub-circuit to be connected to it.

Determination of size of conductor :

* The conductor used in domestic wiring must not be of size less than 1/1.2 mm in copper or 1/1.40 mm in aluminium wire.

* If the size of the conductor of the cable increases the current density decreases.

voltage drop decreased to (2% + 1V) for light load and 5% for power load wiring.

No. and diameter (layers) of wire (mm)	current rating
1/1.12	5
3/0.736 & 3/0.91	10, 15
7/0.736	20

current density	(X-sectional area of conductor)
5 amp/mm²	less than 5 mm²
4 amp/mm²	(5 – 10) mm²
2-5 amp/mm²	(10 – 20) mm²
2	(20 – 40) mm²

Layout:

position of main board:

meter board, and fuse is supplied, fixed and sealed by the supplier and two leads (one phase, one neutral) are taken out from the meter to be connected to the consumer's main board, which is the starting point for internal wiring. mainboard are fixed at a height of about 1.5 meters.

position of switches and socket outlets:

switches are fixed at an usual height of 1.25 meters, 1.35 meters, 1.4 meters above the floor. In nurseries, in children hospital a much higher standard height is desirable, say 1.6 meters to 1.8 meters. In school 1.8 meters is a good standard height.

Height and size of lamps:

2.25 meters to 2.5 meters is a good avg. height for ordinary pendants or brackets to give a general illumination in the room.

Dining room:

The right place for the light source is over the centre of the dining table.

Q) Draw a neat diagram showing the position of the switchboards, distribution board and accessories with necessary connections in looping-in system for a hall of 15m × 6m × 4.5m height. The hall is to be fitted with fan and light points.

Soln :- floor area of hall = 15 × 6 = 90 m^2

$1\ m^2 \longrightarrow$ 10 watt

$90\ m^2 \longrightarrow$ 10 watt × 90 = 900 watt

i.e. 10 lamps of 100 watt each will be fitted and let 4 ceiling fan of 60 watt each will be fitted.

Total load = 10 × 100 + 4 × 60 = 1240 watt

Assuming supply voltage of 240 volts

Line current = $\frac{1240}{240}$ = 5.2 amp

So 3/0.736 mm, twin core, 650 V grade, copper conductor pvc cable having current carrying capacity of 10 amp. will be used between meter board and main distribution board.

Since the maximum number of points in a circuit must not exceed 10 and maximum load which can be connected in one circuit through loop-in system, is 800 watt we will have two circuits. Each of them feeding 7 points and a load of 620 watt.

Full load current in each circuit = $\frac{620}{240}$ = 2.6 amp.

So 1/1.12 mm, single core, 650V grade, copper conductor pvc cable will be used for circuit wiring.

* The height at which meter board, main switchboard are to be fitted = 1.5 meters from ground level
* The height at which casing-caping will be fixed = 3.5 meters from the ground level.
* The meter board is to be fixed on entrance wall at a distance of 2 meter from the left hand side wall.