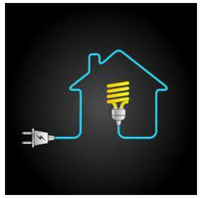


EEE 414: Electrical Services Design

Course Schedule:

Time: 11am-1:30pm, Wednesday, Venue - VLSI Lab

Course Teacher:

Yeasir Arafat

Associate Professor

EEE, BUET

EEE 414: Electrical Services Design

Lectures based on

BNBC 2020 (Vol. 3, Part VIII, Ch. 1): Electrical and Electronic Engineering Services for Buildings

Lecture1:	Modue1:	INTRODUCTION
Lecture2:	Modue2:	LIGHTING AND ILLUMINATION
	Modue3:	DESIGN/DRAWING OF ELECTRICAL INSTALLATIONS
Lecture3:	Modue4:	Distribution Wiring in a Building
	Modue5:	Power Supplies in a Building
Lecture4:	Modue6:	Earthing System Design
	Modue7:	Lightning Protection System Design
	Modue8:	Data/Telecom, FDAS, Security System Design
	Modue9:	Compliance Issues of a Building

Earthing and Lightning Protection System Design for Buildings

Design of Grounding, Earthing and Bonding

M6: Earthing System Design - Outline

- Earthing used in Buildings
- System and Equipment Earthing
- Difference between Grounding, Earthing, Bonding
- Arrangements of Earthing Systems
- Integral parts of Earthing System
- Minimum cross-section area of ECC
- Installation of Earth Electrodes
- Earthing Busbars
- Earthing Pit

1.3.32 Earthing

1.3.32 Earthing

1.3.32.1 General

Earthing refers to connecting the exposed conductive part of electrical equipment and also the extraneous conductive parts of earthed bodies like water pipe to the general mass of the earth to carry away safely any fault current that may arise due to ground faults. The object of an earthing system is to provide a system of conductors, as nearly as possible at a uniform and zero, or earth, potential. The purpose of this is to ensure that, in general, all parts of equipment and installation **other than live** parts shall be at earth potential, thus ensuring that persons coming in contact with these parts shall also be at earth potential at all times.

1.3.32 Earthing

1.3.32.2 Earthing used in electrical installation for buildings

The usual method of earthing is to join the exposed metal work to earth via a system of earth continuity conductors (**ECC**) connected to an **earth electrode** buried in ground through a system of **earth lead** wires. In conjunction with a **fuse**, or similar device, this then forms a protective system.

Thus, if a live conductor accidentally comes into contact with an exposed metal, the fuse or protective device operates. As long as the overall resistance of the protective system is **low**, a large fault current flows which **blows the fuse**. This cuts off the supply and isolates the faulty circuit, preventing risk of shock, fire, or damage to equipment/installation.

1.3.32.2 Earthing used in Buildings

In Electrical installation for buildings, following types of earthing systems are required to be installed:

(i) L.T. circuit/system earthing,

(ii) Equipment earthing (LT side),

(iii) Substation neutral earthing,

(iv) Substation LT system earthing, and

(v) H.T. circuit earthing for a substation.

The purpose of L.T. circuit/system earthing is to limit excessive voltage from line surges, from cross-overs with higher voltage lines, or from lightning, and to keep noncurrent carrying enclosures and equipment at zero potential with respect to earth.

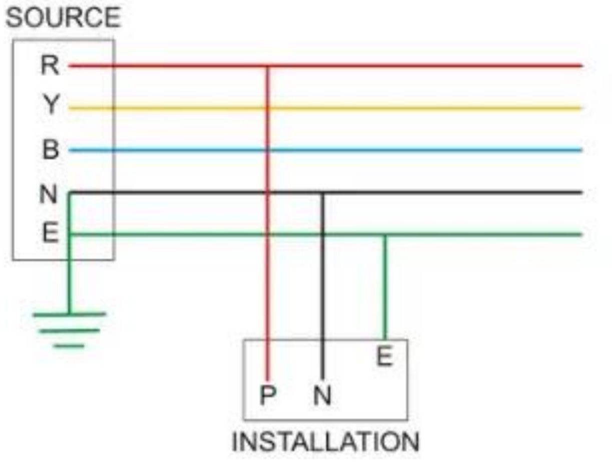
1.3.32.2 Earthing used in Buildings

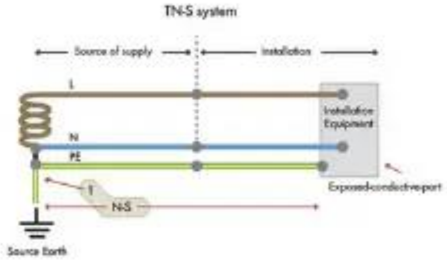
Earthing the system helps facilitate the opening of **overcurrent** protection devices in case of earth faults.

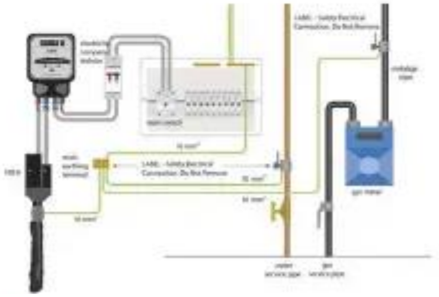
Earthing associated with current carrying conductors is normally essential for the **protection and safety of the system** and is generally known as **circuit/system earthing**.

While earthing of non-current carrying metal work and conductor is essential for the **safety of human life, animals, and property** and it is generally known as **equipment earthing**.

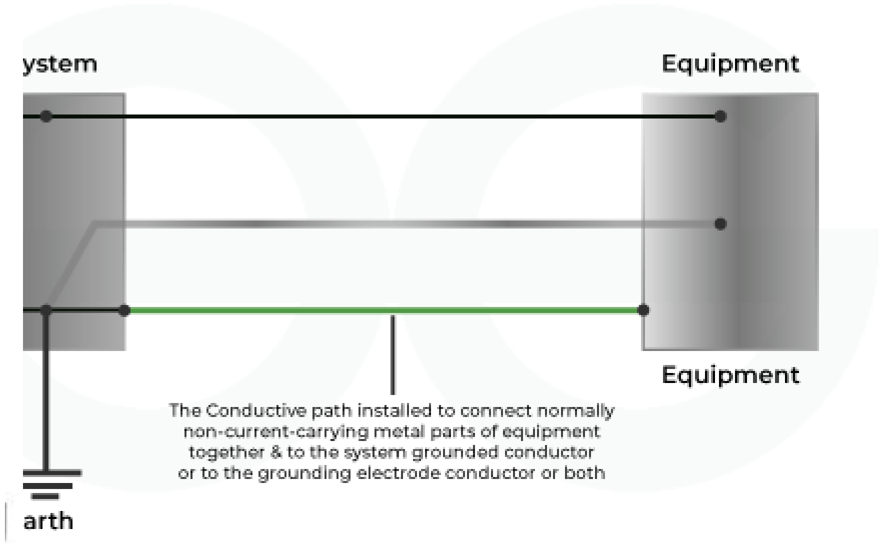
What is System Earthing?







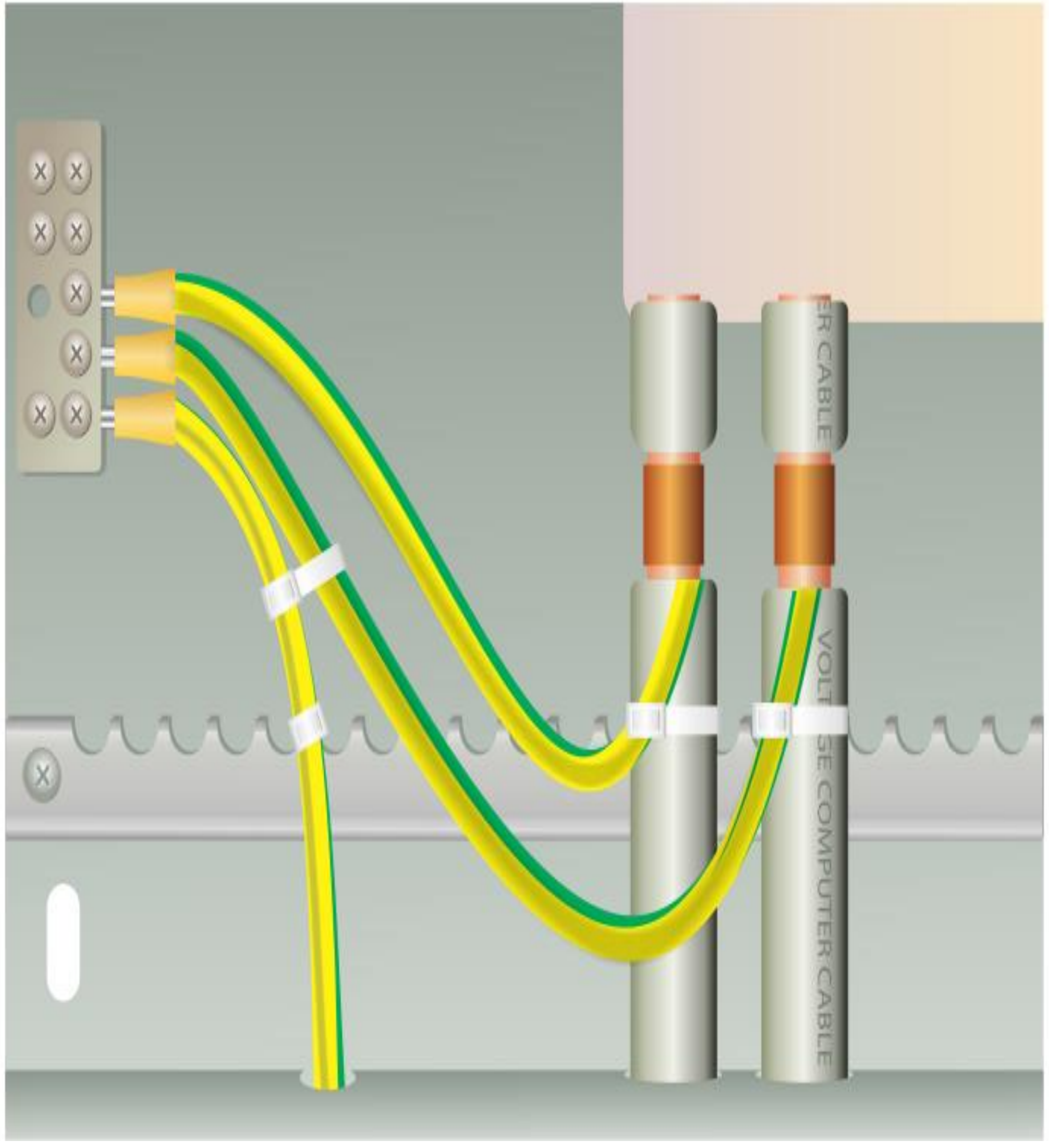
Equipment Earthing



Earthing - Basic Electrical Engineering

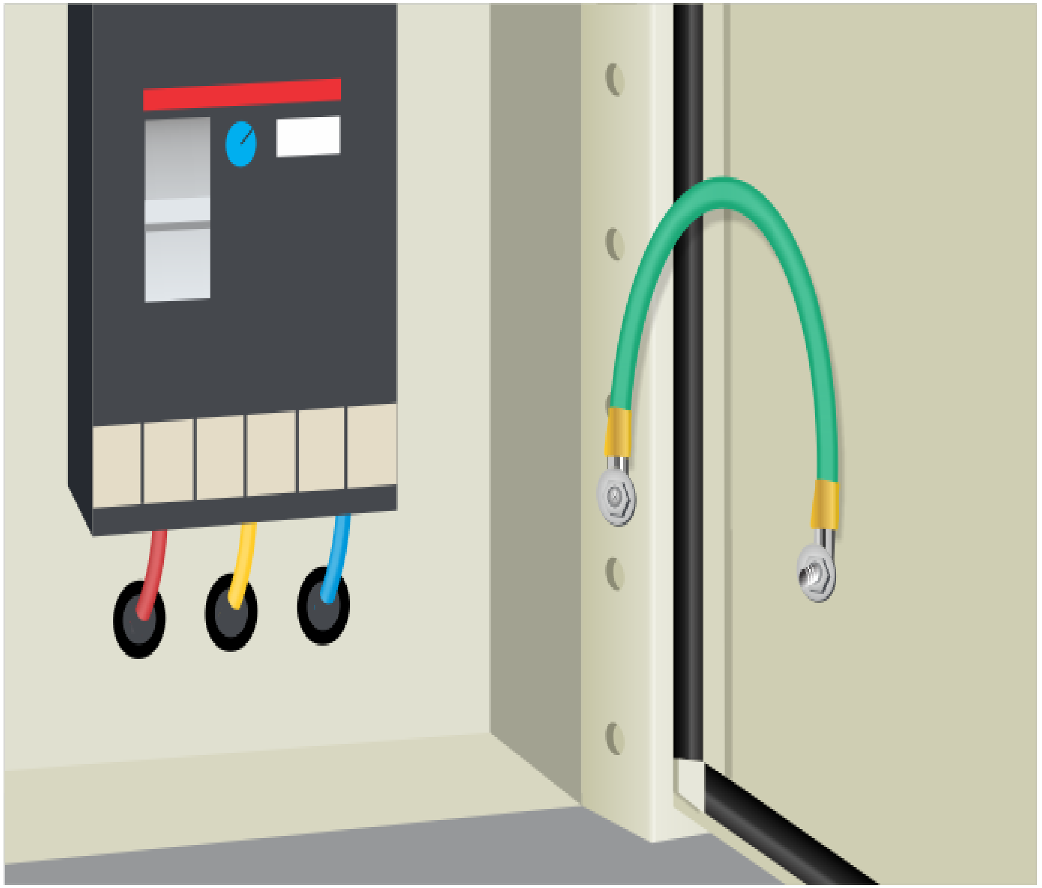
Earthing VS Grounding	
Earthing	**Grounding**
This method protects human beings from electric shocks.	This method protects the entire power system from malfunctioning.
The earth wire used is green in colour.	The wire used for grounding is black in colour
Earthing is primarily used to avoid shocking the humans.	Grounding is primarily used for unbalancing when the electric system overloads.
Earthing is located under the earth pit, between the equipment body underground.	It is located between the neutral of the equipment being used and the ground.

Purpose of Equipotential Bonding



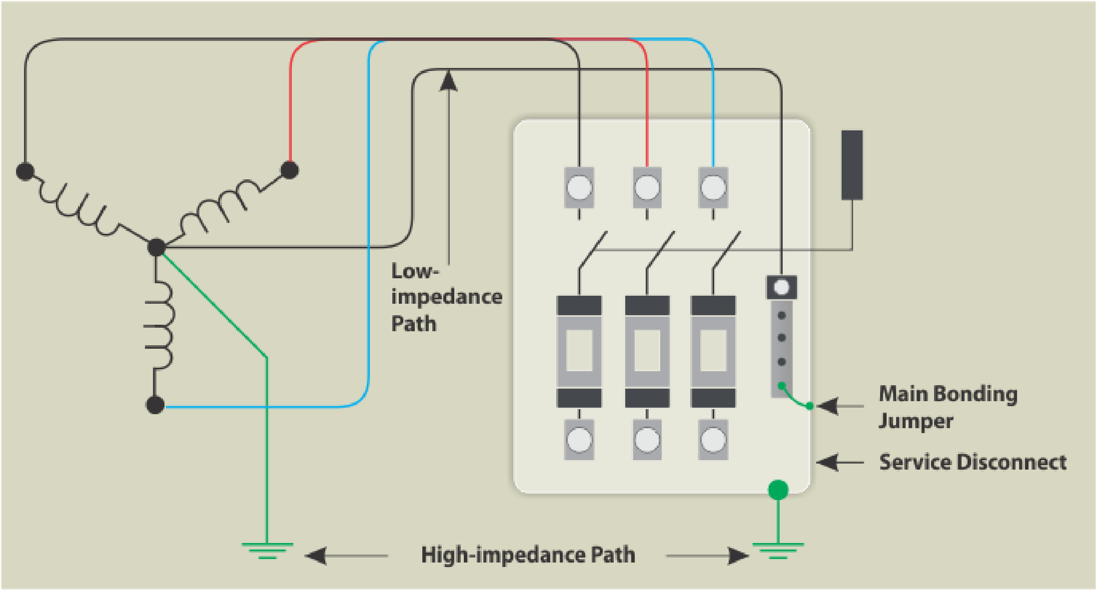
- Simply put, **joining 2 electrical conductors is bonding**. Connecting 2 **electrical or metallic object to form equipotential** between them is called Bonding. By forming equipotential, we are **preventing current flow between them**. Equipotential Bonding is always done on metallic parts which do not have any potential or which are not designed to carry any current.
- Purpose of Equipotential Bonding is personal safety of someone who may **accidentally touch a metallic object** and to **protect the equipment**. Due to **lightning strike**, if any metallic part is not connected to the earthing system, a potential difference will be generated which can create **sparks** that can cause a **fire** or **harm nearby** humans or equipment.
- If a person touches equipment which are not **electrically bonded**, then they are at risk of **receiving an electrical shock** due to the difference in the potential.

Earthing

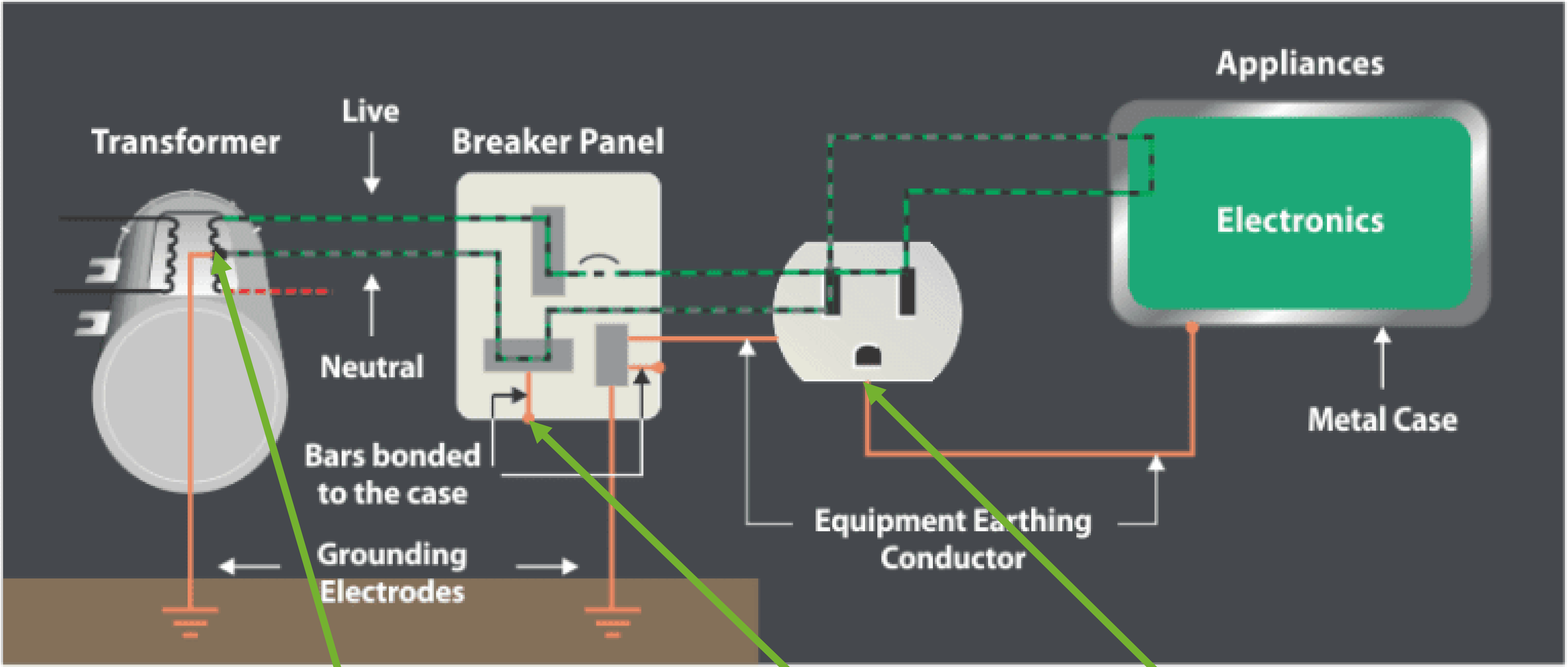


- Earthing refers to connecting **equipment or metallic parts** which do **not carry current under normal conditions** to the earth using Earth Electrodes. This could include the **frames of electrical equipment frames, enclosures, supports etc**. and in this case, the term used would be **body earthing**. Rebar clamps can be used to Earth the rebar structure of a building as well.
- At the time of a **fault**, very high levels of current will flow through the system. As a result, a potential difference is produced between the external metallic parts of the system and the ground. Due to this change in the potential, if a person comes in the contact with the system the current would flow through them instead and cause an **electric shock**. Thus, non-current carrying metallic parts are connected to the earth to so that these kinds of fault currents can flow safely to the ground.

Grounding



- Grounding refers to **connecting the current carrying parts to the earth**. For example, in the case of a distribution transformer system whose neutral point is generally known as the star point, it is **directly or indirectly connected to earth** to protect the transformer & distribution system in case of abnormal conditions in the electric circuits.
- In a case where the system neutral is connected to earth without any resistance or impedance, this system is known as a **Solidly Grounded** System*.
- #415 V systems should be solidly grounded systems and 415 V systems in **Mines** should be resistance grounded. Systems above 415 V may be resistance grounded as per application requirements in industrial plants.



Grounding, Bonding, Earthing

1.3.32.3 Arrangements of Earthing Systems

(a) The **value of resistance** <u>from the **consumer's main earthing terminal**</u> to the **earthed point** of the supply, or to earth, is in accordance with the protective and functional requirements of the installation, and expected to be continuously effective.

(b) <u>Earth **fault** currents</u> and <u>earth **leakage** currents</u> likely to occur are carried <u>without danger, particularly</u> from the point of view of <u>thermal, thermomechanical and electromechanical stresses</u>.

(c) Where a <u>number of installations have separate earthing arrangements</u>, <u>protective conductors running between any two of the separate installations</u> shall either be <u>capable of carrying the maximum fault current likely to flow through them</u>, or be <u>earthed within one installation only</u> and <u>insulated from the earthing arrangements of any other</u> installation.

1.3.32.4 Integral parts of Earthing System

The integral parts of an Earthing System are:

(a) Earth electrode(s) - buried under the ground

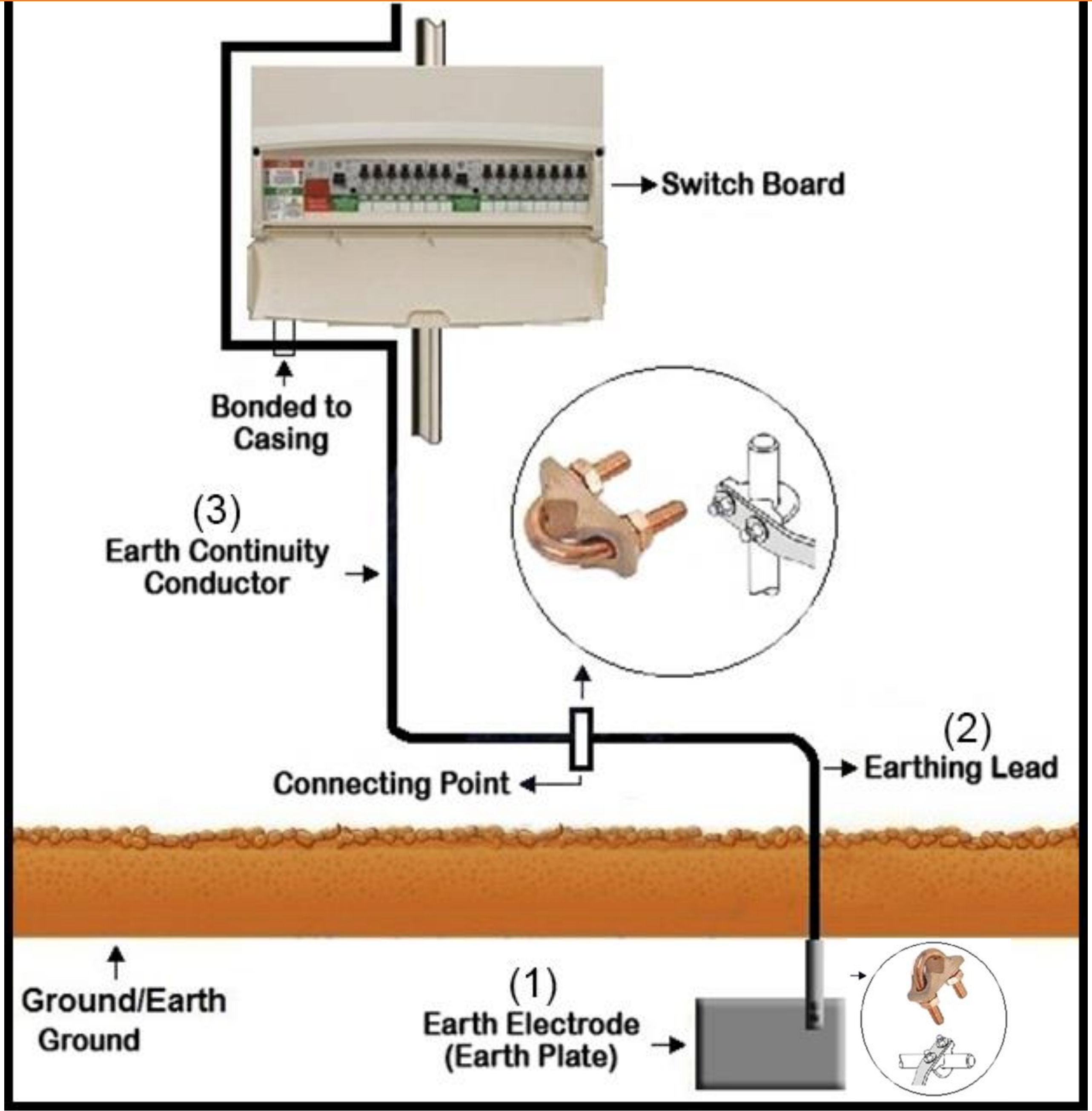
(b) Earth lead cables/wires - connecting the earth electrode(s) with earthing busbar system. This is also need to interconnect the earth electrodes when there are **more than one** earth electrode.

(c) Earth continuity conductor (**ECC**) - for linking earthing busbar at the substation LT panel or MDB of a building.

(d) Earth electrode clamp -

Connections of (i) ECC, (ii) Earth lead and (iii) Earth electrode must be made in appropriate and long lasting manner because poor/loss connection will render the earthing system ineffective.

Integral parts of Earthing System



[a] Earth electrode(s) (1)

[b] Earth lead cables/wires (2)

[c] Earth continuity conductor, ECC (3)

[d] Earth electrode/lead clamp (circled)

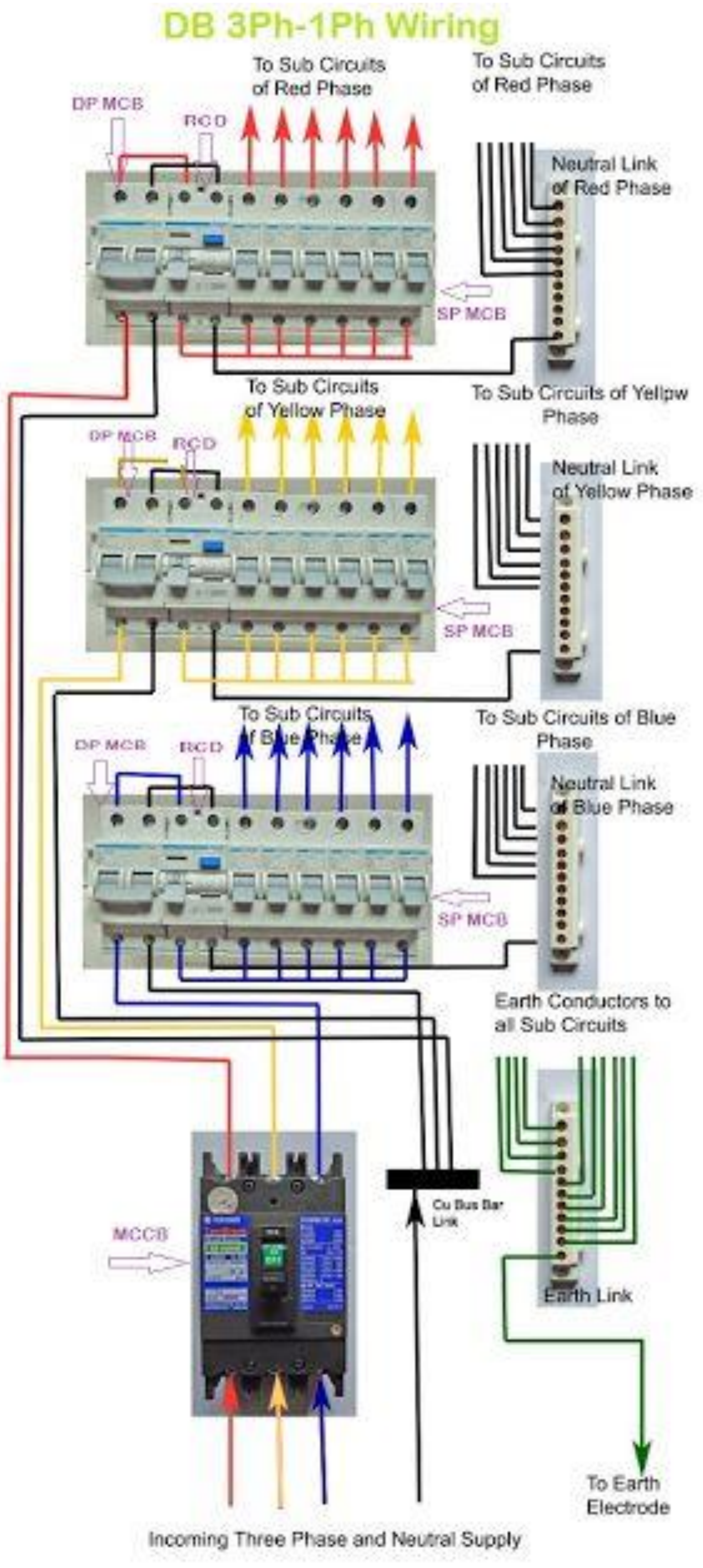
1.3.32.5 Earth continuity conductors (ECC)

The ECC runs along the circuits / sub-circuits, socket circuits, interlinking circuits among BDB->SDB->DB->FDB->MDB->LT panel earthing busbar of the **substation**. At each point an ECC shall be terminated in a **copper earthing busbar**. In metal switch boards **back boxes** and in metal socket **back boxes** appropriate copper or brass **bolt nut** termination shall be provided.

ECC joins or bonds together all the metal parts of an installation.

PVC insulated wiring copper cables ([*]BYA) of appropriate size having Green + Yellow bi-colour insulation shall be used as ECC.

The minimum size of the ECC shall be same as [#]size of the phase conductor for the PVC insulated/[$]sheathed ([*]BYA/[$]BYM) wiring copper cables of appropriate size having Green + Yellow bi-colour insulation.


DB 3Ph-1Ph Wiring
To Sub Circuits of Red Phase
To Sub Circuits of Red Phase
DP MCB
RCD
Neutral Link of Red Phase
SP MCB
To Sub Circuits of Yellow Phase
To Sub Circuits of Yellpw Phase
DP MCB
RCD
Neutral Link of Yellow Phase
SP MCB
To Sub Circuits of Blue Phase
To Sub Circuits of Blue Phase
DP MCB
RCD
Neutral Link of Blue Phase
SP MCB
Earth Conductors to all Sub Circuits
MCCB
Cu Bus Bar Link
Earth Link
To Earth Electrode
Incoming Three Phase and Neutral Supply

1.3.32.6 Earth lead cable/wire

Earth Lead cable/wire runs between an **earth electrode** and the earthing **busbar** of the MDB/DB or between an **earth electrode** and the **LT panel earthing busbar** of the substation.

Often **more than one** earth electrodes are needed. In such a case **duplicate earth lead cables/wires** from **each earth electrode** must be brought to the MDB/DB or to the LT panel earthing busbar of the substation and properly terminated. In addition, in the case of multiple earth electrodes, they must be **interlinked** by additional earth lead cables/wires.

PVC insulated wiring copper cables (*BYA) of appropriate size having Green + Yellow bi-colour insulation shall be used as earth lead wire. At both ends of the earth lead cable/wire, copper **cable lugs** must be fitted using crimp tools or hydraulic press.

1.3.32.6 Earth lead cable/wire

The minimum size of the [$]**earth lead** [#]**cable/wire** shall be **2 numbers** of **1.5 mm^2** PVC insulated wiring copper cables ([*]BYA) of appropriate size having Green + Yellow bi-colour insulation. The ends of the earth lead wires shall be terminated using **crimp tool** fitted **cable lugs** for fitting on the **busbar** or with the **Earth Electrode Clamp**.

(a) An earth lead cable/wire establishes connection between the main earthing busbar and the earth electrode(s). The earth lead wire shall be brought to one or more connecting points, according to size of installation. Usually **more than one earth lead** wires are needed **for one earth electrode** to make sure that this **link never fails**.





1.3.32.6 Earth lead cable/wire

(b) Earth lead cable/ wires shall one of the following types:

(i) PVC insulated cable

(ii) stranded copper cables without insulation

(iii) copper strips (copper bars)

(iv) PVC insulated cable is preferable in most cases.

(v) Earth lead wires shall run through PVC pipe from the earth electrode up to the earthing busbar of the MDB/DB or LT Panel.

(c) #Copper wire used as **earthing lead** must not be smaller than single core stranded **2×4 mm^2** PVC insulated cables $through PVC conduits or GI pipes of appropriate dimension [i.e. 2 nos. of single core 4 mm^2 PVC insulated cables (*BYA) in parallel]. Depending on the current capacity of the **Main incoming line** the size will have to be raised.

(i) PVC insulated cable

(ii) stranded copper cables without insulation

(iii) copper strips (copper bars)

PVC insulated cable is preferable in most cases

Table 8.1.26: Minimum Cross-sectional Area of Copper ECCs in Relation to the Area of Associated Phase Conductors

Cross-sectional Area of Phase Conductor(s) (mm^2)	Minimum Cross-sectional Area of the Corresponding Earth Conductor (mm^2)
Less than 16	Same as cross-sectional area of phase conductor
16 or greater but less than 35	16 mm^2
35 or greater	Half the cross-sectional area of phase conductor

1.3.32.7 Earth electrodes and their installation

Earth electrode shall, as far as practicable, penetrate into **moist soil** (even during the dry season) preferably **below ground water table**. The resistance of an earthing system *measured after installation of electrodes (individually or combined as a single group) shall be **around one ohm**. The types of electrodes used for earthing of electrical installations of a building and their sizes shall be as under:

(a) Copper rod earth electrode: shall have a minimum dia of **12.5 mm** of min length of **3.33 m**. Multiple copper rod earth electrodes may have to be installed to achieve an acceptable value of earthing resistance of around **1 ohm**.

1.3.32.7 Earth electrodes and their installation

(b) Copper plate earth electrodes: shall be **600 mm x 600 mm x 6 mm** minimum in size. The copper plate shall be buried **at least 2 m** below the ground level. Multiple Copper plate earth electrodes may be installed to achieve an acceptable value of earthing resistance of around **1Ω**.

(c) Galvanized Iron pipes: GI pipe earthing shall have a min dia of **38 mm** and of min length of **6.5m**. Multiple GI pipes Earth Electrode may have to be installed to achieve an acceptable value of earthing resistance of **1 ohm**.

Schematic drawings of typical earthing systems are shown in **Figures 8.1.2 to 8.1.4.** For the installation of the earthing system the following points shall be considered.

3.33 m, ϕ12.5 mm

11 ft, ϕ0.5 in

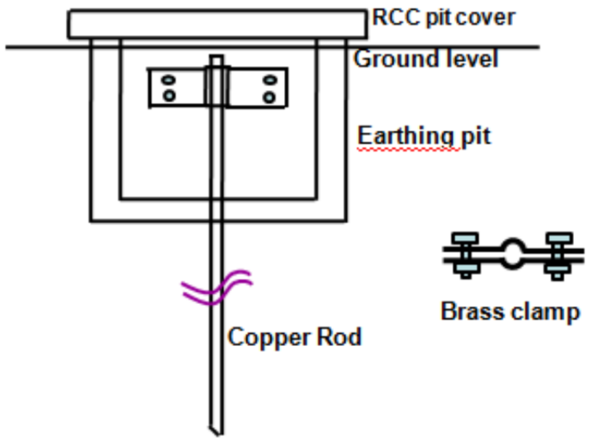


Figure 8.1.2 Copper Rod Earthing

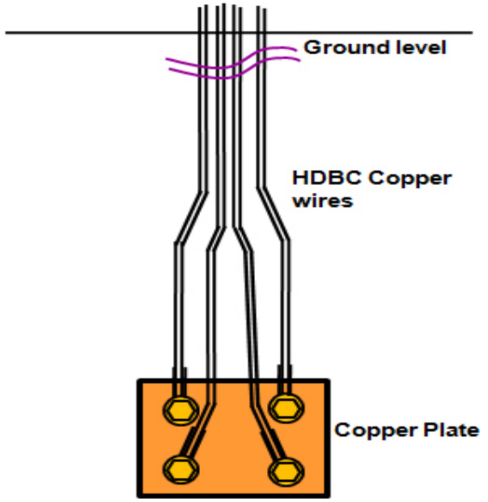
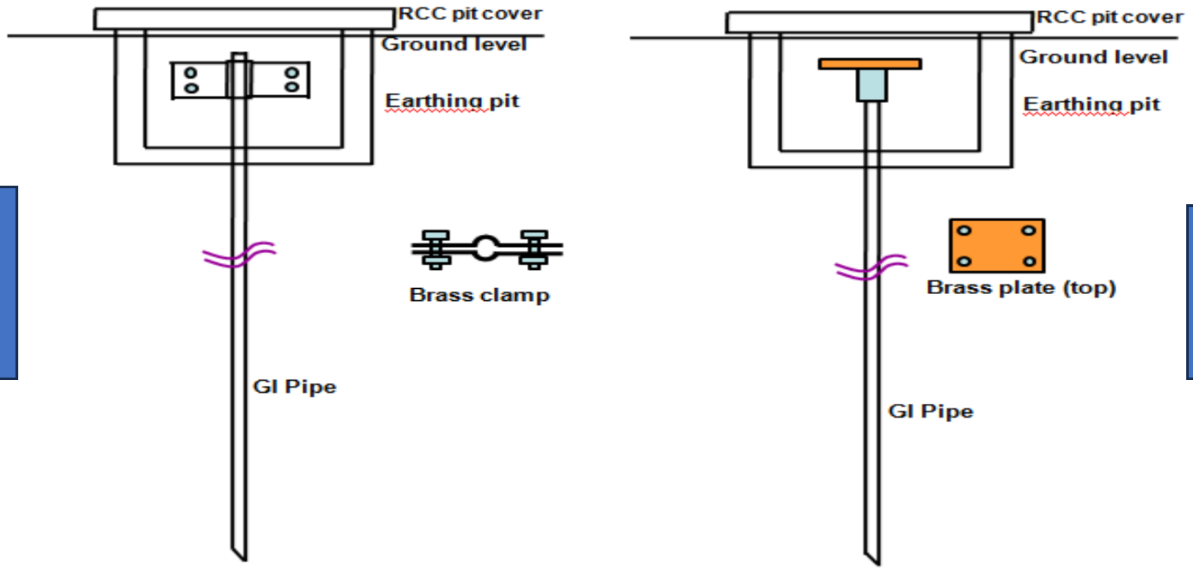


Figure 8.1.3 Copper Plate Earthing

Minimum Plate Size **60 cm x 60 cm x 6 mm**

At least 2 m below the ground

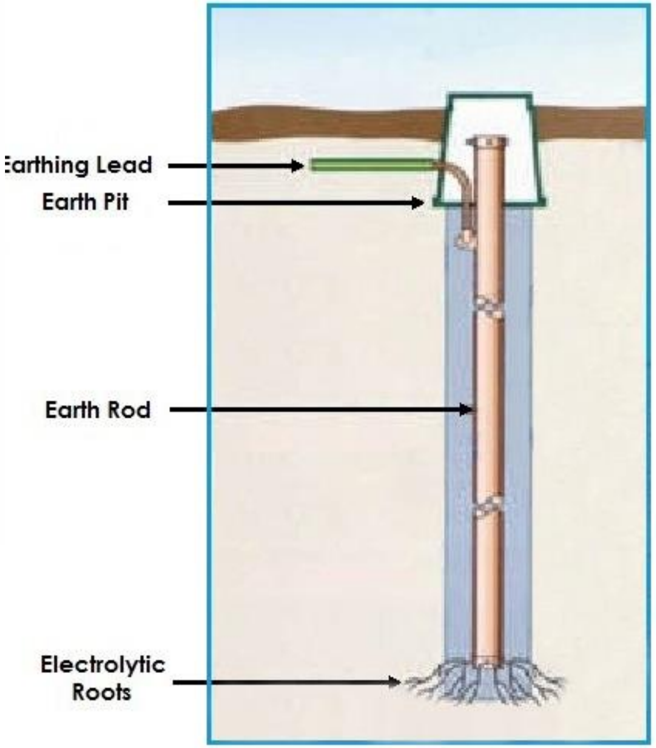
Min depth 6.5 m, min ϕ38 mm

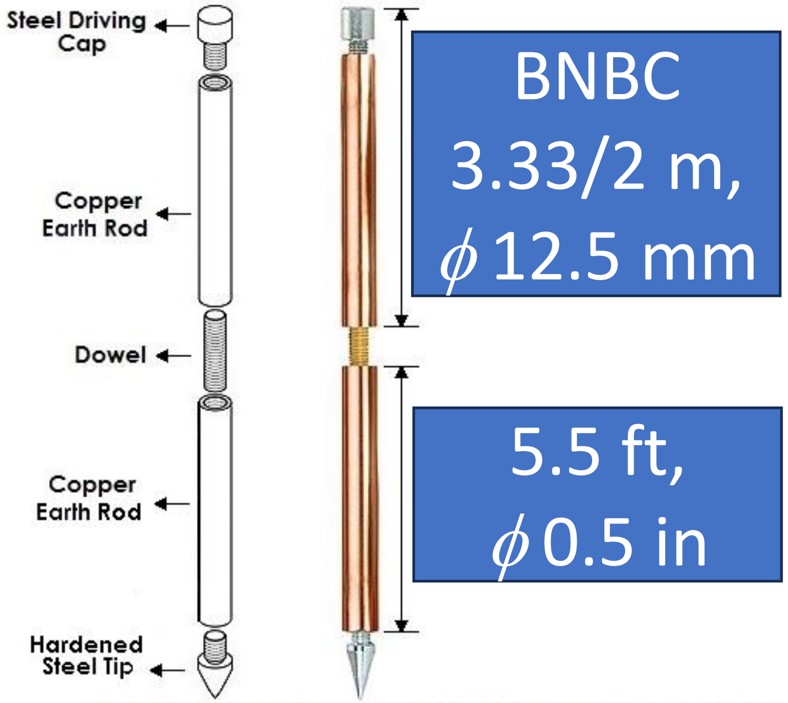


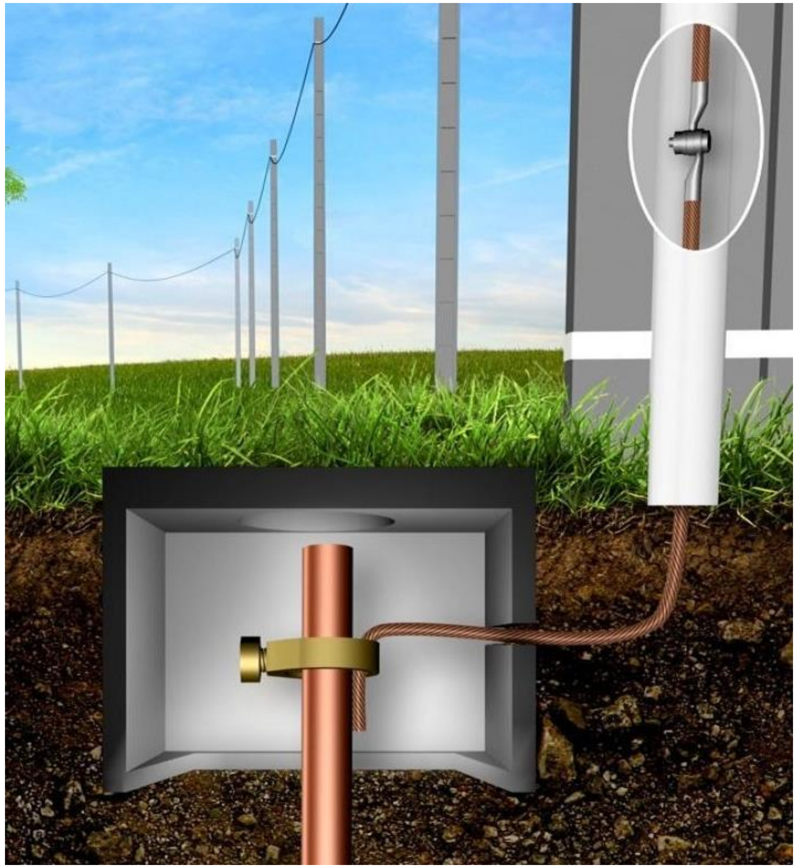
(a) (b)

Figure 8.1.4 Pipe Earthing; (a) Type 1; (b) Type 2

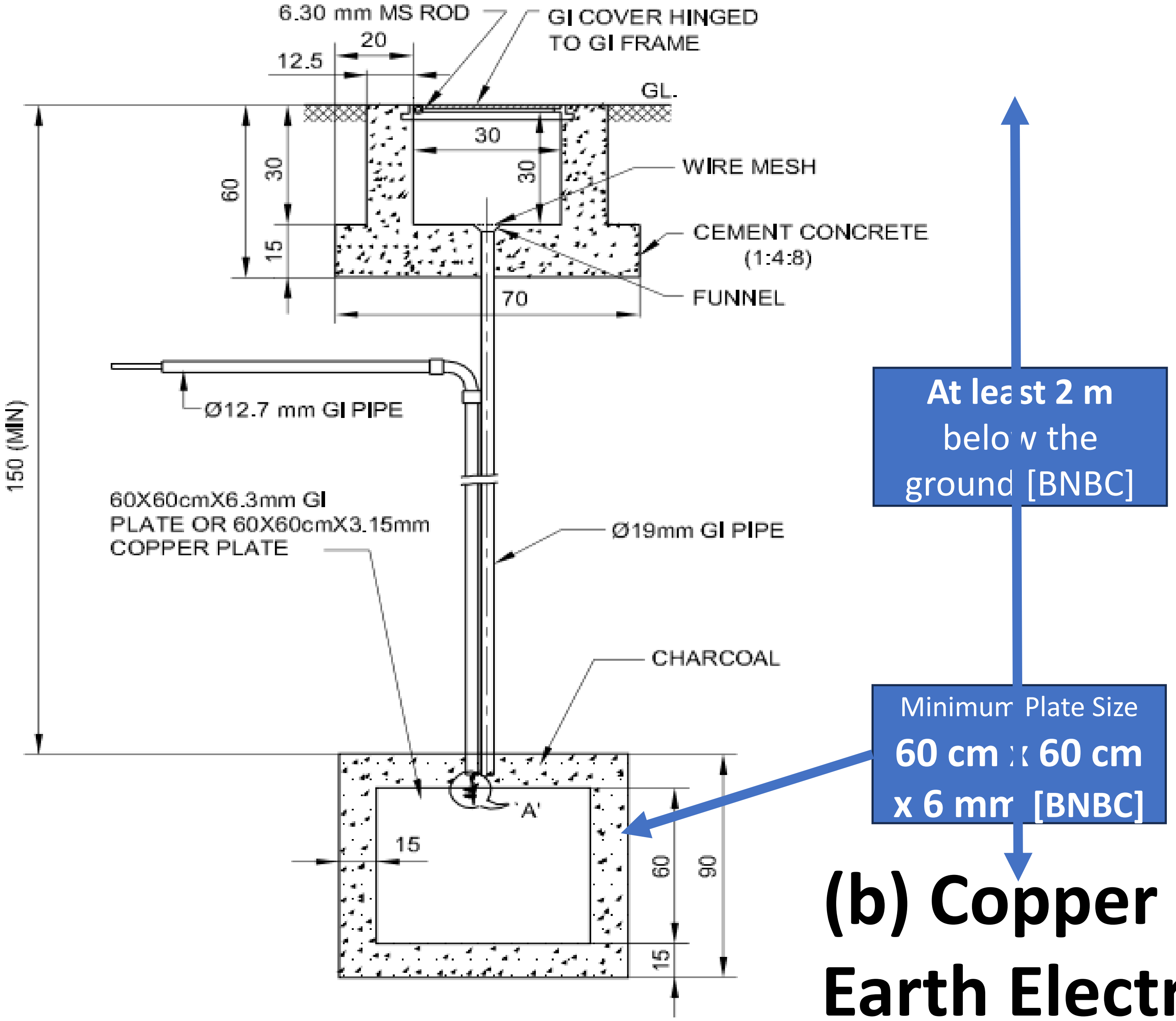
Min depth 21.33 ft, min ϕ1.5 in



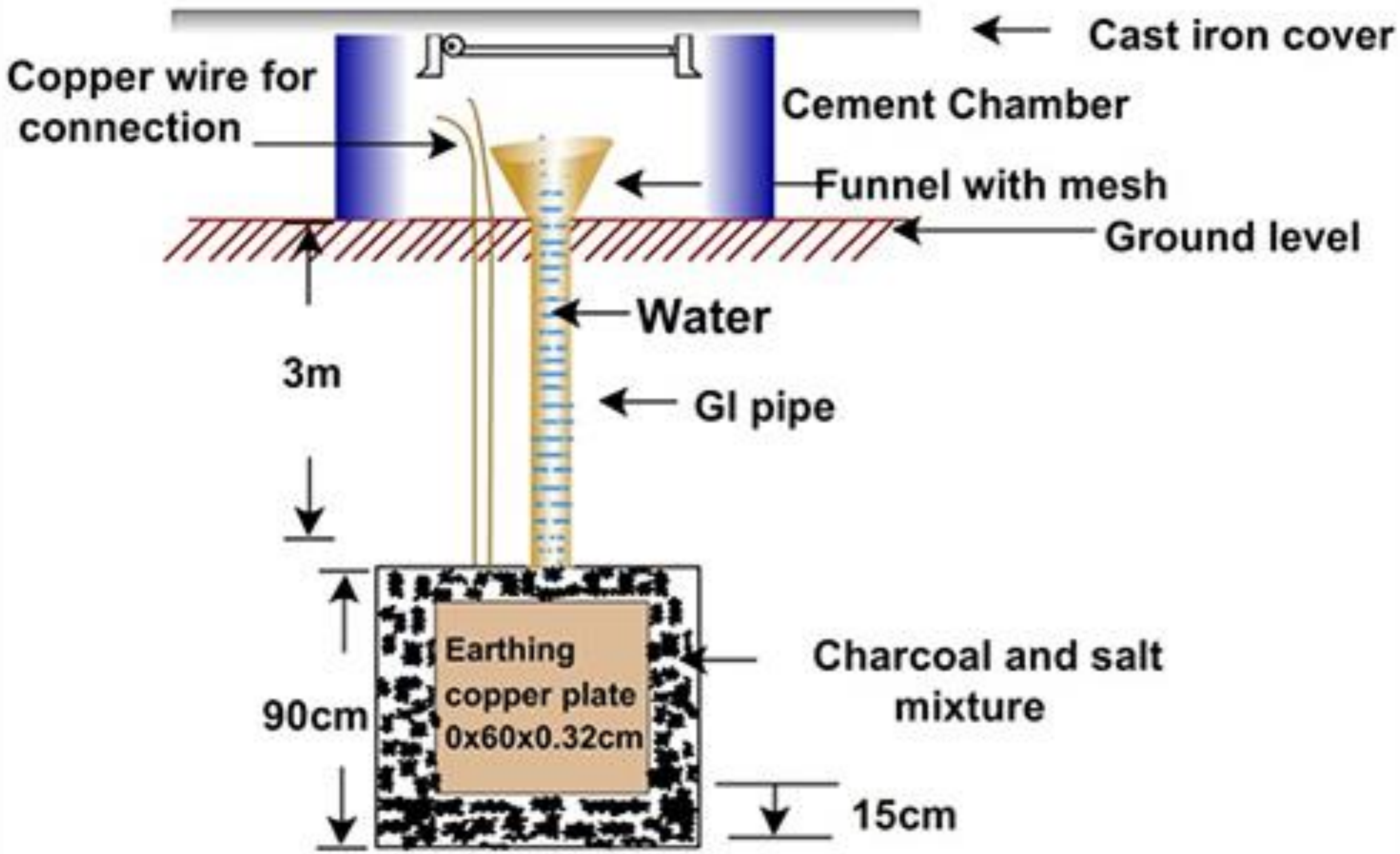




(a) Copper Rod Earth Electrode

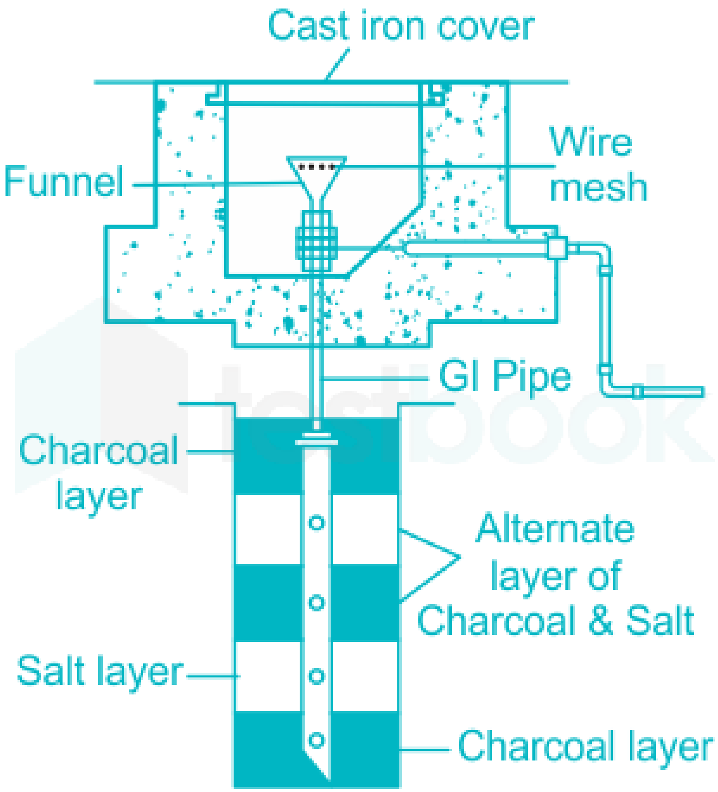


(b) Copper Plate Earth Electrodes

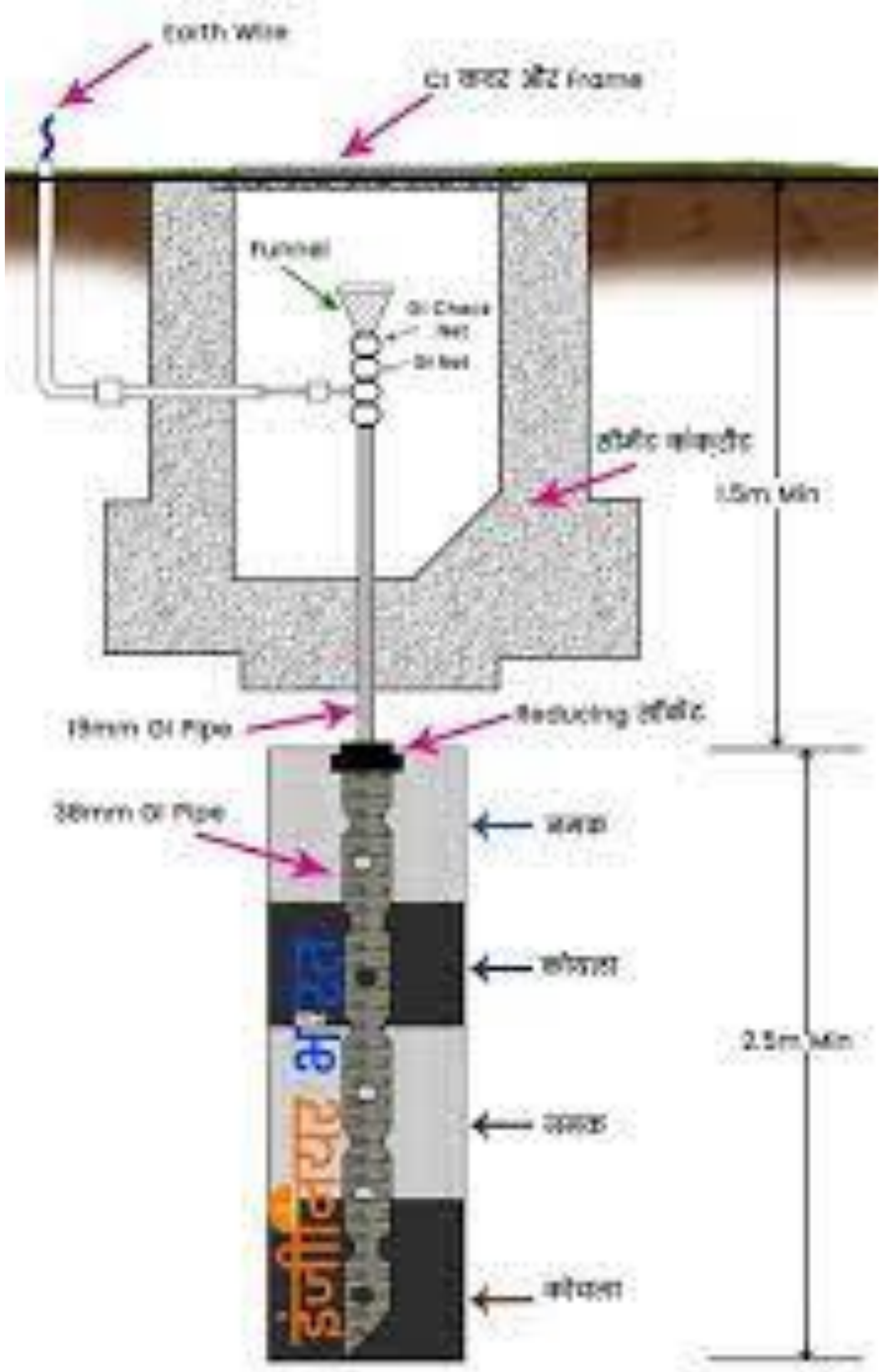


BNBC
Min depth 6.5 m, min ϕ 38 mm

Min depth 21.33 ft, min ϕ 1.5 in

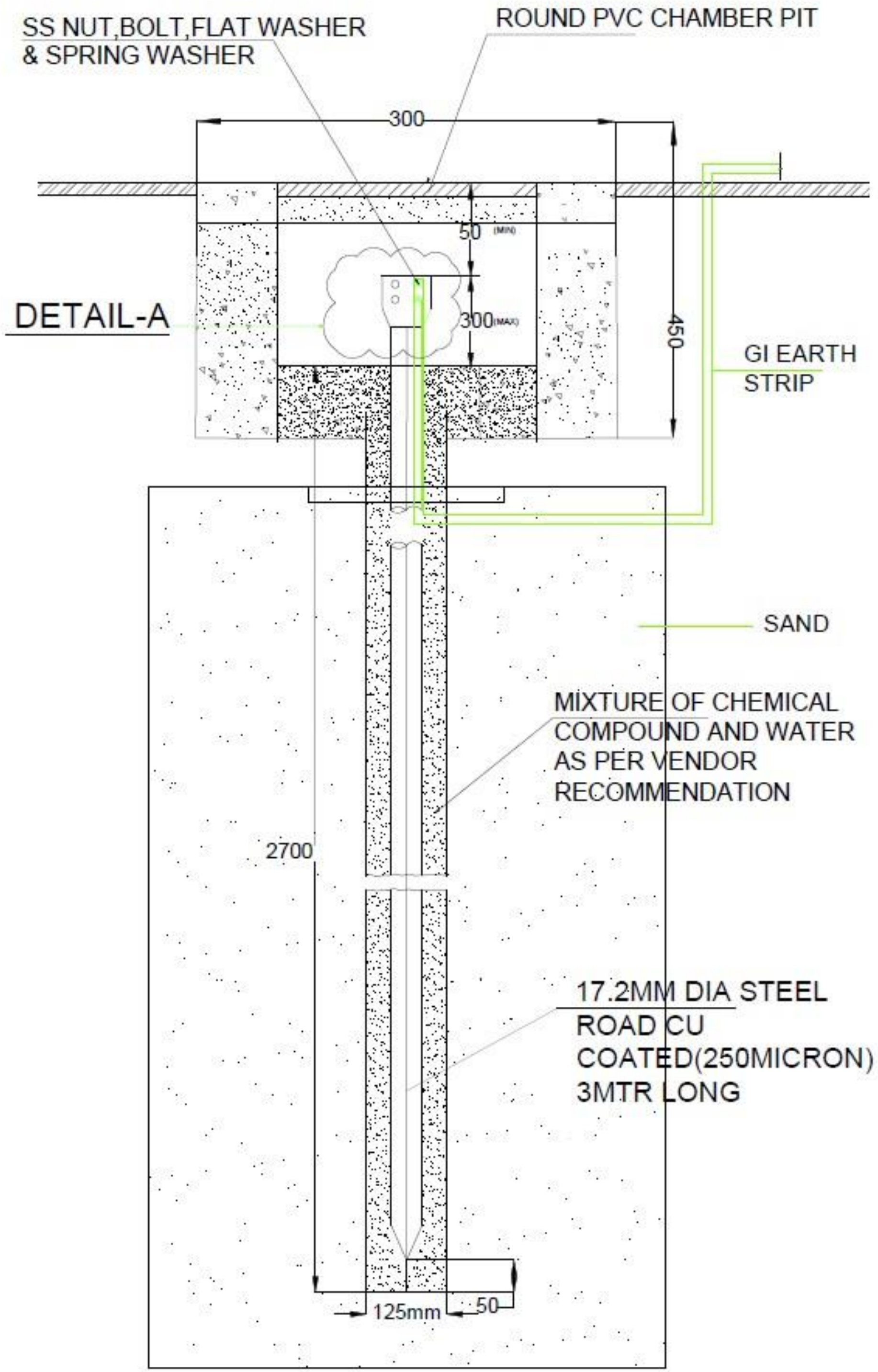


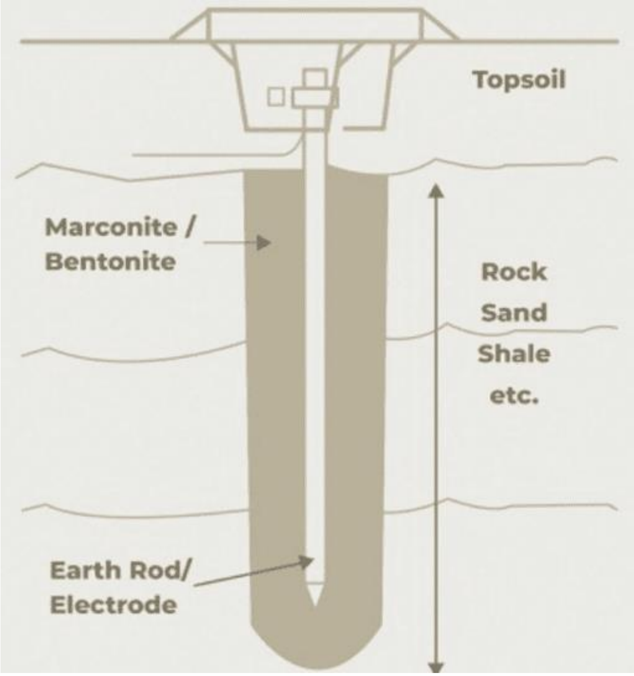
(c) Galvanized Iron (GI) Pipes



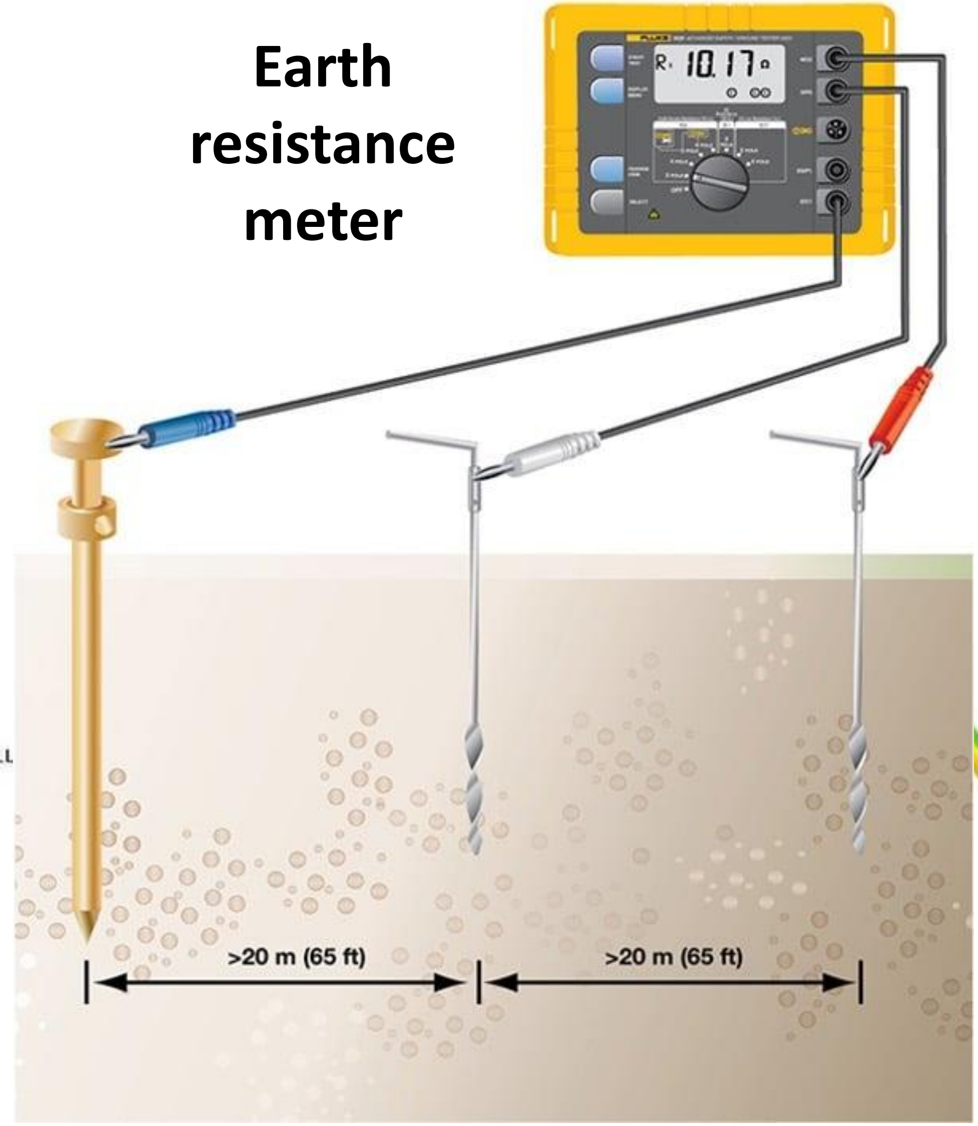
Earth resistance clamp meter

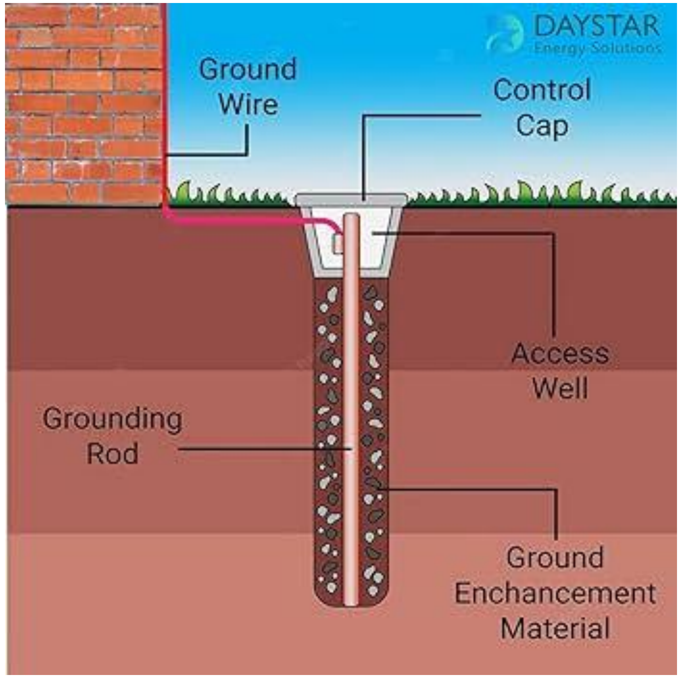
GI Pipes with Chemical

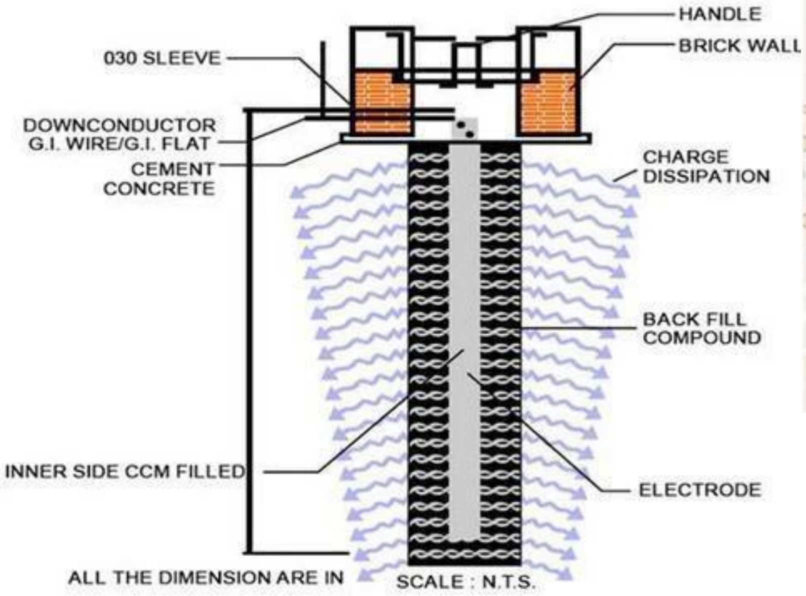




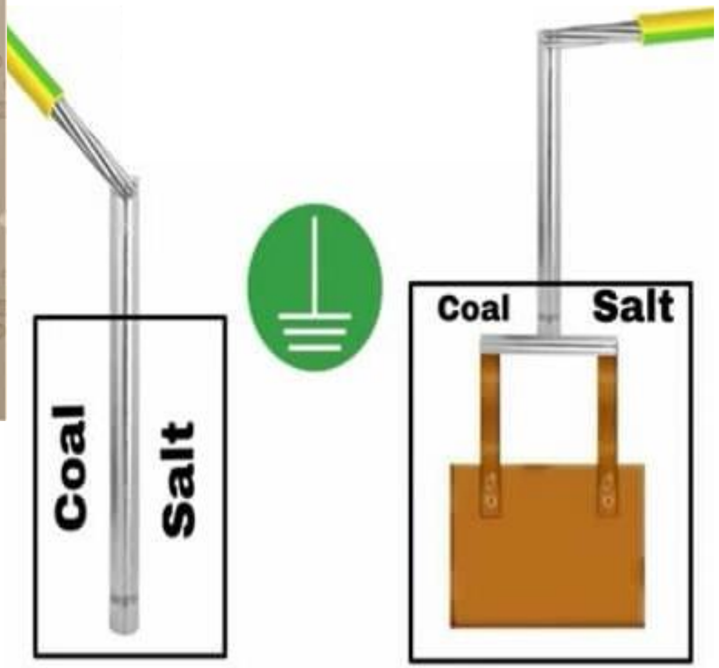
Earth resistance meter







Chemical Earthing



1.3.32.7 Earth electrodes and their installation

(a)* For installing a copper rod earth electrode, a **38 mm** dia* GI pipe shall be driven below ground up to a **depth of 5 m** and shall be withdrawn. The **12 mm dia#** copper rod earth electrode of **4 m length#** shall then be easily driven into that hole up to a **depth of 3.6 m** and **0.33 m** shall be left for placing inside the **earthing pit** described below.

(c) GI pipe earth electrodes driven by tube well sinking method are suggested. For this purpose, **38** (**50** for large plinth area and multi-storied buildings) mm dia GI pipes are recommended for domestic buildings. Length of GI pipe driven below the ground level depends on the earthing resistance which in turn depends on the availability of water table (dry season). However, except high land and mountains, this depth varies between **12 to 25 m**.

1.3.32.7 Earth electrodes and their installation

(d) Multiple numbers of GI pipe earth electrodes need to be used and connected in parallel in order to lower the earthing resistance measured with an earth resistance measuring meter. This is applicable for **copper rod earthing*** and **plate earthing** also.

(e) If multiple **rod, pipe, or plate** electrodes of one grounding system are installed to meet the earth resistance requirements, they shall not be **less than 1.8 m apart**.

Two or more grounding electrodes that are bonded together shall be considered a single grounding electrode system.

1.3.32.8 Brass Clamps on Earth Electrodes

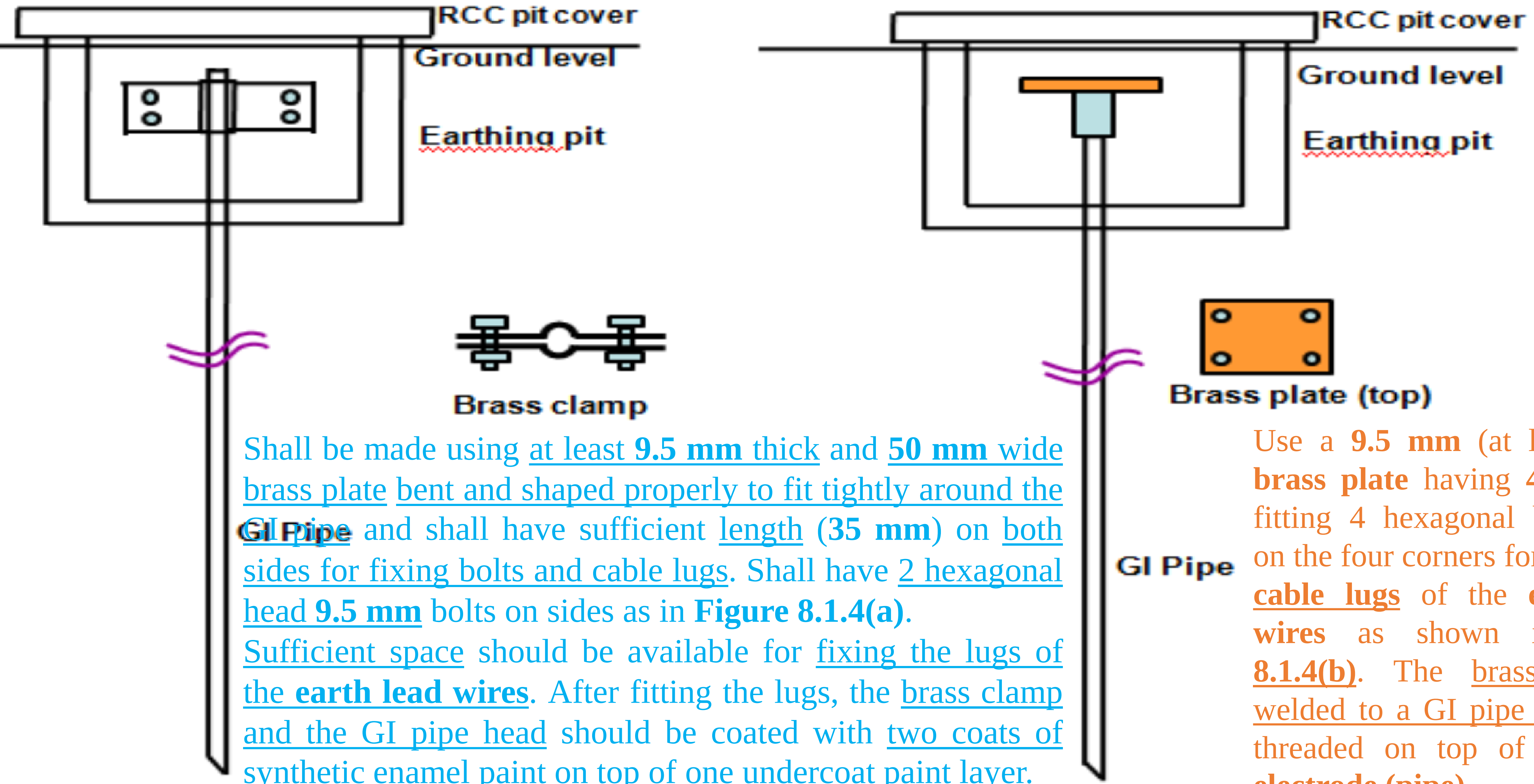
(a) A brass clamp must be fitted on top of a GI pipe earth electrode to terminate the earth lead wire and to maintain electrical contact with the earth electrode and also to terminate the earth lead wire coming from the earthing busbar of the LT panel/MDB/DB. This is needed to establish long lasting and firm connection between the earth electrode and earth lead wire, which in turn means connection between the earth electrode and earthing busbar of an LT panel or MDB/DB.

(b) The Brass clamp shall be made using **at least 9.5 mm thick and at least 50 mm wide** brass plate bent and shaped properly to fit tightly around the GI pipe earth…

1.3.32.8 Brass Clamps on Earth Electrodes

…electrode and shall have sufficient length (**at least 35 mm**) on both sides for fixing bolts and cable lugs. This clamp shall have 2 hexagonal head **9.5 mm bolts** on 1 side and 2 hexagonal head **9.5 mm bolts** on the other side, **Figure 8.1.4(a)**. Sufficient space should be available for fixing the cable lugs of the earth lead wires. After fitting the lugs of the earth lead cables the brass clamp and the GI pipe head should be coated with two coats of synthetic enamel paint on top of one undercoat paint layer.

(c) An alternative to this clamp is to use a **9.5 mm** (at least) thick brass plate having **4 holes** for fitting 4 hexagonal brass bolts on the four corners for fitting the cable lugs of the earth lead wires as shown in **Figure 8.1.4(b)**. The brass plate is welded to a GI pipe socket and threaded on top of the **earth electrode (pipe)**.



Shall be made using at least **9.5 mm** thick and **50 mm** wide brass plate bent and shaped properly to fit tightly around the GI pipe and shall have sufficient length (**35 mm**) on both sides for fixing bolts and cable lugs. Shall have 2 hexagonal head **9.5 mm** bolts on sides as in **Figure 8.1.4(a)**. Sufficient space should be available for fixing the lugs of the **earth lead wires**. After fitting the lugs, the brass clamp and the GI pipe head should be coated with two coats of synthetic enamel paint on top of one undercoat paint layer.

Use a **9.5 mm** (at least) thick **brass plate** having **4 holes** for fitting 4 hexagonal brass bolts on the four corners for fitting **the cable lugs** of the **earth lead wires** as shown in **Figure 8.1.4(b)**. The brass plate is welded to a GI pipe socket and threaded on top of the **earth electrode (pipe)**.

(a) (b)

Figure 8.1.4 Pipe Earthing; (a) Type 1; (b) Type 2

1.3.32.9 Earthing Busbars

A copper earthing busbar shall be provided inside the LT Panel of a substation* or MDB/DB of a building. The earth lead wire coming from the Earth Electrode shall be terminated on this busbar using cable lugs (cable lugs must be fitted using crimp tools or hydraulic press) and brass bolts & nuts.

Copper earthing busbar shall also be provided inside the DBs, FDBs, SDBs and BDBs. Hexagonal head brass screw, nuts & washers are needed for fixing the ECC and earth lead cables with this busbar.

1.3.32.10 Earthing Pit

An earthing pit shall be constructed around the top of the Earth Electrode, below the ground level using 250 mm brick walls on a CC floor with a 150 mm thick RCC slab cover on top having lifting hooks. The top of the earth electrode (in case of pipe earthing) shall remain 375 mm above the top of the bottom CC floor of the pit. The minimum inside dimension of the earthing pit shall be **600 mm × 600 mm × 600 mm**. The outside as well as the inside of the walls of the pit and the floor of the pit shall be cement mortar plastered. The inside shall be net cement finished. The top of the **RCC slab pit cover** shall remain **38 mm** above the ground level. The pit shall be made in such a way that water cannot get in to the pit. One earthing pit is needed for one earth electrode.

Around the top of the Earth Electrode, below the ground level using **250 mm brick walls** on a **CC floor** with a **150 mm** thick RCC slab cover on top having lifting hooks. Minimum **inside** dimension shall be **600 mm × 600 mm × 600 mm**. The outside as well as the inside of the walls of the pit and the floor of the pit shall be cement mortar plastered. The inside shall be net cement finished. The top of the **RCC slab pit cover** shall remain **38 mm** above the ground level.

Design of Lightning Protection System (LPS)

M7: Lightning Protection System Design

- Lightning Protection for Buildings
- Various Indices and Rix Factors
- Rix Assessment (Rix Calculation)
- Integral Parts of an LPS
- Sizes of the Components of LPS
- Protection Zone
- Clearance Calculation
- Surge Arrester Selection
- Horn-gap Lightning Arrester (LA)

1.3.33 Lightning Protection of Buildings

Whether a building needs protection against lightning depends on the **probability of a stroke and acceptable risk levels**. Assessment of the risk and of the magnitude of the consequences needs to be made. As an aid to making a **judgment**, a set of indices is given in **Table 8.1.27** below for the various factors involved.

Table 8.1.27 (a): Index Figures Associated with Lightning Protection Design

(Index A, Index B)

Table 8.1.27 (b): Index Figures Associated with Lightning Protection Design

(Index C, Index D, Index E)

Table 8.1.27 (c) : Index Figures Associated with Lightning Protection Design

(Index F, Index G)

Index A: Use of Structure

Description	Index
Houses and similar buildings	2
Houses and similar buildings with outside aerial	4
Small and medium size factories, workshops and laboratories	6
Big industrial plants, telephone exchanges, office blocks, hotels, blocks of flats	7
Places of assembly, for example, places of workshop, halls, theatres, museums, exhibitions, department stores, post offices, stations, airports, stadiums	8
Schools, hospitals, children’s homes and other such structures	10

Index B: Type of Construction

Description	Index
Steel framed encased with nonmetal roof[a]	1
Reinforced concrete with nonmetal roof	2
Brick, plain concrete, or masonry with nonmetal roof	4
Steel framed encased or reinforced concrete with metal roof	5
Timber formed or clad with any roof other than metal or thatch	6
Any building with a thatched roof	10

[a]A structure of exposed metal which is continuous down to ground level is excluded from the table as it requires no lightning protection beyond adequate earthing arrangements.

Index C: Contents or Consequential Effects

Description	Index
Ordinary domestic or office building, factories and workshops not containing valuable materials	2
Industrial and agricultural buildings with specially susceptible[b] contents	5
Power stations, gas works, telephone exchanges, radio stations	6
Industrial key plants, ancient monuments, historic buildings, museums, art galleries	8
Schools, hospitals, children's and other homes, places of assembly	10

[b]This means specially valuable plant or material vulnerable to fire or the results of fire.

Index D: Degree of Isolation

Description	Index
Structure located in a large area having structures or trees of similar or greater height, e.g. a large town or forest	2
Structure located in an area with a few other structures or trees of similar height	5
Structure completely isolated or exceeding at least twice the height of surrounding structures or trees	10

Index E: Type of Terrain

Description	Index
Flat terrain at any level	2
Hilly terrain.	6
Mountainous terrain 300 m and above	8

Index F: Height of Structure

Description	Index
Up to 9 m	2
9-15 m	4
15-18 m	5
18-24 m	8
24-30 m	11
30-38 m	16
38-46 m	22
46-53 m[c]	30

[c]Structures higher than 53 m require protection in all cases

Index G: Lightning Prevalence

Number of thunderstorm days per year	Index
Up to 3	2
4-6	5
7-9	8
10-12	11
13-15	14
16-18	17
19-21	20
Over 21	21

Explanation of Indices for Some Factors

1.3.33.1 Degree of Isolation (Index D)

The **relative exposure** of a particular building will be an element in determining whether the expense of lightning protection is warranted. In closely built-up towns and cities, the hazard is not as great as in the open country.

1.3.33.2 Type of terrain (Index E)

In hilly or mountainous areas, buildings are more susceptible to damage due to lightning than buildings in the plains or flat terrain. In hilly areas, a building upon high ground is usually subject to greater hazard than one in a valley or otherwise sheltered area.

1.3.33.3 Height of structure (Index F)

Height of the structure is an important factor for the purpose of lightning protection. Taller structures are subject to greater hazards than smaller structures and, therefore, lightning protection is more desirable for tall structures.

1.3.33.4 Lightning prevalence (Index G)

The number of thunderstorm days in a year varies in different parts of a country. However, the severity of lightning storms, as distinguished from their frequency of occurrence, is usually much greater in some locations than others. Hence, the need for protection varies from place to place, although not necessarily in direct proportion to the thunderstorm frequency.

1.3.33.5 Risk Assessment

"Risk Index" is the sum of the indices for **all the factors**, as given in Table 8.1.27 earlier. A few examples of calculation of Risk Index are given in **Table 8.1.28**, based on a marginal Risk **Index of 40**.

Table 8.1.28: Example of Calculation of Risk Index

1) Small residential building
2) Office building
3) Hotel building
4) Building of historical importance
5) Structure of high historical importance
6) Hydroelectric power stations

Table 8.1.28: Example of Calculation of Risk Index

Example	A	B	C	D	E	F	G	Total Index	Recommendation
Small residential building in a thickly **populated** locality (height **less than 10 m**)	2	4	2	2	2	2	21	35	No protection needed, in general
Office building in a locality (**height 20 m**)	7	2	2	2	2	5	21	41	As the figure is around 40, need of protection will depend upon the **importance** of the Building
Hotel building (height **31m**) **exceeding twice** the height of surrounding structures	7	2	2	10	2	16	21	60	Protection essential

Table 8.1.28: Example of Calculation of Risk Index

Example	A	B	C	D	E	F	G	Total Index	Recommendation
Building of historical importance completely isolated (height>55m)	8	4	8	10	2	30	21	83	Protection essential
Structure of high historical importance (height>55m)	-	-	-	-	-	-	-	-	Protection essential as the height>53 m
Structure, such as **hydroelectric power stations**, sufficiently protected by means of surrounding structures, such as high vertical cliffs, high metallic structures or earth wire of transmission system (height 15 m)	7	2	6	2	6	4	21	48	Protected by surroundings

Integral Parts of a Lightning Protection System (LPS)

1.3.33.6 Integral Parts of an LPS

A small* complete lightning protection system shall consist of-

(i) An air spike or air terminal (AT), **(ii) A down conductor,**

(iii) A roof conductor and **(iv) An earth electrode.**

An AT is that part which is intended to intercept lightning discharges. It consists of a vertical thick conductor of **round cross section** mounted on the highest part of the building to protect the required area. However, in general there may be more than one AT. In such a case, roof conductors (made with copper strips or PVC insulated Annealed Stranded copper cables) need to be used to interconnect the ATs. Usually, for each AT, there shall be one down conductor (made with copper strips or PVC insulated Annealed Stranded copper cables i.e. same as roof conductor) going down up to the Earth Electrode pit and connected to the Earth Electrode. In all junctions, appropriate type of copper or brass junction plates or brass clamps must be used to ensure low resistance, firm and long lasting connection.

(a) Air Spike/Air Terminal (AT)

An **AT** shall be made with copper rod of minimum **12 mm** diameter with **tin coating** on top. The terminal shall have a copper/brass **base plate** for mounting on top of roof, column, parapet wall using rowel bolts. The minimum dimension of such a base plate shall be **152 mm x 152 mm x 13 mm**. The length and width may need to be increased depending on the number of connection of the down conductors and the roof conductors. Such connections are to be made using hexagonal head brass bolts and nuts of **10mm** diameter with brass washers. **Minimum height** of the AT shall be **300 mm** above the highest point of the building fulfilling all the conditions of NFPA 780.

(b-c) Down Conductor & Roof Conductor

(b) Down conductor

A Down Conductor shall be made with copper strip or Stranded PVC insulated annealed copper cable.

(c) Roof conductor

A Roof Conductor shall be made with copper strip or Stranded PVC insulated annealed copper cable. This shall run along the periphery of the roof to link all ATs and all down conductors installed on top of a building. The joints shall be made using clamps made of copper strips (of **1/8 inch** minimum thickness) and appropriate brass bolts and washers of **3/8 inch** minimum diameter.

(d-e) Earth Electrode & Earth Inspection Boxes

The **Earth Electrode** is **exactly same type** as the Earth Electrode of the Electrical Distribution (Electrical Installation for Buildings) system described earlier in this document. Considering the practical situation in this country*, Pipe Earth Electrodes are suggested. For each AT, one Earth Electrode is an ideal solution.

(e) Earth inspection boxes

A 18 SWG GI sheet made Earth Inspection Box must be provided for **each** down conductor **1000 mm above the plinth** level of the building (concealed inside the wall) which will contain a copper strip made **clamp** on the insulation peeled down conductor to check the continuity of the Earth Lead Down Conductor and the Earth Electrode and also to measure the Earth Resistance of the system. The box shall have a GI sheet made cover plate.

(f) Earthing Pit for LPS

Earthing pits shall be provided as described in the earthing topic above.

1.3.33.7 # of AT*s Required & Their Installation

Number of Lightning Protection Air Spikes (or ATs) in a building will depend on the nature of the roof top, on the total area of the roof top, on the height of the building, height of the adjacent buildings, height of the nearby towers or other similar structures. However, as a thumb rule, for every **80 m^2 area** at least one air spike should be chosen at the beginning.

During placement of the air spikes, the total number may have to be increased or adjusted.

1.3.33.8 Protection Zone

It is a space within which an AT provides protection by attracting the stroke to itself. A single vertical conductor attracts to itself strokes of **average or above average** intensity which in the absence of the conductor would have struck the ground within a circle having its centre at the conductor and a **radius*** equal to **twice** the height of the conductor. For **weaker than average discharges**, the protected area becomes **smaller**. For practical design it is therefore assumed that **statistically satisfactory protection** can be given to a zone consisting of a cone with its apex at the top of the vertical conductor and a base **radius** equal to the **height** of the conductor. This is illustrated in **Figure 8.1.5**. A horizontal conductor can be regarded as a series of apexes coalesced into a line, and the zone of protection thus becomes a tent-like space (**Figure 8.1.6**).

Earth Electrodes and Ohmic Value for LPS

(a) When there are **several parallel horizontal conductors** the area between them has been found by experience to be **better** protected than one would expect from the above considerations only. The recommended design criterion is that no part of the roof should be **more than 9 m** from the nearest horizontal conductor except that an additional 0.3 m may be added for each 0.3 m or part there of by which the part to be protected is below the nearest conductor.

(b) The earth termination is that part which discharges the current into the general mass of the earth. It is 1 or more earth electrodes. Earth electrodes for lightning protection are no different from earth electrodes for **short circuit** protection systems. The total resistance of an electrode for a Lightning Protection System (LPS) must **not exceed 10 ohms** for buildings up to **10 storied** and **2 ohms** for high rise buildings.

3-Methods to Calculate the # of Down Conductors

(c) The down conductor is the conductor which runs from the air termination to the earth termination. A building with a base area not exceeding 100 m^2 shall be provided with one down conductor. **(1)** For a **larger** building, there shall be one down conductor for the 1st **80m²** plus a further 1 for every **100 m²** or part thereof. **(2)** Alternatively, for a larger building 1 down conductor may be provided for every **30 m** of perimeter. **(3)** Ideally, every AT should have a down conductor.

(d) The material used for lightning conductors **must** be **copper**. The criterion for design is to keep the resistance from air termination to earth electrode to a negligible value.

(e) Recommended dimensions for various components of lightning arrester are given in **Table 8.1.29**. Larger conductors should however be used if the system is unlikely to receive regular inspection and maintenance.

Table 8.1.2 9: Sizes of the Components of Lightning Protection Systems

Components	**Minimum Dimensions**
Air terminals	12 mm dia
Copper strip	20 mm W x 3 mm T
Copper and phosphor bronze rods	12 mm dia
PVC insulated stranded annealed copper cable (minimum size)	19 strands of 1.8 mm dia
<u>Down Conductors</u>	
Copper strip	20 mm x 3 mm
PVC insulated stranded annealed copper cable (minimum size)	19 strands of 1.8 mm dia
<u>Earth Electrode</u>	
Hard drawn copper rods for driving into soft ground	12 mm dia
Hard drawn or annealed copper rods for indirect driving or laying in ground	12 mm dia
Phosphor bronze for hard ground	12 mm dia
Copper clad steel for hard ground	50 mm dia
GI pipe	38 mm/50 mm dia

Table 8.1.2 9: Sizes of the Components of LPS

Components	Minimum Dimensions
Air terminals	
Copper rods	12 mm dia
Copper and phosphor bronze rods	12 mm dia
Roof Conductors	
Copper strip	20 mm W x 3 mm T
PVC insulated stranded annealed copper cable	19strands of ϕ1.8mm
Down Conductors	
Copper strip	20 mm W x 3 mm T
PVC insulated stranded annealed copper cable	19strands of ϕ1.8mm

Table 8.1.2 9: Sizes of the Components of LPS

Components	Minimum Dimensions
Earth Electrode	
Hard Drawn Bare Copper (HDBC) rods for driving into soft ground	12 mm dia
HDBC or annealed copper rods for indirect driving or laying in ground	12 mm dia
Phosphor bronze for hard ground	12 mm dia
Copper clad **steel** for hard ground	50 mm dia
GI pipe	38 mm/50 mm dia

1.3.33.8 Protection Zone

(f) External metal on a building should be bonded to the lightning conductor with bonds at least as large as the conductor.

(g) When a lightning conductor carries a stroke to earth, it is temporarily raised to a potential considerably above that of earth. There is, therefore, a **risk** that the **discharge will flash** over to **nearby metal** and cause damage to the intervening structure. This can be **prevented** by either, (i) providing **sufficient clearance** between conductor and other metal or (ii) by **bonding** these together to ensure that there can be no potential difference between them.

1.3.33.8 Protection Zone: Clearance

The necessary **clearance** is obtained from:

$$D = 0.3\,R + \frac{H}{15\,n}$$

Where,

D = Clearance in metres

R = Resistance to earth in ohms

H = Height of building in metres

n = Number of down electrodes

Since it is often **impracticable to provide the necessary clearance**, the **alternative** technique of bonding is preferred.

(h) Surge Arrester Selection

A surge arrester is a protective device for limiting surge voltages by discharging, or bypassing, **surge current** through it. It also prevents **continued flow of follow-through current** while remaining capable of repeating these functions. It is used to protect **overhead** lines, **transformers** and other electrical apparatus mostly in an **outdoor substation** from lightning voltages traveling through the overhead lines.

(i) Horn-gap Lightning Arrester (LA)

Horn-gap lightning arresters are commonly used for low and medium voltage **overhead** lines. The rating of the surge arrester shall be equal to or greater than the maximum continuous phase to ground power frequency voltage available at the point of application.

(j) LPS* (including number & height of ATs) can also be designed and installed by using **Rolling Sphere Method** following NFPA 780. Minimum height of the Air Terminal shall be in accordance with Sec **1.3.33.6**

Q?

Thanks!

M8: Data/Telecom, FDAS, Security - Outline

- Data/Telecom for Buildings:
- Wiring for Telecommunications
- Telecommunications Outlets
- TV Antennas/Cable TV system
- Data Network for LAN & Internet Services
- Fire Detection and Alarm System
- CCTV, Access Control System, Electronic Security Systems

Data/Telecommunication for Buildings

1.3.34.1 General

Placing concealed **2-pair** indoor cables is needed to get (i) telephone lines of the **wired telephone** companies inside rooms of a building and (ii) to get the **PABX lines** of the building/offices in the building to the respective rooms under the PABXs. In addition to this, **10/20/50 pairs** telephone cables are required to be brought in to the PABX room(s) of the building. Conduits are to be installed for both of these two categories. For the entry of 10/20/50 pair cables, conduits through straight and easy path (in most cases, through one side of the vertical electrical duct) need to be brought in.

1.3.34.2 Concealed telco Wiring

2 pair PVC insulated PVC sheathed annealed copper **telecommunication cable** shall be drawn through sufficient number of **pre-laid 19/25/38 mm** PVC conduits to establish telecommunication network inside a building. A clearance of at least 40 % must be maintained inside the PVC conduits. Sufficient number of 18 SWG GI sheet made pull boxes (with Perspex sheet/ebonite sheet cover plates) at all suitable places must be placed for the ease of pulling these cables.

2 pair PVC insulated PVC sheathed annealed copper telco cable shall be used for wiring between a Telephone DP/Patch panel and a telco outlet. The extra pair shall remain for future maintenance. The minimum size of the copper wire of this cable shall be **0.5 mm**. The copper shall be preferably tinned.

1.3.34.3 Surface telco Wiring

Surface wiring should not be a choice during designing a building wiring. However, if the building is already constructed or under compulsory conditions or for extension of an existing network, one may go for surface wiring. The same 2 pair PVC insulated PVC sheathed annealed copper telecommunication cable shall be used for this purpose. Wiring shall be done either by using channels or by using PVC conduits following the power line surface wiring methods mentions earlier.

Data/Telecommunications for Buildings

1.3.34.4 Telecomm Outlets

Wall mounted Telecommunication outlets shall contain **RJ11 or RJ45** connectors/jacks (shuttered). For simple telephone connection, RJ11 shuttered jacks are sufficient. The outlet box shall have a back-box which may be made of the same polymer material as the front panel or shall be made using 18 SWG GI sheet or 18 SWG **MS** sheet but **painted with two coats** of synthetic enamel paint.

1.3.34.5 Telephone DP/patch panel room and digital PABX room

Should be located near the **vertical riser** duct of the building so that the incoming **50/100** pair UG tele cable can be terminated in the DP/MDF or patch panel for distribution among the flats of a multi-storied residential building or among the offices of a multi-storied commercial/office building. If a digital telephone PABX is to be installed then this can be installed in the same room. A separate earth electrode with earth lead wire will be required for the PABX.

1.3.35 TV Antennas/Cable TV System

In a multi-storied residential/office building, television antennas shall be placed at one suitably sited antenna location on roof top and connect these to individual flats/residences/offices in the same building by **coaxial cables** through concealed conduits.

1.3.35.1 Cable work for TV antennas/cable TV system

Vertical duct and easy entry to each flats/offices must be provided as sharp bending of these cables is difficult and harmful to the cables. These cables must **not** be placed in the **same conduit** with power cables. A distance of **at least 350 mm** must be maintained if a portion runs in parallel with the power cable conduits.

1.3.35 TV Antennas/Cable TV System

RF and Video cables shall be PVC sheathed Co-axial Cables made* with solid Copper centre conductor, **foamed polythene** insulated and further **sealed Aluminium foil** taped and Copper wire braided.

1.3.35.2 TV antenna outlets/cable TV system outlets

Wall mounted television coaxial cable outlets shall contain high quality coaxial connectors/jacks. The outlet box shall have a back-box which may be made of the same polymer material as the front panel or 18 SWG GI sheet or 18 SWG **MS** sheet made but painted with 2 coats of synthetic enamel paint.

1.3.36 Data Net for LAN & Internet Services

Data Communication Network for LAN and Internet Services inside a Building may be installed using Cat 6 Unshielded Twisted Pair (UTP) cables in a concealed manner following the concealed wiring power cables installation procedure mentioned in the wiring methods section of this document. Each of the cables will be terminated at one end at the **8P8C (RJ45) connector based data socket outlet** board in the required rooms at the power socket level. On the other end, the cable will be terminated in the **patch panel**. From the patch panel up to the data socket outlet the cable shall be in one piece i.e., **no joints will be allowed**.

1.3.36 Data Net for LAN & Internet Services

As a result the concealed conduit work needs to be done carefully to have a straight line path and without any bend in the roof slab. Sufficient pull boxes will be required in the roof slab. Pull box will also be needed close to the vertical bend near the bend and ceiling at any downward drop of the conduit. The conduits must have 20 SWG GI pull wires during laying for pulling the cables later.

Because of the nature of these cables more clearances are needed inside the PVC conduits compared to the power cables. If the conduits are running parallel to the power cables then there should be at least a distance of **410 mm** between these two.

Recently **Cat. 7** cables are emerging as a better choice in place of Cat. 6 cables.

Fire Detection and Alarm System inside a Building

1.3.37 Fire Detection and Alarm System

The major parts of a Fire Detection and Alarm System (**FDAS**) inside a Building may be listed as -

(a) A # of different types of Fire Detectors/detection devices wired in a # of radial circuits

(b) Manual call points

(c) A central control panel for fire detection (FACP*)

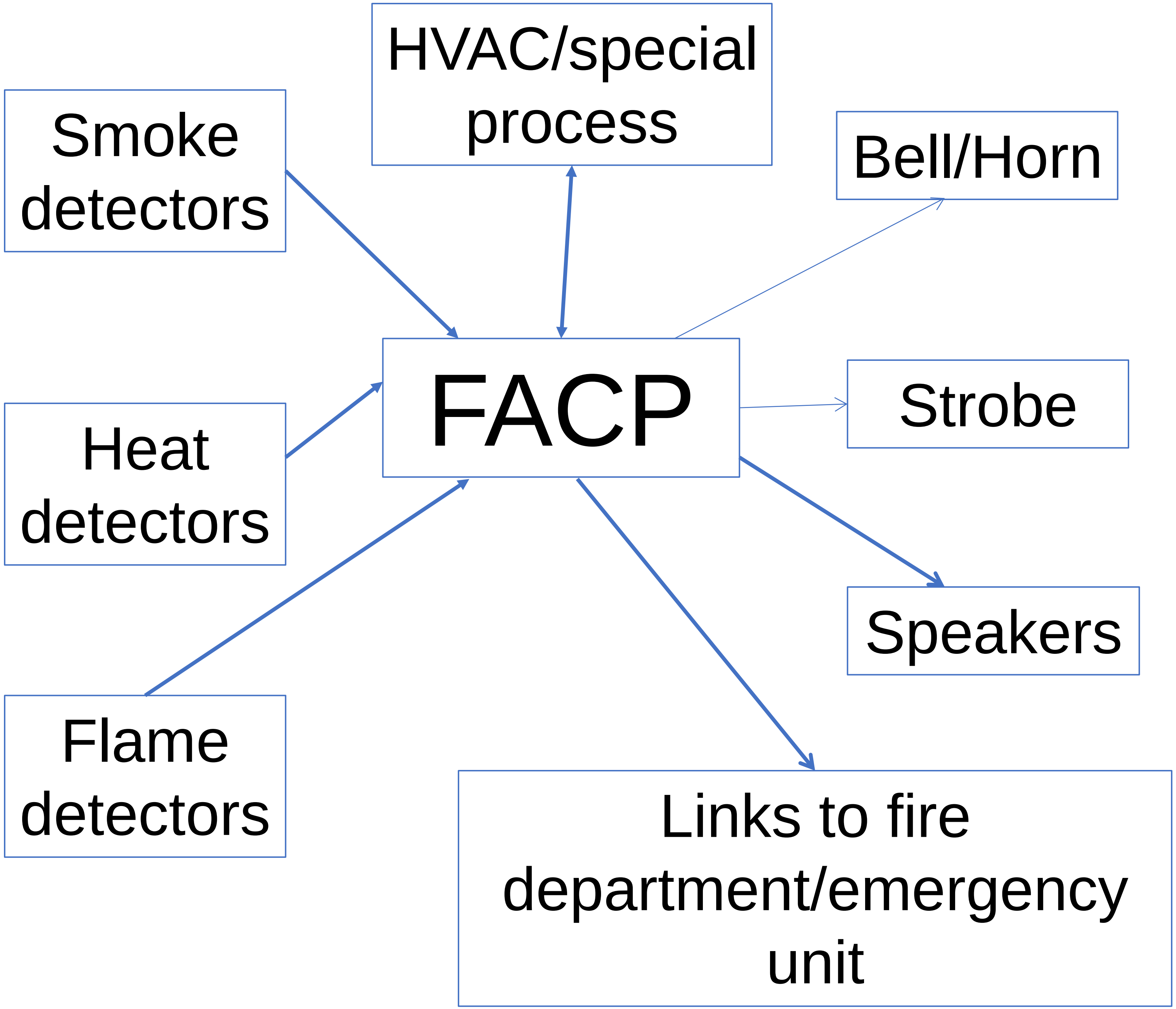
(d) A # of alarm sounders/alarm devices wired in a # of radial circuits

(e) Cables for wiring the fire detectors/detection devices

(f) Cables for wiring the alarm sounders/alarm devices

Key Components of FDAS

- Automatic Detectors
- Automatic Alarm
- Fire Alarm Control Panel (FACP)
- Manual Call Point/Manual Pull Station
- Interconnection Cables
- Interconnection With Fire Department or Special Unit For Emergency Response


HVAC/special process
Smoke detectors
Bell/Horn
FACP
Strobe
Heat detectors
Speakers
Flame detectors
Links to fire department/emergency unit

BLOCK DIAGRAM OF FIRE DETECTOR ALARM SYSTEM

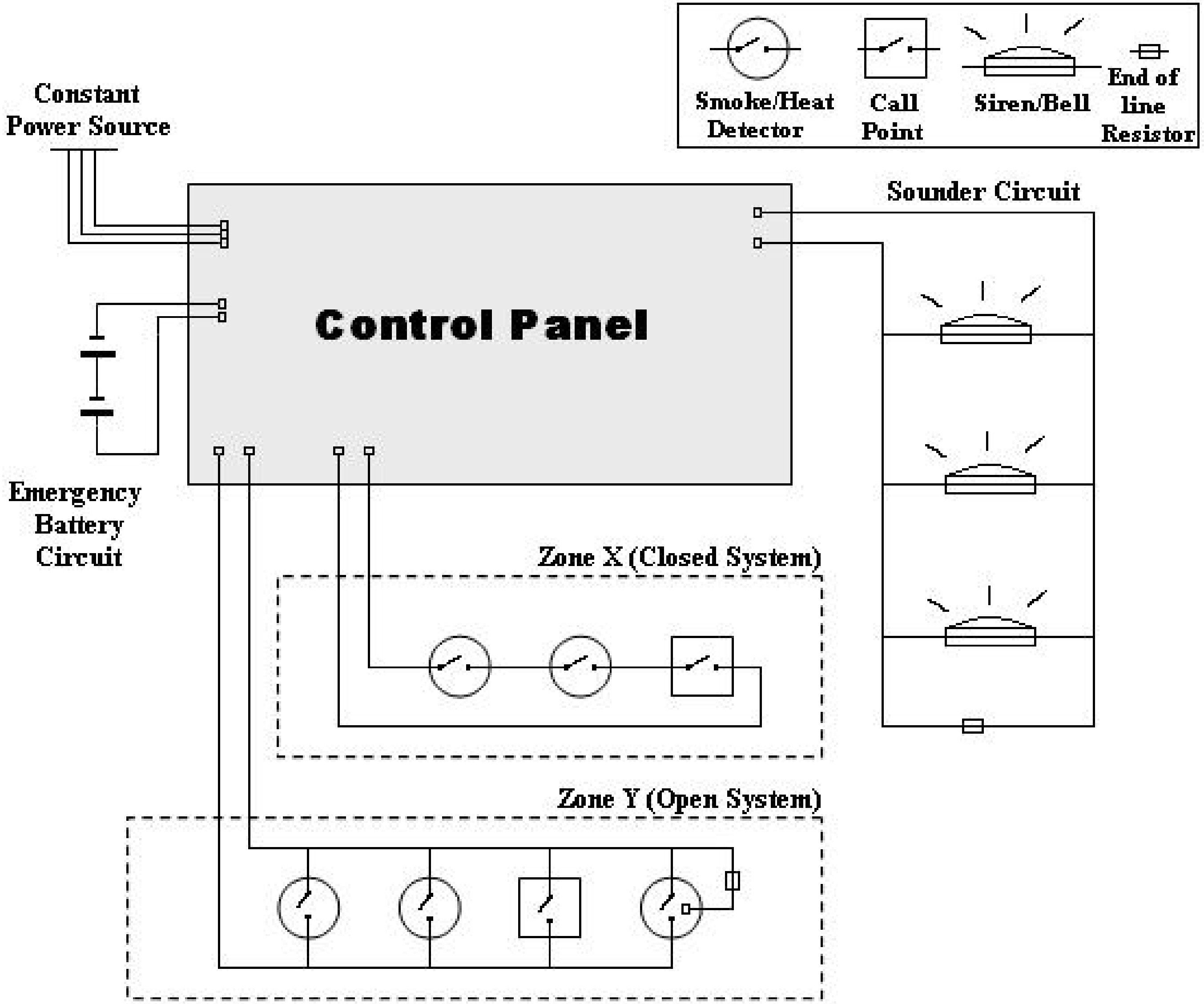
INPUT DEVICES

- Input devices can be triggered automatically or manually depending on their working mechanism.
- Some of the fundamental fire alarm input devices are given below :
  - Detectors
  - Manual call points
  - Input modules

TYPES OF INPUT DEVICES

- INPUT DEVICES
  - HEAT DETECTORS
    - FIXED TEMP TYPE
    - RATE OF RISE TYPE
  - SMOKE DETECTOR
    - PHOTOELECTRIC
    - IONIZATION
  - FLAME DETECTORS
    - ULTRAVIOLET LIGHT
    - INFRARED
  - FIRE GAS DETECTORS

Example of a Simple Fire Detection & Alarm System




NOTIFIER
by Honeywell


VIGILANT
VIGILANT

Repeater panel/Remote anunciator

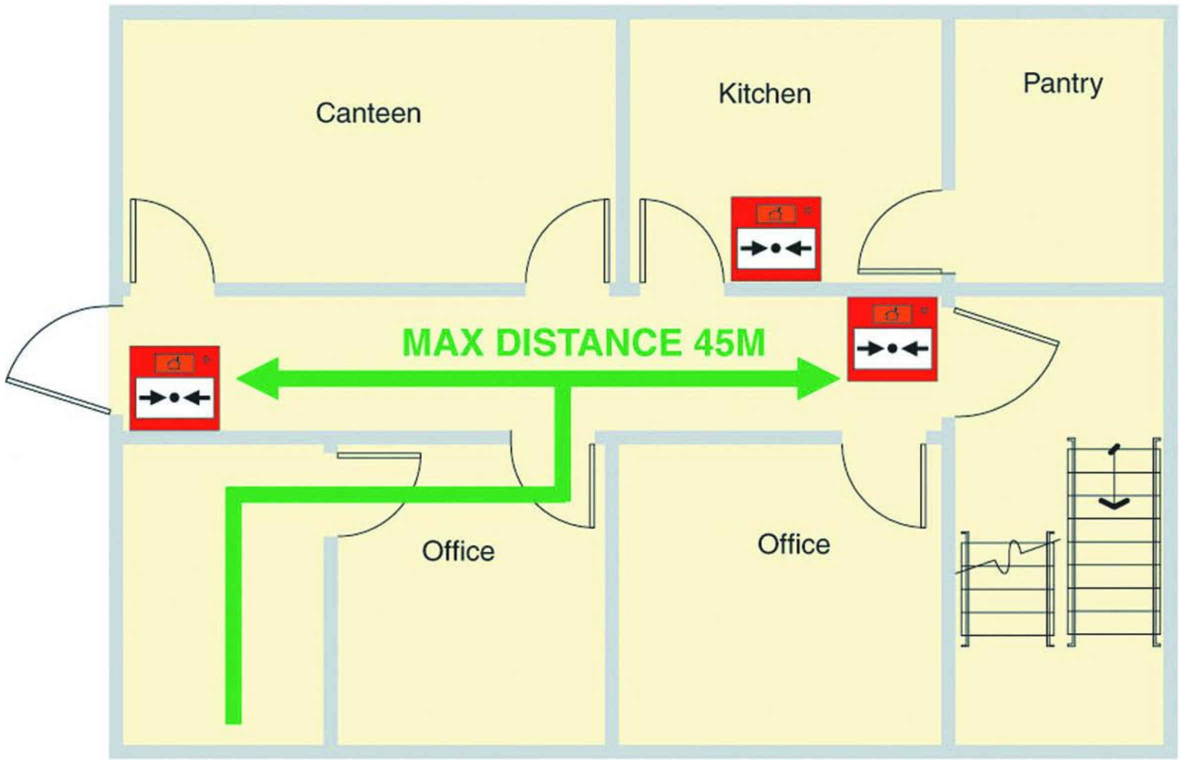
- Replicates the control panel information and control facilities allowing multiple operating points within the system.
- Communicates with the Master Control Panel via an RS422/RS485 or fiber optic or TCP/IP network.
- Backlit LCD display to display system messages.

Manual Call Points

- A manually operated device to initiate fire alarm.
- Simple device and highly reliable when the building is occupied.
- Cannot be used when the building is unoccupied.
- May be activated maliciously.

Siting of Manual Call Points

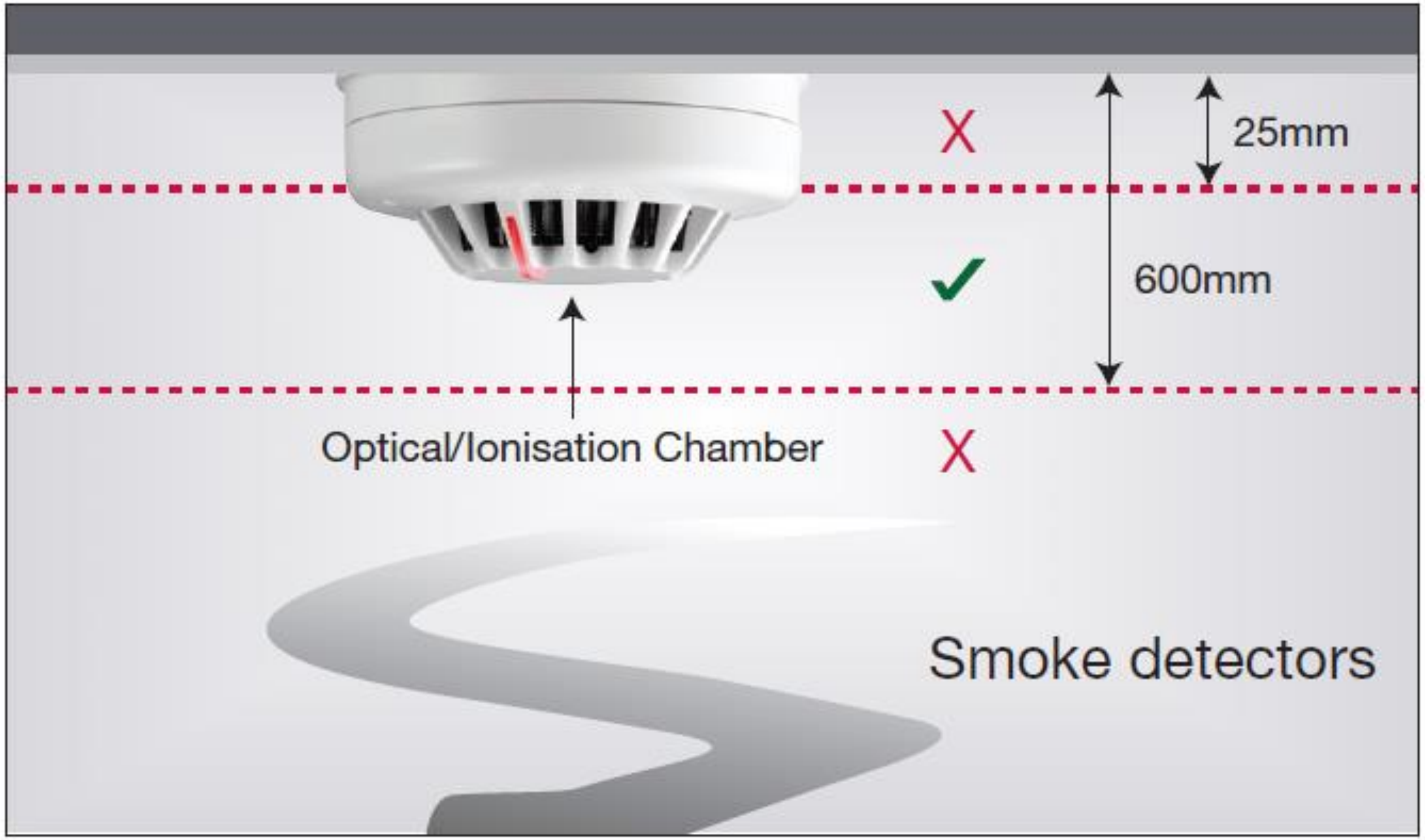
- On all storey exits and all exits to open air



Smoke Detectors

- For **early warning** of fire and wherever life safety is a primary concern.
- **Ionization** type smoke detectors are suitable for fast and flaming fires. Not recommended for environmental reasons.
- **Optical/photoelectric** detectors are suitable for smoldering (slow burning) fires.

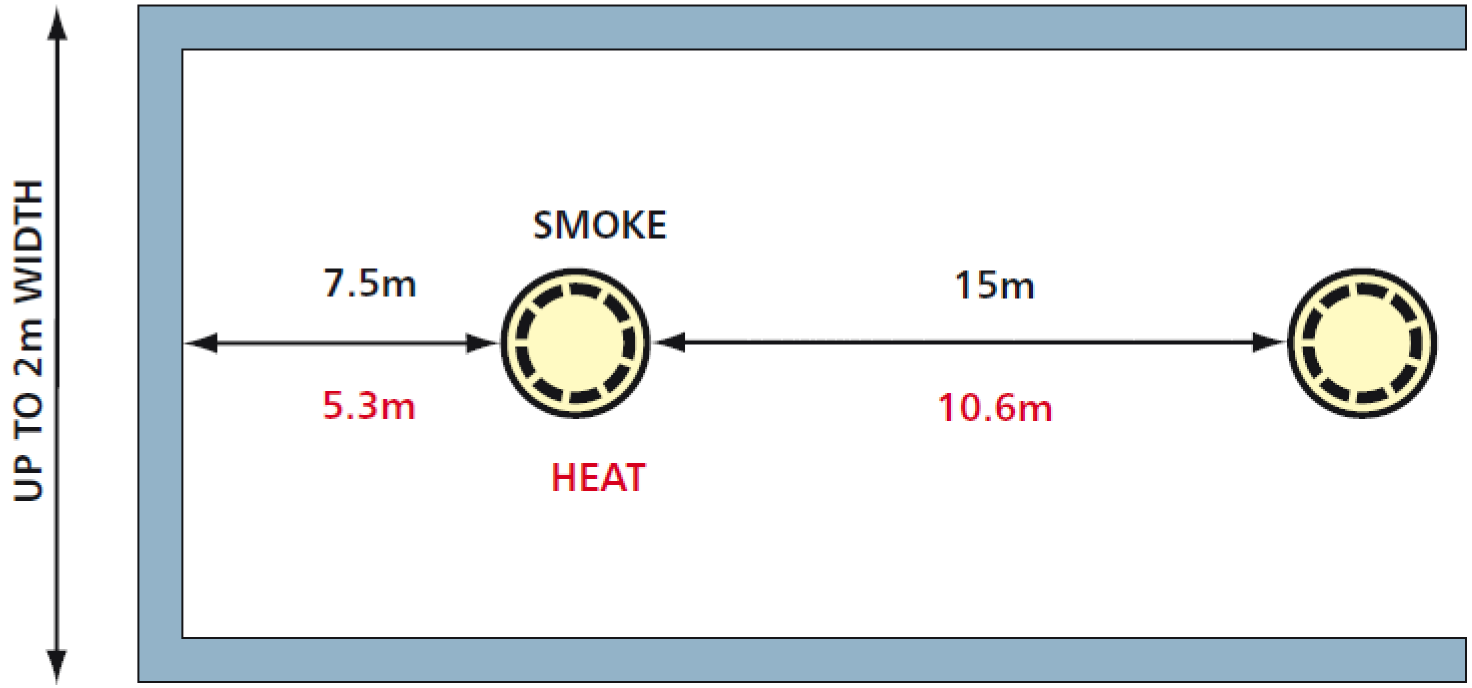
Siting of Smoke Detectors (contd..)



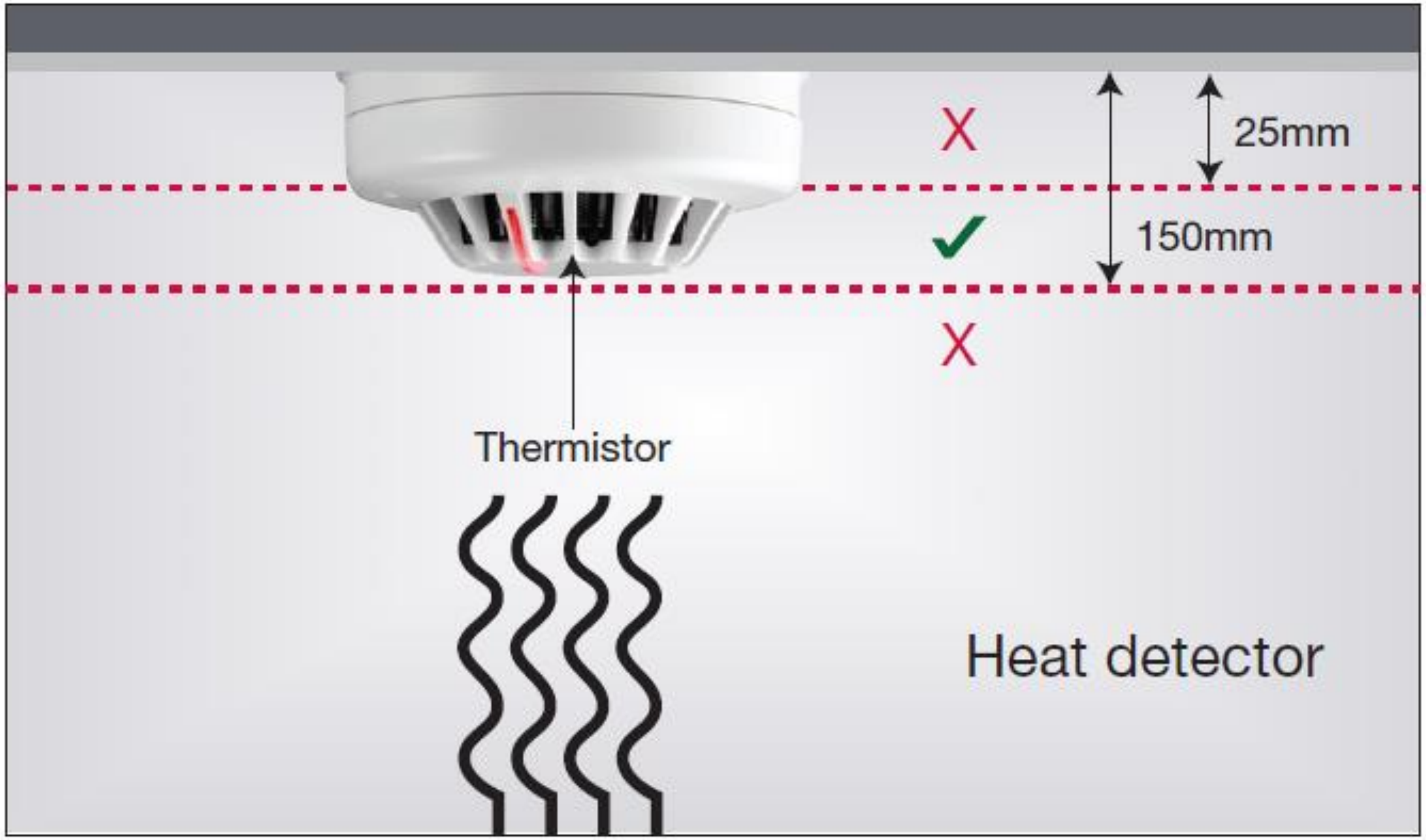
Heat Detectors

- Warns of fire when the surrounding **temperature reaches** a certain level.
- Not recommended for life safety and where fire must be detected before substantial flames.
- Highly reliable and less expensive.
- Suitable for locations where smoke detectors cannot be used e.g. kitchen, parking lot, dust and smoky places etc.
- Addressable or conventional.

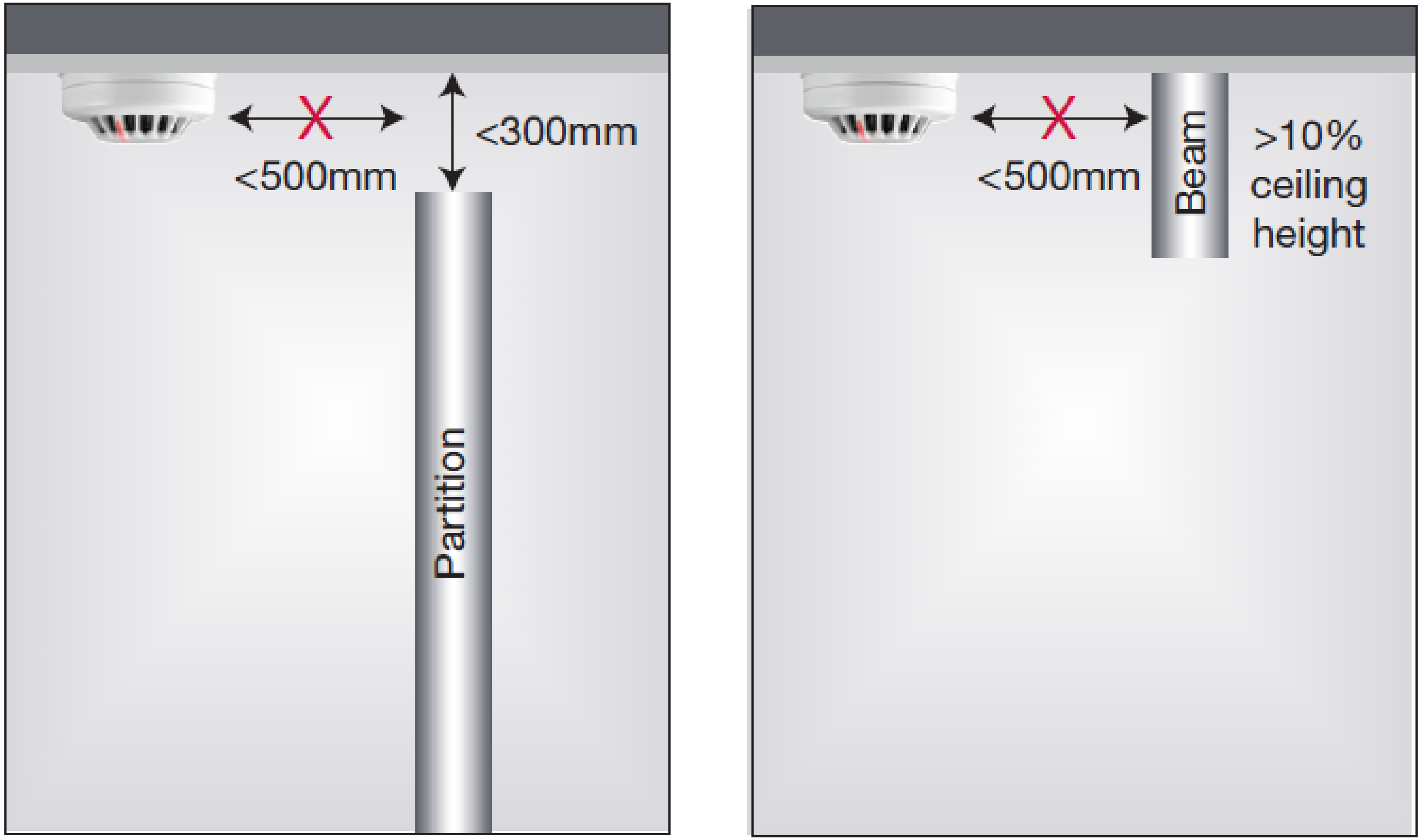
Siting of Heat Detectors (contd..)



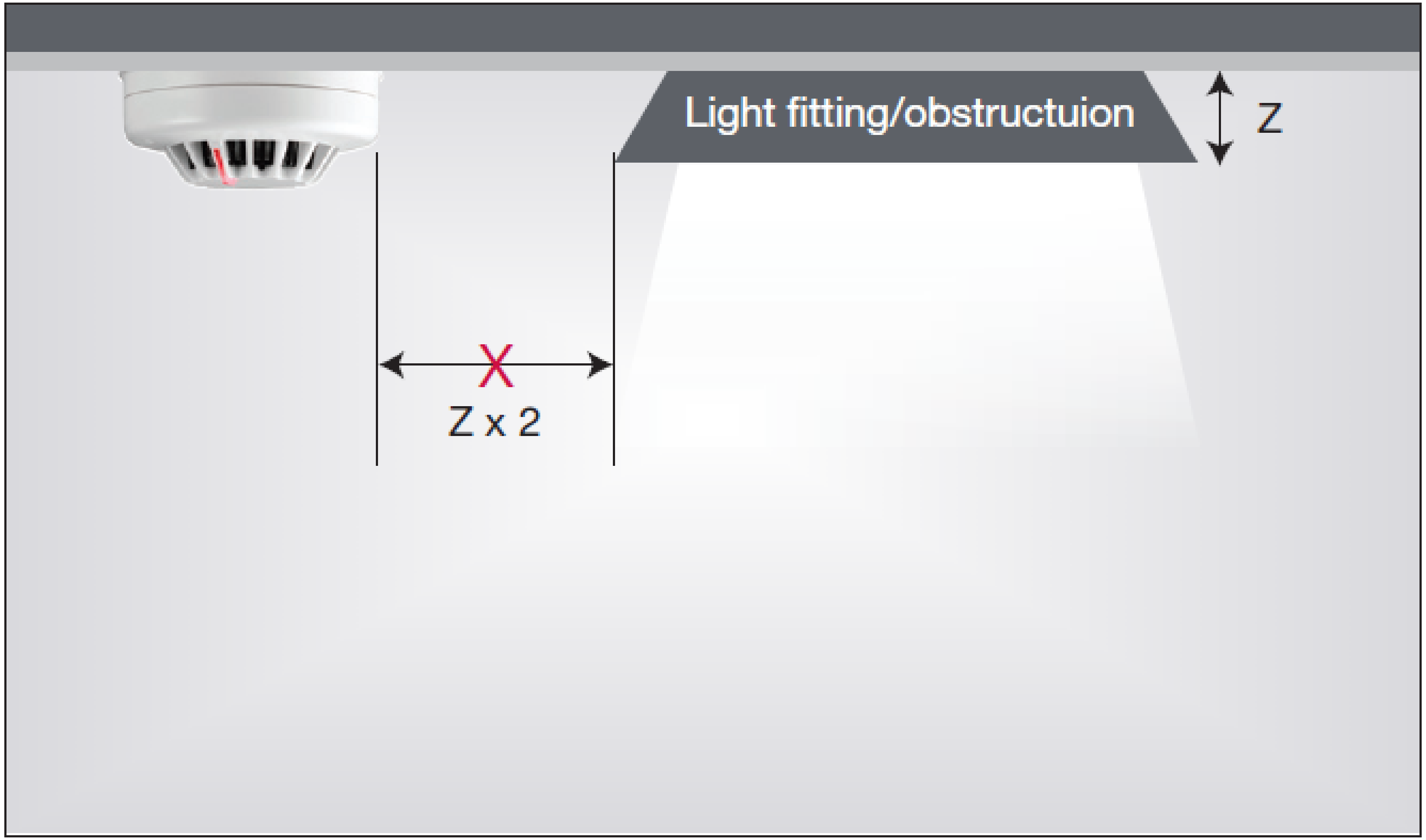
Siting of Heat Detectors (contd..)



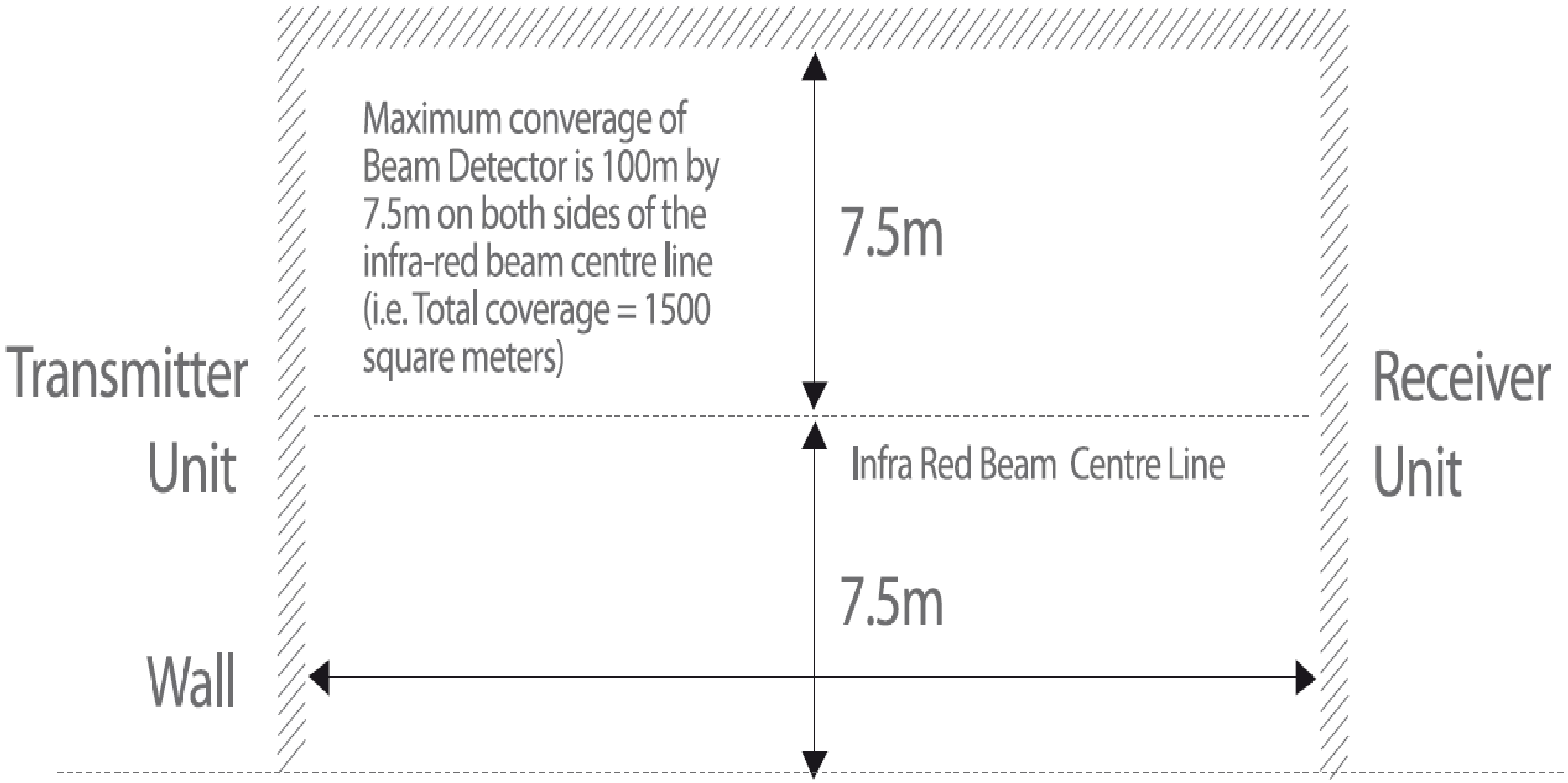
Siting of Detectors Near Obstructions



Siting of Detectors Near Obstructions (contd..)



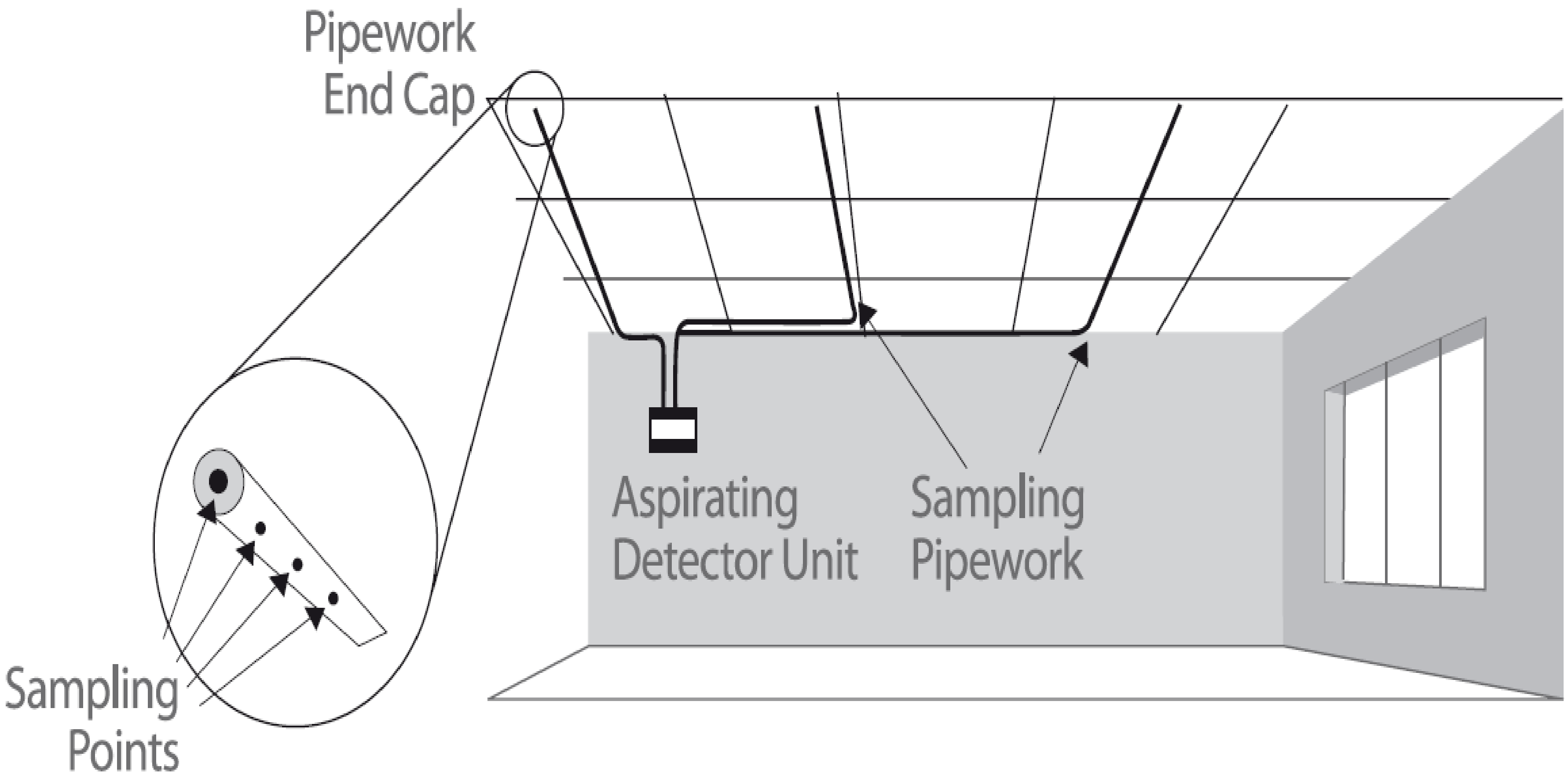
Coverage of Beam Detectors



Aspirating Smoke Detector

- An aspirating smoke detector (ASD), consists of a **central detection unit** which draws air through a **network of pipes** to detect smoke. The sampling chamber is based on a nephelometer that detects the presence of smoke particles suspended in air by detecting the light scattered by them in the chamber.
- In most cases aspirating smoke detectors require a **fan unit** to draw in a sample of air from the protected area through its network of pipes.
- Aspirating smoke detectors can detect smoke before it is visible to the human eye.

Aspirating Smoke Detector (contd..)



Flame Detectors

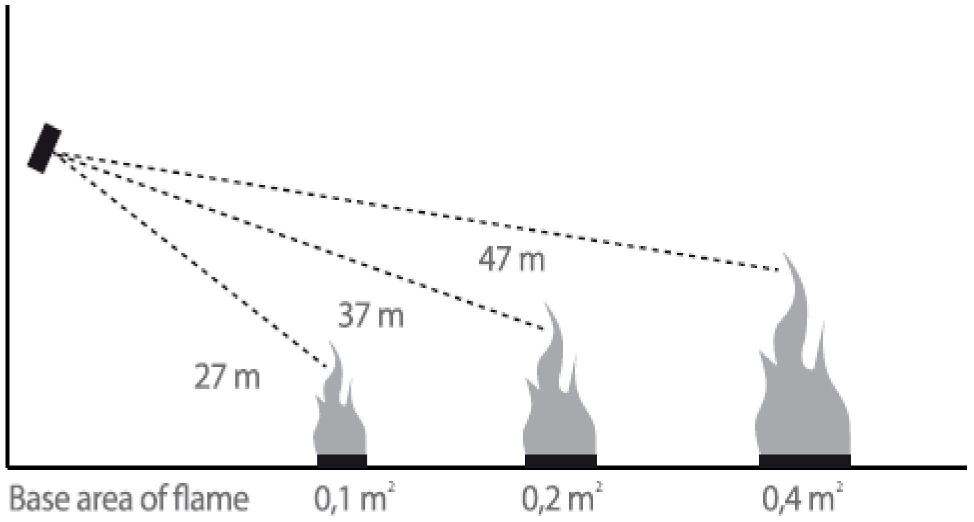
- Detects **electromagnetic radiation** emitted by a flame.

Flame Detectors (contd..)

- Generally used only in high-hazard areas, such as fuel-loading platforms, industrial process areas, high-ceiling areas, and atmospheres in which explosions or very rapid fires may occur.
- Responds to short wavelengths (UV/IR) coming from very high temperatures as available in flames.
- Range of 50 to 65 meters.

Flame Detectors (contd..)

Line of sight should not be blocked in order to ensure full coverage.



Flame detector typical response characteristics (centre line range against petrol flames)

Alarm Devices



A fire alarm system component such as a bell, horn, speaker, light or text display that provides audible, tactile, or visible outputs, or any combination thereof. Typically, they may be categorized into three different types: (a) audible alarms (sounders), (b) visible alarm (strobes/beacons) and (c) voice speaker.

Strobes/Beacons

- Required in spaces where **ambient noise levels** are high enough to preclude hearing sounding equipment, and where **hearing impaired** occupants may be found.
- Visual alarms are to be used where the ambient noise is such (above **90dB**A) that audible warning may not be heard, where **hearing protectors** are in use or where the sounder levels would need to be so high that they might impair the hearing of the building occupant

Sounders

- Typical sound level is 65 dB(A) and +5dB(A) above the maximum background sound level.
- Maximum sound level allowed is 120 dB(A).
- Types include bells, horns, chimes, sirens and electronic sounders. Also, pre-recorded voice message.
- Throughout the building, same sounder for fire alarm.

Sounders (contd..)

- **Bells:** Most common type and appropriate for most buildings.
- **Horns:** well suited to areas where a loud signal is needed.
- **Chimes:** where a soft alarm tone is preferred.
- **Electronic:** solid state sounders with mono or multi tone output normally in the range of 800 to 1000 Hz.
- **Sirens:** operating in the range of 1,200 to 1,700 Hz.

1.3.37 Fire Detection and Alarm System

Control Panel (FACP)

The control panel will indicate in which detection circuit (zone) an alarm or fault condition has been generated and will operate common or zonal sounders and auxiliary commands (for example door release or fire brigade signalling*).

Detectors

A number of types of detectors (smoke detectors, heat detectors, ionization smoke detectors, optical beam smoke detectors, opto-heat detectors) for the installation

FDAS: Audible and Visual Alarm Devices

Alarm devices fall into two types, audible and visual. The audible types are most common, with a variety of types being available from bells to all kinds of different electronic sounders including those containing pre-recorded spoken messages. The choice of device is dependent on local preference, legal requirement and the need to have a tone distinct from all other building audible alarms.

Speech alarms or links to PA systems overcome some of the complacent responses to warning tones and can be used to good effect when carrying out regular fire tests in buildings where there are many people **unfamiliar** with the regular routines - such as hotels. Finally visual alarms are to be used where the hard of hearing may be occupying a building **or** where the ambient noise is such (above **90 dBA**) that audible warning may not be heard, where hearing protectors are in use or where the sounder levels would need to be so high that they might impair the hearing of the building occupant.

FDAS: Cables for Fire Detectors

BS 5839-1 introduced more onerous requirements for types of cables used in fire detection and alarm systems. **Fireproof** cables should now be used for all parts of the system and **enhanced fire resistance** cables should be used where there is a requirement to ensure **cable integrity over a longer period of time**. Example: when connecting to alarm sounders or where connection between sub-panels provides any part of alarm signal path.

Fire alarm cables should be segregated from the cables of other systems; they should be clearly marked, preferably coloured red and should be routed through parts of the building that provide minimum risk. This latter point is particularly relevant where the use of the building is being changed - for example if a fuel store is being moved.

1.3.37 Fire Detection and Alarm System

Specific Areas of Application for Fire Detection and Alarm Equipment

The BS 5839 suite of standards relate to specific areas of application for fire detection and alarm equipment. Specifically part 1 relates to public premises and part 6 relates to residential premises. BS 5839-1 is a comprehensive code of practice for fire detection and alarm systems, the requirements relate to both life and property protection and the standard includes much advice and comment with is very useful in informing the building owner or system specifier of the background to the requirements.

Codes of Practice for Fire Protection Systems

The parts of BS 7273 are codes of practice for different types of fire protection systems. Generally this is considered separately to fire alarm systems but there may be occasions where a trade off can be made between the two systems, or where the two systems interact and must be interfaced.

Standards Related to Design and Performance of Items of Equipment that Make up a FDAS

The EN 54 suite of standards relates to the design and performance of items of equipment that make up FDAS. Each part relates to a different piece of equipment, for example part 3 relates to alarm devices, part 11 to call points, part 4 to power supplies etc.

1.3.37 Fire Detection and Alarm System

Fire Detection Zones

Fire detection zones are essentially a convenient way of dividing up a building to assist in quickly locating the position of a fire. BS 5839-1 has some specific recommendations with respect to detection zones.

Wiring of the fire detection and alarm system will be done using the concealed wiring and the surface wiring methods described in the power line wiring section of this document.

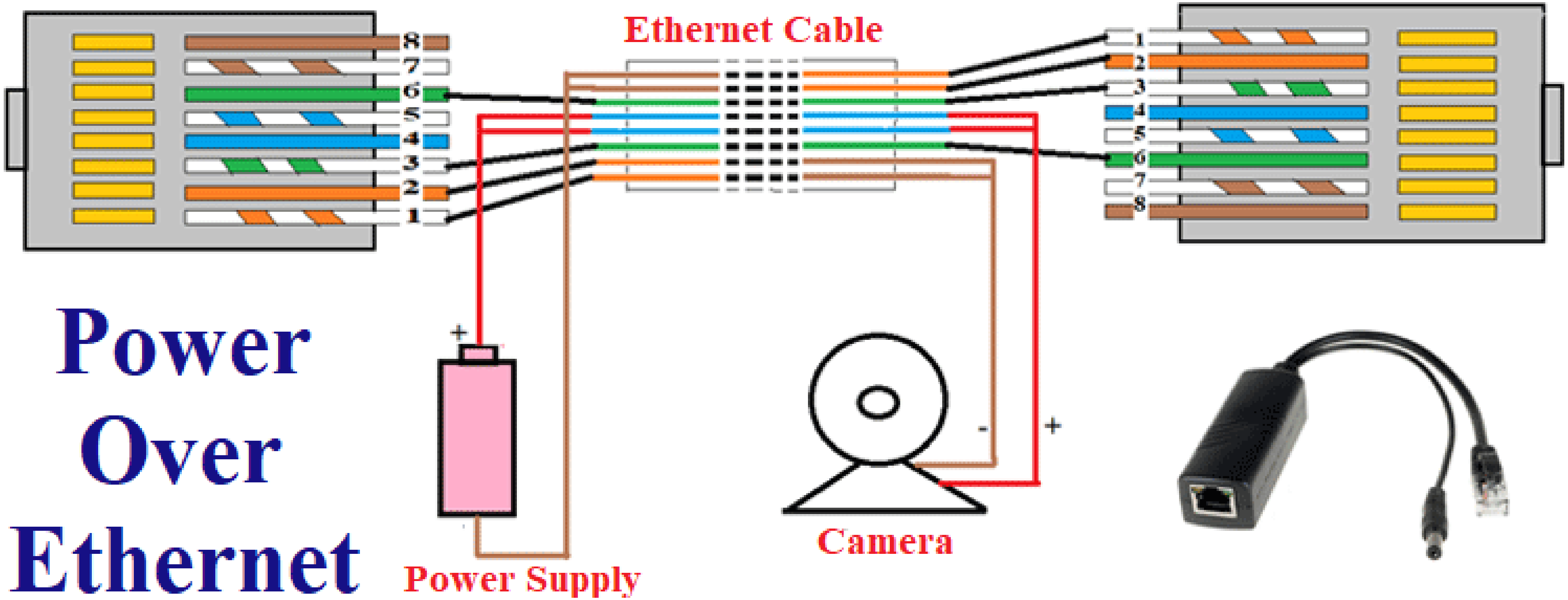
CCTV, Access Control, Electronic Security Systems

1.3.38 CCTV System inside a Building

Installation of cable network for CCTV System inside a Building shall be done following the guidelines given for cable work for television antennas/cable television* system earlier in this document.

For wiring of the power cables# required for the Installation of CCTV system inside a building will be done using the concealed wiring and the surface wiring methods described in the power line wiring section of this document.

Power Over Ethernet



Standards/ad hoc systems that pass **electric power** along with **data** on twisted-pair **Ethernet** cabling. This allows a single cable to provide both a data connection and enough electricity to power networked devices such as Wireless Access Points, IP cameras and VoIP phones.

1.3.39 Access Control System
1.3.40 Electronic Security System

1.3.39 Design and Installation of Access Control System

Wiring of the Installation of access control systems will be done using the concealed wiring and the surface wiring methods described in the power line wiring section of this document.

1.3.40 Installation of Electronic Security Systems

Wiring of the installation of electronic security systems will be done using the concealed wiring and the surface wiring methods described in the power line wiring section of this document.

Q?

Thanks!

M9: Compliance Issues of a Building - Outline

- Qualification of the Contractor of EEE Works in a Building
- Compliance: Inspection and Testing by Qualified Persons
- Related Codes and Standards
- Related Appendices:
  - A. Maximum Demand and Diversity,
  - B. Useful Tables Relating to Conductor Sizes,
  - C. Completion Certificate Form.

Qualifications and Compliance by Inspection and Testing

1.3.41 Qualification of the Contractor of EEE Works in a Building

A **Contractor** who will be working with the electrical and electronic engineering works in a building **must have appropriate ABC license** from the **Electricity Licensing Board*** of Government of Bangladesh.

The contractor must have sufficient number of well trained and **experienced technicians#** to execute the job. For big volume of work, the contractor must have at least one **Electrical Engineer$** assigned for the job.

License Type:

Supervisor Competency Certificate

Electrician License

Contractor License

License Category:

ABC

BC

C

ELB Certified Electrician	:	63646
ELB Certified Supervisor	:	14415
ELB Certified Contractor	:	9730

1.3.42 Inspection and Testing

1.3.42.1 General

Every installation shall, on completion and before being energized, be inspected and tested. Test methods shall be such that no danger to persons or property or damage to equipment occurs even if the circuit tested is defective.

1.3.42.2 Periodic inspection and testing

Periodic inspection and testing shall be carried out in order to maintain the installation in a sound condition after putting it into service. Where an addition is to be made to the fixed wiring of an existing installation, the latter shall be examined for **compliance** with the recommendations of the Code.

1.3.42 Inspection and Testing

1.3.42.3 Checking the conformity with the Bangladesh Standard

The individual equipment and materials which form part of the installation shall <u>generally</u> conform to the relevant Bangladesh Standard (BDS) wherever applicable. If there is <u>no relevant Bangladesh standard</u> specification for any item, these <u>shall be approved</u> by the appropriate authority.

(i) Inspection of the colour identification of cables of wiring

For single phase, Brown for Live, Blue for Neutral, Green + Yellow bi-colour for ECC.

For three phase, Brown for L1, Black for L2, Grey for L3, Blue for

Neutral and Green + Yellow bi-colour for ECC and Earth Lead Wire.

1.3.42 Inspection and Testing

(ii) Inspection of earthing terminal, earthing bus

Inspection should be made to check whether brass made earthing terminals have been provided inside the metal back boxes of the switchboards and socket boards (welded or screwed to the metal back box) and whether the ECCs of the sub circuit have been terminated in these terminals.

Inspection should be made to check whether at least one copper earthing busbar has been provided in the BDBs, SDBs, FDBs, DBs, MDBs and the LT panel and whether ECCs have been appropriately terminated in these busbars using hexagonal head brass bolt and nuts. Also it should be checked whether the Earth Lead Wires have been properly terminated in the LT Panel/MDB/DB as appropriate.

Testing

(iii) Insulation Tests

Insulation test is one of the most important tests for Electrical Installations in a Building. Insulation resistance test shall be made on all electrical equipment, using a self contained instrument such as the direct indicating ohm-meter of the generator type. DC potential shall be used in these tests and shall be as follows or an appropriate Meggar:

Circuits below 230 volts-> 500 volts Meggar

Circuits between 230 volts to 400 volts ->1000 volts Meggar

The minimum acceptable insulation resistance value is **5 mega ohms** for LT lines. Before making connections at the ends of each cable run, the insulation resistance measurement test of each cable shall be made.

Testing

Each conductor of a multi-core cable shall be tested individually to all other conductors of the group and also to earth. If insulation resistance test readings are found to be less than the specified minimum in any conductor, the entire cable shall be **replaced**.

All transformers, switchgears etc. shall be subject to an insulation resistance measurement test to ground after installation but before any wiring is connected.

Insulation tests shall be made between open contacts of circuit breakers, switches etc. and between each phase and earth.

Testing

(iv) Earth Resistance Test and the Continuity Resistance Test

Earth resistance tests shall be made on the system, separating and reconnecting each earth connection using earth resistance meter. The electrical resistance of the Earth Continuity Conductor of different segment shall be measured separately using sensitive digital Ohm meter or by means of resistance bridge instrument. The resistance of the Earth Lead Wire shall be measured from the earthing busbar of the LT Panel/MDB/DB and the earth electrode(s). The electrical resistance of any section shall not exceed **1 ohm**. Where more than one earthing sets are installed, the earth resistance between two sets shall be measured by means of sensitive digital Ohm meter or by means of resistance bridge instrument. The earth resistance between two sets shall not exceed **1 ohm**.

Testing

Operation Tests

Current load measurement shall be made on equipment and on all power and lighting feeders using Clamp on Ammeters. The current reading shall be taken in each phase wire and in each neutral wire while the circuit or equipment is operating under actual load conditions. Clamp on Ammeters are required to take current readings without interrupting a circuit.

All light fittings shall be tested electrically & mechanically to check whether they comply with the standard specifications. FL light fitting shall be tested so that when functioning, no flickering or choke signing* is felt.

1.3.42: (v) Inspection of the Installation

On completion of wiring, a general inspection shall be carried out by **competent personnel*** in order to verify that the provisions of this Code and that of the **Electricity Act of Bangladesh** have been complied with. A **certificate** may be issued on satisfactory completion of the work in a **format** as shown in **Appendix C**. Items to be inspected are detailed in the following sections.

Inspection of Substation Installations

In substation installations, it shall be checked whether:

- The installation has been carried out in accordance with the **approved drawings**;
- Phase to phase and phase to earth clearances are provided as required;

1.3.42: (v) Inspection of the Installation

- All equipment are efficiently earthed and properly connected to the required number of earth electrodes;
- The required ground clearance to live terminals is provided;
- Suitable fencing is provided with gate with lockable arrangements;
- The required number of caution boards, firefighting equipment, operating rods, rubber mats, etc., are kept in the substation;
- In case of indoor substation sufficient ventilation and draining arrangement are made;
- All cable trenches have covers of non-inflammable material;
- Free accessibility is provided for all equipment for normal operation;

1.3.42: (v) Inspection of the Installation

- All name plates are fixed and the equipment are fully painted;
- All construction materials and temporary connections are removed;
- Oil level, busbar tightness, transformer tap position, etc. are in order;
- Earth pipe troughs and cover slabs are provided for earth electrodes/earth pits and the LPS* earth pits are marked for easy identification;
- Earth pipe troughs and oil sumps/pits are free from rubbish, dirt and stone jelly and the earth connections are visible and easily accessible;

1.3.42: (v) Inspection of the Installation

- HT and LT panels and switchgears are all vermin and damp-proof and all unused openings or holes are blocked properly;
- The earth busbars have tight connections and corrosion free joint surfaces;
- Control switch fuses are provided at an accessible height from ground;
- Adequate headroom is available in the transformer room for easy topping up of oil, maintenance, etc.;
- Safety devices, horizontal and vertical barriers, busbar covers/shrouds, automatic safety shutters/door interlock, handle interlock etc. are safe and in reliable operation in all panels and cubicles;

1.3.42: (v) Inspection of the Installation

- Clearances in the front, rear and sides of the main HT and LT and sub-switch boards are adequate;
- The switches operate freely; the 3 blades make contact at the same time, the arcing horns contact in advance; and the handles are provided with locking arrangements,
- Insulators are free from cracks, and are clean;
- In transformers, there is no oil leak;
- Connections to bushing in transformers are tight* and maintain good contact;
- Bushings are free from cracks and are clean;

1.3.42: (v) Inspection of the Installation

- Accessories of transformers like breathers, vent pipe, buchholz relay, etc. are in order;
- Connections to gas relay in transformers are in order;
- In transformers, oil and winding temperature are set for specific requirements to pump out;
- In case of cable cellars, adequate arrangements exist to pump off water that has entered due to seepage or other reasons; and
- All incoming and outgoing circuits of HT and LT panels are clearly and indelibly labelled* for identifications.

1.3.42: Inspection of LT Installation

In Low Tension (LT) or Medium Voltage (MV) Installations, it shall be checked whether:

- All blocking materials that are used for safe transportation in switchgears, contactors, relays, etc. are removed;
- All connections to the earthing system have provisions for periodical inspection;
- **Sharp** cable **bends** are **avoided** and cables are taken in a smooth manner in the trenches or alongside the walls and ceilings using suitable support clamps at regular intervals;
- Suitable linked switch or circuit breaker or lockable push button is provided near the motors/apparatus for controlling supply to the motor/apparatus in an easily accessible location;

1.3.42: Inspection of LT Installation

- Two separate and distinct earth connections are provided for the motor apparatus;
- Control switch fuse is provided at an accessible height from ground for controlling **supply to overhead travelling crane, hoists, overhead busbar trunking**;
- The metal rails on which the crane travels are electrically continuous and earthed and bonding of rails and earthing at both ends are done;
- **Four-core cables** are used for overhead travelling crane and portable equipment, the fourth core being used for earthing, and separate supply for lighting circuit is taken;

1.3.42: Inspection of LT Installation

- If flexible metallic hose is used for wiring to motors and other equipment, the wiring is enclosed to the full lengths, and the hose secured properly by approved means;
- The cables are not taken through areas where they are likely to be damaged or chemically affected;
- The screens and armours of the cables are earthed properly;
- The belts of belt driven equipment are properly **guarded**;
- Adequate precautions are taken to ensure that no live parts are so exposed as to cause danger;
- Installed Ammeters and voltmeters work properly and are tested; and
- The relays are inspected visually by moving covers for deposits of dusts or other foreign matter.

1.3.42: Inspection of Overhead Lines

For overhead lines, every care must be taken so that:

- All conductors and apparatus including live parts thereof are inaccessible;
- The types and size of supports are suitable for the overhead lines/conductors used and are in accordance with approved drawing and standards;
- Clearances from ground level to the lowest conductor of overhead lines, sag conditions, etc. are in accordance with the relevant standard;
- Where overhead lines cross the roads suitable grounded guarding shall be provided at road crossings,

1.3.42: Inspection of Overhead Lines

- Where overhead lines cross each other or are in proximity with one another, suitable guarding shall be provided at crossings to protect against possibility of the lines coming in contact with one another;
- Every guard wire shall be properly grounded/earthed;
- The type, size and suitability of the guarding arrangement provided shall be adequate;
- Stays cables must be provided suitably with the overhead line carrying poles as required and shall be efficiently earthed at the bottom and shall be provided with suitable stay insulators of appropriate voltages;

1.3.42: Inspection of Overhead Lines

- Anti-climbing devices and Danger/Caution Board Notices are provided on all HT supports;
- Clearances along the route are checked and all obstructions such as trees/branches and shrubs are cleared on the route to the required distance on both* side;
- Clearance between the live conductor and the earthed metal parts are adequate; and
- For the service connections tapped off from the overhead lines, cutouts of adequate capacity are provided.

1.3.42: Inspection of Lighting Circuits

The lighting circuits shall be checked to see whether:

- Wooden boxes and panels are avoided in factories for mounting the lighting boards, switch controls, etc.;
- Neutral links are provided in double pole switch fuses which are used for lighting control, and no fuse is provided in the neutral;
- The plug points in the lighting circuit are all 3-pin type, the third pin being suitably earthed;
- Tamper proof interlocked switch socket and plug are used for locations easily accessible;
- Lighting wiring in factory area is enclosed in conduit and the conduit is properly earthed, or alternatively, armoured cable wiring is used;

1.3.42: Inspection of Lighting Circuits

- A separate earth wire is run in the lighting installation to provide earthing for plug points, fixtures and equipment;
- Proper connectors and junction boxes are used wherever joints are in conductors or cross over of conductors takes place;
- Cartridge fuse units are fitted with cartridge fuses only;
- Clear and permanent identification marks are painted in all distribution boards, switchboards, sub-main boards and switches as necessary;
- The polarity has been checked and all fuses and single pole switches are connected on the phase conductor only and wiring is correctly connected to socket outlets;
- Spare knockouts provided in distribution boards and switch fuses are blocked;

1.3.42: Inspection of Lighting Circuits

- The ends of conduits enclosing the wiring leads are provided with ebonite or other suitable bushes;
- The fittings and fixtures used for outdoor use are all of weatherproof construction, and similarly, fixtures, fittings and switchgears used in the hazardous area are of flameproof application;
- Proper terminal connectors are used for termination of wires (conductors and earth leads) and all strands are inserted in the terminals;
- Flat ended screws are used for fixing conductor to the accessories;
- Flat washers backed up by spring washers are used for making end connections.

1.3.42: Accessibility of Connections and Cable joints for Inspection

Except for the following, every connection and joint shall be accessible for inspection, testing and maintenance:

1. A compound-filled or encapsulated joint
2. A connection between a cold tail and a heating element (e.g. a ceiling and floor heating system, a pipe trace-heating system)
3. A joint made by welding, soldering, brazing or compression tool
4. A joint formatting part of the equipment complying with the appropriate product standard.

1.4 Related Codes and Standards

Significant modification, upgradation and additions of the previous electrical engineering section of BNBC of 1993* have been incorporated in this updated version. While making changes and additions, the following documents/regulations/ codes have been taken as reference/guiding sources:

(a) Bangladesh Electricity Act.

(b) IEE wiring Regulation (17^{th}e) **BS: 7671 2008** including all parts.

(c) British Standards (BS).

In addition to these, the following documents/regulations/ codes have also been taken as references as required:

1.4 Related Codes and Standards

(a) National Building Code of India - 2005.

(b) Building Code of Pakistan - latest version.

(c) National Electrical Code of USA (NFPA 70).

(d) International Electrotechnical Commission (IEC) Standards.

(e) ISO 50001 Standard for Energy Management System.

(f) Verband Deutscher Elektrotechniker (Association of German Electrical Engineers, VDE).

However, efforts have been be given to accept a significant part of rules and practices mentioned in IEE wiring Regulation with necessary modifications for our system and suitable for our country.

1.4 Related Codes and Standards

While preparing this document the following Standards and practices are kept in mind.

(a) For having safe domestic electrical systems, domestic electrical installations shall be designed and installed according to the "fundamental principles" given in **British Standard BS 7671 Chapter 13**. These are similar to the fundamental principles defined in international standard **IEC 60364-1**. It is necessary to apply **BS 7671** (the "Wiring Regulations"), including **carrying out adequate inspection and testing** to this standard of the completed works.

- To meet the above mentioned requirements the following rules and guidance shall be followed.
- The rules of the IEE wiring regulations (BS 7671), colloquially referred to as "the regs" (BS 7671: 2008, 17th Edition);

1.4 Related Codes and Standards

- The rules of an equivalent standard approved by a member of the European Economic Area (e.g., DIN/VDE 0100);

(b) Guidance given in **installation manuals** that is consistent with BS 7671, such as the IEE On-Site Guide and IEE Guidance Notes 1 to 7.

(c) Installations in commercial and industrial premises must satisfy the requirements set in Electricity at Work Regulations 1989 (UK) and must follow recognised standards and practices, such as BS 7671 "Wiring Regulations".

Apart from these, some modifications had to be made considering the weather and other local conditions, practices and previous experiences in this country.

1.5 List Of Related Appendices

Appendix A Maximum Demand and Diversity

Appendix B Useful Tables Relating to **Conductor Sizes**

Appendix C Completion Certificate Form

Appendix A: Maximum Demand and Diversity

(also in Lecture 3)

Some information on the determination of the maximum demand for an electrical installation is provided in this appendix. It also includes some notes on the application of allowances for diversity.

Appendix A: Maximum Demand & Diversity

It is impossible however, to specify the appropriate allowances for diversity for every type of installation since determination of such allowances **calls for special knowledge and experience**. The figures shown in **Table 8.A.1** are therefore, intended to act as **guideline**. The current demand of a final circuit is determined by summing the current demands of all points of utilization and equipment in the circuit.

Typical values to be used for this summation are given in **Table 8.A.2**. For blocks of residential dwellings, large hotels, and industrial and large commercial premises, allowances are to be assigned by a competent Engineer.

Appendix A: Maximum Demand & Diversity

The current demand of a circuit supplying a number of final circuits may be assessed by applying the allowances for diversity given in **Table 8.A.2** to the total current demand of all the equipment supplied by that circuit. In the Table, the allowances are appraised either as percentages of the current demand or, where **followed by the letters f.l.**, as percentages of the rated full load current of the current using equipment. After the design currents for all the circuits have been determined, enabling the conductor sizes to be chosen, it is necessary to check that the limitation on voltage drop is met.

Table 8.A.1: Allowances for Diversity

Purpose of final circuit fed from conductors or switchgear to which diversity applies	Type of Premises		
	Individual household installations, including dwellings of a block	Small shops, stores, offices and business premises	Small hotels, boarding houses, guest houses, etc.
1. Lighting	66% of total current demand	90% of total current demand	75% of total current demand
2. Cooking appliances	10 amperes + 30% f.l. of connected cooking appliances in excess of 10 amperes + 5 amperes if socket outlet is incorporated in unit.	100% f.l. of largest appliance + 80% f.l. of 2nd largest appliance + 60% f.l. of remaining appliances	100% f.l. of largest appliance + 80% f.l. of 2nd largest appliance + 60% f.l. of remaining appliances

Purpose of final circuit fed from conductors or switchgear to which diversity applies	Type of Premises		
	Individual household installations, including dwellings of a block	**Small shops, stores, offices and business premises**	**Small hotels, boarding houses, guest houses, etc.**
3. Motors (other than lift motors which are subject to special consideration)	———	100% f.l. of largest motor + 80% f.l. of 2nd largest motor + 60% f.l. of remaining motors	100% f.l. of largest motor + 50% f.l. of remaining motors.
4. Water heater (thermostaticall y controlled)		No diversity allowable	

Table 8.A.2: Current Demand to be Assumed for Points of Utilization and Current using Equipment

Point of Utilization or Current-using Equipment	Current Demand to be Assumed
15 A socket outlets	15 A with diversity applied
13 A socket outlets	13 A with diversity applied
5 A socket outlets	At least 0.5 A
Protected outlets other than the above mentioned socket outlets	Rated current
Lighting outlet	Current equivalent to the connected load, with a minimum of 100 W per lamp holder
House hold cooking appliance	The first 10 A of the rated current plus 30% of the remainder of the rated current plus 5 A if a socket outlet is incorporated in the control unit
All other stationary equipment / Appliances	Standard rated current or nominal current.

Appendix B
Useful Tables Relating to Conductor Sizes

Table 8.B.1: Number of Single-core Wire of Different Sizes for Various Sizes of Metal Conduits

Conductor Cross-sectional Area (mm^2)	Conduit Diameter					
	19 mm	25.4 mm	31.8 mm	38 mm	51 mm	63.5 mm
1.5	5	10	14	-	-	-
2.5	5	8	12	-	-	-
4.0	3	6	10	-	-	-
6.0	2	5	8	-	-	-
10.0	-	3	5	6	-	-
16.0	-	-	3	6	-	-
25.0	-	-	2	4	6	7
35.0	-	-	-	3	5	6
50.0	-	-	-	-	4	5

Table 8.B.2: Number of Single-core Wires of Different Sizes for Various Sizes of PVC Conduits

Conductor Cross-sectional Area (mm^2)	Conduit Diameter				
	19 mm	25 mm	32 mm	38 mm	51 mm
1.5	6	10	14	-	-
2.5	5	10	14	-	-
4.0	3	6	10	14	-
6.0	2	5	8	11	-
10.0	-	4	7	9	-
16.0	-	2	4	5	12
25.0	-	-	2	2	6
35.0	-	-	2	2	5
50.0	-	-	-	2	3

Table 8.B.3: Cross-sectional Area and Weight of Wire Gauges

Gauge System		Diameter	Cross-sectional Area	Weight of Copper	Weight of Aluminium
AWG	SWG	(mm)	(mm^2)	(kg/km)	(kg/km)
6/0	-	14.73	170.46	1515.4	460.4
5/0	-	13.11	134.92	1199.4	365.0
-	7/0	12.70	126.68	1126.2	342.1
-	6/0	11.79	109.09	969.8	294.6
4/0	-	11.68	107.22	953.2	289.4
-	5/0	10.97	94.56	840.7	255.4
3/0	-	10.41	85.16	757.2	229.6
-	4/0	10.16	81.70	720.7	219.6
-	3/0	9.449	70.12	623.4	189.4
2/0	-	9.271	67.51	600.1	182.1
-	2/0	8.839	61.36	545.5	165.7
0	-	8.255	53.52	475.8	144.4
-	0	8.230	53.19	472.9	143.6
-	1	7.620	45.60	405.4	123.1
1	-	7.341	42.22	376.2	114.5
-	2	7.010	38.60	343.1	104.2
2	-	6.553	33.94	299.8	90.80
-	3	6.401	32.18	286.1	86.89
-	4	5.893	27.27	242.5	73.63
3	-	5.817	26.57	236.2	72.01
4	-	5.182	21.09	187.5	57.11
-	6	4.877	18.68	166.1	50.44
5	-	4.623	16.78	149.2	45.25

Gauge System		Diameter	Cross-sectional Area	Weight of Copper	Weight of Aluminium
AWG	SWG	(mm)	(mm^2)	(kg/km)	(kg/km)
-	7	4.470	15.70	139.5	42.39
6	-	4.115	13.30	118.2	35.91
-	8	4.065	12.97	115.3	35.02
7	9	3.658	10.507	93.41	28.49
8	10	3.251	8.302	73.80	22.59
-	11	2.948	6.818	60.61	18.41
9	-	2.896	6.585	58.54	17.91
-	12	2.642	5.480	48.72	14.80
10	-	2.591	5.272	46.87	14.21
-	13	2.337	4.284	38.08	11.58
11	-	2.311	4.196	37.30	11.26
12	-	2.057	3.325	29.55	8.934
-	14	2.032	3.243	28.83	8.756
13	15	1.828	2.627	23.35	7.093
14	16	1.626	2.075	18.45	5.621
15	-	1.448	1.646	14.64	4.460
-	17	1.422	1.589	14.13	4.290
16	-	1.295	1.318	11.72	3.532
-	18	1.291	1.168	10.38	3.154
17	-	1.143	1.026	9.122	2.808
18	19	1.016	0.8107	7.207	2.223
19	20	0.9144	0.6567	5.838	1.773
20	21	0.8128	0.5189	4.613	1.401
21	-	0.7239	0.4156	3.695	1.111

Gauge System		Diameter	Cross-sectional Area	Weight of Copper	Weight of Aluminium
AWG	SWG	(mm)	(mm^2)	(kg/km)	(kg/km)
-	22	0.7112	0.3973	3.532	1.073
22	-	0.6428	0.3243	2.883	0.8756
-	23	0.6096	0.2919	2.595	0.7881
23	-	0.5733	0.2588	2.301	0.6990
-	24	0.5588	0.2453	2.181	0.6620
24	-	0.5105	0.2047	1.820	0.5527
-	25	0.5086	0.2021	1.797	0.5473

PART VIII

Appendix C

Completion Certificate Form (Electrical Works)

I/we certify that the installation detailed below has been installed by me/us and tested and that to the best of my/our knowledge and belief, it complies with the requirements of Bangladesh National Building Code and the Electricity Act of Bangladesh.

Electrical Installation at : ____________________

Voltage and system of supply : ____________________

PARTICULARS OF WORKS

(a) Internal Electrical Installation

	No.	Total load	Type or system of wiring
(i) Light points			
(ii) Fan points			
(iii) Socket points			
2-pin 5 A			
3-pin 13 A Flat pin			
3-pin 15 A Round Pin			

(b) Others

	Description	hp/kW	Type of starting
(1) Motors			
(i)			
(ii)			
(iii)			
(2) Other Plants			

(c) If the work involves installations of overhead line and/or underground cable

(1) (i) Type and description of overhead line

(ii) Total length and number of spans

(iii) Number of street lights and its description

(2) (i) Total length and size of underground cable

(ii) Number of joints

End joint

Tee joint

Straight through joint

(d) Earthing

(i) Description of earthing electrode

(ii) Number of earth electrodes

(iii) Type and short description of Brass Earthing Clamp

(iv) Number of Brass Bolt Nuts provided in the Brass Earthing Clamp for the termination of Earth Lead Cables

(v) Size of each of the main earth lead cables

(vi) Number of main earth lead cables

TEST RESULTS

(a) Insulation Resistance values:

(i) Insulation resistance of the whole system of conductors to earth ________________ mega ohms

(ii) Insulation resistance between the phase conductor and neutral

Between phase R and neutral ________________ mega ohms

Between phase Y and neutral ________________ mega ohms

Between phase B and neutral ________________ mega ohms

(iii) Insulation resistance between the phase conductors in case of polyphase supply

Between phase R and phase Y ________________ mega ohms

Between phase Y and phase B ________________ mega ohms

Between phase B and phase R ________________ mega ohms

(b) Polarity test

Polarity of nonlinked single pole branch switches

(c) Earth continuity test

Maximum resistance between any point in the earth continuity conductor including metal conduits and main earthing lead _____________ohms

(d) Earth electrode resistance

Resistance of each earth electrode

(i) _________________________ ohms

(ii) _________________________ ohms

(iii) _________________________ ohms

(iv) _________________________ ohms

(e) Lightning protective system

Resistance of the whole of lightning protective system to earth before any bonding is effected with earth electrode and metal in/on the structure _______________ ohms

__________________ Signature of Supervisor

__________________ Signature of Contractor

Name and Address __________________
____
____

Name and Address ____________________
____
____

Q?

Thanks!