CHAPTER - TWO

Electrical Installation materials and accessories

2.1. Introduction

- Before any wiring system is installed account must be taken of environment in which system is operate.
  - Commercial
  - Residential
  - Industrial
  - etc

- There are many influences that may contribute to the final design of the installation.

- All materials used for electrical installation purpose should comply with international and local Standards
  - IEC (International Electrotechnical Commission)
  - EBCS (Ethiopian Building code standard)
Cables:

- A great number of cables are available ranging from smallest single core wires used for electronic circuit to the huge oil and gas filled cables used for high voltage transmission systems.

- When conductor is insulated to make a usable piece of equipment for carrying electricity, it becomes cables.

Conductor:

- A conductor may be defined as the conducting portion of a cable, which consists of a single wire or group of wires in contact with each other.

- The ability to be a good conductor of electricity depends on the composition of the material (Resistivity)

<table>
<thead>
<tr>
<th>Conductor Material</th>
<th>Resistivity (Ohm meters at 20°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>$1.64 \times 10^{-8}$</td>
</tr>
<tr>
<td>Copper</td>
<td>$1.72 \times 10^{-8}$</td>
</tr>
<tr>
<td>Aluminum</td>
<td>$2.83 \times 10^{-8}$</td>
</tr>
<tr>
<td>Tungsten</td>
<td>$5.50 \times 10^{-8}$</td>
</tr>
<tr>
<td>Nickel</td>
<td>$7.80 \times 10^{-8}$</td>
</tr>
<tr>
<td>Iron</td>
<td>$1.20 \times 10^{-8}$</td>
</tr>
<tr>
<td>Constantan</td>
<td>$4.60 \times 10^{-8}$</td>
</tr>
<tr>
<td>Nichrome II</td>
<td>$110 \times 10^{-8}$</td>
</tr>
</tbody>
</table>
Conductor:

- The resistance of a material is determined by four properties: material, length, area, and temperature. The first three properties are related by the following equation at $T = 20 \degree C$ (room temperature):

$$R = \frac{\rho \ell}{A}$$

- Copper plentiful material has a low enough resistivity to make it suitable as conductor material.
- Aluminum, cheap and with relatively low resistivity, it is not as suitable as copper. It has to have large cross sectional area to pass the same current and mechanically inferior to copper.
- Tungsten, B/s of high resistivity, it is used mainly for heating element and light – Bulb filament.

Conductor:

- Conductor can be:
  - Solid Conductor
  - Stranded Conductor

Solid Conductor:

- Circular Cross section: 2.5mm$^2$ – 25mm$^2$
- Rectangular Cross section: Usually called Bus Bars
**Stranded Conductor:**

- Used for fixed wiring
- Used for flexible cord

<table>
<thead>
<tr>
<th>Area [mm²]</th>
<th>No of stranded</th>
<th>Diameter [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>0.4</td>
</tr>
<tr>
<td>1.5</td>
<td>7</td>
<td>0.53</td>
</tr>
<tr>
<td>2.5</td>
<td>7</td>
<td>0.67</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>0.85</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>1.04</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>1.35</td>
</tr>
<tr>
<td>16</td>
<td>7</td>
<td>1.7</td>
</tr>
</tbody>
</table>

**Sheathing and insulation**

- With the exception of bare conductors i.e. bus bars and bare risers, all conductors have some sort of insulation
- Cables for fixing wiring
  - Old cables insulated with rubber and paper
  - Modern insulating materials for cables is polyvinyl chloride (PVC)
  - Mineral Insulated metal sheathed cable is another type
Armoured Cable:

- Armoured cable is an extension of the type of cable used in fixed wiring.

Why sheathing and Armouring?

- To withstand working voltage
- To protect from Mechanical Damage

Color Code for insulation cable

- Most wiring regulation require that all conductors have to be identified by some means of to indicate their function.
Conduits

- A conduit is a tube or pipe in which conductors are run.
- In effect replaces the PVC sheathing of a cable providing mechanical protection.

Conduits

- There are three types of conduits:
  1. Metal Conduit
  2. Flexible (metallic) Conduit
  3. Non metallic Conduit (PVC)

1. Metal Conduit

- Used for low voltage installation.

Metal conduit classified as:

- Light gauge steel conduit: Cheap, for dry and little mechanical strength.
- Heavy Gauge steel conduit: Very Expensive, permanent installation.
Conduits

2. Flexible steel conduit Metal Conduit

- Consists of light galvanized steel strip spirally wound
- It is made in size from 19mm to 50 mm external diameter
- Available up to 250m
- No coupling is required
- Since it is flexible no elbow is required for bending

Conduits

3. Non metallic (PVC) Conduit

- A PVC conduit has a wide application
  - Very cheap
  - Light in weight
  - Shock proof
  - Anti – termite: insects, cockroaches
  - Fire resistant
  - Acid and alkaline resistant
  - Available in 3m long
Conduit Box

- There are boxes used in surface as well as recessed

- **Junction Box**: Used for Housing junction of wires and cables

- **Outlet Box**: Are positioned at which conduits terminate and are used for providing connection to light, Socket fan and other points

- **Outlet Box**: Are used for pulling of cables in to the coil

Conduit Accessories

Trucking/Raceways

- Trucking is a fabricated metallic or plastic casing of cables, normally rectangular cross section of which one side is removable or hinged to allow cables laid

Used in where:

- Large Number of cable are required for installation
- For External Wiring to keep visual comfort
Ducting

- In large buildings, it is often an advantage to install a network of ducts in solid concrete.
- Used to accommodate the wiring of electrical systems.

Types:

- Manhole in basement
- Wall guided block

Electrical Installation accessories and Fitting

Switches:

A device used to make or brake contactors in electric circuits by controlling the flow of current.
**Electrical Installation accessories and Fitting**

**Plugs and Sockets**

Are devices that allow electrically operated equipment to be connected to the primary alternating Current (AC) power supply in a building.

- **Type A**
  - Three pin in plug type A
  - Usually used in the UK, Denmark, Greece & Japan
  - 2 pin
  - Not grounded
  - 16 A
  - Almost always 110~127 V
  - Socket compatible with plug type A

- **Type B**
  - Usually used in the USA, Canada, South Africa & Australia
  - 2 pin
  - Grounded
  - 15 A
  - Almost always 110~127 V
  - Socket compatible with plug type B

- **Type C**
  - Commonly used in France, South Korea & Japan
  - 2 pin
  - Not grounded
  - 16 A
  - 220~240 V
  - Socket compatible with plug type C

- **Type D**
  - Mostly used in India & China
  - 3 pin
  - Grounded
  - 15 A
  - 220~240 V
  - Socket compatible with plug type D

- **Type E**
  - Mostly used in Australia, New Zealand, China & Hong Kong
  - 2 pin
  - Non-grounded
  - 10 A
  - 110~120 V
  - Socket compatible with plug type E

- **Type F**
  - Used almost exclusively in Scandinavian countries & Russia
  - 2 pin
  - Grounded
  - 16 A
  - 220~240 V
  - Socket compatible with plug type F

- **Type G**
  - Used exclusively in the UK, Ireland & India
  - 13 A
  - 220~240 V
  - Socket compatible with plug type G

- **Type H**
  - Used exclusively in Singapore, China & Hong Kong
  - 13 A
  - 220~240 V
  - Socket compatible with plug type H

- **Type I**
  - Used almost exclusively in Germany & Switzerland
  - 2 pin
  - Not grounded
  - 16 A
  - 230 V
  - Socket compatible with plug type I

- **Type J**
  - Used almost exclusively in Switzerland, Austria & Germany
  - 2 pin
  - Grounded
  - 16 A
  - 230 V
  - Socket compatible with plug type J

- **Type K**
  - Used almost exclusively in Europe & the USA
  - 2 pin
  - Grounded
  - 16 A
  - 230 V
  - Socket compatible with plug type K

- **Type L**
  - Used almost exclusively in Italy & China
  - 2 pin
  - Not grounded
  - 16 A
  - 230 V
  - Socket compatible with plug type L
Protective Devices

- There are many ways of protecting both installation and electric appliances from risk of Damage, over heating, fire which may occur under fault condition
- Two most common protecting devices
  - Fuse protection
  - Automatic circuit breaking (CB) protection
- Both fuse and CB are connected in series with live wire (Phase)
- In three phase 4 wire system since only three lines are live, fuses & CB are connected in all three lines


**Fuses**

- A fuse consisting of a fusing element with contact, a fuse carrier, and a base

- The fuse element is a short length metal ribbon of wire made up of alloys with low melting point and carries specified amount of current

- When the wire melts we say the fuse ‘BLOW’

- Fault current may be range from simply a large undesired current to the short circuit current which is Maximum

**Terms used in fuse**

**Rated current (I_n)**

- The maximum current a fuse will carry indefinitely without affecting a fusing element

**Fusing current**

- The minimum current that will melt and blow the fuse

**Fusing factor**

- The ratio of minimum fusing current to the current rating and indicates the fusing performance of the fuse

\[
\text{Fusing Factor} = \frac{\text{Fusing Current}}{\text{Rated Current}}
\]
Terms used in fuse

Breaking Capacity (Ib)

- The maximum fault current the Fuse can disconnect from fault without damage associated circuit elements by heat and arcing during breaking.
- Breaking capacity of fuses (Ib) is given in Ampere (A) or Kilo Ampere (KA).

Fuse Data Sheet
Types of Fuses

1. Rewirable Fuse

2. The cartridge

3. High Breaking Capacity [HRC]

Rewirable Fuse

- Semi-enclosed, simple and cheapest

It consists of:

- **Porcelain base:** Carrying the fixed contacts to which the incoming and outgoing live or phase wires are connected

- **Porcelain fuse carrier:** Holding the fusing element consisting of one or more strands of fuse wire

- The fuse wire may be of lead, tinned copper, aluminum or an alloy of tin lead
Disadvantage

- Unreliable operation
- Lack of discrimination
- No current limiting factor
- Slow speed coefficient operation

Cartridge fuse

- The fuse wire is enclosed in a transparent glass tube or bulb, the whole unit is sealed off
- In case of fuse blows, it is to be replaced by new one as cartridge fuse can not be rewired due to its sealing
- It is an improved version of rewirable fuse
- The fusing factor is around 1.5
The rewirable and cartridge fuses are widely used for protecting domestic installation and small industrial loads.

**HRC/HBC** fuses are generally sophisticated version of cartridge fuses and are widely used in industrial installation especially in electric motors

They are Fast acting:

**Discriminate Between starting current and Overload current**

<table>
<thead>
<tr>
<th>Type of Fuse</th>
<th>Average Fusing factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rewirable Fuse</td>
<td>1.8</td>
</tr>
<tr>
<td>Cartridge</td>
<td>1.25 – 1.8</td>
</tr>
<tr>
<td>HRC/HBC</td>
<td>Up to 1.25</td>
</tr>
</tbody>
</table>

Catalog Numbers

<table>
<thead>
<tr>
<th>Catalog Numbers</th>
<th>Dimensions in (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------</td>
</tr>
<tr>
<td>ECEG 4401</td>
<td></td>
</tr>
</tbody>
</table>
| Electrical Installation  |  | By Amare A. 2013/14 | Addis Ababa University | Addis Ababa Institute of Technology | School of Electrical and Computer Engineering

Addis Ababa University
Addis Ababa Institute of Technology
School of Electrical and Computer Engineering
Circuit Breakers

- Is an electromechanical device for making (ON) and braking (OFF) electrical circuit under normal and fault condition (Short circuit and overload)

- A device designed to open and close a circuit by non-automatic means, and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating.

Circuit Breakers

- All circuit breakers perform the following functions:
  - **SENSE** when an overcurrent occurs.
  - **MEASURE** the amount of overcurrent.
  - **ACT** by tripping in a timely manner to prevent damage to the circuit breaker and the conductors it protects.

Types of Circuit Breakers

- **Instantaneous Magnetic Trip-Only Circuit Breakers**
  - provide short circuit protection but do not provide overload protection.
  - This type of circuit breaker is typically used in motor control applications where overload protection is provided by an the overload relay.
Thermal-Magnetic Circuit Breakers

- Has a trip unit that senses heat to detect an overload and senses a magnetic field generated by current to detect a short circuit.
- This type of circuit breaker trips immediately when a short circuit occurs, but delays an appropriate amount of time before tripping in the event of an overload.

Interchangeable Trip Circuit Breakers

- This feature allows the user to change the continuous current rating of the breaker without replacing the breaker.
- This is done by replacing the trip unit with one of a different rating.
Current Limiting Circuit Breakers

- Current limiting circuit breakers protect equipment by significantly reducing the current flowing in the faulted circuit.
- One way to accomplish current limiting is with an additional set of contacts that feature two moveable arms.

Solid-State Circuit Breakers

- Solid-state circuit breakers and thermal-magnetic circuit breakers have similar contact mechanisms, but their trip units are different.
- A solid-state trip unit not only determines when to trip the circuit breaker, but also has programmable features and improved accuracy and repeatability.
- The brain of a solid-state trip unit is a microprocessor.
Circuit Breaker rating

- Voltage Rating
  - Every circuit breaker has a voltage rating that designates the maximum voltage it can handle.
  - The voltage rating of a circuit breaker can be higher than the circuit voltage, but never lower.

- Continuous Current Rating
  - Every circuit breaker has a continuous current rating, which is the maximum continuous current a circuit breaker is designed to carry without tripping.
  - This rating is sometimes referred to as the ampere rating because the unit of measure is amperes, or, more simply, amps.

Time – current curve
Selective Coordination

✓ Is the application of circuit protection devices in series such that, when a fault occurs, only the device nearest the fault opens. The rest of the devices remain closed, leaving other circuits unaffected.

1. **Manufacturer’s name** – This marking may be the manufacturer’s name, trademark or other recognized means to identifying the company that made the circuit breaker.

2. **Type designation** – All circuit breakers are marked with a type designation, which may be a catalog number prefix or a separate designation.

3. **Voltage rating** – All circuit breakers must be marked with a voltage rating. If the rating is not marked “ac” or “dc,” then it is suitable for both.

4. **SWD**: suitable for switching fluorescent lighting loads on a regular basis

5. **HID**: suitable for switching high intensity discharge or fluorescent lighting loads on a regular basis

6. **Trip and reset**: This position must either be marked on the circuit breaker or on the equipment into which it is to be installed.
CHAPTER - Three

Electrical Installation

Electrical installation refers to the practice of electrical wiring and associated systems used to convey electric power to electrical loads in a consumer's premises in a safe, reliable and efficient (Economic) manner.
Consumers

- Residential:
  - Vila, G+ 1, Service quarter

- Public:
  - Churches, Mosques, University, Hospitals, etc

- Commercial:
  - Hotels, Cinema, Supermarket, etc

- Industrial:
  - Small scale to Large scale

Electrical Installation comprises

- The wiring of cables
- Control and isolating switch gears
- Protective devices
- Receptacles
- Transformers
- Electric appliances
- etc
**Electrical Installation comprises**

- It can also include sizing, specifying and erecting standby system (Diesel, photovoltaic panel [PV], wind turbine, fuel cell, etc.)
- Data network and telecommunication
- Signaling (Fire alarm, Bell intruder detection method)

**Regulatory and advisory materials**

- National and International standards for installation
- National and International standards for products
- Codes of practice: EBCS, IEEE IEC
- Legal regulation of the country

**Electrical Installation**

- There are four main sequences of activities usually to be carried out by different qualified, certified, licensed professional, and institution in electrical system

1) **Design**

2) **Construction**

3) **Inspection**

4) **Operation and Maintenance**
Thank you!