BASIC CONCEPTS IN ELECTRICAL DESIGN

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ELECTRICAL CONDUCTORS AND INSULATORS

- **Electrical Conductors**
  - substances that offer a very low resistance to current flow.

- **Insulators**
  - substances that offer a very high resistance to current flow.

Good Electrical Conductors

- Silver
- Copper
- Aluminum
- Nickel
- Brass
- Zinc
- Platinum
- Iron
- Tin
- Lead

Insulating Materials

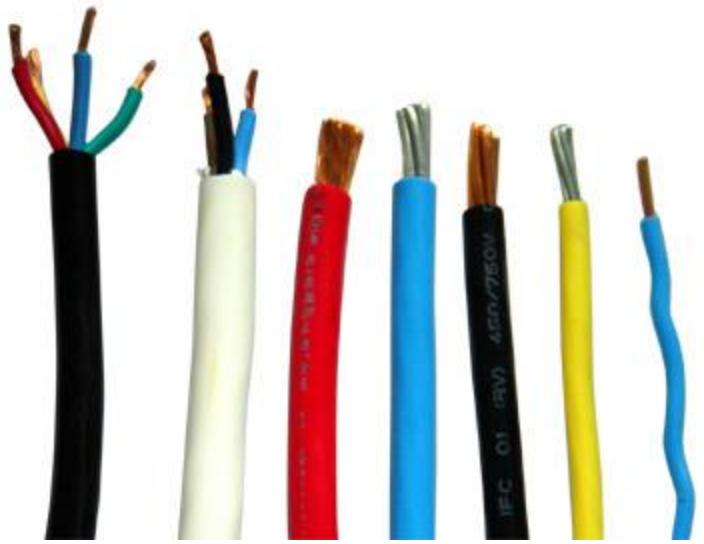
- Rubber
- Porcelain
- Varnish
- Slate
- Glass
- Mica
- Latex

Asbestos
Thermoplastics
Paper
Oils
Wax
Dry air

WIRES AND CABLES

- **Wires**
  - electrical conductors which are 8 mm^2 (AWG no. 8) or smaller

- **Cables**
  - larger than the wires.
  - either solid or stranded.



WIRES AND CABLES

- Wires and Cables are either:

Stranded wire

- consists of a group of wires twisted to form metallic string.
- total circular-mil area is found by multiplying the circular mil area of each strand by the total number of strand.

Cord

- term given to an insulated stranded wire.

WIRES AND CABLES

- CIRCULAR MIL.
  - unit of cross section in the American wire gauge.
  - “mil” means one-thousandth of an inch (0.001 in.).
  - area of a circular wire having a diameter of one mil.

WIRES AND CABLES

- To find the number of circular mils in a circle of a given diameter, we have to square the number of mils in the diameter.

Area in circular mil = (diameter in mils)^2

1 inch = 1,000 mils

MCM = 1,000 circular mils

WIRES AND CABLES

- SQUARE MIL.
  - area of a square having its side equal to 1 mil.

Square mil = (sides)^2
= (1 mil)2 = (0.001 in.)^2
= 1 x 10^{-6} in^2
Square mil = 0.7854 x circular mils

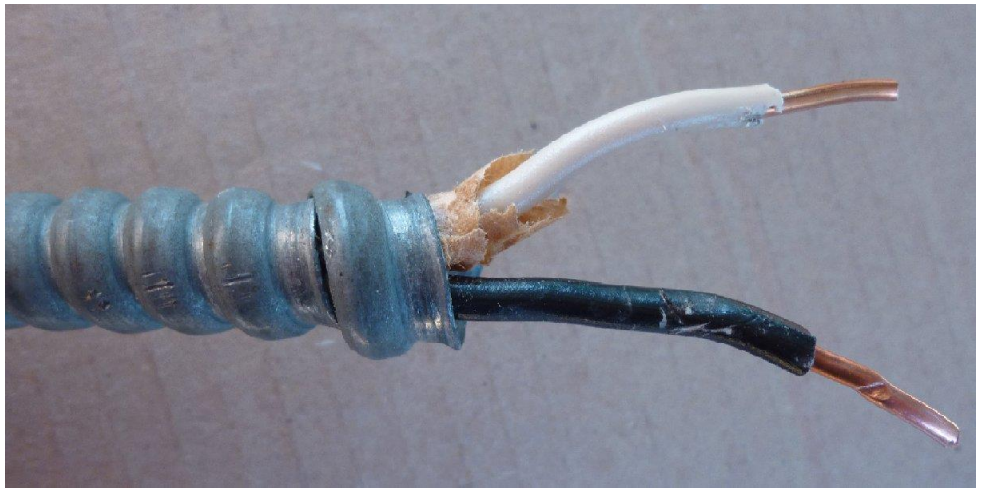
DIFFERENT TYPES OF CABLES

DIFFERENT TYPES OF CABLES

1. **Armored Cable (AC)**

   - a fabricated assembly of insulated conductors enclosed in flexible metal sheath

   - used in both exposed and concealed work.



DIFFERENT TYPES OF CABLES

2. **Metal Clad Cable (MC)**

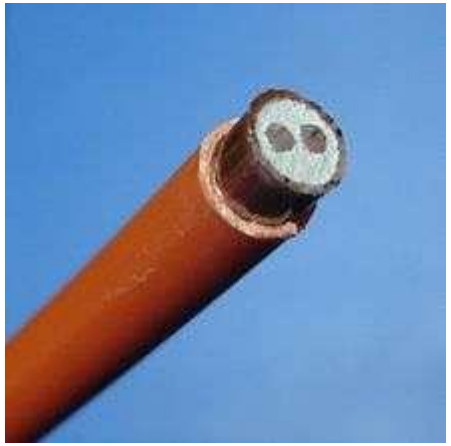
- factory assembled cable of one or more conductors, each individually insulated and enclosed in a metallic sheath of interlocking tape, or a smooth or corrugated tube.

- used specifically for services, feeders, branch circuits, either exposed or concealed and for indoor or outdoor work.

DIFFERENT TYPES OF CABLES

3. Mineral Insulated Cable (MI)

- a factory assembly of one or more conductors insulated with a highly compressed refractory mineral insulation and enclosed in liquid-tight and gas-tight continuous copper sheath.
- used in dry, wet or continuously moist location as service, feeders or branch circuit.



DIFFERENT TYPES OF CABLES

4. Nonmetallic Sheathed Cable. (NM/NMC)

- factory assembled two or more insulated conductors having a moisture-resistant outer sheath, flame-retardant and non-metallic material.
- used specifically for one or two dwelling not exceeding 3 storey buildings.

DIFFERENT TYPES OF CABLES

5. Shielded Nonmetallic Sheathed Cable (SNM)

- a factory assembly of two or more insulated conductors in an extruded core or moisture-resistant and flame-retardant material, covered with an overlapping spiral metal tape.
- used in hazardous locations and in cable trays or in raceways.

DIFFERENT TYPES OF CABLES

6. Service Entrance Cable (SE / USE)

- a single conductor or multiconductor assembly provided with or without an over-all covering, primarily used for services and of the types SE and USE.

DIFFERENT TYPES OF CABLES

7. Underground Feeder and Branch Circuit Cables (Type UF)

- a moisture-resistant cable used for underground, including direct burial in the ground, as feeder or branch circuit.

DIFFERENT TYPES OF CABLES

8. Power and Control Tray Cable (Type TC)

- a factory assembly of two or more insulated conductors with or without associated bare or covered grounding under a metallic sheath.
- used for installation in cable trays, raceways or where supported by a messenger wire.

DIFFERENT TYPES OF CABLES

9. Flat Cable Assemblies (Type FC)

- assembly of parallel conductors formed integrally with an insulating material web designed specifically for field installation in metal surface raceway.

DIFFERENT TYPES OF CABLES

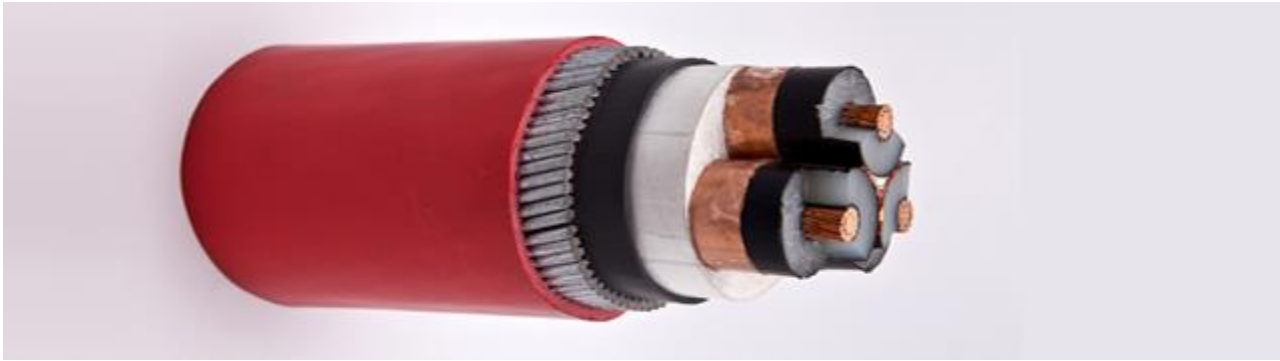
10. Flat Conductor Cable (Type FCC)

- consists of three or more flat conductors placed edge to edge, separated and enclosed within an insulating assembly.
- used for general purpose, appliance branch circuits and for individual branch circuits specifically on hard, smooth, continuous floor surfaces, etc.

DIFFERENT TYPES OF CABLES

11.Medium Voltage Cables (MV)

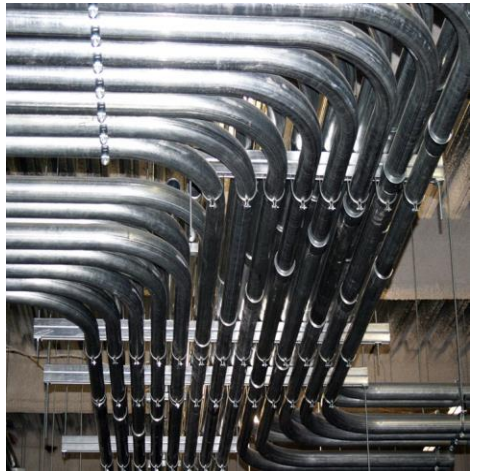
- A single or multi-conductor solid dielectric insulated cable rated 2,001 volts or higher and is used for power systems up to 35,000 volts.
- of different types and characteristics.



RACEWAYS

RACEWAYS

- channels designed for holding wires, cables or bus-bars, which are either made of metal or insulating materials.
- common types of raceways in household wiring are the **a) conduits**, **b) connectors**, and **c) others**.



Conduits

Conduits, pipes or tubings are the most common electrical raceway.

maybe classified as either metallic such as **steel pipes** or nonmetallic such as **PVC**, and the like.

- maybe classified as: rigid metal, flexible metal, rigid nonmetal and flexible nonmetal.

Other Raceways

a) conduit couplings, elbows and other fittings;
b) conduit supports, such as clamps, hangers, etc;
c) cable trays, cablebus;
d) metal raceways;
e) nonmetal raceways.

Conduit Pipe

- Most common electrical raceways used in all types of constructions

Classification with respect to materials

1) Metallic
2) Non-metallic

Conduit Pipe

Classification with respect to its make

1) Rigid
2) Flexible metal
3) Rigid non-metal
4) Flexible non-metal

Purpose of Electrical Conduits

1. To **provide a means** of running wires from one point to another
2. To physically **protect the wires**
3. To provide grounded **enclosure**
4. To protect the surroundings **against effect of fault** in the writing
5. To protect the wiring system **from damage** by buildings and the occupants
6. To **protect the building** from damage by the electric system

OUTLETS, RECEPTACLES and other WIRING DEVICES

Outlet

- a **point in the wiring system** at which current is taken to supply utilization equipment.

Kinds of outlets:

1. convenience outlet or attachment cap,
2. lighting outlet, and
3. receptacle outlet.

Convenience outlet

- or attachment cap

- a device which by insertion in a receptacle, establishes connection between the conductor of the flexible cord and the conductors connected permanently to the receptacle.

Lighting outlet

- an outlet intended for direct connection of a lampholder, a lighting fixture, or a pendant cord terminating in a lampholder.

Receptacle outlet

- an outlet where one or more receptacles are installed.

Junction Box

- not an outlet

- enclosure that protects a connection (the junction) of two or more wires carrying electrical current

Pull box

- box with a blank cover that is inserted in one or more runs or raceways to facilitate pulling-in the conductors

- may also serve to distribute the conductors

Receptacles

- Contact device installed at the outlet for the connection of a single attachment plug.
- Any number of receptacles mounted together in one or more coupled boxes is classified as **one outlet.**
- Included in the general classification of wiring devices.

Mounting the receptacles

1. A wall convenience receptacle is **vertically mounted between 30 to 45 centimeters** above the finished floor line.

2. In industrial areas, shops, workroom and the like, the **mounting height is from 105 to 110 centimeters.** This is above the table height horizontally mounted so the cords will not hang on top of each other

3. The GFI or **GFCI receptacle** should be installed on locations where sensitivity to electric shock is high such as **wet areas**

Switches

- A device that open and closes the circuitry in an electric circuit

Classification of Switches

1. General use switch
2. General use snap switch
3. AC General use snap switch
4. AC-DC General use switch
5. Isolating switch
6. Motor circuit switch

General use switch

- Intended for use in the general distribution and branch circuit rated in amperes

- Capable of interrupting the rated current at a rated voltage

General use snap switch

- Form of general use switch installed in flush device boxes or an outlet box cover

Isolating switch

- Intended for isolating an electric circuit for the power source

TYPES OF WIRES

A. TYPES T, TW, THW

- **Type T**
  - most ordinary type of plastic insulated wire
  - may be used only in dry locations.
- **Type TW**
  - which is identical in appearance to Type T, but may be used in wet or dry locations.
- **Type THW**
  - similar to Type TW but withstand a greater degree of heat, and consequently has a higher ampacity rating in the larger sizes.

TYPES OF WIRES

B. TYPES THHN, THWN

- Comparatively new types of wire

- **Type THH and THW**
  - less thermoplastic insulation, and with a final extruded jacket of nylon.
- **Nylon**
  - exceptional insulating qualities and great mechanical strength, all of which results in a wire which is smaller in diameter than ordinary Types T, TW, TW of corresponding size.

TYPES OF WIRES

C. **TYPE XHHW**

In appearance, it resembles Types T, TW, THW but because of somewhat thinner layer of insulation, the over-all diameter is smaller. The insulation is "cross-linked synthetic polymer," which has an extraordinary properties as to insulating value, heat resistance, and moisture resistance. It may be used in dry or wet locations. While at present, it is an expensive wire, it would be no surprise if in due course of time, this one single type will replace all the many types and subtypes of Type T or R now recognized by the Code.

TYPES OF WIRES

D. **RUBBER-COVERED WIRE**

It consists of copper conductor, tinned to make it easier to remove the insulation, and for easy soldering. Over the copper is a layer of rubber, the thickness of which depends on the size of the wire. Then follows an outer fabric braid which is saturated with moisture-and-fire-resistant compounds; if it is set on fire with a blowtorch, the flame dies out when the torch is removed.

TYPES OF WIRES

E. **OTHER TYPES**

Other types such as the basic Type R, which is suitable for only in dry locations, is no longer being made. The most ordinary kind is Type RHW, which may be used for dry or wet locations. Types RH and RHH have insulation which withstands more heat and therefore have a higher ampacity in the larger size. They may be used only in dry locations.

KINDS OF LOCATIONS

DAMP LOCATION

- Partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations **subjected to moderate degree of moisture**, such as some basements, some barns, and some cold-storage warehouses.

KINDS OF LOCATIONS

DRY LOCATION

- A location **not normally subject to dampness or wetness**. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

KINDS OF LOCATIONS

WET LOCATION

- Installations underground or in concrete slabs or masonry in direct contact with the earth, and **location subject to saturation with water or other liquids**, such as vehicle washing areas, and locations exposed to weather and unprotected.

KINDS OF LOCATIONS

HAZARDOUS (CLASSIFIED) LOCATIONS

- Locations where **fire or explosion hazards may exist** due to flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers

HAZARDOUS LOCATIONS

1. **Class I Locations**

   those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures

   a) **Class I, Division 1**.

      i) in which ignitable concentrations of flammable gases or vapors can exist under normal operating conditions; or

      ii) in which ignitable concentrations of such gas vapors may exist frequently because of repair or maintenance operations or because of leakage; or

      iii) in which breakdown or faulty operation of equipment or processes might release ignatible concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

HAZARDOUS LOCATIONS

1. Class I Locations

b) Class I, Division 2. A Class I, Division 2

I) in which volatile flammable liquids or flammable gases are handled, processes, or used, but in which the liquids, vapors, or gases will normally be confines within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; or

ii) in which ignitible concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operation of the ventilating equipment;

iii) that is adjacent to Class I, Division 1 location, and to which ignitible concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

HAZARDOUS LOCATIONS

2) **Class II Locations.** Class II locations are

- those that are hazardous because of the presence of combustible dust.

a) **Class II, Division 1.** I) in which combustible dust is in the air normal operating conditions in quantities sufficient to produce explosive or ignitible mixtures; or ii) where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitible mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation devices, or from other causes; or iii) in which combustible dusts of an electrically conductive nature may be present in hazardous quantities.

HAZARDOUS LOCATIONS

b) Class II, Division 2.

- a location where combustible dust is not normally in the air in quantities sufficient to produce explosive or ignitible mixtures, and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, but combustible dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment and where combustible dust accumulations on, in, or in the vicinity of the electrical equipment may be sufficient to interfere with the safe dissipation of heat from electrical equipment or may be ignitible by abnormal operation or failure of electrical equipment.

HAZARDOUS LOCATIONS

3. Class III Locations.

hazardous because of the presence of easily combustible fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitible mixtures.

a) **Class III, Division 1**.

- location in which easily ignitible fibers or materials producing combustible flyings are handled, manufactured, or used.

b) **Class III, Division 2**.

- location in which easily ignitible fibers are stored or handled.

References:

Philippine Electrical Code

Electrical Layout and Estimate by Fajardo

Residential Wiring by Mullin