

NOTES class 52

Electrical Wires & Cables

More often than not, the terms wire and cable are used to describe the same thing, but they are actually quite different. Wire is a single electrical conductor, whereas a cable is a group of wires swathed in sheathing. The term cable originally referred to a nautical line of multiple ropes used to anchor ships, and in an electrical context, cables (like wires) are used to carry electrical currents.

Whether indoors or outdoors, proper wire and cable installation is of paramount importance - ensuring a smooth electricity supply, as well as passing electrical inspections. Each wire and cable needs to be installed carefully, from the fuse box to the outlets, fixtures and appliances. The National Electrical Code (NEC) and Local Building Codes regulate the manner of installation and the types of wires and cables for various electrical applications.

- Wires/cables are conducting materials which are made of copper, aluminum, silver, iron, and alloyed metals like nichrome wire, constantan, and German silver wire.
- It is used to conduct power from the point where it is generated to the point where it is used.
- Wires/cables are all electric conductors but not all conductors are wires. These wires are either made of solid or stranded. Most wires are round although square and rectangular forms are also used in specific applications. These wires are manufactured with or without insulation depending upon the application.
- Copper or aluminum wires without insulation are usually used for grounding connection and also for high tension or high voltage transmission lines.
- Nichrome wire, constantan, manganin, and German silver wires are used as resistance wires in electrical equipment and appliances.
- All wires/cables have resistances that oppose the unlimited flow of current and causes voltage drop resulting in the eventual heat developed in the wire. The heat developed varies according to the square of the current in amperes.
- There is a limit to the degree of heat that various types of wire insulation and

sizes can safely withstand. They should not be allowed to reach a temperature that might cause a fire.

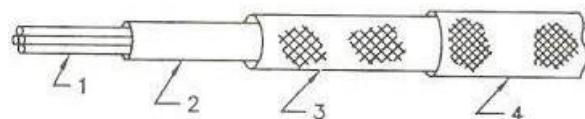
- The Electrical Code specifies the maximum current-carrying capacity in amperes that is safe for wires of different with different insulations and under different circumstances and conditions.

Types of Wires

- ❖ Vulcanised Indian Rubber wire (V.I.R)
- ❖ Tough Rubber Sheathed wire (T.R.S)
- ❖ Poly Vinyl Chloride wire (P.V.C.)
- ❖ Lead Alloy Sheathed wire
- ❖ Weather Proof wires
- ❖ Mineral Insulated Copper Covered wire

Vulcanised Indian Rubber wire (V.I.R)

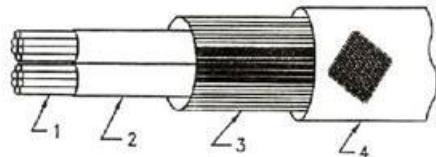
- A VIR wire mainly consists of a tinned conductor having rubber coating.
- Tinning of the conductor prevents the sticking of rubber to the conductor.
- Thickness of the rubber mainly depends on the operating voltage to which the wire is designed.
- Cotton braiding is done over the rubber insulation to protect the conductor from the moisture.
- Finally the wire is finished with the wax for cleanliness.
- They are suitable for low and medium voltage only.
- Now a days this type of wires are not in use since a better quality wires are available at cheaper rate



1. CONDUCTOR 2. RUBBER INSULATION 3. BRAIDING
4. SECOND LAYER OF BRAIDING

Cabe tyre sheath wire (CTS)/Tough Rubber Sheathed wire (T.R.S)

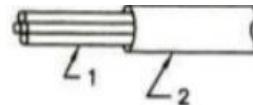
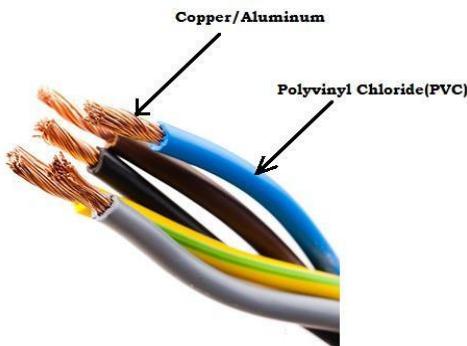
- This type of wire is modification of VIR wire. It consists of the ordinary rubber coated conductors with additional sheath of tough rubber.
- This layer provides better protection against moisture and wear and tear. Also it provides an extra insulation.
- These wires are generally available in single conductor, 2 conductor or 3 conductor



1. CONDUCTOR 2. RUBBER INSULATION 3. RUBBER SHEATH
4. BRAIDING

Poly Vinyl Chloride wire (P.V.C.)

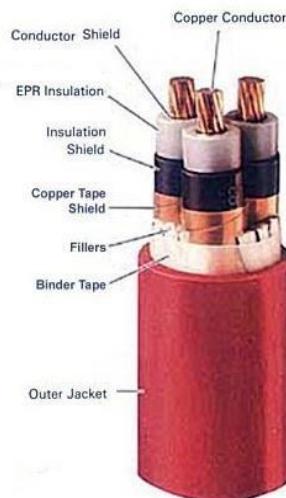
- This is most commonly used wire for wiring purpose.
- Conductor is insulated by poly vinyl chloride (insulating material)
- PVC has following properties:
 - Moisture free
 - Tough
 - Durable
 - Chemically inert
 - High life
 - High dielectric strength
 - No disturb in vibration
- But it softens at high temperatures therefore not suitable for connection to heating appliances
- Available in 600V, 660V, 1100V, widely used long life durable against water, heat, oil, UV light



1. CONDUCTOR 2. PVC INSULATION

Lead Alloy Sheathed wire

- The ordinary wires can be used only at dry places but for damp places these wires are covered with continuous lead sheaths.
- The layer of lead covering is very thin like 0.12 cm thick.
- These wires provide little mechanical protections to the wires.



Weather Proof wires

- These types of wire are used outdoors i.e. providing a service connection from overhead line to building, etc.

- In this type of wire the conductor is not tinned and the conductor is covered with three braids of fibrous yarn and saturated with water proof compound.



Fig: Weather Proof wires

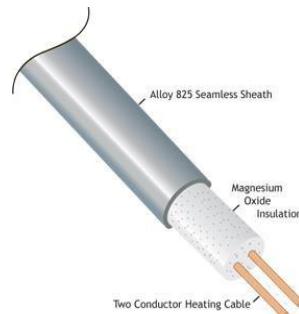


Fig: MICC wire

Mineral Insulated Copper Covered (MICC) wire

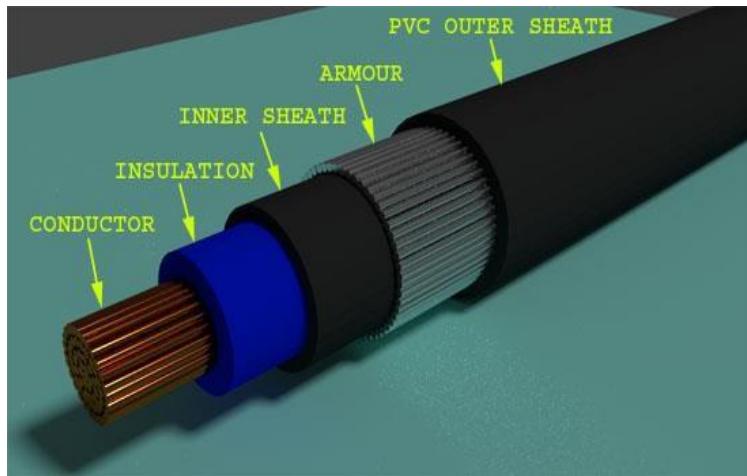
In this type wire copper conductor is coated with magnesium oxide and after that copper coating is done on it. In case of moisture weather PVC coating (serving) is coated on it. It is used in mines, factory, furnace, boiler, rolling mills, etc. magnesium oxide is used for avoiding moisture problems.

CABLES

A power cable is an assembly of two or more electrical conductors, usually held together with an overall sheath. The assembly is used for transmission of electrical power. Power cables may be installed as permanent wiring within buildings, buried in the ground, run overhead, or exposed. Flexible power cables are used for portable devices, mobile tools and machinery.

Construction

The power cable mainly consists of three main components, namely, conductor, dielectric, and sheath. The conductor in the cable provides the conducting path for the current. The insulation or dielectric withstands the service voltage and isolates the conductor with other objects. The sheath does not allow the moistures to enter and protects the cables from all external influences like chemical or electrochemical attack, fire, etc. The main components of electrical power cables are explained below in details.



Conductor

Coppers and aluminum wires are used as a conductor material in cables because of their high electrical conductivity. Solid or number of bare wires made of either copper or aluminum is used to make a power cable.

Insulation

The most commonly used dielectric in power cables is impregnated paper, butyl rubber, polyvinyl chloride cable, polyethylene, cross-linked polyethylene. Paper insulated cables are mostly preferred because their current carrying capacity is high, generally reliable and having a long life. The dielectric compound used for the cable should have following properties.

- The insulator must have high insulation resistance.
- It should have high dielectric strength so that it does not allow the leakage current to pass through it.
- The material must have good mechanical strength.
- The dielectric material should be capable of operating at high temperature.
- It should have low thermal resistance.
- It should have a low power factor.

Inner Sheath

- It is used for protecting the cable from moistures which would affect the insulation. Cable sheath is made up of lead alloy, and these strengths withstand the internal pressures of the pressurized cables. The material used for inner sheath should be nonmagnetic material.
- The aluminum sheath is also used in a power cable because it is cheaper, smaller in weight and high mechanical strength than the lead sheath. In oil-filled cables and telephone, cables corrugated seamless aluminum sheath is used because it has better-bending properties, reduced thickness, and lesser weight.

Armouring

Armouring is the process in which layers of galvanized steel wires or two layers of metal tape are applied over sheath for protecting it from mechanical damage. The steel wires are normally used for armouring because it has high longitudinal strength. Armouring is also used for earthing the cable. When the fault occurs in the cable (due to insulation failure) the fault current flows through the armour and get earthed.

Over Sheath

It gives the mechanical strength to the cables. It protects the cable from overall damage like moisture, corrosion, dirt, dust, etc. The thermosetting or thermoplastic material is used for making over the sheath.

Classification Based Upon Voltage Rating Of the Cable

1. **Low tension cables:** These have a maximum voltage handling capacity of 1000 V (1 kV)
2. **High tension cables:** These have a maximum voltage handling capacity of 11 kV.
3. **Super tension cables:** These have a maximum voltage handling capacity of 33 kV.
4. **Extra high tension cables:** These have a maximum voltage handling capacity of

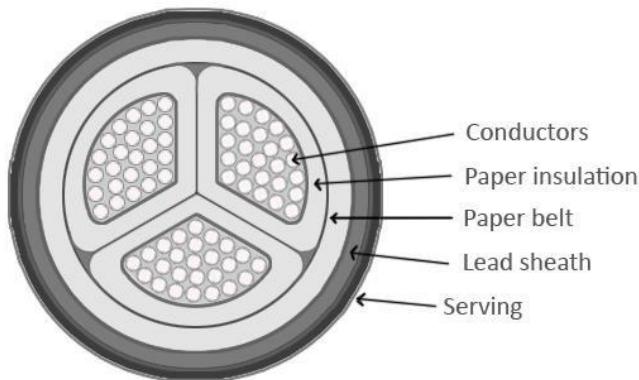
66 kV.

- 5. Extra super voltage cables:** These are used for applications with voltage requirement above 132 kV.

Classification Based Upon Construction of the Cable

1. Belted Cable

In such cables, the conductors (usually three) are bunched together and then bounded with an insulating paper 'belt'. In such cables, each conductor is insulated using paper impregnated with a suitable dielectric. The gaps between the conductors and the insulating paper belt are filled with a fibrous dielectric material such as Jute or Hessian. This provides flexibility as well as a circular shape. As we discussed earlier (in Construction of Cables), the jute layer is then covered by a metallic sheath and armouring for protection. One particular specialty of this cable is that its shape may not be perfectly circular. It is kept non-circular to use the available space more effectively.



There are some limitations of such construction. Since the electric field is tangential, the insulation provided is stressed. As a result, the dielectric strength falls over time. Hence, such construction isn't preferred for voltage levels above 11 kV.

2. Pressure Cables

For voltages beyond 66 kV, the electrostatic stresses in the cables exceed the acceptable values and solid cables become unreliable. This occurs mainly because voids are created when voltages exceed 66 kV. Hence, instead of solid cables, we use

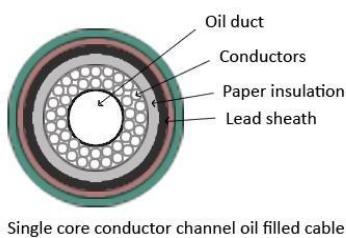
Pressure cables. Typically, such cables are either oil filled or gas filled.

➤ Oil Filled Cables

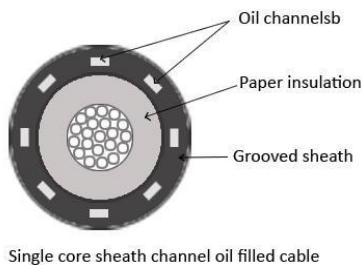
Oil is circulated under suitable pressure through ducts provided for such purpose. This oil supply and pressure are maintained through reservoirs kept at proper distances. The oil used is the same that is employed for impregnation of paper insulators.

➤ Gas Filled Cables

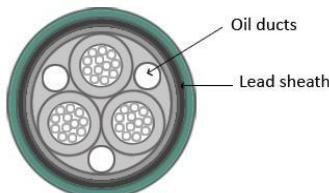
Pressurized gas (usually dry nitrogen) is circulated around cables in an air-tight steel pipe. Such cables are capable of carrying higher values of load current and can operate at higher values of voltage. But the overall cost is more.



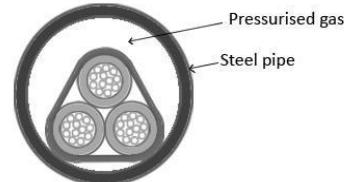
Single core conductor channel oil filled cable



Single core sheath channel oil filled cable



Three core oil filled cable



Three core gas pressure cable