

WIRE AND CABLE INDUSTRY AND COLORANTS –AN OVERVIEW

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Abstract: *Electricity is the most versatile and easily controlled form of energy. At the point of use it is practically loss-free and essentially non-polluting. At the point of generation it can be produced clean with entirely renewable methods, such as wind, water and sunlight. Electricity is weightless, easier to transport and distribute, and it represents the most efficient way of consuming energy.*

In short everyone knows that electricity has become a crucial and indispensable part of our lives. It has been recognized as a basic human need.

While electricity is used constantly throughout the day without much thought, it actually has the potential to cause many issues. If something is not wired properly, it can result in injuries, deaths, fires, and many other problems.

In order to avoid any damage there are certain there are several wire identification standards used throughout the world and many of them depend on color codes.

In this paper materials used for coating of wires and cables described in detail. Various Colorants are also used to provide a suitable color for cable coating. For suitably identification of wires and cables color code system is used. This color code system is specific for a particular country. Also there are some international standards for wire and cable color coding which may be familiar to the end user.

Keywords—*Electricity, Colorants, color codes, wind, water and sunlight.*

I. INTRODUCTION

Electricity – an essential requirement of life. Electricity is one of the greatest technological innovations of mankind. It has also become a part of modern life and one cannot think of a world without it. Electricity has many uses in our day to day life. It is used for lighting rooms, working fans and domestic appliances like using electric stoves, A/C and more. All these provide comfort to people. In factories, large machines are worked with the help of electricity. Essential items like food, cloth, paper and many other things are the product of electricity.(1- 30) It is well known that every electric circuit, regardless of where it is or how large or small it is, has four basic parts: an energy source (AC or DC), a conductor (wire), an electrical load (device), and at least one controller (switch). (31) In short, wire and cables are an essential part of electricity. 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. (32)

II. TYPES OF MATERIALS USED FOR

MANUFACTURING OF COATED WIRE AND CABLES

For manufacturing of coated wire and cables

following seven major types of materials used.

- (1) Resins (thermoplastic and thermoset compounds) for insulation and jacketing;
- (2) Plasticizers to make the plastic flexible and easy to process (and impart other qualities such as impact resistance and abrasion resistance);
- (3) Stabilizers to provide heat resistance during manufacturing as well as visible light, UV rays and heat resistance during product use;
- (4) Flame retardants to slow the spread of an accidental fire and reduce the amount of heat and smoke released;
- (5) Fillers to reduce formulation costs and improve insulation resistance;
- (6) Lubricants to improve the ease of processing; and
- (7) Colorants to give the desired color, which is crucial for identification purposes. (121)

In most facilities, the electricity will come in at one point in the building, and then be distributed to just about every corner through a series of wires. Even the tools and machines that are used are filled with wires that are used to conduct the electricity to perform whatever action is needed.

While electricity is used constantly throughout the day without much thought, it actually has the potential to cause many issues. If something is not wired properly, it can result in injuries, deaths, fires, and many other problems.

This is why there are well-established wire color codes to ensure those working with an around this type of equipment can ensure everything is wired safely and effectively. (33)

There are several wire identification standards, and many of them depend on on color codes as follows :

A. U.S. Wire Color Codes(122)

In the United States, the following color codes are typically used for power wires in “branch circuits,” the wiring between the last protective device (such as a circuit breaker) and the load (such as a tool or appliance).

120/208/240 VOLT AC WIRE COLORS

These systems are common in home and office environments.

- Phase 1 - Black
- Phase 2 - Red
- Phase 3 - Blue
- Neutral - White
- Ground - Green, Green with Yellow Stripe, or Bare Wire

If the wiring system has one phase at a higher voltage than the others, using a “high-leg” connection, that phase’s wires

should be marked with orange. (This is required in NEC article 110.15.) However, these high-leg delta systems are uncommon with newer installations.

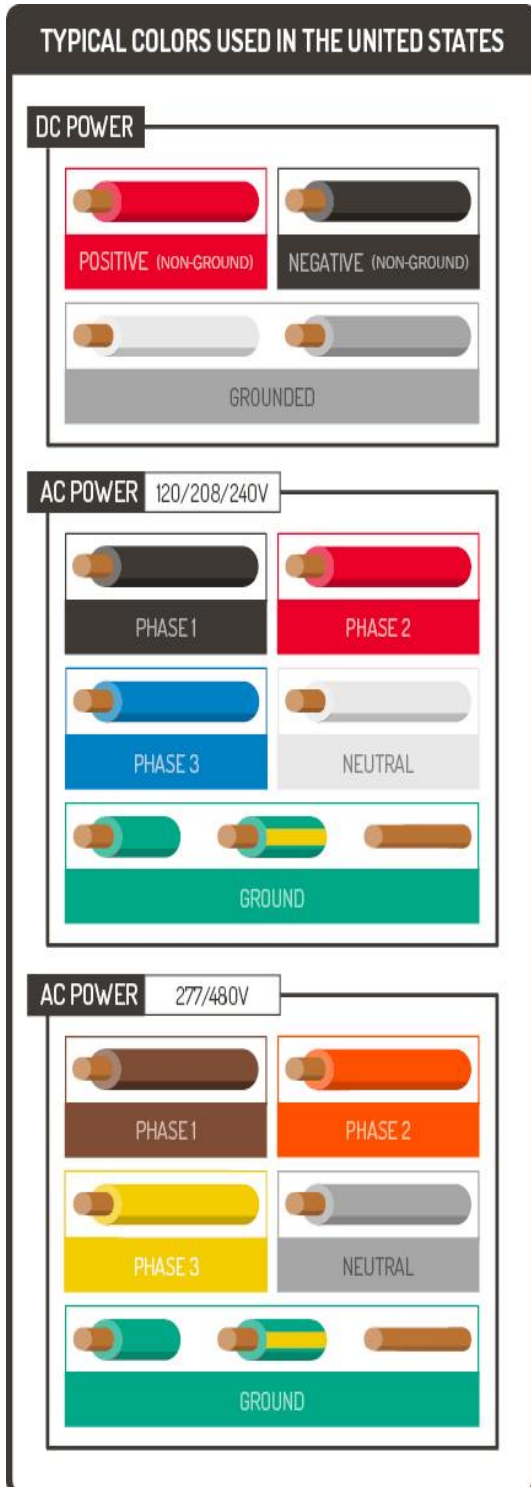


Fig. 1: Typical color used in the U.S. for wire and cables.

277/480 VOLT AC WIRE COLORS

These higher-voltage systems are common for industrial motors and equipment.

- Phase 1 - Brown
- Phase 2 - Orange

- Phase 3 - Yellow
- Neutral - Gray
- Ground - Green, Green with Yellow Stripe, or Bare Wire

For higher-voltage cases, it becomes even more important to have a documented wire labeling system. More detailed labels can include information like circuit identification, or the appropriate disconnection point for lockout/tagout.

DC POWER WIRE COLORS

Solar power systems and many battery systems use DC (direct current) power, rather than AC (alternating current).

- Positive (non-ground) - Red
- Negative (non-ground) - Black
- Ground - White or Gray

B. EUROPEAN (IEC) WIRE COLOR CODES (122)

Most European countries follow a wire color code established by the International Electrotechnical Commission (IEC) for AC branch circuits. This standard was originally published as IEC 60446, but was merged into IEC 60445 in 2010.

- Phase 1 - Brown
- Phase 2 - Black
- Phase 3 - Grey
- Neutral - Blue
- Ground - Green with Yellow Stripe

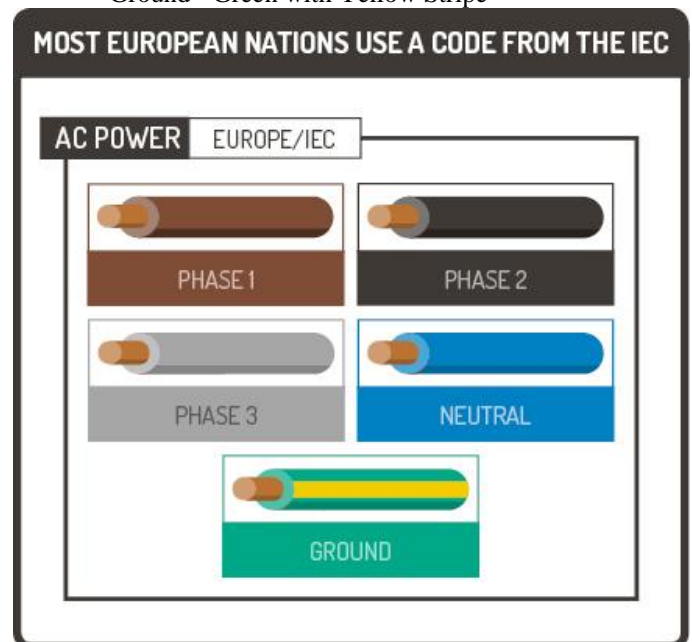


Fig. 2: Typical color used in the Europe for wire and cables.

C. CANADIAN WIRE COLOR CODES FOR AC POWER

In Canada, wire color coding standards are set by the Canadian Electric Code (CEC). The color code for AC power wiring is similar to the code used in the United States:

- Phase 1 - Red
- Phase 2 - Black
- Phase 3 - Blue

- Neutral - White
- Ground - Green with Yellow Stripe

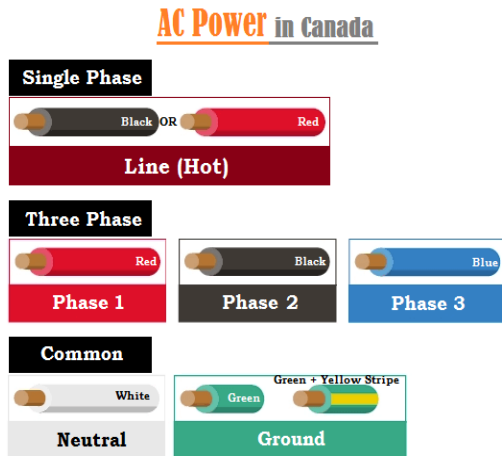


Fig. 3: Typical color used in the Canada for wire and cables. (134)

D. INDIAN WIRE COLOR CODES (34)

In India, wires has standard color code as RGB i.e. Red-Green- Black. Each of these wires have different functions. But, it is the old color coding, where

- RED: Red wire signifies the phase in electric circuit. It is he live wire.
- BLACK: Black wires signifies neutral wire in electric circuit. The neutral wires is connected to neutral bus bar inside an electric panel.
- GREEN: Green wire stands for grounding/ earthing in electric circuit.

The new color coding consist of Brown, Blue and Green wires. Following are functions :

- BROWN: It is a live wire.
- BLUE: It is neutral wire.
- GREEN: It is earthing wire.

In case of a three phase power supply, the combination of Red, Yellow and Blue are used for the active line power conductors, Black color for neutral conductor and Green or Green – Yellow for protective ground.

Function	India Color Code (Old)	India Color Code (New)
Single Phase Line		
Single Phase Neutral		
Single Phase Protective Ground or Earth		
Three Phase Line (L1)		
Three Phase Line (L2)		
Three Phase Line (L3)		
Three Phase Neutral (N)		
Three Phase Protective Earth or Ground (PE)		

Fig. 4 : Typical color used in the India for wire and cables. (134)

III. COLORANT FOR WIRE AND CABLE INDUSTRY

Colorants Colorants are added to wire and cable resins for identification purposes. Vinyl wire and cable compounds can be manufactured in virtually any color. There are two major types of colorants – pigments and dyes. A pigment is insoluble and is dispersed as discrete particles throughout a resin to achieve a color. (121)

The Wire and cable industry use various types of pigments to color polyolefins.(36-42)

Following two types of pigments are used for colouration in in the wire and cable industries.

- Inorganic pigments and
- Organic Pigments (35, 42, 43)

Newer alternatives that are coming in to the market are known as the "mixed-phase metal oxide" pigments. 44-46 Examples : Yellow nickel Titanates (47-50) and blue and green cobalt Aluminates. (51-52) .

Organic pigments are also used but not as popular because they are more difficult to disperse than inorganic ones leading to possible loss in mechanical strength (36)

A dye is soluble in the resin and always an organic based material. Light stability is an important factor when selecting a colorant. Pigments are typically identified by their color families and to some extent their properties. Common inorganic types include lead, cadmium, lead chromate, titanium dioxide, zinc sulfide, iron oxides, cadmium oxides, ultramarines, mixed metal oxides, and carbon black. Titanium dioxide and zinc sulfide are white pigments which can be used in most resins. Iron oxides come in red, yellow, brown, and black. Their heat stability varies and they can be used in a variety of resins. Lead chromates and lead chromate molybdates include bright yellows and oranges. Cadmium comes in reds, yellows, oranges and maroons and is excellent for engineering resins. Chromium oxides are green and show very good heat and light fastness. Ultramarines come in blue, pink and violet shades and work in a wide range of resins. Alternatives to many of these "heavy metal" pigments are the "mixed-phase metal oxide" pigments (e.g., yellow nickel titanates and blue and green cobalt aluminates). Relatively new is a brilliant yellow bismuth vanadate. Orange version compounds have been developed as well. Cerium sulfide now is under commercialization for a range of reds. Organic pigments are also available in a wide range of colors. They, however, are more difficult to disperse than inorganic, which leads to possible loss in mechanical strength. The amount of colorants used in coated wire and cable is small and this makes it less of a priority for developing alternatives. (121)

Table 1. : Pigment colour and application

Pigment	Color	Application
Titanium dioxide (53-60)	White	Used in Variety of resins
Zinc sulphide (61-67)	White	Wide use
Iron oxides (68-73)	Red, yellow, brown, and	Wide use

	black	
Lead chromates and lead chromate molybdates (74-90)	Colors can include bright yellow and orange	Good use
Cadmium (91 -100)	Comes in reds, yellows, oranges and maroons	Excellent for engineering resins
Chromium oxides (101-110)	Green	Shows good heat and light fastness, variety of uses
Ultramarines (111-120)	Comes in blue, pink and violet shades	Works in a wide gamut of resins

India insulated wire and cable market is forecast to grow at a CAGR of 10.3% through 2023, predominantly on account of growing government investments towards infrastructure development projects. Development of Smart Cities across the country under Smart Cities Mission coupled with increasing number of electronic devices per household and development of manufacturing industries under the 'Make in India' initiative, which is driving demand for power, are expected to boost market demand in the coming years. Moreover, growing demand for reliable, efficient energy and data communication from rural areas and tier II and tier III cities and towns would positively influence the country's insulated wire and cable market. (123)

Different major working in India insulated wire and cable market are as follows:

- Polycab Wires Pvt. Limited (124)
- Havells India Limited (125)
- Finolex Cables Limited (126)
- KEI Industries Limited (127)
- RR Kabel Limited (128)
- Universal Cables Limited.(129)
- Uniflex Cables Limited (130)
- V – Guard Industries Limited (131)
- Gupta Power Infrastructure Limited (132)
- KEC International Limited,(133) etc.

IV. CONCLUSION

Wires and cables play a vital role in electrical energy consumption, transmission and distribution system. To conduct all this processes smoothly and without any risk, different types of insulation cover(coating) is necessary. Also there are various international standards for wire and cable color coding in different country. By knowing this standards one can avoid damage and also convenient in electrical wiring in various industries and domestic appliances.

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