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## Electrical Safety in LV System and the Role of Wires

This article is a part of series of articles on LV electrical safety. Readers are requested to go through the previous articles to have a better understanding.

### Wiring in buildings and electrical safety

Wires used in the fixed installation plays a major role in electrical safety. Often the wires are installed inside conduits, voids, cable management system etc. Type of insulation of the wires determines the amount of toxic gases produced in case of fire. But the more important subject is the resistance of the conductor used in wires.

Higher resistance in a wire lead to

- Higher heat dissipation and energy loss,
- Increased voltage drop,
- Reduction in fault current leading to non-operation (or delayed operation) of the protective device
- Non-operation of the protective device leads to “Fire due to short circuit”.

Once installed, it is difficult to change wires. Depending up on the type of installation the current carrying capacities of wires are de-rated. The current carrying capacity reduction factors are determined primarily considering the heat generated and heat dissipation from a typical type of wiring. Influencing factors are

- Type, size and filling factor in a conduit
- Way of installing the conduit (e.g. Inside wall, outside wall etc)
- External influences (ambient temperature, dust, impact, vibration, etc)  
(for more information ref IEC 60364-5-52 or IS732:2019, clause 5.2)

### Resistance of copper conductors in wires

The conductors used in copper wires are divided into four classes and the respective application are

- Class 1** solid conductor: Application - fixed installation.
- Class 2** stranded conductors: Application - fixed installation.
- Class 5** stranded flexible conductors: Application other than fixed installation (e.g. short distance, appliance wiring, panel boards etc).
- Class 6** stranded flexible conductors: Application other than fixed installation (e.g. welding wires).

Out of these 4 types of copper conductors used in wires, class 5 and class 6 wire have approximately 7.5 to 9 % (say 8%) higher resistance compared to class 1 and class 2 conductors. An example from IS 8130 about the resistance of 2.5 sq.mm. conductor is as below.

Size of conductor	Type of copper	Resistance of copper wires in mΩ/m.			
		class 1	class 2	class 5	class 6
2.5 mm <sup>2</sup>	plain	7.41	7.41	7.98	7.98
	tinned	7.56	7.56	8.21	8.21

Resistance of copper conductor		
Sq.mm	Class-2 Ω/km at 20°C	Class-5, Ω/km at 20°C
0.75	24.5	26.0

1	18.1	19.5
1.5	12.1	13.3
2.5	7.41	7.98

### Application of wires with different conductors

For fixed installation (wiring in buildings) copper wires with class 1 or class 2 conductors is recommended. Reduction factors in current carrying capacity of wires (depending upon the type of installation) are made considering lower resistance wires. Wires with class 2 conductors are used inside conduits and are suitable for pulling through conduits.

Class 5 conductors are used in appliance wires and panel wiring as bending and routing of such cables in constricted paths do not yield stress, also handling and installation of such conductors in confined areas is easier. Flexible cable and flexible cords are preferably used for connections to portable appliances and equipment where the lengths are much shorter in comparison to fixed wiring.

### Comparison between wires made of different copper conductors

Cables with class-2 conductor	Cables with class-5 conductor
In terms of installation	
Easy to pass through conduit	Chance of getting stuck in between is higher.
Easy to make connection as chances of strand popping out while connections is the least	Termination is difficult due to higher number of strands
In case of changing connection, it is easy to pull out from conduit	Difficult to pull out cables after installation
Easy to remove insulation without damaging conductor	While removing insulation strand breakage is generally observed
In terms of mechanical strength	
high mechanical strength to withstand stress	Weaker compared to class-2 conductor cable
Cable stays firm in case of vibrations near connections.	Might get loosened in case of vibration
In terms of electrical properties	
Lesser conductor resistance, same as class 1	Higher resistance of conductor when compared to fixed cable

Higher current carrying capacity	Lesser current carrying capacity comparatively
Less leakage current	More leakage of current due to Higher air gap
reduce factor of de-rating	Higher de-rating factors
Less power loss due to lower resistance	6-7% higher power loss as compared to class 2
Environment friendly due to lower power loss	Higher power loss

#### Cable according to clause no. 16.1.2 & Table No. 3 (IS 694:2010)

Size	Class 2 Conductor Resistance as per IS 8130: ohms/km	Insulation Thickness, mm		Mechanical properties	
		Nom.	Min.	Tensile Strength in N/mm <sup>2</sup>	Elongation at break in %
1.5	12.1	0.7	0.53	12.5	150
2.5	7.41	0.8	0.62	12.5	150
4	4.61	0.8	0.62	12.5	150

#### Cable according to clause no. 17.1.2 & Table No. 4 (IS 694:2010)

Size	Class 5 Conductor Resistance as per IS 8130: ohms/km	Insulation Thickness, mm		Mechanical properties	
		Nom.	Min.	Tensile Strength in N/mm <sup>2</sup>	Elongation at break in %
1.5	13.3	0.6	0.44	10	150
2.5	7.98	0.7	0.53	10	150
4	4.95	0.8	0.62	10	150

### Danger in using wires with class 5 conductor in buildings

Using wires with class 5 conductors will lead to 8 % higher resistance, an overall additional heat loss of 8 % in the wiring. This is equal to 16 % higher loss at the wiring in a single-phase circuit.

Apart from the additional heat loss the more dangerous subject while using wires with class 5 conductor is the reduction in fault current and non-disconnection of fault leading to "FIRE DUE TO SHORT CIRCUIT"

**Worldwide copper wires with class 1 or class 2 conductors are used for wiring in fixed installation. In comparison, copper wires with class 5 conductors are used in India. Wires**



**with class 2 conductors rarely available in the market since it is 8% expensive in comparison to class 5 wires.**

In comparison to the complete cost of electrical installation, this additional 8 % cost for low resistance class 2 conductor is not a major factor. In comparison to the cost of building, this additional cost for a low resistance wire is negligible. Even the high-class platinum and gold rated energy efficient and green buildings use wires with higher resistance.

It is not the cost, but the lack of awareness is the main reason for using copper wires with higher resistance in building wiring. Electrical safety seminars and training programs rarely discuss about class 2 and class 5 conductors. As a result, another “lack of awareness” lead to usage of copper wires with higher resistance class 5 conductor in buildings leading to increased chance of accident.

### Conclusion

1. Resistance of the conductor in wires is an important subject in electrical safety.
2. Wires with class 2 copper conductors shall be used for wiring in buildings.
3. Wires with class 5 copper conductor lead to additional heat loss and increases the chance of FIRE DUE TO SHORT CIRCUIT. These conductors are not recommended for wiring in buildings.
4. It is high time in India that the authority concerned shall ban the usage of copper wires with class 5 conductor for wiring in buildings ■

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