# Ensuring Safety Through Cable Selection & Installationa

With proper current & voltage required to be carried by cables in a safe manner cable size & type selection and it's installation remains a subject of great importance for any electrical engineer for the performance and safety of electrical appliances & user's safety.
Though cable and cabling is a vast topic I would like to suggest some views from a cable manufacture's perspective so that safety is not comprised.

## 1. Selection of Cables:

1.1. Standards- Cables should confirm to relevant standards like Nepal Standard, Indian Standard, British Standard, CE, IEC and any compromise with it will create an electrical mismatch thereby risking the performance of electrical equipments & human lives.

1.2. Traceability of cables- Cables are meant to perform for decades and manufacturer must ensure it happens so. Brand name, size, type of cable, standard must be embossed on the cable so that even after several years unlike ink print embossing is easily readable engineers must select an embossed print cable which will make manufacturer more responsible to supply quality cables.

## 2. Raw Material of Cables:

2.1. Conductor Material: Mainly copper and aluminum are used for conductor making. Purity of these materials is directly proportional to conductivity. Copper and Aluminum made from ores are of high purify then that made by melting of scrape. If made by scrape, though cheap, if used in cables will bring in non-uniformity in conductor resistance and hence localized heating which many cause damage to insulation.
Proper selection of conductor material is based on (i) Capital Cost and (ii) Reliability. Copper is more expensive than aluminum but it is higher in reliability. Copper oxides formed at the terminals for copper cables are good conductor while Aluminum oxides formed in Aluminum cables are poor conductor and needs routine cleaning. Also mechanical properties of copper are much better as it doesn't elongate and creep resistance is higher. As a result frequent tightening of terminals is not required in Copper Cables unlike in Aluminum Cables.

### 2.2. Armour Material:

- All Multicore cables if armoured must be done so with special steel which must have sufficient zinc coating (galvanized) so that the steel doesn't corrode over decades. Any corrosion will increase the resistivity of steel and will obstructs fault current from flowing quickly into earth causing damage to equipment. Similarly, for ASCR core steel wire poor zinc coating will corrode the steel and there will be rupture of entire conductor over time.
- Ordinary steel must not be used for armouring purpose. Steel with low silicon and alloyed with copper is required for low resistivity steel.
- All single core cables must be armored with a non magnetic material. This is to avoid any inductive current in Armour which will result into heating and damage to cable.

### 2.3. Dielectric Material:

PVC and XLPE are mainly used as insulating material. Generally PVC is preferred for flexible cables and domestic wiring, while XLPE being a harder material is preferred for Industrial wiring. However, there are several types of PVC used in cables for different applications.
Example:-

- Super soft PVC is used in Sub/mersible cable to prevent PVC from cracking in cold water.
- FRLS PVC with Limit of Oxygen Index above 32% for fire retardant properties in domestic application.

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- High temperature resistant PVC is used in Auto cables which are used for wiring near engines.
- Abrasion resistant PVC for outer sheath of power cable.
- Soft PVC to provide sufficient flexibility in flexible cables.
- Specially formulated PVC can be used to prevent damages to cable by rodents & termites. This is specially important in food industry and areas where termite affect is high. Termites affects cable not for food but because their path is obstructed.

Similarly, there are different grades of XLPE to be used for different applications:-

- XLPE Sioplas is generally used for low voltage cables.
- XLPE made at Reactor level is used for LV ABC and High Voltage Cables.

Proper Selection of insulation material will ensure long life of cable with stable performance. Few other dielectric used are Rubber, Polyolefins, Mineral, Paper, TPE. Rubber compounds are specially formulated using Synthetic and Natural Rubber depending upon the application. Such cables are used for Tunneling work and high temperature application.

One type of polyolefin cable is ZHFR – Zero Halogen Fire Retardant cable and is used in closed spaces with poor ventilation in places like lifts, auditoriums.

Mica mineral is used in fire survival cable. Fire survival cables are type of cable which must be able to flow current over a considerable time (say ½ hrs) while the cable is engulfed in fire. Mica on burning provides a protective environment and doesn't let the conductor to melt due to heat thereby maintaining the current flow to operate fire survival devices. FRLS cable should not be used in lieu of fire survival cable.

It must be noted that XLPE for multicore power cables are not suitable if the cores are to be exposed to sunlight. Non-black XLPE has poor weatherbility and on exposure to UV rays from sunlight it will crack & XLPE insulation will fail leading to water ingression.

**3. Manufacturing of Cable:**

To ensure cables of good quality are made, the manufacturing technique followed should be proper. Some few important points are:-

- Relevant manufacturing standard should be followed. Any deviation and under gauging of conductor and thickness of insulation will result into a non-standard product and will create a miss-match in Electrical System which includes –motors, panels, and drives.
- Insulation should be free of any void, pinhole, and hairline cracks. These defects may result into current leakage, water ingression and may affect cable, equipment & human safety.
- XLPE needs to undergo curing process for which it must be kept in hot water for stipulated hours. Any compromise will result in un-cured material and will damage the XLPE when the cable is put in use.
- The armour coverage around the cores should be more than 95%. If it is less there will be risk of mechanical damage to cables. Also the armour wire or strip should sit tight on cable.
- Shaping of conductors is very important. Proper angle needs to be manufactured for a 3-phase power cable so that, the resultant inductive current is 0. This will prevent inductive current into armour and hence, saving on electrical billing and also safety.
- All single core cables must be armoured by non-magnetic material to prevent inductive current in the armour.
- All 3-phase & neutral cores should be bundled such that it doesn't become loose while stripping the outer PVC.

**4. Testing of Cables:**

To ensure a good quality cable is made testing of raw material, in-process testing of semi-finished material & final testing of cables are very important. Testing is to be done as per requirement of relevant standard of cables and standard testing methods are to be followed. Following are few testing that a manufacturer must do to ensure safe, reliable & long lasting cable is made.

# Tests Significant to Manufacturer and End Users.

| Standard | Name of test | Purpose/Significance |
|---|---|---|
| IS 10810: Part1 | Annealing test for wires | - To relieve the stress in wires developed during Drawing process. |
| IS 10810: Part2 | Tensile test for Aluminum wires | - Aluminum being soft material the wire strength must be checked to ensure wire doesn't break during manufacturing and installation. |
| IS 10810: Part3 | Wrapping test for Aluminum wires | - To ensure Aluminum doesn't break when bent and to relieve the stress in wires developed during Drawing process |
| IS 10810 Part5 | Conductor Resistance Test | - To check the conductor resistance of copper and aluminum so that system design parameters are met. |
| IS 10810 Part6 | Thickness of Insulation & Sheath | - The dielectric material must meet voltage stress and /or mechanical forces which the coverings are expected to withstand in services. |
| IS 10810 Part7 | Tensile strength elongation at break for insulation & sheath material | - To ensure insulation & sheath don't rupture during installation as the insulated sheath of electric cables are unavoidably subjected to mechanical stress and in particular bending. |
| IS 10810 Part10 | Loss of Mass Test | - To check & control the degradation of insulation and sheath when subjected to elevated temperature over life of cable when cables are put into service. |
| IS 10810 Part11 | Thermal ageing in air | - To check and control the degradation of physical properties of insulation & sheath material with temperature over service life of cable. |
| IS 10810 Part12 | Shrinkage test | - To ensure the shrinkage of insulation material doesn't cause any problem in termination when cable gets heated due to cable energization. |
| IS 10810 Part13 | Ozone Resistance Test | - To check the resistance of XPLE to crack when under ozone attack. |
| IS 10810 Part14 | Heat Shock test | - To ensure insulation & sheath don't crack when overheated due to overloading or due to heat as a result of short circuit. |
| IS 10810 Part15 | Hot Deformation Test | - To ensure Insulation & Sheath have enough resistance to softening when maintained at high temperature over a sufficient time. |
| IS 10810 Part18 | Color Fastness to Daylight test. | - To check the color fading of insulation and sheath of cables. |
| IS 10810 Part19 | Bleeding & Blooming Test | - To check if color pigment & oil used in insulation & sheath material get released from the surface. |

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| IS 10810 Part20 | Cold Bend test | - In cold temperature insulation cracks and performance is impacted to check if insulation can withstand extreme cold temperatures. |
| IS 10810 Part28 | Water absorption test. | - There is a possibility of water/moisture to get absorbed by insulating material and affects its insulating properties. |
| IS 10810 Part30 | Hot Set Test | - To check for the cross linking of XLPE compound. If the cross linking is not enough the mechanical & electrical properties of XLPE will be impacted. |
| IS 10810 Part31 | Oil Resistance Test | - To check for the decrease in mechanical property of insulation in contact with oils. |
| IS 10810 Part32 | Carbon Content test for XLPE | - ABC cable need to have enough carbon content to withstand UV radiation or else it will develop cracks. |
| IS 10810 Part37 | Tensile & Elongation test for Armour | - In order to prevent rupture of Armour during laying proper tensile & elongation of Armour is required. |
| IS 10810 Part38 | Torsion test of Armour | - During laying the armour wires are subjected to torsional forces and the armour wire or strip must be able to withstand these forces. |
| IS 10810 Part39 | Zinc adherence test on Armour | - Zinc must sufficiently adhere on the surface of steel else steel will corrode. |
| IS 10810 Part40 | Uniformity of Zinc coating on Armour | - Zinc must be uniformly coated over steel by galvanizing or else steel will corrode. |
| IS 10810 Part41 | Mass of Zinc Coating on Armour | - Enough Zinc must be coated on steel to give long life. |
| IS 10810 Part42 | Resistivity test of Armour material | - Low resistivity of Armour material is required to allow fault and circulating current to quickly pass into earth and protect the equipments. |
| IS 10810 Part 43 | Insulation Resistance | - The insulating material must be able to insulate the conductors from one another and from ground. |
| IS 10810 Part44 | Spark Test | - The test is to ensure there is no ingression of any conductive material in insulating material like wire during manufacturing. |
| IS 10810 Part45 | High Voltage test | - The test is to ensure insulation can withstand the voltage imposed on it during service. |
| IS 10810 Part48 | Dielectric Power Factor Test | - The power factor of the dielectric should be small in order to reduce the heating of dielectric material. |
| IS 10810 Part50 | Bending test | - To ensure cables don't rupture during bending operation during handling and installation. |
| IS 10810 Part53 | Flammability test | - To check flame retarding properties and cables self extinguishing property in case of removal of fire source. |

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| IS 10810 Part54 | Static Flexibility Test | - Cables in lifts are subject to frequent bending and this test is done to ensure cables can withstand such repeated forces. |
| IS 10810 Part55 | Abrasion Test | - Outer sheath of cables are subject to abrasion while laying and can tear apart if abrasion property is poor. |
| IS 10810 Part57 | Flexing Test | - To check flexibility property of flexible cables. |
| IS 10810 Part58 | Oxygen Index Test | - Flame needs oxygen to propagate. By increasing oxygen requirement of cable fire propagation can be limited. |
| IS 10810 Part59 | Halogen Gas Emission test | - Halogen gas is very corrosive and may bring fatality in poorly ventilated areas. Hence, it must be controlled. This test is important in FRLS-H cables. |
| IS 10810 Part60 | Thermal Stability of PVC | - PVC degrades over service life under the influence of temperature. Thermally stable PVC is important for good quality cable. |
| IS 10810 Part61 | Flame Retardant test | - A cable is considered flame retardant if it, when being tested, is ignited but extinguishes again when the external heat supply ceases and the spread of fire is not significant. |
| IS 10810 Part63 | Measurement of Smoke density of cables | - When cables are in fire, they burn and emit smoke. The smoke restricts human evacuation. Hence, low smoke releasing cable is required. |
| IS 10810 Part64 | Measurement of temperature index | - This test helps in assessment of the insulating material properties under heat and fire. |

## 5. Selection of Cable Size:

Firstly cable conductor material – copper/aluminum; insulation material – XLPE / PVC; Armoured or Unarmoured depending if installation is underground or overhead; voltage rating and standard of cables are decided and then the cable size is selected by considering:-

- Voltage drop
- De-rating factors
- Current carrying Capacity

### 5.1. Voltage Drop:

Voltage drops along the length of cable. The allowable permissible voltage drop is 2.5%. Any further voltage drop will not give enough voltage to the appliance and damage the appliance over it's usage life. If Voltage drop is more than 2.5% then higher cable size will be required.

### 5.2. De-rating Factor:

Current ratings for various cables are based on certain assumptions like- air temperature, ground temperature, thermal resistivity of soil, type of insulation, depth of laying, number of cables grouped, type of cable. However, actual conditions may vary and proper de-rating factor must be applied on current requirement and accordingly cable size must be selected.

When PVC and XLPE cables are both grouped together than the current rating of PVC should be applied to XLPE Cables.

### 5.3. Current Carrying Capacity:

For each cable current carrying capacity has been calculated as per relevant standards and tabulated for convenience separately for PVC/XLPE, Armour/Unarmour, Copper/Aluminum in our technical hand book.

### 6. Installation of Cables:

- IEE Wiring Regulation- BS 7671:1992 should be followed for electrical installation at Voltage 1000V AC.
- There is a limitation on bending of cable. Tight bending may rupture the insulating material and cause phase to phase short circuit and result in cable bursting. Cable can be bend maximum up to 12 X D, where D is cable OD.
- The Cable cores must be secured properly at terminals to withstand bursting force.
- The MCB or any other circuit breaker used should have current rating less than the maximum current capacity of cable to protect the cable.

### Our Plans:

We understand that the cables are very important and there should not be any compromise on cable quality. However due to commercial reasons many manufacturer tend to supply under size cable to save on raw material which risks cable, appliances and human lives not immediately but with time. Knowing that while under sizing most compromise is made on conductor material (copper/aluminum) which increases the conductor resistance value for the particular size than required by the standard. We have decided to set up a CR testing Kelvin double bridge in Kathmandu to test for house wiring cables, and a Micro Ohm meter to test for CR of cables in long length in drums for power cables. Though both the tests are very simple we have made arrangements of YouTube tutorials & step by step guide so that, even a lay man can get cables tested for CR values.
We would be happy to get feedbacks so that quality cables are regularly manufactured and supplied.

Regards
Stay Safe, Stay Happy

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