Cable Insulation Materials

The following materials are typically used for cable insulation:

Thermoplastic

Thermoplastic compounds are materials that go soft when heated and harden when cooled:

- PVC (Polyvinyl Chloride) – is the most commonly used thermoplastic insulator for cables. It is cheap, durable and widely available. However, the chlorine in PVC (a halogen) causes the production of thick, toxic, black smoke when burnt and can be a health hazard in areas where low smoke and toxicity are required (e.g. confined areas such as tunnels). Normal operating temperatures are typically between 75C and 105C (depending on PVC type). Temperature limit is 160C (<300mm2) and 140C (>300mm2).

- PE (Polyethylene) – is part of a class of polymers called polyolefins. Polyethylene has lower dielectric losses than PVC and is sensitive to moisture under voltage stress (i.e. for high voltages only).

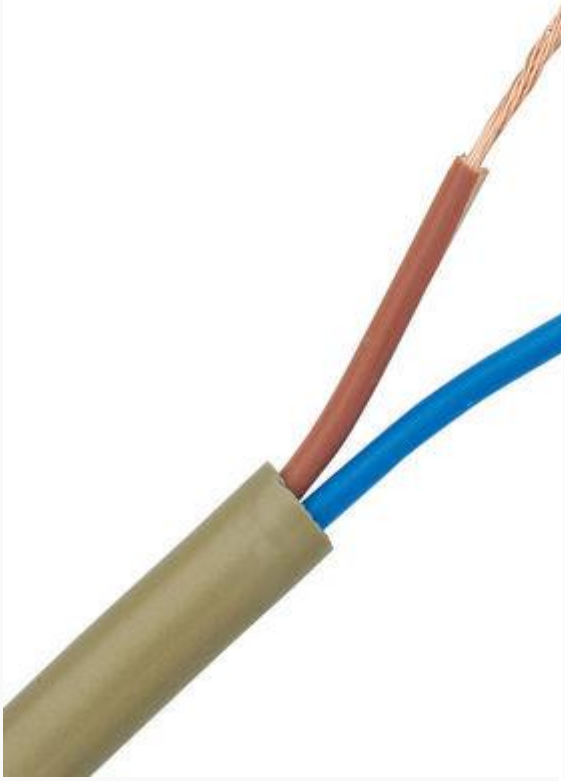

Figure 2. LV/MV cable for outdoor usage with PE sheath

Figure 1. Typical low voltage PVC cable

Thermosetting

Thermosetting compounds are polymer resins that are irreversibly cured (e.g. by heat in the vulcanization process) to form a plastic or rubber:

- XLPE (Cross-Linked Polyethylene) – has different polyethylene chains linked together ("cross-linking") which helps prevent the polymer from melting or separating at elevated temperatures. Therefore XLPE is useful for higher temperature applications. XLPE has higher dielectric losses than PE, but has better ageing characteristics and resistance to water treeing. Normal operating temperatures are typically between 90C and 110C. Temperature limit is 250C.

- EPR (Ethylene Propylene Rubber) – is a copolymer of ethylene and propylene, and commonly called an "elastomer". EPR is more flexible than PE and XLPE, but has higher dielectric losses than both. Normal operating temperatures are typically between 90C and 110C. Temperature limit is 250C.

Figure 3. 3-phase EPR insulated cable for MV

Figure 4. MV cable with XLPE insulation, 33 kV

Paper Based

Paper Based insulation is the oldest type of power cable insulation and is still used mainly for high voltage cables. The paper insulation must be impregnated

with a dielectric fluid (e.g. oil resin or a synthetic fluid). A lead sheath is commonly applied over the insulation to prevent water or moisture ingress into the paper insulation, which is sensitive to moisture.

Figure 5. Oil filled paper insulated cable, 66 kV

Comparison of Materials

A comparison of common insulating materials is as follows:

Material	Advantages	Disadvantages
PVC	▪ Cheap ▪ Durable ▪ Widely available	▪ Highest dielectric losses ▪ Melts at high temperatures ▪ Contains halogens ▪ Not suitable for MV / HV cables
PE	▪ Lowest dielectric losses ▪ High initial dielectric strength	▪ Highly sensitive to water treeing ▪ Material breaks down at high temperatures

XLPE	▪ Low dielectric losses ▪ Improved material properties at high temperatures ▪ Does not melt but thermal expansion occurs	▪ Medium sensitivity to water treeing (although some XLPE polymers are water-tree resistant)
EPR	▪ Increased flexibility ▪ Reduced thermal expansion (relative to XLPE) ▪ Low sensitivity to water treeing	▪ Medium-High dielectric losses ▪ Requires inorganic filler / additive
Paper / Oil	▪ Low-Medium dielectric losses ▪ Not harmed by DC testing ▪ Known history of reliability	▪ High weight ▪ High cost ▪ Requires hydraulic pressure / pumps for insulating fluid ▪ Difficult to repair ▪ Degrades with moisture

Source:

http://www.openelectrical.org/wiki/index.php?title=Cable_Insulation_Materials