Insulating materials

Insulating materials are one of the main components of cables and wires. In order to obtain improved usage properties, manufacturers use an ever broader assortment of insulating materials intended both for cable insulations and sheaths. We have presented below information concerning insulating materials, while thermal and electric properties, and chemical resistance have all been described in the pertinent tables.

PVC a group of plastic materials produced on the basis of plasticized polyvinyl chloride. They are characterised by improved resistance to fire (they do not convey flames), oils, ozone, UV radiation and the majority of dissolvents. The electric permeability of PVC is greater than that of PE polyethylene, which limits the applications of transmission cables insulated with PVC due to their relatively high capacitance (in the case of high frequencies, cables with a PE insulation should be used). PVCs may be freely modified, changing their mechanical, thermal, electric properties, and chemical resistance.

Polyethylene (PE) has good electric properties, and is characterised by a small dielectric constant, small lossiness, and high electric strength and resistivity. The hardness and elasticity of polyethylene depends on its density. Low density polyethylene (LDPE) is more elastic and soft, while polyethylene with a greater density (HDPE) is harder. Polyethylene insulation is light, and resistant to water and the majority of chemical compounds. Due to the small dielectric constant and low lossiness, polyethylene is used as insulation for data transmission cables and wherever low conductor capacitance is required. Polyethylene is not UVresistant, but the addition of antioxidants and pigments makes it resistant to solar radiation and weather conditions. Polyethylene is flammable and propagates flames, and during combustion it discharges flaming drops, but these drawbacks may be eliminated by using admixes that decrease flammability.

Foamed polyethylene is created by the introduction of gas bubbles into the structure of polyethylene (polyethylene foaming process). The dielectric constant of foamed polyethylene decreases in inverse proportion to the degree of foam formation. This material is excellent for the insulation of conductors of concentric cables intended for the transmission of high frequency signals. Due to its low mechanical resistance, during the production process a thin layer of polyethylene is extruded onto foamed polyethylene (foamed polyethylene with a skin)

Cross-linked polyethylene (XLPE) is created during the so-called process of cross-linking PE polyethylene, which consists in the formation of additional bonds between crosswise polyethylene chains; this type of polyethylene retains the electrical properties of thermoplastic polyethylene, however its mechanical properties are superior. A cross-linked polyethylene insulation is used primarily in power engineering cables, also due to the low lossiness and high electrical strength. The long-term temperature permitted for XLPE insulations is 90 °C (PVC 70 °C), while the temperature permitted during a short-circuit is as high as 250 °C (PVC 160 °C); in consequence, the long-term current-carrying capacity is approx. 20% than that of PVC**.**

Polypropylene (PP) has electric properties similar to those of polyethylene, but it is harder and more resistant to temperature. It is stiffer than polyethylene, and is used mainly for insulating cables with small dimensions.

Thermoplastic elastomers (TPE) are a group of plastic materials with exceptional properties. Although they can be extruded in the same way as the majority of thermoplastic materials, their usage properties are similar to those of rubber. Their fundamental feature is resistance to a wide range of temperatures.

Halogen-free plastic materials (HFFR) do not contain chemical elements from the halogen group and during combustion do not emit aggressive and poisonous gases and smoke. Their electric and mechanical properties are similar to those of PVCs.

Properties of insulating materials

Electric properties of insulating materials

	Electric strength kV/mm at a temperature of. 20°C	Dielectric constant at 50 Hz and 20 °C	Dielectric loss coefficient	Resistivity at 30 °C [Ω·cm]
PVC	25	3,5-6,5	0,1	10^{12}-10^{15}
Heat resistant PVC	25	3,5-6,5	0,1	10^{12}-10^{15}
Oil resistant PVC	25	3,5-6,5	0,1	10^{12}-10^{15}
Polyethylene	70-85	2,3	0,0001-0,0003	10^{17}
Cross-linked polyethylene	30	2,3	0,0005	10^{17}
Foamed polyethylene	50	depends on the degree of foam formation	0,00015	10^{17}
Polyurethane	20	4-8	0,03-0,08	10^{10}-10^{13}
Polypropylene	75	2,3	0,0008	10^{17}

Thermal properties of insulating and sheathing materials

	PVC	Heat resistant PVC	LDPE	HDPE
Operating temp. [°C]	-40 up to 80	-20 up to 105	-50 up to 70	-50 up to 100
Melting point [°C]	>140	>140	105-110	130
Oxygen index	23-42	23-42	≤ 22	≤ 22

	Foamed PE	XLPE	PUR	Silicone	Neoprene rubber
Operating temp. [°C]	-40 up to 70	-35 up to 90	-55 up to 80	-60 up to 180	-30 up to 90
Melting point [°C]	105		150		
Oxygen index	18-30	≤ 22	20-26	25-35	≤ 22

Properties of insulating materials

Chemical resistance of insulating and sheathing materials

Type of material	Concentration	Temp. to [°C]	PVC	Flame ratardant PVC	Oilproof PVC	PE	PUR	Silicone	Halogen-free material	Neoprene rubber
Ethyl alcohol	100	20	-	-	-	+	O	+	O	+
Methyl alcohol	100	20	O	O	O	+	O	+	O	O
Petrol		50	-	-	-	-	+	O	-	-
Ethylene glycol		50	O	O	+		+	O	O	
Concentrated hydrochloric acid	100	20	-	-	-	+	-	-	-	-
Hydrochloric acid	20	20	+	+	+		+	+	O	
Sulphuric acid	50	50	+	+	+		+	+	O	
Citric acid			+	+	+		O	+	+	+
Acetic acid	20	20	O	O	O		O	+	+	
Soda lye	50	50	+	+	+		+	+	O	
Butter		50	+	+	+		+	+	O	
Gear oil		100	+	+	+		+	+	O	
Machine oil		20	O	O	+		+	+	O	O
Diesel fuel			-	-	O		+	O	O	
Engine oil		120	+	+	+	-	+	+	-	
Vegetable oils			+	+	+	+	+	+	-	O
Olive oil		50	+	+	+	+	+	+	-	
Brake fluid			O	O	O		O	+	-	
Mercury	100	20	+	+	+	+	+	+	+	+
Sea water		20	+	+	+		+	O	O	+

+ resistant
O resistant under certain conditions
- not resistant

NOTE: The above table is made on the basis of knowledge and experience, but should only be considered as an aid in selection of appropriate wiring, since the final assessment, in many cases, is made after taking into account hazards occurring in the work environment.