PVC

Polyvinyl chloride (PVC) is durable, cheap, and easily worked. It can be made softer and more flexible by the addition of plasticizers. There are many formulations for the variety of different applications. The many varieties of PVC also differ in pliability and electrical properties.

PE

Polyethylene (PE) is a thermoplastic polymer consisting of long chains produced by combining the ingredient monomer ethylene. It has good electrical properties. In terms of flexibility, polyethylene can be rated stiff to very hard, depending on molecular weight and density—low density being the most flexible, with high-density, high-molecular weight formulation being very hard. Moisture resistance is rated excellent. Black and specially formulated colored versions have excellent weather resistance.

LDPE

Low Density Polyethylene has a high degree of short and long chain branching, which means that the chains do not pack into the crystal structure as well. It has, therefore, less strong intermolecular forces as the instantaneous-dipole induced-dipole attraction is less. This results in a lower tensile strength and increased ductility. LDPE is created by free radical polymerization. The high degree of branching with long chains gives molten LDPE unique and desirable flow properties.

HDPE

High Density Polyethylene has a low degree of branching and thus stronger intermolecular forces and tensile strength. The lack of branching is ensured by an appropriate choice of catalyst (for example, chromium catalysts or Ziegler-Natta catalysts) and reaction conditions. It is generally used as a sheathing material where it provides high resistance to water penetration, is very hard, has low coefficient of friction, and is abrasion resistant.

XLPE

By introducing chemical bonding between the chains in PE we get cross-linked polyethylene (XLPE), a thermoset type of PE. It improves the properties of the cables and makes it suitable for power transmission. XLPE has very good mechanical strength, low density. It can be used at high temperature above 110°C where the normal Polyethylene compounds are thermally unstable.

Polyamide (Nylon)

Nylon is a generic designation for a family of synthetic polymers known generically as polyamides. It has good durability, high elongation, excellent abrasion resistance and high resilient. It also resists insects, fungi, molds, midew, rot and many chemicals.

Polypropylene

Polypropylene (PP), also known as polypropene, is normally tough and flexible, especially when copolymerized with ethylene. It is similar as polyethylene in electrical properties. This material is primarily used as an insulation material. Typically, it is harder than polyethylene. This makes it suitable for thin wall insulations.

Polyurethane

Polyurethane (PUR and PU) combines the best properties of both rubber and plastic. This material is used primarily as a cable jacket material. It has excellent oxidation, oil, and ozone resistance. Some formations also have good flame resistance. It is a hard material with excellent abrasion resistance.

TPE

Thermoplastic Elastomer. TPE is cross linkable elastomers with styrenic rubbers which gives homogenous compound excellent hybrid properties with rubbery effect. TPE gives advantage to cost effective and achieves high performance applications and specification to thermoset rubbers. TPE is normally tough, cut resistant, flexible, smooth, with vibrant coloring.

LSZH

Low smoke zero halogen or low smoke free of halogen is composed of thermoplastic or thermoset compounds that emit limited smoke and no halogen when exposed to high sources of heat, e.g. flame. In a fire, a halogen-containing plastic material releases, e.g. hydrogen chloride, a poisonous gas that forms hydrochloric acid when it comes in contact with water. Designated Halogen-free cables, on the other hand, do not produce a dangerous gas/acid combination or toxic smoke when exposed to flame. Low smoke zero halogen cable reduces the amount of toxic and corrosive gas emitted during combustion. This type of material is typically used in poorly ventilated areas such as aircraft or rail cars. Low smoke zero halogen is becoming very popular and, in some cases, a requirement where the protection of people and equipment from toxic and corrosive gas is critical.
It is often lighter, so overall cable network system weights can be reduced. The environmental impact of halogen free cabling can be lower if there are fewer toxic chemicals.

HFFR (Low smoke , Flame retardant , Halogen-free and Thermoplastic compounds)

When PVC is not acceptable due to the problems chlorine (halogen) containing materials present in the event of a fire HFFR must be used. (In accordance with IEC 60092-359 type SHF1). The materials will not propagate a fire along a cable run, drip or give off black smoke. No acid gases will be released during a fire that can corrode and damage expensive equipment.

CPE

Chlorinated Polyethylene. An oil, ozone and heat resistant sheathing compound.

Rubber

Rubber normally includes natural rubber and SBR compounds.

Natural rubber is an elastomer (an elastic hydrocarbon polymer) that was originally derived from latex, a milky colloid produced by some plants. It is normally very stretchy and flexible and extremely waterproof. Rubber exhibits unique physical and chemical properties. Rubber's stress-strain behavior exhibits the Mullins effect, the Payne effect, and is often modeled as hyperelastic. Owing to the presence of a double bond in each repeat unit, natural rubber is sensitive to ozone cracking.

Styrene-butadiene rubber (SBR) is asynthetic rubber copolymer consisting of styrene and butadiene. It has good abrasion resistance and good aging stability when protected by additives. it offers good durability, less shrinkage and flexibility, as well as being resistant to emulsification in damp conditions.

Synthetic rubber

Synthetic rubber is any type of artificial elastomer, invariably a polymer. An elastomer is a material with the mechanical (or material) property that it can undergo much more elastic deformation under stress than most materials and still return to its previous size without permanent deformation. Synthetic rubber serves as a substitute for natural rubber in many cases, especially when improved material properties are required.

Silicon Rubber

Silicone rubber is an elastomer (rubber-like material) composed of silicone—itself a polymer—containingsilicon together with carbon, hydrogen, and oxygen. Silicone rubber offers good resistance to extreme temperatures, being able to operate normally from −55 °C to +300 °C. At the extreme temperatures, the tensile strength, elongation, tear strength and compression set can be far superior to conventional rubbers although still low relative to other materials. Organic rubber has a carbon to carbon backbone which can leave them susceptible to ozone, UV, heat and other ageing factors that silicone rubber can withstand well. This makes it one of the elastomers of choice in many extreme environments. Compared to organic rubbers, however, silicone rubber has a very low tensile strength.[1] For this reason, care is needed in designing products to withstand even low imposed loads. The material is also very sensitive to fatigue from cyclic loading. Silicone rubber is a highly inert material and does not react with most chemicals.

Nitrile Butadiene Rubber (NBR)

Nitrile butadiene rubber (NBR) is a family of unsaturated copolymers of 2-propenenitrile and various butadiene monomers (1,2-butadiene and 1,3-butadiene). Although its physical and chemical properties vary depending on the polymer's composition of nitrile, this form of synthetic rubber is generally resistant to oil, fuel, and other chemicals (the more nitrile within the polymer, the higher the resistance to oils but the lower the flexibility of the material).

NBR/PVC

NBR/PVC is admixture of NBR and PVC. It unite both advantages of those two materials. It has better ability to resist oil, chemicals, ozone and weather.

Polybutadiene

Polybutadiene is a highly resilient synthetic rubber. Heat buildup is lower in polybutadiene rubber based products subjected to repeat flexing during service. It is sensitive to oxidation and ozone owing to the reactivity of the double bond present in every repeat unit. Anti-oxidants are normally added to protect against cracking and deterioration.

EPR

Ethylene Propylene Rubber. A water and ozone resistant, flexile, cross linked high grade insulation material. However, relatively poor cold traction and cut growth resistance limits the use to blends with other types of rubber.

EVA (Flame retardant halogen-free termoset compound)

EVA, ethylene vinyl acetate, is a multi-functional elastomer, which resists the combined deteriorating influences of heat, oil and weather. (In accordance with IEC 60092-359 type SHF2).

For offshore applications, EVA can be compounded to produce high quality cable sheathing with low smoke and flame propagation, and with no emission of halogenous acids.

It is a polymer that approaches elastomeric materials in softness and flexibility, yet can be processed like other thermoplastics. The material has good clarity and gloss, barrier properties, low-temperature toughness, stress-crack resistance, hot-melt adhesive water proof properties, and resistance to UV radiation. EVA has little or no odor and is competitive with rubber and vinyl products in many electrical applications.

Neoprene (Polychloroprene)

Neoprene in general has good chemical stability, and maintains flexibility over a wide temperature range. It is both oil-resistant and sunlight-resistant, making it ideal for many outdoor applications. The most stable colors are Black, Dark Brown, and Gray. The electrical properties are not as good as other insulation materials.

CSPE (CSM)

Chlorosulphonated Polyethylene. Oil, ozone and heat resistant sheathing material.

EPDM

EPDM (ethylene-propylene-diene elastomer), is a hydrocarbon rubber that combines electrical performance suitable for fire resistant offshore cables with mechanical toughness and resistance to ozone, UV light and heat. It's wet electrical properties are unique. It is very flexile at high and low temperatures (-55°C to 150°C). It has good insulation resistance and dielectric strength, as well as excellent abrasion resistance. EPDM also has better cut-through resistance than Silicone rubber, which it replaces in some applications.

EPDM exhibits satisfactory compatibility with fireproof hydraulic fluids, ketones, hot and cold water, and alkalis, and unsatisfactory compatibility with most oils, gasoline, kerosene, aromatic and aliphatic hydrocarbons, halogenated solvents, and concentrated acids.

PVDF

Polyvinylidene fluoride, or polyvinylidene difluoride (PVDF) is a highly non-reactive and pure thermoplastic fluoropolymer. PVDF is a specialty plastic material in the fluoropolymer family; it is used generally in applications requiring the highest purity, strength, and resistance to solvents, acids, bases and heat and low smoke generation during a fire event. Compared to other fluoropolymers, it has an easier melt process because of its relatively low melting point of around 177 °C. It has a low density (1.78) and low cost compared to the other fluoropolymers.

Polytetrafluoroethylene

It is a synthetic fluoropolymer oftetrafluoroethylene. The most well known brand name of PTFE is Teflon. PTFE is a fluorocarbon solid, as it is a high-molecular-weight compound consisting wholly of carbon and fluorine. It is hydrophobic. PTFE has one of the lowest coefficients of friction against any solid.

PTFE has excellent dielectric properties. Combined with its high melting temperature, this makes it the material of choice as a high-performance substitute for the weaker and lower melting point polyethylene that is commonly used in low-cost applications. This material has excellent temperature range and chemical resistance. It is not suitable where subjected to nuclear radiation and does not have good high voltage characteristics.

PFA

Perfluoroalkoxy (PFA) is very similar in composition to the fluoropolymers PTFE and FEP (fluorinated ethylene-propylene). PFA and FEP both share PTFE’s useful properties of low coefficient of frictionand non-reactivity, but are more easily formable. PFA is similar to FEP in terms of its mechanical properties. These two are both superior to PTFE with regards to their flexibility. However, their ability to endure repetitive folding (flex life) is actually lower than PTFE. PFA has a higher flex life than FEP. PFA is preferable to FEP where heat is concerned, but PTFE itself is slightly more resistant to heat than both. PFA is more affected by water absorption and weathering than FEP, but is superior in terms of salt spray resistance.

FEP

In terms of corrosion resistance, Fluorinated ethylene propylene (FEP) is the only other readily available fluoropolymer that can match PTFE's own resistance to caustic agents, as it is a pure carbon-fluorine structure and fully. Thermally, FEP stands out from PTFE and PFA by having a melting point of 260 °C (500 °F), around forty degrees lower than PFA and lower again than PTFE. Electrically, PTFE, FEP and PFA have identical dielectric constants, but FEP's dielectric strength is only surpassed by PFA. However, whilst PFA has a similar dissipation factor to PTFE, FEP's dissipation is around six times that of PFA and EFTE (making it a more non-linear conductor of electrostatic fields).

TFE

TFE Teflon is extrudable in a hydraulic ram type process. Lengths are limited due to amount of material in the ram, thickness of the insulation, and preform size. TFE must be extruded over a silver- or nickelcoated wire. The nickel- and silver-coated designs are rated 260°C and 200°C maximum, respectively. The cost of Teflon is approximately 8 to 10 times more per pound than PVC compounds.

Characteristics of Thermoplastic Insulating and Sheath Materials

Designation			Electrical				
VDE initial-code	Abbre-viations	Materials	Density	Break down voltage	Specific volume resistivity	Dielectric-constant	Dielectric loss factor tan δ
			g/cm^3	KV/mm (20°C)	Ohm·cm 20°C	50 Hz/20°C	
Y	PVC	Polyvinylchloride compounds	1,35 – 1,5	25	10^{13}– 10^{15}	3,6 – 6	4×10^{-2} to 1×10^{-1}
Yw	PVC	Heat-resistant 90°C	1,3 – 1,5	25	10^{12}– 10^{15}	4 – 6,5	
Yw	PVC	Heat-resistant 105°C	1,3 – 1,5	25	10^{12}– 10^{15}	4,5 – 6,5	
Yk	PVC	Cold resistant	1,2 – 1,4	25	10^{12}– 10^{15}	4,5 – 6,5	
2Y	LDPE	Low density Polyethylene	0,92 – 0,94	70	10^{17}	2,3	2×10^{-4}
2Y	HDPE	High density Polyethylene	0,94 – 0,98	85	10^{17}	2,3	3×10^{-4}
2X	VPE	Cross-linked Polyethylene	0,92	50	10^{12}– 10^{16}	4 – 6	2×10^{-3}
O2Y		Foamed Polyethylene	0,65	30	10^{17}	1,55	5×10^{-4}
3Y	PS	Polystrole	1,05	30	10^{16}	2,5	1×10^{-4}
4Y	PA	Polyamide	1,02 – 1,1	30	10^{15}	4	2×10^{-2} to 1×10^{-3}
9Y	PP	Polypropylene	0,91	75	10^{16}	2,3 – 2,4	4×10^{-4}
11Y	PUR	Polyurethane	1,15 – 1,2	20	10^{10}– 10^{12}	4 – 7	$2{,}3 \times 10^{-2}$
	CPE	Chlorinated Polyethylene	1,16	20	10^{12}-10^{13}	5,5	$2{,}8 \times 10^{-2}$
12Y	TPE-E	Polyester Elastomer	1,2 – 1,4	40	$>10^{10}$	3,7 – 5,1	1.8×10^{-2}
91Y	TPE-O	Polyolefine Elastomer	0,89 – 1,0	30	$>10^{10}$	2,7– 3,6	

<table>
<tr><th colspan="3">Designation</th><th colspan="8">Thermic</th></tr>
<tr><th rowspan="2">VDE initial-code</th><th rowspan="2">Abbre-viations</th><th rowspan="2">Materials</th><th colspan="2">Working temp.</th><th>Melt-temp.</th><th>Oxygen index LOI</th><th>Heating value H_0</th><th>Thermal-conductivity</th><th rowspan="2">Corrosive gases in case of fire</th><th>Radiation resistance</th></tr>
<tr><th>Perma-nent (°C)</th><th>Short time(°C)</th><th>+°C</th><th>(% O_2)</th><th>$MJ \cdot kg^{-1}$</th><th>$W \cdot K^{-1} \cdot m^{-1}$</th><th>Mrad</th></tr>
<tr><td>Y</td><td>PVC</td><td>Polyvinylchloride compounds</td><td>-30 +70</td><td>+100</td><td>>140</td><td rowspan="2">23-42</td><td>17-25</td><td rowspan="4">0,17</td><td rowspan="4">Hydrogen chloride</td><td rowspan="4">80</td></tr>
<tr><td>Yw</td><td>PVC</td><td>Heat-resistant 90°C</td><td>-20 +90</td><td>+120</td><td>>140</td><td>16-22</td></tr>
<tr><td>Yw</td><td>PVC</td><td>Heat-resistant 105°C</td><td>-20 +105</td><td>+120</td><td>>140</td><td rowspan="2">24-42</td><td>16-20</td></tr>
<tr><td>Yk</td><td>PVC</td><td>Cold resistant</td><td>-40 +70</td><td>+100</td><td>>140</td><td>17-24</td></tr>
<tr><td>2Y</td><td>LDPE</td><td>Low density Polyethylene</td><td>-50 +70</td><td>+100</td><td>105-110</td><td rowspan="3">⩽22</td><td rowspan="4">42-44</td><td>0,3</td><td rowspan="4">No</td><td rowspan="4">100</td></tr>
<tr><td>2Y</td><td>HDPE</td><td>High density Polyethylene</td><td>-50 +100</td><td>+120</td><td>130</td><td>0,4</td></tr>
<tr><td>2X</td><td>VPE</td><td>Cross-linked Polyethylene</td><td>-35 +90</td><td>+100</td><td>—</td><td>0,3</td></tr>
<tr><td>O2Y</td><td></td><td>Foamed Polyethylene</td><td>-40 +70</td><td>+100</td><td>105</td><td>18-30</td><td>0,25</td></tr>
<tr><td>3Y</td><td>PS</td><td>Polystrole</td><td>-50 +80</td><td>+100</td><td>>120</td><td>≤22</td><td>40-43</td><td>0,25</td><td>No</td><td>80</td></tr>
<tr><td>4Y</td><td>PA</td><td>Polyamide</td><td>-60 +105</td><td>+125</td><td>210</td><td rowspan="2">⩽22</td><td>27-31</td><td>0,23</td><td rowspan="3">No</td><td rowspan="2">10</td></tr>
<tr><td>9Y</td><td>PP</td><td>Polypropylene</td><td>-10 +100</td><td>+140</td><td>160</td><td>42-44</td><td>0,19</td></tr>
<tr><td>11Y</td><td>PUR</td><td>Polyurethane</td><td>-55 +80</td><td>+100</td><td>150</td><td>20-26</td><td>20-26</td><td>0,25</td><td>100(500)</td></tr>
<tr><td></td><td>CPE</td><td>Chlorinated Polyethylene</td><td>-55 +60</td><td>+110</td><td>150-170</td><td>22-27</td><td>27,6</td><td>0,144</td><td>Hydrogen chloride</td><td>50</td></tr>
<tr><td>12Y</td><td>TPE-E</td><td>Polyester Elastomer</td><td rowspan="2">-50 +100</td><td>+140</td><td>190</td><td>≤29</td><td>20-25</td><td>0,5</td><td rowspan="2">No</td><td>10</td></tr>
<tr><td>91Y</td><td>TPE-O</td><td>Polyolefine Elastomer</td><td>+130</td><td>150</td><td>≤25</td><td>23-28</td><td>1,5</td><td>10</td></tr>
</table>

Designation			Mechanical				Halogen
VDE initial-code	Abbre-viations	Materials	Tensile strength N/mm²	Elongation at break %	Shore hardness	Water absorbtion %	Halogen-free
Y	PVC	Polyvinylchloride compounds	10-25	130-350	70-95(A)	0,4	No
Yw	PVC	Heat-resistant 90°C					
Yw	PVC	Heat-resistant 105°C					
Yk	PVC	Cold resistant					
2Y	LDPE	Low density Polyethylene	10-20	400-600	43-50(D)	0,1	Yes
2Y	HDPE	High density Polyethylene	20-30	500-1000	60-63(D)		
2X	VPE	Cross-linked Polyethylene	12,5-20	300-400	40-45(D)		
O2Y		Foamed Polyethylene	8-12	350-450	—	—	Conditional*
3Y	PS	Polystrole	55-65	300-400	35-50(D)	0,4	Yes
4Y	PA	Polyamide	50-60	50-170	—	1,0-1,5	
9Y	PP	Polypropylene	20-35	300	55-60(D)	0,1	
11Y	PUR	Polyurethane	30-45	500-700	70-100(A)	1,5	Yes**
	CPE	Chlorinated Polyethylene	12,5	700	70(A)	0.01	No
12Y	TPE-E	Polyester Elastomer	30	>300	85(A) 70(D)	1,5	Yes
91Y	TPE-O	Polyolefine Elastomer	20		55(A) 70(D)		

*The propellent may be e.g. Fluor-Chlor-Hydrocarbon

**depend on the type compound

Designation			Properties							
VDE initial-code	Abbre-viations	Materials	Oxidation resistance	Heat resistance	Oil resistance	Low-temperature flexibility	Weather, sun resistance	Ozone resistance	Abrasion resistance	Flame resistance
Y	PVC	Polyvinylchloride compounds	E	G-E	F	P-G	G-E	E	F-G	E
Yw	PVC	Heat-resistant 90°C								
Yw	PVC	Heat-resistant 105°C								
Yk	PVC	Cold resistant								
2Y	LDPE	Low density Polyethylene	E	G	G-E	E	E	E	G	P
2Y	HDPE	High density Polyethylene	E	E	G-E	E	E	E	E	P
2X	VPE	Cross-linked Polyethylene	E	G	G	O	G	E	F-G	F-G
O2Y		Foamed Polyethylene	E	G	G	E	E	E	F	P
3Y	PS	Polystrole	E	E	G	E	F-G	F	G	P
4Y	PA	Polyamide	E	E	E	G	E	E	E	P
9Y	PP	Polypropylene	E	E	F	P	E	E	F-G	P
11Y	PUR	Polyurethane	E	G	E	G	G	E	O	P
	CPE	Chlorinated Polyethylene	E	E	E	E	E	E	E-O	E
12Y	TPE-E	Polyester Elastomer	E	E	E	E	E	E	E	F
91Y	TPE-O	Polyolefine Elastomer	E	E	F	E	E	E	F	F-G

P = Poor; F= Fair; G = Good; E = Excellent; O = Outstanding

Designation			Properties						
VDE initial-code	Abbre-viations	Materials	Water resistance	Acid resistance	Alkali resistance	Aliphatic hydrocarbons resistance (Gasoline, kerosene, etc)	Aromatic hydrocarbons resistance (Benzol, toluol, etc.)	Halogenated hydrocarbons resistance (Degreaser solvents)	Alcohol resistance
Y	PVC	Polyvinylchloride compounds	F-G	G-E	G-E	P	P-F	P-F	P-F
Yw	PVC	Heat-resistant 90°C							
Yw	PVC	Heat-resistant 105°C							
Yk	PVC	Cold resistant							
2Y	LDPE	Low density Polyethylene	E	G-E	G-E	G-E	P	G	E
2Y	HDPE	High density Polyethylene	E	E	E	G-E	P	G	E
2X	VPE	Cross-linked Polyethylene	G-E	G-E	G-E	F	F	F	E
O2Y		Foamed Polyethylene	E	G-E	G-E	G	P	G	E
3Y	PS	Polystrole	G	G-E	E	P	P	P	E
4Y	PA	Polyamide	P-F	P-F	E	G	G	G	P
9Y	PP	Polypropylene	E	E	E	P-F	P-F	P	E
11Y	PUR	Polyurethane	P-G	F	F	P-G	P-G	P-G	P-G
	CPE	Chlorinated Polyethylene	E	E	E	G-E	E	E	E-O
12Y	TPE-E	Polyester Elastomer	E	F	F	G-E	E	E	E-O
91Y	TPE-O	Polyolefine Elastomer	E	G	G	G-E	E	E	E-O

P = Poor; F= Fair; G = Good; E = Excellent; O = Outstanding

Characteristics of Elastomer Insulating and Sheath Materials

Designation			Electrical				
VDE initial-code	Abbre-viations	Materials	Density	Break down voltage	Specific volume resistivity	Dielectric-constant	Dielectric loss factor tan δ
			g/cm^3	KV/mm (20°C)	Ohm·cm 20°C	50 Hz/20°C	
G	NR SBR	Natural rubber Styrene-butadiene rubber	1,5-1,7	20	10^{12}–10^{15}	3-5	$1{,}9 \times 10^{-2}$
2G	SiR	Silicon rubber	1,2-1,3	20	10^{15}	3-4	6×10^{-3}
3G	EPR	Ethylene Propylene Rubber compounds	1,3-1,55	20	10^{14}	3-3,8	$3{,}4 \times 10^{-3}$
4G	EVA	Ethylene vinyl acetate compounds	1,3-1,5	30	10^{12}	5-6,5	2×10^{-2}
5G	CR	Polychloroprene compounds	1,4-1,65	20	10^{10}	6-8,5	5×10^{-2}
6G	CSM	Chlorosulphonated polyethylene compounds	1,3-1,6	25	10^{12}	6-9	$2{,}8 \times 10^{-2}$
	EPDM	Ethylene-propylene-diene elastomer	0,86-2,0	35	10^{21}	2,2-3,0	$0{,}5 \times 10^{-3}$-1×10^{-2}
	NBR	Nitrile butadiene rubber	1,0-1,49	20	10^{14}-10^{15}	6-8,5	5×10^{-2}-$5{,}5 \times 10^{-2}$
	NBR/PVC	Nitrile butadiene rubber/ Polyvinylchloride	0,144-0,24	20	10^{10}	6-8,5	5×10^{-2}
	BR	Polybutadiene	0,9-1,0	20	10^{10}	3-4	5×10^{-2}

<table>
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<tr><th>Permanent (°C)</th><th>Short time(°C)</th><th>+°C</th><th>(% O_2)</th><th>$MJ \cdot kg^{-1}$</th><th>$W \cdot K^{-1} \cdot m^{-1}$</th><th></th><th>Mrad</th></tr>
<tr><td>G</td><td>NR
SBR</td><td>Natural rubber
Styrene-butadiene rubber</td><td>– 65
+ 60</td><td>+120</td><td>—</td><td>%22</td><td>21–25</td><td>—</td><td rowspan="4">No</td><td>100</td></tr>
<tr><td>2G</td><td>SiR</td><td>Silicon rubber</td><td>– 60
+180</td><td>+260</td><td>—</td><td>25–35</td><td>17–19</td><td>0,22</td><td>50</td></tr>
<tr><td>3G</td><td>EPR</td><td>Ethylene Propylene Rubber compounds</td><td>– 30
+ 90</td><td>+160</td><td>—</td><td rowspan="2">%22</td><td>21–25</td><td>—</td><td>200</td></tr>
<tr><td>4G</td><td>EVA</td><td>Ethylene vinyl acetate compounds</td><td>– 30
+125</td><td>+200</td><td>—</td><td>19–23</td><td>—</td><td>100</td></tr>
<tr><td>5G</td><td>CR</td><td>Polychloro-prene compounds</td><td>– 40
+100</td><td>+140</td><td>—</td><td rowspan="2">30–35</td><td>14–19</td><td>—</td><td rowspan="2">Hydrogen chloride</td><td rowspan="2">50</td></tr>
<tr><td>6G</td><td>CSM</td><td>Chlorosul-phonated polyethylene compounds</td><td>– 30
+ 80</td><td>+140</td><td>+160</td><td>19–23</td><td>—</td></tr>
<tr><td></td><td>EPDM</td><td>Ethylene-propylene-diene elastomer</td><td>– 30
+110</td><td>+120</td><td>+160</td><td>30–35</td><td>14–19</td><td>0,26</td><td>No</td><td>50</td></tr>
<tr><td></td><td>NBR</td><td>Nitrile butadiene rubber</td><td>– 40
+110</td><td>+140</td><td>+160</td><td>30–35</td><td>14–19</td><td>0,25</td><td>No</td><td>50</td></tr>
<tr><td></td><td>NBR/
PVC</td><td>Nitrile butadiene rubber/ Polyvinylchloride</td><td>– 40
+105</td><td>+140</td><td>+160</td><td>28</td><td>14–19</td><td>0,25</td><td>Hydrogen chloride</td><td>50</td></tr>
<tr><td></td><td>BR</td><td>Polybutadiene</td><td>–70
+70</td><td>+140</td><td>+160</td><td>30–35</td><td>14–19</td><td>0,25</td><td>No</td><td>50</td></tr>
</table>

<table>
<tr><th colspan="3">Designation</th><th colspan="4">Mechanical</th><th>Halogen</th></tr>
<tr><th rowspan="2">VDE initial-code</th><th rowspan="2">Abbre-viations</th><th rowspan="2">Materials</th><th>Tensile strength</th><th>Elongation at break</th><th rowspan="2">Shore hardness</th><th>Water absorbtion</th><th>Halogen-free</th></tr>
<tr><th>N/mm²</th><th>%</th><th>%</th><th></th></tr>
<tr><td>G</td><td>NR
SBR</td><td>Natural rubber
Styrene-butadiene rubber</td><td rowspan="3">5–10</td><td rowspan="2">300–600</td><td>60–70 (A)</td><td rowspan="5">1,0</td><td>No</td></tr>
<tr><td>2G</td><td>SiR</td><td>Silicon rubber</td><td>40–80 (A)</td><td rowspan="2">Yes</td></tr>
<tr><td>3G</td><td>EPR</td><td>Ethylene Propylene Rubber compounds</td><td>200–400</td><td>65–85 (A)</td></tr>
<tr><td>4G</td><td>EVA</td><td>Ethylene vinyl acetate compounds</td><td>8–12</td><td>250–350</td><td>70–80 (A)</td><td>No</td></tr>
<tr><td>5G</td><td>CR</td><td>Polychloroprene compounds</td><td rowspan="2">10–20</td><td>400–700</td><td>55–70 (A)</td><td rowspan="2">No</td></tr>
<tr><td>6G</td><td>CSM</td><td>Chlorosulphonated polyethylene compounds</td><td>350–600</td><td>60–70 (A)</td><td>1,5</td></tr>
<tr><td></td><td>EPDM</td><td>Ethylene-propylene-diene elastomer</td><td>10-25</td><td>250-500</td><td>40–90 (A)</td><td>0.2</td><td>Yes</td></tr>
<tr><td></td><td>NBR</td><td>Nitrile butadiene rubber</td><td>10-25</td><td>350-650</td><td>40–90 (A)</td><td>1</td><td>Yes</td></tr>
<tr><td></td><td>NBR/PVC</td><td>Nitrile butadiene rubber/ Polyvinylchloride</td><td>10-20</td><td>400-700</td><td>80-90 (A)</td><td>1</td><td>No</td></tr>
<tr><td></td><td>BR</td><td>Polybutadiene</td><td>10-15</td><td>200-400</td><td>48–80 (A)</td><td>1</td><td>Yes</td></tr>
</table>

P = Poor; F= Fair; G = Good; E = Excellent; O = Outstanding

Designation			Properties							
VDE initial-code	Abbre-viations	Materials	Oxidation resistance	Heat resistance	Oil resistance	Low-tempe-rature flexibility	Weather, sun resistance	Ozone resistance	Abrasion resistance	Flame resistance
G	NR SBR	Natural rubber	F	F	P	G	F	P	E	P
		Styrene-butadiene rubber	G	F	P	E	F	P	E	P
2G	SiR	Silicon rubber	E	G	F-G	O	O	O	F	F-G
3G	EPR	Ethylene Propylene Rubber compounds	G	E	F	G-E	E	E	G	P
4G	EVA	Ethylene vinyl acetate compounds	G	G	G	F-G	G-E	G	G-E	P
5G	CR	Polychloro-prene compounds	G	G	G	F-G	G	G	G-E	G
6G	CSM	Chlorosul-phonated polyethylene compounds	E	E	G	F	E	E	G	G
	EPDM	Ethylene-propylene-diene elastomer	E	E	P	G-E	E	E	G	P
	NBR	Nitrile butadiene rubber	F	G	G-E	F	F-G	P	G-E	P
	NBR/ PVC	Nitrile butadiene rubber/ Polyvinylchloride	E	G	G	F	G	G	E	G
	BR	Polybutadiene	G	F	P	E	F	P	E	P

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Designation			Properties						
VDE initial-code	Abbre-viations	Materials	Water resistance	Acid resistance	Alkali resistance	Aliphatic hydrocarbons resistance (Gasoline, kerosene, etc)	Aromatic hydrocarbons resistance (Benzol, toluol, etc.)	Halogenated hydrocarbons resistance (Degreaser solvents)	Alcohol resistance
G	NR	Natural rubber	G-E	F-G	F-G	P	P	P	G
	SBR	Styrene-butadiene rubber	E	F-G	F-G	P	P	P	G
2G	SiR	Silicon rubber	G-E	F-G	F-G	P-F	P	P-G	G
3G	EPR	Ethylene Propylene Rubber compounds	G-E	G-E	G-E	P	F	P	P
4G	EVA	Ethylene vinyl acetate compounds	G	G	G	G	P-F	P	F
5G	CR	Polychloro-prene compounds	G	G	G	G	P-F	P	F
6G	CSM	Chlorosul-phonated polyethylene compounds	G-E	E	E	F	F	P-F	G
	EPDM	Ethylene-propylene-diene elastomer	G-E	G-E	G-E	P	F	P	P
	NBR	Nitrile butadiene rubber	G-E	G	F-G	E	G	P	E
	NBR/ PVC	Nitrile butadiene rubber/ Polyvinylchloride	E	G	G	G-E	G	G	G
	BR	Polybutadiene	E	F-G	F-G	P	P	P	F-G

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Characteristics of High Temp. Insulating and Sheath Materials

Designation			Electrical				
VDE initial-code	Abbre-viations	Materials	Density	Break down voltage	Specific volume resistivity	Dielectric-constant	Dielectric loss factor tan δ
			g/cm^3	KV/mm (20°C)	Ohm·cm 20°C	50 Hz/20°C	
10Y	PVDF	Polyvinylidene fluoride	1,7–1,9	25	10^{14}	9–7	$1,4 \times 10^{-2}$
7Y	ETFE	Ethylene-Tetrafluorethylene	1,6–1,8	36	10^{16}	2,6	8×10^{-4}
6Y	FEP	Fluorinated ethylene propylene	2,0–2,3	25	10^{18}	2,1	3×10^{-4}
5YX	PFA	Perfluoroalkoxypolymeric	2,0–2,3	25	10^{18}	2,1	3×10^{-4}
5Y	PTFE	Polytetrafluorethylene	2,0–2,3	20	10^{18}	2,1	3×10^{-4}
	E-CTFE	Ethylene-Chlorotrifluoroethylene	1,67–1,69	39	10^{15}	2,5	9×10^{-3}

Designation			Thermic							
VDE initial-code	Abbre-viations	Materials	Working temp.		Melt-temp.	Oxygen index LOI	Heating value H_0	Thermal-conductivity	Corrosive gases in case of fire	Radiation resistance
			Perma-nent (°C)	Short time(°C)	+°C	(% O_2)	$MJ \cdot kg^{-1}$	$W \cdot K^{-1} \cdot m^{-1}$		Mrad
10Y	PVDF	Polyvinylidene fluoride	– 40 +135	+160	>170	40–45	15	0,17	Hydrofluoric	10
7Y	ETFE	Ethylene-Tetrafluore-thylene	–100 +150	+180	>265	30–35	14	0,24	Yes	10
6Y	FEP	Fluorinated ethylene propylene	–100 +205	+230	>225	>95	5	0,26	Yes	1
5YX	PFA	Perfluoroalkoxy-polymeric	–190 +260	+280	>290	>95	5	0,21	Yes	0,1
5Y	PTFE	Polytetra-fluorethylene	–190 +260	+300	>325	>95	5	0,26	Yes	0,1
	E-CTFE	Ethylene-Chlorotri-fluoroethylene	–100 +140	+170	>242	>60	14	0,14	Yes	0,01

Designation			Mechanical				Halogen
VDE initial-code	Abbre-viations	Materials	Tensile strength	Elongation at break	Shore hardness	Water absorbtion	Halogen-free
			N/mm^2	%		%	
10Y	PVDF	Polyvinylidene fluoride	50–80	150	75–80 (D)	0,01	No
7Y	ETFE	Ethylene-Tetrafluorethylene	40–50	150	70–75 (D)	0,02	
6Y	FEP	Fluorinated ethylene propylene	15–25	250	55–60 (D)	0,01	
5YX	PFA	Perfluoroalkoxy-polymeric	25–30	250	55–60 (D)	0,01	
5Y	PTFE	Polytetra-fluorethylene	80	50	55–60 (D)	0,01	
	E-CTFE	Ethylene-Chlorotri-fluoroethylene	48	200-300	75 (D)	0,1	

Designation			Properties							
VDE initial-code	Abbre-viations	Materials	Oxidation resistance	Heat resis-tance	Oil resis-tance	Low-tempe-rature flexibility	Weather, sun resistance	Ozone resis-tance	Abrasion resistance	Flame resis-tance
10Y	PVDF	Polyviny-lidene fluoride	O	O	E	F	E-O	E	E	E
7Y	ETFE	Ethylene-Tetrafluore-thylene	E	E	E	E	E	E	E	G
6Y	FEP	Fluorinated ethylene propylene	O	O	O	O	O	E	E	O
5YX	PFA	Per-fluoroalkoxy-polymeric	E	E	E	E	E	E	G	E
5Y	PTFE	Polytetra-fluorethylene	O	O	E-O	O	O	O	O	E
	E-CTFE	Ethylene-Chlorotri-fluoroethylene	O	O	O	O	O	E	E	E-O

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Designation			Properties						
VDE initial-code	Abbre-viations	Materials	Water resis-tance	Acid resis-tance	Alkali resis-tance	Aliphatic hydrocarbons resistance (Gasoline, kerosene, etc)	Aromatic hydrocarbons resistance (Benzol, toluol, etc.)	Halogenated hydrocarbons resistance (Degreaser solvents)	Alcohol resis-tance
10Y	PVDF	Polyviny-lidene fluoride	E	G-E	E	E	G-E	G	E
7Y	ETFE	Ethylene-Tetrafluore-thylene	E	E	E	E	E	E	E
6Y	FEP	Fluorinated ethylene propylene	E	E	E	E	E	E	E
5YX	PFA	Per-fluoroalkoxy-polymeric	E	E	E	E	E	E	E
5Y	PTFE	Polytetra-fluorethylene	E	E	E	E	E	E	E
	E-CTFE	Ethylene-Chlorotri-fluoroethylene	E	E	E	E	E	E	E

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