Applies only to the base materials. Deviations are possible depending on the use/design. Please refer to the relevant page in the catalogue.

Usage criteria / Parameter	Material resistant to org. oils	Polyvinylchloride	Polyethylene	Polyurethane	Polytetrafluoroethylene	Tetrafluoroethylene Hexafluoropropylene copolymer
Abbreviations	Special TPE	PVC	PE	PUR	PTFE	FEP
Code as per VDE	–	Y	2Y	11Y	5Y	6Y
Operating temperature	-50 +120	-30 +70	-50 +70	-50 +90	-190 +260	-100 +200
Dielectric constant	2.4	4.0	2.3	4.0 – 6.0	2.1	2.1
Volume resistivity (Ω x cm)	1015	1012 – 1015	1017	1012	1018	1018
Tensile strength in N/mm² (MPa)	5 – 20	10 – 25	15 – 30	15 – 45	15 – 40	20 – 25
Elongation at break in %	400 – 600	150 – 400	400 – 800	300 – 600	240 – 400	250 – 350
Water absorption (20 °C) in %	1 – 2	0.4	0.1	1.5	0.01	0.01
Weather resistance	very good	good	good	very good	very good	very good
Fuel resistance	good	moderate	moderate	good	very good	very good
Oil resistance	Resistance to org. oil: very good	moderate	moderate	good	very good	very good
Flammability	flammable	self-ext-inguishing	flammable	self-ext-inguishing*	non-flammable	non-flammable

Usage criteria / Parameter	Ethylene tetrafluoroethylene	Chloroprene rubber	Silicone rubber	Ethylene propylene dien rubber	Thermoplastic elastomer polyolefin based	Thermoplastic elastomer polyester based
Abbreviations	ETFE	CR	SI	EPDM	TPE-O	TPE-E
Code as per VDE	7Y	5G	2G	3G	–	12Y
Operating temperature	-100 +150	-40 +100	-60 +180	-30 +120	-40 +120	-70 +125
Dielectric constant	2.6	6.0 – 8.0	2.8 – 3.2	3.2	2.7 – 3.6	3.7 – 5.1
Volume resistivity (Ω x cm)	10^{16}	10^{13}	10^{15}	10^{14}	5×10^{14}	10^{12}
Tensile strength in N/mm² (MPa)	40 – 50	10 – 25	5 – 10	5 – 25	≥ 6	3 – 25
Elongation at break in %	100 – 300	300 – 450	200 – 350	200 – 450	≥ 400	280 – 650
Water absorption (20 °C) in %	0.01	1	1.0	0.02	1.5	0.3 – 0.6
Weather resistance	very good	very good	very good	good	moderate	very good
Fuel resistance	very good	moderate	low	moderate	moderate	good
Oil resistance	very good	good	moderate	moderate	moderate	very good
Flammability	non-flammable	self-ext-inguishing	hardly flammable	flammable	flammable	flammable

* only with additional flame retardant

Insulation resistance

The insulation of cables and wires is used to electrically isolate the individual conductors. For this reason, as opposed to the conductor, the insulation should have very high electrical resistance (which can also be expressed as a low conductivity).

To achieve this goal, a number of different materials can be used. The mechanical and electrical properties of these materials can differ. The most commonly used materials include mixtures based on PVC, PE or TPE.

Terminology

A number of different terms are used to describe the insulation resistance. To help differentiate and better understand these terms, they are explained here in brief.

Volume resistance

Resistance value that results from the measurement of a test specimen when a DC voltage is applied. It results from the test voltage applied to the two electrodes, which are attached to the surfaces of the test specimen (e. g. wire insulation), and the current between these electrodes.

Volume resistivity (specific contact resistance)

This is a relative value that depends on the properties of the material in terms of electrical insulation. In practice, this value relates to a unit of volume; it is typically specified in Ω x cm. For PVC core insulation a typical value is: > 20 GΩ x cm

Insulation resistance

The insulation resistance for a cable can be determined from the volume resistivity and the ratio of the core outer diameter to conductor diameter. Typical units of measurement here are MΩ x km or GΩ x km.

In type standards for cables and wires, minimum values for the insulation resistance are usually required. These values are specified for the maximum operating temperature as a function of the nominal cross section and insulation wall thickness.

Example: For an oil-resistant H05VV5-F control cable, these values are defined in EN 50525-2-51. The minimum value of the insulation resistance of a 3 x 1.5 mm^2 cable must be at least 0.010 MΩ x km.

The real-world values are often more than an order of magnitude higher than these values, well above the requirements of the standard.

Measurement methods

A differentiation must be made between lab measurements performed on a core to test the insulation and real-world measurements performed on complete, potentially installed cables and wires.

Determination of insulation resistance and volume resistivity of the core

Demonstration of compliance with the aforementioned requirements is achieved with measurements according to EN 50395 (VDE 0481-395). For this purpose, a 5-metre sample of the cable is completely stripped and the cores are placed in a water bath for 2 hours. The water bath was previously heated to the maximum operating temperature of the cable (valid for cables with a maximum conductor temperature of up to 90 °C).

Between the conductor and the water bath, 80 - 500 V DC is applied and after 1 minute the insulation resistance is measured at each core. With this value, the insulation resistance of a 1-km length is calculated for each core. Neither of the calculated values may be below the specified minimum value in the type standard. Refer to the above example under “Insulation resistance”.

The volume resistivity can be used for comparisons as it is a material constant and is independent of the insulation wall thickness and the conductor cross-section.

In practical applications these values are used to compare different materials and represent a reproducible measuring method for the manufacturers of cables and wires.

Measurements on complete cables

The above values cannot be compared with resistance values that are determined using a “dry measurement” on the complete cable or on installed cables. In those cases, the resistance value is determined using the leakage current between two adjacent cores within a cable and the measurement voltage of the meter.

Values determined using this method have a very high variance as they are influenced by numerous factors, such as:

- Conditioning of the cable, in particular moisture absorption by the insulation
- Climate conditions during the measurements, in particular the cable temperature
- Individual contact conditions of the insulation of both cores
- Conductivity of the materials that have a common surface contact to the insulated cores
- Installation situation of the cable, as locations in which the cable is subject to external pressure, for example due to bending or clamping (cable glands), can lead to a deformation of the insulation. This increases the contact area between the insulated cores, which increases the leakage current and results in a lower insulation resistance value.

The aforementioned effects of temperature and air humidity are significant and vary greatly in practical applications, as the conditions are not standardised. For example, measurements have shown that between 20 °C (common ambient temperature) and 70 °C (maximum cable operating temperature) the insulation resistance can change by a factor of 1:100 to 1:1000. This means that the temperature during the measurement has such a great effect that measured results that were performed at different temperatures are no longer comparable.

Conclusion

The cable data provided above can be used to compare different cable types but under no circumstances can they be used to compare with measurements of finished cables or electrical systems (such as according to VDE 0100-600 Part 6).