

Technical Information



281

TECHNICAL INFORMATION

Materials » Chemical resistance » Information about fluoroplastics, stirrer shafts and tubing » Determination of threads

BOLA Materials

General information

Fluoroplastics belong to the family of thermoplastics. Due to their high molecular weight, polytetrafluorethylene as well as modified PTFE (PTFE-TFM) cannot be processed with the classic thermoplast methods like injection moulding or extrusion. Both materials are transferred from powder form to semi-finished products by using special press-sintering techniques or the so called paste extrusion. All other fluoropolymers like PFA, FEP, ETFE, ECTFE, PVDF, THV or PVF are processed using the known production methods for thermoplastics.

The fully fluorinated materials PFA and FEP in particular require a corrosion resistant construction of the processing machines. With increasing the content of fluorine, the fluoropolymers offer a better chemical and higher thermal load.

Especially PTFE, PTFE-TFM, PFA and FEP have the following unique properties:

- » almost universal chemical resistance
- » high thermal load capacity (-200 °C up to +250 °C)
- » non-flammable
- » resistant to environmental changes (weather, light)
- » non-adhesive
- » ultra low friction coefficient
- » unbreakable
- » physiologically safe
- » inert, tasteless, odourless
- » UV-resistant
- » not ageing, the properties do not change even during long-term storage
- » without any aggregates like plasticizers or antioxidants
- » unlimited sterilization with steam or ethylene oxide possible. A sterilization using high-energy radiation is not recommended.

All other fluorinated thermoplastics include beside the fully fluorinated monomer block tetrafluorethylene additional, non-fluorinated components. This allows to adapt systematically the properties and thus to facilitate the processing and to enlarge the range of applications.

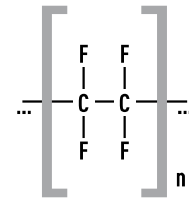
The chart below gives some general advice on the choice of the best suitable fluoropolymers:

Properties	PTFE	TFM	PFA	FEP	ETFE	THV	PCTFE	ECTFE	PVDF	PVF
Continuous operating temperature [°C]	250	250	250	205	150	110	140	125	120	110
Tear strength [MPa]	30	30	28	25	40	22	31	42	45	30
Permeation (Helium)	-	o	o	o	+	+	+++	++	+++	+++
Sterilisable with Y-radiation	-	-	-	-	o	++	o	+	+	+
Chemical resistance	+++	+++	+++	+++	+	o	++	++	o	o

Definition: - not suitable, not recommended
o possible, moderate to good
+ good
+++ very good, best choice

PTFE – Polytetrafluorethylene

Discovered in 1938 by research-chemists of the DuPont (USA) it was not introduced to the market until 1946. A partly crystalline fluoroplastic that belongs to the family of thermoplastics (but not suitable for injection moulding). The strong bond of the fluorine atom to the carbon atom as well as the almost complete shielding of the unbranched carbon chain by fluorine atoms result in a remarkably high chemical and thermal load. PTFE has a thermal resistance ranging from -260 °C up to +250 °C, at short term up to +300 °C (e. g. no brittleness in boiling helium at -269 °C). This temperature range is not reached by any other plastic material. The continuous operating temperature depends on the load. This means that PTFE can be used from -200 °C to +250 °C at moderate mechanical load. PTFE labware has a white appearance and a non-adhesive surface which is easy to clean. Furthermore, this material has excellent slip characteristics. A lubrication of turning steel or glass shafts is not necessary. Semi-finished PTFE rods are fabricated by isostatic pressing processes or extrusion. The final products are produced by machining the semi-finished materials.



Trade names

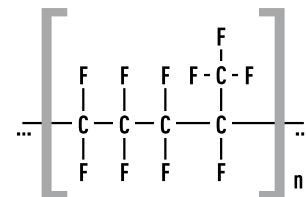
3M™ Dyneon™ PTFE
by Dyneon
Teflon® by Chemours
Fluon® by AGC
Chemicals Europe

PTFE - TFM

A further development of the classic Polytetrafluorethylene (PTFE) with additional modifier (PPVE). Due to a five times lower molecular weight going along with a lower melting viscosity, the single particles merge to an almost pore-free polymer structure. Compared to PTFE, the tightness as well as the barrier effect at the same wall thickness are doubled. The flowing under pressure load, so-called cold flow, is reduced by factor three. This is particularly advantageous at high working temperatures. PTFE-TFM has an almost universal chemical resistance. Sticking of any contaminations is prevented by an extremely smooth surface. Special methods allow a simple and safe heat seal. This material is ideal for e. g. digestion vessels or gaskets. As a consequence of the excellent barrier function, chemicals cannot penetrate the material. Instruments and components made of PTFE-TFM are therefore especially suitable for frequently changed products.

FEP – Tetrafluorethylene-Perfluoropropylene

A molten copolymer of tetrafluorethylene and perfluoropropylene with a high-molecular, partly crystalline structure which had been introduced on the market in 1960. Its mechanical and chemical properties are comparable with those of PTFE, however, the upper limit of the permanent working temperature is 50 °C lower (max. +205 °C). FEP is a typical thermoplastic material, which can be processed with the known production methods for this kind of material. New types with lower melting viscosity (= high melt flow index MFR) allow the processing at higher speed. FEP labware is translucent to transparent and non-porous.

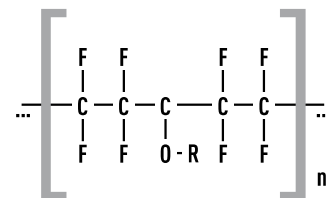


Trade names

Teflon® FEP by Chemours
Dyneon™ Fluorothermoplastics
FEP by Dyneon
Neoflon® by Daikin

PFA – Perfluoroalkoxy Copolymer

Fluorinated hydrocarbon with a high-molecular, partly crystalline structure. Compared to PTFE, it has additional side chains consisting of perfluorated alkoxy groups. PFA can be processed using thermoplastic production methods and offers chemical and thermal properties equal to those of PTFE. PFA labware is translucent to transparent, non-porous and particularly useful in high-purity work. Big components with a total weight of several kilograms can be fabricated in a „single shot“ by using transfer moulding.



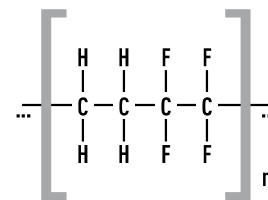
Trade names

Teflon® PFA by Chemours
Dyneon™ Fluorothermoplastics
PFA by Dyneon

BOLA Materials

ETFE – Ethylen-Tetrafluorethylene Copolymer

Partly fluorinated ethylene-tetrafluorethylene copolymer. Unlike the high-molecular PTFE which can be processed only by means of pressing or sintering, ETFE can be thermoplastic processed as already described before for PFA and FEP. I. e. this plastic material can be injection moulded or extruded with appropriate machines. In laboratories, this material is mainly used as compound with glass fibres for e. g. screw caps or screw joints. ETFE films have an excellent tear resistance. They are pervious to UV-rays and are therefore used for laboratory green houses as the VIS as well as the UV spectrum of the sun light can pass.

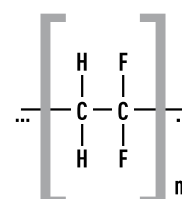


Trade names

Fluon® ETFE Resins by AGC
Chemicals Europe
Tefzel® by Chemours
Dyneon™ Fluorothermo-
plastics ETFE by Dyneon

PVDF – Polyvinylidene Fluoride

A fluoroplastic that can be machined or thermoplastic processed. Characterised by a good to excellent chemical resistance. Unlike PTFE, it is much harder and more rigid but its functional temperature range is lower. Within the range of fluoropolymers, PVDF is the best qualified self-supporting structural material due to its high rigidity. Its advantages over other fluoroplastics are its easy processing, the high mechanical values and the low specific weight. PVDF is mainly used for the production of components used in high-purity water supply systems. It is the only fluorothermoplastic with piezoelectric properties.

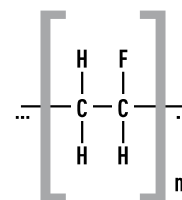


Trade names

Solef® PVDF by Solvay
Kynar® PVDF by Arkema

PVF – Polyvinylfluoride

Containing fluorine, it displays a stronger chemical linkage than common polymers and thus a better inherent stability. It shows its unique properties when used at temperatures ranging from -70 °C to +110 °C, whereas temperatures of up to +200 °C can be withstood. Polyvinylfluoride does not contain any softener, is resistant to fading and can be easily cleaned due to its dirt-repelling surface. In particular, foils, films and bags for gas analysis are made of PVF.



Trade names

Tedlar® Foils by DuPont

THV – Tetrafluorethylene-Hexafluorpropylene-Vinylidenfluoride Terpolymer

THV consists of the monomers tetrafluorethylene, hexafluorpropylene and vinylidenfluoride. This fluorothermoplastic has properties close to those of elastomers but does not require vulcanization. This material can be thermoplastic processed by injection moulding or extrusion. Due to the low processing temperature of approx. +200 to +250 °C a corrosion resistant construction of the processing machines might not be necessary. In laboratories, THV is mainly used for non-permeating tubing especially for the transport of hydrocarbons, fuel or mineral oils. In the lab and production areas of the semi-conductor and photovoltaic industry, THV is the preferred material for clean-room curtains as well as for blind tiles and cover plates for machines as it is one of few plastic materials which are FM 4910 approved. This standard includes a low inflammability, low build-up of soot of grime while burning in an external flame, low release of toxic products in case of fire.

Trade names

Dyneon™ Fluorothermo-
plastics THV by Dyneon

Standard Plastics – Technical Plastics - High-performance Plastics

General Information

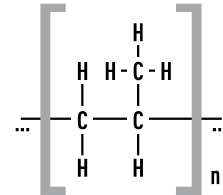
The permanent operating temperature is the most common characteristic to distinguish between standard plastics, technical plastics and high-performance plastics: for standard plastics, the limit is 90 to max. 100 °C, technical plastics can be operated within a range of 90 up to 150 °C. All high-performance plastics have a permanent operating temperature of more than 150 °C.

The permanent operating temperature is defined as the maximum temperature with which the material can be operated for 20.000 hours but without losing more than 50 % of its original rigidity and ductility. This means, a plastic material having a rigidity of 40 MPa in new condition has to show a rigidity of minimum 20 MPa after having been stored at its maximum permanent operating temperature for 20.000 hours.

Standard-Plastics

PP – Polypropylene

A polymer of ethylene with isotactic arrangement of methyl groups. It does not belong to the family of fluoro-plastics. PP can be autoclaved (at +121 °C) and is distinguished by good mechanical and chemical properties almost up to its softening point. PP labware is unbreakable and an economical alternative with, however, restricted chemical and thermal resistance.

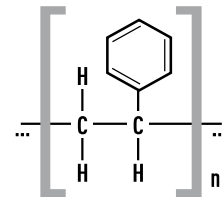


Trade names

Norolen® by BASF
Hostalen® by BASF

PS – Polystyrene

A polymerisation product of styrene. Polystyrene is one of the most commonly used plastic materials. For many years it has been processed by injection moulding, extruding or blowing. Because of its structure, it belongs to the family of amorphous thermoplastics and is transparent, inflexible and brittle. Polystyrene has a low thermal and chemical resistance. New developed PS-HI types provide an increased impact strength (HI = High Impact).



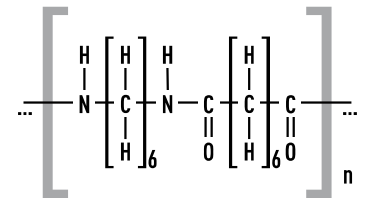
Trade names

Lacqrene® by ATO
Vestyron® by Innovene
Edistir® by Montedison

Technical Plastics

PA – Polyamides

Condensation polymers obtained either from amino acids respectively from their lactams (e. g. caproic lactam) or diamine and dicarboxylic acid (e. g. adipic acid and hexamethylene-diamine). In general, polyamides are defined according to the number of carbon atoms of their monomers, e. g. PA 6 = polycarbonic lactam or PA 12 = polylauric lactam. PA 6 is the most commonly used polyamide. All polyamides are characterised by high strength and scuff resistance. The application range varies from simple turned parts such as screws or nuts to plain bearings or toothed wheels.

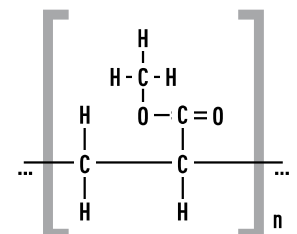


Trade names

Ultramid® by BASF
Durethan® by Bayer
Grilon® by Ems Chemie

PMMA – Polymethylmethacrylate

An acrylic resin based on methyl methacrylate. It has become generally known under the trade name Plexiglas®. On the one hand, PMMA is approx. 60 times more elastic than window glass but on the other hand it is approx. 10 times more permeable than silicate glass. Of course, the hardness of its surface does not correspond to that of glass but compared with other materials it can be easily polished to high brilliance. As to weight, Polymethylmethacrylate is much more lightweight than normal window glass.



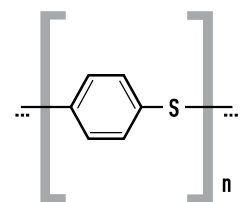
Trade names

Plexiglas® by Evonik Röhm
Perspex® by ICI
Oroglass® by Rohm and Haas

High-performance Plastics

PPS – Polyphenylsiloxan

Technical high-performance plastic. This macromolecule consists of phenylene rings and one S-atom which provide a good chemical resistance even at high working temperatures. PPS is particularly suitable for the production of moulded pieces which are exposed to high mechanical and thermal stresses. Injection moulding is the most common processing technology for this material, in addition, single components can be made of semi-finished products by cutting. Special glass-fibre reinforced compounds offer an improved rigidity, sturdiness and dimensional stability under heat compared to non-reinforced compounds.

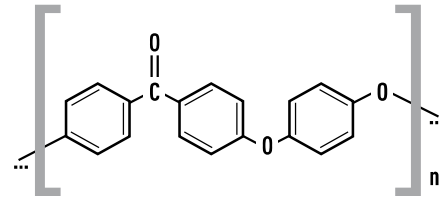


Trade names

Fortron® by Celanese
Ryton® by Phillips
Petroleum Chemicals
Alton® by Intern. Polymer Corp.

PEEK – Polyetheretherketone

Partly crystalline thermoplastic that withstands high temperatures. Due to its unique properties, PEEK is mainly used for high-value and highly stressable components. The high upper working temperature (+250 °C), the good chemical stability and resistance to hydrolysis as well as the high mechanical values of this material will allow PEEK to become the material of the future. PEEK components are commonly used as HPLC fittings, screw joints or as tubing. Its natural colour is brown, its price is considerably higher than that of PTFE or PFA. PEEK is available in many different types, e. g. modified for self-lubricating bearings.



Trade names

Victrex® by Victrex
VESTAKEEP® PEEK by Evonik

287

Materials - Chemical Resistance

Please note:

All information in our catalogue is based on current technical knowledge, experience and manufacturers' data. Users should check the suitability of parts and materials described in the catalogue before purchase.

BOLA does not accept any warranty claims as to suitability and fitness of purpose of the materials and products described in this catalogue. Users should avoid making any assumptions on, or interpretation of, the data herein. **Therefore we cannot provide warranty and cannot accept responsibility for any damage.**

Additionally, an overview stating the chemical resistance of all BOLA materials against many different substances from A like Accumulator Acid up to Z link Zinc Nitrates is available for download on our website in pdf-format:

<http://www.bola.de/en/technical-information/bola-materials/material-properties.html>

Categories of substances

Classes of substances at +20 °C	PTFE	PFA	FEP	ETFE	ECTFE	PVDF	PP	PA	PS	PMMA
Aldehydes	+	+	+	+	+	+	o	o	-	-
Alcohols	+	+	+	+	+	+	+	-	o	o
Amines	+	+	+	+	+	o	o	o	+	-
Bases/Caustic solutions	+	+	+	+	+	+	+	o	o	-
Esters	+	+	+	+	+	o	+	+	-	-
Ether	+	+	+	o	o	o	o	o	-	-
Glycols	+	+	+	+	+	+	+	+	+	o
Ketones	+	+	+	o	o	o	o	+	-	-
Hydrocarbons, aliphatic	+	+	+	+	+	+	o	+	-	-
Hydrocarbons, aromatic	+	+	+	+	+	+	o	+	-	-
Hydrocarbons, halogenated	o	+	+	+	+	+	o	o	-	-
Mineral oils	+	+	+	+	+	+	-	+	+	o
Oxidizing agents, strong	+	+	+	o	o	+	o	-	-	-
Vegetable oils	+	+	+	+	+	+	o	+	+	o
Acids inorganic	+	+	+	o	o	+	+	-	+	o
Acids organic	+	+	+	o	o	+	+	-	o	+
Lubricating oils	+	+	+	+	+	+	+	+	+	+

Definitions and abbreviations:

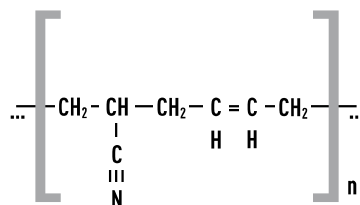
- + **Excellent chemical resistance** – continuous exposure for more than 30 days does not cause any damage or only minor damages.
- o **Limited chemical resistance** – depending on the plastic material, a continuous exposure for a longer period of time may cause damages such as cracks, decrease of mechanical strength, discoloration, etc.
- **Poor resistance** – the plastic material can be deformed or destroyed.

Elastomers

Their main characteristic is their elasticity: Elastomers can easily be stretched and bent and return to their original shape and size after being released. These synthetic materials are most commonly used for o-rings, flat gaskets or resilient elements.

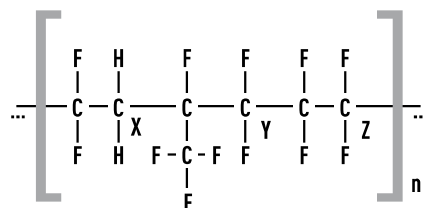
NBR – Acrylonitrile-Butadiene-Caoutchouc

Elastomer on the base of acrylonitrile-butadiene-caoutchouc which is mainly used as budget-priced sealing material (e. g. O-rings for stop-cocks). This material has a good resistance to mineral oils and fats as well as to HFA, HFB and HFC-hydraulic fluids. It has a very good elasticity. PERBUNAN® (its well-known trade name of BAYER AG) is not resistant to brake fluids on the basis of glycol, HFD liquids, aromatic compounds (e. g. benzol), ester, ketone and amines as well as in concentrated acids and caustic solutions. Due to its restricted chemical resistance, PERBUNAN® is not the ideal material for chemistry.



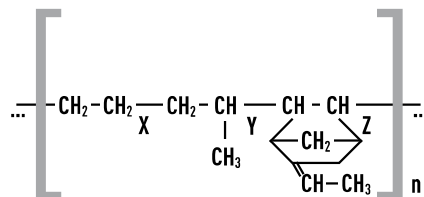
FKM – Fluorocaoutchouc

Elastomer on the base of fluorocaoutchouc, more familiar as VITON® (DuPont). Many O-rings, lip seals and sleeves are made of FPM. It has a very good resistance to heat, chemicals, weather and ozone. Furthermore, it is resistant to sulphurated mineral oils and fats and to hardly inflammable HFD liquids (basis phosphor ester or chlorinated hydrocarbon). It is not resistant to anhydrous ammonia, caustic soda, potassium, ketones, ether, dioxane, as well as some amines and organic acids. For BOLA products, FPM is mainly used as sealing material, mostly protected from the medium by a PTFE sealing lip.



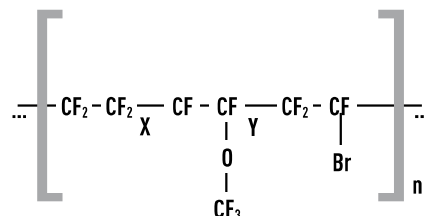
EPDM

EPDM 3 is an elastomer on the base of ethylene-propylene-diene-caoutchouc which is mostly used for gaskets and O-rings. The main applications are in the area of hot water, steam and suds. It is not resistant to hydraulic fluids on the base of mineral oil but it is weather-proof, non-ageing and resistant to ozone. At BOLA, EPDM O-rings are mainly used for applications where VITON® O-rings are not sufficient.



FFKM – Perfluoro-Caoutchouc

An elastic sealing material with natural recovery and good accommodation to the sealing surfaces and a chemical resistance comparable with PTFE. FFKM O-rings have a very high chemical and thermal resistance. Such seals can withstand virtually all kinds of chemicals and can be used at long duration conditions with temperatures up to +260 °C. Perfluoro-caoutchouc is better known under the trade names KALREZ® by DuPont, CHEMRAZ® by Greene Tweed, respectively Dyneon™ Perfluoroelastomers PFE by Dyneon.



Elastomers - Chemical Resistance

Classes of substances at 20°C	NBR	FKM	FFKM	EPDM
Water	++	++	++	++
Acids	+	+	++	++
Lyes	+	+	o	++
Oils and fats	+	++	++	-
Fuels	+	++	++	-
Ozone	o	++	++	++
Hydrocarbon, aliphatic	++	++	++	-
Hydrocarbon, aromatic	-	++	++	-
Hydrocarbon, chlorinated	-	++	++	-
Temperature range, °C	-40 up to +130	-20 up to +200	-20 up to +250	-30 up to +140

Definition: - not suitable, not recommended
 o possible, moderate to good
 + good
 +++ very good, best choice

Materials - Physical Properties

Property	Standard	Unit	PTFE ¹	PFA	FEP	ETFE	ECTFE	PVDF	PP	PA	PS	PMMA ³	PPS	PEEK
Density	DIN 53 479	g/cm ³	2.14–2.19	2.12–2.17	2.12–2.17	1.71–1.78	1.67–1.70	1.75–1.78	0.904–0.907	1.10–1.15	1.04–1.05	1.19	1.65	1.32
Service temperature without loading		°C	250–260	250–260	200–205	150–180	150–180	150–170	90–100	80–100	55–70	80	250	260
Inflammability			non-flammable	non-flammable	non-flammable	self-extinguishing	self-extinguishing	self-extinguishing	flammable	flammable	flammable	yes	self-extinguishing	V-0
Water absorption	DIN 53 495	%	<0.01	0.03	<0.01	<0.1	<0.1	0.03	<0.05	9–10	<0.3	—	0.02	0.5
Transparency			opaque	milky opaque	milky opaque	milky opaque	milky opaque	opaque	milky opaque	milky opaque	transparent	transparent	black	
Radioreistance		MGy	0.006	0.040	0.010	0.030	0.010	0.100	0.020	0.040	10	0.050	—	
Food suitability			Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	
Mechanical	Standard	Unit	PTFE ¹	PFA	FEP	ETFE	ECTFE	PVDF	PP	PA	PS	PMMA ³	PPS	PEEK
Tensile strength 23 °C	DIN 53 456	N/mm ²	29–39	27–32	19–25	36–48	41–54	38–50	25–40	40–60	35–60	72	195	
at 70 °C			—	—	—	—	—	—	18–28	18–28	28–38	35	150	
at 150 °C			14–20	15–21	4–6	8–12	3.5–4.5	7.5–10.5	—	—	—	—	70	
Limit of elasticity 23 °C	DIN 53 455	N/mm ²	10	14	12	24	34	46	25–40	40–80	32–57	—	—	97
Elongation a. tear 23 °C	DIN 53 455	%	200–500	300	250–350	200–500	200–300	20–250	400–800	40–280	2–4	—	1.9	50
Tension E-module 23 °C	DIN 53 457	N/mm ²	400–800	650	350–700	500–1200	1200–1800	800–1800	1100–2100	1600–2000	2900–3500	3300	14700	3600
Limit of bending stress at 23 °C	DIN 53 452	N/mm ²	18–20	15	—	25–30	50	55	45–60	40–60	breaks	—	—	
Bending E-module	DIN 53 457	N/mm ²	600–800	650–700	660–680	1000–1500	1700	1200–1400	800–1500	1000–1600	3000–3400	—	—	
Ball hardness 13/60	DIN 53 456	N/mm ²	25–30	25–30	23–29	34–40	55–65	62–68	58–80	50–80	110–160	—	—	200
Rockwell hardness R	ASIM d-785		—	—	—	45–55	85–95	100–115	—	90–100	—	—	100	99
Shore hardness D	DIN 53 505		55–72	60–65	55–60	63–75	70–80	73–85	70–75	—	—	—	—	
Coefficient of friction dyn. against steel, dry	²		0.05–0.2	0.2–0.3	0.3–0.35	0.3–0.5	0.65	0.2–0.4	0.3–0.5	0.3–0.35	—	0.5	0.4	
Thermal	Standard	Unit	PTFE ¹	PFA	FEP	ETFE	ECTFE	PVDF	PP	PA	PS	PMMA ³	PPS	PEEK
Melting temperature	ASTM 2116	°C	327	300–310	253–282	265–275	240–247	165–178	158–167	215–221	—	—	285	335
Dimensional stability u. heat A (18.5)Kp/cm ³	DIN 53 461	°C	50–60	—	51	71–74	76	80–92	55–60	55–80	70–88	105	—	152
heat B (4,6) Kp/cm ³	DIN ISO R 75		130–140	—	70	104	115	146–150	85–95	165–195	76–100	—	—	
Coeff. of linear thermal expansion		K x 10 ⁻⁵	10–16	10–16	8–14	8–12	4–8	8–12	15–18	6–12	6–8	7	2.6–4.8	
Thermal conductivity at 23 °C	DIN 52612	W/K x m	0.23	0.22	0.20	0.23	0.15	0.17	0.22	0.21–0.23	0.15–0.16	0.19	0.20	0.25
Specific heat at 23 °C		Kj /Kg x K	1.01	1.09	1.17	1.95	—	1.38	1.68	1.5–2.1	1.18–1.34	—	—	2.16
Oxygen value		%	>95	>95	>95	30	60	43	<30	<30	<30	1.47	56	35
Electrical	Standard	Unit	PTFE ¹	PFA	FEP	ETFE	ECTFE	PVDF	PP	PA	PS	PMMA ³	PPS	PEEK
Dielectric constant at 10 ³	DIN 53 483		2.0–2.1	2.06–2.1	2.1	2.6	2.6	7.8–9.0	2.26–2.4	4–12	2.4–2.74	3.6	4.0	3.2
at 10 ⁴			2.0–2.1	2.06–2.1	2.06–2.1	2.6	2.5	6.4–7.6	2.25	3.5–9	2.5	2.7	4.1	3.2
Dielectric loss factor at 10 ³	DIN 53 483	10 ⁻⁴	0.3–0.5	0.2	2–8	6–8	90	120–200	<4	270–2700	1–20	0.06	2	3.0
at 10 ⁴			0.7–1.0	0.8	2–8	50	90	1500–1900	<5	300–3300	1–14	0.02	20	
Volume resistivity	DIN 53 482	Ω x cm	10 ¹⁸	10 ¹⁸	10 ¹⁸	10 ¹⁶	10 ¹⁵	10 ¹⁴	>10 ¹⁵	10 ¹²	>10 ¹¹	10 ¹⁵	>10 ¹³	5x10 ¹⁴
Surface resistivity	DIN 53 482	Ω	10 ¹⁷	10 ¹⁷	10 ¹⁴	10 ¹⁴	10 ¹⁴	10 ¹³	>10 ¹³	10 ¹⁰	>10 ¹³	5 x 10 ¹³	>10 ¹⁵	10 ¹²
Creep resistance	DIN 53 480	KA3c	—	—	KA3c	—	—	KA1	KA3c	KA3a-b	KA2-1	600	—	KC 150
Arc resistance	ASTM 495	sec	>360	—	>300	>75	135	>30	—	—	—	—	—	
Dielectric strength	DIN 53 481	KV/mm	40–80	50–80	50–80	60–90	50–80	40–80	60–90	30–80	60–90	30	25–28	25
Gas permeability	Standard	Unit	PTFE ¹	PFA	FEP	ETFE	ECTFE	PVDF	PP	PA	PS	PMMA ³	PPS	PEEK
Nitrogen permeability		cm ³ /m ² d/bar	0.7	—	3.8	4.7	1.5	0.06	4.3	0.5	0.27	1	—	
Oxygen permeability		cm ³ /m ² d/bar	2.05	—	30	15.6	0.39	0.05	19	1.2	2.35	1	—	
Carbon dioxide permeability		cm ³ /m ² d/bar	5.7	—	60	38	17	0.2	61	4	8	—	4	
Water vapor permeability		g/m ² /d	0.03	—	2	0.6	9	4.5	2.1	1	14	300	—	

¹ Not extrudable thermoplastic >> ² Not a standardised test. Friction coefficient is subject to different effects and can therefore only be used as a guide.
³ Tested partially by methods other than those stated; upon request additional physical characteristics available based on the actual test methods used.

All information stated without engagement.