HEUTE + COMP. GMBH + CO

Always in our element

A group of companies with unlimited options.

PTFE PTFE Compounds PFA

Technical Information

Fluoroplastics – Essential properties

Ever greater demands make it necessary to employ a broad spectrum of fluoroplastics. HEUTE + COMP. can comply with your specifications and implement your ideas, whether as a one-off component or in mass production. Offering top-quality products made from a variety of materials, we are a high-performance partner to our customers.

PTFE (polytetrafluorethylene), better known under the trade names Teflon, Dyneon™, Hostaflon® and Fluon®, is characterized in particular by its superior resistance to chemicals and temperatures, its low friction values and good insulating properties. The thermoplastic fluorocarbons—PFA (perfluoralkoxy copolymer) and FEP (perfluroethylene propylene)—are used as linings or jacketing for metallic components and achieve corrosion protection comparable to that of PTFE. An extensive range of partially fluorinated polymers rounds out the options.

Among the engineering plastics, the superior position of PTFE is uncontested, based simply on its superb properties. If great resistance to chemicals (acids, bases and organic compounds) is required across a wide temperature range, it has been shown in practice that even high-quality steels and other special metals (such as titanium and tantalum) are subject to certain limitations. Here the fluorocarbons open the way to broad application areas. The following criteria are of significance in this regard.

Resistance to chemicals

PTFE, PFA and FEP are resistant to almost all organic and inorganic compounds. They are distinguished by a strong carbon-fluorine bond in the molecular chain. Only substances similar to them in their molecular structure, such as melted or dissolved alkali metals, pure fluorine, perfluorokerosene, chlorotrifluorides, and some other fluorine compounds can—under certain circumstances—attack the material.

Non-stick properties

The very low intermolecular forces are responsible for the fact that, of all the solid materials, PTFE has the lowest coefficients of friction, almost identical in the static and dynamic ranges. The coefficient of friction that is measured will depend on the pressure and the sliding speed, the surface with which it is in contact, and any supplementary lubrication which may be used. The result: superior non-friction properties, eliminating any stick-slip effect.

Temperature resistance

PTFE/PFA can be used at temperatures of from 250°C to +260°C, FEP to a maximum of +205°C. These are values which exceed almost all the commercially available plastics, at both the top and bottom of the scale.

Electrical properties

Fluoropolymers have excellent properties, particularly in the high-frequency range and better than almost all other plastics. The specific volume resistance of PTFE is almost independent of temperature up to 150°C and exceeds 10^{18} Ω x cm.

Affinity for water
- PTFE/FEP water absorption approx. 0.01%,
- PFA water absorption approx. 0.03%
These features can be traced back to the special characteristic of the compounds of fluorine and carbon. The main carbon chain, together with the extreme bonding energies of the fluorine and carbon atoms, lends great stability to the macromolecule.
In addition, the size of the fluorine and carbon atoms has a beneficial effect on a symmetrical chain configuration. All the fluorine atoms form a dense, helical covering on the chain of carbon atoms and thus prevent any reaction when contact is made with other chemical compounds.

PVDF –
An exceptional polymer
The two atoms of fluorine contained in the polyvinylidene fluoride molecule lend this polymer special properties, seldom found among the plastics. This thermoplastic material exhibits the following properties:

- Superb mechanical properties
- Wear resistance
- Flame resistance
- Resistance to UV rays
- High impact strength and good resistance to stress cracking
- Good dimensional stability

PCTFE –
A plastic for extreme conditions
Polychlorotrifluoroethylene features properties that are rare in other materials, making it suitable for a number of extreme application situations:

- Maintaining mechanical and chemical qualities at temperatures from -250°C to +180°C
- Non-flammable
- Can withstand liquid oxygen
- Resistant to creep and compression
- Resistance to ionizing radiation and "hard" UV rays

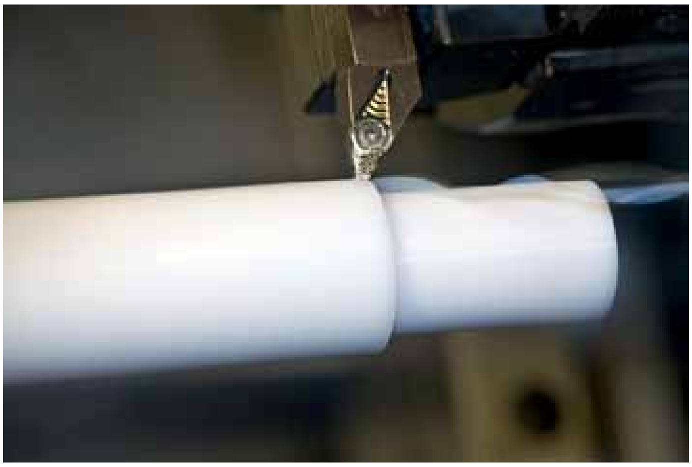
Since its mechanical properties remain largely unchanged even near absolute zero, PCTFE is the material of choice for refrigeration technology. PCTFE shrinks by just 0.01% as its temperature falls from 23°C to -250°C. That is about one-third of the shrinkage found in other fluorocarbons.

The permeability of PCTFE to gaseous and liquid media is extraordinarily low, provided that the PCTFE is chemically resistant to the medium.

The following table shows the permeation coefficients for PCTFE (measured in cm³ of gas per 1 cm² of a panel 1 mm thick, per second and cm Hg, multiplied by 10^{-10}). When compared with other polymers, the values for PCTFE are lower by a factor of up to 10^{-2}.

Permeation coefficients for PCTFE

	Gaseous media					
Temp. in °C	N_2	O_2	CO_2	H_2	H_2S	Water vapor
0	-	0.07	0.35	3.20	-	-
25	0.05	0.40	1.40	9.80	-	1.00
50	0.30	1.40	2.40	24.00	0.35	10.00
75	0.91	5.70	15.00	-	2.00	28.00
100	-	-	-	-	-	100.00



PTFE, PFA and FEP are processed using and of a variety of techniques attuned to the particular type of material. PTFE granulate is processed with ram extrusion or a molding process with subsequent sintering. A special sintering method, in an inert atmosphere, ensures that semi-finished products made of glass-fiber reinforced PTFE are gas tight.

Thermal post-processing of the semi-finished product can modify the material's characteristics in a closely defined fashion. Examples include:

- Quenching: A low crystallinity structure is created which will, however, exhibit a larger amount of internal stress. Consequence: The material is less suitable for manufacturing products with very narrow tolerances.
- Tempering: Heat treatment with subsequent conditioning of the semi-finished products — prior to subsequent cutting — ensure low internal stresses.

CERTIFICATE

TÜV NORD

Management system as per
ISO/TS 16949:2009
(3rd edition, 2009-06-15)

Evidence of conformity with the above standard has been furnished and is certified in accordance with TÜV NORD CERT procedures for

HEUTE + COMP. GMBH + CO

Heute + Comp. GmbH + Co.
Kaiserstraße 186 - 188
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Germany

Scope

Processing of fluoroplastics
Plastic processing
without product design responsibility (according to section 7.3)

IATF Registration No. 0119008
Certificate Registration No. 44 111 070822-001

Valid from 2011-03-18
Valid until 2014-03-17

Certification body
at TÜV NORD CERT GmbH

Essen, 2011-03-18

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.

TÜV NORD CERT GmbH Langemarckstrasse 20 45141 Essen www.tuev-nord-cert.com

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Quality / TS16949

In addition to satisfying the DIN ISO 9001 quality management standard, we were certified in 2005 as per Technical Specification 16949, governing quality management. Our day-to-day objective is to achieve maximum customer satisfaction. Only the highest quality in the processes associated with production and services can turn out perfect results.
The time-tested methods and techniques set forth in TS 16949 have helped us for many years now.

Your advantages when you select a certified supplier:

- Highest quality along the entire value creation chain
- Early communications during the development phase, in conjunction with Advanced Product Quality Planning (APQP) and project management
- Improving your competitive position with the support of a supplier delivering top-quality goods.

BAM

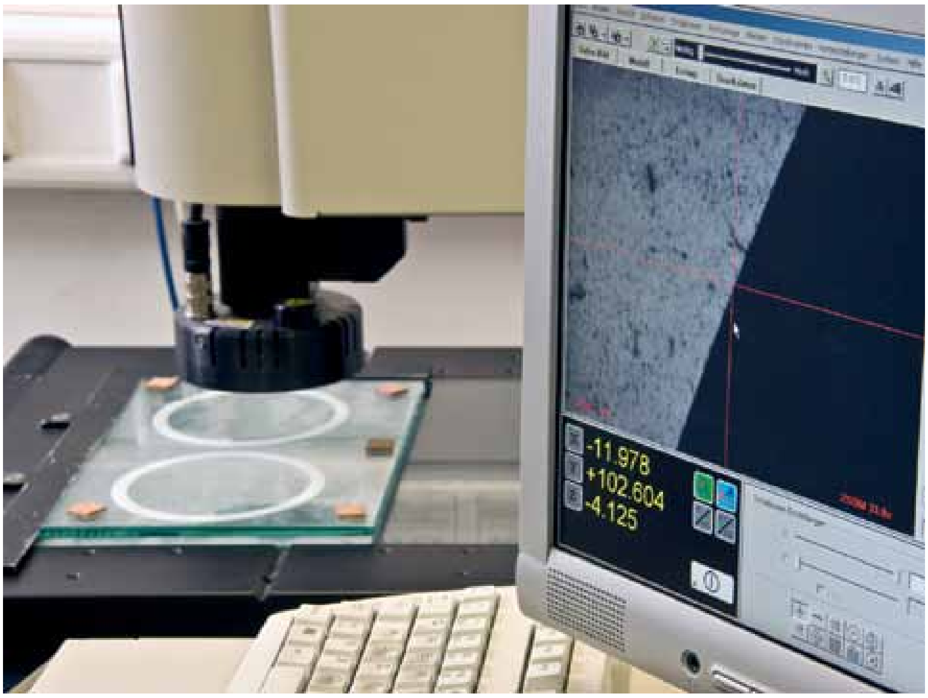
Some materials are tested by the BAM (Federal Institute for Materials Research and Testing in Germany) in regard to their behavior under pressure, in an oxygen-rich atmosphere, and are categorized accordingly. Discussing your requirements with our technicians early in the design phase makes it easier to select the appropriate feedstock materials. This normally facilitates obtaining approval for your final product.

KTW / WRC / W270
(drinking water certification)

Here again—and working in close cooperation with our feedstock suppliers—we offer a range of certified materials. The selection will depend on the specifics of the situation. Once again, this may speed the certification of your fixture.

FDA (Food and Drug Administration)

It is possible to use materials bearing a declaration of conformity, issued by their manufacturers.



PTFE fillers

In spite of its superior properties, the uses for PTFE without any filler are limited. This is due to the cold flow phenomenon inherent to the material at high mechanical loading. The material will have to be augmented with organic or inorganic fillers, usually coming to a proportion of between 5 and 40 percent. Several fillers may be used simultaneously to optimize specific aspects.

This publication and its contents are based on statements by the feedstock manufacturers, the technical literature, and the results of our own laboratory investigations. All the information represents current knowledge at the time of publication.

No guarantee is given for specific product properties or suitability for specific applications. The individual data cited here are mean values; the values experienced in practice may exceed or fall below these values, depending on the processing and application conditions.

Flawless product quality and maintenance of tolerances as per GKV standards (Confederation of the Plastics Processing Industry) are guaranteed in compliance with our General Terms of Business.

Filler	**Quantity (% by weight)**	**Influence of the filler**
Glass fibers	5 to 25%; max. 40%; also in combination with graphite, carbon and molybdenum disulphide	+ Increases pressure resistance, stiffness, wear resistance, + Reduces cold flow + Resistant to organic solvents - Not resistant to bases and acids
Carbon (electrographite)	5 to 25%; max. 35%; also in combination with graphite, bronze and molybdenum disulphide	+ Increases pressure resistance and wear resistance + Good dry running properties + Increased hardness + Improvement of thermal conductivity + Conductive – at high filler loads + Resistant to hydrofluoric acid - Sensitive to strongly oxidizing media (acids, bases, halogens)
Bronze	Up to 60% of filler loading, also in combination with graphite, carbon and molybdenum disulphide	+ Increases pressure resistance and wear resistance + Increases hardness + Improvement of thermal conductivity + Reduces cold flow - Limited resistance to chemicals - Sensitive to bases and strongly oxidizing acids
Graphite	Up to 15%, also in combination with glass, bronze and carbon	+ Improves slip properties and thermal conductivity + Reduces the coefficient of friction + Low wear at soft, metallic contact surfaces - Sensitive to strongly oxidizing media (acids, bases, halogens)
Conductive pigment	< 2%	+ Reduces the electrical resistance
Carbon fiber	up to 20%	+ Increases pressure resistance, wear resistance
		+ Low wear at soft, metallic contact surfaces
Molybdenum disulphide (MoS_2)	up to 5%, also in combination with glass and bronze	+ Reduces the coefficient of friction + Increases wear resistance - Sensitive to strongly oxidizing media (acids, bases, halogens)
Ekonol	up to 20%	+ Low wear of soft mating surfaces + Good friction properties
Stainless steel	up to 60%	+ Improves thermal conductivity + Reduces cold flow - Largely resistant to chemicals

Test method	Filler	Filler loading % by weight	volume	ISO 1183	Internal (similar to ISO 527)	Internal (similar to ISO 527)	ISO 2039	Internal (similar to DIN 53441)	DIN 52 612
Material number				Density g/cm³	Tensile strength N/mm²	Elongation at break %	Ball indentation hardness N/mm²	Deformation under load in %	Thermal conductivity W/m x K
0200 *1D/0200	None	0 0	0 0	2.15 2.17	40 30	380 500	26 35	15.5 to 17.2 8.2 to 9.0	0.25 0.25
0315 0315x** 0320 0325 0325x** *1D/0325 *1D/0325x**	Glass fiber	15 15 20 25 25 25 25	13 13 17 22 22 22 22	2.21 2.21 2.23 2.24 2.24 2.24 2.24	17 18.5 16 16 20 16 16	340 200 300 320 120 350 100	29 29 29 34 42 41 50	17 9.5 15 14 6.0 to 7 6.5 3.9 to 4.9	0.38 0.35 0.35 0.40 0.40 0.40 0.40
0410 0425 *1D/0425 *1D/0433	Carbon	10 25 25 33	11 27 27 36	2.14 2.09 2.09 2.05	22 14 14 16	350 190 40 30	30 38 37 44	11.0 to 13.0 5.5 to 6.5 4.0 to 4.5 3.1	 0.70 0.70 0.93
0560	Bronze	60	28	3.85	14	105	40	8.4	0.71
0850	Stainless steel	50	-	3.32	19	105	45	4	0.71
1215	Graphite	15	15	2.1	16	170	32	11.3	0.93

*1D = Pressure resistant, reduced cold flow; **x = Sintered under inert gas

Coefficient of linear expansion as a factor of temperature

	Temperature interval in °C									
Material designation	-100 to -50	-50 to +10	+10 to +30	+30 to +100	+100 to +200	+200 to +260	+260 to +300	+300 to +350	average +30 to +200	average +30 to +300
PTFE, virgin (0200)	0.98	1.15	2.44	1.22	1.61	2.56	4.21	15.0	1.45	2.07
PTFE, pressure-resistant (1D/0200)	0.88	0.99	2.49	1.23	1.54	2.37	4.16	18.0	1.41	2.03

At 19°C, PTFE experiences a structural transition (crystallinity) involving a marked change in volume. This is also the reason why all tests are carried out at elevated room temperature of 23°C.

Effect of the coefficient of thermal expansion in various PTFE compounds (measured in $K^{-1}x10^{-4}$)

	PTFE, virgin (0200)	PTFE + 15% glass (0315)	PTFE + 25% glass (0325)	PTFE + 25% carbon (0425)	PTFE + 33% carbon (0433)	PTFE + 15% graphite (1215)	PTFE + 60% bronze (0560)
Measurement parallel to direction of compression force							
30 to 100°C	1.60	1.27	0.99	0.96	0.73	1.17	0.95
30 to 200°C	1.90	1.47	1.24	1.14	0.90	1.42	1.27
30 to 300°C	2.50	1.99	1.80	1.16	1.28	2.01	1.79
Measurement perpendicular to direction of compression force							
30 to 100°C		0.79	0.76	0.80	0.63	0.86	0.70
30 to 200°C		1.02	0.94	1.01	0.81	1.07	0.94
30 to 300°C		1.52	1.40	1.52	1.18	1.56	1.39

Deformation under load

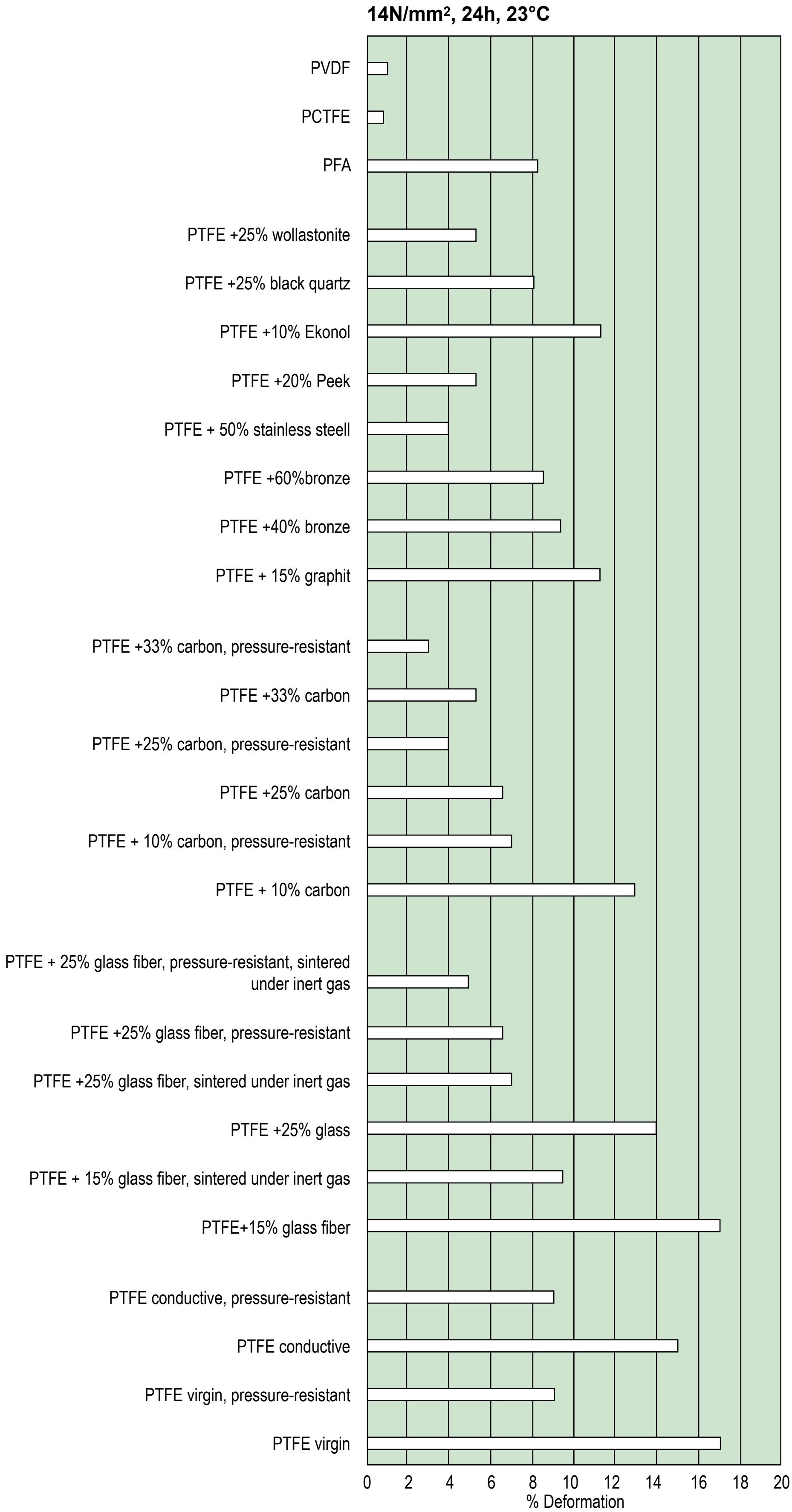
Determining total deformation and permanent deformation in PTFE after pressure application and after 24 hours, in relation to pressure level and temperature

The test specimen for the test results listed below (see page 9) is a cylinder 10 mm tall and 10 mm in diameter.

The exact height of the specimen is measured before it is placed in a climate chamber, between two metal blocks.

Once the test specimen has been heated, the appropriate weights are placed on the upper block to add load. After 100 hours under this load, the climate chamber is cooled to room temperature; the specimen is removed and measured immediately. This value is given in the table as TD or total deformation after 100 hours of loading at test temperature.

After 24 hours without any loading the PD or permanent deformation is measured.



Temp	Last	0200		1D/0200		0325		03235X		1D/0325		1D/0325X		0560	
°C	N/mm²	GV %	BV %	GV %	BV %	GV %	BV %	GV %	BV %	GV %	BV %	GV %	BV %	GV %	BV %
23	5.0	2.1	0.8	1.4	0.7	1.1	0.6	0.8	0.5	0.6	0.5	0.5	0.4	1.0	0.3
	7.5	3.1	1.7	2.3	0.8	2.3	1.3	1.8	0.7	1.3	0.8	1.3	0.7	1.6	0.9
	10.0	6.3	2.8	3.7	1.5	4.4	2.6	2.8	1.4	2.3	1.3	2.0	1.0	2.4	1.5
	15.0	16.5	9.6	9.2	4.4	14.0	8.9	7.0	4.1	6.5	4.2	4.9	2.5	8.4	4.9
50	1.0	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.1	0.2	0.1	0.2	0.1	0.3	0.2
	2.5	0.7	0.7	0.5	0.4	0.8	0.7	0.3	0.2	0.4	0.3	0.5	0.4	0.5	0.4
	5.0	2.5	1.8	1.8	1.7	1.5	1.3	1.0	0.8	1.0	0.8	0.8	0.6	1.1	0.9
	7.5	5.4	4.8	2.7	2.5	3.1	2.8	1.9	1.7	1.9	1.5	1.5	1.3	2.4	2.0
	10.0	10.4	8.6	4.2	3.7	6.7	5.7	3.5	3.0	3.4	3.2	2.6	2.1	4.5	3.6
	12.5	16.5	14.3	7.6	6.1	12.3	10.6	6.5	5.4	5.8	4.8	4.0	3.3	7.5	6.0
	15.0	23.3	21.2	11.3	9.6	19.0	16.5	9.5	8.1	10.4	8.0	6.2	5.3	11.2	9.6
100	1.0	0.7	0.4	0.6	0.5	0.7	0.7	0.3	0.3	0.5	0.5	0.5	0.4	0.6	0.5
	2.5	1.8	1.7	1.2	1.2	1.4	1.3	0.7	0.7	0.7	0.6	0.7	0.6	1.3	1.2
	5.0	6.4	6.1	2.8	2.7	3.3	3.1	2.4	2.2	2.0	1.8	1.5	1.4	2.8	2.3
	7.5	13.0	11.4	6.2	4.7	9.6	8.7	5.6	5.0	3.9	3.5	3.2	2.8	6.0	4.9
	10.0	20.8	19.7	10.5	8.8	18.7	17.6	8.6	7.8	8.6	7.4	5.6	5.0	10.7	9.8
	12.5	30.5	29.0	17.0	15.8	26.2	24.7	14.1	13.1	15.0	13.6	9.1	8.3	16.4	15.0
	15.0	37.2*	35.1*	23.1	21.0	32.8*	31.5	19.7	18.6	24.8	23.2	14.0	13.7	22.0	20.1
150	1.0	1.2	1.2	0.7	0.6	1.7	0.8	0.7	0.6	0.8	0.8	0.7	0.5	0.7	0.6
	2.5	3.2	2.6	1.6	1.6	2.1	2.0	1.6	1.5	1.5	1.3	1.3	1.2	1.7	1.6
	5.0	10.9	9.9	4.5	3.9	6.1	5.7	4.0	3.7	2.8	2.6	2.4	2.2	4.8	4.6
	7.5	21.7	21.1	10.1	9.5	16.7	16.1	9.3	9.0	7.6	7.2	5.2	4.9	11.7	11.2
	10.0	34.0*	33.2*	19.2	18.3	31.0	29.8	17.0	16.0	19.6	17.6	11.4	10.7	19.3	18.7
	12.5	42.3*	41.5*	29.3	27.9	38.7*	37.6*	24.9	23.9	30.0	29.0	18.5	17.6	25.5	25.0
	15.0	46.9*	46.3*	38.0*	36.8*	44.8*	43.8*	30.5	29.8	38.7*	37.7*	26.5	25.6	31.4*	30.6*

Temp	Last	1215		0425		1D/0425		1D/0433	
°C	N/mm²	GV %	BV %	GV %	BV %	GV %	BV %	GV %	BV %
23	5.0	1.2	0.4	0.5	0.3	0.4	0.3	0.4	0.2
	7.5	2.3	1.2	1.4	0.7	0.8	0.4	0.8	0.6
	10.0	3.4	1.5	2.7	1.2	1.7	0.6	1.4	0.9
	15.0	11.3	6.9	8.5	5.0	4.3	1.8	3.1	1.5
50	1.0	0.5	0.3	0.2	0.1	0.2	0.1	0.1	0.0
	2.5	0.6	0.5	0.4	0.1	0.4	0.4	0.3	0.2
	5.0	1.6	1.2	1.0	0.8	0.6	0.5	0.5	0.2
	7.5	3.3	2.6	2.4	2.0	1.3	1.0	0.9	0.7
	10.0	6.8	5.8	4.6	4.0	2.0	1.5	1.5	1.3
	12.5	11.0	9.0	8.7	7.8	3.2	2.7	2.6	2.3
	15.0	18.6	15.7	14.0	12.3	5.4	4.4	4.5	3.6
100	1.0	0.4	0.4	0.3	0.2	0.3	0.3	0.3	0.3
	2.5	1.4	1.3	0.9	0.5	0.8	0.4	0.5	0.4
	5.0	3.9	3.4	2.7	1.9	1.6	1.2	0.9	0.8
	7.5	9.4	8.6	6.1	5.1	2.8	2.1	2.0	1.8
	10.0	16.5	15.5	11.4	10.3	5.2	4.1	3.7	3.2
	12.5	24.6	23.4	19.0	17.5	8.4	7.2	6.6	6.1
	15.0	30.2	29.1	26.3	24.8	14.1	12.4	11.2	10.6
150	1.0	0.8	0.7	0.5	0.4	0.4	0.4	0.4	0.4
	2.5	2.1	1.9	1.5	1.5	0.9	0.6	0.6	0.5
	5.0	6.5	6.0	4.7	4.3	2.0	1.9	1.4	1.3
	7.5	16.0	15.2	12.7	12.2	4.6	4.1	3.2	2.9
	10.0	26.3	25.5	22.9	22.5	9.6	9.1	6.8	6.2
	12.5	35.8*	34.9*	31.6*	30.9*	17.8	17.1	16.8	16.2
	15.0	43.5*	42.8*	36.9*	35.8	25.7*	24.5*	24.9	24.2

At deformation levels of more than 25 to 30 percent, the test specimen bulges so much that additional stiffening takes place and the measured values are falsified. These values are indicated with an asterisk (*) in the tables.

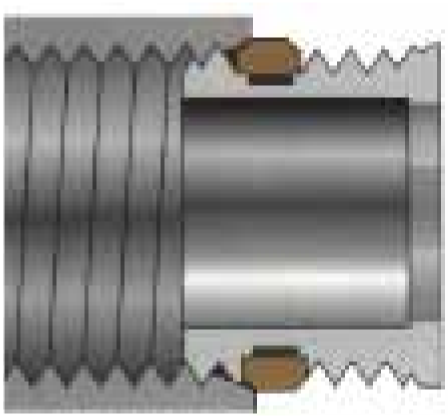
The measured values can be applied to real applications only to a limited extent, since appropriate design measures can be applied to achieve encapsulation of the PTFE, resulting in a corresponding reduction in the flow properties.

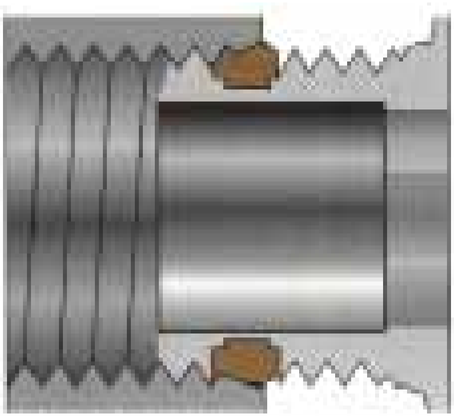
Thread seals made of a special PTFE compound manufactured by HEUTE + COMP. have been on the market for more than thirty years now. More than 200 million such rings have been used successfully in a wide variety of applications.
This kind of seal was developed in collaboration with customers from the plumbing sector who were looking for an alternative to the traditional hemp fiber seals and were dissatisfied with PTFE tape and all its inadequacies.
This technology gradually made its breakthrough in many other industries, as well. Thus there is a variety of uses in mechanical engineering and automotive production (examples there include diesel fuel injection and steering gears).
The PTFE thread sealing rings made by HEUTE + COMP. are based on the principle described in the following paragraph. A groove is milled into the outside threads and the base of that groove is knurled, at its center, with a specially designed, sharp-edged knurling pattern. The width of the knurling will depend on the pitch of the threads and the width of the groove. Knurling is applied only along a strip in the center of the groove so that a smooth area about 0.5 mm wide is left on the left and right of this strip. The two narrow strips ensure that, once the ring has been mounted, a tight seal is made and no medium can flow under the ring.

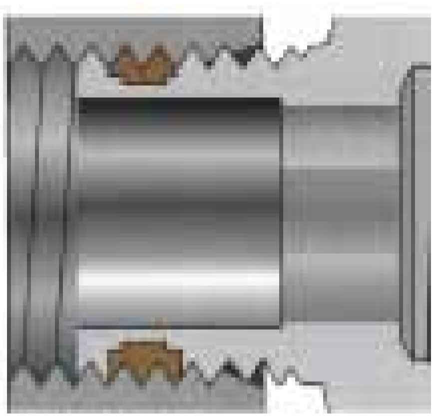
A conical jig covers the threads as far down as the groove. The PTFE sealing ring is stretched as it passes over this jig during mounting. It then snaps into the groove. Thanks to the snap-back effect of the special PTFE compound, the sealing ring seats in the knurling on the bottom of the groove to prevent rotation. As a rule, the mating parts can be screwed together at once.

The shorter the time required for stretching, the faster is the snap-back phase. When dealing with small threads (from about M10) it can be helpful to shorten the snap-back period by briefly heating the ring to approx. 100 to 120°C once it has been mounted. The mating piece (with the female threads) will have to be provided with an entry chamfer of about 60°. This ensures that the sealing ring is threaded evenly into the inside threads during assembly. This entry chamfer causes forces that press the ring fully into the knurling.
The clear advantages of the thread sealing ring made of the special PTFE compound, when compared with hemp or sealing tape, are:

- The preassembled sealing element is fixed to the threaded section thanks to the snap-back effect and can neither be lost nor overlooked when making the connection.
- It is possible to align the threaded components by turning them forward and back so as to put them into the correct position for assembly.
- The threaded joint can be disassembled and reassembled since the resilient PTFE compound, thanks to its memory effect, will return to the original shape when disassembled, so that there will be sufficient pressure to restore the seal.







As described above, the first use of these thread sealing rings was in the plumbing trade. Due to the special situations sometimes found in that trade (connection threads recessed in a masonry wall, for instance), it was not always possible to expect that brand new components would be involved when mounting new fixtures. Old connectors with considerable wear and tear to the threads are often encountered. It is necessary to take this special situation into account when designing the thread sealing ring.

Due to these adverse assembly situations, the thread sealing rings are designed to include “reserve material”. This means that the volume of the ring itself is greater than the volume of the groove. Consequently, when assembling new and dimensionally correct parts, a small portion of the ring will be sheared off and not moved into the threads.

Although irrelevant to the rotation function, this effect can be compensated for by a minor variation in the diameter of the groove and/or the insertion torque arising during assembly can be adjusted.

It goes without saying that the thread sealing rings are subjected to the testing typical for plumbing applications, to assure compliance with the KTW (Plastics in Drinking Water) and WRC (formerly Water Research Centre) standards.

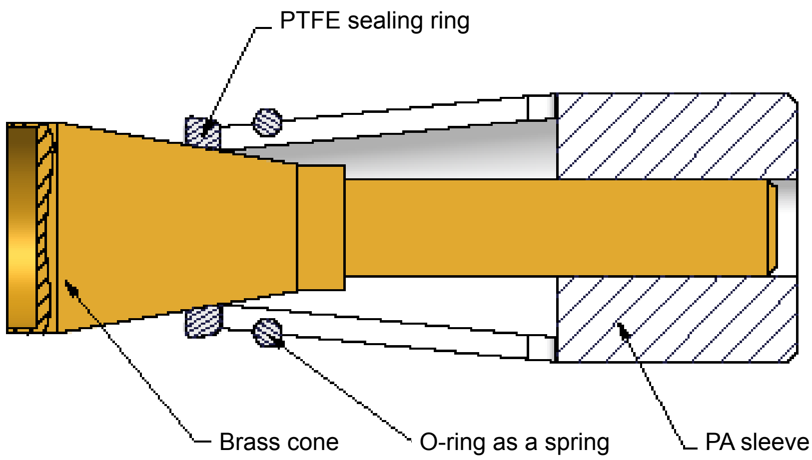
In the meantime the PTFE rings have found their way into a number of hydraulic applications. Even when dealing with oscillating pressures of up to 400 bar this type of seal—which does not swell, become brittle or age—has proven its qualities. Testing for brief periods at markedly higher pressures has also been successfully completed.

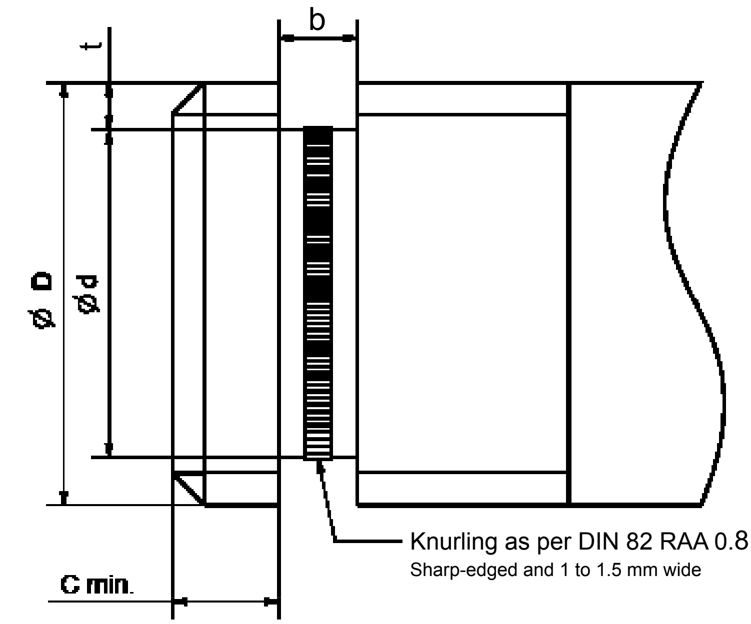
The thread sealing rings are not limited to use as a component to prevent leaks. In many applications the rotational forces are most important.

When using an adjustment screw to make a height correction, for instance, it will be necessary to turn the screw down and back through some distance until the desired position has been reached. The screw is then to remain in this position. At the same time, a seal is to be created in the threading. This is a combination of tasks that a thread sealing ring can carry out with full reliability.

The advantages of this sealing ring come to bear especially where space is limited, since it can handle a number of functions all at once.

In order to cope with these numerous exacting demands, the thread sealing ring is made up from a PTFE compound developed specially for this purpose and identified by its brown color.





Metric thread

Thread pitch	t	C min	b
0.75	0.8	1.5	1.55
1	1	2	2.05
1.25	1.2	2.5	2.55
1.5	1.4	3	3.1
1.75	1.6	3.5	3.6
2	1.8	4	4.1
2.5	2.2	5	5.1
3	2.6	6	6.2

Inch thread

Thread E	Dimension d prior to knurling	C min	b
1/4“	$10.4^{+0.1}$	3.5	$3.7^{-0.1}$
3/8“	$13.9^{+0.1}$	3.5	$3.7^{-0.1}$
1/2”	$17.6^{+0.1}$	3.5	$3.7^{-0.1}$
3/4”	$23.1^{+0.1}$	3.5	$3.7^{-0.1}$
1”	$29.1^{+0.1}$	4.5	$4.6^{+0.1}$
1 1/4“	$37.6^{+0.2}$	4.5	$4.6^{+0.1}$
1 1/2“	$43.6^{+0.2}$	4.5	$4.6^{+0.1}$

PTFE compensator

PTFE compensators are distinguished by their superb resistance to chemicals and their ability to withstand high temperatures. Utilized as connector elements between structural components, they compensate for changes in length due to thermal expansion, permit relative movements in the axial and lateral angular directions and through angles, and suppress the transmission of vibrations.

Typical applications will be found in chemical industry equipment and in medical technology.

Low fold thickness makes for the greatest possible elasticity. That is why high-quality PTFE materials are used since they guarantee low porosety. Highly crystalline materials ensure great resistance to diffusion while low-crystalline PTFE guaranteed good elasticity, flexural strength, and resilience. To increase the pressure resistance at the ends and connection areas, reinforced PTFE (incorporating fillers like glass fibers, carbon etc.) can be used at the desired locations while making the semi-finished products.

Special sintering in an inert gas atmosphere makes sure that GFR PTFE will be absolutely leak-proof.

PTFE compensators are manufactured by cutting or milling. There are two types, differentiated by their cross-sectional shape:

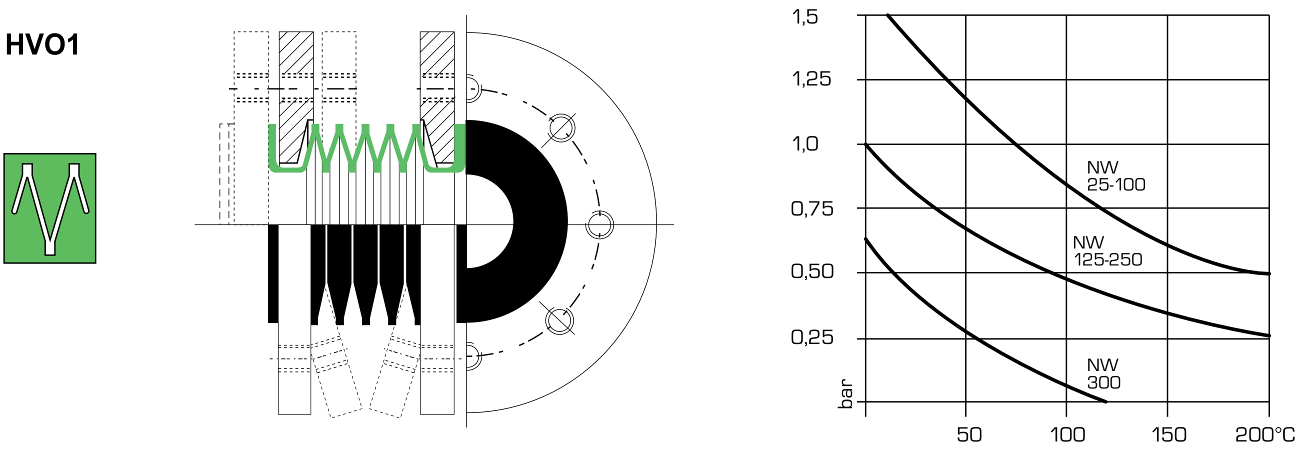
- Type HVO-1 — V shaped

Punched folds. High-flexibility boot with the greatest elongation in relationship to the installed length. For low pressures applications (see the chart).

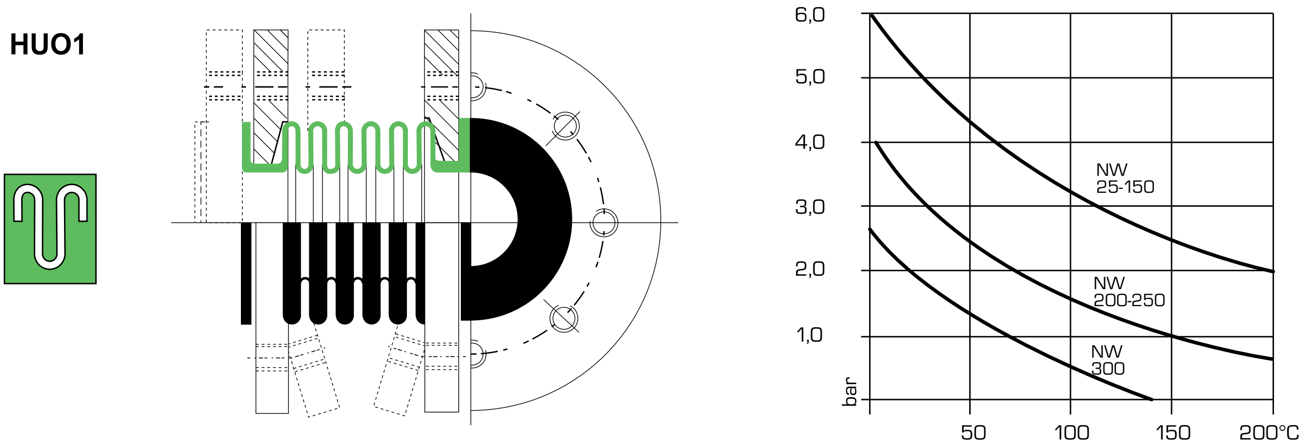
- Type HUO2 — U shaped

Folds manufactured by cutting or milling. Folds punched to achieve a rounded shape offer great stability in their shape. These can be used, depending on the temperature and dimensions, up to a maximum pressure of 6 bar. With the integration of a special PTFE support tube, this type can also be used for vacuum. Shorter compression and elongation paths than for type HV01.

HVO1



HUO1



Cast housings for chemicals pumps, ball valve casings, butterfly valve disks, structural components and the like — all of which need sure protection against corrosion — are fitted with linings and coatings in a transfer molding process. The technology requires that the protective shell be no less than about 3 mm thick.

Property	Test temperature	Unit of measure	PFA
Tensile strength	23 °C 150 °C 200 °C	MPa MPa MPa	31.6 20.3 16.4
Elongation at break	23 °C 150 °C 200 °C	% % %	379 489 557
Yield stress	23 °C 150 °C 200 °C	MPa MPa MPa	15.5 4.8 3.3
Tensile modulus	23 °C 150 °C 200 °C	MPa MPa MPa	529 97 64
Coefficient of thermal expansion	21 °C to100 °C 100 °C to150 °C 150 °C to200 °C	10^{-5}1/K 10^{-5}1/K 10^{-5}1/K	11.6 14.9 19.2

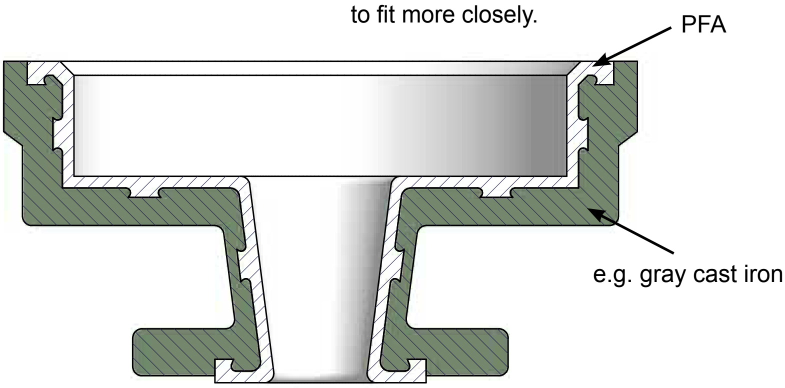
As opposed to PTFE, the fluorothermoplastics (PFA, FEP, PVDF etc.) are processed using the familiar injection molding process. PFA (perfluoroalkoxy) — a copolymer of tetrafluoroethylene and perfluorinated co-monomerss — displays largely the same properties as PTFE in regard to temperature resistance, chemical resistance, low surface tension, and good resistance to pressure.

FEP (perfluorinated ethylene-propylene) —a partially crystalline copolymer made up of tetrafluoroethylene and hexafluoropropylene — can tolerate a maximum temperature of about +205°C when in use. In order to satisfy the wide range of demands found in actual use, there is a wide range of materials available, with a broad spectrum of flow indices.

Suitable design options such as dovetail grooves running around the circumference of the sealing strips or in cylindrical areas ensure perfect mechanical fixing between the substrate and the lining material which, by nature, will not stick to the substrate. Depending on the thickness of the lining wall, a certain amount of shrink and separation of the lining from a cylindrical metal component is unavoidable unless additional mechanical anchor points are provided.

It is important to ensure that—right from the design stage for the metal parts—the best possible situation be created for the subsequent installation of the lining. Creating the largest possible radii at inside corners of workpieces or holes will reduce local stresses in the plastic used for the lining.

Only when coating metallic objects (such as butterfly valve disks) will the shrinkage inherent to the material cause the covering to fit more closely.



Guideline values for fluoroplastics

	Abbreviation for the plastic	PTFE	FEP	PFA	ETFE	PVDF	PCTFE	ECTFE
Property	Unit of measure							
Working temperature. injection molding and extrusion	°C	-	340 to 400	340 to 370	300 to 340	200 to 250	260 to 290	275-300
Maximum continuous duty temperature without stress	°C	260	205	260	150 briefly 180	150	150 briefly 180	140 briefly 180
Becomes brittle below	°C	-250	-100	-200	-100	-60	-40	briefly 180
Crystallite melting point	°C	327	-30	-5	-10	-12	-40	240
Raw density	g/cm³	2.14 to 2.23	2.12 to 2.17	2.14 to 2.17	1.67 to 1.75	1.76 to 1.78	2.07 to 2.12	1.68
Tensile strength	N/mm²	20 to 40	15 to 21	15 to 30	35 to 45	40 to 60	30 to 40	42 to 48
Elongation at break	%	140 to 400	240 to 350	300	200 to 500	25 to 400	20	200
Modulus of elasticity (tension)	N/mm²	350 to 750	350 to-500	600	1000	1000 to 3000	1300	1400
Flexural stress limit	N/mm²	18 to 20	-	15	26	55	55 to 67	50
Notched impact strength (20°C)	kJ/m²	16				22	8 to 9	
Izod impact strength								
at +20 °C	J/m	160	N/A	N/A	N/A	200	160-270	N/A
at -57 °C	J/m	107	160		1000	-10 °C 100	-	110
Shore D hardness		55-60	58	62	67-73	77-82	73-79	
Linear thermal expansion coefficient	10^{-5} x K^{-1}	16	12	13	13	10	5	8
Thermal conductivity at +20°C	W/mK	0.24	0.23	0.26	0.24	0.17	0.26	0.14
Oxygen index	Vol. pct. % 0_2	95	95	95	32-37	44-48	94	64
Specific volume resistance	Ohm x cm	10^18	1018	10^18	10^16	1014	1015	1015
Surface resistivity	Ohm	10^17	1016	10^17	1015	1015	1015	1014
Water absorption. comparative values. 24 h	%	0	<0.01	0.03	0.02	0.03	0	0.01
Swelling agents		None in the useful temperature range		Some halogenated solvents at elevated temperatures		Ketones, esters at higher temperatures	Some organo-chlorides	None
Susceptible to chemical attack by		Melted or dissolved metallic sodium, fluorine, FCL3 at higher temperatures		Similar to PTFE and FEP	Fuming H2SO4 and similar	Fuming HNO3 and H2SO4, amine, pyridine	Similar to PTFE	

	Abbreviation for the plastic	POM homopolymer	POM copolymer	PA6 dry	PA6 conditioned	PA66 dry	PA66 conditioned	PA12
Property	Unit of measure							
Tensile strength	N/mm^2	67 to 69	-	-	-	-	-	55
Elongation at yield strength	%	-	-	20	30	17	33	6 to 8
Max. continuous duty temperature	°C	-	-	80 to 120	-	85 to 150	-	70 to 80
Melting temperature	°C	175	164 to 168	220	-	255 to 265	-	172 to 180
Density	gr/cm^3	1.42	1.41	1.10 to 1.14	1.10-1.14	1.12 to 1.15	1.12-1.15	1.01 to 1.02
Yield stress	N/mm^2	67 to 85	62 to 71	65 to 90	40 to 50	70 to 90	50 to 65	50
Elongation at break	%	-	-	20 to 100	150 to 250	10 to 50	50 to 220	200
Modulus of elasticity (tension)	kN/mm^2	2.9 to 3.5	2.7 to 3.2	2.3-2.5	1.2 to 1.4	2.7 to 3.0	1.6 to 2.0	1.2 to 1.6
Flexural stress limit	N/mm^2	-	-	120 to 130	45	130 to 140	50	70-85
Notched impact strength Izod. ISO 180/1A	kJ/m^2							
at +23 °C		-	4 to 7	6 to 11	-	4-6	7 to 12	5-6
at - 30 °C		-	4 to 7	3 to 10	-	4-6	4 to 5.5	5-6
Rockwell hardness		M92 to 94	M80	R120	R90	R120	-	R110
Thermal conductivity	W/mK	0.37	0.31	0.23	-	0.27	-	0.30
Coefficient of thermal expansion 20/100°C	10-5xK-1	1.1	1.2	6 to 10	-	7 to 10	-	11
Ball indentation hardness 358/10	N/mm^2	-	-	160	70	140 to 170	100 to 110	75 to 100
Specific volume resistance	Ohm x cm	-	1014	1015	1012	1015	1012	1015
Dielectric strength	kV/mm	70	70	50 to 150	30-80	100 to 150	30 to 80	90
Water absorption 23°C. 50% RH	%	-	-	-	3.5 to 4	-	2.5 to 3	0.9
Water absorption 23°C. saturated	%	0.9 to 1.4	0.65	9.5	9.5	8.5	8.5	1.5
Impact strength Izod. ISO 180/I C	%							
at +23°C	kJ/m^2	-	80	N/A	N/A	160 to N/A	N/A	N/A
at -30°C			70 to 160	N/A	N/A	120 to 290	140 to 356	N/A
Notched impact strength Charpy. DIN 53453								
Charpy. DIN 53453 +23 °C	kJ/m^2	-	-	3-6	N/A	2-3	15-20	6-15
- 40 °C	kJ/m^2	-	-	2-4	N/A	<2	-	5-10
Bemerkungen				Tough and impact resistant even at low temperatures		Best hardness, stiffness and temperature resistance of the non-reinforced PA types		Increased dimensional stability at falling water absorption

Additional technical information on

- PFA linings
- PTFE compensators
- PCTFE
- PEEK

is available on request.

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