

Compounds and Semi-Finished Products Made from PTFE.

The exceptional compound for custom-tailored functionality



elringklinger
Kunststofftechnik

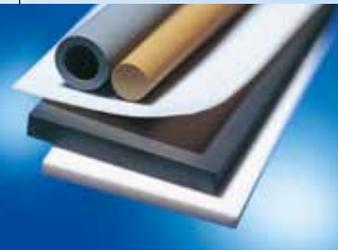
Compounds and Semi-Finished Products Made from PTFE: Properties and

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**Principles
Properties
Performance**



**Porous PTFE
for optical applications
and media separation**



**Laminates
Xymon**



**Semi-Finished PTFE products
Films/sheets, plates, rings,
circular blanks, solid rods,
tubes**



PTFE – Tailored for Top Performance and Functional Reliability

Innovations in Plastics

For over 50 years, ElringKlinger Kunststofftechnik has been a technology leader in the field of seals and engineering design elements. For our customers around the world, we develop and produce individual, user-oriented solutions from PTFE or PTFE compounds and other high-performance plastics as well as PTFE composite components, including plastics or metals. Our solutions successfully stand the test of the toughest requirements in the field – at high levels of cost effectiveness and reliability.

PTFE – the material that provides the basis for technical solutions in a wide range of applications. Tailor-made by the specialist. With superior properties offering a host of functional and cost benefits.

Standard

Standard PTFE, for example, has an exceptionally wide thermal application range. It offers virtually unlimited chemical resistance as well as being resistant to light, weather and hot water vapor. It has very good sliding properties, good electric and dielectric properties, it is anti-adhesive and physiologically harmless.

Modified PTFE

Derived from standard PTFE, a new product – modified PTFE – is created by co-polymerization with a small quantity of a perfluorinated modifier and reduction of the molecular weight. Although modified PTFE can be processed by the same methods used for standard PTFE, it has a clearly improved profile of properties, such as reduced cold flow and permeation as well as smaller pore volume and a lower stretch void index (SVI).

Applications

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Approvals and Regulations
(Product Stewardship) ATEX,
food contact, BAM, IMDS



Processing Instructions
Compression molding and
sintering, Ram extrusion



Compounds

Compounds based on PTFE and modified PTFE are filled with glass fibers, carbon fibers, carbon, graphite, molybdenum sulfide, bronze or organic fillers (high-performance thermoplastics). Fillers are used to achieve a multiple of the material's original wear resistance and thermal conductivity as well as a significant reduction of cold flow under load and reduction of thermal expansion.

Technical Consulting Support

We will be pleased to support you in selecting the optimum material or semi-finished product. This assures that you will receive a tailored and cost-effective solution best meeting your needs.

Quality and Environmental Policy

Top quality and an active commitment to environmental protection are key to ElringKlinger's sustained success in the marketplace. That is why we are certified according to ISO/TS 16949 and DIN EN ISO 14001.

Our Products Made from PTFE

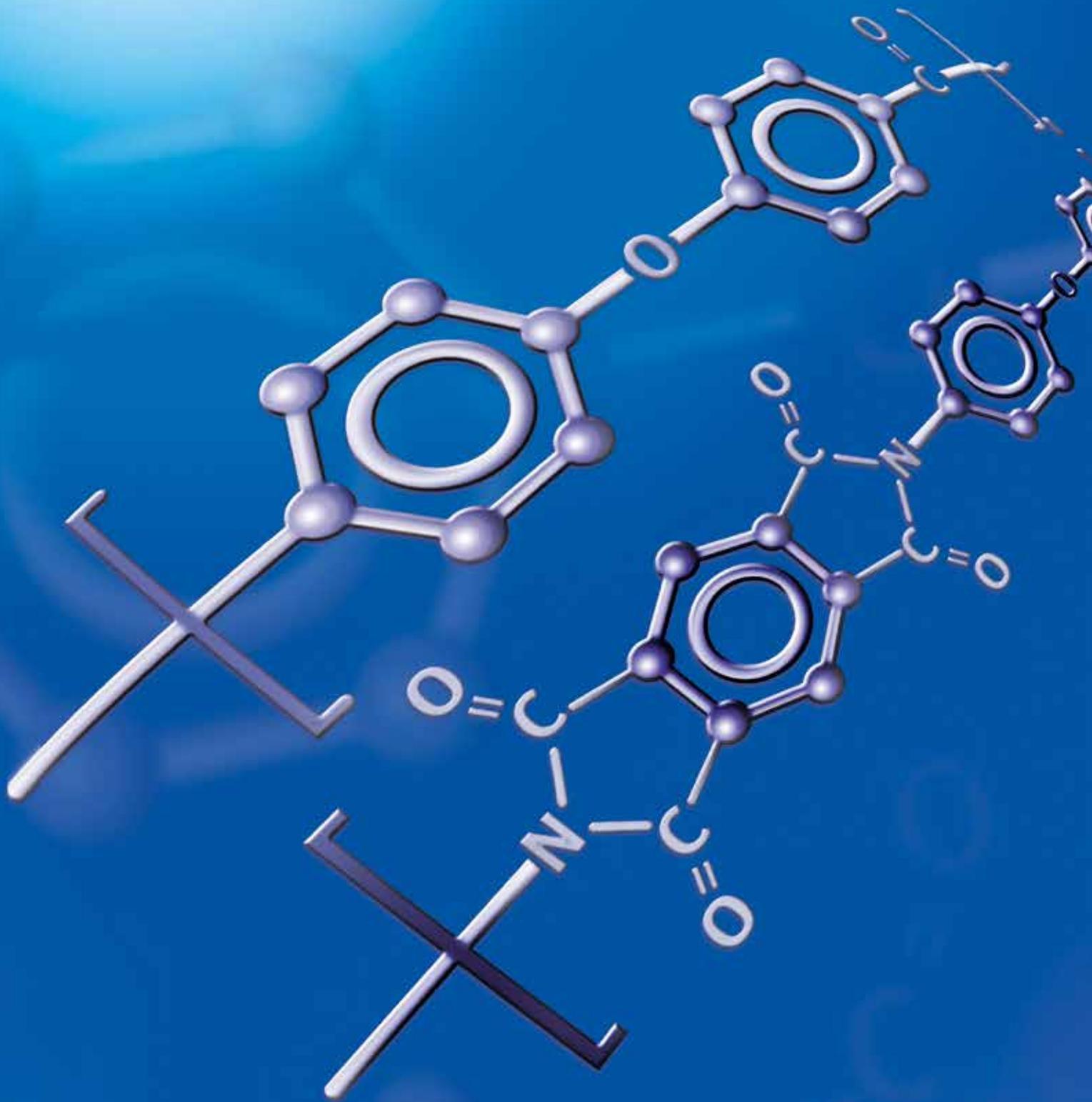
- Guide band for pistons and rods
- Radial shaft seals (oil seals) with PTFE sealing lip
- Sealing elements in large dimensions of up to 3000 mm diameter
- Engineering design elements
- Membranes/diaphragms with a PTFE elastomer composite
- Spring-energized seals
- Memory packings
- PTFE hoses
- Piston rings for compressors
- Composite seals
- Bellows
- Porous PTFE for media separation
- Porous PTFE for optical applications
- PTFE semi-finished products

(1) Limit Values

Limit values have been compiled with great care based on years of experience. Values, however, will not be deemed binding and are provided without guarantee. Please note that the desired functional performance is only assured when considering the specific conditions of a particular application. In any event, we recommend sampling and testing. Sampling and testing services are available from our development department offering a wide range of resources for material characterization, determination of application-specific properties and test rigs for component and system testing.

(2) Diagrams

The information provided in these diagrams is based on comparative values determined by ElringKlinger. These values have been obtained under specifically defined conditions and may not be transferred exactly to other applications. The diagrams, however, allow you to draw a basic comparison between our compounds and semi-finished products.



PTFE – Cost-Effective and Versatile Special Plastics



Thanks to their exceptional properties PTFE and modified PTFE as well as the compounds made from these materials offer new technical problem-solving approaches to design engineers.

Despite higher material costs compared to conventional, mass-produced plastics, PTFE parts may well be the more cost-effective alternative.

When used in critical applications, PTFE offers longer service life, higher reliability and improved functionality to give you a greater competitive edge in difficult markets.

These unusual properties make PTFE perfectly suited for use as a special-purpose plastic material for a wide range of applications.

Typical Uses

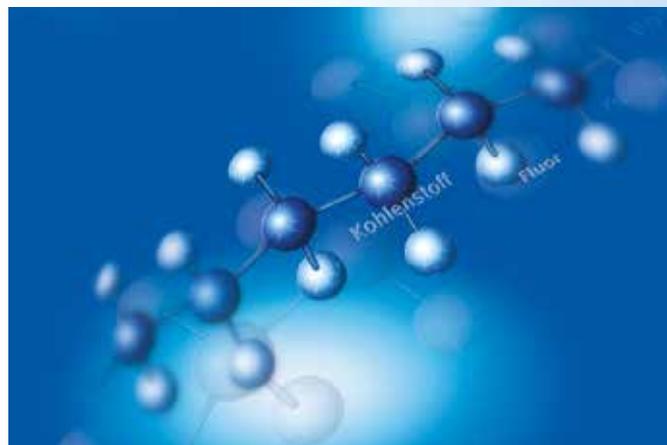
- Sealing and anti-friction elements for mechanical and automotive engineering
- Corrosion protection in the chemical industry based on unfilled PTFE, compounds or laminates
- Insulation material for electronics and electrical engineering
- Seals for automotive fuel supply and fuel injection systems
- Automotive exhaust gas sensor components
- Sealing and anti-friction elements for aircraft
- Coatings for pistons, heating elements, rolls, membranes, etc.
- Medical apparatus engineering
- Use of PTFE products in the food processing industry
- Use of PTFE hoses in the chemical, pharmaceutical and automotive industries
- Large seals for oil and gas production (offshore plants)
- Seals and anti-friction elements for wind turbine generator systems

Synthesis

Polytetrafluoroethylene (PTFE) is a partially crystalline substance obtained from the monomer tetrafluoroethylene (TFE) by polymerization. The macro-molecules created in this process have a linear structure. PTFE's chain structure has two interesting characteristics:

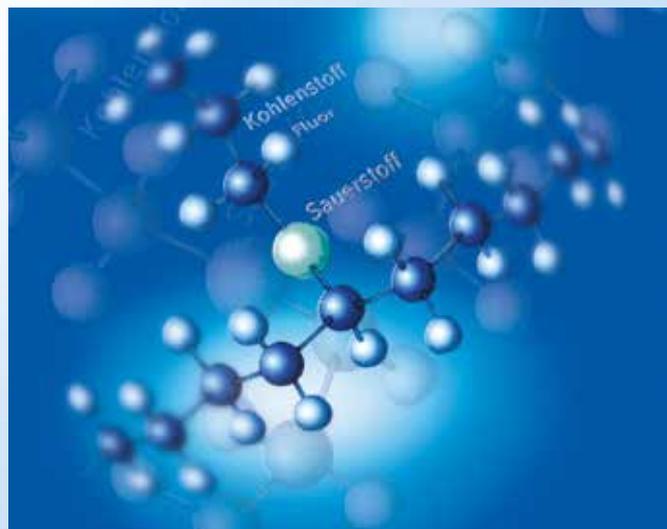
PTFE

The carbon chain is almost completely shielded by fluorine atoms, thus being protected from external influences. The carbon-fluorine combination is one of the strongest bondings in organic chemistry (dissociation energy: 460 KJ/mol). This gives PTFE its exceptionally high chemical and thermal resistance.



Modified PTFE

Modified PTFE is obtained from the monomer, tetrafluoroethylene (TFE) and a modifier (which is perfluorinated as well), perfluoropropylvinylether (PPVE). The shorter molecular chains (compared to PTFE) have a higher tendency to crystallize. This would degrade the mechanical properties of the material. The modifier effectively inhibits crystallization. This means that with modified PTFE it is possible to combine thermoplastic property components – due to the shorter molecular chains – with the good mechanical properties of standard PTFE.



Physical and Chemical Properties of Unfilled PTFE



Special Characteristics

This material is characterized by a concentration of outstanding properties which is unique in the family of plastics:

- An exceptionally wide thermal application range from -260°C up to +260°C (short-term up to 300°C)
- Virtually universal chemical resistance
- Light and weather resistance
- Hot water vapor resistance
- Very good sliding properties
- Anti-adhesive behavior
- Non-combustible ; LOI > 95
- Good electric and dielectric properties
- No absorption of water
- Physiologically harmless (BgVV, EU and FDA approvals for use with foodstuffs)

Benefits of Modified PTFE

While retaining the positive properties that are typical for PTFE, modified PTFE has additional benefits:

- Cold flow reduced by the factor of 3
- Reduced permeation of chemicals and gases down to half of the PTFE value
- Porosity reduced to half of PTFE's porosity
- Minimum tendency for pore formation during drawing processes
- Suitable for welding, using special methods

Shortcomings

Besides these benefits, unfilled PTFE has a few shortcomings as well:

- Cold flow behavior
- Relatively low wear resistance
- Low resistance to high-energy radiation
- Poor adhesion behavior of PTFE
- PTFE is not suitable for injection or welding processes

Compounds Based on PTFE and Modified PTFE

Fillers are incorporated into PTFE for the following reasons:

- Wear resistance is increased significantly
- Cold flow under load is significantly reduced
- Depending on the type of filler used, thermal conductivity may increase by a multiple
- Thermal expansion is reduced

- If required, the electric properties of the PTFE matrix may be modified by the selection of appropriate fillers
- In addition, the choice of filler influences wear behavior of the mating surface

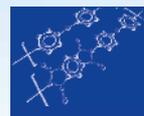
The influences on the ultimate properties of the compound, which may be influenced by both the PTFE matrix and the filler, have been summarized in the following table:

Influencing parameter	Mechanical property	Cold flow	Friction coefficient	Wear	Chemical resistance	Expansion coefficient	Thermal conductivity
<i>Effects when exchanging PTFE for mod. PTFE</i>	→	↘ ↘	→	→	→	→	→
<i>Influence of fillers on the product properties of compounds</i>	↘	↘	↗	↘ ↘	↘	↘	↗

Trends: → Positive
 → Neutral
 ↘ Negative

The direction of the arrows indicates the decrease or increase of the parameter. The color of the arrows describes the influences on the ultimate properties of the compound.

The Most Commonly Used Fillers and their Influences on Compound Properties:



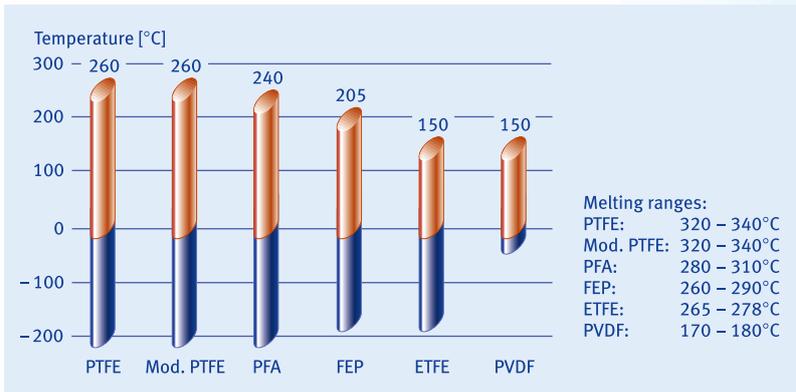
<i>PTFE-Type</i>	<i>Influence of Fillers</i>	<i>Filler Content in % of Weight</i>	<i>Limits of Use</i>
PTFE filled with glass fibers	<ul style="list-style-type: none"> • higher pressure and wear resistance as well as better thermal conductivity • very good chemical resistance • good dielectric properties 	up to 40%	resistant to organic solvents, non-resistant to alkaline solutions and acids
PTFE filled with carbon fibers	<ul style="list-style-type: none"> • very low deformation under load • good wear resistance, even in water • higher thermal conductivity and lower thermal expansion than glass fibers • very good chemical resistance 	up to 25%	carbon fibers are chemically inert
PTFE filled with carbon	<ul style="list-style-type: none"> • high pressure resistance and hardness • good sliding properties and wear behavior • good thermal conductivity • good chemical resistance • low volume and surface resistivity • electrically conductive 	up to 35%, also in combination with graphite	compound is brittle, filler may be attacked by oxidizing media
PTFE filled with graphite	<ul style="list-style-type: none"> • good lubricating effect • low friction coefficient • no static charging • good thermal conductivity • very good chemical resistance 	typically up to 5%, in exceptional cases up to 15%, also in combination with glass fibers or carbon	high abrasion when used with hard metals, is attacked by oxidizing media
PTFE filled with molybdenum disulfite (MoS ₂)	<ul style="list-style-type: none"> • good sliding properties and wear behavior • good no-lube operation in combination with bronze 	up to 10%, also in combination with glass fibers or bronze	not resistant when used with hot, concentrated sulfuric acid
PTFE filled with bronze	<ul style="list-style-type: none"> • good sliding properties and wear behavior • low cold flow • good thermal conductivity • lower chemical resistance • high pressure resistance 	up to 60%, also in combination with MoS ₂	may be attacked by acids and water
PTFE filled with organic fillers (high-performance thermoplastics)	<ul style="list-style-type: none"> • outstanding sliding properties and wear behavior • good chemical resistance • high pressure resistance in some cases • suitable for soft mating surfaces, e.g. aluminum • non-abrasive 	up to 20%, may be higher in combination with different fillers	depending on the respective filler

Thermal Properties

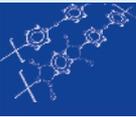
Thermal Resistance

The thermal resistance of PTFE ranges from -260°C up to +260°C, with short-term resistance up to +300°C. (e.g. no brittling in boiling helium at -269°C). This temperature range is not achieved by any other plastic. Permanent service temperatures, however, depend on the respective load and stress factors. With regard to field applications, this means that PTFE exposed to moderate mechanical stress can be used at temperatures from -200°C up to +260°C.

Temperature Limits of Selected Fluoroplastics⁽²⁾



Thermal Expansion of PTFE and Modified PTFE



When designing assembly components the relatively high thermal expansion of these materials must be taken into consideration:

- 10 – 30°C: $\alpha = 21 \times 10^{-5} \text{ 1/K}$
- 30 – 100°C: $\alpha = 11 \times 10^{-5} \text{ 1/K}$
- 30 – 200°C: $\alpha = 13 \times 10^{-5} \text{ 1/K}$
- 30 – 300°C: $\alpha = 19 \times 10^{-5} \text{ 1/K}$

If PTFE assembly components are cooled down from +20°C to -260°C this will result in an app. 2% shrinkage in length.

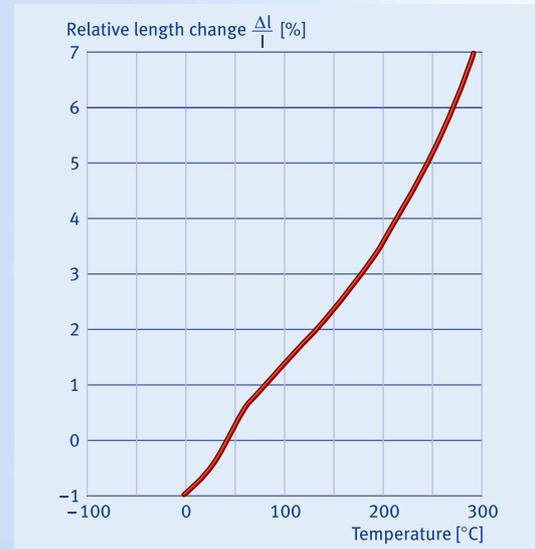
The development of the linear expansion coefficient shows two conspicuous ranges:

- At 19°C there is a transformation within the crystal lattice (<19°C triclinic, >19°C hexagonal).
- At app. 327°C there is an even higher degree of unsteadiness, the crystal melting point

Note

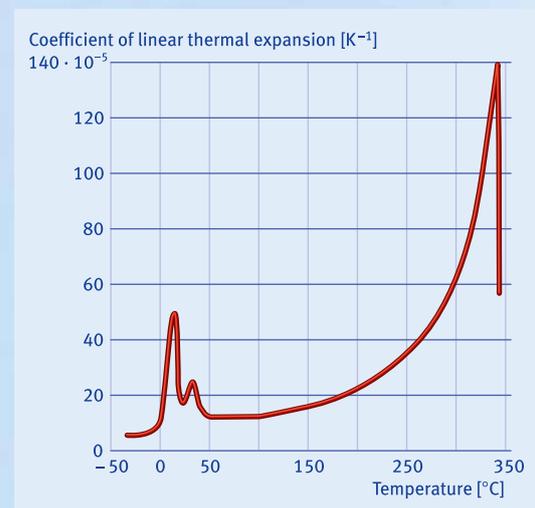
- When performing accurate measurements of PTFE components with narrow tolerance specifications it is imperative to perform the measurements at a temperature of 23 +/- 2°C.
- PTFE compounds generally have a lower thermal expansion. The correlation between temperature and thermal expansion is shown below (see graph on the following page).

Relative change in length of unfilled PTFE depending on temperature⁽²⁾



Crystallite transformation at 19°C (triklinic -> hexagonal)

Linear expansion coefficient of unfilled PTFE depending on temperature⁽²⁾



Crystallite transformation at 19°C (triklinic -> hexagonal)

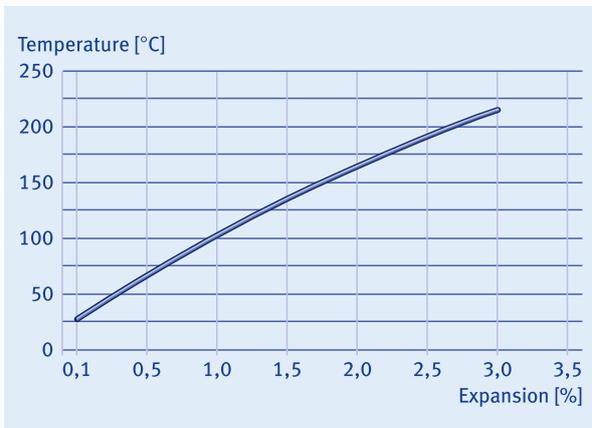
Thermal Properties

Thermal expansion of unfilled PTFE and PTFE compounds, measured lengthwise and crosswise to the pressing direction⁽²⁾

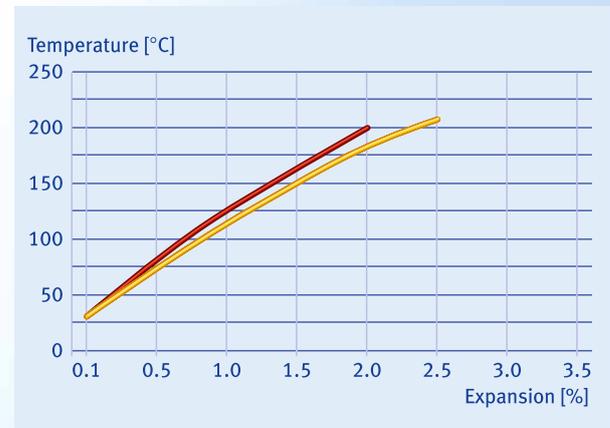
Test piece: diameter 16 mm, length 40 mm

■ *crosswise* ■ *lengthwise* ■ *crosswise = lengthwise*

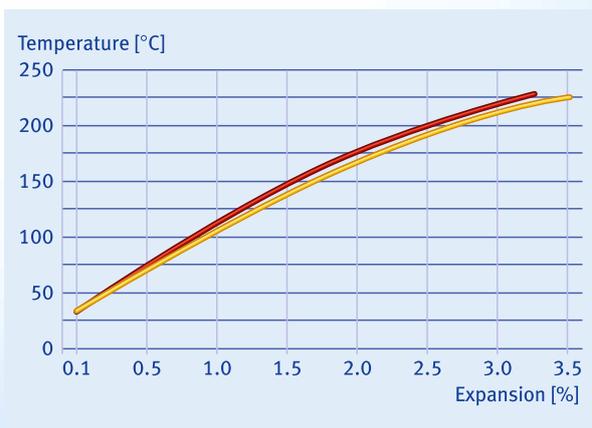
PTFE virgin



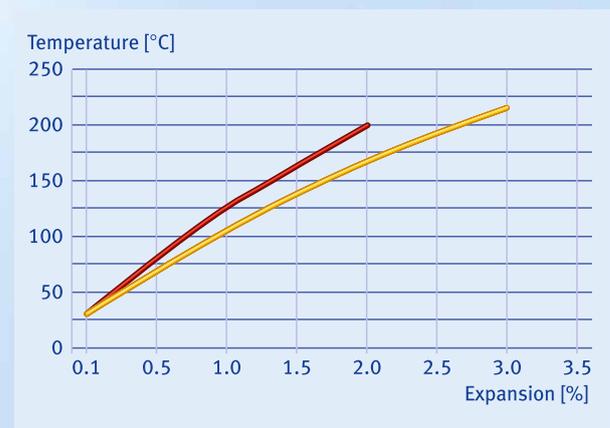
PTFE with 60% bronze

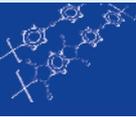


Compound HS 21059

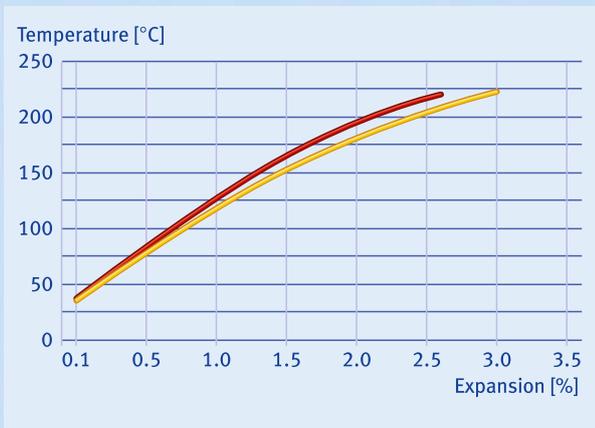


PTFE with 25% glass fibers

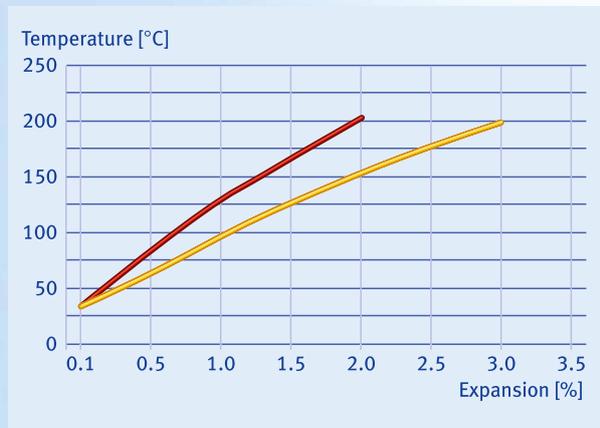




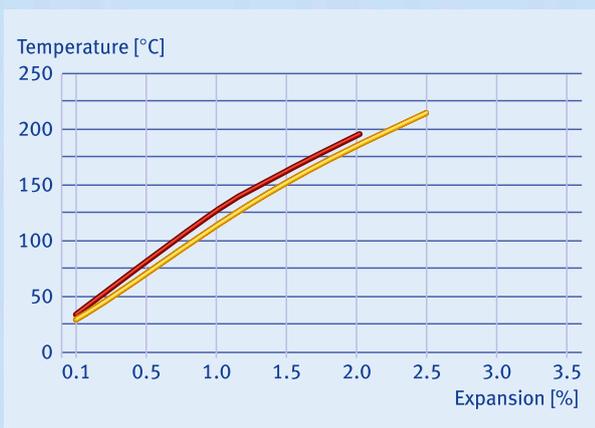
Compound HS 21037



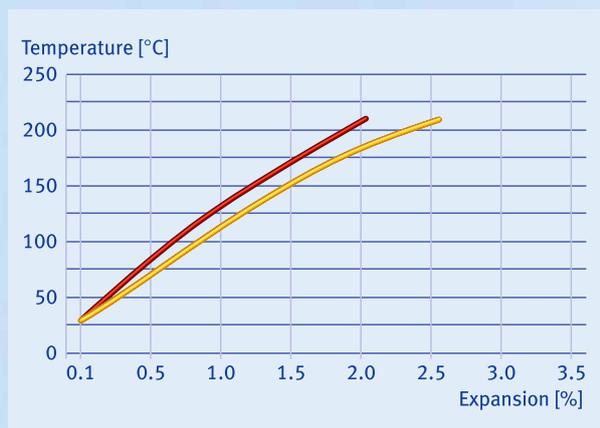
PTFE with 10% glass fibers and 10% graphite



PTFE with 25% carbon



PTFE with 30% carbon and 3% graphite



Chemical and Physical Behavior

Chemical Resistance

The strong fluorine-carbon bonding and the almost complete shielding of the C-atoms by fluorine give PTFE and modified PTFE compounds virtually universal chemical resistance.

- Neither solvents like alcohols, esters and ketones nor aggressive acids (such as fuming sulfuric or nitric acid, hydrofluoric acid, etc.) change the properties of PTFE
- Merely when used in coolants (e.g. Freon (R-12), dichlorodifluoromethanes) a reversible 4 – 10% increase in weight has been measured
- A chemical reaction (browning) of PTFE only occurs with melted or dissolved alkali metals
- At higher temperatures and pressures PTFE reacts with elementary fluoro- and chlorotrifluoride
- Monomers like styrene, butadiene or acrylonitrile can penetrate PTFE or modified PTFE in small amounts, and in the event of conditions triggering a spontaneous polymerization, this may lead to swelling of the material

For these reasons, extensive tables and chemical resistance lists are not required for PTFE.

Light and Weather Resistance

PTFE has outstanding light and weather resistance.

Consequently, PTFE is suitable for outdoor use and use in extreme weather conditions without limitation and without any notable changes to its mechanical or electrical properties.

High-Energy Radiation

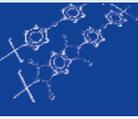
PTFE is not radiation-resistant. Consequently, this plastic material should not be used in areas exposed to radiation. An extremely high dose of radiation may result in the decomposition of PTFE: Due to ruptures in the molecular chain the polymeric properties of the material successively deteriorate. This disintegration can ultimately lead to the release of the monomer and thus the release of gaseous TFE in addition to other corrosive and toxic combinations.

- With an absorbed radiation dose of 102 J/kg the polymeric properties begin to change
- With a radiation dose of $5 \cdot 10^4$ J/kg: reduction of tensile strength by 50-90%. Reduction of ultimate elongation by $> 90\%$

Combustibility

Combustion tests have shown that of all plastic materials fluoro-polymers are the most difficult to inflame. The gaseous disintegration products will only ignite within the range of an external flame. After removing the igniting flame the combustion process stops immediately. The ignition temperature measured on semi-finished PTFE products according to ASTM D 1929 are within the range of 500 to 560°C, the LOI index (oxygen index) is 95%. According to Underwriters Laboratories (UL) the various PTFE types are listed in fire class V-0. The relative electrical and mechanical temperature index (RTI) for PTFE is generally at 180°C.

If a higher value is required for a particular application, a special measurement must be performed.



Water Absorption

PTFE absorbs practically no water. Even after storage in water according to DIN 53472/8.2 no absorption of water has been noted.

Physiological Properties

Unfilled PTFE is physiologically inert. FDA, EU and BgVV approvals have been granted.

For glass fiber compounds as well as for fillers PEEK and PPSO₂ FDA compliance statements are available.

Cyto-toxicity tests have been performed successfully. Consequently, the use of this material is permissible in both medical and food technology applications.

A highly positive characteristic in this respect is the material's resistance to hot vapor, which means that PTFE components used in the medical, pharmaceutical and food industries are well suited for sterilization.

Sliding Properties

Among other factors, the very low intermolecular forces result in PTFE having the lowest coefficient of friction of all solid materials. With PTFE, the static and dynamic coefficient of friction is virtually identical. This means that there is no »stick-slip effect«.

Even at temperatures below 0°C these favorable sliding properties are retained. Starting at 20°C, PTFE's friction coefficient shows a slight increase. Unfilled PTFE and modified PTFE show roughly the same abrasion behavior. With dynamic seals of the same design made from modified PTFE, the surface compression (⇒ radial force) is often higher than with the same seals made from regular PTFE. The reason is that due to lower cold flow the modified PTFE seal does not back away as much nor drops off over time as much as the regular PTFE seal. While this characteristic may result in higher compound abrasion on one hand, it often guarantees effective sealing over a longer period of time on the other. The addition of fillers tends to

increase the coefficient of friction; abrasion, however, is significantly reduced.

Friction coefficients PTFE/cast perlite in no-lube operation⁽¹⁾
($p = 0.2 \text{ N/mm}^2, T = 30^\circ\text{C}$,
 $R_{z, \text{cast perlite}} \leq 1.5 \mu\text{m}$)

PTFE Type	Sliding Speed	
	v = 0.5 m/s	v = 1.0 m/s
PTFE unfilled	0.25	0.27
PTFE +25% glass fibers	0.15	0.15
PTFE +15% graphite	0.14	0.14
PTFE +25% carbon	0.22	0.21
PTFE +60% bronze	0.20	0.22

Wear Behavior

The wear resistance of pure PTFE is relatively low. The reason is that PTFE molecules, due to their complete enclosure by fluorine atoms, are capable of developing merely minimal intermolecular interaction. In the crystalline regions of the material the molecular layers, similar to graphite, can be pushed off layer by layer under tribological load. In the amorphous areas the polymer composite is more stable due to intermolecular interlooping, however, this accounts for no more than roughly 30 vol % of the polymer.

A significant improvement of wear resistance is achieved by fillers such as carbon, graphite, glass and carbon fibers, bronze or organic fillers.

Compared to PTFE with mineral or metallic fillers, the newly developed special compounds, HS 21059, HS 21037 and HS 10300, even in absolutely dry-running operations have clearly improved wear behavior and very low abrasion tendency on the mating surface, even if the mating surface is unhardened.

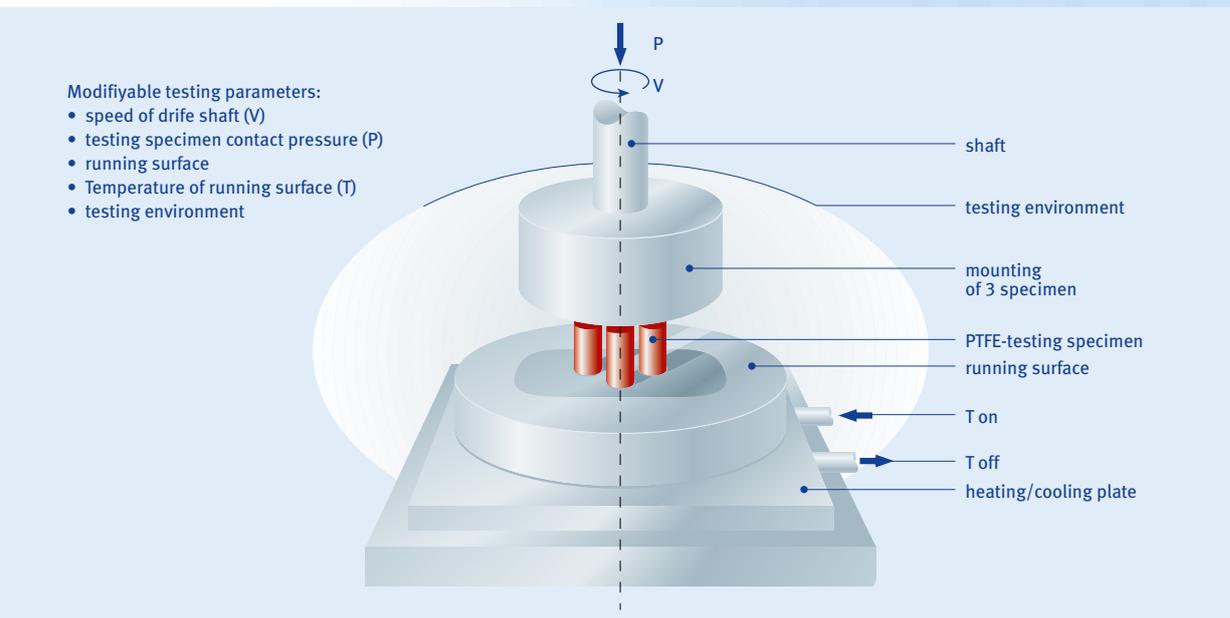
The sliding friction coefficients of the respective mating surfaces are of lesser importance for abrasion behavior. Rather, wear is much more dependent on operating conditions (medium, pressure, speed, temperature, lubrication, surface roughness). Since no PTFE compound is able to meet all requirements, the PTFE compound type best suiting the particular application must be determined.

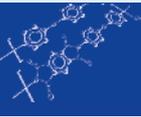
When performing wear tests the fact that every testing method provides its own set of data must be taken into account.

A direct compound comparison therefore is only possible within each particular test method – using identical or similar testing parameters.

The objective should always be to test materials under conditions resembling actual field applications as closely as possible. Elring-Klinger's development labs provide such capabilities.

Long-time test rig





Wear of Unfilled PTFE Compared to Various PTFE-Compounds

Long-term wear in dry-running (oil-free) conditions⁽²⁾

Test conditions:

Test atmosphere: air

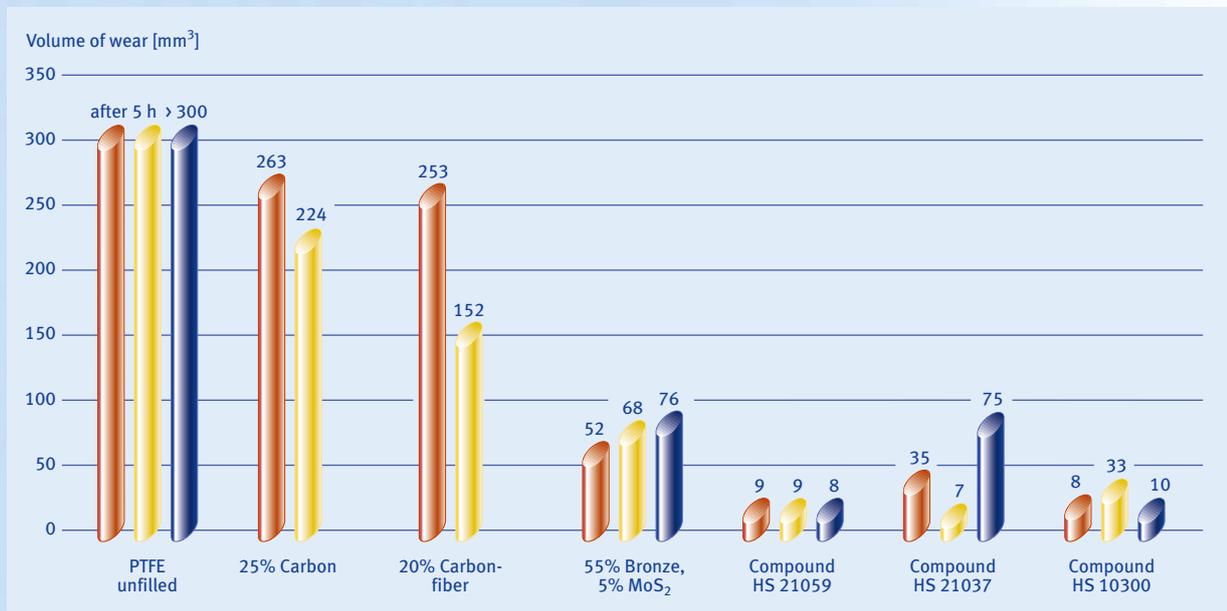
T = 100°C

v = 4 m/s

p = 0.42 N/mm²

Rz = 2 µm

Test period: 100 h

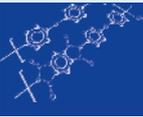


■ X210 Cr12 ■ GG25 ■ Alu hard-anodized

Properties of Fluoroplastics

Physical Properties of PTFE Compared to Fluorothermoplastics⁽¹⁾

Properties	Test method	Unit	Compounds					
			PTFE	PTFE mod.	FEP	PFA	PCTFE	PVDF
Density	ISO 12086	g/cm ³	2.15 – 2.19	2.15 – 2.19	2.12 – 2.17	2.12 – 2.17	2.10 – 2.20	1.76 – 1.78
Tensile strength 23°C	ISO 12086	N/mm ²	22 – 40	22 – 40	18 – 25	27 – 29	30 – 38	38 – 50
Ultimate elongation 23°C	ISO 12086	%	250 – 500	400 – 700	250 – 350	300	80 – 200	30 – 40
Ball indentation hardness 23°C	ISO 12086	N/mm ²	23 – 32	23 – 32	23 – 28	25 – 30	30	65
Yield strength 23°C	ISO 12086	N/mm ²	10	11	12	14	40	46
Tensile E-modulus 23°C	ISO 12086	N/mm ²	400 – 800	440 – 880	350 – 700	650	1000 – 2000	800 – 1800
Bending E-modulus 23°C	ISO 12086	N/mm ²	600 – 800	660 – 880	660 – 680	650 – 700	1200 – 1500	1200 – 1400
Bending stress limit 23°C	ISO 12086	N/mm ²	18 – 20	18 – 20		15	52 – 63	55
Shore hardness D 23°C	ISO 12086		55 – 72	55 – 72	55 – 60	60 – 65	70 – 80	73 – 85
Melting temperature	ASTM 2116	°C	327	327	253 – 282	280 – 310	185 – 210	165 – 178
Permanent service temperature, unloaded		°C	260	260	205	260	150	150
Thermal expansion coefficient 10 ⁻⁵	DIN 53752	K ⁻¹	10 – 16	10 – 16	8 – 14	10 – 16	4 – 8	8 – 12
Thermal conductivity 23°C	DIN 52612	W/K · m	0.25	0.25	0.2	0.22	0.19	0.17
Specific heat 23°C		KJ/kg · K	1.01	1.01	1.17	1.09	0.92	1.38
Oxygen index		%	>95	>95	>95	>95	>95	>43
Water absorption	DIN 53495	%	<0.01	<0.01	<0.01	<0.03	<0.01	<0.03



Physical Properties of Unfilled PTFE Compared to Various PTFE Compounds⁽¹⁾

Properties	Test method	Unit	Compounds							
			PTFE unfilled	PTFE + 60% bronze	PTFE + 10% AP* + 1% carbon black	PTFE + 25% glass fiber	PTFE + 15% graphite	PTFE + 10% glass fiber + 10% graphite	PTFE + 25% carbon	PTFE + 30% carbon + 3% graphite
Density	ISO 12086	g/cm ³	2.15	3.85±5%	2.04±3%	2.23±3%	2.16±3%	2.17±3%	2.09±3%	2.0±4%
Tensile strength 23°C	ISO 12086	N/mm ²	≥ 25	≥ 12	≥ 14	≥ 14	≥ 12	≥ 14	≥ 13	≥ 10
Ultimate elongation 23°C	ISO 12086	%	≥ 280	≥ 120	≥ 160	≥ 160	≥ 120	≥ 200	≥ 100	≥ 60
Ball indentation hardness 135/60 23°C	ISO 12086	N/mm ²	≥ 22.6	≥ 33	≥ 32	≥ 27	≥ 28	≥ 30	≥ 34	≥ 40
Specific resistivity	DIN VDE 0303 Teil 30 IEC 93	Ω·cm	>10 ¹⁸			>10 ¹⁵	>10 ¹⁰	>10 ¹²	>10 ²	
Surface resistivity	DIN VDE 0303 Teil 30 IEC 93	Ω	>10 ¹⁷			>10 ¹⁵	>10 ¹¹	>10 ¹²	>10 ²	
Thermal conductivity	DIN 52612	W/m · K	0.25	0.6 – 0.8	–	0.4 – 0.5	0.7 – 0.9	0.4 – 0.6	0.5 – 0.7	0.6 – 0.8
Thermal expansion	see Thermal expansion curves page 11 to 13									

*AP = aromatic Polyester

For applications in gaseous or liquid oxygen, please ask for our special PTFE types with BAM test.

Properties of Fluoroplastics

Electric Properties⁽¹⁾

The following table summarizes some of the electric characteristics of fluoroplastics.

Properties	Test method	Unit	Compounds				
			PTFE	FEP	PFA	PCTFE	PVDF
Dielectric constant	DIN 53483	10 ³ Hz	2.1	2.1	2.06 – 2.1	2.5 – 2.8	7.8 – 9.0
		10 ⁶ Hz	2.1	2.1	2.06 – 2.1	2.3 – 2.4	6.4 – 7.6
Dielectric loss factor	DIN 53483	10 ³ Hz · 10 ⁻⁴	0.3	2 – 8	0.2	250 – 300	120 – 200
		10 ⁶ Hz · 10 ⁻⁴	0.7	2 – 8	0.8	80 – 120	1500 – 1900
Specific resistivity	DIN 53482	Ω · cm	10 ¹⁸	10 ¹⁸	10 ¹⁸	10 ¹⁸	10 ¹⁵
Surface resistivity	DIN 53482	Ω	10 ¹⁷	10 ¹⁶	10 ¹⁷	10 ¹⁵	10 ¹³
Resistance to tracking	DIN 53480		KA 3c	KA 3c		KA 3c	KA 1
Dielectric strength	DIN 53481	KV/mm	40 – 80	50 – 80	50 – 80	50 – 70	40 – 80

It is remarkable that the specific volume resistivity of PTFE remains nearly constant up to app. 150°C.

Another, particularly interesting, property of PTFE is its low dielectric constant and low dielectric loss factor.

The dielectric strength of a non-porous PTFE film with a thickness of 0.2 mm is app. 60 KV/mm. When using modified PTFE, the dielectric strength with this film thickness may increase to app. 100 KV/mm.

When measuring the dielectric strength of thicker films a higher test voltage must be applied. This changes the disruptive discharge mechanism, e.g. as a result of humidity or ionization processes. Empirical values for the dielectric strength of films/sheets with a thickness of a few millimeters are within the range of 30 – 40 KV/mm; in the case of modified PTFE slightly higher.

Chemical and Physical Behavior



Adhesive Behavior

Adhesivity of pure PTFE is very low (anti-adhesive), which is attributable to the shielding of the carbon chain by the fluorine atoms and their low polarization capabilities. As a result, wetting of PTFE is difficult (contact angle with water 126°).

This property basically applies to PTFE compounds as well, though to a lesser extent. The wetting behavior of highly filled compounds may differ significantly from unfilled PTFE. This applies to both water and other solvents as well as to adhesives.

Benefit

- No adhesion of media with assembly component linings, sheathing, etc.

Shortcoming

- Wetting difficulties preclude adhesive bonding of PTFE in this state

Adhesive Bonding Capability

Low intermolecular forces and the low polarization capabilities of the fluorine atoms are the reasons why PTFE offers poor adhesive bonding capabilities. Adhesive bonding therefore requires a chemical pre-treatment of the surface, e.g. by sodium dissolved in ammonia.

Weldability

Yet PTFE may be welded as well under certain conditions. In this case, a PFA hot melt adhesive is used as the coating connecting the two PTFE surfaces.

Modified PTFE may also be welded without any welding aids. For thin films/sheets, rail-type contact welding equipment capable of applying the required temperatures of app. 350°C is suitable.

Thicker profiles require a special welding process: in the contact zone the two mating surfaces are fused by a local temperature cycle similar to a standard sintering curve.

Benefit

- PTFE surface does not have to be etched

Shortcoming

- Fusion occurs only at very high temperatures 325 – 335°C (≅ crystallite melting temperature of PTFE)

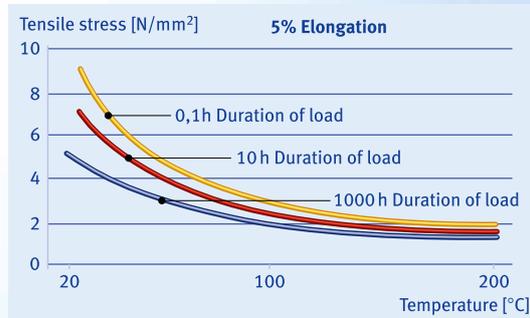
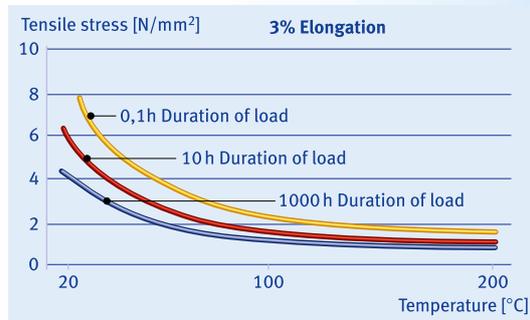
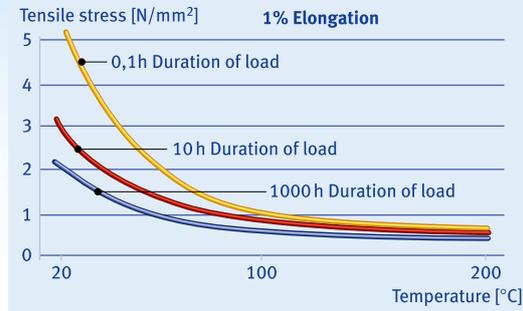
Physical Behavior

Cold Flow Properties

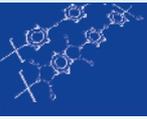
PTFE migrates – i.e. flows – under constant tensile or compression stress as early as at room temperature. This property depends on the level of compression or tensile stress applied, the period of exposure to such stress as well as on temperature.

Due to these properties PTFE parts exposed to higher stress or load levels are either enclosed, thus preventing migration, or PTFE compounds with clearly improved pressure resistances are used. The utilization of modified PTFE is another suitable measure to reduce cold flow.

Stress-Strain Diagrams for Unfilled PTFE⁽²⁾



Mechanical Properties

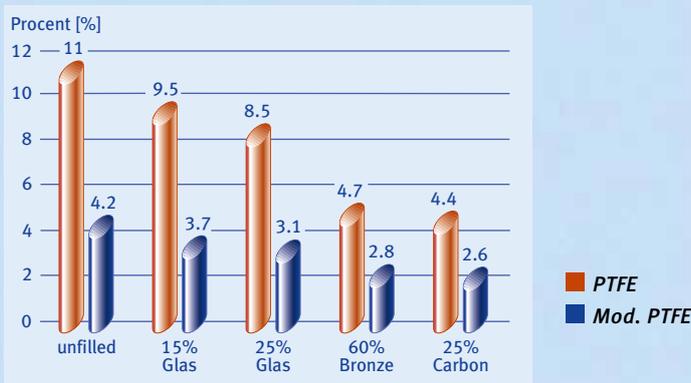


Deformation under Load (Cold Flow) of PTFE Compounds and Compounds Based on Modified PTFE

The characteristic values for compression stress, which occurs more frequently than tensile stress in field applications, are shown in the following diagrams. These graphs clearly show the lower deformation of PTFE compounds with glass fiber, carbon or bronze fillers. When evaluating cold flow it is obvious that there is a significant gain in performance when using compounds based on modified PTFE.

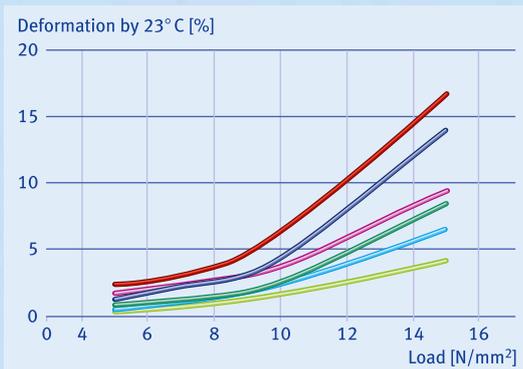
Deformation under load according to ASTM D621⁽²⁾

(15 N/mm², 100 h load + 24 h restoring time (= permanent deformation), 23°C, compressed specimen: Ø 10 mm, 10 mm high)



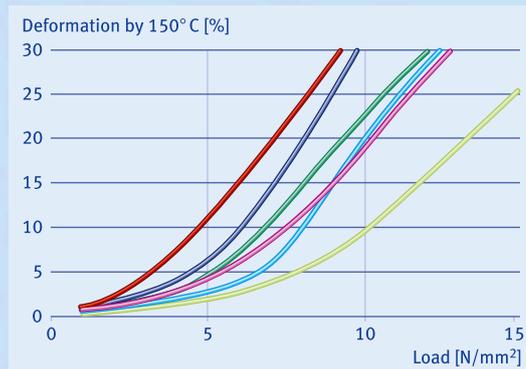
Deformation under load of PTFE, PTFE Compounds and the Modified Alternatives⁽²⁾

Test temperature: 23°C
Test cycle: 100 h, no restoration



Deformation under load of PTFE, PTFE Compounds and the Modified Alternatives⁽²⁾

Test temperature: 150°C
Test cycle: 100 h, no restoration

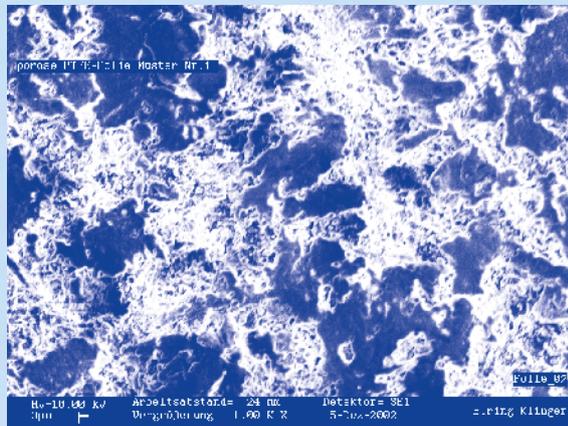




Porous PTFE for Optical Applications and Media Separation

By using a special compression molding and sintering process it is possible to produce porous PTFE.

The size of the pores is spread statistically in a range between 1 and 20 μm . The average pore diameter is app. 2 μm with versions subjected to higher compression, and app. 6 μm with more permeable settings.



Scanning electron microscopy image of P 150 (example):

Statistical spreading of pore sizes by formation of 'gussets' during compression molding of largely pre-sintered PTFE; incomplete flow of the particles during the sintering process

The picture shows the structure of this new type of porous material: One of the major characteristics of this material is its high mechanical strength, which enables 'self-supporting' engineering solutions. In this regard, it has an advantage over competitor products which are unsintered and therefore highly mechanically fragile.

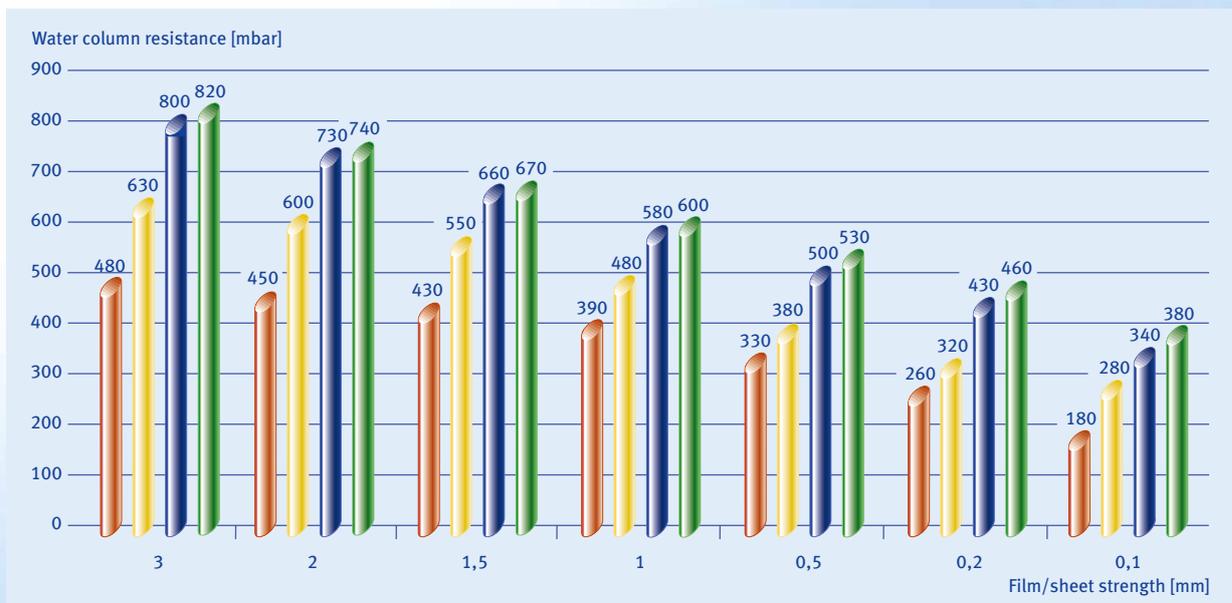
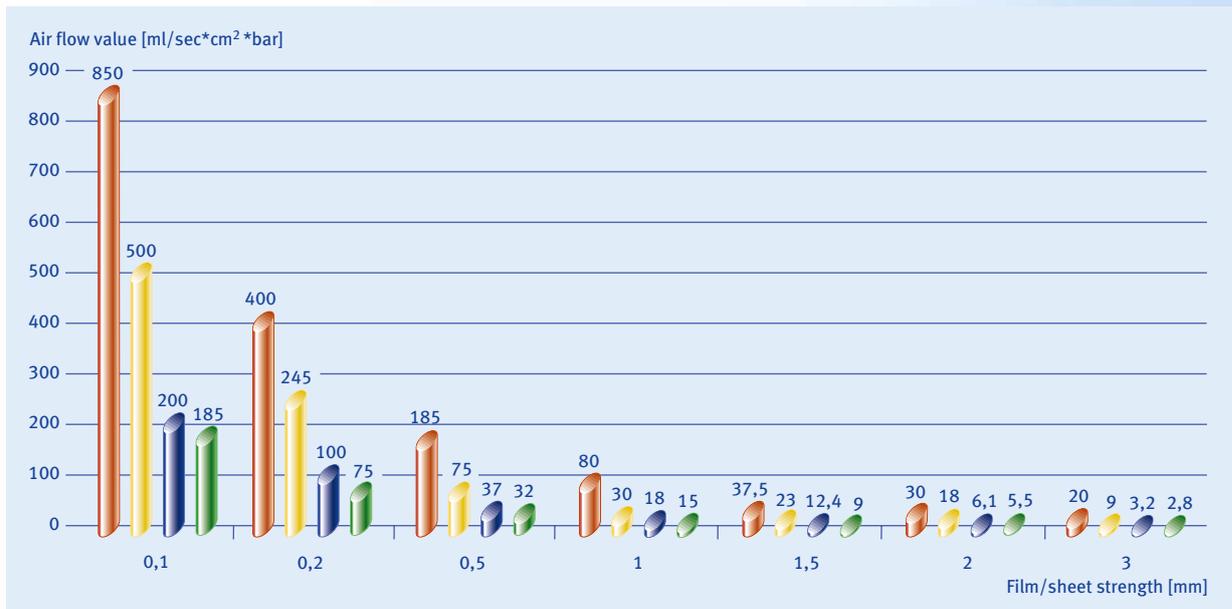
Applications

Applications of porous PTFE for media separation, characterization of porous PTFE materials

Air permeability and water column resistance are the standard parameters used to characterize porous PTFE for media separation applications.

For film and sheet thicknesses in the range between 0.1 to 3.0 mm and “pore values” ranging from P 60 to P 200 the values are as follows:

Air Permeability and Water Column Resistance of Porous PTFE⁽²⁾



■ P 60 ■ P 100 ■ P 150 ■ P 200

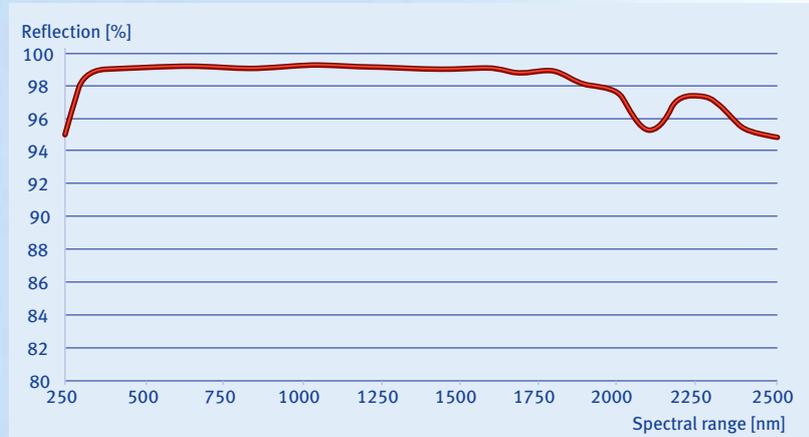
Optical Applications of Porous PTFE

Porous PTFE is also superbly suited for optical applications because of its high reflective capabilities in the UV, the visible and the near infrared range. In the spectral range between 250 – 2000 nm the reflective capacity is nearly constant and thus independent of wavelength.

Typical applications are Ulbricht integrating spheres to measure diffuse reflection and stray transmission, to characterize light sources (e.g. light bulbs or LEDs), or to measure the power of lasers, laser diodes and LEDs).



The Reflection Spectrum of Porous PTFE in the Spectral Range from 250 – 2500 nm⁽²⁾



In addition to these applications, porous PTFE is used for Lambertian reflectors and diffusers. These, for example, are used as reflection normals, base material for integrating spheres, projection walls or detection sensors and optical attenuators.

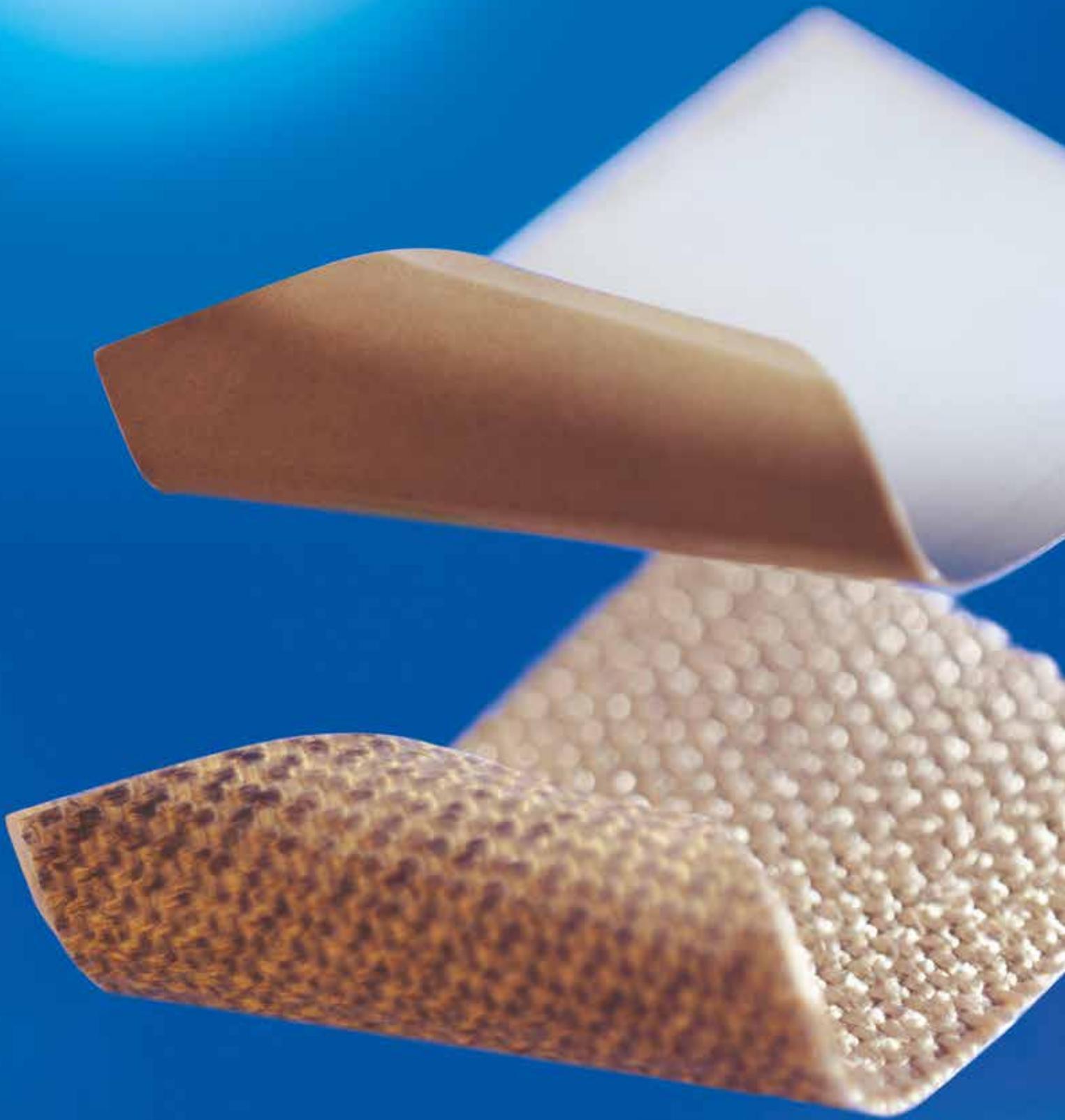


Availability of Porous PTFE

Typical forms of application are films and sheets ranging in thickness between 0.1 and 3.0 mm; however, it is also possible to manufacture plates of virtually any desired thickness. The film or sheet width is usually within the range of 100 mm for lower P-value settings but may reach widths of up to app. 1300 mm with P 250. Particularly for filters or optical applications, 'anything is possible' that can be manufactured from the semi-finished products described above by means of cutting technology.

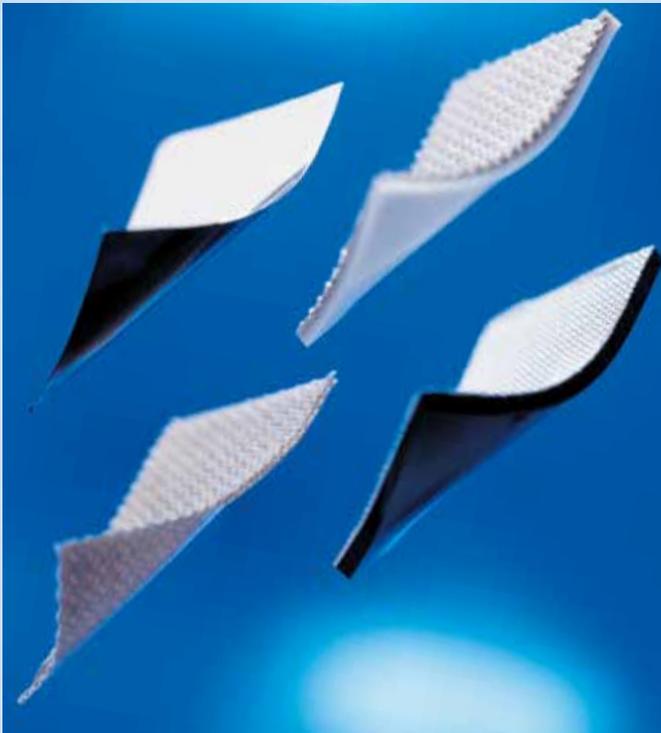
Filter inserts requiring high strength levels in the fitting area can be produced from a material combination: "compact PTFE in the fitting area – porous PTFE in the filter area."





Laminates Based on PTFE and Modified PTFE

Laminates are reinforced PTFE, consisting of a PTFE film, sheet or plate on one hand and a substrate on the other. The layers of material are firmly bonded to each other. Possible substrates include fabrics, fibers or knitted fabrics as well as films or sheets.



They consist of glass, metal, ceramics, elastomers or high-performance polymers. Constructions with up to 7 layers are not uncommon.

Sheet made from conductive PTFE or modified PTFE, laminated with a glass fabric. Lamination with a carbon fiber fabric is possible, as well, for improved chemical resistance, particularly in hydrofluoric acid applications.



Areas of Application

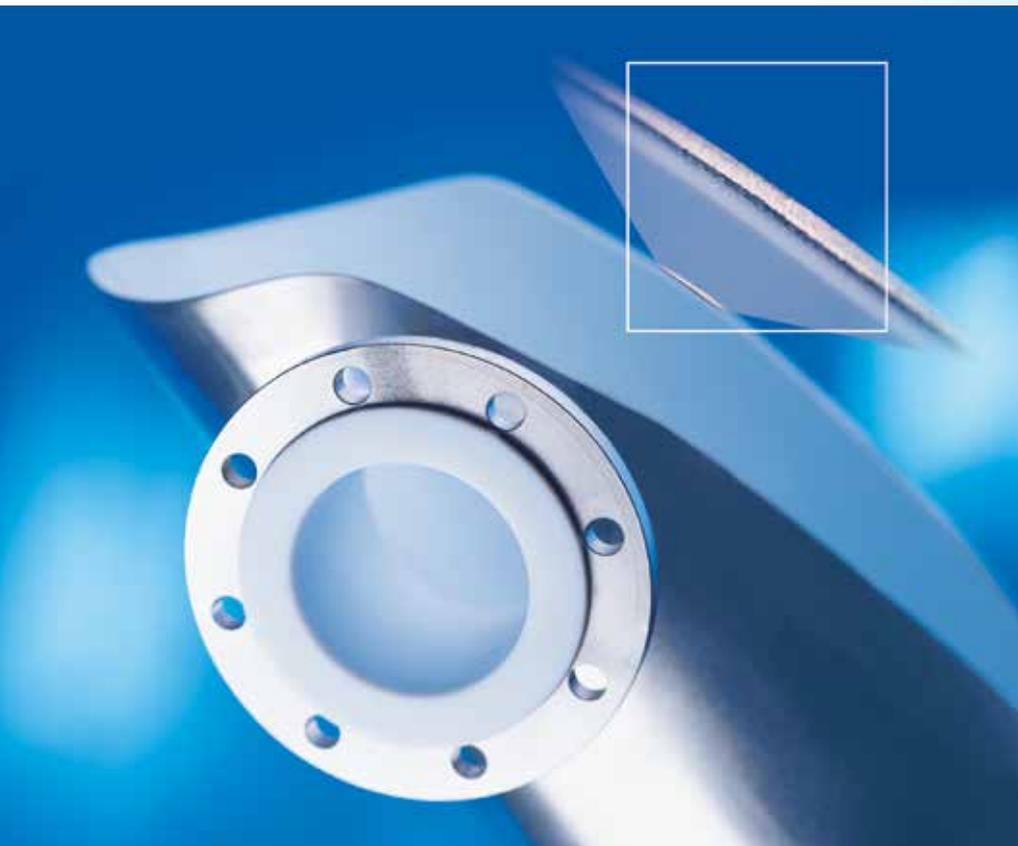
Typical applications include linings for plant and equipment engineering, assembly components for electrical and electronic applications, diaphragms in pump and sensor engineering or optically permeable composite for textile architectural projects.

Laminates based on standard PTFE excel with regard to the following properties:

- Outstanding resistance to a wide range of chemicals
- Very broad service temperature range. Upper limits are merely set by the resistance of the adhesive used
- Very good anti-adhesion properties
- Resistance to deformation and stress cracking
- No embrittling, no aging

When using modified PTFE as a film or sheet material these properties are improved further by:

- Polymer structure with higher density and fewer pores
- Lower permeability
- Better weldability



Structure and applications of laminates based on PTFE and modified PTFE illustrated by the example of a tank lining.

XYMON, an All-New Type of Fluoropolymer Compound

Xymon – ElringKlinger’s new composite material based on fluoroplastics – is far superior to conventional PTFE compounds in terms of its mechanical values, with no sacrifice made to its outstanding chemical properties.

Properties

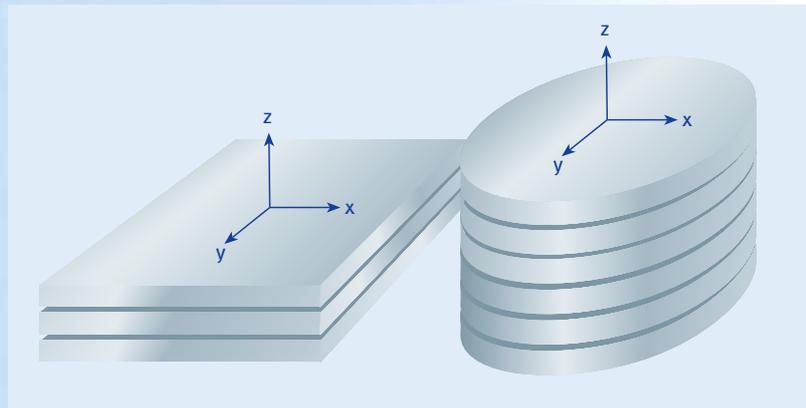
- Virtually universal chemical resistance
- Extremely high tensile strength
- High pressure resistance
- Superior cold flow resistance
- High abrasion resistance

Application examples

- Valve seals
- Bearings
- Fittings
- Valve seats
- Flat seals/gaskets
- Pump vanes
- Valve components
- Piston rings
- Automotive seals

Synthesis

Xymon is a fluoropolymer compound reinforced by long carbon fibers (C-fibers) with an anisotropic property profile. It is manufactured as a plate, disc or ring. The main orientation of the long carbon fibers is in the xy-plane:



All fibers are evenly dispersed in the xy-plane.

Compared to unfilled PTFE or typical compounds with carbon or glass fiber fillers, there is an immense gain in properties, measured parallel to the fiber orientation:⁽¹⁾

	XYMON UC-3000	XYMON UC-1500	PTFE 25% carbon	PTFE 25% glas fiber	PTFE unfilled
Elasticity modulus	10000 MPa*	5000 MPa*	–	800 MPa	750 MPa
Tensile strength	60 MPa*	45 MPa*	15 MPa	17 MPa	33 MPa
Deformation under load	< 1%	< 2%	8.5%	14%	15%

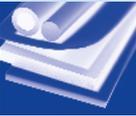
* Parallel to fiber orientation.

Chemical Resistance

The very good resistance of the C-fibers and the fact that they are tightly enclosed by the fluoropolymer give Xymon its unique resistance which closely approaches that of pure PTFE. The material may be used, for example, in hydrofluoric acid, hydrochloric acid, phosphoric acid, mineral oils, tetrahydrofuran and many other media.



Semi-Finished Products – High-Performance Variety for Further Processing



ElringKlinger Kunststofftechnik offers semi-finished products as films/sheets, plates, rings, rods and tubes. The complete product offering is available in four different material versions:

- Virgin PTFE
- Virgin modified PTFE
- Compounds
- Porous PTFE

Compounds-semi-finished products

There is a differentiation made between compounds with anorganic fillers – such as glass fibers, glass pellets, carbon, carbon fibers, bronze, molybdenum disulfide, graphite – and compounds with organic fillers. These include polyimide (PI) polyphenylenesulfide (PPS), polyphenylenesulfidedioxide (PPSO₂), polyetheretherketone (PEEK) polyamideimide (PAI) or aromatic polyesters (Econol®, SumikaSuper®).

On request, compounds tailored to virtually any requirement can be produced. Thanks to our in-house compounding we offer app. 500 different compounds.

Unless stated otherwise or specified by the customer, semi-finished products are produced on the basis of non-free-flowing compounds.

This assures full exploitation of the quality that can possibly be achieved by the basic compound.

Porous PTFE

In case of porous PTFE, density, porosity, air flow value or water column resistance can be varied across a wide range and adapted to specific customer requirements.

Approvals and Regulations

For critical applications, special approvals are often required. Thanks to the preferential use of high-grade raw materials – both in terms of the PTFE matrix and the fillers – ElringKlinger Kunststofftechnik supports applications by providing specific certificates, such as for uses involving contact with foodstuffs or the presence of oxygen.

In addition, compliance – to the extent applicable – is confirmed for EU Directives, such as 2002/95/EG (RoHS) and 2002/96/EG (WEEE) as well as many other requirements regulated by KTW, USP Class VI, 3-A Sanitary, NSF, VDA, WRAS or GADSL.

Pages 39 and 40 show examples of various types of PTFE and PTFE compounds and the extent to which they have been awarded BgVV, EU, FDA and BAM approvals/test.

Products

Unless stated otherwise, applicable GKV values for physical properties and tolerances are those most recently issued.

With porous PTFE, the material properties can be adjusted in the following ranges:

<i>Property</i>	<i>Dimension</i>	<i>Minimum</i>	<i>Maximum</i>
Density	g/cm ³	1.20	1.80
Porosity	Vol. %	40	20
Air flow value (1 mm)	ml/sec x cm ² x bar	100	10
Water column (1 mm)	mbar	300	700

Due to the reduced physical properties, particularly of the highly porous versions of this product line, the maximum dimensions which can be produced may turn out to be smaller than those stated below for “compact” PTFE or compounds.

Films/Sheets

Films or sheets are semi-finished products with a maximum thickness of 5 mm, which are skived from blocks.



Available Dimensions

<i>Thickness (µm)</i>	<i>Width Min. (mm)</i>	<i>Width Max. (mm)</i>
30 – 100	10	300
100 – 5000	10	1600

Plates

Plates are available with thicknesses ranging from 6 – 150 mm in the following standard dimensions:

<i>Length (mm)</i>	<i>Width (mm)</i>
300	300
500	500
620	620
1000	500
1000	1000
1200	300
1200	1200
1500	1500
2000	1000
2000	500
3000	1000

Due to the availability of single plate tools a wide range of special dimensions can be fabricated according to customer specifications.

Please note:

Skive films/sheets and standard plates with thicknesses between 0.5 – 50 mm are available in PTFE ex factory!

Rings

A total of over 2,500 tool combinations are on hand to cover the ring diameter range from 30 mm up to 3000 mm. Ring heights of up to 80 mm are standard; heights of up to 150 mm are available on request.

If required, rings up to 3000 mm can be cut to final dimensions.

Hollow Cylinders

Hollow cylinders are cylinders with a core bore of 150 mm.

The following dimensions are available

Max. outer diameter (mm)	Max height (mm)
600	1600
700	150
1500	70

Solid Rods

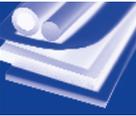
Compression-molded solid rods can be manufactured in the following dimensions:

	Diameter (mm)	Length (mm)
Minimum	80	1000
Maximum	500	1000

Isostatically Compression-Molded Tubes and Special Parts

ElringKlinger Kunststofftechnik has isostatic compression molding machines in various dimensions. They enable the manufacture of isostatically compression-molded rods and special parts up to the following dimensions:

Max. diameter (mm)	Max. height (mm)
400	1500
700	1100



Approvals and Regulations (Product Stewardship)

ATEX

ATEX Directive 94/9/EC (Equipment Directive)

On July 1st, 2003 ATEX Directive (Atmosphères Explosibles = potentially explosive atmospheres) 94/9/EC came into effect as the national European standard EN 13436, requiring even non-electrical equipment for explosion-hazardous areas to be approved across Europe. The ATEX directive regulates explosion protection of non-electrical systems, equipment and components in potentially explosive areas and thus sets forth the requirements to be met by equipment manufacturers.

Atmospheres are deemed potentially explosive if they tend to be explosive due to ambient and operating conditions. The ATEX directive defines an explosive atmosphere as a “mixture of combustible substances in the form of gases,

vapors, mist or dust and air in atmospheric conditions in which the combustion process after ignition is transmitted to the entire unburned mixture“.

ATEX compliance certificates pertain to equipment and components. For materials, respective certificates are not required, however, raw material manufacturers provide relevant material parameters to support ATEX applications.

Definition of Materials and Nominal Ratings

In addition to the effort involved in identification/labeling, declaration of EC compliance, acceptance and certification of ATEX-compliant equipment, the primary focus of manufacturers is on the selection of suitable materials. One of the key criteria for material selection is the avoidance of electro static discharge (ESD) between objects with different electric potentials. Electro static discharges result in electric arcs which ignite an explosive atmosphere. The resulting component damage amounts to millions of dollars or euros every year. One of the measures to prevent this is the use of materials with special physical properties, particularly with specific electrostatic dissipation properties. Selecting suitable materials with the requisite properties is the responsibility of the component manufacturer, dependent on the respective equipment category.

Nominal material ratings for ATEX applications are as follows:

- Name of material
- Mechanical properties (bending strength, tensile strength)
- Temperature resistance (TI)
- Electric properties (resistance to tracking, surface resistivity, electric strength, flammability, light resistance, chemical resistance)

PTFE and PTFE Compounds for ATEX Applications

PTFE and PTFE compounds are a suitable choice for ATEX applications: High-grade PTFE and PTFE compounds qualify for ATEX applications due to their excellent long-term temperature resistance, chemical resistance and stability vis-à-vis UV radiation (light resistance).

LOI values and a “UL 94 Flame Class“ rating of 94V-0 also qualify these products at a very high level with regard to flammability.

High-grade conductive PTFE compounds are available, which meet electric requirements (resistance to tracking, surface resistivity and electric strength). Temperature resistance is at a high level as well, i.e. in the range of 180°C (RTI values according to UL).

If higher RTI values are required for special applications, these must be determined by separate measurements.



PTFE and PTFE Compounds in Contact with Food

Basic Legal Requirements for Food Contact

Within the EU, the basic legal requirements pertaining to materials or objects coming into contact with foodstuffs are determined by the EU system and the directives of the European Commission as well as the respective national law of the member countries. In view of the progress which has been made with harmonization, applications in the plastics sector are increasingly subject to EU directives.

The world's leading regulatory system for food applications is that of the U.S. Food and Drug Administration (FDA). Any company planning to market components coming into contact with foodstuffs should, irrespective of their target market, consider the two major regulatory systems, i.e. the EU and FDA, as well as country-specific regulations.

In Germany, the legal requirements to be met by materials or objects coming into contact with foodstuffs are set out in the "Consumer Goods and Supplies Regulation" (Bedarfsgegenständeverordnung - LMBG). Furthermore, the plastics recommendations issued by the former "Federal Institute for Consumer Health Protection and Veterinary Medicine" (Bundesinstitut für gesundheitlichen Verbraucherschutz und Veterinärmedizin – BgVV) are applied. This institute was dissolved effective November 1st, 2002. The newly created Federal Institute for Risk Assessment (Bundesinstitut für Risikobewertung – BfR) assumed the responsibility for food safety and consumer protection. According to current knowledge, BgVV plastics recommendations will be succeeded by the EU system in conjunction with the EU harmonization process by 2005.

Migration (Release of PTFE and Compound Components)

Of the polymer components of PTFE and PTFE compounds, the following may migrate specifically:

Virgin PTFE (Migration)

Of virgin PTFE components, the following may migrate:

- Monomers (such as TFE, HFP and PPVE)
- Monomers which have not reacted: oligomers with low molecular weight

Of virgin PTFE components, the following are "usually" incapable of migration:

- Additives (usually migrating with other polymers)
- Virgin PTFE types are "usually" produced without additives and are absolutely free of
 - additives such as antioxidants, lubricants, plasticizers as well as stabilizers (flame-retardant additives, UV absorbers)

Virgin PTFE Compounds (Migration)

Of virgin PTFE compound components, the following may migrate:

- Monomers (such as TFE, HFP and PPVE)
- Monomers which have not reacted: oligomers with low molecular weight
- Additives (e.g. glass fiber, graphite as well as E-carbon components)

Due to the properties of PTFE described above (migration behavior) and excellent purity criteria (free of antioxidants, lubricants, plasticizers and stabilizers such as flame-retardant additives and UV absorbers), PTFE is the preferred material for applications making maximum demands on purity and physiological harmlessness regarding contact with foodstuffs as well as pharmaceutical applications and those requiring bio-compatibility.



Consequences for Finished Product Manufacturers

- The migration values furnished by the polymer manufacturer are provided for information only; the responsibility rests with the entity putting the finished product on the market.
- Limits (such as SMLs, OMLs...) are beyond the control of the polymer manufacturer, since this manufacturer has no influence on
 - modifications of the material and production process control
 - the form of the finished article or the
 - parameters influencing the intended application such as (type of food, temperatures, exposure time and dosage...)

The following table provides information on PTFE and PTFE compounds suitable for contact with foodstuffs as regards the aforementioned regulatory systems, i.e. EU law, LMBG and FDA. For all applications, confirmations must be obtained from the raw material manufacturers on a case by case basis.

<i>Product Description</i>	<i>Compliant with</i>		
	<i>BgVV</i>	<i>EU</i>	<i>FDA</i>
Virgin PTFE, standard PTFE (S-PTFE)	•	•	•
Virgin PTFE, modified PTFE (S-PTFE modified)	•	•	•
Virgin PTFE emulsion/paste (E-PTFE)	•	•	•
Virgin PTFE modified PTFE (E-PTFE modified)	•	•	•
PTFE – E-carbon compound	•	•	–
PTFE – graphite compound	•	•	–
PTFE – carbon – graphite compound	–	–	–
PTFE – glass fiber compound	•	•	•
PTFE – glass fiber compound – graphite compound	•	•	–
PTFE conductivity compound	•	•	–
PTFE conductivity compound (FDA)	•	•	•
PPTFE – bronze compound	–	–	–

Notes

- 1) Table is provided for information and orientation only, none of the information provided may be used as confirmation or certification of compliance with applicable food regulations.
- 2) Products marked “•“ “may” comply with the regulatory system pertaining to foodstuffs, however confirmations/certification of compliance with food regulations must be obtained from the raw material manufacturers.

PTFE and PTFE Compounds in the Presence of Oxygen (BAM)

Due to their excellent properties related to contact with oxygen PTFE and PTFE compounds are suitable for versatile uses in systems and equipment operating with oxygen, such as sealing elements for fittings (valves and pressure regulators), and in flange and threaded connections for piping.

Materials and components intended for use in systems and equipment operating with oxygen must be suitable from the perspective of safety engineering and are therefore subjected to special tests.

Many materials that are not combustible in the normal atmosphere will burn in a high-oxygen atmosphere: aside from highly flammable substances like oil and grease, rubber and plastic, aluminum, steel and brass can burn in oxygen as well.

BAM – Test Procedures for Sealing Materials

Over the past five decades, the Federal Institute for Material Research and Testing (Bundesanstalt für Materialforschung und -prüfung – BAM) as a trade association-approved institute for testing has developed test procedures and evaluation criteria for the safe operation of oxygen systems and equipment as well as for testing and evaluating non-metallic sealing materials and seals:

1. Ignition temperature in compressed oxygen
2. Aging resistance in compressed oxygen
3. Impact of oxygen pressure surges
4. Tests of flat seals/gaskets in flange connections
5. Reactivity with liquid oxygen in case of impact stress

These test procedures enable determinations to be made of the permissible operating conditions with regard to safety.

PTFE and PTFE Compounds for Applications in Contact with Oxygen

BAM tests “non-metallic materials” from PTFE and PTFE compounds for specific areas of application in oxygen systems and equipment.

The BAM tests commissioned by raw material manufacturers are normally intended to provide test results for orientation only.

For special applications, the respective report must be obtained from the raw material manufacturer.



IMDS The International Material Data System

Background (EU Directive 2000/53/EC on End-of-Life Vehicles)

The International Material Data System (IMDS) was introduced based on national and international environmental legislation requiring every manufacturer to assume responsibility for the environmental impact of its products (EU Directive 2000/53/EC on End-of-Life Vehicles, Kreislaufwirtschaftsgesetz (Recycling Industry Act), ISO 14040ff, Integrated Product Policy ...).

To comply with this requirement, manufacturers must have exact knowledge of the composition of automotive assembly components as well as the materials and substances used in such components. The Association of the Automotive Industry (Verband der Automobilindustrie – VDA) therefore decided in 1996 to supplement the first sampling report according to the VDA Handbook by the page, “Components of Purchased Parts (Material Data Sheet)”. Furthermore, in 1998 the VDA board decided to create a system allowing material data sheets to be produced and processed electronically.

The International Material Data System (IMDS)

The web-based International Material Data System (IMDS) is an IT concept supporting electronic processing of the requisite data. It is used for electronic gathering and reporting of product data.

The System Uses the Following Lists:

- List of pure substances
- List of reportable substances
- GADSL (Global Automotive Declarable Substance List)

Further Information May Be Obtained at the Following URLs:

- International Material Data System IMDS: www.mdsystem.com
- EDS, Informationstechnologie und Service GmbH, Frankfurt: www.eds.de
- EUR-Lex, the Internet portal for the laws of the European Union: <http://europa.eu.int/eur-lex/de/index.html>

We will not assume any liability for the contents of these websites.

Processing Information

Processing (Molding Powder S-PTFE) PTFE is processed using techniques which are very similar to processing sintered materials. Due to its high melting viscosity PTFE cannot be processed like other high-performance thermoplastics.

At high temperatures (340 – 380°C) PTFE merely becomes highly viscous, thus precluding injection molding or normal extruding processes. Semi-finished products are therefore manufactured by compression molding and sintering or by ram extrusion.

Compression Molding and Sintering

PTFE powder is inserted into a cylindrical mold and subsequently compressed under high pressure. It is important that the air enclosed in the mold can escape almost completely.

The powder is compressed either on hydraulic presses with speed, pressure and time control, on isostatic or automatic presses. After the compression molding process, the preformed parts are sintered in electrically heated ovens with recirculating air according to pre-defined programs. The compression and sintering parameters must be adjusted to the respective PTFE powder form or, in the case of compounds, the composition. This is a prerequisite for ensuring optimum material properties.

Ram Extrusion

Ram extrusion is a compression molding process allowing the manufacture of continuous profiles. The granulate is fed into a cylindrical extrusion tube via a metering device, compressed with a hydraulically operated ram and – inside the tube – moved to a zone heated to sintering temperature.

In the sintering zone the various metered batches “melt” together, creating a continuous profile.

Processing (E-PTFE, Paste Powder)

PTFE produced by emulsion polymerization can be processed by so-called paste extrusion. The powder is mixed with a lubricant, for example naphtha, to create a paste, and then processed into simple profiles, such as strands, tubes or bands, at room temperature, using a piston press.

Extrusion is followed by drying to remove the lubricant. Afterwards the material achieves its ultimate properties by sintering at app. 350 – 380°C.

E-PTFE compounds may be processed by paste extrusion as well.



Take our plastics know-how to the test.

The information provided in this brochure, based upon many years' experience and knowledge, does not claim completeness. No liability is assumed for damage claims on the basis of this information. All parts must be installed by trained and specialized staff. Product range and technical specifications subject to modification. No liability assumed for errata.



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