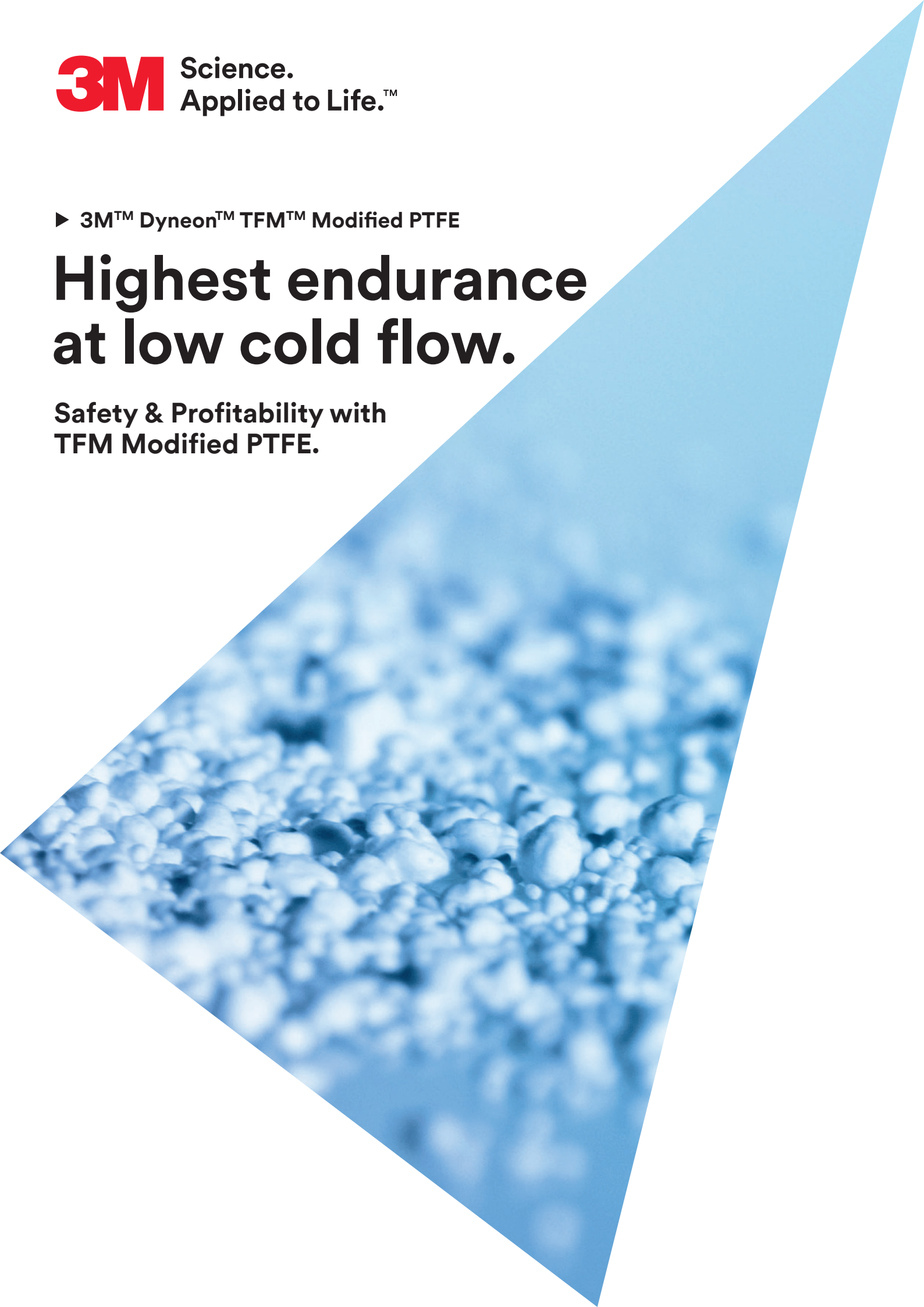
3M Science. Applied to Life.™

▶ 3M™ Dyneon™ TFM™ Modified PTFE

Highest endurance at low cold flow.

Safety & Profitability with TFM Modified PTFE.



3M™ Dyneon™ TFM™ Modified PTFE

Extend the service life of your equipment.

The demands placed on process engineers by modern chemical plant construction are becoming ever more complex. Apparent contradictions often need to be combined in a well balanced solution.

Sustainable production, improved plant security, environmental and health protection combined with an innovative economic strategy – together, these requirements confront today's developers with a great challenge.

In comparison to Standard 3M™ Dyneon™ PTFE, TFM Modified PTFE has acquired an excellent reputation for its premium characteristics as a lining and sealing material in systems and apparatus engineering. The product is particularly distinguished in terms of offering a high level of reliability.

The extended service life of the equipment and reduced cleaning effort result in lower system downtimes with a higher level of security and hence ultimately help to improve profitability.

Are you looking for better ways to implement your ideas into practice?

Apart from the excellent properties of TFM Modified PTFE, the significantly wider scope of manufacturing and application options of this material provides completely new approaches in design, construction and production of systems and units.

3M™ Dyneon™ PTFE and 3M™ Dyneon™ TFM™ Modified PTFE

Outstanding features for your safety.

The difference between Standard PTFE and second-generation PTFE can be deduced from the modified chemical structure of the polymer.

The molecular weight of TFM Modified PTFE is one-fifth that of Standard PTFE. This means that the PTFE particles fuse better, thus significantly contributing to a better weldability of components made of TFM Modified PTFE.

The relatively low molecular weight of TFM Modified PTFE would normally give rise to an end product with higher crystallinity and hence lower mechanical properties. However, the perfluoropropyl vinyl ether (PPVE) modifier in TFM Modified PTFE specifically inhibits crystallization, thus increasing the amorphous content while maintaining the preferred mechanical properties of Standard PTFE. In addition, the modifier ensures better distribution of the crystallites in the amorphous matrix and dramatically reduces cold flow.

The processing of TFM Modified PTFE utilises familiar compression moulding and sintering methods.

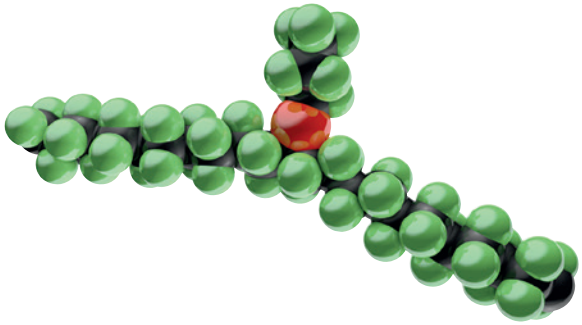
Dyneon PTFE's Molecular Chain

Dyneon PTFE consists of extremely long, linear carbon chains entirely surrounded by fluorine atoms. The fluorine atoms sterically shield the carbon atoms and protect the molecule from chemical attack. The high-energy carbon-fluorine bond helps ensure that the shielding effect is retained even under extreme service conditions.

The proven properties of Standard Dyneon PTFE are

- excellent all-round chemical resistance
- very wide service temperature ranges
- excellent dielectric properties
- no embrittlement or aging
- very good non-stick properties
- high dimensional stability and stress cracking resistance

Dyneon TFM Modified PTFE Molecular Chain



The linear polymer chain of TFM Modified PTFE additionally incorporates a perfluoropropyl vinyl ether (PPVE) modifier. The modifier content is less than 1%. For this reason, TFM Modified PTFE is classified as a homopolymer PTFE under ISO 12086.

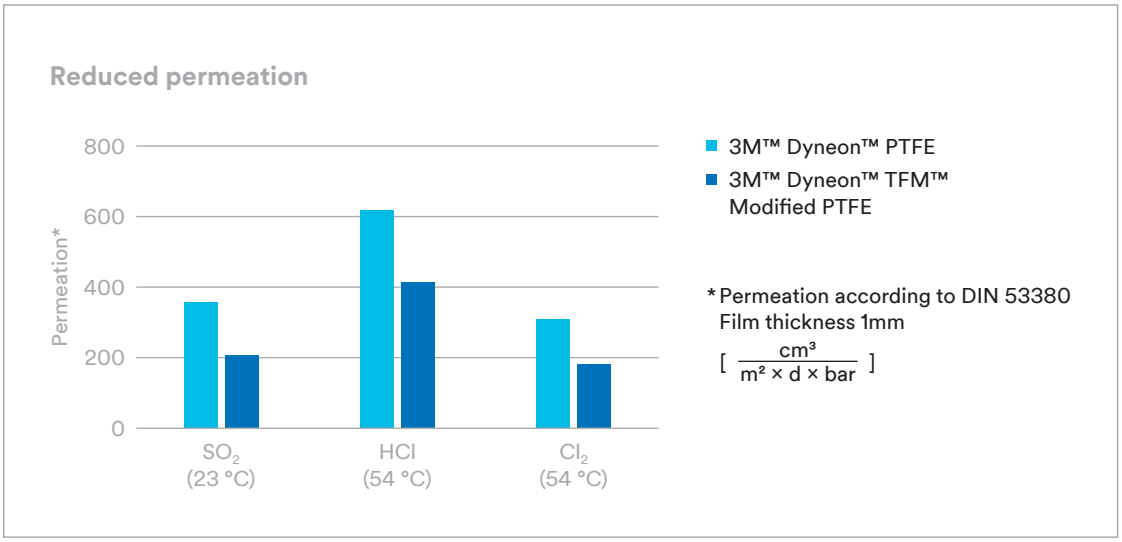
Advantages of Dyneon TFM Modified PTFE at a glance

- improved weldability
- substantially lower deformation under load
- denser polymer structure with fewer voids
- lower permeability
- better compression stress relaxation, particularly at elevated
- temperatures
- higher transparency
- better film quality
- smoother surfaces on machined parts

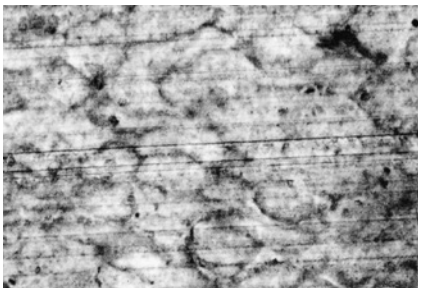
At the same time, TFM Modified PTFE has the same excellent chemical resistance and thermal stability as Standard PTFE.

3M™ Dyneon™ TFM™ Modified PTFE

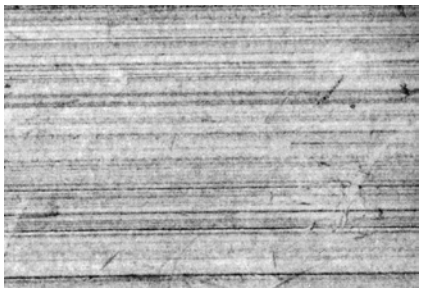
Upping particle density!



Skived films under an optical microscope at 25x magnification.



Unmodified Dyneon PTFE; the original particle boundaries are clearly discernible after the sintering process.



TFM Modified PTFE; the original particle boundaries are no longer discernible because of better fusion between the particles.

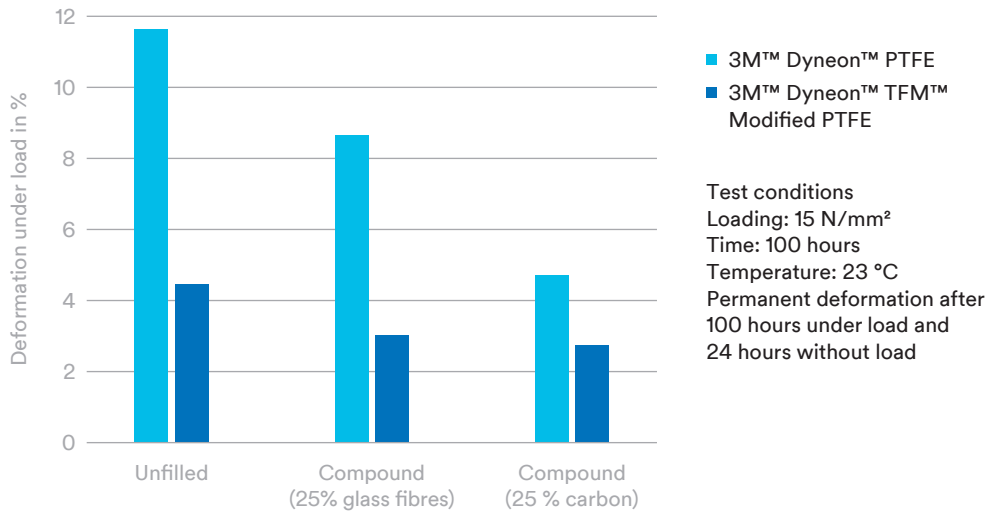
Deformation under load of TFM Modified PTFE and related Compounds.

The cold flow or deformation under load of TFM Modified PTFE is significantly lower than that of Standard PTFE. This applies both to unfilled TFM Modified PTFE and TFM Modified PTFE compounds.

The disadvantages associated with the use of fillers such as limited chemical resistance, changed mechanical properties and possible product contamination can be avoided by using virgin unfilled TFM Modified PTFE.

Gaskets made from unfilled TFM Modified PTFE are replacing Standard PTFE compounds in many applications in semiconductor manufacturing, the pharmaceutical and chemical processing industries.

Deformation under load.



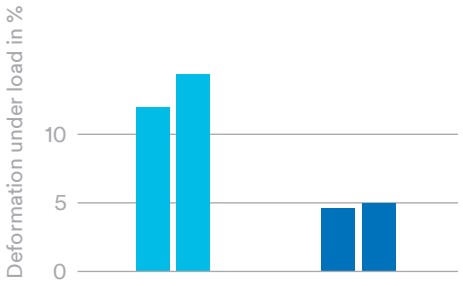
Test conditions
Loading: 15 N/mm²
Time: 100 hours
Temperature: 23 °C
Permanent deformation after 100 hours under load and 24 hours without load

3M™ Dyneon™ PTFE and 3M™ Dyneon™ TFM™ Modified PTFE

Reliability – especially at high temperatures.

Comparison of properties

Permanent total deformation after repeated loading of a test specimen, in each case measured at 150 °C



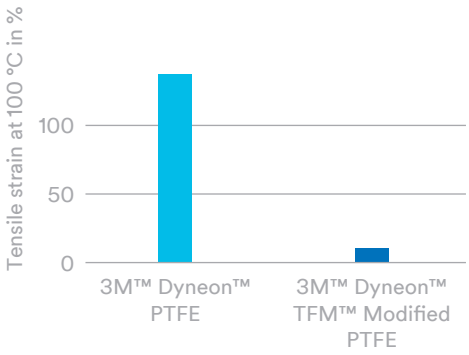
- 3M™ Dyneon™ PTFE
- 3M™ Dyneon™ TFM™ Modified PTFE

Test conditions
Loading: 15 N/mm²;
Repeated loading of a test specimen,
2 test cycles
Time: 100 hours per cycle
Temperature: 150 °C
Permanent deformation after 24 hours without load

The difference in deformation under load measured at room temperature becomes even greater at elevated temperatures.

Strain behavior under static tensile load

The strain behaviour of TFM Modified PTFE is relatively low particularly at elevated temperatures. This is a very important property for components assembled under pre-stress such as lip seals.



Test conditions
Static tensile load: 5 MPa
Time: 100 hours Permanent deformation

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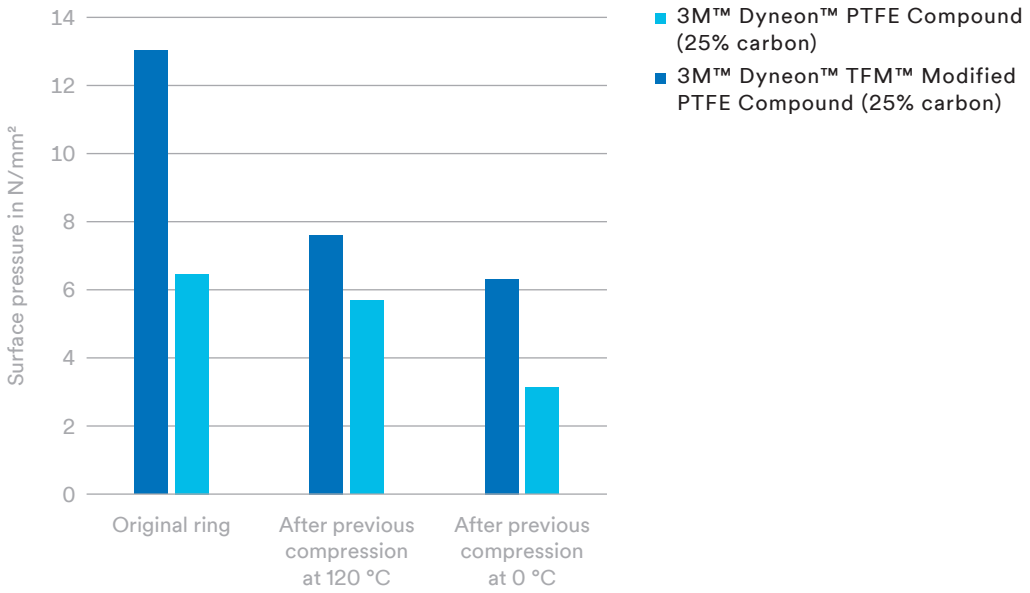
For longer and smooth operation.

Comparison of properties.

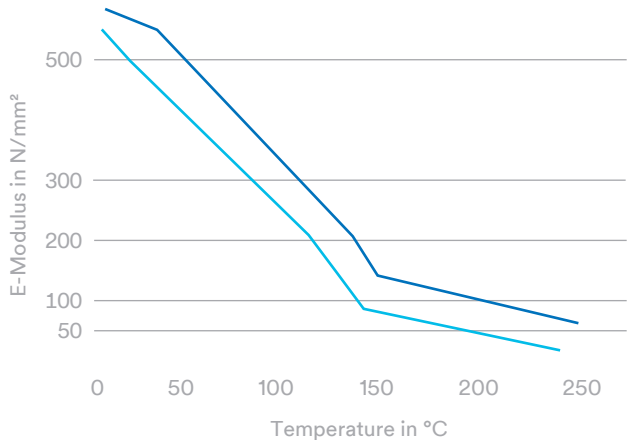
Compression stress relaxation (recovery) determined by measuring surface pressure



Moulded parts made from TFM Modified PTFE and TFM Modified PTFE carbon compounds undergo partially reversible deformation when compressed.

To determine their compression stress relaxation after deformation, ball valve seating rings in original condition and after previous compressive deformation were compressed at 120 °C by 8% of their initial height. Compression stress relaxation improves with increasing surface pressure. The graph shows that the compression stress relaxation of a TFM Modified PTFE carbon compound is significantly better than that of a compound made from Standard PTFE. This property is of great importance for manufacturers of pipe fittings because it means that sealing properties will last longer giving longer service life.

Effect of temperature on the elastic modulus

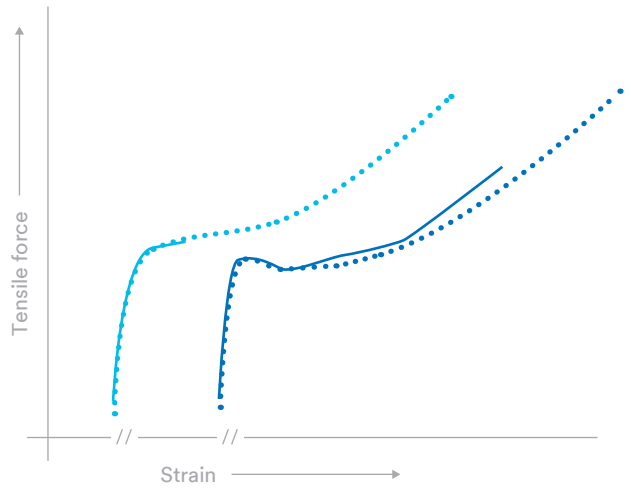


- 3M™ Dyneon™ PTFE
- 3M™ Dyneon™ TFM™ Modified PTFE

Note: Like other materials, TFM Modified PTFE shows a decline in elastic modulus with increasing temperature but to a lesser extent than Standard PTFE. This advantage of TFM Modified PTFE over Standard PTFE becomes even greater with increasing temperature.

Tensile stress-strain graph of welded specimens and original material

The excellent weldability of TFM Modified PTFE is demonstrated by tensile stress-strain testing



- 3M™ Dyneon™ PTFE
- 3M™ Dyneon™ TFM™ Modified PTFE
- Original specimen
- Welded specimen

Note: During short-time loading, the welds attain some 80 to 85% of original material strength, as measured by ultimate tensile strength and elongation at break. In the case of TFM Modified PTFE, the curves for the original and welded specimens follow an identical path up to the yield point and beyond. Welds in Standard PTFE already fail at low strain.

The new freedom in processing.

Basic processing methods for 3M™ Dyneon™ TFM™ Modified PTFE	
General compression molding (free-flowing and non-free-flowingTFM Modified PTFE powders)	- Production of semi-finished and finished products, billets, skived films, rods, sheets and pipes
Automatic moulding (free-flowing TFM Modified PTFE powders)	- Seating rings for ball valves - Bearings, piston rings - Sealing elements - Semi-finished products for machining
Isostatic moulding (free-flowing TFM Modified PTFE powders)	- Pipe linings - Coating of steel parts - Pump impellers, pump bodies, floats and insulators - Tanks and containers - Semi-finished products for machining
Ram extrusion (free-flowing TFM Modified PTFE powders)	- Pipe linings - Rods - Semi-finished products for machining (gaskets)
Paste extrusion (emulsion polymer powders)	- High-performance tubing - Pipe linings - Flat gaskets
Additional processing methods	
Laminating press method	- Laminates for bearings - Printed circuits, electronics industry - Connectors
Sheets with glass fabric backing (made from compression moulded sheets or skived films)	- Corrosion-resistant lining of steel tanks
Compounding	- Manufacturing of high-performance compounds
Thermoforming	- Low moulding and deep drawing of cups, bottles, containers - diaphragms and form parts
Welding	- Production of complicated, large-volume form parts (e.g. loose-fit linings for the chemical industry) (see next page)
Metal encapsulation	- Corrosion-resistant, crack-free encapsulation of steel components - Reinforcement of TFM Modified PTFE structures with steel inserts

Better weldability.

There are three main methods that are used to weld 3M™ Dyneon™ TFM™ Modified PTFE under production conditions:

Hot-tool butt welding

1.

This method can be borrowed from conventional thermoplastic welding technology. However, it has limited applications, e.g. in the joining of TFM Modified PTFE and PFA components or TFM Modified PTFE profiles with very small cross sections.

Welding by a localized sintering cycle...

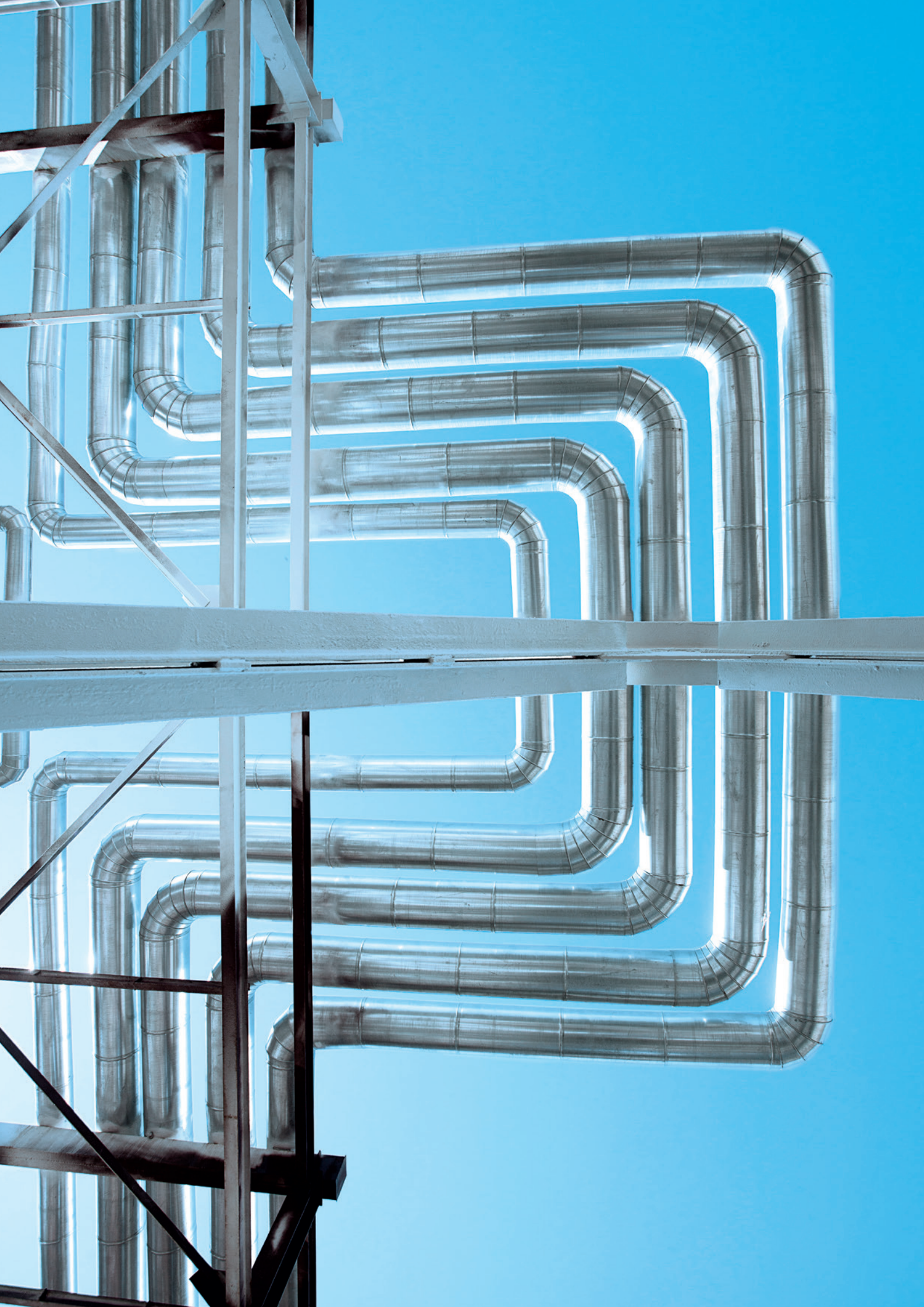
2.

... in the welding zone with the aid of special welding tools. This welding method is far more suited to the properties of TFM Modified PTFE than the above method. In addition to good contact between the parts to be joined, the temperature and contact pressure settings are also important for good welding results.

Hot gas welding with PFA

3.

If the first two methods described are unsuitable, there is another possible welding method in which the melt-processable fluorothermoplastic PFA is used as welding filler. In this method, the TFM Modified PTFE parts are heated with hot air above the gel temperature and then joined using molten PFA.



From product properties to advantages in applications.

20 years of innovation for practical applications. The many options available for processing 3M™ Dyneon™ TFM™ Modified PTFE open up entirely new application areas. Production processes can be optimised and products in many sectors of industry improved in response to practical requirements. These are only examples for the wide field of application of fluoropolymers.

Electrical/electronics industry

The high dielectric strength of TFM Modified PTFE permits weight reduction when used in very thin skived films for cable insulation.

Chemical processing equipment

Increased plant service life combined with maximum safety through corrosion-resistant linings, less environmental impact through better sealing against volatile chemicals and the production of complex components due to improved weldability make TFM Modified PTFE the ideal material for customised solutions.

Mechanical and automotive engineering

The improved efficiency of waste-gas reducing aggregates requires amongst others the use of new high-speed lubricants and gasket designs. The universal fuel, lubricant and additive resistance in combination with the longevity of gaskets made of TFM Modified PTFE continually helps to develop optimised solutions.

Semiconductor industry

It is important to avoid even minute production impurities and at the same time to shorten cleaning cycles for the production components. Production under cleanroom conditions combined with the use of aggressive chemicals impose particular requirements on the materials to be used. Extremely high purity of the TFM Modified PTFE, ultra smooth finished-part surfaces and good weldability are opening up new opportunities for design and production and also contribute to optimised system efficiency.

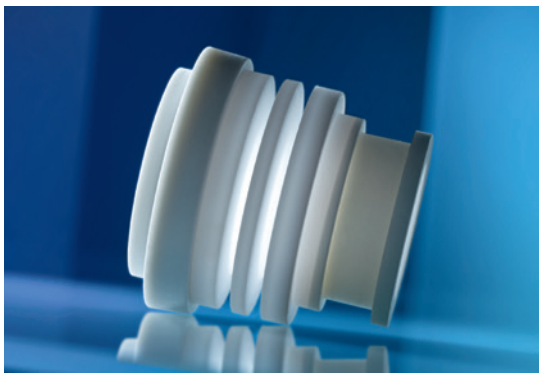
Not only do we supply you with material – our experienced applications engineers also assist you in finding optimal solutions for your individual tasks.

▸ **We are here to support you. Please contact us to discuss your applications.**

3M™ Dyneon™ TFM™ Modified PTFE

Typical fields of application.

- Chemical processing engineering
- fittings, shut-off devices, pumps, apparatus engineering
- semiconductor industry
- production, storage and transport of ultra-purity chemicals
- electronics industry
- machine and apparatus engineering
- vehicle construction and aerospace industry



▶ **Further information and technical support is available to you on our internet site www.dyneon.eu**

Technical Information and Test Data

Technical information, test data, and advice provided by Dyneon personnel are based on information and tests we believe are reliable and are intended for persons with knowledge and technical skills sufficient to analyze test types and conditions, and to handle and use raw polymers and related compounding ingredients. No license under any Dyneon or third party intellectual rights is granted or implied by virtue of this information.

General recommendations on health and safety in processing, on work hygiene and on measures to be taken in the event of accident are detailed in our material safety data sheets.

You will find further notes on the safe handling of fluoropolymers in the brochure “Guide for the safe handling of Fluoropolymers Resins” by PlasticsEurope, Box 3, B-1160 Brussels, Tel. +32 (2) 676 17 32.

The present edition replaces all previous versions. Please make sure and inquire if in doubt whether you have the latest edition.

Important Notice

All information set forth herein is based on our present state of knowledge and is intended to provide general notes regarding products and their uses. It should not therefore be construed as a guarantee of specific properties of the products described or their suitability for a particular application. Because conditions of product use are outside Dyneon’s control and vary widely, user must evaluate and determine whether a Dyneon product will be suitable for user’s intended application before using it. The quality of our products is warranted under our General Terms and Conditions of Sale as now are or hereafter may be in force.

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