BASF
We create chemistry

Thermoplastic Polyurethane Elastomers (TPU)

Elastollan® – Material Properties

Elastollan®

Elastollan® is the brand name for thermoplastic polyurethane (TPU) from BASF. It stands for maximum reliability, consistent product quality and cost efficiency. Elastollan® can be extruded into hoses, cable sheathing, belts, films and profiles, and can also be processed using blow molding and injection molding technologies. Over the last few decades, the numerous benefits of Elastollan® in all its forms – aromatic or aliphatic, very soft or glass fiber-reinforced, flame retardant or highly transparent – have been clearly demonstrated across every sector of industry.

Elastollan® is, amongst others, distinguished by the following properties:

- high wear and abrasion resistance
- high tensile strength and outstanding resistance to tear propagation
- excellent damping characteristics
- very good low-temperature flexibility
- high resistance to oils, greases, oxygen and ozone.

This extensive product portfolio, which makes use of a variety of raw materials and formulations, is the starting point for successfully bringing innovative customer projects to fruition.

We thrive on creative ideas and complex challenges – come and talk to us!

Elastollan®

Chemical structure

Elastollan®

Elastollan® is essentially formed from the inter-reaction of three components:

1. polyols (long-chain diols)
2. diisocyanates
3. short-chain diols

The polyols and the short-chain diols react with the diisocyanates through polyaddition to form linear polyurethane. Flexible segments are created by the reaction of the polyol with the diisocyanate. The combination of diisocyanate with short-chain diol produces the rigid component (rigid segment). Fig. 1 shows in diagrammatic form the chain structure of thermoplastic polyurethane.

The properties of Elastollan® grades depend on the nature of the raw materials, the reaction conditions, and the ratio of the starting materials. The polyols used have a significant influence on certain properties of the thermoplastic polyurethane. Either polyester-based polyols or polyether-based polyols are used in the production of Elastollan®.

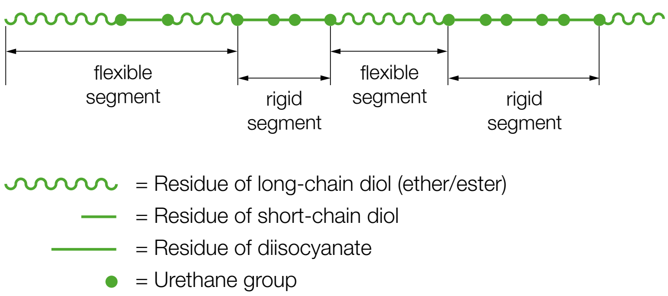


Fig. 1: Structure of thermoplastic polyurethane

The products are distinguished by the following characteristic features:

Using polyester polyols:
- highest mechanical properties
- highest heat resistance
- highest resistance to mineral oils

Using polyether polyols:
- highest hydrolysis resistance
- best low-temperature flexibility
- resistance to microbiological degradation

In addition to the basic components described above, many Elastollan® formulations contain additives to facilitate production and processability. Further additives can also be included to modify specific properties. Such additives include mold release agents, flame retardants, UV-stabilizers and plasticizers as well as glass fibers to increase rigidity.

Physical properties

Mechanical properties

The physical properties of Elastollan® are discussed below. The test procedures are explained in some detail. Typical values of these tests are presented in our brochure "Elastollan® – Product Range" and in separate data sheets.

Tests are carried out on injection molded samples using granulate which is pre-dried prior to processing.

Before testing specimens are conditioned for 20 hours at 100 °C and then stored for at least 24 hours at 23 °C and 50 % relative humidity. The values thus obtained cannot always be directly related to the properties of finished parts.

The following factors affect the physical properties to varying degrees:

- part design
- processing conditions
- orientation of macromolecules and fillers
- internal stresses
- moisture
- annealing
- environmental conditions

Consequently, finished parts should be tested in relation to their intended application.

Physical properties

Mechanical properties

Rigidity

The versatility of polyurethane chemistry makes it possible to produce Elastollan® over a wide range of rigidity. Fig. 2 shows the range of E-modulus of TPU and RTPU in comparison to other materials.

The modulus of elasticity (E-modulus) is determined by tensile testing according to DIN EN ISO 527-1A, using a test specimen at a testing speed of 1 mm/min. The E-modulus is calculated from the initial slope of the stress-strain curve as ratio of stress to strain.

It is known that the modulus of elasticity of plastics is influenced by the following parameters:

- temperature
- moisture content
- orientation of macromolecules and fillers
- rate and duration of stress
- geometry of test specimens
- type of test equipment

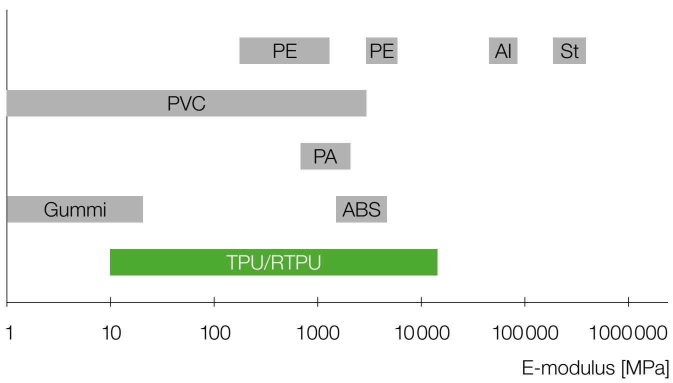


Fig. 2: Comparison of E-modulus of TPU and RTPU with other materials

Figs. 3–5 show the modulus of elasticity of several Elastollan® grades as a function of temperature. E-modulus values obtained from the tensile test are preferable to those from the bending test, since in the tensile test the stress distribution throughout the relevant test specimen length is constant.

Physical properties

Mechanical properties

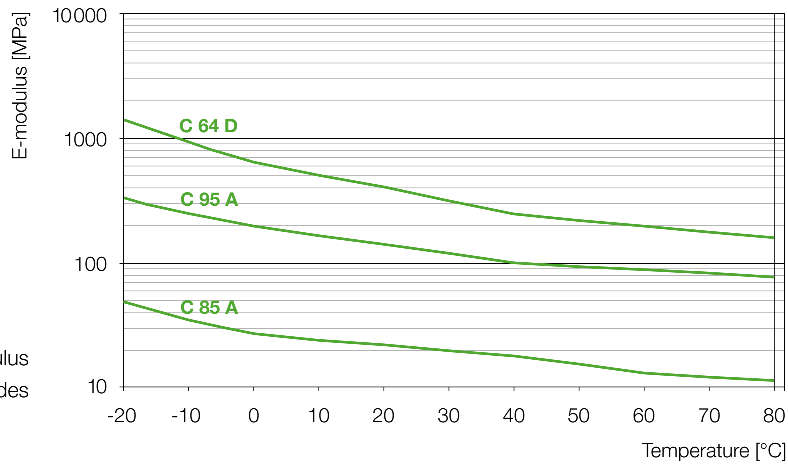


Fig. 3: Influence of temperature on E-modulus
Elastollan® polyester grades

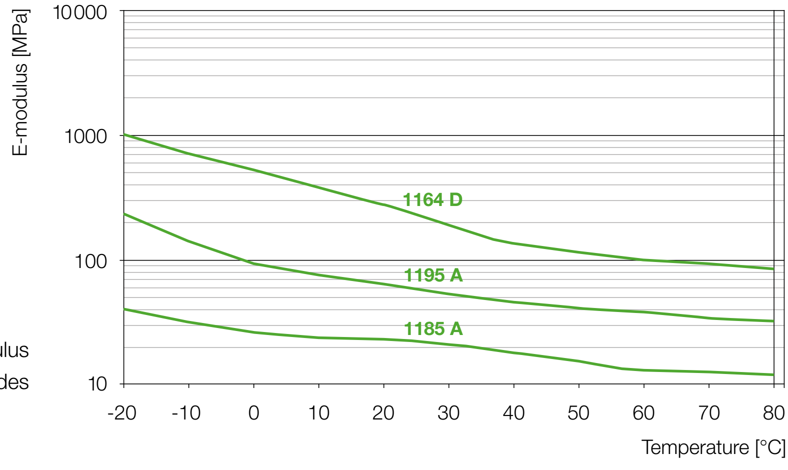


Fig. 4: Influence of temperature on E-modulus
Elastollan® polyether grades

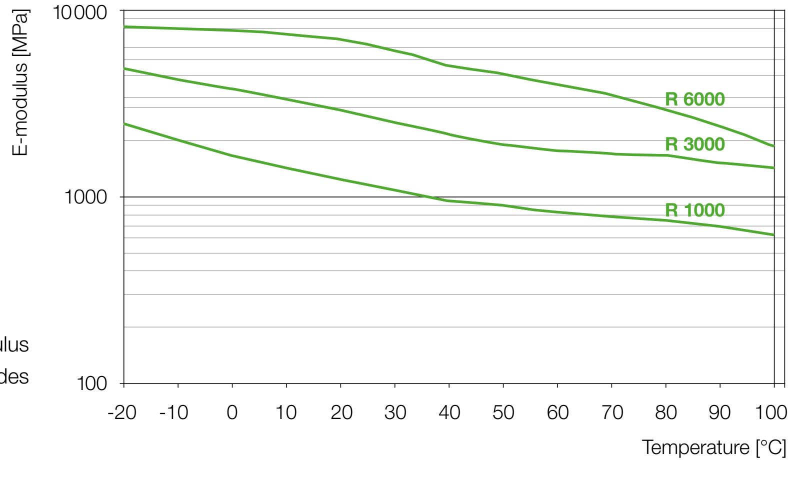


Fig. 5: Influence of temperature on E-modulus
Elastollan® glass fibers reinforced grades

Physical properties

Mechanical properties

Shore hardness

The hardness of elastomers such as Elastollan® is measured in Shore A and Shore D according to DIN ISO 7619-1 (3s). Shore hardness is a measure of the resistance of a material to the penetration of a needle under a defined spring force. It is determined as a number from 0 to 100 on the scales A or D.

The higher the number, the higher the hardness. The letter A is used for flexible grades and the letter D for rigid grades. However, the ranges do overlap.

Fig. 6 shows a comparison of the Shore hardness A and D scales for Elastollan®. There is no general dependence between Shore A and D scales. Under standard atmospheric conditions (i.e. 23 °C, 50 % relative humidity), the hardness of Elastollan® grades ranges from 60 Shore A to 74 Shore D.

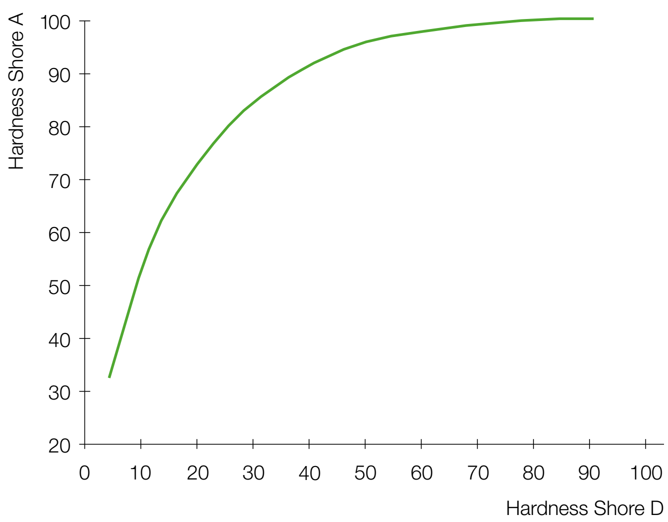


Fig. 6: Relationship: Shore A to Shore D

Physical properties

Mechanical properties

Glass transition temperature

The glass transition temperature (Tg) of a plastics is the point at which a reversible transition of amorphous phases from a hard brittle condition to a visco-elastic or rubber-elastic condition occurs. Glass transition takes place, depending on hardness or rather amorphous portion of a material, within a more or less wide temperature range. The larger the amorphous portion (softer Elastollan® product), the lower is the glass transition temperature, and the narrower is this temperature range.

There are several methods available to determine glass transition temperature, each of them possibly yielding a different value, depending on the test conditions. Dynamic testing results in higher temperature values than static testing. Also the thermal history of the material to be measured is of importance. Thus, similar methods and conditions have to be selected for comparison of glass transition temperatures of different products.

Fig. 7 shows the glass transition temperatures of several Elastollan® grades, measured by differential scanning calorimetry (DSC) at a heating rate of 10 K/min.

The Tg was evaluated according to DIN EN ISO 11357-2 on the basis of the curve, the slope of which is stepped in the transition range. The torsion modulus and the damping curves shown in figs. 8 to 13 enable Tg's to be defined on the basis of the damping maximum. Since this is a dynamic test, the Tg's exceed those obtained from the DSC measurements.

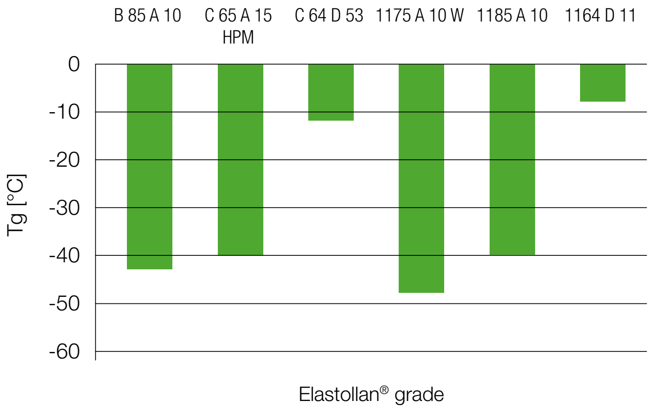


Fig. 7: Glass transition temperature (Tg) from DSC at 10 K/min

Physical properties

Mechanical properties

Torsion modulus

The torsion vibration test as specified in DIN EN ISO 6721-2 is used to determine the elastic behavior of polymeric materials under dynamic torsional loading, over a temperature range. In this test, a test specimen is stimulated into free torsional vibration. The torsional angle is kept low enough to prevent permanent deformation. Under the test parameters specified in the standard, a frequency of 0.1 to 10 Hz results as temperature increases.

During the relaxation phase the decreasing sinusoidal vibration is recorded. From this decay curve, it is possible to calculate the torsion modulus and damping. The torsion modulus is the ratio between the torsion stress and the resultant elastic angular deformation.

Figs. 8–13 show the torsion modulus and damping behavior over a temperature range for several Elastollan® grades. At low temperature torsion modulus is high and the curves are relatively flat. This is the so-called energy-elastic temperature range, where damping values are low.

With rising temperature, the torsion modulus curve falls and damping behavior increases. This is the so-called glass transition zone, where damping reaches a maximum.

After the glass transition zone, the torsion modulus curve flattens. This condition is described as entropyelastic (rubber-elastic). At this temperature the material remains solid with increasing temperature, torsion modulus declines more sharply and damping increases again. Here, the behavior pattern is predominantly visco-elastic.

The extent of each zone varies according to Elastollan® grade. However, as a general statement, the transition becomes more obvious with the lower hardness Elastollan® grades.

Physical properties

Mechanical properties

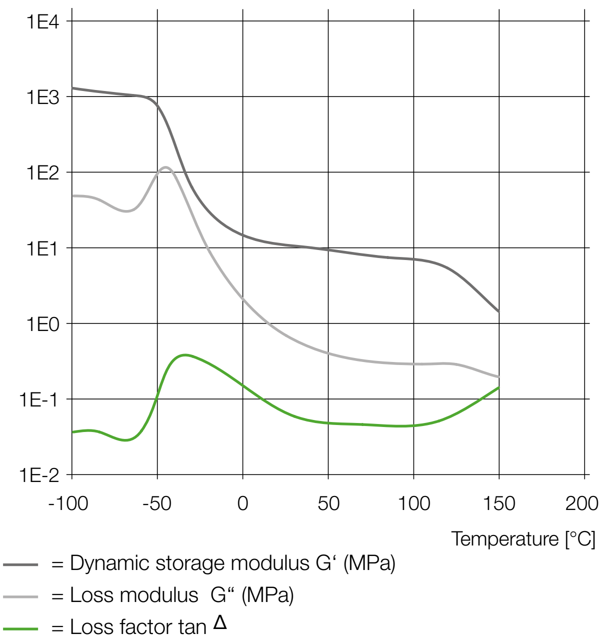


Fig. 8: Elastollan® C 85 A 10

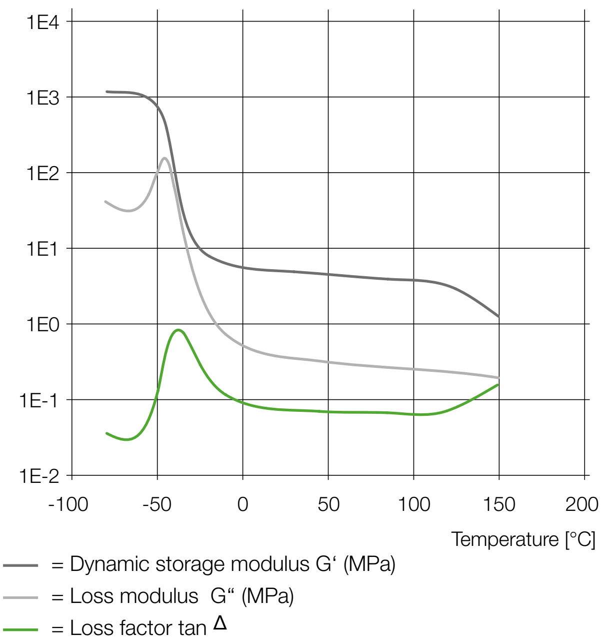


Fig. 9: Elastollan® C 65 A HPM

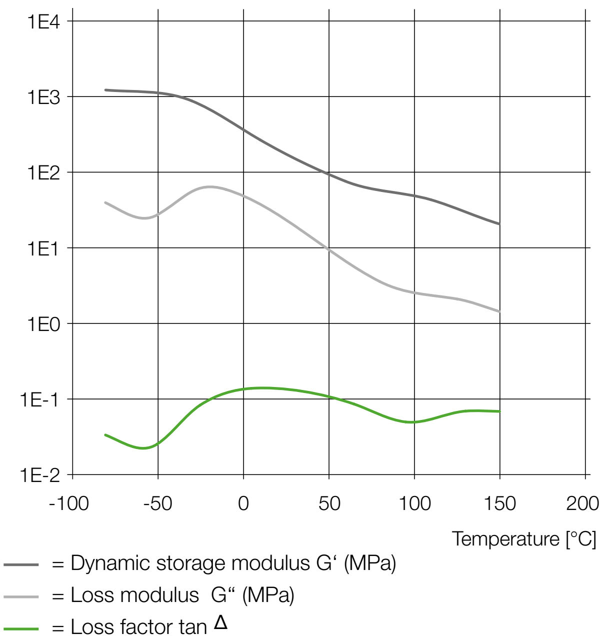
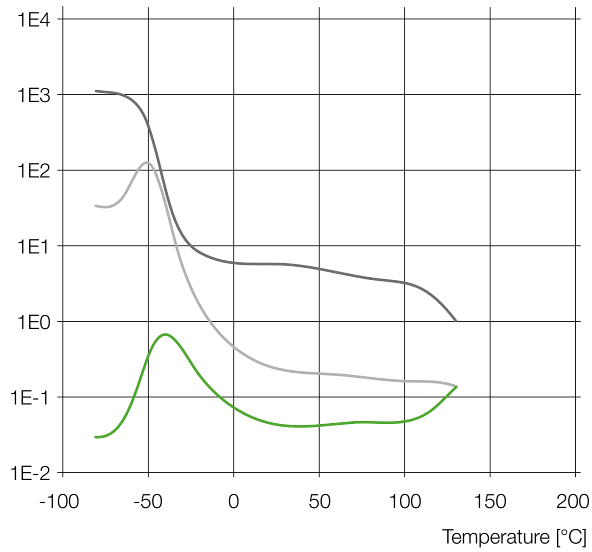


Fig. 10: Elastollan® C 64 D

Physical properties

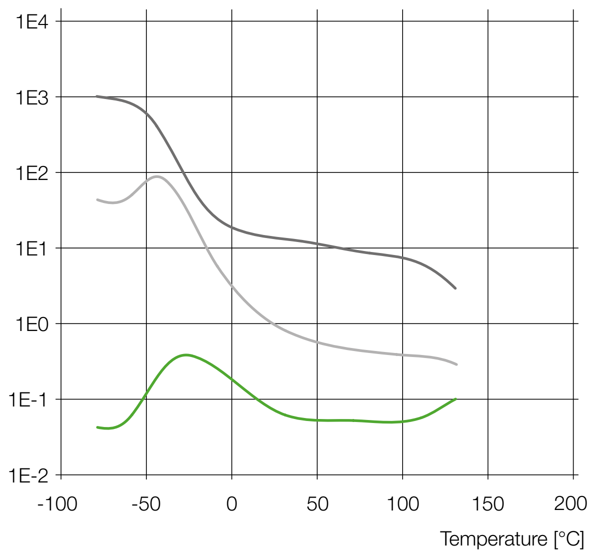
Mechanical properties

Torsion modulus



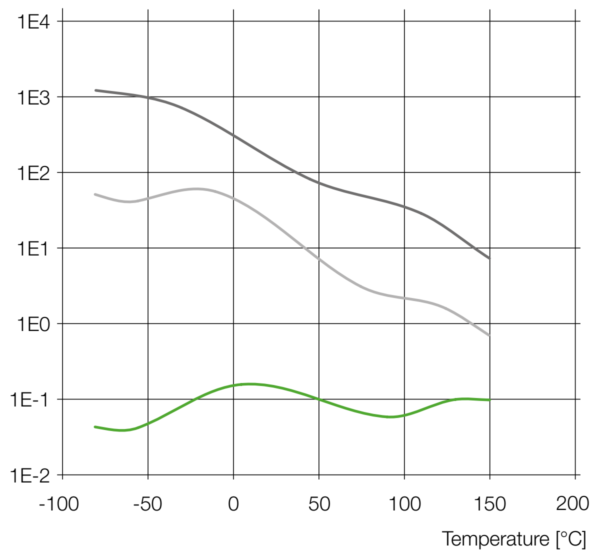
— = Dynamic storage modulus G‘ (MPa)
— = Loss modulus G“ (MPa)
— = Loss factor tan Δ

Fig. 12: Elastollan® 1175 A 10 W



— = Dynamic storage modulus G‘ (MPa)
— = Loss modulus G“ (MPa)
— = Loss factor tan Δ

Fig. 11: Elastollan® 1185 A 10



— = Dynamic storage modulus G‘ (MPa)
— = Loss modulus G“ (MPa)
— = Loss factor tan Δ

Fig. 13: Elastollan® 1164 D

Physical properties

Mechanical properties

Tensile strength

The behavior of elastomers under short-term, uniaxial, static tensile stress is determined by tensile tests as specified in DIN EN ISO 527-2-5A and may be presented in the form of a stress-strain diagram. Throughout the test, the tensile stress is always related to the original cross-section of the test specimen.

The actual stress, which increases steadily owing to the constant reduction in cross-section, is not taken into account. Typical strength and deformation characteristics can be seen in the tensile stress-strain diagram (Fig. 14):

Strength characteristics:

- The yield stress σ_γ is the tensile stress at which the slope of the stress-strain curve becomes zero.
- Tensile strength σ_{max} is the tensile stress at maximum force.
- Tear strength σ_B is the tensile stress at the moment of rupture of the specimen.

Deformation characteristics:

- The yield strain ε_γ is the elongation corresponding to the yield stress.
- Maximum force elongation ε_{max} is the elongation corresponding to the tensile strength.
- Elongation at break εB is the elongation corresponding to the tear strength

In the case of unreinforced Elastollan® grades at room temperature, differences are not generally observed, e.g., tear strength and tensile strength correspond (Fig. 15). A yield stress is only observed with rigid formulations at lower temperatures. For glass fiber-reinforced Elastollan® grades (R grades), yield stress coincides with tensile strength (Fig. 16).

In one respect, the stress-strain diagrams on the following pages, determined according to DIN EN ISO 527-2-5A at a rate of 200 mm/min, present the typical high elongation to break of Elastollan®. On the other hand, they also include diagrams of lower deformations. The curves relating to the R grades were determined according to DIN EN ISO 527-2-1A at a rate of 50 mm/min.

Physical properties

Mechanical properties

Tensile strength

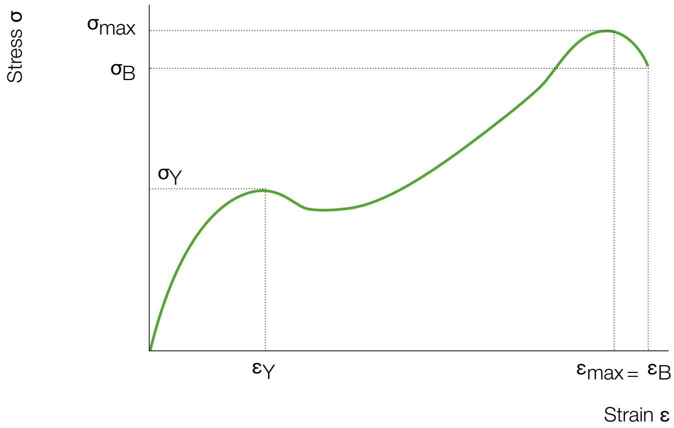


Fig. 14: Typical stress-strain curve from tensile testing

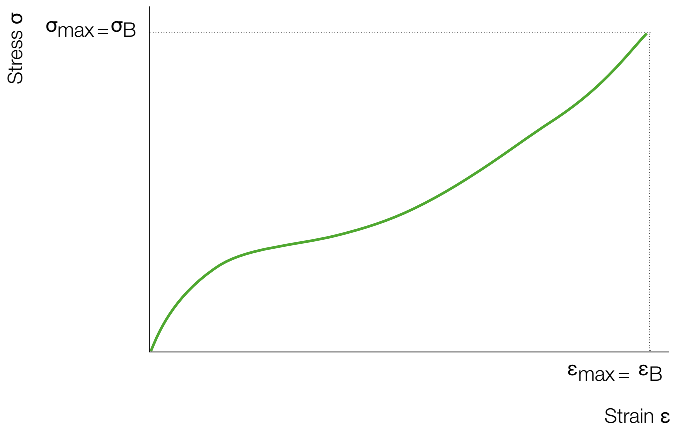


Fig. 15: Characteristic stress-strain curve for unreinforced Elastollan®

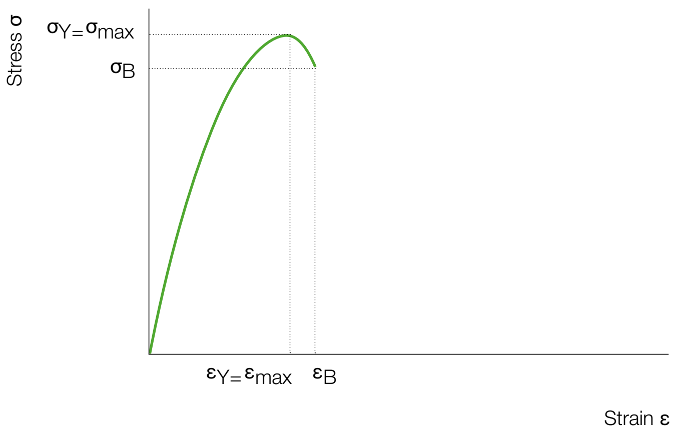


Fig. 16: Characteristic stress-strain curve for reinforced Elastollan®

Physical properties

Mechanical properties

Tensile strength

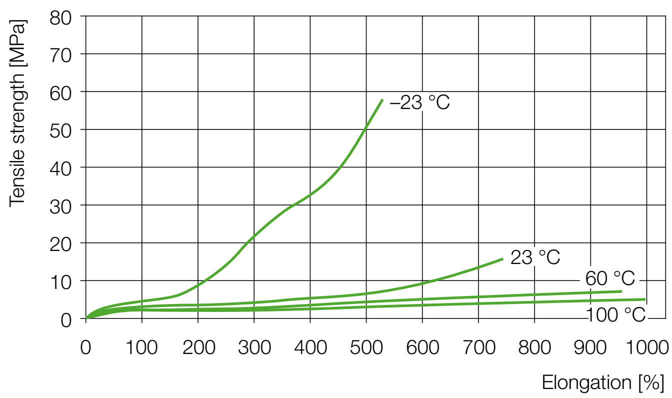


Fig. 17: Elastollan® C 65 A HPM

Note:
The graphs shown on pages 15 and 16 were determined according to DIN EN ISO 527-2-5A at a rate of 200 mm/min until failure of the part.

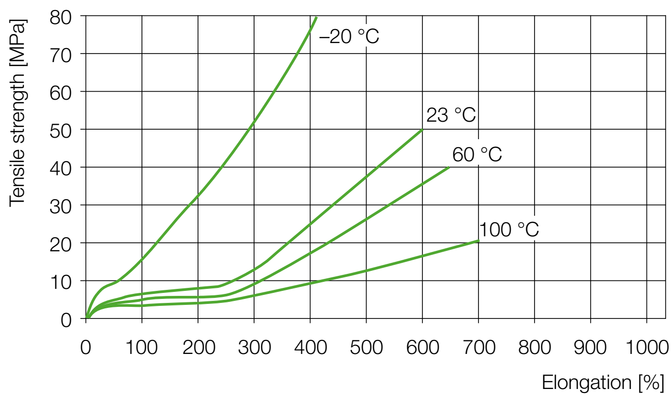


Fig. 18: Elastollan® C 85 A

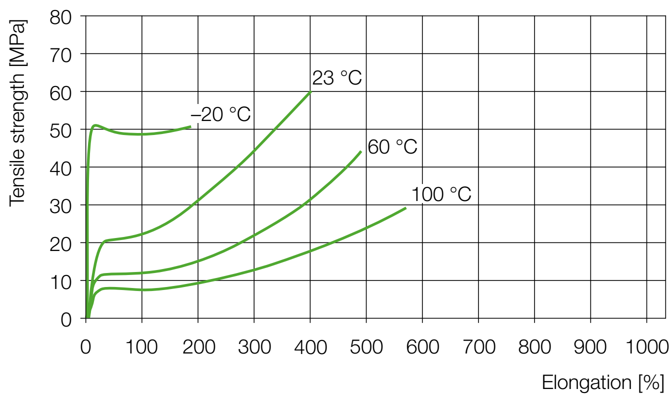


Fig. 19: Elastollan® C 64 D

Physical properties

Mechanical properties

Tensile strength

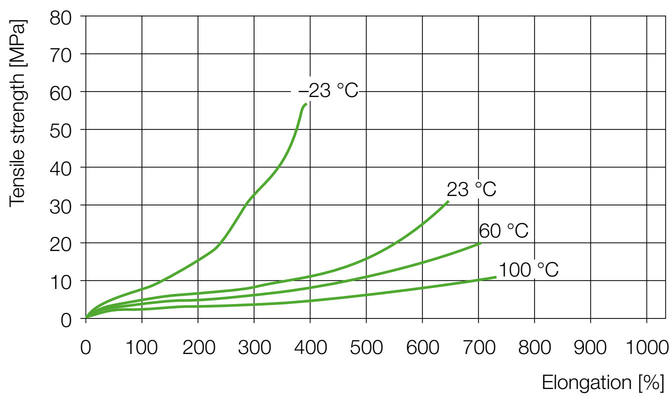


Fig. 20: Elastollan® 1175 AW

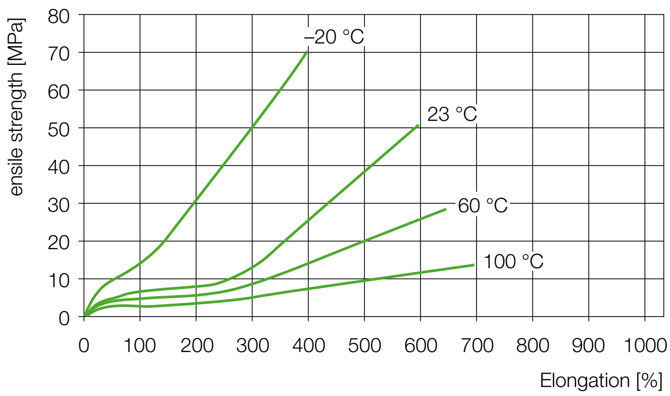


Fig. 21: Elastollan® 1185 A

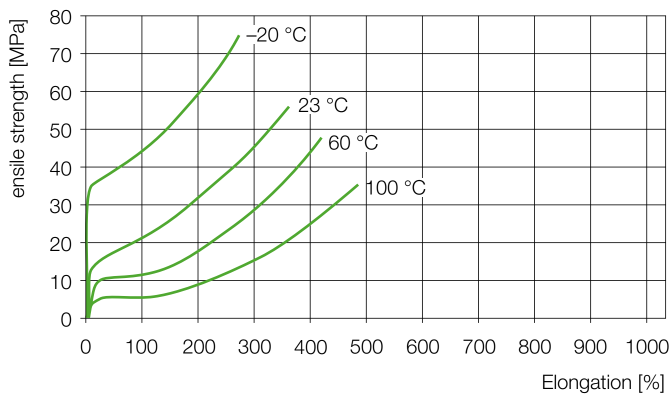


Fig. 22: Elastollan® 1164 D

Physical properties

Mechanical properties

Tensile strength

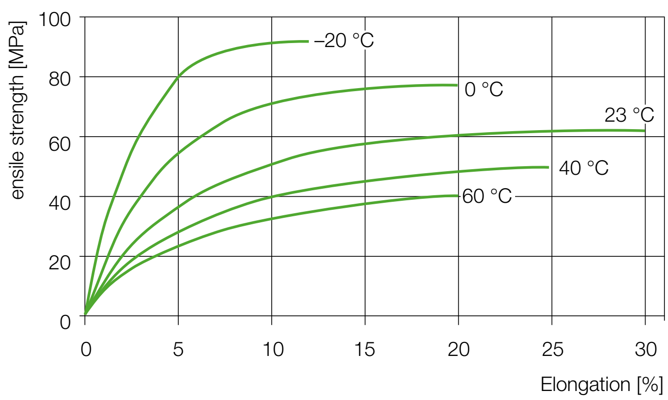


Fig. 23: Elastollan® R 1000

Note:
The graphs on page 17 were determined according to DIN EN ISO 527-2-1A at a rate of 50 mm/min until failure of the part.

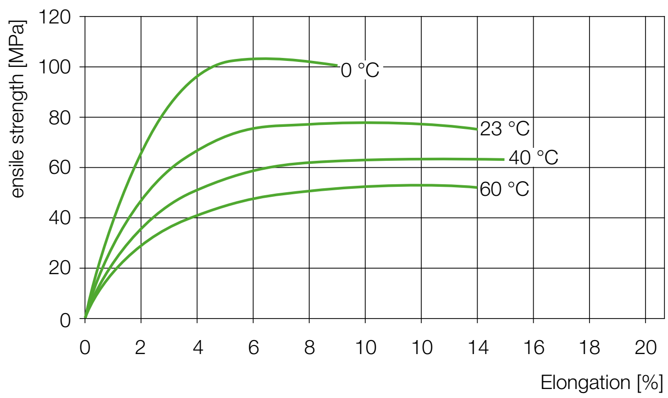


Fig. 24: Elastollan® R 3000

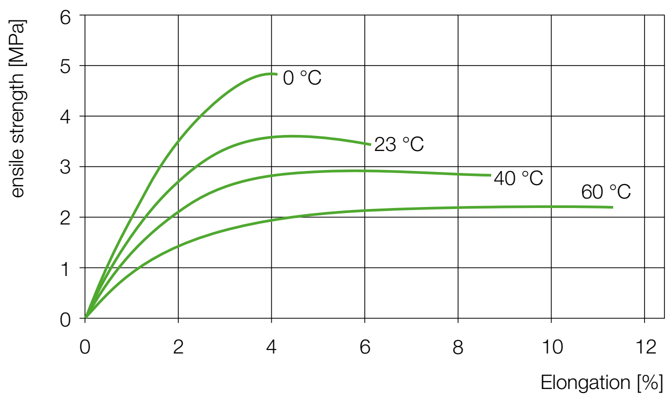


Fig. 25: Elastollan® R 6000

Physical properties

Mechanical properties

Tear strength

Tear strength is the term which defines the resistance of a notched test specimen to tear propagation. In this respect, Elastollan® is far superior to most other of plastics.

The test is conducted in accordance with DIN ISO 34–1Bb using an angle specimen with cut. The specimen is stretched at right angles to the incision at a rate of 500 mm/min until tear. The tear resistance [kN/m] is the ratio between maximum force and specimen thickness.

The diagrams show tear strength for several Elastollan® grades, relative to temperature.

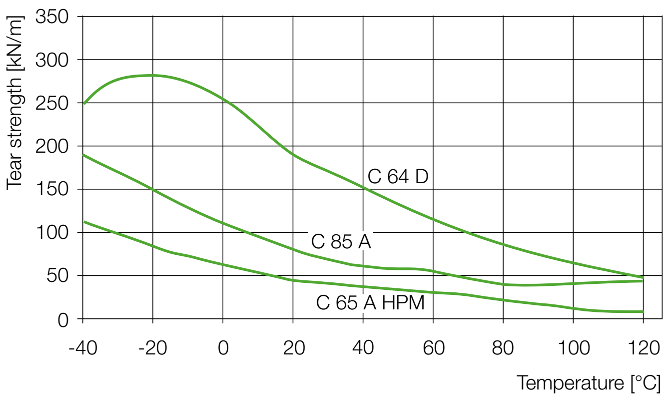


Fig. 26: Tear strength in relation to temperature
Elastollan® for polyester grades

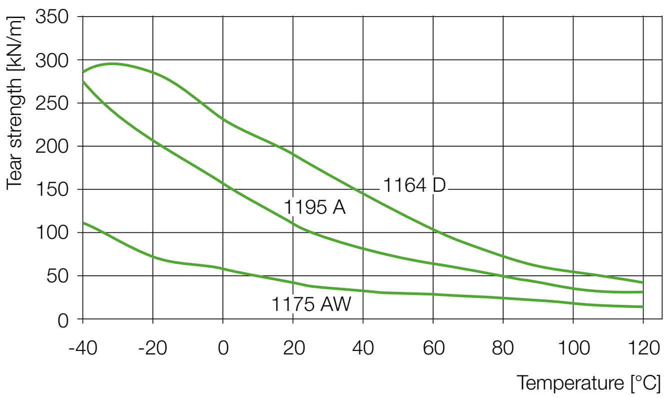


Fig. 27: Tear strength in relation to temperature
Elastollan® for polyether grades

We would be pleased to send you the following brochure:
Elastollan®- Product Range, with detailed information about
the technical properties of Elastollan®.

Physical properties

Mechanical properties

Creep behavior

A pure elastic deformation behavior, whereby the elastic characteristic remains constant, does not occur with any material. Due to internal friction, there exist at any time both a visco-elastic and a viscous deformation portion, causing a dependence of the characteristic values on the stress duration and intensity.

These non-elastic portions are considerably influenced by temperature and time. This dependence should be a pre-consideration in the case of plastics operating at ambient temperature under long term load.

Behavior under long-term static stress can be characterized according to ISO 899 by means of creep tests, whereby a test specimen is subject to tensile stress using a load. The constant deformation thus caused is measured as a function of time. If this test is conducted applying different loads, the data yield a so-called isochronous stress-strain diagram.

Such a diagram can be used to predict how a component deforms in the course of time under a certain load, and also how the stress in a component decreases with a given deformation (Figs. 28 to 32).

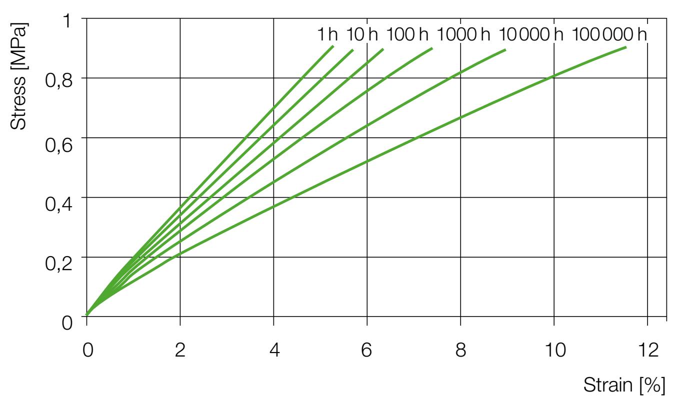


Fig. 28: Isochronous stress-strain lines at 23 °C Elastollan® C 85 A

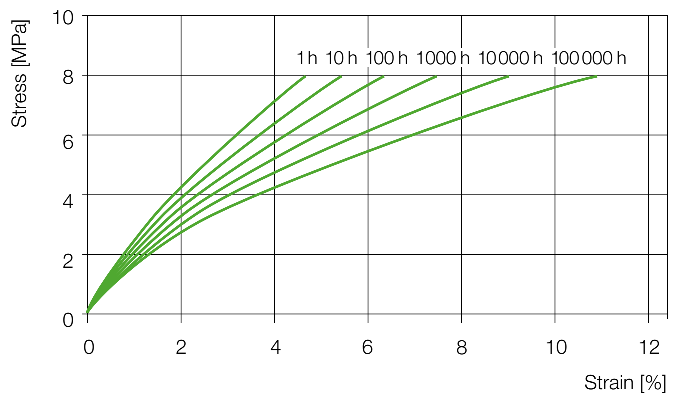


Fig. 29: Isochronous stress-strain lines at 23°C Elastollan® C 64 D

Physical properties

Mechanical properties

Creep behavior

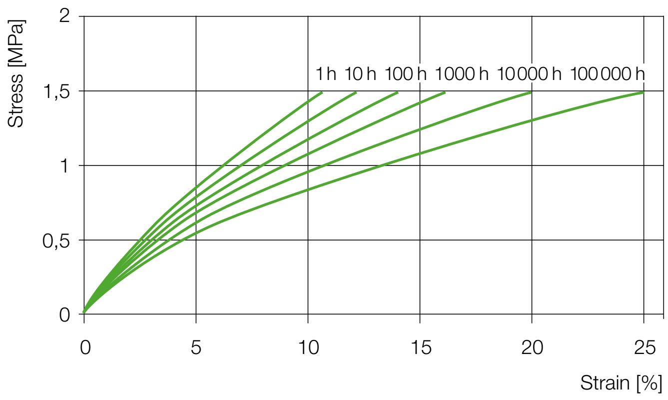


Fig. 30: Isochronous stress-strain lines at 23 °C
Elastollan® 1185 A

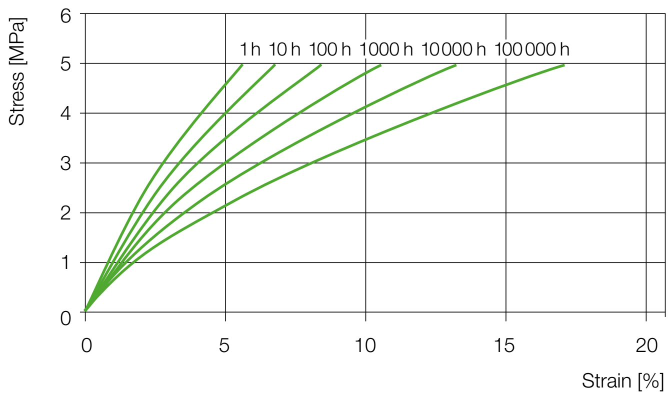


Fig. 31: Isochronous stress-strain lines at 23 °C
Elastollan® 1164 D

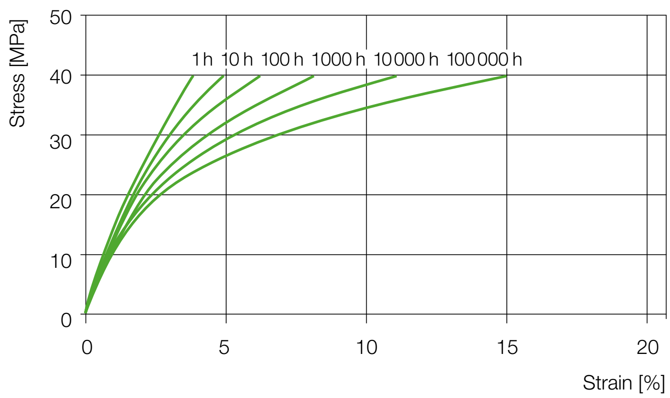


Fig. 32: Isochronous stress-strain lines at 23 °C
Elastollan® R 3000

Physical properties

Mechanical properties

Compression set

Compression set [%] is determined by a constant deformation test over a period of 24 hours at 70 °C or 72 hours at room temperature and is standardized in DIN ISO 815. In application, in the event of compressive stress one should not exceed 5 % compression for the more rigid grades and 10 % for the more flexible grades, if noticeable compression set is to be avoided. To achieve the best resistance to compression set annealing of the finished parts is recommended.

Impact strength

Elastollan® grades have outstanding low-temperature impact strength. You will find further information on impact strength in the table (page 28-33) or in the product information.

Abrasion

Abrasion [mm^3] is determined in accordance with ISO 4649. A test specimen is guided at a defined contact pressure on a rotating cylinder covered with paper. The total is approx. 40 m. The mass loss due to abrasion wear is measured, taking into account the density of the material and the sharpness of the test paper. The abrasion is given as the loss of volume in mm^3.

Elastollan® shows very low abrasion. Under practical conditions, TPU is considered to be the most abrasion resistant elastomeric material. Thorough pre-drying of the granulate prior to processing is however essential to achieve optimum abrasion performance. You will find further information on abrasion in the current Elastollan® Product Range or the product information.

Physical properties

Thermal properties

Thermal expansion

As all materials, Elastollan® is subject to a temperature-dependent, reversible variation in length. This is defined by the coefficient of linear expansion α [1/K] in relation to temperature and determined in accordance with ISO 11359-1-2. Fig. 33 and 34 compare the coefficients of linear expansion of some Elastollan® grades with steel and aluminum and illustrates the dependence on temperature and Shore hardness.

As shown the values for reinforced Elastollan® (glass fiber content 20 %) are similar to those for steel and aluminum. The influence of temperature is obvious and has to be considered for many applications.

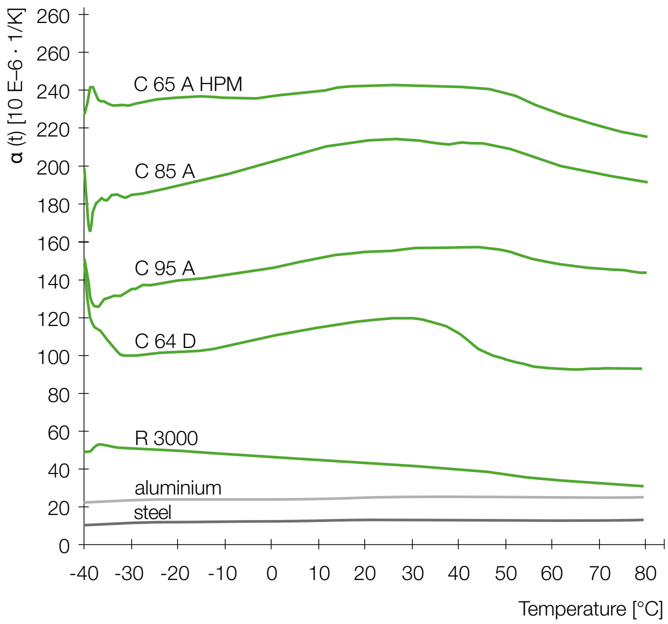


Fig. 33: Coefficient of thermal expansion α [1/K] various Elastollan® hardnesses (ester grades)

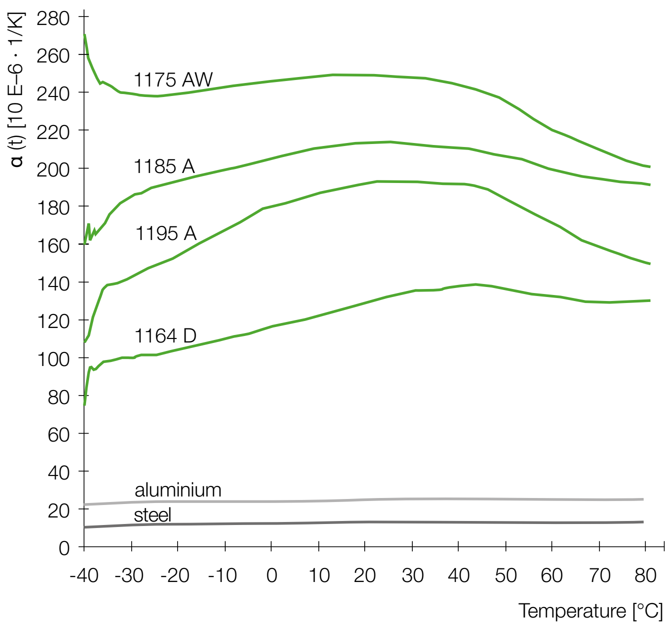


Fig. 34: Coefficient of thermal expansion α [1/K] various Elastollan® hardnesses (ether grades)

Physical properties

Thermal properties

Thermal data

Thermal data provide information on the thermal properties of a produced part as well as the melt during the production process.

Properties	according to	Unit	Values soft → hard
Thermal conductivity	DIN 52612-1	W/(m·K)	0.19 → 0.25
Heat of combustion	DIN 51900		
– heating value		J/g	25000 → 29000
– burning value		J/g	26000 → 31000
Specific heat	DIN 51005		
– room temperature		J/(g·K)	1.7 → 2.3
– melt temperature		J/(g·K)	1.7 → 2.3

Table 1: Representative values of thermal data of Elastollan®, more detailed information available on pages 28-33.

Melting-lamination temperature

In the thermomechanical analysis (TMA), the plastic deformation of a solid object is measured as a function of the temperature. During the measurement, a constant, usually low imposed load, acts on the test specimen. The measured deformation in the sample as a function of the temperature can be used among other things to determine the melting behavior at a very low shear rate. This allows the melting temperature during thermal bonding processes to be deduced. The details of the measurement are stipulated in DIN EN ISO 11359-3.

Product	Shore		TMA Onset (BASF hrs.)
	A	D	
991 A 10 FC	90	46	136,4
890 A 10	91	48	146,2
1190 A 10	91	44	161,3
B 90 A 11	92	44	174,0
C 90 A 10	94	47	186,1

Table 2: Standard thermal values, Elastollan®

Physical properties

Thermal properties

Thermal deformation

Various tests can be used to compare the application limits of plastics at increased temperature. These include the determination of the Vicat Softening Temperature (VST) according to ISO 306 and the determination of the Heat Deflection Temperature (HDT) according to ISO 75.

Vicat softening temperature

In the course of this test, a loaded needle (Vicat A: 10 N, Vicat B: 50 N) with a diameter of 1 mm^2 is placed on a test specimen, which is located on a plane surface within a temperature transfer medium. The temperature of the medium (oil or air) is increased at a constant heating rate (50 K/h or 120 K/h). The VST is the temperature at which the needle penetrates by 1 mm into the test material.

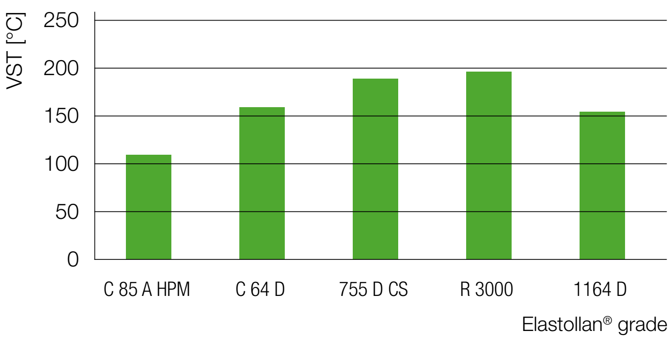


Fig. 35: Vicat temperature (VST) according to DIN EN ISO 306, Vicat A 120

Heat deflection temperature

Similarly to the Vicat test, the test set-up is heated in a heat transfer medium at a rate of 120 K/h. The arrangement is designed as 3-point bending test, the test piece being stressed at a constant load which corresponds to a bending stress of 1.80 MPa, 0.45 MPa or 8 MPa (method A, B or C), depending on the rigidity of the material. The temperature at which the test piece bends by 0.2 to 0.3 mm (depending on the height of the test piece) is indicated as HDT.

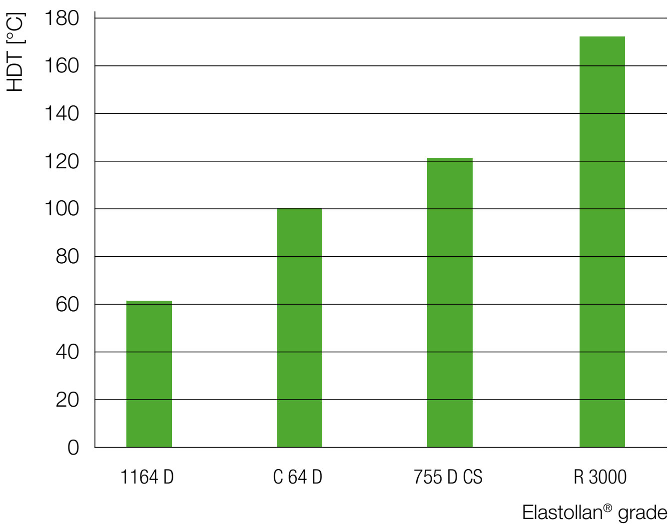


Fig. 36: Heat deflection temperature (HDT) according to DIN EN ISO 75, method B

Physical properties

Thermal properties

Maximum service temperature

The life expectancy of a finished TPU part will be influenced by several factors and is difficult to predict exactly. In order to be able to compare materials with one another under the aspect of “maximum service temperature”, prolonged storage tests according to DIN EN ISO 2578 at various temperatures are used to ascertain so-called “long-term air ageing”.

The diagrams below can be used to infer the time after which a material at a particular temperature goes below or above a particular limiting criterion:

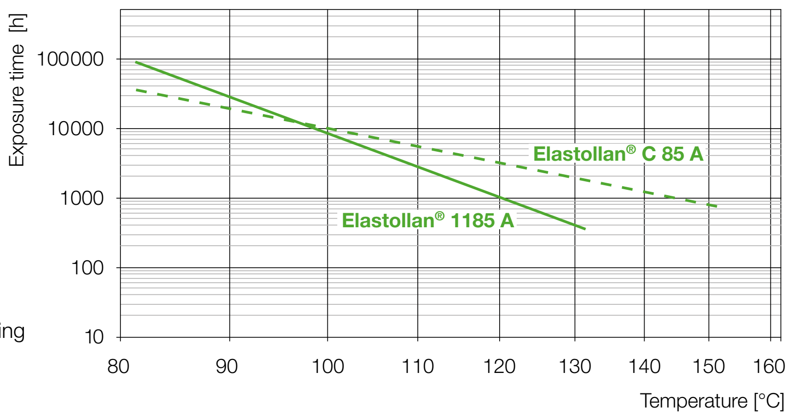


Fig. 37: Long-term air ageing

End criterion: tensile strength 20 MPa

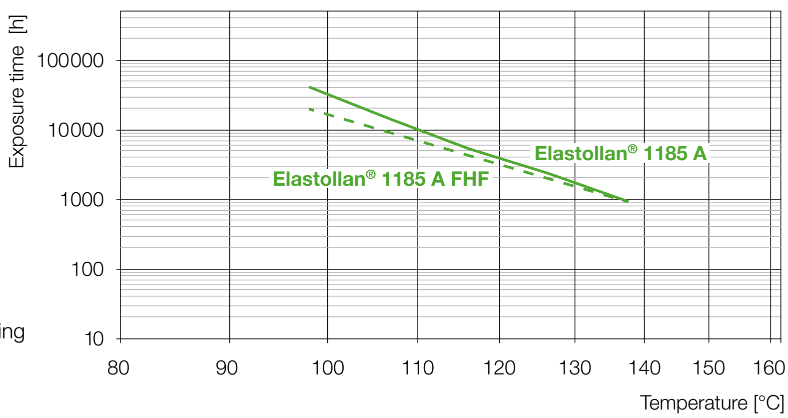


Fig. 38: Long-term air ageing

End criterion: Elongation of break 300 %

Physical properties

Electrical properties

General

The electrical conductivity of plastics is very low. They are, therefore, frequently used as insulating materials. Information on relevant properties for electrical applications must therefore be made available. For Elastollan® grades standard resistance measurements are made on conditioned test specimens (20 h, 100 °C) after storage in the standard conditioning atmosphere, i.e. 23 °C, 50 % relative humidity.

Allowance should be made for the fact that resistivity and dielectric properties are dependent on moisture content, temperature and frequency.

Tracking

Tracking results from the progressive formation of conductive paths on the surface of a solid insulating material. It is generated by the action of electrical loading and electrolytic impurities on the surface.

The Comparative Tracking Index (CTI) determined in accordance with IEC 60112 is the maximum voltage at which a material will withstand 50 drops of a defined test solution without tracking.

Dielectric strength

Dielectric strength according to IEC 60243 is the ratio between disruptive voltage and the distance of the electrodes separated by the insulating material. Disruptive voltage is the a.c. voltage at which point the insulating material breaks down.

Surface resistivity

The specific surface resistance is the resistance of the surface of a test piece. It is measured between two electrodes of dimensions prescribed in DIN EN 62631-3-2, fixed to the surface at a specified distance.

Volume resistivity

Volume resistivity as defined in DIN EN 63631-3-1 is the electrical resistance of the bulk material measured between two electrodes, relative to the geometry of the test piece. The type of electrode arrangement makes it possible to ignore surface resistance.

Dielectric constant

Dielectric constant is the ratio of capacity measured with the insulating material compared with that for air. This constant is determined in accordance with IEC 60250 and is temperature and frequency dependent.

Dielectric loss factor

When an insulating material is used as dielectric in a capacitor, an adjustment of the phase displacement between current and voltage occurs. The displacement from the normal angle of 90 ° is known as the loss angle. The loss factor is defined as the tangent of the loss angle. As with dielectric constant, it varies with temperature and frequency. Values are provided for various frequencies at 23 °C.

Physical properties

Elastollan® (TPU) Unreinforced Grades

Typical values at 23 °C for uncolored products	Unit	Test method
Features		
Symbol		
Density	g/cm³	ISO 1183
Water absorption, equilibrium in water at 23 °C	%	similar ISO 62
Moisture absorption, equilibrium in standard cond. atmo. 23 °C / 50 % r.h.	%	similar ISO 62
Flammability		
Flammability acc. to UL94 (thickness)	class (mm)	UL 94
GWFI (thickness)	°C (mm)	IEC 60695-2-12
GWIT (thickness)	°C (mm)	IEC 60695-2-13
Oxygen index	%	ISO 4589-1/-2
Railway: Spec. Optical density of smoke DS mx. (20min.), 25 kW/m², 2mm	-	EN ISO 5659-2: 2007-04
Railway: Toxicity of smoke CIT NLP acc. to EN 45545-2: 2013-08	-	NF X70-100-1/-2
Testing of materials for automobile interior, burning rate ≤ 100mm/min (d = 2.0 mm)		ISO 3795, FMVSS 302[1]
Electrical properties		
Dielectric constant at 1 MHz		IEC 60250
Dielectric factor at 1 MHz	10^{-4}	IEC 60250
Volume resistivity	Ω·m	DIN EN ISO 62631-3-1
Surface resistivity	Ω	DIN EN ISO 62631-3-2
CTI, test liquid A	-	IEC 60112
Dielectric strength EB1	kV/mm	IEC 60423-1
Thermal properties		
Heat distortion temperature HDT A (1.80 MPa)	°C	ISO 75-1/-2
Heat distortion temperature HDT B (0.45 MPa)	°C	ISO 75-1/-2
Thermal conductivity, 23 °C	W/(m·K)	DIN 52612-1
Specific heat capacity, 23 °C	J/(g·K)	-
Mechanical properties		
Hardness	Shore	ISO 7619-1 (3s)
Tensile modulus of elasticity	MPa	ISO 527-2-5A
Tensile strength	MPa	ISO 527-2-5A
Strain at break	%	ISO 527-2-5A
Charpy impact strength +23 °C	kJ/m²	ISO 179-1eU
Charpy impact strength -30 °C	kJ/m²	ISO 179-1eU
Charpy notched impact strength +23 °C	kJ/m²	ISO 179-1eA
Charpy notched impact strength -30 °C	kJ/m²	ISO 179-1eA
Processing		
Melt mass flow rate MFR, test temperature/load	g / 10 min.	ISO 1133
Melt temperature range for injection-molding	°C	
Mold temperature range for injection-molding	°C	

Footnote:
[1] passed: +
[2] product not UL-listed

Values after tempering (20 h, 100 °C) in conditioned state

Physical properties

Unreinforced Grades

C 78 A 10 (A 15)	C 85 A 10	C 59 D 53	1175 A 10 W	1185 A 10 FHF	1185 A1 0 HFFR[2]	1190 A 10 FHF
1,18	1,19	1,23	1,14	1,23	1,42	1,25
			1.4	1.4		
			0.5	0.4		
HB (0.9)	HB (0.9-3)	HB (0.75)	V0 (0.9-1.1), V2 (1.2)	V0 (0.75-3.0)	-	V0 (0.75-3.0)
			960 (2.0)	875 (2.0)	930 (1.5)	875 (1.5)
			875 (2.0)	850 (2.0)	800 (1.5)	800 (1.5)
			25-26	24	32	24
				627 (2.0)	181 (1.6)	405 (1.7)
				0.36	0.11	0.44
+	+	+	+	+	+	+
6.0	6.0	5.0	6.5	5.5	6.2	
700	700	600	1.400	960	1.108	
1,00E+11	1,00E+11	1,00E+12	1,00E+9	1,00E+9	1,00E+7	
1,00E+13	1,00E+13	1,00E+15	1,00E+14	1,00E+14	1,00E+12	
600	600	600	600	600	600	
23	23	28	25	26		
0.18	0.21	0.22		0.32		
1.7	1.7	1.5		1.5		
80 (A)	87 (A)	57 (D)	75 (A)	89 (A)	86 (A)	90 (A)
		250				
50	50	50	40	35	23	25
650	650	500	700	600	580	550
N	N	N	N	N	N	
N	N	N	N	N	N	
N	N	N	N	N	N	N
N	N	12	N	120	77	46
10-40 (190/21.6)	20-60 (200/21.6)		20-60, 190/10	25-45, 200/21.6	10, 180/5	25-45, 200/21.6
200-220	205-225	220-230	210-220	215-225	215-225	215-225
15-50	15-50	15-70	20-40	20-40	20-40	20-40
Thermoplastic polyester polyurethane with excellent mechanical properties, very strong dampening and rebound properties and a very high wear resistance.	Thermoplastic polyester polyurethane with excellent mechanical properties, very strong dampening and rebound properties and a very high wear resistance.	Thermoplastic polyester polyurethane with excellent mechanical properties, very strong dampening and rebound properties and a very high wear resistance.	Thermoplastic polyether polyurethane with excellent hydrolysis resistance, flexibility at cold temperatures and resistance against microorganisms.	Thermoplastic polyether polyurethane with excellent hydrolysis resistance, flexibility at cold temperatures and resistance against microorganisms; flame-retardant without halogens.	Thermoplastic polyether polyurethane with excellent hydrolysis resistance, flexibility at cold temperatures and resistance against microorganisms; flame-retardant without halogens; reduced density and toxicity of smoke.	Thermoplastic polyether polyurethane with excellent hydrolysis resistance, flexibility at cold temperatures and resistance against microorganisms; flame-retardant without halogens.

Physical properties

Elastollan® (TPU) Unreinforced Grades

Typical values at 23 °C for uncolored products	Unit	Test method
Features		
Symbol		
Density	g/cm³	ISO 1183
Water absorption, equilibrium in water at 23 °C	%	similar ISO 62
Moisture absorption, equilibrium in standard cond. atmo. 23 °C / 50 % r.h.	%	similar ISO 62
Flammability		
Flammability acc. to UL94 (thickness)	class (mm)	UL 94
GWFI (thickness)	°C (mm)	IEC 60695-2-12
GWIT (thickness)	°C (mm)	IEC 60695-2-13
Oxygen index	%	ISO 4589-1/-2
Railway: Spec. Optical density of smoke DS mx. (20min.), 25 kW/m², 2mm	-	EN ISO 5659-2: 2007-04
Railway: Toxicity of smoke CIT NLP acc. to EN 45545-2: 2013-08	-	NF X70-100-1/-2
Testing of materials for automobile interior, burning rate ≤ 100mm/min (d = 2.0 mm)		ISO 3795, FMVSS 302[1]
Electrical properties		
Dielectric constant at 1 MHz		IEC 60250
Dielectric factor at 1 MHz	10^{-4}	IEC 60250
Volume resistivity	Ω·m	DIN EN ISO 62631-3-1
Surface resistivity	Ω	DIN EN ISO 62631-3-2
CTI, test liquid A	-	IEC 60112
Dielectric strength EB1	kV/mm	IEC 60423-1
Thermal properties		
Heat distortion temperature HDT A (1.80 MPa)	°C	ISO 75-1/-2
Heat distortion temperature HDT B (0.45 MPa)	°C	ISO 75-1/-2
Thermal conductivity, 23 °C	W/(m·K)	DIN 52612-1
Specific heat capacity, 23 °C	J/(g·K)	-
Mechanical properties		
Hardness	Shore	ISO 7619-1 (3s)
Tensile modulus of elasticity	MPa	ISO 527-2-5A
Tensile strength	MPa	ISO 527-2-5A
Strain at break	%	ISO 527-2-5A
Charpy impact strength +23 °C	kJ/m²	ISO 179-1eU
Charpy impact strength -30 °C	kJ/m²	ISO 179-1eU
Charpy notched impact strength +23 °C	kJ/m²	ISO 179-1eA
Charpy notched impact strength -30 °C	kJ/m²	ISO 179-1eA
Processing		
Melt mass flow rate MFR, test temperature/load	g / 10 min.	ISO 1133
Melt temperature range for injection-molding	°C	
Mold temperature range for injection-molding	°C	

Footnote:
[1] passed: +
[2] product not UL-listed

Values after tempering (20 h, 100 °C) in conditioned state

Physical properties

Unreinforced Grades

1192 A 11 FHF[2]	SP 3092 A 10 HFFR	1195 A 10 / 1195 A 15	1154 D 10	1154 D 10 FHF	1174 D 11	1280 D 10 FHF
1,25	1,62	1,15	1,17	1,27	1,20	1,32
				1.4		
				0.4		
V0 (0.8-3.2)		HB (0.5-3.0)	HB (1.0)	V0 (3.0), V2 (0.75)		V2 (0.45 - 3.0)
960 (1.5)	960 (1.5)	750 (2.0)		960 (2.0)		850 (1.5)
825 (1.5)	750 (1.5)	775 (2.0)		875 (2.0)		800 (1.5)
29	>40	24		24		
244 (1.7)	78 (1.6)			282 (0.78)		
0.55	0.10	0.10		0.40		
+	+	+	+	+	+	+
		7.5	4.5	4.5	4.0	
			600	640	400	
		1,00E+12	1,00E+13	1,00E+10	1,00E+15	
		1,00E+15	1,00E+15	1,00E+14	1,00E+15	
		600	600	600	600	
			36		37	
		0.30	0.31	0.37		
			1.6		1.5	
91 (A)	95 (A)	96 (A)	53 (D)	58 (D)	75 (D)	80 (D)
			150	160	560	2,300
17	15	55	50	30	65	49
550	400	500	450	400	380	10
		N	N	50	N	
		N	18	3	5	
38, 200/21.6	10, 180/5.0	30-80, 210/10.0	20-70, (230/2.16)	30-70, 230/2.16		28, 230/2.16
215-225		210-235	210-230	225-235	220-235	210-230
20-40		15-70	15-70	30-60	15-70	20-40
Thermoplastic polyether polyurethane with excellent hydrolysis resistance, flexibility at cold temperatures and resistance against microorganisms; improved flame-retardancy without halogens.	Thermoplastic polyether polyurethane with excellent hydrolysis resistance, flexibility at cold temperatures and resistance against microorganisms; reduced smoke density and toxicity.	Thermoplastic polyether polyurethane with excellent hydrolysis resistance, flexibility at cold temperatures and resistance against microorganisms as well as high mechanical strength and durability	Thermoplastic polyether polyurethane with excellent hydrolysis resistance, flexibility at cold temperatures and resistance against microorganisms.	Thermoplastic polyether polyurethane with excellent hydrolysis resistance, flexibility at cold temperatures and resistance against microorganisms; flame-retardant without halogens.	Thermoplastic polyether polyurethane with excellent hydrolysis resistance, flexibility at cold temperatures and resistance against microorganisms.	Thermoplastic polyether polyurethane with excellent hydrolysis resistance, flexibility at cold temperatures and resistance against microorganisms; flame-retardant without halogens.

Physical properties

Elastollan® (TPU), Reinforced Grades

Typical values at 23 °C for uncolored products	Unit	Test method
Features		
Symbol		
Density	g/cm³	ISO 1183
Water absorption, equilibrium in water at 23 °C	%	similar ISO 62
Moisture absorption, equilibrium in standard cond. atmo. 23 °C / 50 % r.h.	%	similar ISO 62
Flammability		
Flammability acc. to UL94 (thickness)	class (mm)	UL 94
GWFI (thickness)	°C (mm)	IEC 60695-2-12
GWIT (thickness)	°C (mm)	IEC 60695-2-13
Oxygen index	%	ISO 4589-1/-2
Railway: Spec. Optical density of smoke DS mx. (20min.), 25 kW/m², 2mm	-	EN ISO 5659-2: 2007-04
Railway: Toxicity of smoke CIT NLP acc. to EN 45545-2: 2013-08	-	NF X70-100-1/-2
Testing of materials for automobile interior, burning rate ≤ 100mm/min (d = 2.0 mm)		ISO 3795, FMVSS 302[1]
Electrical properties		
Dielectric constant at 1 MHz		IEC 60250
Dielectric factor at 1 MHz	10^{-4}	IEC 60250
Volume resistivity	Ω·m	DIN EN ISO 62631-3-1
Surface resistivity	Ω	DIN EN ISO 62631-3-2
CTI, test liquid A	-	IEC 60112
Dielectric strength EB1	kV/mm	IEC 60423-1
Thermal properties		
Heat distortion temperature HDT A (1.80 MPa)	°C	ISO 75-1/-2
Heat distortion temperature HDT B (0.45 MPa)	°C	ISO 75-1/-2
Thermal conductivity, 23 °C	W/(m·K)	DIN 52612-1
Specific heat capacity, 23 °C	J/(g·K)	-
Mechanical properties		
Hardness	Shore	ISO 7619-1 (3s)
Tensile modulus of elasticity	MPa	ISO 527-2-5A
Tensile strength	MPa	ISO 527-2-5A
Strain at break	%	ISO 527-2-5A
Charpy impact strength +23 °C	kJ/m²	ISO 179-1eU
Charpy impact strength -30 °C	kJ/m²	ISO 179-1eU
Charpy notched impact strength +23 °C	kJ/m²	ISO 179-1eA
Charpy notched impact strength -30 °C	kJ/m²	ISO 179-1eA
Processing		
Melt mass flow rate MFR, test temperature/load	g / 10 min.	ISO 1133
Melt temperature range for injection-molding	°C	
Mold temperature range for injection-molding	°C	

Footnote:
[1] passed: +
[2] product not UL-listed

Values after tempering (20 h, 100 °C) in conditioned state

Physical properties

Reinforced Grade R 3000
1,38
HB (0.75 -3.0)
725 (1.9)
650 (1.9)
+
600
1,00E+9
1,00E+15
600
35
126
162
73 (A)
2,800
80
10
120
70
30
10
25, 230/2.16
225-245
40-70

Glas fiber reinforced thermoplastic polyurethane with excellent properties such as very high impact strength, high stiffness combined with balanced elongation, low thermal expansion, low shrinkage and good paintability.

Physical properties

Gas permeability

Gas permeability

The passage of gas through a test specimen is called diffusion. This takes place in three stages:

1. Solution of the gas in the test specimen.
2. Diffusion of the dissolved gas through the test specimen.
3. Evaporation of the gas from the test specimen.

The diffusion coefficient Q [m²/(s · Pa)] is a material constant which specifies the volume of gas which will pass through a test specimen of known surface area and thickness in a fixed time, with a given partial pressure difference. The coefficient varies with temperature and is determined in accordance with DIN 53536.

Elastollan® grade	Gas						
	Ar	CH_4	CO_2	H_2	He	N_2	O_2
C 80 A	12	11	200	45	35	4	14
C 85 A	9	6	150	40	30	3	10
C 90 A	5	4	40	30	25	2	7
C 95 A	3	2	20	20	20	1	4
1180 A	14	18	230	70	50	6	21
1185 A	9	14	180	60	40	5	16
1190 A	7	9	130	50	30	4	12
1195 A	6	5	90	40	20	3	8

Table 3: Gas permeability coefficient Q $[m^2/(s \cdot Pa)] \cdot 10^{-18}$

Table 3 shows the gas diffusion coefficients of Elastollan® grades for various gases at a temperature of 20 °C.

The variation of diffusion coefficient with temperature using Elastollan® 1185 A and nitrogen as example is illustrated in Fig. 39.

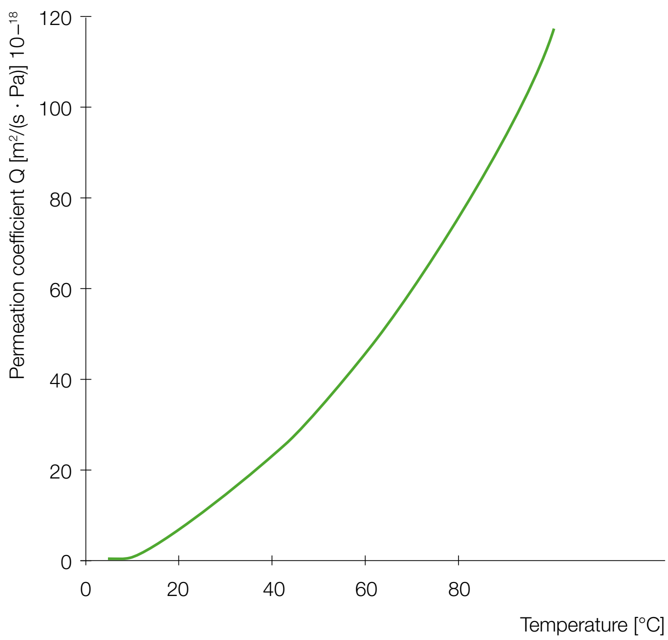


Fig. 39: Affect of temperature on permeability coefficient: Elastollan® 1185 A with nitrogen

Physical properties

Gas permeability

Water vapor permeability

The water vapor permeability WDD [g/(m^2 · d)] of a plastic is determined in accordance with DIN 53122-1. This is defined as the amount of water vapor passing through 1 m^2 of test specimen under set conditions (temperature, humidity differential) in 24 hours, and is roughly in inverse proportion to specimen thickness.

The figures shown in Table 4 were obtained with a temperature of 23 °C, a humidity differential of 85 % relative humidity and with a film thickness of 50 µm.

Elastollan® grade	WDD
E 890 A	83
E 1185 A	183
E SP 883 A	192
E SP 806	261
E 1170 A	388
E SP 9109	686
E 1385 A	786

Table 4: Water vapor permeability WDD [g/(m^2 · d)] according to DIN 53122-1, 23 °C at 85 % r.h., 50 µm film.

Chemical properties

Swelling

General
The suitability of a plastic for a particular application often depends on its resistance to chemicals. Thermoplastic polyurethanes can have very different behavior on contact with chemical substances, since the compositions thereof are very different in some cases and the various components can react to different degrees on contact with other substances.

Therefore, it is not always possible to undertake a clear separation of the effects described below. For particular applications, a specific stability test with regard to swelling characteristics and mechanical properties is advisable.

Swelling
Swelling is the fundamental physical process of the absorption of liquid substances by a solid. In this process, the substance enters into the material without chemical interaction between the substance and the plastic. This results in an increase in volume and weight with a corresponding reduction in mechanical values. After evaporation, a reduction in swelling occurs and the original properties of the product are almost completely restored. Thus, swelling is a reversible process.

Chemical properties

Chemical resistance

General
Chemical resistance depends on the period of exposure, the temperature, the quantity, the concentration and the type of the chemical substance. In the case of chemical degradation of polyurethane, the chemical reaction results in cleavage of the molecular chains. This process is generally preceded by swelling. In the course of degradation, polyurethane loses strength, and in extreme cases this can lead to disintegration of the material.

Acids and alkaline solutions
Elastollan® products are attacked by concentrated acids and alkaline solutions even at room temperature. Any contact with these substances should be avoided. Elastollan® is resistant to short-time contact with dilute acids and alkali solutions at room temperature.

Saturated hydrocarbons
Contact of Elastollan® with saturated hydrocarbons such as diesel oil, isooctane, petroleum ether and kerosene, results in a limited swelling. At room temperature, this swelling amounts to approx. 1 - 3 % and the resultant reduction in tensile strength is no more than 20 %. After evaporation and reversal of the swelling, the original mechanical properties are almost completely restored.

Aromatic hydrocarbons
Contact of Elastollan® with aromatic hydrocarbons such as benzene and toluene, results in considerable swelling even at room temperature. Absorption can result in a 50 % weight increase with a corresponding reduction in mechanical properties.

Lubricating oils and greases
No reduction in strength occurs after immersion in test oils IRM 901, IRM 902, and IRM 903 at room temperature. There is also no reduction in tensile strength after 3 weeks immersion at 100 °C. Elastollan® is in principal resistant to lubricating oils and greases, however irreversible damage can be caused by included additives. Compatibility testing in each individual lubricant is to be recommended.

Solvents
Aliphatic alcohols, such as ethanol and isopropanol, cause swelling of Elastollan® products. This is combined with a loss of tensile strength. Rising temperatures intensify these effects. Ketones such as acetone, methylethylketone (MEK) and cyclohexanone are partial solvents for thermoplastic polyurethane elastomers. Elastollan® products are unsuitable for long-term use in these solvents.

Aliphatic esters, such as ethyl acetate and butyl acetate, cause severe swelling of Elastollan®. Highly polar organic solvents such as dimethylformamide (DMF), dimethylsulphoxide (DMSO), N-methylpyrrolidine and tetrahydrofuran (THF) dissolve thermoplastic polyurethane.

Chemical properties

Chemical resistance

For the following media, the resistance of Elastollan® has been tested:

Reagents	Code
Adblue	11.
Acetic Acid	1.
Alcohol	11./16.
Ammonium Chloride Solution	10.
Ammonium Solution	10.
Anti-freeze	14.
ASTM-Oils 1, 2 and 3	13./15.
Battery Acid	5.
Benzyl Alcohol	16.
Bleach	7.
Boric Acid	1.
Brake Fluid	14.
Butyric Acid	1.
Calcium Hydroxide Solution	9.
Citric Acid	2.
Ethanol = Ethyl Alcohol	11./16.
Ethyl Acetate	14./15.
FAM Test Fluids A, B and C, according to DIN 51604	12./16.
Formic Acid	1.
Gasoline	12./16.
Diluted Hydrochloric Acid	4.
Hydrogen Peroxide	7.
IRM Oils	13.
Iso-Propanol = Isopropyl Alcohol	11./16.
Lactic Acid	1.
LauricAcid	1.
Methanol = Methyl Alcohol	11./16.
Diluted Nitric Acid	6.
Oleic Acid	1.
Phenol Solution	1.
Diluted Phosphoric Acid	3.
Propionic Acid	1.
Sea Water	0.
Silicone Oil = Dimethyl Polysiloxane	14.
Slaked Lime = Calcium Hydroxide Solution	9.
Diluted Soda Lye	9.
Soda Solution	9.
Sodium Bisulphate Solution	3.
Sodium Hydroxide Solution	9.
Sodium Hypochlorite Solution	7.
Sodium Nitrate Solution	7.
Sodium Sulphite Solution	8.
Stearic Acid	1.
Diluted Sulphuric Add	4.
Tap Water	0.
Trichloroethane	14./15.
Triethanolamine Solution	9.
Urea Solution	10.
Water	0.

Solvents	Code
Acetic Ester	15.3
Acetone	15.4
Amyl Acetate	15.3
ASTM-Oils 1, 2 and 3	13./15.7
Benzene	15.2
Benzyl Alcohol	16.
Biodiesel Fuel	16.
Butane	15.1
Butyl Acetate	15.3
Chlorobenzene	15.6
Chloroform	15.5
Cyclohexane	15.1
Dimethyl Acetamide	15.8
Dimethyl Formamide = DMF	15.8
Dimethyl Sulphoxide = DMSO	15.8
Diesel Fuel	16.
Ethane	15.1
Ethanol	16./11.
Ethyl Acetate = Acetic Ester	15.3
Ethylene Glycol = Glycol	16.
FAM Test Fluids A, B and C, according to DIN 51604	16./12.
Fuel A, B, C and D, according to ASTM D 471	16.
Glycol = Ethylene Glycol	16.
Glycerine	16.
Hexane	15.1
Iso-Octane	15.1
Iso-Propanol = Isopropyl Alcohol	16./11.
Kerosine	15.1
Methane	15.1
Methanol	16./11.
Methylen Chloride	15.5
Methyl Ethyl Ketone = MEK	15.4
Methyl Isobutyl Ketone = MIBK	15.4
N-Methyl Pyrrolidone = NMP	15.8
Octane	15.1
Paraffin Oil	15.1
Pentane	15.1
Petroleum Ether	15.1
Propane	15.1
Pyridine	15.8
Tetrachloroethylene	15.5
Tetrahydrofurane	15.8
Toluene	15.2
Trichloroethane	15.5
Xylene	15.2

Chemical properties

Chemical resistance

Test conditions

Test Specimens
Standard 5A test piece according to DIN EN ISO 527-2, all test rods were pretempered for 20 h at 100° C.

Test Temperature
Reagents: 60° C; Solvents: 23° C

Test Criteria
Reagents: accomplishing a remaining tensile strength of 20 MPa. Solvents: reduction in tensile strength due to swelling after three weeks immersion.

The resistance is indicated roughly in terms of days, weeks, months or years. According to a general rule of thumb, resistance may be extrapolated to double when reducing temperature by 10° C, and when increasing temperature by 10° C, to half.

Tests were performed with Elastollan® standard ester grades (e.g. 500, 800), Elastollan® 85 A and standard ether grades (e.g. 1100). Swelling and solution are primarily affected by the number of hydrogen bonds effective between the linear molecular chains, which increases with hardness. From this, it can be derived that harder products suffer less swelling, and their chemical resistance is higher.

Highly polar substances may in part or completely break down the molecular interactions which in turn causes strong swelling or dissolving of Elastollan®.

Chemical properties

Chemical resistance

Chemical resistance

Code:	tested:	Elastollan® standard-ester (e.g. 500, 800) 23 °C	60 °C	Elastollan® C 85 A 23 °C	60 °C	Elastollan® ether grades (e.g. 1100) 23 °C	60 °C
0. Water	Tap Water	Years	Months	Years	Months	Years	Years
	Sea Water	Years	Months	Years	Months	Years	Years
1. Weak Acids, Carbonic Acids	3 % Acetic Acid	Weeks	Days	Weeks	Days	Years	Months
	3 % Lactic Acid	Weeks	Days	Weeks	Days	Years	Months
	3 % Boric Acid	Months	Weeks	Months / Years	Weeks / Months	Years	Months
	3 % Phenolic Solution	Weeks / Months	Days	Months / Years	Weeks	Years However, tensile strength only 50 % due to swelling	Months
	The action of 3 % solutions of formic acid, propionic acid, butyric acid, lauric acid, oleic acid, stearic acid etc., will be comparable.						
2. Chelating Carbon Acids	3 % Citric Acid	Months	Days	Months	Days	Years	Months
3. Weak Mineral Acids	3 % Sodium Bisulphate Solution	Months	Days / Weeks	Months / Years	Weeks	Years	Months
	3 % Phosphoric Acid	Months	Days	Months	Weeks	Years	Months
4. Strong Mineral Acids	3 % Hydrochloric Acid	Days	Hours	Days	Hours	Years	Months
	The action of 3 % sulphuric acid will be similar.						
5. Battery Acid	Battery Acid	Days	Hours	Days	Hours	Years	Months
6. Oxidizing Mineral Acids	3 % Nitric Acid	Days	Hours	Days	Hours	Days	Hours
7. Oxidizing Solutions, pH-value around 7	Hydrogen Peroxide 35 %	Weeks / Months		Months		Months	
	Sodium Nitrate, 3 %	Months / Years	Weeks	Years	Months	Years	Months
	Sodium Hypochlorite= Bleach (Javelle Water), 3 %	Weeks Surface becomes tacky	Days	Weeks	Days	Months	Weeks
	Bleach (Javelle Water), 0.5 %	Months Surface becomes tacky	Weeks	Months	Weeks	Years	Months
8. Reducing Solutions	Sodium Sulphite, 3 %	Months / Years	Weeks / Months	Years	Months	Years	Months
9. Alkaline Solutions	Saturated Calcium Hydroxide (Slaked Lime)	Months / Years	Weeks	Years	Months	Years	Months
	3 % Soda Solution	Months / Years	Weeks	Years	Months	Years	Months
	3 % Soda Lye (Caustic Soda)	Weeks	Days	Months	Weeks	Years	Months
	3 % Triethanolamine Solution	Months	Weeks	Months / Years	Months	Years	Months
10. Basic Solutions	3 % Urea Solution	Months	Weeks	Months / Years	Weeks	Years	Months
	3 % Ammonium Solution	Days	Hours	Weeks	Days	Years	Months
	3 % Ammonium Chloride Solution	Months / Years	Weeks / Months	Years	Months	Years Reduced tensile strength due to swelling	Months

Chemical properties

Chemical resistance

Code:	tested:	Elastollan® standard-ester (e.g. 500, 800)		Elastollan® C 85 A		Elastollan® ether grades (e.g. 1100)	
		23 °C	60 °C	23 °C	60 °C	23 °C	60 °C
11. Adblue	Adblue	Weeks	Weeks	Months	Weeks	Months / Years	Months
12. Alcohols	Methanol	Days		Weeks / Months		Months	
	Ethanol	Months		Months		Years	
	Iso-Propanol	Months		Months		Years	
13. FAM Test Fluids acc. to DIN 51604*	Test Fluid C	Months		Years		Years	
	Test Fluid B	Days		Months		Years Strong swelling	
	Test Fluid C	Days		Weeks		Years Strong swelling	
14. ASTM-Oils acc. to ASTM D 471-06**	IRM 901	Years	Months	Years	Months	Years	Months
	IRM 902	Years	Months	Years	Months	Years	Months
	IRM 903	Years	Months	Years	Months	Years	Months
15. Miscellaneous	Anti-freeze (Glysantine/Water 1/1.5)	Months	Weeks	Months / Years	Weeks	Years	Months
	Silicone Fluid (Dimethyl Polysiloxane)	Years	Months	Years	Months	Years	Months
	Brake Fluid	Hours	Hours	Hours	Hours	Hours	Hours
		Brake fluid/many hydraulic oils attack TPU					
	Ethyl Acetate	Months		Months		Months Reduced tensiled due to swelling	
	Volume swelling:	75 %		70 %		70 %	

* DIN 51 604, 03.1984, is the standard, etablished by FAM to assess the resistance of plastic materials to automotive fuels.

** The IRM reference oils are mineral oils with different paraffin and aromatics contents. The formerly used ASTM oils 1, 2 and 3 were replaced by the IRM oils 1, 2 and 3 owing to health risks, and are no longer available. The IRM oils 1, 2 and 3 are very similar in terms of their characteristics, but not identical.

(FAM = Fachausschuß Mineral- und Brennstoffnormung-Professional committee for standardization of fuel stuffs)

(ASTM = American Society for Testing and Materials)

Test fluid A consists of:
50.0 % by volume toluene
30.0 % by volume iso-octane
15.0 % by volume di-isobutylene
5.0 % by volume ethanol

Test fluid B consists of:
42.0 % by volume toluene
25.5 % by volume iso-octane
13.0 % by volume di-isobutylene
15.0 % by volume methanol
4.0 % by volume ethanol
0.5 % by volume water

Test fluid C consists of:
20.0 % by volume toluene
12.0 % by volume iso-octane
6.0 % by volume di-isobutylene
58.0 % by volume methanol
2.0 % by volume ethanol
2.0 % by volume water

Chemical properties

Chemical resistance

Solvents resistance

16. Solvents	No degradation of Elastollan® products occurs, however, according to the solvent class a variable degree of swelling and consequent reduction in tensile strength (after evaporation of the solvents, the tensile strength recovers approx. its original value). Methanol should be considered more as a chemical reagent than as a solvent. TPU is soluble in some solvents. As test procedure, 5A test rods (DIN EN ISO 527-2) were immersed in the solvent for three weeks at 23° C, and tested for tensile strength and residual swell 15 minutes after withdrawal. The values of volume swelling and reduction of tensile strength are rounded values.

Code:	**tested:**	**Elastollan® standard-ester (e.g. 500, 800)**		**Elastollan® C 85 A**		**Elastollan® ether grades (e.g. 1100)**	
		% Swelling	**%** Reduction of Tensile strengh	**%** Swelling	**%** Reduction of Tensile strengh	**%** Swelling	**%** Reduction of Tensile strengh
16.1. Aliphatic Hydrocarbons	Pentan	3	20	4,5	10	10	20
	Cyclohexan	4	15	7	10	22	10
	Isooctan	2.5	none	2.5	none	7.5	none
	Elastollan® grades behave similarly in other aliphatic and cyclo-aliphatic hydrocarbons such as methane, ethane, propane, butane, hexane, octane, petroleum ether, paraffin oil, diesel oil and kerosine (although additives can present problems).						
16.2. Aromatic Hydrocarbons	Toluene	52	55	60	45	65	50
	Other aromatic hydrocarbons such as benzene and xylene have a similar affect.						
16.3. Aliphatic Esters	Ethyl Acetate	75	70	70	65	70	75
	Other short-chained esters such as butyl acetate and amyi acetate have a similar affect.						
16.4. Aliphatic Ketones	Methyl Ethyl Ketone	105	80	110	80	130	90
	Other short-chained aliphatic ketones such as acetone and methyl isobutyl ketone = MIBK have a similar affect.						
16.5. Aliphatic Halogenated Hydrocarbons, 1 C-atom	Methylene Chloride	175	75	155	65	190	95
	Chloroform	280	75	260	70		practically dissolved
		20	40	28	35	50	45
2 C-atoms and higher	Tetrachloroethylene	54	39	65	39	75	54
	Trichloroethane						
	Other aliphatic halogenated hydrocarbons with 2 C-atoms and higher have a similar affect.						
16.6. Aromatic Halogenated Hydrocarbons	Chlorobenzene	90	60	100	55	110	60
	Other aromatic halogenated hydrocarbons have a similar affect.						
16.7. ASTM-Oils acc. to ASTM D 471-06**	IRM 901 at 100 °C 500 h	none	1	none	none	1	6
	1000 h			none	6	1	14
	IRM 902 at 100 °C 500 h	3	8	3	none	9	4
	1000 h			4	18	10	5
	IRM 903 at 100 °C 500 h	7	20	7	none	18	8
	1000 h			12	50	20	30
16.8. Agents Dissolving TPU	Tetrahydrofurane	> 450	practically dissolved	> 450	practically dissolved		dissolved
	Dimethyl Formamide (DMF)		dissolved		dissolved		dissolved
	Dimethyl Acetamide		dissolved		dissolved		dissolved
	N-Methyl Pyrrolidone (NMP)		dissolved		dissolved		dissolved
	Dimethyl Sulphoxide (DMSO)		dissolved		dissolved		dissolved
	Pyridine		dissolved		dissolved		dissolved

Chemical properties

Chemical resistance

Code:	tested:	Elastollan® standard-ester (e.g. 500, 800) % Swelling	% Reduction of Tensile strengh	Elastollan® C 85 A % Swelling	% Reduction of Tensile strengh	Elastollan® ether grades (e.g. 1100) % Swelling	% Reduction of Tensile strengh
17. Alcohols and Fuels	Methanol	18	80 poor resistance	18 limited resistance for sev. weeks	58	28	60
	Ethanol	16	52	18	52	33	64
	Iso-Propanol	14	44	17	42	30	50
	Benzyl Alcohol	300	95 poor resistance	270 poor resistance	85	not measurable	partly dissolved poor resistance
	Ethylene Glycol	2	none	2	none	4	15
	Glycerine	none	none	none	none	none	none
FAM Test Fluids acc. to DIN 51 604*	Test Fluid A	39	55	45	50	67	60
	Test Fluid B	38	72 poor resistance	38 limited resistance for sev. weeks	55	68	74
	Test Fluid C	21	60	24 limited resistance for sev. weeks	50	43	70
Diesel Fuel	Diesel Fuel	3,0	15	5,0	none	11	none
Biodiesel Fuel RME at 60°C	Biodiesel Fuel			9	9	27	21
Fuel Types ASTM D 471	Fuel A = Iso-Octane	2.5	none	2.5	none	7.5	none
	Fuel B = Iso-Octane Toluene 70 % / 30 %	13	30	18	32	25	36
	Fuel C = Iso-Octane Toluene 50 % / 50 %	21	40	27	38	38	44
	Fuel D = Iso-Octane Toluene 60 % / 40 %	17	37	21	36	31	44

* DIN 51 604, 03.1984, is the standard, etablished by FAM to assess the resistance of plastic materials to automotive fuels.

** The IRM reference oils are mineral oils with different paraffin and aromatics contents. The formerly used ASTM oils 1, 2 and 3 were replaced by the IRM oils 1, 2 and 3 owing to health risks, and are no longer available. The IRM oils 1, 2 and 3 are very similar in terms of their characteristics, but not identical.

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6.0 % by volume di-isobutylene
58.0 % by volume methanol
2.0 % by volume ethanol
2.0 % by volume water

Chemical properties

Microbiological resistance

Microbiological resistance

When using polyester-based thermoplastic polyurethane under climatic conditions of high heat and humidity, parts can be damaged by microbiological attack. In particular, micro-organisms producing enzymes are able to affect the molecule chains of polyester-based TPU. The microbiological attack initially becomes visible as discoloration. Subsequently, surface cracks occur which enable the microbes to penetrate deeper and to cause a complete destruction of the TPU (ref. Fig. 40).

Polyether-based thermoplastic polyurethane is resistant to microbiological attack. The saponification number (SN) formerly DIN VDE 0472, part 704 is an important criterion for microbiological resistance. Unfilled TPU is resistant to microbes up to a saponification number of 200 mg KOH/gm, which is the limiting value according to VDE 0282/10.

Depending on formulation and hardness, polyether-based TPUs achieve a saponification number of around 150, polyester-based TPUs around 450. With regard to polyether-polyester mixtures, the saponification number can be calculated from the quantitative portions. Small inclusions of up to approx. 10 % of ester urethane in ether urethane (e.g. addition of ester-based color masterbatches) do not impair the microbiological resistance (SN remains < 200). Larger inclusions of ester-based TPU result in a reduction in the microbiological resistance.

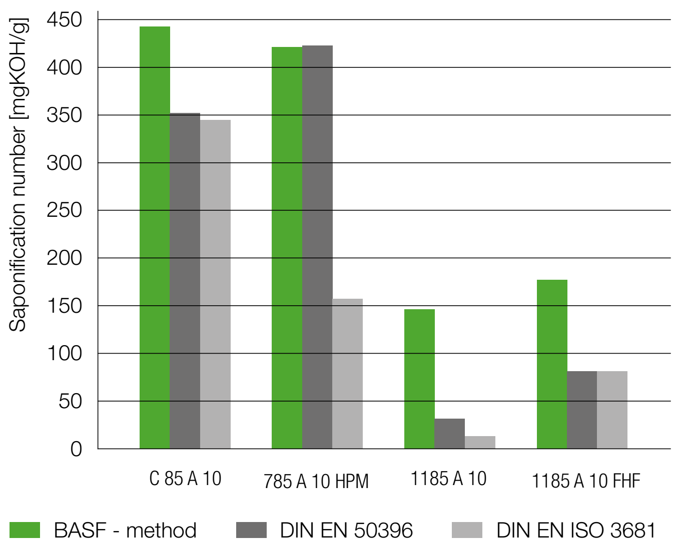

Fig. 40: Saponification number of selected Elastollan® grades

Chemical properties

Hydrolysis resistance

Hydrolysis resistance

If polyester based polyurethanes are exposed for lengthy periods to hot water, moisture vapor or tropical climates, an irreversible break-down of the polyester chains occurs through hydrolysis. This results in a reduction in mechanical properties. This effect is more marked in flexible grades, where the polyester content is correspondingly higher than in the harder formulations. Due to a good stabilization, a degradation of polyester-based Elastollan® is rarely experienced at room temperature.

Because of its chemical structure, polyether-based Elastollan® is much more resistant to hydrolytic degradation.

The following diagrams compare hydrolysis resistance of polyether- and polyester-based TPU.

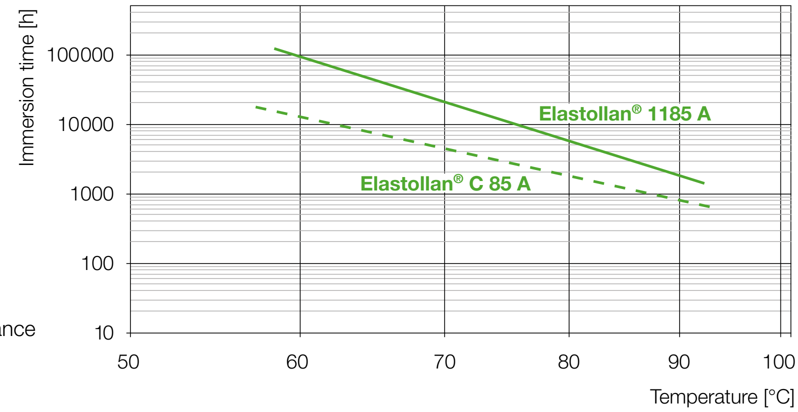

Fig. 41: Long-term hydrolysis resistance

End criterion: tensile strength 20 MPa

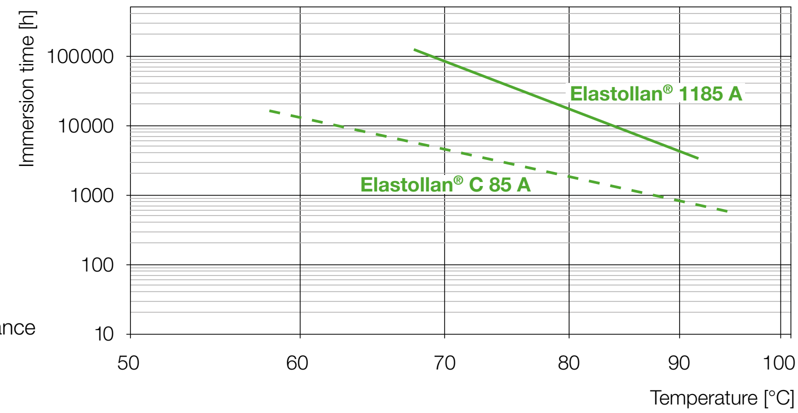

Fig. 42: Long-term hydrolysis resistance

End criterion: Elongation of break 300 %

Chemical properties

Radiation resistance • Ozone resistance

UV radiation

Plastics are chemically degraded by the effect of UV radiation. The degree of ageing depends on duration and intensity. In the case of polyurethanes, the effect is seen initially as surface embrittlement. This is accompanied by a yellowing in color and a reduction in mechanical properties.

It is possible to improve UV resistance by addition of color pigments which prevent the deep penetration of UV rays and thus mechanical destruction. Moreover, dark color shades, in particular black, mask the surface discoloration. The ageing process can also be delayed by the addition of UV stabilizers. Suitable masterbatches are available.

High energy radiation

Elastollan® is superior to most other plastics in its resistance to high energy radiation. Resistance to α-, β- and γ-radiation is dependent on such factors as the intensity of the radiation, the shape and dimensions of the test specimen, and the atmosphere in the test area.

The addition of crosslinking agents and subsequent β- and γ-radiation can effect crosslinking of Elastollan®. The maximum achievable degrees of crosslinking are around 90 %. This is a method to improve short-term heat deflection temperature and chemical resistance.

Ozone resistance

The ozone molecule (O_3) is formed by the union of three oxygen atoms. It is generated from reaction of oxygen in the atmosphere under the influence of high energy UV-radiation. Ozone is highly reactive, especially with organic substances. Rubberbased elastomers are destroyed through cracking under the influence of ozone.

Elastollan®, on the other hand, is resistant to ozone. The test according to VDE 0472 results in "crack-free", stage 0. There is neither a loss of elasticity nor an increase of surface hardness.

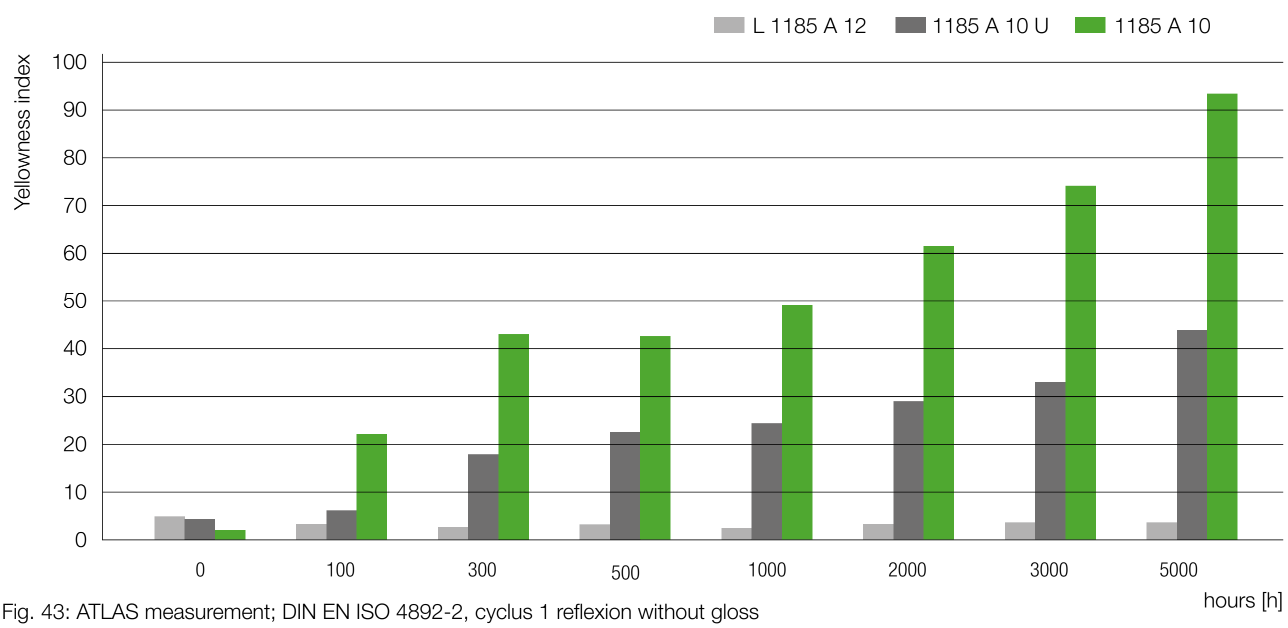

Fig. 43: ATLAS measurement; DIN EN ISO 4892-2, cyclus 1 reflexion without gloss

Fire behavior

Fire behavior

Like all organic materials, plastics are flammable. The primary and secondary fire properties for them are classified according to various norms and standards.

Primary fire properties:

- Flammability and active continued burning
- Contribution to flame spread
- Release of heat

Secondary fire properties:

- Flaming droplets / particles
- Smoke density
- Smoke toxicity
- Corrosiveness of fire gases

As the fire properties are very often tested on the end product, the design and the structure of the end product has a substantial impact on the subsequent fire properties. For example, the thickness of a cable sheath is crucial for the smoke density that is to be expected.

The respective fire scenario has a crucial bearing on the application of a particular test. If the components are subsequently to be fitted in rail vehicles, for example, tests in accordance with DIN EN 45545 are relevant. In automotive construction, the tests conducted include those according to FMVSS 302.

For numerous applications in the electrical industry, a classification of the plastics under UL (Underwriters Laboratories) 94 is indispensable. For many Elastollan® grades, corresponding tests have been conducted. Depending on the wall thickness, the Elastollan® grades with halogen-free flame retardance achieve V0, V1 or V2. Unfilled standard grades generally achieve UL-HB. As well as the fire class, further properties such as HWI, HAI, RTI and CTI have also been determined for selected Elastollan® grades. The current classifications can be viewed on the UL website under File No. E140250.

DIN EN 45545: For applications in rail vehicles, the materials are subjected, depending on the application and deployment location, to selected flame tests and then classified into what are known as “hazard levels”. Depending on the design of the components, selected Elastollan® grades achieve very good classifications, e.g. R22/R23 HL3.

FMVSS 302 (Federal Motor Vehicle Safety Standard): All Elastollan® grades meet this standard, which permits a maximum burn rate of 4 inches/min (101.6 mm/min) with a defined test setup.

DIN EN 50267-2-2 (IEC 60754): The demands of this standard with regard to the corrosiveness of the fire gases are met by all unmodified and plasticizer-containing Elastollan® grades. Additives can influence the fire behavior of Elastollan®.

Fire behavior

The fire properties of the individual materials can be very different in the different fire scenarios. The results cannot simply be transferred from one test to another, which makes it more difficult to make predictions when choosing materials for new applications. For instance, materials displaying very good cable fire properties do not necessarily receive a good classification according to UL94V.

One of the ways to improve the quality of such predictions is to use the cone calorimeter, which can be used to determine many material-specific properties. BASF's extensive database and many years of experience of interpreting these values allow us to offer our customers expert advice when it comes to selecting the right materials.

One example that should be cited here is the classification of the flame retardancy of selected Elastollan® grades according to Petrella (Petrella R.V., The assessment of full scale fire hazards from cone calorimeter data, J. of Fire Science, 12 (1994), p. 14), which is based on cone calorimeter measurements and allows predictions to be made for cable applications.

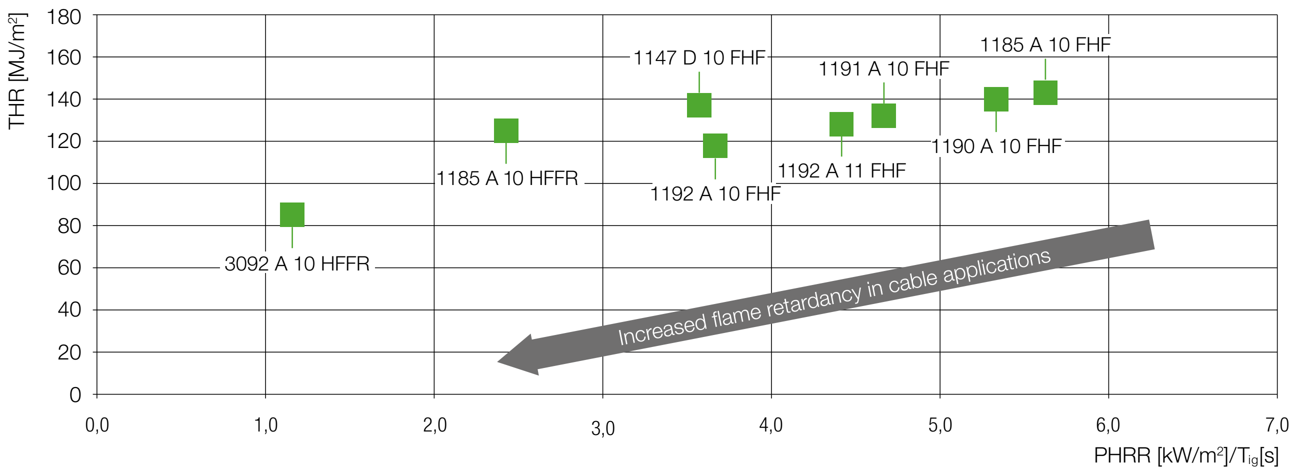

Fig. 44: Classification of flame retardancy according to Petrella; selected Elastollan® FHF and HFFR grades

Food contact

Food contact
The new Elastollan® FC portfolio consists of more than 20 products and concentrates and includes both ether- and ester-based grades. This comprehensive portfolio means that BASF can help customers to develop a wide range of TPU applications with food contact.

BASF's Elastollan® FC grades comply with both the guidelines in the EU legislation on food contact applications and (apart from the concentrates listed below*) the FDA (Food and Drug Administration) regulations. They are produced in accordance with the stringent safety standards of the GMP (Guidance for Good Manufacturing Practice 2023/2006/EG).

To determine the suitability of these BASF products for certain applications a thorough evaluation by the processor(s), manufacturer(s) and/or distributor(s) is required. Where specific regional regulations do not exist, the current legal EU and US requirements as well as globally accepted standards for consumer articles, food contact articles and medical devices should be used as reference. Please contact our Sales Office in case of further questions.

* Suitable only for EU-regulated markets
Conc 917/3 FC
Conc 917/4 FC
Conc V 2871 FC

Please find more detailed information on the food contact portfolio in the Elastollan® Product Range.

Quality management

Quality guidelines

▪ The orientation on customers processes and on employees are important elements of the Quality Management.

▪ The customer requirements are determined regularly and fulfilled with the aim of the increase of the customer satisfaction.

▪ Targets are agreed with the persons responsible for process in all units of competence and the realization is followed regularly.

▪ Targets, methods and results of the Quality Management are continually imparted in order to support the consciousness and the cooperation of all employees in the process of the continuous quality improvement.

▪ Instead of later debugging, the principle of avoidance of defects is realized.

▪ Organizational and personnel measures will be concentrated on effective quality management to ensure the implementation of the quality targets.

Management systems / certificates

Customer satisfaction is the basis for sustained business success. Therefore, we want to meet the customers' requirements for our products and services, now and for long-term future. To ensure success in a reliable way, BASF introduced a quality management system several years ago including all divisions. Each business process is regularly assessed and further developed based on informative performance indicators. The target is to reach optimum efficiency and almost perfect coordination of all activities and operations. Each employee is asked to make a contribution to quality assurance and continuous improvement with its capabilities and ideas at its workplace.

Our integrated Quality and Environmental Management-System is based on following standards:

DIN EN ISO 9001
IAFT 16949 (with product development)
DIN EN ISO 14 001 (environmental management system)
DIN EN ISO 14 001 (environmental management system)

Selected product literature:

- Thermoplastic Polyurethane Elastomers (TPU) – Think, create, Elastollan®
- Elastollan® – Product Range
- Elastollan® – Processing Recommendations

Note
The data contained in this publication are based on our current knowledge and experience. In view of many factors that may affect processing and application of our product, these data do not relieve processors from carrying out their own investigations and tests; neither do these data imply any guarantee of certain properties, nor the suitability of the product for a specific purpose. Any descriptions, drawings, photographs, data, proportions, weights, etc. given herein may change without prior information and do not constitute the agreed contractual quality of the product. It is the responsibility of the recipient of our products to ensure that any proprietary rights and existing laws and legislation are observed. (August 2019)

Further information on Elastollan®
can be found on the Internet:
www.elastollan.de

Please visit our websites:
www.plastics.basf.com
www.plastics.basf.de

Request of brochure:
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