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

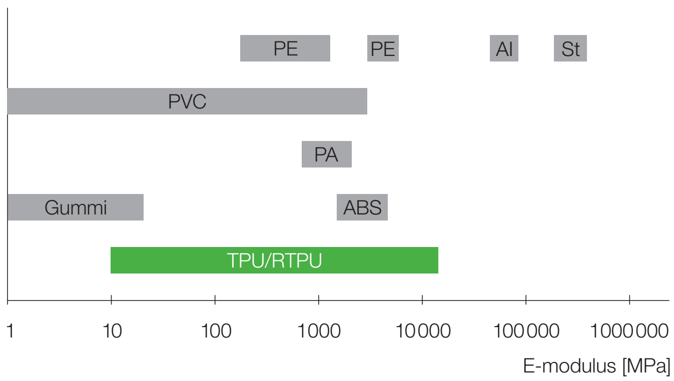


Fig. 2: Comparison of E-modulus of TPU and RTPU with other materials

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

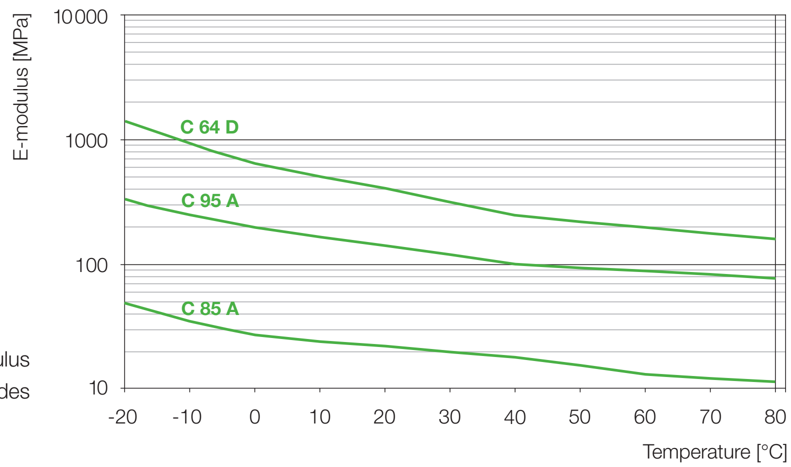


Fig. 3: Influence of temperature on E-modulus
Elastollan® polyester grades

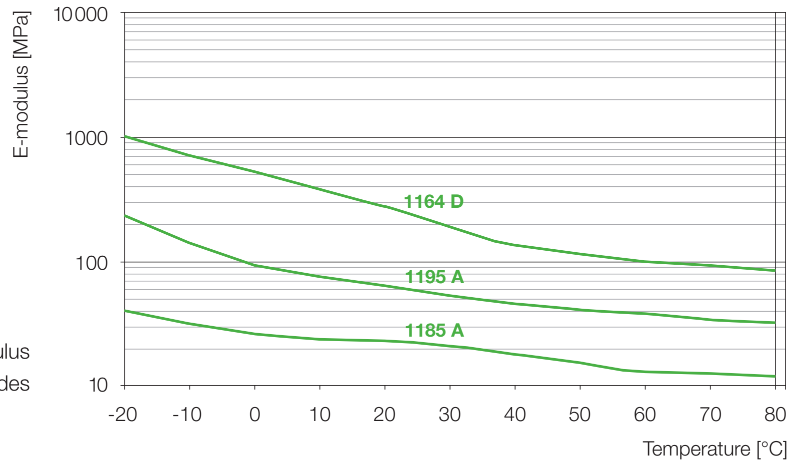


Fig. 4: Influence of temperature on E-modulus
Elastollan® polyether grades

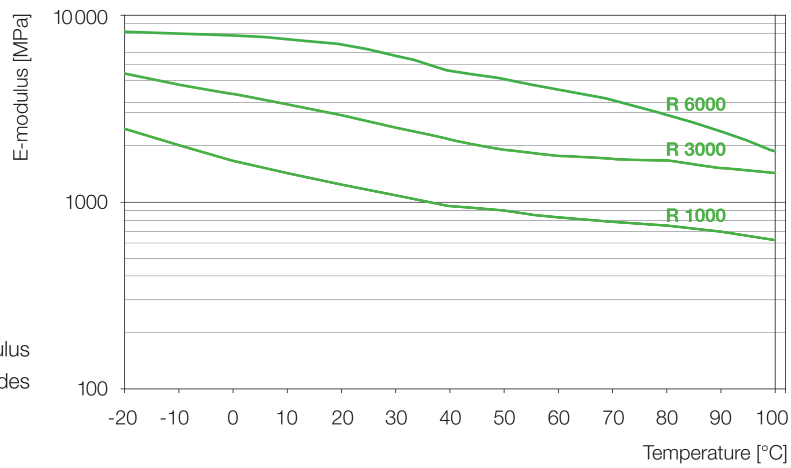


Fig. 5: Influence of temperature on E-modulus
Elastollan® glass fibers reinforced grades

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.

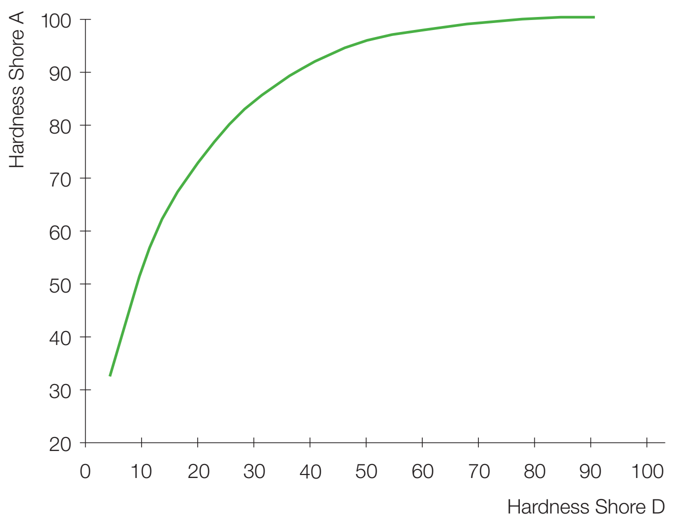


Fig. 6: Relationship: Shore A to Shore D

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.

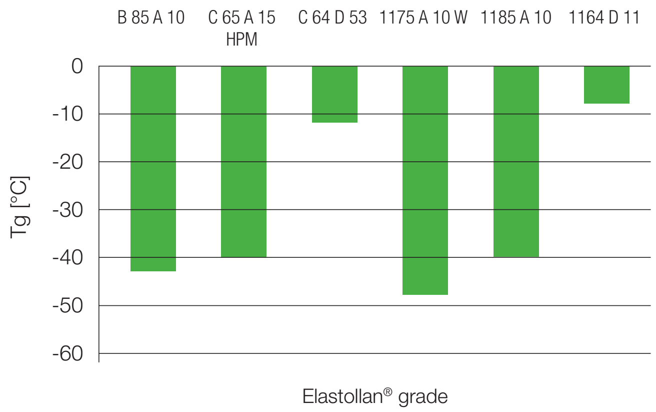


Fig. 7: Glass transition temperature (Tg) from DSC at 10 K/min

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

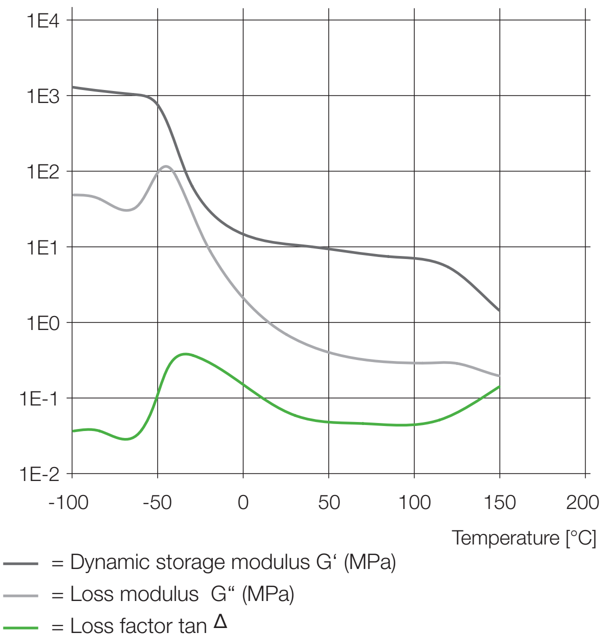


Fig. 8: Elastollan® C 85 A 10

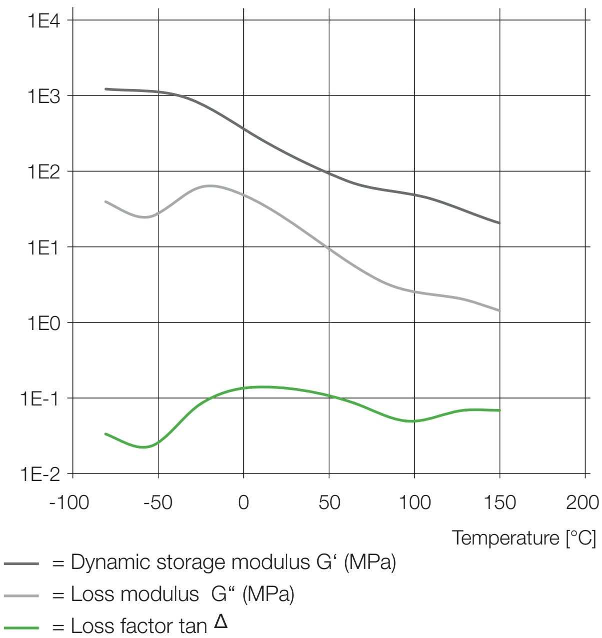


Fig. 10: Elastollan® C 64 D

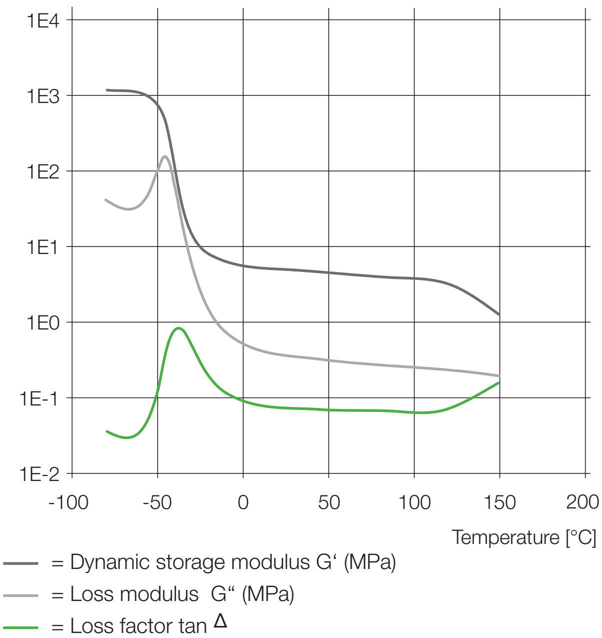
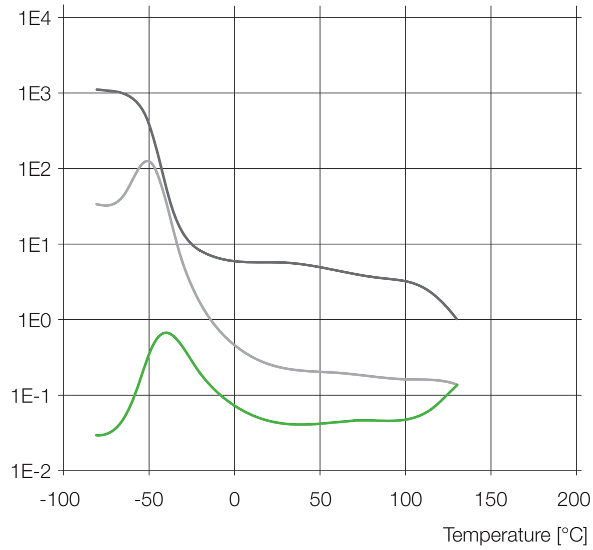


Fig. 9: Elastollan® C 65 A HPM

Physical properties

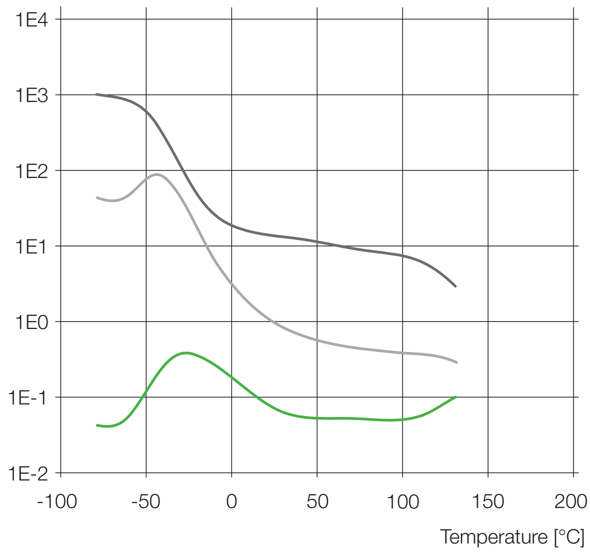
Mechanical properties

Torsion modulus



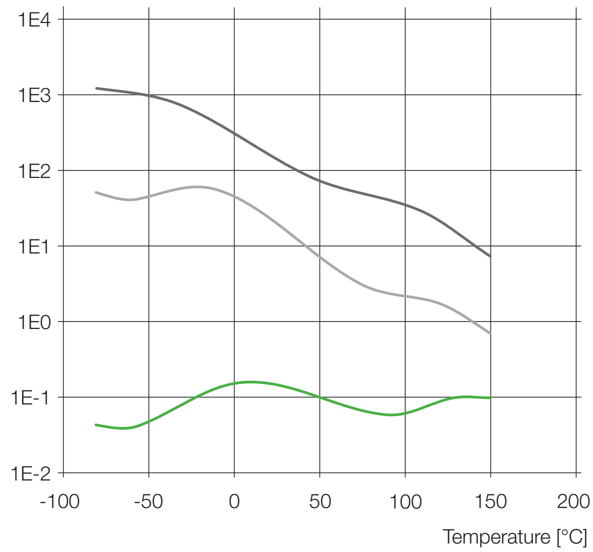
— = Dynamic storage modulus G‘ (MPa)
— = Loss modulus G“ (MPa)
— = Loss factor tan Δ

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

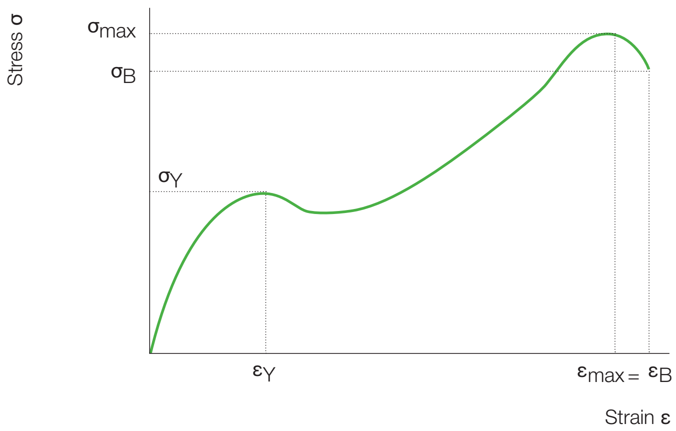


Fig. 14: Typical stress-strain curve from tensile testing

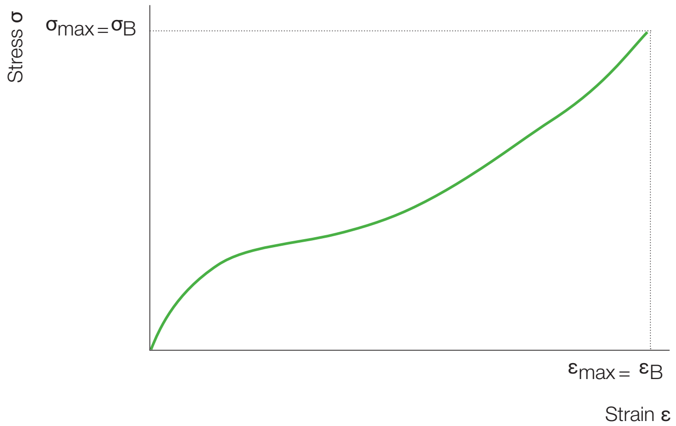


Fig. 15: Characteristic stress-strain curve for unreinforced Elastollan®

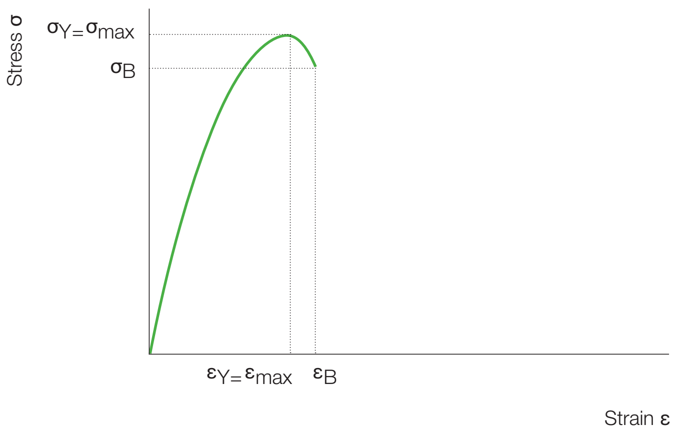


Fig. 16: Characteristic stress-strain curve for reinforced Elastollan®

Physical properties

Mechanical properties

Tensile strength

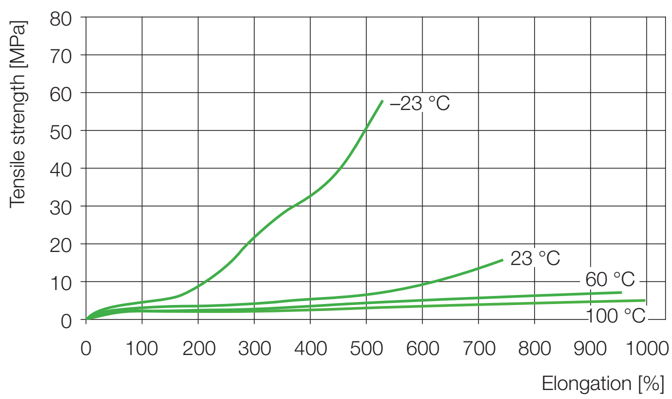


Fig. 17: Elastollan® C 65 A HPM

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.

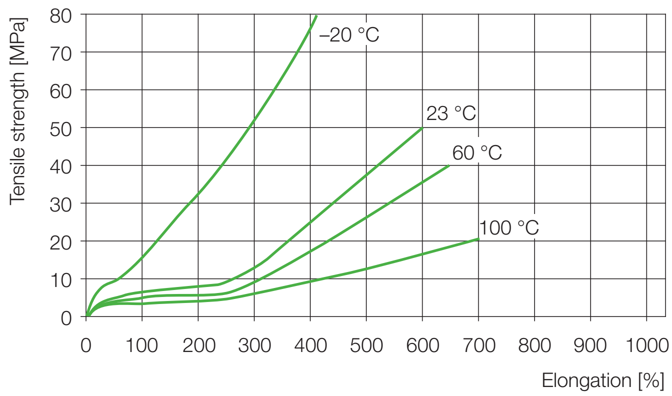


Fig. 18: Elastollan® C 85 A

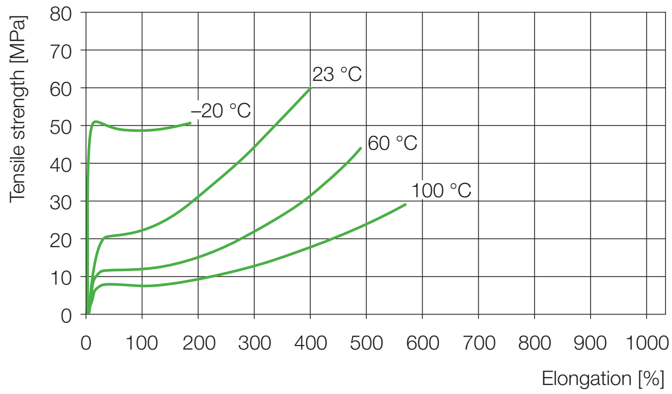


Fig. 19: Elastollan® C 64 D

Physical properties

Mechanical properties

Tensile strength

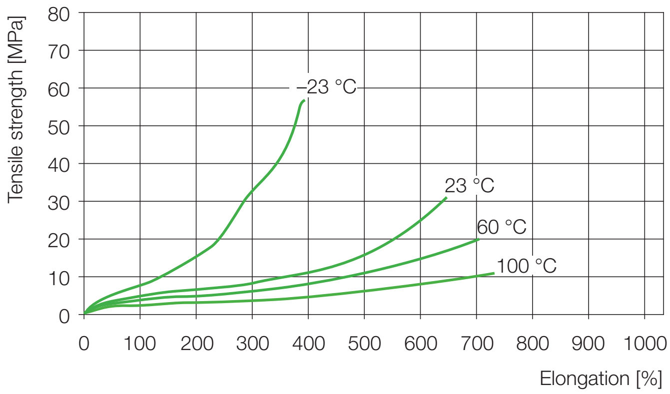


Fig. 20: Elastollan® 1175 AW

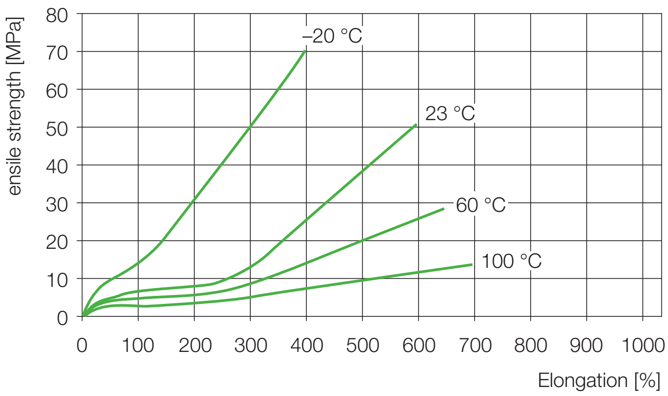


Fig. 21: Elastollan® 1185 A

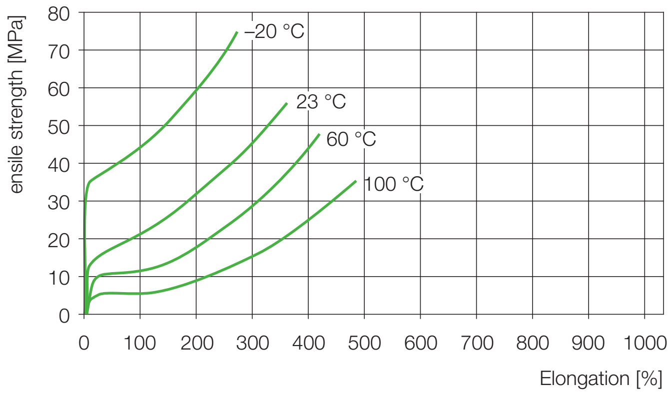


Fig. 22: Elastollan® 1164 D

Physical properties

Mechanical properties

Tensile strength

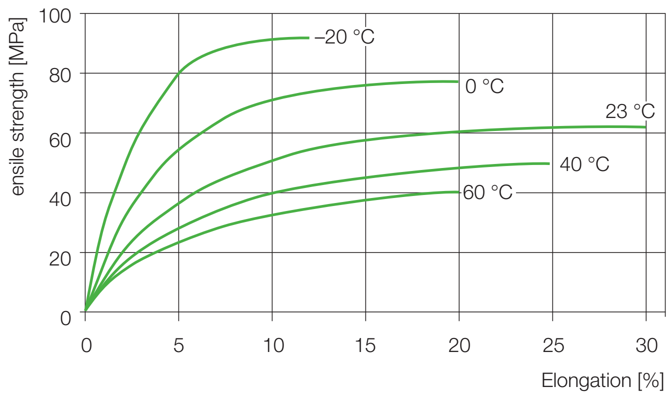


Fig. 23: Elastollan® R 1000

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.

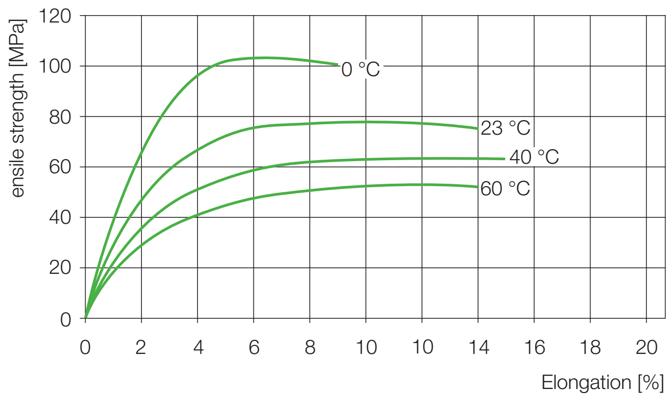


Fig. 24: Elastollan® R 3000

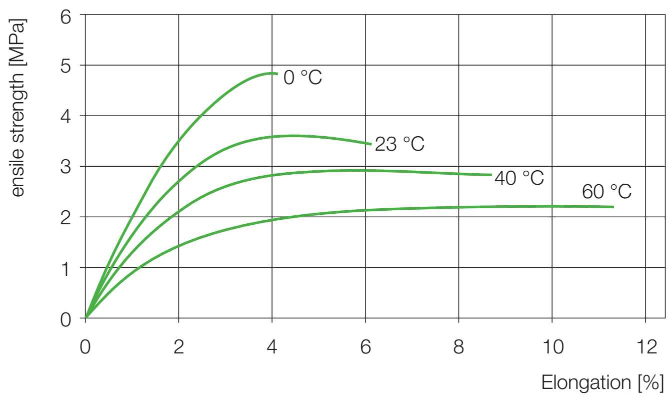


Fig. 25: Elastollan® R 6000

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.

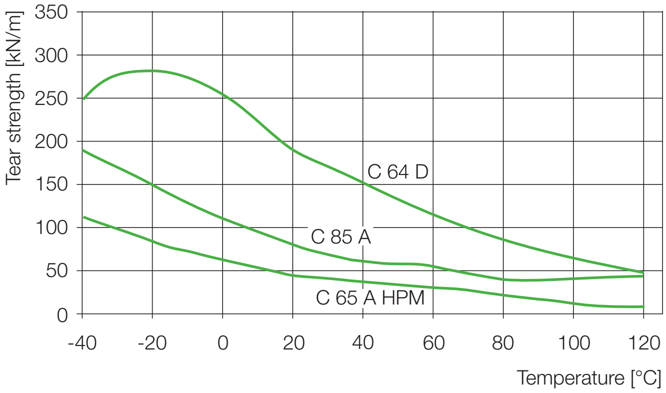


Fig. 26: Tear strength in relation to temperature
Elastollan® for polyester grades

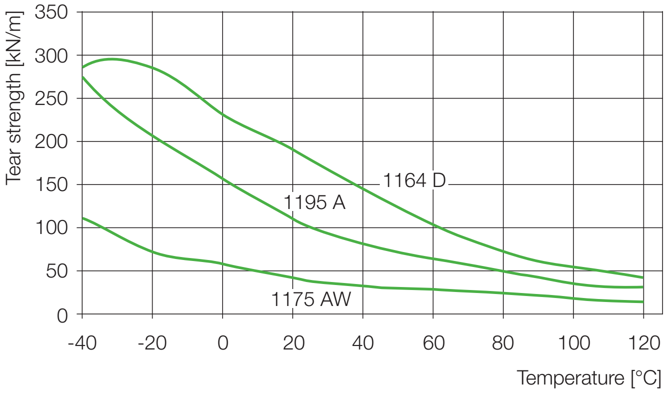
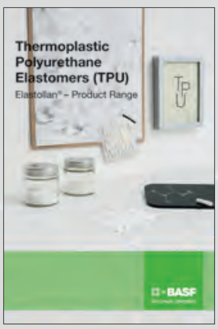


Fig. 27: Tear strength in relation to temperature
Elastollan® for polyether grades



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).

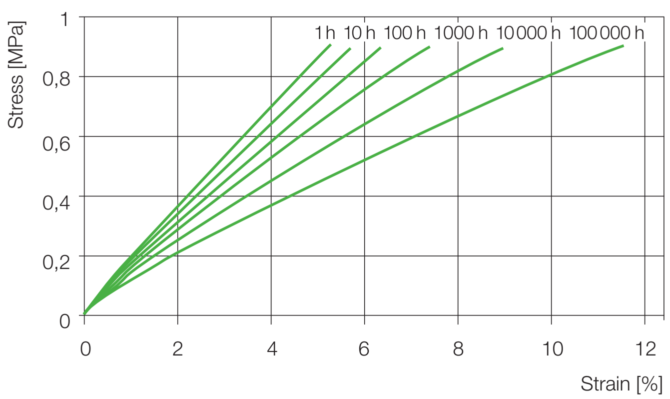


Fig. 28: Isochronous stress-strain lines at 23 °C Elastollan® C 85 A

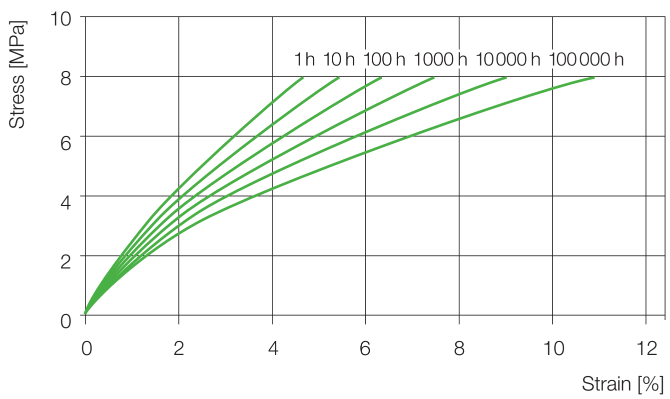


Fig. 29: Isochronous stress-strain lines at 23°C Elastollan® C 64 D

Physical properties

Mechanical properties

Creep behavior

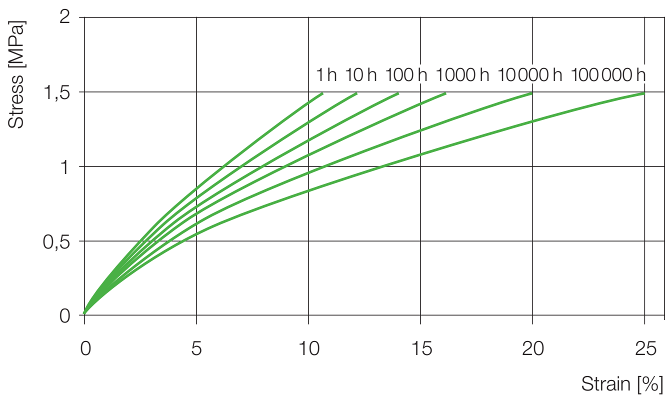


Fig. 30: Isochronous stress-strain lines at 23 °C
Elastollan® 1185 A

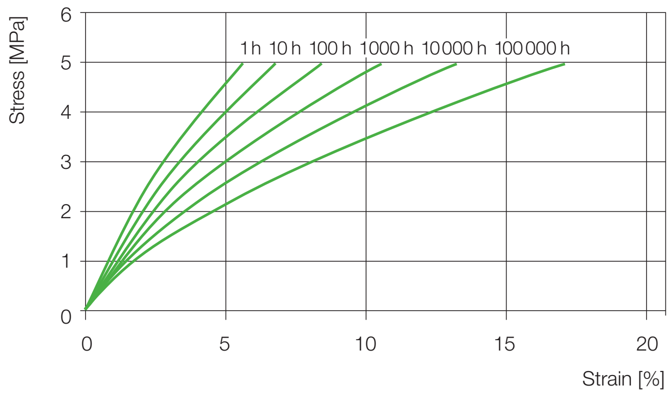


Fig. 31: Isochronous stress-strain lines at 23 °C
Elastollan® 1164 D

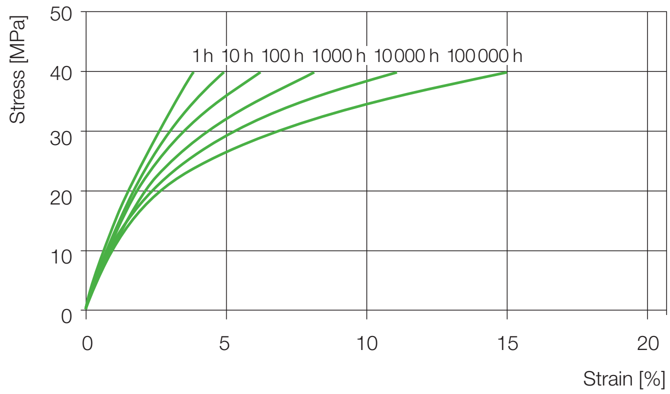


Fig. 32: Isochronous stress-strain lines at 23 °C
Elastollan® R 3000

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.

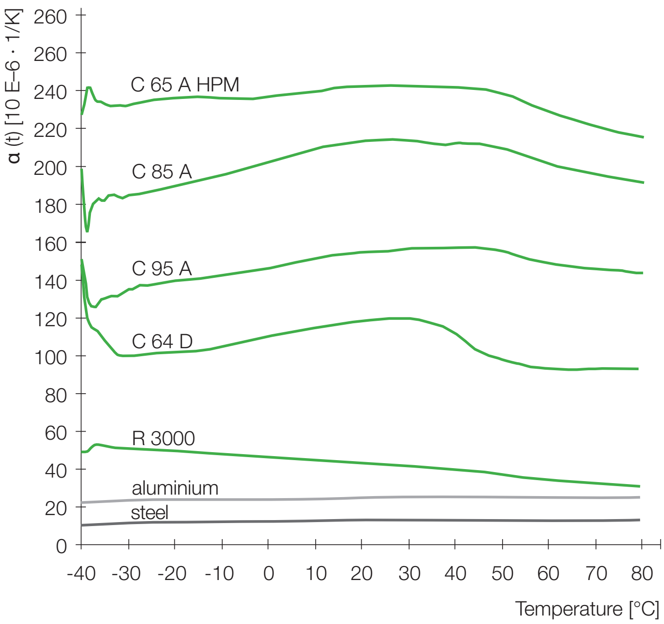


Fig. 33: Coefficient of thermal expansion α [1/K] various Elastollan® hardnesses (ester grades)

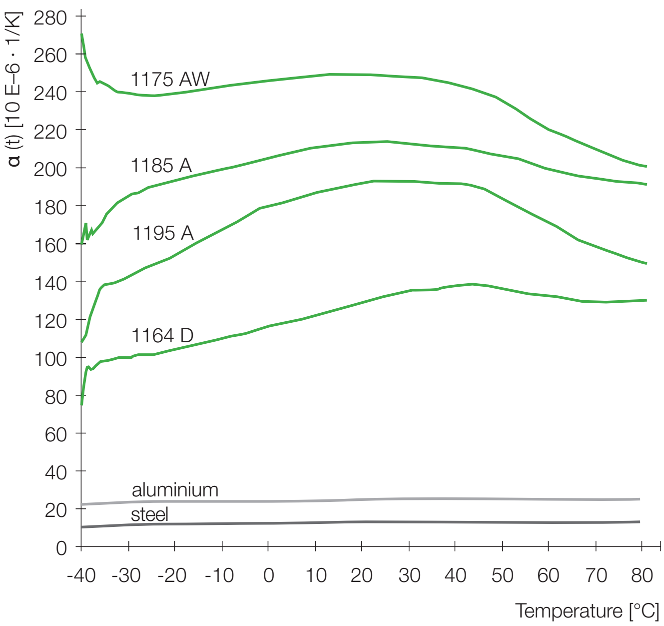


Fig. 34: Coefficient of thermal expansion α [1/K] various Elastollan® hardnesses (ether grades)

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 A	Shore D	TMA Onset (BASF hrs.)
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.

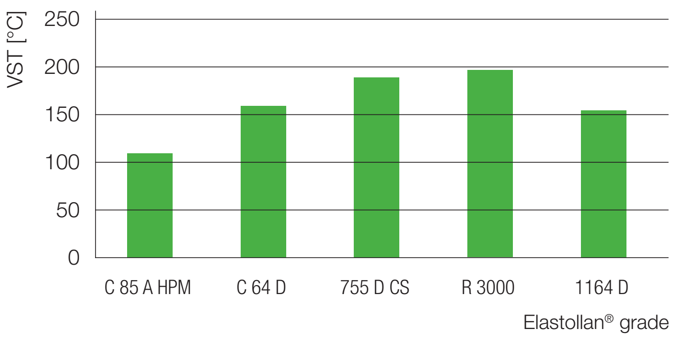


Fig. 35: Vicat temperature (VST) according to DIN EN ISO 306, Vicat A 120

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.

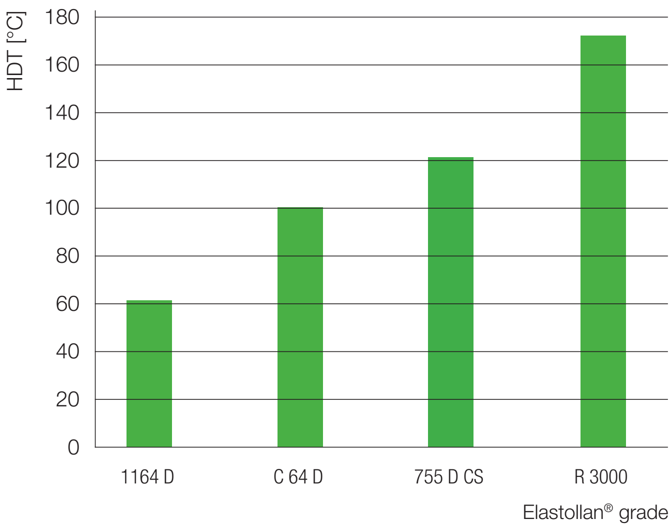


Fig. 36: Heat deflection temperature (HDT) according to DIN EN ISO 75, method B

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:

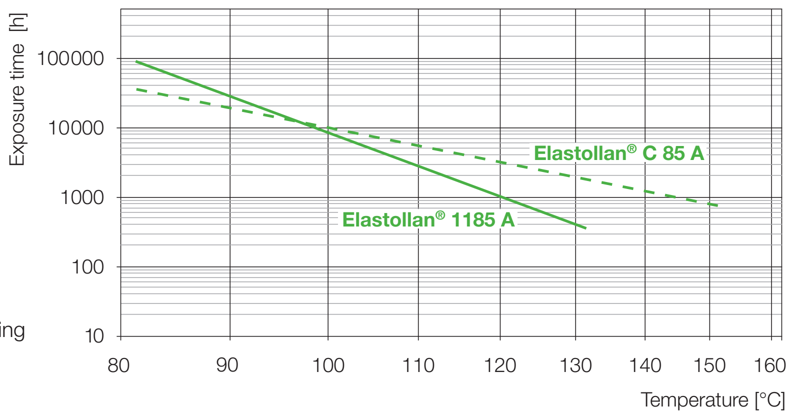


Fig. 37: Long-term air ageing

End criterion: tensile strength 20 MPa

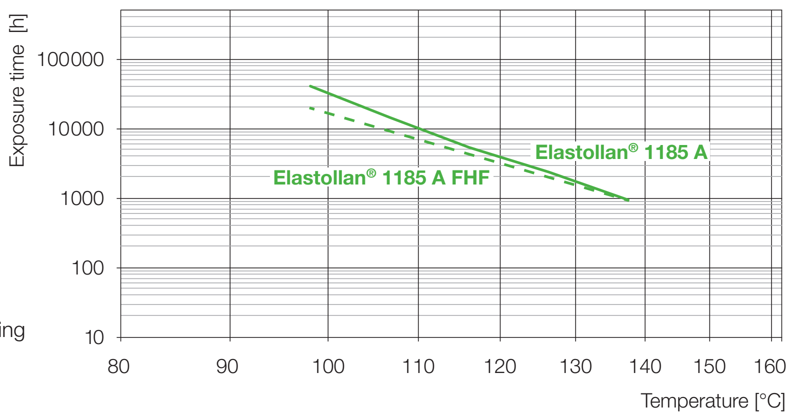


Fig. 38: Long-term air ageing

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 [$m^2/(s \cdot Pa)$] 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.

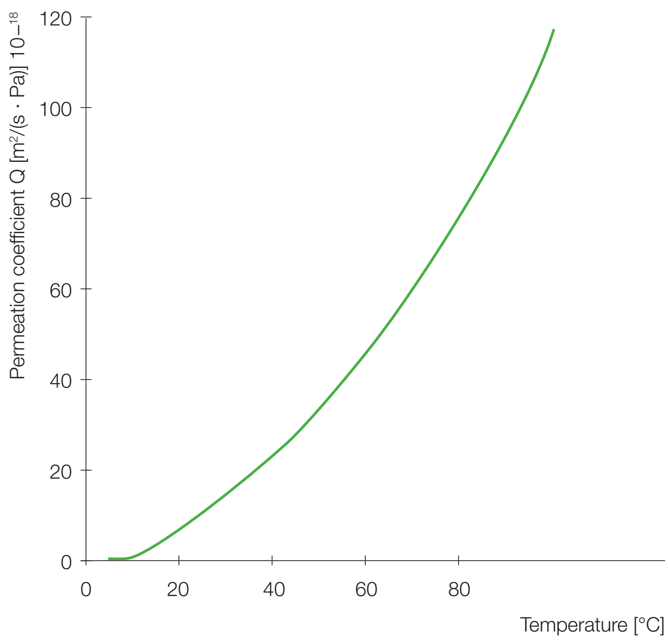


Fig. 39: Affect of temperature on permeability coefficient: Elastollan® 1185 A with nitrogen

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.