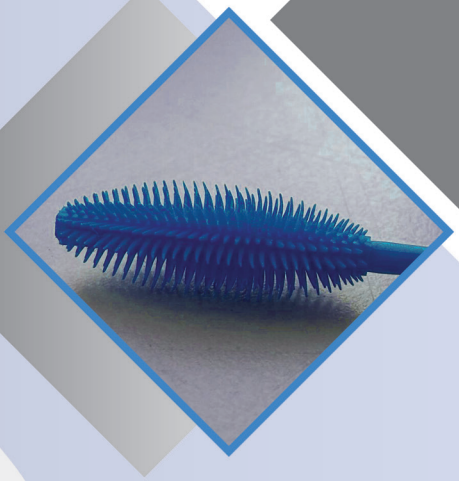
SIPOLPRENE®

Ether Ester Thermoplastic Elastomers



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SIPOLPRENE®
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The company

Founded in 1998, Sipol® SpA (Società Italiana Polimeri) is a chemical company focused on manufacturing high performance polymers dedicated to both the adhesive and the engineering plastics domains.

Thanks to its complete range of co-polyesters and co-polyamides, the firm operates successfully in Automotive, Footwear, Packaging and other industrial sectors.

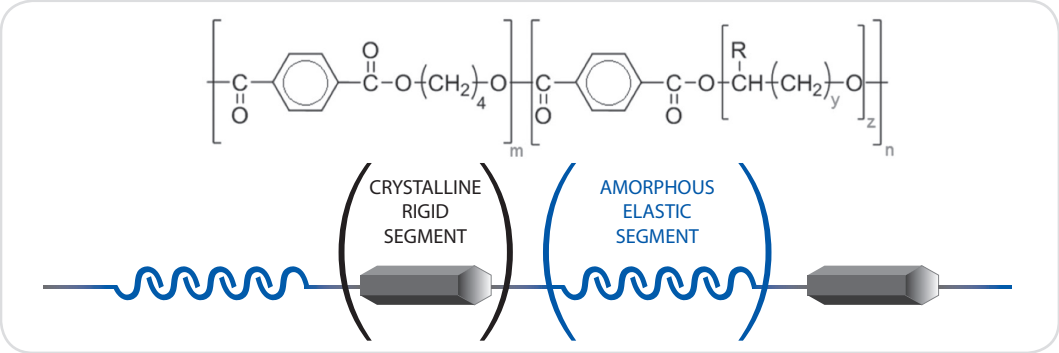
Sipol® SpA develops and produces thermoplastic ether-ester elastomers (TPC-ET) and specialty hotmelt adhesives (co-polyester and co-polyamide based) in its plant located in Mortara, which is about 40 km south-west of Milan, on a 40 000 m^2 site.

Sipol® SpA has been producing co-polyesters since 2000 and the present portfolio consists of more than 100 different co-polyester grades. Concerning co-polyamides, production started in 2015 and now Sipol® SpA boasts more than 30 different co-polyamide grades.

Sipol's business policy is based on marketing its superior competence in polymer chain modification. According to application needs, the R&D department creates new copolymers by inserting different blocks (co-monomers) into the polymer chain, producing tailor-made materials designed to match application requirements with flexibility and efficiency.

SIPOLPRENE®
General Information

SIPOLPRENE® is the registered trademark of Sipol® SpA for its family of thermoplastic ether-ester elastomers. These engineering polymers are made through the combination of rigid polyester blocks (crystalline segment) and flexible long-chain polyether blocks (amorphous segment).
By varying the structure of these blocks, it is possible to determine the final properties of the polymers.



SIPOLPRENE® structure

The rigid part is basically a PBT chain, while the flexible part is a polyether.

The higher the number ***n***, the softer is the resulting polymer.
On the contrary, by bringing ideally ***n*** to *0*, the polymer becomes a simple PBT.

It is evident that the ratio between rigid and flexible segments is the first and simplest way to drive the polymer hardness.

A second level of modification can be achieved by tuning parameter ***z***, the molecular weight of the polyether chain.

This, of course modifies the polymer characteristics as concerns mechanical properties vs temperature, gas permeability, and chemical resistance.
Additional modifications can be achieved by changing ***R*** and ***y*** (the ether unit), thus modifying the polymer polarity.

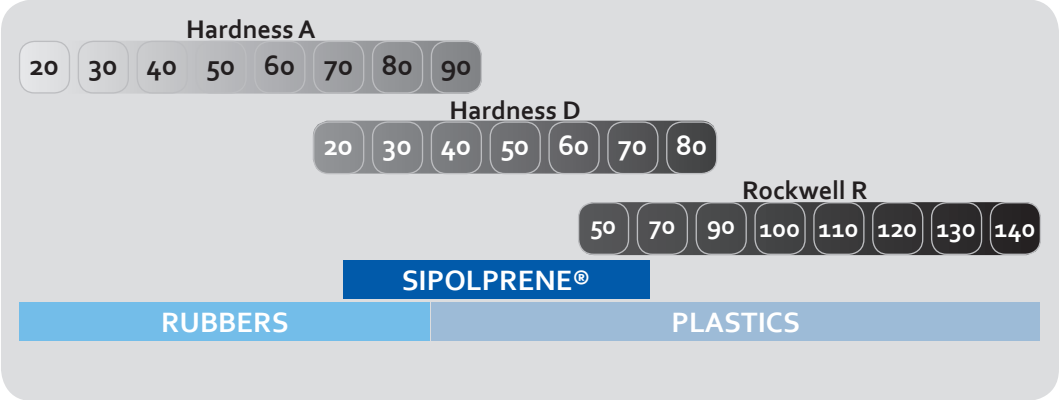
The double soul of the **SIPOLPRENE®** macromolecular chain, (polyester-rigid and polyether-soft) allows the polymer to match the qualities of flexible plastics with the performance of thermoplastic elastomers.

As thermoplastic elastomer, it can easily be processed by using many different techniques, such as injection molding, extrusion, blow molding, etc.

At microscopic level, the resulting structure, which is a block copolymer made of short hard segments alternating with long flexible segments, is biphasic in morphology.
The presence of hard polyester blocks assures heat resistance, chemical resistance and easy processing; amorphous polyether regions improve softness and elasticity, directly connected to the material hardness.

One of the most important characteristic that makes **SIPOLPRENE®** different from most engineering plastic resins and thermoplastic elastomers is that all **SIPOLPRENE®** products, due to their block copolymer structure, show mechanical characteristics like modulus, tenacity and resilience that are less affected by temperature variations.

This higher mechanical performance constancy makes **SIPOLPRENE®** the right engineering choice for applications where a high standard is required for safety or reliability reasons.



SIPOLPRENE® compared to rubbers and plastics regions according to different hardness scales

Product range

Sipol core business is polymerization and it is based on its superior competence in polymer chain modification, producing both standard grades and tailor-made materials designed to match application needs and requirements. Therefore, Sipol portfolio doesn't include compound products. **SIPOLPRENE®** range consists of High Performance and Specialty Grades of various melting points and hardness levels.

High Performance Grades

SIPOLPRENE®	HARDNESS SHORE D (instantaneous)	MELTING TEMPERATURE (°C)
25170	28	173
25185	29	184
35180	35	177
35195	36	195
46185	45	186
55200	53	198
58210	58	211
63210	62	211
68217	68	217
72220	72	218

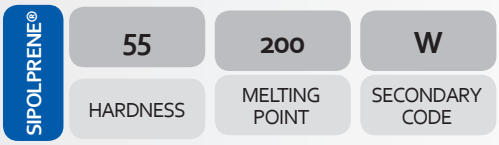
SIPOLPRENE® HIGH PERFORMANCE GRADES

Specialty Grades

- **Sipolprene® 35150**, where melting temperature is lowered to 150°C in order to make it suitable for PVC modification by compounding (polymer alloy).
- **Sipolprene® reporting "1"** as last digit (*Sipolprene® 55211* and *Sipolprene® 40171*) is modified in order to increase crystallization rate, offering faster cycles in injection moulding.
- **Sipolprene® B range** has an enhanced water vapour permeability, which allows its use to produce breathable films and membranes.

Product coding

The Main Code is composed of five digits XXYYY where the first two roughly indicate the hardness ShD (XX) and the remaining three (YYY) indicate the melting point.



A Secondary Code can be added for non-standard viscosity, specific stabilization package and black versions.

SECONDARY CODE	DESCRIPTION
LV	Low viscosity
HV	High viscosity directly achieved in polymerization
R	Very high viscosity reached through solid state polymerization
K	Heat stabilized
W	UV stabilized
MD	Metal de-activated for high performance cable jacketing
H	Hydrolysis stabilized
N	Improved NOx resistance
L	Enhanced lubrication
B	Black coloring through masterbatch dry blending

SIPOLPRENE® product secondary coding: modified viscosity, additives and coloring

Physical
mechanical properties

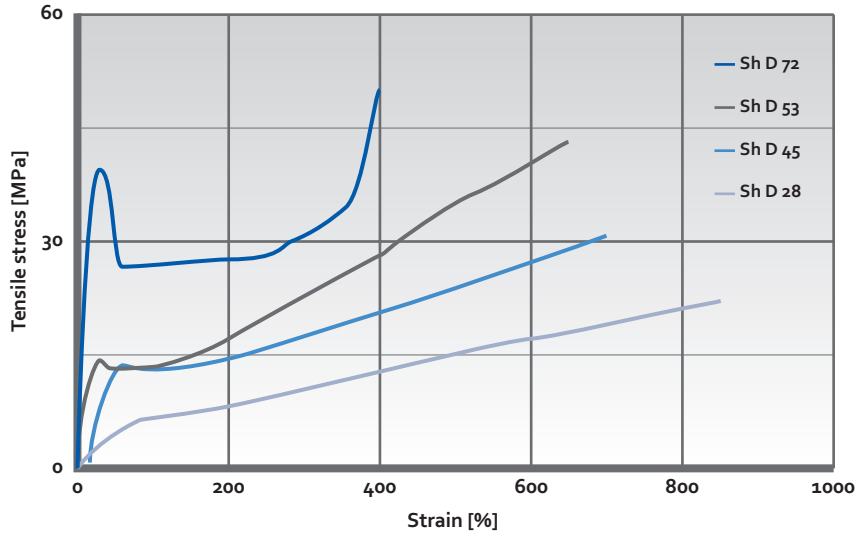
SIPOLPRENE® materials combine flexibility, temperature and chemical resistance with dimensional stability, flexural fatigue resistance and high impact strength. **SIPOLPRENE®** products have a good abrasion and tear resistance, good electrical properties and an excellent overmolding adhesion to various plastic materials due to their polar structure.
Mechanical properties of various **SIPOLPRENE®** products are strictly related to both their chemical composition and hardness. The more the hard-block content (rigid polyester), the higher the hardness and they pass from essentially elastomeric polymers (28 - 45 Shore D) to plastomeric ones (53 - 72 Shore D). The result is an increasing load, stiffness, tear, creep, chemical and temperature resistance. Equally, there is a decrease in fatigue and impact resistance.
Their field of application covers a wide temperature range, starting from -65°C up to 185°C, depending on the selected grade.

low medium high

	SOFT GRADES 28-45 Sh D	HARD GRADES 53-72 Sh D
Hard segment content	low	high
Soft segment content	high	low
Crystallinity	low	high
Flexibility	high	low
Dimensional stability	medium	high
Creep resistance	medium	high
Thermal stability	medium	high
Chemical resistance	medium	high
Low temperature impact	high	medium
Flex fatigue	high	medium

SIPOLPRENE® HIGH PERFORMANCE GRADES characteristics

The best way to comprehend the elastic behavior of **SIPOLPRENE®** is to refer to their stress/strain curves. Tensile strength values are obtained from stress/strain curves determining the point of maximum stress on the curve. Maximum tensile values can be used in rating the relative material strain stress: generally, the softer the polymer the lower the yield point and the higher the elongation at yield.
This defines the strain range where the material has elastic properties.



SIPOLPRENE® stress-strain curves by hardness

SIPOLPRENE®'s outstanding creep resistance is explained by its excellent retention of mechanical properties under constant load, for long periods of time. This important feature makes it the ideal candidate for automotive, sealing and snap fit applications. **SIPOLPRENE®'s** high resistance to creep ensures that parts will be long lasting. Finally, **SIPOLPRENE®** has excellent compression set resistance compared to other thermoplastic elastomers.

Resistance to chemicals and oils

Having a polyester skeleton, **SIPOLPRENE®** generally shows good resistance to grease and to hydrocarbons.

However, **SIPOLPRENE®** become less stable when in contact with polar solvent, ie. hot water, concentrated acids and/or bases, and alcohol above temperatures of 60°C .

CHEMICAL AGENT	CHEMICAL RESISTANCE	
	SOFT GRADES 28-45 Sh D	HARD GRADES 53-72 Sh D
Acetic acid, glacial	🟢	🟢
Acetone	🟡	🟡
Acetylene	🟢	🟢
Antifreeze solution	🟢	🟢
Benzene	🟡	🟡🟢
Butane	🟢	🟢
Carbon dioxide	🟢	🟢
Carbon monoxide	🟢	🟢
Carbon tetrachloride	🔴	🟡
Chloroform	🔴	🔴🟡
Cyclohexane	🟢	🟢
Ethyl acetate	🟡	🟡
Ethanol	🟢	🟢
Ethylene glycol	🟢	🟢
Formaldehyde, 40%	🟡	🟡
Formic acid	🟡	🟡
Freon	🟢	🟢
Gasoline	🟢	🟢
n-hexane	🟢	🟢
Hydrochloric acid	🔴	🔴
Hydrogen	🟢	🟢
Isooctane	🟢	🟢
Isopropyl alcohol	🟢	🟢
Methanol	🟢	🟢
Methyl ethyl ketone	🟡	🟡🟢
Mineral oil	🟢	🟢
Naphtha	🟢	🟢
Nitric acid	🔴	🔴
Phenol	🔴	🔴
Soap solution	🟢	🟢
Silicone grease	🟢	🟢
Sodium chloride solution	🟢	🟢
Sodium hydroxide 15%	🟢	🟢
Sodium hydroxide 35%	🟡	🟡
Sulfuric acid > 50%	🔴	🔴
Tetrahydrofuran	🟡	🟡🟢
Toluene	🟡	🟡🟢
Xylene	🟡	🟡🟢
Water (70°C)	🟡	🟡
Water (100°C)	🔴	🔴

🟢 = Good resistance. No effect regarding material or its properties.
🟡 = Moderate effect regarding material or its properties.
🔴 = Not recommended.

SIPOLPRENE® chemical resistance
(if not indicated results are refer to tests at room temperature)

Electrical properties

A high dielectric constant together with a good dissipation factor make **SIPOLPRENE®** suitable for low voltage applications where high mechanical properties and resistance to high temperatures are appreciated over traditional thermoplastics.

SIPOLPRENE®	ELECTRIC STRENGTH	VOLUME RESISTIVITY	
		at 23°C	at 90°C for 1h
	kV/mm	Ω·cm	Ω·cm
	IEC 60243-1	*IEC 62631-3-1*	
25170	16	1E+12	1E+10
35150	16	1E+12	1E+11
35180	16	1E+12	1E+11
35195	18	1E+12	1E+11
46185	17	1E+12	1E+11
55200	18	1E+12	1E+11
63210	18	1E+13	1E+11
68217	19	1E+15	1E+12
72220	20	1E+16	1E+13

SIPOLPRENE® electric strength and volume resistivity values

SIPOLPRENE®	RELATIVE PERMITTIVITY		DISSIPATION FACTOR	
	frequency 50Hz	frequency 1kHz	frequency 50Hz	frequency 1kHz
	IEC 60250			
25170	5,0	4,5	7,1E-2	4,6E-3
35150	5,3	5,0	4,9E-2	8,2E-3
35180	5,1	4,9	7,2E-2	7E-3
35195	4,9	4,7	5,9E-2	5,4E-3
46185	5,0	4,8	5,3E-2	6,7E-3
55200	4,7	4,5	4,7E-2	8,2-3
63210	4,4	4,1	5,7E-2	8,5E-3
68217	3,9	3,7	6,2E-2	8,8E-3
72220	3,7	3,5	6,4E-2	9E-3

SIPOLPRENE® dielectric properties

SIPOLPRENE®
vs other thermoplastic elastomers

	SBS	SEBS	TPO	TPV	TPU	SIPOLPRENE® TPC-ET
Density (g/cm^3)	0,9-1,2	0,9-1,2	0,9-1,2	0,9-1,1	1,1-1,4	1,09-1,25
Hardness (Shore A/D)	25A-50D	0A-60D	60A-60D	20A-65D	65A-70D	28D-72D
Temperature range of usage (°C)	-50 / 90	-50 / 110	-60 / 110	-50 / 140	-40 / 110	-65 / 185
Compression Set (70/100 °C)	Bad	Good Excellent	Bad Moderate	Excellent	Moderate Good	Moderate Good
Abrasion Resistance	Good	Moderate Good	Moderate Good	Moderate Good	Excellent	Excellent
Hydrocarbons/Fat Resistance	Bad	Moderate	Moderate Good	Moderate Good	Excellent	Excellent
Non polar/Aqueous Solvent Resistance	Good	Excellent	Good Excellent	Excellent	Moderate Good	Moderate
UV Resistance	Bad Moderate	Excellent	Excellent	Excellent	Good	Moderate Good

Bad
Moderate
Good
Excellent

Strengths	▪ Widely available ▪ Elastic at low T	▪ Widely available	▪ Good performance at low temperature	▪ Wide product range ▪ Good performance / price ratio	▪ Wide product range ▪ Good performance	▪ Excellent resistance to high temperature ▪ Superior resistance to mechanical stress ▪ Good chemical resistance ▪ Food contact compliance
Weaknesses	▪ Low UV and ozone resistance	▪ Low performance performance / price ratio	▪ Bad elasticity over 60°C	▪ Limited resistance to hydrocarbons and fat	▪ Low performance performance / price ratio	Moderate resistance to: ▪ UV ▪ Ozone ▪ Hydrolysis

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Material processing

Drying

SIPOLPRENE® is hygroscopic and therefore it is necessary to dry the granules before use. If the product is exposed to air at room temperature, it absorbs moisture. Moisture, at injection molding temperatures, acts as a sort of catalyst for hydrolytic depolymerization.
Thus, the lower the moisture content the higher the quality of the molded parts.
Drying is highly recommended through the use of dry air or nitrogen flowing–ovens. The use of dehumidifiers accelerates the whole drying process. Normally 4 hours at 70-80°C should be enough, faster drying cycles can be obtained by increasing the temperature at 110 °C for a maximum period of 3 hours.

Extrusion

The range of viscosity of **SIPOLPRENE®** makes them typically suitable for injection moulding.
However, they may be processed in extrusion, adjusting the temperature profile in the extruder, as low as possible in order to gain melt strength and output stability.

SIPOLPRENE®	Melting Temperature	Feed zone	Compression zone	Melt conveying zone	Die
	°C	°C	°C	°C	°C
35180	177	165-180	180-195	190-200	190-205
35195	195	185-200	195-205	200-210	200-220
46185	186	180-195	190-200	195-205	195-210
55200	198	190-205	200-210	205-215	205-220
58210	211	200-215	210-220	215-225	215-230
63210	211	200-215	210-220	215-225	215-230
68217	217	205-220	215-225	220-230	220-235
72220	218	210-225	220-230	220-230	225-235
35150	150	140-155	160-175	160-175	160-180
40171	170	160-175	170-190	175-185	175-190
55211	213	205-220	215-225	220-230	220-230

SIPOLPRENE® General temperature profiles for extrusion

Injection molding

Standard injection molding screws can be used. The injected product weight should be in a range between 40% and 70% of the maximum shot capacity, and therefore the machine and relative barrel diameter should be compatible with these values.
The screw should have a L/D ratio of from 17 to 23 and a thread depth ratio of 1:2.
A check valve is also recommended.
Nozzles should be short in order to minimize friction and pressure loss.
The hopper must have a tight-fitting lid to keep the pellets dry during processing.
SIPOLPRENE® exhibits good thermal stability at the temperatures required for manufacturing (from 160 to 240°C).
This minimizes the problem of viscosity decrease during the hold-up time in injection and the formation of degradation byproducts. Besides, **SIPOLPRENE®'s** thermal properties also make it possible to use a percentage of reground product (e.g. from process scrubs) mixed to virgin ones during injection.

SIPOLPRENE®	Melting Temperature	Mold T	Melt T	Nozzle	Front Zone 3	Center Zone 2	Rear Zone 1
	°C	°C	°C	°C	°C	°C	°C
25170	173	20-30	200	200	190	160	130
25185	184	20-30	210	210	200	170	130
35180	177	20-30	210	210	200	170	130
35195	195	30-40	225	225	215	190	150
46185	186	25-35	220	220	210	175	140
55200	198	30-40	225	225	215	190	150
58210	211	40-50	240	240	220	200	180
63210	211	40-50	240	240	220	200	180
68217	217	40-50	245	240	230	210	200
72220	218	40-50	245	240	230	210	200
35150	150	20-30	180	180	170	130	100
40171	170	20-30	200	200	190	160	130
55211	213	40-50	240	240	220	200	180

SIPOLPRENE® General temperature profiles for injection molding

To gain an optimal appearance of molded parts, it is highly recommended to keep the mold temperature between 20°C and 50°C depending on wall thickness.
Injection pressure should be set at the minimum required to fill mold cavities. To avoid irregular shrinkage during cooling, higher holding pressures are necessary.
High injection speed allows to achieve good surface finishing and it is recommended for thinner parts. The screw speed should be generally in the range of 30 - 100 rpm.

Grade of **SIPOLPRENE®**, molding conditions, geometry and design of the moulded part have influence on post-moulding shrinkage. The following shrinkage values, measured on test specimens molded (2mm thickness), are only an indication to help the operator in predicting shrinkage.

SIPOLPRENE®	Typical Longitudinal Shrinkage Value
	%
25170	0,5
25185	0,5
35180	0,8
35195	0,7
46185	0,9
55200	1,3
58210	1,4
63210	1,4
68217	1,5
72220	1,5
35150	0,4
40171	0,8
55211	1,5

Typical longitudinal shrinkage values of **SIPOLPRENE®**

Polymer modifier

Thanks to its high compatibility with PVC, PET, SEBS, ABS and TPU, **SIPOLPRENE®** is frequently used in compounding as a modifier to improve some specific properties of the final compound.
The range of possible modifications, brought on by compounding **SIPOLPRENE®** with other polymeric materials, is extremely wide. The most common modifications are, for example, its use in PVC compounds to improve their low temperature resistance and to reduce the amount of added plasticizer.
Furthermore, in SEBS compounds, **SIPOLPRENE®** can be blended to gain thermal resistance (Vicat) or to modify the adhesion to polar substrates for 2K molding applications.

Recycling

SIPOLPRENE® scraps can be reground and added to fresh granules. A maximum of 25% is recommended to avoid significant changes in melt flow rate and mechanical properties.

2K - Molding

The soft nature of **SIPOLPRENE®** and its chemical structure, which allows to achieve a good adhesion to several rigid engineering plastics products, make it a material of choice in 2K-molding application where "soft touch" or functional flexible properties are needed and other thermoplastic elastomers do not provide sufficient adhesion.
The table below shows an overview of the adhesion properties of **SIPOLPRENE®** and other polymers to several substrates.

	PP	PA	PS	ABS	POM	PC	PET	PBT	PVC
SBS	🟢	🔴	🟢	🔴	🔴	🔴	🔴	🔴	🔴
SEBS	🟢	🟡	🟡	🟡	🟡	🟡	🟡	🟡	🟡
TPO	🟢	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴
TPU	🔴	🟢	🟡	🟢	🟡	🟢	🔴	🟢	🟢
TPV	🟢	🟡	🔴	🟡	🔴	🟡	🔴	🔴	🔴
SIPOLPRENE®	🔴	🟡	🟢	🟢	🔴	🟢	🟡	🟢	🟢

🔴 No adhesion
🟡 Adhesion only with modified grades
🟢 Excellent / good adhesion

Advantages of **SIPOLPRENE®** in 2K-Molding compared to other thermoplastic elastomers

SIPOLPRENE®

HIGH PERFORMANCE GRADES

Properties	Test methods	U.M.	25170	25185	35180	35195	46185	55200	58210	63210	68217	72220
Density	ASTM D 792 ISO 1183	g/cm3	1,09	1,09	1,11	1,11	1,15	1,19	1,20	1,22	1,25	1,25
Hardness Instantaneous / 15 s	ASTM D 2240 ISO 868	Shore D	28/25	29/26	35/33	36/33	45/42	53/50	58/55	62/59	68/65	72/69
Stress at break	ASTM D 638 ISO 527	MPa	22	22	24	22	32	43	44	50	54	53
Elongation at break	ASTM D 638 ISO 527	%	850	700	800	750	700	650	550	500	450	400
Flexural Modulus	ASTM D 790 ISO 178	MPa	25	25	45	45	80	180	230	300	550	650
Tear Strength	ASTM D 1004	N/mm	80	85	110	112	138	147	185	210	245	250
Melting Temperature	ASTM D 3418 ISO 11357-3	°C	173	184	177	195	186	198	211	211	217	218
Vicat A/50	ASTM D 1525 ISO 306	°C	73	98	111	137	149	177	190	195	208	210
Glass Transition Temperature	ASTM D 3418 ISO 11357-2	°C	-65	-65	-46	-45	-38	-20	-8	3	30	28
Abrasion Resistance	D 1044 (Taber H-18 1Kg)	mg/1000 rev	70	70	55	60	55	50	45	40	35	35
Water absorption (23°C x 24h immersion)	MI 08	%	0,8	0,8	0,7	0,7	0,5	0,4	0,3	0,2	0,2	0,1
MFI 230°C - 2.16 Kg	ASTM D 1238 ISO 1133	g/10 min	-	-	34	28	34	20	23	23	20	19
MFI 220°C - 2.16 Kg	ASTM D 1238 ISO 1133	g/10 min	-	20	-	-	-	-	-	-	-	-
MFI 200°C - 2.16 Kg	ASTM D 1238 ISO 1133	g/10 min	12	-	-	-	-	-	-	-	-	-
MFI 190°C - 2.16 Kg	ASTM D 1238 ISO 1133	g/10 min	-	-	-	-	-	-	-	-	-	-
Izod impact strength (notched) (23°C)	ASTM D 256 ISO 180	J/m	no break									70
Izod impact strength (notched) (-40°C)	ASTM D 256 ISO 180	J/m	no break					65	40	30	15	5

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SPECIALTY GRADES				
35150	40171	55211	B4319	B5422
1,15	1,18	1,21	1,21	1,22
37/33	38/36	54/51	44/41	53/50
28	23	34	27	35
600	380	350	500	500
50	55	150	75	130
100	105	120	116	132
150	170	213	193	218
105	103	183	152	195
-55	-35	-18	-	-
65	120	90	72	74
0,7	3,2	1,8	30	20
-	-	12	30	15
-	-	-	-	-
-	-	-	-	-
9	10	-	-	-
no break				
no break	15	60	no break	190

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The information provided in this documentation corresponds to our current knowledge at the date of publication.
This information may be subject to revision as additional knowledge and experience become available.
The data provided falls within the normal range of product properties and must be considered as guiding and typical values, relates only to the specific material; this data may not be valid for such material used in combination with any other materials or additives, unless expressly indicated otherwise.
The data provided must not be used to define specification limits nor used alone as basis of design; they are not intended to substitute for any testing you may need to determine the suitability of a specific material for your particular application.
User is responsible to check the suitability of product for intended processes and applications.
Since Sipol cannot anticipate all variations in actual end-use conditions, Sipol makes warranties and assumes no liability in connection with any use of this information.
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