SABIC Innovative Plastics™

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Xenoy* PC/PBT/PET resin

Delivering high performance and productivity in Automotive, Building and Construction, Consumer, and Healthcare industries worldwide.

Sharing our futures

Content

When success hangs in the balance

Consider the high-performance balance of properties from Xenoy* PC/PBT/PET resin

Strong chemical resistance, heat resistance, low-temperature impact resistance, high flow and weatherability. An excellent candidate for applications from automotive to consumer products to building and construction.

Imagine being able to build energy absorber (EA) systems with improved performance and reduced cost and package space. With Xenoy resin you can.

SABIC is committed to supporting Xenoy* resin customers as they select resin grades for their demanding applications. While our products feature unique value propositions to assist customer success, we also offer superb technical guidance and product development tools. And Xenoy resin features a unique selection of custom color capabilities, including express, small-lot service, color matching and a portfolio of striking visual effects.

Applications for Xenoy resin constantly evolve. And so do their performance properties, offering increasing innovation, better performance values and unique aesthetics for tomorrow.

Xenoy resin

These include more than 100 hard-working grades, all with their own balance between strong chemical resistance, heat resistance, low temperature impact resistance, high flow and weatherability.

Xenoy PC/PBT/PET resin is a versatile semi-crystalline family of polycarbonate (PC) resin blended with polybutylene terephthalate (PBT) and/or polyethylene terephthalate (PET) resin, used across industries in a broad variety of production processes and applications.

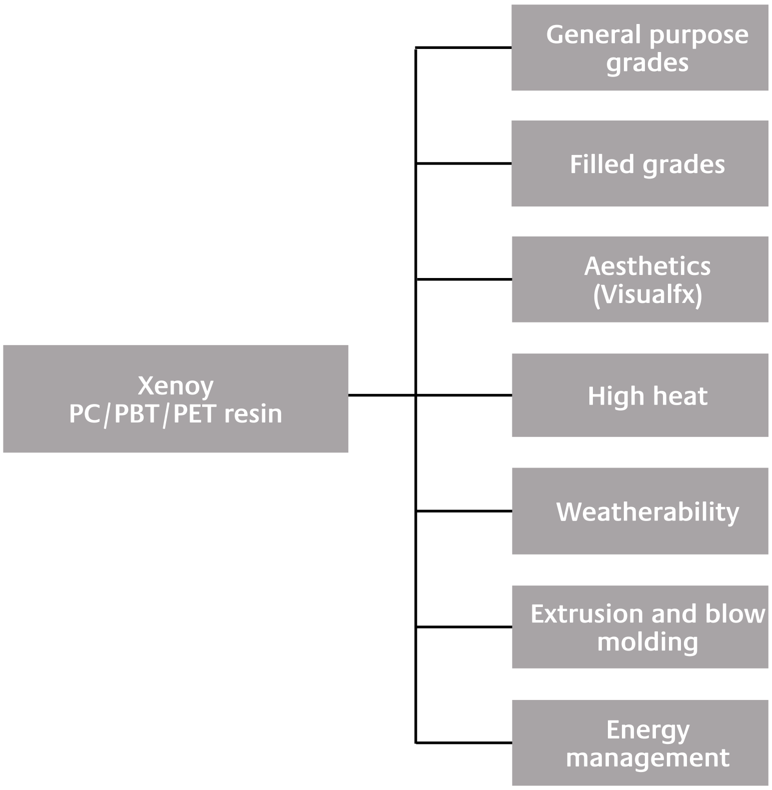
Certain grades offer very good UV resistance and color retention for cost efficiency, improved productivity and higher yields. Aesthetic options range from high- to low-gloss materials, countless colors and Visual**fx*** resin decorative surfaces.

Products using Xenoy resin include automotive body panels, door handles, front grilles, energy absorbers and interior components requiring low-gloss, molded-in color. Other applications range from power tools, oven handles, beer kegs, lawn mower decks, outdoor enclosures and building supplies.

Typical property profiles of Xenoy resin

- Chemical resistance: fuels, lubricants, solvents, cleaning fluids, adhesives
- Impact performance: low temperature impact ranging down to –60ºC
- Weatherability: UV stabilized versions and inherent special weatherable grades exist for optimal mechanical and color retention, according to SAEJ1960, J1885 and G26
- Heat resistance: dimensional stability under sunload or paint-curing temperatures up to 120°C
- Dimensional stability vs. other crystalline thermoplastic materials: low moisture absorption, low shrinkage, low warpage, low CTE
- High flow, thinwall capability
- Molded-in color and Visual**fx** resin

Table 1: Xenoy PC/PBT/PET resin performance products



2. General purpose Xenoy* resin

Unfilled Xenoy resin features a good balance of chemical resistance, impact and flow characteristics and heat resistance. Grades that have enhanced UV stability have the U or UV suffix. The results are mechanical long-term durability, high impact strength and good surface appearance, with processing benefits like a wide and robust processing window and low shrinkage. These features are an excellent material of choice for power tool and outdoor enclosure applications, as well as exterior and interior automotive components.

UV stability, impact strength, chemical resistance and heat resistance make Xenoy resin an outstanding choice for flash-light housings.

Table 2 – Typical unfilled Xenoy resin grades

X5101	Hydrostable, excellent low-temperature impact for enhanced long-term properties and improved safety
5220	Good chemical resistance and impact
CL100S	General-purpose grade for unpainted exterior automotive applications, improved release
CL300	Designed for thinwall applications. It has an excellent flow and can be painted primerless with water based or solvent based paint systems.
XD1641	Low plate out, high flow material for exterior automotive applications
CL500U	Excellent chemical resistance and good impact. UV stabilized
1731	Low CTE, high modulus and good chemical resistance with good weatherability

Xenoy resin safety shoe toe cap brings light weight, impact strength and chemical resistance, with many color options available.

3. Filled Xenoy* resin

Featuring good surface appearance, low shrinkage, high-heat capability, good chemical resistance and high impact strength, filled Xenoy resins are excellent for automotive applications like tailgates, door handles, spoilers and trunk lids. Dimensional stability, excellent gap and flush (low CTE) and high flow are added benefits.

Mineral-filled Xenoy resin for offline painted fuel filled flaps to give you long-term dimensional stability, excellent paint quality and ease of processing the part.

Table 3 – Typical filled Xenoy resin grades

X5410	Mineral-filled PC+PET resin with high heat dimensional stability for paint systems. It has very low CTE and excellent flow impact balance for automotive exterior applications such as body panels, tailgates, spoilers, rockerpanels or tankflaps.
X6320	10% mineral-filled PC+PBT resin developed for painted door handles
XD1647	15% mineral filled, impact modified, PC + PBT blend for reduced CTE, combined with good chemical resistance
1760	11% glass-filled PC+PBT, impact/chemical resistant, excellent physical property retention in automotive exteriors
1760E	High-flow version of 1760
XD1607	22% glass-filled PC + PBT, balance between surface appearance and mechanical properties. Especially suitable for gas assist moldings.
6370	30% glass-filled PC + PBT impact modified thermoplastic alloy, improved toughness and ductility

Mineral-filled injection molded Xenoy resin spoilers for excellent dimensional stability at high heat and robust part performance.

Xenoy resin doorhandles
- Specially modified for gas-assist moldings
- Superior dimensional stability, impact-strength balance
- Good surface appearance and paintable

4. Aesthetic Xenoy* resin

A variety of solutions exist for applications that require a highly aesthetic surface appearance. State-of-the-art color technology allows for large part molding with a very consistent color over the whole part. This technology is available in high gloss and for low gloss as well; it can eliminate the need for costly paint processes, while offering some of the most outstanding custom color capabilities in the industry. A molded-in color solution exists for those applications that require clear coating for enhanced surface hardness and superior weatherability.

Xenoy resin for robust aesthetics and performance in all enviroments/circumstances.

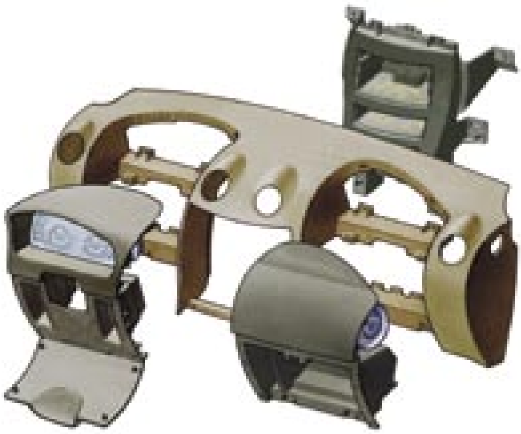
An extensive color palette is available, as well as unique aesthetic options from Visual**fx*** resin technology with effects like Flame, Speckle, Stone and Marble. In general, product finish durability can be enhanced through the use of clear-coat processes.

SABIC also offers its world-class ColorXpress* services, providing fast turnaround color matching and rapid delivery. For optimal effects during part design, aesthetic solutions are available from SABIC's Innovation Centers in Selkirk, NY; Bergen op Zoom, The Netherlands; or Shanghai, China.

Molded-in color Xenoy* resin is an excellent candidate material for products like automotive components, large body panels, power tools and security devices.

Table 4 – Typical aesthetic Xenoy resin grades

FXX210SK	Modified PC + PBT injection molding resin, Sparkle effect
XD1622	High flow PC + PBT blend, excellent impact flow, gasoline resistance For exterior body panels with durable, clear-coated, molded-in colors



4.1 Low-Gloss Xenoy Resin

Offering a unique, inherent low-gloss effect, low-gloss Xenoy resin is a cost-effective, drop-in solution for paint free applications. Other benefits include excellent heat resistance, superior scratch resistance vs. TPO, chemical resistance and weathering performance to 1250k/Jm² (J1885).

Low-gloss finishes are typically used on instrument panel retainers, glove boxes, interior trim and car top covers.

Table 4.1 – Typical low-gloss Xenoy resin grade

X5500	Very low gloss on textured and flat surfaces, high heat, chemical resistance, high flow for interior applications. Will be commercially available in January 2006.

Low Gloss

Paint Free

Molded-in color Xenoy resin delivers a cost-effective, high-quality solution for body panels for both manufacturer and end user. Manufacturing costs are reduced by weight savings, part integration and eliminating the need for painting. The end users enjoy lower cost of ownership through dent resistance up to -40°C, and long-lasting good looks.

5. High-heat Xenoy* resin

High-heat Xenoy PC/PET blend resin offers a 10 to 15°C increase in heat resistance over regular Xenoy resin, while maintaining excellent flow and surface finish. In addition, they have outstanding dimensional stability, low CTE at high heat, good adhesion to glues and paints (PU-based, epoxy), high color jetness and good UV resistance.

Philips Oral Healthcare selected Xenoy resin for the Sonicare brush head due to its excellent chemical resistance to whitening toothpastes.

Potential applications include automotive exterior components like front grilles and door handles, and parts from oven handles to beer kegs to road markers.

Table 5 – Typical high-heat Xenoy* resin grades

X2500UV	High heat, high impact, creep resistance, UV stabilized
XD859	Good flow, high heat, excellent impact over wide temperature range
RCX201	Good heat/dimensional stability and good flow
2735	Unreinforced PC+PET alloy, excellent low temperature/ chemical resistance and good elevated temperature performance

High-heat Xenoy resin door handles for excellent durable appearance, high impact and UV stability.

6. Weatherable Xenoy* resin

Best-in-class weatherability combined with good chemical resistance, impact strength at sub-zero temperatures and heat resistance are some of the benefits of the Xenoy resin weatherable grades. This can help eliminate paint processes, while accessing a multitude of weatherable colors.

Thermo King has selected weatherable Xenoy resin for their refrigeration unit because of its outstanding durability.

The weatherables offer extensive process benefits like consistently reproducible molded-in color, outstanding melt flow and low plate-out. They are a natural candidate material for applications from lawn mowers, agricultural equipment, sports products, outdoor enclosures and power tools, and are used throughout the automotive industry.

Moreover, most standard grades are available in a UV-stabilized version, giving enhanced durability compared to its reference grade.

As exact weatherability performance is very much dependent on the exact color used, please contact your local SABIC Innovative Plastics representative when considering Xenoy* resin for weatherable applications.

Table 6 – Typical weatherable Xenoy resin grades

X2300WX	High heat, impact modified, UV-stabilized
X5300WX	Excellent weatherability, chemical resistance; good mechanical performance, molded-in color capability
X5600WX	Best combination of excellent weatherability and heat performance, impact modified
5220U	Good retention of mechanical properties under UV, excellent low temperature/chemical resistance
6380U	30% glass-filled, UV-stabilized PBT blend improved surface appearance

Xenoy resin is an excellent material solution for power tool applications, presenting a balance of high heat, chemical resistance and dimensional stability.

7. Extrusion/blow molding Xenoy* resin

For processes requiring high melt strength, such as extrusion, thermoforming and blow molding, several Xenoy resin grades are available. X4700 and its weatherable counterpart X4700WX balance heat, hydrolytic stability, impact and chemical resistance, and can be easily extruded into its final shape, such as window profiles or pipe.

New, high-impact PC/PBT blend resin, with improved hydrolytic stability, specially designed for extrusion of window spacers, in a double-glazing system.

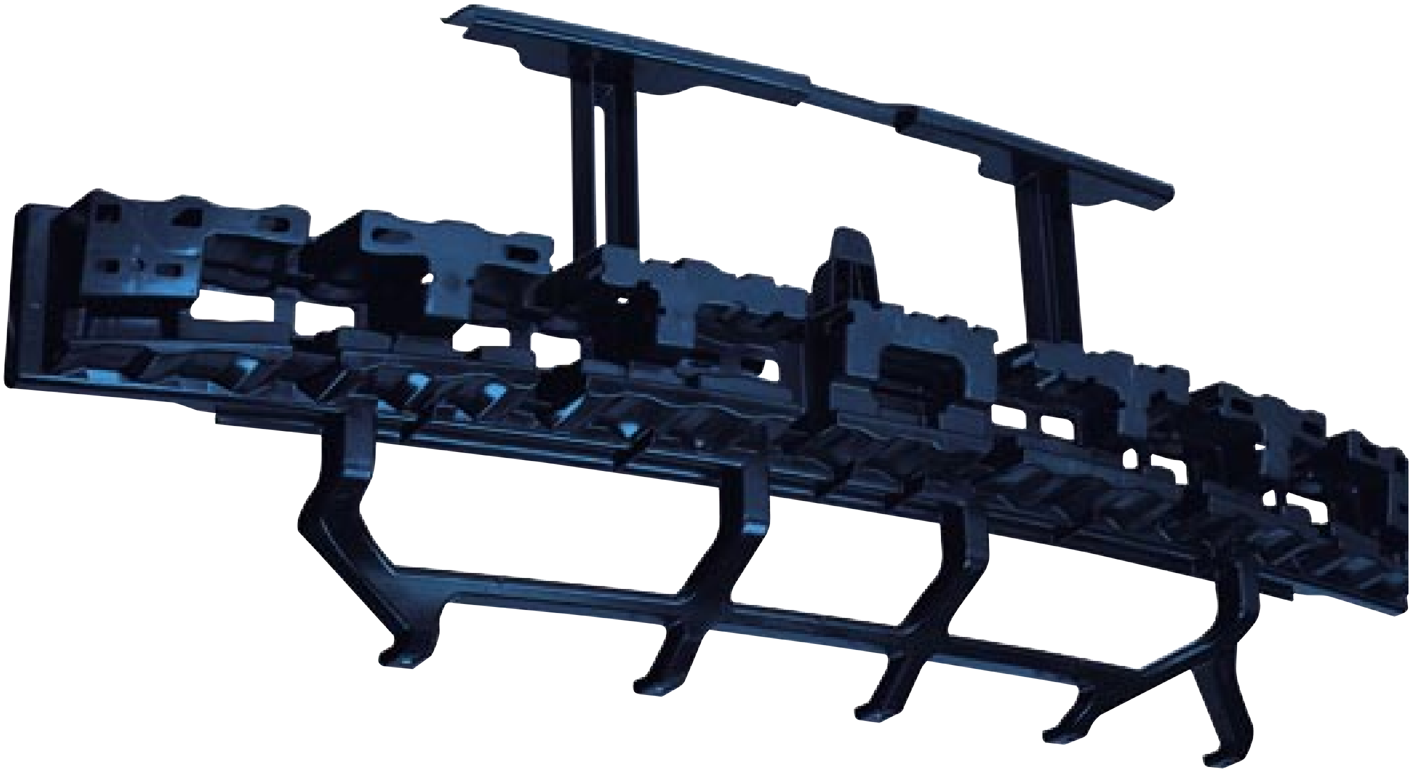
Melt strength goes up from CL402(U) and 1402B towards X4000BM, the Xenoy* resin grade with the highest melt strength, offering an excellent performance in very large blow molded parts.

Table 7 – Typical alternative extrusion/blow molding Xenoy resin grades

X4000BM	Highest melt strength, for extra large parts
X4700	PBT + PC, heat stabilized, impact modified and opaque, for extrusion applications where higher melt strength is desired
X4700WX	Similar to Xenoy X4700 resin with improved UV-performance
CL402(U)	High viscosity, optional UV-stabilized grade for blow molding applications
1402B	Blowmoldable, unreinforced PC/polyester alloy, high melt viscosity/strength, excellent low-temperature impact

Blow moldable Xenoy resin is an excellent option for large parts because of its high hang strength, impact, processing window and excellent regrind stability. It offers significant weight reduction and functional integration versus steel systems.

Some applications are very demanding when it comes to absorbing energy multiple times. With Xenoy resin, foamed energy absorbers can be replaced using less package space at lower cost and better overall performance.



SABIC Innovative Plastics works closely with the automotive industry to address increasingly stringent safety legislation and performance demands. Innovative, cost-effective energy absorbing systems based on high performance Xenoy resin can be relied upon to comply with stricter pedestrian safety legislation and insurance industry requirements for low speed impact performance.

Xenoy* resin improves part performance with respect to

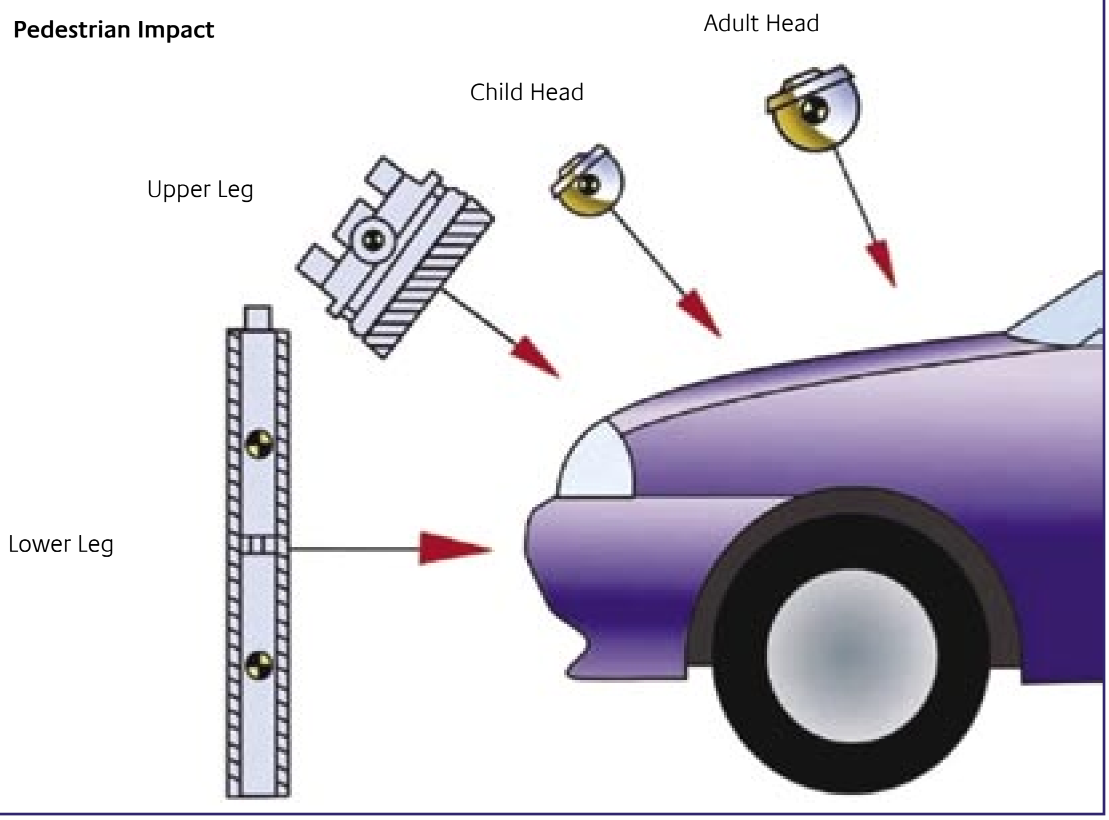
- Better low-speed performance
- Consistency over temperature
- IIHS damagability
- Cost benefit vs. 5 mph foam systems
- Functional integration
- Designs for pedestrian protection
- Styling freedom

Potential application benefits for EP carriers and beams include lower mass (from 15-25 percent) and complexity reduction.

Table 8 – Typical energy management Xenoy resin grades

X5101	Excellent ductility, improved hydrostability for off-line, solvent-based painted exterior automotive applications, as well as interior applications that need low temperature ductility and hydrostability for passenger safety requirements
1103	Unreinforced, impact-modified PBT + PC alloy, excellent low-temperature impact and chemical resistance, range of gray, black colors
X1200UV	High-impact PBT + PC, low-temperature impact resistance, UV stabilized, near IR absorption capability

Pedestrian Impact



9. Xenoy* resin product information

Attributes	Typical grade	Made in†	Heat	Impact:
		A = Americas E = Europe P = Pacific	Vicat B/50 in °C (ISO 306)	Izod notched in kJ/m² at 23°C (-30°C) (ISO 180/1A)
General purpose				
General purpose	5220	A, E, P	125	55 (35)
General purpose – improve mold release	CL100S	E	125	46 (21)
Very high flow	XD1641	E	120	35 (16)
Chemical resistance	CL500U	E	114	65 (25)
High flow	CL300	E	116	42 (20)
Low temperature impact	5720U	A		
Dimensional stability	1731J	A, P	130	59 (16)
Aesthetic				
Sparkle visual effect	FXX210SK	E	115	32
Molded-in color, clearcoat capability	XD1622	E	115	45 (22)
High heat				
General purpose	XD859	A	131	40 (20)
High flow	RCX201	P		
Low temperature impact	2735	A		
UV stabilized	X2500UV	E	130	40 (25)
Weatherable				
General	5220U	A, E, P	125	55 (35)
High heat and weatherability	X2300WX	A	135	51 (19)
Best weatherability	X5300WX	A, P	135	30 (10)
Heat and weatherability	X5600WX	A	130	50 (20)
30% GF, Impact modified, UV stable	6380U	E	180	10 (7)
Extrusion and blow molding				
Extrusion	X4700	E	120	50 (35)
UV stabilized	X4700WX	E	120	50
Blow molding	1402B	A, P		
UV stabilized	CL402U	E	123	53 (45)
Highest melt strength	X4000BM	A, P	120	50 (20)
Energy management				
Fatigue resistance	X1200UV	A	123	56 (35)
Low temperature impact	1103	A, P	124	56 (48)
Hydrostable	X5101	E	121	50 (30)
Filled				
10% GF	1760, 1760E	A, P	135	3 (3)
20% GF	XD1607	E	126	7 (6)
30% GF	6370	A	148	10 (6)
10% MF	X6320	A, P	138	5 (5)
15% MF Impact Modified	XD1647	E	125	12
10% MF High Flow	X5410	P	137	7 (7)

* U: UV stabilized
* WX: weatherable
* BM: blow molding
† Many of these grades are available globally

Modulus:	Flow:	Heat	Impact:	Modulus:	Flow:
Flexural in MPa (ISO 178)	MVR in cm^3/10min at 250°C, 5.0kg (ISO 1133)	HDT in °C, 0.45 (1.82MPa), 6.4mm (ASTM D 648)	Izod notched in J/m at 23°C (-30°C) (ASTM D 256)	Flexural in MPa (ASTM D 790)	MFR in g/10 min at 250°C, 5.0kg (ASTM D 1238)
2000	14.5	107 (99)	710 (299+)	2000	15.5
2200	20				
2300	16 (2.16kg)				
1900	14				
2100	30				
		118 (99)	854 (534+)	1950	8.2
2200	8	120 (105)	814 (176)	2100	9.6
2200	9 (2.16kg)				
1900	13 (2.16kg)				
2200	10 (265°C, 2.16kg)	115 (104)	640	2200	9.8 (265°C, 2.16kg)
		131	392 (50)	2150	20.4 (265°C, 2.16kg)
		129 (112)	747 (464)	2100	15 (265°C, 5.0kg)
2200	4 (265°C, 1.2kg)				
2000	14.5	107 (99)	710 (299+)	2000	15.5
2150	20.5 (280°C, 2.16kg)	132 (118)	791 (420)	2200	35 (265°C, 5.0kg)
2200	25 (265°C, 5.0kg)	120 (106)	748 (169)	2450	26.5 (265°C, 5.0kg)
2150	30 (265°C, 5.0kg)	128 (119)	800 (267)	2500	32 (265°C, 5.0kg)
6500	9 (265°C, 1.2kg)				
1900	6				
1900	7				
		(96)	694 (534)	2000	10.3 (265°C, 5.0kg)
1900	6				
1800	6 (265°C, 5.0kg)	121	715 (530)	2200	6.6 (265°C, 5.0kg)
2300	15	(88, 3.2mm)	828 (668)	2300	15.3
1900	11.6	110 (91)	801 (641)	1950	12.2
2000	13				
4000	14	125 (116)	48	3900	15
6500	11				
7750	12	204 (148)	170 (112)	5450	13
3550	16	135 (115)	45 (45)	3550	20
3450	13				
2700	17 (265°C, 2.16kg)	134 (121)	87 (82) [+:-40°C]	3000	19 (265°C, 2.16kg)

10.1 Properties and Design

General properties

Xenoy thermoplastic alloys are based on a technology that blends crystalline and amorphous resins to achieve an outstanding combination of mechanical strength, chemical resistance and dimensional stability.

Design calculations for Xenoy resin are no different than for any other material. Physical properties of plastic are dependent on the expected temperature and stress levels. Once this dependency is understood, and the end-use environment has been defined for an application, standard engineering calculations can be used to accurately predict part performance.†

Mechanical properties

In general, Xenoy resin exhibits excellent mechanical properties. These are retained across a broad range of temperatures and also through time. Time and temperature will normally only result in slight decreases of the original properties. The impact resistance of Xenoy resin in particular remains fairly constant over a range of temperatures. Only at extremely low temperatures will the material become stiffer and more brittle.

Stiffness

The stiffness of a part is defined as the relationship between the load and the deflection of a part. The most important material property for stiffness is the stress/strain curve (see figures 1 and 2).

In general, the Young's modulus, which is determined from the stress/strain curve, is the best parameter to be used when comparing the stiffness of materials.

A further important consideration in the calculation of part stiffness is the temperature at which the load is applied, as can be seen in figure 3. The stress/strain curves of filled and unfilled Xenoy resin, like those of other thermoplastics, are strongly influenced by temperature.

†Data measured on test bars. To determine actual performance, the final part must be tested before end use.

Figure 1 – Stress-strain curve of standard Xenoy resin at room temperature and 0.8333%/sec. strain rate

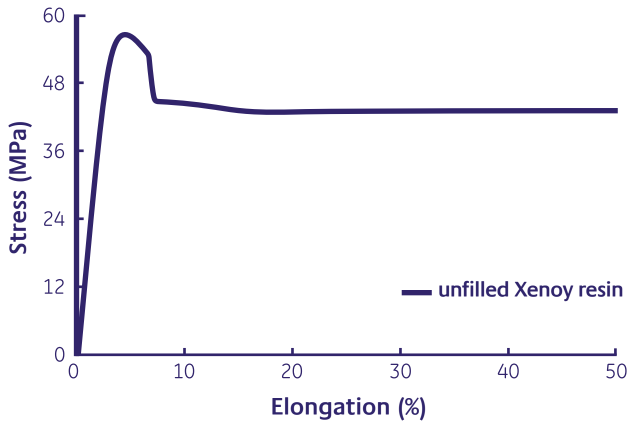


Figure 2 – Stress-strain curve of filled and unfilled Xenoy resin at room temperature and 0.8333%/sec. strain rate

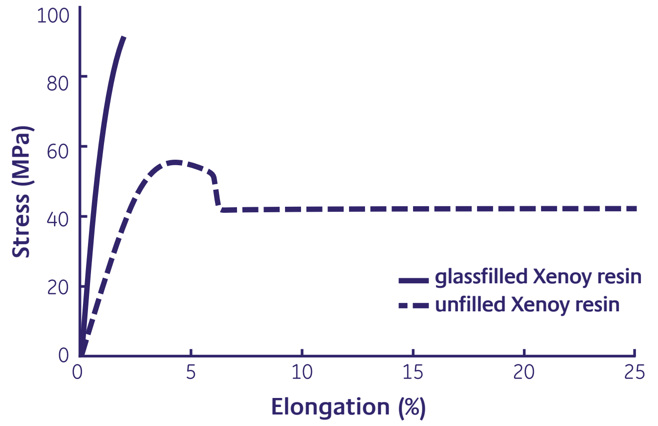
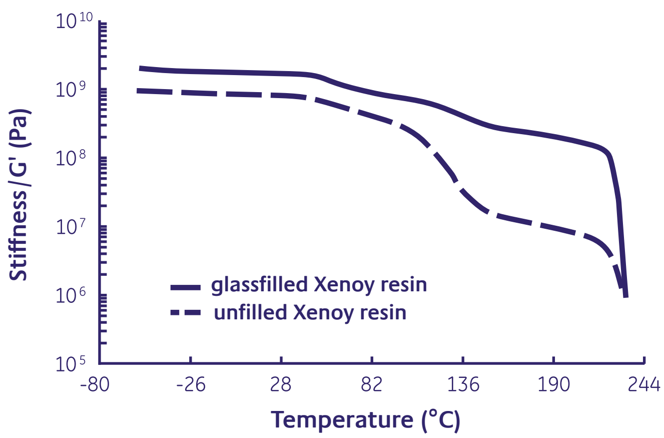


Figure 3 – DMA bending curve of filled and unfilled Xenoy resin at 6.3 rad/sec



Strength
The strength of a part is defined as the maximum load that can be applied to a part without causing part failure under given conditions. In order to be able to determine the strength of a part, failure has to be first defined. The right definition of failure depends on the application and how much deformation is allowed.

Material strength is a stress/strain related property which is inherent to the material. The tensile test provides the most useful information for engineering design. For unfilled Xenoy* resin grades subjected to small strains, the stress increases proportionally with the strain. However, early in the test non-linearity will occur.

In fact close observation of the stress/strain curve reveals that a proportional part does not exist. With larger strains, yield will occur and the maximum stress is reached. If the strain is further increased, necking will occur. The neck will propagate through the structure until the material fails. The speed of deformation in the application is vital, as shown in figure 4.

Impact strength
Impact strength can be described as the ability of a material to withstand an impulsive loading. There are several factors which determine the ability of a plastic part to absorb impact energy. In addition to the type of material these factors include:
• Wall thickness
• Geometric shape and size
• Material flow
• Operating temperature and environment
• Rate of loading
• Stress state induced by loading

For ductile polymers such as Xenoy* resin, the load at which yield occurs in a part is affected by the last three factors. Of even more significance to design is the fact that, under the appropriate circumstances, the impact behavior of a ductile polymer will undergo a transition from a ductile and forgiving response to a brittle and catastrophic one. Usually this change in behavior is described in terms of a ductile/brittle transition temperature above which the failure is more ductile by nature, and below which it is more brittle, as illustrated in figure 5.

Figure 4 – Stress-strain curve until start of necking of standard Xenoy resin at room temperature and various speeds

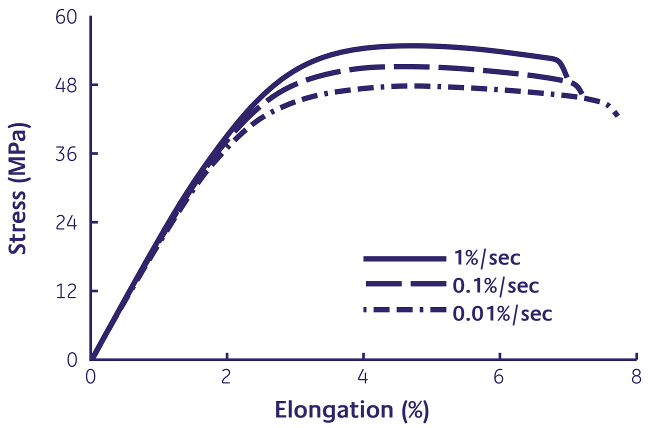
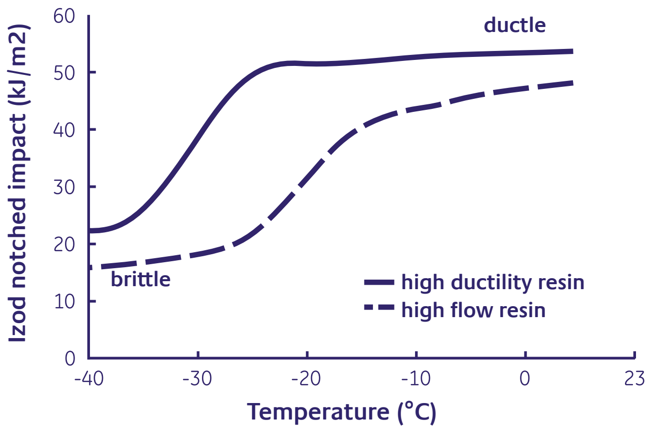


Figure 5 – Izod notched impact of standard Xenoy resin as a function of temperature



There are many methods and norms for evaluating the impact resistance of a material. The most common norms include ISO, ASTM and DIN. In general, standard samples are molded and subjected to the impact test. Examples of the various tests include Izod, Charpy, Tensile, Falling Dart or High Speed impact. In some cases a notch is deliberately introduced into the test sample in order to concentrate stress at the point of impact. The determination of the ductile/brittle temperature as a function of the wall thickness gives some guidance in the prediction of whether a part with a given wall thickness will behave in a brittle or a ductile manner at a given temperature and test conditions.

As stated earlier, the impact level, ductility or brittleness depends on the sample geometry. Changing the geometry of the test samples by reducing sample thickness will result in increased impact strength and, consequently, a reduced ductile/brittle temperature. This means that, while a higher flow Xenoy resin material normally exhibits inferior impact resistance, it may still behave in a ductile manner at low temperatures because it can be molded in thin walled parts.

Behavior over time

There are two types of phenomena which should be considered. Static time dependent phenomena such as creep are caused by the single, long-term loading of an application. Dynamic time dependent phenomena such as fatigue, on the other hand, are produced by the cyclic loading of an application. Both types of behavior are heavily influenced by the operating environment and component design.

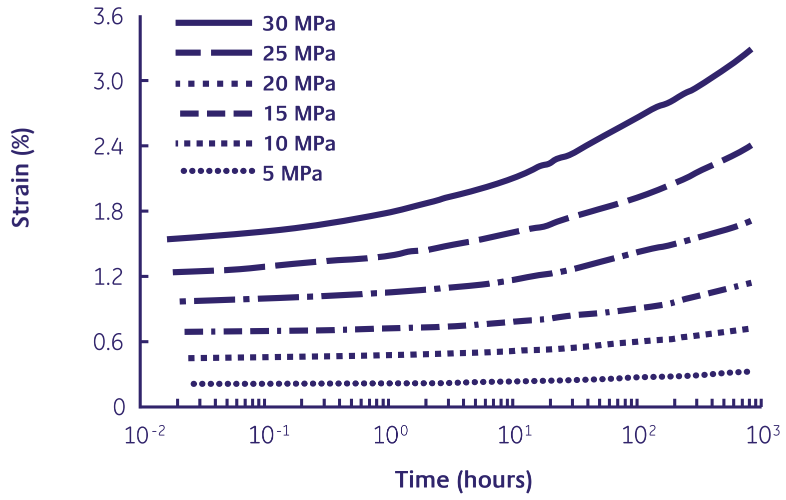
Creep behavior

Under the action of an applied force, a viscoelastic material undergoes a time dependent increase in strain which is called creep or cold flow. Creep is defined as the increasing deformation of a geometrical shape when subjected to a constant load over a defined period of time. The creep rate for any material is dependent on temperature, load and time.

In situations where Xenoy resin parts are fixed to other parts under stress, or where stress is induced under the influence of the different thermal expansion coefficients of neighboring materials, a thorough analysis of creep behavior is required.

As shown in figure 6, the creep of semicrystalline materials such as Xenoy resin increases in direct proportion to the applied force. However, creep varies greatly with temperature, creep of the material becomes significantly larger at higher temperatures once the PBT in Xenoy has passed through the glass transition temperature. The curves illustrate the initial deformation due to the applied load on a specimen. Up to this point, the response is elastic in nature and therefore the specimen will fully recover after the load is removed. However, continued application of the load will result in a gradual increase in deformation. In other words it “creeps.”

Figure 6 – Creep performance of standard Xenoy resin as a function of time at room temperature and different stress levels



Fatigue endurance

Fatigue is an important design consideration for parts subjected to cyclic loading or vibration. Structural components subjected to vibration, components subjected to repeated impacts, reciprocating mechanical components, plastic snap-fit latches and molded-in plastic hinges are all examples where fatigue can play an important role. Cyclic loading can result in mechanical deterioration and fracture propagation through the material, leading to ultimate failure. When parts are subjected to cyclic loading, fatigue failure can occur, often at a stress level considerably below the yield point of the material. In such applications, a uniaxial fatigue diagram could be used to predict product life. These curves can be used to determine the fatigue endurance limit, or the maximum cycle stress that a material can withstand without failure.

Fatigue tests are usually conducted under tensile conditions, though bending and torsional testing is also possible. A specimen of material is repeatedly subjected to a constant deformation at a constant frequency, and the number of cycles to failure is recorded. The procedure is then repeated over a range of deflections or applied stresses. The test data are usually presented as a plot of log stress versus log cycles; this is commonly referred to as an S-N curve, as shown in figure 7.

S-N curves obtained under laboratory conditions may be regarded as “ideal.” However, practical conditions usually necessitate the use of a modified fatigue limit, as other factors may affect performance, including, most notably, the type of loading, the size of the component and the loading frequency.

However, fatigue testing can only provide an indication as to a given material’s relative ability to survive fatigue. It is therefore essential that tests are performed on actual molded components, under actual end-use operating conditions.

Thermal properties

The Vicat softening temperature is widely used to provide an accurate measure of the thermal performance of engineering thermoplastics. The Vicat temperature of a Xenoy* grade can determine whether it can be used in an application which is subjected to short-term high heat exposure. A good example of this is the paint curing process where temperatures as high as 100°C are applied (see figure 8).

Figure 7 – Fatigue performance of Xenoy resin (standard resin) with a frequency of 5 Hz at room temperature

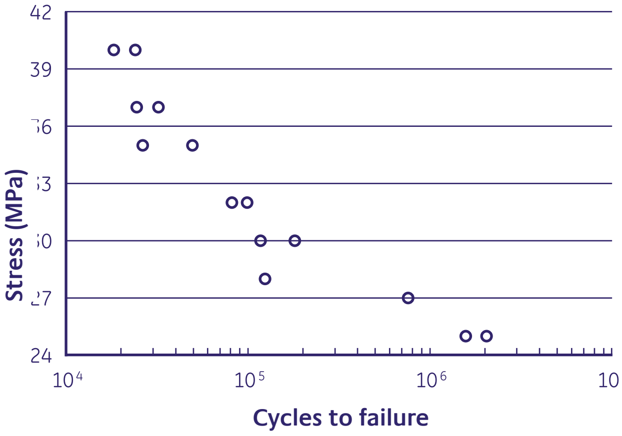
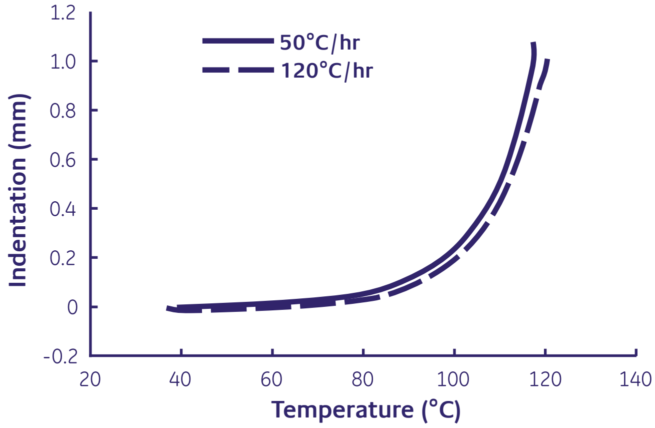


Figure 8 – Vicat indentation of Xenoy resin as a function of temperature



Mold shrinkage

Mold shrinkage refers to the shrinkage that a molded part undergoes when it is removed from a mold and cooled at room temperature. Expressed as an average percentage, mold shrinkage can vary considerably depending on the mold geometry, the processing conditions and the type of resin.

For a semi-crystalline material like Xenoy resin, shrinkage depends on the ratio of amorphous and crystalline components. Typical examples are given in figure 9.

The packing or holding pressure phase in the injection molding process has a significant effect on shrinkage. In general, the higher the holding pressure and the longer it is effective, the smaller the shrinkage.

Processibility

For molding or extrusion processes, the material's flow properties are critical. These are measured based on melt flow length and melt temperature. The flow lengths of SABIC Innovative Plastics materials are given as calculated disk flow lengths, where the injection pressure is plotted against the radial flow length. Determination of the calculated disk flow length is important when trying to predict whether or not a part can be filled.

The melt flow length of a material is a function of viscosity, shear properties and thermal properties. Common viscosity tests include melt viscosity, MV, and melt volume rate, MVR, measurements.

In general, for a simple comparison or quality assurance check, the MVR is measured. However, as materials show significantly different MV curves, more accurate comparisons for design calculations should be made according to the MV curves rather than on the MVR. MV tests are carried out over a large range of shear rates. Figure 10 shows the MV curves of various Xenoy grades.

In order to facilitate the flow of the material in the tool, the melt temperature can be varied since the viscosity of semi-crystalline materials is a function of the temperature, as shown in figure 11.

Figure 9 – Shrinkage of different combinations of PC and PBT

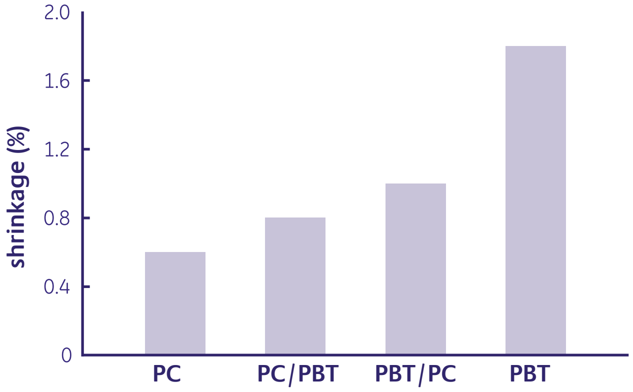


Figure 10 – Capillary melt viscosity of Xenoy resin at 260°C

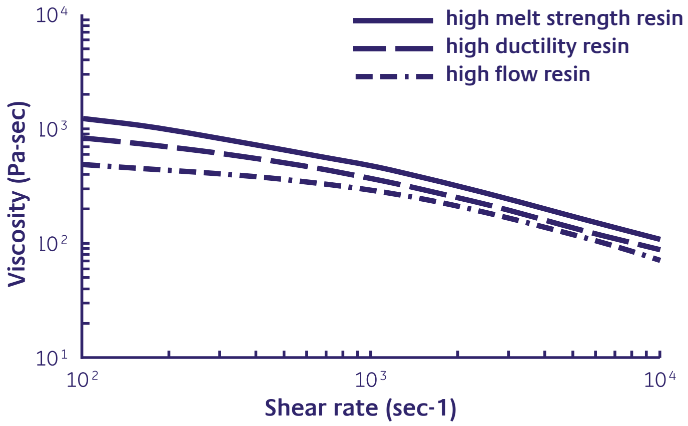
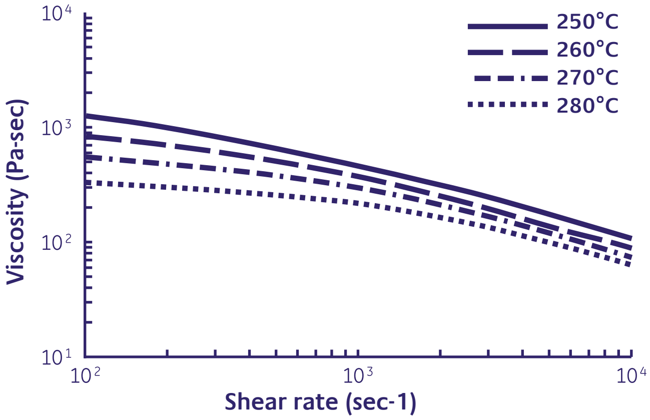


Figure 11 – Capillary melt viscosity of standard Xenoy resin at various temperatures

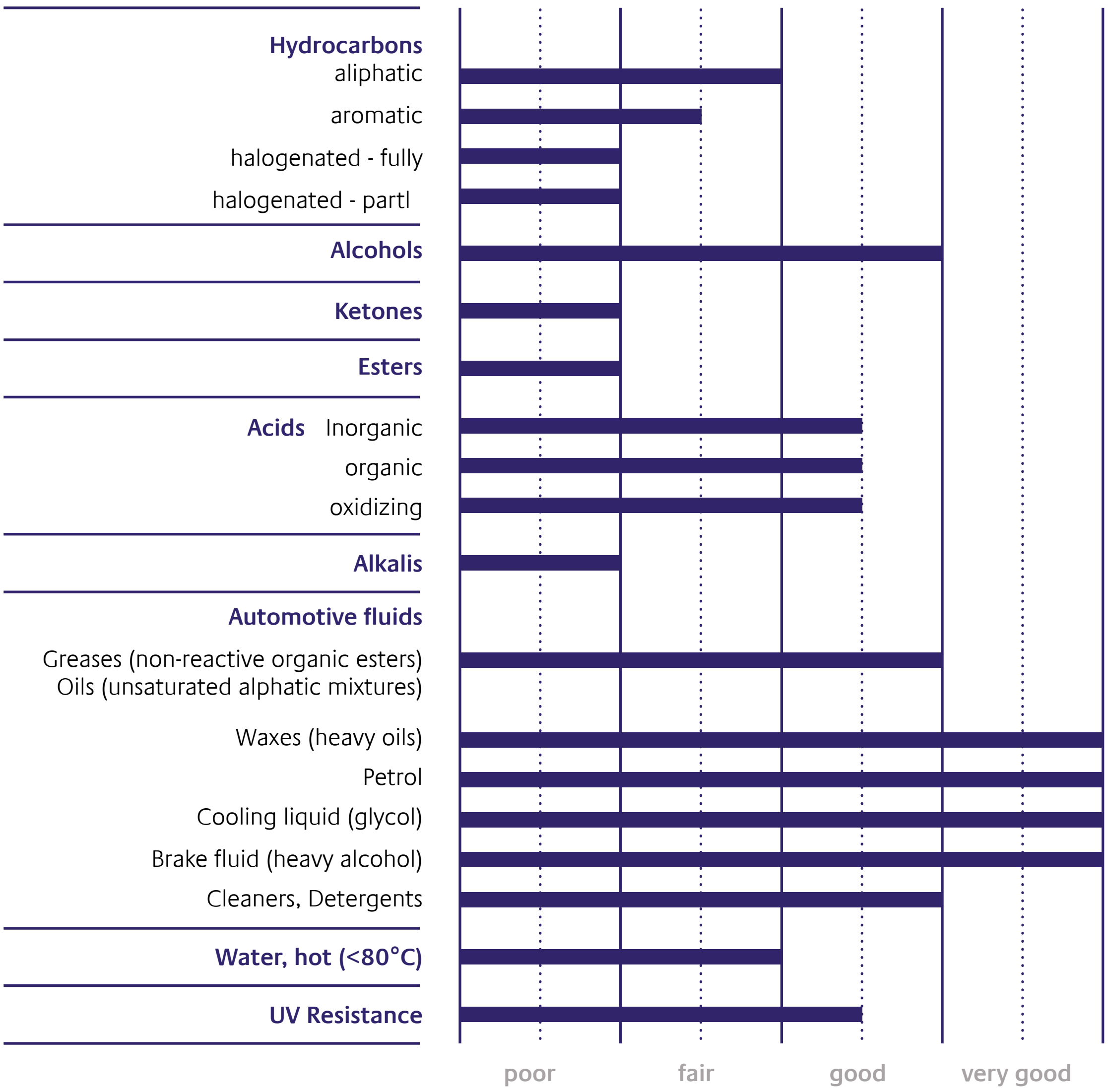


Chemical resistance[†]

As a semi-crystalline material, Xenoy* resin exhibits excellent chemical resistance. Of particular note is its good retention of properties when exposed to automotive fluids. Figure 12 provides an overview of Xenoy resin's resistance to a range of chemicals. Readers are asked to refer to the chemical compatibility guide for more detailed information.

[†] In all cases, testing of the application under working conditions is strongly recommended. The actual performance and interpretation of the results of end use testing are the end producer's responsibility.

Figure 12 – Chemical resistance of Xenoy resin



poor
not recommended
- will result in failure or severe degradation

fair
found marginal
- only for short exposures at lower temperatures or when loss of mechanical properties is not critical

good
found acceptable in normal conditions
- long-term exposure will result in minor loss of properties
- higher temperaturesmay result in major loss of properties

very good
found unaffected in its performance with regards to time, temperature and stress, according to agency requirements

10.2 Processing

Xenoy thermoplastic alloys can be successfully processed by injection molding, extrusion and blow molding. Extruded sheet from Xenoy resin can be thermoformed. Standard equipment can be used and the processing range is very broad. Fast cycle times are possible and any rejects can be ground and reused, providing contamination has not occurred during processing.

Pre-drying

Most thermoplastic materials absorb atmospheric moisture which will show on the surface of the part as streaking or splay and can, at normal processing temperatures, cause polymer degradation. This consequently lowers property levels, in particular impact strength. Xenoy resin therefore must be thoroughly dried before processing to optimize material stability during molding and to produce tougher, ductile parts.

For all Xenoy resin grades except those containing PET, it is recommended to pre-dry the material for a minimum of 2 hours at 110°C. For Xenoy blends with PET, the drying time should be at least 4 hours at 120°C. Excessive drying times of over 24 hours will not affect the properties of the polymer but they might decrease release performance during processing.

The moisture content prior to processing should not exceed 0.02%. This target is easily reached with standard dehumidifying dryers, usually within 2 hours (see next).

Equipment

Dryer

- Dehumidifying dryers are recommended for the pre-drying of Xenoy resin.
- Hot air circulation dryers are also successfully used, although account must be taken of longer drying times and therefore of reduced throughput.
- Tray oven dryers are not recommended because of their limited production capability.
- Due to the high drying temperatures required for Xenoy resin, it is important to check the suitability of the vacuum hoses transporting the material from the dryer to the hopper.

Hopper

The residence time of the material in the hopper should not be more than 30 minutes. The dimensions of the hopper are not so important as long as there is the possibility to adjust the hopper loading level and to keep the lid closed to avoid moisture pick-up.

Screw geometry and design

- High compression ratio screws or those with a short compression zone, such as a nylon type screw, should not be used. It is recommended to use a conventional 3-zone screw with a L:D ratio of 22:1-25:1 and a compression ratio of 2:1-2.5:1.
- Conventional metallic materials for screw and barrel are acceptable for the processing of unfilled Xenoy resin. However, screws and cylinders of a bimetallic type with high abrasion and corrosion resistance are preferred for glass and mineral-filled Xenoy grades.
- The clearance between the flight of the screw and the barrel should be kept to a minimum to prevent leakage of the molten material across the flight land which would cause inconsistencies in plasticizing and dosing.

A vented barrel and screw is not a satisfactory alternative to pre-drying and is therefore not recommended for Xenoy* resin. If a vented barrel is used, then the level of moisture which is present in the material, and the percentage of the shot capacity, will have a considerable influence on whether any degradation is encountered as a result of hydrolysis.
- The screw should be equipped with a sliding ring back flow valve. As Xenoy resin has a low melt viscosity, the performance of the valve is extremely important in the avoidance of surface defects, particularly when using a slow initial injection speed.
- Ball check valves are not recommended because they may cause local material degradation as a result of excessive shear or hang-up.
- Energy transfer, ET, screws provide good results in terms of throughput, impact performance and melt consistency.

Nozzles

A free-flowing nozzle with its own heater band and temperature control is generally recommended for processing Xenoy resin.
- The nozzle temperature should be kept 10°C to 15°C below the melt setting to prevent material drooling or stringing.
- Nozzle openings have to be as large as possible: the diameter should be 1mm smaller than that of the sprue tip in the mold.

Processing conditions

Melt temperature

In order to get the correct melt temperature, a profiled barrel temperature setting should be used. Following the recommendations in the relevant material data sheet, the temperature should increase progressively from the hopper to the machine nozzle. The temperature of the cooling ring around the hopper zone should be between 40°C and 60°C. When higher temperatures are used, the polymer may stick to the screw, creating a so-called "cold ring."It should be noted that the set melt temperature is seldom the same as the actual melt temperature which is determined by a number of combined factors: the cylinder heater settings, screw rotation speed, back pressure and residence time.

Therefore the actual melt temperature should be measured while the machine is running using hand-held pyrometers.

Back pressure

A machine back pressure of 5-10 bar is recommended in order to improve melt quality and maintain a consistent shot size. For glass reinforced grades, careful monitoring of back pressure is advisable in order to minimize fiber damage.

Screw rotation speed

The screw rotation speed, rpm, should be adjusted to suit the molding cycle but must not result in a screw surface speed of more than 0.5m/s. For a screw with a diameter of 30mm this means a maximum 190rpm and for a screw of 150mm diameter it is a maximum of 38rpm. The screw speed should be selected to enable screw rotation during the entire cooling cycle without delaying the overall cycle. Material degradation can occur at too high screw speeds due to excessive shear heating.

Suck back

Drooling problems may be experienced on nozzles which have poor temperature control. If these problems persist after the nozzle temperature has been adjusted, the careful use of melt decompression or suck back is advised. The suck back stroke should be just enough to keep the resin in and the air out, as entrapped air can cause melt degradation and create molding problems such as splay or burning. Suck back can also be used to depressurize hot runner systems.

Screw cushion

A screw cushion of 5-10mm is recommended for a screw diameter of 50-100mm. Above a screw diameter of 100mm, a screw cushion of 10-15mm is advised. Without a cushion it is not possible for the after pressure to have an effect.

Shot capacity and residence time

Normally shot weight should be between 30%-80% of the barrel capacity. When processing Xenoy resin on the upper limit of the melt temperature range, however, it is recommended that the shot size is 60%-80% of the barrel capacity to minimize residence time.

The recommended residence time for Xenoy resin is between 4 and 8 minutes, depending on the selected melt temperature. A too long residence time can result in material degradation. A too short residence time, on the other hand, may cause molding parameters to fluctuate, thereby reducing the plastification and the homogeneity of the material.

Injection speed and pressure

A medium to fast injection speed is desirable for all Xenoy grades. Care should be taken to providing adequate venting when selecting a fast injection speed. Programmed injection, with slow initial cavity filling, will provide a better surface finish around the gate area for nearly all gating systems.

In general, the injection pressure should be as low as possible to obtain parts without flash but sufficiently high to completely fill the part during the injection stage.

After pressure

After pressure compensates for volume shrinkage of the melt in the mold during cooling. Due to the speed at which Xenoy resin crystallizes, the effect of after pressure is determined by the part design, wall thickness, flow length and gate.

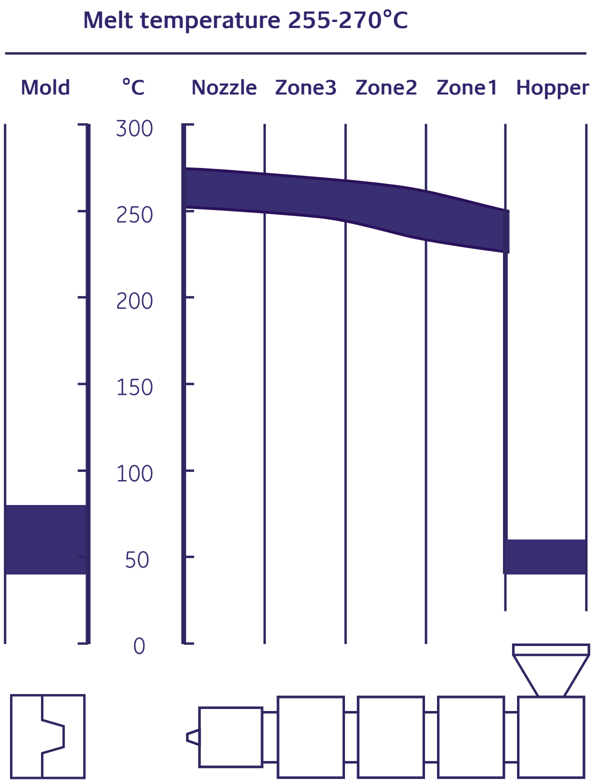
If the part has thin walls with narrow gates, the material will freeze off very quickly which means that the level of after pressure should be high for a short period of time. If, on the other hand, the part has thick wall sections and large gates, a moderate or low after pressure can be applied for a longer period of time.

When the after pressure is too low, this will result in visible sink marks as well as voids and uneven part shrinkage. When the pressure is too high, localized stresses can occur, particularly in the gating area, and ejection problems can be created. High stress will show up as warpage after painting or heat treatment.

Mold temperature

Mold temperature is extremely important and therefore should be checked regularly. For a semi-crystalline material like Xenoy resin, high mold temperatures will produce higher degrees of in-mold crystallization. This in turn will result in high shrinkage values. Too low mold temperatures, on the other hand, may result in crystallization after molding, with the risk of warpage during secondary operations. Typical mold temperatures for unfilled and filled Xenoy grades are shown in figures 13 and 14.

Figure 13 – Typical molding temperatures for unfilled Xenoy resin



Clamping force

There are various factors influencing the required level of clamping force. These include the projected surface area of the part, the thickness of the part, the length of flow from the part and the injection speed and pressure.

Normally pressures are between 40 and 50 N/mm2. However, for complex thinwall components, requiring fast injection speeds combined with high injection pressures, a clamping force of up to 80 N/mm2 projected surface area can be required.

Venting

Good mold venting is essential to prevent blistering or burning and to aid cavity filling. Ideally the vents should be located at the end of the material flow paths. Inadequate or poorly located venting can result in incomplete filling, poor weld line strength, uneven shrinkage, warping and the need for excessive injection pressure to fill the cavity.

For Xenoy* resin, ideal vents have a depth of 0.05mm to 0.1mm and a width of 4mm to 8mm, and should be located at the end of the material flow paths. Additional vents can be placed between the clearance of moving cores, ejector pins and sleeves and between the mold inserts.

Purging of the barrel

Immediate, thorough purging of the cylinder is required when changing to another material after using Xenoy resin. The best purging materials for Xenoy resin are general purpose PS and HDPE. The cylinder temperature should then be lowered if the resin to be molded afterwards are POM, ABS or PA.

The heating should never be switched off when PC/PBT or PC/PET is in the barrel but the barrel temperature should be reduced to 160°C.

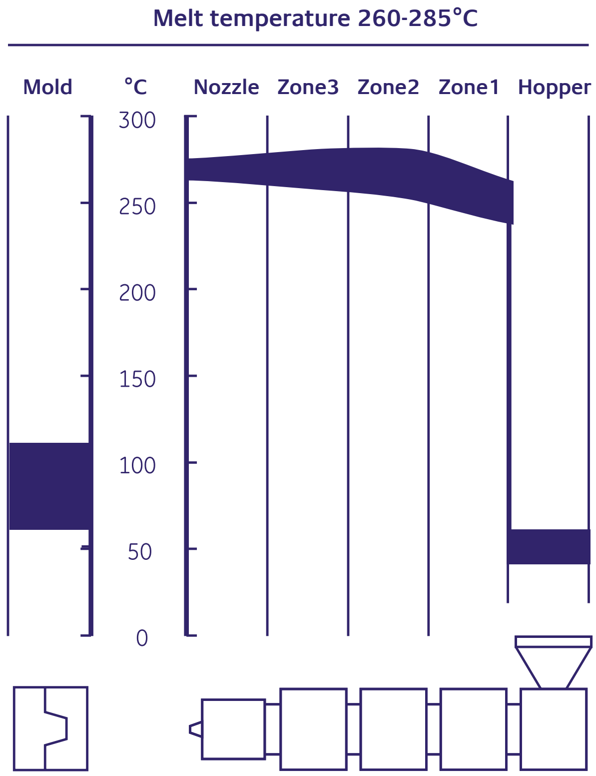
Reuse

Properly molded Xenoy resin can be reground, dried and remolded repeatedly. Attention must be given to ensuring that the regrind is clean and free from impurities.

Particular care in the pre-drying of the regrind must be taken because it has a faster moisture pick-up rate than virgin material. In general drying should be carried out at 110°C for an extra hour.

Regrind utilization may produce a slight change in color, UV resistance or impact properties. Great care should be taken therefore in applications where impact performance and/or agency compliance are required.

Figure 14 – Typical molding temperatures for filled Xenoy resin



10.3 Secondary Operations

Although Xenoy resin parts are often molded as finished components, the design and ultimate use of certain parts may require machining, assembly or finishing operations. Xenoy resin makes a wide variety of secondary operations possible for the design engineer.

Welding

Welding is a commonly used permanent assembly technique for engineering thermoplastics. Xenoy resin parts can be welded using different processes. Selecting the right process depends on the size, shape and function of the part:

- Hot Plate Welding allows excellent weld strengths to be achieved but the resin may stick to the hot plate. Heating by radiation hot plate can overcome this problem but requires precise part dimensions and process control.
- Friction Welding, using either the vibration, orbital or rotation method, can be applied to both unreinforced and glass-reinforced Xenoy grades. A special weld design for vibration welding has proven successful for "class A" automotive exterior applications. Ribs of only 25% of wall thickness are placed on the back of the visible surface, and welded together.
- Ultrasonic Welding is commonly used.
- Induction Welding
- Laser Welding

Laser welding offers an interesting possibility to generate welds that are gas tight in a clean and efficient way without flash. 3-D contours can be welded with this technology.

While pigmentation, fillers and morphology of the blend have an influence on IR transparency and laser weldability, it is therefore recommended to test each grade and new application for suitability for laser welding.

Xenoy XL1351 resin is a grade with high laser transparency and can be used in combination with laser welding. Impact modified Xenoy resin grades have generally lower laser transparency. Laser welding is still possible for natural grades and grades with suitable dyes only. These materials require higher power due to absorption and scattering of the laser beam in the material. The result is a widening of the weld seam.

Adhesives

In general, Xenoy resin parts can be bonded to other plastics, glass, aluminium, brass, steel, wood and other materials. Compatible adhesives include epoxy, polyurethane 2K, silicones, acrylic 2K and cyanoacrylate. Polyurethane 1K adhesive systems and reactive hot melts generally require the use of a primer to enhance adhesion.

Cleaning parts

Thorough cleaning of Xenoy resin parts before bonding is essential in order to avoid adhesion failure. All oil, grease, paint, mold releases, rust oxides, etc., must be removed by washing with solvents which are compatible with Xenoy resin. These solvents include isopropyl alcohol, heptane or a light solution of detergents.

Mechanical assembly

Mechanical assembly techniques are widely used with Xenoy resin parts. To achieve optimum results, mechanical fasteners should be kept free from oil and grease. Depending on the type of fastener, a permanent stress or deformation is applied locally. Clamp forces should be controlled or distributed over a large surface area. This is in order to decrease local stresses in the part after assembly and to minimize the risk of loosening the fasteners through creep and relaxation. Notches in the design as well as notches resulting from mechanical fasteners should be avoided.

Recommended assembly techniques

Thread-forming screws rather than thread cutting screws are recommended. Screws with a maximum flank angle of 30° are preferred for minimal radial stresses.

- Inserts which leave low residual stresses can be used. Installation by heat or ultrasonic are the preferred techniques. Press and expansion inserts produce high hoop stresses in bosses and should therefore be used with caution.
- Snap fit assembly
- Rivets
- Staking

Painting

Xenoy resin's inherently high UV resistance means that parts can be left unpainted. On the other hand, compatibility with most painting systems, without the need for pre-treatment, allows the same part to be painted if required. This provides wide manufacturing flexibility as common moldings can be used for different models or applications.

Painting of engineering thermoplastics can have a critical influence on the performance of an application. What follows here is a brief introduction to the painting of Xenoy resin. However, for more detailed information contact SABIC Innovative Plastics' Technical Marketing Department.

Xenoy CL300 resin

This impact modified, high flow grade was specifically developed for the manufacture of offline painted exterior automotive applications. The material's relatively high stiffness (E modulus 2050 MPa), allows it to be used in applications with a wall thickness of down to 2.2-2.5mm. This means shorter cycle times and more cost-effective manufacturing.

Adhesion

The adhesion performance of Xenoy CL300 resin with both water-based basecoats and solvent-based topcoats, satisfies even the toughest automotive specifications. The water-based basecoat can be applied directly onto the substrate without the need for an adhesion-promoting treatment.

Chemical Resistance

The material's inherent chemical resistance has been tested with a range of solvent-based topcoats and, in each case, no attack has been recorded, even with a 1% applied strain.

Impact Performance

The type of paint system selected has a major influence on the ductility of the plastic substrate. Key factors include the overall flexibility of the paint layer, the chemical nature of the topcoat and the paint adhesion.

A fully flexible paint system will follow the deformation of the substrate upon impact, whereas insufficient flexibility in the paint layer will cause a crack which will propagate into the substrate and result in brittle failure.

In applications using a solvent-based basecoat or uni-color, the solvent will penetrate the outer layer of the substrate forming a diffused interface. This produces excellent adhesion performance but can have a significant effect on impact performance. In parts where a fully flexible topcoat is used, the failure at -30°C will be ductile when the impact is on the painted side, but less ductile if the impact is on the unpainted side. However, the combination of Xenoy* CL300 resin painted with a water-based basecoat and a 2K PUR fully flexible clearcoat shows a ductile failure mode at -30°C, both when impacted upon the painted and the unpainted side (see figure 15).

Clearcoats for colored Xenoy resin

In traditional paint systems for off-line painted automotive exterior parts, the colored basecoat and clear topcoat combination is widely used. However, in the latest development in the off-line painting of Xenoy resin, only a single operation is required to have a finished part. In one step a clearcoat is applied to a colored Xenoy resin substrate. In addition to providing shorter, more cost-effective production cycles, this allows the use of different decoration techniques in which the base color of the substrate plays a key role.

Selection of the best Xenoy resin grade, color and clearcoat system is critical to the successful production of applications using this new process. It is essential that all new applications are thoroughly tested for adhesion performance and weathering and impact resistance prior to industrialization. Assistance in making the selection of the correct combinations is available from SABIC Innovative Plastics' Technical Marketing Department.

Reuse

The Xenoy resin recovered from unpainted exterior body panels can be reused for parts such as off-line painted fixing brackets and beams, or in glass-filled structural applications. It may not be used, however, for unpainted exterior parts.

When reusing off-line painted parts, the currently used 2K polyurethane-based paint systems have to be first removed. A paint removal process has been developed which chemically separates the paint layer from the Xenoy resin substrate, providing regrind material which is comparable to that of recycled Xenoy resin from unpainted parts

Heat Resistance

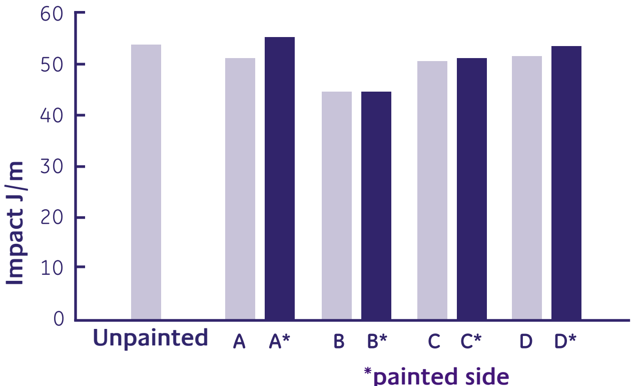
The amorphous polycarbonate in the Xenoy polymer blend provides the required heat resistance and paintability at elevated temperatures, thereby ensuring that large automotive exterior parts are not distorted during paint curing.

Primerless painting

Primerless painting not only contributes to a more cost-effective body panel system, but also produces less solvent emission and waste during the painting operation.

Xenoy CL300 resin has been tested using a range of both water-based primerless paint systems and solvent-based uni-colors. With both systems the material has been proven in terms of adhesion performance, chemical resistance, impact performance and cosmetics. The grade's excellent flow properties result in no knit line marks, while consistently high UV resistance protects against discoloration.

Figure 15 – High speed impact test on painted Xenoy CL300 resin at 1.1 m/s (4 km/hr) and -30°C



Paint system (primerless)

A: "Nordic Green" metallic water-borne basecoat + 2K PUR flexible clearcoat

B: "Nouveau Red" metallic water-borne basecoat + 2K PUR flexible clearcoat

C: 2K PUR Uni-single coat "Provence Green" (solvent-based)

D: 2K PUR Uni-single coat "Radiant Red" (solvent-based)

Contact us

Americas Headquarters
SABIC Innovative Plastics
One Plastics Avenue
Pittsfield, MA 01201
USA
T 413 448 7110
F 413 448 5573

European Headquarters
SABIC Innovative Plastics
Plasticslaan 1
PO Box 117
4600 AC
Bergen op Zoom
The Netherlands
T +31 164 292911
F +31 164 292940

Technical Answer Center
T 0800 1 238 5060 *toll free
(if mobile disruption +36 1 238 5060)

Pacific Headquarters
SABIC Innovative Plastics
1266 Nanjing Road (W)
Unit 902-907, Plaza 66)
200040 Shanghai
China
T +86 21 3222 4500
F +86 21 6289 8998

Email
productinquiries@sabic-ip.com