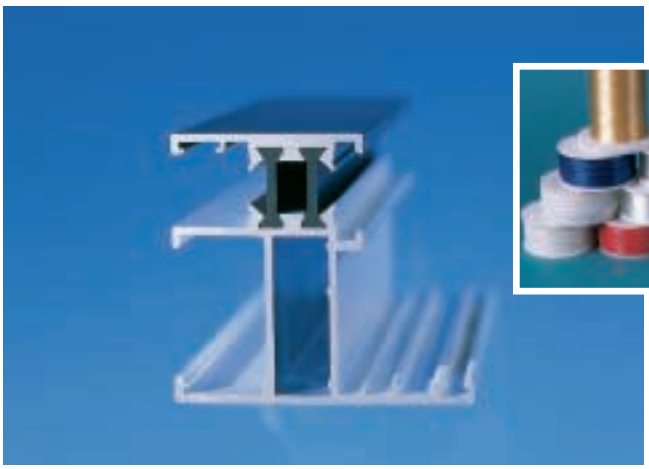
DuPont™ Engineering Polymers

Extrusion Applications



DUPONT®

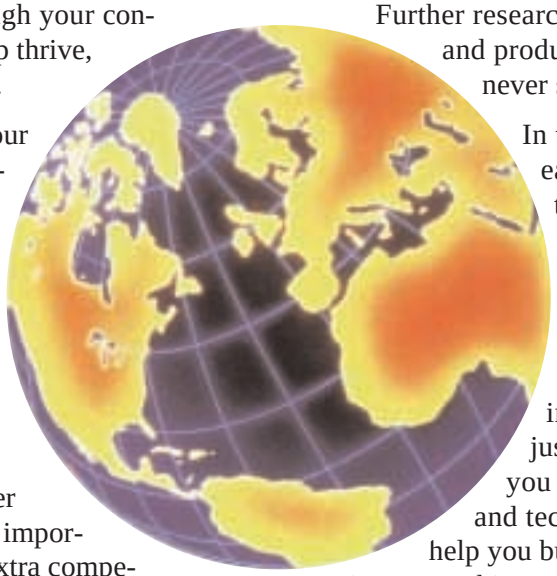
The miracles of science™

Start with DuPont… a partnership that works

Today you need more from your materials suppliers than just materials.You need a resource that is willing and able to join in at the earliest stages of the product development process. One that can carry a project from concept through design, component analysis, materials selection, prototyping, testing, quality control, and even commercialisation. You need a fully fledged partner.

DuPont can be that partner. We believe that true partnership is a dynamic process of teamwork and sharing. And we recognise that only through your continued success will our relationship thrive, to bring out the best in both of us.

If you let our people work with your people from the initial design concept, and on through every stage from prototyping to full production, we can share our unrivalled experience, and help you choose the optimum engineering polymer for your needs. The result? A very competitive new product with time-proven success built in.



DuPont engineering polymers offer you the properties and benefits so important to giving your products that extra competitive edge: lightweight materials for lightweight parts and components; resistance to corrosion and abrasion; self-lubrication; reduced processing costs; integral colour; reduced finishing time; easier assembly, and greater customer satisfaction. All these advantages add up to new opportunities in design, manufacture and finished part cost.

We wrote the book on engineering polymers. Nylon, which we invented back in the 1930s, led to the development of ZYTEL®, the first real engineering thermoplastic. Today we offer the broadest range of semi-crystalline engineering polymers available from a single supplier, and they all offer new possibilities for the replacement of traditional materials such as metal, rubber and wood, as well as better alternatives to many other plastics.

Further research at DuPont technical centres and production plants around the world never stops.

In today's competitive markets, each new product launch seems to require more and more investment. So it pays, at the earliest stage, to take full advantage of the latest developments in engineering polymers by starting with DuPont and calling us in at the initial concept stage. More than just selling polymers, we share with you a world of practical experience and technological know-how that can help you build a real competitive advantage into everything you design and manufacture.

This brochure contains a great deal of information, but it is by no means complete. For more detailed data, contact your local DuPont representative.

Engineering Polymers

CRASTIN® PBT thermoplastic polyester resin

DELRIN® acetal resin

HYTREL® thermoplastic polyester elastomer

ZYTEL® nylon resin (PA66, PA6, PA612)

Speciality Polymers

CRYSTAR™ polyester resin

ELVALOY® polymer modifier

Fluoropolymers

TEFLON® PTFE fluorocarbon resin

TEFLON® FEP fluorocarbon resin

TEFLON® PFA fluorocarbon resin

TEFZEL® ETFE fluorocarbon resin

Profiles

DuPont offers a number of ZYTEL® nylon and CRASTIN® PBT grades for profile extrusion:
– Unreinforced, high viscosity.
– Toughened/supertough.
– Glass reinforced.
– Mineral reinforced.

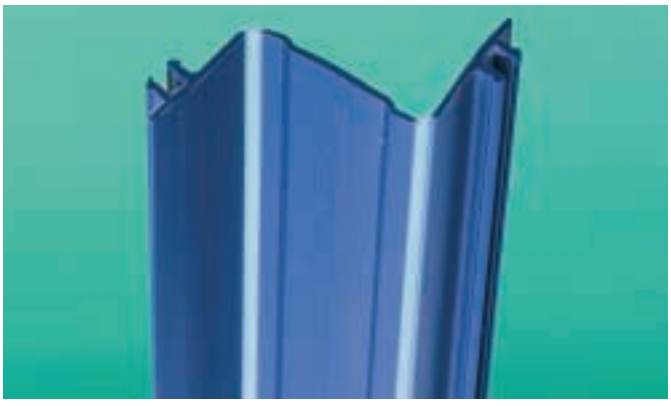
Major applications include thermal break profiles for aluminium framed window constructions.

Aluminium window frame with thermal break profile of ZYTEL®

Some softer grades of HYTREL® thermoplastic polyester elastomer are also suitable for profile extrusion. Examples include "V-belts" and "T-belts" for conveying applications.

"V-belts and T-belts" of HYTREL® for conveying applications

Some products have been tailored to specific applications. For example, low melting point HYTREL® grades (eg. 4056 and HTR6108) for co-extrusion with PVC.



Co-extruded HYTREL®-PVC hinge

Stock shapes (rods, plates and tubes)

Recognised for their ease of machining and excellent balance of end-use properties, DuPont DELRIN® acetal resin and ZYTEL® nylon are well established as industry standards for the production of stock shapes.

Stock shapes (rods, plates and tubes) of DELRIN® and ZYTEL®

In addition to improved productivity versions of these traditional materials, DuPont now offers CRYSTAR™ PET, CRASTIN® PBT, and HYTREL® TEEE resins for manufacture of stock shapes.

A major research program has recently resulted in the introduction of a broad portfolio of DELRIN® acetal resins with significantly improved low friction/low wear properties based on a number of technologies including:
– Chemical lubricants.
– Silicon oil.
– TEFLON® PTFE.
– KEVLAR® aramid.

VESPEL® and TRIBON® parts

DuPont also offers a wide range of ultra-high performance stock shapes based on VESPEL® polyimide and TRIBON® composite technologies. These are easy to machine into complex shapes with tight tolerances.

These components find many uses in the automotive, aerospace, industrial equipment and semiconductor industries in applications with extremes of temperature and/or wear.

Hose, tubing and pipes

DuPont Engineering Polymers, in particular ZYTEL® nylon and HYTREL® thermoplastic polyester elastomer, find widespread use in hose, tubing and pipe applications. These materials are also used in co-extrusions and constructions with other materials such as :

– TEFLON® PTFE and FEP fluoropolymers.
– TEFZEL® ETFE fluoropolymer.
– Elastomers.
– KEVLAR® aramid fibre or other reinforcements.
– Other polymers (PE, PVC, ABS, etc.).

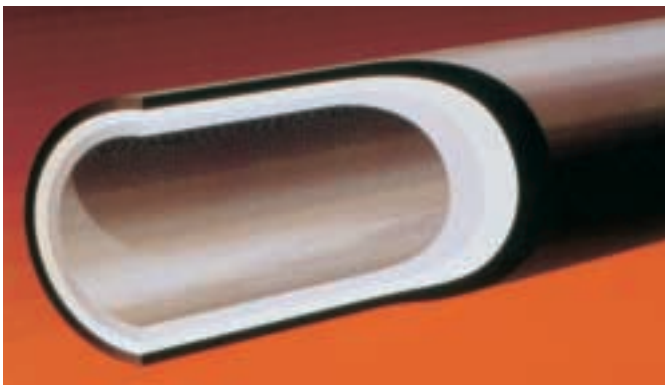
Based on its excellent balance of end-use properties, and processing advantages versus thermoset rubber HYTREL® thermoplastic polyester elastomer is widely used to produce the liners and covers of high pressure hoses for hydraulic, water, hydro-cleaning and paint

High pressure hoses of HYTREL®

spray applications. Various grades of ZYTEL® nylon and ZYTEL® FN flexible nylon alloy are also used for a variety of hose applications including automotive air-conditioning hose. HYTREL® is also used in truck air-brake tube as a cost effective alternative to PA11 or PA12, and has recently received ISO compliance for use in this application.

Truck air brake tubes of HYTREL®

TEFZEL® ETFE, ZYTEL® nylon and co-extrusions of these materials are being increasingly adopted for automotive fuel lines, as manufacturers upgrade their designs to meet the inceasingly severe emmissions standards.



Co-extruded TEFZEL®-nylon automotive fuel line

Recent developments include the use of a co-extruded ZYTEL® nylon barrier layer to improve the performance of PE pipes.

Co-extruded barrier of ZYTEL® inside PE pipe

Hose mandrels

In addition, a number of ZYTEL® nylon and HYTREL® thermoplastic polyester elastomer grades are well suited to the production of hose mandrels, used in the manufacture of rubber hoses.

Hose mandrels made from Engineering Polymers can offer a number of benefits over thermoset rubber and other thermoplastics including flexibility and good dimensional stability (without machining) even after many re-uses.

As a result, hose mandrels of HYTREL® or ZYTEL® are increasingly preferred, especially for hose applications requiring tight tolerances.

Filaments

DuPont offers one of the broadest ranges of Engineering Polymers for filaments including:

– ZYTEL® PA66, PA6, PA612 resins
– CRASTIN® PBT resins.
– CRYSTAR™ PET resins.
– HYTREL® TEEE resins.
– TEFLON® PTFE and FEP resins.
– TEFZEL® ETFE resins.
– TYNEX® Filaments.
– CHINEX® Filaments.
– OREL® Filaments.

Major consumer applications include toothbrushes, paint brushes, and cosmetic brushes.

Brushes (toothbrush/paintbrush/abrasive/cosmetic) of ZYTEL®, TYNEX® and CHINEX®

Other well known uses for filaments made from Engineering Polymers include hook and loop fasteners (eg. Velcro) and dental floss.

Monofilament of ZYTEL® for hook and loop fasteners

Typical industrial applications include the paper industry, where ZYTEL® nylon and CRASTIN® and CRYSTAR™ polyester filaments have been tailored to meet the specific demands of paper machinery belting in each of the key manufacturing steps:

– Forming.
– Pressing.
– Drying.

Paper machinery belting (forming/pressing/drying) of ZYTEL® and CRASTIN®

Many innovations are currently taking place in filaments design. These include:

– Shaped filaments for improved toothbrushes.
– Hollow filaments for improved paint brushes.
– New “active” seating fabrics based on recent innovations include the development of flexible filament systems of HYTREL®, and patented co-extruded filament technology.

High-tech chair fabrics of HYTREL®

Wire and cable

DuPont Engineering Polymers offers a number of speciality materials for the wire and cable industry:
– ZYTEL® PA66, PA6, PA612 resins.
– CRASTIN® PBT resins.
– HYTREL® TEEE resins.

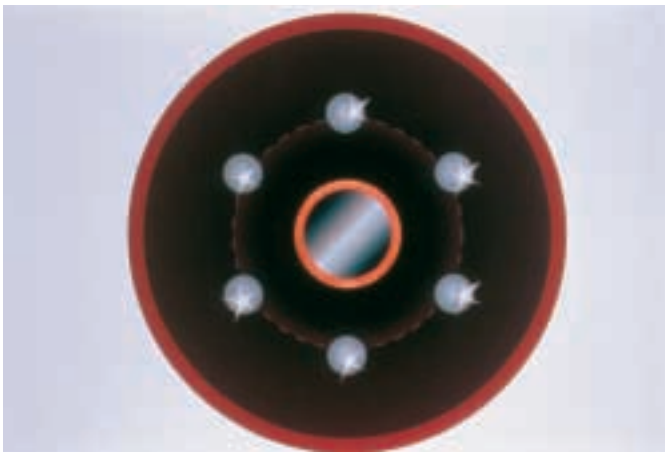
Conveyor belt cable encapsulated in HYTREL®

These products have been tailored to specific end-use requirements where commodity polymers such as PVC or PE do not perform satisfactorily.

Important applications include hydrolysis resistant CRASTIN® PBT for loose tube fibre optic cable constructions.

Loose tube fibre optic cable of CRASTIN® PBT

Combination of HYTREL® thermoplastic polyester elastomer and ZYTEL® nylon are also used to protect subsea fibre optic cables such as the recent Fibre-optic Link Around the Globe (FLAG) which runs for over 15000 km from the UK to Japan.



FLAG fibre optic cable using HYTREL® and ZYTEL®

HYTREL® thermoplastic polyester elastomers are also widely used in retractable cable applications due to the superior elastic memory of HYTREL®.

Retractable coiled truck cable of HYTREL®

Latest materials developments include Hytrel® HTR8303, a high performance TEEE designed to meet the extreme heat ageing and hydrolysis resistance demands of automotive industry Class-4 specifications for high temperature (engine bay) wiring.

High temperature automotive wiring with sheath of HYTREL®

In addition to its Engineering Polymers, DuPont offers a large portfolio of other materials and technologies for the wire and cable industry including:

Fluoropolymers:

– TEFLON® PTFE, FEP and PFA resins.

– TEFZEL® ETFE resins.

ELVALOY® NH technologies:

ELVALOY® NH ("Non-Halogen") is a familiy of 4 new technologies which enable flexible alloys of different polymers to be produced which contain no halogens, but compete with common halogen-containing plastics such as PVC.

Film, sheet and laminates

Almost all of the extrusion grades of DuPont Engineering Polymers can be converted into film, sheet, or laminate form using conventional extrusion casting or coating processes.

Specific grades may also be blown into film.

Typical products manufactured by flat die extrusion processes include polymer belting, fabric and non-woven laminates, and polymer films.

In addition, the low friction, low wear properties of extruded DELRIN® and high molecular weight ZYTEL® sheet make them particularly suitable for shims and bearing surfaces.

HYTREL® has unique applications in sheet and film, due to its ease of processing, good surface finish and mechanical properties. Its exceptional flex life and impact strength, combined with the absence of plasticisers make it highly suitable for dynamic applications such as belting, conveyors and impact absorbing layers. HYTREL® films and sheets can be produced with thicknesses ranging from 15 microns (0,015 mm) to more than 3 mm.

In some cases, HYTREL® is also added to other film and sheet materials to improve impact strength and flexibility.

The possibility of reinforcement with fabrics, non-wovens, KEVLAR® or steel and the suitability of many joining processes make Engineering Polymers the first choice for many of the most demanding applications.

Compositions

Designation	Description	Key Applications
CRASTIN® PBT	**thermoplastic polyester resin**	**p. 8**
CRASTIN® 6129	Medium viscosity	Tubing, monofilaments, stock shapes (rods, plates, tubes etc), sheeting
CRASTIN® 6130	Low-medium viscosity	Tubing, monofilaments, stock shapes (rods, plates, tubes etc), sheeting
CRASTIN® S600F10	Medium viscosity	Tubing, monofilaments, stock shapes (rods, plates, tubes etc), sheeting
CRASTIN® CE1085	Medium viscosity, hydrolysis resistant	Loose tubes for fibre optic cables
CRASTIN® ST820	High viscosity, supertough	Profiles, tubing, pipes
CRASTIN® BM6450XD BK	Ultra-high viscosity, supertough	Profiles, pipes,
CRASTIN® SK605	30 % glass fibre reinforced	Profiles, tubing, pipes
CRASTIN® SK608	45 % glass fibre reinforced	Profiles, tubing, pipes
CRASTIN® SK609	50 % glass fibre reinforced	Profiles, tubing, pipes
DELRIN®	**acetal resin**	**p. 20**
DELRIN® 111P	High viscosity acetal	Small tubes
DELRIN® DE7031	High viscosity acetal	Stock shapes (rods, plates, tubes etc)
HYTREL®	**thermoplastic polyester elastomer**	**p. 10**
HYTREL® G3548L	Very low modulus	Thin films, sheeting, PVC co-extrusion
HYTREL® 4056	Low modulus, high performance (mechanical properties)	Hoses covers and liners, PVC co-extrusion
HYTREL® G4074	Low modulus (heat stabilised)	Profiles, tubing, hose covers and liners, wire and cable, film and sheeting
HYTREL® G4078	Low modulus	Profiles, tubing, hose covers and liners, wire and cable, film and sheeting, PVC co-extrusion
HYTREL® G4774	Low-medium modulus (heat stabillsed)	Profiles, hose mandrels, tubing, hose covers and liners, wire and cable, film and sheeting
HYTREL® G5544	Medium modulus (heat stabilised)	Profiles, hose mandrels, tubing, hose covers and liners, wire and cable, film and sheeting
HYTREL® 5556	Medium modulus, high performance (mechanical properties)	Profiles, tubing, hose covers and liners, monofilaments, wire and cable, film and sheeting
HYTREL® 5586	High viscosity version of 5556	Profiles, tubing, hose covers and liners
HYTREL® 6356	Medium-high modulus, high performance (mechanical properties)	Tubing, hose covers and liners, monofilaments, wire and cable, film and sheeting
HYTREL® 6358	Medium-high modulus (heat stabilised)	Tubing, hose covers and liners, monofilaments, wire and cable, film and sheeting
HYTREL® 7246	High modulus, high performance (mechanical properties)	Tubing, hose covers and liners, monofilaments, wire and cable, film and sheeting
HYTREL® 7248	High modulus	Tubing, hose covers and liners, monofilaments, wire and cable, film and sheeting
HYTREL® 8238	Very high modulus	Monofilaments, wire and cable, film and sheeting
HYTREL® HTR4275 BK	Medium modulus, high viscosity (heat stabilised)	Profiles, large diameter tubing, blown film and sheeting
HYTREL® HTR5612 BK	Medium modulus, high viscosity (heat stabilised)	Profiles, large diameter tubing, blown film and sheeting
HYTREL® HTR6108	Medium modulus (low permeability to oils, fuels and plasticisers)	PVC co-extrusion, petrocheminal and containment liners
HYTREL® HTR8068	Low-medium modulus (flame retardant: UL94 VO at 1,5 mm)	Tubing, hose covers, wire and cable, sheeting
HYTREL® HTR8163HV BK	Medium-high modulus, Medium viscosity (heat stabilised)	Aire brake tubing, high temperature automotive tubing
HYTREL® HTR8223 BK	Medium modulus, high viscosity (heat stabilised)	Profiles, large diameter tubing, blown film and sheeting
HYTREL® HTR8241	High viscosity version of 6356	Hose mandrels, tubing, hose liners, sheeting
HYTREL® HTR8303	High viscosity (excellent heat ageing and hydrolysis resistance)	High temperature automotive wiring
ZYTEL® PA66	**nylon resin**	**p. 14**
ZYTEL® 101L	Medium viscosity	Abrasion resistant wire and cable
ZYTEL® 103HSL	Medium viscosity, heat stabilised PA66	Abrasion resistant wire and cable
ZYTEL® E40	High viscosity (RV 95-150)	Monofilaments, stock shapes (rods, plates, tubes etc), wire and cable, sheeting
ZYTEL® E42A	High viscosity (RV 180-310)	Monofilaments, stock shapes (rods, plates, tubes etc), wire and cable, sheeting
ZYTEL® E50	High viscosity (RV 240-470)	Monofilaments, stock shapes (rods, plates, tubes etc), pipes, sheeting
ZYTEL® E51HSB	High viscosity, heat stabillsed (RV = 240-470)	Monofilaments, stock shapes (rods, plates, tubes etc), pipes, sheeting
ZYTEL® E53	High viscosity (RV = 470-600)	Profiles, monofilaments, stock shapes (rods, plates, tubes etc), pipes, sheeting
ZYTEL® 408	Toughened	Tubing, push-pull cables, wire and cable
ZYTEL® 450	Toughened	Tubing, push-pull cables, wire and cable
ZYTEL® 490	Toughened	Tubing, push-pull cables, wire and cable
ZYTEL® ST801	Toughened	Push-pull cables
ZYTEL® EFE8073	High viscosity, supertough	Profiles, tubing, push-pull cables
ZYTEL® PA6	**nylon resin**	**p. 17**
ZYTEL® 7300T	Toughened	Tubing, wire and cable
ZYTEL® ST7301	Supertough	Tubing, wire and cable
ZYTEL® ST811HS	Plasticised, heat stabilised, supertough	Flexible tubing, hose covers
ZYTEL® PA612	**nylon resin**	**p. 18**
ZYTEL® 158	Medium viscosity	Tubing, monofilaments, wire and cable, film
ZYTEL® 159L	High viscosity	Tubing, monofilaments, wire and cable, film
ZYTEL®	**speciality nylon resin**	**p. 19**
ZYTEL® FN714	PA66 based flexible nylon alloy	Tubing, wire and cable
ZYTEL® FN718	PA66 based flexible nylon alloy	Tubing, wire and cable
ZYTEL® FN727	PA6 based flexible nylon alloy	Automotive air conditioning hose

Properties of non-flame retardant CRASTIN® PBT grades

	Property	Test conditions	ISO test method	Units	CRASTIN® 6129	CRASTIN® 6130	CRASTIN® S600F10	CRASTIN® CE1085
MECHANICAL	Yield stress	23°C	527-1/2	MPa	58	58	58	58
	Yield strain	23°C	527-1/2	%	3,6	3,6	3,6	3,6
	Tensile modulus	1 mm/min	527-1/2	MPa	2700	2700	2700	2700
	Tensile creep modulus	1 h 1000 h	899	MPa	2600 1800	2600 1800	2600 1800	
	Flexural strength		178	MPa	85	85	85	
	Charpy impact strength (notched)	23°C –30°C	179/1eA	kJ/m²	4 4	5	4 4	
	Charpy impact strength (unnotched)	23°C –30°C	179/1eU	kJ/m²	NB NB		NB NB	
THERMAL	Melting temperature, by DSC	10°K/min	3146 C	°C	225	225	225	225
	Temperature of deflection under load	0,45 MPa 1,8 MPa 5,0 MPa	75	°C	160 60 *	160 60 *	160 60 *	160 60
	Coefficient of linear thermal expansion	parallel (in flow direction) normal (perpendicular to flow)	11359-1/-2	10^{-4}/°K	1,3 1,3	1,3 1,3	1,3 1,3	1,3 1,3
	Thermal conductivity		DIN 51046	W/(mK)	0,25	0,25	0,25	
	Vicat softening temperature	50 K/h; 10 N 50 K/h; 50 N	306	°C	215 175	215 175	215 175	
	Relative temperature index • electrical • mechanical with impact • mechanical without impact	3,0 mm	UL 746B	°C	 75 75 75		 130 115 120	
	Flammability	0,75 mm 1,5 mm 1,5 mm 1,5 mm 1,5 mm	UL 94/IEC 60695 UL 94/IEC 60695 ASTM D635 ASTM D635 ASTM D635	 cm/min s mm	HB HB 2,6 * *	HB HB 2,6 * *	HB HB 2,6 * *	HB HB
	Oxygen index		4589	%	22	22	22	22
	Glow wire flammability	3 mm	IEC 60695-2-1	°C	750	750	750	750
ELECTRICAL	Surface resistivity	1 mm	IEC 60093	ohm	10^{15}	10^{15}	10^{15}	$>10^{14}$
	Volume resistivity	1 mm	IEC 60093	ohm·m	$>10^{13}$	$>10^{13}$	$>10^{13}$	$>10^{14}$
	Electrolytical corrosion		IEC 60426	rating	A1	A1	A1	
	Comparative tracking index	CTI, >3 mm CTI-M, >3 mm	IEC 60112	V	>600 350 M	>600 350 M	>600 350 M	600 350 M
OTHERS	Density		1183	kg/m³	1310	1310	1310	1310
	Humidity absorption	23°C, 50 % RH	Similar to 62	%	0,20	0,20	0,20	0,20
	Water absorption	Saturation, immersed	Similar to 62	%	0,50	0,50	0,50	0,50
	Ball indentation hardness	H 358/30 H 961/30	2039-1	MPa	139	139	139	
PROCESSING	Processing temperature range			°C	230-240	230-240	230-240	
	Melt mass-flow rate	250°C/2,16 kg	1133	g/10 min	7,4-10,8	13,4-17,4	8-12	
	Shrinkage range (extrusion)			%	2-3	2-3	2-3	

* Properties are not applicable for this material.
1) Annealed.

Crastin® ST820	Crastin® BM6450XD BK	Crastin® SK605	Crastin® SK608	Crastin® SK609
35	33	*	*	*
9	11	*	*	*
1600	1500	10000	15000	16000
		9000 6600		15000 11600
67	50	210	255	270
85 13 NB NB	110	12 11 70 80	 63 70	11,5 12,2 52 68
225	220	225	225	225
105 50 *	135 [1)] 50 [1)]	220 205 180	220 210 190	222 215 196
1,9 1,9		0,3 0,9	0,2 0,8	0,2 0,8
		0,28	0,32	0,33
215 125		220 213	220 215	220 215
		 130 130 130		 130 125 130
 HB 4,6 * *		HB HB 3,0 * *	HB HB 2,5 * *	HB HB 2,4 * *
		19	20	20
700		750	750	750
$>10^{15}$		$>10^{14}$	$>10^{14}$	$>10^{14}$
$>10^{13}$		$>10^{14}$	$>10^{14}$	$>10^{14}$
		A1	A1	A1
>600 >600 M		450 200 M	475 200 M	500 200 M
1210	1210	1530	1670	1710
0,12		0,13	0,11	0,10
0,31		0,37	0,27	0,25
78 		 200	 222	 230
	240-260			
	2-3			

All the above information is subject to the disclaimer printed on the back page of this document.

Typical properties of HYTREL® thermoplastic polyester elastomers

	Property[1]	Test conditions	ISO test method	Units	G3548L	4056	G4074	G4078W
MECHANICAL	Stress at break (tensile)[2]	50 mm/min	527-1/2	MPa	10	30	21	17
	Strain at break (tensile)[2]	50 mm/min	527-1/2	%	200	420	340	310
	Stress at 5% strain	50 mm/min	527-1/2	MPa	1,7	2,4	2,4	3,0
	Stress at 10% strain	50 mm/min	527-1/2	MPa	2,6	3,6	3,8	4,5
	Tensile modulus	1 mm/min	527-1/2	MPa	28	53	55	51
	Flexural modulus		178	MPa				
		–40°C			62	155	207	166
		23°C			32	62	60	66
		100°C			7	27	33	16
THERMAL	Melting temperature, by DSC	10°K/min	3146 C	°C	156	154	170	170
	Temperature of deflection under load		75					
		0,45 MPa		°C	N/A	50	50	50
		1,8 MPa		°C	N/A	N/A	N/A	N/A
	Vicat softening temperature	10 N	306	°C	75	108	110	120
OTHERS	Density		1183	kg/m^3	1150	1170	1180	1180
	Water absorption	Saturation, immersed	Similar to 62	%	5,0	0,7	3,7	5,4
	Hardness, durometer D	Max. reading	ASTM D2240	points	35	40	40	40
		15 s	868		26	34	34	34
	Initial tear resistance	2 mm, die C	34	kN/m	51	101	81	88
	Resistance to flex cut growth, Ross [pierced]			Cycles to 5 × cut	>10^6	>10^6	>10^6	>10^6
	Abrasion resistance			mg/1000 rev.				
		Taber, CS-17 wheel			30	3	9	20
		Taber, H-18 wheel			310	100	193	260
PROCESSING	Processing temperature range			°C	165-185	165-185	175-195	175-195
	Melt mass-flow rate		1133	g/10 min	10	5,3	5,2	5,3
		Temperature/Load		°C/kg	190/2,16	190/2,16	190/2,16	190/2,16
	Shrinkage range (extrusion)			%	1,8 ± 0,5	1,2 ± 0,5	1,8 ± 0,5	1,9 ± 0,5

1) All properties were measured on injection-moulded specimens at 23°C, unless specified otherwise.
The values shown are for unmodified grades. Colourants or additives of any kind may alter some or all of these properties. The data listed here fall within the normal range of product properties, but they should not be used to establish specification limits or used alone as the basis of design.
2) ASTM Type IV dumbbells diecut from injection moulded slab 2 mm thick.

G4774	G5544	5556	5586	6356	6358	7246	7248	8238	HTR4275 BK
20	35	42	40	46	41	53	46	50	40
275	480	500	500	490	420	450	350	400	450
3,8	6,0	6,9		12,0	9	14,0	14,0	27,6	7,6
6,0	10,5	10,3	11	16,0	13,1	20,0	20,0	30,3	10,3
108	185	180	180	280	280	525	525	1150	150
320 117 69	850 183 125	760 180 110	760 200 110	1800 296 150	1850 290	2410 527 207	2390 544	3030 1116 255	910 160 59
208	215	203	200	211	213	218	218	223	196
65 45	100 45	70 45	70 40	85 45	85 45	95 45	95 45	105 40	68 45
175	190	180	180	195	195	205	205	210	174
1200	1220	1200	1200	1220	1220	1250	1250	1280	1160
4,1	2,.2	0,6		0,6		0,6	0,3	0,6	0,6
47 43	55 50	55 52	55 52	63 58	63 58	72 68	72 68	82 (104R) 74	55 52
94	123	158	158	175		200		206	163
$>10^6$	8×10^5	5×10^5		5×10^5		3×10^4		N/A	5×10^4
13 168	9 116	6 64		7 77		13 47		9 20	20 227
210-225	215-230	210-225	210-225	215-230	215-230	220-235	220-235	225-240	210-225
11 230/2,16	10 230/2,16	7,5 220/2,16	4,5-6,0 220/2,16	8,5 230/2,16	9 230/2,16	12,5 240/2,16	13 240/2,16	12,5 240/2,16	1,8 230/2,16
2,6 ± 0,5	2,7 ± 0,5	2,4 ± 0,5	2,4 ± 0,5	2,6 ± 0,5	2,6 ± 0,5	2,7 ± 0,5	2,7 ± 0,5	2,8 ± 0,5	2,4 ± 0,5

N/A = not applicable
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Typical properties of HYTREL® thermoplastic polyester elastomers (continued)

	Property[1]	Test conditions	ISO test method	Units	HTR5612 BK	HTR6108	HTR8068	HTR8163HV BK
MECHANICAL	Stress at break (tensile)[2]	50 mm/min	527-1/2	MPa	36	42	13	35
	Strain at break (tensile)[2]	50 mm/min	527-1/2	%	450	400	240	280
	Stress at 5% strain (tensile)	50 mm/min	527-1/2	MPa	5,5	7,6	3,9	
	Stress at 10% strain (tensile)	50 mm/min	527-1/2	MPa	8,3	9,7	5,2	
	Tensile modulus	1 mm/min	527-1/2	MPa	115		140	350
	Flexural modulus		178	MPa				
		−40°C			510		650	
		23°C			134	186	174	
		100°C			46	59	50	
THERMAL	Melting temperature, by DSC	10°K/min	3146 C	°C	201	168	169	210
	Temperature of deflection under load		75					
		0,45 MPa		°C	55			100
		1,8 MPa		°C	45			
	Vicat softening temperature	Method A (10 N)	306	°C	155	148	110	195
		Method B (50 N)						
OTHERS	Density		1183	kg/m^3	1160	1240	1430	1230
	Water absorption	Saturation, immersed	Similar to 62	%	0,6	0,24	1,9	
	Hardness, durometer D	Max. reading	ASTM D2240	points	50	60	46	62
		15 s	868					62
	Initial tear resistance	2 mm, die C	34	kN/m	147	150	75	
	Resistance to flex cut growth, Ross [pierced]			Cycles to 5 × cut	6×10^5			
	Abrasion resistance			mg/1000 rev.				
		Taber, CS-17 wheel			38	18	25	
		Taber, H-18 wheel			186	145		
PROCESSING	Processing temperature range			°C	205-220	175-195	175-195	220-230
	Melt mass-flow rate		1133	g/10 min	3,0	5	4,6	5
		Temperature/Load		°C/kg	230/2,16	190/2,16	190/2,16	230/2,16
	Shrinkage range (extrusion)			%	2,4 ± 0,5	2,6 ± 0,5	1,9 ± 0,5	2,6 ± 0,5

1) All properties were measured on injection-moulded specimens at 23°C, unless specified otherwise.
The values shown are for unmodified grades. Colourants or additives of any kind may alter some or all of these properties. The data listed here fall within the normal range of product properties, but they should not be used to establish specification limits or used alone as the basis of design.

2) ASTM Type IV dumbbells diecut from injection moulded slab 2 mm thick.

HTR8223 BK	HTR8241	HTR8303
25	29	25
420	305	160
3,5		
5,5		
70	350	670
210 86 44	325	1200 750 125
192	209	221
	95	89
153	110	210
1130	1230	1160
0,6		0,4
45	63 62	64
115	117	
$>2 \times 10^6$		
15 105		0,0249 0,1215
205-220	220-230	235-255
0,4 230/2,16	4,3 230/2,16	0,5 270/2,16
2,4 ± 0,5	2,6 ± 0,5	2,7 ± 0,5

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Properties of ZYTEL® nylon resins

	Property	Test conditions	ISO test method	Units	PA66 ZYTEL® 101L DAM	PA66 ZYTEL® 101L 50% RH	PA66 ZYTEL® 103HSL DAM	PA66 ZYTEL® 103HSL 50% RH
MECHANICAL	Yield stress	50 mm/min	527-1/2	MPa	83	53	85	54
	Yield strain	50 mm/min	527-1/2	%	4,5	25	4,4	25
	Nominal strain at break	50 mm/min	527-1/2	%	22	>50	20	>50
	Tensile modulus	1 mm/min	527-1/2	MPa	3100	1200	3100	1250
	Charpy impact strength (notched)	23°C	179/eA	kJ/m^2	5	15	5	14
		–30°C			4	4	4	4
	Charpy impact strength (unnotched)	23°C	179/eU	kJ/m^2	NB	NB	NB	NB
		–30°C			NB	NB	NB	NB
THERMAL	Melting temperature, by DSC	10° K/min	3146 C	°C	263		263	
	Temperature of deflection under load	0,45 MPa	75-1/2	°C	200		200	
		1,8 MPa			70		70	
	Vicat softening temperature	50 N	306	°C	240		240	
	Coefficient of linear thermal expansion	Parallel (in flow direction)	11359-1/-2	10^{-4}/°K	1,0		1,0	
		Normal (perpendicular to flow)			1,1		1,1	
ELECTRICAL	Surface resistivity	23°C	IEC 60093	ohm	10^{12}	$>10^{15}$	10^{12}	10^{12}
	Volume resistivity	23°C	IEC 60093	ohm · m	10^{12}	10^{11}	10^{13}	10^{11}
	Comparative tracking index (CTI)	23°C	IEC 60112	V	600		525	
	Flammability [1]	1,5 mm	UL 94/IEC 60695		V-2		V-2	
OTHERS	Density		1183	kg/m^3	1140		1140	
	Humidity absorption	23°C, 50% RH	Similar to ISO 62	%	2,7		2,7	
	Water absorption	Saturation, immersed	Similar to ISO 62	%	8,5		8,5	
	Rockwell hardness		2039-2					
		Scale M			79	59		
		Scale R			121	108		
PROC.	Processing temperature range			°C	275-300		275-300	
	Shrinkage range (extrusion)			%	2,3 ± 0,5		2,3 ± 0,5	

1) Numerical flame test ratings are not intended to present behaviour of moulded parts in real life fire conditions; each end-user must determine whether any potential flammability hazards exist with parts moulded from ZYTEL® nylon resins. UL yellow cards available upon request.

PA66		PA66		PA66		PA66		PA66	
ZYTEL® E40		ZYTEL® E42A		ZYTEL® E50		ZYTEL® E51HSB		ZYTEL® E53	
DAM	50% RH	DAM	50% RH	DAM	50% RH	DAM	50% RH	DAM	50% RH
85	55	86	52	82	54	85	55	85	55
4,4	28	5	27	4,5	27	4,4	29	4,6	29
50	>50	>50	>50	>50	>50	>50	>50	>50	>50
3000	1200	3100	1200	3000	1200	3000	1200	3000	1200
6	20	6	20	6	20	7	22	7	25
4	3	3	4	6				3	4
NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
NB	NB	NB	NB	NB	NB			NB	NB
263		263		263		263		263	
205		205		205		205		205	
70		70		75		70		74	
242		242		245		243		243	
1,0		1,0		1,0		1,0		1,0	
1,0		1,0		1,0		1,0		1,0	
10^{13}		10^{13}	10^{11}			10^{13}		10^{13}	
600				600		600		600	
			HB						
1140		1140		1140		1140		1140	
2,7		2,7		2,7		2,7		2,7	
8,5		8,5		8,5		8,5		8,5	
275-300		275-300		275-300		275-300		275-300	
2,5 ± 0,5		2,5 ± 0,5		2,6 ± 0,5		2,6 ± 0,5		2,6 ± 0,5	

Properties of ZYTEL® nylon resins (continued)

	Property	Test conditions	ISO test method	Units	PA66 ZYTEL® 408 DAM	PA66 ZYTEL® 408 50% RH	PA66 ZYTEL® 450 DAM	PA66 ZYTEL® 450 50% RH
MECHANICAL	Yield stress	50 mm/min	527-1/2	MPa	61	43	55	40
	Yield strain	50 mm/min	527-1/2	%	6	26	5,4	24
	Nominal strain at break	50 mm/min	527-1/2	%	35	>50	28	>50
	Tensile modulus	1 mm/min	527-1/2	MPa	2200	1100	2200	1000
	Charpy impact strength (notched)	23°C	179/eA	kJ/m²	20	25	15	25
		–30°C			15	6	10	8
	Charpy impact strength (unnotched)	23°C	179/eU	kJ/m²	NB	NB	NB	NB
		–30°C			NB	NB	NB	NB
THERMAL	Melting temperature, by DSC	10° K/min	3146 C	°C	263		263	
	Temperature of deflection under load	0,45 MPa	75-1/2	°C	155		90	
		1,8 MPa			65		65	
	Vicat softening temperature	50 N	306	°C	210		200	
	Coefficient of linear thermal expansion	Parallel (in flow direction)	11359-1/-2	10^{-4}/°K	1,32		1,61	
		Normal (perpendicular to flow)			1,32		1,61	
ELECTRICAL	Surface resistivity	23°C	IEC 60093	ohm	10^{15}	$>10^{15}$		
	Volume resistivity	23°C	IEC 60093	ohm · m	10^{13}	10^{11}	$>10^{13}$	10^{10}
	Comparative tracking index (CTI)	23°C	IEC 60112	V	600		600	
	Flammability [1]	1,5 mm	UL 94/IEC 60695		HB		HB	
OTHERS	Density		1183	kg/m³	1090		1080	
	Humidity absorption	23°C, 50% RH	Similar to ISO 62	%	2,2		2,2	
	Water absorption	Saturation, immersed	Similar to ISO 62	%	6,8		6,4	
	Rockwell hardness		2039-2					
		Scale M			71			
		Scale R			115			
PROC.	Processing temperature range			°C	275-300		275-300	
	Shrinkage range (extrusion)			%	2,5 ± 0,5		2,8 ± 0,5	

1) Numerical flame test ratings are not intended to present behaviour of moulded parts in real life fire conditions; each end-user must determine whether any potential flammability hazards exist with parts moulded from ZYTEL® nylon resins. UL yellow cards available upon request.
2) Annealed.

PA66		PA66		PA66		PA6		PA6		PA6	
ZYTEL® 490		ZYTEL® ST801		ZYTEL® EFE8073		ZYTEL® 7300T		ZYTEL® ST7301		ZYTEL® ST811HS	
DAM	**50% RH**	**DAM**	**50% RH**	**DAM**	**50% RH**	**DAM**	**50% RH**	**DAM**	**50% RH**	**DAM**	**50% RH**
55	50	50	43	52	40	68	40	48	30	31	
5,5	29	5,7	38	5,5	32	4	30	4	32	4	
33	>50	40	>50			25	>50	>50	>50	>50	>50
2100	950	2000	900	2000	1100	2750	890	1900	660	900	400
65	104	90	115	84	100	14	110	80	130	70	130
20	15	20	20			9	5	19	18	14	13
NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
NB	NB	NB	NB			NB	NB	NB	NB	NB	NB
263		263		263		223		223		219	
85		130		208 [2)]		75		85		170	
70		65		65 [2)]		55		55		45	
220		205				195				95	
1,52		1,2				1,04				1,3	
1,52		0,9				1,22					
		10^{15}	10^{15}								
		10^{12}	10^{11}								
600											
HB		HB				HB		HB		HB	
1080		1080		1070		1100		1060		1040	
2,3		2,2				2,6				2,3	
7,1		6,7				9				6,8	
										57	
		112								70	57
275-300		275-300		275-300		230-250		230-250		230-250	
2,6 ± 0,5				2,9 ± 0,5		2,2 ± 0,5				2,8 ± 0,5	

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Properties of ZYTEL® nylon resins (continued)

	Property	Test conditions	ISO test method	Units	PA612 ZYTEL® 158 DAM	PA612 ZYTEL® 158 50% RH	PA612 ZYTEL® 159L DAM	PA612 ZYTEL® 159L 50% RH
MECHANICAL	Yield stress	50 mm/min	527-1/2	MPa	62	52		
	Yield strain	50 mm/min	527-1/2	%	4,3	19		
	Nominal strain at break	50 mm/min	527-1/2	%	35	>50		
	Tensile modulus	1 mm/min	527-1/2	MPa	2400	1550		
	Charpy impact strength (notched)	23°C	179/eA	kJ/m^2	4,2	8		
		–30°C			4,2	4		
	Charpy impact strength (unnotched)	23°C	179/eU	kJ/m^2	NB	NB		
		–30°C			NB	NB		
THERMAL	Melting temperature, by DSC	10° K/min	3146 C	°C	218		218	
	Temperature of deflection under load	0,45 MPa	75-1/2	°C	135			
		1,8 MPa			60		61	
	Vicat softening temperature	50 N	306	°C	180			
	Coefficient of linear thermal expansion	Parallel (in flow direction)	11359-1/-2	10^{-4}/°K	1,2			
		Normal (perpendicular to flow)			1,2			
ELECTRICAL	Surface resistivity	23°C	IEC 60093	ohm	10^{12}			
	Volume resistivity	23°C	IEC 60093	ohm · m	10^{13}	10^{11}		
	Comparative tracking index (CTI)	23°C	IEC 60112	V	600			
	Flammability [1]	1,5 mm	UL 94/IEC 60695		HB			
OTHERS	Density		1183	kg/m^3	1060		1060	
	Humidity absorption	23°C, 50% RH	Similar to ISO 62	%	1,3			
	Water absorption	Saturation, immersed	Similar to ISO 62	%	3,0		0,25	
	Rockwell hardness		2039-2					
		Scale M						
		Scale R			114	108		
PROC.	Processing temperature range			°C	225-245		225-245	
	Shrinkage range (extrusion)			%	2,5 ± 0,5			

1) Numerical flame test ratings are not intended to present behaviour of moulded parts in real life fire conditions; each end-user must determine whether any potential flammability hazards exist with parts moulded from ZYTEL® nylon resins. UL yellow cards available upon request.

PA66		PA66		PA6	
ZYTEL® FN714		ZYTEL® FN718		ZYTEL® FN727	
DAM	50% RH	DAM	50% RH	DAM	50% RH
27	25	30		23	25
		50	>50	44	>50
		>50	>50	>50	>50
550	240	960	420	770	350
		125 35		130 65	
		NB NB	NB NB	NB NB	NB NB
263		263		223	
175		50		45	
		220		180	
				1,2	
10^{13}	10^{11}				
1020		1040		1020	
275-300		275-300		230-250	

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Typical properties of DELRIN® acetal resins

	Property	Test conditions	ISO test method	Units	111P	DE7031
MECHANICAL	Yield stress	50 mm/min	527-1/2	MPa	72	72
	Yield strain	50 mm/min	527-1/2	%	19	19
	Nominal strain at break	50 mm/min	527-1/2	%	40	40
	Tensile modulus	1 m/min	527-1/2	MPa	3200	3200
	Charpy impact strength (notched)	23°C –30°C	179/1eA		12 8	12 8
THERMAL	Melting temperature, by DSC	10°K/min	3146 C	°C	178	178
	Temperature of deflection under load	unannealed 1,8 MPa annealed	75	°C	105 110	105 110
	Vicat softening temperature	50 N	306	°C	160	160
	Coefficient of linear thermal expansion	–40°C to 30°C 30°C to 60°C 60°C to 105°C	ASTM D696	10^{-4}/°K		
ELECTR.	Surface resistivity		IEC 60093	ohm		
	Volume resistivity		IEC 60093	ohm·m		
	Flammability	1,5 mm	UL 94/IEC 60695		HB	HB
OTHERS	Density		1183	kg/m³	1420	1420
	Water absorption 24 hours immersion Equilibrium at 50% RH Saturation, immersed		Similar to ISO 62	%	 0,30 0,22 0,9	 0,30 0,22 0,9
	Rockwell hardness	Scale M Scale R	2039/2		M 92 R 120	
PROCESSING	Processing temperature range			°C	185-215	185-215
	Melt mass-flow rate	2,16 kg/190°C	1133	g/10 min	2,3	2,3
	Shrinkage range (extrusion)			%	2,5-3,5	2,5-3,5
	Chemical resistance	All resins have outstanding resistance to neutral chemicals,including a wide variety of solvents				

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