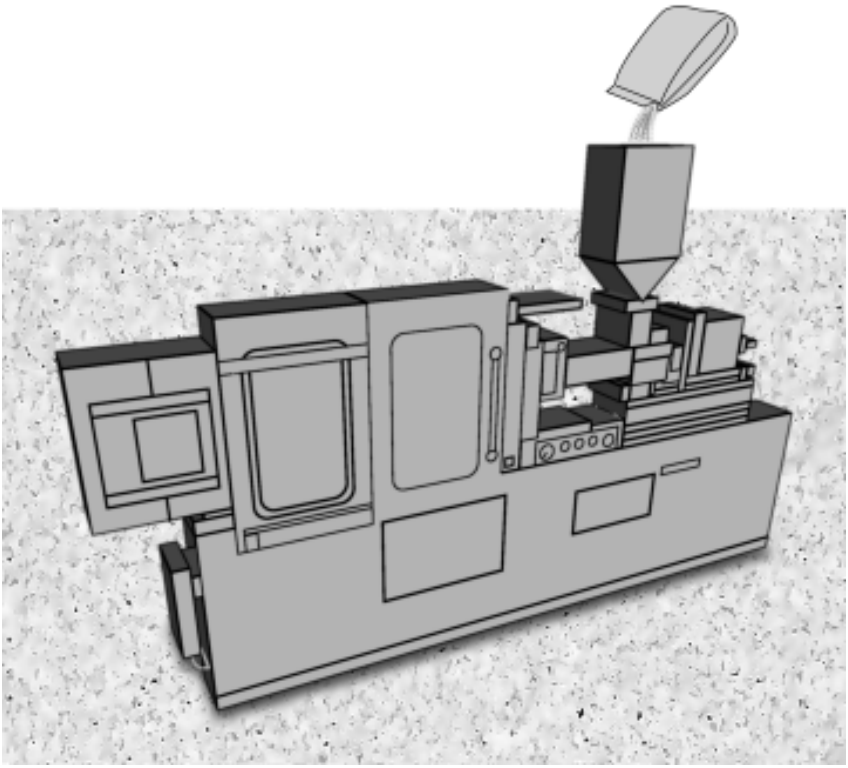
DuPont Engineering Polymers



Crastin® PBT

thermoplastic polyester resin

Responsible Care®
A Public Commitment
Product Stewardship

Crastin® PBT thermoplastic polyester resins are polybutylene terephthalate resins modified to offer exceptional performance in a variety of demanding applications. Crastin® can be processed on conventional injection molding machines using standard industry practices. However, specific attention to processing details will enhance quality and productivity. For detailed molding information, refer to the Crastin® thermoplastic polyester resin molding guide. For additional information on safety, health, and environmental concerns, refer to the MSDS or call Dial DuPont First at (800) 441-0575. For automotive inquiries, call (800) 533-1313.

Drying Considerations

For both virgin resin and rework, hopper dryers sized to afford the following conditions are strongly recommended:

- Moisture content must be below 0.04 wt %.
- Dry for 2–4 hr at 120°C (250°F).
- Dryer dewpoint must remain below –20°C (–4°F).
- Air flow minimum of at least 1 cfm/lb/hr.

Alternative Drying

- Dry at least 8 hr at 82°C (180°F).

Note: Moisture content above 0.04 wt% will result in loss of strength and toughness.

Melt Temperatures

Crastin® has good stability at the following processing temperatures:

- 250°C (480°F) in parts using 30–70% of machine-rated capacity operating on cycles under 60 sec.
- 260°C (500°F) for parts that require 60–80% of machine capacity in cycles less than 45 sec.

Note:

- Processing temperatures should be matched to part size.
- Excessive residence times and/or temperatures can cause degradation.
- Melt temperatures below 230°C (445°F) can lead to dangerous overpressure situations.

Mold Temperatures

Crastin® crystallizes rapidly and can be successfully molded over a broad range of mold temperatures:

- 30–130°C (85–265°F).
- Unreinforced resins with mold temperatures under 65°C (150°F) will produce short cycle times.
- Reinforced resins with mold temperatures over 65°C (150°F) will produce better surface aesthetics, flow, and dimensional stability.

Note: In order to mold Crastin® into parts with optimum mechanical properties and post-molded dimensional stability, mold temperatures must be controlled to produce a sufficient degree of crystallization of the polymer.

Operating Conditions

- Fast injection speeds (1–3 sec), especially in thin sections.
- Screw speeds should be adjusted to result in screw retraction times shorter than the cooling cycle.
- Back pressure (50 psi) will result in better quality melt and improved shot-to-shot uniformity.

Note:

- Fast injection speed also improves knitline strength and surface appearance.
- High screw speeds should be avoided with glass-reinforced resins to avoid loss of mechanical properties due to glass fiber breakage.

Shrinkage Considerations

Shrinkage in semicrystalline resins such as Crastin® is from:

- Crystallization of the polymer.
- Thermal contraction of the part as it cools to room temperature.

Causes of part distortion include:

- A high level of glass fiber orientation.
- Poor mold temperature uniformity.
- Large changes in wall thickness of the part.

Note: High mold temperatures and thick part sections may increase shrinkage. Shrinkage in reinforced resins is controlled by glass fiber orientation, which results in different shrinkage rates parallel to and perpendicular to direction of flow.

Safety Considerations

While processing Crastin®, all of the potential hazards associated with molding thermoplastic polyester resins must be anticipated and either eliminated or guarded against by following established industry procedures. Hazards include:

- Thermal burns resulting from exposure to hot molten polymer.
- Fumes generated during drying, processing, and regrind operations.
- Formation of gaseous and liquid degradation products.

MSDSs include such information as hazardous components, health hazards, emergency and first aid procedures, disposal procedures, and storage information.

Note: Adequate ventilation and proper protective equipment should be used during all aspects of the molding process. Refer to the DuPont Ventilation Guide for more detailed information.

DUPONT®

Delrin®

acetyl resins

Responsible Care®
A Public Commitment
Product Stewardship

Delrin® acetal resins are thermoplastic polymers made by the polymerization of formaldehyde. They have gained widespread recognition for reliability in many thousands of engineering components all over the world. Delrin® has been used in the automotive, appliance, construction, hardware, electronics, and consumer goods industries, among others. For detailed molding information, refer to the Delrin® acetal resins molding guide. For additional information on safety, health, and environmental concerns, refer to the MSDS or call Dial DuPont First at (800) 441-0575. For automotive inquiries, call (800) 533-1313.

Drying Considerations

- Virgin resin is usually handled without drying.
- Opened bags or molding regrind resins are easily dried in a circulating air oven or hopper dryer unit at 80°C (175°F) for 4 hr or less.
- Toughened Delrin® acetal resins, such as Delrin® 100ST and Delrin® 500T, should be dried 2–4 hr at 80°C (175°F) for optimum physical properties.

Note: Hopper dryers have occasionally been used to preheat the resin and increase cylinder melting capacity or to decrease mold deposit and improve surface appearance when large amounts of reground resins are used.

Melt Temperatures

Delrin® acetal resin is a crystalline resin with a melting point of 178°C (352°F). The preferred melt temperature range is 210–220°C (410–430°F) for standard grades and 200–210°C (390–410°F) for impact modified grades (Delrin® 100ST and Delrin® 500T). Recommended cylinder temperatures for residence times between 3 to 5 min are as follows:

Typical Cylinder Temperature Settings

	Temperature Setting, °C (°F)			
Resin Type	**Nozzle**	**Front**	**Center**	**Rear**
Standard Grades	190 (375)	215 (420)	215 (420)	215 (420)
D100ST D500T	190 (375)	205 (400)	205 (400)	205 (400)

Note: The proper design of the injection unit (cylinder and screw) and proper thermal settings will result in uniform melt and crystallinity, resulting in minimum internal stress and uniform mold shrinkage.

Mold Temperatures

In order to obtain maximum dimensional stability, surface gloss, flow, and minimum molded-in stress, the following mold temperatures are recommended for Delrin® acetal resins:

- Surface temperatures of 80–100°C (176–212°F) are recommended for standard grades.
- Surface temperatures of 40–60°C (105–140°F) are recommended for Delrin® 100ST and Delrin® 500T.

Notes:

- Mold temperature has a major effect on both mold shrinkage and post-molding shrinkage.
- In fast cycling operations, it may be necessary to use a lower mold coolant temperature in order to maintain a mold surface temperature in the recommended range.

Operating Conditions

- **Back pressure** should only be used when increasing cylinder temperature or when other changes are not effective or possible.
- Normal **injection pressures** lie in a range of 70–112 MPa (10–16 kpsi), but an injection pressure of 80–100 MPa (11–14 kpsi) may be necessary to obtain maximum part toughness and elongation. Delrin® 100 may require a pressure of 100 MPa or more.
- High **injection rates** are required for molding thin section parts. Lower injection rates are required when molding parts with thick sections and relatively small gates. Use 1 sec/mm of part thickness as first approach.

Note: Avoid hold-up spots in the machine where molten resin can accumulate and degrade, resulting in excess formaldehyde gas.

Shrinkage Considerations

The mold shrinkage of Delrin® acetal resins is dependent upon such factors as:

- Mold temperature
- Screw forward time
- Gate size
- Injection pressure
- Melt temperature
- Part thickness
- Composition (i.e., glass, filler, colorants)

Note: Good molding practices, however, lead to choices among these variables so that the mold shrinkages of Delrin® 500 and several other compositions are very often near 2.0% (0.020 mm/mm [in/in]).

Post-Molding Shrinkage

Hot molds of 90°C (194°F) or higher, measured on the cavity surface, reduce the post-molding shrinkage to an almost negligible amount.

Safety Considerations

While processing Delrin®, all of the potential hazards associated with thermoplastic elastomer resins must be anticipated and either eliminated or guarded against by following established industry procedures. Hazards include:

- Thermal burns resulting from exposure to hot molten polymer
- Fumes generated during drying, processing, and regrind operations
- Formation of gaseous and liquid degradation products

Never mix or process acetal with halogenated polymers or chemicals such as PVC or flame retardant resins. The HCl or HBr given off will cause rapid degradation of Delrin®.

MSDSs include such information as hazardous components, health hazards, emergency and first aid procedures, disposal procedures, and storage information.

Note: Adequate ventilation and proper protective equipment should be used during all aspects of the molding process. Refer to the DuPont Ventilation Guide for more detailed information.

DUPONT®

Hytrel®

polyester elastomer

Responsible Care®
A Public Commitment
Product Stewardship

Hytrel® polyester elastomers combine many of the most desirable characteristics of high-performance elastomers and flexible plastics. Hytrel® features exceptional toughness and resilience, high resistance to creep, impact and flex fatigue, flexibility at low temperatures, and good retention of properties at elevated temperatures. In addition, Hytrel® resists deterioration from many industrial chemicals, oils, and solvents. For detailed molding information, refer to the Hytrel® polyester elastomer molding guide. For additional information on safety, health, and environmental concerns, refer to the MSDS or call Dial DuPont First at (800) 441-0575. For automotive inquiries, call (800) 533-1313.

Drying Considerations

Hytrel® polyester elastomer must be dried prior to and during processing to produce quality parts that will perform properly. Drying considerations are as follows:

- Resin moisture content must be below 0.1%.
- Dehumidified air ovens are recommended with effective drying for 2–3 hr at 100°C (210°F) or overnight at 70°C (160°F).
- Drying without the use of a dehumidified air oven will require an additional 4–6 hr at 100°C (210°F) in dry weather.

Notes:

- Degradation due to moisture will result in poor physical properties and brittleness, but no visual defects may be apparent.
- Already dried resin that has been exposed to moisture must be re-dried prior to molding.

Melt Temperatures

Recommended Optimum Melt Temperatures and Injection Molding Set-up Conditions for Hytrel®

Grade	Recommended Optimum Melt Temperature	Melt (Stock) Temperature Range	Typical Cylinder Temperatures			
			Nozzle	Front	Center	Rear
Hytrel®						
G3548W	190°C (375°F)	180–205°C (355–400°F)	180°C (355°F)	190°C (375°F)	190°C (375°F)	165–190°C (330–375°F)
4056	180°C (355°F)					
G4074	200°C (390°F)	190–220°C (375–425°F)	190°C (375°F)	205°C (400°F)	205°C (400°F)	180–205°C (355–400°F)
G4078W	200°C (390°F)					
4069,	230°C (445°F)	220–250°C (430–480°F)	220°C (430°F)	235°C (455°F)	235°C (455°F)	205–235°C (400–455°F)
4556, 5526	230°C (445°F)					
5556	230°C (445°F)					
G4774, G4778	240°C (465°F)	235–260°C (455–500°F)	235°C (455°F)	245°C (475°F)	245°C (475°F)	220–245°C (430–475°F)
G5544	240°C (465°F)					
6356	240°C (465°F)					
7246	245°C (475°F)	240–260°C (465–500°F)	240°C (465°F)	245°C (475°F)	245°C (475°F)	220–245°C (430–475°F)
8238	245°C (475°F)					
Specialty						
3078	205°C (400°F)	190–210°C (375–410°F)	190°C (375°F)	205°C (400°F)	205°C (400°F)	180–205°C (355–400°F)
HTR6108	205°C (400°F)					
HTR8068	205°C (400°F)					
5555HS	230°C (445°F)	220–250°C (430–480°F)	220°C (430°F)	235°C (455°F)	235°C (455°F)	205–235°C (400–455°F)

Mold Temperatures

A surface temperature of 45°C (115°F) is recommended for all grades of Hytrel® resin.

Notes:

- Mold temperature has little effect on mechanical properties, but the main effect is on shrinkage.
- Mold temperature should be measured with a thermocouple directly on the cavity's surface.
- Lower mold temperatures will reduce cycle time and improve ejection, particularly when using the softer resin grades.
- Higher mold temperatures will improve surface appearance.

Operating Conditions

- **Injection speed** varies with part thickness and geometry.
- Normal **injection pressures** should be set to the minimum pressure required for filling the cavity.
- **Hold pressure** should be set equal to the injection pressure for grades above 55D and should be set to follow a decreasing profile for grades below 47D.
- **Screw forward time** has a strong influence on shrinkage, and, in general, is shorter for the harder grades of Hytrel®.
- **Screw rotation speed** of 100 rpm is adequate for a resin grade with no additives, but should be increased (along with back pressure) with the use of additives, to improve mixing.
- **Back pressure** of 0.34–0.55 MPa (50–80 psi) can be used to improve melt homogeneity.
- **Proper venting** is useful due to fast cavity fill rates.

Shrinkage Considerations

The mold shrinkage of Hytrel® is dependent upon such factors as:

- Resin grade
- Part geometry and thickness
- Mold design
- Gate size
- Mold temperature
- Melt temperature
- Screw forward time
- Injection pressure

Shrinkage of Hytrel® (ASTM D955)
(Measured on standard test specimen, in flow direction 3.2 mm [0.125 in] thick, molded at recommended conditions)

Resin Grade	Shrinkage, %	Resin Grade	Shrinkage, %
Standard		**High-Performance**	
G3548W	0.5	4056	0.5
G4074	0.8	4069	0.8
G4078W	0.8	4556	1.1
G4774	1.4	5526	1.4
G4778	1.4	5556	1.4
G5544	1.6	6356	1.5
		7246	1.6
		8238	1.6
Specialty			
5555HS	1.4		

Safety Considerations

While processing Hytrel®, all of the potential hazards associated with molding thermoplastic elastomer resins must be anticipated and either eliminated or guarded against by following established industry procedures. Hazards include:

- Thermal burns resulting from exposure to hot molten polymer
- Fumes generated during drying, processing, and regrind operations
- Formation of gaseous and liquid degradation products

MSDSs include such information as hazardous components, health hazards, emergency and first aid procedures, disposal procedures, and storage information.

Note: Adequate ventilation and proper protective equipment should be used during all aspects of the molding process.

Minlon®

mineral reinforced nylon resin

Responsible Care®
A Public Commitment
Product Stewardship

Minlon® is the DuPont tradename for its mineral and mineral/glass reinforced nylon resins. Mineral particles and glass fibers are chemically bonded with nylon to provide a material exhibiting the excellent chemical resistance and retention of properties at high temperatures characteristic of nylon, while enhancing stiffness, strength and heat resistance. Minlon® also exhibits better dimensional stability and creep resistance than unreinforced nylon and lower warpage than glass reinforced nylon. For more detailed molding information, refer to the Minlon® molding guide. For additional information on safety, health, and environmental concerns, refer to the MSDS or call Dial DuPont FIrst at (800) 441-0575. For automotive inquiries, call (800) 533-1313.

Drying Considerations

Minlon® resins are supplied ready to mold directly from the shipping container. However, if the resin is exposed to moisture, dehumidified hopper or tray oven dryers sized to afford the following conditions are strongly recommended:

- Resin moisture content below 0.20% for optimum processing and molded properties.
- Dryer dew point below –18°C (0°F).
- Drying temperature of 80°C (175°F). Temperatures above this for longer than a few hours can cause discoloration.
- Drying times of 2–4 hr are generally sufficient for minimal exposure to ambient humidity. However, resin exposed for several days may require up to 20 hr drying time.

Melt Temperatures

Barrel settings to obtain the melt temperatures listed below depend on the hold-up-time in the molding machine. Typically, parts molded with a long residence time should use an increasing temperature profile and a melt temperature at the low end of the recommended range, while parts molded with a short residence time should use a decreasing profile and a melt temperature at the high end of the range.

Minlon® Grade	Typical Melt Temp. °C (°F)
10B40, 20B, 22C	295–305 (560–580)
11C40, 12T	280–300 (540–570)

Mold Temperatures

Minlon® nylon resins crystallize rapidly and can be successfully molded using a broad range of mold temperatures.

- Typical mold temperature range = 65–120°C (150–250°F).
- Mold temperatures above 80°C (175°F) should be used to achieve optimum dimensional stability and surface gloss.

Operating Conditions

- Faster **injection speeds** (<1 sec) will normally provide the highest gloss, but slower speeds can be used to obtain a matte finish.
- **Injection pressure** will vary depending on part geometry, gate size and location and mold and melt temperatures.
- Minimum **screw speed** (50–100 rpm) should be used so that the screw retraction time is about 75% of the available mold closed time.
- Little to no **back pressure** (less than 0.3 MPa [50 psi]) is normally used to minimize machine wear and glass fiber breakage.

Shrinkage Considerations

The mold shrinkage of parts molded out of Minlon® is highly dependent on molding and design parameters such as:

- part geometry
- cycle time
- melt temperature
- mold temperature
- gate location
- gate size

Mold Shrinkage of Minlon®, %
(based on a 3 × 5 × 1/8 in end gated plaque)

	Flow	Transverse
Minlon® 10B40	0.8	1.0
Minlon® 11C40	0.9	1.3
Minlon® 12T	1.0	1.2
Minlon® 20B	0.3	1.0
Minlon® 22C	0.5	1.0

Note: The values shown above are intended as approximate guides for estimating mold shrinkage. For complicated precision parts, prototype molds should be used to obtain more accurate dimensional data.

Safety Considerations

While processing Minlon® nylon resins, all of the potential hazards associated with molding thermoplastic resins must be anticipated and either eliminated or guarded against by following established industry procedures. Hazards include:

- Thermal burns resulting from exposure to hot molten polymer
- Fumes generated during drying, processing, and regrind operations (see ventilation guide)

MSDSs include such information as hazardous components, health hazards, emergency and first aid procedures, disposal procedures, and storage information.

Note: Adequate ventilation and proper protective equipment should be used during all aspects of the molding process. Refer to the DuPont Ventilation Guide for more detailed information.

Rynite® PET

thermoplastic polyester resin

Responsible Care®
A Public Commitment
Product Stewardship

Rynite® PET glass-reinforced thermoplastic polyester resins contain uniformly dispersed glass or glass fibers/mineral in polyethylene terephthalate (PET), specially formulated for rapid crystallization during the injection molding process. This makes possible the production of high-performance parts by conventional injection molding techniques. Rynite® PET resins are available in a variety of compositions. For detailed molding information, refer to the Rynite® PET thermoplastic polyester resin molding guide. For additional information on safety, health, and environmental concerns, refer to the MSDS or call Dial DuPont First at (800) 441-0575. For automotive inquiries, call (800) 533-1313.

Drying Considerations

In order to mold parts with excellent strength, toughness, dimensional stability, and surface appearance, recommended drying is as follows:

Drying Conditions for Rynite® PET Resins

Inlet Hopper			
Air Temperature	107–135°C (225–275°F)		
Dew Point of Air	–18°C (0°F) or lower		
Airflow Rate	0.8–1.0 CFM per lb/hr resin processed (3.0–3.7 m^3/hr per kg/hr resin processed)		
Inlet Desiccant Bed			
Air Temperature	66°C (150°F) or lower		
Drying Time at	**107°C (225°F)**	**121°C (250°F)**	**135°C (275°F)**
Virgin Resin	8	3	2
Recycled Regrind	8	4	3
Wet Resin	8	6	4
Maximum	16	9	6

Note:

- Moisture content above 0.02 wt % will result in loss of strength and toughness.
- Parts molded from wet resin will not exhibit surface defects, but will still suffer poor end-use performance.

Melt Temperatures

Cylinder temperature settings for Rynite® PET resins depend upon a number of factors, e.g., the size and type of machine, shot size, cycle, etc. The recommended typical cylinder and melt temperatures are as follows:

Typical Cylinder and Melt Temperatures

Resin Series	Cylinder Settings, °C (°F)				Preferred Melt Temperature Ranges
	Rear	Center	Front	Nozzle	
500, 800, 900; PCR, RE5XXX	260–290 (500–550)	260–295 (500–560)	265–295 (510–560)	275–300 (530–570)	280–300 (535-575)
400, Flame Retardant, RE9XXX, Color Stable, SST35	260–275 (500–530)	260–280 (500–540)	260–280 (500–540)	260–290 (500–555)	270–290 (520–555)

Note: The nozzle temperature should be adjusted to prevent nozzle freeze-off or drool.

Mold Temperatures

In order to obtain maximum dimensional stability, surface appearance, and cycle, the following mold temperatures are recommended for Rynite® PET resins:

Part Thickness, in (mm)	Preferred Minimum* Mold Temperature, °C (°F)
0.030 (0.75)	110 (230)
0.060 (1.5)	105 (220)
0.125 (3.1)	100 (210)
0.250 (6.3)	90 (190)

Note: When mold temperatures below 90°C (190°F) are used, the initial warpage and shrinkage will be lower, but the surface appearance will be poorer and the dimensional change will be greater when parts are heated above 90°C (190°F).

* Subtract 25°F (≈ 12°C) for HP and SST grades.
Add 30°F (≈ 15°C) for color stable grades, and some special RE grades.
Refer to molding information on data sheets.

Operating Conditions

- Rynite® PET resins exhibit high flow, so **injection pressures** can be set lower than comparable settings for glass reinforced 6/6 nylon and PBT resins.
- Fast **injection speeds** (1–4 sec) especially in thin sections.
- The **screw speed** should be adjusted so that the screw retraction time is about 75% of the available mold closed time.
- The **screw RPM** should be slow (with little or no back pressure) in order to minimize glass fiber breakage.

Note:
- Fast injection speed also improves knitline strength and surface appearance.
- Adequate mold venting will prevent part burning associated with fast fill rates.

Shrinkage Considerations

Shrinkage in crystalline resins such as Rynite® PET are from:
- Crystallization of the polymer.
- Thermal contraction of the part as it cools to room temperature.
- High mold temperatures and thick part sections.

Causes of part distortion include:
- A high level of glass fiber orientation.
- Poor mold temperature uniformity.
- Large changes in wall thickness of the part.

Note: Glass orientation tends to dominate shrinkage in glass reinforced resins, which results in different shrinkage rates parallel to and perpendicular to the direction of flow.

Safety Considerations

While processing Rynite® PET, all of the potential hazards associated with thermoplastic polymer resins must be anticipated and either eliminated or guarded against by following established industry procedures. Hazards include:
- Thermal burns resulting from exposure to hot molten polymer.
- Fumes generated during drying, processing, and regrind operations.
- Formation of gaseous and liquid degradation products.

MSDSs include such information as hazardous components, health hazards, emergency and first aid procedures, disposal procedures, and storage information.

Note: Adequate ventilation and proper protective equipment should be used during all aspects of the molding process. Refer to the DuPont Ventilation Guide for more detailed information.

Zenite™ LCP

liquid crystal polymer resin

Responsible Care®
A Public Commitment
Product Stewardship

Zenite™ LCP is the DuPont trademark for its liquid crystal polymer (LCP) resins. Zenite™ LCP 6000 and 7000 series resins are wholly aromatic polyester resins, and are easily melt processed. The materials feature excellent toughness, dimensional stability, and creep resistance even at very high temperatures. Processing Zenite™ LCP under high shear will contribute to superior physical properties over a wide temperature range, low thermal expansion, and low mold shrinkage—especially in the flow direction. For detailed molding information, refer to the Zenite™ LCP molding guide. For additional information on safety, health, and environmental concerns, refer to the MSDS or call Dial DuPont First at (800) 441-0575. For automotive inquiries, call (800) 533-1313.

Drying Considerations

For virgin resin and regrind, dehumidified oven or hopper dryers sized to afford the following conditions are recommended:

- Moisture content must be below 0.010 wt %.
  Dry virgin resin for:
  2.5 hr at 121°C (250°F) or
  1.5 hr at 135°C (275°F) or
  1.0 hr at 149°C (300°F).
  When using resin/regrind of unknown moisture, add 1.5 hr to the above temperature choices.
- Dryer air flow rate should be 3.0–3.7 m^3/hr per kg/hr (0.8–1.0 CFM per lb/hr) of resin processed.

Alternative Drying

- Drying resin for longer lengths of time (overnight) is not detrimental.

Note: If degradation should occur because of excessive moisture, there will be no evidence (such as splay) on the surface of the parts.

Melt Temperatures

Zenite™ LCP resins exhibit excellent melt stability and have a broad melting range versus other engineering plastics.

Typical Processing Conditions for Molding Zenite™ LCP Resins

Zenite™ Resin Series	Typical Cylinder Temperatures			Preferred Melt Temperature Range
	Rear °C (°F)	Center °C (°F)	Front °C (°F)	°C (°F)
6115L 6130, 6130L 6140, 6140L	343 (650)	350 (662)	350 (662)	350–360 (662–680)
7130	352 (665)	357 (675)	357 (675)	363–371 (685–700)

Note:

- Melt temperatures molded below the recommended values can lead to poor physical properties (especially brittle parts).
- In order for all zones to reach and be controlled at the desired settings, high wattage ceramic heater bands are required for the 7000 series resins.

Mold Temperatures

Zenite™ LCP resins mold well over a wide range of mold temperatures as exhibited below:

- The common temperature range is 65–110°C (150–230°F).
- Temperatures of 40–150°C (100–130°F) have been used.
- High temperatures should be used for thin-walled hard-to-fill parts.
- Low temperatures are suggested for complex parts if a sticking problem is experienced.

Notes:

- Good safety practices require using high temperature rated hoses for hot water or hot oil heaters.
- Since mold temperature is a product of many variables, it must be measured at start-up (once on cycle) and after any major process change.

Operating Conditions

- Injection pressures of 200–400 bar (3000–6000 psi) are typically used.
- Injection rates of 0.2–1.0 sec are used over almost 100% of the stroke in order to utilize high flow, low viscosity resin characteristics (especially in small parts).
- Pack pressure is typically 80% that of injection pressure (e.g., for complex parts, start with 138 bar [2000 psi]) pack pressure and slowly increase.
- Screw forward time should be increased until the part reaches maximum weight (thin section part weight must be achieved by increasing injection pressure).

Note: Overall cycle time is determined by the interaction of part thickness and geometry, molding machine and part design.

Shrinkage Considerations

The mold shrinkage of Zenite™ LCP resins depends upon the orientation of the molecules and fillers, part thickness and design, and processing conditons. A guide is shown below:

Effect of Part Thickness on Mold Shrinkage, %
Mold Temperature: 93°C (200°F)

Thickness mm (in)	Zenite™ 6130		Zenite™ 7130	
	Flow	Transverse	Flow	Transverse
0.8 (0.031)	–0.07	0.5		
1.6 (0.062)	0.07	0.8	–0.1	0.9
3.2 (0.125)	0.1	0.7	0.0	0.8

Note: Negative shrinkage (i.e., growth) can occur due to molecular alignment in the flow direction in thin wall section parts, especially at higher mold temperatures or when annealed at very high temperatures.

Safety Considerations

While processing Zenite™ LCP, all of the potential hazards associated with liquid crystal polymer resins must be anticipated and either eliminated or guarded against by following established industry procedures. Hazards include:

- Thermal burns resulting from exposure to hot molten polymer.
- Fumes generated during drying, processing, and regrind operations.
- Formation of gaseous and liquid degradation products.

MSDSs include such information as hazardous components, health hazards, emergency and first aid procedures, disposal procedures, and storage information.

Note: Adequate ventilation and proper protective equipment should be used during all aspects of the molding process.

DUPONT®

Zytel®
nylon resin

Responsible Care®
A Public Commitment
Product Stewardship

Zytel® nylon resins are thermoplastic polyamides having properties that place them high on the list of engineering plastics. Zytel® nylon resins are tough and withstand repeated impact. They are highly resistant to abrasion and have good chemical resistance to oils, greases, alaphatic and aromatic hydrocarbons, etc. Molded articles retain their shape at elevated temperatures, are strong in thin sections, and have low coefficients of friction. Zytel® nylon resins may be reinforced with glass fibers and a variety of additives for enhanced property performance. For detailed molding information, refer to the Zytel® nylon resin molding guide. For additional information on safety, health, and environmental concerns, refer to the MSDS or call Dial DuPont First at (800) 441-0575. For automotive inquiries, call (800) 533-1313.

Drying Considerations

Zytel® nylon resins are supplied ready to mold directly from the shipping containers. However, if exposed to moisture, hopper dryers or tray ovens sized to afford the following conditons are strongly recommended:

- Moisture content must be below 0.2 wt %.
- Moisture content for extrusion grades must be below 0.02 wt %.
- Dryer dew point must remain below –18°C (0°F).
- Drying temperature of 80°C (175°F).
- Drying time of 20 hr on bag opened for several days.

Note: Air temperature in excess of 95°C (200°F) for longer than 3 hr will discolor nylon.

Melt Temperatures

Resin	Typical Cylinder Temperatures for Screw Machines						Preferred Melt Temperature	
	Rear		Center		Front			
	°C	°F	°C	°F	°C	°F	°C	°F
Nylon 66: Zytel® 101, 101L, 103HSL, 105 BK010, 122L, 132F	280	540	275	525	270	520	280–305	535–580
Zytel® 42A	290	550	275	525	270	520	275–285	530–550
Modified Nylon 66: Zytel® 408L, 408HS, 450HSL, ST801, ST801W, 3189	295	560	280	535	275	525	290–295	550–560
Nylon 612: Zytel® 151L, 158L, 153HSL, 157HSL BK010	240	460	230	445	225	440	230–290	450–550
Amorphous Nylons: Zytel® ST901L	300	570	285	545	280	535	255–295	490–560

Mold Temperatures

Zytel® nylon resins can be successfully molded over a broad range of mold temperatures:

- 0–95°C (30–200°F)
- 70°C (160°F) is the optimum mold temperature

Mold surface temperature depends upon:

- cycle time
- melt temperature
- mold design (size and location of cooling channel)
- temperature and mold heat exchange rate

Note: Mold surface temperature determines part quality aspects such as shrinkage, surface appearance, and post-molding shrinkage.

Operating Conditions

- Faster injection speeds of <1.5 sec, especially in thin sections.
- Slower injection speeds of 1.5 to 5 sec, especially in thicker sections.
- Screw speeds should be adjusted so that the screw retraction time is at least 90% of the mold closed time.
- The minimum amount of back pressure should be used consistently with uniform screw recovery times.

Note: Fast injection speed also improves knitline strength and surface appearance.

Shrinkage Considerations

Shrinkage in nylon resins such as Zytel® results from thermal contraction of the part as it cools to room temperature and depends upon processing conditions.

Mold shrinkage of Zytel® (based upon a 3 × 5 × 1/8 in end gated plaque, flow direction, at standard processing conditons)

Zytel® ST901L	0.6%
Zytel® 151L, 158L, 153HSL, 157HSL BK010	1.1%
Zytel® 132F	1.2%
Zytel® 101, 101L, 103HSL, 105 BK010, 408L, 408HS, 42A	1.5%
Zytel® 122L	1.6%
Zytel® 450HSL, ST801	1.8%
Zytel® ST801W, 3189	2.1%

Safety Considerations

While processing Zytel®, all of the potential hazards associated with molding thermoplastic polyamide resins must be anticipated and either eliminated or guarded against by following established industry procedures. Hazards include:

- Thermal burns resulting from exposure to hot molten polymer
- Fumes generated during drying, processing, and regrind operations
- Formation of gaseous and liquid degradation products

MSDSs include such information as hazardous components, health hazards, emergency and first aid procedures, disposal procedures, and storage information.

Note: Adequate ventilation and proper protective equipment should be used during all aspects of the molding process. Refer to the DuPont Ventilation Guide for more detailed information.

Zytel® DMX

nylon resin

Responsible Care®
A Public Commitment
Product Stewardship

Zytel® DMX is a family of modified nylon 66 resins with significantly improved dimensional stability and more consistent mechanical properties across various humidity levels compared to traditional nylon 66 resins. The glass-reinforced Zytel® DMX grades offer a significant reduction in warpage, while maintaining the outstanding processing ease and high flow typical of glass-reinforced nylon 66. The Super Tough DMX grades offer minimum loss of stiffness with moisture pick-up. For detailed molding information, refer to the Zytel® or Zytel® GRZ nylon resin molding guide. For additional information on safety, health, and environmental concerns, refer to the MSDS or call Dial DuPont First at (800) 441-0575. For automotive inquiries, call (800) 533-1313.

Drying Considerations

Zytel® DMX resins are supplied ready to mold directly from the shipping container. However, if the resin is exposed to moisture, dehumidified hopper or tray oven dryers sized to afford the following conditions are strongly recommended:

- Resin moisture content below 0.20% for optimum processing and molded properties.
- Dryer dew point below –18°C (0°F).
- Drying temperature of 80°C (175°F). Temperatures above this for longer than a few hours can cause discoloration.
- Drying times of 2–4 hr are generally sufficient for minimal exposure to ambient humidity. However, resin exposed for several days may require up to 20 hr drying time.

Melt Temperatures

Zytel® DMX has good stability at the following processing temperatures:

Zytel® DMX Grades	Typical Melt Temp. °C (°F)
61G15H, 61G30H	275–290 (530–555)*
ST601H	290–295 (555–560)

* Melt temperatures over 290°C (555°F) should be avoided for the glass reinforced grades.

Mold Temperatures

Zytel® DMX nylon resins crystallize rapidly and can be successfully molded using a broad range of mold temperatures.

Glass Reinforced Grades:

- Typical mold temperature range = 65–120°C (150–250°F).
- Mold temperatures above 80°C (175°F) should be used to achieve optimum dimensional stability and surface gloss.

Super Tough Grades:

- Typical mold temperature range = 40–95°C (100–200°F).

Operating Conditions

- Faster **injection speeds** particularly in thin-walled parts will normally provide the highest gloss and knitline strength. However, the optimum fill rate for a part depends upon resin composition, part geometry, gate size and melt temperature.
- **Injection pressure** will vary depending on part geometry, gate size and location and mold and melt temperature.
- Screw speeds should be adjusted to result in screw retraction times approximately 90% of the time available for recharging the melt to maximize mixing and minimize fiber breakage in the glass reinforced grades.
- Back pressure should be kept to a minimum.
- Hold-up times greater than 10 minutes should be avoided.

Shrinkage Considerations

Shrinkage in semicrystalline resins such as Zytel® DMX is dependent upon molding and design parameters such as:

- part geometry
- cycle time
- melt temperature
- mold temperature
- gate location
- gate size

Mold shrinkage*, %

Resin	Flow	Transverse
61G15H BK407	0.5	1.2
61G30H BK407	0.2	0.9
ST601H BK010	1.4	1.1
ST601H NC010	1.5	1.1

* Based on a 3 × 5 × 1/8 in end gated plaque.

Safety Considerations

While processing Zytel® DMX, all of the potential hazards associated with molding nylon resins must be anticipated and either eliminated or guarded against by following established industry procedures. Hazards include:

- Thermal burns resulting from exposure to hot molten polymer
- Fumes generated during drying, processing, and regrind operations
- Formation of gaseous and liquid degradation products

MSDSs include such information as hazardous components, health hazards, emergency and first aid procedures, disposal procedures, and storage information.

Note: Adequate ventilation and proper protective equipment should be used during all aspects of the molding process. Refer to the DuPont Ventilation Guide for more detailed information.

Zytel® GRZ

nylon resin

Responsible Care®
A Public Commitment
Product Stewardship

The DuPont family of glass reinforced Zytel® nylon resins, commonly known as GRZ, maintain the excellent properties characteristic of the Zytel® base resin, with enhanced strength, stiffness, dimensional stability, creep and heat resistance. Zytel® GRZ resins are available based on nylon 66, nylon 612, nylon copolymers and blends, in addition to modified nylons for superior impact performance. Each is also available with many different levels of glass fiber loading. For more detailed molding information, refer to the Zytel® GRZ molding guide. For additional information on safety, health, and environmental concerns, refer to the MSDS or call Dial DuPont First at (800) 441-0575. For automotive inquiries, call (800) 533-1313.

Drying Considerations

Zytel® GRZ resins are supplied ready to mold directly from the shipping container. However, if the resin is exposed to moisture, dehumidified hopper or tray oven dryers sized to afford the following conditions are strongly recommended:

- Resin moisture content below 0.20% for optimum processing and molded properties.
- Dryer dew point below –18°C (0°F).
- Drying temperature of 80°C (175°F). Temperatures above this for longer than a few hours can cause discoloration.
- Drying times of 2–4 hr are generally sufficient for minimal exposure to ambient humidity. However, resin exposed for several days may require up to 20 hr drying time.

Melt Temperatures

Barrel settings to obtain the melt temperatures listed below depend on the hold-up-time in the molding machine. Typically, parts molded with a long residence time should use an increasing temperature profile and a melt temperature at the low end of the recommended range, while parts molded with a short residence time should use a decreasing profile and a melt temperature at the high end of the range.

GRZ Series	Typical Melt Temp. °C (°F)
70G, 71G, 74G, 80G, 84G	290–305 (550–580)
72G	270–280 (520–540)
73G	260–280 (500–540)
77G	280–305 (540–580)
82G	280–295 (540–560)

Mold Temperatures

Glass reinforced Zytel® nylon resins crystallize rapidly and can be successfully molded using a broad range of mold temperatures.

- Typical mold temperature range = 65–120°C (150–250°F).
- Mold temperatures above 80°C (175°F) should be used to achieve optimum dimensional stability and surface gloss.

Operating Conditions

- Faster injection speeds (<1 sec) will normally provide the highest gloss, but slower speeds can be used to obtain a matte finish.
- Injection pressure will vary depending on part geometry, gate size and location and mold and melt temperatures.
- Minimum screw speed (50–100 rpm) should be used so that the screw retraction time is about 75% of the available mold closed time.
- Little to no back pressure (less than 0.3 MPa [50 psi]) is normally used to minimize machine wear and glass fiber breakage.

Shrinkage Considerations

The mold shrinkage of parts molded out of Zytel® GRZ is highly dependent on molding and design parameters such as:

- part geometry
- cycle time
- melt temperature
- mold temperature
- gate location
- gate size

Mold shrinkage of GRZ, %
(based on a 3 × 5 × 1/8 in end gated plaque)

	Flow	Transverse
Zytel® 70G13L	0.6	1.3
Zytel® 70G33L	0.4	1.1
Zytel® 70G43L	0.3	0.8
Zytel® 71G13L	0.8	1.4
Zytel® 71G33L	0.4	1.2
Zytel® 77G33L	0.2	0.6
Zytel® 77G43L	0.1	0.5
Zytel® 8018	0.9	1.3
Zytel® 80G33L	0.4	1.2

Note: The values shown above are intended as approximate guides for estimating mold shrinkage. For complicated precision parts, prototype molds should be used to obatin more accurate dimensional data.

Safety Considerations

While processing Zytel® GRZ nylon resins, all of the potential hazards associated with molding thermoplastic resins must be anticipated and either eliminated or guarded against by following established industry procedures. Hazards include:

- Thermal burns resulting from exposure to hot molten polymer
- Fumes generated during drying, processing, and regrind operations (see ventilation guide)

MSDSs include such information as hazardous components, health hazards, emergency and first aid procedures, disposal procedures, and storage information.

Note: Adequate ventilation and proper protective equipment should be used during all aspects of the molding process. Refer to the DuPont Ventilation Guide for more detailed information.

Zytel® HTN

high temperature nylon resin

Responsible Care®
A Public Commitment
Product Stewardship

Zytel® HTN (high temperature nylon) resins are high temperature, semicrystalline glass-reinforced nylon copolymers having a unique combination of properties such as low moisture absorption (property retention and dimensional stability), good high temperature properties (high melting point, high glass transition temperature, low coefficient of linear thermal expansion), and chemical resistance (to motor transmission and transformer oils, glycols and water). The Zytel® HTN family of resins extends significantly the performance possibilities of DuPont's injection molding Zytel® nylon resin family. For detailed molding information, refer to the Zytel® HTN resin molding guide. For additional information on safety, health, and environmental concerns, refer to the MSDS or call Dial DuPont First at (800) 441-0575. For automotive inquiries, call (800) 533-1313.

Drying Considerations

The typical drying considerations for Zytel® HTN resins are as follows:

- Moisture content must be below 0.1 wt %.
- Dryer dewpoint must remain below –40°C (–40°F).
- Drying temperature of 100°C (212°F).

Approximate Drying Times for Zytel® HTN

Freshly-opened bag	6–8 hr
Bag opened for several days	10–20 hr

Melt Temperatures

The typical processing temperatures for Zytel® HTN resins are as follows:

Typical Cylinder and Melt Temperatures

Resins		Machine Settings				Pref. Melt Temp.
		Rear	Center	Front	Nozzle	
HTN51G35HSL and	°C	305–320	305–320	310–320	320–325	320–330
HTN51G45HSL	°F	580–610	580–610	590–610	610–617	610–625
HTNFR51G35L	°C	300–315	305–315	305–315	310–320	315–325
	°F	570–600	580–600	580–600	590–610	600–617
HTNFR52G30L	°C	305–320	310–320	310–320	315–325	315–330
	°F	580–610	590–610	590–610	600–617	600–625

Mold Temperatures

Zytel® HTN resins should be processed using the following mold surface temperature guidelines:

51 SERIES: Mold temperature range of 135–155°C (275–310°F)

52 SERIES: Mold temperature range of 85–130°C (185–265°F)

Operating Conditions

- Injection pressures in the range of 400–1065 bar (6000 to 16,000 psi).
- Fast injection speeds (0.5 to 4 sec)
- Screw speeds should be adjusted so that the screw retraction time is at least 90% of the mold closed time.
- The minimum amount of back pressure should be used consistently with uniform screw recovery times.

Notes:

- Fast injection speed also improves knitline strength and surface appearance.
- High screw speeds should be avoided with glass-reinforced resins to avoid loss of mechanical properties due to glass fiber breakage.

Shrinkage Considerations

Shrinkage in Zytel® HTN resins depends upon:

- Resin composition
- Glass fiber content and orientation
- Part thickness and part design
- Mold design and processing conditions

A guide to mold shrinkage for Zytel® HTN resins:

Mold Shrinkage %

Thickness mm (in)	Mold Temp °C (°F)	HTN51G35HSL		HTN51G45HSL		HTNFR51G35L		HTNFR52G30L	
		Flow	Trans-verse	Flow	Trans-verse	Flow	Trans-verse	Flow	Trans verse
3.2 (0.125)	100 (212)	0.2	0.8	0.2	0.6	0.2	0.7	—	—
	120 (248)	—	—	—	—	—	—	0.3	0.9
	140 (285)	0.3	0.9	0.2	0.9	0.2	0.7	—	—
1.6 (0.0625)	100 (212)	0.1	0.5	0.1	0.4	0.1	0.4	—	—
	120 (248)	—	—	—	—	—	—	0.2	0.9
	140 (285)	0.2	0.9	0.1	0.9	0.1	0.8	—	—

Data determined on plaques 75 × 130 × thickness, mm plaque (3 × 5 × thickness, in)

Safety Considerations

While processing Zytel® HTN nylon resins, all of the potential hazards associated with molding thermoplastic resins must be anticipated and either eliminated or guarded against by following established industry procedures. Hazards include:

- Thermal burns resulting from exposure to hot molten polymer
- Fumes generated during drying, processing, and regrind operations (see ventilation guide)
- Formation of gaseous and liquid degradation products.

MSDSs include such information as hazardous components, health hazards, emergency and first aid procedures, disposal procedures, and storage information.

Note: Adequate ventilation and proper protective equipment should be used during all aspects of the molding process. Refer to the DuPont Ventilation Guide for more detailed information.

Start with DuPont

For more information on Engineering Polymers: (800) 441-0575

http://www.dupont.com/enggpolymers/americas

For Automotive Inquiries: (800) 533-1313

U.S.A.

East

DuPont Engineering Polymers
Chestnut Run Plaza 713
P.O. Box 80713
Wilmington, DE 19880-0713
(302) 999-4592

Automotive

DuPont Engineering Polymers
Automotive Products
950 Stephenson Highway
Troy, MI 48007-7013
(313) 583-8000

Asia Pacific

DuPont Asia Pacific Ltd.
P.O. Box TST 98851
Tsim Sha Tsui
Kowloon, Hong Kong
852-3-734-5345

Canada

DuPont Canada, Inc.
DuPont Engineering Polymers
P.O. Box 2200
Streetsville, Mississauga
Ontario, Canada L5M 2H3
(905) 821-5953

Europe

DuPont de Nemours Int'l S.A.
2, chemin du Pavillon
P.O. Box 50
CH-1218 Le Grand-Saconnex
Geneva, Switzerland
Tel.: ##41 22 7175111
Telefax: ##41 22 7175200

Japan

DuPont Kabushiki Kaisha
Arco Tower
8-1, Shimomeguro 1-chome
Meguro-ku, Tokyo 153
Japan
(011) 81-3-5434-6100

Mexico

DuPont S.A. de C.V.
Homero 206
Col. Chapultepec Morales
11570 Mexico D.F.
(011 525) 250-8000

South America

DuPont America do Sul
Al. Itapecuru, 506
Alphaville—CEP: 06454-080
Barueri—São Paulo, Brasil
Tel.: (055-11) 7266.8531
Fax: (055-11) 7266.8513
Telex: (055-11) 71414 PONT BR

DuPont Argentina S.A.
Avda.Mitre y Calle 5
(1884) Berazategui-Bs.As.
Tel.: (541) 319-4484/85/86
Fax: (541) 319-4417

Printed in U.S.A.
Reorder No.: H-78789 (99.5)

DuPont Engineering Polymers