Properties and Processing Guide

Hytrel® DYM

family of polyester elastomers

Start with DuPont

Copyright © 1999 E.I. du Pont de Nemours and Company. All rights reserved.

Table of Contents

Hytrel® DYM Family of Polymers Properties and Processing Guide

General Information

Hytrel® is the DuPont registered trademark for its family of thermoplastic polyester elastomers. Hytrel® DYM polymer compositions have been specially developed for their use in applications such as air bag deployment doors. The Hytrel® DYM polymers exhibit a wide range of stiffness characteristics and easy processibility.

This report provides detailed guidelines for injection molding of the Hytrel® DYM polymers. The desirable properties of these polymers depend on proper processing of the resin. This report reviews the type of equipment as well as the processing conditions necessary to achieve high quality parts with high productivity and lists the typical properties of these resins. Hytrel® DYM polymers are thermally stable at the recommended molding temperatures. Like other polyesters, they are moisture-sensitive and must be dried before processing to moisture level < 0.1%, to achieve acceptable processing characteristics and minimal degradation.

Product Description

The Hytrel® DYM polymers are high performance thermoplastic polyester elastomers that are characterized by outstanding impact strength at both low and high temperatures. The Hytrel® DYM polymers provide service over a broad temperature range maintaining flexibility and impact strength at temperatures as low as –40°C and significant strength and integrity at high temperatures up to about 110°C.

The Hytrel® DYM polymers are based on polyester chemistry. They contain no plasticizers and have excellent resistance to tear and abrasion. They can be painted without the use of adhesion promoters or primers.

The Hytrel® DYM resins are supplied as meltcut pellets (approximately 2.3–5 mm [0.1–0.2 in] in diameter by 2–3 mm [0.08–0.12 in] long). They are packaged in 25 kg (55 lb) multi-wall paper bags with a moisture barrier inner wall. Palletized units contain 40 bags or 1000 kg (2200 lb) net weight, wrapped in polyolefin film on disposable wooden pallets. They are also available in 500 kg (1103 lb) bulk boxes with a moisture resistant liner. Property data sheets on individual grades can be obtained through your local sales office listed at the end of this bulletin, through a DuPont sales representative or through the world wide web: www.dupont.com/enggpolymers/americas (on limited resins). A summary of the grades of Hytrel® DYM resins and their typical properties is given in **Table 1**.

Table 1
Physical Properties of Hytrel® DYM Resins (Injection Molded Test Pieces)

Property	ASTM Test	Units	DYM100BK	DYM160BK
Hardness, Durometer D	D 2240	points	45	50
Processing				
Melt Flow Rate	D 1238	g/10 min	9	8
Test Conditions: at °C (°F)/2.16 kg load			220 (428)	220 (428)
Melting Point	D 3418[b]	°C (°F)	192 (378)	201 (395)
Stress/Strain	D 638[c]			
Tensile Strength		MPa (psi)	30 (4350)	27 (3915)
Elongation at Break		%	630	500
Stress at 5% Strain		MPa (psi)	4.2 (610)	5.0 (725)
Stress at 10% Strain		MPa (psi)	6.1 (890)	8.0 (1160)
Stress at 15% Strain		MPa (psi)	7.3 (1060)	9.7 (1400)
Stiffness				
Flexural Modulus:	D 790	MPa (psi)		
at –40°C (–40°F)			153 (22,150)	500 (71,000)
at 22°C (72°F)			100 (14,500)	160 (23,000)
at 100°C (212°F)			55 (7,900)	77 (11,000)
Toughness				
Initial Tear Resistance, Die C				
parallel	D 1004	kN/m (lb/in)	122 (700)	140 (826)
perpendicular			123 (705)	156 (895)
Izod Impact (notched)		J/m (ft·lb/in)		
at 23°C (72°F)	D 256		No break	No break
at –40°C (–40°F)			No break	No break
at –60°C (–76°F)			No break	No break
Drop Wt. Impact at –40°C	D 3763[d]			
Force at Max		N(lb)	3000 (670)	3670 (817)
Total Energy		J/(ft·lb)	48 (35)	43 (33)
Failure Mode			Ductile	Ductile
Abrasion Resistance				
Taber, CS-17 wheel, 1 kg load	D 1044	mg/1000 cycles	6	4
Taber, H-18 wheel, 1 kg load	D 1044	mg/1000 cycles	80	120
Miscellaneous				
Specific Gravity	D 792	—	1.15	1.17
Water Absorption (24 h)	D 570	%	0.6	0.6
Softening Point, Vicat	D 1525	°C (°F)	155 (311)	160 (320)
Heat Deflection Temperature	D 648			
0.5 MPa (66 psi)		°C (°F)	54 (130)	60 (140)
1.8 MPa (264 psi)		°C (°F)	46 (115)	48 (119)
Mold Shrinkage	D 955[e]	%		
Length			1.5	1.5
Width			1.4	1.7

[a] These are values based on our experience to date. They are subject to change as additional data are accumulated and statistically treated. Additives of any kind may alter some or all of these properties. Processing conditions may also influence properties.

[b] Differential Scanning Calorimeter

[c] Head speed 50 mm/min [2 in/min].

[d] ASTM D3763 Conditions: 12.7 mm (0.5 in) TUP, 76 mm (3 in) clamp, drop weight 45 kg (100 lb), drop height 500 mm (20 in).

[e] Specimens 25 mm X 25 mm (5 in X 5 in), 0.25 mm (0.05 in) thick

Table 1 (continued)
Physical Properties of Hytrel® DYM Resins (Injection Molded Test Pieces)

DYM350BK	DYM500BK	DYM600BK	DYM830BK	HTX8298BK
55	55	55	59	65
13	14	13	17	13
240 (464)	240 (464)	240 (464)	240 (464)	240 (464)
223 (435)	223 (435)	223 (435)	222 (432)	223 (435)
26 (3770)	26 (3770)	30 (4350)	36 (5260)	36 (5220)
590	510	500	480	300
12 (1740)	12 (1740)	12 (1740)	18 (2610)	23 (3330)
14 (2030)	14 (2030)	15 (2175)	20 (2900)	24 (3480)
15 (2175)	20 (2175)	16 (2320)	21 (3045)	25 (3625)
700 (100,000)	740 (104,000)	770 (110,000)	1250 (180,000)	1950 (280,000)
400 (57,000)	500 (72,000)	600 (85,500)	830 (120,000)	1300 (188,000)
104 (15,000)	102 (14,700)	120 (17,000)	150 (20,000)	200 (30,000)
112 (643)	130 (740)	140 (800)	155 (886)	180 (1000)
115 (660)	150 (858)			
No break	No break	No break	No break	100 (1.8)
No break	No break	No break	160 (2.9)	75 (1.4)
230 (4.2)	350 (6.4)	230 (4.2)	140 (2.5)	
3350 (750)	3500 (790)	3450 (780)	4000 (900)	3350 (750)
48 (35)	48 (35)	45 (33)	50 (36)	48 (35)
Ductile	Ductile	Ductile	Ductile	Ductile
6	7	2	40	50
80	108	130	200	200
1.18	1.18	1.19	1.2	1.22
0.7	0.7	0.7	0.5	0.7
164 (328)	165 (330)	164 (328)	160 (320)	164 (328)
54 (130)	55 (130)	79 (175)	90 (195)	104 (220)
46 (115)	45 (114)	43 (110)	46 (115)	50 (122)
1.4	1.5	1.4	1.5	1.2
1.7	1.7	1.5	1.6	1.2

Melt Properties

The Hytrel® DYM family of thermoplastic polyester elastomers has good flow characteristics for injection molding. The melt viscosity and, hence, the melt flow vary depending on the composition of the resin. The melt viscosity of selected grades vs. temperature is shown in **Figure 1**. The mold flow characteristics are available on representative grades in the Mold Flow data base.

Thermal Properties

When handled properly, the Hytrel® DYM polymers have outstanding thermal stability. In the melt under normal operating conditions, the evolution of gaseous by-products is minimal for most grades. This stability, combined with a chemically pure polymer with no plasticizers, minimizes problems such as changes in viscosity with hold-up time in the injection unit or the formation of black specs at the recommended processing temperatures. An exception to this is during the use of pigment concentrates and additives, where processing outside optimum recommended conditions can accelerate thermal decomposition.

Hytrel® DYM polymers are considered to be "semi-crystalline" in nature. Melting, crystallization and glass transition temperatures of various grades are shown below in **Table 2**. The glass transition measurement from change in tan delta vs. temperature is more sensitive to composition than loss in shear modulus vs. temperature variation. The tan delta vs. temperature and the shear modulus vs. temperature plots for the Hytrel® DYM polymers are shown in **Figure 2** and **Figure 3** respectively.

Figure 1. Melt Viscosity vs. Melt Temperature at Shear Rate of 1000 s^{-1}

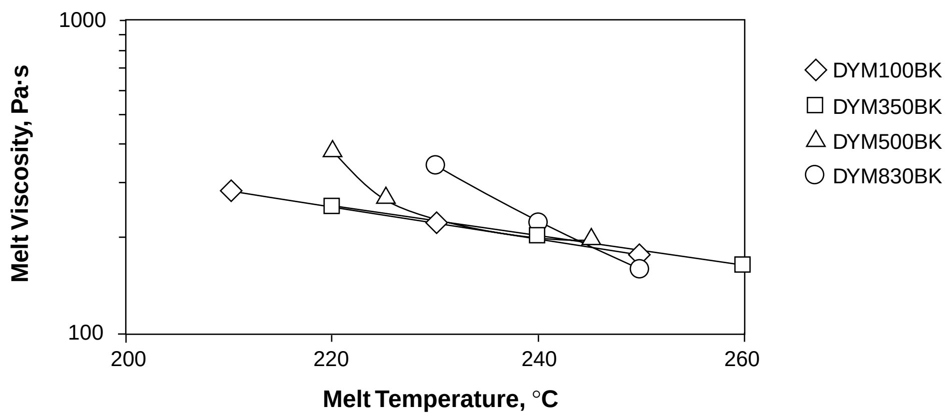


Table 2
Thermal Properties of Hytrel® DYM Resins

Grade	Tm		Tc		delta H_f	Tg	
	°C	°F	°C	°F	J/g	°C	°F
Hytrel® DYM100BK	192	(378)	127	(261)	21	-52	(-62)
Hytrel® DYM160BK	201	(395)	164	(327)	23	-37	(-35)
Hytrel® DYM350BK	223	(435)	178	(353)	26	-58	(-73)
Hytrel® DYM500BK	223	(435)	181	(358)	25	-62	(-80)
Hytrel® DYM600BK	223	(435)	183	(362)	27	-58	(-73)
Hytrel® DYM830BK	222	(432)	193	(380)	28	-64	(-84)
Hytrel® HTX8298BK	223	(435)	192	(378)	36	-67	(-89)

Tm: Melting Temperature (Peak of DSC endotherm)
Tc: Crystallization Temperature (Peak of DSC exotherm)
delta H_f: Heat of fusion (from DSC endotherm)
Tg: Glass Transition Temperature (DMA, from tan delta measurement)

Figure 2. Tan Delta vs. Temperature

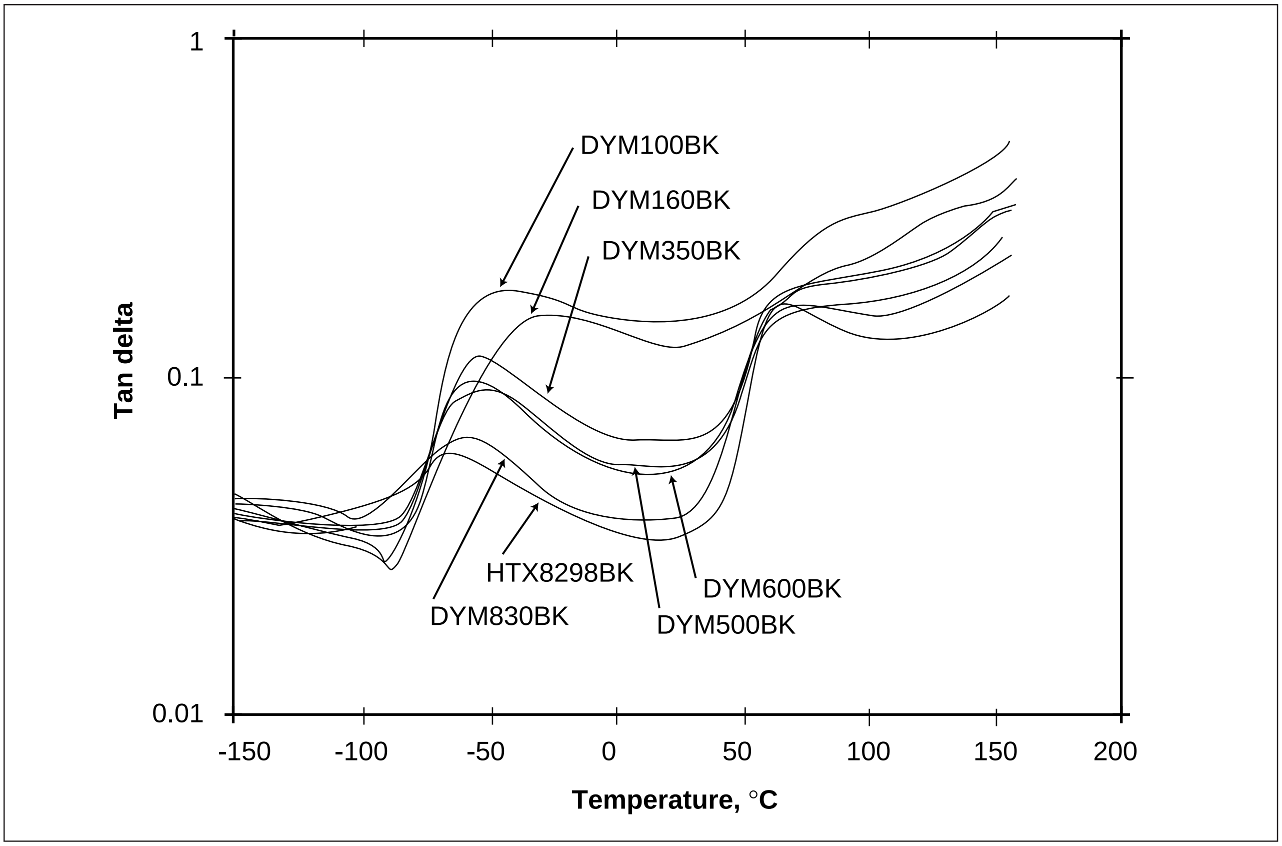
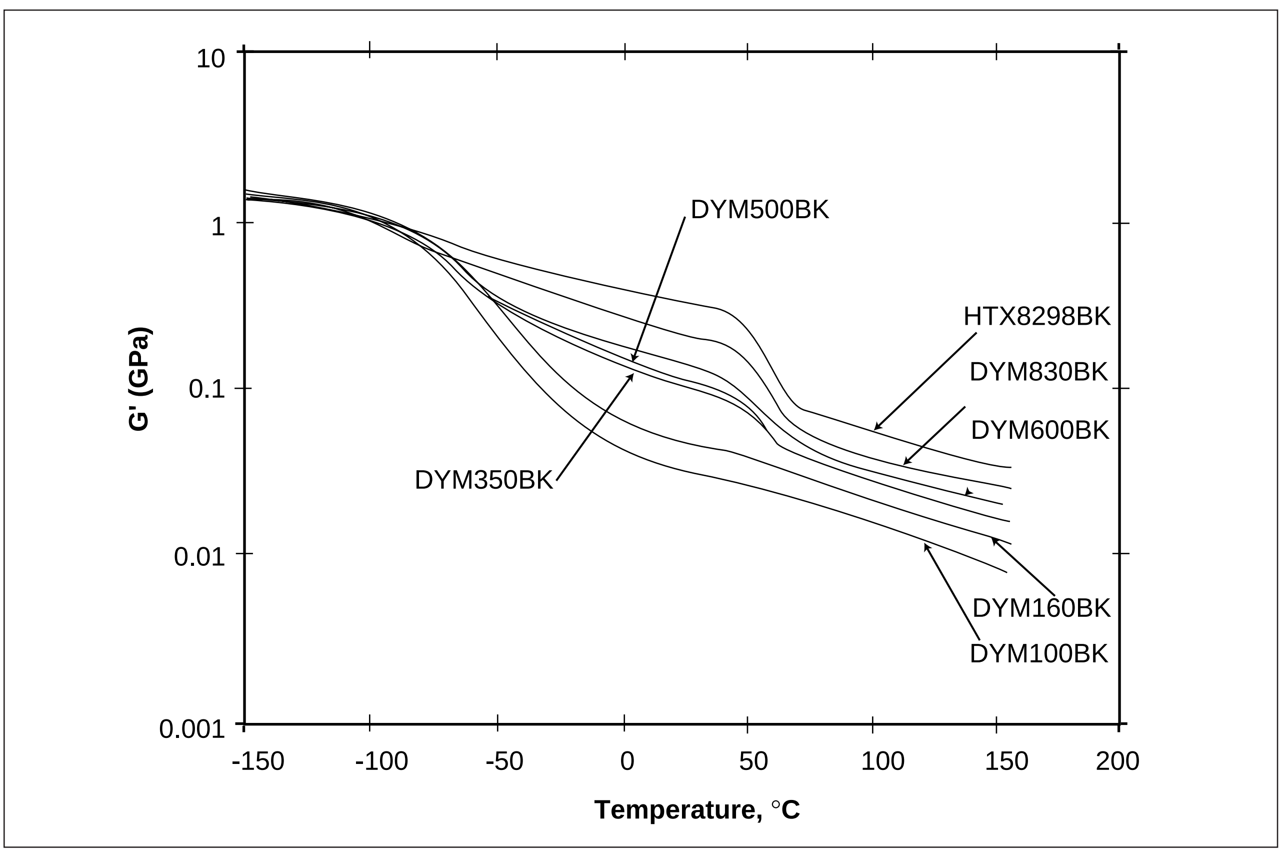


Figure 3. Shear Modulus vs. Temperature



The thermal stability of the Hytrel® DYM polymers permits exposure at melt temperatures of up to 10–15 minutes, total hold-up time, in the molding machine with minimal effect on properties. **Figure 4** shows the melt flow rate for Hytrel® DYM100BK resin samples, after exposure at 220°C (430°F) and 250°C (480°F), DYM350BK and DYM500BK after exposure at 240°C (465°F) and 260°C (500°F) for periods up to one hour. **Figure 5** shows processing stability of Hytrel® DYM100BK, DYM350BK and DYM500BK resins, predried below the moisture content of 0.1% and then injection molded at various melt temperatures.

This stability can be compromised if the moisture level is not maintained below 0.1% or the melt temperature is above the recommended limits.

Figure 4. Thermal Stability vs. Melt Temperatures at Different Holdup Times (moisture <0.1%)

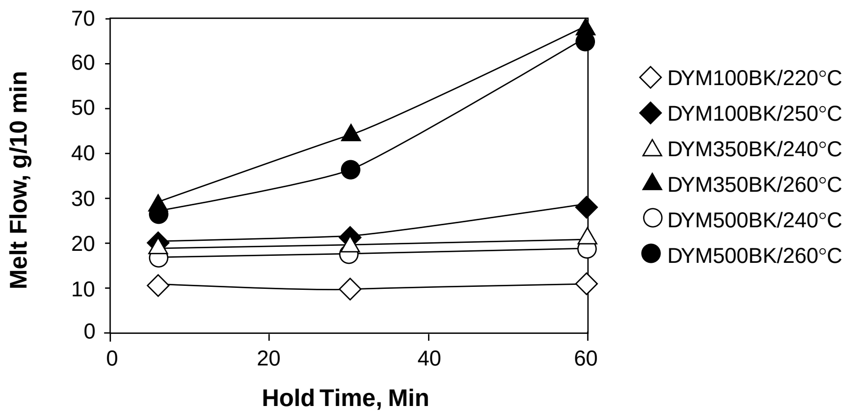
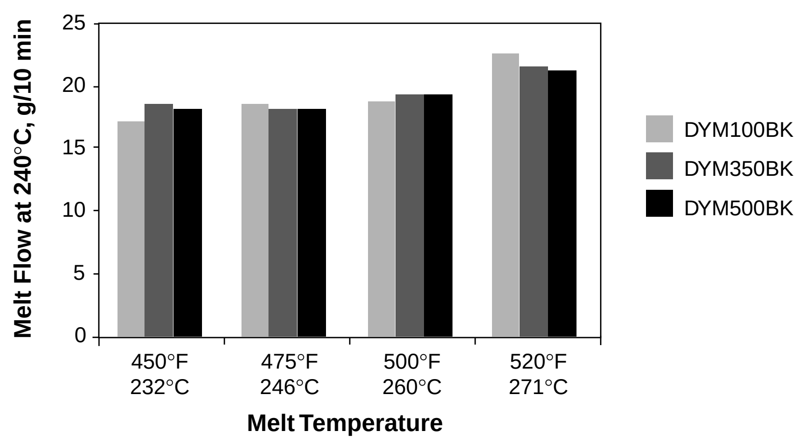


Figure 5. Effect of Processing Temperature on Resin Stability



Material Handling

Drying

The Hytrel® DYM polymers must be dried prior to processing. It is critical to ensure that the resin is dry during processing to make quality parts that give good service performance.

At temperatures substantially above the melting point, excess moisture causes hydrolytic degradation of the polymer. Such degradation results in poor physical properties and brittleness. No visual defects may be apparent but poor in-service performance can occur, particularly at low temperatures.

Generally no degradation of the polymer or imperfections in the molding occur if the moisture content is less than 0.1%. When dry polymer is subjected to 50% relative humidity, 0.1% moisture increase occurs in about 2 hours, whereas at 100% relative humidity, it occurs in less than 1 hour as represented by moisture pick-up vs. time in **Figure 6**. Therefore, pellets so exposed should be re-dried before use. When drying, dehumidified air ovens are recommended. Effective drying with such ovens takes place in 2–3 hours at 100°C (210°F) or overnight at 70°C (160°F) . It is also important to ensure that the dehumidifying medium is dry prior to drying the polymer. **Table 3** lists the equilibrium moisture pick up and the recommended drying conditions for the Hytrel® DYM resins.

During the drying operation, the air flow is very important. For each pound per hour of resin dried, 0.8 to 1 cubic ft/min (CFM) of air flow is required. Depending on the dryer design lower air rates will significantly reduce resin temperature in the hopper dryer. The dew point of the air entering the hopper must be –18°C (0°F) or lower throughout the drying cycle in order to adequately dry Hytrel® DYM resins.

Figure 6. Moisture Absorption of DYM350BK at Ambient Temperature

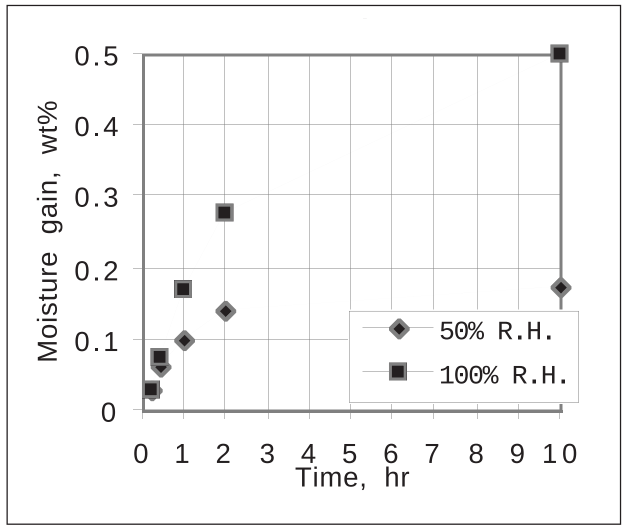


Table 3
Equilibrium Moisture Content and the Recommended Drying Conditions for Hytrel® DYM Resins

Grade	Moisture	Dehumidified drier			
	(24 hr) %	Temp °C (°F)	Time hr	Temp °C (°F)	Time hr
Hytrel® DYM100BK	0.70	100 (210)	2–3	70 (160)	12–48
Hytrel® DYM160BK	0.70	100 (210)	2–3	70 (160)	12–48
Hytrel® DYM350BK	0.65	100 (210)	2–3	70 (160)	12–48
Hytrel® DYM500BK	0.65	100 (210)	2–3	70 (160)	12–48
Hytrel® DYM600BK	0.65	100 (210)	2–3	70 (160)	12–48
Hytrel® DYM830BK	0.60	100 (210)	2–3	70 (160)	12–48
Hytrel® HTX8298BK	0.55	100 (210)	2–3	70 (160)	12–48

Purging

Low or high density polyethylene resins can be used for purging Hytrel® DYM polymers. It is recommended that the injection unit be purged when the machine is shut down. The venting of gases generated during processing at high temperatures or long residence times should be considered. To prevent cross contamination, proper clean up and purging is always recommended before and after molding.

Regrind

Based on limited testing, the use of regrind with the Hytrel® DYM resins at levels up to about 25% has been found to have a negligible effect on the physical properties. However, the use of regrind in air bag deployment door applications should be carefully considered since the quality of regrind is essential to retain mechanical properties. The following points should be carefully considered:

- Keep the thermal history of regrind as short as possible to maintain the high quality of the polymer.
- Use grinders with properly adjusted, sharp knives shaped for polyethylene cutting to produce clean regrind with a minimum amount of fines.
- Regrind should be about the same size as the virgin pellets.
- Excessive amounts of fines should be removed.
- Degraded or contaminated regrind must be discarded.
- All regrind needs to be dried before molding.

The melt flow rate test can be used to check the quality of regrind.

Molding Equipment

The Hytrel® DYM resins can be molded on standard injection molding machines. A press capacity of 3–5 tons per square inch of part projected area is recommended. There is no need to consider special corrosion resistant or wear resistant metals for the machine or molds.

Screw Design

General purpose screws with a gradual transition zone are recommended. To avoid excessive shear of the polymer or bridging of the elastomeric pellets, screw compression ratio should not exceed 3.5:1 and the metering zone should be relatively deep, from 2.5 to 3.0 mm (0.100 to 0.120 in) for a 60 mm (2.35 in) screw. For a more uniform polymer melt and mixing, screw L/D (length to diameter) ratio should be at least 20:1, and a compression ratio at least 2.5:1. Suggested screw designs are summarized as follows:

Screw Diameter, mm (in)	Feed Zone Depth, mm (in)	Metering Zone Depth, mm (in)
51 (2.0)	8.13 (0.320)	2.54 (0.100)
63 (2.5)	9.65 (0.380)	2.79 (0.120)
89 (3.5)	10.16 (0.400)	3.17 (0.125)

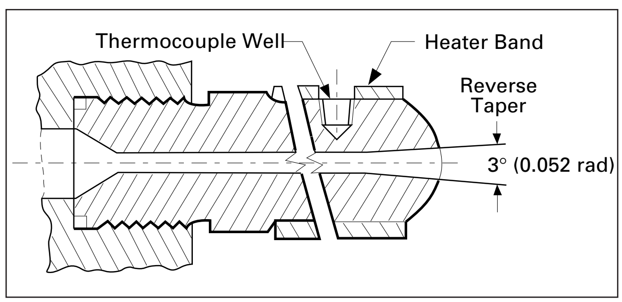
Feed section length—50% of screw length

Transition section length—25%

Metering section length—25%

At the screw tip, non-return valves ensure the consistency of shot weight and cavity pressure from shot to shot. **Figure 7** shows the recommended non-return valve design.

Figure 7. Reverse Taper Nozzle



Nozzle Design

Nozzles with reverse taper as shown in **Figure 8** are recommended for processing Hytrel® DYM resins. Shut-off nozzles are not required because Hytrel® DYM resins do not drool at normal operating temperatures. Nozzle diameter somewhat larger than normal is recommended to reduce pressure drop in filling the mold.

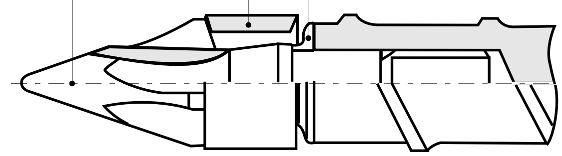
Clamping Force

The force required to hold the mold closed against injection pressure depends on;

- Injection pressure to fill the mold and pack out parts
- Injection speed required for filling the part
- The dimensions of the part and runner at the mold parting line
- Mold details—lateral slide actions, core pull requirements etc.
- Precision and tolerance requirements.

Most well built molds can be adequately clamped if the machine has 48–49 MPa (3.5–5.0 tons/sq. in) based on the projected area, since injection pressures are seldom over 100 Mpa (14 kpsi) and fill rates are moderate. Higher available clamping pressure gives more freedom in choosing suitable molding parameters.

Figure 8. Non-Return Valve



Molding Conditions

Melt Temperature

The melt temperature should be taken directly from the molten polymer (using a needle pyrometer) and should be checked periodically during production. Typical melt temperatures and cylinder settings are shown in **Table 4.**

Table 4
Recommended Optimum Melt Temperatures and Injection Molding Setup Conditions for Hytrel® DYM Resins

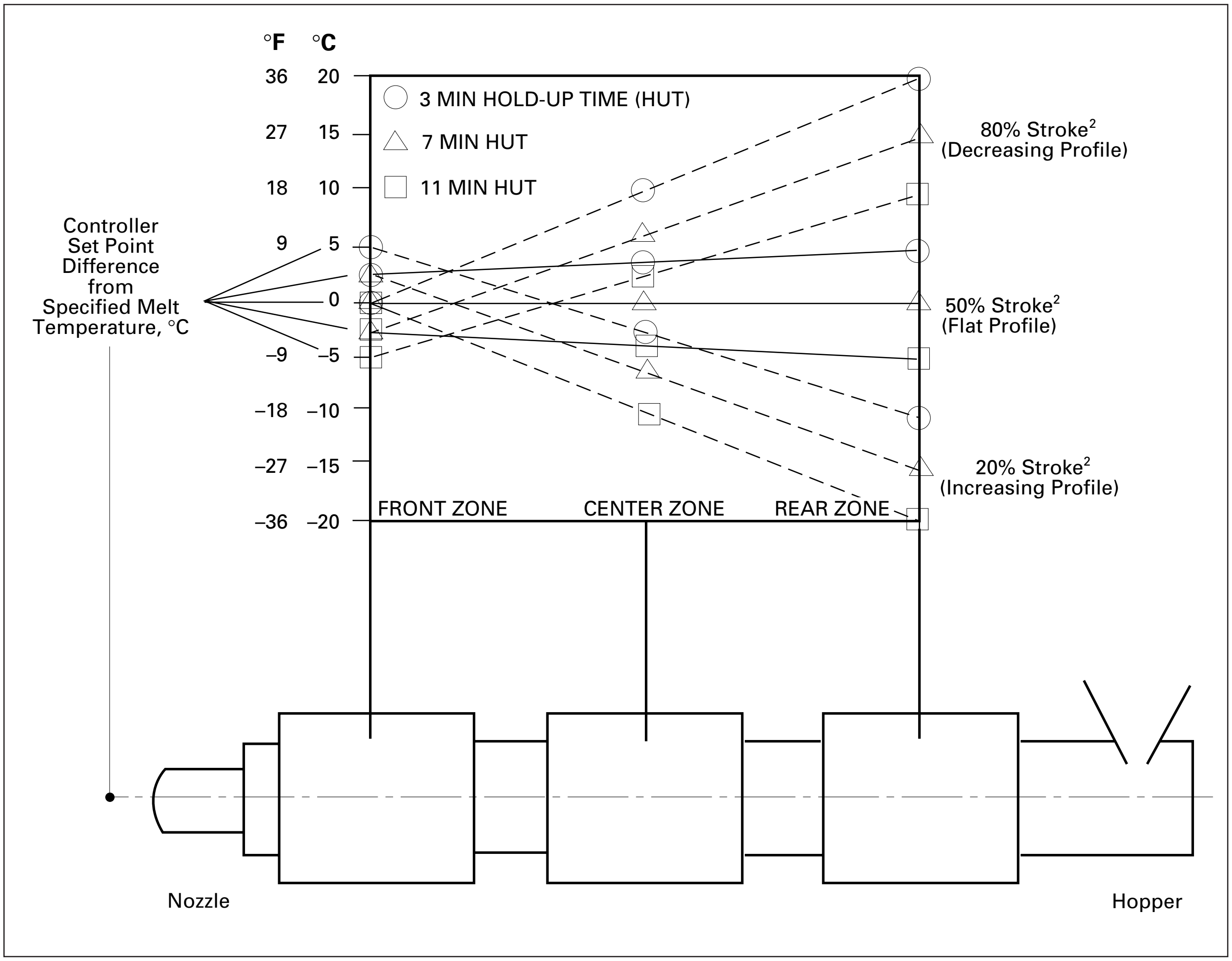
Grade	Optimum Melt Temperature	Melt (Stock) Temp. Range	Typical Cylinder Temperatures			
			Nozzle	Front	Center	Rear
DYM100BK DYM160BK	230°C (445°F)	220–250°C (430–480°F)	220°C (430°F)	235°C (455°F)	235°C (455°F)	205-235°C (400–455°F)
DYM350BK DYM500BK DYM600BK	240°C (465°F)	235-260°C (455–500°F)	230°C (445°F)	245°C (475°F)	245°C (475°F)	215-245°C (420–475°F)
DYM830BK HTR8298BK	245°C (475°F)	240–260°C 465–500°F)	235°C (455°F)	250°C (480°F)	250°C (480°F)	220–250°C (430–480°F)

Cylinder Temperature Profile

A rising cylinder temperature profile (lower rear temperature) is normally preferred when higher than recommended melt temperatures are used to minimize sticking of pellets to the screw. Occasionally, a decreasing cylinder temperature profile can be used to reduce screw torque or to improve melt homogeneity.

As a general guideline, the graph in **Figure 9** can be used to define the optimum cylinder temperature profile, as based on hold up-time (HUT) and percent of stroke used. Screw design, however, should also be taken into consideration.

Figure 9. Cylinder Settings[1] for a Specified Melt Temperature— Recommended Controller Set Points from Target Value



[1] Barrel residence time, shot size and desired melt temperature each influences the barrel settings for optimum melt quality.
[2] The percent stroke refers to the portion of the actual machine shot capacity.

Nozzle Temperature

The nozzle temperature should be adjusted to prevent freeze-off or drool. For optimum performance, it should be controlled independently at a point near the orifice. To prevent drooling in certain cases, the use of pressure relief (suck-back) is recommended.

Mold Temperature

Mold temperature should be measured with a thermocouple directly on the cavity surface. Recommended mold temperature is 45°C (115°F). Mold temperatures of between 25–65°C (75–150°F) have been demonstrated. Mold temperature has little effect on mechanical properties. The main effect is on shrinkage.

Lower mold temperatures can reduce cycle time and improve ejection, but will reduce as-molded shrinkage. Higher mold temperatures can improve surface finish and increase flow length potential, but may increase shrinkage and lengthen the cycle.

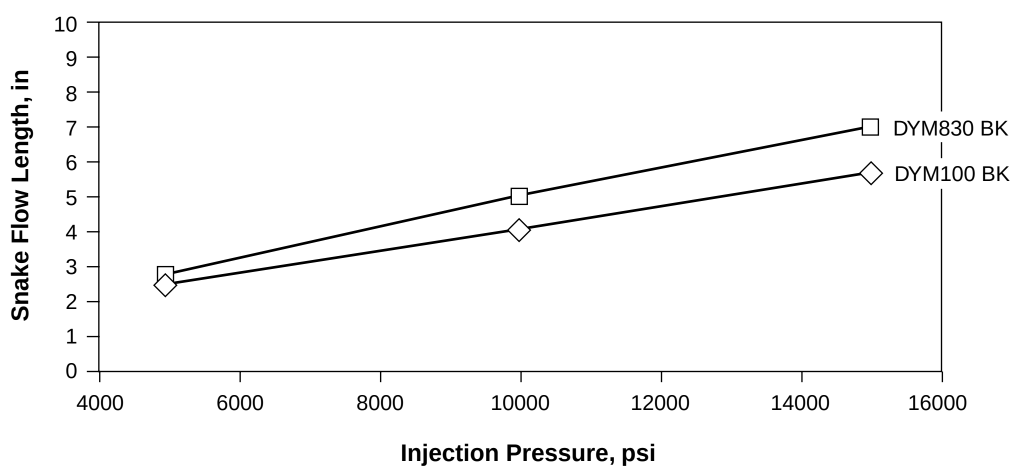
Injection Speed

Injection speed will vary with part thickness and geometry. In general, thin parts should be filled faster than thick parts. Air bag doors with thin tear seams should be filled rapidly to avoid premature freezing of the polymer in the thin tear seam. Excessively high fill rates can cause jetting, turbulence or severe shear heating that may result in surface defects.

Injection and Hold Pressure

The injection pressure should be set to the minimum pressure required for filling the cavity. The hold pressure is typically held constant with sufficient time and pressure to optimize dimensions and appearance. A decreasing pressure profile can be used to reduce sticking of the part or distortion at the gate. High pressure will reduce the apparent mold shrinkage, but increase flash. **Figure 10** shows the influence of injection pressure on snake flow length of representative Hytrel® DYM resins.

Figure 10. Snake Flow Length on DYM resins at Various Injection Pressures, 1 mm (0.04 in) thick



Screw Forward Time

The holding pressure should be maintained for the time necessary to avoid sink marks and for the gate to seal. Typically, the screw forward time for Hytrel® DYM polymers should be 5–6 seconds for each mm of part thickness. Screw forward time should be adjusted to achieve maximum part weight and minimum shrinkage.

Screw Rotation Speed and Back Pressure

For Hytrel® DYM polymers, a medium to fast screw speed is usually adequate (100 RPM is typical). Minimal back pressure of 0.34 to 0.55 MPa (50 to 80 psi) is recommended. Higher back pressure and screw speed can be used to improve mixing in the polymer.

Cycle Time

Molding cycle time is dependent on part size and on polymer melt and mold cavity temperatures. For air bag doors with 2 to 4 mm part thickness, cycle time of 30 to 60 seconds is typical.

Mold Design

The following paragraphs stress some of the important aspects that should be considered when designing molds for air bag deployment doors and other parts made of Hytrel® DYM polymers.

Material of Construction

No special materials are required since the Hytrel® DYM family of polymers have no corrosive effect on the alloys commonly used for injection molds and cavities.

Mold Surface Finish

Textured and matte finished cavity surfaces work well with Hytrel® DYM polymers. Highly polished, plated mold finishes may cause difficulty in ejecting parts.

Sprue Bushing Design

An incorrect sprue bushing frequently causes sprue sticking and unnecessary cycle delays. The diameter of the sprue at the smaller end should be equal to the diameter of the runner it feeds. A standard bushing should have a taper of at least 2.5°, but larger tapers can result in less sprue sticking.

A properly mated injection nozzle and sprue bushing facilitates ejection of the sprue. The diameter of the hole in the nozzle should be 0.5–1.0 mm (0.02–0.04 in) less than that of the sprue bushing. Since the Hytrel® DYM polymers are elastomeric, sprue pullers with a generous undercut (e.g. "Z" pullers, sucker pin, or offset undercut type) are needed for sprue removal.

Runners

Runners should be streamlined to reduce turbulence. A full round or trapezoidal runner should be used whenever possible to minimize pressure drop and for ease of removal. A trapezoidal runner should have its depth not less than 75% of its width. Runner systems should have a balanced layout. Runner section depends on the runner length and the size of the parts. A typical runner for an air bag door is 4–8 mm (0.16–0.32 in) diameter. To improve flow and to facilitate ejection, the surface of the runners should be smooth, but not polished.

Hot Runner Systems

Runnerless molding, both insulated and hot runner, can be used with Hytrel® DYM polymers. It is important to work closely with the supplier of the hot runner system in order to optimize the design for the particular needs of each application. Some important items to consider when selecting or specifying a hot runner system are shown below.

TEMPERATURE CONTROL—Sufficient heating capacity and control must be provided to ensure that neither freezing nor overheating occur. Uniform temperature throughout the hot runner system is important. Temperature controls should be capable of maintaining a temperature difference of no more than 5–10°C (10–20°F) throughout the system.

BALANCED FLOW—Each branch of the runner system must have the same flow length, size and pressure drop to each cavity or part section.

RESIN HOLD-UP—The hot runners must have smooth contours and no areas of resin hold-up which can cause degradation of the polymer.

SIZING—Hot runners should be sized to minimize pressure drop. A reasonable limit should be used to keep the pressure drop in the runner system to less than 25% of the total pressure to fill the parts. Shear rate should be uniform in each branch of the runner. Excessively high shear should be avoided, but it should be sufficient to keep material moving close to the melt channel walls (500–1000 sec^{-1}). Temperature rise due to frictional heating should be minimized and limited to about 20°C (35°F) maximum. Hot runner systems do increase the residence time of the polymer at melt temperature. The total polymer residence time including the machine and the runner system should be less than 15 minutes.

Gate Type and Size

Conventional rectangular, round, or tunnel gates can be used with Hytrel® DYM polymers. Wider fan gates or flash gates are recommended for applications where flow lines and distortion at the gate are an issue. For thick section molding, sprue gates are usually required to eliminate sinks.

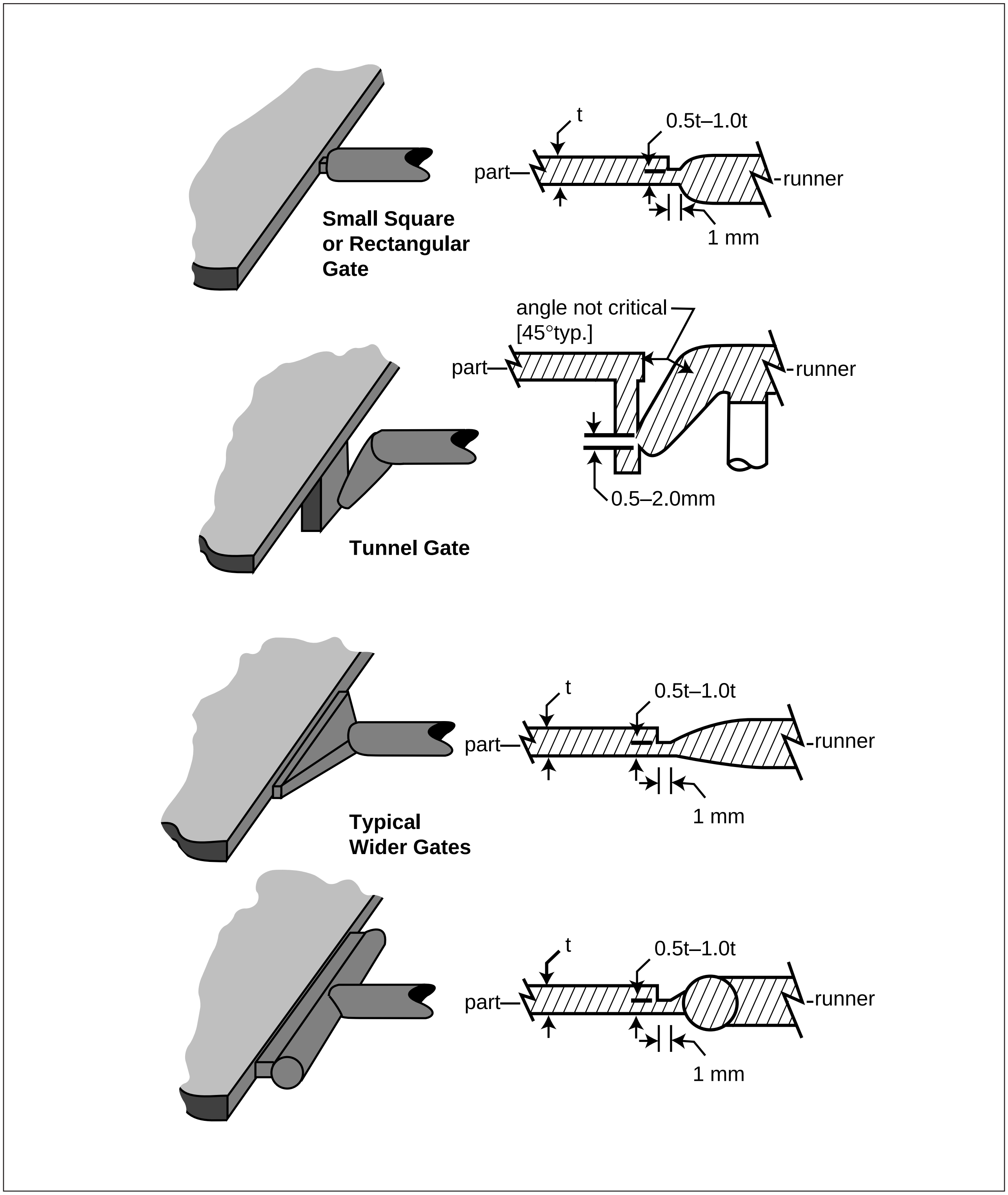
Tunnel gates as small as 0.5 mm (0.02 in) diameter can be used. The edges of the gate should be kept sharp to help break the gate. If the gate is large in diameter or the edges are radiused, the gate may be difficult to break off.

Gate dimensions are important. Gates too small will require high injection pressure and will result in high shear forces. Oversized gates may lead to longer hold time to avoid flow back, sink marks and degating problems. In general, gate thickness should be half the part thickness. For parts less than 1.5 mm (0.06 in) thick, the gate should be the same thickness as the part. Gate lands should be between 0.5-1.0 mm (0.02-0.04 in).

To avoid sink marks and filling problems, the gate should be located in the thickest section of the part.

See **Figure 11** for gate details.

Figure 11. Typical Gate Configurations



Gate Location

For air bag deployment doors, the location of the gate relative to the tear seam is very important in producing a part that is durable and performs well. With thin tear seams, the polymer can freeze prematurely at the seam, resulting in trapped air and poor weld line strength. If polymer flow is stopped or slowed at the seam, it can freeze in as little time as 1 second. Two recommended gate location concepts are shown in **Figure 12**.

In the case with flow across the seam, the gate should be located in the portion of the cavity with the larger volume of material on the gate side of the seam. The position of the gate should be such that the portion of the cavity near the gate can be filled uniformly before the material is pushed across the seam. This design works best for parts that have a rather small tear seam length and relatively little difference between part length and width. In the case for flow parallel to the tear seam, the part is gated at two locations, one on either side of the tear seam. In this design, the two flow fronts proceed equally along the length of the seam, knitting together as they flow. If the cavity volumes on either side of the tear seam are different, it is necessary to size the two gates differently to get equal flow along the seam. Mold filling analysis can be an effective tool for evaluating gate location and sizing.

Venting

Venting provides a path for the escape of air from the cavity as the polymer displaces it. Flow into any cavity can be seriously reduced by inadequate venting of the cavity. When runners are long or large in diameter, they should be vented as well. This is important since fast cavity fill rates are normally used with Hytrel® DYM polymers.

Use of mold release spray is not recommended during processing with Hytrel® DYM polymers as it can interfere with the post molding paint adhesion. If such mold release spray is used, the venting problems may be made more obvious. If venting is poor, hydrocarbon based spray will leave a burned dark spot where the air is trapped. Poor venting may also cause pitting or corrosion of the metal surfaces of the mold. This is the result of repeated brief exposure to very high temperatures from rapid compression of air and gases. In some cases, when adequate venting can not be provided, it may be desirable to use stainless steel for cavities or to plate them with chrome or electroless nickel.

Venting problems may be aggravated by high melt temperature, long holdup time or holdup areas in the molding cylinder, which will generate more than normal amounts of gases.

The vent opening into the mold should be broad, but thin. Vent openings up to 6 mm (0.25 in) wide should not be deeper than 0.04 mm (0.0015 in) to minimize the danger of flash. Vents are positioned at points of final fill to prevent burning of the part from trapped air which can be compressed to very high temperatures. Sometimes air entrapment can not be predicted before initial molding trial, and vents must be added after the molds are made for production. An example of 'good' venting is represented in **Figure 13**.

Figure 12. Gating Concepts for Air Bag Deployment Door Molds

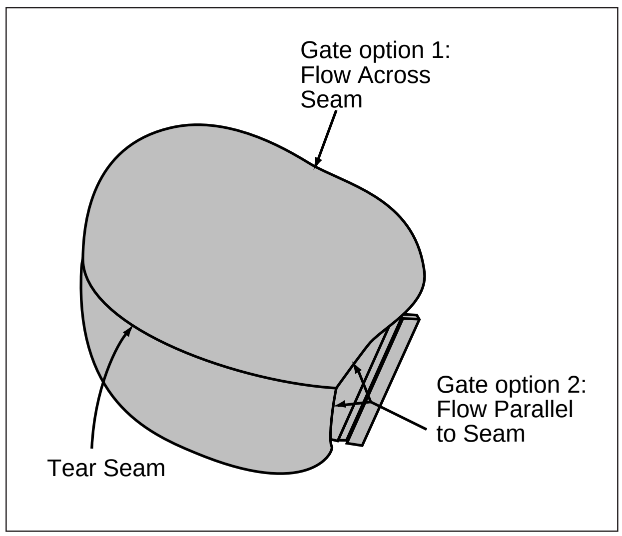
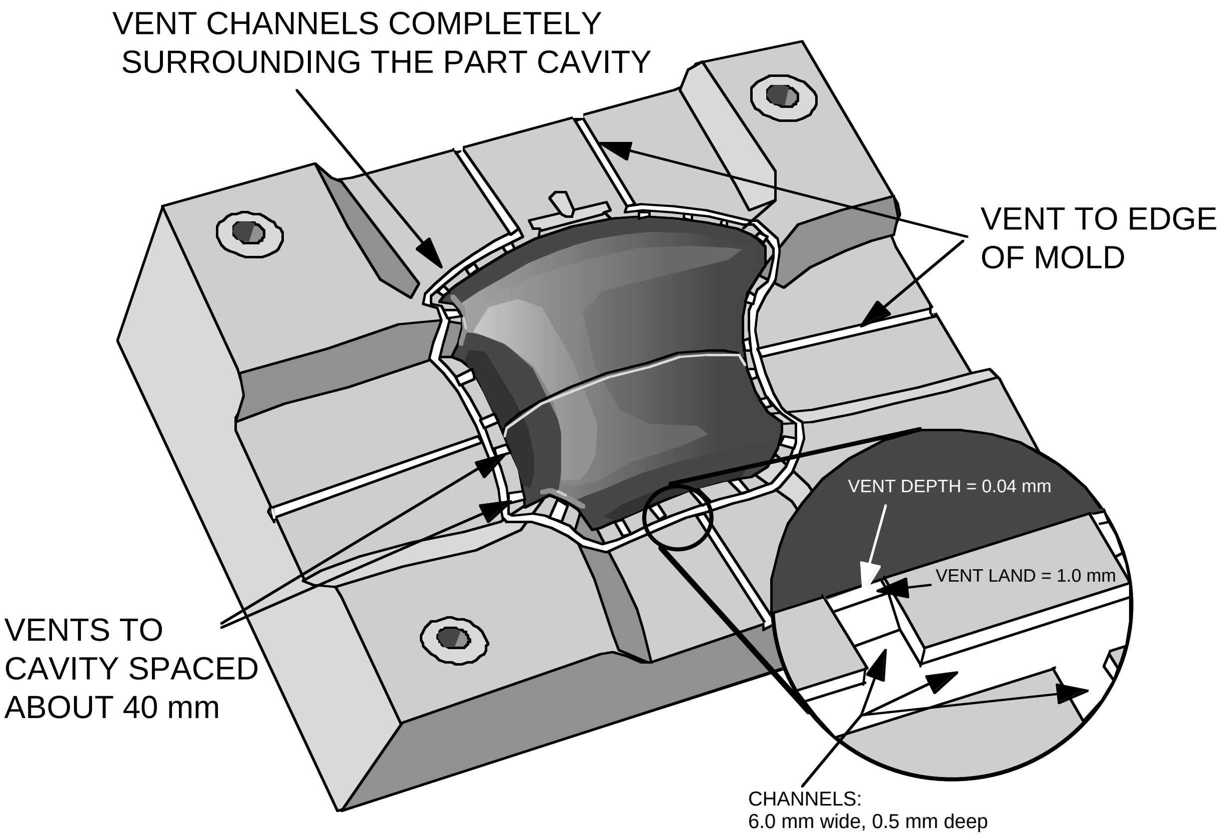


Figure 13. Venting for Optimum Molding



Undercuts

The depth of undercut that can be stripped from the mold will vary with size and shape of the part, overall cycle, and mold temperature. Undercuts should be radiused generously to aid ejection and should be no more than 0.8 mm (0.03 in) deep. Placing the undercut near the ejection or stripper plate helps avoid distortion of the part on demolding.

Part Ejection

Ample draft, 0.5 to 2.0° taper per side, will ease ejection especially when a core is removed from a deep part or a part is removed from a deep cavity. When a mold must have very little or no draft, stripper plates are recommended for ejection. When pin ejectors are used, they should have a large surface area and act on the thickest sections of the part. Ejector mechanism should be located to provide uniform stripping of the part from the mold.

If the part is small, the knockouts should be shaped proportionately to the part (i.e., ring, disc, etc.). If the part is large, use 13–25 mm (0.5–1.0 in) diameter pins if design permits.

Undercuts should have room to flex during ejection.

To reduce possible sticking problems, a matted surface finish on molds is preferable.

Shrinkage

The shrinkage of Hytrel® DYM polymers in injection molding process depends on numerous factors such as:

- Grade of Hytrel® DYM resin
- Molding conditions (injection pressure, screw forward time, mold temperature)
- Part geometry and thickness
- Mold design, runner, sprue system, gate size.

The nominal shrinkage values obtained as per ASTM D955 test procedure on test specimens of 3.2 mm (0.125 in) thickness molded at standard conditions are listed in **Table 1** on page 2 and 3.

Mold Temperature: 45°C (115°F)

Melt Temperature: as recommended in Table 4

Injection Pressure: 10,000 psi

SFT: optimum

Figures 14–16 show the influences on shrinkage of different injection molding parameters. They can be applied to any of the Hytrel® DYM polymers and will provide general guidelines to help in predicting the shrinkage. Nevertheless, they cannot give an exact value. The shrinkage evaluation for precision parts should be made on a prototype tool.

The shrinkage values given in the following figures should be added to or subtracted from the nominal shrinkage in order to get a first approximation of final shrinkage. The shrinkage values were measured on a 5 in × 5 in specimen.

Post Mold Shrinkage

Post mold shrinkage is measured after annealing parts at 120°C (248°F) for 4 hours. The absolute value of post-mold shrinkage for parts molded at recommended conditions is low, less than 0.1%.

Figure 14. Effect of Thickness and Flow Direction on Shrinkage of DYM100BK

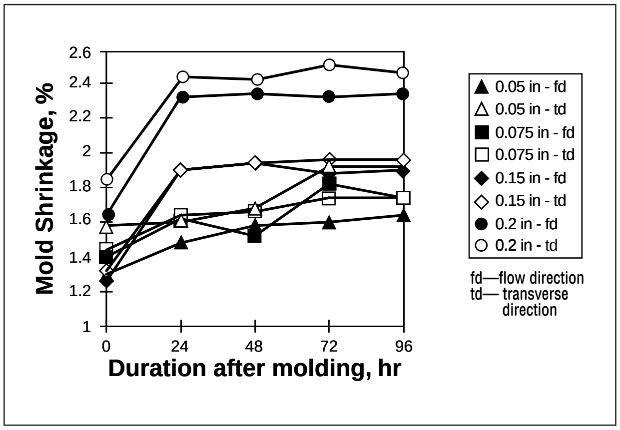


Figure 15. Effect of Thickness and Flow Direction on Shrinkage of DYM350BK

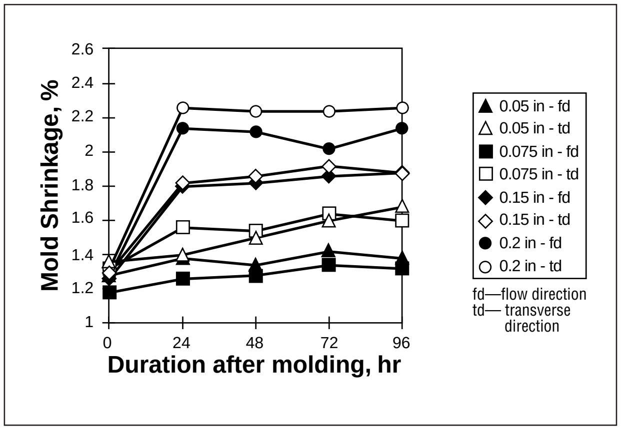
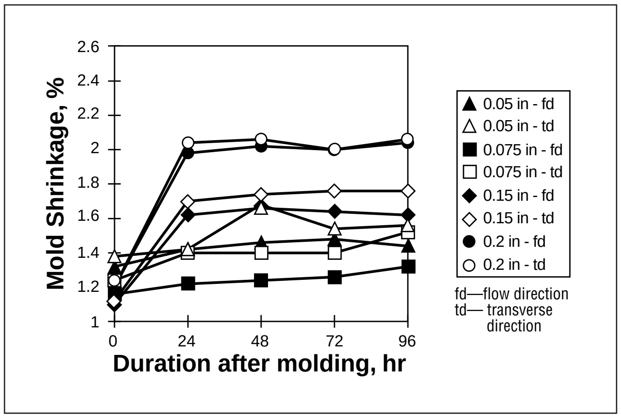


Figure 16. Effect of Thickness and Flow Direction on Shrinkage of DYM500BK



Tensile Properties

Tensile elongation and tensile modulus measurements are among the most important indications of strength in a material and are the most widely specified properties of plastic materials. The tensile test is a measurement of the ability of a material to withstand forces that tend to pull it apart and to determine to what extent the material stretches before breaking. The tensile modulus of elasticity is an indication of the relative stiffness of a material and can be determined from a stress-strain diagram. Different types of materials are often compared on the basis of tensile strength, elongation, and tensile modulus.

Tensile Stress-Strain

A stress-strain curve shows the relationship of an increasing force on a test sample to the resulting elongation of the sample. Some of the factors that affect the curve are: temperature, type of resin, rate of testing, etc.

Tensile properties over a range of temperatures are shown in **Figures 17–22**. Because of the elastomeric nature of Hytrel® DYM resins, elongation before break is high; as a result, low-strain-level and high-strain-level curves are presented separately to facilitate selection of strain levels.

The effect of the direction of the flow on the tensile properties, over a range of temperatures, is shown in **Figures 23–25**.

Tensile Strength

The tensile strength values are obtained from stress-strain curves by noting the maximum stress on the curve. The maximum tensile values are given in **Table 1** and can be used in rating the relative resin strengths.

Generally, the stiffer grades of Hytrel® DYM resins show higher tensile strengths and shorter elongations than the softer grades. The stiffer grades are higher in the crystalline polyester hard segment and therefore behave more like typical engineering plastics.

Yield Strength

The yield strength, also taken from the stress-strain curve, is the point at which the material continues to elongate (strain) without additional stress. The yield strength often has a lower value than the tensile strength. For Hytrel® DYM resins, the maximum stress is usually at the breaking point; however, for some of the harder grades at low temperatures, the maximum stress may be at the yield point. The more flexible grades behave more like elastomeric materials. They do not show any yield under the conditions used in the tests.

In the design of plastic parts, yield strength is the most common reference, as it is uncommon for a part to be stressed beyond the yield point. It is good practice to design within the proportional limit, which is substantially below the yield point.

Figure 17. Tensile Properties—Hytrel® DYM100BK

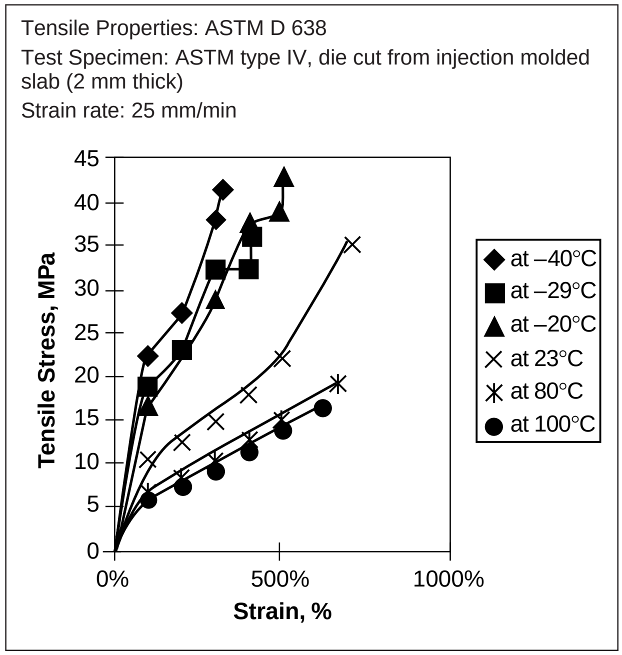


Figure 18. Tensile Properties of Low Strain Hytrel® DYM100BK

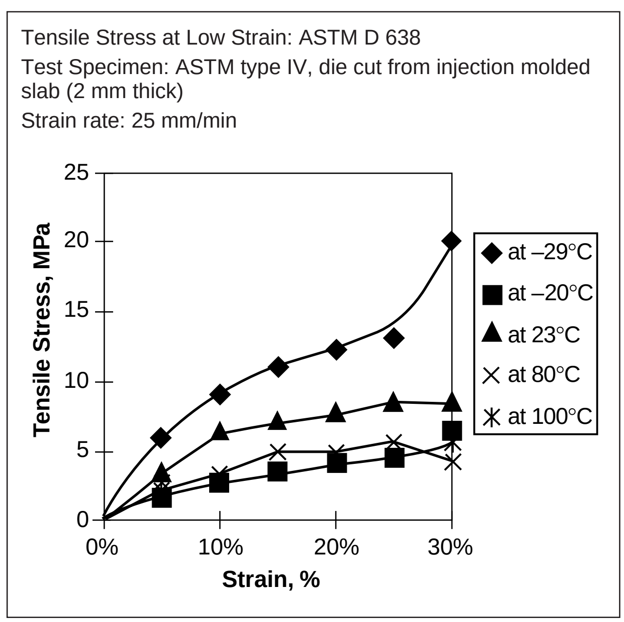


Figure 19. Tensile Properties—Hytrel® DYM350BK

Tensile Properties: ASTM D 638
Test Specimen: ASTM type IV, die cut from injection molded slab (2 mm thick)
Strain rate: 25 mm/min

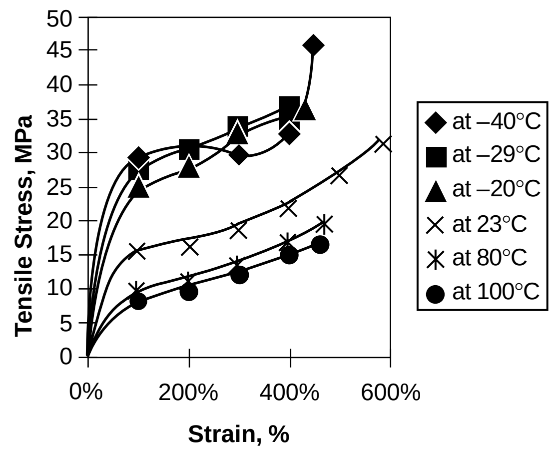


Figure 20. Tensile Properties of Low Strain Hytrel® DYM350BK

Tensile Stress at Low Strain: ASTM D 638
Test Specimen: ASTM type IV, die cut from injection molded slab (2 mm thick)
Strain rate: 25 mm/min

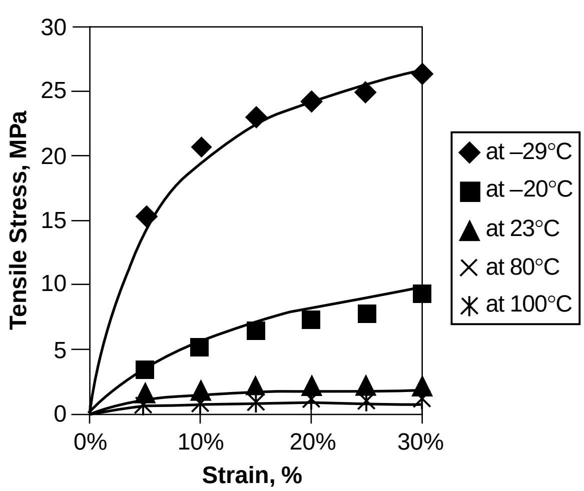


Figure 21. Tensile Properties—Hytrel® DYM500BK

Tensile Properties: ASTM D 638
Test Specimen: ASTM type IV, die cut from injection molded slab (2 mm thick)
Strain rate: 25 mm/min

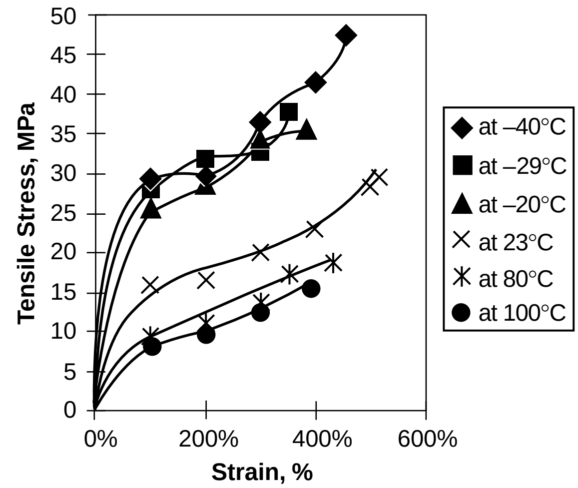


Figure 22. Tensile Properties of Low Strain Hytrel® DYM500BK

Tensile Properties at Low Strain: ASTM D 638
Test Specimen: ASTM type IV, die cut from injection molded slab (2 mm thick)
Strain rate: 25 mm/min

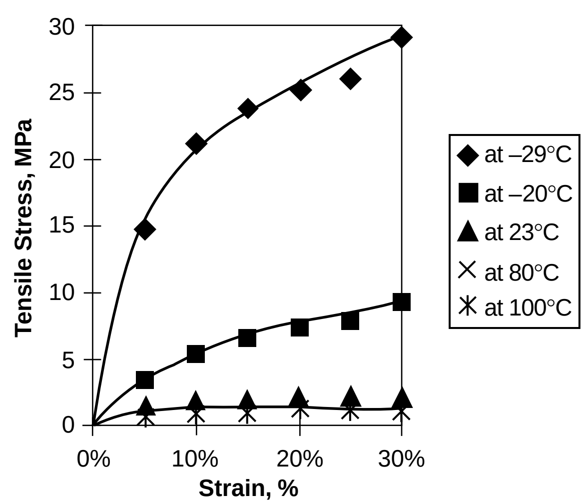


Figure 23. Tensile Properties—DYM100BK (Flow and Transverse Direction)

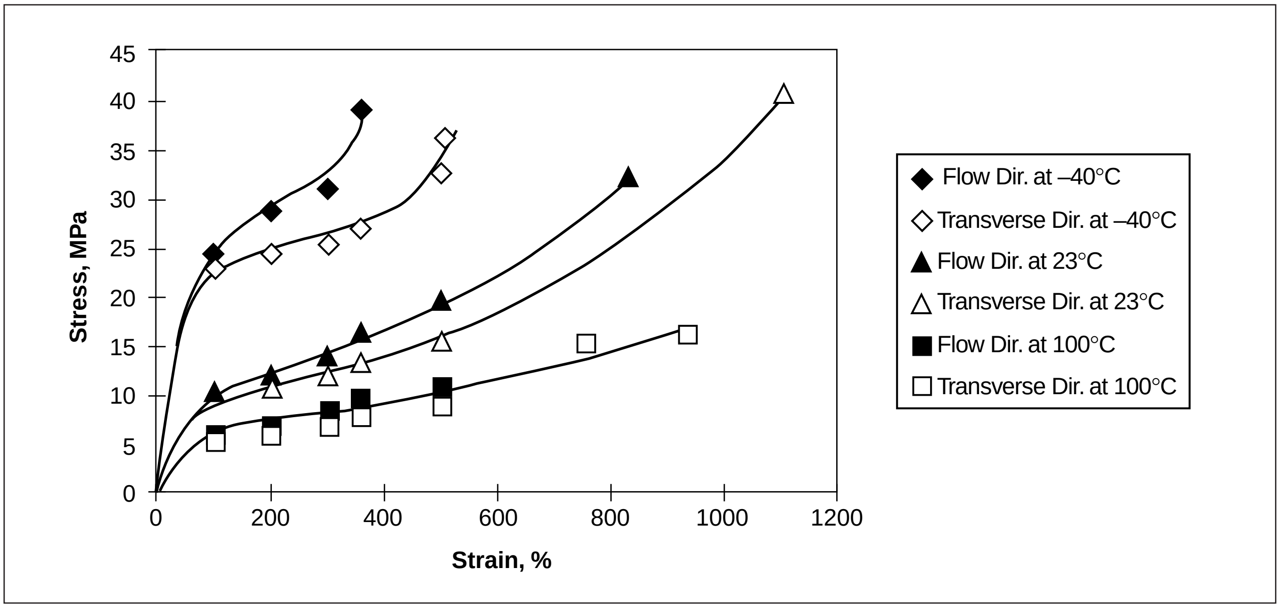


Figure 24. Tensile Properties—DYM350BK (Flow and Transverse Direction)

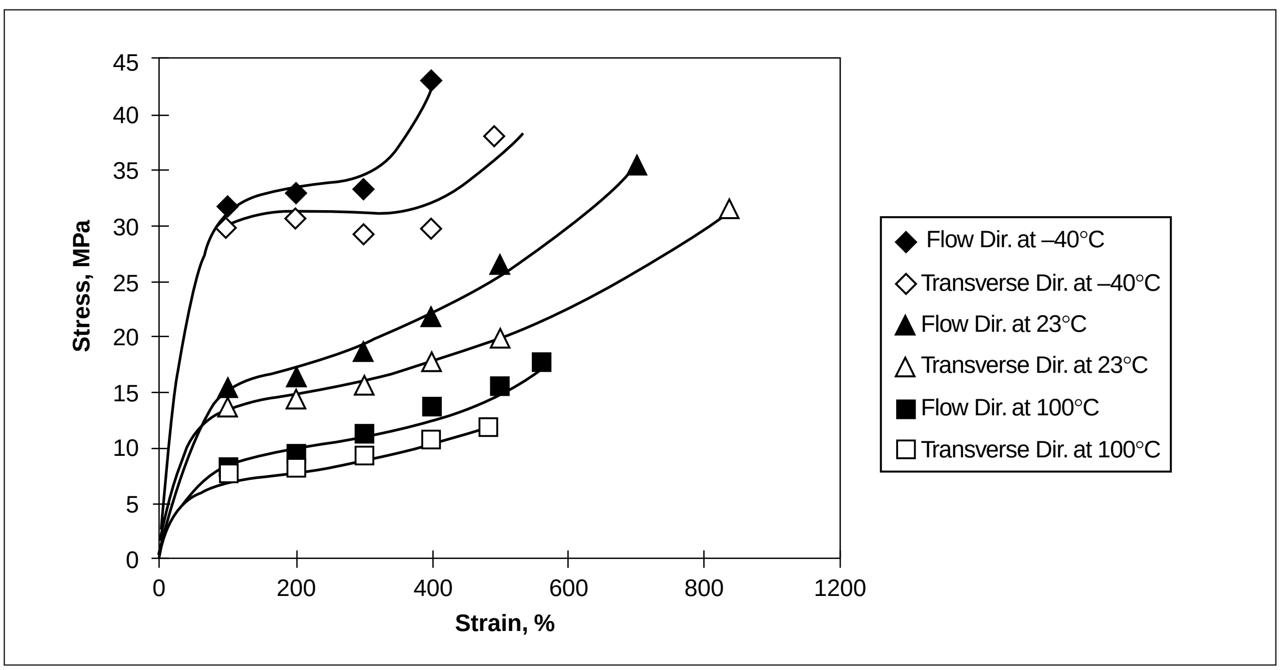
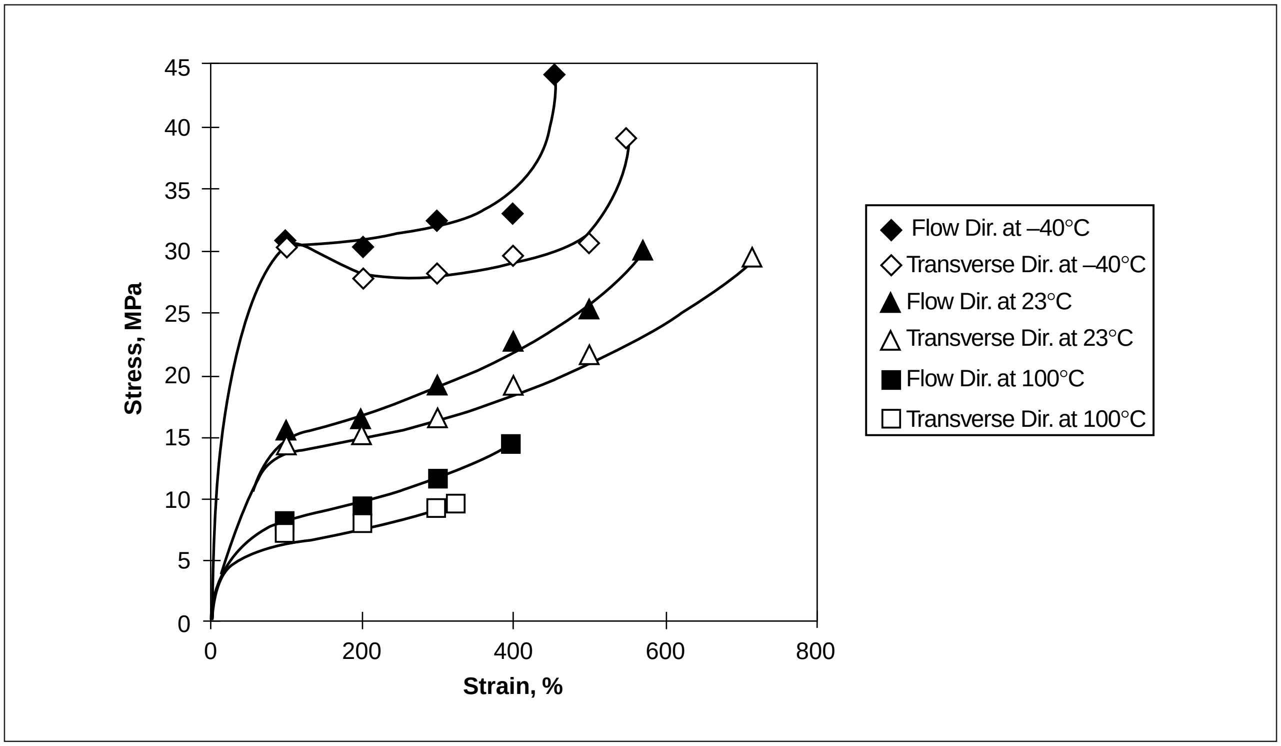


Figure 25. Tensile Properties—DYM500BK (Flow and Transverse Direction)



Poissons' Ratio

Poissons' ratio measures the relative ability of a material to deform at right angles to applied stress. It permits the mathematical determination of a material's physical characteristics and values in a direction perpendicular to the direction of loading.

Poissons' ratio is defined as the ratio of the transverse strain to the longitudinal strain of a material. For plastics, the ratio is affected by time, temperature, stress, sample size, etc.

Poissons' ratio for most Hytrel® DYM resins at 23°C (73°F) is 0.45. The value does not change significantly from resin to resin.

Electrical Properties

Electrical measurements show that Hytrel® DYM resins are suitable for low voltage, electrostatic paint application. The properties shown in **Table 5** were measured on injection molded plaques with the dimensions 76 × 127 × 1.9 mm (3 × 5 × 0.075 in).

Table 5
Electrical Properties at Room Temperature and 50% RH.

Property	ASTM Method	DYM100 BK	DYM350 BK	DYM500 BK
Volume Resistivity, Ω·cm	D 257	2.07E+12	7.87E+12	5.51E+12
Dielectric Strength, V/mil	D 149	579.68	488.31	514.67
Dilelectric Constant	D 150			
100 Hz		4.893	4.551	4.424
1 KHz		4.844	4.509	4.39
1 MHz		4.573	4.252	4.184
Dissipation Factor	D 150			
100 Hz		0.01616	0.01158	0.00962
1 KHz		0.0071	0.00648	0.00546
1 MHz		0.02864	0.02686	0.02424

Identity and Trademark Standards

Guidelines for Customer Use—Joint ventures and authorized resellers

Only joint ventures and resellers who have signed special agreements with DuPont to resell DuPont products in their original form and/or packaging are authorized to use the Oval trademark, subject to the approval of an External Affairs representative.

Guidelines for Customer Use—All other customers

All other customer usage is limited to a product signature arrangement, using Times Roman typography, that allows mention of DuPont products that serve as ingredients in the customer's products. In this signature, the phrase, "Only by DuPont" follows the product name.

Hytrel® Only by DuPont   or   Hytrel®
Only by DuPont

A registration notice ® or an asterisk referencing the registration is required. In text, "Only by DuPont" may follow the product name on the same line, separated by two letter-spaces (see above example). When a DuPont product name is used in text, a ® or a reference by use of an asterisk must follow the product name. For example, "This device is made of quality DuPont Hytrel® polyester elastomer for durability and corrosion resistance."

*Hytrel is a DuPont registered trademark.

Rev. August. 1995

DUPONT®

Hytrel®

polyester elastomer

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
(248) 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) 722-1456

South America

DuPont America do Sul
Al. Itapecuru, 506
Alphaville—CEP: 06454-080
Barueri—Sao Paulo, Brasil
Tel.: (055-11) 7266-8531/8647
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

The data listed here fall within the normal range of properties, but they should not be used to establish specification limits nor used alone as the basis of design. The DuPont Company assumes no obligations or liability for any advice furnished or for any results obtained with respect to this information. All such advice is given and accepted at the buyer's risk. The disclosure of information herein is not a license to operate under, or a recommendation to infringe, any patent of DuPont or others. DuPont warrants that the use or sale of any material that is described herein and is offered for sale by DuPont does not infringe any patent covering the material itself, but does not warrant against infringement by reason of the use thereof in combination with other materials or in the operation of any process.

CAUTION: Do not use in medical applications involving permanent implantation in the human body. For other medical applications, see "DuPont Medical Caution Statement," H-50102.

Printed in U.S.A.
[Replaces: H-72139 (96.12)]
Reorder No.: H-81087 (99.9)

DuPont Engineering Polymers