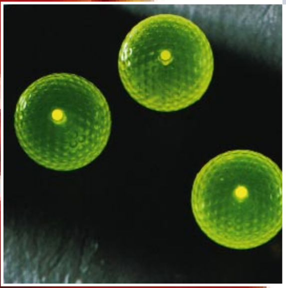
Bayer

Polymers Division

A processing guide for

INJECTION MOLDING



TEXIN AND DESMOPAN

THERMOPLASTIC POLYURETHANES

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INTRODUCTION

PRODUCT DESCRIPTION

Texin and Desmopan resins are thermoplastic polyurethane elastomers (TPUs) based on polyesters, polyethers, special copolymers, and blends of polyurethane and polycarbonate, which exhibit a wide range of properties suitable for many different applications. Finished parts made from Texin and Desmopan resins possess all the excellent properties which are normally associated with polyurethane elastomers. These properties include:

- High tensile and tear strength.
- Excellent abrasion resistance.
- Excellent resistance to fuels, oils, ozone, and oxygen.
- High elasticity and resilience combined with high load-bearing capacity and hardness.
- Hydrolysis and microbe resistance.

Product by Grade Type

Texin and Desmopan resins are available in unreinforced general-purpose grades of various hardness. Desmopan KU2-8651 resin, the softest grade available, is used in applications where high flexibility is required. Desmopan 453 resin, a harder and more rigid grade, is used for low-deflection, load-bearing applications. Texin 390 resin has intermediate hardness and modulus.

Several modifications of the general Texin and Desmopan resin grades which have been designed to meet

Table 1 **Texin and Desmopan TPU Injection Molding Resins**

Resin Type: Old Name	Resin Type: New Name	Shore Hardness
Polyesters – Specialty		
Texin 345D	**Desmopan 445**	45D
Texin 355D	**Desmopan 453**	53D
Texin 360D	**Desmopan 459**	60D
Polyesters – General-Purpose		
Texin 445D	**Texin 245**	45D
Texin 455D	**Texin 255**	55D
Texin 458D	**Texin 260**	60D
Texin 470D	**Texin 270**	70D
Texin 480A	**Texin 285**	87A
Texin 591A	**Texin 390**	88A
Texin 688A	**Texin 185**	87A
Polyethers		
Texin 970D	**Texin 970U**	70D
Texin 985A	**Texin 985**	86A
Texin 990A	**Texin 990**	90A
Texin DP7-1018	**Texin 950**	50D
Polyethers, ***continued***		
Texin DP7-1047	**Texin 950U**	50D
Texin DP7-1051	**Texin 985U**	86A
Texin DP7-1052	**Texin 945U**	45D
Texin DP-7-1078	**Texin 990R**	90A
Polyurethane/Polycarbonate Blends		
Texin 3203	**Texin 3203**	60D
Texin 3215	**Texin 3215**	75D
Texin 4203	**Texin 4203**	60D
Texin 4206	**Texin 4206**	65D
Texin 4210	**Texin 4210**	70D
Texin 4215	**Texin 4215**	75D
Special Market Grades		
Texin 5265	**Texin 5265**	65D
Texin 5286	**Texin 5286**	86A
Texin 5370	**Texin 5370**	70D

specific requirements are available. Properties intermediate to those of the standard grades of Texin and Desmopan TPU resin can also be obtained by blending any combination of Texin and Desmopan resins, provided they are thoroughly mixed. For some applications, it is necessary to mix different formulations in a melted state to achieve the required blend uniformity.

Table 1 lists various grades of Texin and Desmopan resins suitable for injection molding. Further details about the suitability of injection molding Texin and Desmopan resins or blending these resins for your application are available by contacting a Bayer Corporation Technical Group representative for Texin and Desmopan resins at 412-777-2000.

Product by Market

Texin and Desmopan TPU resins are used to mold a variety of automotive components such as cams, gears, and mechanical parts, as well as for exterior applications. In-line skate boots, ski goggle frames, and shoe components are among the consumer applications for Texin and Desmopan resins. Industrial-mechanical applications include mine screens, caster wheels, cable connectors, and hydraulic seals. Medical applications include a variety of diagnostic devices, tubing and catheters, and connectors. Additional information regarding medical grades and their usage can be found in the "General Information" section on page 47 of this brochure.

NOMENCLATURE

Grade Designation

The grade designation for Texin and Desmopan resins consists of two parts:

1. **Product Information Number.** The first digit represents the basic composition of the resin grade, as shown in Table 2. The last two digits represent hardness.* If the last two digits are equal to or greater than 75, the hardness value is Shore A. If the last two digits are less than 75, the value is Shore D. For example, Texin 985 resin is a polyether-based TPU with a Shore hardness of 85A.

*These values are provided as general information only. They are approximate values and are not part of the product specification.

Table 2 Grade Composition and Designations for Texin and Desmopan Resins

Composition	Designation
Basic Polyester	1
Polyester, Good Hydrolytic Stability	2
Polyester, Better Hydrolytic Stability	3
Polyester, Good Low and High Temperature Performance	4
Special Polyester/Polyether Mixture	5
Future Grades	6
Special Copolymers	7
Future Aliphatics	8
Polyether	9

Table 3 Performance Additives and Designations for Texin and Desmopan Resins

Performance Additive	Designation
UV and Heat Stabilizers	U
Better Mold Release	R
Special Additive	S
Low Viscosity	L

2. **Suffix.**
   A capital letter following the three-digit product information number represents the type of performance additive in the grade, as listed in Table 3.

Color Designation

Texin and Desmopan TPU are supplied as natural resins in pellet form. (See Figure 1.) The molded part color can vary from nearly transparent to translucent to opaque, depending on the wall thickness of the article. Some grades of Texin and Desmopan resins are also offered in black or gray color as a "salt-and-pepper" resin blend.

COLORING THE RESIN

Texin and Desmopan resins can be colored by blending in color concentrates or by dry blending the pigments directly onto the pellets. A list of color concentrates, pigments, and dyes suitable for Texin or Desmopan resins is available from your Bayer Corporation Technical Group representative for Texin and Desmopan resins at 412-777-2000.

Before blending any colorants into the Texin or Desmopan resins, be sure the resin is dry. (See "Drying" on page 14.) If a color concentrate is used, dry it in the same manner as the Texin or Desmopan resin. Dry the pigments or dyes at a temperature as high as is practical. Many inorganic pigments contain water which must be removed before the pigment is incorporated into Texin or Desmopan TPU resins. These inorganic pigments may be adequately dried by heating them to 450°F (233°C) for 30 – 45 minutes.

After the pigment has been properly dried, tumbler-blend it or the color concentrate into the Texin or Desmopan resins pellets in the desired concentration for 5 – 10 minutes. This blend can then be injection-molded with a color dispersion nozzle. If more than 10

Figure 1 **Texin and Desmopan Resin Pellets**

minutes will elapse before the color blend is processed, protect the color blend from exposure to moisture or dry it prior to introducing it to the injection molding machine.

COLORING MOLDED PARTS

When a given part must be produced in a wide range of colors and it is uneconomical to mold each color separately, dip dying may be employed. Parts molded of Texin or Desmopan TPU can be successfully dyed with colorants known as “disperse dyes.” However, some regulatory organizations (e.g., FDA) limit the choice of color that may be used. A list of suggested dyes may be obtained from a Bayer Corporation Technical Group representative for Texin and Desmopan resins.

PACKAGING AND LABELING

Texin and Desmopan resins are available in 25-lb (10-kg) boxes, 50-lb (20-kg) bags, 300-lb (135-kg) drums, 1,000-lb (450-kg) cartons, and bulk trucks.

The boxes, bags, and cartons have polyethylene liners in which the resin is sealed to help prevent contamination from dust, dirt, and moisture.

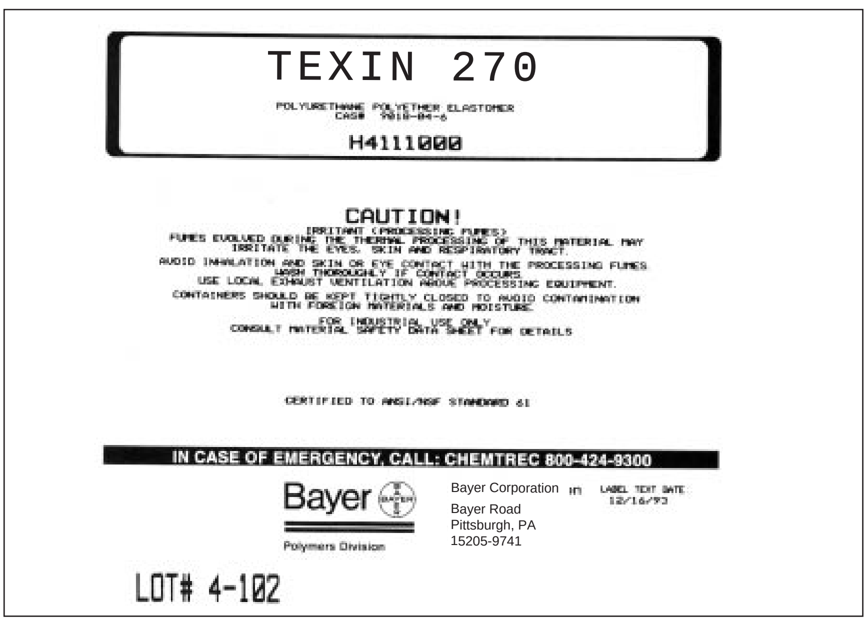
When opening and resealing the bags and cartons, be careful to avoid the introduction of dust or dirt. Any particulate contamination in the feedstock will show up in the finished part.

Texin and Desmopan TPU resins are hygroscopic. In fact, moisture absorption begins as soon as the resin is exposed to the air. Resin exposed to the air for as little as 15 minutes can absorb enough moisture to cause injection molding problems. Resin exposed to the air for a few days or processed wet will suffer a permanent reduction in property performance. Therefore, keep each package of Texin or Desmopan resins sealed until it is to be used.

Avoid storing Texin and Desmopan TPU resins where the temperature exceeds 95°F (35°C). Also avoid storage areas that are subject to high humidity or in close proximity to steam pipes or other hot lines.

An example of a label for Texin and Desmopan resins is shown in Figure 2.

Figure 2 Label Information for Texin and Desmopan Thermoplastic Polyurethane Resins



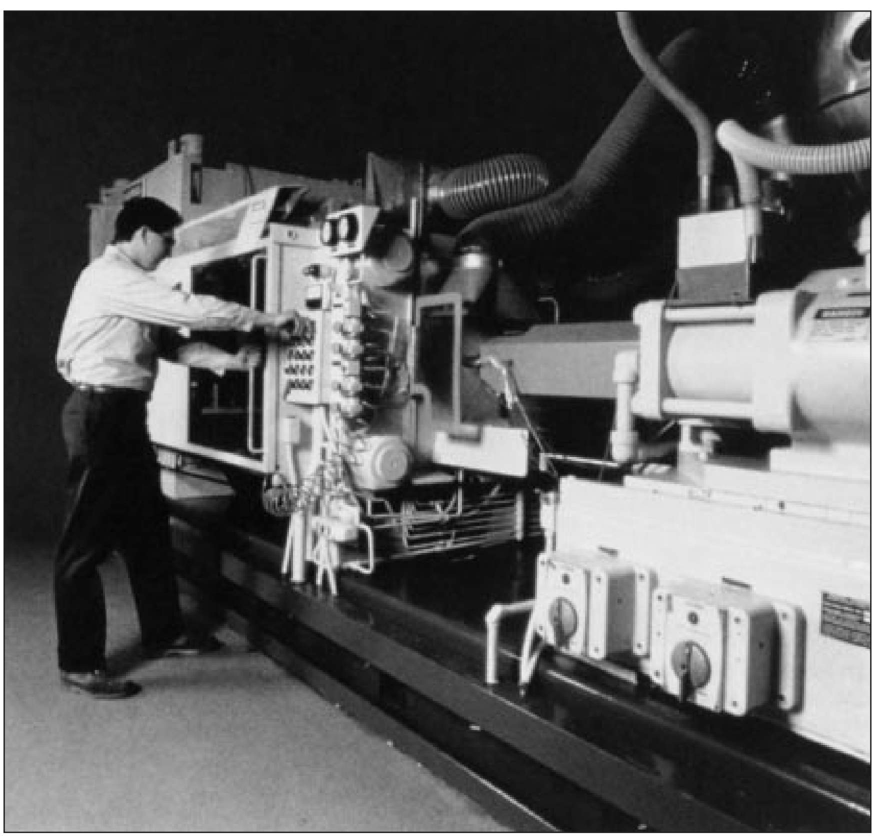
MACHINE SELECTION

MACHINE TYPE AND DESIGN

Texin and Desmopan resins can be molded on both in-line reciprocating screw-type and plunger or ram-type injection molding machines. An in-line reciprocating screw machine like the one shown in Figure 3 is preferred because it produces a more homogeneous material and a more uniform melt temperature. It also permits processing at lower temperatures, which is generally an advantage.

Use a machine that can provide temperature control up to 475°F (246°C) and injection pressure of up to 15,000 psi (103 MPa). The mold clamp force needed for Texin and Desmopan resins is 3 – 5 t/in.^{2} (40-70 kPa) of a part's projected area.

Figure 3 **Typical Injection Molding Machine**



SCREWS: MATERIAL, CONFIGURATION, AND WEAR

Following are important considerations in choosing a screw for injection molding Texin and Desmopan resins:

- A general-purpose screw with a length-to-diameter ratio (L/D) of at least 20:1 is satisfactory (see Figure 4).
- A compression ratio of 2:0-1 to 3.0:1 is preferred. A 2.5:1 compression ratio is applicable for most situations. Rapid-transition (nylon-type) screws are not recommended because of the excessive melt temperature and consequent degradation of the resins that can occur with them.
- Chrome-plated screws are recommended for ease of cleaning.
- An abrasion-resistant, bimetallic barrel liner, such as Xaloy,* is preferred.

*Xaloy is the registered trademark of Xaloy, Inc.

NON-RETURN VALVES

Non-return valves prevent the molten polymer in the holding space in front of the screw from flowing back into the screw during the injection cycle.

When processing Texin or Desmopan TPU resins, use a free-flowing, sliding check-ring style non-return valve made of fully hardened H-13 steel, preferably nitrided to retard wear (see Figure 5).

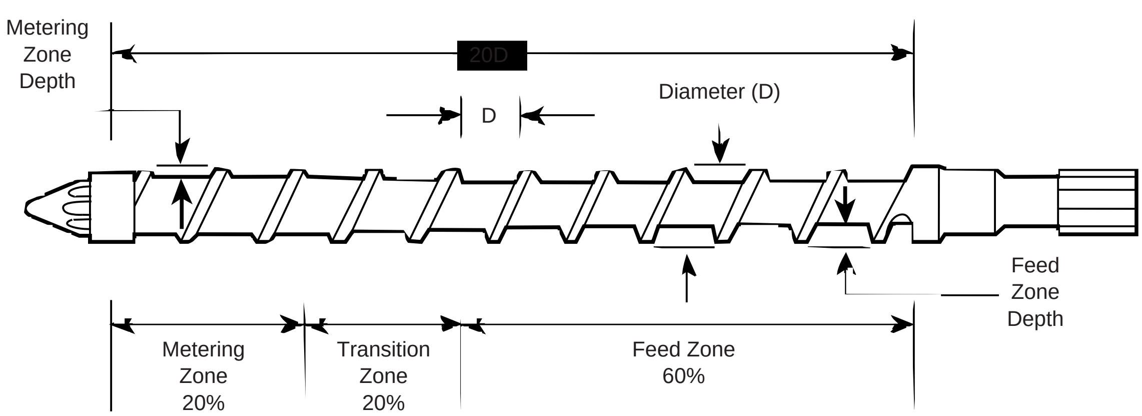
Good flow characteristics, as shown in Figure 6, are essential in a non-return valve. A fully channeled tip will minimize flow restrictions because Texin and Desmopan TPUs, like most thermoplastics, will degrade when subjected to excess shear at flow restrictions.

NOZZLE TYPES AND TIPS

Most standard steel nozzle types used with other thermoplastics are satisfactory for molding Texin or Desmopan resins. A straight-through nozzle or a replaceable-tip nozzle with a reverse taper at the nozzle exit are recommended. (See Figure 7.)

Reverse-taper nozzles are desirable when drool is a problem. Their flow path narrows to a small diameter, then

Figure 4 **Screw Profile**



$$\text{Compression Ration} = \frac{\text{Feed Depth Zone}}{\text{Metering Zone Depth}}$$

The injection molding screw feeds the resin from the throat of the resin hopper through the barrel of the injection molding machine to the nozzle. The screw should be chrome-plated and highly polished.

widens where the nozzle meets the sprue bushing. This causes the melt to tear off inside the nozzle, allowing the portion of the material forming a cold slug for the succeeding shot to be removed with the sprue. (See Figure 9.)

The nozzle should be as short as possible. If a long nozzle is necessary, it should have a large internal diameter proportional to its length. It is essential that the nozzle and sprue bushing mate properly. The nozzle orifice should be slightly smaller (about 20%) than the sprue bushing orifice.

Nozzle Temperature Control

A separate temperature control for the nozzle is preferred. Heater bands on the nozzle with separate temperature controls will help to prevent cooling or solidification of the melt in the nozzle. A rapid-cycling, variable temperature controller is preferred to a slow-cycling controller.

It is important that all heater bands work properly. Burned-out bands can result in material hang-ups or cause other bands to overwork, both of which can overheat or burn the material.

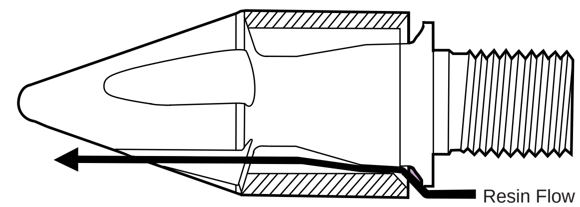
PROCESS CONTROLS

Texin and Desmopan TPU resins are melted in the barrel by a combination of heat transferred from external heaters through the barrel wall and frictional heat generated by screw rotation. The ratio of external heat to frictional heat depends upon the power of the heaters, the resin throughput rate and residence time, and the length and geometry of the screw.

Figure 5 **Free-Flowing, Sliding Check-Ring Style Non-Return Valve**

This type of valve checks the return of material during the injection cycle. Ball-check valves are not recommended.

Figure 6 **Flow Characteristics of the Non-Return Valve**



Note:
Cross-sectional area in valve should equal cross-sectional area of the screw metering section.

Proper temperature control on an injection molding machine involves maintaining a specified melt temperature at as constant a level as possible over a long period of operation. With proper temperature control, injection molding machinery can run automatically. Proper temperature control can also lead to improved part quality and economies.

Increasing the temperature of the external heaters might seem to be a solution when a less-than-optimum screw is used. However, because the thermal conductivity of plastics is low, a large temperature gradient across the melt could occur, causing inconsistencies in processing or, in extreme cases, degradation of the melt itself.

Increasing the back pressure can provide additional frictional and external heat to the melt. However, an increase in back pressure results in only a slight increase in frictional heating with deep-flighted screws. Increased back pressure can also increase the cycle time due to prolonged screw retraction. Therefore, adjustment of back pressure is not always a solution to a less-than-optimum screw design.

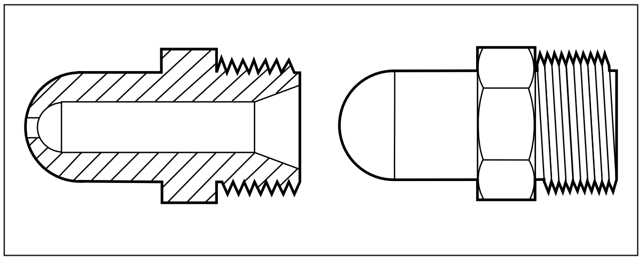
Temperature

An obvious solution to regulating melt temperature would be to locate temperature sensors directly in the plasticating melt. This has not been satisfactorily accomplished, however, because the sensor would interfere with and be destroyed by the flow of the material and movement of the screw. Nor can a sensor easily be sealed against leakage at the high injection pressures.

The solution, then, has been to locate temperature sensors in wells drilled into the cylinder walls and regulate melt temperature by measuring and controlling the cylinder wall temperature. However, the depth of the well affects

Figure 7 **Removable and Non-Removable Nozzle Tips**

Figure 8 **Internal Flow Channel of a Standard Nozzle Tip**



Either standard straight-through or reverse-taper nozzles are recommended for molding Texin and Desmopan resins.

the temperature measured by the sensor, since a temperature gradient exists in the cylinder wall. To minimize this effect, the thickness of the steel at the bottom of the well is usually equal to its diameter.

In order to further minimize error, periodically check to make sure that the sensors are clean and fit firmly in the wells. Impurities, such as charred pellets, or a cushion of air between the cylinder wall and the sensor have led to readings that are inaccurate by as much as ±54°F (±30°C).

The temperature measured by the sensor is seldom exactly equal to the temperature of the plastic melt. Therefore, adjust cylinder and nozzle temperature set-points to get an actual measured melt temperature that is within the recommended range for the grade of the Texin or Desmopan resins being processed.

Time and Pressure

Uniform molding cycles are essential to maintaining optimum processing conditions and producing the highest-quality parts. State-of-the-art closed-loop control systems can ensure both the precise injection stroke and switch-over point that are critical for molding quality parts. This control equipment can adjust hold pressure in increments to minimize sinks and voids. In addition, it can maintain melt pressure in the mold cavity uniformly from shot to shot despite variations in the operating conditions of the machine.

Some advanced controls adjust the holding pressure and cooling time to ensure that each part is ejected from the mold at the same temperature and weight. This improves part-to-part weight and dimensional uniformity.

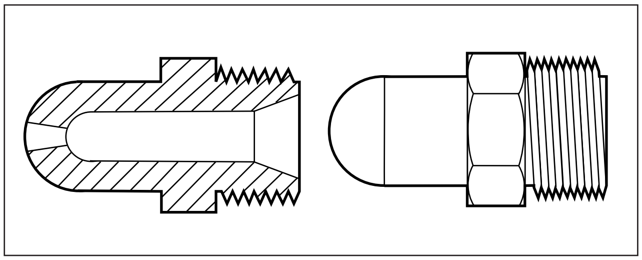
Shot Size and Machine Capacity

When running on screw-type machines, utilization of 40% – 80% of the barrel capacity is desirable. Although shot weights smaller than 40% have been molded successfully, the material can degrade when the shot weight is too small and excessive heat builds up in the melt.

Machine Ventilation

A ventilation hood should be located at the front or nozzle end of the molding machine to remove any fumes generated during injection molding or purging.

Figure 9 **Internal Flow Channel of a Reverse-Taper Nozzle Tip**



The reverse-taper type is preferred, however, because it causes the melt to tear off inside the nozzle. This allows the portion of the material forming a cold slug to be removed with the sprue.

DRYING

MATERIAL HANDLING

Texin and Desmopan TPU resins are hygroscopic, meaning that they will absorb and react with moisture in the atmosphere. As Figure 10 shows, Texin and Desmopan TPU resins exposed to the atmosphere begin absorbing moisture immediately. Moisture in the resin adversely affects processing and the quality of the molded part. So even though Texin and Desmopan resins are supplied in sealed containers, it is essential to use a desiccant dehumidifying hopper dryer to keep the resin dry during processing.

Warm to room temperature any sealed containers which have been stored in unheated warehouses before opening them. This will help prevent rapid condensation of ambient moisture on cool pellets.

Single drums or cartons can take 24 hours or more to warm. Stacked containers can take a week or longer.

DRYING EQUIPMENT

Desiccant Hopper Drying

Use a desiccant dehumidifying hopper dryer to remove moisture from Texin or Desmopan resin and to maintain proper resin moisture content of less than 0.03% during processing. The dryer must meet the following requirements to properly remove moisture from Texin or Desmopan TPU resins:

- Hopper dryer should be sufficient to ensure that the resin remains in the

Moisture Absorption Rate of Texin and Desmopan Resins **Figure 10**

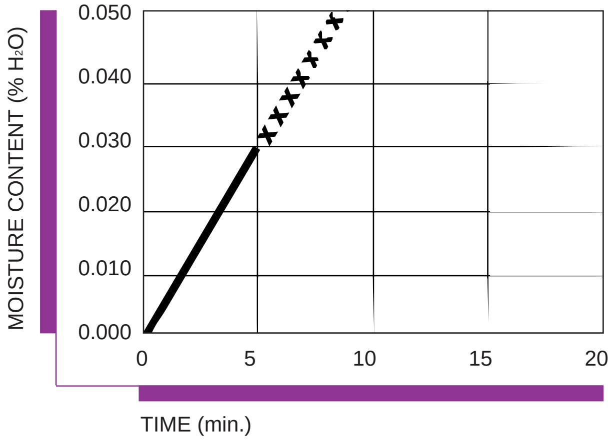


Figure 11 **Typical Desiccant Dehumidifying Hopper Dryer System**

drying hopper at least 2 hours prior to being injection molded.

- Hopper inlet air temperature of 180° – 230° F (82° – 110° C). For softer materials, use lower temperatures in this range. Temperatures in excess of 230° F (110° C) may cause the pellets to block in the hopper.

- Airflow to the hopper of 1.0 cubic foot per minute (CFM) for every pound of resin per hour of throughput.

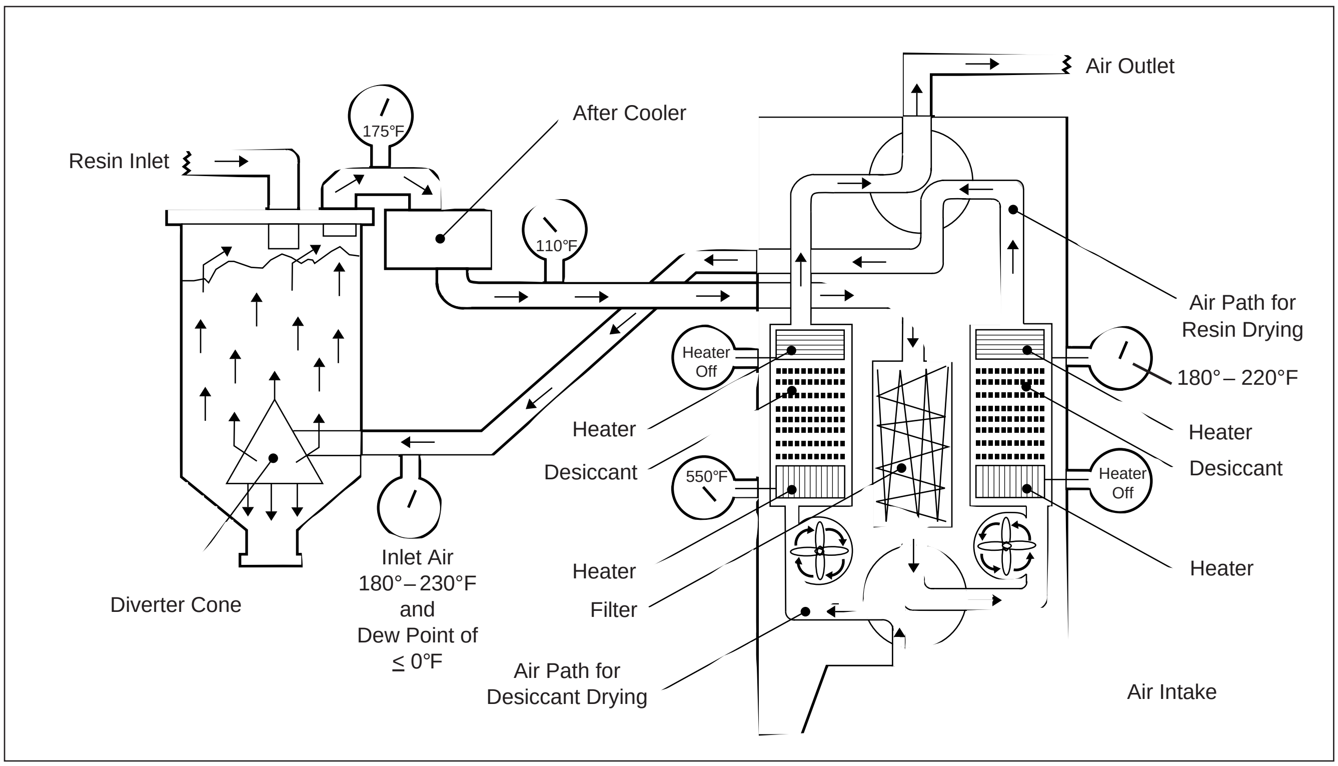
- Dew point of the inlet air to the hopper at 0° F (-18° C) or less.

Some recent dryer designs perform to less demanding requirements. However, use caution when deviating from these guidelines since the quality of parts molded of Texin and Desmopan resins depends on low moisture content.

A typical desiccant dehumidifying hopper dryer system and airflow are shown in Figures 11 and 12. Note that the hopper is tall and cylindrical and has a diverter cone to diffuse the air uniformly and reduce channeling of the pellets. It should be sized to accommodate the throughput rate of the molding machine and allow for a drying time of 2 – 3 hours prior to and during processing.

If the hopper dryer has not been used for 24 hours, dry-cycle it before introducing the Texin or Desmopan resins. This will help to ensure the desiccant is dry prior to processing (refer to the manufacturer's recommendations for the procedure). Then load the resin and dry it for at least 2 hours prior to being introduced into the molding machine.

Figure 12 **Desiccant Dehumidifying Hopper Dryer System Airflow**



Hot Air Oven Drying

The use of a conventional hot air drying oven is not recommended as a substitute for a dehumidifying hopper dryer. However, if it is the only method available, then the recommended oven temperature is 200°– 220° F (93°– 104° C) for 2 – 4 hours. Place the resin pellets in the drying trays at a depth of 1 in. (25.4 mm) or less. Dry no other types of resin in an oven containing Texin or Desmopan resins. Once oven-dried resin has been put in the hopper, close and heat it during processing. Otherwise, the resin should remain in that hopper for no longer than 30 minutes.

Another way to avoid unwanted moisture absorption by oven-dried resin is to transfer small amounts of dried resin from the oven tray to the hopper during injection molding.

If regrind is used, dry it to the same moisture content level as required for virgin pellets. In fact, it may be necessary to dry regrind longer than virgin pellets due to the irregular shape and size of the regrind pellets. Beware of excessive “fines” (very small particles cause by grinding). Fines melt more rapidly and may cause black specks to form.

Figure 13 **Bubble Formation During Purging**

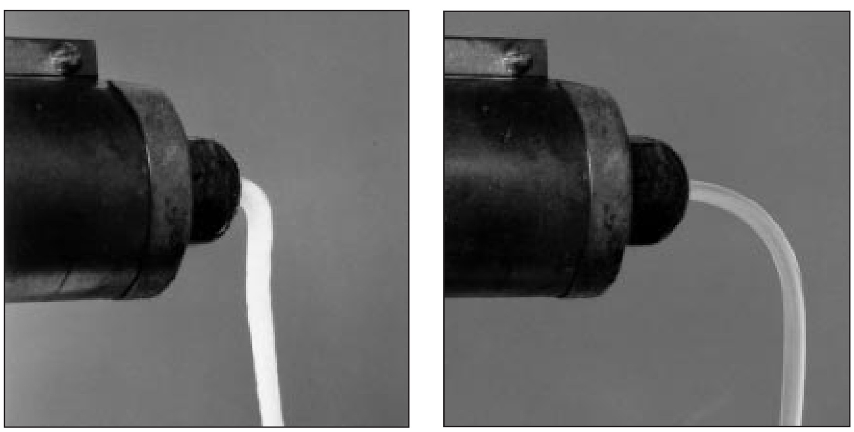


Table 4 **Dehumidifying Hopper Dryer Troubleshooting Guide**

Improper Drying Condition	Drying Equipment Defect	Possible Corrective Action
Poor Dew Point	• Dirty filter(s).	• Clean or replace filter(s).
	• Saturated desiccant.	• Dry-cycle machine for several complete cycles. Saturated desiccant is a common problem with machines that are not in continuous use.
	• Excessive return air temperature.	• Add after-cooler on return air line.
	• Burned-out heater(s).	• Repair or replace heater(s).
	• Contaminated or worn-out desiccant.	• Replace desiccant.
	• Bad heater thermostat or thermocouple.	• Repair or replace thermostat or thermocouple.
	• Malfunctioning regeneration cycle timer.	• Adjust or replace timer.
	• Air control butterfly valves not seating.	• Adjust valve seating.
	• Moist room air leaking into the dry process air.	• Check all hose connections and tighten as required.
		• Check all hoses for leaks and replace as needed.
		• Check filter covers for secure fit and tighten as required.
	• Desiccant beds not switching.	• Check electrical connections.
		• Check switching mechanism.
Material Residence Time in Hopper Too Short	• Dryer hopper too small for the amount of material being processed per hour.	• Use a larger dryer hopper.
	• Not keeping hopper at least 2/3 filled.	• Keep drying hopper full.
Incorrect Process Air Temperature	• Incorrect drying air temperature.	• Dial in correct temperature of 180° – 230°F (85° – 110°C).
	• Dryer temperature controller malfunction.	• Repair or replace controller.
	• Thermocouple malfunction.	• Repair or replace thermocouple.
	• Faulty process air heating elements.	• Repair or replace heating elements.
	• Supply voltage different than required heater voltage.	• Check supply voltage against name-plate voltage.
	• Non-insulated inlet-air hose.	• Repair or replace inlet-air hose.
	• Excessive changeover temperature.	• Increase reactivation airflow.
Insufficient Inlet Airflow (Good dew point but resin still wet.)	• Dirty or clogged filter.	• Clean or replace filters.
	• Incorrect blower rotation.	• Change blower rotation. (Consult equipment manufacturer's electrical instructions.)
	• Obstruction in air ducts.	• Remove air duct obstruction.

Optimizing the injection molding process involves several variables:

- Ratio of heat transferred by external heaters to frictional heat.
- Injection speed and pressure.
- Holding pressure and time.
- Cooling time.
- Mold temperature.

The following processing data represent the range for initial processing settings to be used during start-up and may need adjustment to meet the requirements of individual parts.

Processing parameters that optimize the appearance of a molded part can be easily determined. However, these same settings may not give the part its optimum dimensions or shape. When molding parts which must hold to critical dimensional tolerances, conduct a statistical study to optimize both dimensions and appearance. Then adjust certain processing parameters to change part dimensions as required.

Figure 14 **Temperature Zones / Machine Cross Section**

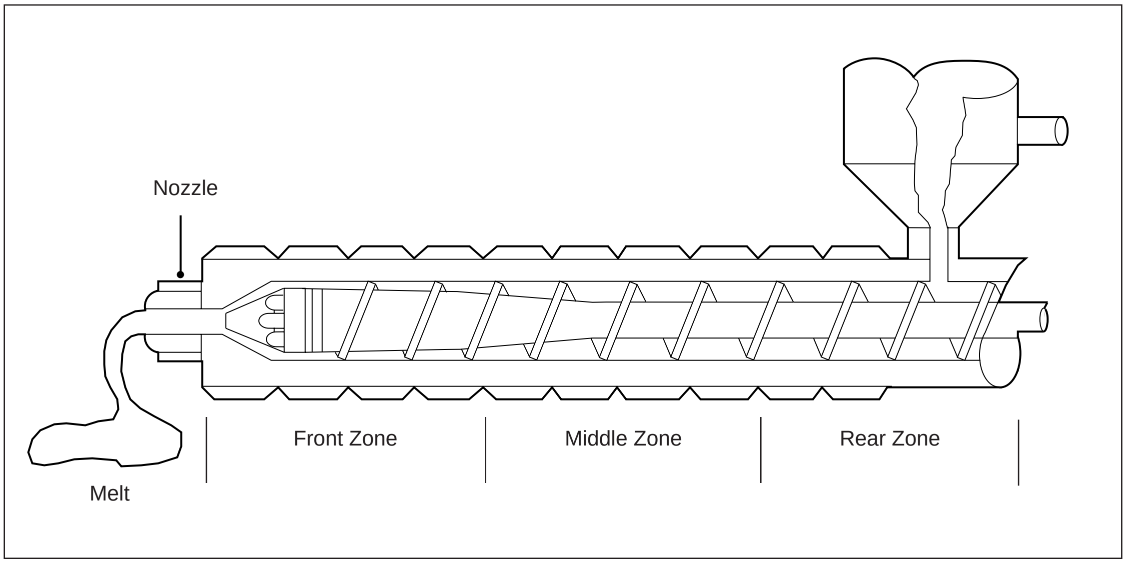


Table 5 **Suggested Starting Conditions for Processing Texin and Desmopan TPU Resins**

Conditions	Texin 185 Texin 985 Desmopan KU2-8651 KU2-8655	Texin 245 Texin 285 Texin 390 Texin 990 Desmopan 445	Texin 245 Texin 260 Desmopan 453 Desmopan 459	Texin 270 Texin 970U Texin 3203 Texin 4203 Texin 4206	Texin 3215 Texin 4210 Texin 4215
Processing Temperatures					
Zones					
Rear	350° – 380°F (177° – 193°C)	360° – 390°F (183° –199°C)	380° – 410°F (193° – 210°C)	410° – 455°F (210° – 235°C)	430° – 450°F (221° – 232°C)
Middle	360° – 390°F (183° – 199°C)	360° – 400°F (183° – 204°C)	380° – 420°F (193° – 216°C)	415° – 460°F (213° – 238°C)	440° – 460°F (227° – 238°C)
Front	360° – 400°F (183° – 204°C)	360° – 410°F (183° – 210°C)	390° – 430°F (199° – 221°C)	420° – 460°F (216° – 238°C)	440° – 460°F (227° – 238°C)
Nozzle	365° – 405°F (185° – 207°C)	370° – 415°F (188° – 213°C)	400° – 440°F (204° – 227°C)	425° – 465°F (218° – 241°C)	450° – 475°F (232° – 246°C)
Melt*	**385°– 465°F (196°–241°C)**	**385°– 465°F (196°–241°C)**	**385°– 465°F (196°–241°C)**	**385°– 465°F (196°–241°C)**	**385°– 465°F (196°–241°C)**
Mold **	60°–110°F (16°– 43°C)	60°–110°F (16°– 43°C)	60°–110°F (16°– 43°C)	80°–110°F (27°–43°C)	80°–110°F (27°–43°C)
Machine Conditions					
Injection Pressure	6,000 – 15,000 psi (41 – 103 MPa)	6,000 – 15,000 psi (41 – 103 MPa)	6,000 – 15,000 psi (41 – 103 MPa)	6,000 – 15,000 psi (41 – 103 MPa)	6,000 – 15,000 psi (41 – 103 MPa)
Injection Speed	Slow	Slow	Medium	Medium	Medium
Hold Pressure	5,000 – 10,000 psi (33 – 69 MPa)	5,000 – 10,000 psi (33 – 69 MPa)	5,000 – 10,000 psi (33 – 69 MPa)	5,000 – 10,000 psi (33 – 69 MPa)	5,000 – 10,000 psi (33 – 69 MPa)
Injection Cushion	0.125 in. max (3.175 mm max)	0.125 in. max (3.175 mm max)	0.125 in. max (3.175 mm max)	0.125 in. max (3.175 mm max)	0.125 in. max (3.175 mm max)
Back Pressure	200 psi max (1.4 MPa max)	200 psi max (1.4 MPa max)	200 psi max (1.4 MPa max)	200 psi max (1.4 MPa max)	200 psi max (1.4 MPa max)
Screw Speed	40 – 80 rpm	40 – 80 rpm	40 – 80 rpm	40 – 80 rpm	60 – 80 rpm
Clamp Tonnage	3 – 5 t/in.^{2} (0.5 – 0.8 mt/cm^2)	3 – 5 t/in.^{2} (0.5 – 0.8 mt/cm^2)	3 – 5 t/in.^{2} (0.5 – 0.8 mt/cm^2)	3 – 5 t/in.^{2} (0.5 – 0.8 mt/cm^2)	3 – 5 t/in.^{2} (0.5 – 0.8 mt/cm^2)
Cycle Time	20 – 60 sec.	20 – 60 sec.	20 – 60 sec.	20 – 60 sec.	20 – 60 sec.
Injection Time	5 – 10 sec.	5 – 10 sec.	5 – 10 sec.	5 – 10 sec.	5 – 10 sec.

* To obtain proper melt temperature, take an air shot and measure the melt with a heated pyrometer probe.
** Check mold temperature on the part cavity and core surface.

Table 6a Barrel Heating Temperatures

Zones	Texin 185 Texin 985 Desmopan KU2-8651 KU2-8655	Texin 245 Texin 285 Texin 390 Texin 990 Desmopan 445	Texin 245 Texin 260 Desmopan 453 Desmopan 459	Texin 270 Texin 970-U Texin 3203 Texin 4203 Texin 4206	Texin 3215 Texin 4210 Texin 4215
Rear	350° – 380°F (177° – 193°C)	360° – 390°F (183° –199°C)	380°– 410°F (193° – 210°C)	410° – 455°F (210° – 235°C)	430° – 450°F (221° – 232°C)
Middle	360° – 390°F (183° – 199°C)	360° – 400°F (183° – 204°C)	380° – 420°F (193° – 216°C)	415° –460°F (213° –238°C)	440° – 460°F (227° –238°C)
Front	360° – 400°F (183° – 204°C)	360° – 410°F (183° – 210°C)	390° – 430°F (199° –221°C)	420° – 460°F (216° –238°C)	440° –460°F (227° –238°C)

Barrel Heating Zones

The initial barrel temperature ranges are approximate and can vary, depending on screw geometry, frictional heating, cycle time, and material flow length. Take care to maintain a consistent melt temperature and inspect the heater bands periodically.

Table 6b Nozzle Temperatures

Processing Temp.	Texin 185 Texin 985 Desmopan KU2-8651 KU2-8655	Texin 245 Texin 285 Texin 390 Texin 990 Desmopan 445	Texin 245 Texin 260 Desmopan 453 Desmopan 459	Texin 270 Texin 970-U Texin 3203 Texin 4203 Texin 4206	Texin 3215 Texin 4210 Texin 4215
Nozzle	365° – 405°F (185° –207°C)	370° – 415°F (188° – 213°C)	400° – 440°F (204°–227°C)	425°– 465°F (218° – 241°C)	450° – 475°F (232° – 246°C)

Nozzle

It is important that the nozzle be equipped with an independent heating system to maintain a constant melt temperature. The optimum nozzle temperature is slightly higher than the front barrel zone. The normal processing range for the nozzle temperature setting is 365°– 475°F (188°– 246°C).

Table 6c Melt Temperatures

Processing Temp.	Texin 185 Texin 985 Desmopan KU2-8651 KU2-8655	Texin 245 Texin 285 Texin 390 Texin 990 Desmopan 445	Texin 245 Texin 260 Desmopan 453 Desmopan 459	Texin 270 Texin 970-U Texin 3203 Texin 4203 Texin 4206	Texin 3215 Texin 4210 Texin 4215
MELT*	← 385° – 465°F (196° – 241°C) →				

* To obtain the proper melt temperature, take an air shot and measure the melt with a heated pyrometer probe.

Melt Temperature

When Texin and Desmopan TPU resins are processed properly, the melt should appear homogeneous and be slightly off-white or beige in color. Excessive transparency usually indicates too high a melt temperature. If the melt appears bubbly, moisture is probably present and further drying is necessary.

Check the actual temperature of the melt at the nozzle from an air shot and correct the temperature control settings accordingly. To obtain an accurate melt temperature measurement, make an air shot from a normal processing cycle and immediately insert a pre-heated thermocouple probe into the center of the melt. Keep it in the melt until the maximum temperature is reached (see Figure 15).

Figure 15 **Making an Accurate Melt Temperature Reading**

To obtain an accurate melt temperature for adjusting the controller settings, make an air shot from a normal processing cycle. Immediately insert the temperature probe into the center of the melt until the maximum temperature is reached.

Table7a Injection Pressures

Machine Conditions	Texin 185 Texin 985 Desmopan KU2-8651 KU2-8655	Texin 245 Texin 285 Texin 390 Texin 990 Desmopan 445	Texin 245 Texin 260 Desmopan 453 Desmopan 459	Texin 270 Texin 970-U Texin 3203 Texin 4203 Texin 4206	Texin 3215 Texin 4210 Texin 4215
Injection Pressure	← 6,000 – 15,000 psi (41 – 103 MPa) →				

Injection Pressures

Injection pressures of 6,000 – 15,000 psi (41 – 103 MPa) are adequate for molding most parts from Texin or Desmopan TPU resins. Low injection pressure may not fill the mold completely with resin. Too much pressure may cause the material to overpack and flash the part.

Table 7b Hold Pressures

Machine Conditions	Texin 185 Texin 985 Desmopan KU2-8651 KU2-8655	Texin 245 Texin 285 Texin 390 Texin 990 Desmopan 445	Texin 245 Texin 260 Desmopan 453 Desmopan 459	Texin 270 Texin 970-U Texin 3203 Texin 4203 Texin 4206	Texin 3215 Texin 4210 Texin 4215
Hold Pressure	← 5,000 – 10,000 psi (33 – 69 MPa) →				

Hold Pressure

Holding pressures of about 60% – 80% of the injection pressure are the general rule.

Table 7c Injection Speed

Machine Conditions	Texin 185 Texin 985 Desmopan KU2-8651 KU2-8655	Texin 245 Texin 285 Texin 390 Texin 990 Desmopan 445	Texin 245 Texin 260 Desmopan 453 Desmopan 459	Texin 270 Texin 970-U Texin 3203 Texin 4203 Texin 4206	Texin 3215 Texin 4210 Texin 4215
Injection Speed	Slow	Slow	Medium	Medium	Medium

Injection Speed

In general, fill the mold as rapidly as possible to minimize the appearance of weld lines, improve weld-line strength, improve surface finish, and lower the required injection pressure. Overall injection time depends on the machine and part geometry. Fast injection speed is necessary for thin-walled parts to fill the mold cavity before the material cools. Slow injection speeds may be necessary to minimize jetting or weld lines.

Table 7d Injection Cushion

Machine Conditions	Texin 185 Texin 985 Desmopan KU2-8651 KU2-8655	Texin 245 Texin 285 Texin 390 Texin 990 Desmopan 445	Texin 245 Texin 260 Desmopan 453 Desmopan 459	Texin 270 Texin 970-U Texin 3203 Texin 4203 Texin 4206	Texin 3215 Texin 4210 Texin 4215
Injection Cushion	← 0.125 in. (3.175 mm) max. →				

Injection Cushion

Avoid excessive injection cushion. Best results can be obtained when the cushion does not exceed 0.125 in. (3.175 mm). Too much cushion may lead to over-packing the part. No cushion may lead to the screw bottoming out, preventing complete packing of the part.

Table 7e Back Pressure

Machine Conditions	Texin 185 Texin 985 Desmopan KU2-8651 KU2-8655	Texin 245 Texin 285 Texin 390 Texin 990 Desmopan 445	Texin 245 Texin 260 Desmopan 453 Desmopan 459	Texin 270 Texin 970-U Texin 3203 Texin 4203 Texin 4206	Texin 3215 Texin 4210 Texin 4215
Back Pressure	← 200 psi (1.4 MPa) max. →				

Back Pressure

Keep back pressure 200 psi (1.4 MPa) if possible.

Table 7f Screw Speed

Machine Conditions	Texin 185 Texin 985 Desmopan KU2-8651 KU2-8655	Texin 245 Texin 285 Texin 390 Texin 990 Desmopan 445	Texin 245 Texin 260 Desmopan 453 Desmopan 459	Texin 270 Texin 970-U Texin 3203 Texin 4203 Texin 4206	Texin 3215 Texin 4210 Texin 4215
Screw Speed	40 – 80 rpm	40 – 80 rpm	40 – 80 rpm	40 – 80 rpm	60 – 80 rpm

Screw Speed

A rotational screw speed of 40 – 80 rpm can be used with Texin and Desmopan resins. However, screw speeds in the low range, 20 – 40 rpm, are preferred. Low screw speed results in a more homogeneous temperature distribution in the melt than high screw speed.

Table 7g Clamp Tonnage

Machine Conditions	Texin 185 Texin 985 Desmopan KU2-8651 KU2-8655	Texin 245 Texin 285 Texin 390 Texin 990 Desmopan 445	Texin 245 Texin 260 Desmopan 453 Desmopan 459	Texin 270 Texin 970-U Texin 3203 Texin 4203 Texin 4206	Texin 3215 Texin 4210 Texin 4215
Clamp Tonnage	← 3 – 5 t/in.^{2} (0.5 – 0.8 mt/cm^2) →				

Clamp Tonnage

Properly matching the size of the injection molding machine and the part to be molded is very important. Due to the flow characteristics of Texin and Desmopan resins, a minimum clamping pressure of 3 – 5 t/in.^{2} (0.5 – 0.8 mt/cm^2) of projected part surface area is required.

Table 7h Mold Temperature

Machine Conditions	Texin 185 Texin 985 Desmopan KU2-8651 KU2-8655	Texin 245 Texin 285 Texin 390 Texin 990 Desmopan 445	Texin 245 Texin 260 Desmopan 453 Desmopan 459	Texin 270 Texin 970-U Texin 3203 Texin 4203 Texin 4206	Texin 3215 Texin 4210 Texin 4215
Mold*	60° – 110°F (16° – 43°C)			80° – 110°F (27° – 43°C)	

* Check mold temperature on the part cavity and core surfaces.

Figure 16 **Measuring Mold Temperature**

Mold Temperature

Optimal mold temperature varies according to part thickness and the particular grade of Texin or Desmopan TPU resin being processed. Thicker parts require a lower temperature to effectively cool the resin within a reasonable cycle time. Softer resin grades should be molded using a lower mold temperature than the harder grades. The range may be from about 60°F (16°C) for Texin 285 resin to 110°F (43°C) for Texin 453 resin.

Check mold temperature on the steel cavity and core surfaces rather than relying on the mold temperature control settings (see Figure 16).

To help ensure proper mold temperature, temperature controllers on the mold are necessary for molding Texin or Desmopan resins. Ordinary water-circulating heat exchanger units are satisfactory. They should be capable of maintaining mold temperatures in the range of 50° – 150°F (10° – 66°C). A separate controller for each half of the mold is desirable because of the need to operate two halves at different temperatures to effect the proper release of some parts.

Shot Weight

Utilization of 40% – 80% of the barrel capacity is preferred when processing Texin and Desmopan resins on screw-type machines. Although shot weights smaller than 40% can be molded successfully, the material can degrade when the shot weight is too small and excessive heat builds up in the melt.

Cycle Time

The optimum cycle to produce quality parts includes a fast fill, a hold time just long enough for the gates to freeze, and a cooling time long enough so that the part ejectors do not penetrate the part. Cooling time is the major portion of the total molding cycle. The cooling requirements of a part are strongly dependent on its wall thickness, runner size, and sprue size.

MOLD RELEASE AGENTS

Should they be necessary, non-silicone-type mold releases, such as a dry fluorocarbon, are recommended. Silicone lubricants work well but generally leave a film on the parts for several shots after application and may cause performance problems in electronic products. Consult a Bayer Corporation Technical Group representative for Texin and Desmopan resins to help determine the best solution to a part release problem.

PART EJECTION

Pin ejection can be used provided that the pin areas are as large as practical for the part. Use air or plate ejection instead of pin ejection whenever possible, particularly on parts with thick sections. Pins can occasionally indent or pierce thick parts which take time to solidify. There is less tendency to stretch or distort parts with air or plate ejection.

USING REGRIND

For all grades of Texin and Desmopan TPU resins, up to 20% regrind may be used with virgin material, depending upon the end-use requirements of the molded part and provided that the material is kept free of contamination and is properly dried at 180°– 230°F (82°– 110°C) for 1– 3 hours. (See “Drying” on page 14 for details.) Any regrind used must be generated from properly molded parts, sprues, and/or runners. All regrind must be clean, uncontaminated, and thoroughly blended with virgin resin prior to drying and processing. Under no circumstances should degraded, discolored, or contaminated material be used for regrind. Materials of this type should be discarded.

Improperly mixed and/or dried resin may diminish the desired properties of Texin and Desmopan resins. You must conduct testing on finished parts produced with any amount of regrind to ensure that your end-use performance requirements are fully met. Regulatory organizations, e.g., Underwriters Laboratories (UL), may have specific requirements limiting the allowable amount of regrind. Because third-party regrind generally does not have a traceable heat history, nor offer any assurance that proper temperatures, conditions, and/or materials were used in processing, extreme caution must be exercised in buying and using regrind from third parties.

The use of regrind material should be avoided entirely in those applications where resin properties equivalent to virgin material are required, including, but not limited to, color quality, impact strength, resin purity, and/or load-bearing performance.

MACHINE PREPARATION

Purging and Cleaning

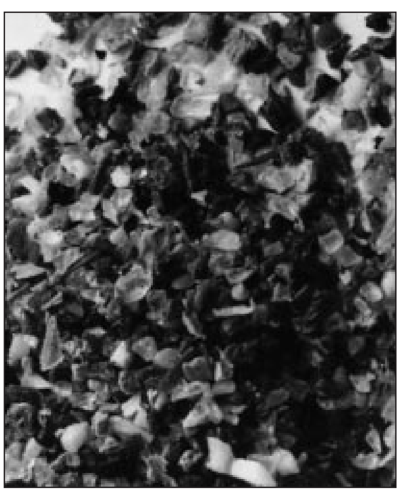
Before molding Texin or Desmopan resins, thoroughly purge or mechanically clean (Figure 18) any residual material from the machine. Commercial purging compounds are the best materials for cleaning the internal parts of the molding machine prior to introducing Texin or Desmopan TPU resin. High-density polyethylene or polypropylene are an effective substitute. After purging, introduce Texin or Desmopan resins and rapidly make air shots of the melt until it is free of any contamination.

Mechanical cleaning is more thorough than purging and is preferred by many molders. The same procedure can be used either before molding Texin and Desmopan resins or after a molding run.

Follow these steps:

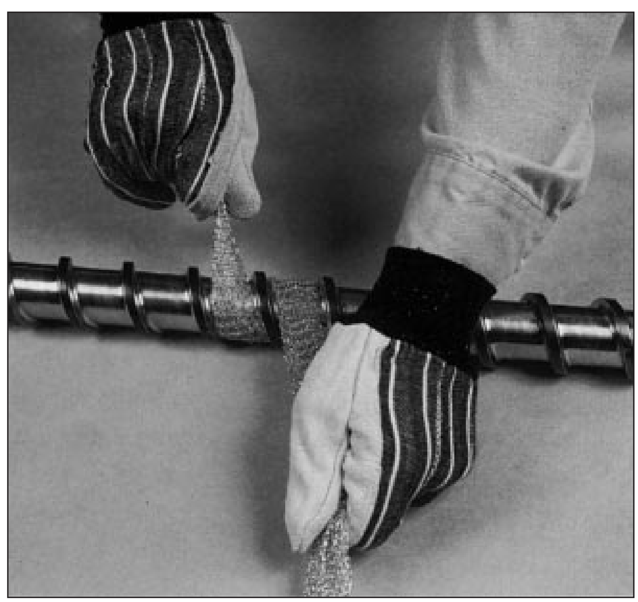
1. Flush the cylinder rapidly with the purging compound.
2. Remove the nozzle while keeping the heat on in the main cylinder.
3. Clean the nozzle either by heating it in a muffle furnace or by soaking it in dimethyl acetamide (follow the manufacturer's MSDS recommendations) after it has cooled.
4. Once the nozzle has been removed, turn off the heat on the main cylinder and push the screw forward until a few flights are exposed.
5. Remove the hot melt from the screw with a brass brush and a brass knife. Push the screw forward and clean it in this manner until all of the flights are clean.
6. Remove the screw and clean the barrel with a rotary-type brush on an extension rod attached to an electric drill.

Figure 17 **Regrind Pellets**



Recommended grinder screen size is 0.31 in. (8mm).

Figure 18 **Mechanical Cleaning of the Screw**



Startup Procedure

Suggested starting process conditions for Texin and Desmopan TPU resin are listed in Table 8. Use these parameters as guidelines for setting initial machine conditions. However, many factors such as part design, machine type, and mold design affect the determination of the final molding conditions. Therefore, the final conditions used may vary considerably from those listed here.

Start with a short-shot that contacts the ejector pins, then increase the shot size and injection pressure until the mold is filled. Make initial shots with less than maximum injection pressure.

Shutdown Procedure

Shut down the molding machine at the end of a production run according to the procedure for either a short- or long-term shutdown. Observing the proper shutdown procedure is important to prepare the machine to restart production and to avoid problems that may be caused by the material or machine during future startups.

Temporary Shutdown

When brief interruptions in the molding cycle occur, make air shots periodically to prevent degrading of the material in the barrel.

Short-Term Shutdown

For shutdowns limited to a period of 4 – 6 hours:

- Shut off the hopper feed.
- Purge the machine empty, or make shots until no material remains in the machine.
- Move the screw forward.
- Lower all heat zones on the cylinder and nozzle to 300° F (150° C).

Long-Term Shutdown

For a shutdown exceeding 6 hours or extending to several days:

- Shut off the hopper feed.
- Flush the machine with a commercial purging compound, high-density polyethylene or polypropylene and purge it empty.
- Leave the screw forward in the cylinder.
- Turn off all heat zones.

When molding with Texin or Desmopan resins is completed, clean the machine thoroughly by mechanical cleaning. (See “Machine Preparation, Purging and Cleaning,” page 26.)

Changing from Texin or Desmopan Resins to Another Material

Follow the same procedure as for a long-term shutdown.

POST-MOLD CONDITIONING

Most parts molded of Texin or Desmopan resins are placed in service without annealing because they attain essentially all of their ultimate properties shortly after normal fabrication. Thus, post-mold conditioning is generally unnecessary.

However, when lower compression set or better creep and tensile decay are required for the application, post-curing/annealing the parts will enhance these properties. Desmopan 400 series of ester-based TPU have the best compression set properties.

To achieve ultimate physical properties immediately after fabrication, anneal the molded parts at 230° F (110° C) for 14 –18 hours. A circulating air oven with a temperature control accuracy of ± 9° F (± 5° C) is satisfactory for post-mold annealing.

If the parts are stored for a period of 2 – 3 weeks after molding, then the curing effect achieved from exposure to ambient air can approach that of elevated temperature curing.

Table 8 Suggested Starting Conditions for Processing Texin and Desmopan TPU Resins

Conditions	Texin 185 Texin 985 Desmopan KU2-8651 KU2-8655	Texin 245 Texin 285 Texin 390 Texin 990 Desmopan 445	Texin 245 Texin 260 Desmopan 453 Desmopan 459	Texin 270 Texin 970U Texin 3203 Texin 4203 Texin 4206	Texin 3215 Texin 4210 Texin 4215
Processing Temperatures					
Zones					
Rear	350° – 380°F (177° – 193°C)	360° – 390°F (183°–199°C)	380° – 410°F (193° – 210°C)	410° – 455°F (210° – 235°C)	430° – 450°F (221° – 232°C)
Middle	360° – 390°F (183° – 199°C)	360° – 400°F (183° – 204°C)	380° – 420°F (193° – 216°C)	415° – 460°F (213° – 238°C)	440° – 460°F (227° – 238°C)
Front	360° – 400°F (183° – 204°C)	360° – 410°F (183° – 210°C)	390° – 430°F (199° – 221°C)	420° – 460°F (216° – 238°C)	440° – 460°F (227° – 238°C)
Nozzle	365° – 405°F (185° – 207°C)	370° – 415°F (188° – 213°C)	400° – 440°F (204° – 227°C)	425° – 465°F (218° – 241°C)	450° – 475°F (232° – 246°C)
Melt *	**385°– 465°F (196°–241°C)**	**385°– 465°F (196°–241°C)**	**385°– 465°F (196°–241°C)**	**385°– 465°F (196°–241°C)**	**385°– 465°F (196°–241°C)**
Mold **	60°–110°F (16°– 43°C)	60°–110°F (16°– 43°C)	60°–110°F (16°– 43°C)	80°–110°F (27°–43°C)	80°–110°F (27°–43°C)
Machine Conditions					
Injection Pressure	6,000 – 15,000 psi (41 – 103 MPa)	6,000 – 15,000 psi (41 – 103 MPa)	6,000 – 15,000 psi (41 – 103 MPa)	6,000 – 15,000 psi (41 – 103 MPa)	6,000 – 15,000 psi (41 – 103 MPa)
Injection Speed	Slow	Slow	Medium	Medium	Medium
Hold Pressure	5,000 – 10,000 psi (33 – 69 MPa)	5,000 – 10,000 psi (33 – 69 MPa)	5,000 – 10,000 psi (33 – 69 MPa)	5,000 – 10,000 psi (33 – 69 MPa)	5,000 – 10,000 psi (33 – 69 MPa)
Injection Cushion	0.125 in. max (3.175 mm max)	0.125 in. max (3.175 mm max)	0.125 in. max (3.175 mm max)	0.125 in. max (3.175 mm max)	0.125 in. max (3.175 mm max)
Back Pressure	200 psi max (1.4 MPa max)	200 psi max (1.4 MPa max)	200 psi max (1.4 MPa max)	200 psi max (1.4 MPa max)	200 psi max (1.4 MPa max)
Screw Speed	40 – 80 rpm	40 – 80 rpm	40 – 80 rpm	40 – 80 rpm	60 – 80 rpm
Clamp Tonnage	3 – 5 t/in.^{2} (0.5 – 0.8 mt/cm^2)	3 – 5 t/in.^{2} (0.5 – 0.8 mt/cm^2)	3 – 5 t/in.^{2} (0.5 – 0.8 mt/cm^2)	3 – 5 t/in.^{2} (0.5 – 0.8 mt/cm^2)	3 – 5 t/in.^{2} (0.5 – 0.8 mt/cm^2)
Cycle Time	20 – 60 sec.	20 – 60 sec.	20 – 60 sec.	20 – 60 sec.	20 – 60 sec.
Injection Time	5 – 10 sec.	5 – 10 sec.	5 – 10 sec.	5 – 10 sec.	5 – 10 sec.

* To obtain proper melt temperature, take an air shot and measure the melt with a heated pyrometer probe.
** Check mold temperature on the part cavity and core surface.

TOOLING

The following information is presented as an overview. Detailed information is available in the *Design Manual for Engineering Resins*, which can be obtained by contacting a Bayer Corporation Technical Group representative for Texin and Desmopan resins at 412-777-2000.

MOLD SHRINKAGE

The mold shrinkage values for parts molded of Texin and Desmopan TPU resin are provided in Table 9. For most parts, a value of 0.010 in. per in. (mm/mm) can be used with reliable results. Complicated part designs and flow patterns can make shrinkage complex. Parts with undercuts that are pushed from the mold with no side action will not hold tight tolerances.

MOLD DESIGN

Material Selection

Mold steels, such as AISI P-20, S-7, and H-13, are commonly used for Texin and Desmopan resins. Aluminum (Type 6061 T-6) can be used for short-run or prototype molds.

Surface Finish

Because Texin and Desmopan TPU resins can stick to highly polished surfaces, a rougher mold surface finish can be used. An SPI D-2 finish (formerly SPE/SPI #5 or vapor hone) is an excellent choice for our TPU resin. Where possible, the surface treatment should extend to sprue bushings, runners, etc., to help ensure easy ejection of the entire shot.

Venting

Trapped gas will produce a marred surface, usually a white color. In more serious cases, it will prevent the mold from completely filling.

Venting enables trapped gas or air to easily escape from the mold. But since Texin and Desmopan resins are quite free-flowing at their melt temperature, even very shallow venting can lead to part flash. Therefore, attempt corrective measures before venting the mold. Design the part and tool so that the flow is uniform and inject the melt slowly to allow a gradual escape of any trapped gas or air.

If venting is necessary, it should be as shallow as possible. Start at a depth of 1/2 mil and increase the depth as needed.

Table 9 **Shrinkage Values for Parts Molded of Texin and Desmopan TPU Resins**

Sample Thickness	Shrinkage
< 0.125 in. (< 3.175 mm)	0.007 – 0.010 in./in. (mm/mm)
0.125 – 0.250 in. (3.175 – 6.35 mm)	0.010 – 0.015 in./in. (mm/mm)
> 0.25 in. (> 6.35 mm)	0.015 – 0.020 in./in. (mm/mm)

Part Draft

A generous draft and taper help to avoid problems removing the part from the mold. Incorporate a 2° or greater taper on all part walls in the direction of the draw (see Figure 19). A lesser taper may require frequent use of a mold release agent to aid part removal from the tool.

Texturing

Typically, the surface texture of the mold depends upon the end-use requirements of the finished part. Textured surfaces require an additional 1° of draft for every 0.001 in. (0.025 mm) depth of texturing.

Weld Lines

Weld lines are created whenever two flow fronts come together in the cavity during injection of the melt. This generally occurs on the side of a molded-in hole opposite the gate or where the flows from multiple gates meet. In general, Texin and Desmopan resins exhibit good weld-line strength. Vents at the weld line can help eliminate trapped gasses.

Undercuts

Parts with undercuts up to 375 mils have been successfully molded with Texin and Desmopan TPU resin. Parts with small undercuts can be removed from a mold using normal pin or plate ejection. However, with pin or plate ejection there is the danger of tearing the part or stretching it out of shape. This can be avoided by using an air ejection system to blow the parts off the core. Air ejection works particularly well with low-durometer materials.

Tolerances

It is difficult and expensive to mold to close tolerances. Thus, keep the number of close tolerance dimensions to a minimum. Obviously, holding a large number of close-tolerance dimensions on any part is much more difficult than getting a single dimension correct.

Since Texin and Desmopan TPU resins are elastomeric, the suggested tolerance expectations are outlined in Table 10.

Figure 19 **Draft Angle, Length, and Taper Relationship**

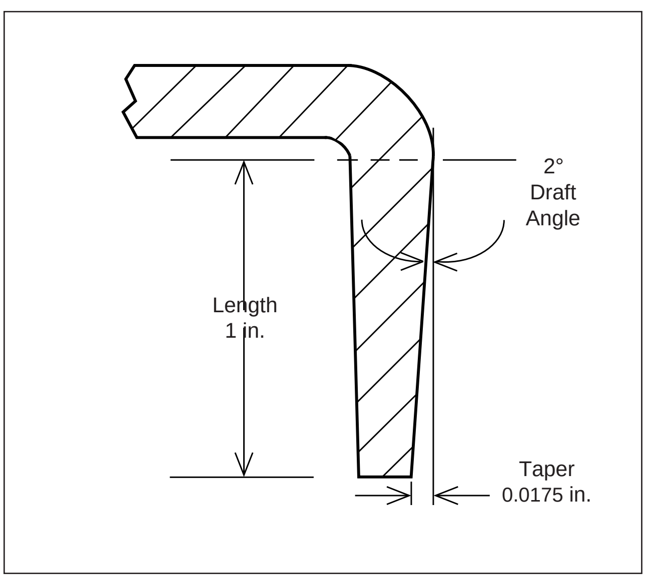


Figure 20 **Sprue Design**

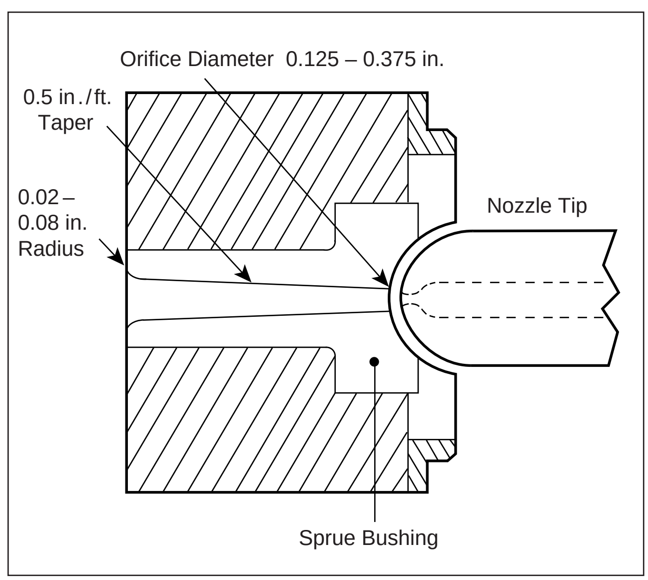
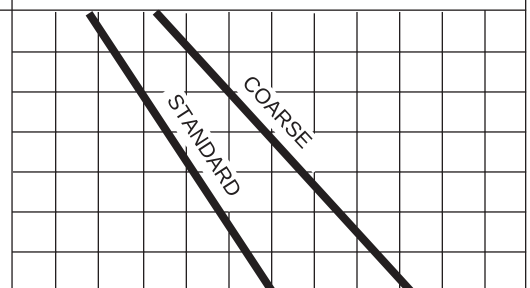
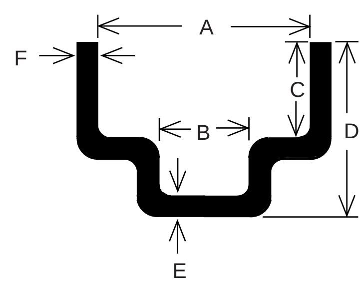


Table 10 **Tolerances for Texin and Desmopan TPU Resins**

Drawing Code	Dimensions (in.)	Material Texin and Desmopan Polyurethane Plus or Minus in Thousandths of an Inch* 1 2 3 4 5 6 7 8 9 10 11	
A = Diameter or Length	0.000		
B = Diameter or Length	1.000		
C = Depth	2.000		
	3.000		
	4.000		
	5.000		
	6.000		
	6.000 to 12.000 For each inch over 6.000 add (in.)	Standard ± 0.004	Coarse ± 0.006
	Over 12.000 For each inch over 12.000 add (in.)	0.005	0.007
Height D	Single Cavity 0.000 – 1.000	0.004	0.006
	Multiple Cavity 0.000 – 1.000	0.004	0.006
	For each inch over 1.000 add (in.)	0.002	0.002
Bottom Wall E	0.000 to 0.100	0.003	0.004
	0.100 to 0.200	0.003	0.004
	0.200 to 0.300	0.004	0.005
Sidewall F Dimension		Section thickness to be held relatively constant	
Draft Allowance		1/2°	1°

Data in this chart denote the dimensional tolerances which are considered feasible for designing parts of Texin and Desmopan resins.

* These tolerances do not apply to screw threads, gear teeth or fit of mating parts; dimensions in these classifications can generally be held to closer limits. These tolerances do not include allowance for aging characteristics of material.



MOLD COOLING

Use molds sufficiently cored for cooling to achieve uniform temperatures over the mold surface.

Small molds require channels drilled about 2.5 in. (63.5 mm) between centers and 0.43755 in. (11.1 mm) in diameter, with 0.250 in. (6.35 mm) pipe threads for the intake and outlet fittings. Large molds require channels drilled 4 in. (101.6 mm) between centers and 0.7187 in. (18.2 mm) in diameter, with 0.5 in. (12.7 mm) pipe threads for the intake and outlet fittings.

Molds having long, thin cores may be cooled by using bubblers, baffles, or heat pipes to achieve uniform mold surface temperatures.

MOLD TYPES

2- or 3-Plate Molds

The selection of either two- or three-plate mold construction for processing Texin and Desmopan resins is usually determined by part geometry, production volume, scrap considerations, cosmetics, and cost.

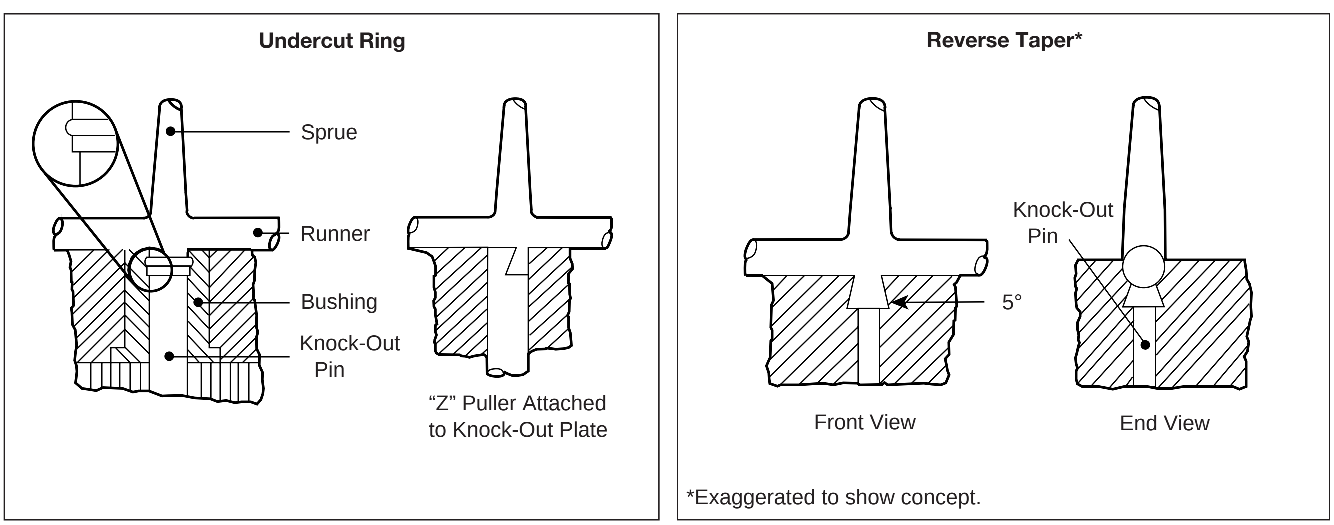
Single- and Multiple-Cavity Molds

Texin and Desmopan resins can be successfully processed in both single- and multi-cavity molds. Which type is used is dictated by the complexity of the part and the required production volume.

Sprue Bushings

Sprue bushings should be as short as possible with a taper of 0.50 in./ft (0.42 mm/cm) or 0.75 in./ft (0.63 mm/cm). A taper of 0.75 in./ft (0.63 mm/cm) is preferred for ease of release. If the sprue has little or no taper, it will be difficult to break the sprue from the nozzle. It is important that no nicks or undercuts be present on the surface of the sprue bushing. A "vapor-honed" type surface finish can be used for the sprue, if desired. The sprue bushing spherical radius should match the nozzle radius and the sprue orifice diameter should be about 20% larger than the nozzle orifice diameter. (See Figure 20.)

Figure 21 **Sprue Pullers**



Sprue Pullers

Use sprue pullers of any common design, but avoid any that restrict flow of the melt. A 5° reverse-taper sprue puller, as shown in Figure 21, works well.

Cold-slug wells are recommended and should be built into the base of the sprue and at every branch or sharp turn in the runner system. This provides a trap for cold, solidified material, keeping it out of the cavity.

RUNNERS AND RUNNER SYSTEMS

Round runner systems are preferred for Texin and Desmopan resins. Full-round cross sections are best (see Figure 22). A primary runner of 0.250 – 0.750 in. (6.35 – 19.05 mm) diameter, with secondary runners of 0.250 in. (6.35 mm) diameter, are commonly used. However, these dimensions can vary according to part size and configuration.

Keep runners as short as possible to reduce unnecessary pressure drops between the sprue and gate, and to reduce scrap.

Hot Runner Molds

Texin and Desmopan TPU resin can be successfully molded using insulated or hot runner systems. Hot runner molds can practically eliminate the use of regrind because there is no sprue scrap or runner system with each shot. Hot runner molds are more expensive than conventional molds but the added cost can be offset on extended production runs where the use of regrind might be impractical.

A diameter of at least 1 in. (2.54 mm) is suggested for insulated runners. The addition of cartridge heaters to the insulated runner block allows start-up without going through the procedure of removing the solidified runner.

Figure 22 **Runner Design**

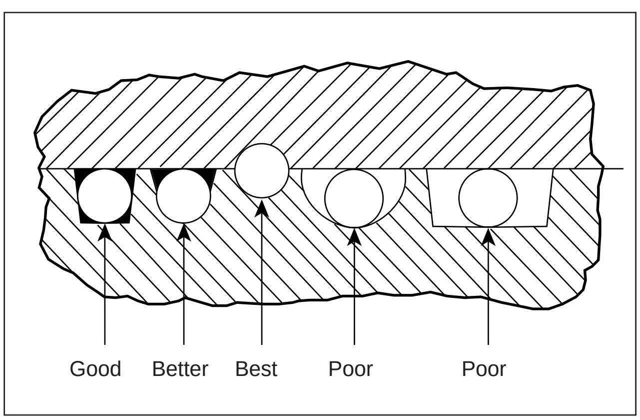
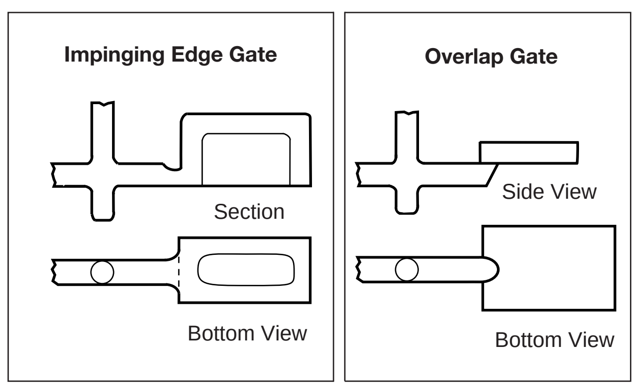


Figure 23 **Gate Designs Which Prevent Jetting**



The suggested diameter of hot runners is at least 0.50 in. (12.7 mm). The best results with hot runner molds have been obtained by using hot tips in the second plate. Consult the hot runner mold supplier's technical staff when selecting a system for Texin and Desmopan resin.

GATING

Gate type and location are determined by the part design. Any of the gating styles typically used in injection molding can be used successfully with Texin and Desmopan TPU resin.

Regardless of the type employed, locate the gate in the thickest section of the part to control sinks, voids, molded-in stresses, and/or warpage in the finished part. To minimize jetting, position the gate so that the melt flow impinges on a core, core pin, or an opposite wall (see Figure 23). Also locate the gate to help prevent the trapping of gas caused by backflow, which can result in burning or filling difficulty.

Table 11 lists suggested gate dimensions for various part thicknesses.

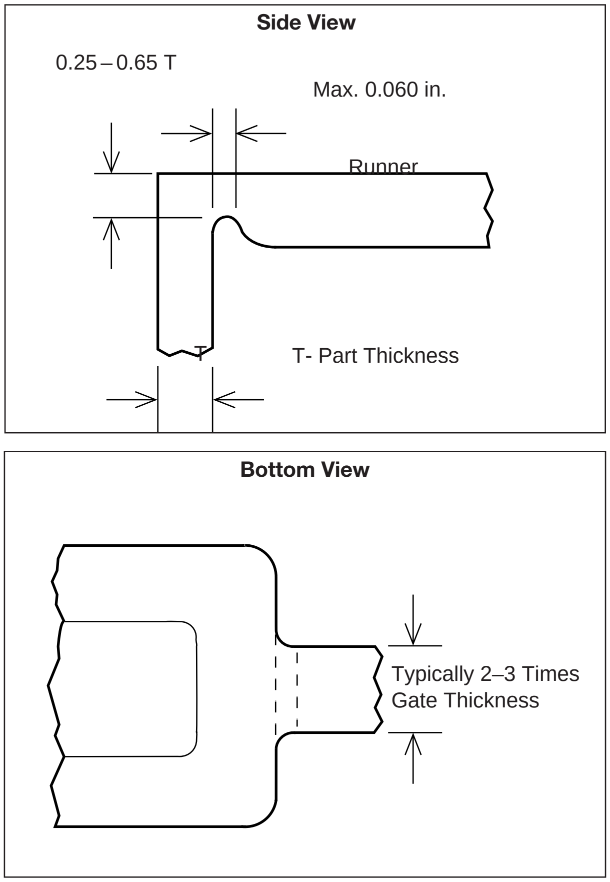
Sprue Gate

Normally, sprue gates are located in the center of the part. If possible, provide a cold slug well in the core side opposite the sprue gate.

Table 11 **Suggested Minimum Gate Dimensions for Parts Molded of Texin and Desmopan TPU Resins**

	Thickness		
	< 0.125 in. (< 3.175 mm)	**0.125 – 0.250 in. (3.175 – 6.35 mm)**	**> 0.250 in. (> 6.35 mm)**
Round			
Diameter	0.030 in.	1/2 Thickness of Part	1/2 Thickness of Part
Land Length	0.030 in.	0.040 in.	0.060 – 0.080 in.
Rectangular			
Thickness	0.030 in.	1/2 Thickness of Part	1/2 Thickness of Part
Land Length	0.030 in.	0.040 in.	0.060 – 0.080 in.

Figure 24 **Rectangular Edge Gate**



Edge Gates

Edge gates, whether rectangular or round, must be large enough to avoid frictional burning. Examples of edge gate dimensions are shown in Figure 24. Variations of edge gating are shown in Figure 25.

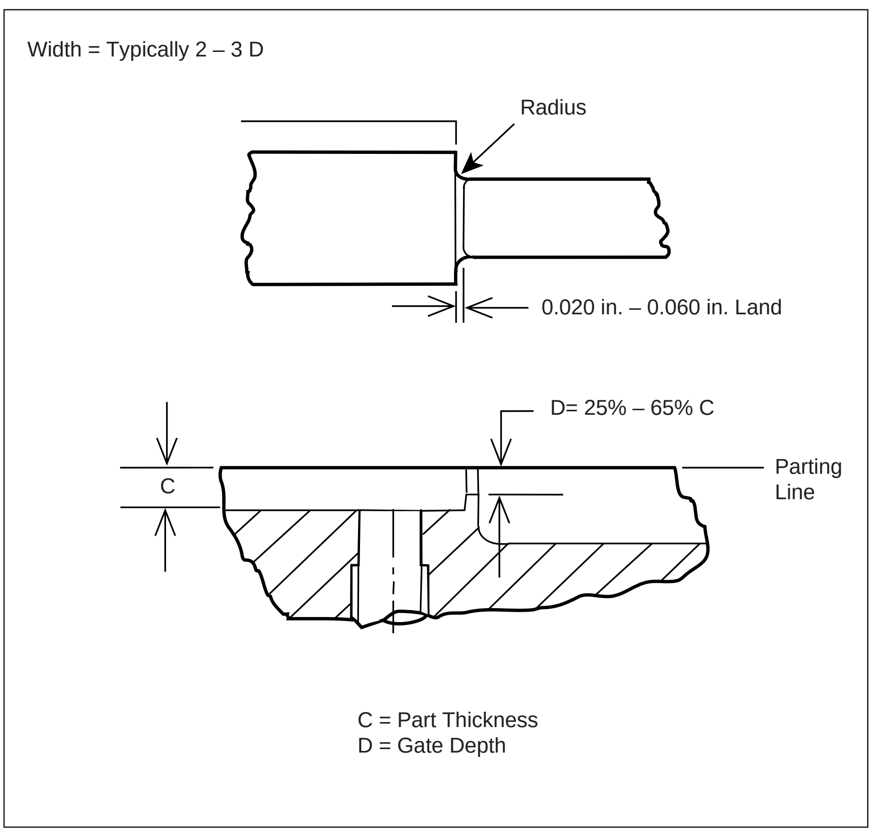
Disc and Ring Gates

This type of gate works particularly well for cylindrical parts with relatively thick sections. It generally results in less part distortion than would several pin-point gates.

Pinpoint Gates

Due to the shear-sensitivity of Texin and Desmopan resins, avoid using pinpoint gates except for very small parts.

Figure 25 **Variations of Edge Gating**



INSERT MOLDING

Inserts of a variety of materials and design can be used with Texin and Desmopan TPU. Since parts molded of Texin and Desmopan resins, unlike parts made of rigid plastic, are not prone to crazing, no minimum wall section is needed around a molded-in insert. The thickness of the wall is determined solely by pull-out or torque strength. The thicker the wall, the greater the resistance to pull-out or torque. The design of the insert need not be limited to a straight, smooth wall, but can have knurls, splines, reverse tapers, or undercuts.

Metal Inserts

Inserts of steel, aluminum, brass, zinc, and other metals can be molded into Texin and Desmopan elastomers. In many cases, sufficient bond strength can be obtained simply by degreasing the inserts, applying an adhesive to the inserts, and heating them to 220°– 250°F (104°– 121°C) before placing them in the mold. Polyurethane-based adhesives work well. Consult a Bayer Corporation Technical Group representative for Texin and Desmopan resins for a list of adhesives that may be used.

Additional mechanical anchoring — that is, using an insert with knurls, splines, reverse tapers, or undercuts — can help ensure additional reliability. If mechanical anchoring cannot be provided, then roughen the contact surface of the metal, giving it a "tooth."

Nonmetal Inserts / Over-Molding

Texin and Desmopan TPUs can be joined to many nonmetallic materials, including other thermoplastics to obtain a molded part with both flexible and rigid components. Usually, the rigid substrate (molded part) is produced first and placed, after a short time (less than 3 hours to be sure of proper bonding), in an injection mold and the flexible component injected onto it. This rigid-to-flexible sequence is used because the more rigid material generally accounts for the greater mass of the finished part.

The success of bonding Texin and Desmopan TPU with another thermoplastic by injecting one material directly onto the other is dependent on three factors:

1. Chemical affinity (adhesion).
2. Mechanical anchoring potential of the substrate material.
3. Processing order.

A suggested pairing of a number of combinations of Texin and Desmopan TPU with other engineering thermoplastics on the basis of their processing order is provided in Table 12.

The processing order of the material is a function of the application and the design of the part, too. The following processing considerations are also crucial to achieving a good bond:

- The two materials should be joined together in the freshly molded state.
- The second material must be able to partially melt the substrate material.
- Both materials should contain just enough mold release for demolding the final part.

Table 12 Bonding Properties of Different Materials

Substrate	Material Injection Molded to Substrate	Assessment
ABS	TPU	Good Adhesion
PC	TPU	Good Adhesion
PC / ABS Blend	TPU	Good Adhesion
Rigid PVC	TPU	Good Adhesion
Rigid TPU	TPU	Good Adhesion
PBT	TPU	Inadequate Adhesion
PA	TPU	Inadequate Adhesion
TPU	ABS	Good Adhesion
TPU	PC	Good Adhesion
TPU	PC / ABS Blend	Good Adhesion
Flexible TPU	Rigid TPU	Good Adhesion
TPU	PBT	Better Adhesion, Depending on Type
TPU	PA	Better Adhesion, Depending on Type
PE	TPU	No Adhesion
PP	TPU	No Adhesion
TPU	PE	No Adhesion
TPU	PP	No Adhesion

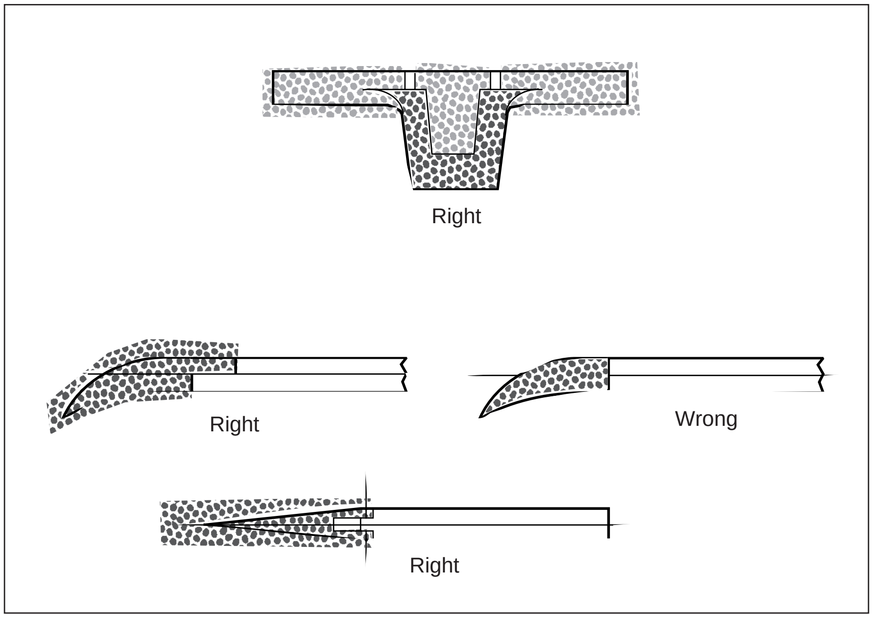
Problems can occur in the rigid-flexible bond if too much time (several hours or even days) has elapsed between molding the rigid substrate and the over-molding flexible component. These defects usually are due to one or more of the following substrate problems:

- Blooming of additives to the surface.
- Excessive release agent.
- Post-mold shrinkage (tightness of the part in the mold cavity and changes in part dimensions).
- Problems with partial melting (due to aging).
- Surface contamination.

If the substrate will be produced and placed in intermediate storage before re-inserting it into a mold for injection of the second material, then some provisions for mechanical anchoring are essential. This is particularly important if the second material will not partially melt the substrate material.

The layout of the contact surfaces is another important consideration for an optimum connection (see Figure 26). The contact surfaces should be as large as possible. In addition, the wall thickness of the material injected onto the substrate should be ample, and the flow paths as short as possible. Otherwise, the heating capacity of the molten material may be inadequate to sufficiently melt the substrate for a good bond.

Figure 26 **Examples of Rigid/Flexible Designs**



BLISTERS AND SPLAY MARKS

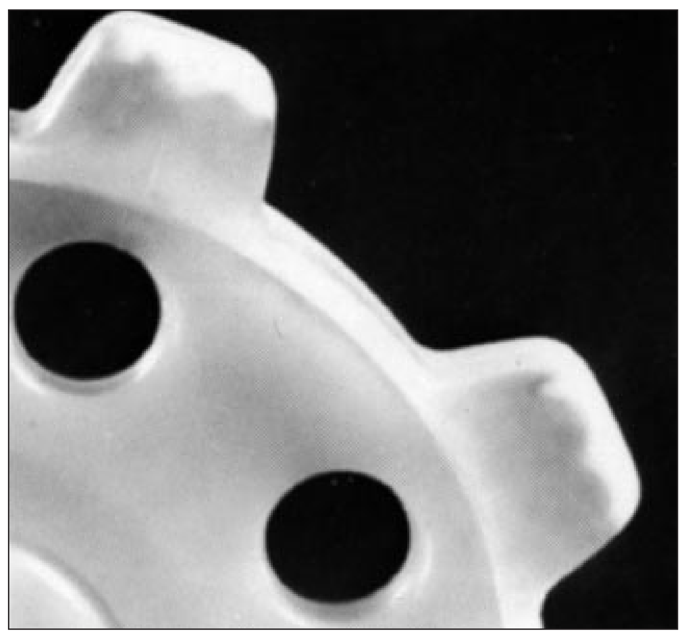
Description of Problem	Possible Causes	Possible Corrective Action
Blisters can form on the surface of the part from moisture in the resin or trapped air in the mold. Splay marks, which appear as silver-white marks generally following the flow paths of the melt, also can be the result of wet resin or resin that has overheated.	• Wet material.	• Check drying procedure. • Measure moisture content of resin pellets in hopper.
	• High melt temperature.	• Reduce material temperature by: ▼ Lowering cylinder zone temperatures. ▼ Decreasing screw speed. ▼ Reducing back pressure.

Figure 27 Blister and Splay Marks

BURN MARKS

Description of Problem	Possible Causes	Possible Corrective Action
Burn marks appear as a brown blush or streaks of discoloration on the surface.	• High injection velocity.	• Decrease injection speed. • Increase gate size. • Change gate position.
	• High melt temperature.	• Check for overheated bands or nozzle heaters.

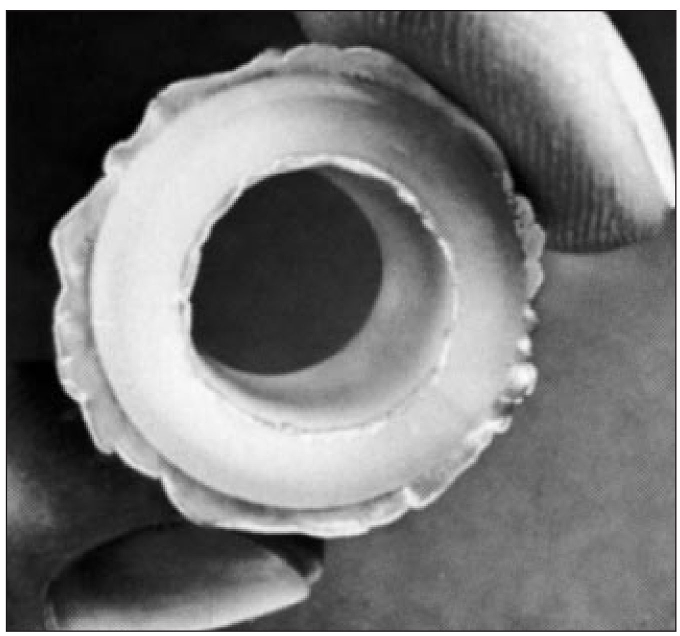
Figure 28 **Burn Marks**



FLASH

Description of Problem	Possible Causes	Possible Corrective Action
Flash is a thin, surplus web of plastic material attached to the molded part along the parting line. Flash formation is dependent on the fit of the mold at the parting line, the applied clamping force, and the viscosity of the resin melt.	• Incorrect processing.	• Lower injection pressure. • Decrease injection speed. • Reduce overall cycle time.
	• High melt temperature.	• Lower material temperature by: ▼ Increasing cylinder zone temperatures 10°F (18°C). ▼ Decreasing screw speed. ▼ Reducing back pressure.
	• Mold setup.	• Check mold closure and lockup. • Check platen alignment.
	• Insufficient clamp pressure.	• Increase clamp tonnage.
	• Excessive vent depth.	• Improve mold venting.

Figure 29 **Flash**



SHORT SHOTS

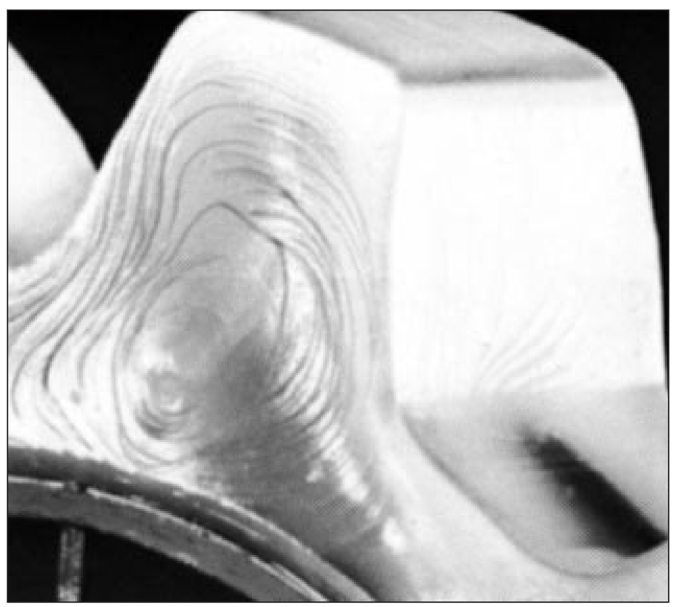
Description of Problem	Possible Causes	Possible Corrective Action
Insufficiently or incompletely filled parts are symptomatic of short shots.	• Insufficient melt temperature.	• Raise material temperature by: ▼ Raising cylinder zone temperatures. ▼ Increasing screw speed.
	• Insufficient injection pressure.	• Increase injection pressure.
	• Insufficient injection speed.	• Increase injection speed.
	• Insufficient feed.	• Increase resin feed.
	• Undersized nozzle orifice.	• Increase size of nozzle, sprue, runner system.

Figure 30 **Short Shots**

SINKS

Description of Problem	Possible Causes	Possible Corrective Action
Depressions in the surface of the part are generally caused by either insufficient injection pressure or an excessively high melt temperature. Other possible causes are degradation of the material through moisture and insufficient gate size. Increasing injection pressure may result in excessive flash, requiring an increase in clamping force.	• Insufficient injection pressure.	• Increase injection pressure.
	• Excessively high melt temperature.	• Reduce melt temperature.
	• Wet material.	• Check drying procedure.
	• Insufficient gate size.	• Increase size of nozzle, sprue, runner system. • Move gates closer to thick sections.

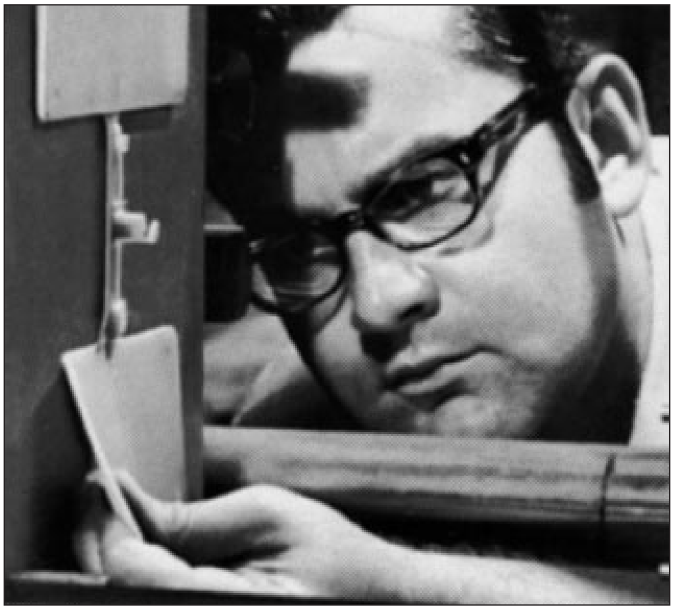
Figure 31 **Sinks**



STICKING PARTS

Description of Problem	Possible Causes	Possible Corrective Action
Parts that do not eject freely will prevent molding machines from cycling automatically. Efficiency and productivity suffer. Insufficient cooling, improper ejector design, highly polished or chrome-plated mold surfaces, and moisture are the most common causes of part sticking.	• Insufficient cooling.	• Lower melt temperature.
	• Improper ejector design.	• Lower mold temperature.
	• Highly polished or chrome-plated mold surfaces.	• Increase cooling time.
	• Wet material.	• Check drying procedure. • Measure moisture content of pellets in hopper.

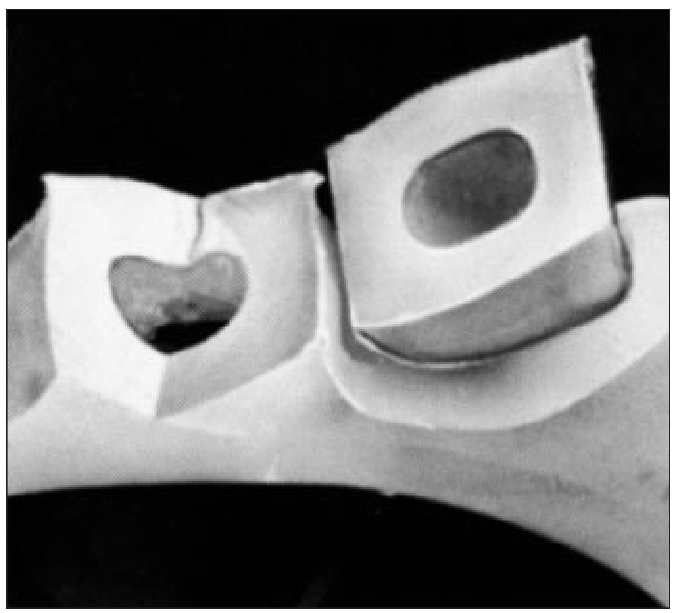
Figure 32 **Sticking Part**



VOIDS

Description of Problem	Possible Causes	Possible Corrective Action
Voids occur when moisture from insufficiently dried resin vaporizes and becomes trapped in the hot melt. A frothy or excessively dark shot indi-cates that the melt is overheating and may result in voids in the molding. Note: Avoid large-increment temperature changes when molding with Texin resins. Change the temperature in steps of 5° –10° F (9° – 18° C) until the proper melt condition is achieved.	• Wet material.	• Check drying procedure.
	• Overheating.	• Reduce heat, back pressure, or screw speed. • Check heater bands and controller for malfunction.

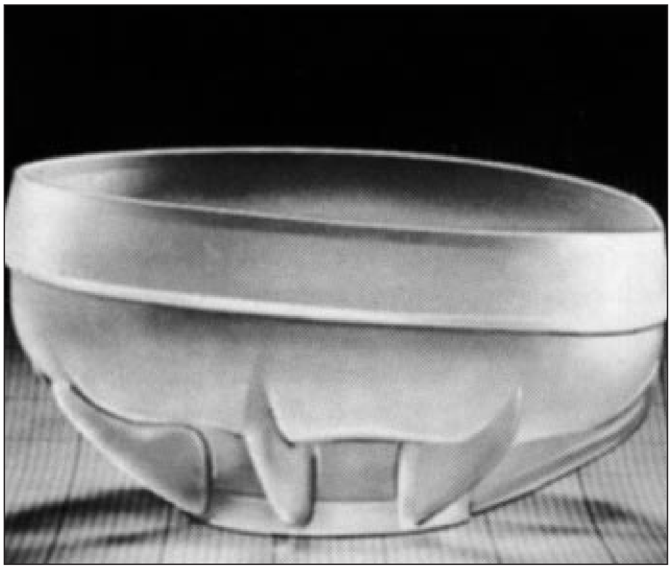
Figure 33 **Voids**



WARPAGE

Description of Problem	Possible Causes	Possible Corrective Action
Due to variations in part geometry and wall thickness, sections of a molded part cool at different rates from the ejected melt temperature to room temperature. Differential shrinkage occurs and the part tends to become concave on the side that cooled last, most likely around the gate area.	• Unequal mold-half temperatures.	• Check for uniform mold temperature.
	• Distortion upon ejection.	• Check for uniform part ejection.
	• Material not set up completely prior to ejection.	• Decrease injection speed. • Decrease injection pressure. • Increase cooling time. • Lower material temperature.

Figure 34 **Warpage**



GENERAL

Wear safety glasses and/or face shields when processing Texin and Desmopan resins, especially during purging, and use proper gloves and other appropriate garments when handling hot tools and auxiliary equipment. Material Safety Data Sheets (MSDS) are available and should be consulted prior to processing Texin and Desmopan polyurethane elastomer resins.

HEALTH AND SAFETY PRECAUTIONS

Appropriate literature has been assembled which provides information concerning health and safety precautions that must be observed when handling Bayer Corporation products mentioned in this publication. Before working with any of these products, you must read and become familiar with the available information on their hazards, proper use, and handling. This cannot be overemphasized. Information is available in several forms, e.g., Material Safety Data Sheets (MSDS) and product labels. Consult your local Bayer Corporation representative or contact the Product Safety and Regulatory Affairs Department in Pittsburgh, Pennsylvania at 412-777-2000.

For materials that are not Bayer Corporation products, appropriate industrial hygiene and other safety precautions recommended by their manufacturer(s) should be followed.

DEVELOPMENTAL PRODUCT INFORMATION

Any product in this publication with a grade designation containing the letters DP, KU, or KL is classified as a developmental product and is not considered part of the Bayer Corporation line of standard commercial products. Complete commercialization and continued supply are not assured. The purchaser/user agrees that Bayer Corporation reserves the right to discontinue supply at any time.

REGULATORY COMPLIANCE

Some of the end-uses of the products described in this brochure must comply with the applicable regulations, such as the FDA, NSF, USDA, and CPSC. If you have questions on the regulatory status of Texin and Desmopan resins, please contact your local Bayer Corporation representative or the Bayer Corporation Regulatory Affairs Manager in Pittsburgh, Pennsylvania.

MEDICAL GRADE INFORMATION

It is the responsibility of the medical device, biological product, or pharmaceutical manufacturer to determine the suitability of all component parts and raw materials, including Texin and Desmopan TPU resins, used in its final product in order to ensure safety and compliance with FDA regulations. This determination must include, as applicable, testing for suitability as an implant device and suitability as to contact with and/or storage of solutions/liquids, including, without limitation, medication, blood, or other bodily fluids. Under no circumstances, however, may Texin and Desmopan TPU resins be used in any cosmetic reconstructive or reproductive implant applications, nor may any Bayer Corporation resin be used in any other bodily implant applications for greater than 29 days, based on Tripartite Guidance Tests. Furthermore, for aromatic grades of Texin and Desmopan TPU resins, longer term uses are not permissible because possible hydrolysis of solid urethane may produce aromatic amines, such as methylene dianiline (MDA). If you have any questions on the regulatory status of Texin and Desmopan resins, please contact your local Bayer Corporation representative or the Bayer Corporation Regulatory Affairs Manager in the Health, Environment, and Safety Department in Pittsburgh, Pennsylvania.

STERILIZATION INFORMATION

The sterilization method and the number of sterilization cycles a part made from Texin and Desmopan TPU resins can withstand will vary depending upon the type and grade of resin, part design, and processing parameters. Therefore, the manufacturer must evaluate each application to determine the sterilization method and the number of cycles for exact end-use requirements. Parts molded from Texin and Desmopan TPU resins are sterilizable using ethylene oxide, radiation, or dry heat. Steam sterilization methods must not be used with aromatic grades of Texin and Desmopan TPU resins because possible hydrolysis of solid urethane may produce aromatic amines, such as methylene dianiline (MDA).

BIOCOMPATIBILITY INFORMATION

The medical grades of Texin and Desmopan TPU resins have met the biocompatibility requirements for U.S. Pharmacopoeia Procedure 23 Class VI, with human tissue contact time of 29 days or less.

TECHNICAL SUPPORT

To get material selection and/or design assistance, just write or call and let us know who you are and what your needs are. So that we can respond efficiently to your inquiry, here are some of the points of information we would like to know: physical description of your part(s) and engineering drawings, if possible; material currently being used; service requirements, such as mechanical stress and/or strain, peak and continual service temperature, types of chemicals to which the part(s) may be exposed, stiffness required to support the part itself or another item, impact resistance and assembly techniques; applicable government or regulatory agency test standards; tolerances that must be held in the functioning environment of the part(s); and any other restrictive factors or pertinent information of which we should be aware.

In addition, we can provide processing assistance nationwide through a network of regional Field Technical Service Representatives. We can help customers optimize the quality and performance of their parts by offering the following types of assistance: on-site processing, equipment, and productivity audits; startup and troubleshooting support; and tool design.

Upon request, Bayer Corporation will furnish such technical advice or assistance it deems to be appropriate in reference to your use of our Texin and Desmopan products. It is expressly understood and agreed that, since all such technical advice or assistance is rendered without compensation and is based upon information believed to be reliable, the customer assumes and hereby expressly releases Bayer Corporation from all liability and obligation for any advice or assistance given or results obtained. Moreover, it is your responsibility to conduct end-use testing and to otherwise determine to your own satisfaction whether Bayer Corporation products and information are suitable for your intended uses and applications.

For assistance, contact any of our regional sales offices listed on the back cover, or call or write us at the following address:

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Texin Product Management
100 Bayer Road, Building 8
Pittsburgh, PA 15205-9741
Phone: 412-777-2000

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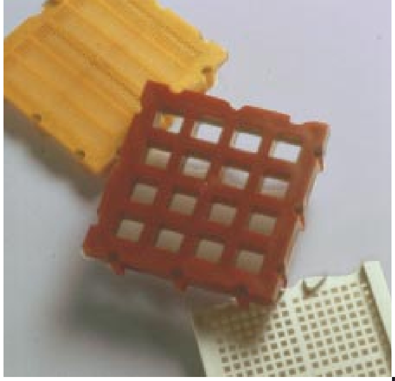

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