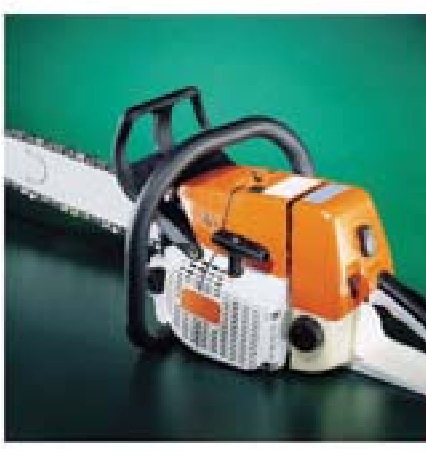
LANXESS
Energizing Chemistry

A processing guide for
INJECTION MOLDING

DURETHAN
POLYAMIDE



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INTRODUCTION

PRODUCT DESCRIPTION

Durethan polyamide resin is recognized worldwide as a high–quality engineering thermoplastic. Parts molded of Durethan resins are used in a variety of markets in applications which depend on high strength, good impact strength even at cold temperatures, high dynamic load capacity, excellent processibility, excellent abrasion and wear resistance, chemical resistance, thermal stability, high dynamic fatigue resistance, and good electrical insulating properties. Glass-fiber-reinforced grades of Durethan resin also exhibit high heat resistance.

As with most high-performance engineering thermoplastics, certain methods and procedures should be followed when injection molding parts with Durethan resin. This guide is intended to provide the molder with appropriate information for processing Durethan polyamide resins. For information on part design, consult the LANXESS Corporation publication, *Part and Mold Design-Thermoplastics.*

Product by Grade Type

Durethan polyamide resin is available in general-purpose unreinforced and glass-fiber-reinforced grades, and impact-modified unreinforced, glass-fiber-reinforced, and mineral-filled grades.

For information on other Durethan resins suitable for other types of processing, such as film extrusion, blow molding, or profile extrusion, contact LANXESS Corporation or your Technical representative for Durethan resin at 800-LANXESS.

Product by Market

The family of Durethan polyamide 6 resins is marked by well-balanced properties that have enabled its use in a variety of markets and applications. They include automotive exterior, interior, and under-the-hood components; furniture; consumer appliances; power tool housings; electrical/electronic wiring devices and switches; industrial/mechanical components; lawn and garden equipment; and packaging film for medical, food, and industrial goods.

Table 1 Grade Composition and Designations for Durethan Resins

Composition	Designation
Unfilled (Unreinforced)	B + Grade Number
Unfilled/Impact-Modified	BC + Grade Number
Reinforced	BKV + Grade Number
Reinforced/Impact-Modified	BKV + 100-Series Grade Number
Mineral-Filled	BM + Grade Number
Reinforced/Warpage Control	BG + Grade Control
Transparent	T + Grade Number

NOMENCLATURE

Grade Designation

There are two groups of Durethan resins: Durethan “A” resins, which are polyamide (nylon) type 66 engineering polymers; and Durethan “B” resins, which are polyamide type 6 resins. LANXESS Corporation offers primarily Durethan B resins in the United States plus speciality grades of Durethan “C” copolymer and Durethan “T” transparent resin.

The grade designation for Durethan resin consists of three parts:

1. Prefix	A series of letters describing the grade composition.
2. Grade Number	A number indicating viscosity for unfilled grades and the amount of filler in reinforced grades.
3. Suffix	A letter indicating the type of performance additive in the grade.

Table 1 lists the grade composition and designations for Durethan polyamide 6 resins. Table 2 lists the performance additives and designations.

Color Designation

Opaque colors, as well as natural tints, are available in pellet form. The color coding system for Durethan polyamide is listed in Table 3.

Table 2 Performance Additives and Designations for Durethan Resins

Performance Additive	Designation
Heat Stabilized	H
Internal Mold Release	S
Nucleating Agent	K
Mixed Filler	X
Antioxidant	W
Impact Modified (Low)	Z

Table 3 Color Coding System for Durethan Polyamide Resin

Color	Code
Natural	1000 – 1499
Blacks	1500 – 1999
Grays	2000 – 2999
Whites	3000 – 3999
Browns	4000 – 4999
Yellows	5000 – 5999
Oranges	6000 – 6999
Reds	7000 – 7999
Blues	8000 – 8999
Greens	9000 – 9999

PACKAGING AND LABELING

All injection molding grades of Durethan resin are supplied as dried pellets in vacuum-sealed, moisture-tight, multi-walled 55-lb (25-kg) bags. A pallet of 30 bags weighs 1,650 lb (750 kg). The pallets are shrink-wrapped for shipping. Take care not to slit the bags when removing the shrink-wrapping.

Some grades are available in 1,102-lb (500-kg) or 2,204-lb (1000-kg) boxes. Boxed resin is also dried and sealed in special liners.

The bags and cartons are sealed to help prevent contamination from dust or dirt. Be careful when opening and resealing them that dust or dirt does not get in among the clean resin. Any particulate contamination in the feedstock will show up in the finished molding.

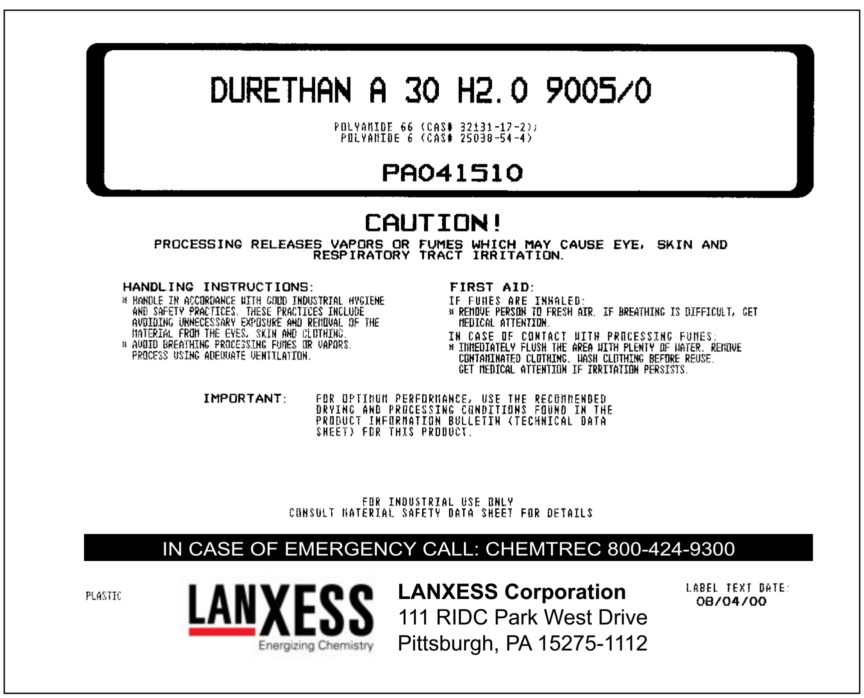
Durethan resin is hygroscopic and will begin absorbing moisture as soon as it is exposed to the air. Resin which has become moisture-contaminated can cause injection molding problems. Resin exposed to moisture for more than a few hours and processed without having been properly dried will suffer a permanent reduction in physical properties. Therefore, keep each bag or carton of Durethan resin sealed until it is to be used and avoid storing it in areas that are subject to high humidity. (See also "Drying," page 15, for more information.)

If properly sealed in their bags, most grades of Durethan resin can be stored for at least one year if not exposed directly to the weather. If the resin is to be stored outdoors, you must protect the bags from sunlight and rain, which can deteriorate the packaging.

An example of a label for Durethan resin is shown in Figure 2.

Figure 1 Durethan Polyamide Resin Pellets

Figure 2 Label Information for Durethan Polyamide Resin



DURETHAN A 30 H2.0 9005/0

POLYAMIDE 66 (CAS# 32131-17-2);
POLYAMIDE 6 (CAS# 25038-54-4)

PA041510

CAUTION!

PROCESSING RELEASES VAPORS OR FUMES WHICH MAY CAUSE EYE, SKIN AND RESPIRATORY TRACT IRRITATION.

HANDLING INSTRUCTIONS:
* HANDLE IN ACCORDANCE WITH GOOD INDUSTRIAL HYGIENE AND SAFETY PRACTICES. THESE PRACTICES INCLUDE AVOIDING UNNECESSARY EXPOSURE AND REMOVAL OF THE MATERIAL FROM THE EYES, SKIN AND CLOTHING.
* AVOID BREATHING PROCESSING FUMES OR VAPORS. PROCESS USING ADEQUATE VENTILATION.

FIRST AID:
IF FUMES ARE INHALED:
* REMOVE PERSON TO FRESH AIR. IF BREATHING IS DIFFICULT, GET MEDICAL ATTENTION.

IN CASE OF CONTACT WITH PROCESSING FUMES:
* IMMEDIATELY FLUSH THE AREA WITH PLENTY OF WATER. REMOVE CONTAMINATED CLOTHING. WASH CLOTHING BEFORE REUSE. GET MEDICAL ATTENTION IF IRRITATION PERSISTS.

IMPORTANT: FOR OPTIMUM PERFORMANCE, USE THE RECOMMENDED DRYING AND PROCESSING CONDITIONS FOUND IN THE PRODUCT INFORMATION BULLETIN (TECHNICAL DATA SHEET) FOR THIS PRODUCT.

FOR INDUSTRIAL USE ONLY
CONSULT MATERIAL SAFETY DATA SHEET FOR DETAILS

IN CASE OF EMERGENCY CALL: CHEMTREC 800-424-9300

PLASTIC

LANXESS Energizing Chemistry

LANXESS Corporation
111 RIDC Park West Drive
Pittsburgh, PA 15275-1112

LABEL TEXT DATE:
08/04/00

MACHINE TYPE AND DESIGN

Reciprocating screw machines are preferred for injection molding Durethan resins. Of the conventional injection molding machines available, they provide the most uniform plasticating of molten material.

The design of reciprocating screw machines has many variables, including:

- Screw length, diameter, and configuration.
- Number and wattage of barrel heaters.
- Nozzle type.
- Size and location of mold gates.

A typical reciprocating-screw injection molding machine is shown in Figure 3.

SCREWS: MATERIAL, CONFIGURATION AND WEAR

The following are important considerations in choosing a screw for injection molding Durethan polyamide resin:

- A three-zone general-purpose screw of traditional geometry is recommended (see Figure 4). The preferred metering and feed zone depths are shown in Figure 5.
- Screws with a length-to-diameter ratio (L/D) in the range of 18:1–22:1 are recommended. An L/D ratio of 20:1 is preferred. If a shorter screw is used, reduce the screw pitch to obtain 20 flights, as shown in Figure 6.
- Screws with an L/D ratio greater than 22:1 can cause material degradation. Once again, if a shorter screw is used, reduce the pitch to obtain 20 flights.

Figure 3 Typical Injection Molding Machine

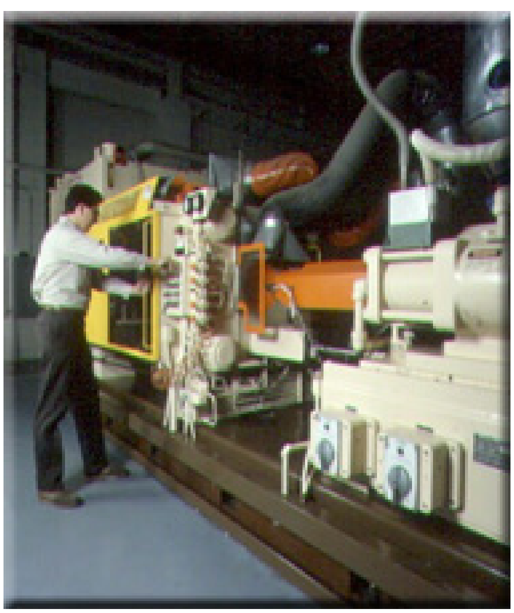


Figure 4 Typical Injection Molding Screw

- Best results are achieved when the flight-to-depth ratio of the feed section to the metering section is between 2.0:1 and 2.5:1.

- The screw pitch should equal the screw diameter for diameters less than 3.2 in. (80 mm). The screw pitch should be about 90% of the diameter for screw diameters greater than 3.2 in. (80 mm).

- Screws should be chrome-plated and highly polished. The flight lands should not be plated, however, because the plating may chip off and contaminate the resin melt.

- Use screws made of surface-hardened steel for injection molding glass-fiber-reinforced or mineral-filled Durethan resin. The glass fibers can chip and abrade the chrome plating, contaminating the melt.

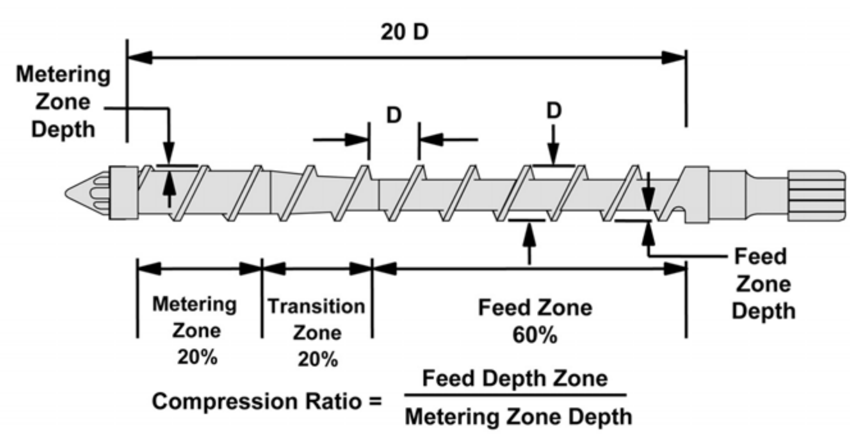
- An abrasion-resistant, bimetallic barrel liner, such as Xaloy,* is preferred. Avoid using worn barrels, since they can develop a layer of degraded resin that can break loose and contaminate the melt.

*Xaloy is the registered trademark of Xaloy, Inc.

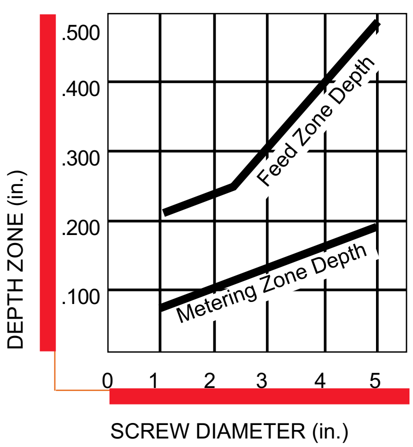
Durethan resins, which are crystalline thermoplastics, require high plasticizing efficiency because of their high specific heat. Short screws and high throughput rates will accomplish this. Special screws with reduced flight depths and shorter pitches may be required in some cases.

Avoid using increasing-core-diameter (progressive core) and short-transition-zone types of screws for processing Durethan resins. These types of screws may not produce a homogeneous melt, thereby causing inconsistent results.

Figure 5 Screw Profile



Preferred Screw Flight Depths **Figure 6**



NON-RETURN VALVES

A free-flowing, sliding check-ring non-return valve is recommended for injection molding Durethan resins (see Figure 7). It prevents the molten polymer in the holding space in front of the screw from flowing back into the screw during the injection cycle. Ball-check valves are not recommended.

Good flow characteristics, as shown in Figure 8, are essential. A fully channeled tip will minimize flow restrictions.

Good flow characteristics are an important requirement of the non-return valve because Durethan polyamide, like other thermoplastics, will degrade when subjected to excessive shear at flow restrictions.

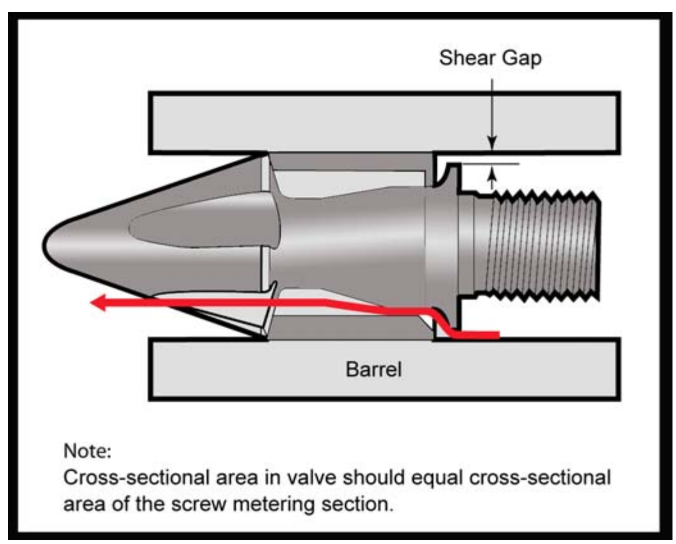
For strength, the check ring of small-diameter screws often has a larger external diameter than the screw core. The shear gap that is formed between the ring and screw can cause degradation and discoloration when shear-sensitive grades and pigments are processed. Therefore, this seal flange should be only as large as necessary for the strength of the check ring.

With small-diameter screws, keep the shear gap length under 0.080 in. (2 mm). Even with large-diameter screws, keep the length under 0.160 in. (4 mm).

The valve and check ring are subject to severe wear, especially when molding glass-fiber-reinforced plastic. Make frequent visual inspections of the non-return valve to see that it is functioning properly.

Figure 7 **Free-Flowing Sliding Check-Ring-Style Non-Return Valve**

Figure 8 **Flow Characteristics of the Non-Returning Ring Valve**



NOZZLES: TYPES AND TIPS

Nozzles are available with and without removable tips (see Figure 9). The melt viscosity of Durethan resin is low enough that the melt can leak or drool from the nozzle between injection cycles and blemish the molded part. Adjustments to the nozzle temperature and suck-back settings usually correct drooling problems. Occasionally, a shut-off nozzle is required to prevent drool. Two common types of shut-off nozzles are the sliding shut-off nozzle and the needle shut-off nozzle (see Figures 10 and 11).

Nozzle Materials

Standard steel nozzles are acceptable. However, type 420 stainless steel offers better protection against black specks in long production runs.

Nozzle Size

The nozzle should be as short as possible with its internal diameter determined by its length and required throughput. Nozzles up to 6 in. (150 mm) long require an internal diameter of 0.375 in. (9 mm). The major inside diameter at the threaded end should be exactly equal to the diameter of the end cap.

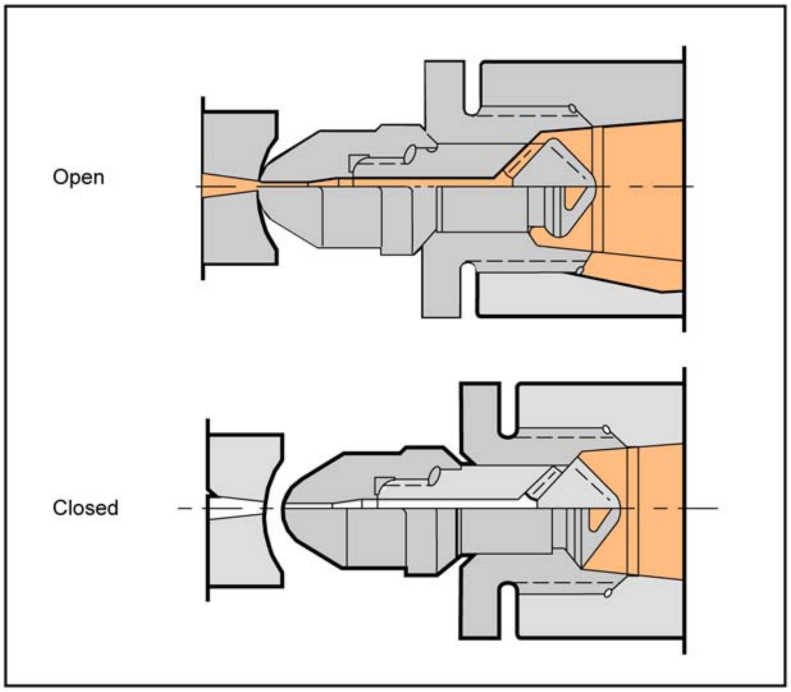
Proper mating and firm seating of the nozzle and sprue bushing are essential. The nozzle discharge opening must not exceed the diameter of the sprue bushing inlet, otherwise it will form an undercut that could stick to the sprue. To promote material flow, the nozzle opening should be at least 80% of the diameter of the spure bushing inlet.

Nozzle Temperature Control

The nozzle must have an independent heater and controller system to maintain the proper nozzle temperature because heat drained from the nozzle by the mold can cause the melt to cool enough to solidify. Permitting the

Figure 9 Removable and Non-Removable Nozzle Tips

Figure 10 Sliding Shut-Off Nozzle



nozzle to come in contact with the mold only during the injection and pressure-holding phases of the molding cycle will also help prevent the melt from cooling and solidifying in the nozzle.

PROCESS CONTROLS

Durethan resin is melted in the barrel by a combination of heat transferred from external heaters through the barrel wall and frictional heating 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.

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.

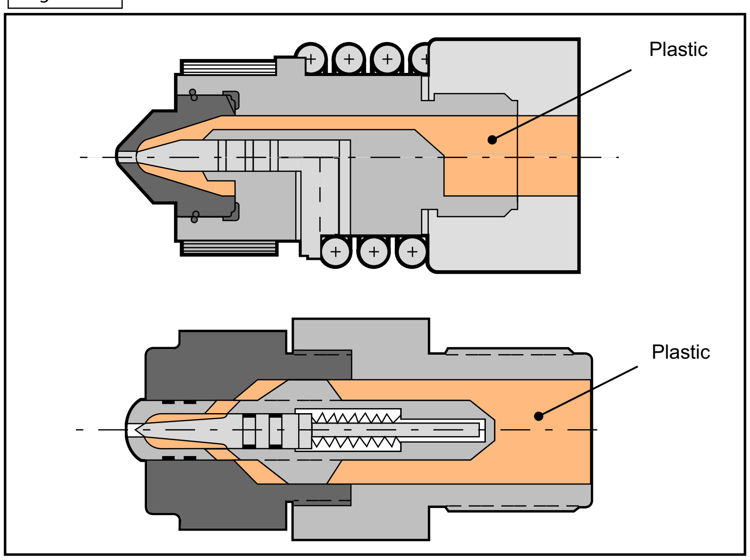
Short residence time in the barrel can lead to insufficient heating of the melt. The solution is to achieve a greater proportion of the heat needed to plasticate the resin by using a screw of optimum design that provides increased friction.

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 cause excessive fiberglass breakage in reinforced grades of Durethan resin. In addition, the cycle time might increase because increasing the back pressure also prolongs screw retraction. Therefore, adjustment of back pressure is not always a solution to a less-than-optimum screw design.

Needle Shut-Off Nozzles (Closed)

Figure 11



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 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 Durethan resin 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. They can adjust hold pressure in increments to minimize sinks and voids. In addition, they 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

Utilization of 25% – 65% of the barrel capacity is preferred. Excessive residence time at elevated temperatures can cause Durethan resins to degrade. It is recommended that the material remain in the barrel at processing temperatures for no longer than 10 minutes, on average.

Machine Ventilation

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

Table 4 **Suggested Starting Conditions for Processing Durethan Resins**

Conditions	B 30 S B 31 SK	BC 30 BC 40SR2 BC 304	BKV 15/30/40/50 BKV 115/130/140 BM 30X/40X
Processing Temperatures			
Zones			
Rear	470°–480°F (245°–250°C)	490°–500°F (255°–260°C)	470°–480°F (245°–250°C)
Middle	480°–500°F (250°–260°C)	500°–520°F (260°–270°C)	480°–510°F (250°–265°C)
Front	500°–520°F (260°–270°C)	520°–535°F (270°–280°C)	510°–535°F (265°–280°C)
Nozzle	500°–520°F (260°–270°C)	520°–550°F (270°–290°C)	520°–550°F (270°–290°C)
Melt*	**480°–520°F (250°–270°C)**	**520°–550°F (270°–290°C)**	**520°–550°F (270°–290°C)**
Mold **	175°–250°F (75°–120°C)	160°–195°F (70°– 90°C)	160°–230°F (70°–110°C)
Machine Conditions			
Injection Pressure	←	10,000 –20,000 psi (70 –140 MPa)	→
Hold Pressure	←	50% of Injection Pressure	→
Back Pressure	←	50 –150 psi (345 –1,035 kPa)	→
Injection Speed	←	Moderate to Fast	→
Injection Cushion	←	0.125 –0.250 in. (3 –6 mm)	→
Screw Speed	←	60 –100 rpm	→
Clamp Tonnage	←	2 –4 t/in.^{2} (22–55 kPa)	→

* 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.

DRYING

MATERIAL HANDLING

Even though Durethan polyamide is supplied in sealed, moisture-tight, multi-walled bags, dried and ready for processing, use a desiccant dehumidifying hopper dryer to keep the resin dry during processing. Moisture-contaminated resin may lead to processing problems and affect the surface finish of the part.

Warm to room temperature any sealed bags that have been stored in an unheated warehouse before opening them. This will help prevent rapid condensation of ambient moisture on cool pellets.

Single bags can take up to 24 hours to warm up. Stacked bags, pallets, or boxes can take up to a week to reach ambient temperatures.

When exposed to atmospheric moisture, most grades of Durethan resin will absorb moisture at levels beyond the preferred limit of less than 0.10% in less than an hour. Therefore, prevent exposing the resin to undried air, and once a bag is opened, dry exposed resin prior to processing.

DRYING EQUIPMENT

Use a desiccant dehumidifying hopper dryer to remove moisture from Durethan resin and to maintain proper resin moisture content levels during processing. A typical dessicant dehumidifying hopper dryer system and airflow are shown in Figures 12 and 13. Note that the drying hopper is tall and cylindrical and has a diverter cone and baffles to diffuse the air uniformly and retard channeling of the pellets. The hopper must be capable of holding 4 times the output per hour of the injection molding machine. This will ensure that the resin remains in the drying hopper at least 4 hours.

The use of a vented-barrel molding machine is *not* recommended for Durethan polyamides because the molten resin can discolor from contact with the oxygen in the air that is present at the vent.

Figure 12 Typical Desiccant Dehumidifying Hopper Dryer System

DRYING CONDITIONS

Observe the following drying conditions for proper moisture removal from Durethan polyamide resins:

- Drying inlet air temperature to the hopper: 170°–180°F (77°–82°C). Drying temperatures above 180°F (82°C) may cause material discoloration.
- Dew point of the inlet air to the hopper: 0°F (-18°C) or less.
- Airflow to the hopper: 1.0 cubic foot per minute (CFM) for every pound of resin per hour of throughput.

The acceptable moisture content of Durethan resin to ensure optimum property performance is less than 0.10%. Use a dew-point meter to periodically monitor the moisture content of the inlet air throughout the molding operation.

If the resin being processed comes from an opened container and/or contains regrind or color concentrate, the time required to adequately dry it for processing may be as long as 72 hours.

Figure 13 **Desiccant Dehumidifying Hopper Dryer System Airflow**

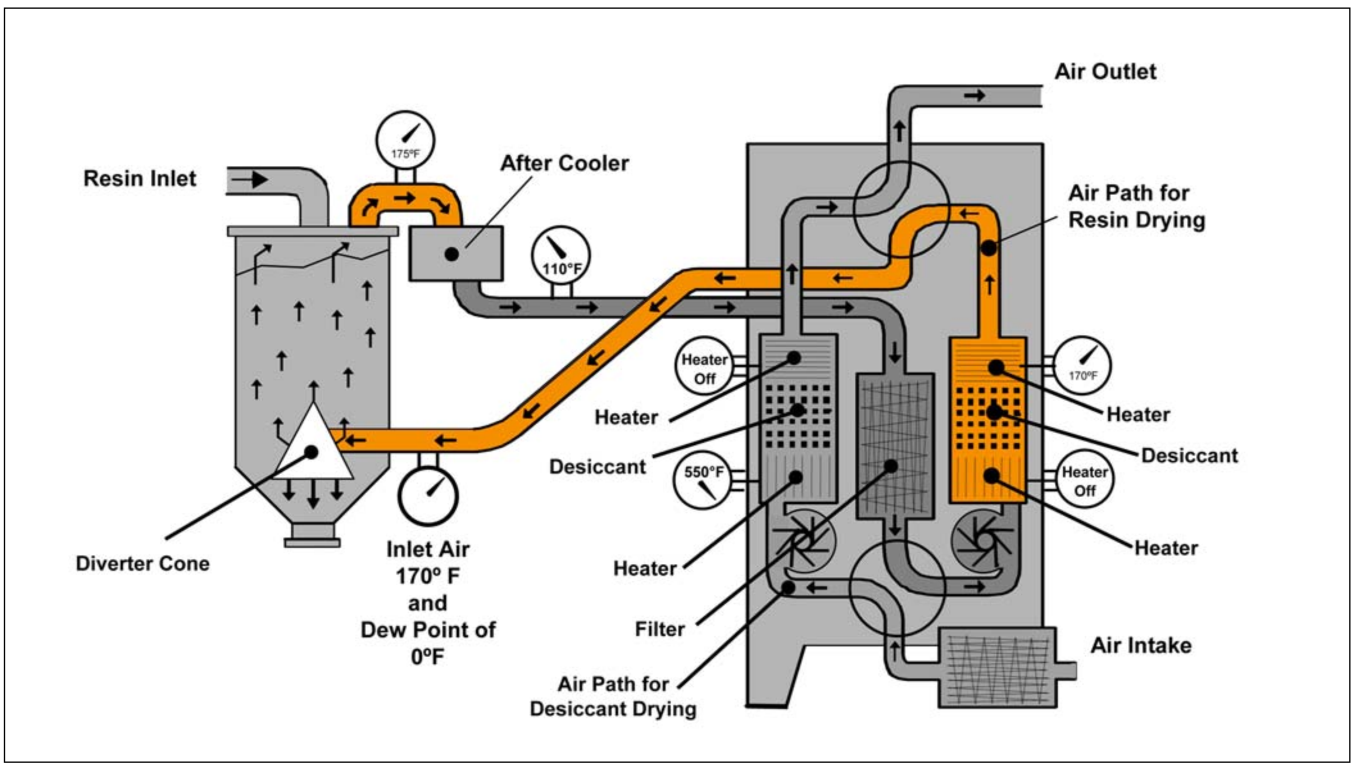


Table 5 **Dehumidifying Hopper Dryer Troubleshooting Guide**

Improper Drying Condition	Possible Causes	Possible Corrective Action
Poor Dew Point (Check inlet air hopper with a dew-point meter, the only sure way to check dryness. A dew point greater than 0°F/ -18°C is poor.)	• Dirty filter(s). • Saturated desiccant. • Excessive return air temperature. • Burned-out heater(s). • Contaminated or worn-out desiccant. • Bad heater thermostat or thermocouple. • Malfunctioning regeneration cycle timer. • Air control butterfly valves not seating.	• Clean or replace filter(s). • Dry-cycle machine for several complete cycles. Saturated desiccant is a common problem with machines that are not in continuous use. • Add after-cooler on return air line. • Repair or replace heater(s). • Replace desiccant. • Repair or replace thermostat or thermocouple. • Adjust or replace timer. • Adjust valve seating.
Material Residence Time in Hopper Too Short	• Dryer hopper too small for the amount of material being processed per hour. • Not keeping hopper at least 2/3 filled. • Moist room air leaking into the dry process air.	• Use a larger dryer hopper. • Keep drying hopper full. • 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.
Incorrect Process Air Temperature	• Incorrect drying air temperature. • Dryer temperature controller malfunction. • Thermocouple malfunction. • Faulty process air heating elements. • Supply voltage different than required heater voltage. • Non-insulated inlet air hose. • Excessive changeover temperature.	• Dial in correct temperature (170°–180°F/77°–82°C). • Repair or replace controller. • Repair or replace thermocouple. • Repair or replace heating elements. • Check supply voltage against name-plate voltage. • Repair or replace inlet-air hose. • Increase reactivation airflow.
Insufficient Inlet Airflow (Good dew point but resin still wet.)	• Dirty or clogged filter. • Incorrect blower rotation. • Obstruction in air ducts.	• Clean or replace filters. • Change blower rotation. (See equipment manufacturer's electrical instructions). • Remove air duct obstruction.

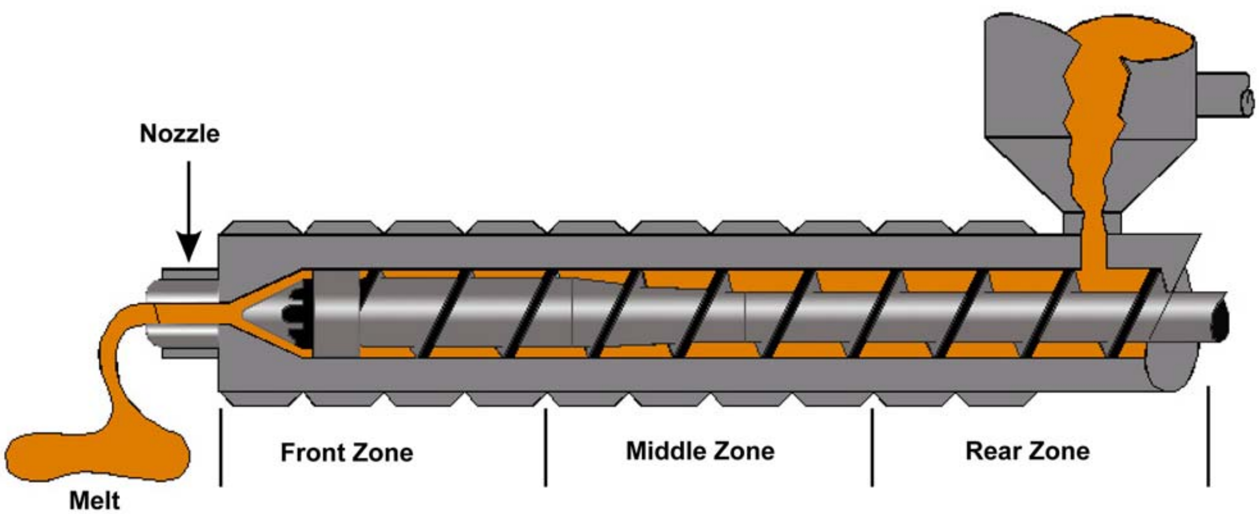
Optimizing the injection molding process involves several variables:

- 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 were obtained over a long period on a variety of molding machines and molded parts. They 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



TYPICAL PROCESSING TEMPERATURES

Table 6a Barrel Heating Temperatures for Durethan Resin

Processing Temperature	B 30 S B 31 SK	BC 30 BC 40SR2 BC 304	BKV 15/30/40/50 BKV 115/130/140 BM 30X/40X
Zones			
Rear	470°–480°F (245°–250°C)	490°–500°F (255°–260°C)	470°–480°F (245°–250°C)
Middle	480°–500°F (250°–260°C)	500°–520°F (260°–270°C)	480°–510°F (250°–265°C)
Front	500°–520°F (260°–270°C)	520°–535°F (270°–280°C)	510°–535°F (265°–280°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. Higher-viscosity and glass-fiber-reinforced grades require settings near the upper limits of the range. In all cases, however, the temperature profile should increase incrementally from the rear of the barrel to the nozzle.

Take care to maintain a consistent melt temperature and inspect the heater bands periodically. Durethan resins are sensitive to overheating or remaining in the melt phase for a prolonged time. Do not exceed a maximum melt temperature of 550°F (290°C) for any grade of Durethan resin.

Table 6b Nozzle Temperatures for Durethan Resin

Processing Temperature	B 30 S B 31 SK	BC 30 BC 40SR2 BC 304	BKV 15/30/40/50 BKV 115/130/140 BM 30X/40X
Nozzle	500°–520°F (260°–270°C)	520°–550°F (270°–290°C)	520°–550°F (270°–290°C)

Nozzle

It is important that the nozzle be equipped with an independent heating system and controller to maintain a constant melt temperature. In most cases, the optimum nozzle temperature is below the front zone temperature, in the range of 500°–520°F (260°–290°C).

Table 6c   Melt Temperatures for Durethan Resin

Processing Temperature	B 30 S B 31 SK	BC 30 BC 40SR2 BC 304	BKV 15/30/40/50 BKV 115/130/140 BM 30X/40X
MELT*	480°–520°F (250°–270°C)	520°–550°F (270°–290°C)	520°–550°F (270°–290°C)

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

Melt Temperature

The optimum melt temperature for most parts is in the range of 480°–550°F (250°–290°C). Lower melt temperatures can minimize drool while higher melt temperatures can assist in filling complicated parts or parts with thin walls.

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

Figure 14   **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.

MACHINE CONDITIONS

Table 7a Injection Pressure for Durethan Resin

Machine Conditions	B 30 S B 31 SK	BC 30 BC 40SR2 BC 304	BKV 15/30/40/50 BKV 115/130/140 BM 30X/40X
Injection Pressure	10,000 – 20,000 psi	10,000 – 20,000 psi	10,000 – 20,000 psi

Injection Pressure

The injection of molten Durethan resin into a mold is usually done in two phases: the primary, injection phase and the secondary, hold phase. In the injection phase, the melt is rapidly injected into the mold at a pressure of 10,000–20,000 psi (70–140 MPa) until the mold is just filled.

Too little injection pressure may not fill the mold completely with resin. Too much injection pressure can lead to flash and overpacking. The injection pressure also influences surface quality and orientation. Therefore, use only enough pressure to fill the mold.

Table 7b Hold Pressure for Durethan Resin

Machine Conditions	B 30 S B 31 SK	BC 30 BC 40SR2 BC 304	BKV 15/30/40/50 BKV 115/130/140 BM 30X/40X
Hold Pressure	50% Injection Pressure	50% Injection Pressure	50% Injection Pressure

Hold Pressure

Ideally, the secondary or hold pressure should be 50%–60% of the primary, injection pressure — just high enough to prevent sinks and voids.

The hold phase packs out the mold and compresses the material to the proper density. Packing produces mold textures, eliminates sinks and voids, and establishes internal orientation. Overpacking during this phase can lead to flash, shrinkage and warpage problems, and part ejection problems.

Table 7c Injection Speed for Durethan Resin

Machine Conditions	B 30 S B 31 SK	BC 30 BC 40SR2 BC 304	BKV 15/30/40/50 BKV 115/130/140 BM 30X/40X
Injection Speed	Moderate to Fast	Moderate to Fast	Moderate to Fast

Injection Speed

Durethan resin requires a rapid injection speed. If the injection speed is too slow, the flow front can cool down and begin to solidify. This prevents satisfactory mixing of flow fronts after flowing around an insert or hole, for example, which can show up in the finished parts as pronounced weld lines. Weld line strength can be diminished. Slow injection speed can also reduce surface quality.

A slow or graduated injection speed may be necessary when the melt stream does not encounter a wall as it enters the cavity. Otherwise, the material can spray the length of the mold (jetting) then fill in irregularly around this mass.

Table 7d Injection Cushion for Durethan Resin

Machine Conditions	B 30 S B 31 SK	BC 30 BC 40SR2 BC 304	BKV 15/30/40/50 BKV 115/130/140 BM 30X/40X
Injection Cushion	0.125 – 0.250 in.	0.125 – 0.250 in.	0.125 – 0.250 in.

Injection Cushion

A slight cushion of 0.125–0.250 in. (3–6 mm) is suggested. Without a slight cushion the screw may bottom out and prevent complete packing of the mold. Too much cushion may lead to longer time in the barrel and material degradation. Any fluctuation in the amount of cushion, once it has been set, is an indication that either the screw is slipping or the non-return valve is allowing resin to back-flow.

Table 7e Back Pressure for Durethan Resin

Machine Conditions	B 30 S B 31 SK	BC 30 BC 40SR2 BC 304	BKV 15/30/40/50 BKV 115/130/140 BM 30X/40X
Back Pressure	50 – 150 psi	50 – 150 psi	50 – 150 psi

Back Pressure

The function of back pressure is to control shear heating and improve melt uniformity. It also removes any air drawn in with the pellets.

Set the nominal back pressure at 50–150 psi (345–1,035 kPa). Back pressure that is too low may cause inconsistent feeding and trapped air. During injection, this air is compressed and heated, causing black or brown degradation and bubbles in the part. Back pressure that is too high may cause thermal damage to the material through over-shearing. With filled resin grades, high back pressure can cause excessive fiberglass breakage.

Table 7f Screw Speed for Durethan Resin

Machine Conditions	B 30 S B 31 SK	BC 30 BC 40SR2 BC 304	BKV 15/30/40/50 BKV 115/130/140 BM 30X/40X
Screw Speed	60 – 100 rpm	60 – 100 rpm	60 – 100 rpm

Screw Speed

The recommended screw speed for Durethan resin is 60–100 revolutions per minute (rpm).

A slow screw speed provides a more uniform temperature distribution than can be achieved with a high screw speed by providing enough time for heat to be introduced through the cylinder wall of the injection molding machine and conducted across the cross-section of the screw channel.

However, a screw speed that is too slow can lead to long cycles and poor shear heating. A screw speed that is too fast can lead to excessive shear heating which may degrade the resin melt and cause discoloration.

Allow the screw to rotate until just before the mold opens.

Table 7g Clamp Tonnage for Durethan Resin

Machine Conditions	B 30 S B 31 SK	BC 30 BC 40SR2 BC 304	BKV 15/30/40/50 BKV 115/130/140 BM 30X/40X
Clamp Tonnage	2 – 4 t/in.^{2}	2 – 4 t/in.^{2}	2 – 4 t/in.^{2}

Clamp Tonnage

Properly matching the size of the injection molding machine to the part to be molded is very important. A clamp tonnage of 2–4 t/in.^{2} (25–55 kPa) of projected part surface area is required to prevent the mold from blowing open and causing flash.

Table 8 Mold Temperature for Durethan Resin

Machine Conditions	B 30 S B 31 SK	BC 30 BC 40SR2 BC 304	BKV 15/30/40/50 BKV 115/130/140 BM 30X/40X
Mold Temperature*	175° – 250°F (75° – 120°C)	160° – 195°F (70° – 90°C)	160° – 230°F (70° – 110°C)

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

Mold Temperature

Even when optimally molded, crystalline resins such as Durethan resins contain a substantially amorphous fraction. (This is why crystalline resins are also referred to as semi-crystalline.) Properties of the part depend on the crystalline-to-amorphous ratio, which is determined by the temperature of the mold and rate of cooling. Therefore, molding conditions, especially mold temperature, must be carefully chosen and maintained to ensure consistent part quality.

While low mold temperatures result in rapid cooling and high output rates, the quality of the parts is adversely affected. The degree of orientation, internal stresses, and post-shrinkage increase, and surface quality is reduced. Rapid cooling can cause the formation of an amorphous outer layer which can reduce the physical properties and chemical resistance of the part. High mold temperature and slow cooling, however, result in higher crystallinity, better dimensional control, better properties, and better chemical resistance.

Recommended mold temperatures for various grades of Durethan B resin are provided in Table 8. Check the temperature of the mold on the part cavity and core surfaces rather than relying on mold temperature control settings (see Figure 16). Set the temperature on the stationary half of the mold different than the moving half of the mold to control warpage in a molded part.

Mold Temperature Control

Melts of Durethan resin must be injected into hot molds to help ensure the quality of the molded part. Internal stresses, shrinkage, dimensional tolerance, surface quality, and mechanical properties — all are influenced by the temperature of the mold.

Maintain a uniform temperature across the mold surface and between the cavity and core to allow the molded part to shrink uniformly and thus avoid distortion and variations in dimensional tolerances. To achieve this, adjust the coolant flow rates, coolant temperature, and cooling circuit to provide maximum cooling to the hottest areas.

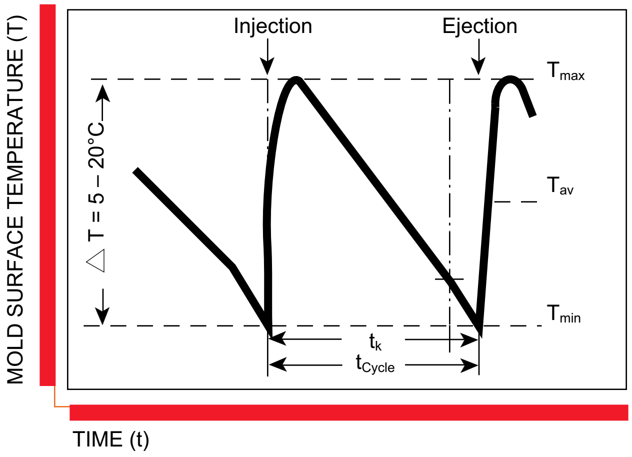
Circulating a heat transfer fluid through channels cut into the mold body is one effective way to control and maintain mold temperature. The fluid can be heated to raise the temperature of the mold, and it can remove heat given off by the plastic melt as it cools.

Electrical resistance heaters (cartridge heaters) provide an effective way to maintain elevated mold temperatures. The cartridges are inserted into wells cut in the mold and controlled by external rheostats.

Circulating heat transfer fluids are preferred to electric cartridge heaters because they can readily add or remove heat as required. The fluid is easy to pump, provides very efficient heat transfer, and can be circulated in areas that are often inaccessible to electric cartridge heaters. The use of heat transfer fluids also aids in achieving a consistent mold temperature over extended production runs.

Figure 16 **Measuring Mold Surface Temperature During the Injection Molding Cycle**

Variation in the Temperature of the Mold Surface During the Injection Molding Cycle **Figure 17**



Regardless of which type of heater is used, a separate controller for each half of the mold is desirable because it is sometimes necessary to operate the core half of the mold at a slightly lower temperature than the cavity half. This helps retain the part on the core when the mold is opened, aiding in part removal. Some complicated molds with large lifters and cams may require additional control zones.

Considering the high mold temperatures achieved in processing Durethan resin, observe all precautions recommended by the manufacturer of the heat transfer system. Use shielded hoses and automatic shut-off fittings, and secure the fastening of all the fittings to avoid spills, leaks, and operator injury.

The temperature of the mold surface can vary as much as 36°F (20°C) during the injection molding cycle. Minimizing wide temperature fluctuations can be achieved simply by insulating the mold halves from the platens.

Following are some additional ways to improve temperature control:

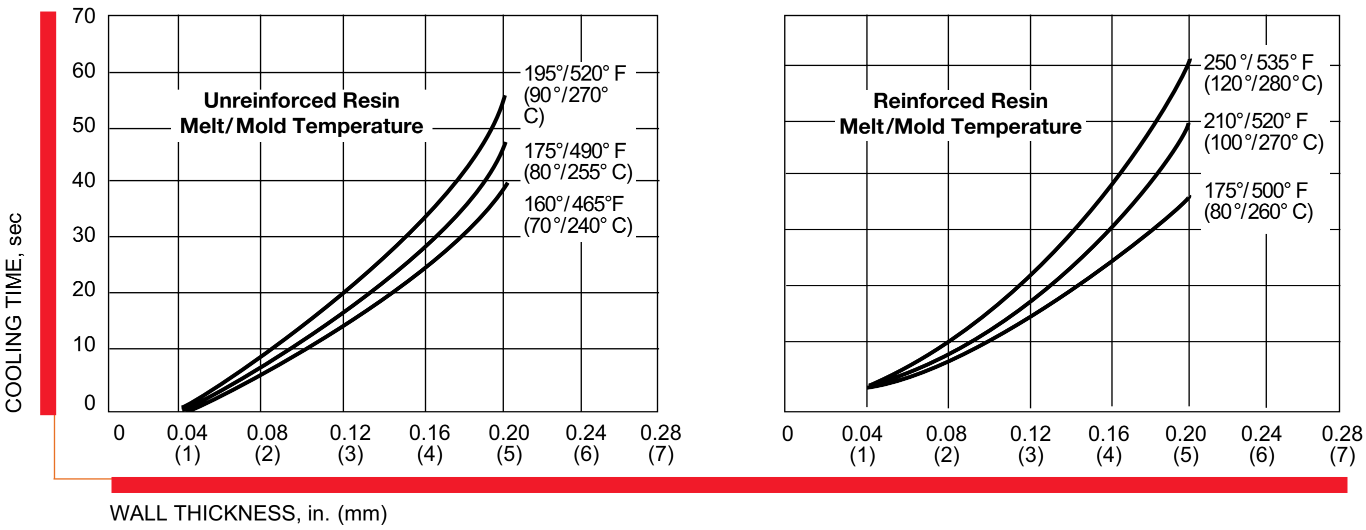
- Match fluid circulator capacity to the size of the mold.
- Place sheets of insulating material between mold halves and platens.
- Clean out rust and scale periodically from cooling channels.
- Use conditioned water or other heat transfer fluids.
- Use high coolant throughput rates to maintain turbulent flow and efficient cooling.
- Avoid unbalanced parallel cooling circuits because flow rate through a more restricted circuit will be too low.
- Install filters in front of the mold inlet to control fluid contamination.
- Match electric cartridge size and quantity to the size of the mold.
- Minimize the time the mold is open during the molding cycle.
- Use bubblers and heat pipes to displace additional heat from the mold.

Residence Time

It is recommended that Durethan resin remain in the barrel at a melt temperature of 535°F (280°C) for no more than 30 minutes. High temperatures necessitate shorter residence times as do certain additives and coolants.

Effect of Part Wall Thickness on Total Mold Cycle Time at Various Mold and Melt Temperatures, °F (°C)

Figure 18



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 that the part ejectors do not penetrate the part. Cooling time is the major portion of the total molding cycle. The cooling time required for a part depends on its wall thickness (see Figure 18), runner size, and sprue size. Normally, faster cycles are achieved with glass- and mineral-reinforced resins than with unreinforced resins.

MOLD RELEASE AGENTS

Mold lubrication may be a good idea for start-up shots. Mold release agents intended for high-temperature molds are recommended. Avoid using silicone lubricants for molding parts with Durethan resin which will be used for electronic applications because they may affect the end-use performance of the device.

If you are experiencing a problem with parts sticking to the mold, consult a LANXESS Corporation technical representative for Durethan resin at 800-LANXESS to help you determine the best solution.

PART SHRINKAGE

Thermoplastics shrink after filling a mold cavity due to contraction as the melt cools. Crystalline plastics such as some polyamides will shrink an additional amount as the polymer chains order themselves into compact crystalline regions. Fillers and other additives influence shrinkage to varying degrees.

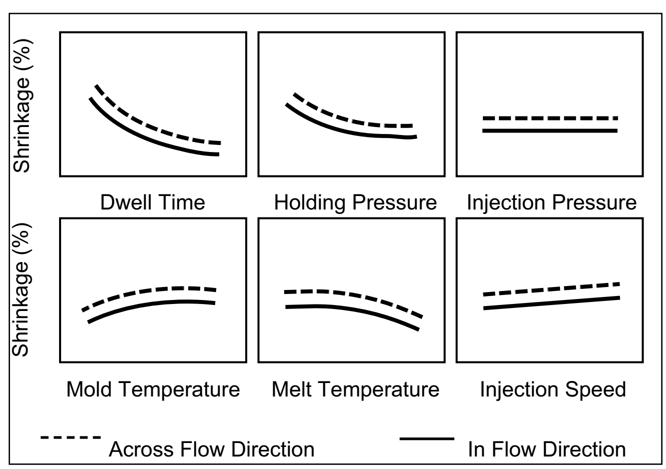
Various molding process parameters also influence shrinkage. For example:

- Increasing the melt temperature decreases shrinkage.
- Increasing the mold temperature increases shrinkage.
- Increasing the injection rate increases shrinkage.
- Increasing the holding pressure decreases shrinkage.
- Increasing the holding time decreases shrinkage.

These effects on unfilled Durethan resins are shown graphically in Figure 19.

Fiberglass-reinforced Durethan resin exhibits more complex shrinkage behavior. During injection molding the individual fibers tend to align in the direction of flow. They restrict the shrinkage of the plastic, the effect being greater in the flow direction than in the cross-flow direction. While typical shrinkage values for unfilled Durethan resins are 1.0%–1.4% in both directions, the typical shrinkage values for 30% glass-fiber-reinforced Durethan resin are about 0.3% in the flow direction and 0.9% in the cross-flow direction.

Figure 19 **Effect of Process Conditions on Shrinkage with Non-Reinforced Grades of Durethan Resin**



The difference in flow versus cross-flow shrinkage can cause warping in molded parts. Proper part and mold design achieved with the aid of mold filling analysis programs can reduce this effect.

For more information, refer to the LANXESS Corporation publication, *Part and Mold Design-Thermaplastics*, or consult a LANXESS Corporation technical representative for Durethan resin at 800-LANXESS.

PART EJECTION

The ejection of a part from a mold is affected by the surface quality of the mold core, the adhesion of the part to the core, and by the shape of the part. While the surface quality of the mold core and the shape of the part cannot be controlled by varying the processing parameters, the adhesion of the part to the core can be controlled.

The adhesion of a part to the mold core is a result of friction between the part and the mold surface. Material shrinkage on to the core increases frictional forces. Therefore, keeping part shrinkage to a minimum can control the amount of frictional force and reduce the adhesion of the part to its mold.

COLOR CONCENTRATES

Coloring Durethan polyamide can be accomplished by blending with concentrates from either LANXESS or other commercial sources. Thoroughly blend the color concentrate with the virgin resin and properly dry the mixture prior to introducing it to the molding machine.

When using commercial color concentrates, take care to ensure that the color carrier is polyamide.

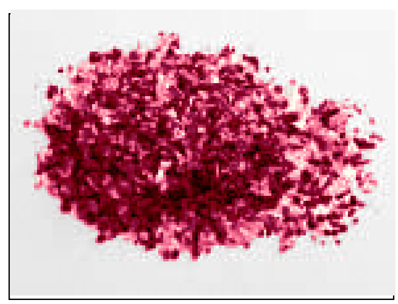
USING REGRIND

Up to 10% regrind may be used with all grades of virgin Durethan polyamide resin, depending upon the end-use requirements of the molded part and provided that the material is kept free of contamination and is properly dried (170°–180°F/77°–82°C for 4 or more hours). (See “Drying,” page 15, for details.) Any regrind used must be generated from properly molded parts, sprues, and/or runners. All regrind used must be clean, uncontaminated, and thoroughly blended with the virgin resin prior to drying and processing.

Under no circumstances should degraded, discolored, or contaminated material be used for regrind. Discard such materials.

Improperly mixed and/or dried resin may diminish the desired properties of Durethan resin. 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 agencies and/or organizations, e.g., Underwriters Laboratories (UL), may have specific

Figure 20 **Regrind Material**



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

requirements limiting the allowable amount of regrind. LANXES does not recommend the use of third-party regrind because it generally does not have a traceable heat history, nor does it offer any assurance that proper temperatures, conditions, and/or materials were used in processing. Use extreme caution when buying and using third-party regrind.

Avoid using regrind material entirely when resin properties equivalent to virgin material are required, including, but not limited to, color quality, impact strength, resin purity, and/or load-bearing performance.

POST-MOLD CONDITIONING

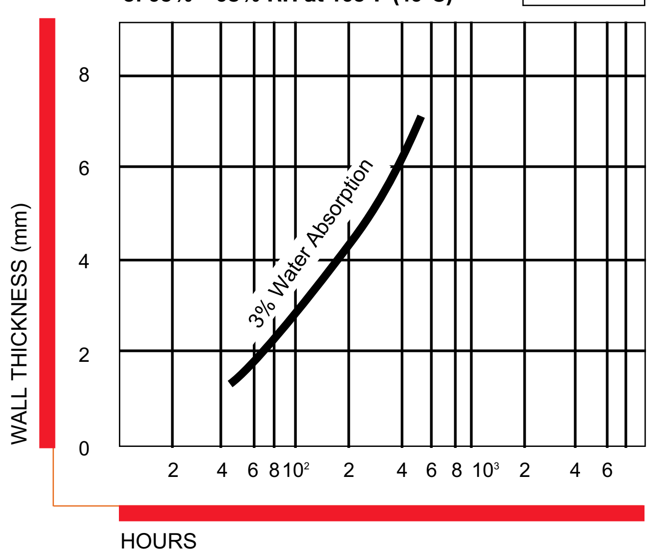
The moisture content of parts molded of Durethan resin affects various properties. Rigidity and strength both decrease with increasing moisture content, while elongation and impact strength increase with increasing moisture content. Moisture absorption from the atmosphere is dependent upon temperature, relative humidity, and the part wall thickness, and the process is usually slow.

Since some applications require high elongation for immediate assembly, or high impact resistance in order to be put into immediate service, it is desirable to quickly increase the moisture content of parts molded of Durethan resin. This can be done by moisturizing/conditioning the parts above the equilibrium moisture content level for the Durethan polyamide grade before the parts' assembly or use. Any excess moisture will be lost to the atmosphere or redistributed internally.

One way of accelerating the moisturizing/conditioning of parts molded of Durethan resin is to place them in a

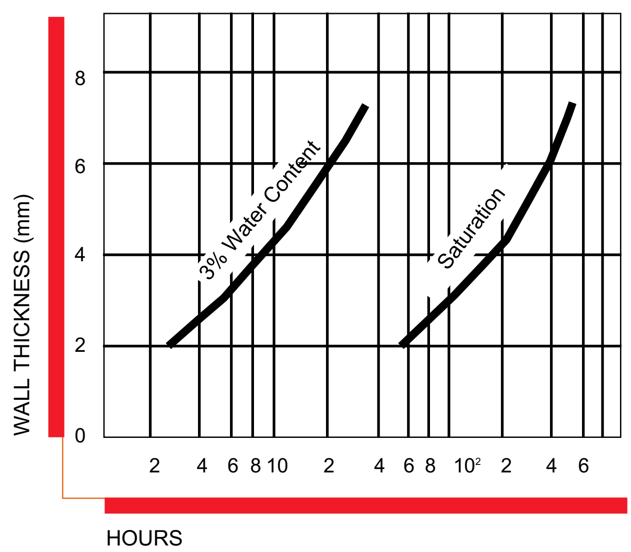
Moisture Absorption Rate of Parts Molded of Durethan B Resin, Exposed to a "Tropical Environment" of 95% – 98% RH at 105°F (40°C)

Figure 21



Water Absorption by Non-Reinforced Durethan B Resin Immersed in Water at 140°F (60°C) as a Function of Wall Thickness and Time

Figure 22



"tropical" environment of 95% RH at 105°F (40°C). Exposure time is dependent upon part wall thickness and the desired level of conditioning, which is determined by end-use performance requirements.

Another, more common method of conditioning is to immerse the parts in water at 140°–176°F (60°–80°C). However, while this method quickly introduces some moisture into the part, it is not as effective as "tropical" conditioning because only the outer portions of the part are conditioned. It takes a relatively long time for the water to migrate inward.

Moisture uptake rates for both "tropical" conditioning and immersion conditioning are shown in Figures 21 and 22.

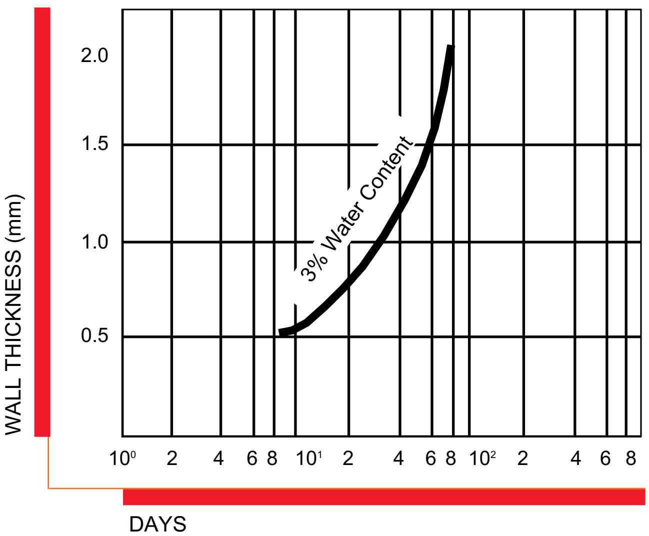
Conditioning differs for parts molded of unreinforced and reinforced Durethan resins.

Unreinforced

Figure 23 shows the moisture absorption rate of parts molded of unreinforced Durethan resin having various wall thicknesses when stored in a

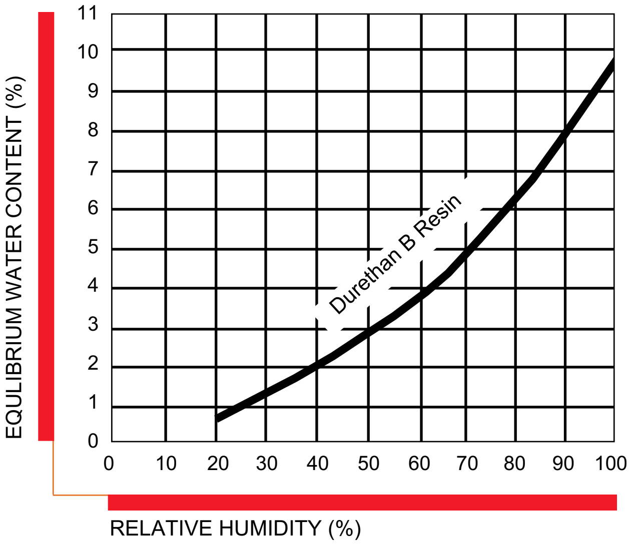
Water Absorption by Non-Reinforced Durethan B Resin When Stored in a Standard Atmosphere of DIN 50014 as a Function of Wall Thickness and Time

Figure 23



Equilibrium Moisture Content of Durethan B Resin as a Function of Relative Humidity, Measured at Room Temperature

Figure 24



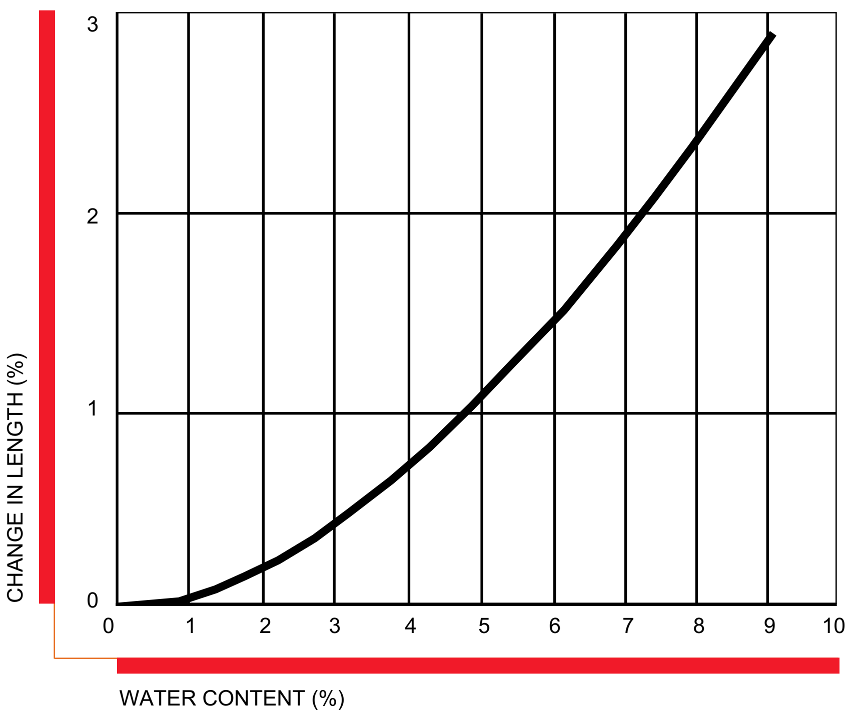
standard test environment of 73°F (23°C) and 50% relative humidity. The material was brought to the desired level of conditioning to properly determine potential property performance according to DIN 50014.

Wall thickness strongly influences the length of time required to attain equilibrium moisture content. The equilibrium moisture content of a part is directly related to the ambient temperature and relative humidity, as shown in Figure 24.

During conditioning, moisture absorption will enlarge the part and cause a change in dimensions. An example is shown in Figure 25. Therefore, a balance must be achieved between the level of end-use performance and dimensional accuracy required.

Linear Change in Length of Rectangular Bars Injection Molded in Various Grades of Durethan B Resin as a Function of Water Content*

Figure 25



* Length of injection molded rectangular bars 120 x 10 x 4 mm in various grades of Durethan B resin as a function of water content. Storage temperature: 20°C. The curve represents average values derived from numerous measurements.

Reinforced

The mechanical properties of parts molded of filled or reinforced Durethan resins are less dependent upon moisture content. If conditioning is required, use approximately the same conditioning parameters used for parts molded of unreinforced Durethan resins.

The equilibrium moisture content is lower for parts molded of reinforced Durethan resin grades than for parts molded of unreinforced grades. For example, parts molded of 30% glass-reinforced BKV 30 resin have approximately 1.5% equilibrium moisture content in a standard atmosphere versus 3.0% for a typical unfilled grade at the same conditions.

Avoid conditioning temperatures higher than 140°F (60°C) for parts molded of reinforced Durethan resins. Prolonged exposure to hot water can adversely affect the bond between the resin and reinforcement.

The dimensional change of parts molded of reinforced Durethan resins after conditioning is less than that of parts molded of unreinforced resins. The exact amount depends on the level of reinforcement.

For more information on post-mold conditioning parts molded of Durethan resin, consult the LANXESS publication, *Durethan Polyamide — Environmental Conditioning*, which can be obtained from LANXESS Corporation by contacting a LANXESS technical representative for Durethan resin at 800-LANXESS.

MACHINE PREPARATION

Purging and Cleaning

An essential requirement for molding the highest-quality parts with Durethan resin is a cylinder that is completely free of any residual polymer from a previous run. Deposits of residual material can loosen and contaminate the Durethan polyamide.

One method of removing residual material from the molding machine is to purge it with general-purpose polystyrene (PS) or a similar high-temperature purging compound.

Follow the purging material manufacturer's guidelines for use.

Another method is mechanical cleaning, as shown in Figure 26. It is more thorough than purging and can be used either prior to running Durethan resin or upon the completion of a run. Follow these steps:

1. Flush the cylinder rapidly with polystyrene.

2. Remove the nozzle while keeping the heat on in the main cylinder.

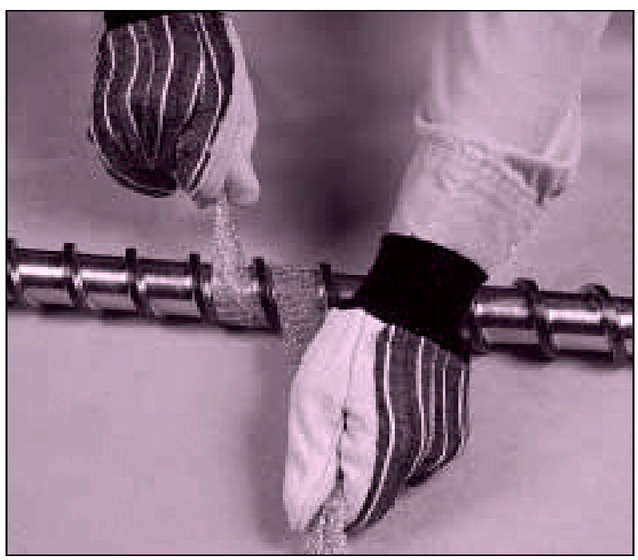
3. Clean the nozzle either by heating it in a muffle furnace or by soaking it in an appropriate solvent (follow manufacturer's MSDS safety recommendations) after it has cooled.

4. Once the nozzle has been removed, turn off the heat in 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 way 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 25 **Mechanical Cleaning of the Screw**



START-UP PROCEDURE

Suggested starting conditions for processing Durethan resins are provided in Table 9. Allow enough machine heat-up time for the barrel to reach molding temperatures for at least 1/2 hour before rotating the screw or feeding pellets. Then make several initial short shots with less than maximum injection pressure to prevent overpacking. Overpacking can make part removal difficult. After the initial short shots, increase injection pressure and speed, shot weight, and melt temperature until the mold is properly filled.

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 proper shutdown procedure is important to prepare the machine to restart production and to avoid material or machine problems during future start-ups. For example, if a full barrel of Durethan polyamide is allowed to cool and shrink inside the molding machine, it may pull particles of poorly adhered chrome from the surface of the screw. These particles would contaminate future moldings.

Short-Term Shutdown

For short-term production breaks of less than 30 minutes, purge the cylinder upon start-up and continue molding. For shutdowns limited to a period of 2 – 5 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 shutdowns exceeding 5 hours or extending to several days:

- Shut off the hopper feed.
- Flush the machine with general-purpose polystyrene and purge it empty.
- Leave the screw forward in the cylinder.
- Turn off all heat zones.

Table 9 **Suggested Starting Conditions for Processing Durethan Resins**

Conditions	B 30 S B 31 SK	BC 30 BC 40SR2 BC 304	BKV 15/30/40/50 BKV 115/130/140 BM 30X/40X
Processing Temperatures			
Zones			
Rear	470°–480°F (245°–250°C)	490°–500°F (255°–260°C)	470°–480°F (245°–250°C)
Middle	480°–500°F (250°–260°C)	500°–520°F (260°–270°C)	480°–510°F (250°–265°C)
Front	500°–520°F (260°–270°C)	520°–535°F (270°–280°C)	510°–535°F (265°–280°C)
Nozzle	500°–520°F (260°–270°C)	520°–550°F (270°–290°C)	520°–550°F (270°–290°C)
Melt*	**480°–520°F (250°–270°C)**	**520°–550°F (270°–290°C)**	**520°–550°F (270°–290°C)**
**Mold ** **	175°–250°F (75°–120°C)	160°–195°F (70°– 90°C)	160°–230°F (70°–110°C)
Machine Conditions			
Injection Pressure	← 10,000 – 20,000 psi (70 – 140 MPa) →		
Hold Pressure	← 50% of Injection Pressure →		
Back Pressure	← 50 – 150 psi (345 – 1,035 kPa) →		
Injection Speed	← Moderate to Fast →		
Injection Cushion	← 0.125 – 0.250 in. (3 – 6 mm) →		
Screw Speed	← 60 – 100 rpm →		
Clamp Tonnage	← 2 – 4 t/in.^{2} (22–55 kPa) →		

* 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.

The information in this section is presented as an overview. Detailed information is available in the LANXESS Corporation publication, *Part and Mold Design-Thermoplastics,* which can be obtained by contacting a technical representative for Durethan resin at 800-LANXESS.

MOLD DESIGN

Material Selection

As with other filled engineering resins, it is recommended that production molds made from hardened tool steels such as A-2, A-6, S7, HB or D-2 be used with Durethan resins.

Surface Finish

A variety of tool surfaces such as chrome, electroless nickel, boron, or nitride have been used successfully with Durethan polyamide resins, depending upon the end-use requirements of the molded part.

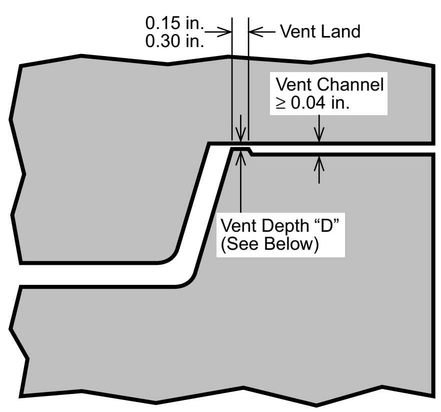
The standard finish for most molds is SPE/SPI #2.

Venting

Mold venting is particularly important for fast-filling materials like Durethan resin. As a mold cavity fills, the air being displaced by the molten resin must have a way out of the tool. Venting enables the displaced air to easily escape from the mold. This permits faster filling, prevents material burns and deterioration of the cavity surfaces, and results in stronger weld lines.

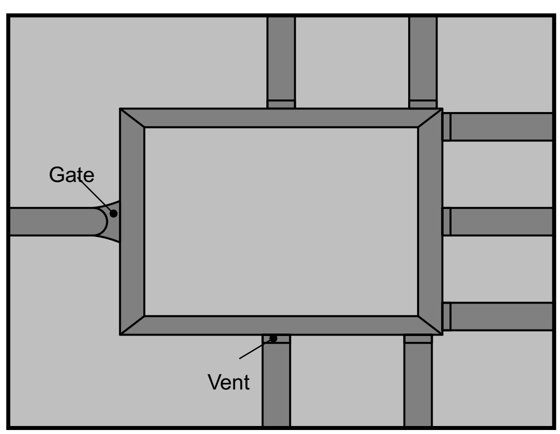
Recommended vent dimensions are 0.0005–0.0015 in. (0.015– 0.040 mm) deep by 0.25–0.75 in. (6–19 mm) wide. At a distance of 0.15–0.30 in. (4–8 mm) from the cavity, vent channels should be deepened to 0.04 in. (1.0 mm) or more (see Figure 27).

Figure 27 **Vent Depth**



Typical Vent Depth “D” Range for Durethan Resins	
0.0005 - 0.0015 in.	Typical Applications
0.0005 - 0.0010 in.	Applications Requiring Minimal Finish

Figure 28 **Vent Placement**



Part Draft

The walls of parts molded of Durethan resin require 1° of draft per side in the direction of draw to aid part ejection from the tool, subject to the functional requirements of the part (see Figure 29). Glass-fiber-reinforced nylon shrinks less than standard resin grades and requires draft angles of 1°–2.°

Texturing

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

Weld Lines

Weld lines are created wherever two flow fronts come together in the mold cavity during injection of the resin melt. With glass-reinforced grades of Durethan resin, the glass fibers do not intermingle well at the flow fronts, creating an area of reduced strength. Try to locate any weld lines away from areas of the part requiring full material strength.

Undercuts

Undercuts can make it difficult to remove parts from the mold. Therefore, avoid undercuts, especially when using glass-fiber-reinforced Durethan resin because of its high rigidity.

Tolerances

Tight-tolerance molding can be accomplished with good machine controls. The amount of cross-flow shrinkage in reinforced grades of Durethan resin is typically several times greater than the shrinkage in the flow direction. Consider flow orientation when assigning and evaluating tolerances.

MOLD TYPES

2- or 3-Plate Molds

The selection of either two- or three-plate mold construction for processing Durethan resin is usually determined by part geometry, production volume, scrap considerations, cosmetics, and cost. The resin's property performance potential is not a determining factor.

Figure 29 **Draft**

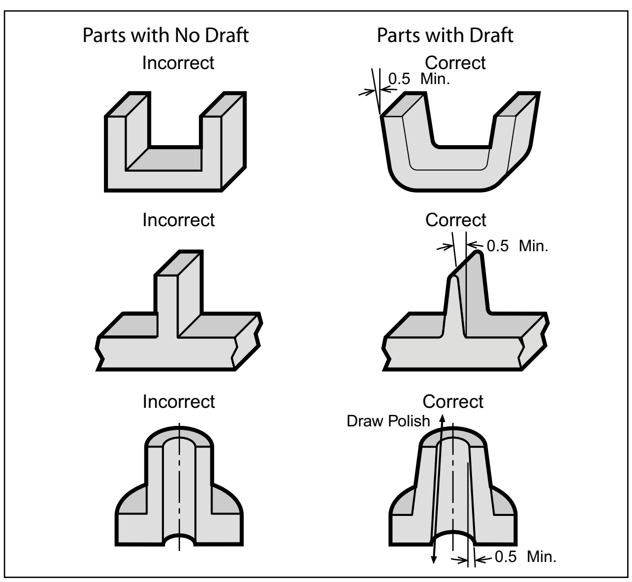
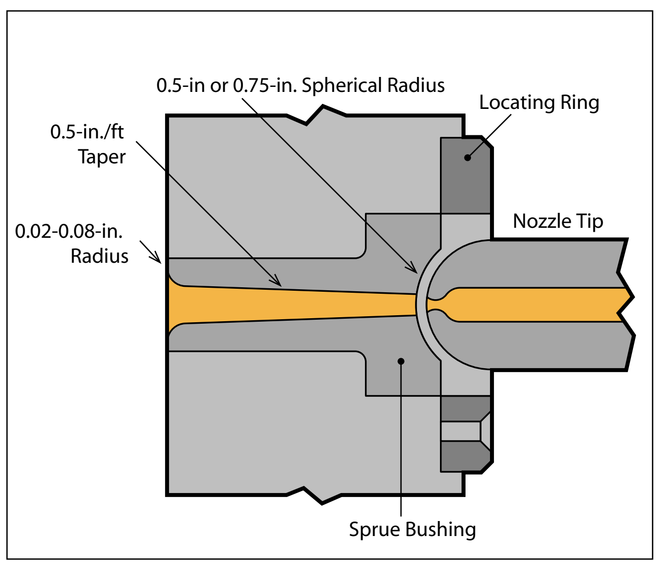


Figure 30 **Sprue Design**



Single- and Multi-Cavity Molds

Durethan resin 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 CONSIDERATIONS

The size of the sprue is determined by the size of the shot and the molding machine to be used. Keep the sprue highly polished to facilitate easy removal from the stationary half of the mold.

Sprue Bushings

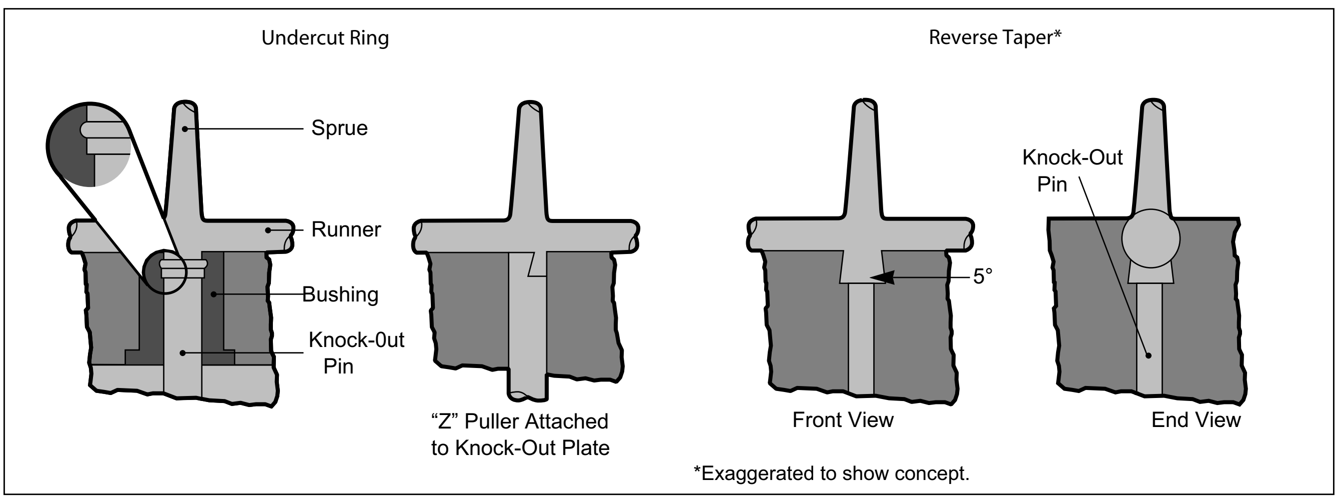
Use sprue bushings having a taper of 0.5 in./ft (0.42 mm/cm) and an orifice (small end) diameter of 0.125 – 0.375 in. (3.2 – 9.5 mm), depending on the size of the molding. The spherical radius of the bushing should be equal to or, preferably, slightly larger than that of the nozzle. The nozzle discharge opening must not exceed the diameter of the sprue bushing inlet to avoid forming an undercut that could stick the sprue. To promote flow, the sprue inlet opening should be about 20% larger than the nozzle orifice. A generous radius of 0.02 – 0.08 in. (0.5 – 2.0 mm) is recommended at the transition from the sprue into the runner system or the mold cavity (see Figure 30).

Sprue Pullers

Use sprue pullers of any common design, but avoid any that restrict the flow of the material. A 5° reverse-taper sprue puller, as shown in Figure 31, 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.

Figure 31 Sprue Pullers



RUNNERS AND RUNNER SYSTEMS

Keep runners as short as possible to reduce unnecessary pressure drops between the sprue and gate. Full-round cross sections are best.

It is essential that the runner system be balanced to ensure uniform filling of all cavities, especially for precision parts. Naturally balanced runner systems have total symmetry in the length and diameter of the runner elements and layout geometry. This helps ensure that each cavity of multi-cavity molds receive polymer flow at the same temperature and pressure, promoting consistent part quality.

Hot Runner Molds

It is possible to use hot runner molds with Durethan resins. However, the low melt viscosity can cause drooling or nozzle tip freeze-off problems. Proper design of the hot drop tip area is crucial for Durethan resins. Consult the hot runner supplier's technical staff when selecting a system for Durethan polyamides. Filled or reinforced grades may require hardened components and inserts.

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 Durethan resin.

Regardless of the type employed, locate the gate in the thickest section possible to control sinks, voids, molded-in stresses, and/or warpage in the finished part.

The gate land length should be as short as possible and never longer than 0.060 in. (1.5 mm). To reduce jetting, position the gate so that the melt flow impinges on an opposite wall or a core pin at a

Figure 32 **Runner Design**

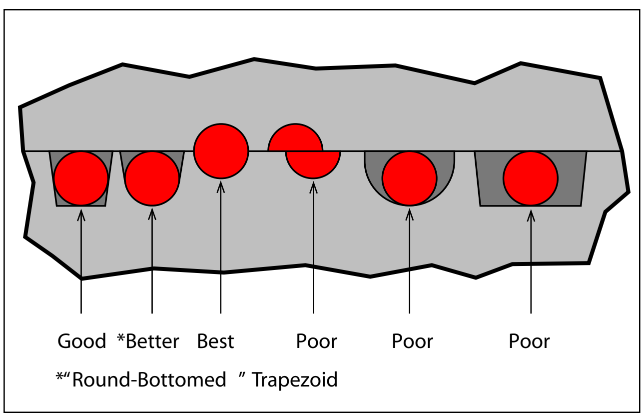
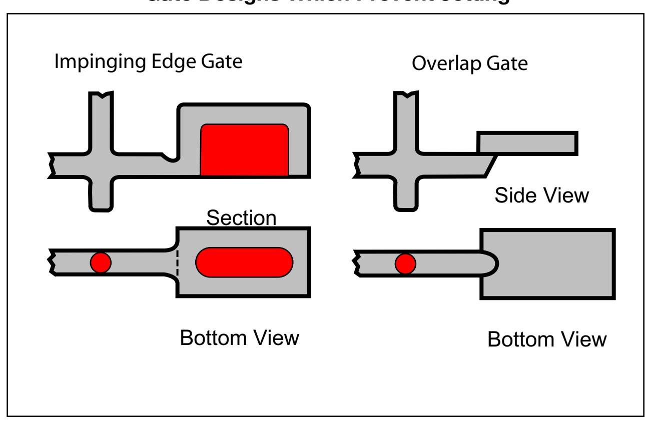


Figure 33 **Gate Designs Which Prevent Jetting**



distance of within three times the gate diameter (see Figure 33). Gates for glass-fiber-reinforced grades of Durethan resin should be about 25% larger than for standard grades.

Edge Gates

Examples of edge gate dimensions are shown in Figure 34. The gate thickness (depth) can vary from 45% to 65% of the nominal part thickness. The gate width is usually 2 or 3 times the gate thickness. Even wider gates are used to reduce shear in large-volume parts. A rounded edge where the gate meets the cavity will reduce gate blush. A wide flare will help the material to enter smoothly and reduce chances for surface blemishes at the gates.

Pinpoint Gates

The diameter of pinpoint gates varies from 0.040 to 0.100 in. (1.0 to 2.5 mm), depending on part thickness and weight. Place the gate on a small conical tab with a cone angle of 60°–90° to improve impact strength and reduce the possibility of gate blush. Keep land length as short as possible. A typical pinpoint gate is shown in Figure 35.

Sprue Gates

Sprue gates are simple but tend to promote splay in parts having heavy walls. The diameter of the sprue base is usually controlled by the required sprue length, so keep the sprue as short as possible.

A minimum radius of 0.015 in. (0.4 mm) at the sprue/cavity edge is recommended. Sprues which are too large can cause lengthy cycle times.

Figure 34 **Common Edge Gate**

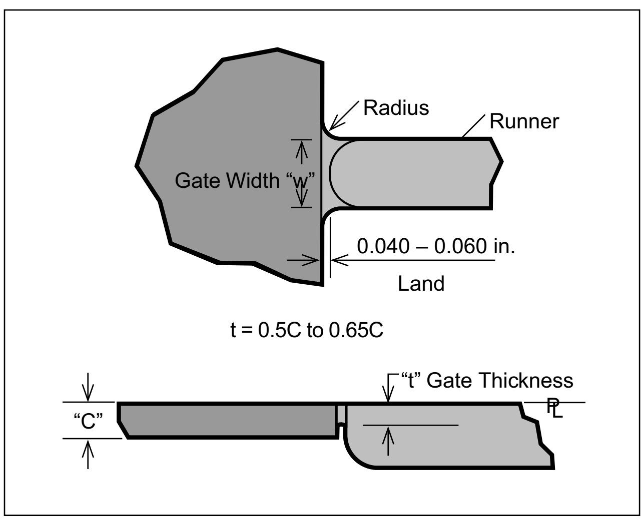
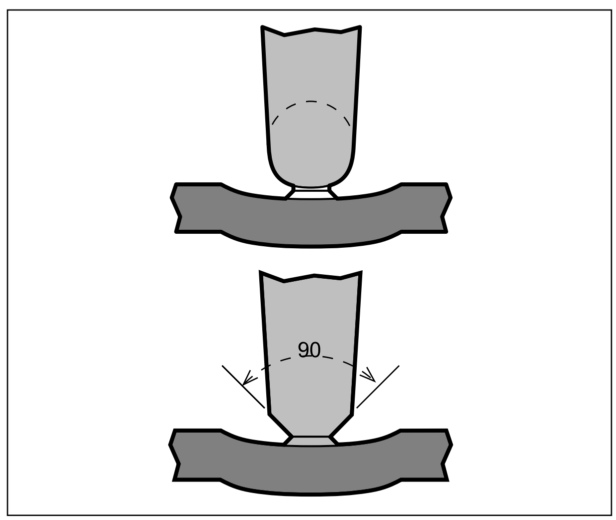


Figure 35 **Typical Pinpoint Gate**



Tunnel Gates

Tunnel gates are variations of the pin-point gate. Maintain a sharp edge on the gate steel in order to properly shear off the gate without tearing it from the part. Hardened gate inserts are recommended for filled or reinforced grades.

Ring (or Diaphragm) Gates

Ring gates work well with cylindrical parts because weld lines can be avoided in most cases. A variation of this type of gate is often used for parts such as filter bowls.

INSERT MOLDING

Molded-in inserts have been used with Durethan resin with good results. Before using a molded-in insert, consider the balance between tool design, insert loading methods (manual or robotic), and part end-use requirements.

When using molded-in inserts, heat them to at least the same temperature as the mold before placing them in the tool. This will minimize any stress that may be caused by wide temperature differentials.

MOLDED-IN STRESS

Take all reasonable care to minimize stress within the part during the molding operation. This is critical to help ensure that the molded part meets its required level of end-use performance and that the material can provide its expected level of property performance. Use suggested processing temperatures, machine conditions, adequate gating, and part and tool design to avoid any unnecessary molded-in stress.

Figure 36 **Tunnel-Gate Configuration**

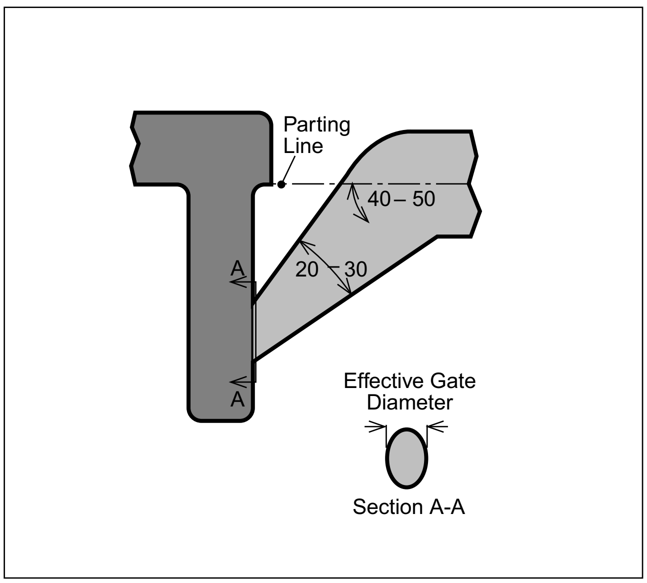
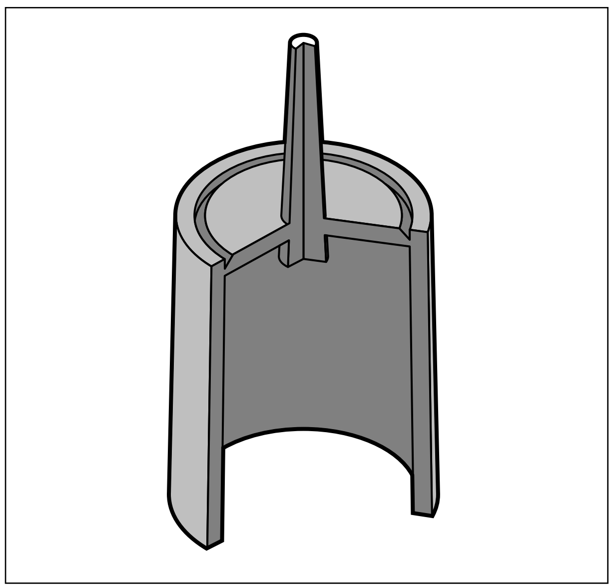


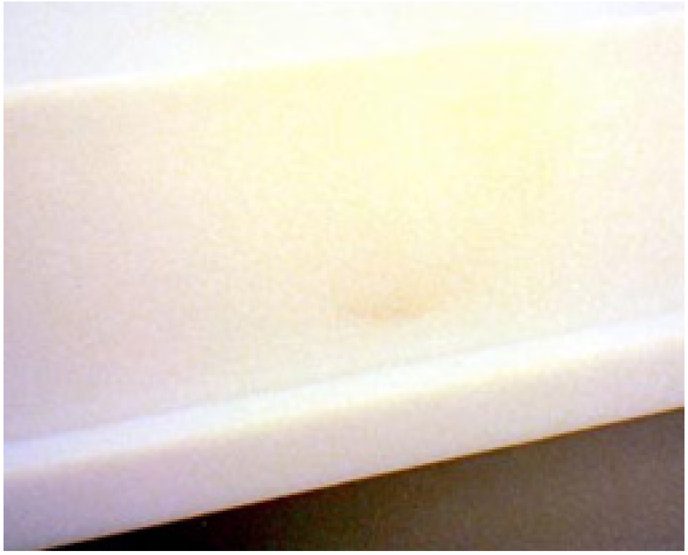
Figure 37 **Diaphragm Gate**



BURN MARKS

Description of Problem	Probable Causes	Possible Corrective Action
Localized burning and degradation of the polymer can occur when entrapped air rapidly compressed by the injected melt elevates the tool surface temperature as it discharges from the vent.	• Gate/runner size/shape.	• Enlarge flow areas. • Radius sharp corners. • Reduce injection speed.
	• Barrel overheating. • Nozzle overheating.	• Check actual melt temperature. • Check heater bands and controllers. • Check for blockage. • Increase tip inside diameter to at least 80% of sprue bushing size. • Check heater bands and controllers.
	• Inadequate mold venting.	• Add or enlarge vents to a maximum depth of 0.0010 in. (0.025 mm). • Check vent channels for blockage.

Figure 38 **Burn Marks**



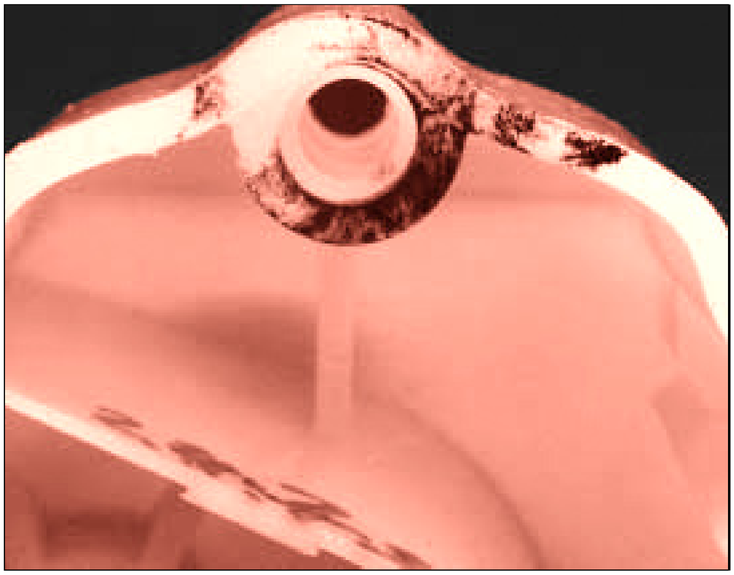
DIMENSION CONTROL

Description of Problem	Probable Causes	Possible Corrective Action
The inability of a plastic part to retain the precise shape in which it was molded is often caused by improper processing conditions and incorrect mold design. Orientation of glass fiber and part geometry can also contribute to the loss of dimensional control in molded parts.	• Incorrect processing conditions.	• Check for uniform feed and cushion, cycle to cycle. • Fill mold as rapidly as possible. • Increase cooling time. • Increase mold temperature to the upper portion of the recommended range for the resin being processed. • Check the machine for erratic performance.
	• Incorrect mold design.	• Balance cavities and runner system for uniform flow. • Increase gate size and / or relocate gate. • Reduce the number of cavities in use. • Check for uniform cooling with a surface pyrometer. • Check tool design for proper shrink factor. • Check cooling system. • Adjust the temperature of the mold halves separately.

DISCOLORATION

Description of Problem	Probable Causes	Possible Corrective Action
Surface discoloration appears mainly at the weld line or at the end of a flow path. It is usually caused by air trapped in the mold and typically appears before burn marks develop.	• Contamination.	• Purge the machine. • Check hopper and feed zone for contaminants.
	• Overheating.	• Lower material temperatures by: ✔ Lowering cylinder zone temperatures. ✔ Decreasing screw speed. ✔ Reducing back pressure. • Lower nozzle temperature. • Decrease injection speed.
	• Inadequate venting.	• Check vents in mold. • Clean vents. • Provide additional venting.
	• Long residence time.	• Check screw for excessive clearance. • Move mold to smaller shot-size press. • Reduce overall cycle time.

Figure 39 Discoloration



FLASH

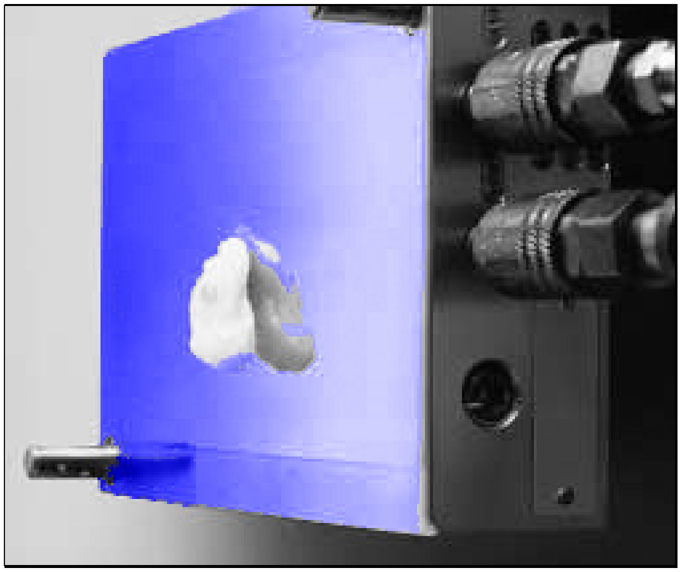
Description of Problem	Probable Causes	Possible Corrective Action
Flash is a thin, surplus web of plastic material attached to the molded part along the parting line. Flash formation depends on the fit of the mold at the parting line, the applied clamping force, and the viscosity of the resin melt.	• High melt temperature.	• Lower material temperatures by: ✔ Lowering cylinder zone temperatures. ✔ Decreasing screw speed. ✔ Reducing back pressure.
	• Incorrect processing.	• Lower injection pressure. • Reduce overall cycle time. • Decrease injection speed.
	• Mold setup.	• Check mold closure and lockup. • Check platen alignment.
	• Excessive vent depth.	• Check that the vent depth is at a maximum depth of 0.0010 in. (0.025 mm).
	• Insufficient clamp pressure.	• Move mold to a larger tonnage machine.
	• Wet material.	• Check drying procedure. • Measure moisture content of pellets in the hopper.

Figure 40 Flash

NOZZLE DROOL

Description of Problem	Probable Causes	Possible Corrective Action
Drool is usually caused by an increase in pressure on the melt from steam in the injection molding machine barrel generated by moisture in the resin.	• High melt temperature.	• Lower nozzle temperature. • Lower material temperatures by: ✔ Lowering cylinder zone temperatures. ✔ Decreasing screw speed. ✔ Reducing back pressure.
	• Incorrect processing conditions.	• Lower pressure in machine cylinder. • Reduce injection forward time. • Increase decompress time. • Reduce overall cycle time.
	• Wet material.	• Check drying procedure. • Measure moisture content of pellets in the hopper.
	• Incorrect nozzle.	• Change to smaller-orifice nozzle. • Use reverse-taper nozzle. • Use decompression.

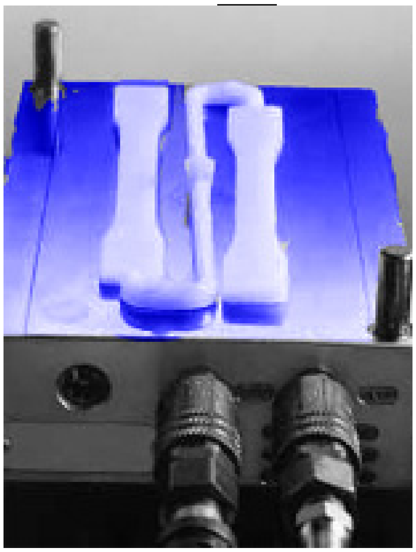
Figure 41 **Nozzle Drool**



NOZZLE FREEZE-OFF

Description of Problem	Probable Causes	Possible Corrective Action
Due to the rapid crystallization of polyamide resins, material in the nozzle can freeze off if the nozzle internal diameter is too small, the mold temperature is too low, or a nozzle heater band is defective.	• Excessive heat loss at nozzle.	• Raise nozzle temperature. • Raise mold temperature. • Insulate nozzle from sprue bushing. • Decrease cycle time. • Change to lower-orifice nozzle.
	• Low melt temperature.	• Raise material temperature by: ✔ Raising zone temperatures—first the zone, then the nozzle. ✔ Increasing screw speed.

Figure 42 Nozzle Freeze-Off



SHORT SHOTS / COLD FLOW

Description of Problem	Probable Causes	Possible Corrective Action
Short shots are typically used in the start-up procedure of any tool to determine the correct process parameters for the part. When this is done, make sure that the initial shot weight, contacts the ejector pins to facilitate part release.	• Incorrect processing conditions.	• Increase injection speed. • Increase injection pressure. • Increase injection time.
	• Insufficient venting.	• Check vents in mold. • Clean vents. • Provide additional venting. • Check for worn non-return valve or check ring.
	• Low melt temperature.	• Raise material temperature by: ✔ Raising cylinder zone temperatures. ✔ Increasing screw speed. • Raise mold temperature.
	• Insufficient resin feed.	• Increase size of nozzle, sprue, gate and/or runner system. • Check for an obstruction in the hopper throat. • Increase shot size.

Figure 43 **Short Shots**

SINKS/VOIDS

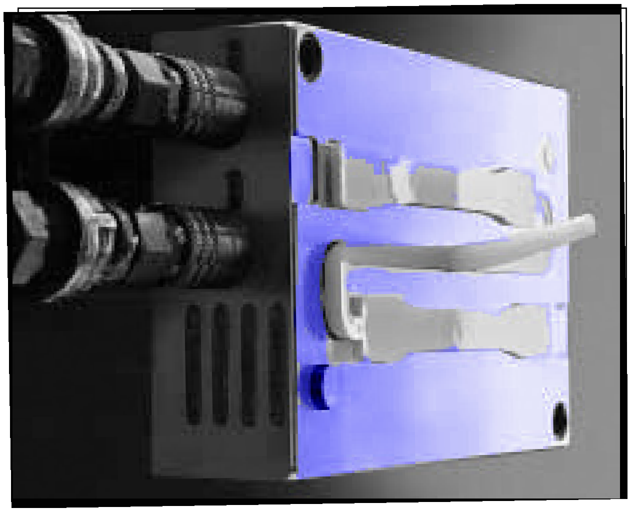
Description of Problem	Probable Causes	Possible Corrective Action
Sinks and/or voids can result when insufficient material is injected into the cavity and often occurs in the thickest sections of the part. Voids occur when the part's external surfaces solidify more rapidly and shrinkage continues internally. Sinks are associated with high mold temperatures; voids are associated with colder mold temperatures.	• Insufficient resin feed.	• Increase shot size and/or decrease cushion.
	• Incorrect processing conditions.	• Increase injection pressure. • Increase hold pressure and/or injection time. • Increase injection speed.
	• Insufficient flow.	• Increase size of nozzle, sprue, gate, and/or runner system. • Move gates closer to thick sections.
	• Incorrect temperatures.	• Lower mold temperature in the presence of sinks. • Raise mold temperature in the presence of voids. • Reduce melt temperature.
	• Wet material.	• Check for proper drying.

Figure 44 Sinks/Voids

STICKING: CAVITY / SPRUE

Description of Problem	Probable Causes	Possible Corrective Action
Parts and / or sprues that do not eject freely will prevent molding machines from cycling automatically. Insufficient part draft and / or a mismatched sprue bushing and nozzle are typical causes.	• Mold overpacking.	• Decrease injection pressure. • Decrease injection speed. • Decrease booster time. • Adjust feed for constant cushion. • Decrease melt temperature.
	• Material not set up in the mold.	• Increase cooling time. • Lower mold temperature.
	• Incorrect mold design.	• Check mold for insufficient draft and / or undercuts. • Draw polish the cores.
	• Sprue hang-up.	• Check sprue bushing fit with nozzle. • Increase nozzle temperature.

Figure 45 Sticking: Cavity / Sprue



POOR SURFACE FINISH / LACK OF GLOSS

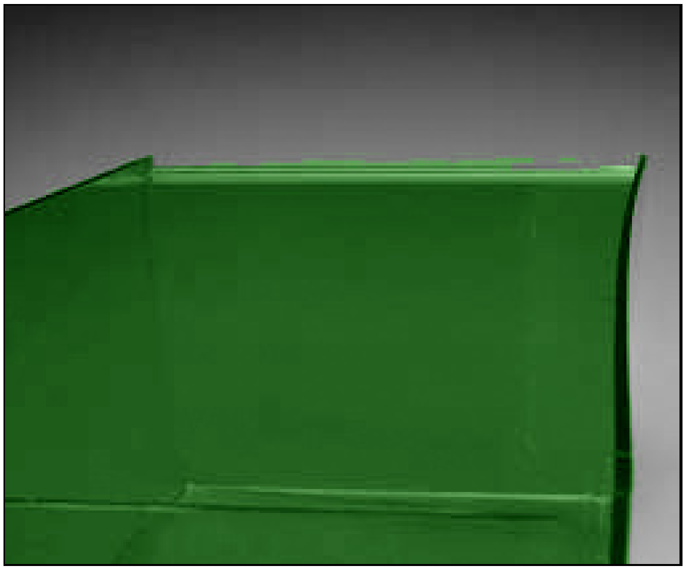
Description of Problem	Probable Causes	Possible Corrective Action
A poor or dull surface finish is a typical sign that the part is not fully crystallized and the mold temperature must be increased. Underpacked parts will exhibit a surface blemish at weld lines and in the area which fills last.	• Incomplete crystallization.	• Raise mold temperature.
	• Mold underpacking.	• Increase feed and / or injection pressure. • Increase injection speed. • Raise material temperature by: ✔ Raising cylinder zone temperatures. ✔ Increasing screw speed.

Figure 46 Poor Surface Finish / Lack of Gloss

WARPAGE / PART DISTORTION

Description of Problem	Probable Causes	Possible Corrective Action
Sections of a molded part cool at different rates from the ejected melt temperature to room temperature due to variations in part geometry and wall thickness. Differential shrinkage occurs and the part tends to become concave on the side that cooled last. Glass fiber reinforcement can contribute to warpage because the fibers tend to orient in the direction of flow and thus create less shrinkage in the flow direction than in the cross-flow direction.	• Unequal mold-half cooling.	• Check for uniform mold temperatures.
	• Distortion upon ejection.	• Check for uniform part ejection. • Reduce drop-height for part.
	• Glass fiber alignment.	• Decrease injection speed. • Increase injection pressure. • Move gates to improve fiber orientation.
	• Material not set up completely prior to ejection.	• Increase cooling time. • Lower material temperature.

Figure 47 Warpage



WELD LINES

Description of Problem	Probable Causes	Possible Corrective Action
Weld lines occur where two melt streams join and the leading surfaces of the contacting melt streams are colder than the body of the melt and do not become fully fused. When the melt streams do not fuse well, the result is weakness at the weld line. Weld line strength depends primarily on the material temperature at the weld junction and secondarily on injection and holding pressure.	• Incomplete remixing of melt streams within the part.	• Increase injection pressure. • Increase injection speed. • Increase injection time. • Raise mold temperature. • Raise material temperature.
	• Insufficient injection pressure.	• Vent the cavity in the weld area. • Provide an overflow adjacent to weld area.
	• Insufficient injection speed.	• Change gate location to alter flow pattern. • Increase gate and runner system size.

Figure 48 Weld Lines

SAFETY CONSIDERATIONS

GENERAL

Good molding practice calls for operators to wear safety glasses and/or face shields, 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 Durethan polyamide resins.

HEALTH AND SAFETY INFORMATION

Appropriate literature has been assembled which provides information concerning health and safety precautions that must be observed when handling LANXESS 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 and product labels. Consult your LANXESS Corporation representative or contact the Product Safety and Regulatory Affairs Department in Pittsburgh, Pennsylvania at 800-LANXESS.

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

GENERAL INFORMATION

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Any product in this publication with a grade designation containing the letters DP, KU, or KL is classified as a developmental product. Testing of properties and application suitability is not final. Further information, including data which could change or add hazards associated with use, may be developed. Such information might be needed to properly evaluate and/or use this product. Use is undertaken at the sole risk of the purchaser. Such material is sold "as is" without warranty or guarantee. Commercialization and continued supply are not assured. LANXESS Corporation reserves the right to discontinue at any time.

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Some of the end uses of the products described in this publication must comply with applicable regulations, such as those of the FDA, USDA, NSF, and CPSC. If you have questions on the regulatory status of these products, contact your LANXESS Corporation representative or the Regulatory Affairs Manager in Pittsburgh, Pennsylvania.

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; current material 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, LANXESS Corporation will furnish such technical advice or assistance it deems to be appropriate in reference to your use of our product, Durethan polyamide resin. 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 LANXESS 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 or not LANXESS 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:

LANXESS Corporation
Durethan Product Management
111 RIDC Park West Drive
Pittsburgh, PA 15275-1112
Phone: 800-LANXESS

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