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Quick Guide to Injection Molding

Torlon® PAI

Torlon® polyamide-imide (PAI) resins process under a unique set of conditions and certain aspects of the injection molding equipment are specific to this material. Because Torlon® PAI is a reactive polymer, the polymer will increase in molecular weight via chain extension, branching and cross-linking when heated. To avoid this during injection molding and to produce high-quality components, specific equipment considerations and processing procedures must be followed.

Equipment

Injection Molding Machine

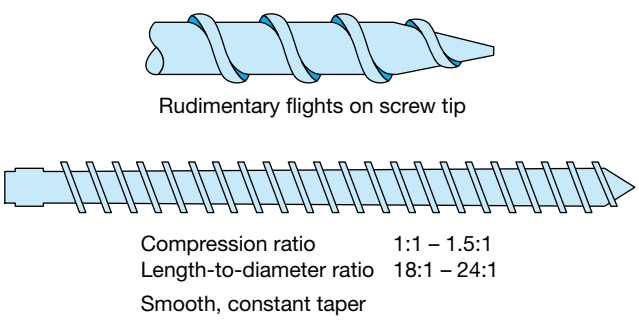
- Modern reciprocating screw injection molding machines with microprocessor controls capable of closed loop control are recommended for molding Torlon® PAI resin.
- Barrel size should be such that 50 % to 80 % of the barrel is used for each shot to minimize residence time.
- Clamp tonnage should allow for at least 4 tons of clamp pressure per square inch (620 kg/sq cm) of projected part area.
- A reverse taper nozzle is recommended.

Screw Design

- Low compression ratio screw with no check device is necessary.
- Compression ratio between 1 : 1 and 1.3 : 1 is recommended.
- L/D (length to diameter) ratio of the screw should be between 18 : 1 and 24 : 1.

Please contact Solvay for assistance with specifying screw designs and locating suitable screw manufacturers.

Figure 1: Screw design



Drying

- Torlon® PAI resins are hydroscopic and require drying before injection molding.
- Drying equipment must be capable of achieving temperatures of at least 121 °C (250 °F) and maintaining a dew point of –40 °C (–40 °F).
- Capacity of the drying system should be adequate to allow the recommended drying time in a continuous operation, which is typically 12 hours at the above conditions. Shorter drying times can be achieved at higher temperatures (see Figure 2).
- Moisture analysis equipment is recommended to insure that the maximum recommended moisture content of 500 ppm (0.05 %) is achieved.
- Resin must be kept dry throughout the entire molding process.

Figure 2: Drying time at various temperatures using dessicant drying system

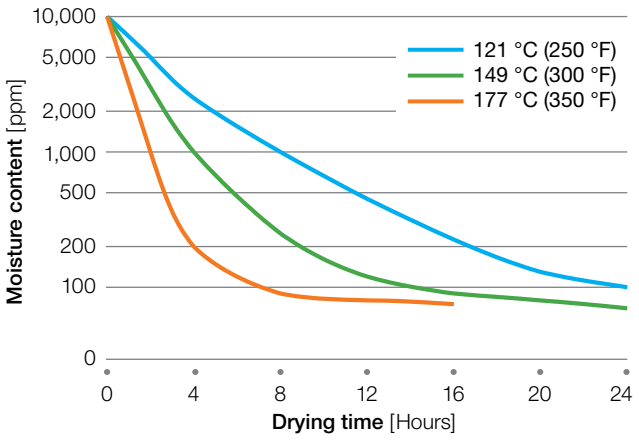


Table 1: Starting point molding conditions

Drying Instructions[1]	
Drying temperature	149 °C (300 °F)
Drying time	8 hours
Molding Conditions	
Target melt temperature	360 °C – 382 °C (680 °F – 720 °F)
Barrel temperatures	
Rear zone	304 °C (580°F)
Middle zone	327 °C (620°F)
Front zone	343 °C (650°F)
Nozzle temperature	371 °C (700 °F)
Mold temperature	177 °C – 232 °C (350 °F – 450 °F)
Injection speed	High
Hold pressure	Approximately 50 % of pressure needed to achieve injection speed
Back pressure	Moderate, 7 bar – 14 bar (100 psi – 200 psi)
Screw speed	50 rpm – 100 rpm

[1] *Optional drying temperatures and times are shown in Figure 2*

Process Control and Monitoring

The molding process should be controlled by screw velocity and position, not by pressure and time. This will insure a controlled injection rate and fill time. The following three parameters can be monitored to insure that the process is in control once acceptable parts are molded:

- **Injection time:** This is the time it takes the screw to move forward from full shot position to the transfer position. It is a critical parameter and should be monitored continuously.
- **Final cushion position:** This is the final position of the screw after the part has been injected and fully packed. It is a volumetric indication of the amount of polymer injected into the mold and should be monitored continuously.
- **Pressure required to achieve injection velocity:** This is an indication of the relative viscosity of the polymer and should be monitored as well.

Injection time and final cushion position parameters should be equipped with alarms and tightly controlled, as even small changes can have significant effect on the quality of molded parts.

Pressure can be allowed to fluctuate slightly, but within an established processing “band.” Typically, this parameter will change significantly before either of the other two change, and it can be used to detect a processing problem before unacceptable parts are produced.

Shutdown and Purging

Torlon® PAI resins must not be left in the barrel of the molding machine during process interruptions or at the completion of a molding run.

Suitable purge compounds with thermal capabilities in excess of 371 °C (700 °F) are commercially available and should be used to completely purge the Torlon® PAI resin from the machine. Please contact Solvay for recommended materials and their suppliers.

Failure to follow proper purging procedures can result in contamination in subsequent molding runs and even damage the equipment.

Post Cure

Parts injection molded from Torlon® PAI must undergo a thermal process known as post cure. This step is necessary to achieve properties detailed in the Torlon® PAI Design Guide. Uncured or inadequately cured parts will not perform at the expected levels.

The post cure process involves placing molded parts in a forced air oven and thermally treating them using a series of increasing temperatures for varying times. The standard cure cycle shown in Table 2 is suitable for parts with maximum cross-sectional thickness of 7.6 mm (0.3 inch).

Solvay can help you determine the best cure schedule for your application and test that molded parts are fully cured.

Table 2: Standard 17-day cure cycle

Time	Cure Temperature
1 Day	149 °C (300 °F)
1 Day	191 °C (375 °F)
1 Day	204 °C (400 °F)
1 Day	218 °C (425 °F)
1 Day	232 °C (450 °F)
1 Day	243 °C (470 °F)
1 Day	252 °C (485 °F)
10 Days	260 °C (500 °F)

Maximum cross-sectional thickness of 7.6 mm (0.3 inch)

Table 3: Troubleshooting guide[1]

Problem	Probable Cause	Suggested Remedy
Brittle parts	Wet material	Dry the resin
Burn marks	Vents clogged	Clean vents
	Insufficient venting	Deepen vents
	Fill rate too fast	Dry the resin or slow injection speed
Cavity not filling	Injection time too short	Lengthen boost time
	Gate too small	Open gate
	Insufficient venting	Deepen vents
	Shot size too small	Increase shot
	Injection speed too slow	Increase injection speed
Flash	Boost time too long	Shorten boost time
	Clamp pressure too low	Increase clamp pressure
	Mold damaged or misaligned	Resurface or realign mold
	Wet material	Dry the resin
Internal voids	Wet material	Dry the resin
	Gate too small	Open the gate
	Runner too small	Open runner
	Runner too long	Relocate gate
	Injection rate too slow	Increase rate
	Hold time too short	Lengthen hold time
	Hold pressure too low	Increase hold pressure
	Resin melt or mold too cold	Raise temperature
	Insufficient venting	Deepen or add vents
	Jetting	Redesign gate
Post blowing	Wet material	Dry the resin
	Cycle too short	Lengthen mold-closed time
Progressively shorter shots	Residence time too long	Purge and reduce cycle
	Barrel temperature too high	Reduce barrel temperature
	Shot size too small	Use a smaller capacity press or add dummy cavity to increase shot size

[1] *This guide is a quick reference to commonly encountered molding problems and should be helpful to experienced molders. Please contact one of our technical service engineers if you require additional information or assistance.*

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