EASTMAN TRITAN
copolyester

Injection Molding Processing Guidelines for Eastman Tritan™ Copolyester

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Introduction

Eastman Tritan™ copolyester provides the customer with clarity as well as excellent toughness, chemical resistance, dishwasher durability, dimensional stability, low and stable shrinkage rates, and other enhanced physical properties. Versions of *Tritan* are also available with various additive packages, such as mold release, UV, and color. To optimize these physical properties and widen the processing window, some processing guidelines are listed.

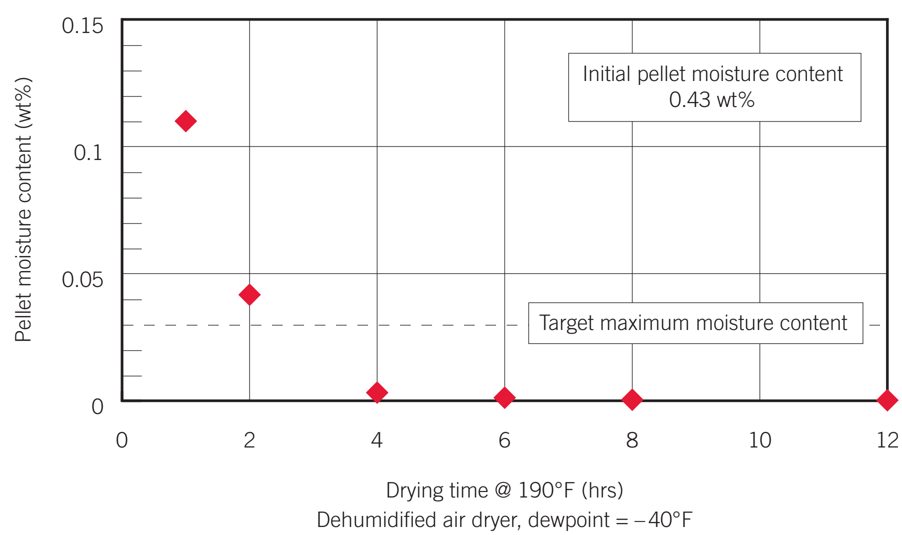
Drying

Effective drying of *Tritan* copolyesters is key to shot-to-shot consistency and optimum part performance. The following are important points to consider for proper drying of *Tritan* copolyesters.

- **Dew Point:** Use a desiccant type or similar drying system providing dry air at a minimum dew point of -29°C (-20°F).
- **Time and Temperature:** Dry the *Tritan* copolyester at 88°C (190°F) for 4 hours minimum. If longer residence time in the dryers is required, such as overnight, lower the set temperature to 82°C (180°F). The inlet air temperature needs to be controlled within +/–3°C (+/–5°F) throughout the drying cycle. Figure 1 shows the effect of drying time on pellet moisture content.
- **Air Flow:** The dryer should have sufficient air flow to assure a uniform pellet temperature throughout the dryer. A minimum of 3.7 m^3/hr air flow is suggested for each kilogram of polymer processed per hour (1.0 cfm per pound per hour of polymer processed).
- **Moisture Content:** The goal of drying is to lower the moisture content of the polymer to 0.03% or lower as measured by the Karl Fisher method, or by weight loss methods calibrated for *Tritan* copolyester. Weight loss methods involve a heating temperature near 160°C (320°F) for this polymer.

Figure 1

Effect of drying time on pellet moisture content in Eastman Tritan™ copolyester.



Processing

Barrel and Melt Temperatures

Consistent part production requires attention to all phases of the injection molding process. Processing conditions should be optimized to ensure material integrity and maximum part performance. Shown below are some recommendations for processing Eastman Tritan™ copolyesters.

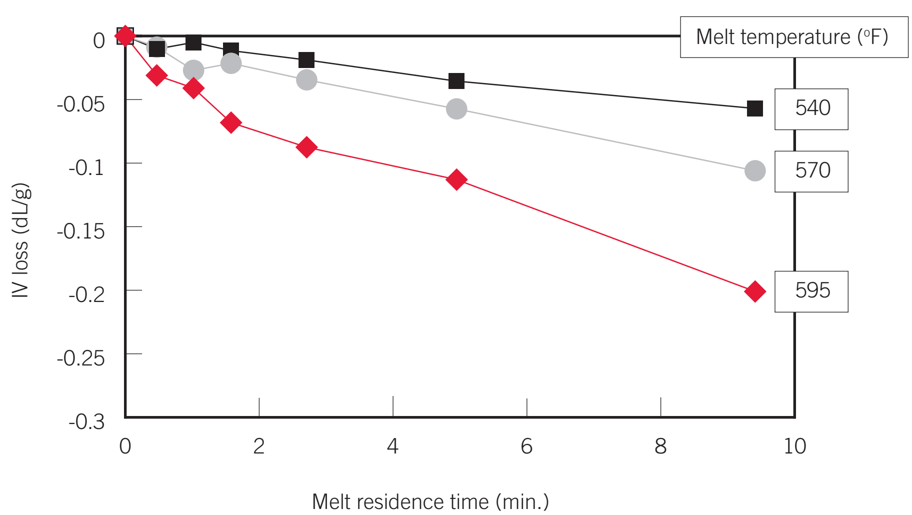
- Processing at the optimal processing temperature and minimum residence time in the machine will assist in maximizing physical properties.
- Well-dried material is the key for shot-to-shot uniformity. Engineering materials, such as *Tritan* copolyester, can suffer degradation at their processing temperatures due to hydrolytic degradation.
- Normal processing temperatures are in the range of 282°C (540°F) plus or minus 5°C –10°C (10°F –20°F) measured by air shot. Parts run at faster cycle times utilizing higher barrel capacity, 50%–80%, can be run at the higher end of the melt temperature range. Conversely, when parts are molded with long cycle times utilizing a minor amount of the barrel capacity, 10%–25%, the processor should strive to run the *Tritan* copolyester at the lower range of the proposed melt temperature.
- A flat temperature profile setting is normally used when shot size is approximately 50% of barrel capacity; i.e., a barrel with a three-zone system might have settings as follows:

Rear Zone	282°C (540°F)[A]
Center Zone	282°C (540°F)[A]
Front Zone	282°C (540°F)[A]
Nozzle Zone	282°C (540°F)
Hot Runners	282°C (540°F)
Actual Melt Temperature (purged on cycle)	282°C (540°F)

- In special situations *Tritan* copolyester does have a wider processing window, depending on the process, ranging from approximately 260°C (500°F) where flow and screw recovery becomes stiff, up to approximately 304°C (580°F) where splay may begin at 10 minute melt residence times. 282°C (540°F) is generally a good setting while targeting a melt residence time (screw and hot runner time) of 5–6 minutes. Figure 2 shows the effect of melt residence time on material integrity over a range of melt temperatures.

Figure 2

Inherent viscosity (IV) loss in Eastman Tritan™ copolyester as a function of melt residence time over a melt temperature range. IV is a commonly used molecular weight indicator in copolyesters.



[A] Since each machine is different, the barrel set temperatures might need to be set as much as 10°C to 20°C (20°F to 40°F) lower than the targeted melt temperature due to shear heating. It is good practice to determine the actual melt temperature, temperature inside machine nozzles, and inside hot sprues and runners using a pyrometer. Also, it is important that the casting around the throat of the injection molding machine is cooled to provide for optimum pickup of the material.

Mold Temperatures

Good temperature uniformity through the mold, and good temperature control to a set point are the keys.

- Actual mold surface temperatures ranging from 60°C to 66°C (140°F to 150°F) produce the best low-stress parts. Recall that the actual water temperature going into the mold may be lower than mold surface temperature if heat transfer is relatively slow.
- Amorphous Eastman Tritan™ copolyester requires colder molds than some other plastics, so preparing cooling ahead of time pays dividends in cycle time and processability. High mold temperatures, even in small areas of the mold, can cause sticking. Ample mold cooling channels, uniform wall thickness design, good cooling of pins and thin steel areas, good cooling near hot spots such as sprues or hot runners, insulating areas around hot runners, good water supply with few flow restrictions, and thermolators for exact setting control of water temperature all assist in generating fast cycling parts with good surface appearance.
- With good cooling as outlined above, the cooling portion of the cycle can be minimized to a point where the part is solidified and easily ejected while the larger diameter sprue is often still soft and rubbery.
- Additional cooling could be needed to prevent sprue sticking. Review the mold construction guidelines on page 7 for additional information.

Fill Speed

- Fill speeds used for *Tritan* copolyester are slower than typical plastics. Machines with fill speed profile capability are recommended. Where fill speed profiling is available, starting the fill at a very slow speed such as 13 mm (0.5 in.) per second for the first 5% to 15% of the shot, then increasing to 43 mm (1.7 in.) per second then slowing to 23 mm (0.9 in.) per second is often successful. The slower initial fill speed minimizes gate blush. Where direct sprue gating into the part is used, a moderate to fast fill rate, such as 38 mm (1.5 in.) to 56 mm (2.2 in.) per second, is suggested.
- Gate geometry is also very important to part appearance near the gate. If the gate or runner has sharp corners or other non streamlined features in the flow channel, these may need to be radiused to reduce blush near the gate. Gate thickness as well as speed can influence gate blush. Gate thicknesses less than 1.1 mm (.045 in.) are not suggested for most gate types.

Screw Speed (RPM)

- Plastication should be slowed to the minimum speed necessary to recover the screw during part cooling and sit at the rear position only 2 to 5 seconds before the mold opens. This minimizes high speed shear and tends to make the melt more uniform. In processing *Tritan* copolyester, lower rpm can make screw recovery more steady and consistent.

Pack and Hold

- Where direct sprue gating into the part is used, longer hold times in combination with lower hold pressures might be necessary. If a void develops at the base of the sprue, the sprue has a tendency to stick in the mold, separating at the part. By packing out the void, this strengthens the sprue such that it will now release with the part. Having long hold times of 8 to 12 seconds and lower hold pressures of 34 MPa (5,000 psi.)* to 52 MPa (7,500 psi.)* will feed material to the sprue to fill the void, not while overpacking the sprue. Overall cycle time does not have to be extended if the cooling time is decreased by the same amount the hold time is increased. Sticking can also happen with a conventional runner at the junction of the runner and sucker pin. Again, if the sprue sticks in the mold, utilizing the same methodology will help to solve the problem.

**Note that these pressures are actual melt pressures, not gauge pressures (often gauge readings are 1/10 actual pressures depending on machine and barrel).*

Cushion Size

- The cushion size should be at the absolute minimum to assure the screw does not hit bottom and to assure the pack and hold pressures are getting into the part. The cushion left at the end of the pack and hold are typically 5 mm to 10 mm (0.2 in. to 0.4 in.) depending on machine size and injection speed. Larger cushions can add to hold up time in the barrel and aggravate degradation. If the screw continues to move forward at the end of the shot, when adequate time is given to come to a stop, this is a sign of a leaking check valve. A leaking check valve may also cause short shots and shot-to-shot variability.

Back Pressure

- Back pressure is usually kept to a minimum of about 10 MPa (1,500 psi.).* However, to improve melt uniformity (and mix concentrates), increase melt temperature, or to get rid of air entrapment (air splay), back pressure can be increased gradually to as much as 15.5 MPa (2,250 psi.).* High back pressures can aggravate drooling into the mold and require additional decompression.

**Note that these pressures are actual melt pressures, not gauge pressures (often gauge readings are 1/10 actual pressures depending on machine and barrel).*

Decompression (Suck Back)

- In general use, very small or no decompression. Decompression tends to pull air back into the nozzle causing splay in the next shot. Very small amounts of decompression can be used to reduce drool if needed.

Screw and Barrel Design

- Eastman Tritan™ copolyester has been processed in a wide variety of "general purpose" screws with compression ratios in the 2.8:1 or 3:1 range and L/D ratios of 18–22:1. The transition zone should have a gradual transition (typically 4–6 diameters) so that the high shear heating of a sudden transition is avoided. Screws should be chosen to be compatible with the hardness of the barrel material to minimize wear as with any plastic material. Unfilled materials, such as *Tritan* copolyester, are generally very mild on screw wear. Corrosion of barrel and screw parts is not expected with *Tritan* copolyester.

Table 1

Summary of the recommended drying and processing conditions for injection molding of Eastman Tritan™ copolyesters.

Condition	TX1000 and TX1001	TX2000 and TX2001
Drying conditions		
Drying temperature, °C (°F)	88 (190)	88 (190)
Drying time, hr	4	4
Dryer air dewpoint, °C (°F)	<–29 (<-20)	<–29 (<-20)
Processing temperatures		
Zones °C (°F)		
• Rear	Set barrel temperatures to reach target melt temperature, up to 10°C to 20°C (20°F to 40°F) below target depending on shear heating	
• Center		
• Front		
Nozzle °C (°F)	282 (540)	282 (540)
Hot runners °C (°F)	282 (540)	282 (540)
Melt temperature °C (°F)	282 +/– (540 +/–)	282 +/– (540 +/–)
Mold temperature, °C (°F)	60 (140)	66 (150)
Machine conditions		
Injection speed	slow	
Screw speed (rpm)	minimum	
Pack and hold pressure (MPa)	35–50	
Cushion (in.)	0.2–0.4	
Back pressure (MPa)	10–15	

Purging

Purging other polymers to Eastman Tritan™ copolyester:

- Purge with clear undried polycarbonate or clear polycarbonate regrind at 270°C–290°C (518°F–555°F) melt temperature to eliminate the previous polymer. After an adequate amount of purging (this will vary depending on the previous polymer used), the polycarbonate that is in the barrel of the injection molding machine can be followed directly with the *Tritan* copolyester without any further purging. Note that the *Tritan* copolyester may have a hazy appearance until all polycarbonate has cleared the injection system, often in 10–15 shots depending on shot size used.

Purging from *Tritan* copolyester to other polymers:

- Purge with acrylics, polystyrene, commercial purging compounds, or the polymer to follow the *Tritan* copolyester.

Annealing

When mold surface temperatures are maintained in the suggested ranges, relief of residual stress through annealing is typically unnecessary. This recommendation should be evaluated in individual cases where residual stress is of particular concern.

Cold Runner Mold Construction Guidelines for Eastman Tritan™ Copolyester

The following guidelines are to minimize cold sprue sticking, reduce cycle time, and open the processing window:

- Design molds to maintain the desired uniform mold surface temperature of 60°C–66°C (140°F–150°F) even when run at aggressive cycle times.
- Taper to be 3° minimum (included angle) on the sprue bushing.
- Orifice size of the sprue bushing where the sprue bushing meets the nozzle should be 4 mm (5/32 in.) diameter to 7 mm (9/32 in.) diameter. Larger parts will need orifice diameters of 7 mm (9/32 in.) diameter while smaller parts will need only 4 mm (5/32 in.) diameter orifice.
- Shorten the sprue bushing "L" dimension to less than 75 mm (3 in.) in length.
- The sprue bushing is to have a high polish in the sprue area.
- Increase cooling around the sprue bushing—suggest upper and lower water line circuits.
- Maintain good surface contact between the sprue bushing and mold surface.
  - Suggest line-on-line interference fit.
  - The surface contact is to be on the head of the sprue bushing as well as the shaft.
- Water line spacing 50 mm (2 in.) to 64 mm (2.5 in.) between center lines.
- Air poppets should be offset from the center line of the sprue as far as possible.

For example, a sprue bushing for a medium size part should have a length of 75 mm (3 in.) or less and a sprue bushing orifice diameter of 5.5 mm (7/32 in.).

In cases where aggressive molding cycles are desired, substitute a Performance Products™ alloy sprue bushing for the steel sprue bushing. Alloy sprue bushings are fabricated from raw materials that enjoy significantly better thermal efficiency than traditional steel sprue bushings.

Hot Runner Mold Construction Guidelines for Eastman Tritan™ Copolyester

- Design molds to maintain the desired uniform mold surface temperature of 60°C–66°C (140°F–150°F) even when run at aggressive cycle times.
- Cleanly separate the hot and cold areas of the mold by good insulation systems so that melt is uniform at 282°C (540°F), and the well-cooled mold is maintained at its uniform surface temperature of 60°C–66°C (140°F–150°F) especially including the area around the gate. Ideally the melt should be maintained at the same temperature generated at the discharge of the screw all the way through the machine nozzle, mold sprue, hot runner manifold, and hot runner drops and tips.
- Balanced runner systems are suggested so that flow, temperatures, and pressures are equal and simultaneous to all cavities.

Other Available Information

For more information, please visit eastman.com for data sheets, Material Safety Data Sheets, General Processing and Design Guidelines, or contact your Eastman representative at 1-800-EASTMAN.