Eastman TRITAN™
copolyester

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Drying and processing guidelines for injection molding

Contents

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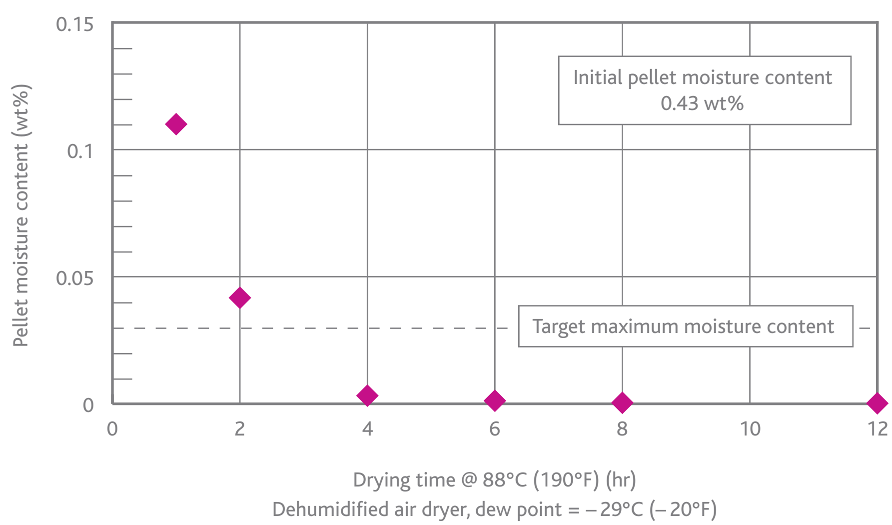
Eastman Tritan™ copolyester provides customers excellent toughness, as well as clarity, chemical resistance, dishwasher durability, dimensional stability, low and stable shrinkage rates, and other enhanced physical properties. Versions of Tritan are also available with various additive packages, such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

Drying

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

- **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 Tritan for 4 hours minimum at 88°C (190°F). If longer residence time in the dryers is required, such as overnight, lower set temperature to 82°C (180°F). Inlet air temperature needs to be controlled within ±3°C (±37°F) throughout the drying cycle. Figure 1 shows the effect of drying time on pellet moisture content.
- **Airflow:** The dryer should have sufficient airflow to assure a uniform pellet temperature throughout the dryer. A minimum of 0.06 m^3/min/kg airflow 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. 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. Some recommendations follow for processing Eastman Tritan™ copolyester.

- Processing at the optimal processing temperature and minimum residence time in the machine will assist in maximizing physical properties.
- Well-dried material is key for shot-to-shot uniformity. Engineering materials, such as Tritan, can suffer degradation at their processing temperatures because of hydrolytic degradation.
- Normal processing temperatures are in the range of 282°C (540°F) plus or minus 5°–10°C (10°–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 barrel capacity, 10%–25%, the processor should strive to run Tritan 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:

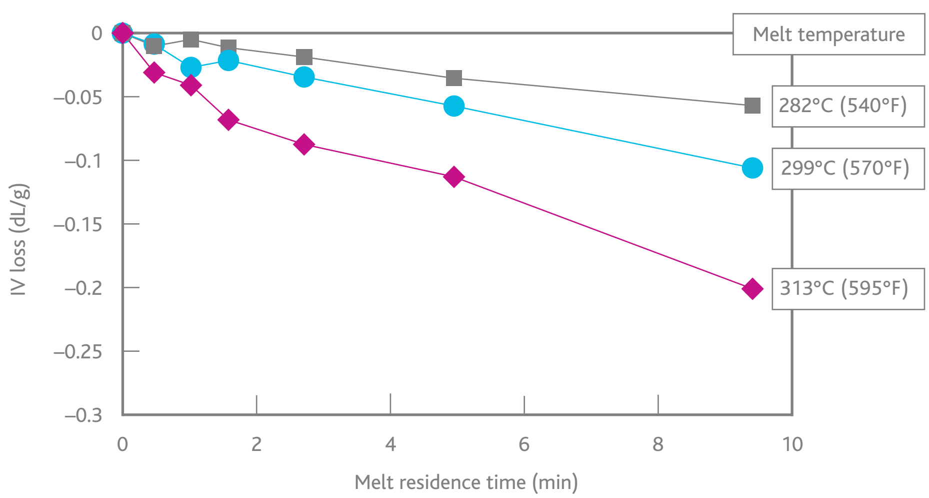
Rear zone	282°C (540°F)[a]
Center zone	282°C (540°F)[a]
Front zone	282°C (540°F)[a]
Nozzle zone	282°C (540°F)
Hot runners	282°C (540°F)
Actual melt temperature (purged on cycle)	282°C (540°F)

[a]*Since each machine is different, the barrel set temperatures might need to be set as much as 10°–20°C (20°–40°F) lower than the targeted melt temperature because of shear heating. It is good practice to determine 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 optimum pickup of material.*

- In special situations, Eastman Tritan™ copolyester does have a wider processing window, depending on the process, ranging from approximately 260°C (500°F) where flow and screw recovery become stiff, up to approximately 304°C (580°F) where splay may begin at 10-minute melt residence times. A good setting is generally 282°C (540°F) 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 is a function of melt residence time over a melt temperature range. IV is a commonly used molecular weight indicator in copolyester.



Mold temperatures

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

- Actual mold surface temperatures ranging from 38°–66°C (100°–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 previously outlined, 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/injection speed

- Fill speed used for Eastman Tritan™ copolyester is 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%–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 38–56 mm (1.5–2.2 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 nonstreamlined 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 1.0 mm (0.045 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 Eastman Tritan™ copolyester, lower rpm can make screw recovery more steady and consistent.

Pack and hold pressure

- 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. Packing out the void strengthens the sprue so that it will now release with the part. Having long hold times of 8 to 12 seconds and lower hold pressures of 34–52 MPa (5,000–7,500 psi)[1] will feed material to the sprue to fill the void while not 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 occur 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 solve the problem.

Cushion size

- Cushion size should be at the absolute minimum to ensure the screw does not hit bottom and the pack and hold pressures are getting into the part. The cushion left at the end of the pack and hold are typically 5–10 mm (0.2–0.4 in.) depending on machine size and injection speed. Larger cushions can add to holdup 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.

[1] *Note these pressures are actual melt pressures, not gauge pressures (often gauge readings are ⅒ actual pressures depending on machine and barrel).*

Table 1
Summary of drying and processing conditions

Condition	Eastman Tritan™ copolyester	
	TX1000 and TX1001	TX2000 and TX2001
Drying conditions		
Dryer air dew point, °C (°F)	⩾–29 (⩾–20)	⩾–29 (⩾–20)
Drying time, hr	4	4
Drying temperature, °C (°F)	88 (190)	88 (190)
Dryer airflow, m³/hr	⩾3.7	⩾3.7
Moisture content, %	⩽0.03	⩽0.03
Processing temperatures		
Zones, °C (°F)		
• Rear	Set barrel temperatures to reach target melt temperature, up to 10°–20°C (50°–68°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		
Fill/injection speed	slow	
Screw speed, rpm	minimum	
Pack and hold pressure, MPa (psi)	34–52 (5,000-7,500)	
Cushion size, mm (in.)	5–10 (0.2–0.4)	
Back pressure, MPa	10–15	

Back pressure

- Back pressure is usually kept to a minimum of about 10 MPa (1,500 psi).[2] 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).[2] High back pressures can aggravate drooling into the mold and require additional decompression.

Decompression (suck back)

- In general use, there is very little 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.

Other considerations

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, are generally very mild on screw wear. Corrosion of barrel and screw parts is not expected with Tritan.

Purging

Purging with other materials is not needed when Eastman Tritan™ copolyester is going to be run again after a shutdown. For a machine shutdown, such as on a weekend, simply shut off the pellet feed, run the screw empty, and turn off heats to the barrels and hot runners. Start up again with barrel heats which take the longest, then turn on hot runners with just enough time to reach set point at the same time as barrels. When set points are reached, start right away to avoid sitting and cooking the polymer. For short shutdowns such as during brief repairs, generally if the machine is sitting at set temperature longer than about 10 minutes, it's suggested to purge (air shots) the barrel contents and restart molding.

Purging from Eastman Tritan™ copolyester to other polymers:

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

[2]Note these pressures are actual melt pressures not gauge pressures (often gauge readings are 1⁄10 actual pressures depending on machine and barrel).

Annealing

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

Mold construction

The following guidelines are to minimize cold sprue sticking or sticking around the gate, reduce cycle time, and open the processing window.

General guidelines

- Design molds to maintain the desired uniform mold surface temperature of 38°–66°C (100°–151°F) even when run at aggressive cycle times.
- Use water line spacing of 2–2.5x diameter of cooling line between center line.
- Air poppets should be offset from the center line of the sprue or gate as far as possible.
- Balanced runner systems are suggested so that temperatures and pressures are similar for all cavities and flow is simultaneous to all cavities.

Cold runner/cold sprue guidelines

- Taper to be 3° minimum (included angle) on the sprue bushing.
- Shorten the sprue bushing "L" dimension to less than 75 mm (3 in.) in length.
- Orifice size of the sprue bushing where the sprue bushing meets the nozzle should be 4–7 mm (5⁄32–9⁄32 in.) diameter. Larger parts will need orifice diameters of 7 mm (9⁄32 in.) while smaller parts will need only 4 mm (5⁄32 in.).

  For example, a sprue bushing for a medium-sized 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.).
- 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.
  - Surface contact is to be on the head of the sprue bushing as well as the shaft.
- Use high heat transfer alloy sprue brushings such as Performance Alloy Performance Sprue Bushings®. Alloy sprue bushings are fabricated from raw materials that enjoy significantly better thermal efficiency than traditional steel sprue bushings.

Hot runner mold guidelines

- Cleanly separate the hot and cold areas of the mold with 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 38°–66°C (100°–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.
- Valve gates are the preferred gating style for hot runner systems with Tritan copolyesters.

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