Eastman TRITAN™
copolyester

EASTMAN

Processing guide

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Introduction

Eastman Tritan™ copolyester offers features and benefits—excellent impact strength, chemical resistance, dimensional stability, and low shrinkage—that make it suitable for use in a broad variety of commercial applications. Parts produced with Tritan are aesthetically appealing in clears and tints or with molded-in color. When combined with proper part design, suitable mold design, and recommended processing parameters, the parts provide excellent value.

This molding manual will assist designers and molders in producing the best parts from Eastman Tritan™ copolyester while enhancing ease of molding.

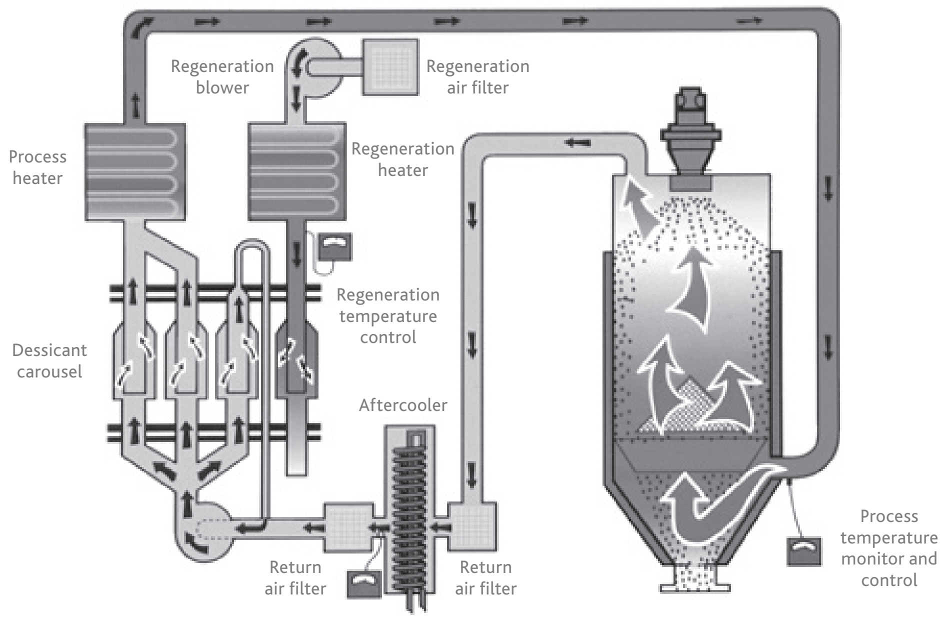
Drying

Proper drying of Eastman Tritan™ copolyester is key to shot to shot consistency and part performance.

All polyester resins readily absorb moisture. Desiccant or compressed air dryers must be used to dry the pellets prior to processing in the injection molding machine. A typical desiccant dryer is shown in Figure 1.

Drying is an absolute necessity to prepare Eastman Tritan™ copolyester for molding. If pellets are not dried, moisture will react with the molten polymer at processing temperatures, resulting in a loss of molecular weight. This loss leads to lowered physical properties such as reduced tensile and impact strengths.

Figure 1
Typical dessicant dryer



Molded parts may not show any noticeable defects
such as splay but may still exhibit lower physical properties.

Drying equipment

Multibed desiccant dryers are recommended to properly dry the resin. These dryers have two or more desiccant beds. Dryers that have three or four beds typically have shorter start-up times due to quicker bed regeneration. Desiccant dryers are available from many suppliers. Work with your desiccant dryer vendor to select the optimum dryer for the molding job. Locating the drying hopper on the feed throat of the molding machine is preferred. Planning should include consideration for throughput rate, ease of maintenance, reliability, and low variability of the four elements necessary for proper drying (drying temperature, drying time, dryness of air, and airflow).

Tray dryers can be used only if they are supplied with air dried by a good desiccant bed system. Tray dryers with heating only (and no desiccant) do not adequately dry the pellets. Good dryers for production typically include either rotating beds or other means to keep continuous airflow through a freshly regenerated bed while other beds are regenerated offline. Tray dryers with manually charged single beds are also generally not recommended for continuous production operations.

Drying conditions

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.

- 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 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.

Dryer diagram and troubleshooting

Dryers require routine checking and maintenance. A mechanic who understands dryers and has the time and support to maintain them is needed. The following information is provided to help give that understanding. Dryer suppliers can help also.

Common dryer problems

- Poor airflow caused by clogged filters.
- Air passing through the middle of the load rather than dispersing through the pellets, caused by unfilled hopper.
- Supply/return dry air lines allowing ambient "wet" air to contaminate dry air.
- Wet air contamination through loader on top of hopper.
- Lack of cooldown on air returning to the bed in absorption process. Air should be cooled below 65°C (150°F) to increase the desiccant's affinity for moisture, thus improving efficiency. An aftercooler is required when drying some resins.
- Reduced desiccant effectiveness caused by worn-out or contaminated desiccant.
- Nonfunctioning regeneration heater and/or process heater.
- Blower motor turning backwards.
- Airflow not being shifted when controls call for bed change; one bed stays in process continuously.

Elements necessary for proper drying

A discussion of the four elements necessary for drying plastics follows.

Drying temperature

Resin must be dried at a specific temperature. Air circulating through the hopper is heated by the process heater or after heater. Air temperature should be measured at the inlet to the hopper and controlled at the recommended drying temperature for a given resin. Exceeding this temperature will cause premature softening or melting of pellets to the point of sticking together, causing failure to feed freely to the bottom of the dryer for unloading. Drying at temperatures below the recommended setpoint will result in inadequate drying. When the controlling thermocouple is located away from the hopper, the setpoint may need to be raised to offset heat loss from the air during transport to maintain the desired hopper inlet temperature. Check the temperature over several cycles of the process heater. If the actual temperature overshoots the setpoint, adjust the setpoint accordingly to avoid overriding temperatures. Drying temperature should be held constant within ±3°C (±5°F). Insulated supply hoses and hoppers make drying much more effective and save energy costs.

It is also important to maintain air temperature (at least 205°C [400°F]) in the regeneration loop of the dryer. The regeneration loop is a separate system from the process loop, so the presence of hot air in the process loop does not guarantee that the regeneration loop is functioning.

Drying time

Pellets to be dried need to be in the hopper at the proper conditions. If the dryer is turned on from a cold start, it must warm up to the proper temperature and the dew point of the air must be reduced to –30°C (–20°F) or below before drying time can be counted.

Choosing the hopper size is critical; only when the hopper size is adequate for the rate of processing will the proper residence time in the hopper be possible. For example, if a 454-g (1-lb) part is being run on a 1-minute cycle, then 27.2 kg (60 lb) of dry material will be needed each hour. If 6 hours is required for drying, then at least 164 kg (360 lb) of material must be in the hopper continuously (27.2 kg/h X 6 h [60 lb/h X 6 h]). The hopper should be built so that plastic pellets in all parts of the hopper will move uniformly downward as material is removed from the bottom. Funneling pellets down the center of the hopper while pellets near the outside move more slowly will result in inadequate drying.

In routine operation, drying time is maintained by keeping the hopper full. If the hopper level is allowed to run low, residence time of the plastic in the hopper will be too short and the material will not be adequately dried. For this reason, and to compensate for less-than-perfect plug flow through the dryer, the hopper should be larger than the exact size calculated.

Dryness of air

Dry air comes from the desiccant beds in the closed air circulation loop of the dryer/hopper system. Desiccant beds must be heated and regenerated before they can dry incoming processed air. After regeneration, it is beneficial to cool down the regenerated bed with closed loop (previously dried) air as opposed to ambient air.

Returning processed air from the top of the pellet hopper is filtered before it is blown through the desiccant bed and onto the heater and hopper. Dryers used for polyesters should be equipped with aftercoolers to cool the returning processed air. Air temperature should be below 65°C (150°F) to increase the desiccant's affinity for moisture, thus improving efficiency.

The desiccant in the beds is typically a very fine claylike material in pea-size pellets. It slowly loses its usefulness and must be replaced periodically—usually about once a year. Use of plastic with a high dust content (such as regrind) or materials containing certain additives will reduce the life of the desiccant by coating the pellets or saturating them with a nonvolatile material. Good filters can help extend the life of the bed and the heater elements.

Air dryness can be checked by dew point meters, either portable or installed inline in the dryer (built-in dew point meters and alarms are the wise choice for polyesters). These meters give a direct reading of the dew point of the air tested. When the dryer has rotating beds, the meter must run long enough for all beds to be checked. Each bed can normally be online for 20–40 minutes or longer; a new bed should rotate into position before the dew point rises above –30°C (–20°F). (Also see "Moisture measurement" on this page.)

Airflow

The usual airflow rate requirement for drying is 0.06 cubic meter of hot, dry air per minute for each kilogram of material processed per hour (0.06 m^3/min per kg/h) or 1 cubic foot of hot, dry air per minute for each pound of material processed per hour (1 cfm per lb/h). For example, if 109 kg (240 lb) of material is used per hour, airflow should be at least 6.7 m^3/min (420 cfm). Minimum airflow to ensure good air distribution is usually about 2.8 m^3/min (100 cfm) for smaller dryers.

Airflow can be checked by inline airflow meters, by portable meters, or much less accurately by disconnecting a hose going into the hopper and feeling the airflow.

If there are dust filters in the circulation loop, these should be cleaned or replaced periodically to avoid reduction in the airflow rate.

Moisture measurement

Dew point meters, as already mentioned, can be either portable or, preferably, built into the dryer. They measure only the dryness of the air, not the dryness of the plastic pellets in the hopper. Use of the dew point meter along with measurements of temperature, airflow, and time can give an accurate indication of whether the plastic pellets are being dried properly.

Weight loss type moisture meters are instruments that measure the moisture inside pellets. These meters can give a general indication of the effectiveness of the drying system in reducing the moisture level in plastic pellets. However, most are usually not accurate enough to use as a quality control method to ensure adequate dryness of polyesters to prevent degradation during process. A moisture level in the range of 0.005%–0.015% is desired, and this is determined using analytical means other than the preceding.

Dryers require routine monitoring and maintenance. A mechanic with the knowledge, time, and resources is key. Dryer suppliers can also help.

Processing information

Some of the parameters to consider in choosing a machine for molding Eastman Tritan™ copolyester are barrel and melt temperatures, mold temperatures, fill speed, screw speed (rpm), pack and hold, cushion size, back pressure, decompression (suck back), screw and barrel design, purging, and annealing.

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 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 the key for shot-to-shot uniformity. Engineering materials, such as Tritan, 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°–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 the 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; a barrel with a three-zone system might have settings as follows.

Mold temperatures

Good temperature uniformity through the mold and good temperature control to a setpoint are key to successful molding.

- Actual mold surface temperatures ranging from 38° to 66°C (100° 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.
- 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 previously, 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 6 of PP-DUR-618 for additional information.

Fill speed

- Fill speeds used for Eastman 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%–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. When 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 1.1 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 2–5 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

Where direct sprue gating into the part is used, longer hold times in combination with lower hold pressures may 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 such that it will now release with the part. Having long hold times of 8–12 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 happen with a conventional runner at the junction of the runner and sucker pin.

[1] *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

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 is 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.

Back pressure

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

Decompression (suck back)

In general use, very little or no decompression occurs. 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, are generally very mild on screw wear. Corrosion of barrel and screw parts is not expected with Tritan.

Purging

Purging other polymers to Eastman Tritan™ copolyester:

- The material most effective in purging is a polymer similar to the material to be run. Polyethylene and polypropylene should be avoided because they can mix with the new material and cause streaks for extended periods of time. Use caution and refer to the manufacturer's recommendations for the material used in the previous run.

Table 1

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

Drying conditions	
Drying temperature, °C (°F)	88 (190)
Drying time, h	4
Dryer air dew point, °C (°F)	<–29 (<–20)
Processing temperatures	
Zones, °C (°F)	
• Rear	Set barrel temperatures to reach target melt temperature, up to 10°–20°C (20°–40°F) below target depending on shear heating.
• Center	
• Front	
Nozzle, °C (°F)	282 (540)
Hot runners, °C (°F)	282 (540)
Melt temperature, °C (°F)	282 ± 10 (540 ± 20)
Mold temperature, °C (°F)	60 (140)
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

Shutdown

In general, the feed can be shut off and molding continued on cycle until the screw is run dry. If you are changing to another material, purge with a polymer similar to the material to be run. Run the screw dry and turn off the power.

Always leave the screw forward; otherwise, a large slug of material must be remelted. If the slug does not fully melt before the screw is injected forward, check-ring damage may result.

- Retain 20–60-g (0.70–2.11-oz) samples of the pellets and parts for follow-up testing of IV (inherent viscosity) or molecular weight.
- Document and save all setup conditions, changes to conditions, and their effects on part quality. Add comments regarding what worked well and what caused problems. Provide copies to all trial team members and to your Eastman representative. When the job goes to production, give copies to all persons involved.

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