EASTMAN

Injection molding process training for
Eastman Tritan™ copolyester

Medical grade copolyesters

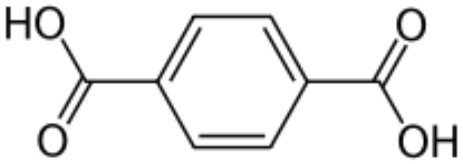
Agenda

- Introduction
  - What are copolyesters?
  - Eastman innovations in the medical industry
  - Copolyesters for the medical market
- Molding cell selection and machine capability
- Importance of drying
- Molding process
- Resources to help you be successful

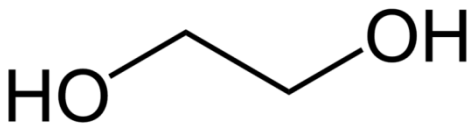
Introduction

What are polyesters?

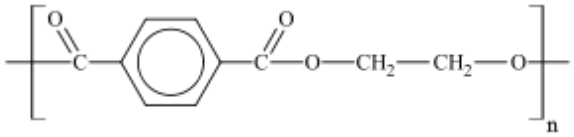
- Polyester is a category of polymers which contain the ester functional group in their main chain.
- There are many polyesters.
  - The term "polyester" as a specific material most commonly refers to polyethylene terephthalate (PET).



Terephthalic acid (TPA)



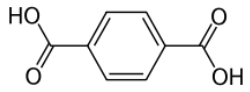
Ethylene glycol (EG)



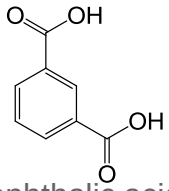
Polyethylene terephthalate

What are copolyesters?

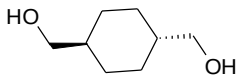
- Copolyester forms when modifications are made to polyesters.
  - Combinations of diacids and diols
  - For example, by introducing other diacids such as isophthalic acid (IPA) or other diols such as cyclohexane dimethanol (CHDM) to the polyester polyethylene terephthalate (PET), the material becomes a copolyester due to its comonomer content.
- Suitable for many types of applications ease of processing, toughness, clarity, chemical resistance and their status as BPA-free.
- Need for heat resistance led to the development of Eastman Tritan™ copolyesters.



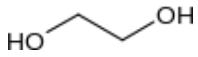
Terephthalic acid (TPA)



Isophthalic acid



Cyclohexane dimethanol (CHDM)



Ethylene glycol (EG)

Eastman innovations in the medical market

1970

Eastman Tenite™

Eastman Eastar™

Eastman Durastar™

Eastman Tritan™

2020

Eastman™ copolyesters for the medical market

- Safe and sustainable alternatives for the health care industry
- A portfolio of products that have been tested for FDA/ISO 10993 and USP Class VI Biological Evaluation after Gamma and EtO sterilization.
- Balance of properties: great chemical resistance with ease of processing, clarity, toughness, improved heat resistance and BPA free status.

Brand owners

- Lower system cost
- High quality performance
- Improved performance
- Safe and sustainable

Hospitals & clinics

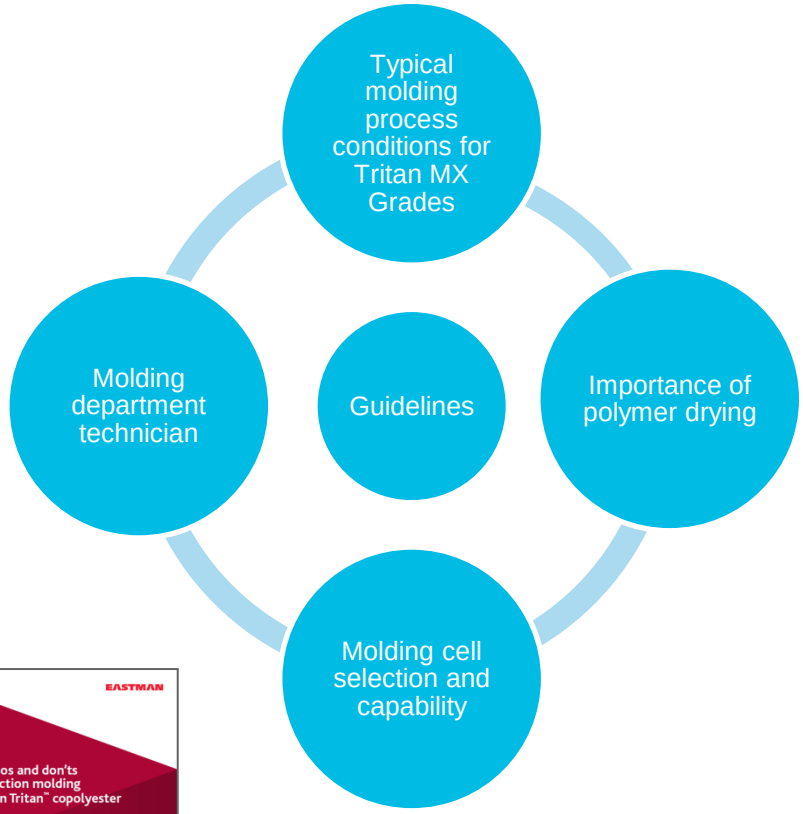
- EPP compliant products
- Products with improved reliability
- Reduced environmental impact
- Improved sustainability

Patients

- Peace of mind
- Low toxicity
- Reliable performance

Copolyesters with a unique balance of properties

- Great chemical resistance
- Easy processing
- Clarity
- Toughness
- Improved heat resistance
- BPA free
- Low and stable shrinkage rates and other enhanced physical properties. To optimize these physical properties and widen the processing window some drying and processing guidelines are in the following resources.



Molding cell selection and capability

Injection molding cell selection and capabilities

- Is your molding cell capable?
  - Is the mold clamp tonnage requirements within machine performance capabilities?
  - Is the barrel capacity on this machine appropriate for the candidate mold?

    Recommendations are >25% and <80% of barrel capacity utilization per molding cycle.
  - Is the screw profile of this machine acceptable for processing Tritan?

    Late model, single-stage screw profile may be appropriate.

Calculate melt residence time:

$$\frac{1.4 \text{ x melt delivery system cap (oz)}}{\text{sp.grav.P.S.(1.06)}} \text{ X } \frac{\text{sp.grav Tritan(1.17)}}{\text{molded shot wt(oz)}} \text{ x } \frac{\text{molding cycle (sec)}}{1} \text{ x } \frac{1 \text{ min}}{60 \text{ sec}} = \text{Residence time} * (\text{min})$$

Injection molding cell selection and capabilities

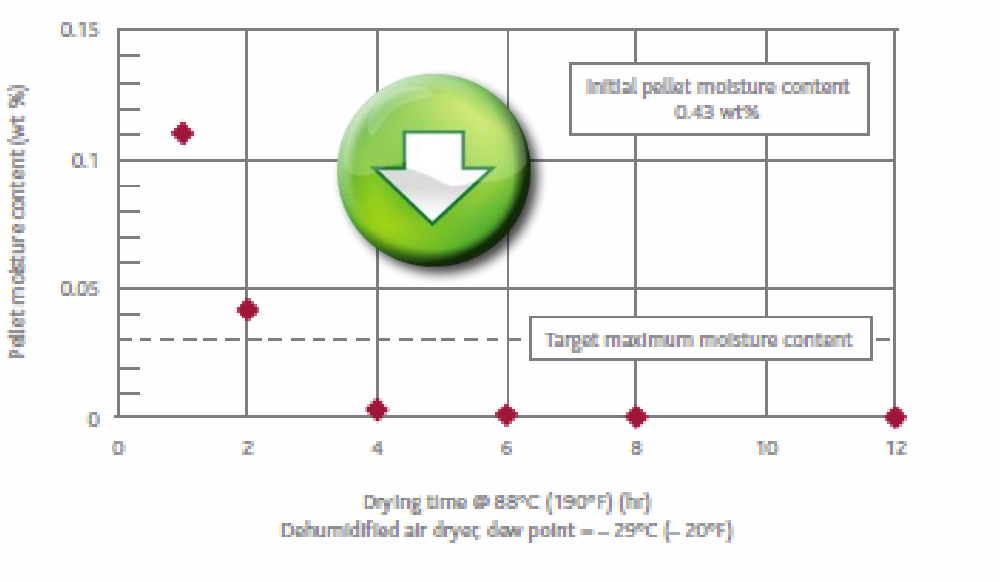
- Is a current “Load Sensitivity” test on file for this machine?
  - *See RJG Load Sensitivity test template.*

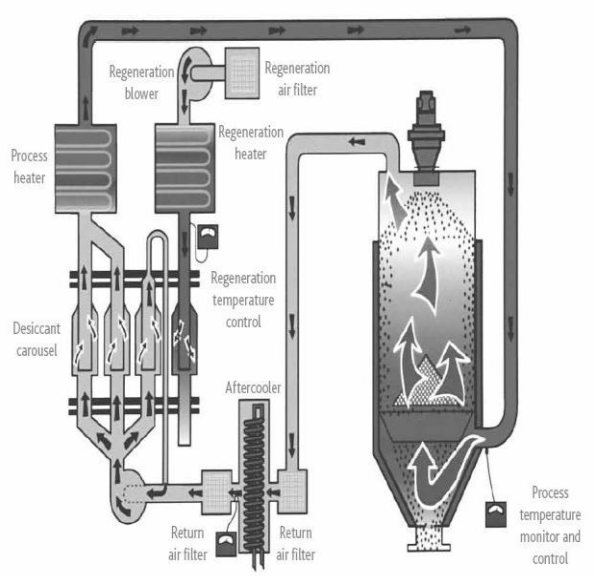
- Is a current “Injection Speed Linearity” study on file for this machine?
  - *See RJG Injection Speed Linearity test template.*

- Has a “Dynamic Check Ring Repeatability” test been performed on this machine recently?
  - *See RJG Dynamic Check Ring Repeatability test template.*

Importance of drying

Importance of drying copolyesters





Typical multiple desiccant bed polymer drying system

Suggested Tritan drying conditions	
Drying temperature °C (°F)	88 °C (190°F)
Drying time, hours	4 hours
Dryer dew point °C (°F)	Minimum: −30°C (−20°F) Preferred: −40°C (40°F)

Importance of drying copolyesters

Hydrodynamics portable
dew point meter and temperature pyrometer

Dryer troubleshooting guide

Problem	Possible cause	Corrective action
High dew point (wet air)	Desiccant worn out or saturated	Dry cycle machine or replace desiccant
	Incorrect desiccant type	Replace desiccant with type and size recommended by dryer manufacturer
	Regeneration heaters burned out	Replace heaters
	Regeneration filter plugged	Clean or replace filter
	Regeneration blower reversed	Reverse electrical connections
	Air leaks	Check and repair auto loader seal and/or hoses to hopper
	Beds not changing at the proper time	Reset or repair controller
	Return air too hot	Add or repair aftercooler
Low airflow	Dirty air filter	Clean or replace filter
	Fan motor reversed	Reverse electrical connections
	Hoses reversed between inlet and outlet	Connect dryer outlet to inlet at the bottom of the hopper
	No hose clamps; hose disconnected	Connect and clamp hoses
	Hose smashed or cut	Repair or replace hose
Short residence time	Hopper too small	Use larger hopper
	Hopper not full	Keep hopper full
	Tunneling or "rat holes"	Remove clumped material or install proper spreader cones
Temperature high or low (or varying more than ~3°C [~5°F])	Incorrect temperature setting	Set correct temperature
	Temperature controller malfunction	Calibrate or replace temperature controller
	Dryer not designed to maintain correct range	Repair or replace dryer
	Thermocouple loose or malfunction	Repair or replace thermocouple
	Heater malfunction	Repair or replace heater

Molding process

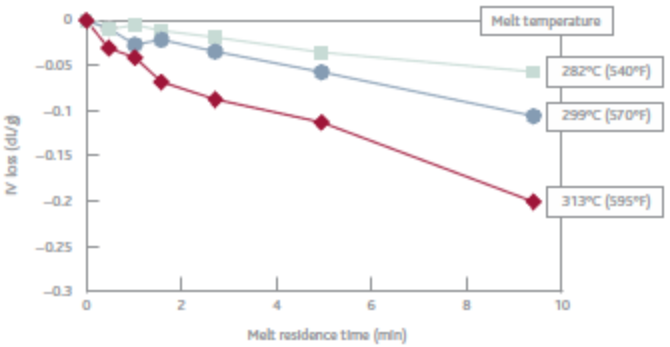
Typical molding process conditions for Tritan MX grades

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 the 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 (40°–50°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 at the lower range of the proposed melt temperature.



Mold temperatures

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

- Actual mold surface temperatures ranging from 60°–66°C (140°–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.

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.

Pack and hold pressure

- Where direct sprue gating into the part is used, longer hold times in combination with lower hold pressures

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

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.

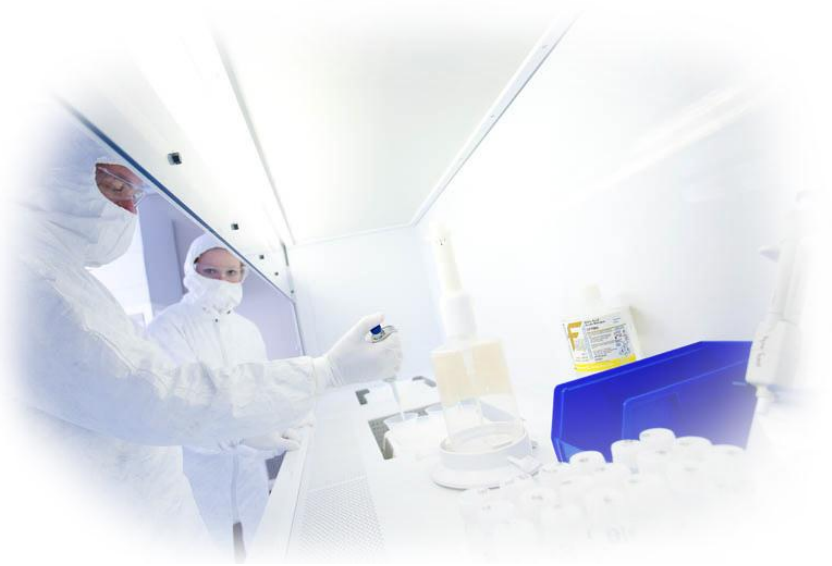
Before development of production molding process, perform pressure drop study to determine net mold cavity fill pressures.

Resources to help you be successful

Resources to help YOU be successful

Literature

- Polymer-specific
  - Tritan processing guide—TRS-MED-244
  - Tritan “Dos and Don'ts”—TRS-MED-239
  - Appropriate Tritan MSDS
  - Trouble Shooting Guide—PPD-MED-407
- Current mold drawings and operating guide
- Quality standards and fitness-for-use specifications



Instruments

- Hand held pyrometer
  - Barb probe to confirm melt temperature
  - Contact probe to confirm mold surface temperatures
- Hydrodynamics portable dew point meter
- Molding machine
  - Applicable operating manual
  - Applicable maintenance manual

Questions?

For more information, visit TritanMoldIt.com.