Eastman **TRĒVA**™
engineering bioplastic

Guidance for injection molding Eastman Trēva™ engineering bioplastic

SAFETY CONSIDERATIONS

SUMMARY

Eastman Trēva™ engineering bioplastic is a cellulosic polymer manufactured by converting wood cellulose into a thermoplastic with properties suitable for the various plastic molding processes, including injection molding and extrusion. Although Trēva has an ample processing range, it cannot withstand high temperatures for long periods of time and will degrade and become yellow or amber. At even higher temperatures and/or longer times, it can produce solid black or charred material that has the potential to block injection nozzles and/or hot tips on molds and possibly cause entrapment and pressurization of flammable gases.

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Eastman TRĒVA™
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This document provides guidance for proper processing of Trēva to avoid unusual and/or extreme processing conditions that can create safety issues.

HIGHLIGHTS OF PROCESSING

- Prepare for Trēva molding by warming the machine to 220°C. After warming, raise quickly to the desired processing temperature to begin molding.
- Shut down Trēva molding by lowering temperature to 220°C and running the barrel empty. Optionally, follow with purge compound and then with polypropylene or polyethylene.
- During continuous processing, high temperatures (>260°C) and long residence times (>20 minutes) are not recommended, since they will cause Trēva to turn yellow and/or create black specks.
- When the machine is idle, extreme temperatures (270°–280°C) and long residence times (>40 min) may cause Trēva to char (turn black), block the nozzle or hot tips, and, in extreme cases, degrade enough to create flammable gases.

DETAILS FOR PROCESSING

Start-up

- Prior to start-up, understand the shutdown procedure used for the previous run and whether the machine was properly purged before shutdown. It may affect the start-up procedure.
- Prepare for Trēva molding by warming the machine to 220°C. After warming, raise quickly to the processing temperature (225°–245°C) to begin molding.
- If the machine was previously run empty but not properly purged before shutting down, start-up may be attempted with extra caution. Soak at a maximum barrel temperature of 230°C. If the nozzle and barrel do not start to clear out with softened material, they are likely blocked with charred material. It will be necessary to cool the machine to room temperature and perform appropriate manual clean-out.
- If the machine was shut down and left with a barrel full of Trēva, the barrel and nozzle may be blocked with severely degraded or charred material. Normal start-up should not be attempted. It will be necessary to perform appropriate manual clean-out at room temperature.
- If the machine has been properly purged prior to shutdown, normal start-up procedures and temperatures (225°–245°C) can be followed.
- To minimize risk of black specks, start up with nozzle and barrel zones at the same temperature.
- When machine soak time has completed, increase the nozzle temperature as needed for standard processing (perhaps 10°–15°C higher than barrel).
- Do not allow the machine to sit idle with Trēva in the barrel more than 10 minutes before moving material through the barrel.

Hot runners

- The barrel and nozzle should be heated first. Hot runners and tips can be turned on at a lower temperature and then raised when the barrel is near the desired processing temperature.
- Keep the barrel purged with fresh material as the hot runners and tips are brought up to temperature.
- When estimating total residence time in the melt, include hot runner volume along with volume in the barrel.

Process interruptions

- Do not leave Trēva idle above 260°C in the barrel or hot runner for more than 20 minutes. At lower temperatures, 225°–240°C, do not leave it idle in the barrel for more than 40 minutes. These are unsuitable conditions that will lead to yellowing, degradation, black specks, and, in extreme cases, the buildup of flammable gases.
- If Trēva is overheated in this manner, immediately reduce temperatures to 230°C or less and purge with fresh material. It may also be necessary to use a purge compound such as Dyna-Purge® D2 to eliminate black specks.
- Depending on shot size and processing temperatures, significant process interruptions may lead to yellowing of Trēva and potential black specks in molded parts. Therefore, process interruptions should be minimized, and molders should assess their process setup and operation relative to fitness-for-use requirements specific to their application.
- Never leave the barrel and nozzle full of Trēva for long interruptions, since it is likely to char and create black specks. In the extreme case, excessive char may prevent safe start-up for subsequent molding.

Process shutdown

- For normal shutdown after molding, it may be preferable to use a commercial purge compound in the first step, followed by purge with polyethylene or polypropylene.
- Using commercial purge compound is optional, and some molders may find it unnecessary, depending on the next polymer to be used.

- Barrel and hot runner temperatures should be lowered to 220°C just prior to running the barrel empty of Trēva.
- Shutdown should be done with the objective of clearing the barrel, nozzle, and hot runners of all Trēva. Run the barrel empty and immediately purge with a commercial purge compound such as Dyna-Purge D2. Purging should be done through the hot runners and followed with polypropylene or polyethylene, which can be left in the runners and barrel for the next start-up with Trēva.
- Never leave Trēva in the barrel and nozzle during shutdown, as this material is likely to char and may prevent safe start-up for subsequent molding.

Normal processing temperatures

- Processing Trēva is best at 225°–240°C with residence time of 3–5 minutes.
- To minimize yellowing of Trēva during molding, processors should avoid using excessively high barrel temperatures and machine/mold combinations that give excessive residence time in the melt.
- Depending on a molder's fitness-for-use requirements, short residence times may allow higher barrel temperature.

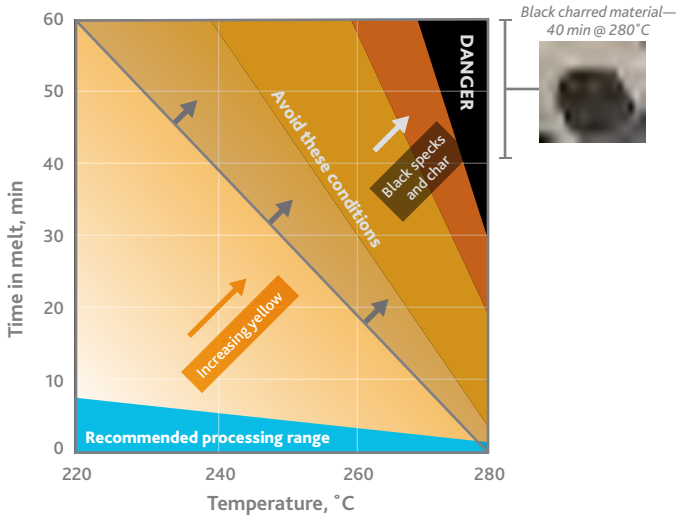
Excessive processing temperatures

- Trēva should not be processed at barrel temperatures above 260°C.
- Above 260°C, the process window for start-up and melt residence time becomes too small to be practical. Under these conditions it will be very difficult to avoid significant yellowing, black specks, and diminished physical properties.
- In the event of mismanaged start-ups, interruptions, or shutdowns, operating above 260°C is likely to char the material and may prevent safe start-up for subsequent molding.
- Extreme ranges should be avoided, since excessive time and temperature can cause Trēva to degrade to solid char.

Graph of processing conditions

- Figure 1 shows Trēva's response to high temperature and time in an oven test and represents the expected response of Trēva in molding or extrusion conditions.
- The blue shaded area shows the approximate recommended processing range for Trēva.
- The dark shaded area shows conditions to be avoided (high temperature, excessive melt residence time).
- The black shaded area in the upper right, marked "DANGER," shows conditions at which it is possible to degrade Trēva to solid char and create flammable gases.

Figure 1. Thermal stability of Trēva



ADDITIONAL PROCESSING INFORMATION AND RESOURCES

- For additional information on processing Trēva, refer to publication SP-MBS-5431, Injection molding—Processing and design guide.
- The information provided in this bulletin is not intended to include or anticipate all aspects of design, processing, or handling of Trēva. For additional information regarding the use of Trēva, refer to the resources listed at our website or contact an Eastman representative.

Eastman **TRĒVA**™
engineering bioplastic

Injection molding

Processing and design guide

Eastman Trēva™ engineering bioplastic is a versatile, cellulose-based thermoplastic that delivers sustainability benefits, high-level end-use performance, and design and brand flexibility. Trēva's composition is about half cellulose, sourced from trees derived exclusively from sustainably managed forests. Trēva is BPA-, BPS-, and phthalate-free.

Benefits

- Excellent chemical resistance to skin oil, sunscreen, and household cleaners
- Excellent flow in injection molding thin-wall parts
- Low birefringence for optical quality
- Excellent gloss and colorability

Applications

- Eyeglass frames and wearable electronics
- See-through electronic displays
- Electronics housings, cosmetics cases, and other intricate moldings
- Automotive interior components requiring chemical resistance and high aesthetics

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MATERIAL PREPARATION

Storage and handling

Protect Trēva in storage and handling from excessive humidity, moisture, or contamination with other plastics or foreign matter.

Drying

Dry Trēva pellets at 75°–85°C for 2–4 hours. Drying is most effective using desiccant dryers with low dew point (–30° to –40°C), but it is possible to use nondesiccant forced-air dryers, hopper dryers, or ovens to dry Trēva. Pellet moisture will not significantly affect physical properties of molded parts. However, drying is helpful to minimize moisture-related surface defects, such as splay, and to ensure good feeding on the screw and stable injection pressure and fill time.

Once material is dried, it is important to prevent reexposure to ambient conditions when material is transferred from the dryer to the injection molding machine

Regrind

Trēva is targeted for high-aesthetic applications, which may not be amenable to the quality and cleanliness challenges of using regrind. If regrind is used, it is the molder's responsibility to ensure its suitability for the application. Keep regrind clean and free of contamination from other plastics, including some cellulosic plastics. Trēva is compatible with propionates but is not compatible with acetates or butyrates.

Regrind must be dried prior to processing, whether it is preblended with virgin pellets or fed separately to the molding machine.

Studies have shown:

- Quality regrind is achievable by typical granulating equipment.
- Minimal physical and mechanical property changes occur using up to 50% perpetual regrind.

EQUIPMENT SELECTION

Injection molding machine

Select injection molding machine size to keep melt residence time at 3–5 minutes or less. This can be aided by keeping cooling time to a minimum and choosing a machine that uses at least 35% of its maximum shot capacity. Excessive residence time in the melt at higher process temperatures can lead to slight yellowness in the molded part. Residence time can be estimated by the following equation:

Residence time = (maximum shot size/actual shot size) × cycle time × 1.4

During process interruptions lasting longer than 6–8 minutes, depending on processing temperatures, it is critical to empty the barrel and leave the screw forward. Once it is confirmed that the barrel is empty, leave the screw forward and turn off barrel heats, as well manifold heats if applicable. Upon resuming the process, bring barrel heats up to normal operating temperatures. Once barrel heats are at temperature, bring manifold to temperature if applicable. While the manifold is heating up, purge the barrel with virgin Trēva using a slow screw speed. It is important to note that barrel pressures should be monitored during purging to ensure material is flowing through the barrel. After the barrel is purged and the manifold is at temperature, cover the mold B half with cardboard or similar, and purge 5–10 shots through the manifold to remove any degraded material. Trēva can be easily removed from mold surfaces by wiping with a cotton cloth. Normal operating procedures can be resumed.

Screw selection

Trēva can be processed well on general-purpose screws with length/diameter (L/D) ratio of 18:1 to 20:1 and compression ratio greater than 2. Trēva is best processed with screws that have a feed depth greater than 0.25 in. (6 mm) and a compression ratio greater than 2.8.

On machines and screws that are not optimally sized or designed, problems with screw recovery can occur. Following are possible solutions to resolve screw recovery problems:

- For a process with a cycle time not limited by screw recovery time, screw recovery can be improved by decreasing screw speed.
- Increasing barrel temperatures can improve screw recovery; however, slight yellowing of parts can occur.
- The addition of 0.03% to 0.05% of zinc stearate or calcium stearate powder directly to the material in the feeder can improve screw recovery; however, slight yellowing of parts can occur.

If there are questions about a particular screw, machine, and mold combination, contact your Eastman technical representative for further information and guidance.

Type of mold

Trēva can be processed on a wide range of molds and gate designs, including:

- Cold runner molds with edge, web, pin, or fan gates
- Three-plate molds with tunnel or restricted/pinpoint gates
- Hot runner molds with valve gates in a well-balanced hot runner system. A well-designed system should prevent hot spots, have reliable valve gate timing, have well-maintained thermocouples and valve gate pins, and ensure proper seating of manifold heaters.

Thermal tips are not recommended, since accumulation of degraded material in the thermal tip may cause brown spots or streaks to appear during extended runs. If these are noticed, it is recommended to purge the system with HDPE or another suitable purging compound.

Additionally, if thermal tips are used, the system should be immediately purged after a shutdown that lasts longer than 1–2 minutes to prevent material degradation.

- Gate size/thickness range may be 0.7–1.5 mm, depending on thickness and size of the molded part and the required part aesthetics. Depending on gate aesthetic requirements, cold trimming may not be suitable for certain applications with large gates.

If there are questions about a gate design, contact your Eastman technical representative for further information and guidance

Precautions to avoid excessive heating and unsafe conditions

- Prepare for Trēva molding by warming the machine to 220°C. After warming, raise quickly to the desired processing temperature to begin molding.
- Shut down Trēva molding by lowering temperature to 220°C and running the barrel empty. Optionally, follow with purge compound followed with polypropylene or polyethylene.
- During continuous processing, high temperatures (>260°C) and long residence times (>20 minutes) are not recommended, since they will cause Trēva to turn yellow and/or create black specks.
- When the machine is idle, extreme temperatures (270°–280°C) and long residence times (>40 min) may cause Trēva to char (turn black), block the nozzle or hot tips, and, in extreme cases, degrade enough to create flammable gases.

PROCESSING SETUP

Molding parts with typical thickness (1.5–3.0 mm) can be done across the full range of suggested molding conditions (see Trēva processing summary). Avoid excessive pack and hold pressures, which can lead to warpage or excessive stress near the gate. Parts should be packed just to the point of eliminating sinks or voids. Temperatures at the upper end of the recommended range can improve weld line strength.

For optically clear parts requiring low birefringence, it is helpful to use higher melt and mold temperatures along with faster injection speeds and a profiled pack pressure. Additionally, gate thickness and width may need to be optimized based on part design and geometry.

Molding thin parts (0.7–1.2 mm) may lead to excessive polymer orientation, which can cause warpage or surface blemishes. For these parts, it is critical to avoid having significant pressure on the melt at the time of gate freeze, which could result in noticeable warpage. For nominally flat parts, a ramped pack profile can improve overall flatness.

For example, a part with a 3-second gate freeze could have pack profiles as follows (flat vs. ramped):

Increment	1	2	3	4	5	6
Duration, s	0.6	0.6	0.6	0.6	0.6	0.6
Flat pack profile, psi	500	500	500	500	500	0
Ramped pack profile, psi	1500	1200	900	600	300	0

Contact your Eastman technical representative to ensure optimal performance when molding thin parts.

SHUTDOWN AND PURGING

For shutdown of Trēva, purge the entire system (barrel and manifold) with HDPE or another suitable purging compound if possible. Ensure the barrel is empty and leave the screw forward.

It is sufficient to shutdown with Trēva by ensuring the barrel has been purged of all material and leaving the screw forward. Trēva, like all other thermoplastics, should not be left idle in a barrel at processing temperatures for an extended period, doing so will result in excessive material degradation. For a manifold system, once the production is complete, immediately turn off manifold heats to prevent material degradation.

At restart, bring barrel heats up to normal operating temperatures. Ensure that the nozzle and manifold gates are free from blockages. Do not apply additional heat to the barrel or manifold in attempt to remove blockages, as this will cause increased material degradation. Once barrel heats are at temperature, bring manifold to temperature if applicable. While the manifold is heating up, purge the barrel with virgin Trēva using a slow screw speed. It is important to note that barrel pressures should be monitored during purging to ensure material is flowing through the barrel. After the barrel is purged and the manifold is at temperature, cover the mold B half with cardboard or similar, and purge 5–10 shots through the manifold to remove any degraded material. Trēva can be easily removed from mold surfaces by wiping with a cotton cloth. Normal operating procedures can be resumed.

Trēva processing summary	
Parameter	**GC6011, GC6021**
Drying time, hr	2–4
Drying temperature, °F (°C)	165–185 (75–85)
Barrel set temperature, °F (°C)	440–480 (225– 250)
Target melt temperature, °F (°C)	460–500 (240–260)
Mold temperature, °F (°C)	150–190 (65–88)
Injection speed, in./s (cm/s)	1–7 (3–18)
Injection pressure, psi (MPa)	1000–1500 (7–10)
Pack/hold/cooling time, s	2–4/4–6/5–10
Screw recovery speed, rpm	100–200
Screw back pressure, psi (MPa)	100–200 (0.7–1.38)
Residence time in melt, min	3–5

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