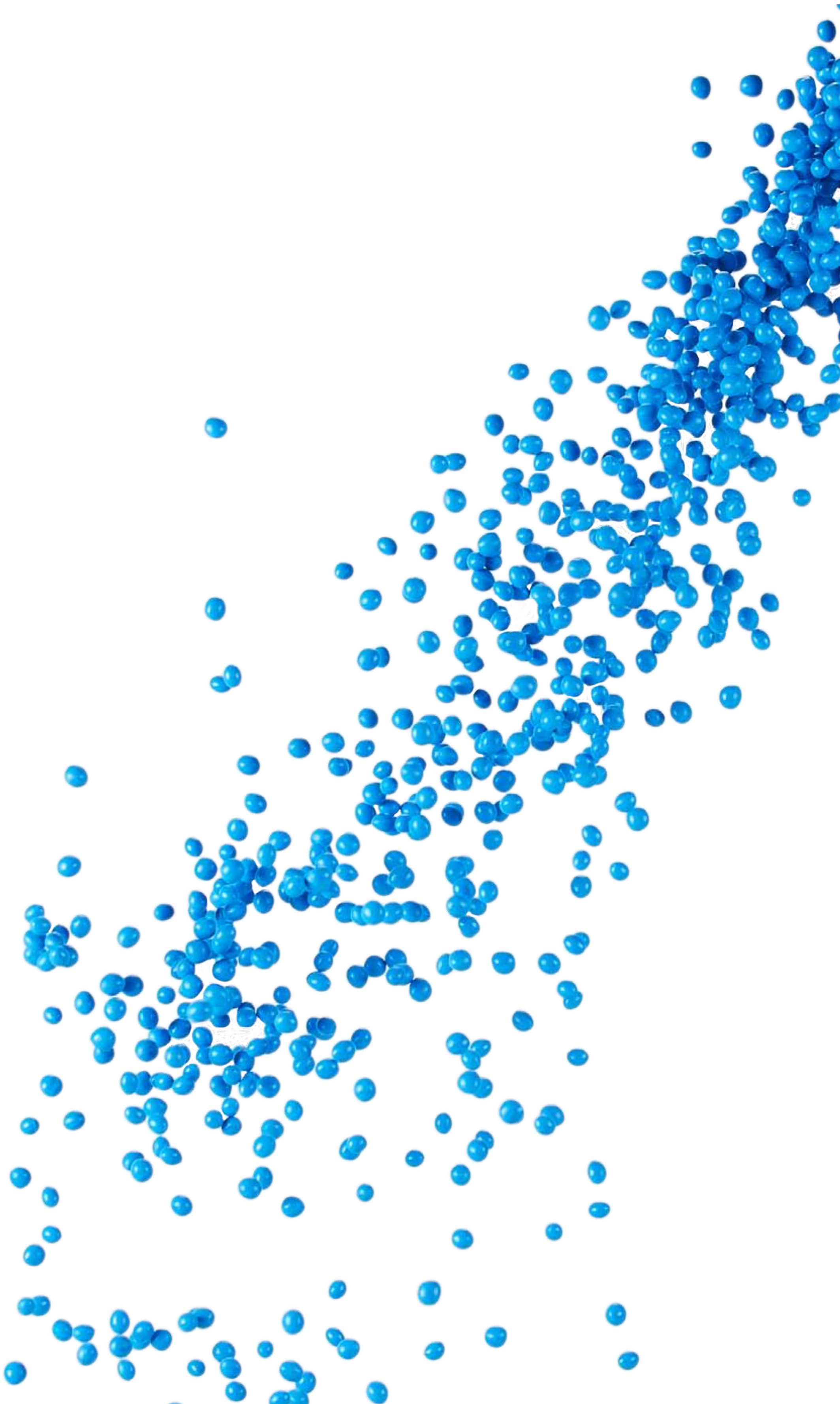
KRAIBURG TPE

CUSTOM-ENGINEERED TPE AND MORE

Injection Molding and Extrusion

Processing of Thermoplastic Elastomers



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1 The company KRAIBURG TPE

KRAIBURG TPE has been developing and producing thermoplastic elastomers for decades. Due to a strong specialisation in this area, KRAIBURG TPE is an established leader in competence and innovation. With strategically selected production facilities and sales subsidiaries in East Asia and the Pacific, Europe, and North America, KRAIBURG TPE provides its regional customers with quick, efficient, and local service to address their individual requirements.

The high-performance product and service portfolio of KRAIBURG TPE is aligned with current market and customer requirements. The offering is supplemented with special custom products. The company's entire worldwide product range is produced to uniform high quality standards.

2 Thermoplastic elastomers – properties

Thermoplastic elastomers (TPE) are delivered to customers in the form of granulate. The KRAIBURG TPE granulate can be processed without the addition of further materials and is distinguished by extremely good mechanical values and the following characteristics:

Adhesion

TPEs can be efficiently combined with other thermoplastics in co-injection molding processes. Products from KRAIBURG TPE adhere with PP, PE, and PS, as well as engineering thermoplastics such as PC, ABS, SAN, PBT, etc. They can even be combined with polyamides, such as PA6, PA66, and PA12 with outstanding results.

UV resistance

The UV resistance of KRAIBURG TPE products conforms to the highest demands for use in automotive exterior applications, and can pass the three-year cycle according to the VW standard PV 3930. TPE fulfil the strict standards of RAL-GZ 716 and CSTB/DER/BV-PEM for use on buildings.

Fluidity

KRAIBURG TPE produces its compounds with varying viscosity depending on market requirements. The product portfolio offers compounds with very low viscosity, e.g. to meet the requirements for overmold injection to prevent glass breakage. However, the portfolio also offers highly viscous TPE which have very high melt strength.

Haptics

With the use of two-component technology, soft surfaces can be applied to handles and housings in order to generate pleasing haptics. Various handle surfaces can be produced depending on customer requirements. Soft surfaces with low or high friction.

Temperature stability

With high-quality raw materials, TPE compounds from KRAIBURG TPE have excellent heat ageing performance, even at high temperatures. Depending on the application, the portfolio covers temperature ranges of up to 140 °C with dynamic loads.

Coloring

TPEs can be precisely colored with commonly available master batches. KRAIBURG TPE can also supply pre-colored materials in nearly every color with very tight color tolerances.

Thermoplastic elastomers combine these positive characteristics and enable processors, designers, and OEMs a great many possibilities and advantages.

3 KRAIBURG TPE – the products

KRAIBURG TPE offers a customer-specific, market-oriented portfolio of thermoplastic elastomers known by the trade names THERMOLAST®, COPEC®, For Tec E® and HIPEX®.

THERMOLAST®

These compounds are divided into five strong product groups which are available under the names THERMOLAST® K, THERMOLAST® V, THERMOLAST® A and THERMOLAST® M. The versatility of our THERMOLAST® compounds with respect to hardness, color, surface composition, and mechanical characteristics provides nearly unlimited freedom for the design and function of end products.

COPEC®

COPEC® materials are distinguished by especially pleasing haptic characteristics. The TPE provides a ‚velvety' feel. COPEC® compounds are also distinguished by their resistance to skin oils and numerous cleaning agents.

For Tec E®

For Tec E® compounds adhere extremely well to PA 6.6 and many other semi aromatic polyamides. The materials are resistant to skin oils and various chemicals.

HIPEX®

HIPEX® is used for applications with high temperatures and contact with oil. The temperature-resistant, chemical resistant TPE is frequently used in areas close to engines or transmissions.

Scan this code with your smart phone's QR reader* for
further information about our product portfolio on www.kraiburg-tpe.com.

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4 Advantages of thermoplastic elastomers

4.1 Processing advantages of thermoplastic elastomers

The success story of thermoplastic elastomers is based predominantly on the advantages of multi-component injection molding. TPE compounds can be processed like plastics; however they have the properties of elastomers. This enables efficient processing for high unit quantities – particularly with two-component technology.

4.2 Advantages in the injection molding process

Differences in processing in comparison with conventional elastomers:

- No vulcanisation is necessary
- Suitability for processing methods of conventional thermoplastics
- Investments in new machinery are normally not necessary
- Economical processing
- Short cycle times
- Wide processing window
- Low energy consumption
- 100% recyclable
- Easy to color
- Non-corrosive
- Use of standard tool steels

4.2.1 Co-injection molding

Co-injection molding is frequently selected due to its low assembly expense and short production time, and leading to economic part production.

Co-injection molding allows simple production of hard-soft combinations, such as seals, anti-slip elements, and handles. For design reasons, TPE compounds with different colors are often used in combination with other thermoplastics. Housings are often overmolded with thermoplastic elastomers due to the pleasant soft and warm surface properties.

Advantages

- Adhesion to standard thermoplastics
- Variations in hardness, flexibility
- Greater design leeway (color, surface characteristics, etc.)
- High productivity
- No assembly of multiple parts
- Quality control only takes place for a single item
- Low part weight
- Additional benefits for end consumers (design, quality, function, etc.)

4.2.2 Requirements for co-injection molding

The following requirements are important for a two-component system: The TPE must be adapted to the properties of the thermoplastic. The central characteristic is the polarity. This must be similar between TPE and thermoplastic. KRAIBURG TPE has developed various series of products adapted to thermoplastics for this purpose.

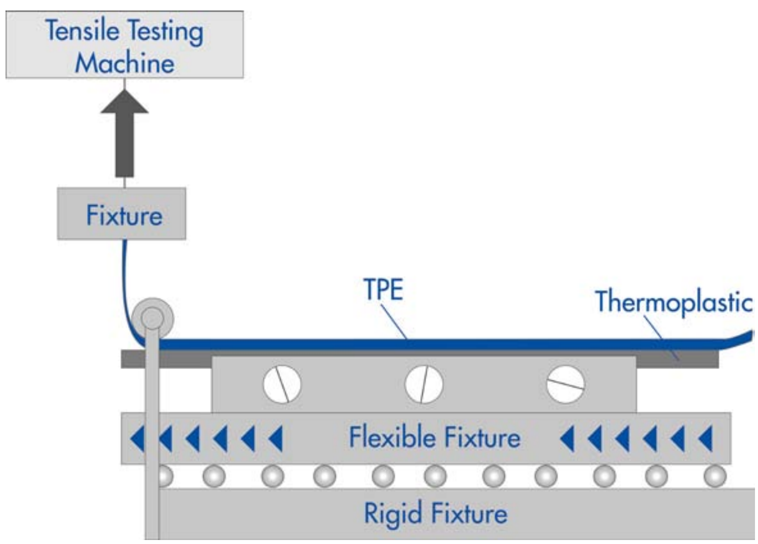
The products can basically be classified in three groups:

- Non-polar thermoplastics such as PP or PE
- Polar thermoplastics such as ABS, PC, SAN, PBT, POM
- Polyamides

The second most important factor for good adhesion is the melting and a good wetting of the first component. This is achieved with a high heat supply (melt and tool temperature) of the soft component. A high wall thickness of the TPE aids the bonding with the hard component. Adhesion is prevented due to a migration of substances, such as mold release agents or other additives on the surface.

In order to enable comparability between adhesion compounds, the adhesion quality is tested on the basis of the guideline VDI 2019.

The testing setup depicted below shows how the peeling force is measured in N/mm depending on the path which the upper clamp of the tensile testing device travels. This path is referred to as a peeling path. The percentage by which the TPE expands is indicated therein.



Test specimen dimensions
Thermoplastic part: 130 x 60 x 2 mm
TPE part: 130 x 20 x 2 mm

We would be pleased to provide sample plates (produced on a co-injection molding machine).

Please observe that the process, adjusted parameters, and the part geometry and composition of the hard component have a crucial influence on the adhesion results. The final adhesion quality is only achieved after a storage period of approximately 24 hours.

Our application technology department can assist in matters ranging from the product idea to the choice of material, testing, and serial production.

4.3 Advantages in the extrusion process

In addition to the injection molding process, extrusion offers a good processing possibility for TPE. You can use a TPE on a standard plastic extrusion line. Multi-component-parts are frequently produced in the extrusion process. The TPE is either co-extruded directly on a thermoplastic or TPEs with different hardnesses are combined. KRAIBURG TPE offers a variety of compounds with adhesion to PP, PE, ABS, PS, PC, PVC-U (Rigid-PVC), etc.

Advantages

- No vulcanisation is necessary
- Suitability for processing techniques for conventional plastics
- Investments in new machinery are normally not necessary
- Economical processing
- 100% recyclable
- Easy to color
- Non-corrosive
- Adhesion to nearly all common thermoplastics
- Variations in hardness, flexibility

4.4 Packaging and storage

Depending on product density, TPE compounds are supplied in 20 kg (B102) or 25 kg (B100) sacks, octabins with loose fill, or in Big-Bags. When stored for an extended period of time, the material should be kept dry and protected from light.

The following package types are available from KRAIBURG TPE:

B100 (sacks)

- 8 layers of 3 sacks each (24 sacks) loosely stacked on one-way pallets (CP2) and wrapped in stretch film
- For compounds with a density of 1.05 g/cm^3 or higher
- Maximum weight: 600 kg (25 kg per sack)
- Length: 1.20 m · width: 0.80 m · height: 1.25 m
- Pallets not stackable

B102 (sacks)

Differences to B100:

- For compounds with a density of up to 1.05 g/cm^3
- Maximum weight: 480 kg (20 kg per sack)

S100 (sacks in carton)

- 18 sacks in a carton, stacked on a one-way pallet (CP2)
- For compounds with a density of 1.05 g/cm^3 or higher
- Maximum weight: 450 kg (25 kg per sack)
- Length: 1.20 m · width: 0.80 m · height: 1.05 m
- Pallets stackable

S102 (sacks in carton)

Differences to S100:

- For compounds with a density up to 1.05 g/cm^3
- Maximum weight: 360 kg (20 kg per sack)

S140 (sacks, ground and cover made of carton) - only available for compounds > 40 ShA

- 24 loose sacks, stacked on a one-way pallet (CP3)
- For compounds with a density of 1.05 g/cm^3 or higher
- Maximum weight: 600 kg (25 kg per sack)
- Length: 1.14 m · width: 1.14 m · height: 0.95 m
- Pallets stackable only in container

S142 (sacks, ground and cover made of carton) - only available for compounds > 40 ShA

Differences to S140:

- 25 loose sacks, stacked on a one-way pallet (CP3)
- For compounds with a density up to 1.05 g/cm^3
- Maximum weight: 500 kg (20 kg per sack)

C100 (octagonal, standard octabin)

- Loose fill in a large octabin on a one-way pallet (CP1)
- Maximum weight: 400 to 500 kg, depending on compound/density
- Length: 1.20 m · width: 1.00 m · height: 0.90 m
- Pallets can be stacked up to three high

C110 (octagonal, small octabin)

- Loose fill in a small octabin on a one-way pallet (CP2)
- Maximum weight: 300 to 350 kg, depending on compound/density
- Length: 1.20 m · width: 0.80 m · height: 0.90 m
- Pallets can be stacked up to three high

C130 (octagonal, large octabin) - only possible starting with an order size of 2,500 kg

- Loose fill in a large octabin on a one-way pallet (CP1)
- Maximum weight: 800 to 1,000 kg, depending on compound/density
- Length: 1.20 m · width: 1.00 m · height: 1.75 m
- Pallets not stackable

C140 (Big-Bag) - only possible starting with an order size of 2,500 kg

- Loose fill in a bulk material container (Type 05) on a CP3 pallet
- Maximum weight: 750 to 1,000 kg, depending on compound/density
- Length: 1.14 m · width: 1.14 m · height: 1.65 m
- Pallets not stackable

Please note: There is a risk of blocking with compounds having a hardness < 30 shore A. This must be taken into account for transport and/or storage.

4.5 Pre-drying

With the variety of different TPEs, the need for pre-drying must be defined depending on the composition of the recipe. Please refer to the compound's processing instructions for the exact parameters for pre-drying at www.kraiburg-tpe.com.

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The specified times should not be exceeded. Pre-drying improves the surface-quality of all TPEs.

In co-injected applications, if the hard component must be pre-dried, then pre-drying of the TPE is also recommended. Thermoplastic elastomers with adhesion on PP do not have to be pre-dried. Materials with adhesion on technical thermoplastics, such as PC or PA, must be pre-dried.

When processing by extrusion, pre-drying is basically recommended for wall thicknesses > 3 mm.

4.6 Coloring

With few exceptions, the materials of our standard series of compounds are transparent, translucent, naturally colored, or black. We can provide nearly any color on request. The compound's inherent color also permits coloring in light and bright colors. However, the coloring process, e.g. by useing color masterbatches on the injection molding machine or in the extruder, is quite simple. THERMOLAST® compounds can be precisely colored and offer good color stability in comparison with EPDM/PP.

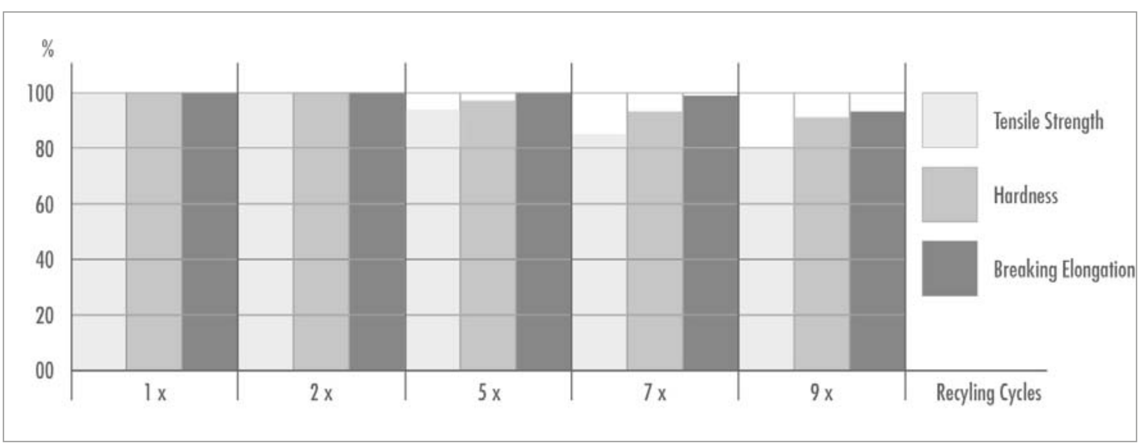
Universal master batches are suitable for coloring. Depending on the color, an additive of 2 to 5% should be used. In the process, observe the specifications of the color batch supplier. The coloring is not likely to lead to significant changes in material properties. The hardness usually increases by approximately 0.5 to 2 Shore A, depending on the master batch.

4.7 Recycling

Due to their thermoplastic character, thermoplastic elastomers can be recycled. An admixture of up to 15 % in virgin material is possible.

Shearing and cutting mills are predominantly used for thermoplastic elastomers, fibrous or (soft) tenacious materials. Slowly rotating cutting mills have been demonstrated to be beneficial. Shredding down to 2 to 10 mm particles must be done by shearing with sharply ground blades.

The cooler the sprue/component is, the better the shredding ratio. The following graphic shows the change of mechanical values with the use of 100 % recycling material after various recycling cycles. In total, the material was milled eight times and injection-molded nine times.



Mechanical values after x recycling cycles in % of original values

5 The injection molding process

5.1 The injection molding machine

Thermoplastic elastomers from KRAIBURG TPE can be processed in conventional injection molding machines for thermoplastics with standard three-zone-screws.

The screws should have a compression ratio of at least 2:1 and an L/D ratio of at least 20. Under special conditions it may be advantageous to use barrier screws, e.g. in order to achieve greater plasticising capacity. Processing with open nozzles is possible. Working with shut-off nozzles is advantageous.

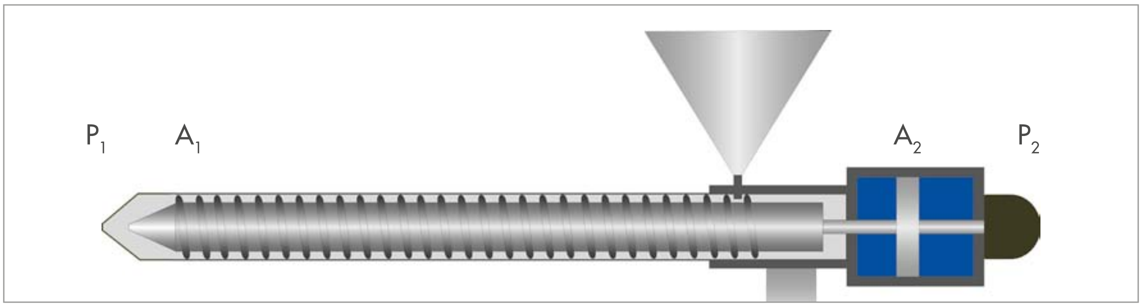
The screw size has to be chosen wisly to the residence time. The hot runner volume should not exceed one or two times the shot weight. THERMOLAST® K compounds are generally suitable for quite long residence times. For COPEC® und HIPEX®, the overall residence time should not exceed five minutes. For precise details about the respective compound, get in touch with your contact partner at KRAIBURG TPE.

5.2 Cleaning the machine

Before processing, we recommend cleaning the injection molding line with polypropylene. If a material change is pending, the unit must be run empty with the remaining granulate and cleaned with PP. The machine must be PVC-free.

5.3 Hydraulic / specific pressure

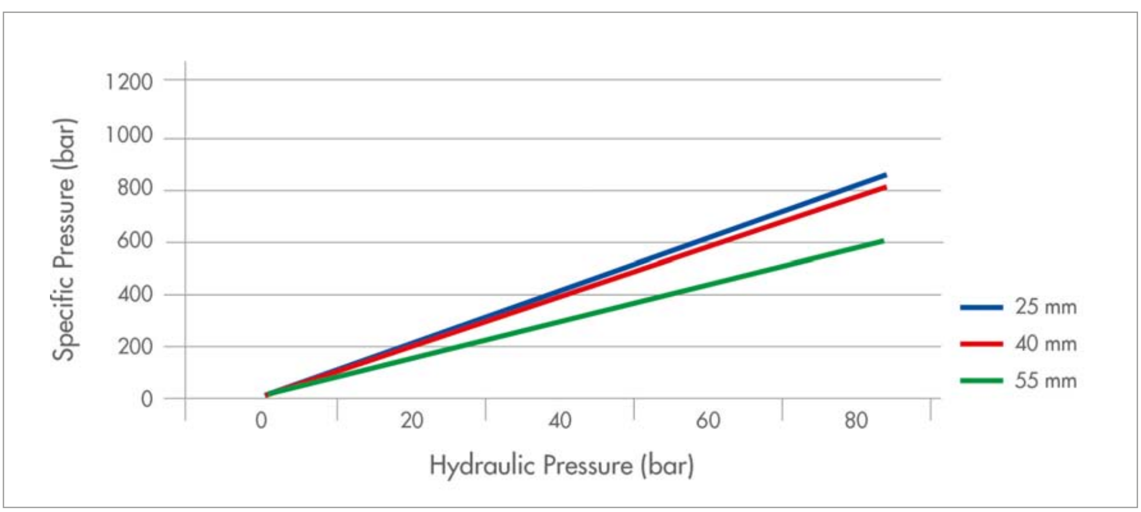
Modern injection molding machines can switch the display between hydraulic and absolute / specific pressures and units. The conversion takes place according to the following formula: $P_1 = \frac{P_2 \times A_2}{A_1}$



P_1: Specific pressure; A_1: Surface cross-section of the auger; P_2: Hydraulic pressure; A_2: Flat hydraulic press

Absolute / specific pressures must be used for the machine settings. In doing so, pressures of different machines in different sizes can be compared with each other. The specific pressure is the pressure which is applied directly on the material.

A diagram which indicates the specific pressure vs. the hydraulic pressure is often fixed on machines. If this is not the case, a precise conversion of pressures can be requested from the machine manufacturer.



Conversion table of hydraulic to specific pressures of various screw diameters

5.4 Processing parameters

Since KRAIBURG TPE compounds are often developed precisely according to customer requirements, there are differences in the processing behaviour between grades. For more detailed information about the individual products, please refer to our product data base.

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5.5 Cylinder and melt temperature

In general, the cylinder temperature from the first zone after the fill hopper increases by 10 to 20 °C per zone. The temperature at the nozzle should be equal to or 5 to 10 °C below the cylinder temperature of the last previous heating zone.

With THERMOLAST® products, the viscosity is influenced usually by shearing. The temperature has less influence on the viscosity than with other thermoplastics.

Possible effects with a high melt temperature:

- Better adhesion
- Longer flow paths

Possible effects with a low melt temperature:

- Prevention of thermal damage

5.6 Tool temperature

The optimal tool temperature varies depending on the compound, particularly for co-injection molding.

In general, we recommend 25 to 40 °C. With thin-walled parts, 40 to 60 °C is recommended. For processing in co-injection molding, the hard material is the component which determines the temperature.

Possible effects with a high tool temperature:

- Better adhesion
- Less surface defects

Possible effects with a low tool temperature:

- Reduced adhesion

5.7 Injection pressure and speed

Injection pressure and speed influence the structural viscosity of the material and can thus differ depending on the compound. With highly viscous compounds, it is essential that the material has undergone sufficient shearing. In this case, the cavity should be filled with a high injection pressure and higher injection speed of approximately 50 to 80% of the machine capacity. The resulting injection time should be 0.5 to 2 seconds. In the process, long flow paths can also be achieved with very thin-walled parts.

The dependency of the flow behaviour on temperature and injection pressure is shown in the following table, based on testing with three highly viscous THERMOLAST®:

Processing parameter flow path spiral in cm / pressure limited to 900 bar (specific pressure)									
Temperature	200 °C			220 °C			240 °C		
Speed mm/sec	30	50	75	30	50	75	30	50	75
TC4GPN	71	131	–	81	133	–	83	124	–
TC6GPN	68	93	–	69	107	164	70	126	183
TC9GPN	57	59	58	70	72	72	72	90	90

Possible effects with a high flow speed

- Consistent surface
- Better adhesion

Possible effects with a low flow speed

- Lower tensions

5.8 Filling study / volumetric filling

The optimal speeds and injection pressures are determined based on a filling study The filling study begins with the start-up of the machine at a reduced speed and without pack pressure. The shot weight is increased in 10 % increments, beginning with half of the calculated volume. Therefore, the effectiveness of the ejectors are guaranteed.

The resulting incomplete parts demonstrate the filling behaviour of the tool. With multiple cavity tools or for molded parts with more than one gate, a filling study will show any inconsistent filling and/or a gate system which has not been balanced. Moreover, indications of the expected joint lines and possible air entrapments are also highlighted.

The tool should be filled to 100 % without pack pressure. The pack pressure should only be switched on thereafter, in order to counteract shrinkage and possible sink marks.

5.9 Pack phase

The gate freezes off when the plasticised plastic has cooled down to the extent that it is solidified at the gate. The sealing point is determined based on a combination of pack pressure time and pack pressure level. The pack pressure phase has a significant influence on many quality features, such as shrinkage, sink marks, warpage, weight, and dimensions.

Starting with approximately 40 to 60% of the necessary injection pressure, the pack pressure time is systematically increased without generating overfilling. The weight is determined after each shot and charted. This is continued until weight increases are no longer detectable, which means the part weight remains the same. Now the sealing point for this pack pressure has been reached. If sink marks are still present, the procedure is repeated with a higher pack pressure. In this manner, an optimal result is approached step-by-step.

In order to ensure that the tool is not opened with the increased pressure, we recommend attaching an appropriate measuring gauged on the tool (precision 1/1000). If it has been determined that the tool opens, the pressure must be reduced by 10%. It must also be determined whether the tool gives way in the contour.

Possible effects with a higher pack pressure:

- Overfilling of the cavity
- Difficulties in removal from the mold, delamination
- Deformations in the gate area
- Better adhesion for flowing seams
- Loss of adhesion near the gate

Possible effects with a lower pack pressure:

- Sink marks on thick-walled parts
- Higher shrinkage

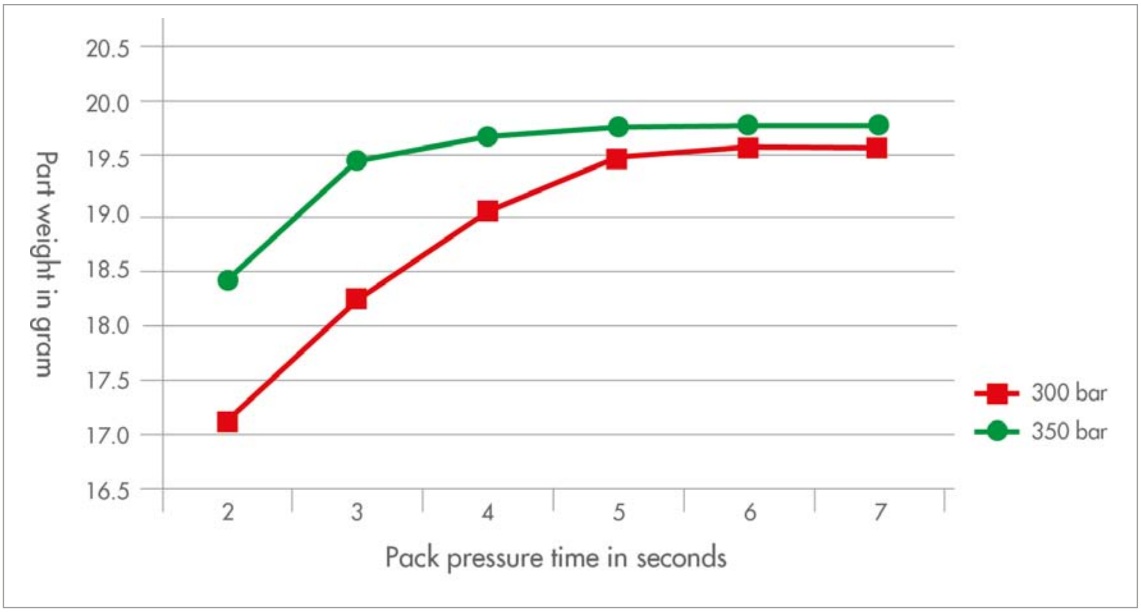

Diagram for determining sealing point

5.10 Back pressure and screw speed

In general, a back pressure of approximately 20 to 100 bar is recommended. A guideline value for the screw speed is 25 to 75 rpm. The material behaves similarly to polypropylene in regard to the screw speed.

Possible effects with a higher back pressure:

- Better distribution, e.g. with addition of color master batches or other additives
- Increased homogeneity of the melt
- Longer plasticising time with consistent screw speed
- Possible deformations in the gate region

Possible effects with a lower back pressure:

- Non-homogeneous melt

5.11 Residual melt cushion

This refers to the material remaining in front of the screw tip after the end of the pack pressure phase. The residual melt cushion guarantees a clean pressure transfer during the pack pressure phase. It should basically be kept low, but it should not be omitted. The dosing path must be selected such that a cushion is also present in unfavourable conditions. An optimal residual melt cushion is 3 to 5 mm for a small screw diameter (e.g. 25 mm), and 5 to 10 mm for a larger screw diameter (e.g. 80 mm).

Effects with a large residual melt cushion

- Long residence time
- Burn streaks or material degradation possible

Effects with a small residual melt cushion

- Sink marks
- Damage to the machine nozzle by the screw tip

5.12 Gating

Due to the excellent flow properties of KRAIBURG TPE materials, the use of multiple gates can often be omitted for large cavities. It is important to remember that for TPE compounds viscosity decreases strongly with shear. Therefore, the position of the gate must be chosen such that the material comes into direct contact with a wall or a core shortly after entering the cavity. An free flow must be avoided.

The relationship between the wall thickness of the injection molded part and gate diameter plays a crucial role. The recommendation for the diameter of the gate is ideally between 0.4 and 0.6 mm, with a maximum diameter of 1.0 mm. A very clean gate area is achieved with a slight depression (lens).

5.13 Venting

With optimal venting, cycling times can be reduced. Venting can take place at the tool split line. With some geometries, venting at the point furthest from the gate or at the weld line position is recommended. With a filling study, the correct position for venting can be determined. Vent channels with a depth of 0.005 to 0.02 mm are recommended.

Possible effects of too little venting:

- Cavities not completely filled
- Surface defects
- Burn marks
- Insufficient adhesion quality with two-component parts

Possible effects of too much ventilation:

- Formation of flash

5.14 Tool surface and ejection

TPE usually has high surface friction. Soft compounds also tend to adhere to smooth tool surfaces. Eroded tools reduce the adhesion of the molded part and thereby facilitate removal from the mold.

The ejectors should be designed according to the hardness of the compound. Instead of ejector pins, ejectors with bigger surface should be used. Undercut parts can often be manufactured with simple undercut tools without sliders, wherein the parts are pressed out of the mold. Air-pressure-assisted ejectors are beneficial for soft compounds and deeper undercuts.

If a polished surface of the hard component could lead to insufficient adhesion quality in a two-component system, an eroded surface is recommended.

5.15 Shrinkage

Shrinkage varies depending on the flow direction due to the anisotropic behaviour of thermoplastic elastomers. We would be glad to assist you in the design of your tool and provide you the shrinkage values from test plaques, as well as additional information about the conditions under which the plaques were produced.

Please note that the shrinkage values can never be assumed to be precise values, because the shrinkage of a compound can be influenced by the following factors:

- Processing parameters
- Sprue system (hot runner / cold runner)
- Tool temperature
- Tool design
- Part geometry
- Melt temperature
- Flow direction

Effects on shrinkage with a change of injection molding conditions: Shrinkage is higher in the flow direction than the cross flow direction (anisotropic behaviour).

	Changes in the injection molding conditions	Effects on shrinkage
Melt and tool temperature	▲	▲
Cooling time in the tool	▲	▼
Pack pressure	▲	▼

6 Injection molding overview: Trouble-shooting

Problem	Possible cause	Possible solutions
Part is not full	Entrapped air due to insufficient venting	1. Check whether the vent channels are open 2. Check the position of the vent channels 3. Increase the size of the vent channels 4. Change the filling behaviour by reducing or increasing injection speed / pressure 5. Apply vacuum to vent channels 6. Reduce clamping pressure
	Feed system	1. Check whether gate is open 2. Increase the gate size 3. Increase manifold sizes
	Melt and/or tool too cold	1. Increase cylinder and nozzle temperature 2. Increase tool temperature 3. Increase injection speed 4. Increase screw speed
	Residual melt cushion too small	1. Check residual melt cushion and increase
Sink marks (do not mix up with entrapped air)	Pack pressure too low	1. Increase pack pressure
	Insufficient venting	1. Reduce clamping force 2. Reduce injection speed 3. Create ejector bore 4. Provide venting
Warpage / deformation of the part	Molecular orientation	1. Increase melt and tool temperature 2. Increase injection speed
	Part is overfilled	1. Reduce back pressure 2. Match filling and the injection time
	Inconsistent tool filling	1. Change gate position 2. Ensure consistent tool temperature 3. Increase injection speed and back pressure

Problem	Possible cause	Possible solution
Black spots / unmelted particles	Contamination	1. Clean with stiff flowing PP or HDPE 2. Check color concentrate; basic PP or PE, **not** PVC
Adhesion in tool	Part is too warm	1. Reduce cylinder and nozzle temperature 2. Reduce tool temperature 3. Extend cooling time
	Part is overfilled	1. Under-fill and approach the fill point in steps
	Tool design	1. Increase draft angles 2. Use mold release agent 3. Add surface texture to the tool
Formation of clumps on the sprue	Moisture	1. Dry granulate 2. Using a vented screw, check whether the vents are closed 3. Apply vacuum to vent channels
Flow lines	Melt and / or tool too cold	1. Increase cylinder and nozzle temperature 2. Increase tool temperature 3. Increase injection speed 4. Increase screw speed and back pressure 5. Check suitability of screws
	Tool design	1. Change gate position 2. Increase the gate size 3. Increase manifold sizes
Bubbles (not to be confused with entrapped air)	Melt solidifies too quickly	1. Increase tool temperature 2. Increase screw speed and back pressure
	Moisture	1. Dry granulate 2. Using a vented screw, check whether the vents are closed 3. Apply vacuum to vent channels
	Back pressure too low	1. Increase back pressure
	Pack pressure too low	1. Increase pack pressure and pack pressure time

Problem	Possible cause	Possible solutions
Poor and / or no adhesion with co-injection molding at the start / middle of the flow path	Pack pressure too high (cold materials are sliding past to each other)	1. Reduce pack pressure
	Injection speed too low	1. Increase injection speed
Poor and / or no adhesion with co-injection molding at the flow path end	Processing / tool temperature too low	1. Increase processing / tool temperature
	Injection speed too low	1. Increase injection speed
	Insufficient venting	1. Reduce clamping pressure 2. Reduce injection speed 3. Create ejector bore 4. Provide venting
Poor and / or no adhesion with co-injection molding in general	Unsuitable material combination	1. Check material compatibility
	Use of release agent	1. Processing without release agent
	Pre-molded part not free from grease and / or dust for the transfer process	1. Clean pre-molded part (wear gloves, if applicable) 2. Clean tool

7 The extrusion process

7.1 The extruder

Basically, extruders designed for conventional standard plastics are also suitable for the processing of KRAIBURG TPE materials (e.g. universal or polyolefin extruders). Some limitations must be observed with PVC extruders. If you have any questions, contact your contact person at KRAIBURG TPE.

7.2 Cleaning the machine

Before processing, we recommend cleaning the extruder with polypropylene or polyethylene. Especially careful cleaning should take place after processing with PVC. If a material change is pending, the unit must be run empty with the remaining TPE and cleaned in the same manner as before the processing.

7.3 Screws, screens, perforated discs

The use of three-zone screws has shown the best results. The length of the screw should be at least 25 D; the compression ratio should not be less than 3.5:1. The auger should be capable of sufficiently shearing the material. A barrier screw can be advantageous. As a basic principle, we recommend working with a perforated disc and screen in order to increase the pressure.

7.4 Processing parameters

Processing parameters provide an overview and general recommendations for the processing of thermoplastic elastomers from KRAIBURG TPE. In general, experience gathered processing the material with the existing equipment must always be taken into account. Since THERMOLAST®, COPEC® and For Tec E® compounds are often developed precisely according to requirements, there can be differences in the processing.

Individual recommendations can be found in the processing instructions at www.kraiburg-tpe.com. Our application technology department can advise you and, if desired, provide trial assistance.

Scan this code with your smart phone's QR reader* for
information about the processing instructions for TPE at www.kraiburg-tpe.com.

* Our KRAIBURG TPE app including a QR reader is available free of charge in the App Store or online at http://www.kraiburg-tpe.com/de/news_press/multimedia

7.5 Processing temperature

Typical processing temperatures for extrusion:

	Temperature
Feed zone	140–160 °C
Compression zone	150–170 °C
Metering zone	160–180 °C
Connection	170–180 °C
Tool	180–220 °C

The maximum processing temperature should not exceed 250 °C. Higher temperatures or excessively long material residence times in the unit can cause thermal damage.

7.6 Tool temperature

The tool temperature is normally between 180 and 220 °C.

7.7 Calibration

Calibration is generally not necessary. As the hardness of the compound increases and with co-extrusion with standard thermoplastics, supporting elements may be necessary.

7.8 Extrusion tool

Simple matrix tools are sufficient for the processing of KRAIBURG TPE materials for many applications. In the process, the die land should be kept as short as possible – max. 3 to 4 mm. This applies particularly if the surfaces of the tool have not been sufficiently polished.

Elaborate multi-plate tools with corresponding flow corrections are beneficial due to lower longitudinal shrinking and less warpage of the profile. They can also enable higher production speeds. Air assistance is beneficial when working with hollow chamber profiles.

Of course, KRAIBURG TPE components can also be co-extruded with each other. Due to the wide spectrum of extrusion compounds, there are a number of combination possibilities (hardness, transparency, color, haptics, etc.).

8 Extrusion overview: Problems and solution approaches

Problem	Possible cause	Possible solutions
Rough extrudate	Melt too cold	1. Increase extruder temperature 2. Increase nozzle temperature
	Non-homogeneous melt / unmelted particles	1. Use of screws with higher compression ratio or mixing zone
	Unfavourable nozzle design	1. Shorten the die land 2. Check dimensions
Inconsistent cross-section	Pulsing	1. Reduce ejection output 2. Use of a screw with long feed or metering zone 3. Use of screen packages to increase back pressure and / or reduced mesh size 4. Reduce nozzle temperature
Black spots / particles not melted	Contamination	1. Clean with stiff flowing PP or HDPE 2. Check color concentrate; basics PP or PE, **not** PVC
Odour or discoloration	Melt too hot	1. Reduce cylinder temperature 2. Reduce nozzle temperature 3. Reduce screw speed 4. Use of screen packages with larger mesh size for reduction of the back pressure 5. Use of a screw with lower compression ratio
Bubbles, porosity	Moisture	1. Dry granulate
High pressure in the extruder / low flow rate	Melt too cold	1. Increase extruder temperature 2. Increase nozzle temperature
	Clogged screen	1. Clean or replace screen package

Notes

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