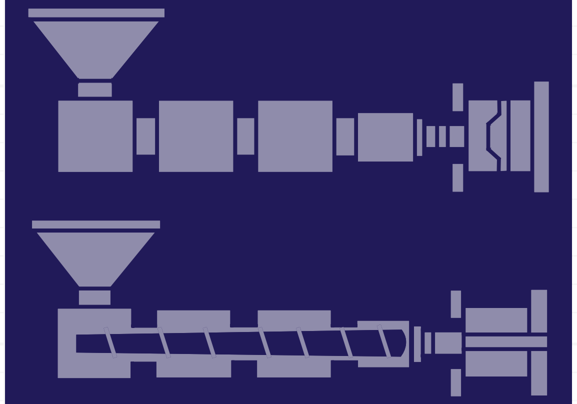
TPE PROCESSING GUIDE



HEXPOL TPE

CONTENTS

INTRODUCTION

We’ve created this processing guide for our TPE (Thermoplastic Elastomer) compounds. The parameters shown are not suitable for TPU compounds.

The information we provide is intended to be advisory, to help when designing your tool and when processing TPE. We can also support in tooling design and process optimisation, helping to reduce the cost of your finished part.

Please also consider the grade specific processing information provided on the technical datasheet.

Please contact us for further information.

INJECTION MOULDING

Our TPE compounds are widely used for producing injection moulded parts with very high elasticity and flexibility. However, please keep in mind that these properties are affected by the design of the parts and the material flow. The physical characteristics can vary depending on orientation (at right angles and along the direction of injection), i.e. the material is anisotropic. Under normal process conditions, the effects of molecular orientation are exhibited in the TPE material. This orientation is a function of the shear to which the molten polymer is subjected and it results in a higher modulus of elasticity and rigidity at right angles to the direction of flow.

By using process parameters that minimise shear; such as lower injection pressure, velocity and higher working temperature, the orientation effects can be minimised. The degree of orientation is also affected by the mould design. The following factors help to minimise orientation:

- Largest practicable gate
- Gate location that minimises the flow distance in the cavity
- Shot blasted or electrical discharge machined (EDM) instead of polished surface

If the injection moulding temperature is too low, there will be a risk of cold flow in the part, which can lead to poor strength.

EQUIPMENT

Our TPE compounds can be processed in most conventional injection moulding machines. These may contain one or several cavities. The number of cavities should be limited to achieve reliable production. It is important that the injection-moulding machine is not too large. A recommendation is at least 30 % of the shot volume of the machine should be delivered in every shot.

SCREW DESIGN

Most injection moulding machines are equipped with universal screws that have a compression ratio of between 2:1 and 3:1, a 60-degree tip angle and some form of reverse flow inhibitor. Such screws are excellent for processing TPEs. Special screws with short sections and higher compression ratios (3:1 to 4:1) may be good at low screw speeds.

NOZZLES

Most nozzle types can be used. Our TPE compounds based on SEBS may remain stationary in the nozzle for a short period of time, since the material does not degrade at normal process temperatures and does not give rise to high gas pressures. On the other hand, TPE compounds based on SBS must not remain stationary in the nozzle for any length of time, since the material is more sensitive to thermooxidative degradation, i.e. it is broken down more easily by heat in the presence of atmospheric oxygen.

PRE-DRYING

Pre-drying is generally not necessary, since they do not absorb moisture under normal storage conditions. Please refer to the individual datasheet if pre-drying is required.

MOULD DESIGN

Our TPE compounds can be processed easily in most conventional moulds and can often be injected into moulds made for other materials, with little or no modification required. However, some aspects should be considered when designing a mould specifically for TPE. In the design of the part, wide variations in material thickness should be avoided and efforts made to provide radii at all edges and tips. Also avoid long, thin cores, since it is difficult to restrict the temperature. A polished mould surface can create a vacuum between the mould wall and the part, as the material being injected forces the air ahead of it. This can lead to the part being gripped in the mould by suction. A coarser finish, such as a shot blasted surface or one produced by EDM, improves the release properties.

SHRINKAGE

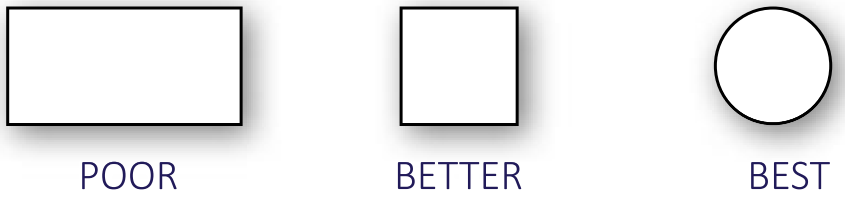
When designing your mould you'll need to consider shrinkage properties. For TPEs the shrinkage can vary between 0.5 % and 2.5 % principally depending on the material grade, the part and the location of the gate. Shrinkage also depends on the orientation in the part which depends on the processing parameters. Please contact us → for further advice.

RUNNERS

Cylindrical runners between the gate and the cavity inlet are the best solution, since the surface area is smaller than, for example, a semi-circular runner with the same cross section.

Secondary runners should also be cylindrical and should be of smaller diameters. If possible, they should also branch off at right angles from the primary runner. If balanced flow is required, all secondary runners should be of the same length. Cold slugs can be avoided if the primary runner continues a little way after the branch-off point, see Figure 2.

To shorten cycle time insulated or heated runner systems can be used for parts that have thin cross sections. Hot runner systems should be larger than cold runner systems, to maintain a constant mould pressure. The lowest temperature of the material in the runner, during unloaded parts of the cycle, should be around 175°C for SBS material and 185°C for SEBS based materials.



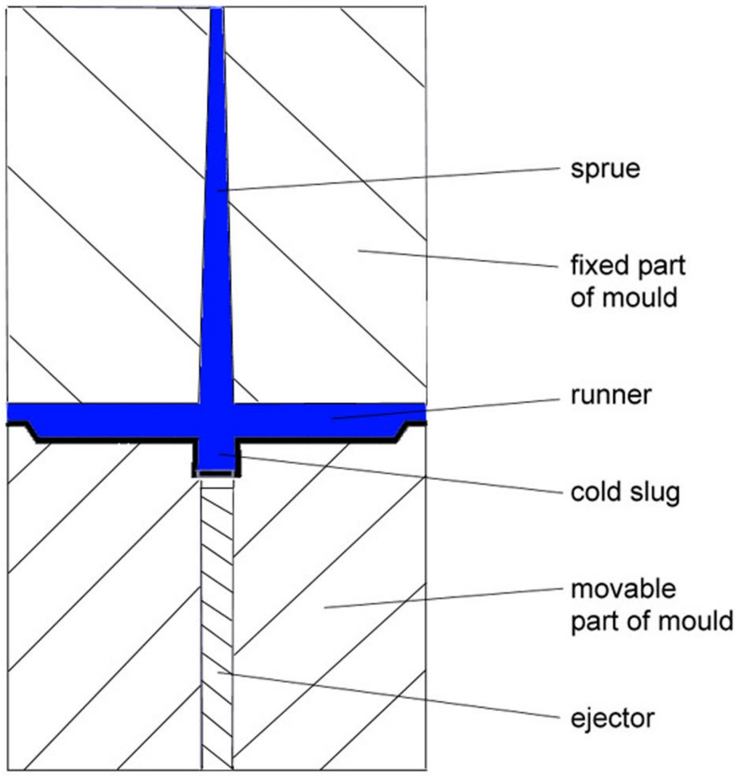


FIGURE 2 : COLD SLUG

GATES, INTAKE AND VENTING

Our TPE compounds will produce good results when injection moulded with standard gates conforming to conventional design practice. Different gates are shown in Figure 3 →

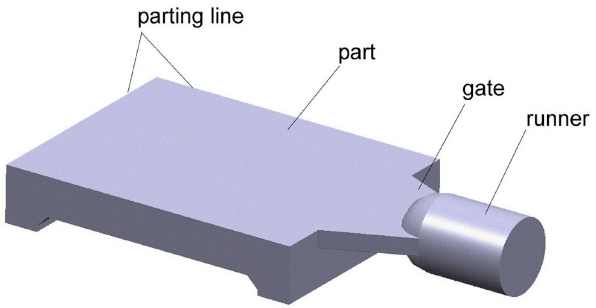
A general rule is that the gate should be just big enough to fill the mould. The volume in the gate runners (hot runners) should be as small as possible. If the volume is too large there is a risk of cold flow and the maximum strength will not be achieved.

Standard gates with a draft angle of 2.5 degrees perform well. However, the type of gate extractor should be decided based on the specific grade. For soft grades, it is advisable to use extractors of the reverse cone or "finger" type, which give back draft. Tunnel or film gates are the usual gate types. More than one gate per stripper should be avoided since homogenisation problems may occur.

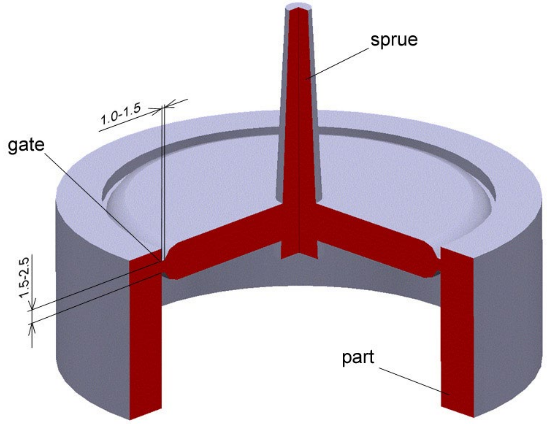
The gate should be as short as possible but with adequate sealing effect. Gates should be located in areas dictated by conventional design principles. To achieve the best surface, the gate should be located so that the melt meets obstacles or resistance immediately after the gate. For very thin parts, a film gate or several gates should be used.

Since TPEs should be injection moulded at normal to high injection speeds, venting is necessary. A vent groove depth of 0.01 to 0.02 mm is generally sufficient.

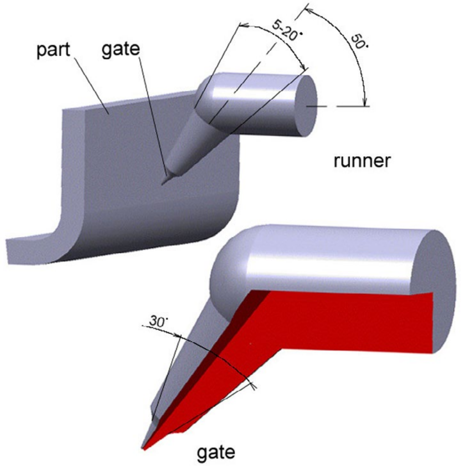
FIGURE 3 : EXAMPLES OF DIFFERENT GATES



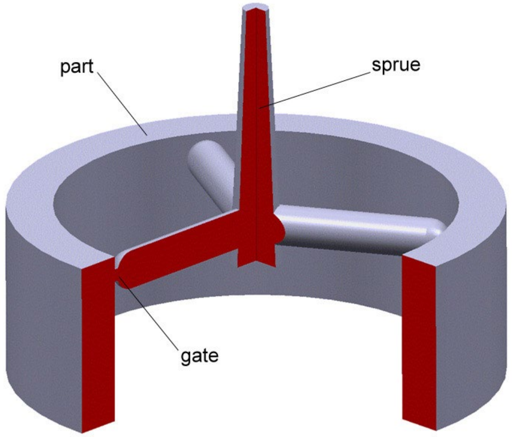
Fan gate



Diaphragm gate



Submarine gate



Multiple-pinpoint gate

MOULD COOLING

Moulds should have adequate cooling channels to give temperature control, allowing heat to dissipate quickly and uniformly and ensuring short cycle times.

Shrink marks are a result of non-uniform volume reduction during cooling from the molten to the solid state. Shrink marks may occur in sections that are thicker than 6 mm. This can be avoided by preventive design in which ribs and reinforcing sections are used to achieve a uniform cross-section, see Figure 1.

Due to the flexibility of the material, even parts with back draft can be injection moulded and then ejected as usual.

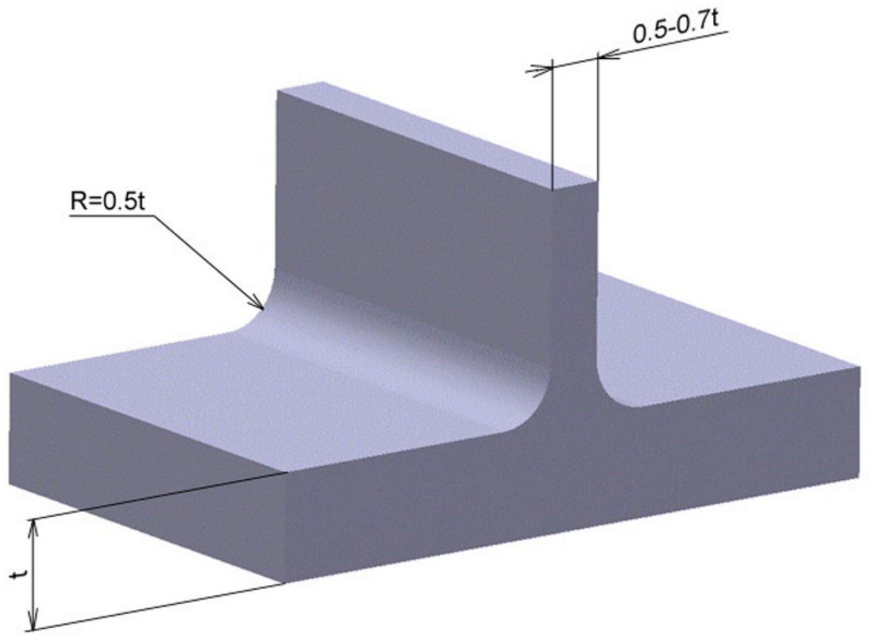


FIGURE 1. Reinforcing ribs should be approximately half the thickness of the adjacent wall

EJECTION

To allow for a fully automatic operation, the tool has different types of ejectors. Since TPEs have a high surface friction and some of our materials are soft and flexible, the ejector system should be carefully considered.

The design should be based on the specific grade and, above all, the hardness. Ejector plates are generally recommended for soft grades. Air is often used for ejecting deep-drawn parts. The use of compressed air can facilitate mechanical ejection by eliminating the vacuum.

If only ejector pins are used, they should be as large as possible and should act on the stiffest sections of the part. Normal ejector systems perform well on harder compounds.

A mould surface produced by EDM or by shot blasting is recommended for best release. This surface finish allows air to circulate between the mould and material and produces a velvety mat surface on the finished part. A draft angle of between 0.25 degrees and 1 degree is also desirable on the walls and cores.

PROCESS PARAMETERS

These recommendations should be regarded as guidelines, experience is always the best guide in selecting process parameters. Please also refer to the individual datasheet to confirm grade specific processing parameters and predrying details.

CYLINDER TEMPERATURE

The normal mix temperature for SEBS based compounds in the cylinder should be 190 - 245°C for parts of a standard size. If large parts are being moulded, temperatures up to a maximum of 260°C may be necessary. SEBS based compounds are very stable against thermal degradation but SBS compounds can degrade if they are overheated or if a screw with excessively high compression ratio is used. The cylinder temperature for SBS should be between 150 and 205°C, but should not exceed 220°C.

We recommend cleaning of the cylinder after a stoppage with HDPE or PP.

CLAMPING FORCE

Our TPEs rarely require high clamping force. Depending on the mould size and design the mould pressure may vary between 25 and 45 MPa. This is enough to keep the mould closed and to prevent flash on the product.

INJECTION PRESSURE

Our TPEs can be injection moulded at a wide range of pressures. However, for the best results use the minimum pressure necessary for smooth and uniform filling of the mould. Extremely high pressures often result in increased orientation or the risk of overheating, due to friction.

Because of the rubber-like properties of TPEs, solidification in the gate will not occur in the same way as with rigid thermoplastics. For the same reason, an overpressure may result in overfilling and a consequent warpage. If a high injection pressure is needed for filling the cavity, the pressure time should match as closely as possible with the time necessary for filling the mould. Depending on the size of the product and its surface area, injection pressures may range between 35 and 150 MPa.

INJECTION SPEED

The viscosity of the SEBS compound is more dependent on the shear rate and less dependent on the temperature than the viscosity of SBS material, which in turn, is more dependent on the shear rate than thermoplastics in general. This offers benefits in the form of short cooling times and ease of controlling the process. Due to the strong viscosity/shear rate relationship, a high injection velocity is desirable for SEBS based materials to facilitate filling of the mould. Air inclusion at high injection velocities does not pose any problems, providing the mould has sufficient venting. The 'follow-up cushion' should be as small as possible in order to avoid follow-up packing and unsightly gates.

MATERIAL CUSHION

Generally we would recommend a material cushion of about 5 mm.

SCREW SPEEDS AND BACKPRESSURE

Normal screw speeds are between 25 and 75 rpm and should be adjusted so that plasticising will be concluded just before the next shot. The recommended backpressure should be just enough to ensure that no leakage will occur in the mould after the shot.

HOLDING AND HOLDING PRESSURE TIME

As in the case of most thermoplastic materials, the holding time and pressure must be in balance in order to prevent shrink marks due to reverse flow at the gate or warpage due to overfilling. Because of the elastomeric nature of TPEs, overfilling is more likely to cause problems than reverse flow. Short holding times and low holding pressures are recommended to prevent these effects.

DECOMPRESSION

We would generally recommend a decompression of 5 - 15 mm.

CYCLE TIME/COOLING TIME

Due to the quick solidification process, cooling time is generally short compared to other materials. The cycle time is dependent on the size and design of the part.

Typical values are:

Sections up to 2 mm: 15 - 25 s

Sections between 2 and 6 mm: 30 - 60 s

MOULD TEMPERATURE

For SEBS material the mould temperature should normally be between 20 and 60°C. These higher temperatures facilitate flow into the mould, ensure complete filling at reduced injection pressures and they also facilitate a uniform surface without significant increases in the cycle time.

MISCELLANEOUS

Our TPEs are fully recyclable. Material which is to be reworked can be mixed in any proportions with new material. Addition rates of 10 - 25% are recommended. Grinding of soft compounds demands very sharp knives or considerable cooling.

EXTRUSION

Our TPE compounds can easily be extruded, provided that the right process parameters are used. Due to the three-block structure, the flow properties (melt viscosity) are relatively insensitive to temperature changes. However, it responds quickly to changes in shear and/or pressure (applies mainly to materials based on SEBS).

PROCESSING TEMPERATURES

The melt temperatures in the extrusion of SEBS compounds are normally 150 - 210°C, but due to the unique saturated olefin intermediate block, process temperatures of up to 260°C are permissible. A temperature profile from the feed zone to the die of 170, 180, 190, 200 and 210°C is suitable as initial setting, and can therefore be adjusted to suit the SEBS grade used and the type of screw. (Lower temperature for the softer compounds). SEBS compounds are easy to process and offer benefits such as high thermal stability, resistance to degradation caused by shear and friction and fast solidification of melts.

The melt temperatures of SBS compounds in extrusion are between 150 and 205°C, and should not exceed 205°C. A temperature profile along the extruder cylinders, from 150°C at the infeed zone to 205°C at the die, gives the highest output. A reverse temperature profile can be employed if a high degree of homogeneity of the melt is to be achieved or if heavy vibrations should occur. This will give a lower output.

EXTRUDER DESIGN

Long extruders with a length/diameter (L/D) ratio of 20:1 or more are preferable and long feed zones are best. The flow paths of the dies should be as short as possible, to prevent the rough surfaces that may arise due to the material solidification process. Long die adapters should be avoided and both the die and the die adapter should be equipped with heater elements.

The form giving part of the die should be only sufficiently long to provide the required surface finish and product profile. A form giving part which is longer than one cross section or one diameter, may result in surface roughness if followup drawing is used to achieve the required cross section. Significant follow-up drawing from a long form giving part of the die should be avoided, as minor follow-up drawing (10- 20%) may result in increased strength of the product.

SCREW DESIGN

Our TPE compounds are best extruded using screws that have a high compression ratio (3:1) and long, fairly shallow feed zones. Screws with short feed zones may give rise to infeed problems. Screws with compression ratios of 3.0 - 4.5 are normally preferable. As mentioned earlier, the L/D ratio should be at least 20:1.

The softer compounds generally give a lower output at increased backpressure. The frictional heat is lowest on the softer grades and increases substantially on harder grades. Mixing screws or screws with mixing zones are not necessary for achieving a homogeneous melt. However, such screws may contribute towards an improvement in extruders with shorter L/D ratios than those mentioned above.

OTHER EQUIPMENT

The most common calibration and take-up units for PP and PVC are also suitable for our TPE compounds based on SEBS. Recalibration is usually unnecessary for the softer grades.

In sheet extrusion, the temperatures of the cooling and polishing rolls should be between 60°C and 80°C. Clean and bright polished rolls and roll temperature control are necessary for minimising sticking, which may sometimes occur with the softer compounds.

The size of extruded products can be adjusted by follow-up drawing/follow-up stretching, this also enables the properties to be modified.

PRODUCTION CAPACITY

The extruder capacity is affected by many factors, such as screw design, available motor power, melt temperature, backpressure and heat available.

Our TPE compounds have extrusion rates comparable to other thermoplastics. The production rate tends to be lower for the softer grades, the rate increases with increasing hardness and rigidity.

ABOUT HEXPOL TPE

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300+ EMPLOYEES WORLDWIDE

PRODUCTION PLANTS
Sweden, UK, Germany, China, USA

GLOBAL CAPACITY
> 80,000 tonnes p.a.

HEXPOL GROUP HEADQUARTERS
Malmö, Sweden

34,796+ PROPRIETARY FORMULATIONS

KEY MARKETS
Consumer, automotive, medical, construction, industrial

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