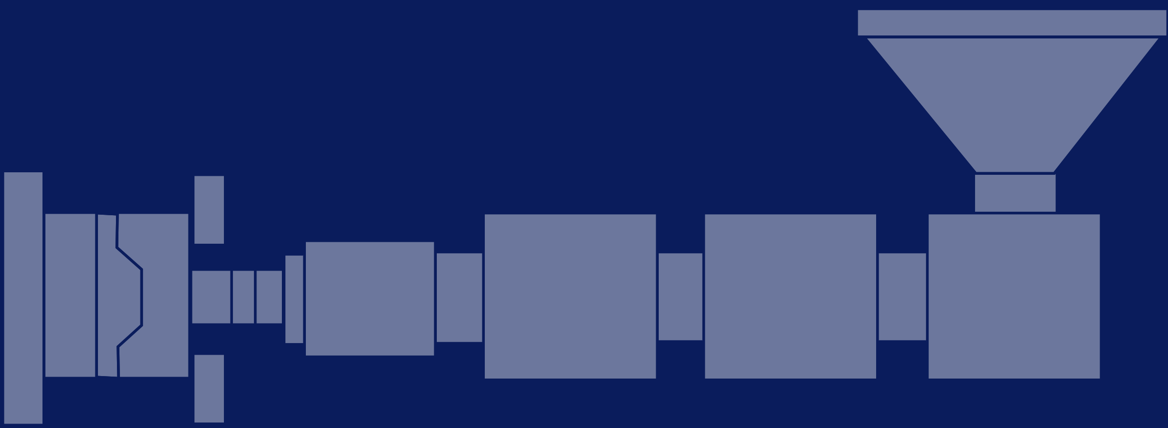
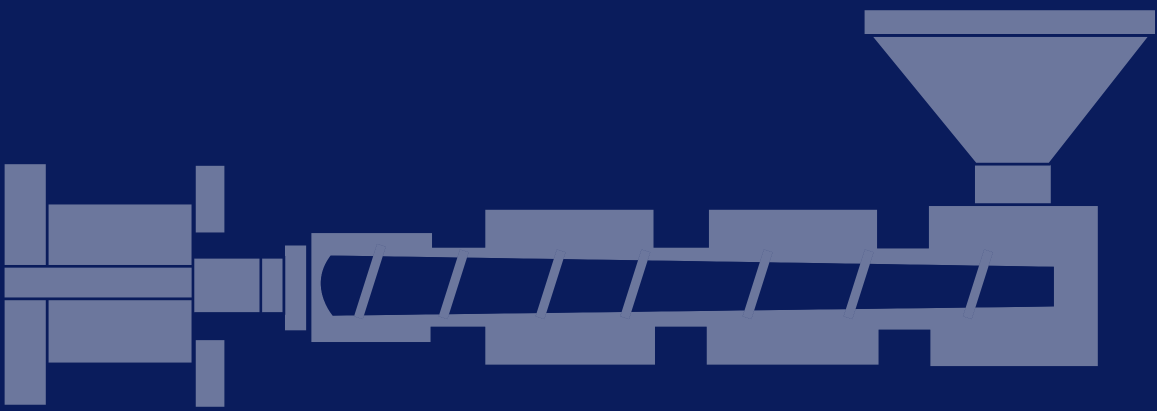
dryflex®

mediprene®





ELASTO
A HEXPOL COMPANY

PROCESSING GUIDE

Contents

Introduction

The selected thermoplastic elastomer (TPE) material does not acquire its final properties until after it has been processed, i.e. the design/geometry of the part and the method of processing, together with the selected material, will determine the final properties of the product.

This process guide is intended to be advisory and help you when designing your tool and when processing TPE. However, ELASTO can through their technical support provide you with support in the tooling design, and help to optimise your process and thus reduce your finished part's costs.

Injection Moulding of Dryflex® and Mediprene®

Dryflex® and Mediprene® thermoplastic elastomers are very widely used for producing injection moulded parts with very high elasticity and flexibility. However, it must be borne in mind that these properties are affected by the design of the parts and the material flow.

The physical characteristics of Dryflex® and Mediprene® are different in different directions (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 thus 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 minimize shear, such as lower injection pressure, velocity and higher working temperature, the orientation effects can be minimized.

The degree of orientation is also affected by the mould design. The following factors minimize the orientation:
- Largest practicable gate.
- Gate location that minimizes the flow distance in the cavity.
- Shot blasted or electrical discharge machined (EDM) instead of polished surface.

If the injection moulding temperature used for Dryflex® and Mediprene® is too low, there will be a serious risk of cold flow in the part, which will lead to poor strength.

Equipment
Dryflex® and Mediprene® 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 used injection-moulding machine is not too large. A recommendation is that 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 Dryflex® and Mediprene®. 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. Dryflex® and Mediprene® 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, Dryflex® and Mediprene® 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 not necessary, since Dryflex® and Mediprene® does not absorb moisture under normal storage conditions. If moisture should nevertheless occur, this will normally be evaporated in the mould and will be expelled through the air vent.

Mould Design
Dryflex® and Mediprene® can be processed easily and economically in most conventional moulds and it can often be injected into moulds made for other materials, with limited modifications or none at all. However, some aspects should be borne in mind when the mould is designed for processing SBS and SEBS. In the design of the part, wide variations in material thickness should be avoided and efforts should also be 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 causes vacuum between the mould wall and the part, since the material being injected forces the air ahead of it. This phenomenon leads to the part being gripped in the mould by suction. A coarser surface, such as a shot blasted surface or one produced by EDM, improves the release properties.

Gates
Standard gates with a draft angle of 2.5 degrees perform satisfactorily with Dryflex® and Mediprene®. However, the type of gate extractor should be decided on the basis of the material grade. For the 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 homogenization problems may occur. Figure 1 below shows an example of a good gate location.

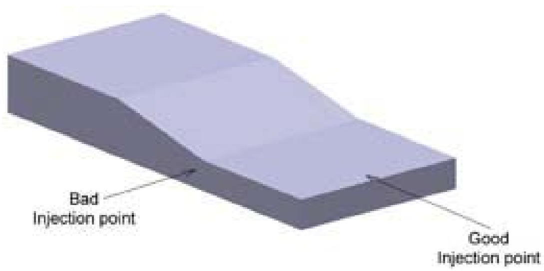
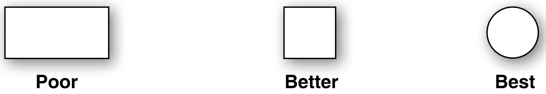


Figure 1. Gate Location

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



Secondary runners should also be cylindrical and should be of somewhat 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 should be avoided if the primary runner is made to continue a little way after the branch-off point, see figure 2 below.

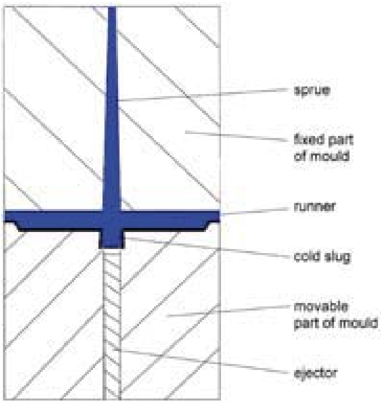


Figure 2. Cold slug

In order to shorten the cycle time and to avoid re-using of the inlet and the runner systems, 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, in order to maintain the mould pressure constant. The lowest temperature of the material in the runner, during unloaded parts of the cycle, should be around 175°C for SBS material and around 185°C for SEBS-based materials.

Gates and Venting
Dryflex® and Mediprene® thermoplastic elastomers will produce good results when they are injection moulded with normal 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 in relation to the part there is a risk of cold flow, which will result in that the maximum strength will not be achieved.

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. The gate should be located in the thinnest area of the part, in order to minimize the risk of inhomogeneous material. Important is that the part is inspected by pulling by hand, please compare with the data sheet values.

Since Dryflex® and Mediprene® 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.

Shrinkage
When a mould is being designed, consideration must be given to the shrinkage properties, in the same way as for other thermoplastic materials. For a SBS material with a PS base, the shrinkage is between 0.4% and 1%, while for a SBS with PP base, it is between 1.0% and 2.5%. The shrinkage of SEBS material is also between 1.0% and 2.5%. The shrinkage depends principally on the material grade, the type of application and the location of the gate.

Ejection
To allow for fully automatic operation, the tool has different types of ejectors. Since Dryflex® and Mediprene® has a high surface friction and since some of the materials are soft and flexible, the ejector system should be closely studied. The design should be based on the specific product 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 may 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 sections of the part that are stiffest and provide the greatest assistance. Normal ejector systems perform satisfactorily on the harder compounds.

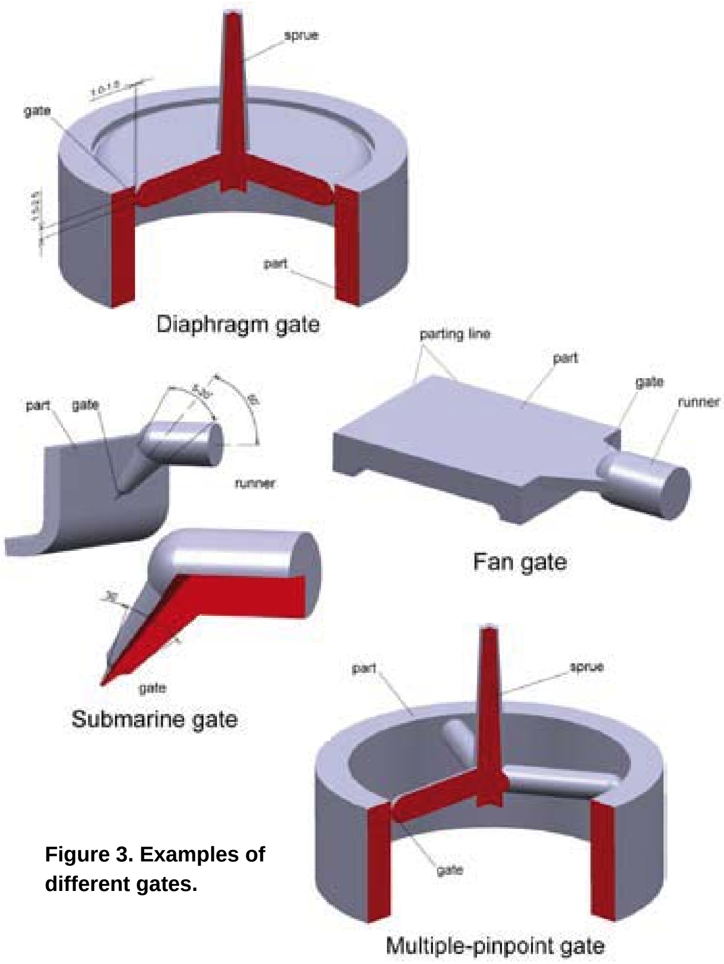


Figure 3. Examples of different gates.

A mould surface produced by EDM or by shot blasting is recommended for best release. This since this surface finish enables air to be admitted between the mould and the material. This produces a velvety mat surface on the finished part. Different roughness of the surface can be selected. A draft angle of between 0.25 degrees and 1 degree is also desirable on the walls and cores.

Mould Cooling
Moulds should have adequate cooling channels to allow the temperature to be controlled. Thereby the heat will be dissipated quickly and uniformly and short cycle times will be ensured.

Shrink marks are a direct result of non-uniform volume reduction during cooling from the molten state to the solid state. In the case of Dryflex® and Mediprene® 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 4. Due to the flexibility of the material, even parts with back draft can be injection moulded and then ejected as usual.

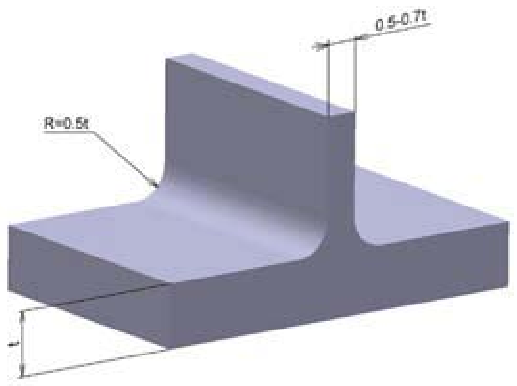


Figure 4. Reinforcing ribs should preferably be around half the thickness of the adjacent wall.

Process Parameters
The recommendations in the following text should be regarded as guidelines, but experience is always the best guide in selecting process parameters for thermoplastic materials.

SEBS-Based Compound

Cylinder Temperature
The normal mix temperature for SEBS in the cylinder should be 190 - 245°C for parts of normal size. If large parts are being moulded temperatures up to 260°C may be necessary.

Injection Pressure
Dryflex® and Mediprene® can be injection moulded at a wide range of pressures. However, the best results will be achieved by using 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 Dryflex® and Mediprene® solidification in the gate will not occur in the same way as on rigid thermoplastics. Of the same reason, an overpressure may result in overfilling and a consequent warp age. If a high injection pressure is needed for filling the cavity, the pressure time should coincide 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 Velocity
The viscosity of the SEBS material 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, provided that 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.

Screw Speeds and Backpressure
Normal screw speeds are between 25 and 75 rpm and should be adjusted so that plasticizing 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 Time and Pressure
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 warp age due to overfilling.

Because of the elastomeric nature of Dryflex® and Mediprene®, overfilling is more likely to cause problems than reverse flow. Short holding times and low holding pressures are therefore recommended to prevent these effects.

Clamping Pressure
High clamping pressures are seldom needed for Dryflex® and Mediprene®. Depending on the mould size and design the mould pressure may vary between 25 and 45 MPa. This is sufficient for keeping the mould closed and to prevent flash on the product.

Cycle Time/Cooling Time
Due to the quick solidification process when using Dryflex® and Mediprene® the 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 30 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
Since SEBS compounds have excellent thermal stability, a cleaning of the cylinder after a stoppage is unnecessary. SEBS compounds have been held in injection moulding machines for more than two hours at process temperature without detectable degradation. If cleaning is required, HDPE or PP can be employed.

Dryflex® and Mediprene® is fully recyclable. Material, which is to be regenerated, can be mixed in any proportions with new material. Recommended is however 10 - 25%. Grinding of soft compounds demands very sharp knives or considerable cooling. Typical process parameters for SEBS are given in Table 1 on page 7.

SBS-Based Compound

Cylinder Temperature
The cylinder temperature for SBS should be between 150 and 205°C, but should not exceed 220°C.

Injection Pressure
Dryflex® and Mediprene® can be injection moulded at a wide range of pressures. However, the best results will be achieved by using the minimum pressure, which is necessary for smooth and uniform filling of the mould. Excessively high pressures often result in increased orientation or in the risk of overheating, due to friction. Because of the rubber-like properties of Dryflex® and Mediprene® solidification in the gate will not occur in the same way as on rigid thermoplastics and overpressure may result in overfilling and consequent warp age. If a high injection pressure is needed for filling the cavity the pressure time should coincide as closely as possible with the time necessary for filling the mould. Depending on the size of product and its surface area injection pressures may range between 35 and 150 MPa.

Injection Velocity
SBS compounds should preferably be injected at moderate injection velocities. This since they do not demand shear rates that are as high as for SEBS compounds, for achieving low viscosity and good flow properties.

Screw Speeds and Backpressure
Normal screw speeds are within the range of 25 - 75 rpm and should be adjusted so that plasticizing is concluded just before the next shot. A backpressure, which is just high enough to ensure that no leakage will occur in the mould after the shot, is recommended.

Holding Time and Pressure
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 warp age due to overfilling. Because of the elastomeric nature of Dryflex® and Mediprene®, overfilling is more likely to cause problems than reverse flow. Short holding times and low holding pressures are therefore recommended to prevent these effects.

Clamping Pressure
High clamping pressures are seldom needed for Dryflex® and Mediprene®. Depending on the mould size and design, the mould pressure may vary between 25 and 45 MPa. This is sufficient for keeping the mould closed and preventing flash on the product.

Cycle Time/Cooling Time
Due to the quick solidification process when using Dryflex® and Mediprene®, the cooling time is generally short compared to the one for 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
The optimum mould temperatures for SBS-based materials are between 20 and 40°C.

Miscellaneous
The SBS compound is sensitive to thermo oxidative degradation and should not be maintained at high process temperatures for extended periods of time. If cleaning is required, HDPE or PP can be used.

Dryflex® is fully recyclable. Material, which is to be regenerated, can be mixed in any proportions with new material. 10 - 25% is however recommended also for the SBS-based Dryflex® and Mediprene®. Grinding of soft compounds requires very sharp knives or considerable cooling. Typical process parameters are given in Table 1 on page 7.

Processparameter	Unit	SBS	SEBS
Machine size (clamping force in tonnes)		90	90
Max. shot weight	g	115	115
Mould type		2-part	2-part
Number of cavities		1	1
Shot weight	g	55	55
Cylinder temperature	ºC		
Rear	ºC	170	180
Centre	ºC	180	190
Front	ºC	190	200
Nozzle	ºC	200	210
Mould temperature	ºC	25	50
Injection pressure			
High	MPa	50	50
Low	MPa	35	50
Injection times		3-5	1-2
Injection rate		moderate	fast
Holding times		2.5	2.5
Clamping times		10	7
Screw speed	Rpm	30	40
Back pressure	MPa	0.55	0.7
Cycle times		20	14

Table 1. Typical process parameters for injection moulding of Dryflex® and Mediprene® thermoplastic elastomers

Extrusion of Dryflex® and Mediprene®

Dryflex® and Mediprene® thermoplastic elastomers 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. It responds however quickly to changes in shear and/or pressure (applies mainly to materials based on SEBS).

The SEBS compounds, with their saturated intermediate blocks, are very stable against thermal degradation. On the other hand, the SBS compounds degrade if they are overheated or if a screw with excessively high compression ratio is used.

Extrusion of SEBS-Based Compound

Long extruders with a length/diameter (L/D) ratio of 20:1 or more are preferable and long feed zones that are normally employed in the extrusion of polyolefines are best for this type of compound. The flow paths of the dies should be as short as possible in order to prevent the occurrence of rough surfaces that may arise due to the material solidification process. Long die adapters should be avoided and important is also that 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 around one cross section or one diameter, may result in surface roughness if followup drawing is used for achieving the required cross section. Although, appreciable follow-up drawing from a long form giving part of the die should be avoided, since minor follow-up drawing (10 - 20%) may result in increased strength of the product.

The melt temperatures in the extrusion of SEBS materials 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.)

Preheating of Dryflex® and Mediprene® SEBS compound has proved to result in higher production output. 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.

Screw Design
SEBS-based Dryflex® and Mediprene® materials 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 SEBS 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. Some typical screw configurations for using SEBS Dryflex® and Mediprene® materials are given in table 2.

Other Equipment
The most common calibration and take-up units for PP and PVC are also suitable for Dryflex® and Mediprene® based on SEBS. Recalibration is usually unnecessary for the softer Dryflex® and Mediprene® grades (SEBS).

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 minimizing sticking to the rolls, which may sometimes occur on the softer SEBS Dryflex® and Mediprene® compounds.

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

Production Capacity
The extruder capacity is effected by many factors, such as screw design, available motor power, melt temperature, backpressure and heat available. SEBS-based Dryflex® and Mediprene® has extrusion rates comparable to other thermoplastics. The production rate for SEBS-based Dryflex® and Mediprene® tends to be lower for the soft, rubber-like types but the rate increases within increasing hardness and rigidity.

Parameters Length/Diameter (L/D)	Single 24:1	Two-stage 24:1
SECTION 1		
Infeed zone		
Thread depth (mm)	12.5	13.8
Number of threads	9	6
Compression zone		
Number of threads	7	4
Melt zone		
Thread depth (mm)	3.6	3.0
Number of threads	8	4
Compression ratio	3.5:1	4.5:1
SECTION 2		
Infeed zone		
Thread depth (mm)	-	14.6
Number of threads	-	4
Compression zone		
Number of threads	-	1.5
Melt zone		
Thread depth (mm)	-	4.2
Number of threads	-	4.4
Compression ratio	-	3.5:1

Table 2. Typical screw configurations for extruding SEBS-based Dryflex® and Mediprene® materials (3.5” or approximately 90 mm screw).

Extrusion of SBS-Based Compound

SBS-based Dryflex® and Mediprene® can be extruded in virtually all types of extruders for thermoplastics. Tapered and polished dies produce the best results. Since Dryflex® and Mediprene® SBS compounds display less swelling than polyolefines, the length of the form-giving part of the die is less critical.

The melt temperatures of Dryflex® and Mediprene® SBS 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.

Due to the unsaturated intermediate block in Dryflex® and Mediprene® SBS compounds, extrusion at high temperatures and/or high shear may result in degradation. A reduction in strength may occur due to molecular splitting, depending on the extent of the degradation. Degradation of Dryflex® and Mediprene® based on SBS produces only material with a lower molecular weight, which is not toxic.

Screw Design

In the recommended design of the screw, the compression ratio should be low, the melt sections should be fairly deeply threaded and the length/diameter ratio should be >20:1. In table 3, typical screw configurations for extruding SBS-based Dryflex® and Mediprene® are shown.

Dryflex® and Mediprene® SBS compounds can display solidification tendencies if there are long flow paths after the melt has left the shear area in the screw. This solidification, which may result in surface irregularities, occurs due to partially physical cross-linking taking place between the end blocks when the melt enters areas with low shear. This solidification may occur if die heating is far from the screw tip due to a long die adapter.

Other Equipment

Follow-up equipment (calibration and take up units) used for conventional thermoplastics can also be employed for Dryflex® and Mediprene® SBS thermoplastic elastomers. When film or sheet is extruded, the polishing roll temperature should be 65 - 80°C in order to minimize sticking.

Due to the rubber like, flexible nature of many Dryflex® and Mediprene® SBS compounds, orientation effects may sometimes occur. Since orientation is a result of stretching appreciable follow-up stretching should be avoided, especially at low extrusion temperatures.

Production Rates

Dryflex® and Mediprene® SBS compounds usually yield higher outputs than the value expected on the basis of the screw design. This is due to the high coefficient of friction of these materials on metal. For a given extruder size, the relationship between output and screw speed is linear. A 3.5” extruder can produce 90kg/h at 30 rpm and around 220 kg/h at 70 rpm.

Parameters Length/Diameter (L/D)	Single 24:1	Two-stage 24:1
SECTION 1		
Infeed zone		
Thread depth (mm)	11.4	12.7
Number of threads	9	6
Compression zone		
Number of threads	8	4
Melt zone		
Thread depth (mm)	4.6	3.5
Number of threads	7	4
Compression ratio	2.5:1	2.5:1
SECTION 2		
Infeed zone		
Thread depth (mm)	-	15.9
Number of threads	-	4
Compression zone		
Number of threads	-	1.5
Melt zone		
Thread depth (mm)	-	5.3
Number of threads	-	4.5
Compression ratio	-	2.95:1

Table 3. Typical screw configurations for extruding SBS-based Dryflex® and Mediprene® material (3.5” or approximately 90 mm screw).

Contact us...

Sweden
t : 46 (0) 532 60 75 00
f : 46 (0) 532 60 75 99
info@elastotpe.com

UK
t : 44 (0)161 654 6616
f : 44 (0)161 654 2333
sales@elastotpe.co.uk

France
t : 33 (0) 160 43 17 17
f : 33 (0) 160 43 11 13
pascal.gruyer@elastotpe.com

For further information about our distributors or to download this and other publications please visit

www.elastotpe.com

ELASTO
A HEXPOL COMPANY

www.elastotpe.com