Injection Molding Guide

DuraGrip®

Melt Processible Elastomer

Good looking rubber parts with fast cycle times and reusable scrap define DuraGrip™

The 6000 and 6100 Series of DuraGrip have been developed especially for the Injection Molding and Overmolding Processes. The 6000 series bonds to PP and PE, while the 6100 series bonds to PC, ABS, Nylon 6 and Nylon 6,6, respectively.

Duro A Hardness	Standard Bonds to PP & PE	Engineering Plastic Bondable Bonds to ASA, SUS, PC, ABS, Nylon 6, 6,6
30	6030NC / BK	--
40	6040NC / BK	--
50	6050NC / BK	6150NC / BK
60	6060NC / BK	6160NC / BK
70	6070NC / BK	6170NC / BK
80	6080NC / BK	6180NC / BK
85		6185BK
90	6090NC / BK	6190NC / BK

*DuraGrip is a trademark of the Ferro Corporation for its tyrenic TPEs.

Material Handling

DuraGrip is supplied in pellet form and is packaged in 25kg. Polyethylene bags. DuraGrip 6000 / 6200 / 6300 Series grades are not hygroscopic and in most cases may be used directly from newly-opened bags without drying. If porosity in the finished part is observed, dry the resin for 3 to 4 hours at 212°F (100°C).

The 6100 Series bondable grades are hygroscopic and do need to be dried for 3 to 4 hours at 212°F (100°C) immediately before use. Moisture content should be reduced to $\leq$ 0.015%

All safety practices normally followed in the handling and processing of melted thermoplastics should be followed for DuraGrip, Melt-Processible Elastomer. The material is not hazardous under normal shipping and storage conditions. However, it should be stored in a cool, dry location to maintain maximum product quality. All pellet transfer operations should be well grounded to avoid static electrical discharges, which could result in a fire or explosion in the presence of combustible dust or vapors.

For further information, please refer to the DuraGrip Safe Handling Guide and the MSDS sheets for these grades

Rheology

The various DuraGrip Series are comprised of alloys of SEBS with various high-melting crystalline plastics. The SEBS component has no crystalline melting point and is essentially amorphous. Once heated above the T_g (glass-transition temperature) of polystyrene, melt viscosity is non-Newtonian, with increasing shear producing a greater reduction than increasing temperature. The crystalline alloy components do have specific crystalline melting points, well above the T_g of polystyrene, which also must be exceeded to achieve alloy melt flow. However, elevating the barrel temperature above recommended temperatures does little to promote melt flow and may result in polymer degradation. Once in the target temperature range, DuraGrip melt flow can best be induced by reducing viscosity through the application of shear. Figure 1 shows the effect of shear rate on viscosity at 190°C.

Figure 1 Viscosity/Shear Rate Data

This rheological behavior of DuraGrip makes it ideally suited for the high shear employed during the injection molding process. The combination of barrel heat and controlled shear imparted by the rotating screw will maintain a properly fluxed, uniform melt in the barrel of the injection molding machine. **High shear through a small gate** and runner system are essential to completely fill the mold.

Table I shows mold flow data for the mold-filling characteristics of DuraGrip as a function of part thickness.

Table I
DuraGrip™ Snake Flow at 425°F (218°C)
125mils (1/8”)

Snake Flow, inches

Injection Pressure	4520 psi	6535 psi
Grade		
6030NC/BK	33	40
6040NC/BK	37	44
6050NC/BK	39	43
6060NC/BK	39	43
6070NC /BK	39	44
6150NC/BK	TBD	TBD
6160NC/BK	“	“
6170NC/BK	“	“

Molding

DuraGrip can be run on a wide range of plastics reciprocating screw injection molding machines.

Successful injection molding of DuraGrip requires an injection molding machine and tool capable of achieving:

- A well fluxed melt from unheated pellets by heating, massing, and shearing the pellets.
- A consistent melt temperature as measured at the nozzle with a needle pyrometer.
- A rapid flow of melt into the mold through small gates to maximize shear and minimize viscosity.
- Venting to facilitate mold filling by permitting trapped air to escape rapidly.
- Maintaining a uniform mold temperature, usually in the range of 70°F to 120°F (21°C to 49°C).

Several characteristics of DuraGrip should be considered in all injection molding processes:

- Both shear and barrel heat must be present to optimize melt viscosity.
- Excessive shear rates can increase melt temperature unacceptably. Screws with shallow flights will increase melt temperature. Shallow metering and/or high compression screws may also raise melt temperature beyond the preferred range. (6000 Series: 390°F – 430°F (199°C – 220°C); 6100 Series: 440°F – 490°F (226°C – 254°C))
- Degradation can occur if DuraGrip is heated > 536°F (280°C) or held at processing temperatures for more than 30 minutes. See section on Material Handling for Safety and Handling precautions.

Regrind

Clean dry scrap from any processing operation can be recycled several times with little change in either processing characteristics or the properties of fabricated products – provided that the scrap resin has been processed within suggested temperature limits. Scrap can be granulated for gravity-fed equipment. Although scrap can be recycled as 80% of the equipment feed, blending at 25% or less with virgin material is advisable to insure consistent processing and finished product appearance.

Injection Molding Equipment

Materials of Construction

DuraGrip Melt Processible Elastomers are generally non-abrasive and non-corrosive. The tool steel should be determined by appearance/dimensional tolerance requirements and the number of the parts to be produced.

For prototyping and small production runs, aluminum can be used. For larger runs and higher quality requirements, H-13, A-2, S-7 or 420 SS is recommended.

Barrel Design

Either hot oil or electric band heaters are suitable for barrel heating. Plastics injection molding machines should be equipped with at least three-zone heating control of the barrel for close temperature control and optimum output rates.

Screw Design

General purpose, gradual transition screws with compression ratios between 2.5 and 3.5 and an L/D of > 20:1 are usually suitable for molding DuraGrip.

Screws with a short compression zone (two flights) and long metering zones (six flights) with very shallow flights should be avoided. They may tend to overheat the melt at high screw speeds (rpm).

Screws equipped with full flow ring check valves or smear tips may be used. Flow passages must be carefully streamlined to eliminate melt stagnation and potential degradation. Ball type check valves are not recommended.

Nozzle Design

Separately heated, short reverse tapered nozzles with uninterrupted flow patterns are suggested. See Figure 4 below.

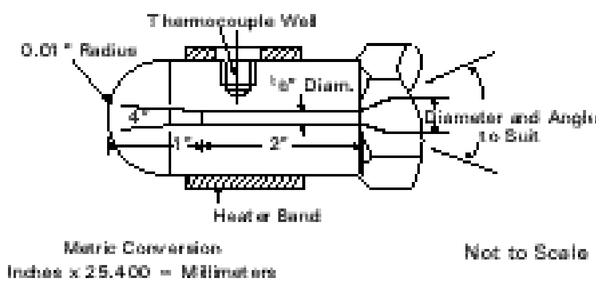

Figure 4. Nozzle (with reverse taper)
Recommended for Molding

Mold Design

Mold Surface Finish

Slightly textured or matte finished mold cavity surfaces are recommended for DuraGrip. They will minimize the appearance of flow lines on molded parts and improve ease of demolding.

Highly polished or chrome plated mold surfaces are required for high gloss requirements in addition to our transparent and clear materials as these materials replicate the mold finish.

Sprue Bushing and Nozzle Design

Properly designed sprue bushings are required to avoid sprue sticking. The diameter of the sprue at the larger end should be equal to the diameter of the runner it feeds. Bushings of higher than standard taper (approximately 0.044 rad [2.5°]), are preferred.

A properly mated injection nozzle and sprue bushing facilitates removal of the sprue. The nozzle should have a 0.75 in (19 mm) spherical radius at the tip with a diameter slightly less (0.031 in. [0.8 mm]) than that of the sprue bushing. Since DuraGrip is elastomeric, very positive type sprue pullers (e.g. "Z" pullers, sucker pins, or offset undercut types) are required for automatic sprue removal.

Runners & Sprues

Runners & Sprues should be streamlined to reduce melt turbulence. A full round or trapezoidal runner should be used whenever possible to minimize pressure drop and sticking. Cold slugs are also recommended at each transition.

In designing the runner system, balanced layouts, minimum number and length of runners and radiused turns are desirable. A draft of 3° to 5° is required to minimize sticking. To improve flow and facilitate automated removal, the surface of the runners should be smooth, but not polished.

Runnerless molding**,** both insulated and hot runner, is possible with SEBS DuraGrip materials. Sufficient heat and temperature control must be provided to insure that neither freezing nor degradation of the polymer occurs.

Gates

Pin gates are particularly effective for solid, round parts. **Diaphragm gates** are preferred for open, round parts. **Film gates**, along the long or longer edge are preferred for rectangular, flat parts.

Gates must be designed to maximize shear to minimize viscosity as DuraGrip enters the mold cavity. The gates must be short and have a small cross-sectional area relative to mold volume. Specifically, the gate cross-sectional area should be in the range of 0.2% to 1.0% of the part volume when measured in inches, and in the range of 0.012% to 0.048% of the part volume when measured in millimeters. A good starting point for a gate opening would be 0.015 in. (0.381mm).

Gates should be located in the thickest section to avoid incomplete fill or sink marks, minimize flow lengths, and to facilitate laminar flow within the mold. This will minimize or eliminate the formation of weld lines. Gates should be located so that the flow length is as short as possible, avoiding obstructions where possible.

Venting

The importance of adequate venting cannot be overemphasized for producing quality injection molded parts of DuraGrip. Lack of sufficient venting can cause:

- Surface imperfections from trapped air.
- Underfill
- Discoloring or burning of the molded part.
- Poor weld line strength.
- Excessively high injection pressures.

Venting provides a path for the air to escape from the cavity as the injected melt displaces it. Melt flow into any cavity can be seriously reduced by inadequate venting of the cavity. It is advisable to make the vent openings into the mold cavity broad and thin. Typical vent openings are 0.0005” to 0.0010” (0.012mm to 0.0.25mm) deep. The width is not as critical as depth, as the width is dependent upon part size and type of gate being used. Always locate a vent opposite the gate, as this will be the point of final fill. Venting opposite the gate prevents burning of the part from trapped air.

Part Shrinkage

The degree of shrinkage for injection molded parts of DuraGrip can be affected by both molding parameters and part geometry. Molding variables include mold temperature, injection time (fill time), injection pressure, and hold pressure (second stage pressure).

Mold temperature is the over-riding variable which affects shrinkage of parts of DuraGrip. Mold temperatures in the range of 70°F to 120°F (21°C to 49°C) are recommended for molding DuraGrip. Higher mold temperatures cause higher shrinkage.

Hold pressure (2^{nd} stage pressure) can also affect the degree of shrinkage (particularly in the flow direction) in parts molded in DuraGrip. Suggested ranges are 150 to 300 psi for the **6000 / 6200 / 6300 Series** and 300 to 500 psi for the **6100 Series**. Higher hold pressures will result in higher shrinkage in the flow direction.

Part geometry variables include part thickness, part/gate thickness and gate layout/location. Shrinkage of parts of DuraGrip is greater for thinner wall sections. Typical shrinkage values for DuraGrip at different thicknesses are shown in Table II.

Table II
Typical Mold Shrinkage of
DuraGrip™ Parts

	Shrinkage (%)			
Thickness	**0.0625” (1/16”)**		**0.125” (1/8”)**	
Grade	**MD***	**CMD****	**MD***	**CMD****
6030NC / BK	2.8	1.3	2.2	1.6
6040NC / BK	2.9	1.3	1.7	1.2
6050NC / BK	2.8	1.4	1.3	1.2
6060NC / BK	2.2	1.5	1.3	1.2
6070NC / BK	2.1	1.1	1.3	1.2
6080NC / BK	2.0	1.0	1.2	1.1

* MD = Machine Direction
** CMD = Cross Machine Direction

Part Ejection

Ample draft, of 3° to 5° taper per side, can ease part ejection, especially when a core is removed from a deep part or when a part is removed from a deep cavity. When a molded part must have very little or no draft, stripper plates are recommended for ejection. When pin ejectors are used, they should have a large surface area and act on the thickest sections of the part. Ejector mechanisms should be located to provide uniform stripping of the part from the mold. The diameter of the ejectors should be as large as possible to minimize surface marks on the part surface.

If the part is small, the knockouts should be shaped proportional to the part (i.e. ring, disc, etc.). If the part is large, use 13-25 mm (0.5-1 in.) diameter pins if design permits.

Undercuts should have room to flex during ejection.

Mold Temperature

The suggested range for mold temperatures is 90°F to 130°F (32°C to 54°C). Mold temperature is critical to insure that the cycle time is optimized. The mold should have adequate cooling to achieve the designed shrinkage, which will aid part ejection. Individual chillers for each side of the tool are also recommended to help retain parts on the movable side.

Reciprocating Screw Injection Molding Processing Parameters

Table III

Suggested Temperature Ranges

Barrel, Nozzle, and Mold

Barrel	6000 / 6200 / 6300 Series Temperature Range	6100 Series Temperature Range
Rear	370°F - 390°F (190°C - 199°C)	400°F - 430°F (204°C -221°C)
Middle	390°F - 410°F (199°C - 210°C)	420°F - 440°F (215°C - 226°C)
Front	420°F - 440°F (215°C - 226°C)	440°F - 460°F (226°C - 238°C)
Nozzle	400°F - 430°F (204°C - 220°C)	440°F - 480°F (226°C - 249°C)
Melt	390°F - 430°F (199°C - 220°C)	440°F - 490°F (226°C - 254°C)
Mold	110°F - 130°F (43°C - 55°C)	110°F - 130°F (43°C - 55°C)

Molding Parameters

	6000 / 6200 / 6300 Series	6100 Series
Injection Speed (fill rate)	1 to 3 cu. in/sec.	1 to 3 cu. in/sec.
Injection Pressure	150 to 600 psi	400 to 800 psi
Injection Time (first stage/boost)	0.5 to 4 sec.	0.5 to 4 sec.
Second Stage Pressure	150 to 300 psi	300 to 500 psi
Second Stage Time	3 to 10 sec	3 to 10 sec
Cooling Time	10 to 20 sec.	10 to 20 sec.
Screw Speed	25 to 100 rpm	50 to 150 rpm
Back Pressure	20 to 75 psi	25 to 75 psi

Shutdown Procedures

Brief shutdowns of 15 minutes or less require no special precautions, provided the measured melt temperature is no greater than 440°F (226°C). If the injection molding machine is to be shut down for longer than 30 minutes, purging before the shutdown is recommended, using low density, low viscosity polyethylene.

For more information on DuraGrip®:

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