FERRO

Injection Molding Guide

Alcryn® Melt Processible Rubber

Good looking rubber parts with fast cycle times and reusable scrap define the molding grades of Alcryn®.

The 2000 Series of *Alcryn®* Melt-Processible Rubber has been developed especially for the Injection Molding Process.*

The information provided in this guide is applicable only to the molding grades of *Alcryn®*:

Black	Neutral
Alcryn® 2060 BK	*Alcryn®* 2060 NC
Alcryn® 2070 BK	*Alcryn®* 2070 NC
Alcryn® 2080 BK	*Alcryn®* 2080 NC
	Alcryn® 2250 UT
	Alcryn® 2265 UT

Alcryn® is a unique plastic to process because it never melts, but softens enough above 300°F that high shear will reduce its viscosity dramatically and enable it to flow rapidly and completely fill a mold cavity. Once shear stops, *Alcryn®* "freezes," maintaining the shape of the molded part..

The ability of *Alcryn®* to achieve dimensional stability without waiting for the part to cool gives *Alcryn®* the advantage of short cycle times that are relatively independent of part thickness. Parts molded from these new grades exhibit excellent definition and surface appearance while maintaining the full range of mid-performance rubber properties.

Properly molded parts will look, feel, and perform like rubber, while providing outstanding oil, heat, and weather resistance.

*The use of *Alcryn®* grades from other than the 2000 Series for injection molding applications is not recommended.

Safety and Handling Precautions

All safety practices normally followed in the handling and processing of melted thermoplastics should be followed for *Alcryn®* melt-processible rubber. The material is not hazardous under normal shipping and storage conditions.

Alcryn® is a partially cross-linked, chlorinated olefin interpolymer alloy. If suggested processing temperatures or holdup time are exceeded during processing, *Alcryn®* can degrade with evolution of gaseous products, including hydrogen chloride (HCl). Polymer degradation is avoided when processing melt temperatures are kept at or below 375°F (190°C). The working time before the onset of degradation decreases as the melt temperature increases beyond 385°F. Evolution of HCl may occur if the melt temperature exceeds 400°F (204°C) for more than 30 minutes.

Cross contamination of the *Alcryn®* and polyacetals (Delrin®*, Celcon®**) must be avoided because acetals react with halogenated polymers, liberating significant quantities of formaldehyde gas and HCl.

Injection molding machines should be thoroughly purged before processing *Alcryn®* molding grades.

For further information, please refer to the *Alcryn®* Toxicity and Handling Guide and the MSDS sheets for these grades.

Material Handling

Alcryn® is supplied in pellet form and is packaged in 55.1 lb. (25 kg) polyethylene bags. *Alcryn®* is not hygroscopic and in most cases *Alcryn®* may be used directly from newly-opened bags without drying. If porosity in the finished part is observed, dry the resin for 1 to 2 hours at 212°F (100°C).

Injection Molding of *Alcryn®*

Rheology

The new molding grades of *Alcryn®* have no crystalline melting point and are essentially amorphous. Flow can only be induced by the application of **shear**. Elevating the barrel temperature above recommended temperatures does little to promote melt flow. The application of shear at elevated temperatures produces a type of pseudoplastic flow known as shear thinning. This is shown graphically in Figure 1. The viscosity of *Alcryn®* is not particularly sensitive to melt temperature. This behavior is shown in Figure 2 where viscosity versus shear rate is plotted over the temperature range of 338°F (170°C) to 374°F (190°C).

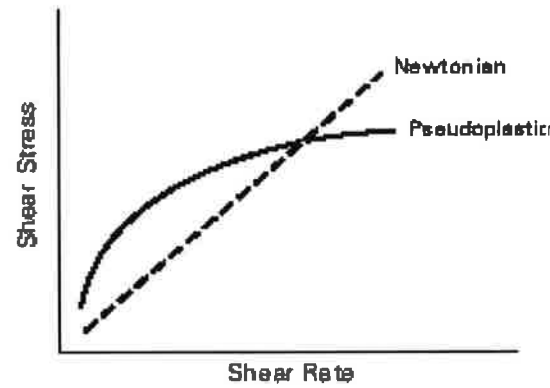

Figure 1. Flow curves for Newtonian and Pseudoplastic Materials.

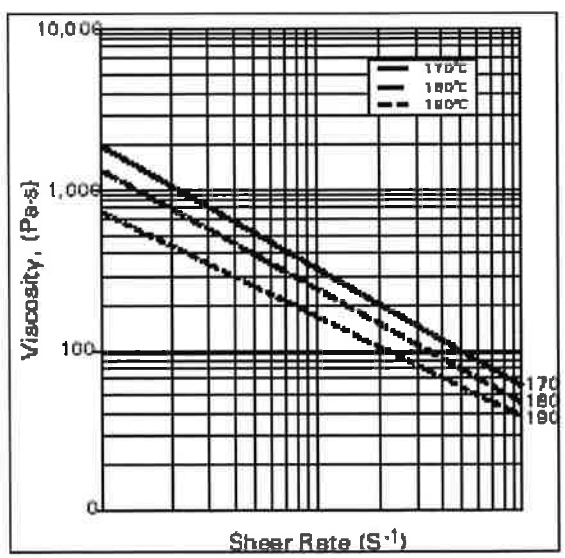

Figure 2. Viscosity/Shear Rate Data

* Delrin® is a registered trademark of E. I. DuPont de Nemours & Co., Inc.

** Celcon® is a registered trademark of Hoechst Celanese Corporation.

This unique rheological behavior makes the molding grades of *Alcryn®* ideally suited to the high shear employed during injection molding. 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 is essential to completely fill the mold. Table I shows flow data for two laboratory tests for the mold-filling characteristics of the *Alcryn®* molding grades, as a function of injection pressure and part thickness (gauge).

Table I
***Alcryn®* Mold Flow at 350°F (177°C)**

	Spiral Flow, in.	Snake Flow, in.		
Gauge Grade	**125 mils P1 / P2***	**100 mils P1 / P2***	**40 mils P1 / P2***	**20 mils P1 / P2***
2060NC	28.4/43.2	22.2/30.6	6.1/10.4	–/3.6
2060BK	23.4/40.0	20.4/36.5	5.3/9.3	–
2070NC	19.4/30.5	15.4/27.6	3.5/7.1	1.7/3.3
2070BK	21.5/33.8	17.1/29.5	4.5/8.1	1.7/3.0
2080NC	–	12.6/22.6	–	–
2080BK	13.6/23.3	11.3/20.3	3.1/5.3	–/2.1

*Injection Pressure P1 = 9,450 psi, P2 = 15,700 psi

Since the molding grades of *Alcryn®* are amorphous, they do not exhibit any discontinuous volume change due to crystallization or solidification. This is shown graphically in Figure 3 where specific volume is plotted versus temperature over a range of pressures. This data provides some basic information related to injection and hold pressure for *Alcryn®*. Since *Alcryn®* is susceptible to overpacking, it is essential that pressure be drastically reduced as soon as the mold cavity is filled. Over-packing can result in warpage and shrinkage.

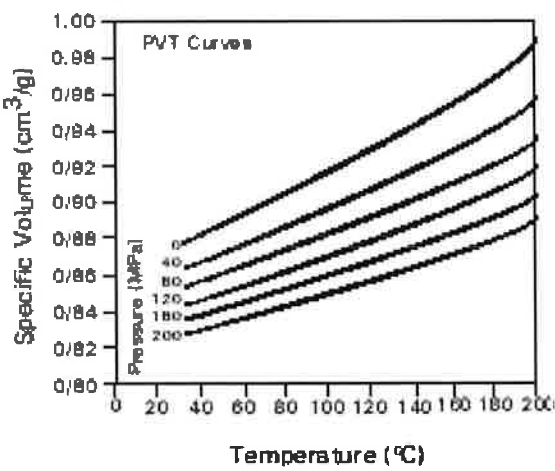

Figure 3. Volume as a Function of Pressure and Temperature

Molding

Alcryn® melt processible rubber can be run on a wide range of plastics reciprocating screw injection molding machines.

Successful injection molding of *Alcryn®* 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 of 340°F to 375°F (171°C to 191°C) 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.
- **Large vents** 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). (In cases of thick parts, cycle time can be dramatically reduced by chilling the mold.)

Several characteristics of *Alcryn®* should be considered in all injection molding processes:

- It does not have a crystalline melting point.
- Both shear and barrel heat must be present to promote flow.
- 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.
- Degradation can occur if *Alcryn®* is overheated (400°F, 204°C) or held at processing temperatures for more than 30 minutes.

See section on 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 100% of the equipment feed, blending at 20% or less with virgin material is advisable to ensure consistent processing and finished product appearance.

Injection Molding Equipment

Materials of Construction

Corrosion resistant materials, such as those typically used for other chlorinated polymers, such as PVC or CPE, are suggested for use with *Alcryn®* to maximize equipment life. "Hastalloy" C-276 is recommended for screws; "Xaloy" 306 is recommended for barrel liners. "Hastalloy" C- 276 is recommended for check-rings.

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 *Alcryn®*.

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.

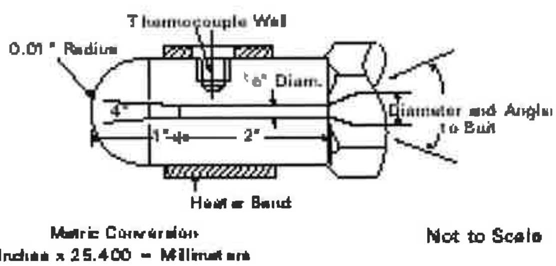

Figure 4. Nozzle (with reverse taper) Recommended for Molding

Mold Design

Materials of Construction

Molds for *Alcryn®* should be designed and constructed using corrosion resistant materials to maximize mold life. Hardened type 420 stainless steel or electroless nickel plated steel are recommended for molds.

Mold Surface Finish

Slightly textured or matte finished mold cavity surfaces are recommended for *Alcryn®*. They will minimize the appearance of flow lines on molded parts. Highly polished or chrome plated mold surfaces may inhibit auto ejection of *Alcryn®* parts because of high surface tension.

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 larger than standard taper (approximately 0.044 rad [2.5°]), are preferred.

A properly mated injection nozzle and sprue bushing facilitates ejection 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 *Alcryn®* is elastomeric very positive type sprue pullers (e.g. "Z" pullers, sucker pins, or offset undercut types) are required for automatic sprue removal.

Runners

Runners should be streamlined to reduce turbulence. A full round or trapezoidal runner should be used whenever possible to minimize pressure drop and sticking. In designing the runner system, balanced layouts, minimum number and length of runners and radiused turns are desirable.

To improve flow and facilitate ejection, the surface of the runners should be smooth, but not polished.

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

Gates

Gates must be designed to maximize **shear** to minimize viscosity as *Alcryn®* enters the mold cavity. The gates must be short and have a small cross-sectional area relative to mold volume. **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. 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 0.020 in. (0.5 mm).

Injection Molding Conditions

The rheology of *Alcryn®* makes it suited to the high **shear** process of injection molding. A combination of barrel heat and shear is necessary to attain a properly fluxed, uniform melt. Melt temperature measured at the nozzle should be maintained between 340°F and 375°F (171°C and 191°C).

Temperature Settings

Suggested injection molding machine temperature settings are as follows:

Reciprocating Screw Injection Molding Machine Barrel, Nozzle, and Mold

Barrel	Temperature Range
Rear	340°F–350°F (171°C–177°C)
Front	340°F–350°F (171°C–177°C)
Nozzle	340°F–350°F (171°C–177°C)
Mold	70°F–120°F (21°C – 49°C)

Molding Stages

Injection Speed (fill rate)	1 to 3 cu. in/sec.
Injection Pressure	700 to 1200 psi
Injection Time (first stage/boost)	0.5 to 2 sec.
Second Stage Pressure	300 to 800 psi
Second Stage Time	3 to 10 sec
Cooling Time	2 to 20 sec.
Screw Speed	50 to 100 rpm
Back Pressure	30 to 80 psi
Shot Size	Control to Fill Mold.

Shutdown Procedures

Brief shutdowns of 1 hour or less require no special precautions, provided the measured melt temperature is no greater than 350°F (177°C). If the injection molding machine is to be shut down for longer than 1 hour or the melt temperature is above 350°F, purging is recommended, using low density, low viscosity polyethylene. During the next start-up the initial material exiting the injection press should be discarded.

For more information on *Alcryn*:

Ferro Corporation
Advanced Polymer Alloys
400 A Maple Avenue
Carpentersville, IL 60110

Toll Free (888) 663-6005

Telephone: (847) 426-3350
Facsimile: (847) 426-3424

Visit Our Website: www.APAinfo.com

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Gates should be located in the thickest section to avoid incomplete fill or sink marks, minimize flow lengths, and to allow a homogenous, parallel flow pattern within the mold. This will minimize or eliminate the formation of weld lines.

Venting

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

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

Venting provides a path for the escape of air from the cavity as melt displaces it. 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. Vent openings up to 0.236 in. (6 mm) wide and should be no deeper than 0.0025 in. (0.06 mm) to eliminate flash. The width is not as critical as depth. 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 gases.

Part Shrinkage

The degree of shrinkage for injection molded parts of *Alcryn®* 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 *Alcryn®*. Higher mold temperatures cause higher shrinkage. Mold temperatures in the range of 70°F to 120°F (21°C to 49°C) are recommended for molding *Alcryn®*. Hold pressure (2nd stage pressure) can also affect the degree of shrinkage (particularly in the flow direction) in parts molded in *Alcryn®*. 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 *Alcryn®* is greater for thinner wall sections. Typical shrinkage values for *Alcryn®* at different thicknesses are shown in Table II.

Table II
Typical Mold Shrinkage of *Alcryn®* Injection Molding Grades

	Shrinkage (in./in.)			
Thickness	0.0625"		0.125"	
Alcryn® Grade	MD*	CMD*	MD*	CMD**
Black				
2060 BK	0.040	0.010	0.030	0.020
2070 BK	0.030	0.005	0.020	0.015
2080 BK	0.030	0.005	0.020	0.015
Neutral				
2060 NC	0.040	0.005	0.030	0.015
2070 NC	0.025	0.005	0.020	0.015
2080 NC	0.020	0.005	0.020	0.015
Translucent				
2250 UT	0.040	0.020	0.030	0.020
2265 UT	0.030	0.010	0.025	0.015

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

Part Ejection

Ample draft, i.e. 0.009 to 0.035 rad (0.5° to 2°) 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. Molds equipped with core pullers have been successfully used for molding hollow parts of *Alcryn®*.

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.

A **matted surface** finish on molds is preferable to a highly polished one for easy-ejection of *Alcryn®* parts. Very smooth surfaces may produce a "suction-cup" effect, holding the part in the mold.