INTRODUCTION

The intent of this technical brochure is to provide molders with a general insight into the characteristics of polypropylene and aspects of design and processing for optimum results. The brochure further focuses on the general corrective procedures for common molding problems. Prospective molders should consult with a CPC technical representative for questions which can't be answered with this free guide.

CHARACTERISTICS OF POLYPROPYLENE

Like all thermoplastic injection molding resins, polypropylene has its own special characteristics. These characteristics not only affect the properties of the finished molded pieces, but they also determine optimum molding conditions. Available as either a homopolymer or a copolymer, polypropylene is offered in a broad range of grades and types whose properties are fully outlined in their respective product data sheets.

Inherent Chemical Properties

Low Density

Polypropylene, with a very low density of 0.90 g/cm, is the lightest of all commercially available thermoplastics. Parts molded from polypropylene are lighter weight, and therefore more parts con be molded on a part-per-weight basis.

High-Temperature Resistance

The relatively high melting point of 334°F (167°C) for Pro-fax polypropylene allows continued use at 220°F (104°C). The resin begins to soften at about 250°F (121°C), but nevertheless can be used intermittently at this temperature. To extend polypropylene's useful temperature range and service life, an antioxidant system is incorporated. However, any environment (such as moisture) that tends to extract the antioxidants may lead to a more rapid breakdown of polypropylene, especially at elevated temperatures.

Chemical Resistance

Polypropylene, like most of the polyolefins, is highly resistant to solvents and chemicals. With few exceptions, inorganic chemicals produce little or no effect on polypropylene exposed for 6 months at temperatures up to 250°F (121°C). The permeation resistance of polypropylene to organic chemicals is greatly dependent on the nature of the chemical, as each type has its own rate of absorption. This, in turn, governs the suitability of the resin to serve in a particular environment.

Stress-Crack Resistance

Polypropylene has excellent resistance to environmental stress cracking. Embrittlement that occurs with other plastics in the presence of oils, detergents, and other stress cracking agents is not observed with this resin. Only very potent oxidizing agents produce stress cracking in polypropylene.

Weathering
(Ultraviolet Resistance)

Polypropylene has limited resistance to weathering or exposure to ultraviolet light, a component of sunlight. The incorporation of 2.0 to 2.5% carbon black pigment has protected polypropylene parts outdoors for up to 20 years. If black is not an acceptable color, incorporation of an ultraviolet stabilizer should be considered.

Other Advantages

- Excellent dielectric properties
- Nonhygroscopic — does not absorb moisture
- Excellent dimensional stability
- High abrasion resistance
- High gloss
- Best contact and see-through clarity of the polyolefins

These optical properties are further enhanced by nucleating agents, which form smaller and more numerous spherulites upon crystallization. Furthermore, the increase in crystallization rates slightly improves the processing and stiffness of the molded part.

Mechanical Properties

Polypropylene has excellent mechanical properties. The numerous homopolymer and copolymer grades offer various combinations of stiffness and impact strength to meet the specific requirements of many injection molding applications.

Stiffness

Polypropylene grades are intermediate in stiffness (and impact) between polystyrene and high-density polyethylene (HDPE). High-impact copolymers and random copolymers are similar in flexural modulus (stiffness) to HDPE, while homopolymer polypropylenes can be stiffer than impact-modified polystyrene.

Impact Strength

For many applications, polypropylene homopolymers provide adequate impact strength at or above room temperature. However, for applications with requirements for low-temperature impact resistance, polypropylene copolymers are recommended. These grades not only improve the impact properties but also reduce the brittleness temperatures of molded parts.

Like other crystalline thermoplastics, polypropylene is relatively notch-sensitive. Thus, notched areas such as sharp corners in molded articles should be avoided, as they reduce the impact resistance of the parts. Recommendations on designing corners can be found on page 10.

Long-Term Creep

The end-use performance of articles injection molded from Pro-fax polypropylene are almost always related to stress, time, and temperature.
The ability of a product to resist deformation under a constant load applied over time is the measure of creep resistance. Tensile creep is defined as deformation in tension, rated in percentage strain that occurs under applied stress.
Pro-fax polypropylene has tensile creep-resistance properties superior to those of other polyolefins, and these properties can be further improved by the addition of glass fibers and other modifiers. Separate data are available on these products.

Figures 1 and 2 depict the tensile creep data for a general purpose polypropylene homopolymer and copolymer. As shown, the homopolymer exhibits better creep resistance than does the copolymer. Different products will show different creep behavior.

Figure 1
Typical Pro-fax 6523 Polypropylene Homopolymer
Tensile Creep at 70°F (21°C)

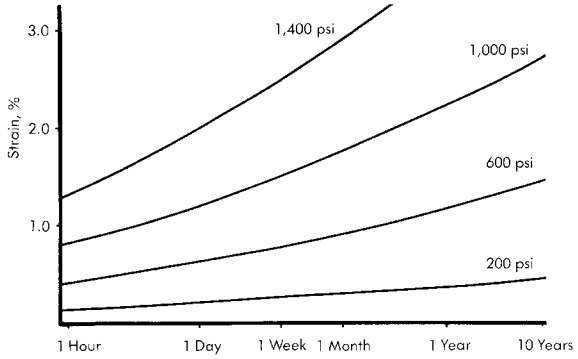
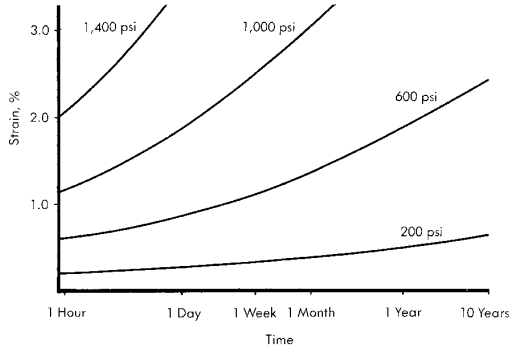


Figure 2
Typical Pro-fax 7523 Polypropylene Copolymer
Tensile Creep at 70°F (21°C)



Furthermore, consideration should be given to design and molding conditions, as they may import “molded-in” strain and orientation effects to the molded parts. These molding-induced effects will affect the behavior of the molded parts.

Flow Properties

From a material standpoint the moldability of Pro-fax polypropylene is determined primarily by its flow properties. Of importance are the following moldability tests:

Melt-Flow Rate

The melt-flow test method, according to ASTM D 1238, is a measurement of the rate of extrusion (in g/ 10 mm) of the molten resin through an orifice of a specified length and diameter under prescribed conditions of temperature and pressure. The *melt-flow rate* used for polypropylene should not be confused with the *melt index* for polyethylene. The apparatus is the same, but the melt-flow rate is determined at 446°F (230°C), 4.76 lbs (2.16 kg) piston force, while the melt index of polyethylene is at 375°F (190°C), 4.76 lbs (2.16 kg) piston force.

The melt-flow rate is a single-point measurement of the melt viscosity (melt's resistance to flow), and is also used to give an estimate of polypropylene's molecular weight. The melt-flow rote is inversely related to the molecular weight (i.e., as the molecular weight increases, the melt viscosity increases and the melt-flow rate decreases).

At the low shear rates employed for the test method, the melt-flow rate cannot be used by itself to give a reliable measure of moldability, owing to the high shear rates encountered in injection molding. Despite this limitation and the limited precision of the melt-flow results attributable to the procedure itself, the melt-flow apparatus is nevertheless widely used in the plastics field. It is an economical, convenient, and fast testing device, and HIMONT recommends this test to its users to enable them to distinguish the variety of available injection molding grades intended to meet their specific needs.

Following is a simplified rating of the available melt-flow ranges into flow characteristics:

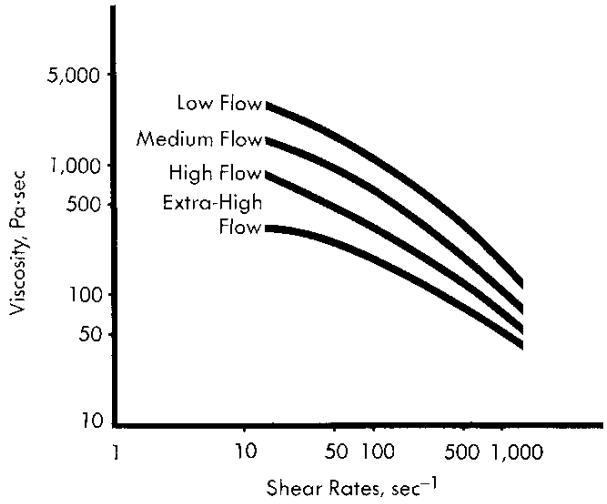
Melt-Flow Range, g/ 10 mm	**Flow Characteristics**
Below 4	Low flows
4 to 10	Medium flows
10to 20	High flows
Above 20	Extra-high flows

Capillary Flow

The capillary flow test, using a capillary rheometer, measures the viscosity of the molten resin at high shear rates similar to those occurring in the injection molding process. This technique provides a better assessment of the resin's moldability

Following is an illustration of the viscosity vs.shear rate curves of typical flow characteristics of polypropylene.

Figure 3
Typical Flow Characteristics at 445°F (229°C)



Injection Flow Number

Of practical use to the injection molder is the injection flow number (IFN). However, this test is not a quality control test, as it compares the polypropylene resin grades only under actual molding conditions.

The IFN rating is an average measurement of the molten resin's mold fill length in millimeters before gate freezeup under a standard set of conditions in an S-shaped mold plate. Figure 4 illustrates the relationship of IFN rating to the melt-flow rate for a 0.040-in. (1.016-mm) wall thickness.

Figure 4
Injection Flow Number vs Melt Flow Rate