THE GUND COMPANY

MANUFACTURERS & FABRICATORS OF ENGINEERED MATERIAL SOLUTIONS

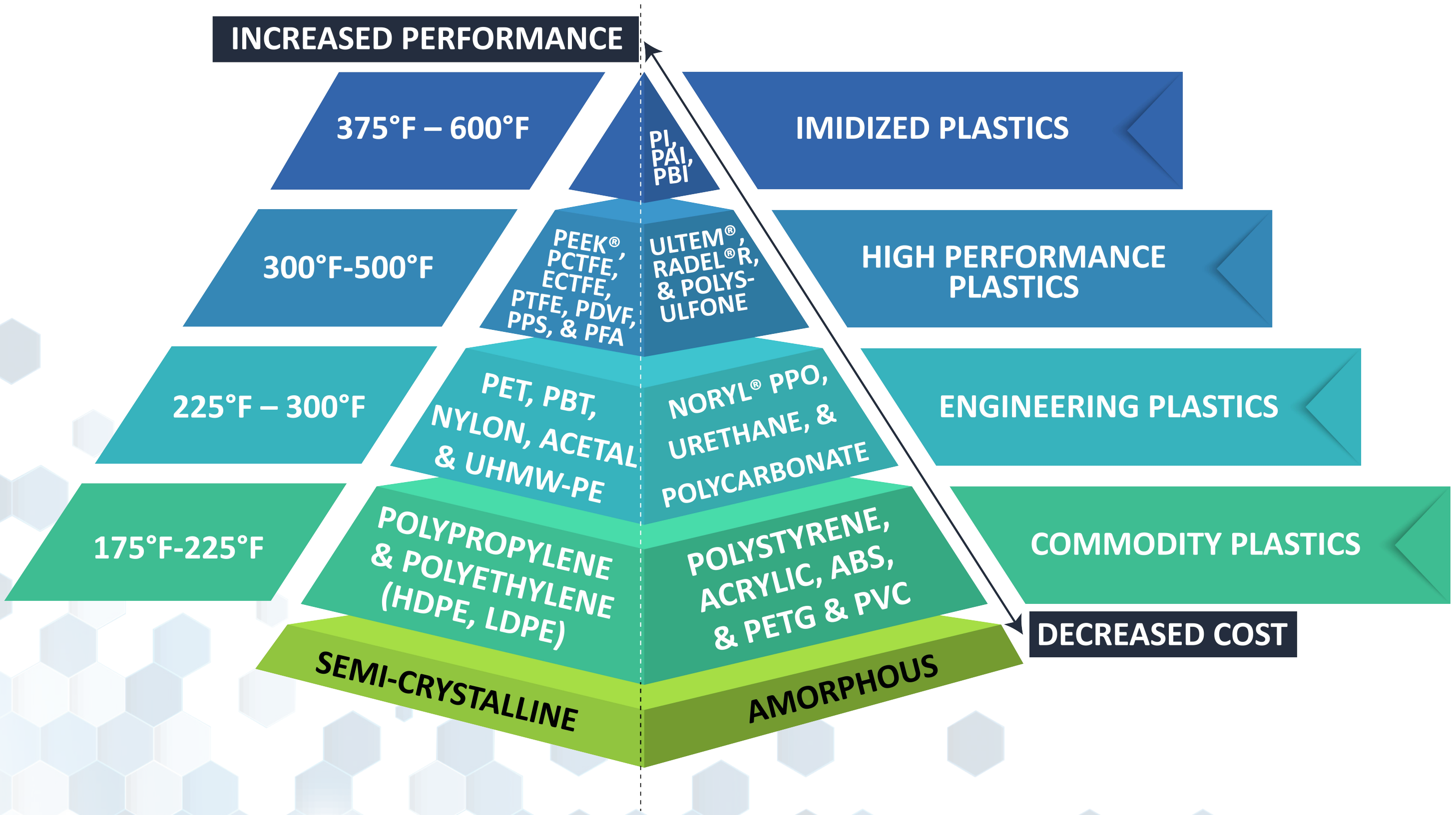
Thermoplastic Material Selection Guide

Thermoplastic materials are suitable for numerous applications and there are many options. Aerospace, defense, medical, satellite communications, food service, and electronics are just a few industries that utilize thermoplastics. However, given the variety of materials, it can be challenging to select the best option considering price, performance, and manufacturability.

Pyramid of Plastics

The pyramid of plastics helps narrow the scope of material options. Of course, it is important to understand which materials are suitable for the application requirements, but it is also important to avoid using an expensive material when a more economical option would work. As the operating temperature and performance of a material increases, often the price will as well.

Thermoplastics can be broken into two groups by composition: Amorphous and Semi-Crystalline thermoplastics. The molecules in an amorphous polymer are oriented randomly, whereas the molecules in a semicrystalline polymer are packed together and organized in an area.



AMORPHOUS	SEMI-CRYSTALLINE
Easy to Thermoform	Challenging to Thermoform
Typically Translucent	Typically Opaque
Softens Over a Range of Tempuratures	Sharp Melting Point
Bonds Well Using Adhesives	Difficult to Bond
Good for Structural Applications	Good for Structural Applications
Poor Fatigue Resistance	Good Fatigue Resistance
Not Ideal for Wear Applications	Good for Wear & Bearing Applications
Subject to Cracking Under Stress	Good Resistance to Cracking from Stress

Amorphous Thermoplastics:

Amorphous thermoplastics are more conducive to thermoforming, they soften over a range of temperatures, and have better bonding ability when combined with adhesives. Compared to semi-crystalline thermoplastics of a similar grade, amorphous plastics often have better dimensional stability and impact resistance. However, amorphous plastics are more prone to fatigue and cracking due to stress.

Semi-Crystalline Thermoplastics:

Semi-Crystalline thermoplastics are great for wear and structural applications. When compared to amorphous thermoplastics, these semi-crystalline tend to have better chemical resistance, electrical properties, and a lower coefficient of friction. However, semi-crystalline plastics are challenging to thermoform, difficult to bond, have a sharp melting point, and have lesser impact strength.

Plastic Families

At the bottom of the pyramid, cost-effective commodity plastics such as ABS, PVC, PET, PP, and PE polymers are found in both semi-crystalline and amorphous forms. Although the operating temperature of these materials is lower and they are generally weaker than higher-performing plastics, they can offer good chemical resistance and machinability (although there is variability between commodity plastics).

Moving up a level in the pyramid, you find engineering plastics such as polycarbonate, nylon (PA), acetal (POM), and UHMW-PE. There is still variation in characteristics between these materials, but in general, they exhibit higher temperature resistance and strength than commodity plastics.

Engineering plastics are higher performing and more expensive than commodity plastics but both are comparatively low cost. They are generally easy to machine, mold, or form, and exhibit good electrical, mechanical, and physical properties for many applications. If one of these materials will work in your application, it is a better choice than high-performance or imidized plastics.

For more demanding or specialized applications, high performance plastics and imidized plastics may be necessary. High-performance plastics such as PEEK, PTFE, and PSS can withstand very high temperatures and offer excellent chemical resistance. Imidized plastics are often suited more for aerospace applications, but can also be used for thermal insulators, high-performance bearings, and electrical connectors in extreme environments. Imidized plastics such as polyamide-imide (PAI), polybenzimidazole (PBI), and polyimide (PI), feature the highest temperature resistance and load-bearing capabilities, among other properties.

MACHINING	MOLDING
Good for Short Runs	Good for High-Volume Production
More Material Availability	Efficient Material Use
Little to no Tooling Cost	Fast Run Time
Quick to Start Production	Capable of Making Complex Parts
Slow Run Time	High Tooling Costs
High Part Price	Slow to Start Production
Limitations in Part Complexity	Low Part Price

Selecting a Material

1. Understand the Operating Temperature of the Application

Operating temperature is an essential property to determine because thermoplastic properties can change dramatically under heat. Mechanical properties such as elasticity and stiffness will change significantly as a thermoplastic crosses the glass transition temperature (Tg). The pyramid is organized by operating temperature, so it's easy to narrow material options to those that operate at a temperature higher than the maximum application operating temperature.

2. Performance Requirements

Once the operating temperature has been determined other performance characteristics will drive the material selection. Every application is unique and typically has one or two key criteria for performance. Here are some typical questions engineers need to consider when narrowing the options during the selection process:

- Are there any forces present on the part? What are they?
- Will the part be used outdoors or subject to UV exposure?
- Will the part come in contact with any chemicals? What are they?
- What kind of electrical stresses are present?

3. Understand Product Volume

Each material can be manufactured or processed in numerous ways. Machining and molding are common methods by which thermoplastics can be transformed into a finished part, but the volume of product required is a significant factor in establishing the most economical method of manufacture.

Machining a part from a sheet or block is a good option for low volume requirements. Tooling costs are minimal, the material is more readily available, and lead times are typically shorter. However, machining is typically slower than other operations and there may be production limitations based on object complexity.

Molding is a great option for high-volume parts. Tooling costs could be significant depending on the part but production speeds are much faster than machining. Material is more efficiently utilized, and part complexity is less of a concern. Tooling lead times and material availability are common drawbacks to molding but can be a small expense for a long-term project.

There are other options such as 3D printing, thermoforming, die-cutting, converting, and punching to name a few, each with pros and cons. Not all thermoplastics can be manufactured by every method, so it's important to know the production volume to help narrow the scope of materials that can be manufactured to utilize the most economical method possible.

4. Establish a Budget

With so many options to choose from, it can be hard to establish a budget. However, understanding the application operating temperature and production volumes can help establish expectations. After steps 1 and 2 are known, it's best to select the material the meets all property requirements and can be manufactured in the most efficient way possible.

Considering all factors – performance requirements, manufacturing requirements, and price requirements, it can be challenging to discover the right material among thousands of options. The Gund Company is here to help.

If you need help finding a solution, The Gund Company has material specialists and application engineers available by email, phone, or web to find the right material solution for your application. We offer a broad selection at competitive pricing, and we can produce your part with one of our many manufacturing and fabrication capabilities at any of our 12 locations worldwide.

For additional information on thermoplastic materials, check out our Thermoplastic Material landing page at:

https://thegundcompany.com/materials-2/thermoplastic-materials/ or contact us below.

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