Material Selection Guide

Plastics are increasingly being used to replace other materials like bronze, stainless steel, aluminum and ceramics. The most popular reasons for switching to plastics include:

- Longer part life
- Elimination of lubrication
- Reduced wear on mating parts
- Faster operation of equipment/line speeds
- Less power needed to run equipment
- Corrosion resistance and inertness
- Weight reduction

With the many plastic materials available today, selecting the best one can be an intimidating proposition. Here are guidelines to assist those less familiar with these plastics.

Step 1 -

Determine whether the component is a:

- Bearing and Wear Application (i.e., frictional forces) OR
- Structural (static or dynamic) Application

Determining the primary function of the finished component will direct you to a group of materials. For example, crystalline materials (i.e., Nylon, Acetal) outperform amorphous materials (i.e., Polysulfone, Duratron® PEI or Polycarbonate) in bearing and wear applications. Within the material groups, you can further reduce your choices by knowing what additives are best suited to your application.

Wear properties are enhanced by MoS_2, graphite, carbon fiber and polymeric lubricants (i.e., PTFE, waxes).
Structural properties are enhanced by reinforcement fibres like glass or carbon.
Once you have determined the nature of the application (Bearing and Wear or Structural), you can further reduce your material choices by determining the application's mechanical property requirements. For bearing and wear applications, the first consideration is wear performance expressed in PV and"k" -factor. Calculate the PV (pressure (psi) x velocity (m/min) required. Using Figure 1, select materials whose limiting PV's are above the PV you have calculated for the application. Further selection can be made by noting the "k" wear factor of your material choices. In general the lower the "k" factor, the longer the wear life of the material.

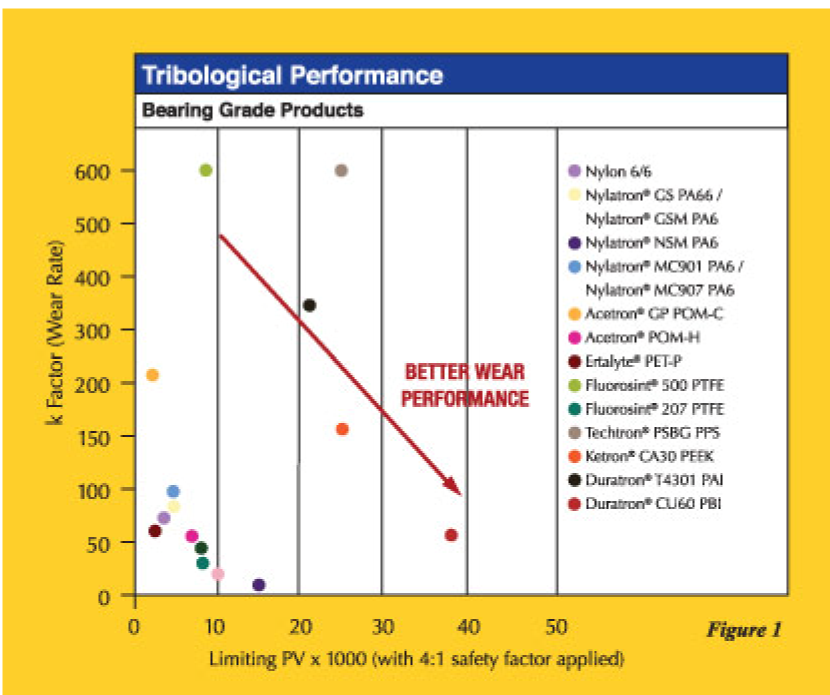


Figure 1

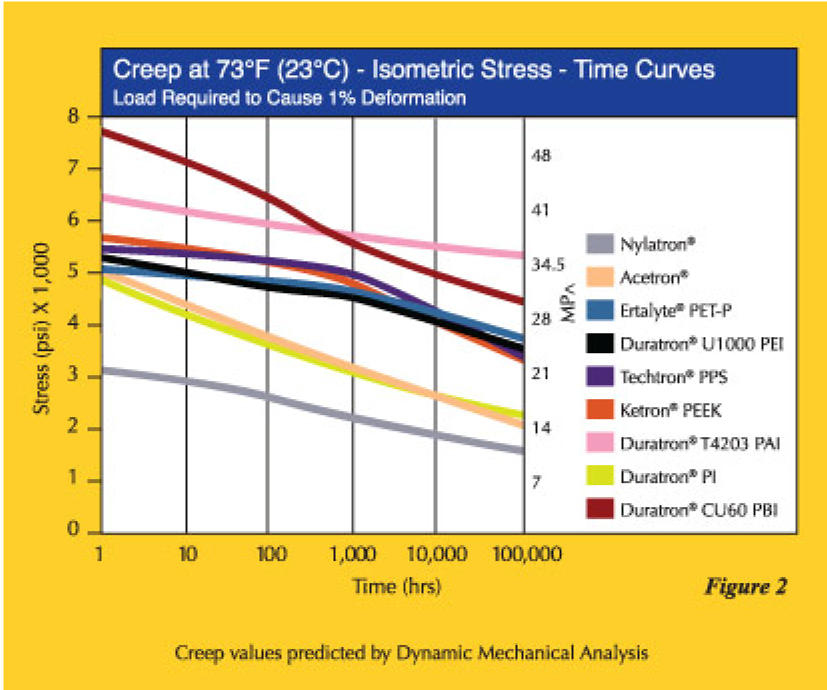


Figure 2

Creep values predicted by Dynamic Mechanical Analysis

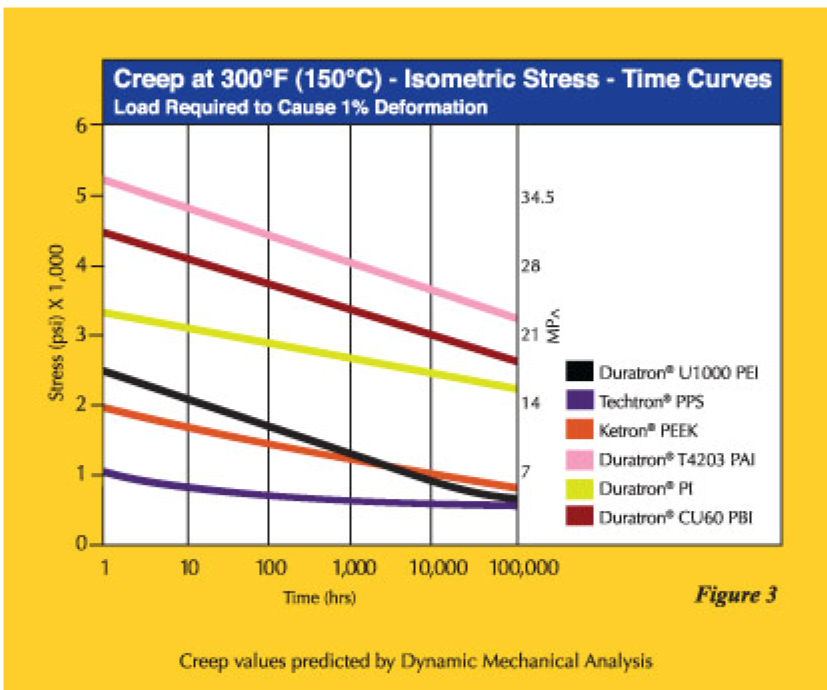


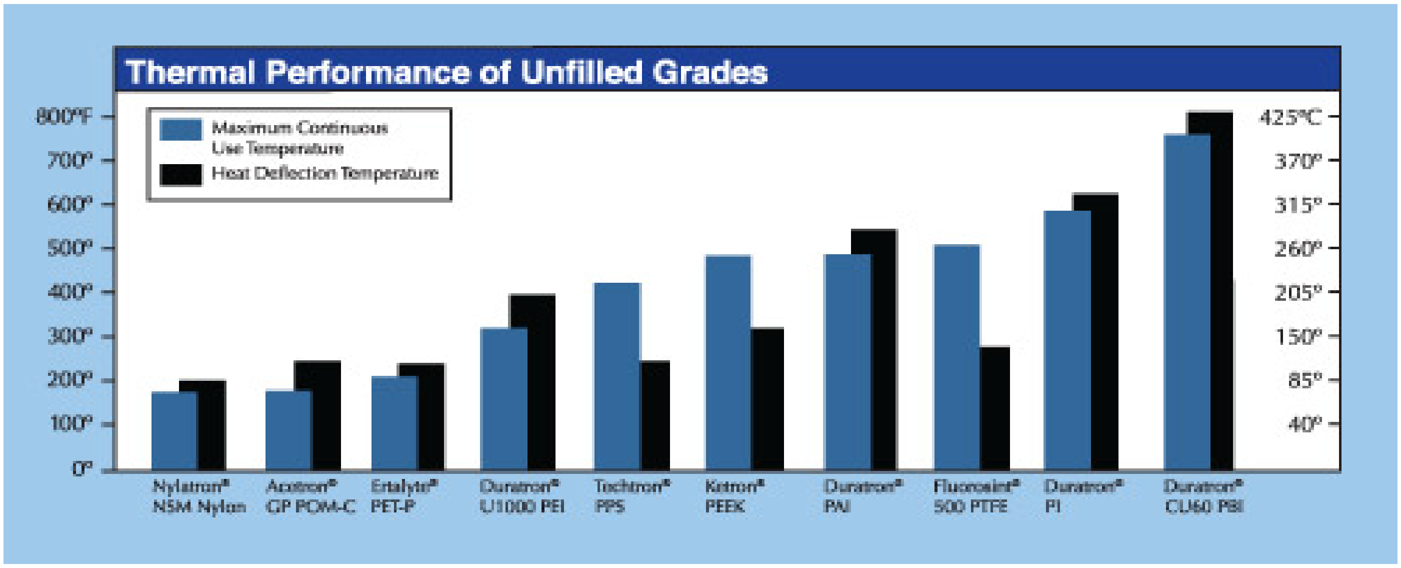
Figure 3

Creep values predicted by Dynamic Mechanical Analysis

Structural components are commonly designed for maximum continuous operating stresses equal to 25% of their ultimate strength at a specific temperature. This guideline is meant to compensate for the viscoelastic behavior of plastics that result in creep. Isometric stress-time curves are provided here to help you characterize a material's strength behavior as a function of time at both room temperature (Figure 2) and at 150 °C (300 °F) (Figure 3).

Step 2
Consider the thermal requirements of your application using both typical and extreme conditions.

A material's heat resistance is characterized by both its **heat deflection temperature** (HDT) and**continuous service temperature**. HDT is an indication of a material's softening temperature and is generally accepted as a maximum temperature limit for moderately to highly stressed, unconstrained components. Continuous service temperature is generally reported as the temperature above which significant, permanent physical property degradation occurs after long term exposure. This guideline is not to be confused with continuous operation or use temperatures reported by regulatory agencies such as Underwriters Laboratories UL.
The **melting point** of crystalline materials and **glass transition temperature** of amorphous materials are the short-term temperature extremes to which form stability is maintained. Most engineering plastics should not be used at or above these temperatures since polymers loose most of their mechanical characteristics at these temperatures.



Step 3
Consider chemicals to which the material will be exposed during use and cleaning.

Quadrant provides chemical compatibility information as a guideline in this brochure although it can be difficult to predict since concentration, temperature, time and stress each have a role in defining suitability for use. Nylon, acetal and Ertalyte® PET-P are generally suitable for industrial environments. Crystalline high performance materials such as Fluorosint® filled PTFE, Techtron® PPS and Ketron™ PEEK are more suitable for aggressive chemical environments (See Figure 5). We strongly recommend that you test under end-use conditions. Specific chemical resistance can be found on the property comparison chart.

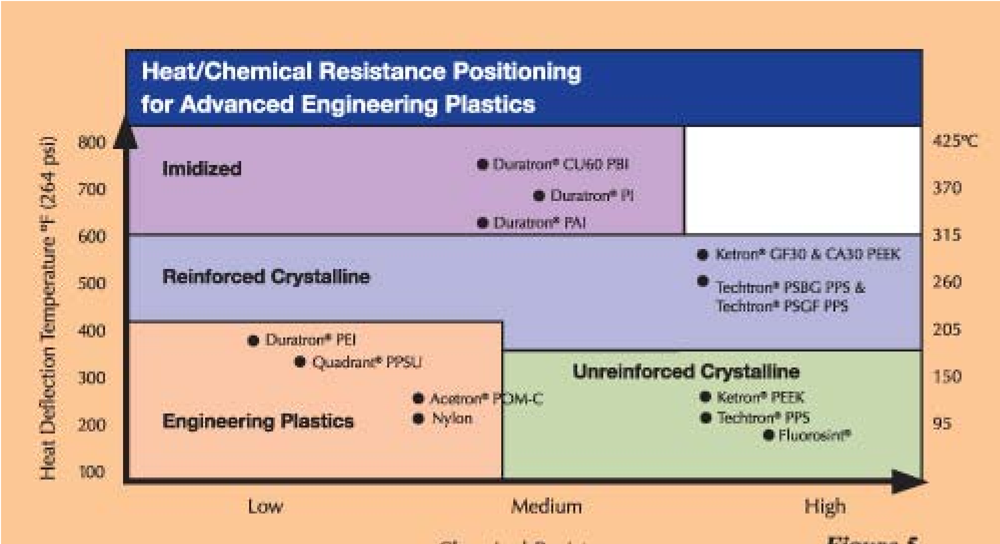


Figure 5

Step 4

Consider additional material characteristics including:

- Relative Impact Resistance/Toughness
- Dimensional Stability
- Regulatory/Agency Compliance

Materials with higher tensile elongation, Izod impact and tensile impact strengths are generally tougher and less notch sensitive for shock loading applications (See Table 1).

Mechanical Property Comparisons

	Tensile Strength psi	Compressive Strength psi	Flexural Modulus psi	Elongation %	Izod Impact (room temp. 23 °C 73 °F)	Water Absorp. (24hr. in moisture environment)
Nylatron® NSM Nylon	11,000	14,000	475,000	20	0.5	0.25
Acetron® GP Acetal	9,500	15,000	400,000	30	1.0	0.2
Ertalyte® PET-P	12,400	15,000	490,000	20	0.5	0.07
Quadrant PPSU	11,000	13,400	345,000	30	2.5	0.37
Duratron® U1000 PEI	16,500	22,000	500,000	80	0.5	0.25
Duratron® U2300 PEI	17,000	32,000	900,000	3	1.0	0.18
Fluorosint®500 PEI	1,100	4,000	500,000	10	0.9	0.10
Techtron® PPS	13,500	21,500	575,000	15	0.6	0.01
40% GF Ryton* PPS	13,000	24,000	1,000,000	2	1.0	0.02
Ketron® 1000 PEEK	16,000	20,000	600,000	20	1.0	0.10
Ketron GF30 PEEK	18,000	26,000	1,000,000	3	1.4	0.10
Duratron® T4203 PAI	18,000	30,000	600,000	5	2.0	0.33
Duratron® T4301 PAI	12,000	24,000	1,000,000	3	0.8	0.28
Duratron® T5530 PAI	14,000	27,000	900,000	3	0.7	0.30
Duratron® PI	13,500	19,000	530,000	3	0.6	0.62
Duratron® PBI	23,000	50,000	950,000	3	0.5	0.40

Engineering plastics can expand and contract with temperature changes 10 to 15 times more than many metals including steel. The coefficient of linear thermal expansion (CLTE) is used to estimate the expansion rate for engineering plastic materials. CLTE is reported both as a function of temperature and as an average value. Figure 6 shows how many different engineering plastics react to increased temperature.

Modulus of elasticity and water absorption also contribute to the dimensional stability of a material. Be sure to consider the effects of humidity and steam.

Agencies such as the Food and Drug Administration (FDA), U.S. Department of Agriculture (USDA), Underwriters Laboratory (UL), 3A-Diary Association and American Bureau of Shipping (ABS) commonly approve or set specific guidelines for material usage within their industrial segments.

Step 5
Select the most cost-effective shape for your part.

Quadrant offers designers the **broadest size and configuration availability**. Be sure to investigate all of the shape possibilities — you can reduce your fabrication costs by obtaining the most economical shape.

Consider Quadrant's many processing alternatives.

For:	Choose:
Long lengths Small diameters Rod, plate, strip, profiles, tubular bar, bushing stock	Extrusion
Large stock shapes Near net shapes Rod, plate, tubular bar, near, net configurations	Casting
Small Shapes in advanced engineering materials Rod, disc, plate, tubular bar	Compression Molding
Small shapes in advanced engineering materials Small diameters Rod, disc, plate, tubular bar	Injection Molding

Note: From process to process, many material choices remain the same. However, there are physical property differences based upon the processing technique used to make the shape.
For example:

- Injection molded parts exhibit the greatest anisotropy (properties are directionally dependent).
- Extruded products exhibit slightly anisotropic behavior.
- Compression molded products are isotropic — they exhibit equal properties in all directions.

Step 6
Determine the machinability of your material options.

Machinability can also be a material selection criterion. All of the Quadrant products in this site are stress relieved to enhance machinability. In general, glass and carbon reinforced grades are considerably more abrasive on tooling and are more notch sensitive during machining than unfilled grades. Reinforced grades are commonly more stable during machining.
Because of their extreme hardness, imidized materials (i.e., Duratron® PAI, Duratron® PI and Duratron® PBI) can be challenging to fabricate. Carbide and polycrystalline diamond tools should be used during machining of these materials. To aid you in assessing machinability, a relative rating for each material can be found on the property comparison charts.

Step 7

Make sure you receive what you specify.

The properties listed in this site are for Quadrant EPP's materials only. Be sure you are not purchasing an inferior product. Request product certifications when you order.

Engineering Notes:

All material have inherent limitations that must be considered when designing parts. To make limitations clear, each material profiled in this site has an Engineering Notes section dedicated to identifying these attributes.

We hope our candor about material strengths and weaknesses simplifies your selection process. For additional information, please contact Quadrant EPP's Technical Services Department.