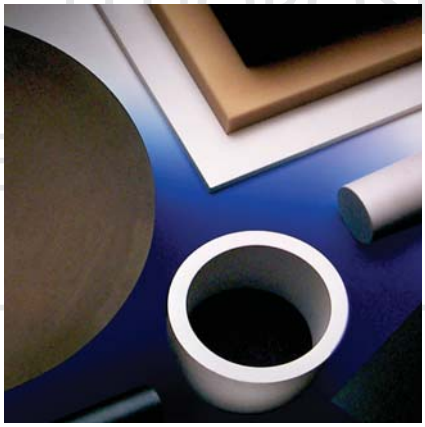
Products and Applications Guide



A guide to selection and performance of machinable engineering plastics.

QUADRANT

You inspire . . . we materialize®

QUADRANT

Global Leader in Engineering Plastics for Machining.

Quadrant Engineering Plastic Products (Quadrant EPP) is the world's leading manufacturer of plastic machining stock.

In 1946, we invented and then patented the first process for extruding nylon stock shapes for machining. The industry we created gives designers more flexibility and design possibilities by producing shapes that can easily be machined into parts. Quadrant assists engineers in selecting the optimum material for their application.

TECHNICAL SUPPORT FROM CONCEPT THROUGH PRODUCTION.

Application and production support when and where you need it. Quadrant's technical support team works with engineers and machinists from material selection through machining, for optimum performance, productivity and cost.

Quadrant locations around the world offer an experienced technical team and the most comprehensive testing laboratories in the industry. You can count on reliable support at every phase of your project:

- Evaluation of performance needs and application environment
- Material selection – including selection software
- Material certifications
- Regulatory agency compliance
- Set-up and production recommendations from experienced machinists
- A wide range of material selection, design and fabrication guides and tools – all available on the Quadrant Engineering Plastic Products web site, **www.quadrantplastics.com**

QUALITY SYSTEMS THAT ENSURE CONSISTENCY.

From full lot traceability to ISO certifications, Quadrant meets your requirements for consistent quality, performance and machinability. As the first to line mark shapes materials, Quadrant set the standard for traceability on our products right back to the resin lot and production shift. We have also kept pace with industry standards and quality systems to comply with the needs of the industries that your company also serves. Count on Quadrant. It is the inspiration behind our drive to provide the best levels of support for our materials in your applications.

TABLE OF CONTENTS

QUADRANT

TABLE OF CONTENTS

GUIDELINES

Effective Selection & Design Techniques

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**

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**

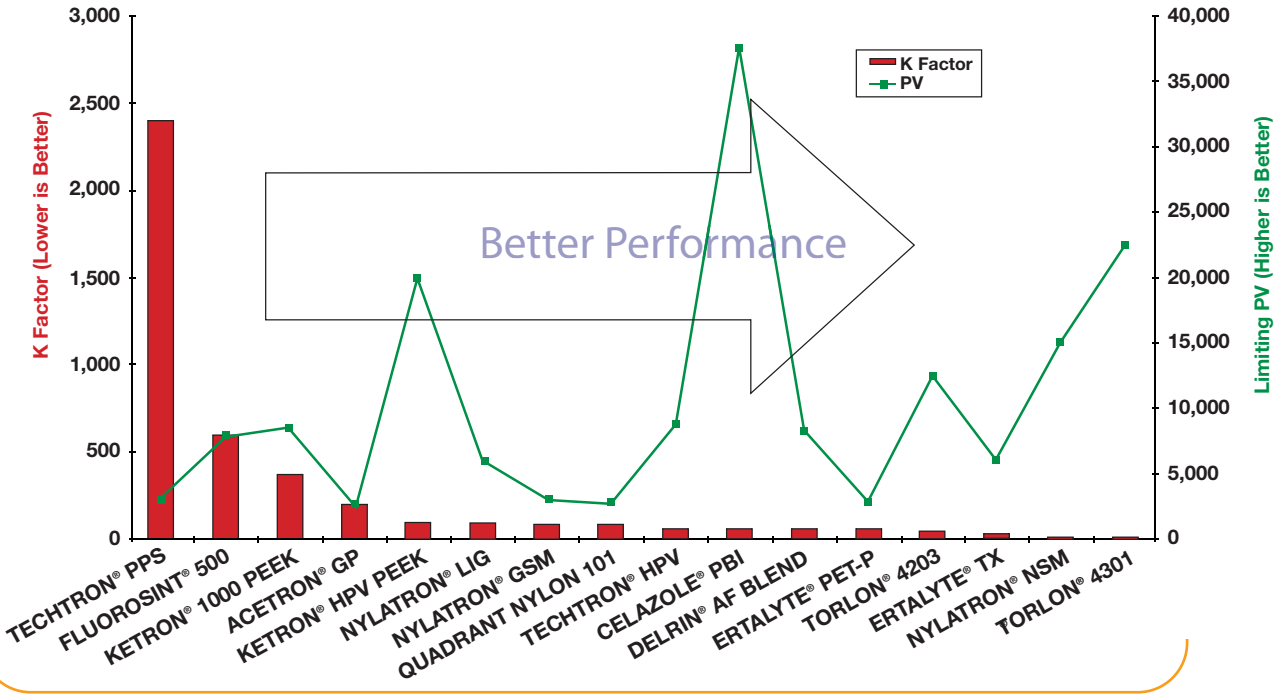
Determining the primary function of the finished component will direct you to a group of materials. For example, crystalline materials (i.e., nylon, acetal) outperform amorphous materials (i.e., polysulfone, Ultem* PEI or polycarbonate) in bearing and wear applications. Within the material groups, you 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 glass fiber and carbon fiber.

Once you have determined the nature of the application (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 (fpm)) 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. The lower the "k" factor, the longer the material is expected to last.

Fig.1 - **WEAR RESISTANCE VS. LOAD BEARING CAPABILITY**



Structural components are commonly designed for maximum continuous operating stresses equal to 25% of their ultimate strength at a specific temperature. This guideline compensates 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 300°F (Figure 3).

Fig.2 - **CREEP AT 73ºF (23ºC) - ISOMETRIC STRESS - TIME CURVES**
Load Required to Cause 1% Deformation

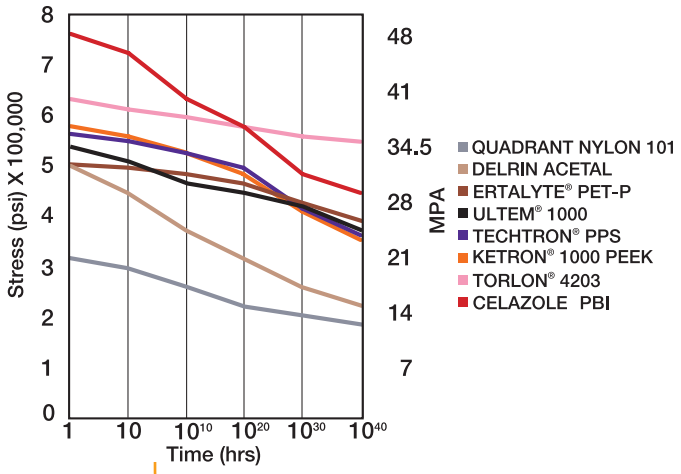
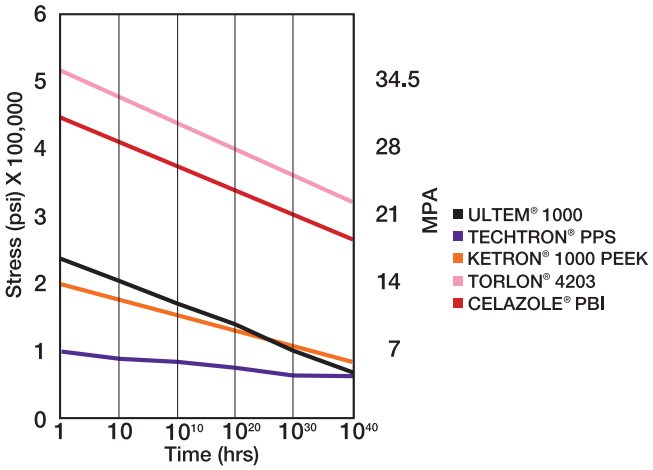


Fig.3 - **CREEP AT 300ºF (150ºC) - ISOMETRIC STRESS - TIME CURVES**
Load Required to Cause 1% Deformation



Creep values predicted by Dynamic Mechanical Analysis

STEP 1 CONTINUED

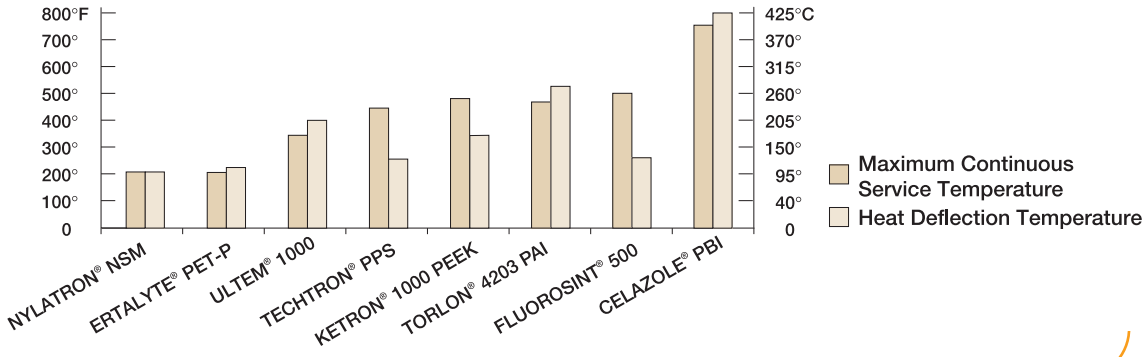
STEP 2

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 temperature 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. For most engineering plastic materials, using them at or above these temperatures should be avoided.

Fig.4 - **EXAMPLES OF THERMAL PERFORMANCE**



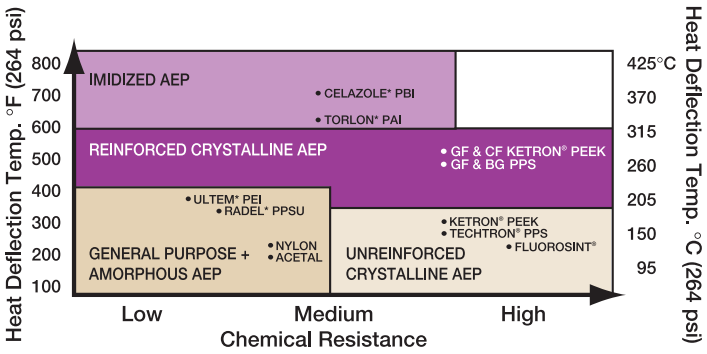
GUIDELINES

STEP 3

Consider chemical exposure 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 pages starting on page 38.

Fig.5 - **HEAT/CHEMICAL RESISTANCE POSITIONING**
for Advanced Engineering Plastics



STEP 4

Before proceeding to steps 5-7, it may be appropriate to 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 applications involving shock loading (see Table 1).

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–Dairy Association and American Bureau of Shipping (ABS) commonly approve or set specific guidelines for material usage within their industrial segments. Check our website for the most current agency compliance information.

Table 1

Mechanical Property Comparisons

	Tensile Strength psi	Compressive Strength psi	Flexural Modulus psi	Elongation %	Izod Impact (73°F)	Water Absorp. (24hr.)
Nylatron® NSM	11,000	14,000	475,000	20	0.5	0.30
Acetron® GP	9,500	15,000	400,000	30	1.0	0.20
Ertalyte® PET-P	12,400	15,000	490,000	20	0.5	0.07
Ertalyte® TX	10,500	15,250	360,000	5	0.4	0.06
Radel® R PPSU	11,000	13,400	345,000	30	2.5	0.37
Ultem® 1000	16,500	22,000	500,000	80	0.5	0.25
Ultem® 2300	17,000	32,000	850,000	3	1.0	0.18
Fluorosint® 500	1,100	4,000	500,000	10	0.9	0.10
Techtron® PPS	13,500	21,500	575,000	15	0.6	0.01
Quadrant GF40 PPS	13,000	24,000	1,000,000	2	1.0	0.02
Ketron® 1000 PEEK	16,000	20,000	600,000	40	1.0	0.10
Ketron® GF30 PEEK	18,000	26,000	1,000,000	3	1.4	0.10
Torlon® 4203 PAI	20,000	24,000	600,000	10	2.0	0.40
Torlon® 4301 PAI	15,000	22,000	800,000	3	0.8	0.40
Torlon® 5530 PAI	15,000	27,000	900,000	3	0.7	0.30
Celazole® PBI	20,000	50,000	950,000	3	0.5	0.40

Dynamic Modulus charts found on pages 8-10 of this brochure illustrate how engineering materials (Figure 7) and advanced engineering plastics (Figure 8) compare in stiffness as temperature increases. Dynamic modulus curves also graphically display a materials softening temperature.

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.

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.

For:	Choose:
Long lengths Small diameters Rod, plate, tubular bar, bushing stock	Extrusion
Large stock shapes Near net shapes Rod, plate, tubular bar, custom cast parts	Casting
Various shapes in advanced engineering materials Rod, disc, plate, tubular bar	Compression Molding
Small shapes in advanced engineering materials High Volumes (>10,000 Parts)	Injection Molding

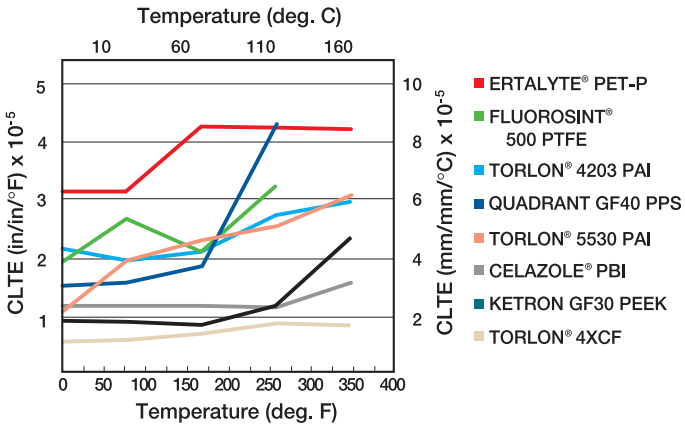
STEP 6

Determine the machinability of your material options.

Machinability can also be a material selection criterion. All of the Quadrant products in this brochure 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., Torlon® PAI and Celazole® 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 that begin on page 38 of this brochure (line 42).

Fig.6 - **COEFFICIENTS OF LINEAR THERMAL EXPANSION**



STEP 7

Make sure you receive what you specify.

The properties listed in this brochure are for Quadrant Engineering Plastic Products' materials only. Be sure you are not purchasing an inferior product. **Request product certifications when you order.**

Tech Notes:

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

We hope our candor about material strengths and weakness simplifies your selection process. For additional information, please contact Quadrant Engineering Plastic Product's Technical Service Department at 1-800-366-0300 or online.

DYNAMIC MODULUS

MODULUS

USING DYNAMIC MODULUS DATA IN MATERIAL SELECTION

Dynamic Modulus. What is it?

Most of us are familiar with the concept of elastic behavior. When a force (stress) is applied to an elastic material the material stretches by an amount

$$\Delta = \text{original length} \times \frac{\text{force per unit area (stress)}}{\text{stiffness (modulus)}}$$

Stress and modulus are frequently denoted by the letters sigma (σ) and (E) respectively. The amount of stretch is usually described as strain (e), the amount of stretch per unit length,

$$\varepsilon = \frac{\sigma}{E} \cdot$$

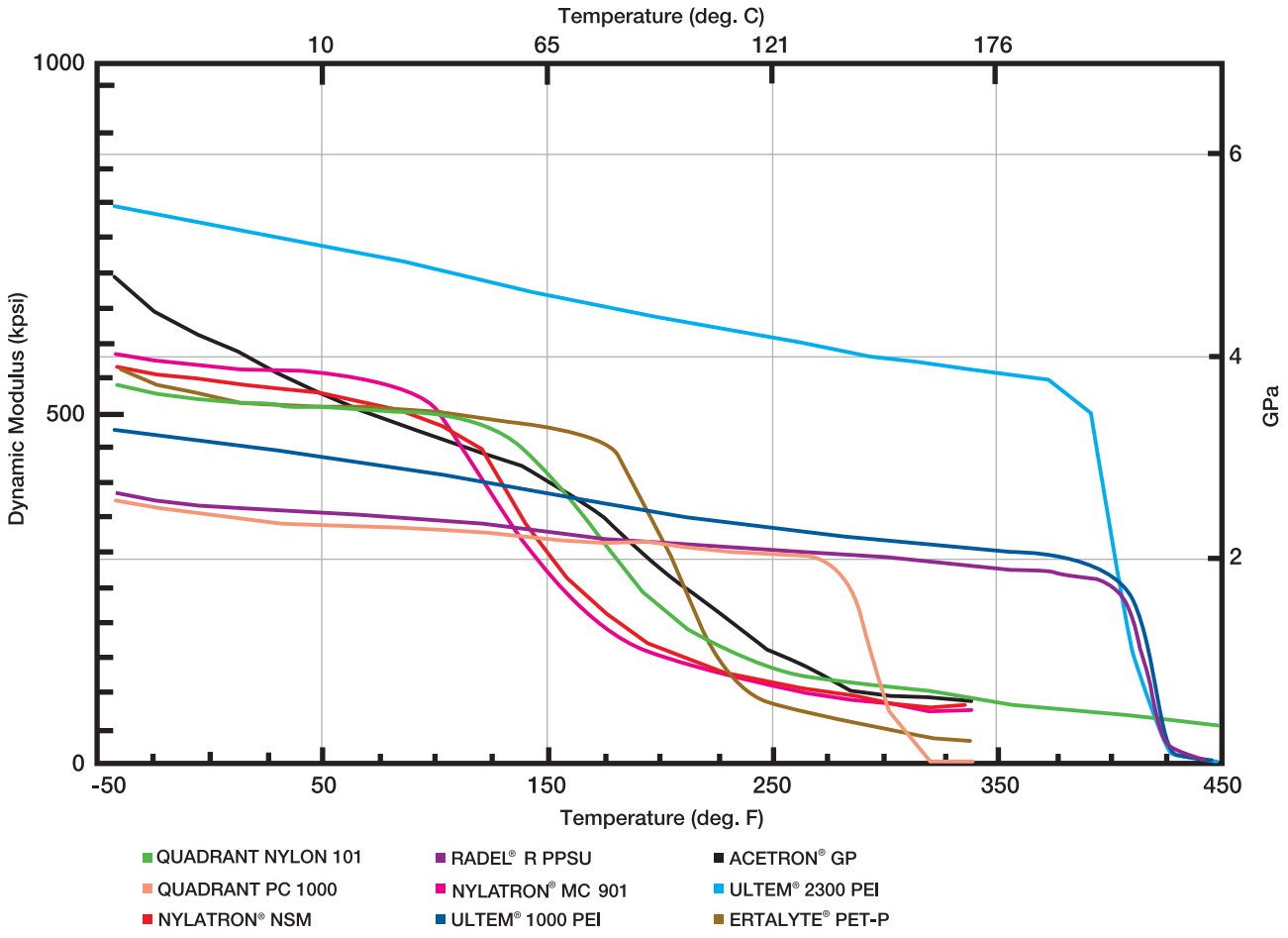
When a force is applied to a perfectly elastic material, it stretches a set amount until the force is removed. It then returns to its original length. No material is perfectly elastic, though some metals and ceramics come close if the strain is not too great. Plastics are viscoelastic. That means that although the equations above can be used to get a fair approximation of their response to load (provided the strain is low, generally 1% or less), the stiffness of the material will depend on how long the material is under load. A viscoelastic material will have a higher modulus, it will be stiffer, when a load is applied for a short time than when it is applied over a long time. We see this behavior as creep. A load which causes a minor deflection when applied for a few minutes causes a larger deflection when left on for several days. The modulus is temperature dependent as well. Materials generally get softer when they are heated and stiffer when they are cooled. The dynamic modulus (DM) curves shown in this publication show the elastic response (stiffness) of our materials to a short duration force at various temperatures. Creep data should be used to predict behavior when a material will be under continuous load for long times. Creep data is available from Quadrant Engineering Plastic Products' Technical Service Department (1-800-366-0300).

SO HOW DO YOU USE THE DYNAMIC MODULUS CURVES? HERE'S AN EXAMPLE.

Suppose your application involves a temperature of 160ºF. It is a dry application. Chemical resistance and wear properties are not critical. You might be considering Nylon 66, Acetal and PET-P. Their stiffness (moduli) at room temperature are fairly similar. All of them have heat deflection temperatures (HDT) well over 160ºF. Which one would be best? Heat deflection temperature tells you nothing more than how hot the material has to get before its stiffness drops to a particular value. For example, by looking at row 17 on pages 38 and 39 of this brochure you would know that Quadrant Nylon 101 at 200ºF is as stiff as Acetron® GP at 220ºF, which is as stiff as Ertalyte® PET-P at 240ºF. At these temperatures they will all have a modulus of about 148,000 psi. What you don't know is: do they retain their room temperature stiffness then soften suddenly at the HDT, or do they gradually soften as temperature is increased? By reviewing the DM curves (pages 9 and 10) you would observe that at 160ºF the dynamic modulus of Nylon 101 is 391,000 psi, Acetron® GP is 386,000 psi and Ertalyte® PET-P is 471,000 psi. At the application temperature Ertalyte® PET-P is over 20% stiffer than either nylon or acetal. If its important to limit deflection under load at this temperature, Ertalyte® PET-P is the better choice.

Dynamic modulus data is a valuable material selection tool.

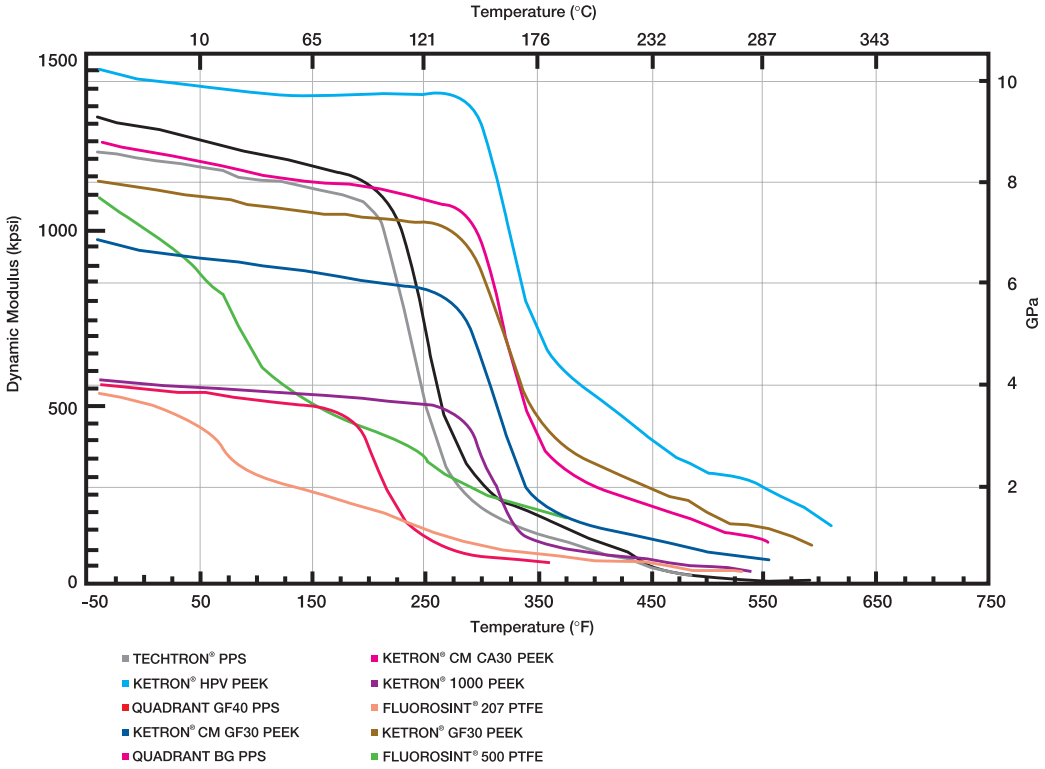
Fig.7 - **ENGINEERING PLASTICS & AMORPHOUS ADVANCED ENGINEERING PLASTICS**



These Dynamic Modulus charts illustrate how materials profiled in this brochure compare in stiffness as temperature increases.

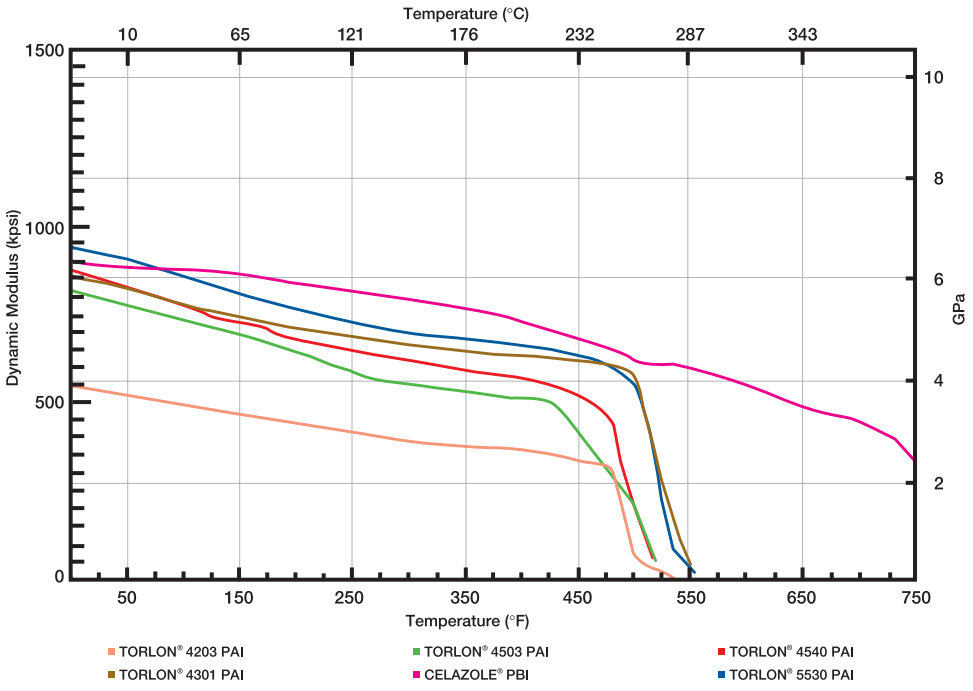
DYNAMIC MODULUS

Fig.8 - **CRYSTALLINE ADVANCED ENGINEERING PLASTICS**



These Dynamic Modulus charts illustrate how materials profiled in this brochure compare in stiffness as temperature increases.

Fig.9 - **IMIDIZED MATERIALS**



These Dynamic Modulus charts illustrate how materials profiled in this brochure compare in stiffness as temperature increases.

NYLON PRODUCTS

PRODUCT PROFILE

FIRST CHOICE FOR ALL GENERAL PURPOSE WEAR AND STRUCTURAL COMPONENTS

- **Broadest size range availability**
- **Good mechanical and electrical properties**
- **Ideal balance of strength and toughness**
- **Many grade options: FDA compliant, Internally lubricated, Heat stabilized**
- **Cast as finished parts and near net shapes (nylon 6)**

NYLON PRODUCTS

Nylon's toughness, low coefficient of friction and good abrasion resistance make it an ideal replacement for a wide variety of materials from metal to rubber. It weighs only 1/7 as much as bronze. Using nylon reduces lubrication requirements, eliminates galling, corrosion and pilferage problems, and improves wear resistance and sound dampening characteristics. Nylon has a proven record of outstanding service in a multitude of parts for such diverse fields as paper, textiles, electronics, construction, mining, metalworking, aircraft, food and material handling.

Nylon is easily fabricated into precision parts using standard metalworking equipment. Its good property profile combined with a broad size range availability have made the material very popular since we first introduced nylon stock shapes in 1946. Today, a variety of extruded and cast nylon grades are available to match specific application demands.

Since nylons are frequently used for wear applications, Table 2 and Figure 10 (on page 13) are provided to assist designers with material selection.

Quadrant is an ISO 9001:2000 registered company that provides full traceability and quality control from raw material to finished product. It is typically supplied in rod, plate, tubular bar or custom shapes including near net castings.

All Quadrant standard extruded and cast nylon grades are profiled on the following pages.

Table 2

Wear Rate, Coefficient of Friction and Limiting PV Data

Nylon	Wear Factor "k" (1)	Comparative Wear Rate to Nylatron® NSM	Coefficient of Friction Static (2)	Coefficient of Friction Dynamic (3)	Limiting PV (4)
Nylatron® NSM	12	1.0	.17–.25	.17–.23	15,000
Nylatron® GSM Blue	65	5.4	.17–.23	.17–.21	5,500
Nylatron® GSM	90	7.5	.21–.25	.19–.23	3,000
Standard Type 6 (a)	100	8.3	.21–.24	.21–.23	3,000
Nylon 6/6	80	6.7	.16–.20	.27–.31	2,700

(1) Measured on ½" I.D. journal at 5000 PV (118 fpm & 42.2 psi)

$K = h/PVT \times 10^{-10}$ (cu.in.min./ft.lb.hr.) where h =radial wear (in) P =normal pressure, (psi) V =sliding speed, (fm) T =test duration, (hrs)

(2) Measured on thrust washer bearing under a normal load of 50 lbs. Gradually increasing torque was applied until the bearing completed at 90° rotation in about one second.

(3) Measured on thrust washer testing machine, unlubricated @ 20 fpm & 250 psi.

(4) Limiting PV (Test value—unlubricated @ 100 fpm (lb.ft/in.2 min.) w/ 4x Safety Factor

(a) Equivalent to Quadrant's MC® 907.

Tech Notes:

Nylons can absorb up to 7% (by weight) water under high humidity or submerged in water. This can result in dimensional changes up to 2% and a corresponding reduction of physical properties. Proper design techniques can frequently compensate for this factor.

PRODUCT APPLICATION:

Sheaves

- **Problem:** *Heavy cast or stamped metal sheaves decreased performance of lifting equipment, required frequent lubrication and shortened the life of the expensive wire rope.*
- **Solution:** *Specially designed Nylatron® GSM sheaves eliminated these problems. Nylon sheaves can be easily machined or custom cast when larger series are required.*
- **Benefits:** *Nylatron GSM is seven times lighter than cast iron, reduces weight on the boom and eliminates corrosion.*

PRODUCT APPLICATION:

Industrial Bearings

- **Problem:** *Bronze bearings are heavy, noisy and require constant lubrication.*
- **Solution:** *Nylatron® NSM bearings can be quickly machined from the many stock sizes of tubular bar and address many of the problems associated with low-tech metal parts.*
- **Benefits:** *The weight reduction allowed by plastic bearings often means savings in other areas. This Nylatron NSM bearing lasts ten times longer than the unfilled cast nylon part that was supplied with the OE truck.*

NYLON PRODUCTS

PRODUCT APPLICATION:

Wear pads

- **Problem:** *Bronze or hybrid metal wear pads are very noisy, tough to lubricate, wear mating surfaces and markedly decrease the amount of control possible in a system.*
- **Solution:** *Machined pads made from Nylatron® nylons are quickly fabricated, easy to replace and improve the efficiency of equipment.*
- **Benefits:** *Lighter in weight than metal, Nylatron NSM or Nylatron 703XL can eliminate chatter and the loss of control associated with it. Higher load capabilities also mean a chance to reduce part size and the possibility of eliminating costly lubrication systems.*

PRODUCT APPLICATION:

Gears

- **Problem:** *Metal gears create noise, wear mating parts and require lubrication.*
- **Solution:** *Gears machined from Nylatron® nylons can solve these problems and be designed using Quadrant's Design and Fabrication Guide.*
- **Benefits:** *Nylatron gears can reduce noise, eliminate lubrication and act as a sacrificial link in a system, thus saving destruction of other costly components.*

	Small/Screw Machine Nylon Parts (Extruded-Type 6/6)	Larger or Near Net Nylon Shapes (Cast-Type 6 Nylons)
For general purpose wear and structural parts (FDA grades available)	**Quadrant Nylon 101** Of all the unmodified nylons, Nylon 101 is the strongest, most rigid and has one of the highest melting points. It is commonly specified for screw machined electrical insulators and food contact parts. It is stocked in both natural and black. Other colors are available on a custom basis. Nylon 101 natural is FDA, USDA, NSF, and 3A-Dairy compliant.	**Nylatron MC® 907 Nylon** Unmodified type 6 nylon offering the highest strength and hardness of the nylon 6 grades. MC 907 natural is FDA, USDA and 3A-Dairy compliant. It is off-white in color and primarily used for food contact parts. **Nylatron MC® 901 Nylon** Heat stabilized nylon offering long-term thermal stability to 260°F. It is blue in color and used in a variety of bearing and structural applications such as wheels, gears, and custom parts.
For improved load bearing capability	**Nylatron® GS Nylon** Molybdenum disulphide (MoS_2) filled nylon offering improved strength and rigidity. With a lower coefficient of linear thermal expansion than Nylon 101, Nylatron® GS parts maintain better fit and clearances, and have less tendency to seize as bearings.	**Nylatron® GSM Nylon** Nylatron GSM contains finely divided particles of molybdenum disulphide (MoS_2) to enhance its load bearing capabilities while maintaining the impact resistance inherent to nylon. It is the most commonly used grade for gears, sheaves, sprockets and custom parts. It is grey-black in color.
For improved load capacity in structural applications	**30% Glass-reinforced Nylon 6/6** For applications requiring higher compressive strength and rigidity, 30% glass reinforced Nylon 6/6 is also available. It is stocked in diameters ranging from 10mm to 150mm (or .394" to 5.910" in meter lengths).	

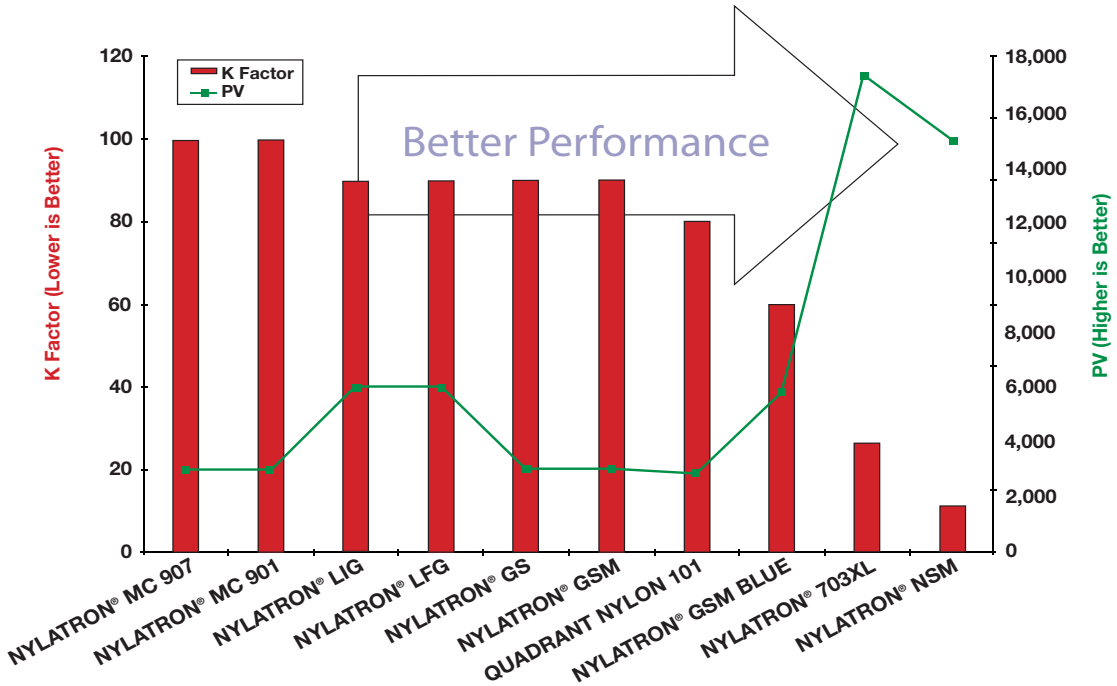
	Larger or Near Net Nylon Shapes (Cast - Type 6 Nylons)
For food contact applications where higher loads and a lower coefficient of friction are beneficial	**Nylatron® LFG** Nylatron LFG takes the performance of Nylatron LIG and adds FDA compliance for applications where food contact is possible. Food packaging and processing equipment users can now benefit from the wear resistance, toughness and low coefficient of friction of this nylon material.
For industrial applications where a lower coefficient of friction is beneficial	**Nylatron® LIG** Nylatron LIG combines the toughness of cast PA6 with an oil-based lubricant that is encapsulated within the nylon matrix. It increases the load bearing performance of the material when compared to unfilled nylons and reduces the coefficient of friction. It is an ideal material for industrial application in conveying and processing industries.
For high load applications where a lower coefficient of friction is needed	**Nylatron® GSM Blue Nylon** The first cast nylon to combine both molybdenum disulphide (MoS_2) and oil for the load capability of Nylatron GSM nylon, plus improved frictional characteristics. It excels in higher pressures, and at low speeds–up to 40 fpm. It offers 20% lower coefficient of friction, 50% greater limiting PV, and a lower "k" factor than Nylatron GSM, making it ideal for slide pads, thrust washers and trunion bearings. Nylatron GSM Blue should be considered for any oil-filled nylon application. It is dark blue in color.
For best wear resistance and lowest coefficient of friction	**Nylatron® NSM Nylon** **Still the best bearing and wear nylon product available today.** Proprietary type 6 nylon formulation produced using Quadrant's Monocast® process. Solid lubricant additives impart self-lubricating, high pressure/velocity and superior wear resistance characteristics. Nylatron NSM was developed specifically for demanding applications where larger size parts are required. It is ideal for bearings, gears and wear pads. **In wear applications, Nylatron NSM lasts up to 10 times longer than standard Type 6 nylon.**
The ultimate in control and load handling capability	**Nylatron® 703XL** This ultra-high performance bearing grade of PA6 provides wear resistance near the levels of Nylatron NSM with superior load bearing capability and an industry first - a near zero level of "stick-slip." This elimination of chatter provides an extraordinary amount of control for high-precision applications.

PRODUCT APPLICATION:

Diffuser Nozzle

- **Problem:** *A submerged stainless steel nozzle was costly to fabricate and a weighty challenge to manipulate.*
- **Solution:** *This custom cast Nylatron® MC901 part replaced a multi-piece assembly and improved performance.*
- **Benefits:** *Chemical and moisture resistance of plastics combined with the production efficiency of custom casting drastically reduced the cost in use of this part.*

Fig.10 - **WEAR RESISTANCE VS. LOAD BEARING CAPABILITY - NYLON MATERIALS**



ACETAL PRODUCTS

PRODUCT APPLICATION:

Scraper blades

- **Problem:** *Dairy nickel and stainless blades were costly and expensive to fabricate.*
- **Solution:** *Acetron® GP porosity-free POM-C plate is machined into scraper blades used in commercial ice cream manufacture.*
- **Benefits:** *The porosity-free Acetron GP blades are easily cleaned and do not entrap dirt or bacteria. The low stress level of Acetron GP means parts that are machined flat, stay flat.*

PRODUCT APPLICATION:

Industrial Bearings and bushings

- **Problem:** *Specialty metals and low-tech plastics don't perform well in some moist environments.*
- **Solution:** *Delrin® AF Blend from Quadrant excels in moist applications and offers longer part life.*
- **Benefits:** *Delrin AF Blend has a lower coefficient of friction than unfilled acetal and lasts longer in most applications. It offers good stability and chemical resistance.*

PRODUCT PROFILE

FOR GENERAL PURPOSE PARTS IN WET ENVIRONMENTS

- **Low moisture absorption**
- **High strength, stiffness**
- **Easy to machine**
- **No centerline porosity in Acetron® GP**
- **Many formulation options: Copolymer, Homopolymer, PTFE filled, and Internally lubricated/enhanced wear grade**

ACETAL PRODUCTS

Acetal provides high strength and stiffness coupled with enhanced dimensional stability and ease of machining. As a semi-crystalline material, acetal is also characterized by a low coefficient of friction and good wear properties—especially in wet environments.

Because acetal absorbs minimal amounts of moisture, its physical properties remain constant in a variety of environments. Low moisture absorption results in excellent dimensional stability for close-tolerance machined parts. In high moisture or submerged applications, acetal bearings outperform nylon 4 to 1. Acetal is ideally suited for close tolerance mechanical parts and electrical insulators which require strength and stiffness. It also offers resistance to a wide range of chemicals including many solvents.

Quadrant offers both homopolymer and copolymer grades of acetal including enhanced bearing grade materials. Acetron® GP acetal is porosity-free and offered as our standard general purpose grade. For slightly higher mechanical properties, we offer a broad size range of the homopolymer acetal (Delrin®) products. For improved frictional properties PTFE-enhanced Delrin AF products are available.

FDA Compliant Acetron® GP Colors

Red | Blue | Green | Yellow | Grey | Brown | Orange

Low minimums - Quick turnaround

Tech Notes:

In general, acetals do not perform as well in abrasive wear applications as nylons. Compensation for moisture related growth generally allows Nylatron® nylons to be used for wet, abrasive applications. If your application requires dimensional consistency in an abrasive, high humidity or submerged environment, Ertalyte® PET–P will often offer improved performance (see page 16).

ACETRON® GP ACETAL

Acetron® GP is Quadrant's general purpose copolymer acetal and is the only porosity-free acetal product available today. Investments in process technology by Quadrant now provide the performance and machinability of acetal without center core porosity. Our in-line photometric quality procedure assures every plate and rod is porosity-free making it the preferred acetal for food contact and medical applications. Acetron® GP natural and black are FDA, USDA, NSF, Canada AG and 3A-Dairy compliant.

DELRIN® ACETAL

Delrin, a homopolymer acetal, is also manufactured and stocked in rod and plate. It offers slightly higher mechanical properties than Acetron® GP Acetal, but may contain a low-density center, especially in larger cross-sections. Acetron® GP Acetal also offers better chemical resistance than homopolymer acetal.

Delrin is better suited for small diameter, thin-walled bushings that benefit from the additional strength and rigidity of homopolymer acetal.

DELRIN® AF BLEND

Delrin AF Blend is a unique thermoplastic material for use in moving parts in which low friction and long wear life are important. It is a combination of PTFE fibers uniformly dispersed in Delrin acetal resin. This combination offers better wear characteristics than unfilled Delrin.

Delrin AF Blend, supplied as a 2:1 blend of Delrin AF100 and Delrin 150 resins, has excellent sliding/friction properties. Bearings made of Delrin AF Blend can operate at higher speeds while exhibiting reduced wear. These bearings are also essentially free of slip-stick behavior because the static and dynamic coefficient of friction are closer than with most plastics.

Delrin AF Blend retains 90% of the strength that is inherent in unmodified Delrin acetal. Some properties are changed due to the addition of the softer PTFE fiber. The natural color of Delrin AF Blend is dark brown. Ertalyte® TX is a better value in many applications where Delrin AP blend is considered. Review Ertalyte® TX's performance or call our tech hotline for more information.

DELRIN® AF 100

coefficient of friction due to additional PTFE content. This added PTFE typically decreases the wear capability and impact strength. Delrin AF 100 is available on a custom basis.

Table 3

Wear Rate, Coefficient of Friction and Limiting PV Data*

Acetal	Wear Factor "k" (1)	Coefficient of Friction Static (2)	Coefficient of Friction Dynamic (3)	Limiting PV (4)
Delrin® AF Blend	60	.11–.21	.15–.23	8,300
Delrin® AF	56	.08–.24	.11–.25	11,980
Acetron® GP	200	.14–.20	.20–.24	2,700
Delrin®	200	.08–.22	.18–.26	2,700
Turcite® A (blue)	213	.30–.34	.20–.24	6,550
Turcite® X1 (red)	72	.28–.32	.20–.24	8,125

(1) Measured on ½" I.D. journal at 5000 PV (118 fpm & 42.2 psi)

K = h/PVT x 10^{-10} (cu.in.min./ft.lb.hr.) where h =radial wear (in) P =normal pressure, (psi) V =sliding speed, (fm) T =test duration, (hrs)

(2) Measured on thrust washer bearing under a normal load of 50 lbs. Gradually increasing torque was applied until the bearing completed at 90° rotation in about one second.

(3) Measured on thrust washer testing machine, unlubricated @ 20 fpm & 250 psi.

(4) Limiting PV (Test value—unlubricated @ 100 fpm (lb.ft/in.2 min.) w/ 4x Safety Factor

PRODUCT APPLICATION:

Gears

- **Problem:** *Clean In Place (CIP) equipment cleaning is a challenge for many metal gears.*
- **Solution:** *Acetron® GP gears are easily fabricated and stand up to repeated cleaning cycles.*
- **Benefits:** *Acetron GP's excellent chemical resistance, low internal stress and dimensional stability add up to better performance particularly in food processing and packaging applications.*

PRODUCT APPLICATION:

Rollers

- **Problem:** *Metal rollers in cargo truck lifts were being damaged in use.*
- **Solution:** *Impact resistant Acetron® GP rollers absorb collisions with loading docks without deforming and causing the system to fail.*
- **Benefits:** *Lighter weight and an ability to bounce-back made tight tolerance Acetron GP rollers a better choice than other materials.*

ERTALYTE® PET-P

PRODUCT APPLICATION:

Piston and valves

- **Problem:** *Various materials were being used in a food filling line.*
- **Solution:** *Standardizing on Ertalyte® PET-P helped the manufacturer broaden the reach of their product by offering greater accuracy and higher performance.*
- **Benefits:** *Ertalyte is very dimensionally stable and extremely resistant to moisture. These properties, combined with good chemical resistance gave the manufacturer a system-wide solution.*

PRODUCT APPLICATION:

Manifold

- **Problem:** *A manufacturer was using aluminum for precision work and acetal with expensive inserts for less demanding applications.*
- **Solution:** *Ertalyte® met design criteria all of the manufacturers products.*
- **Benefits:** *The new design was able to maintain the tight tolerances needed and offer improved stain and chemical resistance.*

PRODUCT PROFILE

STABILITY OF ACETAL

- **Good for both wet and dry environments**
- **High strength and rigidity—ideal for close tolerance parts**
- **Excellent stain resistance**
- **Good wear resistance and excellent dimensional stability**
- **Better resistance to acids than nylon or acetal**

ERTALYTE® PRODUCTS

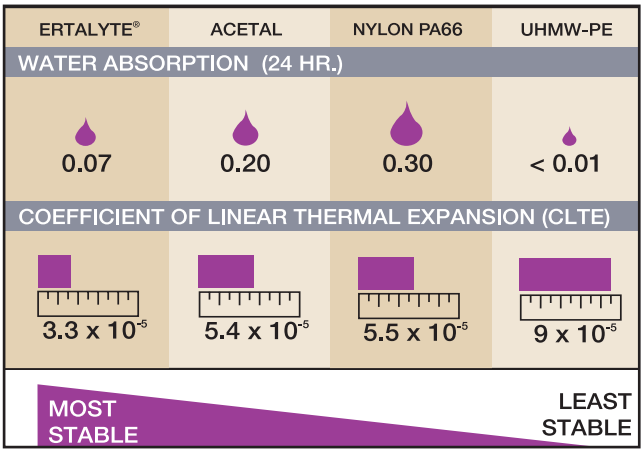
ERTALYTE® PET-P

Ertalyte® is an unreinforced, semi-crystalline thermoplastic polyester based on polyethylene terephthalate (PET-P). It is manufactured from proprietary resin grades. Only Quadrant can offer Ertalyte®. It is characterized as having the best dimensional stability coupled with excellent wear resistance, a low coefficient of friction, high strength, and resistance to moderately acidic solutions. Ertalyte®'s properties make it especially suitable for the manufacture of precision mechanical parts which are capable of sustaining high loads and enduring wear conditions. Ertalyte®'s continuous service temperature is 210°F (100°C) and its melting point is almost 150°F higher than acetals. It retains significantly more of its original strength up to 180°F (85°C) than nylon or acetal (see Figure 9).

In addition, Ertalyte® PET-P offers good chemical and abrasion resistance. Its low moisture absorption enables mechanical and electrical properties to remain virtually unaffected by moisture (see Figure 11). Ertalyte® PET-P can be machined to precise detail on standard metal working equipment.

Ertalyte® is FDA compliant in natural and black. Natural Ertalyte® is also USDA, 3A-Dairy and Canada AG compliant. Ertalyte® is an excellent candidate for parts used in the food processing and equipment industries.

Fig. 11 - **STABILITY OF ENGINEERING MATERIALS**



Tech Notes:

Because it is more rigid and offers greater thermal performance than nylon and acetal, Ertalyte machines differently. For best results, please request a copy of Quadrant's design and fabrication guideline for Ertalyte® PET–P. Ertalyte® and other polyesters have less resistance to hot water than Acetron® GP acetal.

ERTALYTE® TX

Ertalyte® TX is an internally lubricated thermoplastic polyester providing enhanced wear and inertness over general purpose nylon(PA) and acetal(POM) products. Containing uniformly dispersed solid lubricant, Ertalyte® TX provides a lower wear rate and coefficient of friction than unmodified polyesters like PET or PBT and even internally lubricated materials like Delrin® AF blend.

Ertalyte® TX excels under both high pressure and velocity conditions. It is also ideally suited for applications involving soft metal and plastic mating surfaces.

Fig. 12 - **WEAR RATE (k-factor)**

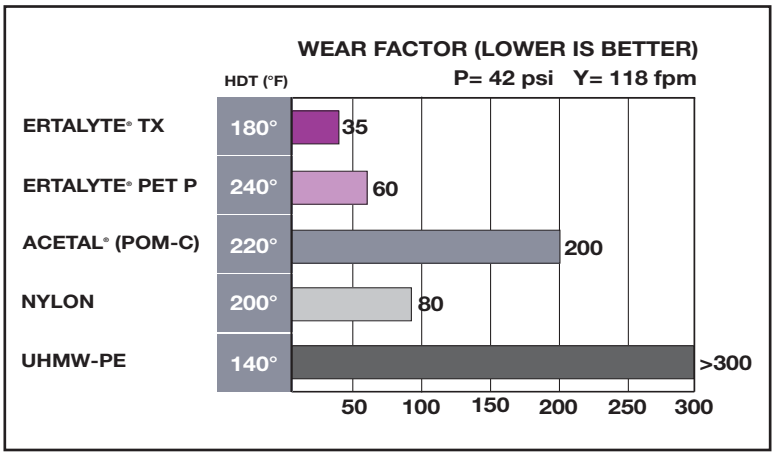
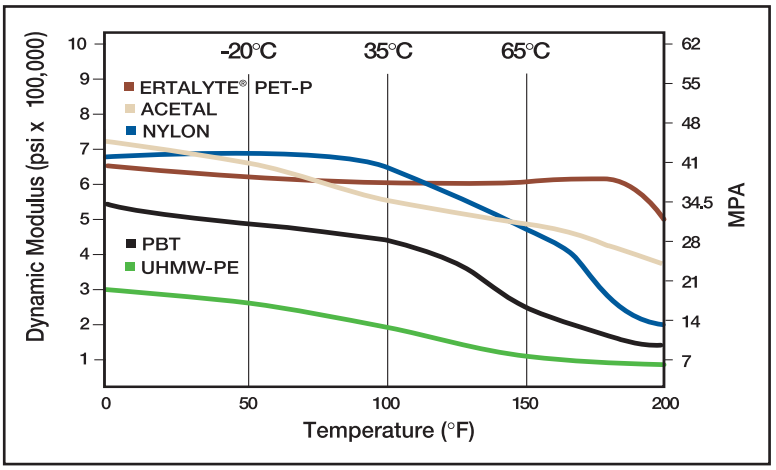
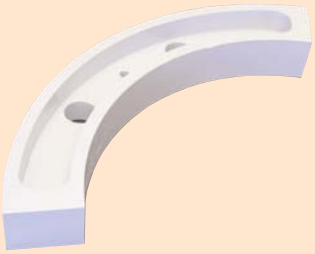


Fig. 13 - **ERTALYTE® OFFERS BETTER STRENGTH IN HIGHER TEMPS**

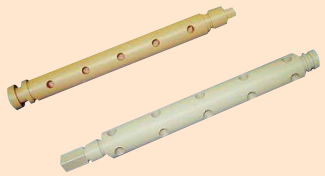




PRODUCT APPLICATION:

Processing equipment bearing

- **Problem:** *A food manufacturer was tired of costly wear of stainless steel parts.*
- **Solution:** *Ertalyte® TX bearings replaced stainless parts that caused contamination and required frequent maintenance.*
- **Benefits:** *FDA compliant Ertalyte TX wears well against other plastics and metals. Its solid lubricant reduces noise and lasts longer than unfilled materials.*



PRODUCT APPLICATION:

Distribution valves

- **Problem:** *High process unit temperatures warped portioning unit components. Additional cooling equipment was required to package hot products.*
- **Solution:** *Quadrant offered Ertalyte® TX for moderate temperature packaging and Ketron® 1000 PEEK for high temperature use.*
- **Benefits:** *Ertalyte TX's dimensional stability and wear resistance drastically improved part life. More costly Ketron 1000 PEEK was also used in specialty units where much higher temperatures were required. The manufacturer was able to eliminate the chilling unit.*

PC 1000

PRODUCT APPLICATION:

Laser housing

- **Problem:** *A housing on laser test equipment was performing, but too costly.*
- **Solution:** *The same housing, machined from PC 1000 polycarbonate performed in the application and met cost targets.*
- **Benefits:** *Good dielectric and UV resistance were required - PC 1000 provided the needed strength and impact resistance.*

PRODUCT APPLICATION:

Manifolds

- **Problem:** *Many industries using acrylic parts need transparent manifolds and sight glasses that can withstand higher temperatures and impact.*
- **Solution:** *PC 1000 is easily machined into these parts and meets the higher performance needs.*
- **Benefits:** *PC 1000 has far higher temperature resistance than acrylic and offers greater impact resistance.*

PRODUCT PROFILE

HIGH IMPACT STRENGTH WITH HEAT RESISTANCE TO 250°F CONTINUOUS USE (120°C)

- **Excellent impact resistance, toughness and elongation properties**
- **Transparent**
- **Good dielectric properties**
- **Economical thermal performance**

PC 1000 POLYCARBONATE

PC 1000 machine grade polycarbonate (PC) is a transparent amorphous thermoplastic which offers very high impact strength and high modulus of elasticity. The material has a 290°F (145°C) heat deflection temperature at 264 psi, absorbs very little moisture and resists acidic solutions. These properties, in addition to good electrical characteristics, make PC 1000 machine grade polycarbonate stock shapes an excellent choice for electrical/electronic applications (see Figures ? and ?). Its strength, impact resistance and transparency also make it an ideal material for transparent structural applications such as sight glasses and windows.

PC 1000 machine grade polycarbonate is stress relieved making it ideal for close tolerance machined parts. Our stock shapes are produced from polycarbonate resins which meet the requirements of ASTM D 3935.

A glass fiber reinforced polycarbonate grade is available upon request.

Fig. 14 - **TENSILE STRENGTH VS. TEMPERATURE**

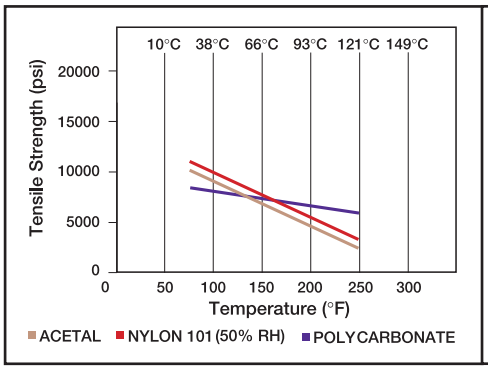
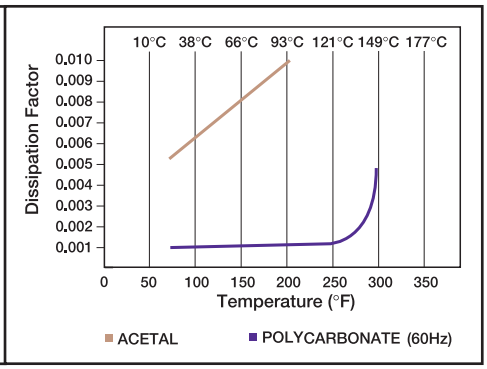


Fig. 15 - **DISSIPATION FACTOR**



Tech Notes:

PC 1000 polycarbonate is machine grade, not optically clear. It can be both mechanically and vapor polished to improve optical clarity. Caution: During machining, never use coolants with an aromatic base.

PSU 1000

PRODUCT PROFILE

HOT WATER & STEAM PERFORMANCE TO 300°F (150°C)

- **Broad temperature range capability**
- **Good thermal and electrical insulation characteristics**
- **Hydrolysis resistant**
- **Radiation stability**
- **Low ionic impurity**

PSU 1000 POLYSULFONE

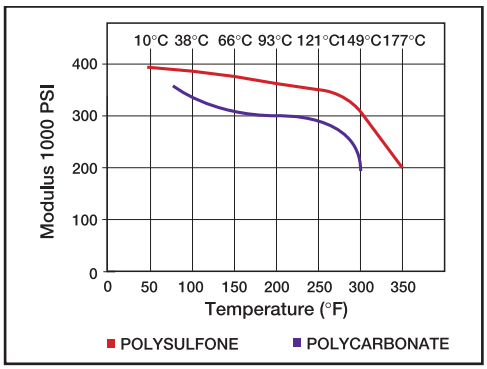
PSU 1000 Polysulfone (PSU) is an amber semi-transparent, heat-resistant, high performance engineering thermoplastic. It offers excellent mechanical, electrical and improved chemical resistance properties relative to polycarbonate. Polysulfone's properties remain relatively consistent over a broad temperature range, from –150°F (–100°C) to 300°F (100°C).

PSU 1000 Polysulfone is hydrolysis resistant for continuous use in hot water and steam at temperatures up to 300°F. Its flame resistance is UL 94-V-0 at 1/4" thickness (6.35mm) and UL 94-V-2 at 1/8" thickness (3.175mm).

PSU 1000 Polysulfone offers high chemical resistance to acidic and salt solutions, and good resistance to detergents, hot water and steam. In addition, polysulfone has excellent radiation stability and offers low ionic impurity levels. PSU 1000 Polysulfone often replaces polycarbonate when higher temperatures, improved chemical resistance or autoclavability is required (see Figure 17). It is commonly used for analytical instrumentation, medical devices and semiconductor process equipment components.

Custom colors can be made to order. Quadrant's PSU 1000 is FDA, USDA, 3A-Dairy compliant and NSF compliant under standards 51 and 61.

Fig. 16 - **FLEXURAL MODULUS VS. TEMPERATURE**



PRODUCT APPLICATION:

Medical carrier

- **Problem:** *Cleaning aluminum parts was tedious and costly.*
- **Solution:** *Parts fabricated from PSU 1000 easily replaced ineffective aluminum.*
- **Benefits:** *The PSU 1000 parts were able to be steam cleaned and more easily dealt with lab chemicals and radiation.*

PRODUCT APPLICATION:

Dialysis equipment components

- **Problem:** *Smaller, lighter equipment is being requested from medical device designers.*
- **Solution:** *PSU 1000 replaced the stainless steel parts used on early designs.*
- **Benefits:** *PSU 1000 is nearly 7 times lighter than stainless steel. - The plastic material easily withstands repeated autoclave cycles.*

Tech Notes:

Polysulfone is not a wear material and may stress craze under high pressures in certain chemical environments. Contact Quadrant's Technical Support Team for help at 800-366-0300 or www.quadrantplastics.com.

RADEL® R PPSU

PRODUCT APPLICATION:

Precision filter components

- **Problem:** *Weight and cleaning processes made stainless steel filter equipment impractical and inefficient.*
- **Solution:** *Varied housings and end caps were machined from lightweight, steam resistant Radel R.*
- **Benefits:** *Drastically reduced part weight yielding a more useful end product. - Allowed unlimited hot water and steam cleaning without part replacement.*

PRODUCT APPLICATION:

Medical wands

- **Problem:** *Fatigue caused by heavy steel tools reduced efficiency of medical personnel.*
- **Solution:** *Instrument handles machined from Radel R improved performance of surgical teams.*
- **Benefits:** *Lighter weight, greater impact resistance and improved autoclavability made Radel R the material of choice in structural medical applications.*

Endoscopic probe positioning ferrule

- **Problem:** *The coated stainless steel wore the mating parts and required constant maintenance.*
- **Solution:** *Intricately machined Radel R ferrules eliminated the wear while offering other benefits.*
- **Benefits:** *Low moisture absorption and good dimensional stability were critical. In addition were the benefits of easy cleaning and improved impact resistance.*

PRODUCT PROFILE

BEST IMPACT & STEAM RESISTANCE TO 400°F (205°C)

- **Highly resistant to steam autoclaving**
- **Impact resistant**
- **High modulus of elasticity and heat resistance**

NOW FDA COMPLIANT

RADEL® R PPSU

Radel® R polyphenylsulfone (PPSU) is an amorphous high performance thermoplastic offering better impact resistance and chemical resistance than polysulfone and polyetherimide (Ultem® PEI).

Radel offers superior hydrolysis resistance when compared to other amorphous thermoplastics as measured by steam autoclaving cycles to failure. In fact, Radel R has virtually unlimited steam sterilizability (see Table 4). This factor makes it an excellent choice for medical devices as steam autoclaves are widely used to sterilize medical devices. It also resists common acids and bases– including commercial washing solutions– over a broad temperature range.

Radel R is available from stock in natural (bone white) and made to order in transparent and custom colors. It is commonly used in sterilization trays, dental and surgical instrument handles, and in fluid handling coupling and fitting applications. Radel R is USP Class VI compliant.

It is suitable for use in electronic assembly equipment and devices that must withstand solder temperatures. Radel has a heat deflection temperature of 405°F (207°C). Radel is FDA compliant and NSF compliant under standards 51 and 61.

Table 4

Steam Autoclave Resistance	
Flexural Stress 1400 psi (9.7 MPa)	Cycles to Crazing
Radel® R	>2000
Ultem 1000	900
Polysulfone	50
Polyethersulfone	45

Fig. 17 - **TENSILE IMPACT VS. STEAM CYCLES**

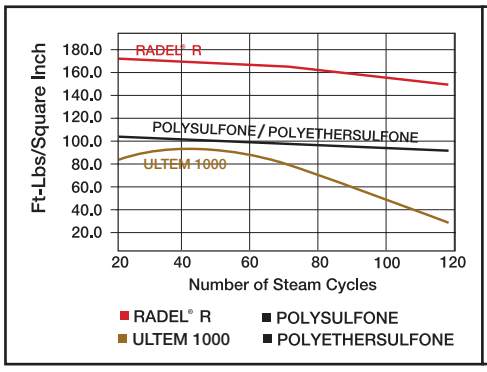
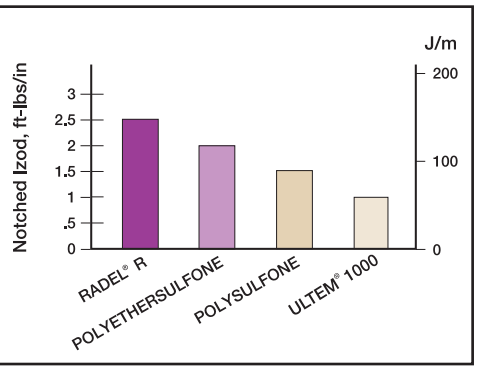


Fig. 18 - **NOTCHED IZOD COMPARISON**



Tech Notes:

Radel R has been approved for use in a variety of medical devices, it is FDA compliant and is appropriate for food contact applications. Radel is not a wear material, and its properties degrade when exposed to sunlight.

ULTEM® PEI

PRODUCT PROFILE

HIGH STRENGTH & HEAT RESISTANCE, PLUS EXCELLENT DIELECTRIC PROPERTIES

- **High strength and performs in continuous use to 340°F (170°C)**
- **High dielectric strength**
- **UL 94-V-0 rated with low smoke**
- **Available in glass-reinforced grades**

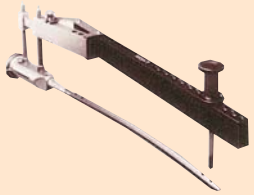
ULTEM® PEI

Ultem l000 polyetherimide (PEI) is an amorphous polymer offering high strength and excellent flame and heat resistance. It performs continuously to 340°F (170°C), making it ideal for high strength/ high heat applications, and those requiring consistent dielectric properties over a wide frequency range. It is hydrolysis resistant, highly resistant to acidic solutions and capable of withstanding repeated autoclaving cycles.

Ultem 2100, 2200 and 2300 are glass-reinforced versions (10, 20, and 30%, respectively) of Ultem 1000 which provide even greater rigidity and improved dimensional stability while maintaining many of the useful characteristics of basic Ultem. Ultem 1000 is FDA and USP Class VI compliant. FDA compliant colors of Ultem are also available on a custom basis.

Ultem commonly is machined into parts for reusable medical devices, analytical instrumentation, electrical/electronic insulators (including many semiconductor process components) and a variety of structural components requiring high strength and rigidity at elevated temperatures.

Quadrant offers a broad range of Ultem 1000 and Ultem 2300 shapes from stock.



PRODUCT APPLICATION:

Sighting Arm

- **Problem:** *Orthopedic surgeons needed a more durable device that didn't require exposure to x-rays.*
- **Solution:** *Ultem 1000 allows the doctor to realign the fracture, lock the beam and drill holes for the required titanium screws.*
- **Benefits:** *Ultem 1000 has greater impact resistance than polysulfone and doesn't require the surgeon to be exposed to x-rays as the original steel part forced.*

PRODUCT APPLICATION:

Insulators

- **Problem:** *Costly, brittle ceramics were constantly being broken during installation of these microwave communication insulators.*
- **Solution:** *Durable Ultem 1000 was easily machined into the parts required.*
- **Benefits:** *Ultem 1000 has drastically greater impact resistance then the original ceramic - Ultem materials have excellent dielectric properties.*

Fig. 19 - **FLEXURAL MODULUS @ 73ºF (23ºC)**

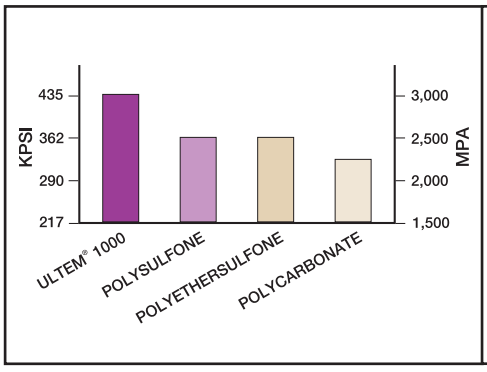
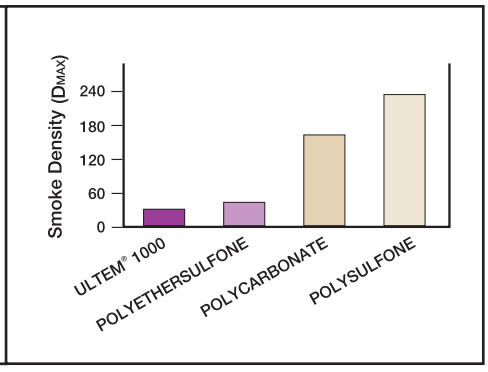


Fig. 20 - **SMOKE EVOLUTION BY NBS TEST**



Tech Notes:

Since Ultem is an amorphous material, selection of appropriate non-aromatic coolants during machining is important. Care must also be used in selecting adhesives and designing press fit components to avoid stress cracking. Contact Quadrant's Technical Support Team for help at 800-366-0300 or www.quadrantplastics.com. Ultem is not designed for use in bearing and wear applications.

FLUOROSINT®

PRODUCT APPLICATION:

Floating Seals

- **Problem:** *A manufacturer that wanted to improve performance in a rotary airlock needed a material with the performance of PTFE and the dimensional stability of a more rigid thermoplastic.*
- **Solution:** *Replacing the graphite-filled PTFE parts with Fluorosint® 500 seals allowed performance gains across the -200°F (-130 C) to 450°F (230°C) operating range.*
- **Benefits:** *With longer part life, better dimensional stability and virtually no wear to mating parts, Fluorosint® 500 reduced maintenance and motor load.*

PRODUCT APPLICATION:

Labyrinth and shroud seals

- **Problem:** *Seals made from aluminum, bronze or Babbitt caused mating part wear that decreased the efficiency of turbo compressors.*
- **Solution:** *Redesigned abradable seals machined from Fluorosint® 500 tubular bar dramatically improved efficiency and helped protect other parts from damage.*
- **Benefits:** *Fluorosint's excellent chemical resistance and forgiving composition can greatly improve the performance of rotating equipment while dealing with shaft movement and pressure changes that can damage metallic seals.*

PRODUCT PROFILE

MOST DIMENSIONALLY STABLE PTFE-BASED PRODUCT

- **Chemical resistance parallels PTFE**
- **Continuous use temperatures to 500°F (260°C)**
- **Better wear resistance than PTFE**
  - **– higher load carrying capability**
  - **– 1/9 of the deformation under load**
  - **– lower coefficient of thermal expansion**

FLUOROSINT® PRODUCTS

Fluorosint's unique properties are the result of a proprietary process in which synthetically manufactured mica is chemically linked to PTFE. This bonding results in properties not normally attainable in reinforced PTFE. Fluorosint grades offer an excellent combination of low frictional properties and dimensional stability.

FLUOROSINT® 500

Fluorosint® 500 has nine times greater resistance to deformation under load than unfilled PTFE (see Figure 21). Its coefficient of linear thermal expansion approaches the expansion rate of aluminum, and is 1⁄5 that of PTFE—often eliminating fit and clearance problems (see Figure 22). It is 1⁄3 harder than PTFE, has better wear characteristics and maintains low frictional properties. Fluorosint® 500 is also non-abrasive to most mating materials.

FLUOROSINT® 207

Fluorosint® 207's unmatched dimensional stability, excellent creep resistance and white color uniquely position this material to serve FDA regulated applications. It is non-permeable in steam and complies with the FDA's regulation 21 CFR 175.300. Its relative wear rate is 1⁄20 the rate of PTFE below 300°F (150°C) making it an excellent choice for aggressive service bearings and bushings.

Tech Notes:

Due to its PTFE matrix, Fluorosint's physical strength characteristics are not as high as other advanced engineering plastics profiled in this guide (i.e., Ketron® PEEK, Torlon® PAI).

Fig. 21 - **DEFORMATION UNDER LOAD**

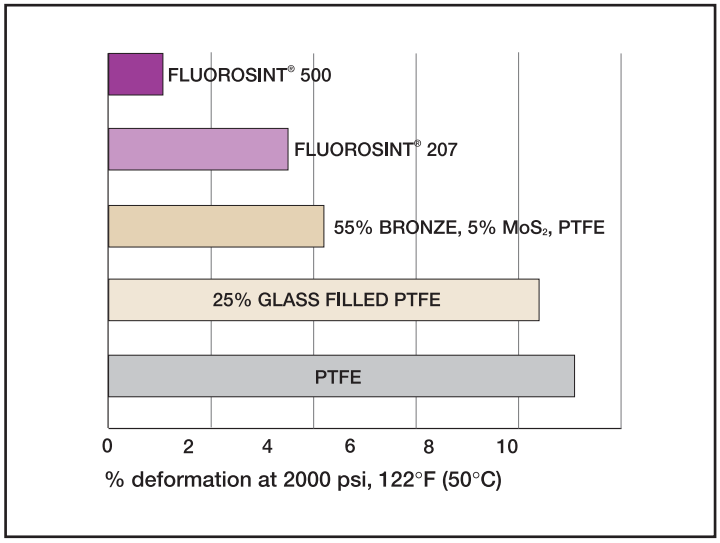
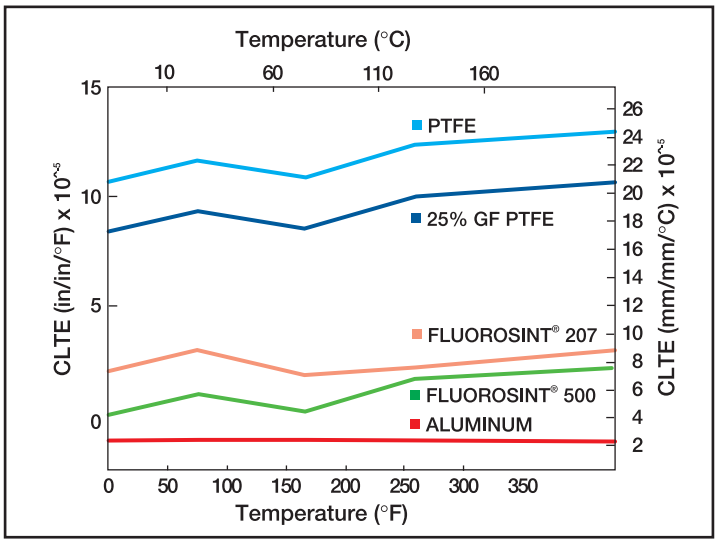


Fig. 22 - **COEFFICIENTS OF LINEAR THERMAL EXPANSION**

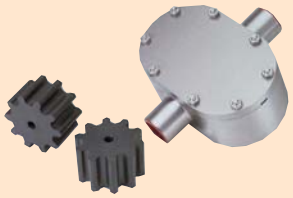


PRODUCT APPLICATION:

Valve seats and seals

- **Problem:** *PTFE seals can easily deform or change shape after machining and installation.*
- **Solution:** *Seats and seals machined from Fluorosint® 207 can maintain the required dimensions and provide the sealing performance needed in challenging services like steam and hot air.*
- **Benefits:** *Fluorosint's dimensional stability is significantly better than that of virgin or low-tech filled PTFE's. It also offers excellent chemical resistance and non-permeability to hot air and steam.*

TECHTRON® & QUADRANT PPS



PRODUCT APPLICATION:

Flow meter rotors

- **Problem:** *A manufacturer used four different materials for a line of industrial flow meters. Inventories and spare parts were required in each material to service customers.*
- **Solution:** *Quadrant compression molded (CM) PPS met the performance criteria for every model and allowed the manufacturer to standardize the rotor material.*
- **Benefits:** *The Quadrant PPS grade is very dimensionally stable and able to withstand the broad range of chemicals that can be present in the application.*

PRODUCT APPLICATION:

Pump lantern rings

- **Problem:** *Pumps used in mining applications were requiring frequent, costly service and reducing output because of downtime.*
- **Solution:** *Quadrant bearing grade (BG) PPS replaced the bronze parts in the original design and reduced wear while increasing efficiency.*
- **Benefits:** *The new PPS parts were machined to tight tolerances reducing recirculation while offering wear resistance that bronze could not match.*

PRODUCT PROFILE

EXCEL IN CORROSIVE ENVIRONMENTS TO 425°F (220°C)

- **Excellent chemical resistance**
- **Essentially zero moisture absorption**
- **Machines to tight tolerances**
- **Excellent alternative to PEEK at lower temperatures**

TECHTRON® & QUADRANT PPS

PPS (polyphenylene sulfide) products offer the broadest resistance to chemicals of any advanced engineering plastic. They have no known solvents below 392°F (200°C) and offer inertness to steam, strong bases, fuels and acids. Minimal moisture absorption (see Figure 25) and a very low coefficient of linear thermal expansion, combined with Quadrant's proprietary stress relieving processes, make these PPS products ideally suited for precise tolerance machined components. In addition, PPS products exhibit excellent electrical characteristics and are inherently flame retardant.

NOW FDA COMPLIANT

TECHTRON® PPS

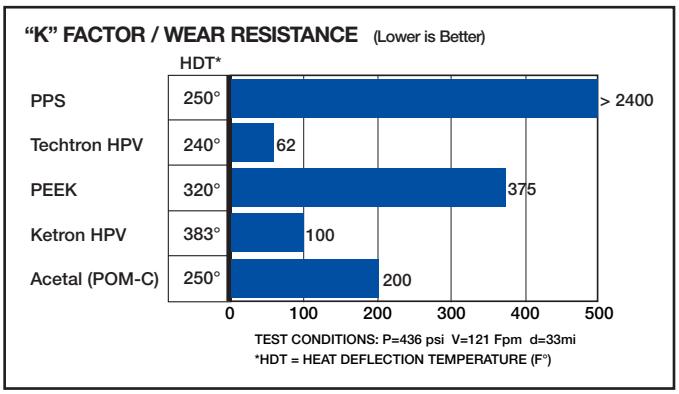
Unlike reinforced PPS products, Techtron® PPS is easily machined to close tolerances. It is ideal for structural applications in corrosive environments or as a PEEK replacement at lower temperatures. Techtron® PPS is off white in color. Techtron® PPS is FDA compliant.

TECHTRON® HPV

Techtron® HPV exhibits excellent wear resistance and a low coefficient of friction. It overcomes the disadvantages of virgin PPS caused by a high coefficient of friction, and of glass fibre reinforced PPS which can cause premature wear of the counterface in moving-part applications.

- Excellent wear and frictional behavior
- Excellent chemical and hydrolysis resistance
- Very good dimensional stability
- Good electrical insulating and dielectric properties
- Inherent low flammability
- Excellent resistance against high energy radiation

Fig. 23 - **TEMPERATURE RESISTANCE**



Tech Notes:

All Quadrant EPP's PPS products offer dimensional stability and strength at moderate temperatures. They are rated for continuous service to 425°F (220°C), but strength and stiffness vary based on temperature and grade. Unreinforced Techtron® PPS is generally not recommended for wear applications. Products like Techtron® HPV, Torlon® PAI or Ketron® PEEK are better selections for wear applications. When designing with Quadrant's compression molded grades, it is important to note its relatively low elongation and impact strength.

QUADRANT GF40 PPS

This product is the most recognized PPS. It is a compression molded analogue to Ryton R4 resin. It offers better dimensional stability and thermal performance than Techtron® PPS and maintains its strength to above 425°F (220°C).

QUADRANT BG PPS

Bearing-grade Ryton is internally lubricated and carbon fiber reinforced compression molded PPS offering a low coefficient of thermal expansion and uncompromised chemical resistance. It is well suited for and wear applications or when an electrically conductive material is required.

Fig. 24 - **CHEMICAL RESISTANCE**

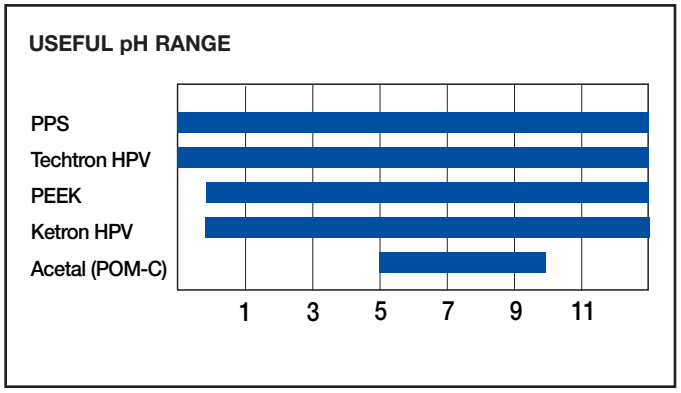
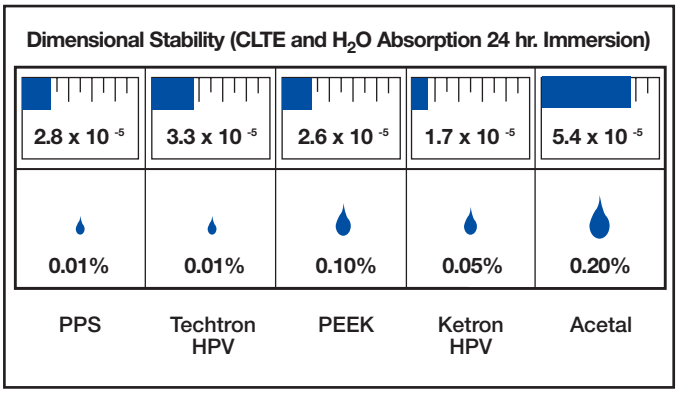


Fig. 25 - **DIMENSIONAL STABILITY**



PRODUCT APPLICATION:

CMP retaining rings

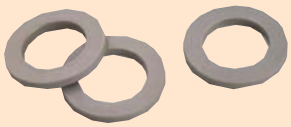
- **Problem:** *Manufacturers of semiconductors needed a material that could maintain critical dimensions and withstand a broad array of aggressive chemicals in an application where developed wafers were being polished.*
- **Solution:** *Techtron® PPS replaced coated metals, acetal, polyester and range of other materials that could deliver the package of benefits that Techtron offers.*
- **Benefits:** *Excellent chemical resistance, superior dimensional stability and ease of machining has made Techtron PPS the premier material for CMP consumables.*

PRODUCT APPLICATION:

Processing equipment bearing

- **Problem:** *A manufacturer of food processing equipment needed a material that could withstand aggressive wash down cycles and perform without lubrication.*
- **Solution:** *Techtron® HPV was used as a bearing in this new unit that offered a more compact, less complicated design that was capable of higher speed and greater output.*
- **Benefits:** *In the past only exotic materials would have worked in this elevated temperature application where lubrication wasn't possible and chemicals were present during cleaning. Techtron HPV PPS combines the chemical resistance of PPS with the wear resistance and performance of premium bearing materials.*

KETRON® PEEK



PRODUCT APPLICATION:

Valve seat

- **Problem:** *Premature replacement of a glass-filled PTFE seat caused excessive warranty expense for a manufacturer of industrial cleaning equipment.*
- **Solution:** *Ketron® 1000 PEEK replaced the poppet seat and allowed increased reliability of the mixing unit in the cleaning equipment.*
- **Benefits:** *Hydrolysis resistant and far more stable than any PTFE, Ketron 1000 PEEK retains its properties after thousands of hours of operation.*

PRODUCT APPLICATION:

Pump wear rings

- **Problem:** *Centrifugal pump wear parts were failing due to corrosion and galling.*
- **Solution:** *The bronze parts shipped with the original units were replaced with Quadrant's Ketron® CA30 PEEK. The PEEK rings eliminated the problem and increased the efficiency of the units.*
- **Benefits:** *The chemical resistance, temperature resistance and good stability of carbon fiber filled PEEK form the ideal material for high temperature, close tolerance applications where chemicals are present.*

PRODUCT PROFILE

CHEMICALLY RESISTANT STRUCTURAL AND BEARING & WEAR MATERIAL FOR CONTINUOUS USE TO 480°F (250°C)

- **Excellent chemical resistance**
- **Very low moisture absorption**
- **Inherently good wear and abrasion resistance**
- **Unaffected by continuous exposure to hot water or steam**

EXTREME MATERIALS

KETRON®

Ketron® PEEK grades offer chemical and hydrolysis resistance similar to PPS, but can operate at higher temperatures. PEEK 1000 offers steam and wear resistance, while carbon-reinforced PEEK provides excellent wear capabilities. Our latest grade, PEEK HPV, offers outstanding bearing performance. PEEK can be used continuously to 480°F (250°C) and in hot water or steam without permanent loss in physical properties.For hostile environments, PEEK is a high strength alternative to fluoropolymers. PEEK carries a V-O flammability rating and exhibits very low smoke and toxic gas emission when exposed to flame.

NOW FDA COMPLIANT

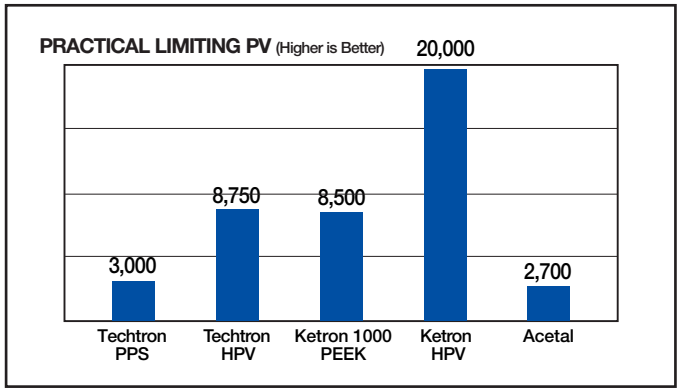
KETRON® 1000 PEEK

This general purpose grade is unreinforced and offers the highest elongation and toughness of all PEEK grades. The newly available black PEEK 1000 is ideal for instrument components where aesthetics are important, as well as for seal components where ductility and inertness are important. Ketron® 1000 PEEK is FDA compliant.

KETRON® GF30 PEEK (30% GLASS-REINFORCED)

The addition of glass fibers significantly reduces the expansion rate and increases the flexural modulus of PEEK. This grade is ideal for structural applications that require improved strength, stiffness or stability, especially at temperatures above 300°F (150°C).

Fig. 26



Tech Notes:

The stiffness of all PEEK grades drops off significantly and expansion rate increases above its glass transition temperature (Tg) of 300°F (150°C). A material like Torlon® PAI would be better suited for close tolerance bearings or seals operating at temperatures higher than 300°F (150°C).

KETRON® CA30 PEEK (30% CARBON FIBER-REINFORCED)

The addition of carbon fibers enhances the compressive strength and stiffness of PEEK, and dramatically lowers its expansion rate. It offers designers optimum wear resistance and load carrying capability in a PEEK-based product. This grade provides more thermal conductivity than unreinforced PEEK— increasing heat dissipation from bearing surfaces improving bearing life and capability.

KETRON® HPV PEEK (BEARING GRADE)

Carbon fiber reinforced with graphite and PTFE lubricants, our newest grade of PEEK offers the lowest coefficient of friction and the best machinability for all PEEK grades. An excellent combination of low friction, low wear, high LPV, low mating part wear and easy machining, make it ideal for aggressive service bearings.

Table 5

Ketron® PEEK offers an excellent combination of physical properties

	Ketron® 1000 PEEK	Ketron® HPV PEEK	Techtron® PPS	Techtron® HPV PPS	Torlon® 4203 PAI	Celazole® PBI
Overall Chem. Resist.	Very Good	Very Good	Excellent	Excellent	Fair	Fair
Moisture Absorption	Very Good	Very Good	Excellent	Excellent	Fair	Poor
Steam Resistance	Good	Good	Good	Good	Poor	Poor
Wear Resistance (dry)	Very Good	Very Good	Poor	Excellent	Good to Very Good	Very Good
Cont. Service Temperature	480°F (250°C)	482°F (250°C)	425°F (220°C)	430°F (221°C)	500°F (260°C)	600°F (315°C)
Heat Deflection Temperature	320°F (160°C)	383°F (195°C)	250°F (120°C)	240°F (115°C)	532°F (280°C)	800°F (425°C)
% Flexural Strength Maintained at: 300°F (150°C)	84%	86%	23%	25%	70%	91%
at: 500°F (260°C)	10%	23%	5%	25%	35%	70%

PRODUCT APPLICATION:

Structural parts

- **Problem:** *Although inexpensive, nylon and acetal semiconductor wafer handling tools were failing due to exposure to aggressive chemicals and high temperatures.*
- **Solution:** *Ketron® 1000 PEEK could easily withstand the temperature and chemical exposure and allowed the manufacturer to standardize their product line.*
- **Benefits:** *The good chemical resistance of PEEK, particularly at elevated temperatures was well suited for this application where limited wear takes place.*

PRODUCT APPLICATION:

Bushings, bearings, seals and back up rings

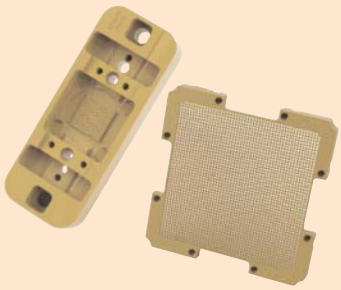
- **Problem:** *Metallic seals don't provide the performance that designers need, while low-tech plastic materials can't withstand the loads that continue to increase.*
- **Solution:** *New generation materials based on PEEK and PPS are able to survive in chemical and steam service while providing the mechanical strength that newer designs need.*
- **Benefits:** *Strength, chemical resistance and dimensional stability all are critical in sealing applications. Quadrant has several modified grades of PEEK and PPS materials that can be matched to you sealing application.*

TORLON® PAI

PRODUCT APPLICATION:

Sliding compressor vanes

- **Problem:** *Rotary compressors needed a vane material that could survive with limited lubrication and maintain close tolerances at high speeds and loads.*
- **Solution:** *Torlon® 4301 was the ideal replacement for the composite material that was previously used.*
- **Benefits:** *Torlon's very low coefficient of expansion, excellent wear resistance and high load capabilities made economic sense for the manufacturer who was able to tout their unit's reliable long-term performance.*



PRODUCT APPLICATION:

Chip nests and sockets

- **Problem:** *Manufacturers of equipment that test completed IC's had problems with dimensional changes of the sockets they used.*
- **Solution:** *Torlon® 4203 and Torlon® 5530 sockets and nests replaced expensive Vespel® PI parts and handle the broad temperature range present during testing.*
- **Benefits:** *The better dimensional stability at temperature helped to increase the reliability of the testing equipment and extend part life.*

PRODUCT PROFILE

STIFFNESS & STRENGTH AT TEMPERATURE EXTREMES

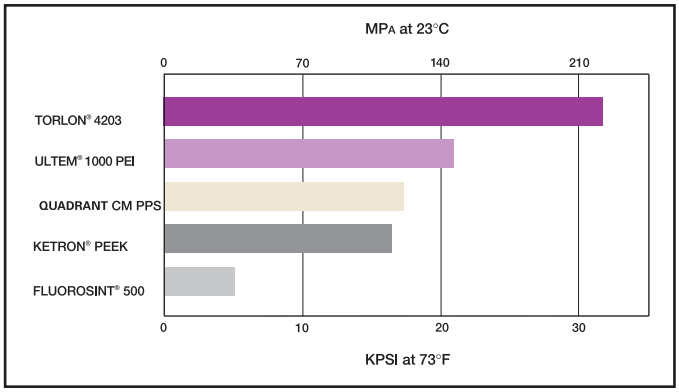
- **Maintains strength and stiffness to 500°F (260°C)**
- **Minimal expansion rate to 500°F (260°C)**
- **Excellent wear resistance in bearing grades**
- **Able to endure harsh thermal, chemical and stress conditions**

TORLON® PAI

With its versatile performance capabilities and proven use in a broad range of applications, Torlon® polyamide-imide (PAI) shapes are offered in extruded and compression molded grades.

Torlon is the highest performing, melt processable plastic. It has superior resistance to elevated temperatures. It is capable of performing under severe stress conditions at continuous temperatures to 500°F (260°C). Parts machined from Torlon stock shapes provide greater compressive strength and higher impact resistance than most advanced engineering plastics (see Figure 27).

Fig. 27 - **COMPRESSIVE STRENGTH COMPARISON**
Unfilled Grades



Tech Notes:

As Torlon PAI has a relatively high moisture absorption rate (see Figure 29), parts used in high temperature service or made to tight tolerances should be kept dry prior to installation. Thermal shock resulting in deformation can occur if moisture laden parts are rapidly exposed to temperatures above 400°F (205° C). Consult Quadrant's Design and Fabrication guide, website or technical service department for post-curing assistance

Torlon PAI's extremely low coefficient of linear thermal expansion and high creep resistance deliver excellent dimensional stability over its entire service range (see Figure 28). Torlon is an amorphous material with a T_g (glass transition temperature) of 537°F (280°C). Torlon stock shapes are post-cured using procedures developed jointly by Solvay Advanced Polymers and Quadrant. This eliminates the need for additional curing by the end user in most situations. A post-curing cycle is sometimes recommended for components fabricated from extruded shapes where optimization of chemical resistance and/or wear performance is required.

For large shapes or custom geometries like tubular bar, compression molded Torlon shapes offer designers the greatest economy and flexibility. Another benefit of selecting a compression molded grade is that resins are cured, or "imidized" prior to molding which eliminates the need to post-cure shapes or parts fabricated from compression molded shapes.

Popular extrusion and injection molding grades of Torlon are offered as compression molded shapes. Typically, you can identify a compression molded grade as having a second digit of "5" in the product name.

Fig. 28 - **COEFFICIENTS OF LINEAR THERMAL EXPANSION**
Torlon vs. PEEK and PPS

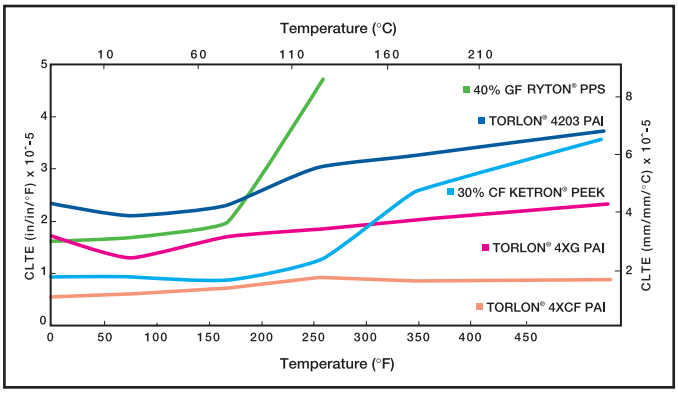
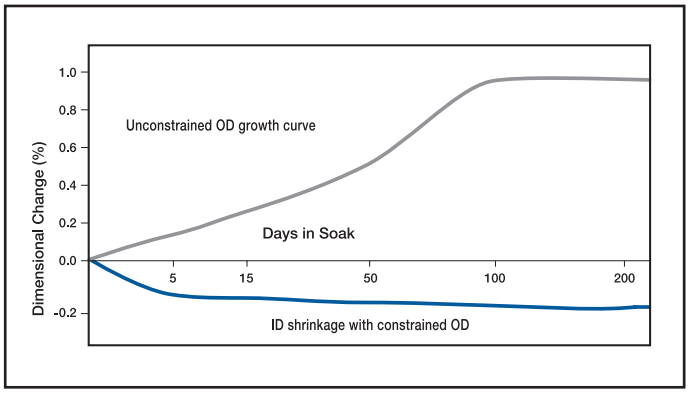


Fig. 29 - **DIMENSIONAL CHANGE VS. MOISTURE**
Torlon 4540 grade sample size 3"OD x 2"ID
(dry samples submerged, 180ºF (80ºC) water)



PRODUCT APPLICATION:

Labyrinth seals

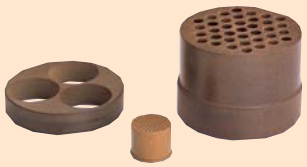
- **Problem:** *Metallic seals needed large operating tolerances to account for pressure changes and potential contact hard impact with a compressor shaft.*
- **Solution:** *Impact resistant Torlon® PAI seals could withstand impact during pressure upsets and tighten up running clearances that increase efficiency.*
- **Benefits:** *Dimensionally stable Torlon seals withstand tough chemical service and wear evenly, protecting the expensive metal shaft and mating parts.*

PRODUCT APPLICATION:

Bearing cages

- **Problem:** *A metallic ball bearing assembly had reached its maximum capability. Designers needed a lighter, higher performance system.*
- **Solution:** *A Torlon® 4301 assembly replaced a steel cage that help hardened steel balls and a bronze bushing.*
- **Benefits:** *Frequently engineering plastics are used to eliminate or revise a system. In this case, the light weight of Torlon coupled with its lubrication-free performance met the needs of this manufacturer's new design.*

TORLON® PAI



PRODUCT APPLICATION:

High temperature electrical connectors

- **Problem:** *Connectors made from several low and mid-range plastics required careful selection based on application environment.*
- **Solution:** *For this manufacturer's critical product line, standardizing on Torlon® 4203 meant confidence that their parts would perform when required.*
- **Benefits:** *High temperatures and demanding electrical performance present in this application required Torlon 4203.*

PRODUCT APPLICATION:

Can mandrel

- **Problem:** *Packaging equipment designers needed a material that had extreme strength and could deal with the impact present in real-world production. Can mandrels are used to form aluminum blanks into beverage and food containers.*
- **Solution:** *Application specific replacement of nylon, UHMW-PE and coated steel mandrels with Torlon® 4203 offered improved performance and less downtime replacing damaged production parts.*
- **Benefits:** *Stiff, strong Torlon 4203 permitted higher production rates because of its ability to operate at higher temperatures.*

	Extruded Grades	Compression Molded Grades
For electrical or high strength applications	**Torlon® 4203** Torlon 4203 polyamide-imide offers excellent compressive strength and the highest elongation of the Torlon grades. It also provides electrical insulation and exceptional impact strength. This grade is commonly used for electrical connectors and insulators due to its high dielectric strength. Its ability to carry high loads over a broad temperature range makes it ideal for structural components such as linkages and seal rings. Torlon 4203 is also an excellent choice for wear applications involving impact loading and abrasive wear.	**Torlon® 4503** This grade is commonly used for dies and patterns of formed metal parts or as thermal insulators and isolators. It is similar in composition to Torlon 4203 PAI, and selected when larger shapes are required.
For general purpose wear and friction parts	**Torlon® 4301** This Torlon PAI is primarily used for wear and friction parts. It offers a very low expansion rate, low coefficient of friction and exhibits little or no slip-stick in use. Torlon 4301's flexural modulus of 1,000,000 psi, is higher than most other advanced engineering plastics. This grade excels in severe service wear applications such as non-lubricated bearings, seals, bearing cages and reciprocating compressor parts.	**Torlon® 4501** Torlon 4501 PAI is well suited for general purpose wear and friction parts. It has a higher compressive strength and can therefore carry more load than Torlon 4540. It is similar in composition to Torlon 4301 PAI, and selected when larger shapes are required.
For best wear resistance and lowest coefficient of friction		**Torlon® 4540** This seal and bearing grade offers a very low coefficient of friction and good wear properties. It was developed specifically for use in rotating equipment. Its composition is the same as the former Torlon 4340 and used when larger (especially tubular) shapes are required. Typical applications for Torlon 4540 PAI include labyrinth seals, wear rings, bushings, and bearings of all types.
Glass reinforced for improved load capacity	**Torlon® 4XG** Torlon 4XG PAI is 30% glass-reinforced. It offers high rigidity, retention of stiffness, a low expansion rate and improved load carrying capabilities. This grade is well suited for applications in the electrical/ electronic, business equipment, aircraft and aerospace industries.	**Torlon® 5530** Torlon 5530 is 30% glass-reinforced. It is ideal for higher load structural or electronic applications. This grade is similar in composition to Torlon 5030 PAI. It is selected for larger shapes or when the greatest degree of dimensional control is required.
Carbon reinforced for non-abrasive wear performance	**Torlon® 4XCF** Torlon 4XCF PAI is 30% carbon fiber-reinforced. It offers exceptional stiffness, non-abrasive wear performance and the lowest coefficient of thermal expansion of all the materials profiled in this guide.	

CELAZOLE® PBI

PRODUCT PROFILE

BEST MECHANICAL PROPERTIES TO 800°F (425°C)

- **Highest mechanical properties of any plastic above 400°F (204°C)**
- **Highest heat deflection temperature 800°F (427°C), with a continuous service capability of 750°F (399°C) in inert environments, or 650°F (343°C) in air with short term exposure potential to 1,000°F (538°C)**
- **Lowest coefficient of thermal expansion and highest compressive strength of all unfilled plastics**

CELAZOLE® PBI

Celazole® PBI is the highest performance engineering thermoplastic available today. It offers the highest heat resistance and mechanical property retention over 400°F of any unfilled plastic (see Figures 30 & 31). It has better wear resistance and load carrying capabilities at extreme temperatures than any other reinforced or unreinforced engineering plastic.

As an unreinforced material, Celazole PBI is very "clean" in terms of ionic impurity and it does not outgas (except water). These characteristics make this material very attractive to semiconductor manufacturers for vacuum chamber applications. Celazole PBI has excellent ultrasonic transparency which makes it an ideal choice for parts such as probe tip lenses in ultrasonic measuring equipment.

Celazole PBI is also an excellent thermal insulator. Other plastics in melt do not stick to PBI. These characteristics make it ideal for contact seals and insulator bushings in plastic production and molding equipment.

Fig. 30 - **COMPARATIVE TENSILE STRENGTH VS. TEMPERATURE**

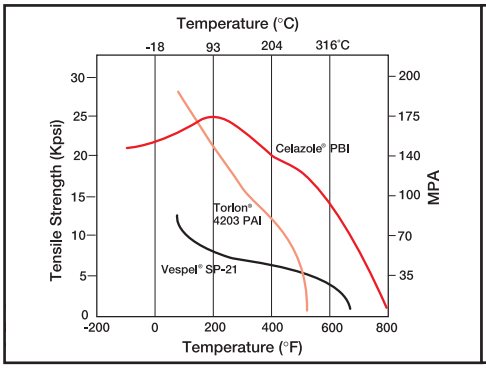
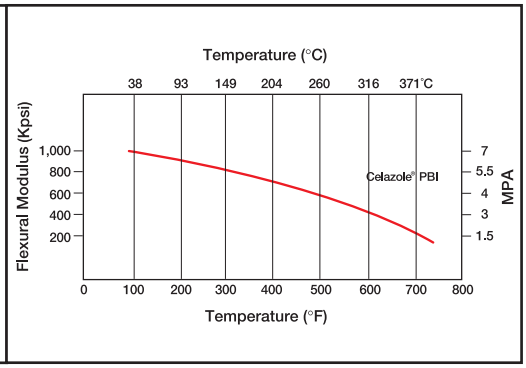


Fig. 31 - **FLEXURAL MODULUS VS. TEMPERATURE**



PRODUCT APPLICATION:

Vacuum Cups

- **Problem:** *Engineers were looking for a more cost-effective solution for an extremely high temperature glass handling application.*
- **Solution:** *Celazole PBI outperformed prior materials and reduced the component cost.*
- **Benefits:** *Celazole is more wear resistant than polyimides. -The Celazole PBI cups reduced product breakage compared to the ceramics tested. - Celazole PBI was more cost effective than pressed carbon or polyimide materials.*

PRODUCT APPLICATION:

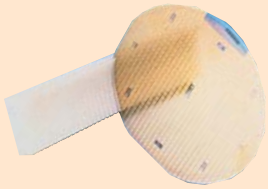
High heat insulator bushings

- **Problem:** *Hot runner systems needed a material that could endure the high temperatures but did not "stick' to the finish molded parts.*
- **Solution:** *Celazole PBI machined bushings outperformed al other materials tested in the application.*
- **Benefits:** *Celazole PBI is unique in its ease of clean up in hot runner systems. Molded parts do not stick to Celazole during their "freeze" cycle in the mold.*

Tech Notes:

Celazole PBI is extremely hard and can be challenging to fabricate. Polycrystalline diamond tools are recommended when fabricating production quantities. Celazole tends to be notch sensitive. All corners should be radiused (0.040" min.) and edges chamfered to maximize part toughness. High tolerance fabricated components should be stored in sealed containers (usually polybags with desiccant) to avoid dimensional changes due to moisture absorption. Components rapidly exposed to temperatures above 400°F (205°C) should be "dried" prior to use or kept dry to avoid deformation from thermal shock.

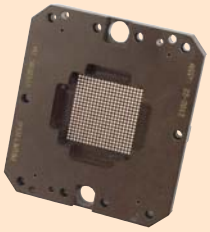
SEMITRON®



PRODUCT APPLICATION:

Water combs

- **Problem:** *Delicate complete and in-process wafers were destroyed by exposure to ESD charges.*
- **Solution:** *Semitron ESd 225, a static dissipative POM was able to replace the unfilled nylon and acetal grades that couldn't handle the static present in the manufacturing environment.*
- **Benefits:** *Economical Semitron ESd 225 safely bleeds away static created during handling while offering the wear resistance of unfilled PA and POM materials.*



PRODUCT APPLICATION:

Test sockets

- **Problem:** *As designers try to get more pins into a smaller space, IC testing becomes more challenging and existing materials couldn't handle the physical demands of testing while managing the possible repeated exposure to ESD.*
- **Solution:** *Semitron ESd 420V is a new material that meets all of the dimensional and thermal demands while providing a demonstrated ability to handle repeated high voltage exposures.*
- **Benefits:** *Semitron ESd 420V is a non-sloughing material that combines the temperature resistance and moisture-resistant dimensional stability of PEI with a new level of ESD management.*

PRODUCT PROFILE

STATIC DISSIPATIVE PRODUCTS WITH THERMAL CAPABILITIES TO 500°F (260°C)

SEMITRON®

The Semitron® ESd family of static dissipative products was designed by Quadrant for use where electrical discharge in operation is a problem. They are commonly used for sensitive electronic components including: integrated circuits, hard disk drives and circuit boards. Semitron products are also an excellent choice for material handling applications, and components in high speed electronic printing and reproducing equipment.

Semitron® ESd products are inherently dissipative and electrically stable unlike many other "dissipative" plastic shapes (see Table 7). They do not rely on atmospheric phenomena to activate, nor are surface treatments used to achieve dissipation. Static electricity is dissipated through these products as readily as it is dissipated along the surface. All of these products dissipate 5 KV in less than 2 seconds per Mil-B-81705C.

SEMITRON® ESd 225 STATIC DISSIPATIVE ACETAL

Semitron® ESd 225 is ideal for fixturing used in the manufacturing of hard disk drives or for handling in-process silicon wafers. It is tan in color.

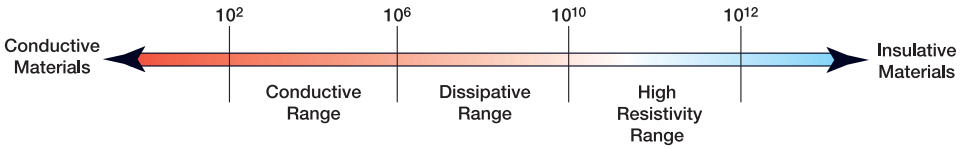
- Surface resistivity: 10^9 –10^{10} Ω / sq.
- Thermal performance to 225°F (107°C)
- Good wear resistance

SEMITRON® ESd 410C STATIC DISSIPATIVE PEI

Semitron® ESd 410C is ideal for handling integrated circuits through the test handler environment. It is black in color and opaque.

- Surface resistivity: 10^4 –10^6 Ω / sq.
- Thermal performance to 410°F (210°C)
- Low stress for tight tolerance machining
- High strength and stiffness

Table 6



Tech Notes:

It is important to know how applied voltage affects the resistance of a material. Some materials exhibit high resistance at low voltages, but when subjected to harsher conditions, they can fall. This is due to dielectric breakdown and is irreversible. This chart illustrates the effect of sequential applications of 100 through 1,000 volts, then a return to 100 volts to determine the hysteresis. Since static electricity can be several thousand volts, consistent performance across the voltage range must be considered.

Some materials are very inconsistent and vary on the "grain" of machining. One pair of lines illustrate the typical variation from side to side (A to B) of the same sample. This example demonstrates the need for consistent behavior in service.

SEMITRON® ESd 420 STATIC DISSIPATIVE PEI

Semitron® ESd 420 is the only, truly dissipative plastic product for use in high temperature applications.

- Surface resistivity: 10^6 –10^9 Ω / sq.
- Thermal performance

SEMITRON® ESd 420V STATIC DISSIPATIVE PEI

Semitron® ESd 420V offers dissipative performance of 10^6 to 10^9 ohms/square over its full temperature performance range. It is a stiff, high strength material that is not subject to dimensional change as a result of exposure to moisture. Semitron® ESd 420V is a cost effective alternative for applications that do not require the thermal performance of ultra-high performance materials.

SEMITRON® ESd 480 STATIC DISSIPATIVE PEEK

This PEEK based static dissipative material provides a dissipative range of 10^6 to 10^9 Ω / sq. Semitron ESd 480 is very dimensionally stable, making it ideal for critical test fixture applications. Its exceptional chemical resistance makes it well suited for use in wafer handling and other structural applications in wet process tools where static dissipation is important. Like all Quadrant Semitron® ESd materials, Semitron ESd 480 is not subject to dielectric breakdown. (See tech note on the prior page)

SEMITRON® ESd 520HR STATIC DISSIPATIVE PAI

Semitron® ESd 520HR has an industry first combination of electrostatic dissipation (ESd), high strength and heat resistance. This new ESd material is ideal for making nests, sockets and contactors for test equipment and other device handling components. The key features of 520HR are its unique ability to resist dielectric breakdown at high voltages (>100V). The graph below demonstrates the electrical performance of plastic materials commonly used in automated test handlers. Typical carbon fiber enhanced products become irreversibly more conductive when exposed to even moderate voltage.

Only Semitron® ESd 520HR maintains its performance throughout the voltage range, while offering the mechanical performance needed to excel in demanding applications.

- Surface resistivity: 10^{10} –10^{12} Ω / sq.

PRODUCT APPLICATION:

Electronics fixture

- **Problem:** *While manufacturing PC hard disks a nearby sensor was picking up static charges that were causing problems with process electronics.*
- **Solution:** *The unfilled plastic part was replaced by a machined fixture made Semitron ESd 520HR.*
- **Benefits:** *The Semitron ESd 520HR sensor could safely withstand the 400°F process temperatures and maintain the precise position required - all while safely bleeding away static charges.*

Fig. 32 - **SURFACE RESISTIVITY**

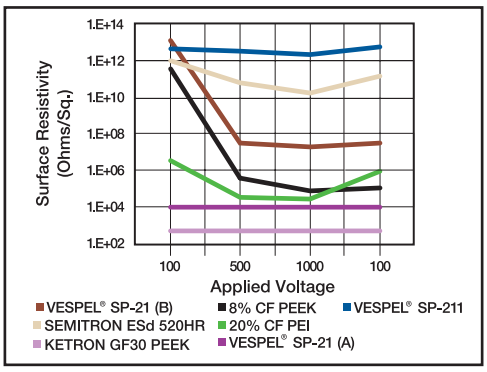


Table 7 - **STATIC DISSIPATION**

(Surface Resistivity, ohms/sq.)	
Semitron® ESd 225	10^9 – 10^{10}
Semitron® ESd 410C	10^4 – 10^6
Semitron® ESd 420	10^6 – 10^9
Semitron® ESd 420V	10^6 – 10^9
Semitron® ESd 480	10^6 – 10^9
Semitron® ESd 520HR	10^{10} – 10^{12}

SPECIALTY CAPABILITIES

TO BE A CANDIDATE FOR CUSTOM CASTING, A COMPONENT SHOULD HAVE:

- A continuous operating temperature (in use environment) between -40°F to 200°F (-40°C to 93°C)
- Continuous working stress that does not exceed 3,500 psi
- A finished part size between 4 oz. and 800 lbs. (equivalent to a 5,600 lb. steel part)
- Sufficient complexity or detail to make machining from a stock shape too costly

SPECIALTY

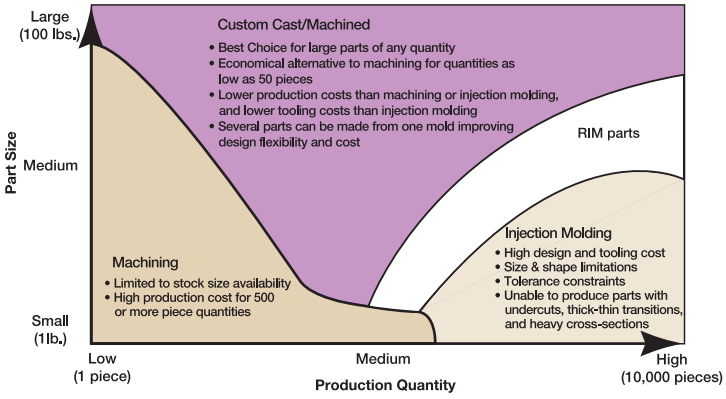
Quadrant Engineering Plastic Products has the unique capability of casting nylon to custom mill shapes, cast blanks, near net shapes or cast to size finished parts. Using this technology, many designers have reduced the total cost to manufacture engineered components. Custom cast nylon parts often effectively replace machined plastic parts, sand cast metal parts, and multipart metal assemblies.

Custom casting offers a manufacturing alternative that bridges the plastic fabrication methods of machining from stock shapes and injection molding of thermoplastic parts. It is ideal for small and medium quantity production runs of parts too large or too costly to injection mold. Part size and production quantities most often custom cast are found in Figure 33.

Nylatron® and Monocast® (MC®) cast nylons produce tough, strong, resilient, and highly wear resistant parts that cost effectively replace bronze, brass, iron, steel and aluminum in many heavy-duty industrial applications.

Custom cast parts are made by a proprietary monomer casting process in which liquid monomer is directly polymerized into nylon polymer in the mold. Parts of virtually unlimited size and thickness, retaining internal soundness can be produced by Custom Casting. Eleven ft. tall slide bars and six feet diameter dryer gear rings that weigh 250 lbs. are just a few of the very large parts Quadrant has produced using Custom Casting. Four inch bearings, bottle handling cams, and gear blanks cast over steel cores are also cost-effectively cast to a near net size, saving machining and assembly time and material costs.

Fig. 33 - **WHERE NYLATRON® CASTING FITS (TYPICAL PART SIZE AND QUANTITIES)**



CUSTOM CASTING OPTIONS

➜ **Custom Mill Shapes** - *Picture 1*

Custom sizes of rod, sheet, tubular bar.

- Large selection of tooling already available
- Limitless size availability
- Lowest cost tooling of any process

Best Choice When You Have:
Less than 100 pieces, or intricate parts that must be machined.

➜ **Near Net Shapes** - *Picture 2*

Castings of close to finish dimensions, supplied sufficiently over size for finish machining.

- Minimal machining required
- Can cast non-critical dimensions
- Most efficient use of material

Best Choice When You Have:
100-1,000 part requirement or when multiple parts are possible from a single near net shape.

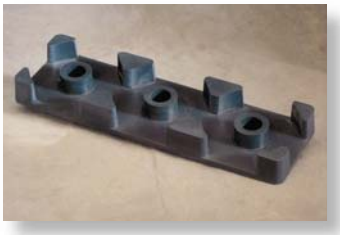
➜ **Cast to Size** - *Picture 3*

Castings the part to complete or nearly finished dimensions. Parts may require no machining, or machining only on critical dimensions.

- Minimal or no finish machining required
- Economical on moderate run sizes

Best Choice When You Have:
Quantities of 1,000 or more per year, or parts that cannot be injection molded due to high tooling cost, geometry, or size.

Picture 1 - Nylatron® MC901 Spur gears are machined from custom size tubular bar.



Picture 2 - Most details on this 16" long x 1-½" thick spring cap were cast to size.

Picture 3 - This 19" diameter Nylatron® GSM sheave requires only finish machining of the bore for bearing press fit.

CUSTOM CASTING APPLICATION

CAN YOU REDUCE YOUR COST TO MANUFACTURE PLASTIC PARTS USING A QUADRANT CUSTOM NYLON CASTING?

The following graphs enable you to evaluate the potential for using a Quadrant custom casting or near net shape to manufacture a given shape. Custom castings can be used to reduce the cost to manufacture certain parts by

1) Eliminating certain difficult (time consuming) machining operations

2) Reducing machining scrap and cycle time by improving the overall material yield

3) Eliminating the machining of less-critical dimensions.

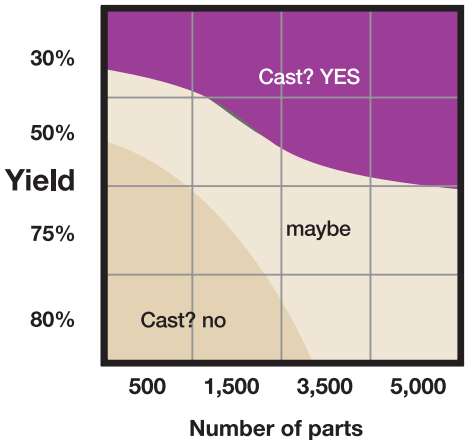
USING THE GRAPHS - STEP-BY-STEP

1. Estimate the weight of the part (in lbs.) and find the appropriate graph below.
2. Estimate the machining yield: finish part weight/weight of the stock shape required to machine the parts if the part was to be machined from a stock shape (rod, plate, tubular bar).
3. Estimate the annual quantity of parts required.

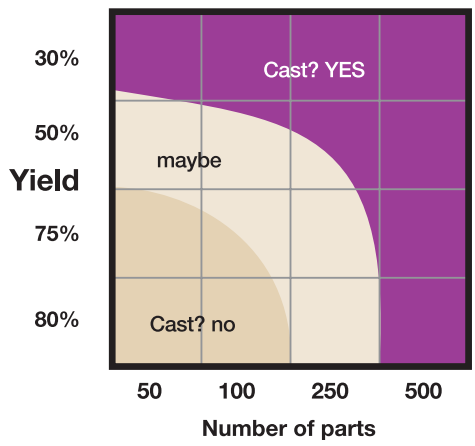
The intersection of the yield and number of parts will indicate whether the part is a good custom cast part: “YES”; potentially a custom cast candidate: “maybe”; or not a good custom casting: ”no.”

Contact Quadrant for help evaluating “maybe” parts or for a quotation of “YES” custom cast parts.

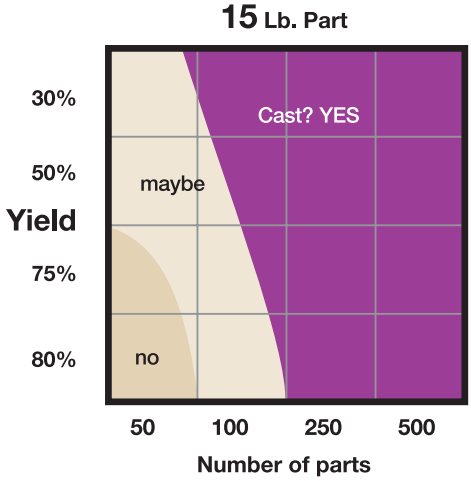
5 Lb. (or less) Part



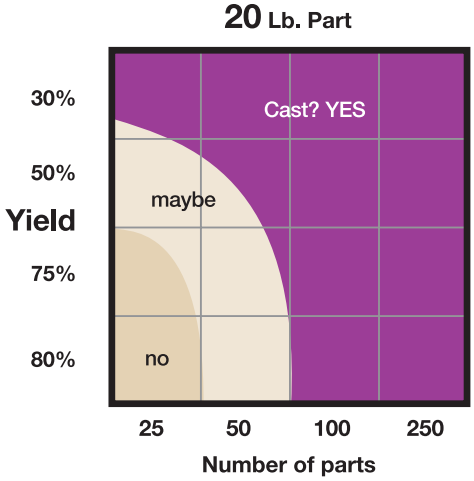
10 Lb. Part



15 Lb. Part



20 Lb. Part



AVAILABILITY

	Product	Rod*	Plate	Tubular Bar	Disc	Other
EXTRUDED	Nylon 101 PA	.062"-6"	.031"-3" (A)(H)	QUI	–	Hex & Square Rod/Bushing Stock
	Nylatron® GS PA	.062"-2"	.031"-2" (A)(H)	QUI	–	Bushing Stock
	Acetron® GP POM	.062"-12"	.031"-4.5" (A,D,H)	1.97"-13.5" OD, .393"-11.8" ID	–	Hex & Square Rod/Bushing Stock
	Semitron® ESd 225 POM	.187"-6"	.25"-4" (A)	–	–	–
	Delrin® POM	.25"-8"	.25"-4" (A,H)	QUI	–	–
	Delrin® AF Blend POM	.25"-6"	.25"-3" (A)	QUI	–	–
	Ertalyte® PET–P	.375"-7.08"	.078"-4" (A,G)	.787"-7.87" OD, .472"-6.3" ID	–	–
	Ertalyte® TX PET–P	.394"-7.88"	.315"-3.94" (G)	.787"-7.87" OD, .472"-6.3" ID	–	–
	PC 1000 PC	.062"-6"	.25"-3.0" (A)	QUI	–	–
	PSU 1000 PSU	.25"-6"	.25"-3.0" (A)	QUI	–	–
	Ultem® 1000 PEI	.125"-6"	.25"-4.0" (A)	QUI	–	–
	Ultem® 2300 PEI	.5"-6"	.375"-3.0" (A)	–	–	–
	Radel® R PPSU	.25"-6"	.25"-3" (A)	–	–	–
	Techtron® PPS	.25"-5"	.25"-2" (B,A)	QUI	–	–
	Techtron® HPV	.236"-3.94"	.196"-3.15" (G)	1.97"-7.88" OD, 1.18"-6.3" ID	–	–
	Ketron® PEEK	.125"-6.0"	.250"-4.0"	1.97"-10" OD, 1.18"-8" ID	–	–
	30% Glass Ketron® PEEK	.236"-4"	.197"-2.36"	QUI	–	–
	Ketron® HPV	.236"-3.94"	.197"-2.36" (G)	1.97"-7.88" OD, 1.18"-6.3" ID	–	–
	Torlon® 4203 PAI	.062"-2"	.25"-1.00" (B)	QUI	–	–
	Torlon® 4301 PAI	.25"-2"	.25"-1.00" (B)	QUI	–	–
	Torlon® 4XG	.375"-1.5"	.187"-.375" (I)	QUI	-	-
	Torlon® 4XCF	.375"-1.5"	.187"-.375" (I)	QUI	-	-
	CF PEEK	.236"-3.15"	.197"-2.36	QUI	-	-
CAST	Nylatron® 703 XL	-	.375"-4"	-	-	Custom Castings
	Nylatron® GSM PA	2"-38"	.187"-6" (A,D)	2"-80" OD, 1"-78" ID	12"-80" dia.	Gear Rings & Custom Castings
	Nylatron® GSM Blue PA	2"-38"	.187"-6" (A,D)	2"-80" OD, 1"-78" ID	12"-80" dia.	Gear Rings & Custom Castings
	Nylatron® LIG	2"-38"	.187"-6" (A,D)	2"-80" OD, 1"-78" ID	12"-80" dia.	Gear Rings & Custom Castings
	Nylatron® LFG	2"-38"	.187"-6" (A,D)	2"-80" OD, 1"-78" ID	12"-80" dia.	Gear Rings & Custom Castings
	Nylatron® NSM PA	2"-38"	.187"-4" (A,D)	2"-80" OD, 1"-78" ID	12"-80" dia.	Gear Rings & Custom Castings
	MC® 901 PA	2"-38"	.187"-6" (A,D)	2"-80" OD, 1"-78" ID	12"-80" dia.	Gear Rings & Custom Castings
	MC® 907 PA	2"-38"	.187"-6" (A,D)	2"-80" OD, 1"-78" ID	12"-80" dia.	Gear Rings & Custom Castings
	PVDF	-	.125"-1"	-	-	-

Key:

QUI = Quote Upon Inquiry
A = 24" Wide x 48" Long
B = 12" Wide x 48" Long
C = 12" Wide x 12" Long
D = 48" Wide x 120" Long
E = 12" Wide x 24" Long
F = 14" Wide x 28" Long
G = 24" Wide x 39" Long
H = 24" Wide x 144" Long
I = 4" Wide x 48" Long

(Capabilities subject to change)

COMPRESSION MOLDED

Product	Rod*	Plate	Tubular Bar**	Disc*	Other
Semitron® ESd 410C PEI	.375"-3"	.375"-2"(C,E)	–	6.25"-10.125" dia.	–
Semitron® ESd 420	–	.375"-2"	–	–	–
Semitron® ESd 420V	–	.375"-1.25"	–	–	–
Semitron® ESd 480	–	.375"-1.25 "	–	–	–
Semitron® ESd 500HR PTFE	–	.25"-2"(C)	–	–	–
Semitron® ESd 520HR PAI	–	.375"-1.5"(C,E,F)	–	–	–
Fluorosint® 500/207 PTFE	.5"-8.75"	.25"-3"(C,E)	1.25" - 54" OD, .5" - 44.5" ID	3.75"-12" dia.	–
Ryton® CM PPS	1.125"-5"	.375"-1.5"(C,E)	1.5" - 8.625" OD, .75" - 7.25" ID	3.5"-11.375" dia.	–
40% Glass Ryton® PPS	1.0"-6"	.375"-2"(C,E,F)	1.5" - 10.5" OD, .75" - 7.125" ID	3.5"-9" dia.	–
Bearing grade Ryton® PPS	1.0"-5"	.375"-1.75"(C,E,F)	1.5" - 12.5" OD, .75" - 10.5" ID	3.5"-11.375" dia.	–
Ketron® PEEK	1.0"-1.25"	–	1.625" - 12.5" OD, .75" - 11" ID	–	–
30% Glass Ketron® PEEK	1.0"-1.625"	–	1.625" - 12.5" OD, .75" - 11" ID	–	–
30% Carbon Ketron® PEEK	1.0"-3.75"	–	1.625" - 36" OD, .75" - 11" ID	3.5"-10.125" dia.	–
Bearing grade Ketron® PEEK	1.0"-2"	–	1.75" - 36" OD, .75" - 29.5" ID	3.5"-9.0" dia.	–
Torlon® 4503 PAI	2.25"-10"	–	1.625" - 36" OD, .75" - 29.5" ID	4"-12" dia.	–
Torlon® 4501 PAI	2.25"-10"	.375"-1.5"(C,E,F)	1.625" - 36" OD, .75" - 29.5" ID	3.5"-15" dia.	–
Torlon® 4540 PAI	2.25"-10"	.375"-1.5"(C,E,F)	1.5" - 36" OD, .75" - 29.5" ID	3.5"-15" dia.	–
Torlon® 5530 PAI	1.625"-10"	.375"-2"(C,E,F)	1.625" - 36" OD, .75" - 29.5" ID	3.5"-15" dia.	–
Duratron® XP PI	.375"-2.875"	.375"-2"(C)	1.875" - 11.75" OD, .75" - 7.5" ID	–	–
Duratron® 150 PI	1.0"-2.875"	.375"-2"(C,E)	1.625" - 7.25" OD, .75" - 5.0" ID	3.5"-8.0" dia.	–
Celazole® PBI	.375"-3.75"	.5"-1.5"(C,E)	1.625" - 10.75" OD, .75" - 7.0" ID	3.5"-8.0" dia.	–

* Length limited by size and material

** Length limited by size, wall thickness and material

(Our capabilities are always growing, so give us a call to see if your configuration is possible.)

Key:

QUI = Quote Upon Inquiry
A = 24" Wide x 48" Long
B = 12" Wide x 48" Long
C = 12" Wide x 12" Long
D = 48" Wide x 120" Long
E = 12" Wide x 24" Long
F = 14" Wide x 28" Long
G = 24" Wide x 39" Long
H = 24" Wide x 144" Long
I = 4" Wide x 48" Long

PRODUCT COMPARISON

		Product Description	Units	Test Method ASTM	Quadrant Nylon 101	Nylatron® GS	Nylatron® GF30	Nylatron® MC® 907	Nylatron® MC® 901	Nylatron® GSM
					Unfilled PA66	MoS_2 Filled PA66	30% Glass Filled PA66	Unfilled PA6	Blue, Heat Stabilized PA6	MoS_2 Filled PA6
					Extruded	Extruded	Extruded	Cast	Cast	Cast
MECHANICAL	1	Specific Gravity, 73°F.	-	D792	1.15	1.16	1.29	1.15	1.15	1.16
	2	Tensile Strength, 73°F.	psi	D638	12,000	12,500	13,500	12,000	12,000	11,000
	3	Tensile Modulus of Elasticity, 73°F.	psi	D638	425,000	480,000	675,000	400,00	400,000	400,000
	4	Tensile Elongation (at break), 73°F.	%	D638	50	25	5	20	20	30
	5	Flexural Strength, 73°F.	psi	D790	15,000	17,000	21,000	16,000	16,000	16,000
	6	Flexural Modulus of Elasticity, 73°F.	psi	D790	450,000	460,000	650,000	500,000	500,000	500,000
	7	Shear Strength, 73°F.	psi	D732	10,000	10,500	-	11,000	11,000	10,500
	8	Compressive Strength, 10% Deformation, 73°F.	psi	D695	12,500	16,000	18,000	15,000	15,000	14,000
	9	Compressive Modulus of Elasticity, 73°F.	psi	D695	420,000	420,000	600,000	400,000	400,000	400,000
	10	Hardness, Rockwell, Scale as noted, 73°F.	-	D785	M85 (R115)	M85 (R115)	M75	M85 (R115)	M85 (R115)	M80 (R110)
	11	Hardness, Durometer, Shore "D" Scale, 73°F.	-	D2240	D80	D85	-	D85	D85	D85
	12	Izod Impact (notched), 73°F.ft. lb./in. of notch	ft. lb./in. of notch	D256 Type "A"	0.6	0.5	-	0.4	0.4	0.5
	13	Coefficient of Friction (Dry vs. Steel) Dynamic	-	QTM 55007	0.25	0.2	-	0.2	0.2	0.2
	14	Limiting PV (with 4:1 safety factor applied)	ft. lbs./in.^{2} min	QTM 55007	2,700	3,000	-	3,000	3,000	3,000
	15	Wear Factor "k" x 10^{-10}	in.^{3}-min/ft. lbs. hr.	QTM 55010	80	90	-	100	100	90
THERMAL	16	Coefficient of Linear Thermal Expansion (-40°F to 300°F)	in./in./°F	E-831 (TMA)	5.5×10^{-5}	4×10^{-5}	2.0×10^{-5}	5.0×10^{-5}	5.0×10^{-5}	5.0×10^{-5}
	17	Heat Deflection Temperature 264 psi	°F	D648	200	200	400	200	200	200
	18	Tg-Glass transition (amorphous)	°F	D3418	N/A	N/A	N/A	N/A	N/A	N/A
	19	Melting Point (crystalline) peak	°F	D3418	500	500	500	420	420	420
	20	Continuous Service Temperature in Air (Max.) (1)	°F	-	210	220	220	200	260	200
	21	Thermal Conductivity	BTU in./hr. ft.^{2} °F	F433	1.7	1.7	1.7	1.7	1.7	-
ELECTRICAL	22	Dielectric Strength, Short Term	Volts/mil	D149	400	350	350	500	500	400
	23	Surface Resistivity	ohm/square	EOS/ESD S11.11	$>10^{13}$	$>10^{13}$	-	$>10^{13}$	$>10^{13}$	$>10^{13}$
	24	Dielectric Constant, 10^6 Hz	-	D150	3.6	-	-	3.7	3.7	3.7
	25	Dissipation Factor, 10^6 Hz	-	D150	0.02	-	-	-	-	-
	26	Flammability @ 3.1 mm (1⁄8 in.) **(5)**		UL 94	V-2	V-2	V-2	HB	HB	HB
CHEMICAL (3)	27	Water Absorption Immersion, 24 Hours	% by wt.	D570 (2)	0.3	0.3	0.3	0.6	0.6	0.6
	28	Water Absorption Immersion, Saturation	% by wt.	D570 (2)	7	7	5.5	7	7	7
	29	Acids, Weak, acetic, dilute hydrochloric or sulfuric acid	@73°F		L	L	L	L	L	L
	30	Acids, Strong, conc. hydrochloric or sulfuric acid	@73°F		U	U	U	U	U	U
	31	Alkalies, Weak, dilute ammonia or sodium hydroxide	@73°F		L	L	L	L	L	L
	32	Alkalies, Strong, strong ammonia or sodium hydroxide	@73°F		U	U	U	U	U	U
	33	Hydrocarbons-Aromatic, benzene, toluene	@73°F		A	A	A	A	A	A
	34	Hydrocarbons-Aliphatic, gasoline, hexane, grease	@73°F		A	A	A	A	A	A
	35	Ketones, Esters, acetone, methyl ethyl ketone	@73°F		A	A	A	A	A	A
	36	Ethers, diethyl ether, tetrahydrofuran	@73°F		A	A	A	A	A	A
	37	Chlorinated Solvents, methylene chloride, chloroform	@73°F		L	L	L	L	L	L
	38	Alcohols, methanol, ethanol, anti-freeze	@73°F		L	L	L	L	L	L
	39	Continuous Sunlight	@73°F		L	L	L	L	L	L
OTHER	40	FDA Compliance			Y	N	N	Y	N	N
	41	Relative Cost (4)			$	$	$	$	$	$
	42	Relative Machinability (1-10, 1=Easier to Machine)			1	1	4	1	1	1

(1) Data represent Quadrant's estimated maximum long term service temperature based on practical field experience.

(2) Specimens 1/8" thick x 2" dia. or square.

(3) Chemical resistance data are for little or no applied stress. Increased stress, especially localized may result in more severe attack. Examples of common chemicals also included.

(4) Relative cost of material profiled in this brochure ($ = Least Expensive and $$$$$$ = Most Expensive)

(5) **Estimated rating based on available data.** The UL 94 Test is a laboratory test and does not relate to actual fire hazard. Contact Quadrant for specific UL "Yellow Card" recognition number.

Key:

A = Acceptable Service

L = Limited Service

U = Unacceptable

QTM = Quadrant Test Method

NOTE: Property data shown are typical average values. A dash (-) indicates insufficient data available for publishing.

	Nylatron® LIG	Nylatron® LFG	Nylatron® GSM Blue	Nylatron® NSM	Nylatron® 703XL	Acetron® GP	Delrin® Acetal	Delrin® AF Blend	Semitron® ESd 225	Ertalyte® PET-P	Ertalyte® TX	Symalit PVDF
	Oil Filled PA6	FDA Compliant Oil Filled PA6	MoS_2 and Oil Filled PA6	Premium, Solid Lubricant Filled PA6	Premium, Solid Lubricant Filled PA6	Premium Porosity-free POM-C	POM-H	PTFE Filled POM-H	Static Dissipative POM	Semi-crystalline PET	Premium, Solid Lubricant Filled PET	Unfilled PVDF
	Cast	**Cast**	**Cast**	**Cast**	**Cast**	**Extruded**	**Extruded**	**Extruded**	**Extruded**	**Extruded**	**Extruded**	**Extruded**
1	1.14	1.14	1.15	1.15	1.11	1.41	1.41	1.5	1.33	1.41	1.44	1.78
2	9,900	9,900	10,000	11,000	9,000	9,500	11,000	8,000	5,400	12,400	10,500	7,000
3	465,000	465,000	500,000	410,000	400,000	400,000	450,000	435,000	200,000	460,000	500,000	300,000
4	50	50	30	20	15	30	30	15	15	20	5	100
5	15,000	15,000	15,000	16,000	13,000	12,000	13,000	12,000	7,300	18,000	14,000	8,000
6	525,000	525,000	500,000	475,000	360,000	400,000	450,000	445,000	220,000	490,000	360,000	290,000
7	9,300	9,300	-	10,000	-	8,000	9,000	7,600	6,000	8,000	8,500	-
8	13,500	13,500	13,000	14,000	10,000	15,000	16,000	16,000	8,000	15,000	15,250	10,000
9	330,000	330,000	425,000	400,000	360,000	400,000	450,000	350,000	175,000	420,000	400,000	160,000
10	M85 (R120)	M85 (R120)	M80 (R117)	M80 (R110)	M65	M88 (R120)	M89 (R122)	M85 (R115)	M50 (R108)	M93 (R125)	M94	M75
11	-	-	-	D85	-	D85	D86	D83	D76	D87	D80	D78
12	1.0	1.5	0.9	0.5	0.7	1	1	0.7	1.5	0.5	0.4	3.0
13	0.14	0.14	0.18	0.18	0.14	0.25	0.25	0.19	0.29	0.2	0.19	-
14	6,000	6,000	5,500	15,000	17,000	2,700	2,700	8,300	2,000	2,800	6,000	-
15	90	90	65	12	26	200	200	60	30	60	35	-
16	5.6×10^{-5}	5.6×10^{-5}	5.5×10^{-5}	5.5×10^{-5}	4.9×10^{-5}	5.4×10^{-5}	4.7×10^{-5}	5×10^{-5}	9.3×10^{-5}	3.3×10^{-5}	4.5×10^{-5}	6.6×10^{-5}
17	200	200	200	200	200	220	250	244	225	240	180	230
18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	420	420	420	420	420	335	347	347	320	491	491	340
20	220	220	200	200	200	180	180	180	180	210	210	300
21	-	-	-	-	-	1.6	2.5	-	-	2	1.9	1.5
22	-	-	-	400	-	420	450	400	-	385	533	260
23		-	$>10^{13}$	$>10^{13}$	$>10^{12}$	$>10^{13}$	$>10^{13}$	$>10^{13}$	$10^{9} - 10^{10}$	$>10^{13}$	$>10^{13}$	$>10^{13}$
24	-	-	-	-	-	3.8	3.7	3.1	4.31	3.4	3.6	6.4
25	-	-	-	-	-	0.005	0.005	0.01	.036	0.02	.02	0.165
26	HB	HB	HB	HB	HB	HB	HB	HB	HB	HB	HB	V-0
27	0.3	0.3	0.3	0.3	0.47	0.2	0.2	0.2	2	0.07	0.06	.03
28	6	6	6	7	7	0.9	0.9	1	8	0.9	0.47	.05
29	L	L	L	L	L	L	L	L	L	A	A	A
30	U	U	U	U	U	U	U	U	U	L	L	A
31	L	L	L	L	L	A	A	A	A	A	A	L
32	U	U	U	U	U	U	U	U	U	U	U	U
33	A	A	A	A	A	A	A	A	A	A	A	A
34	A	A	A	A	A	A	A	A	A	A	A	A
35	A	A	A	A	A	A	A	A	A	A	A	U
36	A	A	A	A	A	A	A	A	A	A	A	L
37	L	L	L	L	L	L	L	L	L	U	U	L
38	L	L	L	L	L	A	A	A	A	A	A	A
39	L	L	L	L	L	L	L	L	L	L	L	L
40	N	Y	N	N	N	Y	Y	N	N	Y	Y	Y
41	$	$	$	$$	$$	$	$	$$	$$	$$	$	$
42	2	2	1	1	1	1	1	1	1	2	2	3

PRODUCT COMPARISON

		Product Description	Units	Test Method ASTM	Techtron® PPS Unfilled PPS Extruded	Quadrant PPS Unfilled PPS Compression Molded	Techtron® HPV Premium, Solid Lubricant Filled PPS Extruded	Quadrant BG PPS Bearing Grade PPS Compression Molded	Quadrant GF40 PPS 40% Glass Filled PPS Compression Molded	Fluorosint® 207 FDA Compliant, Mica Filled PTFE Compression Molded
MECHANICAL	1	Specific Gravity, 73°F.	-	D792	1.35	1.35	1.43	1.52	1.7	2.3
	2	Tensile Strength, 73°F.	psi	D638	13,500	10,000	10,900	2,100	13,000	1,500
	3	Tensile Modulus of Elasticity, 73°F.	psi	D638	500,000	325,000	540,000	980,000	730,000	250,000
	4	Tensile Elongation (at break), 73°F.	%	D638	15	5	5	1	2	50
	5	Flexural Strength, 73°F.	psi	D790	21,000	18,000	10,500	10,000	23,000	2,000
	6	Flexural Modulus of Elasticity, 73°F.	psi	D790	575,000	370,000	535,000	820,000	1,000,000	350,000
	7	Shear Strength, 73°F.	psi	D732	9,000	-	-	-	-	1,700
	8	Compressive Strength, 10% Deformation, 73°F.	psi	D695	21,500	18,000	15,500	15,000	24,000	3,800
	9	Compressive Modulus of Elasticity, 73°F.	psi	D695	430,000	410,000	342,000	800,000	1,300,000	225,000
	10	Hardness, Rockwell, Scale as noted, 73°F.	-	D785	M95 (R125)	M93 (R125)	M84	M93 (R126)	M94 (R125)	R50
	11	Hardness, Durometer, Shore "D" Scale, 73°F.	-	D2240	D85	D85	-	D86	D86	D65
	12	Izod Impact (notched), 73°F.ft. lb./in. of notch	ft. lb./in. of notch	D256 Type "A"	0.6	0.6	1.4	1	1	1
	13	Coefficient of Friction (Dry vs. Steel) Dynamic	-	QTM 55007	0.4	0.4	0.2	0.2	-	0.1
	14	Limiting PV (with 4:1 safety factor applied)	ft. lbs./in.^{2} min	QTM 55007	3,000	3,000	8,750	25,000	-	8,000
	15	Wear Factor "k" x 10^{-10}	in.^{3}-min/ft. lbs. hr.	QTM 55010	2,400	>2,000	62	800	-	30
THERMAL	16	Coefficient of Linear Thermal Expansion (-40°F to 300°F)	in./in./°F	E-831 (TMA)	2.8 x 10^{-5}	2.8 x 10^{-5}	3.3 x 10^{-5}	1.7 x 10^{-5}	2.5 x 10^{-5}	5.7 x 10^{-5}
	17	Heat Deflection Temperature 264 psi	°F	D648	250	250	240	490	490	210
	18	Tg-Glass transition (amorphous)	°F	D3418	N/A	N/A	N/A	N/A	N/A	N/A
	19	Melting Point (crystalline) peak	°F	D3418	540	540	536	540	540	621
	20	Continuous Service Temperature in Air (Max.) (1)	°F	-	425	425	430	450	450	500
	21	Thermal Conductivity	BTU in./hr. ft.^{2} °F	F433	2	2	2.1	2.2	2.1	-
ELECTRICAL	22	Dielectric Strength, Short Term	Volts/mil	D149	540	540	500	-	385	200
	23	Surface Resistivity	ohm/square	EOS/ESD S11.11	>10^{13}	>10^{13}	>10^{13}	<10^{5}	>10^{13}	>10^{12}
	24	Dielectric Constant, 10^6 Hz	-	D150	3	3	-	-	-	2.65
	25	Dissipation Factor, 10^6 Hz	-	D150	0.0013	0.0013	-	-	-	0.008
	26	Flammability @ 3.1 mm (1⁄8 in.) **(5)**		UL 94	V-0	V-0	V-0	V-0	V-0	V-0
CHEMICAL (3)	27	Water Absorption Immersion, 24 Hours	% by wt.	D570 (2)	0.01	0.02	0.01	0.02	0.02	0.03
	28	Water Absorption Immersion, Saturation	% by wt.	D570 (2)	0.03	0.03	0.09	0.03	0.03	2
	29	Acids, Weak, acetic, dilute hydrochloric or sulfuric acid	@73°F		A	A	A	A	A	A
	30	Acids, Strong, conc. hydrochloric or sulfuric acid	@73°F		L	L	L	L	L	A
	31	Alkalies, Weak, dilute ammonia or sodium hydroxide	@73°F		A	A	A	A	A	A
	32	Alkalies, Strong, strong ammonia or sodium hydroxide	@73°F		A	A	A	A	A	U
	33	Hydrocarbons-Aromatic, benzene, toluene	@73°F		A	A	A	A	A	A
	34	Hydrocarbons-Aliphatic, gasoline, hexane, grease	@73°F		A	A	A	A	A	A
	35	Ketones, Esters, acetone, methyl ethyl ketone	@73°F		A	A	A	A	A	A
	36	Ethers, diethyl ether, tetrahydrofuran	@73°F		A	A	A	A	A	A
	37	Chlorinated Solvents, methylene chloride, chloroform	@73°F		A	A	A	A	A	A
	38	Alcohols, methanol, ethanol, anti-freeze	@73°F		A	A	A	A	A	A
	39	Continuous Sunlight	@73°F		L	L	L	A	A	A
OTHER	40	FDA Compliance			Y	N	Y	N	N	Y
	41	Relative Cost (4)			$$$$	$$$	$$$$	$$$$$	$$$$$	$$$$
	42	Relative Machinability (1-10, 1=Easier to Machine)			3	6	3	5	7	1

(1) Data represent Quadrant's estimated maximum long term service temperature based on practical field experience.

(2) Specimens 1/8" thick x 2" dia. or square.

(3) Chemical resistance data are for little or no applied stress. Increased stress, especially localized may result in more severe attack. Examples of common chemicals also included.

(4) Relative cost of material profiled in this brochure ($ = Least Expensive and $$$$$$ = Most Expensive)

(5) **Estimated rating based on available data.** The UL 94 Test is a laboratory test and does not relate to actual fire hazard. Contact Quadrant for specific UL "Yellow Card" recognition number.

Key:

A = Acceptable Service
L = Limited Service
U = Unacceptable
QTM = Quadrant Test Method

NOTE: Property data shown are typical average values. A dash (-) indicates insufficient data available for publishing.

	Fluorosint® 500	Noryl PPO	Quadrant PC 1000	Ketron® 1000 PEEK	Ketron® CM PEEK	Ketron® UHP320 PEEK	Ketron® GF30 PEEK	Ketron® CM GF30 PEEK	Ketron® CA30 PEEK	Ketron® CM CA30 PEEK	Ketron® HPV PEEK	Semitron® ESd 480
	Mica Filled PTFE	Unfilled PPO	Unfilled PC	Unfilled PEEK	Unfilled PEEK	Ultra-high Purity PEEK	30% Glass Filled PEEK	30% Glass Filled PEEK	30% Carbon Fiber Filled PEEK	30% Carbon Fiber Filled PEEK	Premium, Solid Lubricant Filled PEEK	Static Dissipative PEEK
	Compression Molded	Extruded	Extruded	Extruded	Compression Molded	Extruded	Extruded	Compression Molded	Extruded	Compression Molded	Extruded	Compression Molded
1	2.32	1.08	1.2	1.31	1.32	1.31	1.51	1.65	1.41	1.42	1.44	1.47
2	1,100	8,300	10,500	16,000	15,000	16,000	14,000	7,400	19,000	14,000	11,000	14,500
3	300,000	367,000	320,000	630,000	450,000	500,000	1,000,000	850,000	1,100,000	800,000	850,000	940,000
4	10	23	100	40	10	35	2	1.0	5	2	2	1.5
5	2,200	12,900	13,000	25,000	25,000	25,000	23,000	12,000	25,750	30,000	27,500	21,000
6	500,000	397,000	350,000	600,000	600,000	600,000	1,000,000	900,000	1,250,000	1,300,000	1,100,000	1,000,000
7	2,100	8,300	9,200	8,000	-	8,000	14,000	-	-	11,000	10,000	-
8	4,000	13,200	11,500	20,000	17,000	20,000	22,000	19,000	29,000	25,000	26,700	26,500
9	250,000	316,000	300,000	500,000	450,000	500,000	550,000	500,000	-	550,000	1,000,000	570,000
10	R55	M92	M75 (R126)	M100 (R126)	M90 (R125)	M100 (R126)	M103 (R126)	M103 (R124)	M102	M97 (R125)	M85	M107 (R122)
11	D70	-	D80	D85	D85	D85	D89	D86	D93	D86	-	-
12	0.9	2.9	1.5	1	1	1.0	0.8	1.0	1.03	D86Z	.7	1.0
13	0.15	-	-	0.4	0.4	0.4	-	-	0.2	0.24	.21	0.20
14	8,000	-	-	8,500	12,500	25,000	-	-	25,000	41,000	20,000	17,000
15	600	-	-	375	350	-	-	-	150	160	100	-
16	2.5×10^{-5}	3.56×10^{-5}	3.9×10^{-5}	2.6×10^{-5}	2.6×10^{-5}	2.6×10^{-5}	1.2×10^{-5}	1.4×10^{-5}	1×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	1.7×10^{-5}
17	270	260	290	320	320	320	450	450	518	450	383	500
18	N/A	284	293	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	621	N/A	N/A	644	644	644	644	644	644	644	644	644
20	500	200	250	480	480	480	480	480	482	480	482	475
21	5.3	-	1.3	1.75	1.75	1.75	2.98	2.98	6.4	6.37	1.7	-
22	275	701	400	480	480	480	500	550	32	-	-	-
23	$>10^{13}$	-	$>10^{13}$	$>10^{13}$	$>10^{13}$	$>10^{13}$	$>10^{13}$	$>10^{13}$	$<10^{5}$		$<10^{4}$	$10^{6} - 10^{9}$
24	2.85	-	3.17	3.3	3.3	3.3	-	-	-	-	-	-
25	0.008	-	0.0009	0.003	0.003	0.003	-	-	-	-	-	-
26	V-0	-	HB	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0
27	0.1	0.10	0.2	0.1	0.15	0.10	0.1	0.15	.06	0.15	.05	0.18
28	3	-	0.4	0.5	0.5	0.50	0.3	0.5	.3	0.5	.3	1.65
29	A	A	A	A	A	A	A	A	A	A	A	A
30	A	U	U	L	L	L	L	L	L	L	L	L
31	A	A	A	A	A	A	A	A	A	A	A	A
32	U	U	U	A	A	A	A	A	A	A	A	A
33	A	U	U	A	A	A	A	A	A	A	A	A
34	A	L	L	A	A	A	A	A	A	A	A	A
35	A	U	U	A	A	A	A	A	A	A	A	A
36	A	L	U	A	A	A	A	A	A	A	A	A
37	A	U	U	A	A	A	A	A	A	A	A	A
38	A	A	A	A	A	A	A	A	A	A	A	A
39	A	L	L	L	L	L	L	L	A	A	A	A
40	N	N	N	Y	Y	N	N	N	N	N	N	N
41	$$$$	$$$	$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$
42	2	6	3	5	5	5	7	7	7	7	7	4

PRODUCT COMPARISON

		Product Description	Units	Test Method ASTM	Quadrant PSU 1000	Ultem® 1000	Ultem® 2300	Semitron® ESd 410C	Semitron® ESd 420	Semitron® ESd 420V
					Unfilled PSU	Unfilled PEI	30% Glass Filled PEI	Static Dissipative PEI	Static Dissipative PEI	Static Dissipative PEI
					Extruded	Extruded	Extruded	Compression Molded	Compression Molded	Compression Molded
MECHANICAL	1	Specific Gravity, 73°F.	-	D792	1.24	1.28	1.51	1.41	1.34	1.51
	2	Tensile Strength, 73°F.	psi	D638	10,200	16,500	17,000	9,000	11,500	10,000
	3	Tensile Modulus of Elasticity, 73°F.	psi	D638	390,000	500,000	800,000	850,000	640,000	910,000
	4	Tensile Elongation (at break), 73°F.	%	D638	30	80	3	2	2	1.5
	5	Flexural Strength, 73°F.	psi	D790	15,000	20,000	27,000	12,000	14,500	15,800
	6	Flexural Modulus of Elasticity, 73°F.	psi	D790	400,000	500,000	850,000	850,000	650,000	910,000
	7	Shear Strength, 73°F.	psi	D732	9,000	15,000	-	9,000	8,020	-
	8	Compressive Strength, 10% Deformation, 73°F.	psi	D695	13,000	22,000	32,000	19,500	23,800	22,300
	9	Compressive Modulus of Elasticity, 73°F.	psi	D695	375,000	480,000	625,000	600,000	370,000	545,000
	10	Hardness, Rockwell, Scale as noted, 73°F.	-	D785	M82 (R128)	M112 (R125)	M114 (R127)	M115 (R125)	M118	M110 (E78)
	11	Hardness, Durometer, Shore "D" Scale, 73°F.	-	D2240	D80	D86	D86	D85	-	-
	12	Izod Impact (notched), 73°F.ft. lb./in. of notch	ft. lb./in. of notch	D256 Type "A"	1.3	0.5	1	0.8	1	0.5
	13	Coefficient of Friction (Dry vs. Steel) Dynamic	-	QTM 55007	-	0.42	-	0.18	0.28	-
	14	Limiting PV (with 4:1 safety factor applied)	ft. lbs./in.^{2} min	QTM 55007	-	1,875	-	12,000	9,500	-
	15	Wear Factor "k" x 10^{-10}	in.^{3}-min/ft. lbs. hr.	QTM 55010	-	2,900	-	125	100	-
THERMAL	16	Coefficient of Linear Thermal Expansion (-40°F to 300°F)	in./in./°F	E-831 (TMA)	3.1 x 10^{-5}	3.1 x 10^{-5}	1.1 x 10^{-5}	1.8 x 10^{-5}	1.95 x 10^{-5}	1.5 x 10^{-5}
	17	Heat Deflection Temperature 264 psi	°F	D648	340	400	410	410	410	420
	18	Tg-Glass transition (amorphous)	°F	D3418	374	410	410	410	410	420
	19	Melting Point (crystalline) peak	°F	D3418	N/A	N/A	N/A	N/A	N/A	N/A
	20	Continuous Service Temperature in Air (Max.) (1)	°F	-	300	340	340	338	340	340
	21	Thermal Conductivity	BTU in./hr. ft.^{2} °F	F433	1.8	0.85	1.56	2.45	1.51	-
ELECTRICAL	22	Dielectric Strength, Short Term	Volts/mil	D149	425	830	770	N/A	-	-
	23	Surface Resistivity	ohm/square	EOS/ESD S11.11	>10^{13}	>10^{13}	>10^{13}	10^4 –10^6	10^6 –10^9	10^6 – 10^9
	24	Dielectric Constant, 10^6 Hz	-	D150	3.14	3.15	3.7	3	5.63	-
	25	Dissipation Factor, 10^6 Hz	-	D150	0.0008	0.0013	0.0015	0.0013	.266	-
	26	Flammability @ 3.1 mm (1⁄8 in.) **(5)**		UL 94	HB	V-0	V-0	V-0	V-0	V-0
CHEMICAL (3)	27	Water Absorption Immersion, 24 Hours	% by wt.	D570 (2)	0.3	0.25	0.18	0.3	0.5	0.21
	28	Water Absorption Immersion, Saturation	% by wt.	D570 (2)	0.6	1.25	0.9	1.1	2.9	1.4
	29	Acids, Weak, acetic, dilute hydrochloric or sulfuric acid	@73°F		A	A	A	A	A	A
	30	Acids, Strong, conc. hydrochloric or sulfuric acid	@73°F		U	U	U	U	U	U
	31	Alkalies, Weak, dilute ammonia or sodium hydroxide	@73°F		A	A	A	A	A	A
	32	Alkalies, Strong, strong ammonia or sodium hydroxide	@73°F		U	U	U	U	U	U
	33	Hydrocarbons-Aromatic, benzene, toluene	@73°F		U	U	U	U	U	U
	34	Hydrocarbons-Aliphatic, gasoline, hexane, grease	@73°F		L	L	L	L	L	L
	35	Ketones, Esters, acetone, methyl ethyl ketone	@73°F		U	U	U	U	U	U
	36	Ethers, diethyl ether, tetrahydrofuran	@73°F		L	A	A	A	A	A
	37	Chlorinated Solvents, methylene chloride, chloroform	@73°F		U	U	U	U	U	U
	38	Alcohols, methanol, ethanol, anti-freeze	@73°F		A	A	A	A	A	A
	39	Continuous Sunlight	@73°F		L	A	A	A	A	A
OTHER	40	FDA Compliance			Y	Y	N	N	N	N
	41	Relative Cost (4)			$$$	$$$	$$$	$$$$	$$$$$	$$$$$
	42	Relative Machinability (1-10, 1=Easier to Machine)			3	3	7	4	4	4

(1) Data represent Quadrant's estimated maximum long term service temperature based on practical field experience.

(2) Specimens 1/8" thick x 2" dia. or square.

(3) Chemical resistance data are for little or no applied stress. Increased stress, especially localized may result in more severe attack. Examples of common chemicals also included.

(4) Relative cost of material profiled in this brochure ($ = Least Expensive and $$$$$$ = Most Expensive)

(5) **Estimated rating based on available data.** The UL 94 Test is a laboratory test and does not relate to actual fire hazard. Contact Quadrant for specific UL "Yellow Card" recognition number.

Key:

A = Acceptable Service

L = Limited Service

U = Unacceptable

QTM = Quadrant Test Method

NOTE: Property data shown are typical average values. A dash (-) indicates insufficient data available for publishing.

	Radel® R	Torlon® 4203	Torlon® 4503	Torlon® 4301	Torlon® 4501	Torlon® 4540	Torlon® 5530	Torlon® 4XG	Torlon® 4XCF	Semitron® ESd 520HR	Duratron® XP	Celazole® PBI
	Unfilled PPSU	Electrical Grade PAI	Electrical Grade PAI	Bearing Grade PAI	Bearing Grade PAI	Bearing Grade PAI	30% Glass Filled PAI	30% Glass Filled PAI	30% Carbon Fiber Filled PAI	Static Dissipative PAI	Unfilled PI	Unfilled PBI
	Extruded	**Extruded**	**Compression Molded**	**Extruded**	**Compression Molded**	**Compression Molded**	**Compression Molded**	**Extruded**	**Extruded**	**Compression Molded**	**Compression Molded**	**Compression Molded**
1	1.29	1.41	1.4	1.45	1.45	1.46	1.61	1.60	1.47	1.58	1.4	1.3
2	11,000	20,000	18,000	15,000	10,000	13,000	15,000	23,000	22,000	12,000	16,000	20,000
3	340,000	600,000	500,000	900,000	440,000	575,000	900,000	1,000,000	1,200,000	800,000	583,000	850,000
4	30	10	5	3	3	5	3	4	2.5	3%	4	3
5	15,500	24,000	24,000	23,000	20,000	24,000	20,000	30,000	-	20,000	20,000	32,000
6	345,000	600,000	600,000	800,000	650,000	680,000	900,000	980,000	-	850,000	600,000	950,000
7	9,000	16,000	-	16,400	-	-	-	-	-	12,600	-	-
8	13,400	24,000	18,000	22,000	16,000	17,000	27,000	40,000	37,000	30,000	24,000	50,000
9	280,000	478,000	350,000	950,000	359,000	350,000	600,000	700,000	1,000,000	600,000	450,000	900,000
10	M80 (R120)	E80 (M120)	E80 (M119)	E70 (M106)	E70 (M106)	E66 (M107)	E85 (M125)	E90	E91	M108	M110	E105 (M125)
11	D80	-	D90	-	D90	D90	D90	-	-	-	-	D94
12	2.5	2	1.5	0.8	0.5	1.1	0.7	1.0	0.9	0.8	1.4	0.5
13	-	0.35	0.3	0.2	0.2	0.2	0.2	-	.30	0.24	0.23	0.24
14	-	12,500	7,500	22,500	22,500	7,500	20,000	-	14,000	27,000	32,500	37,500
15	>1,000	50	>1,000	10	4.5	315	-	-	75	300	50	60
16	3.1×10^{-5}	1.7×10^{-5}	1.5×10^{-5}	1.4×10^{-5}	2×10^{-5}	2×10^{-5}	2.6×10^{-5}	$.9 \times 10^{-5}$	$.5 \times 10^{-5}$	2.8×10^{-5}	2.7×10^{-5}	1.3×10^{-5}
17	405	532	532	534	534	534	520	-	540	520	680	800 (DMA)
18	428	527	527	527	527	527	527	527	527	527	613	750 (DMA)
19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20	300	500	500	500	500	500	500	500	500	500	580	600
21	2.4	1.8	1.8	3.7	3.7	-	2.5	2.5	3.6	2.6	1.53	2.8
22	360	580	600	-	-	-	700	700	-	475	700	550
23	$>10^{13}$	$>10^{16}$	$>10^{13}$	$>10^{13}$	$>10^{13}$	$>10^{13}$	$>10^{13}$	-	-	$10^{10} - 10^{12}$	$>10^{13}$	$>10^{13}$
24	3.44	4.2	4.2	6	6	-	6.3	-	-	5.76	3.41	3.2
25	0.0017	0.026	0.031	0.037	0.042	-	0.05	-		0.182	0.0038	0.003
26	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0
27	0.37	0.4	0.35	0.4	0.3	0.3	0.3	.3	.3	0.6	0.4	0.4
28	1.1	1.7	1.7	1.5	1.5	1.5	1.5	1.5	1.5	4.6	1.3	5
29	A	A	A	A	A	A	A	A	A	A	A	L
30	L	L	L	L	L	L	L	L	L	L	L	U
31	A	L	L	L	L	L	L	L	L	L	L	L
32	A	U	U	U	U	U	U	U	U	U	U	U
33	L	A	A	A	A	A	A	A	A	A	A	A
34	A	A	A	A	A	A	A	A	A	A	A	A
35	U	A	A	A	A	A	A	A	A	A	A	A
36	L	A	A	A	A	A	A	A	A	A	A	A
37	U	A	A	A	A	A	A	A	A	A	A	A
38	L	A	A	A	A	A	A	A	A	A	A	A
39	L	L	L	A	A	A	L	A	A	L	L	L
40	Y	N	N	N	N	N	N	N	N	N	N	N
41	$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$	$$$$$$	$$$$$$	$$$$$	$$$$$	$$$$$
42	3	5	6	5	6	6	8	8	8	4	5	10

www.quadrantplastics.com

Regional Headquarters

EUROPE

I.P. Noord - R. Tavernierlaan 2
8700 Tielt - Belgium
Tel +32 (0) 51 42 35 11
Fax +32 (0) 51 42 33 00
e-mail: europe.epp@qplas.com

NORTH AMERICA

2120 Fairmont Avenue
PO Box 14235 - Reading, PA 19612-4235
Tel 800 366 0300 / +1 610 320 6600
Fax 800 366 0301 / +1 610 320 6868
e-mail: americas.epp@qplas.com

ASIA-PACIFIC

108 Tai To Tsuen, Ping Shan
Yuen Long - N.T. Hong Kong
Tel +852 (0) 24702683
Fax +852 (0) 24789966
e-mail: asia.epp@qplas.com

Quadrant Engineering Plastic Products Worldwide

BELGIUM
I.P. Noord - R. Tavernierlaan 2
8700 Tielt
Tel +32 (0) 51 42 35 11
Fax +32 (0) 51 42 33 00

CANADA
495 Laird Road
Guelph, Ontario - N1G 3M1
Tel 800 366 0310 / +1 519 837 1500
Fax 800 336 0301 / +1 519 837 3770

FRANCE
Z.A.C. de Satolas Green - PUSIGNAN
69881 MEYZIEU cedex
Tel +33 (0) 4 72 93 18 00
Fax +33 (0) 4 72 93 18 96

GERMANY
Koblenzerstrasse 38
56112 LAHNSTEIN
Tel +49 (0) 2621 6990
Fax +49 (0) 2621 69933

HONG KONG
108 Tai To Tsuen, Ping Shan
Yuen Long,
N.T. Hong Kong
Tel +852 (0) 24702683
Fax +852 (0) 24789966

HUNGARY
Sikert str 2-4
1108 Budapest
Tel +36 (0) 1 2644206
Fax +36 (0) 1 2620145

INDIA
B 166 Yojnavihar,
Delhi 92
Tel +91 (0) 11 2144917
Fax +91 (0) 11 2164541

ITALY
Via Trento 39,
20017 Passirana di Rho,
Milano
Tel +39 02 93 26 131
Fax +39 02 93 50 8451

JAPAN
5-2, Marunouchi 2-chome
Chiyoda-K,
Tokyo 100
Tel +81 (0) 33 2834 267
Fax +81 (0) 33 2834 087

KOREA
97 Samjung-Dong
Ohjung-Ku, Bucheon-city
Tel +82 (0) 32 673 9901
Fax +82 (0) 32 673 6322

MEXICO
Apartado Postal 13
52000 Lerma,
Edo de México
Tel +52 (728) 282 9110
Fax +52 (728) 287 5317

POLAND
Ul. Dziegielowa 7
61-680 Poznan
Tel +48 (0) 61 822 70 49
Fax +48 (0) 61 820 57 51

SOUTH AFRICA
25 Nickel Street, Technicon
P.O. Box 63
Roodepoort 1725
Tel +27 (0) 11 760-3100
Fax +27 (0) 11 763-2811

THE NETHERLANDS
Anth. Fokkerweg 2
7600 AB Almelo
Tel +31 (0) 546 877 777
Fax +31 (0) 546 860 796

UNITED KINGDOM
83 Bridge Road East
Welwyn Garden City
Hertfordshire AL7 1LA
Tel +44 (0) 1707 361 833
Fax +44 (0) 1707 361 838

U.S.A.
2120 Fairmont Avenue - PO Box 14235
Reading, PA 19612-4235
Tel 800 366 0300 / +1 610 320 6600
Fax 800 366 0301 / +1 610 320 6868

Distributed by:

QUADRANT

You inspire . . . we materialize®

LIT. QUADRANT 5/05 010 Printed in U.S.A.