Engineering Plastics For Food Processing and Packaging Equipment

A guide to materials that meet the industry's need for More and Faster production.

QUADRANT

You inspire . . . we materialize®

MORE. FASTER.

In the food processing and packaging industry, it means...

- **Higher demands on the components in your equipment**
- **More frictional heat, more wear, more aggressive, hotter cleaning**
- **A whole new game in material selection**

MORE cuts into downtime, and wear and lubrication become hot issues. That can mean more lubrication cost, and contamination. It can also mean unforeseen part failures from higher wear and from hotter, more aggressive cleaning to turn lines around faster.

FASTER means hotter, and some traditional materials can't take it. For example, higher temperatures mean more dimensional change in traditional parts, causing mating parts to buckle or gap and collect food. It can also mean poor fit and leakage.

New choices for new challenges. Quadrant has a proven and growing portfolio of engineering materials for components that handle these conditions. It includes materials that...

- Reduce weight and power requirements
- Survive a wide range of chemicals and temperatures
- Increase MTBR
- Outwear standard materials by a factor of 10 or more—while reducing frictional drag
- Hold dimensions over wide temperature swings
- Eliminate costly lubrication

To simplify things. A few key properties of engineering plastics—working in concert—have a major effect on equipment productivity. This guide helps simplify the material selection challenge:

- It groups materials by their application area, chemical service and temperature capability
- Each group then compares materials on a few most important properties
- It also compares another key factor—relative cost

We back all of this up with tech support, and the most capable network of plastics distribution and service centers in North America.

EXTREME MATERIALS

Consider Quadrant's EXTREME MATERIALS to improve efficiency and cost. Quadrant's unique Extreme Materials extend part life at a premium that can be negligible in finished part cost. Their low wear and friction reduce downtime and can minimize or eliminate replacement part cost and lost production associated with traditional materials.

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:

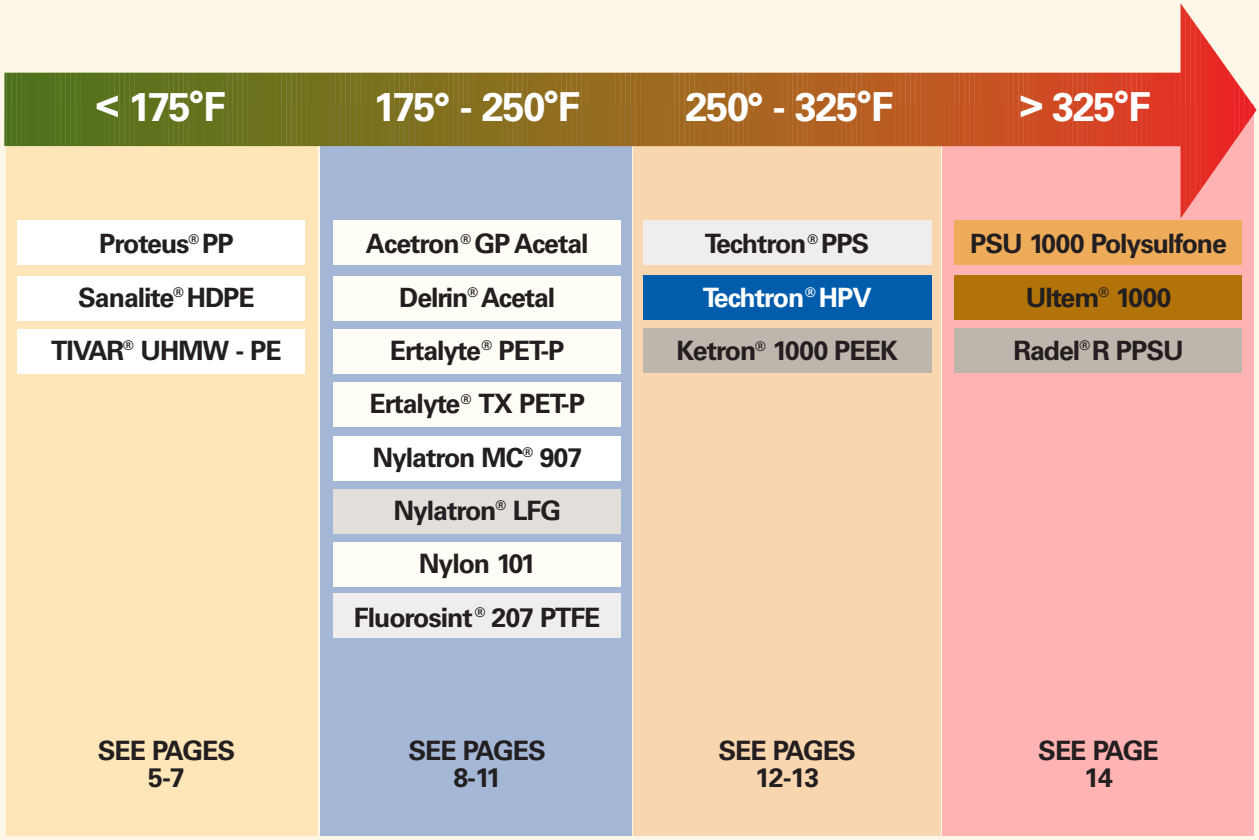
- Evaluation of performance needs and application environment
- Material selection – including selection software
- Material certifications
- Regulatory agency compliance
- Set-up and production recommendations from experienced machinists
- A wide range of material selection, design and fabrication guides 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 sets 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.

ENGINEERING PLASTIC TEMPERATURE PERFORMANCE GROUPS

Values based on Heat Deflection Temperature at 264 psi load.*



***Engineering Note: Heat Deflection vs. Continuous Use Temperature Ratings:**
Quadrant considers Heat Deflection Temperature @ 264 psi (ASTM D648) as typically the best way to compare materials for applications under load. Some supplier data unfortunately reflects only Continuous Use Temperature. This can be very close to the melting point. It is mainly meant to indicate loss of toughness from temperature exposure over time for electrical enclosures. Our data tables (pages 15-18) show both.

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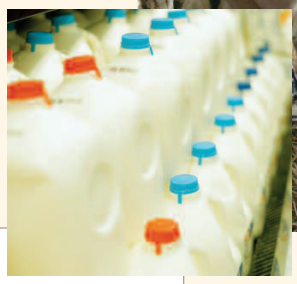
< 175°F Applications

Quadrant stocks a broad range of materials for applications where high temperature is not a factor and where more traditional materials provide the strength in the system. These materials (PP, HDPE and UHMW-PE) are particularly well suited for chute and slide applications, as well as bumpers, supported parts in conveyors and packaging lines. This group also is frequently used as a durable cutting surface in commercial applications.

Proteus® Polypropylene

Manufacturers can rely on the family of Proteus® PP materials to perform in a variety of applications. Its excellent chemical resistance makes it well suited for tanks and corrosion resistant liners where harsh chemicals cause problems in applications below 180°F. Ease of fabrication—vacuum forming, fabricating and welding—make Proteus® PP a solid performer in many food related applications.



Proteus® Homopolymer PP (natural)

This is the most widely used grade. It has a high strength-to-weight ratio, excellent chemical resistance and performs well in corrosive environments, and is easily thermoformed.

Product Profile:

- Performs to 180°F (82°C)
- Resists most acids, alkalis and solvents
- FDA, 3A Dairy and USDA compliant for use in federally inspected meat and poultry facilities

CASE STUDY

Dairy System Coupling

Problem: *A Dairy equipment manufacturer was looking for a coupling that was easy to machine, 3A Dairy compliant and forgiving during the alignment process.*
Solution: *A part machined from Proteus® homopolymer PP met their design criteria.*
Benefits:

- *Proteus® PP is lighter than the metal part it replaced, making it easier to handle.*
- *Harsh cleaning chemicals are no problem for Proteus® PP.*
- *Proteus® PP resists absorbing odors and flavors from the food products passing through.*

Proteus® Premium Gloss (white)

This premium grade, based on homopolymer PP adds a high gloss finish suitable for aesthetic applications.

Product Profile:

- High gloss finish
- Other colors available
- FDA compliant

Proteus® Co-polymer PP (white)

Co-polymer Proteus is modified to improve cold impact strength and toughness characteristics.

Product Profile:

- Performs to 170°F (77°C)
- Higher impact strength
- Cold weather impact strength to -34°F (-37°C)
- More pliable than homopolymer PP
- FDA compliant
- 3A Dairy compliant

< 175°F Applications

High Density Polyethylene—HDPE (white)

HDPE is a widely used basic engineering plastic material with a variety of applications. It meets FDA 21CFR Section 177.1520 and is known for good impact performance under 180°F. It is well suited for tanks, corrosion-resistant wall protection and machined parts in many food industry components. HDPE can be extruded or pressed into sheets up to 4" thick.

Product Profile:

- Vacuum formable
- Excellent chemical resistance
- Good impact resistance
- High strength
- Non-toxic, non-staining
- FDA compliant

Sanalite® HDPE Cutting Board (white)

This is the most widely used grade. It has a high strength-to-weight ratio, excellent chemical resistance and performs well in corrosive environments.

Product Profile:

- Odorless and taste-free
- Pebbled, acid-resistant surface
- Easily cleaned
- Lightweight
- FDA, USDA, NSF and Canada AG compliant
- Consider polypropylene if a harder surface is required

CASE STUDY

Commercial Cutting Board

Problem: *Many commercial kitchens and food processing facilities have struggled with wood cutting boards that absorb liquids, flavors and odors. In addition, many of these grow into bacteria that can contaminate food products.*
Solution: *Sanalite® HDPE or PP cutting boards eliminate these problems.*
Benefits:

- *Easy to clean and disinfect—and will not absorb liquid, flavor or odor.*
- *Sanalite® is lighter than wood which means easier installation.*
- *Cut resistant polymer provides a longer service life.*

TIVAR® Ultra-High Molecular Weight Polyethylene—UHMW PE (white)

Food processing and packaging equipment designers have learned that TIVAR® UHMW materials can improve the efficiency and performance of handling systems. TIVAR® can help eliminate problems like noise, wear of mating parts and stretched chains that can cause costly downtime. With broad temperature performance, TIVAR® materials are ideal for freezing lines and operations that are intermittently exposed to temperatures up to 200°F.

TIVAR® 1000 (white)

TIVAR® 1000 UHMW is a widely recognized engineering material with a remarkable combination of lubricity, chemical resistance and impact strength. It also has no moisture absorption and retains most of its key properties to -22°F (-30°C). A broad range of shapes including sheet, rod, tube and profiles are possible.

A broad range of FDA compliant colors is available!

Product Profile:

- Reduces noise and vibration
- Slippery, wear-resistant surface
- Very low moisture absorption
- Excellent chemical resistance
- FDA, USDA and 3A Dairy compliant

TIVAR® Oil Filled (dark brown, grey)

An FDA compliant lubricant is added to TIVAR® UHMW to enhance its already good bearing performance.

Product Profile:

- Higher PV rating
- FDA and USDA compliant

TIVAR® CleanStat™ (black)

TIVAR® CleanStat provides UHMW performance with the added benefit of static reduction. This helps to manage fines that are generated during manufacturing, processing and packaging operations. Ideal in drums, hoppers, chutes, buckets or any environment where particles are generated and can cause a loss of efficiency.

Product Profile:

- Long-wearing surface with a lower coefficient of friction than steel or aluminum
- Helps to reduce cleaning time
- FDA, USDA and 3A Dairy compliant

CASE STUDY

Candy Mixing Paddle

Problem: *Aggressive cleaning chemicals and elevated temperatures caused failures and costly, frequent replacement of metal and PE mixing paddles. Downtime associated with part replacement increased the plant's production costs.*

Solution: *TIVAR® H.O.T. enhanced UHMW-PE solved the discoloration, galling and wear problems associated with the prior materials.*

Benefits:

- *TIVAR® H.O.T paddles last 6x longer than prior materials.*
- *Discoloration from the elevated temperatures has been completely eliminated.*
- *The enhanced UHMW-PE material is more resistant to harsh cleaning chemicals than stainless steel.*

TIVAR® H.O.T. (white)

Newly developed TIVAR® H.O.T. pushes the performance envelope of UHMW. It offers enhanced chemical and thermal performance in supported applications. With elevated temperature wear life up to 10x longer when compared to standard UHMW, TIVAR® H.O.T. is a new choice for wear strips, rollers and drag flights for the food processing and packaging industry.

Product Profile:

- Lasts up to 10x longer in elevated temperature environments
- Resists abrasion, corrosion, chemicals and moisture
- Excellent release characteristics
- FDA, USDA and 3A Dairy compliant
- Excels in a variety of industrial manufacturing environments where temperatures range up to 275° F

Tech Notes:

- *TIVAR products maintain many of their impact and tensile properties at cryogenic temperatures, making them ideal for flash or quick freeze applications.*

<175° - 240°F Applications

Quadrant materials for this temperature range differ in bearing and wear, temperature and chemical resistance. All are more stable than UHMW in temperature swings, to minimize dimensional change in mating parts. Compare them for the best balance of cost and performance.

For non-food contact applications requiring extreme bearing and wear or structural loads see page 16.

Acetron® GP—copolymer acetal

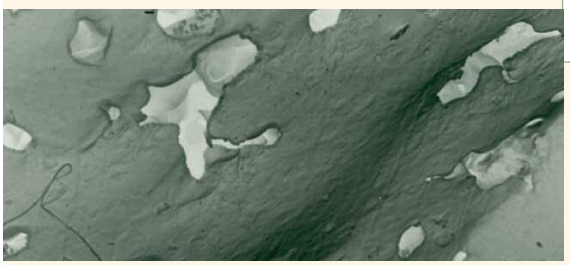
- Improved dimensional stability vs. nylon—lower moisture absorption
- Porosity-free rod and plate—minimizes bacteria build-up, easier to sanitize
- Low, consistent internal stress minimizes dimensional change in machining and use
- Uses: general bearing and wear and mixing components
- Colors: natural (white); black. Standard colors make-to-order
- Compliance: FDA, USDA, NSF, 3A Dairy, Canada AG

CASE STUDY

Commercial ice cream equipment

Problem: *Scraper blades in stainless steel were costly and wore mating parts quickly.*
Solution: *Replacement blades machined from Acetron® GP plate.*
Benefits:

- *Lower part cost, minimal wear and repair cost on mating surfaces*
- *Stiffness and low stress ensure flatness for mixing efficiency*
- *Porosity-free quality minimizes potential for trapped food and bacteria*



Some acetals—even copolymer or claimed porosity-free material—can contain tiny holes that trap dirt and bacteria. (photo-micrograph @ 500x)

*Only Quadrant's **Acetron® GP** combines the assurance or porosity-free performance with the ease of machining that the industry's lowest stress levels provide. (photo-micrograph @ 500x)*

NEW

FDA Compliant Acetron® GP Colors

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

Low minimums—Quick turnaround

ALSO AVAILABLE

Delrin®—homopolymer acetal

- Slightly higher strength than co-polymer acetal
- Uses: General, Structural and Bearing Applications (Porosity may cause sanitation issues)
- Compliance: FDA, NSF, 3A Dairy

Ertalyte® PET-P

- Combines acetal's dimensional stability, nylon's strength—plus better wear resistance
- Higher temperature resistance of 240°F under load allows hotter cleaning solutions
- Resists staining, outperforms nylon, acetal in acidic environments
- Uses: precision parts needing high dimensional stability and temperatures
- Color: natural (bright white); black
- Compliance: FDA, USDA, 3A Dairy, Canada AG
- Withstands "bleach solutions" unlike Nylon/Acetal

Ertalyte® TX PET-P

- Far less wear than standard PET, PBT and lubricated acetals—best in class
- Excels in high velocity load-bearing applications—wet or dry
- Minimizes wear against soft metal and plastic mating parts
- Uses: Upgrade to longer life precision parts—reduce downtime and lubrication
- Color: standard light grey
- Compliance: FDA, USDA, 3A Dairy

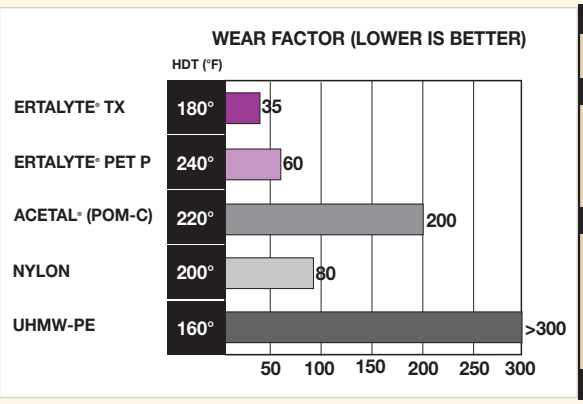
CASE STUDY

Dairy food liquid filling equipment

Problem: *High cost, wear rate of stainless steel.*
Solution: *Pistons and valves machined from Ertalyte® PET-P rod.*
Benefits:

- *Tight tolerances assure fill accuracy and efficiency—with a lower cost part*
- *Lower weight allowed lighter duty, lower cost drives—which outlasted former units*
- *Resistance to various liquids and chemicals afforded more production versatility*

Temperature & Wear Resistance



Dimensional Stability

	ERTALYTE®	ACETAL	NYLON	UHMW-PE
WATER ABSORPTION (24 HR.)	0.07	0.20	0.30	< 0.01
COEFFICIENT OF LINEAR THERMAL EXPANSION (CLTE)	3.3×10^{-5}	5.4×10^{-5}	5.5×10^{-5}	9×10^{-5}

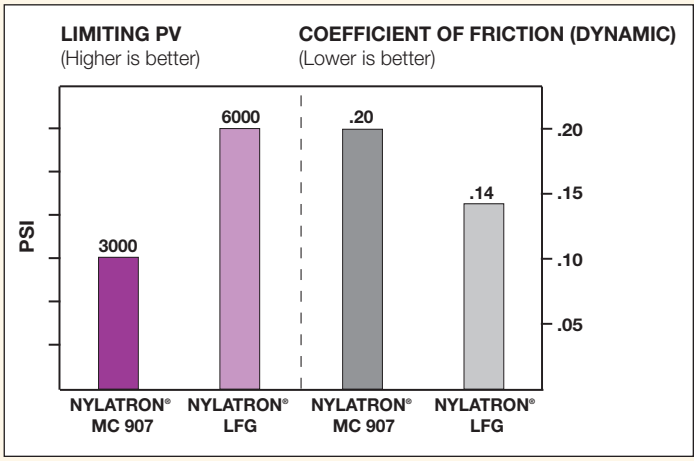
Tech Notes:

- *Ertalyte PET has machining characteristics different from those of nylon and acetal.*
  - Request our machining guidelines for easy adaptations to assure high quality machined parts.
- *All polyesters including Ertalyte are less resistant to hot water and steam than acetal.*
  - Contact Quadrant's technical support team to review specific applications.

<175° - 240°F Applications

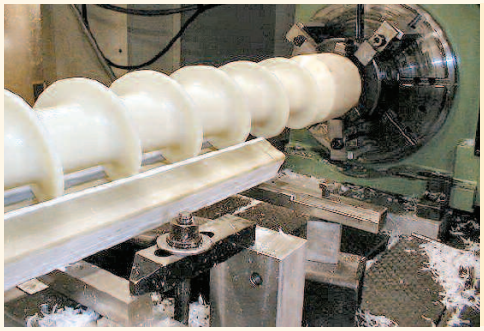
Nylatron® MC 907—unfilled natural cast nylon

- Highest strength and hardness in cast nylon type 6
- Better dimensional stability and strength than UHMW
- Uses: general utility parts
- Color: natural (cream-white)
- Compliance: FDA, USDA, 3A Dairy



Enhanced Wear Resistant Nylatron® LFG—oil filled cast nylon

- Lower coefficient of friction and higher PV
- Improves bearing and wear performance over standard grades
- Uses: alternative to standard cast nylon where external lubrication is impractical
- Color: natural (cream-white)
- Compliance: FDA

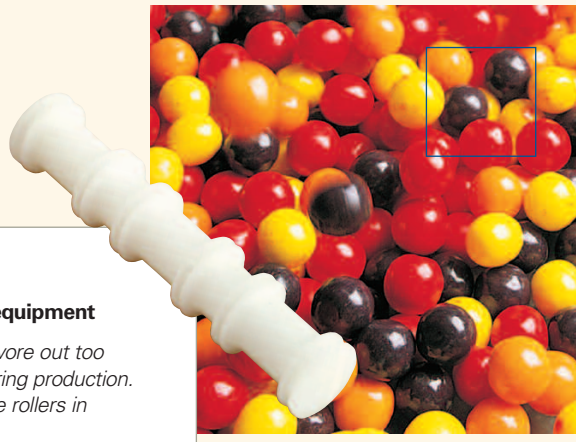


Consider the versatility and cost saving potential of Nylatron Custom Castings:

The nylon casting process allows a range of formulations and sizes including large heavy walled tube, large diameter rod, thick plates and blocks. It also allows casting custom parts and near net shapes that can cut cost vs. machining from a stock shape. This large part is FDA compliant Nylon cast over a steel shaft.

Nylon 101—extruded unfilled type 6/6

- Highest strength and rigidity of all nylon products
- Uses: screw-machined electrical insulators and food contact parts
- Sizes: range includes small diameter rod, thin plate
- Colors: natural (cream-white); black. Standard colors make-to-order
- Compliance: FDA, USDA, 3A Dairy, NSF



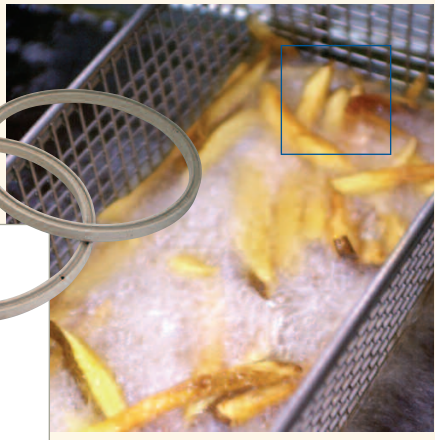
CASE STUDY

Candy manufacturing equipment

Problem: *Metal rollers wore out too quickly and held heat during production.*
Solution: *Make the drive rollers in Quadrant's Nylon 101.*
Benefits:
- *Far longer wear life and time between maintenance cycles*
- *Reduced downtime for system lubrication and parts replacement*

Fluorosint® 207 PTFE

- Unmatched dimensional stability among PTFE's; non-permeable in steam
- Wear life at < 300°F (150°C) 20 times greater than typical filled PTFE
- Nearly 10 times more resistant to deformation under load
- Uses: Aggressive service, tight tolerance bearings and bushings
- Color: standard grey-white
- Compliance: FDA 21 CFR 175.300, USDA
- Ideal for seals and gaskets up to 500°F, where standard PTFE loses stability



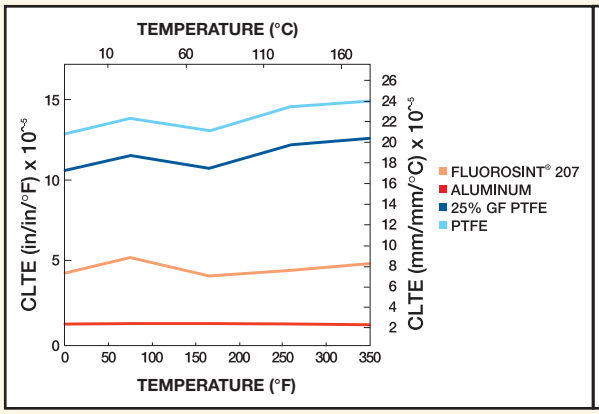
CASE STUDY

Bearings in commercial frying equipment

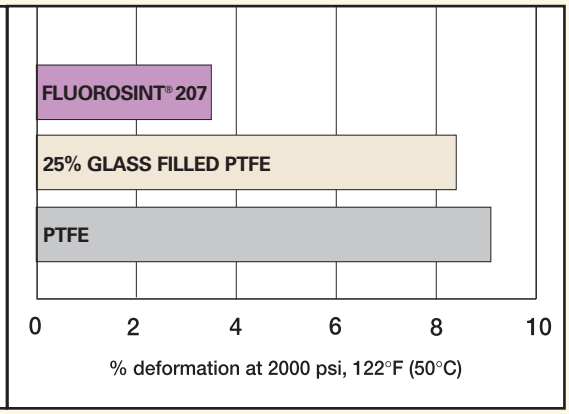
Problem: *Premature part wear at high temperature; contamination from lubrication of metal.*
Solution: *Composite design—bearing surfaces made from Fluorosint 207 supported by metal.*
Benefits:

- *Fluorosint 207 eliminates high wear from dynamic load*
- *Metal adds structural strength and avoids wear exposure*
- *Avoids deformation and degradation from exposure to hot cooking oils*

Coefficients of Linear Thermal Expansion



Deformation Under Load



240° - 325°F Applications

Quadrant has an ongoing development effort in materials for this application range as cleaning methods get hotter and more aggressive. These advanced materials deliver unique levels of wear and chemical resistance, dimensional stability and strength retention. Their diversity provides options for the best balance of cost and performance, without expensive over-engineering.

For non-food contact applications requiring extreme bearing and wear or structural loads see page 16.

EXTREME MATERIALS Techtron® PPS

- Unsurpassed chemical resistance in this range
- Unique Quadrant technology—toughest, most durable unfilled PPS available
- Takes structural load to 240°F—in steam, hot water and cleaning chemicals
- Uses: structural mixing and handling components that see high temperatures in cleaning and use
- Color: standard light grey-beige
- Compliance: FDA

EXTREME MATERIALS Techtron® HPV PPS

- Unique combination of ultra-low wear, extreme chemical resistance in the 200°-240°F range
- No abrasive glass fibers common to filled PPS—minimizes counter-face wear
- Similar electrical, chemical and hydrolysis resistance of natural Techtron PPS
- Uses: cost-effective high performance alternative to PEEK below 250°F
- Color: standard deep blue
- Compliance: FDA compliance pending as of publication date

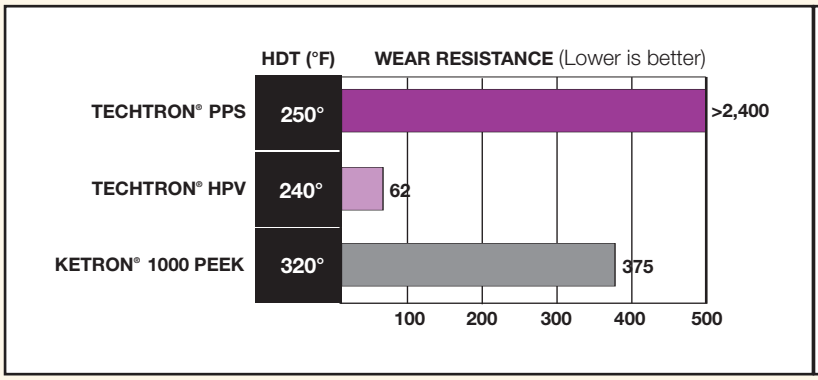
CASE STUDY

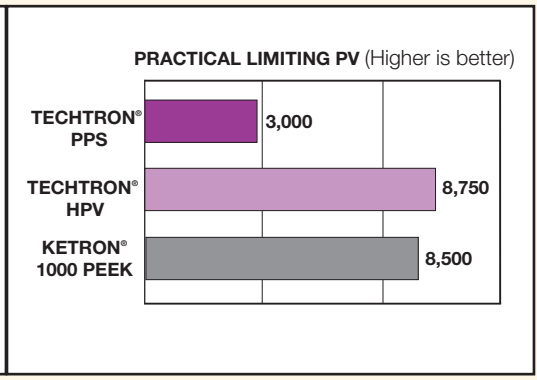
Guide rail—commercial meat portioning and packaging equipment

Problem: *Traditional plastic materials failed as wash-down temperatures increased.*
Solution: *Replace existing material with FDA compliant Techtron® PPS.*
Benefits:

- *Faster line turn-around using hotter cleaning methods*
- *Eliminated part damage and hard to clean gaps from dimensional changes*

Temperature & Wear Resistance

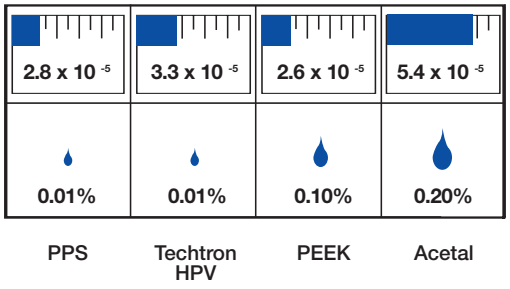




Ketron® 1000 PEEK

- Ideal for food contact bearing and wear applications from 240° - 325°F
- Resists wide range of aggressive, hot chemicals and cleaning solutions
- Uses: Oven and hot process parts; exposure to steam, chemicals under pressure
- Color: natural (light beige)
- Compliance: FDA, USDA, 3A Dairy

Dimensional Stability
(CLTE and H_2O Absorption 24 hr. Immersion)



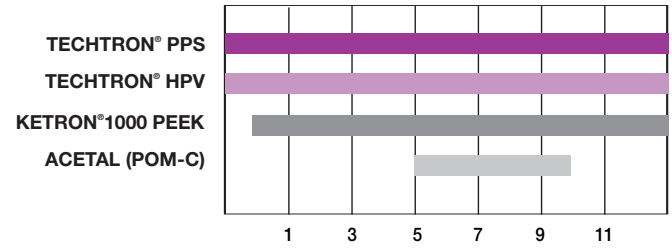
CASE STUDY

High temperature production line

Problem: *High process unit temperatures warped portioning unit components. Required a cooling unit that reduced production efficiency.*
Solution: *Machined components from high temperature resistant Ketron 1000 PEEK.*
Benefits:
- *Eliminated distortion from high temperatures; improved production life of parts*
- *Eliminated cooling unit; closer placement of portioning unit increased production output and efficiency*

Ketron® PEEK offers an excellent combination of physical properties:

	Ketron® 1000 PEEK	Techtron® PPS	Techtron® HPV PPS
Overall Chem. Resist.	Very Good	Excellent	Excellent
Moisture Absorption	Very Good	Excellent	Excellent
Steam Resistance	Good	Good	Good
Wear Resistance (dry)	Very Good	Poor	Excellent
Cont. Service Temperature	480°F (250°C)	425°F (220°C)	430°F (221°C)
Heat Deflection Temperature	320°F (160°C)	250°F (120°C)	240°F (115°C)
% Flexural Strength Maintained at: 300°F (150°C)	84%	23%	25%
at: 500°F (260°C)	10%	5%	25%

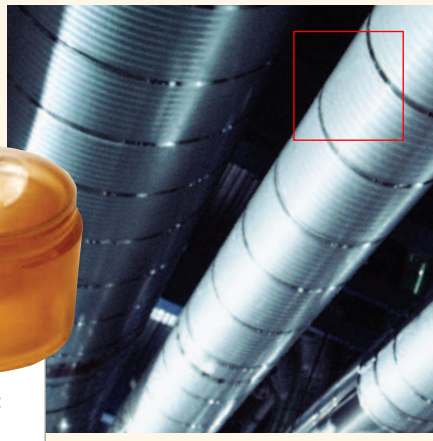


Tech Notes:

- *Designing with high temperature plastics requires adjustments from typical metal designs. Refer to Quadrant's Design and Fabrication Guide for clearances, bearing designs and fit calculations. Visit us at www.quadrantplastics.com or call 800-366-0300.*

>325°F + Applications

The materials in the 300°F+ class open the weight saving and design versatility benefits of engineering plastics to applications once restricted to specialty metals and glass. Their lighter weight can mean lower-cost drive systems—and they can reduce part cost depending on the type of metal or glass replaced.



For non-food contact applications requiring extreme bearing and wear and structural loads, see page 16.

PSU 1000 polysulfone

- Structural strength to 340°F
- Withstands hot water and steam—tough, durable
- Uses: sight glass, material conveying bins
- Color: natural (transparent light amber tint)
- Compliance: FDA, USDA, 3A Dairy

CASE STUDY

Sight glass—hot process equipment

Problem: *Glass breakage concerns; temperature failure in other transparent plastics.*
Solution: *Transparent PSU 1000 polysulfone sight glass units.*
Benefits:
- *Durable—no breakage*
- *Cost effective vs. glass*
- *Resists hot cleaning agents and acidic solutions in processing*

Ultem® 1000 PEI—polyetherimide

- Higher structural strength than polysulfone to 400°F
- Excellent electrical properties—rated UL V-0
- Uses: similar to polysulfone with a higher temperature limit under load
- Color: natural (transparent dark amber)
- Compliance: FDA, USDA and NSF (STD. 51)

Radel® R—PPSU

- Best resistance to multiple sterilization cycles and chemicals in this range
- Higher impact resistance plus strength at temperatures to 410°F
- Excellent electrical properties—rated UL V-0
- Uses: similar to polysulfone, Ultem PEI with greater chemical and impact resistance
- Color: bone white; some colors available make-to-order
- Compliance: FDA

CASE STUDY

Cookie filling distribution spool

Problem: *Costly metal part required dis-assembly to clean. Temperatures eliminated many plastics.*
Solution: *One-piece spools machined from Ultem 1000 PEI.*
Benefits:
- *Durable, long lasting parts withstand high temperatures near baking environment*
- *One piece machined part reduced cost and cleaning time vs. metal assembly*

PHYSICAL PROPERTY GUIDE—Less than 175°F

	Property	Method	Unit	Proteus® PP	Sanalite® HDPE
MECHANICAL	Density	ASTM D792	lbs/ft³	56.30	59.88
	Yield Point	ASTM D638	psi	5,150	4,279
	Elongation at Yield	ASTM D638	%	11	18
	Tensile Break	ASTM D638	psi	5,150	4,423
	Elongation at Break	ASTM D638	%	400	600
	Tensile Modulus	ASTM D638	psi	190,240	224,812
	Flexural Modulus	ASTM D790	psi	212,425	166,796
	Izod Impact	ASTM D4020	ft-lbs/in²	1.20	1.3
	Tensile Impact	DIN 53448	ft-lbs/in²	269	570
	Sand Wheel Wear	ASTM G65	AR-01 steel=100	-	-
	Hardness	ASTM D2240	Type D	78	67
	Static Friction	ASTM D1894	unitless	-	-
	Dynamic Friction	ASTM D1894	unitless	-	-
	Compressive Modulus	ASTM D695	psi	-	-
THERMAL	Coefficient of Thermal Expansion	ASTM D696	°F⁻¹	-	-
	Melt Point	ASTM D3417	°F	329	259-264
	Maximum Operating Temperature		°F	-	-
	Water Absorption	ASTM D570	%	slight	slight

Values are averages and are not specifications. ASTM test methods are under current procedures.

IMPORTANT: This group of materials may ignite and sustain flame under certain conditions. Caution is urged where any material may be exposed to open flame or heat-generating equipment. Use Material Safety Data Sheets to determine auto-ignition and flashpoint temperatures of materials, or consult our tech support team if additional information about this specific group materials is needed.

CHEMICAL RESISTANCE GUIDE—Less than 175°F

	Chemical	%	Temp (F)	Proteus® Homopolymer PP	Sanalite® HDPE
	Chemical Families				
	Acid, Weak - acetic acid, dillute hydrochloric or sulfuric acid		73°F	A	A
	Acid, Strong - conc. hydrochloric or sulfuric acid		73°F	A	A
	Alkalies, Weak - dillute ammonia or sodium hydroxide		73°F	A	A
	Alkalies, Strong - strong ammonia or sodium hydroxide		73°F	A	A
	Hydrocarbons, Aromatic - benzene or toluene		73°F	U	U
	Hydrocarbons, Aliphatic - gasoline, hexane, grease		73°F	U	U
	Ketones, Esters - acetone, methyl ethyl, ketone		73°F	U	U
	Ethers - diethyl ether or tetrahydrofuran		73°F	U	U
	Chlorinated Solvents - methylene chloride, chloroform		73°F	U	U
	Alcohols - methanol, ethanol, anti-freeze		73°F	A	A
	Inorganic Salt Solutions - sodium chloride, potassium cyanate		73°F	A	A
	Continuous Sunlight		73°F	-	-
	Food Industry Typical Exposure				
	Hydrogen peroxide	1	73°F	L	A
	Nitric acid	1	73°F	A	A
	Nitric acid	5	176°F	A	A
	Phosphoric acid	1	73°F	A	A
	Phosphoric acid	5	176°F	A	A
	Sodium hydroxide	1	73°F	A	A
	Sodium hydroxide	5	176°F	A	A
	Sodium hypochlorite (300 ppm active chlorine)		68°F	A	A
	Steam sterilization (single autoclaving)	UD	273°F	U	U
	Steam sterilization (repeated autoclaving)	UD	273°F	U	U
	Sulphuric acid	1	73°F	A	A
	Sulphuric acid	3	140°F	A	A
	Water	UD	140°F	A	A
	Water	UD	176°F	A	A
	Water	UD	203°F	A	A

PHYSICAL PROPERTY GUIDE—175°F to 325°F +

		Product Description	Units	Test Method ASTM	TIVAR®1000 UHMW-PE	Acetron® GP Acetal	Delrin® Acetal	Ertalyte® PET-P
					UHMW Polyethylene	Copolymer Porosity-free Acetal	Homopolymer Acetal	Semi-crystalline Thermoplastic Polyester
MECHANICAL	1	Specific Gravity, 73°F.	-	D792	.93	1.41	1.41	1.41
	2	Tensile Strength, 73°F.	psi	D638	5,800	9,500	11,000	12,400
	3	Tensile Modulus of Elasticity, 73°F.	psi	D638	100,000	400,000	450,000	460,000
	4	Tensile Elongation (at break), 73°F.	%	D638	300	30	30	20
	5	Flexural Strength, 73°F.	psi	D790	3,500	12,000	13,000	18,000
	6	Flexural Modulus of Elasticity, 73°F.	psi	D790	110,000	400,000	450,000	490,000
	7	Compressive Strength, 10% Deformation, 73°F.	psi	D695	3,000	15,000	16,000	15,000
	8	Compressive Modulus of Elasticity, 73°F.	psi	D695	80,000	400,000	450,000	420,000
	9	Hardness, Rockwell, Scale as noted, 73°F.	-	D785	R56	M88 (R120)	M89 (R122)	M93 (R)125
	10	Hardness, Durometer, Shore "D" Scale, 73°F.	-	D2240	D66	D85	D86	D87
	11	Izod Impact (notched), 73°F.	ft. lb./in. of notch	D256 Type "A"	No Break	1	1	0.5
	12	Coefficient of Friction (Dry vs. Steel) Dynamic	-	QTM 55007	0.12	0.25	.25	0.2
	13	Limiting PV (with 4:1 safety factor applied)	ft. lbs./in.^{2} min	QTM 55007	2,000	2,700	2,700	2,800
	14	Wear Factor "k" x 10^{-10}	in.^{3}-min/ft. lbs. hr.	QTM 55010	371	200	200	60
THERMAL	15	Coefficient of Linear Thermal Expansion (-40°F to 300°F)	in./in./°F	E-831 (TMA)	2.0 x 10^{-5}	5.4 x 10^{-5}	4.7 x 10^{-5}	3.3 x 10^{-5}
	16	Heat Deflection Temperature 264 psi	°F	D648	116	220	250	240
	17	Tg-Glass transition (amorphous)	°F	D3418	N/A	N/A	N/A	N/A
	18	Continuous Service Temperature in Air (Max.)	°F	-	180	180	180	210
	19	Thermal Conductivity	BTU in./hr. ft.^{2} °F	F433	2.9	1.6	2.5	2
CHEMICAL (1)	20	Water Absorption Immersion, 24 Hours	% by wt.	D570 (2)	<0.01	0.2	0.2	0.07
	21	Water Absorption Immersion, Saturation	% by wt.	D570 (2)	<0.01	0.9	0.9	0.9
	22	Acids, Weak, 73°F., acetic acid, dilute hydrochloric or sulfuric acid			A	L	L	A
	23	Acids, Strong, 73°F., conc. hydrochloric or sulfuric acid			A	U	U	L
	24	Alkalies, Weak, 73°F., dilute ammonia or sodium hydroxide			A	A	A	A
	25	Alkalies, Strong, 73°F., strong ammonia or sodium hydroxide			A	U	U	U
	26	Hydrocarbons-Aromatic, 73°F., benzene, toluene			L	A	A	A
	27	Hydrocarbons-Aliphatic, 73°F., gasoline, hexane, grease			A	A	A	A
	28	Ketones, Esters, 73°F., acetone, methyl ethyl ketone			A	A	A	A
	29	Ethers, 73°F., diethyl ether, tetrahydrofuran			L	A	A	A
	30	Chlorinated Solvents, 73°F., methylene chloride, chloroform			L	L	L	U
	31	Alcohols, 73°F., methanol, ethanol, anti-freeze			A	A	A	A
	32	Inorganic Salt Solutions, 73°F., sodium chloride, potassium cyanate			-	A	A	A
	33	Continuous Sunlight, 73°F.			-	L	L	L
OTHER	34	Relative Machinability (1-10, 1=Easier to Machine)			2	1	1	2
	35	Flammability @ 3.1 mm (1/8 in.) **(2)**		UL 94	HB	HB	HB	HB

Chemical Resistance: A= Acceptable, L= Limited, U= Unacceptable

(1) 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.

(2) 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.

Ertalyte® TX	Nylatron® MC 907 Nylon	Nylatron® LFG Nylon	Nylon 101	Fluorosint® 207 PTFE	Techtron® PPS	Techtron® HPV	Ketron® 1000 PEEK	PSU 1000 Polysulfone	Ultem® 1000	Radel® R PPSU
Bearing Grade Thermoplastic Polyester	Monocast® FDA compliant Type 6	Oil-filled Type 6	Unfilled Type 66	Synthetic mica-filled PTFE	Polyphenylene sulfide	Bearing Grade Polyphenylene sulfide	Polyetherether-ketone	Unfilled Polysulfone	Unfilled Polyetherimide	Unfilled Polyphenyl-sulphone
1.44	1.15	1.14	1.15	2.3	1.35	1.43	1.31	1.24	1.28	1.29
10,500	12,000	9,900	11,500	1,500	13,500	10,900	16,000	10,200	16,500	11,000
500,000	400,000	465,000	425,000	250,000	500,000	540,000	735,000	390,000	500,000	340,000
5	20	50	50	50	15	5	20	30	80	30
14,000	16,000	15,000	15,000	2,000	21,000	10,500	15,000	15,000	20,000	15,500
360,000	500,000	525,000	450,000	350,000	575,000	535,000	700,000	400,000	500,000	345,000
15,250	15,000	13,500	12,500	3,800	21,500	15,500	20,000	13,000	22,000	13,400
400,000	400,000	330,000	420,000	225,000	430,000	342,000	500,000	375,000	480,000	280,000
M94	M85 (R115)	M85 (R)120	M85(R115)	R50	M95	M84	M100 (R126)	M82 (R128)	M112 (R125)	M80(R120)
D80	D85	-	D80	D65	D85	-	D85	D80	D86	D80
0.4	0.4	1.5	0.6	1	0.6	1.4	1	1.3	0.5	2.5
0.19	0.2	0.14	0.25	0.1	0.4	0.2	0.4	-	0.42	-
6,000	3,000	6,000	2,700	8,000	3,000	8,750	8,500	-	1,875	-
35	100	72	80	30	2,400	62	375	-	2,900	>1,000
4.5×10^{-5}	3.5×10^{-5}	5.6×10^{-5}	5.5×10^{-5}	5.7×10^{-5}	2.8×10^{-5}	3.3×10^{-5}	2.6×10^{-5}	3.1×10^{-5}	3.1×10^{-5}	3.1×10^{-5}
180	200	200	200	210	250	240	320	340	400	405
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	374	419	428
210	200	200	210	500	425	430	480	300	340	300
1.9	1.7	1.7	1.7	-	2.0	2.1	1.75	1.8	0.85	2.4
0.06	0.3	0.3	0.3	0.03	0.01	0.01	0.1	0.3	0.25	0.37
0.47	7	7	7	2	0.03	0.09	0.5	0.6	1.25	1.1
A	L	L	L	A	A	A	A	A	A	A
L	U	U	U	A	L	L	L	U	U	L
A	L	L	L	A	A	A	A	A	A	A
U	U	U	U	U	A	A	A	U	U	A
A	A	A	A	A	A	A	A	U	U	L
A	A	A	A	A	A	A	A	L	L	A
A	A	A	A	A	A	A	A	U	U	U
A	A	A	A	A	A	A	A	L	A	L
U	L	L	L	A	A	A	A	U	U	U
A	L	L	L	A	A	A	A	A	A	L
A	A	A	A	A	A	A	A	A	A	A
L	L	L	L	A	L	L	L	L	A	L
2	1	1	1	1	3	3	5	3	3	3
HB	HB	HB	V-2	V-0	V-0	V-0	V-0	HB	V-0	V-0

CHEMICAL RESISTANCE GUIDE—175°F to 325°F +

Chemicals	Concentration (%)	Temperature (°C)	TIVAR® UHMW-PE	ACETRON® GP DELRIN® (POM)	ERTALYTE® (PET) ERTALYTE® TX	MC® / NYLATRON® (PA)	FLUOROSINT® (PTFE)	TECHTRON® PPS TECHTRON® HPV	KETRON® 1000 PEEK	PSU 1000 POLYSULFONE	ULTEM® PEI	RADEL® R PPSU
Hydrogen peroxide	1	RT	A	A	A	C	A	A	A	A	A	A
Nitric acid	1	RT	A	C	A	B	A	A	A	A	A	A
Nitric acid	5	80	-	C	C	C	A	A	B	A	B	A
Phosphoric acid	1	RT	A	C	A	B	A	A	A	A	A	A
Phosphoric acid	5	80	U	C	B	C	A	A	A	A	A	A
Sodium hydroxide	1	RT	A	A	A	A	A	A	A	A	A	A
Sodium hydroxide	5	80	A	A	C	C	B	A	A	A	B	A
Sodium hypochlorite (300 ppm active chlorine)		20	A	B	A	B	A	A	A	A	A	A
Steam sterilisation (single autoclaving)	UD	134	U	A	A	A	A	A	A	A	A	A
Steam sterilisation (repeated autoclaving)-(*)	UD	134	U	C	C	C	A	A	A	A	A	A
Sulphuric acid	1	RT	A	A	A	B	A	A	A	A	A	A
Sulphuric acid	3	60	A	C	A	C	A	A	B	A	A	A
Water	UD	60	A	A	A	A	A	A	A	A	A	A
Water	UD	80	A	A	B	B	A	A	A	A	A	A
Water	UD	95	A	B	C	C	A	A	A	A	A	A

Legend to the table:
Resistance ratings:
A: Resistant. Little or no change in weight. Small effect on mechanical properties. In general acceptable service life.
B: Partially resistant. In course of time, there is a distinct deterioration in mechanical properties and a change in weight. In many cases a short term exposure or limited number of cleaning cycles may be considered allowable (to be evaluated by practical testing).
C: Non-resistant. After a short time, the material is seriously affected (considerable reduction of the mechanical strength and changes in weight). Using the material under these conditions is not recommended.
NA: Not applicable for this material

Concentration (%):
A number, e.g. 5, indicates "5g of solute per 100g of aqueous solution" (5% by weight).
UD: Undiluted (technically pure chemical)

Temperature (°C):
RT: Room temperature (15 - 25°C)

Important considerations regarding chemical resistance, cleaning and autoclaving:

Many factors can affect chemical resistance of a material, and it is virtually impossible to test and provide data for all potential combinations to which an application can be exposed. Chemical resistance, autoclaving and cleaning data from any source can only serve as a guideline based on tests at specific conditions. The user must make his own determination of a material's suitability for use based on testing of finished parts in their practical environment.

Variables—alone or in combination—that can affect chemical resistance and should be considered include the influence of machined-in stresses, assembly and application loads, part design, cleaning cycle times, pressures, chemical concentrations and combinations, and temperatures.

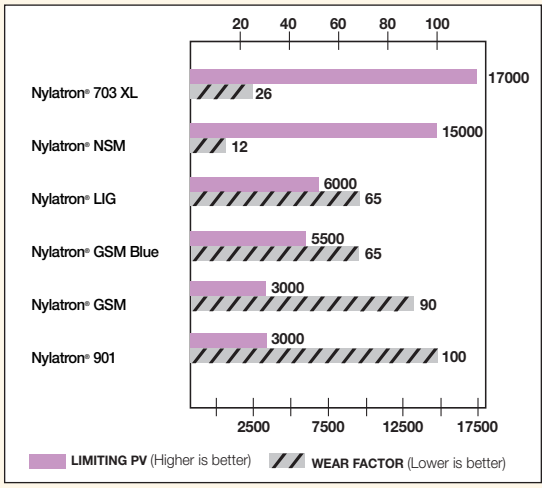
Ratings in the data above—derived from raw material supplier data, literature on chemical resistance of plastics, and from experience—are a guideline only and refer to unstressed parts. In particular the amorphous thermoplastics (PC, PSU, PEI and PPSU) are sensitive to "stress cracking" under certain conditions. Thus, environments normally harmless to unstressed parts may cause stress cracking in contact with stressed parts.

Quadrant has an extensive database of chemical resistance information. Please feel free to contact our technical services group for more specifics about your application.

HIGH PERFORMANCE MATERIALS FOR NON-FOOD CONTACT APPLICATIONS

Minimize down time and improve product performance and life in non-food contact dynamic and structural parts with these high performance materials from Quadrant:

Wear & load bearing capability



Nylatron® 703 XL Nylon—self-lubricating

- **Lowest "slip-stick", highest limiting PV—excellent wear resistance**
- **Coefficient of friction of UHMW-PE—strength, temperature properties of nylon**

Nylatron® NSM Nylon—self-lubricating

- **Best wear resistance of all Nylons**
- **High PV, high strength**

Nylatron® MC-901 Nylon—heat stabilized

- **Long term thermal stability to 260°F**

Nylatron® GSM, GSM Blue and LIG—enhanced performance nylons

- **GSM—MoS_2 filled high compressive strength; GSM Blue oil-filled**
- **LIG—green color, oil filled industrial grade for enhanced wear without MoS_2**

Ketron® HPV—premium bearing grade PEEK

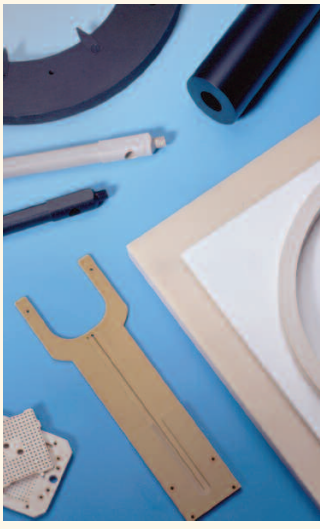
- **Excellent chemical and thermal resistance to 325°F**
- **Lowest wear and coefficient of friction plus best machinability among PEEK grades**

Torlon® PAI—extreme temperature and load resistance

- **High strength and stiffness to 500°F—extremely low thermal expansion**

Celazole® PBI—highest physical properties of any plastic material above 400°F

- **Heat deflection temperature of 800°F**
- **Highest compressive strength and dimensional stability of any unfilled plastic**



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