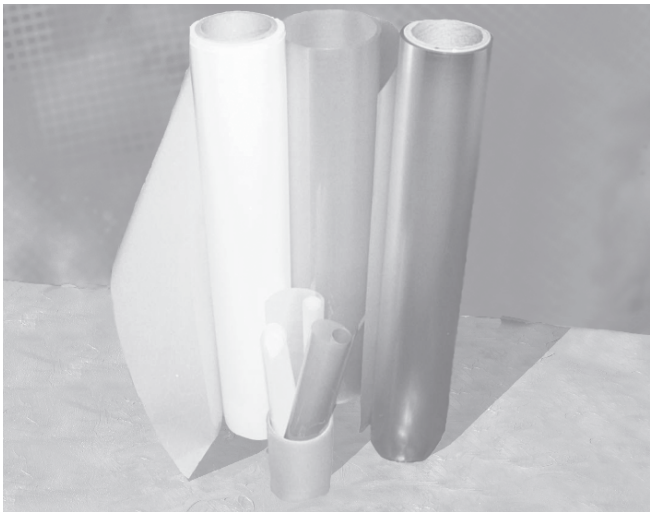
victrex®

HIGH PERFORMANCE PEEK™ POLYMERS

VICTREX® PEEK™ POLYMER

FOR FILMS

VICTREX PEEK provides material solutions for designers seeking extruded film that withstands harsh environments, provides high purity, possesses excellent dimensional stability over a wide temperature range, provides ease of fabrication, and that can be modified with fillers to enhance stiffness, tribological properties, and sealability. VICTREX PEEK provides excellent properties even without fillers, additives, or modifications.



KEY FEATURES

- **High Temperature Performance** — VICTREX PEEK is the most thermally stable thermoplastic on the market. Sheet greater than 30 mil (762 µm) thick has a UL rating of 500°F (260°C) for electrical use and for mechanical use without impact. Victrex has an official UL RTI rating for 2-5 mil (50-127 µm) films. These films carry an RTI for electrical use of 392°F (200°C).
- **Excellent Tribological Properties** — inherently lubricious, very smooth surface finish, low particulation. VICTREX PEEK carries a Limiting Pressure Velocity (Lpv) rating of 20,000 psi-ft/min (42 MPa-m/min) without the presence of external lubricants. The Lpv rating increases to nearly 1,000,000 psi-ft/min (2,100 MPa-m/min) in the presence of small amounts of lubricant.
- **Broad Chemical Resistance** — insoluble in all common solvents. Excellent resistance to acids, bases, oxidizing agents, hydrocarbons, salts, and steam. Superior chemical resistance than many exotic metals. Properties unaffected by exposure to steam at 392°F (200°C) after 2,000 hours.
- **High Strength and Toughness** — highest stiffness and resistance to cyclic fatigue of any thermoplastic. Strength is maintained well over the Glass Transition Temperature (T_g).
- **Electrical Stability** — very stable electrical properties over a wide range of temperatures, frequencies, and humidities.
- **Radiation Resistance** — withstands over 10^9 rads exposure without embrittlement.
- **Low Smoke and Toxic Gas Emission** — very low levels of smoke and toxic gas during combustion. Contains no halogens.
- **Purity** — exceptionally low extractables. Will not leach or outgas oligomers, processing aids, or modifiers.

TAILORED PROPERTIES

Since VICTREX PEEK is a thermoplastic, fillers, reinforcements, and additives can be compounded into the resin to modify film properties. Modifications and example fillers include:

- **Static control** — typically carbon-based fillers.
- **Improved wear resistance** — aramid fibers, PTFE powder.
- **More lubricious and better sealing surface** — PTFE powder.
- **Improved dimensional stability** — a variety of inorganic fillers.

Victrex can provide technical recommendations for filler selections to meet your material needs and provide data sheets for compounded grades.

AMORPHOUS VS. CRYSTALLINE

VICTREX PEEK is a semi-crystalline thermoplastic that can be processed into either amorphous or crystalline state.

Amorphous Films

Relative to crystalline film, amorphous films are transparent, easier to thermoform, have better folding endurance, and are more ductile. Heating amorphous film above T_g will initiate crystallization. Amorphous films will shrink several percent during the crystallization process so they should not be used in applications that require high temperature dimensional stability. Once the film has crystallized, it will remain crystalline unless melted. Additionally, amorphous film takes on all the properties of crystalline film once it has crystallized.

Crystalline Films

Crystalline film is both tan in color and opaque. Crystalline films have the best chemical resistance, hydrolysis resistance, wear properties, and dimensional stability. All injection molded and extruded applications using VICTREX PEEK are the crystalline form of the polymer. A technical data sheet for both amorphous and crystalline films is shown on page four. Fillers can increase high temperature dimensional stability significantly when an application requires lower shrinkage. Contact Victrex for technical recommendations for filled and reinforced films.

APPLICATIONS

VICTREX PEEK-based films are used in a variety of applications. Examples include:

- Composite adhesive films
- Electrical insulation
- Dry transformer insulation
- Flexible surface heaters
- Speaker cones and coils
- Oil field pipe flanges and gaskets
- Specialty laminates
- High temperature labels
- IC packaging (HDD) trays
- Gaskets
- Pressure sensitive tapes
- Printed circuit substrates
- Thermoformed structures
- Industrial slot liners
- Aerospace film applications
- Motor washers

MATERIAL PERFORMANCE

Films thermally age quicker than thick sheet due to high surface area to volume ratio. Generally, the thinner the film the faster the loss of properties. VICTREX PEEK has a Relative Thermal Index (RTI) at 30 mil (762 µm) for electrical and mechanical use without impact of 500°F (260°C) as measured by UL746B. RTI with mechanical impact at this thickness is 356°F (180°C). Victrex has an official RTI measurement for film. Films thicker than 2 mil (51 µm) have an RTI of at least 428°F (220°C) for mechanical strength without impact use.

Table I shows the UL RTI ratings for several high performance films used in the electronics market. All ratings are based on 0.78 mil (20 µm) thick film unless otherwise specified. Note that several materials, such as PEI, and LCP, that have very high RTI in bulk sheet, do not heat age well and have much lower film RTI ratings.

VICTREX PEEK is the only thermoplastic that has similar thermally aging characteristics as thermoset polyimides. Additionally, PTFE is the only material in the table that is more chemically inert than VICTREX PEEK. Due to exceptional strength, low coefficient of friction, and hardness, VICTREX PEEK outperforms the other listed materials in most tribological environments.

Table 1: UL RTI Rating for High Performance 20 µm (0.78 in) Films

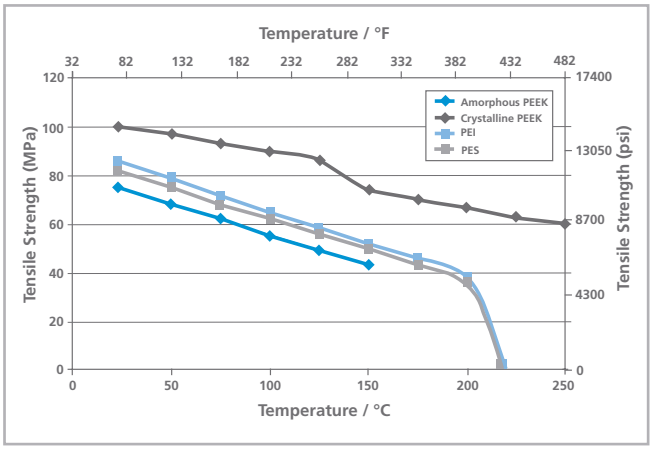
Polymer Type	<302°F (150°C)	304-356°F (151-180°C)	358-464°F (181-240°C)
Crystalline	PET LCP	PEN	VICTREX PEEK
Amorphous	PEI PC	PES	VICTREX PEEK
Thermoset	Epoxy	PTFE	PI

MECHANICAL PROPERTIES AT ELEVATED TEMPERATURES

Figure 1 provides a chart of tensile strength versus temperature for VICTREX PEEK and other high temperature thermoplastic film. The highest tensile strength is obtained from VICTREX PEEK crystalline film. Notice that unlike amorphous materials and many thermosets, crystalline VICTREX PEEK retains mechanical strength well over Tg. The polymer has a very sharp melting transition and can be used close

to its melting point. Mechanical properties can be enhanced by compounding inorganic fillers into the film.

Figure 1: Tensile Strength vs. Temperature



ELECTRICAL PROPERTIES

VICTREX PEEK-based films are excellent electrical insulators. Figure 2 shows dielectric strength versus thickness at various temperatures and Figure 3 shows dielectric constant across a wide frequency and temperature range. Figure 3 samples were 60 mil (1.5 mm) thick and were placed between electrodes and a constant force of 145 psi (1 MPa) was applied. The dielectric properties were measured using a capacitor consisting of three plates.

Figure 2: Dielectric Strength of VICTREX PEEK vs. Thickness at Various Temperatures

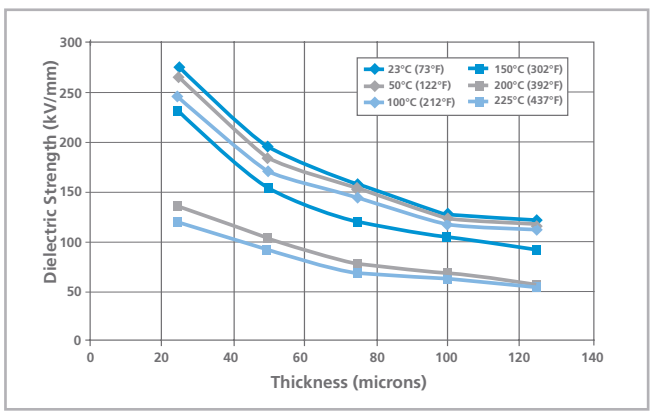
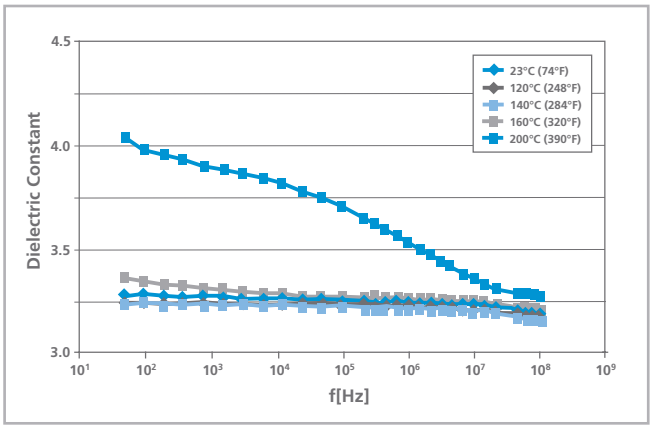


Figure 3: Dielectric Constant of VICTREX PEEK Across a Wide Frequency and Temperature Range



BARRIER PROPERTIES

Crystalline VICTREX PEEK provides good barrier properties. Table 2 lists the permeation of several gasses at 1 atm (1 bar) through 4 mil (102 µm) film.The permeation of the listed gases through amorphous film is roughly twice that of the value listed in the table.

Table 2: Permeation through Crystalline VICTREX PEEK

Gas	Permeation (gm/m²/day/bar)
Oxygen	76
Nitrogen	15
Helium	1600
Carbon Dioxide	420
Methane	8.1
Water Vapor	3.9

FABRICATION TECHNIQUES

VICTREX PEEK-based film can be fabricated with standard techniques such as ultrasonic welding, adhesion, thermoforming, and slitting. Since it can be difficult to bond VICTREX PEEK to substrates, methods of chemical and electronic surface modification have been developed. Contact Victrex for recommendations of adhesive selection and bonding guidelines. Also, crystalline VICTREX PEEK film has a narrow processing window for thermoforming. Amorphous VICTREX PEEK film is more easily thermoformed, but will crystallize in process. Processing parts with narrow draws should be straightforward. For more complex geometries contact Victrex for guidelines and recommendations.

FOR FILMS

Property	Units	Test Method	VICTREX PEEK Amorphous	VICTREX PEEK Crystalline
GENERAL				
Color	—	—	Translucent Grey/Tan	Opaque Grey/Tan
Density	lb/ft^3 (g/cc)	ASTM D 792	78.66 (1.26)	82.40 (1.32)
Typical Crystallinity	%	DSC	0 - 10	30
Shrinkage, 257°F (125°C)	%		0.2	0.1
Shrinkage, 392°F (200°C)	%	—	8 - 12	2
Water Absorp., 24hr, 74°F (23°C)	%	ASTM D 570	0.5	0.5
Area Factor	ft^2/lb/mil (m^2/kg/µm)		152 (1.23)	144 (1.16)
MECHANICAL				
Tensile Strength, yield	ksi (MPa)	ASTM D 882	10 (71)	13.2 (91)
Tensile Elongation, break	%	ASTM D 882	>250	>150
Tensile Elongation, yield	%	ASTM D 882	6	6
Tensile Modulus	ksi (GPa)	ASTM D 882	319 (2.2)	460 (3.2)
Abrasion Resistance	lb/cycles (mg/cycles)	Taber CS, 1kg	4.4x10^{-5}-11x10^{-5} (20-50)	1.1x10^{-5} (5)
Tear Strength, propagation	lb-force/ft (kN/m)	ASTM D 1922	26,500 (388)	5,100 (75)
Tear Strength, initiation	lb-force/ft (kN/m)	ASTM D 1004	2,000 (29.4)	67,600 (990)
Folding Endurance		MIT, 1000 µm	390	115
THERMAL				
Glass Transition Temperature	°F (°C)	DSC	289 (143)	289 (143)
Melting Temperature	°F (°C)	DSC	649 (343)	649 (343)
Thermal Conductivity	BTU/hr/ft/°F (W/m/°C)	ASTM C 177	0.47 (0.25)	0.47 (0.25)
Specific Heat	BTU/lb/°F (kJ/kg/°C)	DSC	0.52 (2.16)	0.52 (2.16)
Coeff. Thermal Expansion <T_g	10^{-5}/°F (10^{-5}/°C)	ASTM D 696	3.3 (6.0)	2.6 (4.7)
Coeff. Thermal Expansion >T_g	10^{-5}/°F (10^{-5}/°C)	ASTM D 696	N/A	6.0 (10.3)
RTI, Electrical Strength	°F (°C)	UL 746B	392 (200)	392 (200)
RTI, Mechanical Strength w/o Impact	°F (°C)	UL 746B	428 (220)	428 (220)
ELECTRICAL				
Dielectric Strength, in air, 50 µm	V/mil (kV/mm)	ASTM D 149*	4800 (189)	5100 (200)
Dielectric Strength, in air, 50 µm	V/mil (kV/mm)	ASTM D 149**	3700 (147)	3700 (147)
Dielectric Strength, in air, after 48 hrs water immersion, 50 µm	V/mil (kV/mm)	ASTM D 149**	3700 (147)	3700 (147)
Dielectric Constant, 1kHz		ASTM D 150	3.3	3.3
Dissipation Factor, 10kHz	—	ASTM D 150	0.0026	0.0026
Surface Resistivity	Ω/sq	ASTM D 257	2.0 x 10^{15}	2.0 x 10^{15}
Volume Resistivity	Ω-cm	ASTM D 257	4.9 x 10^{16}	4.9 x 10^{16}
IGNITION CHARACTERISTICS				
Oxygen Index, 400 µm	%	ASTM D 2863	24	24
UL File Number			E161131	E161131
Flame Retardance	1 mil (25 µm)	UL94	VTM-0	HB
MISCELLANEOUS				
Resistance to Gamma Radiation			Excellent	Excellent
Resistance to Chemicals			Very Good	Excellent
Hydrolysis Resistance 392°F (200°C), 2000 hours			Excellent	Excellent
Agency Approvals			FDA, UL, 3-A	FDA, UL, 3-A

*1/4" type 3 probe **1" probe

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