

# PERFORMANCE ADVANTAGES OF VICTREX® PEEK™ (polyetheretherketone)



Curbell Plastics, Inc.  
High Performance Materials White Paper  
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**VICTREX® PEEK™ polyetheretherketone is one of the most technologically advanced high performance polymers that is commercially available as sheet, rod, tube, and film stock.**

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*Engineers often turn to plastics when they are looking for low cost materials to replace metals in their designs. Since common polymers such as polypropylene, nylon, acetal, and polycarbonate typically cost less than \$3.00 per pound, a cost savings can often be achieved by selecting one of these plastics for an application. That being said, there are times when neither metals nor standard plastic materials will perform in a demanding critical-service application and high performance polymers, often costing more than 10 times the price of conventional plastics, are required.*

*VICTREX® PEEK™ polyetheretherketone is one of the most technologically advanced high performance polymers that is commercially available as sheet, rod, tube, and film stock. The purpose of this article is to describe the performance advantages of VICTREX® PEEK and the benefits of specifying VICTREX® PEEK for demanding applications.*

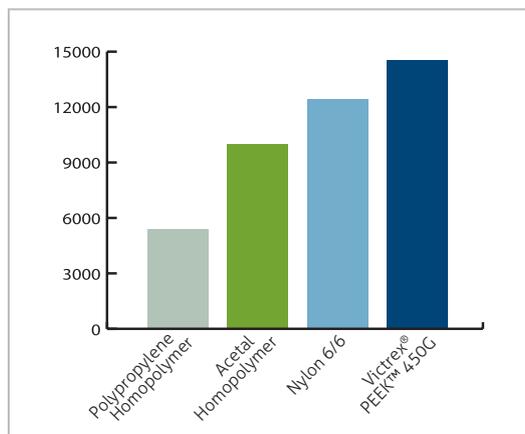
## COMPARING POLYMER PROPERTIES

When evaluating the advantages of VICTREX® PEEK™ compared with other thermoplastics, it is helpful to compare a few of the essential properties of the unfilled base polymer (VICTREX® PEEK 450G) with the properties of other commercially available polymers such as polypropylene, nylon, and acetal.

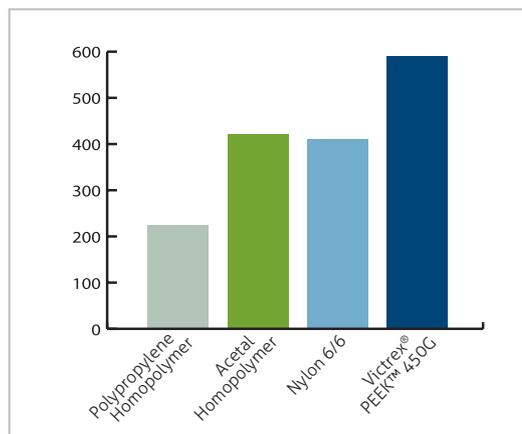
As shown in **figs. 1, 2, and 3**, the room temperature tensile strength, flexural modulus (bending stiffness), and notched Izod impact strength (toughness) of VICTREX® PEEK are considerably higher than those of the other polymers shown. These differences become even more pronounced when one compares property values at elevated temperatures.

HDT (heat deflection temperature) is a measure of the temperature at which a plastic material will soften under a specified load in laboratory conditions. **Figure 4** shows the HDTs of several polymers including VICTREX® PEEK. Clearly VICTREX® PEEK has a higher HDT than the other plastics shown, which is one indication that it can be used at temperatures where other polymers would quickly fail.

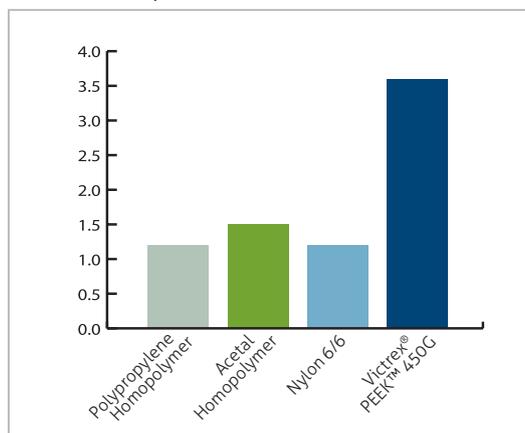
**Figure 1. Tensile Strength (psi) of PEEK and other thermoplastics**



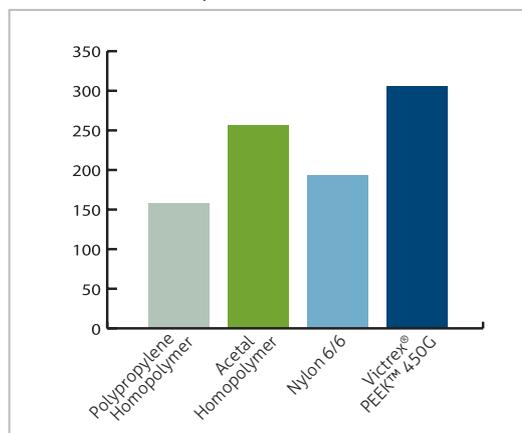
**Figure 2. Flexural Moduli (psi) of PEEK and other thermoplastics**



**Figure 3. Izod Impact Strength (ft-lb/in) of PEEK and other thermoplastics**



**Figure 4. Heat Deflection Temp. (@ 264 psi °F) of PEEK and other thermoplastics**



### MAINTAINING MODULUS

To further illustrate the high temperature capability of VICTREX® PEEK™, **fig. 5** shows how the flexural moduli (bending stiffness) of nylon 6/6 and VICTREX® PEEK vary as a function of temperature. Nylon, like many common plastics, loses virtually all of its mechanical stiffness once the material is heated to 176 F°. In contrast, VICTREX® PEEK maintains most of its stiffness up to temperatures approaching 300 F°. PEEK's ability to maintain stiffness at elevated temperatures is one of the reasons that it is so often specified for high temperature applications in the aerospace, semiconductor, medical, and food processing industries.

The stiffness of VICTREX® PEEK can be greatly increased by adding various fillers and reinforcements including glass or carbon fibers. **Figure 6** shows the flexural modulus of unfilled VICTREX® PEEK 450G as well as 30% glass fiber filled PEEK 450GL30 and 30% carbon fiber filled PEEK 450CA30 at various temperatures. As shown on the graph, the addition of glass reinforcement essentially doubles the stiffness of PEEK and the addition of carbon fiber more than quadruples the stiffness of the material. In fact, the room temperature flexural modulus of carbon fiber filled PEEK is 3300 kpsi, one of the highest values of any commercially available thermoplastic.

Figure 5. Flexural Modulus vs. Temperature

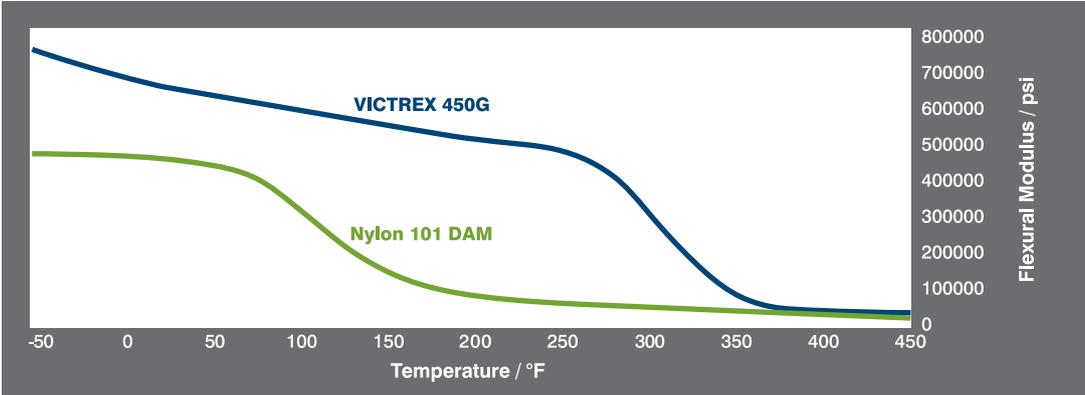
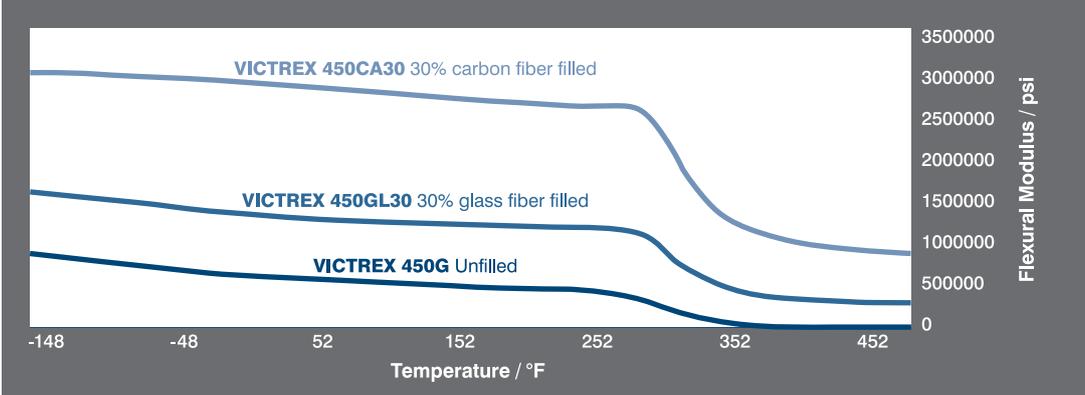


Figure 6. Effects of Various Reinforcements



## DIMENSIONAL STABILITY THROUGHOUT A BROAD TEMPERATURE RANGE

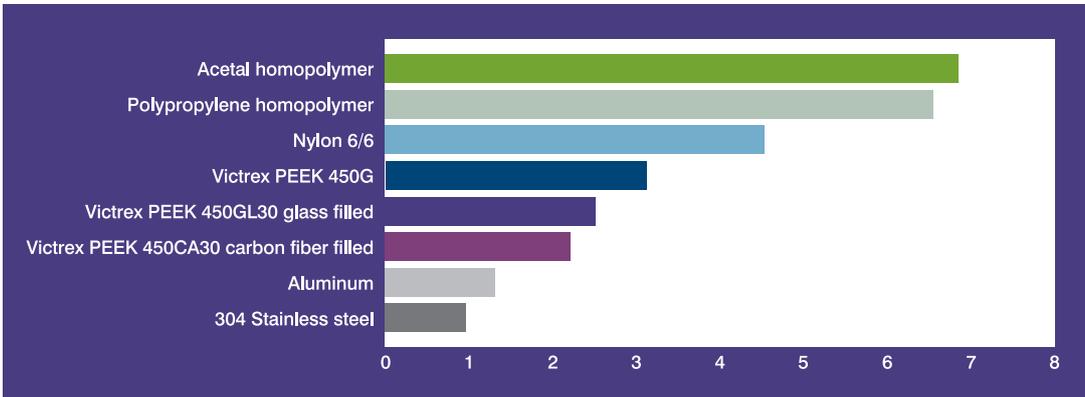
Plastic materials are inherently less stable than metals and ceramics. Maintaining tight tolerances is a continuing challenge for designers and fabricators of plastic components. There is some complexity to this issue since changes in the dimensions of a plastic part can be due to thermal expansion, moisture absorption, swelling from chemical exposure, residual stress, or creep strain. In most instances, it is likely that several of these factors operate together to change the dimensions of a plastic part.

One of the key advantages of VICTREX® PEEK™ is its dimensional stability compared with many other plastic materials. **Figure 7** shows the CTE (coefficient of linear thermal expansion) of unfilled PEEK 450G, glass filled PEEK 450GL30, carbon fiber filled PEEK 450CA30, and several other materials. As shown on the graph, unfilled PEEK 450G will grow at approximately half the rate of other thermoplastics when heated. Filled grades of VICTREX® PEEK exhibit even lower CTEs which are comparable to those of many industrial metals.

*One of the key advantages of VICTREX® PEEK is its dimensional stability compared with many other plastic materials.*

This low rate of thermal expansion can greatly simplify designs when mating metal and plastic parts must stay within tolerance throughout a broad operating temperature range. It is for this reason that VICTREX® PEEK is often selected for tight tolerance applications in the aerospace and semiconductor industries.

**Figure 7.** CTE (Coefficient of Linear Thermal Expansion) of PEEK and other Engineering materials



## NOTEWORTHY CHEMICAL AND STEAM RESISTANCE

Many plastic materials will quickly degrade when exposed to chemicals including hot water and steam. The results of chemical attack can include environmental stress cracking, loss of mechanical properties, swelling, discoloration, or in extreme cases a complete dissolving of the plastic material. These negative effects can be exacerbated at elevated temperatures and when mechanical stress is applied to the plastic part being exposed to the chemical.

VICTREX® PEEK™ has among the best chemical resistance of any thermoplastic material. It is often used in applications where parts are exposed to aggressive chemicals, hot water, and steam. More detailed information regarding the chemical resistance of VICTREX® PEEK can be found in the [VICTREX® PEEK Chemical Resistance Brochure](#).

***VICTREX® PEEK has among the best chemical resistance of any thermoplastic material.***

## RADIATION RESISTANCE IN EXTREME ENVIRONMENTS

Certain wavelengths of electromagnetic radiation including gamma radiation can be very damaging to most plastic materials. The effects of radiation on plastics can include discoloration, loss of tensile strength, and embrittlement (loss of tensile elongation). A number of scientific studies, including a 1987 article by Tsuneo Sasuga and a 1996 article by Kirstin Heiland, have shown that PEEK has outstanding resistance to gamma radiation. (See the references section at the end of this article for bibliographical details of these articles.) Because of this, VICTREX® PEEK is often used in scientific and power generation applications where performance in extreme radiation environments is required.



*Victrex® PEEK™ is often specified for scientific equipment applications because of its purity and excellent chemical resistance.*



*Victrex® PEEK™ is an excellent insulating material for high performance electrical connectors.*

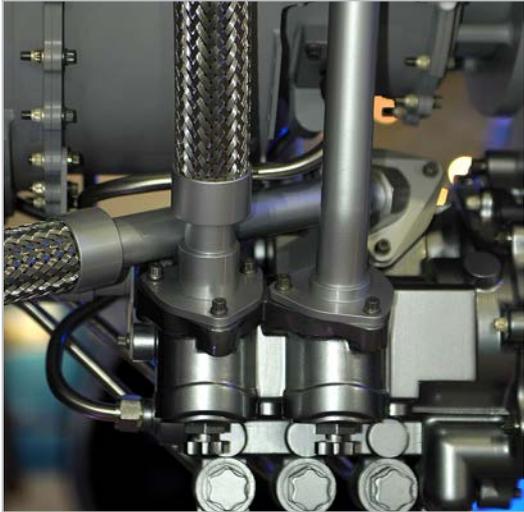
## ENHANCED FRICTION AND WEAR PERFORMANCE

VICTREX® PEEK™ is available with a number of additives that enhance its tribological (friction and wear) properties. These include combinations of PTFE, graphite, and carbon powder as well as other proprietary fillers. The effect of these additives include a dramatic reduction in the coefficient of friction of the material, improved wear life, and a higher limiting PV (pressure-velocity) rating compared with the base polymer. These “bearing grades” of VICTREX® PEEK, such as 450FC30, are often used in friction and wear applications that involve elevated temperatures, high loads and/or speeds, or corrosive chemicals that would quickly degrade metal or conventional thermoplastic bearing materials.

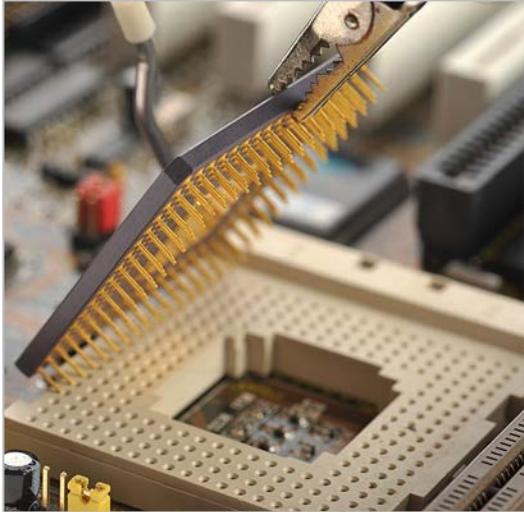
## FLAMMABILITY CHARACTERISTICS

Many plastics will readily burn and some polymers will produce toxic decomposition products. This precludes their use in certain industries, such as the aerospace industry where fire safety is an extremely critical design issue. VICTREX® PEEK resists combustion and it has achieved a UL94 V-0 vertical burn rating for wall sections as thin as 0.060". This makes the material an ideal choice for many applications where flammability is of concern.

It should be noted that flammability, smoke, and toxicity are complex design issues and detailed materials data should be reviewed prior to selecting any thermoplastic for an application where flammability is a consideration.



*Victrex® PEEK™ is often used for aerospace valve components because of its outstanding chemical resistance, creep resistance, and wear properties.*



*Victrex® PEEK™ has seen wide use in semiconductor test equipment because of its dimensional stability and outstanding wear resistance.*

## HIGH PURITY IN DEMANDING APPLICATIONS

A number of critical service applications such as food processing machinery, surgical instruments, semiconductor machinery, and space flight hardware require components made from high purity materials so that they will not contaminate the products or systems that they come into contact with. VICTREX® PEEK™ is an extremely pure material. It is available in grades that meet the most stringent government standards including FDA compliance for direct food contact and USP Class VI compliance for use in medical equipment.

VICTREX® PEEK is even listed in the low outgassing section of NASA's [Outgassing Data for Selecting Spacecraft Materials](#) and the material has seen extensive use in space flight applications.

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***New grades of VICTREX® PEEK™ may be good candidates for your application.***

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## EXCITING NEW GRADES FOR PEEK

Victrex Polymer Solutions is working to develop and commercialize new PEEK-based polymers to benefit our customers. Some new grades offer enhanced mechanical and thermal properties as well as improved friction and wear characteristics that expand the operating envelope of the polymer.

We invite engineers and designers who are interested in new materials technologies to contact Curbell Plastics to discuss your specific application requirements and explore which new grades of VICTREX® PEEK may be good candidates for your application.

## GENUINE VICTREX® PEEK OFFERS PEACE OF MIND

An overview of VICTREX® PEEK polymers would not be complete without some discussion regarding the importance of obtaining authentic Victrex® material. In recent years, a number of companies have introduced generic PEEK plastics that lack the proven service history of VICTREX® PEEK.

Victrex has been engineering and manufacturing PEEK polymers for more than 30 years. Their materials have been tested and approved for use in applications by numerous science and technology organizations including U.S. Department of Energy Laboratories, NASA, and many suppliers to the United States military. Be sure that your critical service plastic components are being manufactured from genuine VICTREX® PEEK. Insist on receiving the appropriate certificates of compliance insuring that genuine VICTREX® PEEK polymers are being supplied.

## VICTREX® PEEK™ REFERENCES AND FURTHER READING

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[Victrex Materials Properties Guide](#)

## ABOUT THE AUTHOR

Dr. Keith Hechtel is Director of Business Development for Curbell Plastics, Inc., based in Orchard Park, NY. Dr. Hechtel has a Master of Science degree in Industrial Technology, a Doctor of Business Administration degree, and more than 25 years of plastics industry experience. Much of his work involves helping companies to identify plastic materials that can be used to replace metal components in order to achieve quality improvements and cost savings. Dr. Hechtel is a recognized speaker on plastic materials and plastic part design. He has conducted numerous presentations for engineers, designers, and fabricators in both industrial and academic settings.

## TECHNICAL EXPERTISE

Curbell white papers are intended to provide engineers and designers with basic information about the engineering polymers available as sheet, rod, tube, and film stock from Curbell Plastics. We invite you to contact Curbell via e-mail at [technicalsupport@curbellplastics.com](mailto:technicalsupport@curbellplastics.com) to discuss applications in detail.

## ABOUT CURBELL PLASTICS

For more than 70 years, Curbell Plastics has been one of the nation's leading providers of plastic sheets, rods, tubes, and films, as well as fabricated parts, adhesives, and prototyping materials. Our customers range from small local businesses to large Fortune 500 companies and government agencies. We partner with organizations in dozens of industries, including aerospace, pharmaceutical, machinery manufacturers and sign fabricators. At Curbell, we understand the unique demands of each market and have the expertise to help you meet your business needs. Whether your objective is to reduce manufacturing costs, improve productivity, or increase product reliability, Curbell can help.

## OUR CAPABILITIES

Our branch network includes sales and warehouse locations throughout the United States. We offer a number of value-added services including custom cutting, fabrication, packaging, and kitting, as well as warehousing for just-in-time delivery. With Curbell, you get the plastics you want and the peace of mind you need, from technical support and design assistance at the earliest stages of product design, through production and after-sale support for each product we sell.

## PUT US TO WORK FOR YOU

At Curbell, we are committed to providing the highest level of service to our customers. We recognize the urgency of customer needs, and we pride ourselves on providing quick and proactive solutions. Our tag line says it all – we appreciate the opportunity to earn your business and we invite you to ***“Put us to work for you.”***

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