victrex®

HIGH PERFORMANCE PEEK™ POLYMERS

VICTREX® PEEK-HT™ polymer is the unique high performance material developed for applications that demand superior higher temperature resistance. With a glass transition temperature of 157°C and a melting temperature of 374°C, VICTREX® PEEK-HT™ delivers extended high temperature performance, while offering all the key characteristics of natural VICTREX® PEEK™, including toughness, strength and chemical resistance.

Across a wide range of demanding industrial, automotive and aerospace applications, VICTREX® PEEK-HT™ offers manufacturers a premium material which is a more cost-effective, lightweight alternative to metals. From engine compartment applications to sub sea connectors and heat exchanger parts, this advanced engineering material provides unlimited design freedom, high precision reproducibility and long-term productreliability.

KEY FEATURES

- Superior high temperature performance
  - Retention of mechanical and physical properties to temperatures 30°C higher than standard VICTREX® PEEK™.
  - Up to 3 times the wear resistance of standard VICTREX® 450G at high temperatures.
  - Excellent long-term creep and fatigue resistance over a wide temperature range.
  - Substantially higher tensile strength and flexural modulus at 250°C.
- Improved compressive strength
- Exceptional resistance to chemicals, solvents and fuels
- Inherent low flammability, low smoke emission
- Good electrical properties
- Excellent hydrolysis resistance
- Consistent ease of processing
- Available in powder or pellets

PEEK-HT™ PROVIDES LONG-TERM RELIABILITY AT ELEVATED TEMPERATURES

Greene, Tweed & Co. chose VICTREX® PEEK-HT™ for its Seal-Connect® 8 pin connector. Designed to withstand the high temperatures generated in oil field exploration and production, VICTREX® PEEK-HT™ provides the needed longterm reliability at elevated temperatures after prolonged exposure to an applied pressure of 138 MPa at 204°C.

VICTREX® PEEK-HT™ also allows short-term exposure to pressures of 172 MPa at 260°C. The VICTREX® PEEK-HT™ connector has eliminated product failure caused by assembly and secondary operations.

For superior high temperature performance

VICTREX® PEEK-HT™...

INJECTION MOLDING GUIDELINES FOR VICTREX® PEEK-HT™ POLYMER

VICTREX® PEEK-HT™ polymer is commonly regarded as the highest performance material capable of being processed on conventional thermoplastic equipment. It is supplied as pellets, coarse powder and fine powder. Pellets are recommended for injection molding, extrusion, monofilament and wire coating operations.

Handling

VICTREX® PEEK-HT™ is supplied in a sealed polyethylene bag inside a heavy-duty cardboard box. We strongly recommend keeping the material sealed inside the original packaging during transportation and storage. When material is required, the boxes should be opened in a clean environment and care taken to avoid contamination. Any remaining material should be resealed in the bag and box as soon as possible and stored in a dry place.

Drying

For best results, powder and pellets should be dried to less than 0.02% w/w moisture (dew point of -40°). This can be done by placing the material in an air-circulating oven for a minimum of 3 hours at 150°C or 2 hours at 160°C, or in a vacuum oven for at least 4 hours at 120°C. The material should be spread evenly in clean shallow trays, in layers about 2.5 cm deep. Materials can be left to dry overnight. Care should be taken not to introduce sources of contamina-tion.

Re-Work

VICTREX® PEEK-HT™ can be reground and added to virgin material to improve production efficiency. However, the level of re-work can affect the quality of the moldings and increase the chances of cross-contamination. Even at low levels, extraneous materials can have a serious effect on molding quality due to the high temperatures required to process VICTREX® PEEK-HT™. Re-work should be restricted to a maximum of 30% w/w for unfilled polymer and 10% w/w for compounds.

Purging

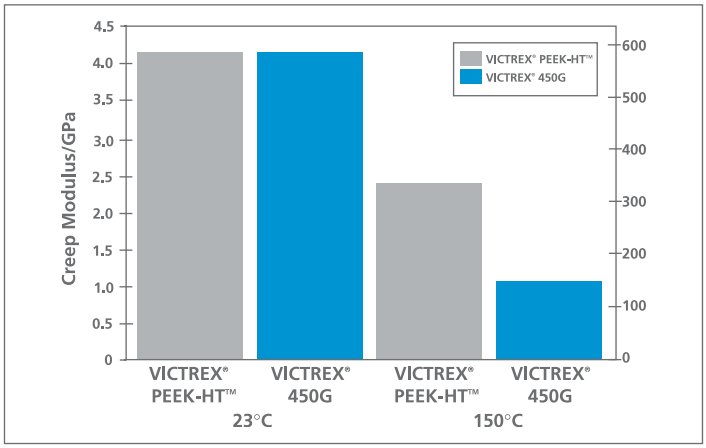
VICTREX® PEEK-HT™ and compounds should be processed on completely clean equipment. This is best done by removing the screw and barrel. If this is not possible, purging is essential. Commercially available purging compounds are acceptable for removing material from the machine prior to introducing VICTREX® PEEK-HT™. However, the purging compound needs to be stable at temperatures above 370°C so that it does not break down when the VICTREX® PEEK-HT™ is introduced. Purging compounds are also effective at removing the VICTREX® PEEK-HT™ from the machine after processing.

Please contact your Victrex Representative for more information on purging compounds.

Materials of Construction

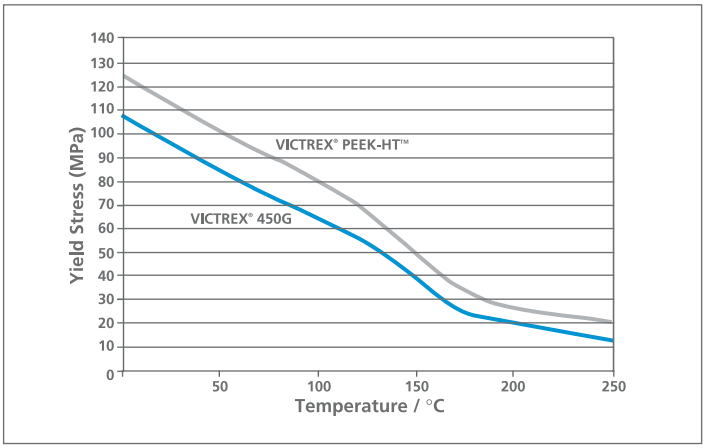
Machine wear is common with all engineering thermoplastics and can be especially severe when processing fiber filled materials. To minimize wear, screws, dies and barrels should be hardened. The most common way to harden tool steel is to coat with nitride. This technique provides the surface hardness necessary to resist extreme abrasion. However, care must be taken to ensure that the VICTREX® PEEK-HT™ does not cool and solidify in contact with the nitride coating (or any other coating). The bond between the polymer and the nitride coating is often strong enough to lift the layer from the steel substrate.

Figure 1: Creep Modulus of VICTREX® PEEK-HT™ at 230 °C and 150 °C (strain 0.1%, time 100s)



While the creep modulus of VICTREX® PEEK-HT™ and VICTREX® 450G are very similar at room temperature, VICTREX® PEEK-HT™ has a creep modulus more than twice that of VICTREX® 450G at 150 °C. This means that VICTREX® PEEK-HT™ can support higher loads than VICTREX® 450G at 150 °C without permanent deformation.

Figure 2: Yield Strength of VICTREX® PEEK-HT™ and VICTREX® 450G



The temperature resistance of VICTREX® PEEK-HT™ allows it to be used an average of 25 °C hotter than VICTREX® 450G at the same tensile stress without permanently yielding.

Steels such as D2, Wexco 777, CPM 9V and H13 are suitable for use in process equipment for VICTREX® PEEK-HT™. Avoid using copper alloys because they can cause degradation at VICTREX® PEEK-HT™ processing temperatures.

The surface finish of metallic components used in transporting VICTREX® PEEK-HT™ melt should be smooth and highly polished. Increasing the surface roughness of these components causes the melt to adhere locally to the metal, which increases the residence time and disrupts polymer flow.

Machine Design

VICTREX® PEEK-HT™ can be processed on most standard reciprocating screw injection molding machines. We do not recommend using plunger-type molding machines.

Barrel Temperatures

In order to successfully mold VICTREX® PEEK-HT™, the cylinder heaters must be capable of maintaining 450°C. However, VICTREX® PEEK-HT™ has a low melt viscosity and normally only needs to be processed at temperatures 10-30°C above the melting point. Barrel and cylinder temperatures are typically run in the range of 385-410°C. Most injection molding machines are capable of operating at these temperatures without modification, but it is a simple process to install higher temperature range controllers and ceramic heater bands.

In order for the pellets to feed properly from the hopper, the feed throat temperature should be between 70 and 100°C. Thermal conduction along the screw and barrel to the hopper may reduce feed efficiency. Water-cooling will help control the feedthroat temperature, but care should be taken to maintain the rear zone temperature.

Barrel Capacity

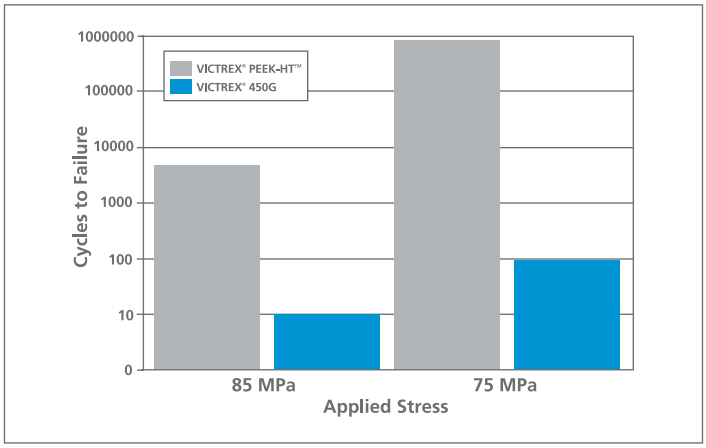
Residence time should be kept to a minimum due to the high processing temperatures of VICTREX® PEEK-HT™. Ideally, the barrel capacity should be between 2 and 5 times the total shot weight including the sprue and runners. If it is necessary to mold VICTREX® PEEK-HT™ on a machine with a very high number of shots in the barrel, reduce the rear zone temperatures 10 to 20°C below the recommended temperature settings.

Nozzles and Shut-off Systems

The nozzle of the barrel is in contact with the sprue bushing for a high percentage of the total cycle time during normal molding operations. The temperature of the sprue bushing is considerably lower than that of the melt and the nozzle. VICTREX® PEEK-HT™ has a sharp melting point and will solidify quickly if the melt temperature in the nozzle is allowed to fall below 375°C. Therefore, it is important to ensure that an adequately large heater is fitted to the nozzle to prevent freeze-off and forming a cold slug. Extended nozzles are not recommended because they increase the likelihood of solidification in the nozzle. Running sprue break with cold sprue bushings is recommended to keep prevent the nozzle from freezing off.

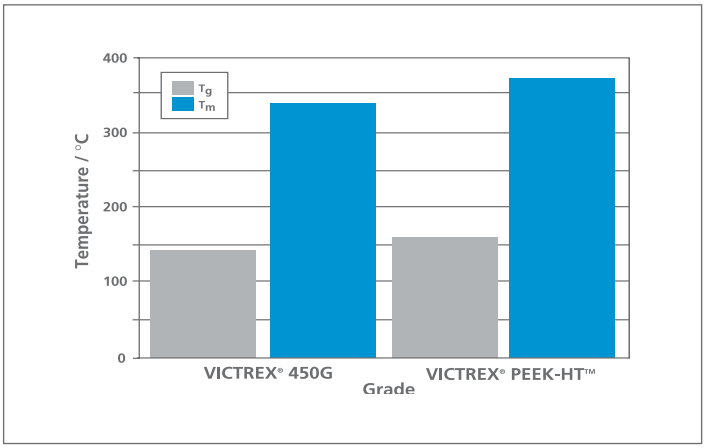
Within the recommended processing temperatures, the viscosity of VICTREX® PEEK-HT™ is generally high enough to allow the use of an open nozzle system. Shut-off nozzles are not recommended due to

Figure 3: Fatigue Properties of VICTREX® PEEK-HT™ and VICTREX® 450G at 23 °C and 0.5 Hz



The molecular structure and semi-crystalline nature of VICTREX® PEEK-HT™ results in much better resistance to fatigue than VICTREX® 450G at high levels of stress.

Figure 4: Melt Temperature and Glass TransitionTemperature of VICTREX® PEEK-HT™ and VICTREX® 450G



The molecular structure and semi-crystalline nature of VICTREX® PEEK-HT™ results in a melting point (T_m) 30 °C higher and a glass transition temperature (T_g) 14 °C higher than VICTREX® 450G.

potential "dead spots" and restricted injection pressures. If excessive die drool is encountered, minor melt decompression (suck-back) can be used in the process cycle.

Heated sprue bushings have been used successfully and can help transport a higher volume of material into a cavity before they freeze off. They keep heat flowing into the material closer to the mold cavity and can aid in keeping thick section free of porosity. With the use of a hot sprue bushing, running sprue break is not necessary. Processing will be more stable without sprue break.

Injection and Clamping Pressures

The injection pressure required to correctly mold parts will be system dependant. However, injection pressures rarely exceed 13.6 MPa (usually 6.8-13.6 MPa) with secondary holding pressures less than 10.2 MPa (usually 3.4-10.2). Back pressure should be nominal (approximately 0.34 MPa) to create a homogenous melt and consistent shot size.

The surface area of the part and runner determine the clamp force required to prevent the mold from opening under maximum injection pressure. This typically corresponds to 50-80 MPa (3.6-5.8 Tons) for unfilled VICTREX® PEEK-HT™ and 65-140 MPa (4.7-10 Tons) for reinforced compounds. However, parts with thin sections and long flow lengths will require higher clamping pressures than those with thick sections and short flow lengths.

The surface finish of metallic components used in trans-porting VICTREX® PEEK-HT™ melt should be smooth and highly polished. Increasing the surface roughness of these components causes the melt to adhere locally to the metal, which increases the residence time and disrupts polymer flow.

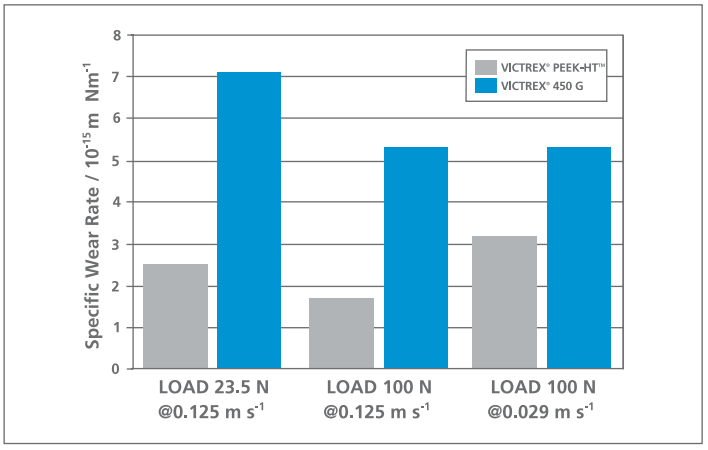
Screw Design and Speed

Most general-purpose screws are suitable for processing VICTREX® PEEK-HT™. The minimum recommended L/D is 16:1, but preferably in the range of 18:1 to 24:1. Long feed sections are required to prevent compaction of unmelted pellets in the compression zone of the screw. The compression ratio should be between 2:1 and 3:1.

The screw tip must utilize a check ring to ensure the development of full and sustained injection pressure. Ring clearance should allow for an unrestricted flow of material during the forward movement of the screw. This typically corresponds to a 3 mm clearance from the screw tip diameter for a medium-sized molding machine.

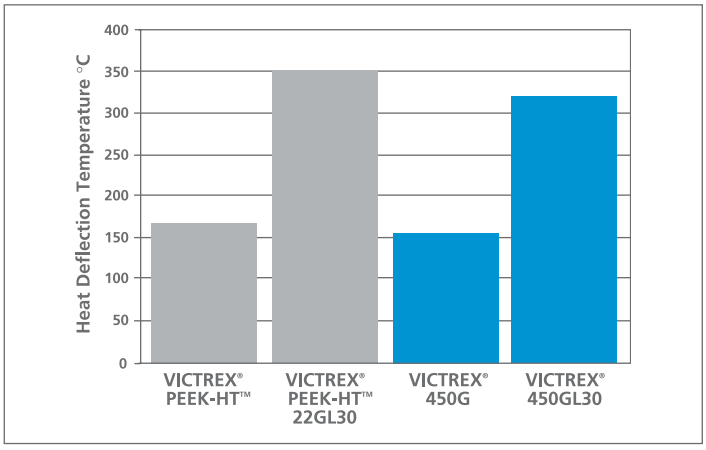
Screw speed should be 50-100 rpm. Speeds below 50 rpm can result in long cycle times while speeds above 100 rpm can cause excessive localized shear heating. Low speeds (50-60 rpm) are recommended for filled grades to minimize fiber attrition.

Figure 5: Wear Properties of VICTREX® PEEK-HT™ and VICTREX® 450G at 23 °C (ASTM D3702 thrustwasher geometry)



In thrust waster tests performed under different PV conditions, VICTREX® PEEK-HT™ exhibited as little as 1/3 the wear of VICTREX® 450G. VICTREX® PEEK-HT™ showed a lower specific wear rate than VICTREX® 450G under all other test conditions.

Figure 6: Heat Deflection Temperature of VICTREX® PEEK-HT™ and VICTREX®450G (unfilled) Compared to VICTREX® PEEK-HT™ 22GL30 and VICTREX®450GL30 (30%Glass Fibre Reinforced)



The Heat Deflection Temperature of VICTREX® PEEK-HT™ is 13°C higher than VICTREX® 450G. When reinforced with 30% glass fiber, the HDT is 30 °C higher than any currently available thermoplastic.

Mold Temperature

Heated molds are required to allow VICTREX® PEEK-HT™ to crystallize and achieve its best properties. Electric and oil heating have both been used successfully, but oilheating gives more consistent temperature control. Oil and electric cartridges can also be used in combination where tool design requires additional heating.

Mold surface temperatures should be a minimum of 180 °C to allow crystallization. This typically corresponds to an oil heater temperature of at least 230 °C. To obtain ideal levels of crystallinity, the mold-surface temperature should be between 190 to 215 °C, but can be run higher depending on part geometry, mold design and desired crystallinity.

Low mold temperatures will yield parts with high levels of internal stress and will have visibly dark, semi-transparent amber edges and corners that indicate low levels of crystallinity. **Obtaining the full mechanical properties of VICTREX® PEEK-HT™ will not be possible with low levels of crystallinity due to the low mold temperature. Processing VICTREX® PEEK-HT™ on a hot tool is necessary.** The material crystallinity can be enhanced and stress can be reduced with heat treatment, but this can also cause distortion.

Operating Temperatures

Grade	Rear Zone °C	Middle Zone °C	Front Zone °C	Nozzle Zone °C
G22	380	382	385	388
G45	382	385	388	390
22GL30	382	388	390	393
22CA30	382	388	393	400

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PROPERTY	TEST METHOD	UNITS	VICTREX® PEEK-HT™	VICTREX® G22GL30	VICTREX® G22CA30
Density (crystalline)	ISO 1183	g cm^{-3}	1.32	1.53	1.41
Typical Crystallinity		%	35		
Tensile Strength	ISO 527-2/1B/50				
23°C		MPa	110	164	218
150°C		MPa	48		
250°C		MPa	17		
Tensile Elongation (Break, 23°C)	ISO 527-2/1B/50	%	20	2.9	2.2
Secant Modulus 23°C	ISO 527-2/1B/50	GPa	3.8		
Flexural Modulus	ISO 178				
23°C		GPa	4.1	9.8	18.2
150°C		GPa	3.1		
Flexural Strength 23°C	ISO 178	MPa	185	265	344
Compressive Strength 23°C	ASTM D695	MPa	137		
Rockwell Hardness (R scale)	ASTM D785		108		
Melting Point (peak of endotherm)	DSC	°C	374	374	374
Glass Transition Temperature (T_g)	DSC	°C	157	157	157
Heat Deflection Temp. @ 1.8 MPa	ISO 75	°C	165	350	
Comparative Tracking Index 23°C	IEC 112	V	150		
Loss Tangent 23°C 1MHz	IEC 112		0.0035		
Relative Permittivity	IEC 250		3.3		
50 Hz 0-150°C			4		
50 Hz 200°C					
Volume Resistivity	IEC 93	10^{16} Ω -cm	4.9		
Flammability	UL 94		V-0 @ 1.6 mm		

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