VICTREX® HT™ Polymer

VICTREX® 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 (315°F) and a melting temperature of 374°C (705°F), VICTREX 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 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 product reliability.

KEY FEATURES

- Superior high temperature performance.
  - Retention of mechanical and physical properties to temperatures 30°C (54°F) 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 (482°F).
- 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.

AVAILABLE GRADES

The VICTREX HT family of high temperature products is available in the following grades:

Table 1: VICTREX HT Products

Nomenclature	Description
VICTREX HT G22	Unfilled
VICTREX HT 22GL30	30 wt% Glass Fiber Reinforcement
VICTREX HT 22CA30	30 wt% Carbon Fiber Reinforcement

VICTREX HT PROVIDES LONG-TERM RELIABILITY AT ELEVATED TEMPERATURES

Greene, Tweed & Co. chose VICTREX HT for its Seal-Connect® 8 pin connector. Designed to withstand the high temperatures generated in oil field exploration and production, VICTREX HT provides the needed long-term reliability at elevated temperatures after prolonged exposure to an applied pressure of 138 MPa at 204°C (20,000 psi at 400°F). VICTREX HT also allows short-term exposure to pressures of 172 MPa at 260°C (25,000 psi at 500°F). The VICTREX HT connector has eliminated product failure caused by assembly and secondary operations.

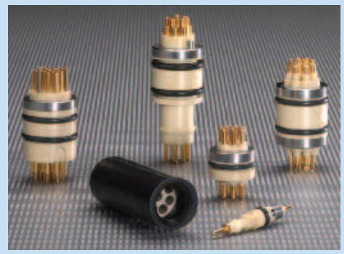
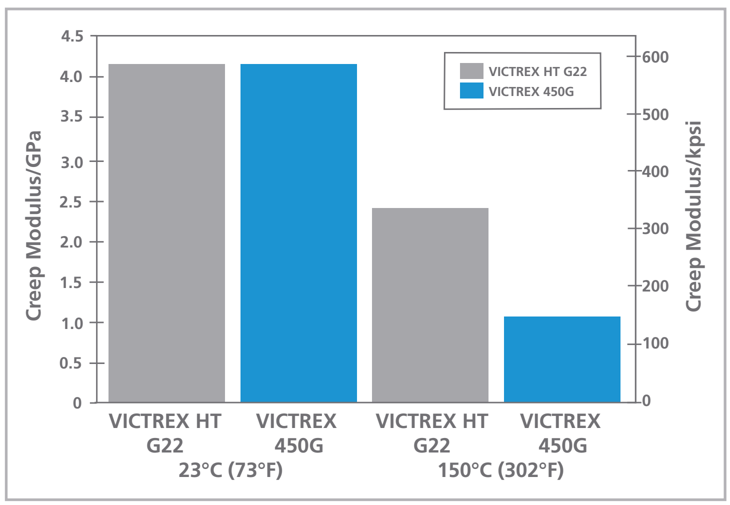
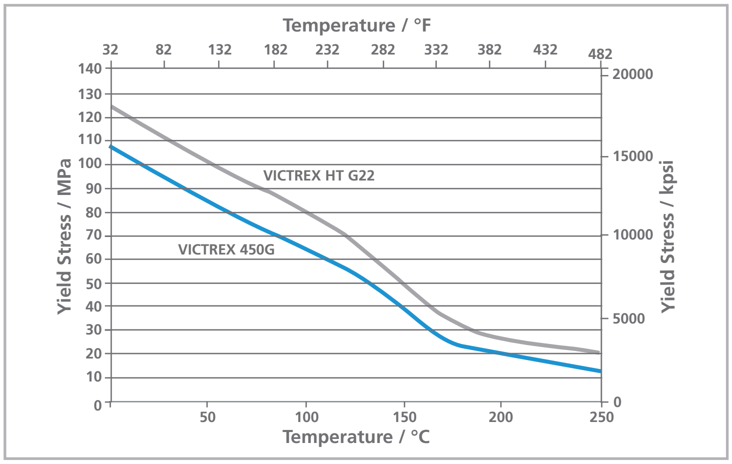


Figure 1: Creep Modulus of VICTREX HT at 23°C (73°F) and 150°C (302°F) (strain 0.1%, time 100s)



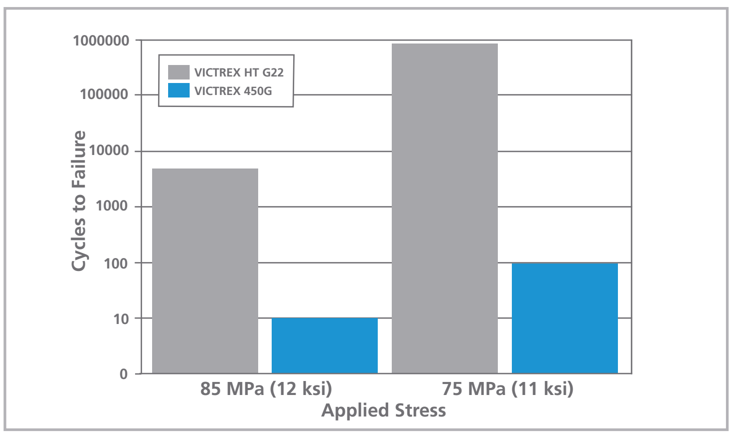
While the creep modulus of VICTREX HT and VICTREX 450G are very similar at room temperature, VICTREX HT has a creep modulus more than twice that of VICTREX 450G at 150°C (302°F). This means that VICTREX HT can support higher loads than VICTREX 450G at 150°C (302°F) without permanent deformation.

Figure 2: Yield Strength of VICTREX HT and VICTREX 450G



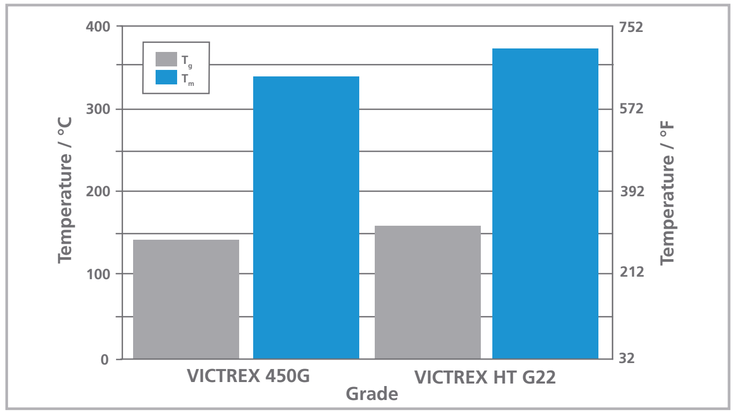
The temperature resistance of VICTREX HT allows it to be used an average of 25°C (45°F) higher temperatures than VICTREX 450G.

Figure 3: Fatigue Properties of VICTREX HT and VICTREX 450G at 23˚C (73˚F) and 0.5Hz



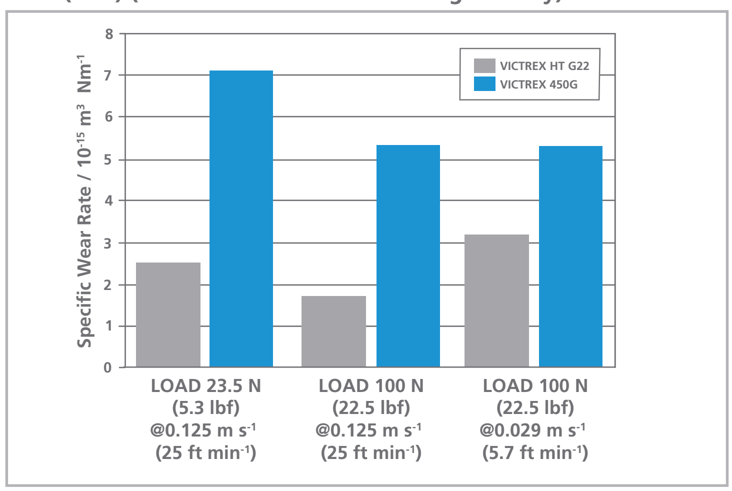
The molecular structure and semi-crystalline nature of VICTREX HT results in much better resistance to fatigue than VICTREX 450G at high levels of stress.

Figure 4: Melt Temperature and Glass Transition Temperature of VICTREX HT and VICTREX 450G



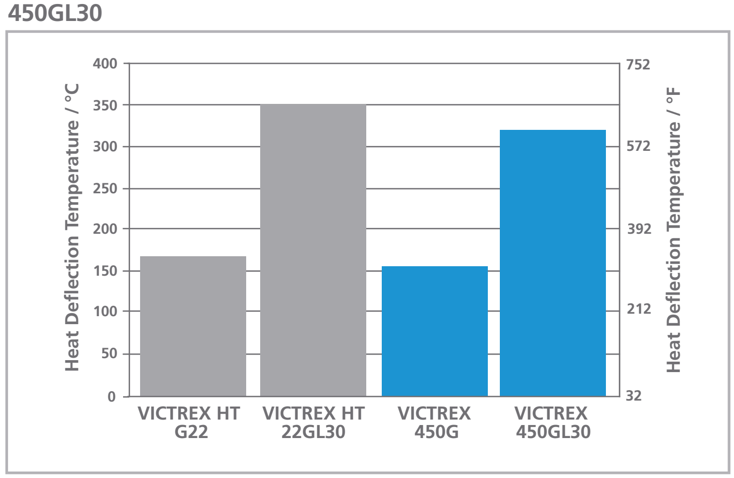
The molecular structure and semi-crystalline nature of VICTREX HT results in a melting point (T_m) 30°C (54°F) higher and a glass transition temperature (T_g) 14°C (25°F) higher than VICTREX 450G.

Figure 5: Wear Properties of VICTREX HT and VICTREX 450G at 23˚C (73˚F) (ASTM D3702 thrust washer geometry)



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

Figure 6: Heat Deflection Temperature of VICTREX HT and VICTREX 450G Compared to VICTREX HT 22GL30 and VICTREX 450GL30



The heat deflection temperature of VICTREX HT is 13°C (23°F) higher than VICTREX 450G. When reinforced with 30% glass fiber, the HDT is 30°C (54°F) higher than any currently available thermoplastic.

INJECTION MOLDING GUIDELINES

VICTREX 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 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 (300°F) or 2 hours at 160°C (320°F), or in a vacuum oven for at least 4 hours at 120°C (250°F). The material should be spread evenly in clean shallow trays, in layers about 2.5 cm (1 in) deep. Materials can be left to dry overnight. Care should be taken not to introduce sources of contamination.

RE-WORK

VICTREX 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 HT. Re-work should be restricted to a maximum of 30% w/w for unfilled polymer and 10% w/w for compounds.

PURGING

VICTREX 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 HT. However, the purging compound needs to be stable at temperatures above 370°C (700°F) so that it does not break down when the VICTREX HT is introduced. Purging compounds are also effective at removing the VICTREX 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 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.

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

The surface finish of metallic components used in transporting VICTREX 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 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 HT, the cylinder heaters must be capable of maintaining 450°C (840°F). Barrel and cylinder temperatures are typically run in the range of 385-410°C (725-770°F). 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 (160 and 210°F). Thermal conduction along the screw and barrel to the hopper may reduce feed efficiency. Water-cooling will help control the feed throat 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 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 HT on a machine with a very high number of shots in the barrel, reduce the rear zone temperatures 10 to 20°C (20 to 35°F) 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 HT has a sharp melting point and will solidify quickly if the melt temperature in the nozzle is allowed to fall much below 375°C (705°F). 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 essential to prevent the nozzle from freezing off.

Within the recommended processing temperatures, the viscosity of VICTREX HT is generally high enough to allow the use of an open nozzle system. Shut-off nozzles are not recommended due to 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 dependent. However, injection pressures rarely exceed 13.6 MPa (2000 psi) (usually 6.8-13.6 MPa [1000-2000 psi]) with secondary holding pressures less than 10.2 MPa (1500 psi) (usually 3.4-10.2 [500-1500 psi]). Back pressure should be nominal (approximately 0.34 MPa [50 psi]) 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 in-2) for unfilled VICTREX HT and 65-140 MPa (4.7-10 Tons in-2) 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.

SCREW DESIGN AND SPEED

Most general-purpose screws are suitable for processing VICTREX 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 (0.12 in.) 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.

MOLD TEMPERATURE

Heated molds are required to allow VICTREX HT to crystallize and achieve its best properties. Electric and oil heating have both been used successfully, but oil heating 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 (355°F) to allow crystallization. This typically corresponds to an oil heater temperature of at least 230°C (450°F). To obtain ideal levels of crystallinity, the mold surface temperature should be between 190 to 215°C (375 and 420°F), 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 HT will not be possible with low levels of crystallinity due to the low mold temperature. Processing VICTREX HT on a hot tool is essential. The material crystallinity can be enhanced and stress can be reduced with heat treatment, but this can also cause distortion.

OPERATING TEMPERATURES

Table 2: Operating Temperatures

Grade	Rear Zone (°C/°F)	Middle Zone (°C/°F)	Front Zone (°C/°F)	Nozzle (°C/°F)
VICTREX HT G22	380/715	382/720	385/725	388/730
VICTREX HT G45	382/720	385/725	388/730	390/735
VICTREX HT 22GL30	382/720	388/730	390/735	393/740
VICTREX HT22CA30	382/720	388/730	393/740	400/750

The figures contained in this table are given for guidance purposes only. See disclaimer on back page.

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Properties of VICTREX HT Polymers

PROPERTY	CONDITION	TEST METHOD	UNITS	VICTREX HT G22 (unfilled)	VICTREX HT 22GL30 (glass filled)	VICTREX HT 22CA30 (carbon filled)
General						
Density	Crystalline	ISO1183	g/cm³	1.32	1.53	1.41
Typical Crystallinity			%	35		
Mechanical						
Tensile Strength	23°C (73°F)	ISO527	MPa (ksi)	110 (16)	200 (29)	250 (36)
	150°C (302°F)		MPa (ksi)	48 (7.0)		130 (19)
	250°C (482°F)		MPa (ksi)	17 (2.5)		75 (11)
Tensile Elongation	Break, 23°C (73°F)	ISO527	%	20	2.9	2.2
Tensile Modulus	23°C (73°F)	ISO527	GPa (ksi)	3.9 (570)	12 (1,700)	25 (3,600)
Flexural Strength	23°C (73°F)	ISO178	MPa (ksi)	185 (27)	300 (44)	360 (52)
Flexural Modulus	23°C (73°F)	ISO178	GPa (ksi)	4.1 (600)	11.0 (1,600)	22 (3,200)
Compressive Strength	23°C (73°F)	ISO604	MPa (ksi)	135 (20)		300 (43)
	120°C (248°F)					210 (30)
	200°C (392°F)					95 (14)
Izod Impact Strength	Notched, 23°C (73°F)	ISO180/A	kJ m^{-2} (ft lb in^{-2})	6.0 (2.9)	11 (5.2)	8.0 (3.8)
	Unnotched, 23°C (73°F)	ISO180/U	kJ m^{-2} (ft lb in^{-2})		70 (33)	45 (21)
Thermal						
Melting Point		ISO3146	°C (°F)	374 (705)	374 (705)	374 (705)
Glass Transition (T_g)		ISO3146	°C (°F)	157 (315)	157 (315)	157 (315)
Coefficient of Thermal Expansion (along flow)	Below T_g	ISO11359	ppm $°C^{-1}$ (ppm $°F^{-1}$)	45 (80)	20 (36)	5 (9)
	Above T_g		ppm $°C^{-1}$ (ppm $°F^{-1}$)	75 (140)	45 (80)	5 (9)
Heat Deflection Temperature	1.8MPa (264psi)	ISO75/A-f	°C (°F)	165 (329)	360 (680)	368 (694)
Electrical						
Dielectric Strength	Thickness 2.5mm	IEC248	kV mm^{-1}	17	16	
Comparative Tracking Index	23°C (73°F)	IEC112	V	150		
Loss Tangent	1MHz, 23°C (73°F)	IEC250		0.0035	0.005	
Volume Resistivity		IEC93	10^{16} Ωcm	5		
Fire, Smoke & Toxicity						
Flammability		UL94		V-0 @ 1.5mm	V-0 @ 1.5mm	na

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