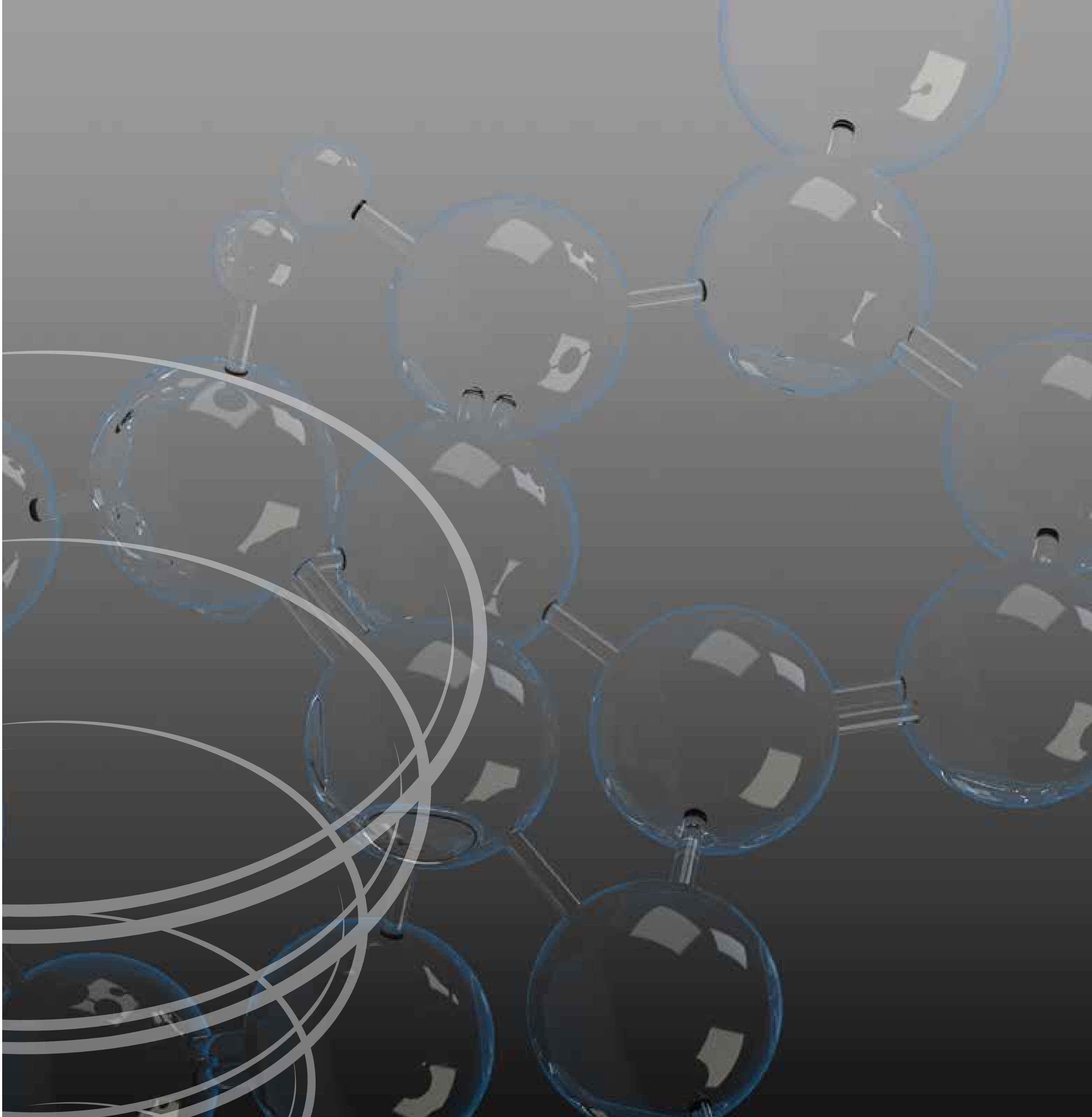


Designing with Engineered Polymers

VORTEX®
Performance Polymers

know-how makes the difference

ERIKS

Contents

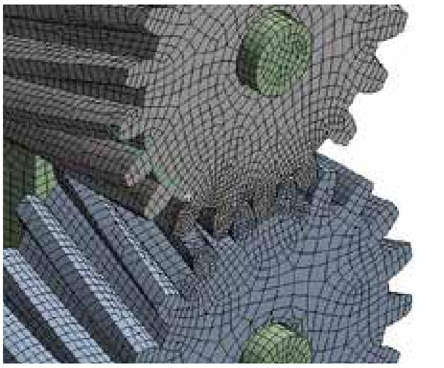
All information in this documentation has been compiled with care to ensure accuracy. Despite this we can bear no liability for error and/or changes in legislation that may affect content. Recommendations are intended as guidelines only, for further information and technical assistance, please consult your Applications Engineer.

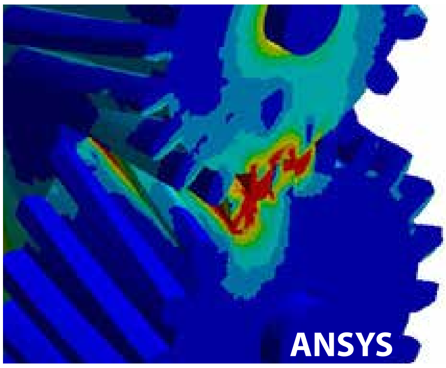
With locations and dedicated application engineers based at all of the major global industry hubs, ERIKS is an ideal partner to service your high performance polymer requirements.

Boasting cutting edge technology centres in the UK, USA, Netherlands, Belgium and Germany, ERIKS operates at the forefront of material science, developing new and tightly controlled, state of the art polymer blends.

Our experienced design engineers work with you to co-create unique innovative solutions, drawing on the performance benefits achievable through in-depth technical knowledge, polymer know-how and production criteria.

ERIKS' design teams work closely with our material scientists to produce accurate materials data upon which our Finite Element Analysis are based, to minimise design iterations in successfully satisfying your application. Then we employ the latest Computer Aided Engineering 3D CAD platforms to capture design intent, which is verified using our contact and non-contact Co-Ordinate Measuring Machine (CMM) Full traceability of product and batch data requirements is standard practice, ensuring the solution you qualify is unchanged throughout the products life cycle.





ERIKS is one of the few companies to have an in-group ISO 13485 plastics machining facility and holds ISO 9001 certification across both of the UK core competence centres.

The selection of materials for your application can be the most critical consideration. Innovation in materials technology, and the design thereof, is consistently changing, opening up new opportunities to enhance your products performance at the same time as reducing overall life cycle cost.

High performing polymers are now the materials of choice, offering exceptional gains from the lightweight nature of the material and high strength derived from scientific development of polymers. These materials also have the ability to resist impact and deformation damage which can be a significant advantage in the right application, while performing at elevated temperatures and high pressures for extended durations.

For harsh environments, high performance polymers are an attractive solution as they are impervious to many chemicals as well as resisting corrosion induced by the environment.

For a cost effective solution, polymers can be processed in to your final required geometry by utilising many different manufacturing processes. The selection of the process is balanced against volume requirements, product life cycle expectations and speed to market needs.

The selected manufacturing processes are tightly controlled to deliver repeatable dimensional and performance quality throughout the life cycle of the product.

"A customer supplier partnership is a shared journey to create a solution for both parties that is better than either could have developed alone."

Dominic Rogers
Business Unit Manager - Plastics

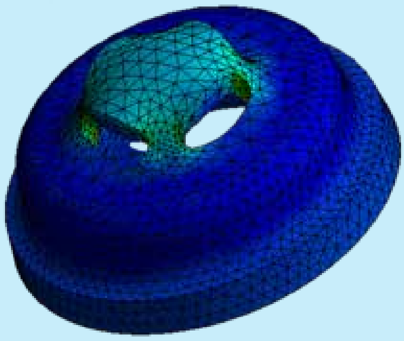
Designing with Engineered Polymers

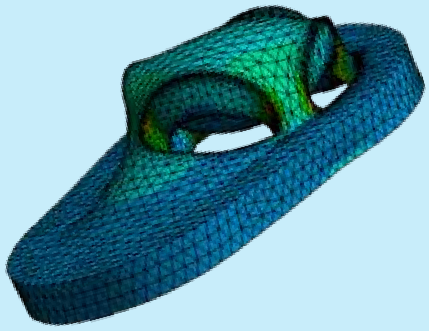
The Vortex® range of Performance Polymers, offers a select range of exceptional thermoplastic and thermoset materials. Each material is chosen specifically for its application suitability. Our teams of engineers and scientists will take all of your technical parameters into account and specify the best turn-key solution, ensuring a consistent and tightly controlled material from the moulding of stock shapes to the machining of a finished component. From Concept-to-Volume (C_2V), Vortex® Performance Polymer solutions will be unsurpassed.

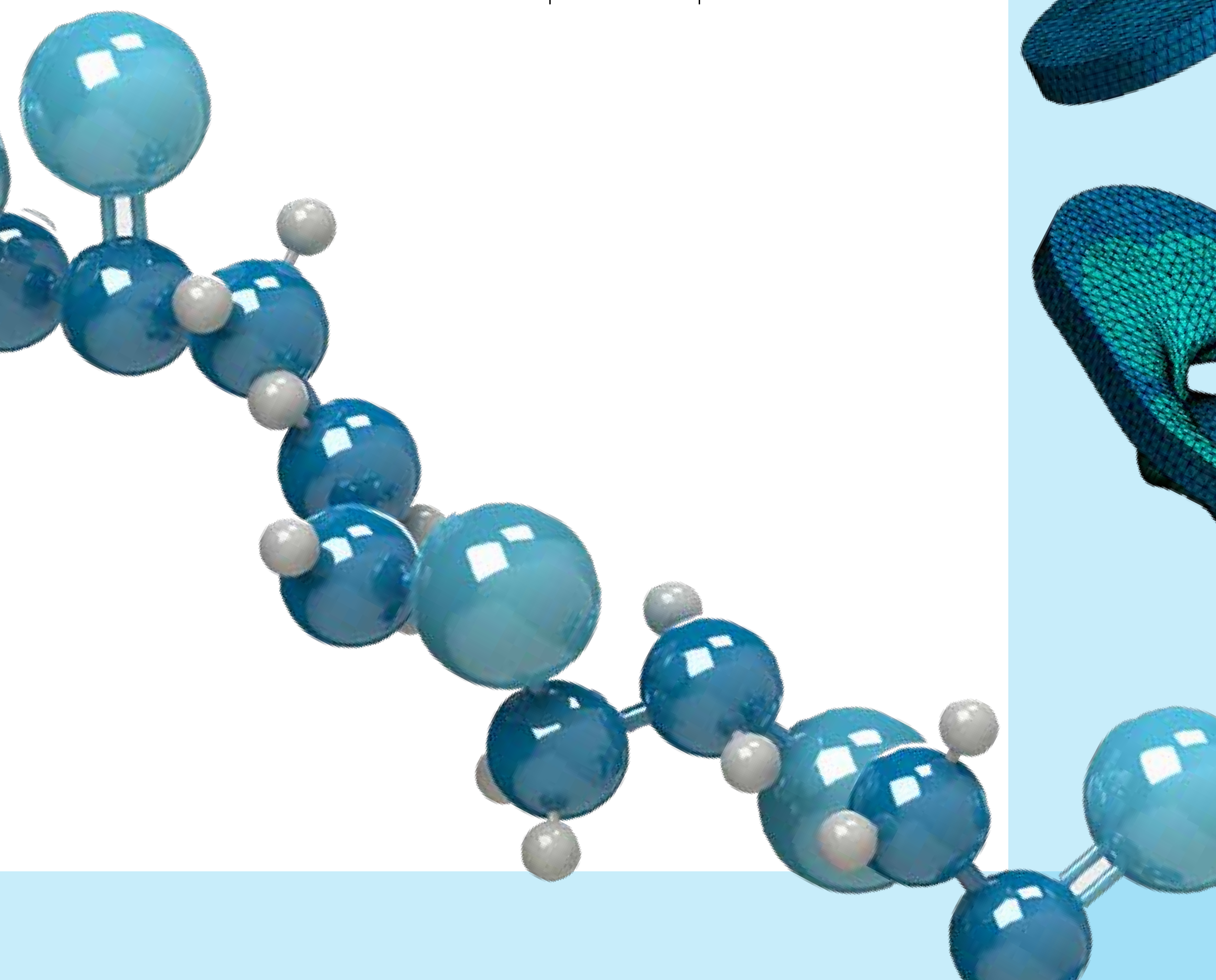
Finite Element Analysis (FEA)

FEA is a mathematical technique to predict deflection strain, stress, reaction force and contact pressure based on dimensional information, physical constraints and material properties. This improves design integrity and speed to product functionality.

Our Materials Technology Centre can generate temperature specific, validated material models on which to base these analyses. FEA allows our engineers to optimise design solutions, minimising product development time and cost.







Prototyping

Our UK product development cell specialises in cutting-edge polymer technologies. Reserved purely for the development of prototypes, the facility allows our customers to bring products to market in the shortest time possible and complements our 3D printing capability, which is limited to fit testing and visual appreciation.

A key component of the cell is a state of the art, CNC, twin-spindle large-diameter 5-axis machining centre. This enables the manufacture of complex polymeric and composite components without the need for costly tooling.

Global Manufacturing Options

The selection and specification of a manufacturing process is highly dependent on the volumes and characteristics required of the finished component. ERIKS can call on its own closely regulated and quality controlled production facilities for the more specialist components or work with one of our specifically selected manufacturing partners to ensure that the lead-time, quality and cost base are at a level that allows you entry into market for your product.

The building blocks to a technology enabled solution are then distributed by our unparalleled global network.

Material Technology Centre

The Material Technology Centre's principal activities are to ensure our high quality standards are maintained and to develop new polymeric solutions for your applications.

Situated in Warrington, this facility benefits from continuous investment in technology and people. This is one of the major factors in ERIKS' success in high performance, engineered polymers.

Capabilities

- Hardness (Shore® D)
- Mechanical property testing
- Chemical and heat ageing
- Ozone resistance
- Material composition
- Dimensional measurements
- Surface defects
- Material properties at temperatures from –90°C to 300°C
- Extraction testing
- Failure analysis
- Ultraviolet Light (UV) resistance
- DMTA – Dynamic Mechanical Thermal Analysis
- FTIR with ATR
- TGA / DSC combined with link to FTIR gas cell
- Modulated DSC

Fourier Transform Infra-red Spectroscopy (FTIR)

Molecules have specific frequencies at which they naturally rotate or vibrate. By exposing a material sample to a spectrum of infra-red frequencies the equipment can identify which molecules are present by detecting which frequencies are absorbed. This technique is used to identify the base polymers material type in quality control and to identify thermo-chemical decomposition.

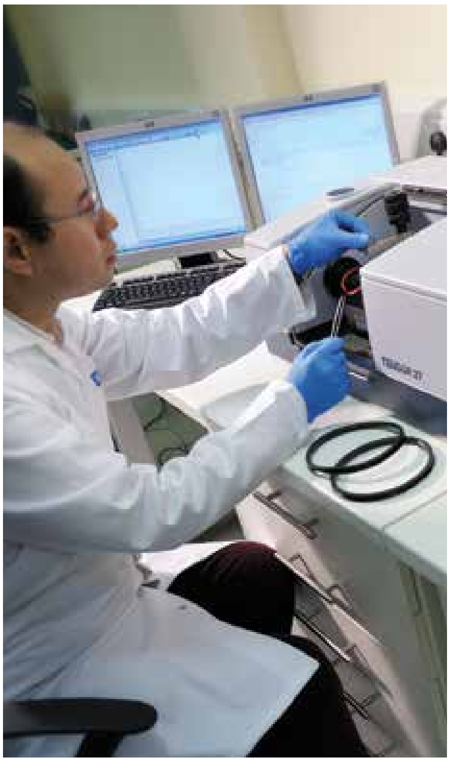
Thermo-Gravimetric Analysis (TGA)

TGA is used to identify weight loss of a polymer blend either isothermally over time or over a ramped temperature range. The relative composition of compounds can be identified, to quantify polymer, organic and inorganic filler contents and types.

Differential Scanning Calorimetry (DSC)

DSC analysis measures changes in enthalpy (exothermic or endothermic energy changes) over time, or, with changes in temperature. DSC analysis can be used as a quality tool (blend consistency), an analytical tool (failure analysis), or in development of new materials (glass transition, oxidation etc).

With modulated DSC (MDSC), the samples are subjected to a nonlinear heating/cooling regime (i.e. sinusoidal). This nonlinear temperature profile allows the measurement of heat capacity effects simultaneously with the kinetic effect, as well as increasing the sensitivity of the system. With the MDSC, overlapping events can also be separated, i.e. measurement of the Tg and molecular relaxation.



VORTEX® Performance Polymers

TEFLEX® Fluoropolymer Parts

CHEMICAL	PEEK 23°C (73°F)	PEEK <100°C (212°F)	PEEK <200°C (392°F)	PPS 23°C (73°F)	PTFE 23°C (73°F)	PI 23°C (73°F)
1,2 Dichloroethane	A	-	-	B	A	-
Acetaldehyde	A	A	-	A	A	-
Acetic Acid, 10% Conc.	A	A	-	A	A	A
Acetic Acid, Conc.	A	A	A	A	A	B
Acetone	A	A	-	A	A	A
Acetonitrile	A	-	-	A	A	-
Acetylene	A	A	-	A	A	-
Aliphatic Esters	A	A	-	-	A	-
Aluminium Chloride	A	A	-	A	A	A
Ammonia, Anhydrous	A	A	A	A	A	-
Ammonia, Aqueous	A	A	A	A	A	-
Ammonium Chloride (10% Conc.)	A	A	-	A	A	-
Ammonium Hydroxide, 10% Conc.	A	-	-	A	A	B
Ammonium Hydroxide, Conc.	A	-	-	A	A	C
Amyl Acetate	A	A	-	A	A	-
Aniline	A	B	-	A	A	C
Aqua Regia	C	C	C	C	A	-
Benzaldehyde	A	-	-	A	A	-
Benzene	A	A	-	A	A	A
Benzoic Acid	A	A	-	-	A	A
Boric Acid	A	A	-	A	A	A
Brake Fluid (Mineral)	A	A	A	A	A	-
Brake Fluid (Polyglycol)	A	A	A	A	A	-
Brine	A	A	-	A	A	-
Bromine (Dry)	C	C	C	B	A	-
Bromine (Wet)	C	C	C	B	A	-
Butane	A	-	-	A	A	-
Butanol	A	-	-	-	A	-
Butyl Acetate	A	-	-	A	A	-
Calcium Chloride	A	A	-	A	A	A
Calcium Hydroxide	A	-	-	A	A	C
Calcium Nitrate	A	-	-	A	A	A
Carbolic Acid	A	-	-	A	A	-
Carbon Dioxide (Dry)	A	-	-	A	A	A
Carbon Monoxide (Gas)	A	A	A	-	A	A
Carbon Tetrachloride	A	A		B	A	A
Chlorine (Gas-Dry)	A	A	C	B	A	-
Chlorine (Gas-Wet)	C	C	-	B	A	-
Chlorine (Liquid)	C	C	C	B	A	A
Chlorine (Wet)	C	C	C	B	A	A
Chlorobenzene	A	A	-	A	A	A
Chloroform	A	A	-	A	A	A
Chromic Acid, 40% Conc.	A	-	-	C	A	C
Citric Acid	A	A	-	A	A	A
Crude Oil	A	-	-	A	A	A
Cyclohexane	A	A	-	A	A	-
Cyclohexanone	A	-	-	A	A	-
Diesel Oil	A	-	-	A	A	-
Diethylamine	A	-	-	A	A	-
Diethylether	A	A	-	A	A	-
Dimethyl Formamide (DMF)	A	-	-	-	A	C
Dimethyl Phthalate	A	-	-	A	A	-
Dimethylsulphoxide (DMSO)	B	B	-	-	A	C
Dioctyl Phthalate	A	-	-	A	A	-
Dowtherm™ G	B	-	-	A	A	-
Ethane	A	-	-	A	A	-
Ethanol	A	A	-	A	A	A
Ethyl Acetate	A	-	-	A	A	A
Ethylene Glycol	A	A	B	A	A	A
Ethylene Oxide (Et0)	A	-	-	A	A	-
Ferric Chloride	B	B	-	A	A	A
Ferric Oxide	A	A	-	A	A	-
Ferrous Chloride	A	-	-	A	A	-
Fluorine	C	C	C	-	C	-
Formaldehyde	A	A	-	A	A	-
Formic Acid	B	B	-	A	A	A
Freon 114	A	-	-	A	A	A
Freon 12	A	-	-	A	A	A
Freon 134a	A	-	-	A	A	A
Fuel Oil	A	-	-	A	A	-
Gas (Natural)	A	-	-	A	A	-
Gasoline	A	-	-	A	A	A
Glycerol	A	-	-	A	A	-
Glycols	A	A	-	A	A	-
Heptane	A	-	-	A	A	A
Hexane	A	-	-	A	A	-
Hydraulic Fluid	A	-	-	A	A	-
Hydrazine	A	A	-	B	A	C

CHEMICAL	PEEK 23°C (73°F)	PEEK <100°C (212°F)	PEEK <200°C (392°F)	PPS 23°C (73°F)	PTFE 23°C (73°F)	PI 23°C (73°F)
Hydrochloric Acid, 10% Conc.	A	A	-	C	A	A
Hydrochloric Acid, Conc.	A	B	-	C	A	C
Hydrofluoric Acid (40%)	C	C	-	B	A	A
Hydrofluoric Acid (70%)	C	C	-	B	A	A
Hydrogen Peroxide	A	-	-	B	A	-
Hydrogen Sulphide (Gas)	A	A	A	A	A	A
Iso-Octane	A	-	-	A	A	-
Isopropanol	A	-	-	A	A	-
Kerosene	A	-	-	A	A	-
Lubricating Oil	A	-	-	A	A	-
Magnesium Chloride	A	A	-	A	A	A
Magnesium Hydroxide	A	-	-	A	A	-
Maleic Acid	A	A	-	-	A	A
Methane (Gas)	A	A	A	A	A	-
Methanol	A	A	-	A	A	A
Methylene Chloride	A	-	-	B	A	A
Methylethyl Ketone (MEK)	A	B	C	A	A	A
Motor Oil	A	A	A	A	A	-
Naphtha	A	A	-	A	A	-
Naphthalene	A	A	-	A	A	-
Nitric Acid, 10% Conc.	A	A	-	B	A	A
Nitric Acid, 50% Conc.	C	C	C	C	A	C
Nitric Acid, Conc.	C	C	C	C	A	C
Nitrobenzene	A	-	-	A	A	A
N-Methyl-2-Pyrrolidone (NMP)	A	-	-	B	A	-
Oils (Di-Ester & Phosphate Ester Based)	A	A	-	-	A	-
Oils (Petroleum)	A	A	-	A	A	-
Oils (Vegetable)	A	A	-	A	A	-
Oleum	C	C	C	C	A	C
Oxygen	A	-	-	A	A	-
Ozone	A	B	-	C	A	-
Pentane	A	-	-	A	A	-
Phenol, Conc.	C	C	C	A	A	A
Phenol, Dilute	A	-	-	A	A	-
Phosphoric Acid, 10% Conc.	A	A	A	A	A	A
Phosphoric Acid, 50% Conc.	A	A	A	A	A	A
Phosphoric Acid, 80% Conc.	A	A	-	A	A	A
Phosphorous Chlorides	A	A	-	A	A	-
Potassium Bicarbonate	A	-	-	-	A	C
Potassium Chloride	A	A	-	A	A	-
Potassium Dichromate	A	-	-	C	A	C
Potassium Hydroxide	A	A	-	A	A	C
Potassium Hydroxide, 10% Conc.	A	-	-	A	A	C
Potassium Hydroxide, 70% Conc.	A	-	-	A	A	C
Potassium Nitrate	A	A	-	-	A	A
Potassium Permanganate	A	-	-	B	A	C
Potassium Sulphate	A	A	-	A	A	-
Propane	A	-	-	A	A	-
Propanol	A	-	-	A	A	-
Pyridine	A	A	-	B	A	A
Silicone Fluids	A	A	-	A	A	-
Silver Nitrate	A	A	-	A	A	-
Skydrol™ Hydraulic Fluid	A	-	-	-	A	-
Sodium Bicarbonate	A	-	-	A	A	C
Sodium Carbonate	A	A	-	A	A	C
Sodium Chloride	A	A	-	A	A	A
Sodium Hydroxide, 10% Conc.	A	A	A	A	A	C
Sodium Hydroxide, 50% Conc.	A	A	A	A	A	C
Sodium Hydroxide, Conc.	A	-	-	A	A	C
Sodium Hypochlorite	A	A	-	B	A	C
Sodium Silicate	A	A	-	A	A	-
Sodium Sulphate	A	A	-	A	A	A
Steam	A	A	A	A	A	-
Styrene (Liquid)	A	-	-	A	A	-
Sulphur Dioxide	A	A	A	A	A	A
Sulphuric Acid, <40% Conc.	B	B	B	A	A	B
Sulphuric Acid, >40% Conc.	C	C	C	C	A	C
Tannic Acid, 10% Conc.	A	A	-	A	A	A
Tar	A	-	-	A	A	-
Tetrahydrofuran (THF)	A	-	-	-	A	-
Toluene	A	-	-	A	A	A
Transformer Oil	A	A	-	A	A	-
Trichloroethylene	A	A	-	B	A	B
Water	A	A	A	A	A	B
Water, Distilled	A	A	-	A	A	B
Water, Sea/Salt	A	A	-	A	A	B
Xylene	A	-	-	A	A	-
Zinc Chloride	A	A	-	A	A	A

KEY:

A = Excellent **B = Moderate** **C = Poor** **Dash (-) = Limited data available**

Material information can also be found on our Chemical Compatibility tool:

http://oring-groove-wizard.eriks.co.uk/chemicalcompatibility.aspx

Materials

Amorphous and Semicrystalline Structures

Thermoplastics can be separated into the categories of amorphous and semicrystalline polymers.

Amorphous polymers have a random molecular structure that does not have a sharp melting point; amorphous materials transition gradually as temperature rises. Amorphous materials lose a substantial amount of their mechanical properties above their glass transition temperature (Tg). Polysulfone (PSU), Polyethersulfone (PES) and Polyetherimide (PEI) are common amorphous thermoplastics.

Semicrystalline polymers have a highly ordered molecular structure; these have a defined and narrow melting point. This melting point is generally above that of the amorphous thermoplastics. Polyethylene terephthalate (PET) and Polyetheretherketone (PEEK) are common semicrystalline plastics.

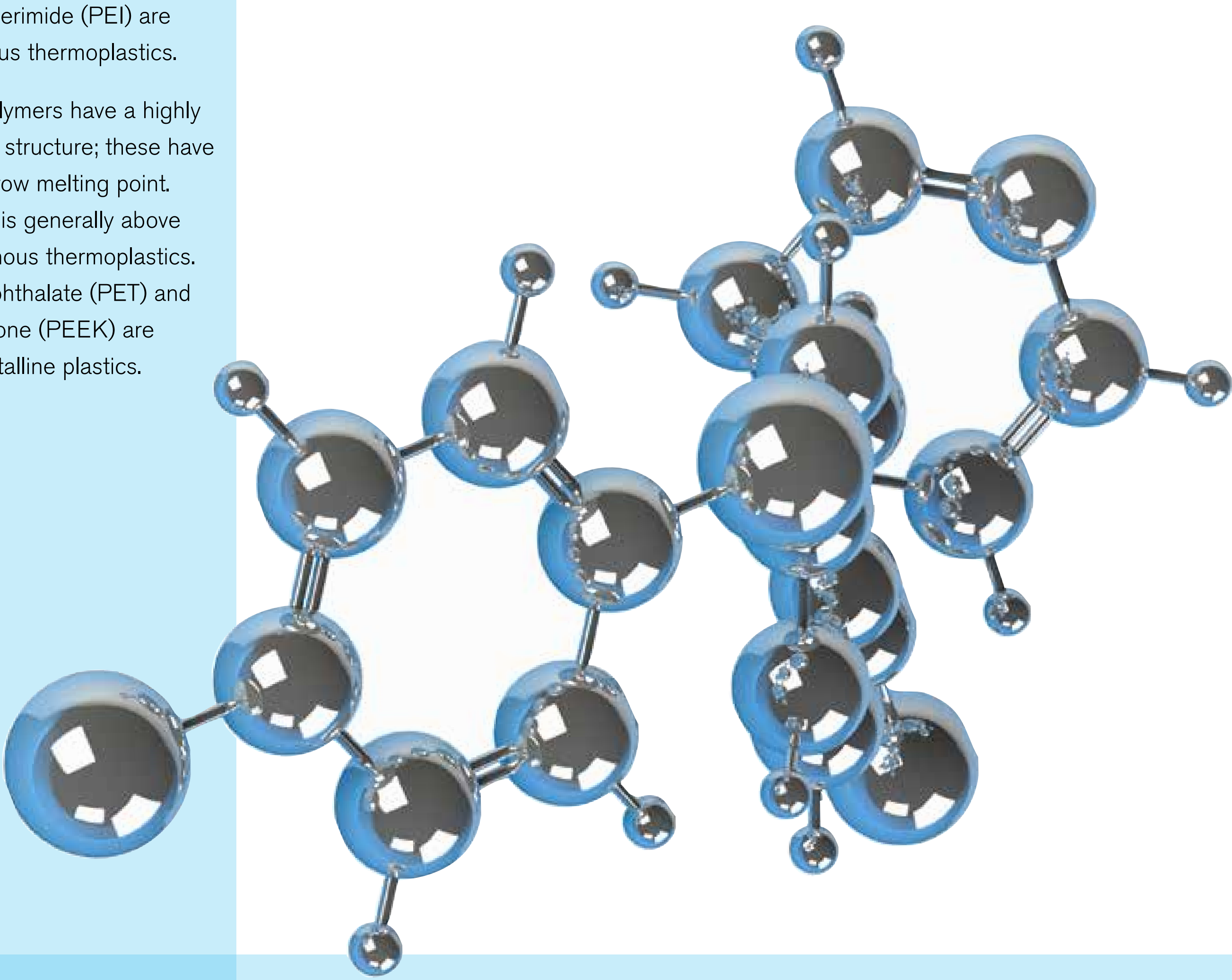
Thermoset Plastics

Thermoset plastics undergo irreversible chemical changes under heat and pressure (crosslinking, curing) and cannot be reformed.

These polymers are generally rigid, tough and heat resistant. Examples are Phenols (Bakelite®), Polyimides and Polyester materials.

Thermoplastics

Thermoplastics are rigid and solid materials at ambient temperatures but at elevated temperatures they can soften and melt. Some of the more common plastics in this category are Polyamide (PA or Nylon), PVC and PEEK.



Features and Processing Methods

Thermoplastic

Processing Method	Tooling Cost	Cycle Time	Precision	Economic Quantity
Extrusion	Moderate	Continuous	Good	>5K
Injection Moulding	High	Short	Good	> 10K
Rotational / Spin Moulding	Low	↓	Moderate	100 to 10K
Compression moulding	Low	Long	Moderate	100 to 10K

Thermoset

Processing Method	Tooling Cost	Cycle Time	Precision	Economic Quantity
Extrusion	High	Long	Good	> 10K
Transfer Moulding	High	↓	Good	> 10K
Injection Moulding	High	Short	Good	> 10K

Cost Benefit/Process Analysis

Process / Feature	Extrusion	Injection Moulding	Rotational /Spin Casting	Thermoforming	Compression Moulding	CNC Machining Centre	CNC Turning Centre
Tooling Cost	Moderate	High	Low	Low	Low	Moderate	Moderate
Economic Quantity	Variable*	>10K	1-3 min	100 - 10K	100 - 10K	>10K	>10K
Precision (Tolerance)	Moderate	Good	Moderate	Low	Moderate	Good	Good
Wall Thickness Control	Moderate	Good	Moderate	Good	Good	Very Good	Very Good
Intricate Shapes	No (Yes in 2 Axes)	Yes	No (Cylindrical Shapes only)	No	Yes	Yes	No (Yes in 2 Axes)
Enclosed Volumes	Yes	No	Yes	No	No	No	No
In Process Part Number Marking	No	Yes	No	Yes	Yes	Yes	No
Achievable Surface Finish	Rough	Fine	Rough	Rough	Rough	Very Fine	Very Fine
Threads	No	Yes	No	No	Yes	Yes	Yes

* Dependant on profile / material

Thermal Polymer Characteristics

Maximum Service Temperature* (T_{max}): The highest temperature at which material can be used for an extended period without significant problems, such as oxidation, chemical change, excessive creep, loss of strength, or other primary property for which the material is normally used.

Minimum Service Temperature* (T_{min}): The minimum temperature at which a material can be used effectively, without becoming too brittle.

Thermal Conductivity (TC): A measure of how well a material conducts heat.

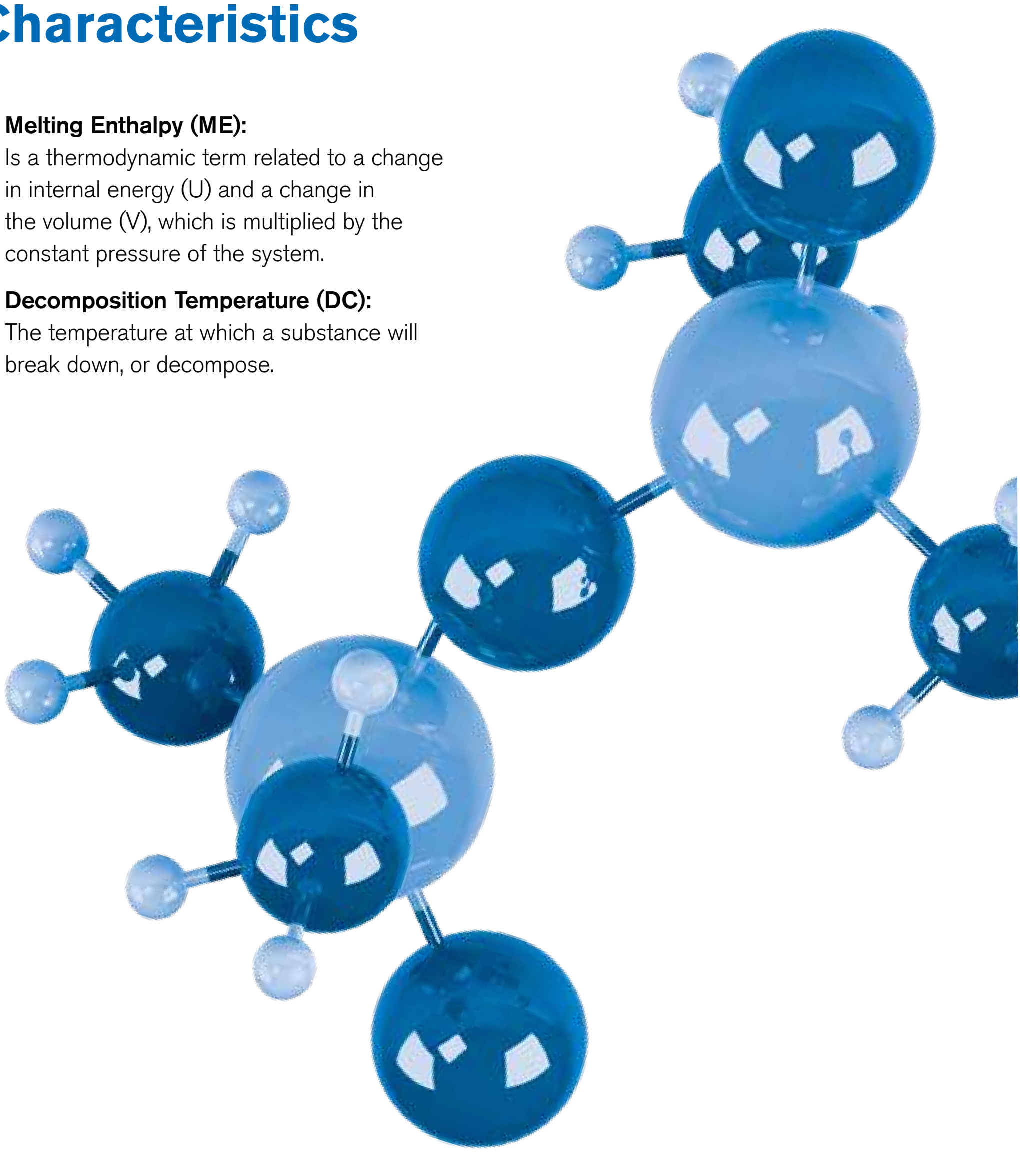
Specific Heat Capacity (SHC): The energy required to raise the temperature of a unit mass of material by one degree of temperature.

Coefficient of Thermal Expansion (CTE): The fraction a material expands per degree of temperature.

Glass Transition (Tg): The temperature at which the mechanical properties of a plastic radically change due to the internal movement of the polymer chains that form the plastic.

Melting Enthalpy (ME): Is a thermodynamic term related to a change in internal energy (U) and a change in the volume (V), which is multiplied by the constant pressure of the system.

Decomposition Temperature (DC): The temperature at which a substance will break down, or decompose.



Thermal Properties of Vortex® Performance Polymers

Vortex® 0315 PolyEtherKetoneEtherKetoneKetone	Vortex® 1127 Polyetheretherketone	Vortex® 1609 Polyimide	PEI Polyetherimide	PSU Polysulphone	PES Polyethersulphone
Tg: 165 - 175 °C	Tg: 145 - 155 °C	Tg: (na) °C	Tg: 215 - 230 °C	Tg: 185 °C	Tg: 225 - 230 °C
MT: 380 - 390 °C	MT: 335 - 345 °C	MT: (na) °C	MT: - °C	MT: - °C	MT: - °C
ME: 60 J/g	ME: 130 J/g	ME: (na) J/g	ME: - J/g	ME: - J/g	ME: - J/g
DC: 580-595 °C	DC: 600 °C	DC: 616 °C	DC: 540 - 550 °C	DC: 530 - 535 °C	DC: 580 - 590 °C
CEAB: 45 $x10^{-6}$/K	CEAB: 50 - 70 $x10^{-6}$/K	CEAB: 50 x 10^{-6} $x10^{-6}$/K	CEAB: 50 $x10^{-6}$/K	CEAB: 50 - 60 $x10^{-6}$/K	CEAB: 60 $x10^{-6}$/K
SHC: 2.6 kJ kg^{-1} K^{-1}	SHC: 2.2 kJ kg^{-1} K^{-1}	SHC: 1.1 kJ kg^{-1} K^{-1}	SHC: 2.0 kJ kg^{-1} K^{-1}	SHC: 1.37 kJ kg^{-1} K^{-1}	SHC: 1.37 kJ kg^{-1} K^{-1}
TC: 0.29 W/m.K	TC: 0.25 W/m.K	TC: 0.29 W/m.K	TC: 0.22 W/m.K	TC: 0.15 W/m.K	TC: 0.18 W/m.K

Key:

Tg: Glass Transition Temperature
MT: Melting Temperature
ME: Melting Enthalpy
DC: Decomposition Temperature
CEAB: Coefficient of Thermal Expansion
SHC: Specific Heat Capacity
TC: Thermal Conductivity
Tested in dry air only

Mechanical Polymer Characteristics

Heat Deflection Temperature (HDT):
The temperature at which a standard test bar deflects a specified distance under a load. It is used to determine short-term heat resistance. It distinguishes between materials that are able to sustain light loads at high temperatures and those that lose rigidity over a narrow temperature range.

The Long-Term Service Temperature (LTST):
The maximum temperature at which plastics can be kept in hot air for 10,000 and 20,000 hours without losing more than 50% of the initial values for their typical properties.

Charpy Impact Test (CIT):
A destructive test of impact resistance, consisting of placing a test coupon in a horizontal position between two supports, then applying a blow of known magnitude. If the specimen does not break, a new specimen is put in position and the magnitude is increased until the specimen breaks.

Tensile Strength (TS):
The maximum tensile stress sustained by the specimen during a tension test Tensile Strength. Tensile strength at yield (TY): The maximum stress that a material can withstand without yielding when subjected to a stretching load. **Tensile strength at break (TB):** The maximum stress that a material can withstand without breaking when subjected to a stretching load.

Tensile Modulus (TM): (Also called modulus of elasticity).
The ratio of nominal stress to the corresponding strain below the proportional limit of a material.

Modulus (M):
Derived from the Latin word meaning "small measure", modulus is the ratio of stress to strain in the linear region of the stress-strain curve. The **Tensile Modulus (TM)** is the ratio of nominal tensile stress to the corresponding strain below the proportional limit of a material. **Young's Modulus (E)**, also known as the Secant Modulus or Elastic Modulus, is the tangent modulus of the initial, linear portion of a stress-strain curve, experimentally determined from the results of tensile testing.

Elongation, Break (EAB):
The increase in distance between two gauge marks at the break point divided by the original distance between the marks. A zero value in the field indicates that it measured less than one.

Compressive Strength (CS):
The ability of a material to sustain a force in a direction opposite of tension.

Shear Strength (SS):
Shear strength is the load at which a plastic or film will yield when sheared between two metal edges. Commonly determined using ASTM D732 punch testing.

Izod Impact Strength (IIS):
A measure of impact strength determined by the difference in energy of a swinging pendulum before and after it breaks a notched specimen held vertically as a cantilever beam. Sample specimen can be either notched or un-notched.

Izod, Notched, LT: The energy required to break specimens in which there is a v-notch to create an initial stress point but measured at low temperature -40°C (-40°F).

Izod, Notched, RT: The energy required to break specimens in which there is a v-notched to create an initial stress point.

Flexural Strength (FS):
Also known as modulus of rupture or bend strength, it is the maximum stress at the point of fracture using a three point flexural test.

Flexural Modulus (FM):
Also known as bending modulus, it is the ratio of stress to strain in flexural deformation. It is calculated from the slope of a stress-strain curve produced during a flexural test.

Density (D):
Mass of material per unit volume.

Mechanical Properties of Vortex® Performance Polymers

Vortex® 0315 PolyEtherKetoneEtherKetoneKetone	Vortex® 1127 Polyetheretherketone	Vortex® 1609 Polyimide	PEI Polyetherimide	PSU Polysulphone	PES Polyethersulphone
TS: 160 MPa	TS: 140 MPa	TS: 72 MPa	TS: 72 MPa	TS: 70 MPa	TS: 83 MPa
EAB: 3.3%	EAB: 2.2%	EAB: 75 %	EAB: 6 %	EAB: 50 - 100 %	EAB: 30 %
TM: 8.8 GPa	TM: 12.5 GPa	TM: 2.6 GPa	TM: 2.2 GPa	TM: 2.5 GPa	TM: 2.7 GPa
FS: 250 MPa	FS: 230 MPa	FS: 110 MPa	FS: 115 MPa	FS: 100 MPa	FS: 110 MPa
FM: 8.8 GPa	FM: 11.5 GPa	FM: 3.1 GPa	FM: 2.5 GPa	FM: 2.5 GPa	FM: 2.9 GPa
IIS: 7.5 J/m	IIS: 6 J/m	IIS: 40 J/m	IIS: 100 J/m	IIS: 70 J/m	IIS: 70 J/m
LTST: -°C	LTST: -°C	LTST: 220 - 280°C	LTST: 170 - 215°C	LTST: 150 - 180°C	LTST: 180 - 220°C
HDT: 315°C	HDT: 315°C	HDT: 275 - 280°C	HDT: 200 - 215°C	HDT: 160 - 174°C	HDT: 200 - 210°C

Key:
TS = Tensile Strength at Yield @ 23°C
EAB = Tensile Elongation
TM - Tensile Modulus @ 23°C
FS = Flexural Strength
FM = Flexural Modulus
IIS = Izod Impact Strength
HDT = Heat Deflection Temperature @ 1.8 MPa
LTST= Long Term Service Temperature

Amorphous

PS-HI – High Impact Polystyrene
TS: 19 - 33 MPa
EAB: 40 - 50%
TM: 1.8 GPa
LTST: 55 - 60°C
HDT: 60 - 80°C
Cost: ▪

PS-GP – General Purpose Polystyrene
TS: 40 - 50 MPa
EAB: < 3%
TM: 3.2 - 3.5 GPa
LTST: 70 - 85°C
HDT: 72 - 82°C
Cost: ▪

ABS – Acrylonitrile Butadiene Styrene
TS: 40 - 60 MPa
EAB: 3 - 20%
TM: 2.0 - 2.6 GPa
LTST: 80 - 95°C
HDT: 90 - 100°C
Cost: ▪

SAN – Styrene Acrylonitrile
TS: 47 - 72 MPa
EAB: 2.0 - 10%
TM: 2.3 - 4.1 GPa
LTST: 55 - 60°C
HDT: 84 - 95°C
Cost: ▪ ▪

PMMA – Polymethylmethacrylate
TS: 56 - 70 MPa
EAB: 3.0 - 3.5%
TM: 3.0 GPa
LTST: 90°C
HDT: 85 - 95°C
Cost: ▪ ▪ ▪

PPO (MODIFIED) – Polyphenylene Oxide
TS: 40 - 90 MPa
EAB: 10 - 60%
TM: 2.0 - 5.4 GPa
LTST: 80 - 260°C
HDT = 129°C
Cost: ▪ ▪

PVC-P – Plasticised Polyvinylchloride
TS: 6 - 20 MPa
EAB: 50 - 460%
TM: 0.002 - 0.020 GPa
LTST: 50°C
HDT: 20°C
Cost: ▪

SBS – Styrene-Butadiene-Styrene
TS: 35 - 40 MPa
EAB: 40%
TM: 1.8 - 2.0 GPa
LTST: 60°C
HDT: 67°C
Cost: ▪ ▪

SMA – Styrene-Maleic Anhydride
TS: 40 - 52 MPa
EAB: 1.8%
TM: 2.0 GPa
LTST: 100°C
HDT: 105°C
Cost: ▪ ▪

ASA – Acrylonitrile Styrene Acrylate
TS: 38 - 70 MPa
EAB: 15 - 45%
TM: 2.3 - 2.9 GPa
LTST: 82 - 120°C
HDT: 82 - 120°C
Cost: ▪ ▪

SB – Styrene-Butadiene
TS: 26 - 30 MPa
EAB: 20 - 80%
TM: 1.8 GPa
LTST: 65 - 77°C
HDT: 70 - 77°C
Cost: ▪ ▪

PVC-P – Unplasticised Polyvinylchloride
TS: 45 - 55 MPa
EAB: 25 - 60 %
TM: 2.50 - 3.02 GPa
LTST: 60 - 70°C
HDT: 64 - 70°C
Cost: ▪

CA – Cellulose Acetate
TS: 30 - 55 MPa
EAB: 5 - 55%
TM: 1.6 GPa
LTST: 45 - 70°C
HDT: 48 - 65°C
Cost: ▪ ▪

CAB – Cellulose Acetate Butyrate
TS: 26 - 50 MPa
EAB: 8 - 80%
TM: 0.7 - 1.5 GPa
LTST: 75 - 100°C
HDT: 62 - 70°C
Cost: ▪ ▪

CAP – Cellulose Acetate Propionate
TS: 26 - 47 MPa
EAB: 30 - 100%
TM: 0.7 - 1.5 GPa
LTST: 75 - 100°C
HDT: 45 - 75°C
Cost: ▪ ▪

CP – Cellulose Propionate
TS: 30 - 45 MPa
EAB: 45 - 65%
TM: 0.8 - 1.5 GPa
LTST: 68 - 100°C
HDT: 61 - 73°C
Cost: ▪ ▪

PET-G – Glycolised Polyethylene terephthlate
TS: 55 MPa
EAB: 300%
TM: GPa
LTST: 60°C
HDT: 70°C
Cost: ▪ ▪

PVC-UX – Crosslinked Unplasticised PVC
TS: 28 - 40 MPa
EAB: 150 %
TM: 2.5 - 3.0 GPa
LTST: 70 - 95°C
HDT: 120°C
Cost: ▪ ▪ ▪

PVC-U – High-Impact Unplasticised PVC
TS: 45 - 55 MPa
EAB: 25 - 60 %
TM: 2.5 - 3.0 GPa
LTST: 60 - 70°C
HDT: 64 - 70°C
Cost: ▪

Semicrystalline

PE-LD – Low Density Polyethylene
TS: 7.0 - 25 MPa
EAB: 50 - 400%
TM: 0.15 - 0.35 GPa
LTST: 40 - 70°C
HDT: 35°C
Cost: ▪

PE-LLD – Linear Low Density Polyethylene
TS: 8.0 - 20 MPa
EAB: 50 - 500%
TM: 0.2 - 1.0 GPa
LTST: 44 - 50°C
HDT: 37 - 44°C
Cost: ▪

PE-MD – Medium Density Polyethylene
TS: 14 - 25 MPa
EAB: 50 - 300%
TM: 0.25 - 0.70 GPa
LTST: 38 - 70°C
HDT: 38 - 43°C
Cost: ▪ ▪

PMP – Polymethyl pentene
TS: 25 - 28 MPa
EAB: 15 - 30%
TM: 1.0 - 2.2 GPa
LTST: 55 - 60°C
HDT: 40 - 50°C
Cost: ▪ ▪ ▪

EVA – Ethylene-vinyl Acetate
TS: 10 - 19 MPa
EAB: 50 - 750%
TM: 0.04 - 0.14 GPa
LTST: 50°C
HDT: 20 - 23°C
Cost: ▪ ▪ ▪

PE-X – Crosslinked Polyethylene
TS: 18 MPa
EAB: 350%
TM: 0.6 GPa
LTST: 90°C
HDT: 60°C
Cost: ▪ ▪ ▪

PB – Polybutene-1
TS: 12 - 17 MPa
EAB: 300 - 380%
TM: 0.21 - 0.26 GPa
LTST: 110°C
HDT: 54 - 60°C
Cost: ▪ ▪ ▪ ▪

PE-Chlorinated – Polyethylene
TS: 12.5 MPa
EAB: 700%
TM: 0.002 GPa
LTST: 60°C
HDT: 25°C
Cost: ▪ ▪ ▪

PE-VLD – Very Low Density
TS: 34 - 400 MPa
EAB: 400 - 700%
TM: 0.10 - 0.20 GPa
LTST: 60°C
HDT: 75 - 95°C
Cost: ▪ ▪ ▪

EMA – Ethylene-methyl Acrylate
TS: 9 - 12 MPa
EAB: 750 - 800%
TM: 0.03 GPa
LTST: 55°C
HDT: 59°C
Cost: ▪ ▪ ▪

PBT – Polybutylene- terephthlate
TS: 30 - 105 Mpa
EAB: 250%
TM: 1.5 - 5.2 GPa
LTST: 65 - 120°C
HDT: 70°C
Cost: ▪ ▪

PA 6 – Polyamide 6
TS: 40 - 50 MPa
EAB: 150 - 250%
TM: 1.2 - 2.8 GPa
LTST: 80 - 120°C
HDT: 60 - 90°C
Cost: ▪ ▪

PP – Polypropylene
TS: 33 MPa
EAB: 150%
TM: 1.5 GPa
LTST: 100°C
HDT: 65°C
Cost: ▪

PP – Polypropylene
TS: 25 MPa
EAB: 300%
TM: 1.2 GPa
LTST: 90°C
HDT: 60°C
Cost: ▪

PET-G – Crystalline Polyethyleneterephthlate
TS: 57 - 75Mpa
EAB: 50 - 200%
TM: 2.47 - 3.0 GPa
LTST: 63 - 100°C
HDT: 63 - 100°C
Cost: ▪ ▪

PA 6/10 – Polyamide 6/10
TS: 50 - 60 MPa
EAB: 70 - 150%
TM: 1.5 - 2.8 GPa
LTST: 60 - 110°C
HDT: 65 - 85°C
Cost: ▪ ▪ ▪

PE-HD – High Density Polyethylene
TS: 10 - 50 MPa
EAB: 400 - 800%
TM: 0.18 - 1.6 GPa
LTST: 55°C
HDT: 46°C
Cost: ▪

KEY
TS = Tensile Strength at Yield @ 23°C
TM = Tensile Modulus @ 23°C
FS = Flexural Strength
FM = Flexural Modulus
IIS = Izod Impact Strength
CTE = Coefficient of Thermal Expansion
EAB = Elongation at break
HDT = Heat Deflection Temperature @ 1.8 MPa
LTST= Long Term Service Temperature
Cost = Relative Cost
All properties are for the natural injection moulding grade resin only and do not include polymers with reinforcements or other functional fillers unless Vortex® grade specified.

ERIKS

Styrenes | Vinyls | Cellulosics | Polyolefins | Acrylics | Polyesters

Increasing Thermo-Chemical Resistance

VORTEX®
Performance Polymers

TS: 55 - 75 MPa
EAB: 110 - 120%
TM: 1.6 - 2.4 GPa
LTST: 95 - 154°C
HDT = 135 - 140°C
Cost: ▪ ▪

PC
Polycarbonate

TS: 68 - 71 MPa
EAB: 50 - 100%
TM: 2.0 - 2.2 GPa
LTST: 130 - 150°C
HDT: 165 - 175°C
Cost: ▪ ▪ ▪

PAR
Polyarylate

TS: 70 MPa
EAB: 50 - 100 %
TM: 2.5 GPa
FS: 100 MPa
FM: 2.5 GPa
LTST: 150 - 180°C
HDT: 160 - 174°C
Cost: ▪ ▪ ▪ ▪ ▪

PSU
Polysulphone

TS: 83 MPa
EAB: 30 %
TM: 2.7 GPa
FS: 110 MPa
FM: 2.9 GPa
LTST: 180 - 220°C
HDT: 200 - 210°C
Cost: ▪ ▪ ▪ ▪ ▪

PES
Polyethersulphone

TS: 83 MPa
EAB: 25 - 75 %
TM: 2.65 GPa
FS: 110 MPa
FM: 2.9 GPa
LTST: 191°C
HDT: 207 - 214°C
Cost: ▪ ▪ ▪ ▪ ▪

PPSU
Polyethersulphone (Block copolymer)

TS: 69 - 124 MPa
EAB: 1.2%
TM: 2.2 - 5.5 GPa
FS: 220 MPa
FM:14 GPa
LTST: 190 - 260°C
HDT: 174°C
Cost: ▪ ▪ ▪ ▪ ▪

Vortex® 1806
Polyphenylene Sulphide

TS: 72 MPa
EAB: 6 %
TM: 2.2 GPa
FS: 115 MPa
FM: 2.5 GPa
LTST: 170 - 215°C
HDT: 200 - 215°C
Cost: ▪ ▪ ▪ ▪ ▪

PEI
Polyetherimide

TS: 72 MPa
EAB: 75 %
TM: 2.6 GPa
FS: 110 MPa
FM: 3.1 GPa
LTST: 220 - 280°C
HDT: 275 - 280°C
Cost: ▪ ▪ ▪ ▪ ▪

Vortex® 1609
Polyimide

TS: 150 MPa
EAB: 5 -10 %
TM: 4.5 GPa
FS: 240 MPa
FM: 5 GPa
LTST: 220 - 280°C
HDT: 275 - 280°C
Cost: ▪ ▪ ▪ ▪ ▪

PAI
Polyamideimide

TS: 137 MPa
EAB: 3 %
TM: 5.9 GPa
FS: 220 MPa
FM: 6.2 GPa
LTST: 180 - 400°C
HDT: 220°C
Cost: ▪ ▪ ▪ ▪ ▪

PBI
Polybenzimideazole

TS: 53 - 58 MPa
EAB: 25 - 45%
TM: 2.6 - 2.7 GPa
LTST: 90 - 110°C
HDT: 105°C
Cost: ▪ ▪ ▪

PVC-C
Chlorinated Polyvinylchloride

TS: 180 MPa
EAB: 2.7 %
TM: 11.8 GPa
FS: 270 MPa
FM: 11.3 GPa
LTST: -°C
HDT: 328°C
Cost: ▪ ▪ ▪ ▪ ▪

Vortex® 1225
Polyetheretherketone

TS: 160 MPa
EAB: 3.3%
TM: 8.8 GPa
FS: 250 MPa
FM: 8.8 GPa
LTST: -°C
HDT: 315°C
Cost: ▪ ▪ ▪ ▪ ▪

Vortex® 1325
Polyetheretherketone

TS: 60 - 100 MPa
EAB:> 50 %
TM: 1.4 - 2.3 GPa
LTST: 125°C
HDT: 102 - 123°C
Cost: ▪ ▪ ▪

PA 6/3/T
Amorphous polyamide

TS: 85 MPa
EAB: 2.6%
TM: 3.7 GPa
LTST: 140°C
HDT: 138°C
Cost: ▪ ▪ ▪ ▪

PPA
Polyphthalamide

TS: 60 MPa
EAB: 100%
TM: 24 GPa
LTST: 150°C
HDT: 150°C
Cost: ▪ ▪ ▪ ▪

PARA
Polyaryl amide

TS: 100 MPa
EAB: 45%
TM: 3.7 GPa
FS: 125 MPa
FM: 4.1 GPa
LTST: -°C
HDT: 152°C
Cost: ▪ ▪ ▪ ▪ ▪

Vortex® 1208
Polyetheretherketone

TS: 140 MPa
EAB: 2.2%
TM: 12.5 GPa
FS: 230 MPa
FM: 11.5 GPa
LTST: -°C
HDT: 315°C
Cost: ▪ ▪ ▪ ▪ ▪

Vortex® 1127
Polyetheretherketone

TS: 110 MPa
EAB: 10%
TM: 4.3 GPa
FS: 170 MPa
FM: 4.1 GPa
LTST: 154 - 315°C
HDT: 380°C
Cost: ▪ ▪ ▪ ▪ ▪ ▪

Vortex® 0315
PolyEtherKetoneEtherKetoneKetone

TS: 35 MPa
EAB: 500%
TM: 0.5 GPa
LTST: 55°C
HDT: 42°C
Cost: ▪ ▪ ▪

PPE-UHMW
Ultra-high Molecular Weight Polyethylene

TS: 20 - 60 MPa
EAB: 30 - 400%
TM: 1.0 - 2.0 GPa
LTST: 74 - 147°C
HDT: 38 - 55°C
Cost: ▪ ▪ ▪

PA 11
Polyamide 11

TS: 50 MPa
EAB: 200%
TM: 1.2 - 1.6 GPa
LTST: 70 - 80°C
HDT: 55°C
Cost: ▪ ▪ ▪

PA 12
Polyamide 12

TS: 85 MPa
EAB: 2.6%
TM: 3.7 GPa
LTST: 140°C
HDT: 138°C
Cost: ▪ ▪ ▪

PPA
Polyphthalamide

TS: 100 MPa
EAB: 40%
TM: 3.3 GPa
LTST: 130°C
HDT: 190°C
Cost: ▪ ▪ ▪

PA 46
Polyamide 46 (Nylon 46)

TS: 260 MPa
EAB: 1.7%
TM: 25 GPa
FS: 380 MPa
FM: 23 GPa
LTST: 154 - 315°C
HDT: 336°C
Cost: ▪ ▪ ▪ ▪ ▪

Vortex® 1204
Polyetheretherketone

TS: 115 MPa
EAB: 30%
TM: 3.7 GPa
FS: 185 MPa
FM: 4.2 GPa
LTST: 90 - 315°C
HDT: 93 - 334°C
Cost: ▪ ▪ ▪ ▪ ▪

Vortex® 0300
Polyetherketone

TS: 40 - 86 MPa
EAB: 4.8 - 300%
TM: 0.7 - 5.5 GPa
LTST: 60 - 200°C
HDT: 50 - 150°C
Cost: ▪ ▪ ▪

PA 66
Polyamide 66 (Nylon 66)

TS: 55 - 165 Mpa
EAB: 1.3 - 2.8%
TM: 2 - 20 GPa
LTST: 230°C
HDT: 200°C
Cost: ▪ ▪ ▪ ▪

LCP
Liquid Crystal Polymer

TS: 15 - 30 MPa
EAB: 300%
TM: 0.60 GPa
LTST: 260°C
HDT: 48 - 60°C
Cost: ▪ ▪ ▪ ▪ ▪

PFA
Perfluoroalkoxy

TS: 42 - 48 MPa
EAB: 200%
TM: 1.4 GPa
LTST: 140 - 166°C
HDT: 63 - 67°C
Cost: ▪ ▪ ▪ ▪ ▪

ECTFE
Ethylenechlorotrifluoroethylene

TS: 30 - 40 MPa
EAB: 175%
TM: 1.3 GPa
LTST: 140 - 150°C
HDT: 67 - 75°C
Cost: ▪ ▪ ▪ ▪ ▪

PCTFE
Polychloro- trifluoroethylene

TS: 17 - 21 MPa
EAB: 140 - 400%
TM: 0.35 - 0.75 GPa
LTST: 250 - 260°C
HDT: 50 - 60°C
Cost: ▪ ▪ ▪ ▪

PTFE
Polytetrafluoroethylene

TS: 17 - 60 MPa
EAB: 4 - 600%
TM: 0.29 - 5.5 GPa
LTST: 42 - 190°C
HDT: 50 - 90°C
Cost: ▪ ▪ ▪

PA 6/12
Polyamide 6/12

TS: 62 - 70 MPa
EAB: 20 - 75%
TM: 2.8 - 3.1 GPa
LTST: 104°C
HDT: 110°C
Cost: ▪ ▪

POM
Polyoxymethylene

TS: 37 - 205 MPa
EAB: 100 - 330%
TM: 1.9 - 3.5 GPa
LTST: 80 - 100°C
HDT: 70 - 90°C
Cost: ▪ ▪ ▪ ▪

EVOH
Ethylene-vinyl Alcohol

TS: 15 - 21 MPa
EAB: 240 - 350%
TM: 0.35 - 0.50 GPa
LTST: 60 - 204°C
HDT: 48 - 60°C
Cost: ▪ ▪ ▪ ▪ ▪

FEP
Fluorinated ethylenepropylene

TS: 35 - 45 MPa
EAB: 200 - 500%
TM: 1.00 GPa
LTST: 160°C
HDT: 90°C
Cost: ▪ ▪ ▪ ▪ ▪

ETFE
Ethylene- tetrafluoroethylene

TS: 30 - 55 MPa
EAB: 50%
TM: 1.3 GPa
LTST: 150°C
HDT: 75 - 82°C
Cost: ▪ ▪ ▪ ▪

PVDF
Polyvinylidenefluoride

TS: 67 - 85 MPa
EAB: 15 - 70%
TM: 2.9 - 3.6 GPa
LTST: 85°C
HDT: 124°C
Cost: ▪ ▪

POM
Polyoxymethylene

TS: 67 - 85 MPa
EAB: 15 - 70%
TM: 2.9 - 3.6 GPa
LTST: 85°C
HDT: 124°C
Cost: ▪ ▪

Vortex® 2001
Phenolics Thermoset

TEFLEX®
Fluoropolymer Parts

Polyamides | Carbonates | Acetals | Phenols | Fluoropolymers | Sulphides/ Sulphones | Imides | PAEK

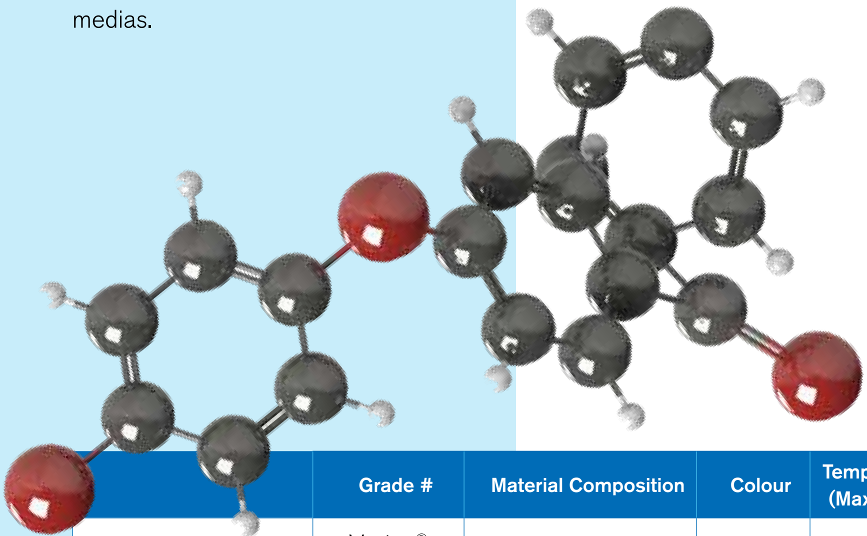
Increasing Thermo-Chemical Resistance

Vortex® Performance Polymers

Vortex® Performance Polymers have been specifically engineered and selected to operate in the most demanding applications which will frequently exceed the polymers glass transition temperature. These temperature excursions will not be detrimental to the mechanical performance of our selected grades. All the Vortex® family of performance polymers offer good to excellent chemical resistance to aggressive medias.

Polyaryletherketone (PAEK)

Polyaryletherketone (PAEK) is a family of semicrystalline thermoplastics with exceptional mechanical strength and high temperature resistance. PAEK has a continuous operating temperature of +250°C and for shorter periods can function up to +350°C . When burned it has low toxic and corrosive fumes along with a low heat output, thus qualifying for use in interior aviation applications. PAEK polymers also offer good, broad chemical resistance.



Polyetheretherketone (PEEK)

Polyetheretherketone (PEEK) is an organic, semicrystalline, thermoplastic polymer used in demanding engineering applications. PEEK also offers resistance to thermal attack in combination with broad chemical resistance.

Polyetheretherketone (PEEK) Matrix Composites

PEEK matrix composites comprise of PEEK as a bonding matrix, integrated with reinforcement such as Carbon or Glass fibre. Often referred to as advanced composites they offer superior strength, stiffness and tribological properties. These composites are often used for metal or alloy replacement where weight, thermal stability and wear characteristics need to be optimised.

Grade #	Material Composition	Colour	Temperature (Maximum)	Description/Material use
Vortex® 1208	Virgin PEEK	Beige	+315°C	Anti-extrusion rings, machine wear-rings, structural components, V-rings - High PV/Temp
Vortex® 1225	Glass filled PEEK	Light Brown	+315°C	All of the above with improved HDT - Excellent in hot aggressive media
Vortex® 1204	Carbon filled PEEK	Black	+315°C	Wear Ring, tight running clearance applications - Very low coefficient of thermal expansion
Vortex® 1127	Carbon fibre, PTFE, graphite filled PEEK	Black	+315°C	Bearing, Wear Ring and tight running clearance applications - Good tribological properties
Vortex® 1325	Glass filled PEEK	Light Brown	+315°C	All of the above and has a lower glass content makes it ideal for valve seats in FDA apps

VORTEX®
Performance Polymers

Vortex® 1127

Performance polymer is reinforced with carbon fibre, graphite & PTFE, semicrystalline polyetheretherketone (PEEK).

Vortex® 1127 has been specifically developed for use in applications where tribological properties are a finite application requirement. It does offer the lowest coefficient of friction within the Vortex® material offerings. As with 1204, the coefficient of thermal expansion and the wear resistance is low, making it an ideal bearing material option.

Vortex® 1204

Performance polymer is carbon fibre reinforced, semicrystalline polyetheretherketone (PEEK).

Vortex® 1204 has been developed for use in applications where higher tensile strength and high modulus are required. It exhibits excellent wear resistance while maintaining a low coefficient of friction. Out of all the Vortex® grades, 1204 offers the lowest coefficient of thermal expansion, critical where dimensional stability is a key design factor. For example – where tight running clearances are required in wear ring type applications in centrifugal pumps.

Vortex® 1208

Performance polymer is an un-reinforced, semicrystalline polyetheretherketone (PEEK). Vortex® 1208 has been developed for use in applications where higher strength and stiffness as well as high ductility are required.

Vortex® 1225

Performance polymer is glass reinforced, semicrystalline polyetheretherketone (PEEK).

Vortex® 1225 has been developed to characteristically exhibit increased shear strength, higher tensile strength and flexural strength for applications that are more mechanically demanding than Vortex® 1208 can be used for. Due to the addition of glass, the HDT improves dramatically to +328˚C verses Vortex® 1208 where HDT is +152˚C. The coefficient of thermal expansion reduces on average by 50% (below Tg).

Vortex® 1325

Is a lower glass reinforced version of Vortex® 1225. The reduction in glass reduces the materials stiffness by reducing the Flexural Modulus by 20%. This reduction makes this particular material selection an ideal option for a valve seat in food manufacturing applications.

Both Vortex® 1225 & 1325 are FDA compliant and light brown in colour.

Vortex® 0300

An option where your application requires higher performance characteristics than a regular PEEK polymer but doesn't require the performance characteristics of Vortex® 0315. It's a halfway house when deciding on performance/capabilities and cost. Vortex® 0300 has higher Tg than PEEK filled or unfilled at Tg 152˚C. It exhibits a lower permanent deformation of PEEK and improved compressive strength.

Vortex® 0315

Performance polymer is the optimum choice for high pressure and high continuous temperature applications. It has the highest extrusion resistance performance when compared to other filled and unfilled Vortex® grades.

Vortex® 360

Performance polymer is a continuously wound carbon fibre/PEEK matrix composite material. This composite offers a lightweight replacement for metal components, low coefficient of thermal expansion, broad chemical resistance, low coefficient of friction, high temperature resistance and resistance to thermal shock.

Vortex® 1806

Vortex® 1806 unfilled polyphenylenesulphide, (PPS) is a high-temperature, semicrystalline thermoplastic material that offers an excellent combination of thermal, mechanical and chemical resistance. PPS can be moulded, extruded, or machined to precise tolerances and in its pure form is opaque white to light tan in colour.

Maximum service temperature is approx. +220°C, and parts can withstand exposure to pressures up to ~70MPa, even at elevated temperatures. PPS offers good chemical resistance and has been found to not dissolve in many aggressive solvents at temperatures below 200°C.

Due to its inherent flame retardancy, PPS is also recommended for high temperature electrical applications. PPS can be un-filled or supplied with various fillers to improve its mechanical properties; due to its relatively low melt viscosity, high filler loadings are possible.

Vortex® 1609

Vortex® 1609 is an un-filled polyimide. Polyimides (PI) are known for their exceptional thermal stability, broad chemical resistance, excellent mechanical properties, and characteristic colours.

Polyimides can be compounded with graphite or glass fibre reinforcement, having flexural strengths of up to 345 MPa (50,000 psi) and flexural moduli of 20 GPa (3 million psi).

Thermoset polyimides exhibit very low creep and high tensile strength; these properties can be maintained during continuous use to temperatures in excess of +300°C (in some instances up to +450°C).

Vortex® 2001

Vortex® 2001 is an un-filled phenolic resin. Phenolic, (PF) resins, also known as phenol formaldehyde resins (PF), are synthetic thermosetting materials created by the reaction of phenols with formaldehyde. These thermosets perform well in most engineering applications such as: hydraulic fluids, oil, glycols, phosphate esters etc.

Phenolic resins demonstrate high dimensional stability and abrasion resistance, and are commonly used in under-bonnet (under-hood) applications requiring high temperature resistance and dimensional stability.

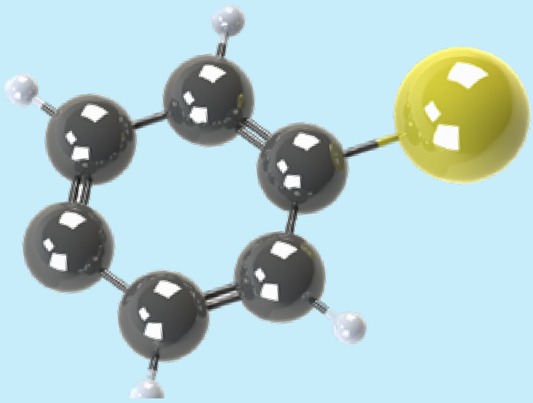
As with other polymers, phenolic materials can be reinforced in various ways, e.g. in the form of composite structures.

PTFE

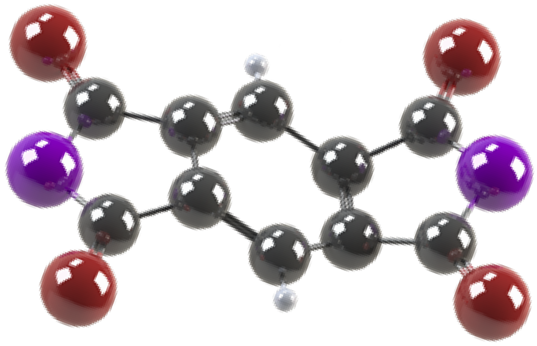
A thermoplastic material with a waxy texture, made by polymerizing tetrafluoroethylene. It is non-flammable, chemically inert, and has a high electrical resistance and an extremely low coefficient of friction.

It is used for making seals, hoses, insulators, bearings, and for coating metal surfaces in chemical plants.

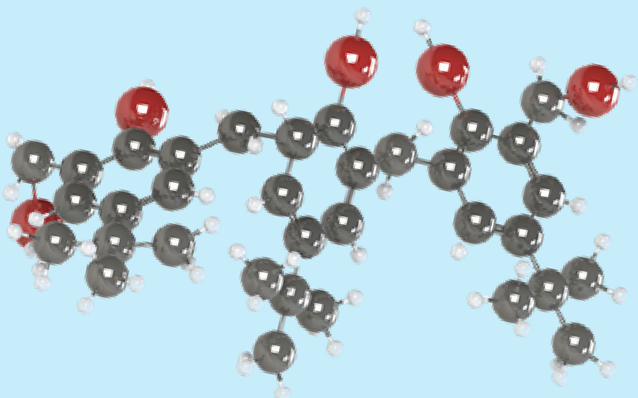
- Excellent combination of strength and chemical resistance
- Moderate temperature performance
- Excellent solvent resistance



- Excellent high temperature strength
- Excellent chemical resistance
- Excellent mechanical properties



- Good dimensional stability
- Low coefficient of thermal expansion
- Good heat resistance



TEFLEX®
Fluoropolymer Parts

- Low friction
- High temperature performance
- Excellent chemical resistance

Defence & Aerospace

Material Options	Carbon Fibre/Thermoplastic composite 0/90 Carbon Fibre/Thermoplastic composite filament wound All grades of Vortex® PAEK /PI & PPS grades
Attributes	Hydrophobic FEA stress/strain design capabilities Low/High Temperature -54˚C to 315˚C Excellent tribological properties Excellent compressive strength Good Fire, Smoke and Toxicity (FST) performance Non-gauling Noncorrosive Tailored electrical properties Oil/fuel resistant Injection mouldable or finished Dimensional stability with precision machined projected tolerance holes
Applications	Hermetic Electronic System Housings Hydraulic/pneumatic Systems Structural components Levers Balance Pistons Housings
Advantage	Light weight Tighter running clearances for bushes/wear components NBC Compliant

ERIKS utilise AS9100 qualified supply chains and are members of the ADS 21st Century Supply Chains Programme (SC-21), embracing its quality toolsets to deliver continuous improvements.

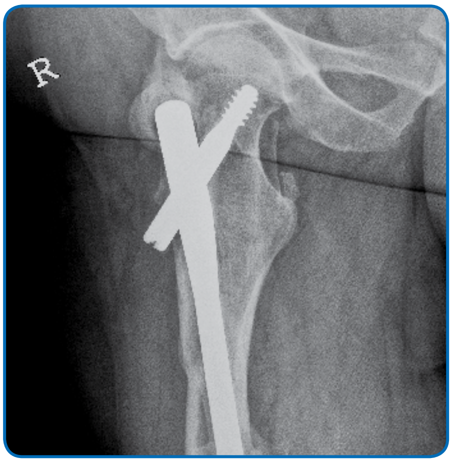
Foreign and Commonwealth Office

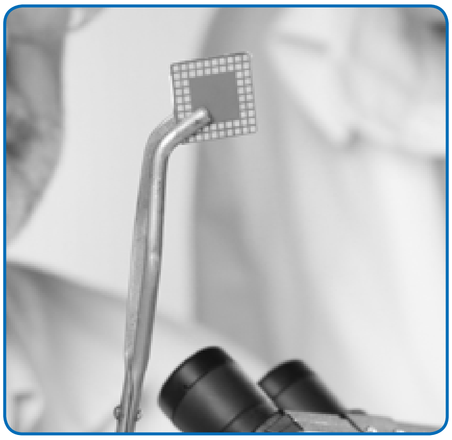
Up-to-date information regarding the export regulations for military equipment from the UK is published by the Foreign and Commonwealth office at fco.gov.uk.

US Department of State International Traffic in Arms Regulations (ITAR)

Components that are specifically designed for military use are subject to export compliance. The US Bureau of Industry and Security maintains a list of Export Administration Regulations (EAR) beneath which components are classified using a Export Control Classification Number (ECCN).

Medical Devices & Life Sciences





Material Options	Carbon Fibre/Thermoplastic composite 0/90 Vortex® 360 - carbon fibre/thermoplastic wound composite All grades of Vortex® and Teflex® Hydroxy appetite loaded PAEK Vortex® 1806 (PPS); Vortex® 1609 (PI); Vortex® 2001 (phenolic)
Attributes	Radiolucent ensuring better visibility under X-Ray/C-Arm For implants – stiffness characteristics are more similar to natural bone Bio compatibility – Interaction of bone & or soft tissue Ease of manufacturing
Applications	Light weight instruments – manifolds Distal and Proximal hole targeting device External Fixators (halo rings) Impactors – e.g. Tibial & Femoral Spine cages Fixation Plates
Advantage	Compliance with manual handling regulations - reducing nurse's need for carrying heavy loads Auto-clavable Dimensional stability Radiolucent Hydrophobic Reduced strain on the extremity being targeted – due to lighter weight instruments ISO 13485 approved manufacturing facility

Plastic components in contact with pharmaceutical products may be required to meet United States Pharmacopoeia (USP), European Pharmacopoeia (Ph. Eur.) or ICH (International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use) standards. Typical examples could include:

- USP<661> Containers – Plastic
- USP<671> Containers – Performance
- USP <88> in-vitro toxicity and USP <87> cytotoxicity
- Phar. Eur. 3.1 and 3.2

For food contact, other standards may apply:

- Regulation (Ec) No 1935/2004 of The European Parliament and of The Council
- Food and Drug Administration (FDA) Food Contact Notification (FCN)
- FDA Code of Federal Regulations (CFR) Title 21, Part 177 Indirect Food Additives: Polymers

For implantable articles, the USA FDA publishes monthly listings of Premarket Notifications [510(k)] and Premarket Approval (PMA) decisions. Within the European Union, the regulatory framework stems from three European Directives:

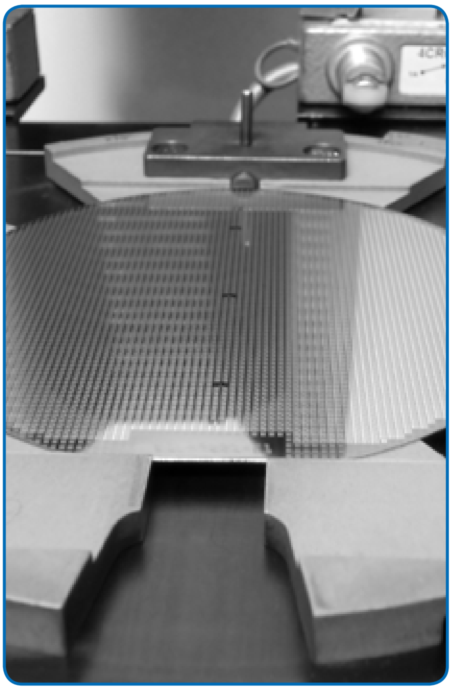
- Directive 90/385/EEC on active implantable medical devices (AIMDD)
- Directive 93/42/EEC on medical devices (MDD)
- Directive 98/79/EC on in-vitro diagnostic medical devices (IVDD)

VORTEX®
Performance Polymers

Chemical Process

Material Options	Carbon Fibre/Thermoplastic composite 0/90 Carbon Fibre/Thermoplastic composite filament wound All grades of Vortex® PAEK /PI & PPS Teflex® (PTFE)
Attributes	Chemical resistance Hydrophobic Non-gauling Non-corrosive & Conductive
Applications	Filters Housings Bearings and Bushings in Rotating equipment Impeller and case wear rings Valve Seats Replacement of metal parts
Advantage	Excellent compressive strength Good tribological properties Abrasion resistance Extending mean time between failure

Semiconductor



Material Options	All grades of Vortex® PAEK /PI & PPS Teflex® (PTFE) Carbon fibre composite bonded to Ceramic
Attributes	Low to zero contamination to wafer Low volume OE Specialist material grades Low out gas properties
Applications	Clamp rings Slit valves Anti extrusion rings Pump bearings for high vacuum pumps
Advantage	Low out gasing materials Broad chemical compatibility High temperature capability Lightweight

Oil & Gas

Material Options	Carbon Fibre/Thermoplastic composite 0/90 Carbon Fibre/Thermoplastic composite filament wound All grades of Vortex® PAEK /PI & PPS Teflex® (PTFE)
Attributes	Specialist material grades to industry standards Thermal electrical isolation Non-gauling Non-corrosive Conductive
Applications	Hermetically sealed over- mouldings / electrical connectors Sealing elements Structural components Electrical connectors Anti-extrusion (AE) ring or back-up ring
Advantage	Good tribological properties Abrasion resistance Extending mean time between failure Optimal resistance to Rapid Gas Decompression (RGD) Non-metallic bearings

Due to the varied nature of applications for high performance thermoplastic materials, a number of different industry specific standards are available to cover general principles, give requirements and recommendations for the selection and qualification of materials/components and give guidance for the quality assurance of such components.

Examples of such standards include:

- API 6A (ISO 10423) "Specification for Wellhead and Christmas Tree Equipment"
- NORSOK M-710 "Qualification of Non-Metallic Sealing Materials and Manufacturers" *
- ISO 23936-1 "Petroleum, petrochemical and natural gas industries -- Nonmetallic materials in contact with media related to oil and gas production - Part 1: Thermoplastics"

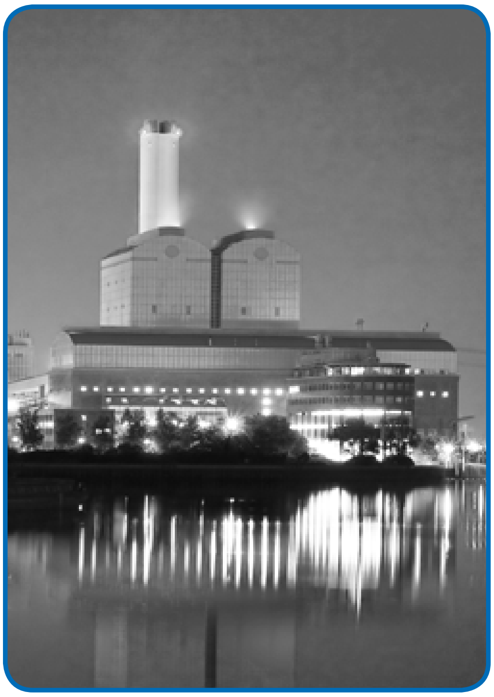
Others exist specifically to address composite materials. Examples include:

- Offshore Standard DNV-OS-C501 "Composite Components"

* "Sour" gas or oil is an often-used term for hydrocarbons containing hydrogen sulphide (H_2S). Those that do not contain significant amounts of hydrogen sulphide are called "sweet". Hydrogen sulphide has a "dipole" which is created from the bond angle of the hydrogen atoms, and is therefore best described as a "Lewis Base" (i.e. an electron donor or nucleophile). The NORSOK M-710 standard includes test criteria to determine the effects of such fluids on thermoplastic materials. In addition to exposure to sour or sweet gas/oil, the effects of corrosion inhibitors should also be accounted for, as it is often the case that where H_2S is present, such chemicals are also found. Corrosion inhibitors can take a number of different forms (e.g. amine, potassium carbonate based).

VORTEX®
Performance Polymers

Utilities & Power Generation



Material Options	All grades of Vortex® PAEK / PI & PPS Teflex® (PTFE) Carbon fibre composite bonded to Ceramic
Attributes	Semi-finished Conductive Good electrical insulator with good dialectric properties Extended mean time between failure
Applications	Water cooling pumps Boiler circulation pumps Valves
Advantage	Bearings Anti extrusion rings Thrust washers Thrust plates

Process Machine Equipment Manufacturers

Material Options	All grades of Vortex® PAEK / PI & PPS Teflex® (PTFE) Carbon fibre composite bonded to Ceramic
Attributes	Low volume OE Fabrication and customisation plus consumables Non gauling Non corrosive
Applications	Structural components Bushes / wear components Housings Butterfly valve seats
Advantage	FDA compliant materials Materials can allow for steam sterilisation Good tribological properties Excellent abrasion resistance

Manufacturing Locations

United Kingdom

- Materials testing and validation
- Design Engineering
- 3D CAD/CAM
- Finite element analysis
- 5-Axis, twin spindle machining centre with in process measurement capability
- In-process validation
- Supply chain and E-Business solutions
- Contact and non-contact CMM
- 2d Routing

Belgium

- Applications engineering
- Supply chain and e-Business solutions
- Sheet cutting and milling
- Thermoforming
- 4-axis milling
- Contact and non-contact CMM
- Stock shape supply

Netherlands

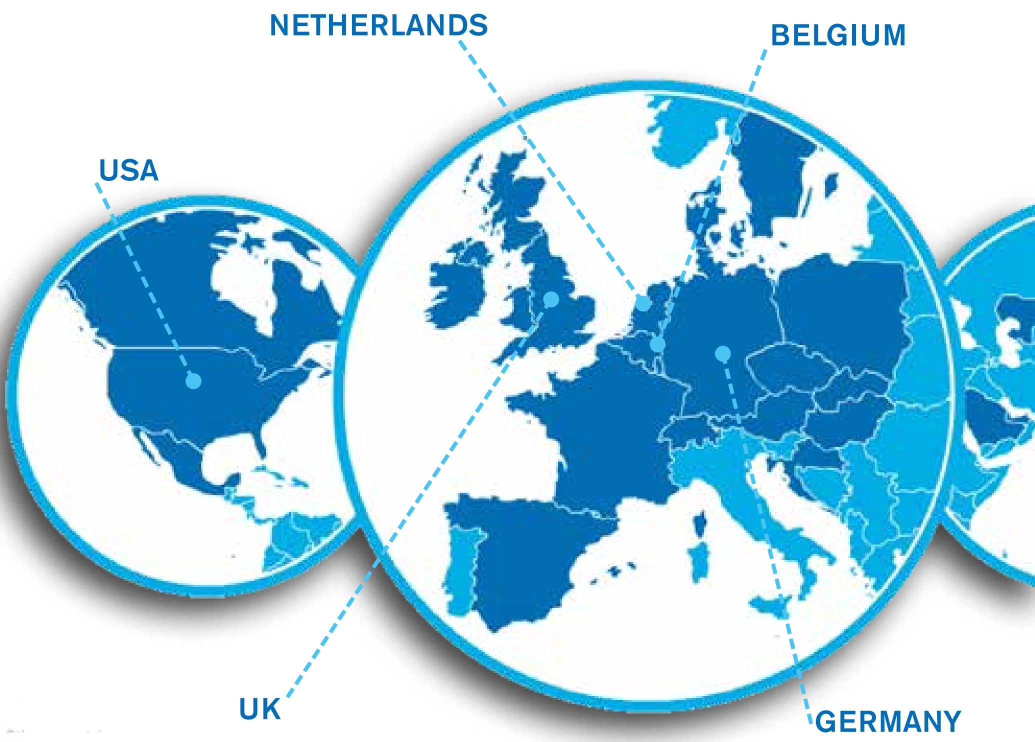
- Materials testing and validation
- Applications engineering
- 3D CAD/CAM with 3D printing
- Supply chain and e-Business solutions
- Sheet cutting and milling
- Thermoforming
- 4-axis milling
- Contact and non-contact CMM
- Stock shape supply

Germany

- Premier manufacturing location
- DIN ISO 13485 facilities
- 5-axis milling
- Large part capabilities
- In-process validation
- 3D CAD/CAM
- Mould flow software

United States

- Applications Engineering
- 3D CAD/CAM
- Finite element analysis
- Contact and non-contact CMM
- Supply chain solutions
- Component design and manufacture
- Quality assurance



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