CRYOGENIC VALVE DESIGN GUIDE-PEEK POLYMERS

Designing Cryogenic Valves with PEEK: Key Considerations for Engineers

MESC SPE 77/302 and SPE 77/200
BY SHELL

SHELL SPEC

victrex

Design Challenges – Things to consider when designing a cryogenic valve using PEEK polymers

Cryogenic valves play a critical role in ensuring safe and efficient operation in extremely low-temperature environments, where material performance is paramount. Polyetheretherketone (PEEK) has emerged as a preferred choice for valve components due to its exceptional combination of mechanical strength, chemical resistance, and thermal stability.
*Victrex will refer to PEEK as CT Polymers in this document.

Unlike traditional fluoropolymers, CT Polymers maintain dimensional integrity and resists brittleness at cryogenic temperatures, making it ideal for demanding applications such as liquefied gas handling.

This guide explores the unique properties of CT Polymers, its advantages over conventional materials, and key considerations for designing reliable cryogenic valves.

VICTREX CT™ Polymers

VICTREX CT™ polymers offer processors and end-users a tailor-made solution to address the challenges of low-temperature environments.

VICTREX CT™ 100

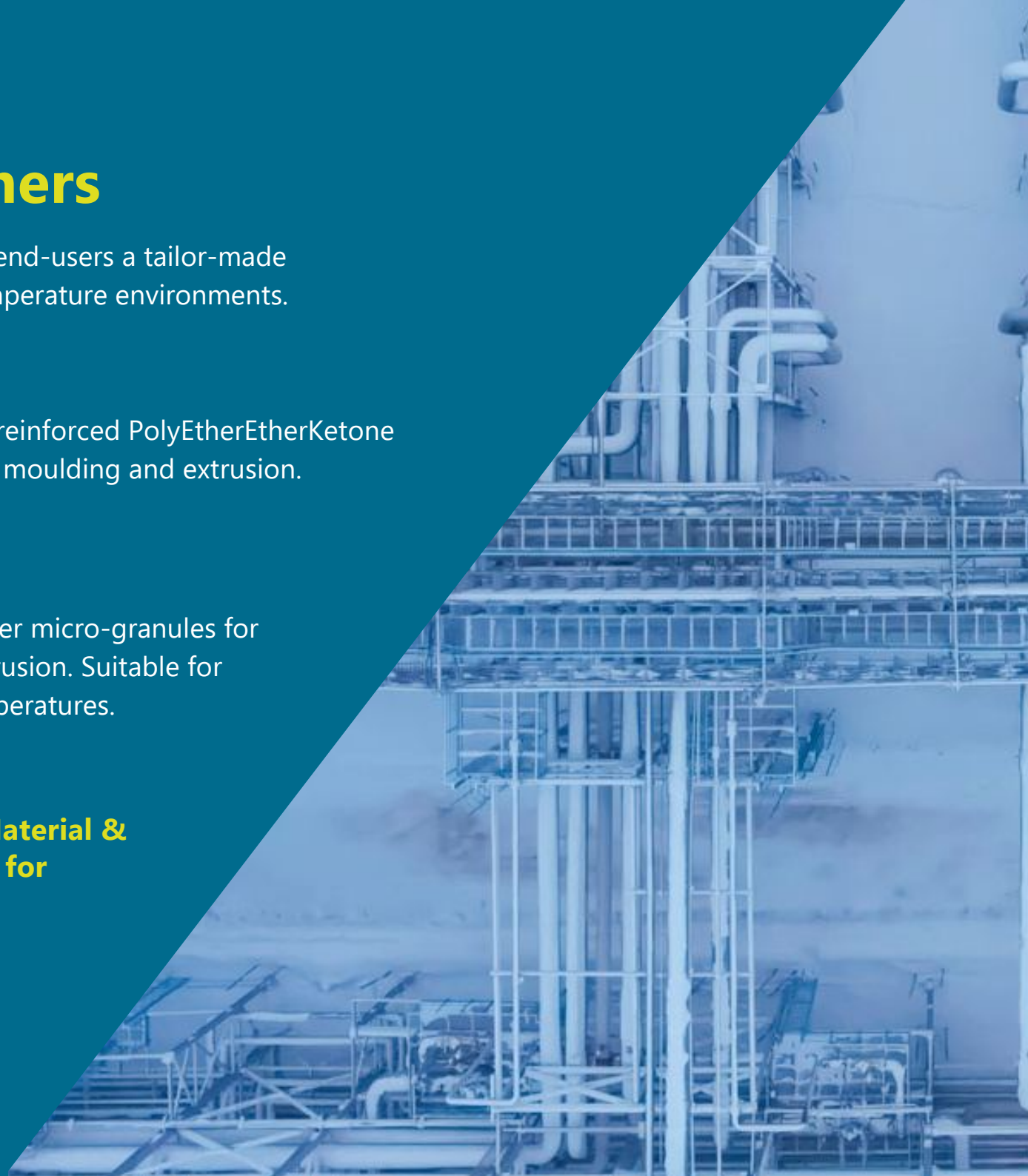
High performance thermoplastic material, unreinforced PolyEtherEtherKetone (PEEK), semi crystalline, granules for injection moulding and extrusion.
Colour natural.

VICTREX CT™ 200

High performance thermoplastic PAEK polymer micro-granules for injection and compression moulding and extrusion. Suitable for dynamic sealing applications at very low temperatures.
Colour: Green.

***VICTREX CT™ polymers meet Shell's Material & Equipment Standards and Code (MESC) for cryogenic ball valves**

LEARN MORE



Key Requirements for Cryogenic Sealing Materials

Cryogenic Valve and Seal Requirements

- Operate reliably from ambient to -196 °C (or lower)
- Maintain dimensional stability under thermal cycling
- Exhibit low permeability to gases
- Provide low friction and wear resistance for dynamic seals
- Resist cold flow and creep under load
- Offer chemical resistance to cryogenic fluids (LNG and LH_2)
- Minimise thermal mismatch with metallic components

Material Comparison Table

Property	VICTREX CT™ 100	VICTREX CT™ 200	PCTFE
Polymer Family	PAEK-based (PEEK derivative)	PAEK-based (PEEK derivative)	Fluoropolymer
Operating Range	-253 °C to +260 °C	-253 °C to +260 °C	-240 °C to +150 °C
Tensile Strength @ -196 °C	High (better than PCTFE)	Higher than CT100 & PCTFE	Moderate
Impact Strength @ -196 °C	High (better than PCTFE)	Higher than CT100 & PCTFE	Moderate
Coefficient of Friction	Moderate	Lower (best for dynamic seals)	Higher (requires more torque)
Thermal Conductivity	Good (better than PCTFE)	Better than CT100 & PCTFE	Low
Coefficient of Thermal Expansion (CTE)	Low, stable	Lower than CT100	Higher
Gas Permeability	Very low	Very low	Extremely low
Chemical Resistance	Excellent	Excellent	Excellent
Wear Resistance	Good	Excellent	Moderate
PFAS Free	Yes	No	No

Application Guidelines

Static Seals (Seats, Gaskets)

Preferred Material: VICTREX CT™ 100

- Outstanding ductility and toughness at -196 °C.
- High compressive strength for tight sealing.

Alternative: PCTFE

- Historically used for static seals; good dimensional stability but lower toughness.

Dynamic Seals (Ball Valve Seats, Gaskets)

Preferred Material: VICTREX CT™ 200

- Lower friction → reduced actuation torque.
- Superior wear resistance and creep resistance.
- Ideal for valves requiring frequent cycling.

PCTFE Limitation

- Higher friction and lower wear resistance → shorter service life.

Design Considerations

Material Behavior at Cryogenic Temperatures

- CT Polymers maintain excellent mechanical properties down to cryogenic temperatures, including high tensile strength and dimensional stability.

- Thermal contraction should be accounted for as this can affect tolerances and sealing interfaces.

Sealing and Leakage Prevention

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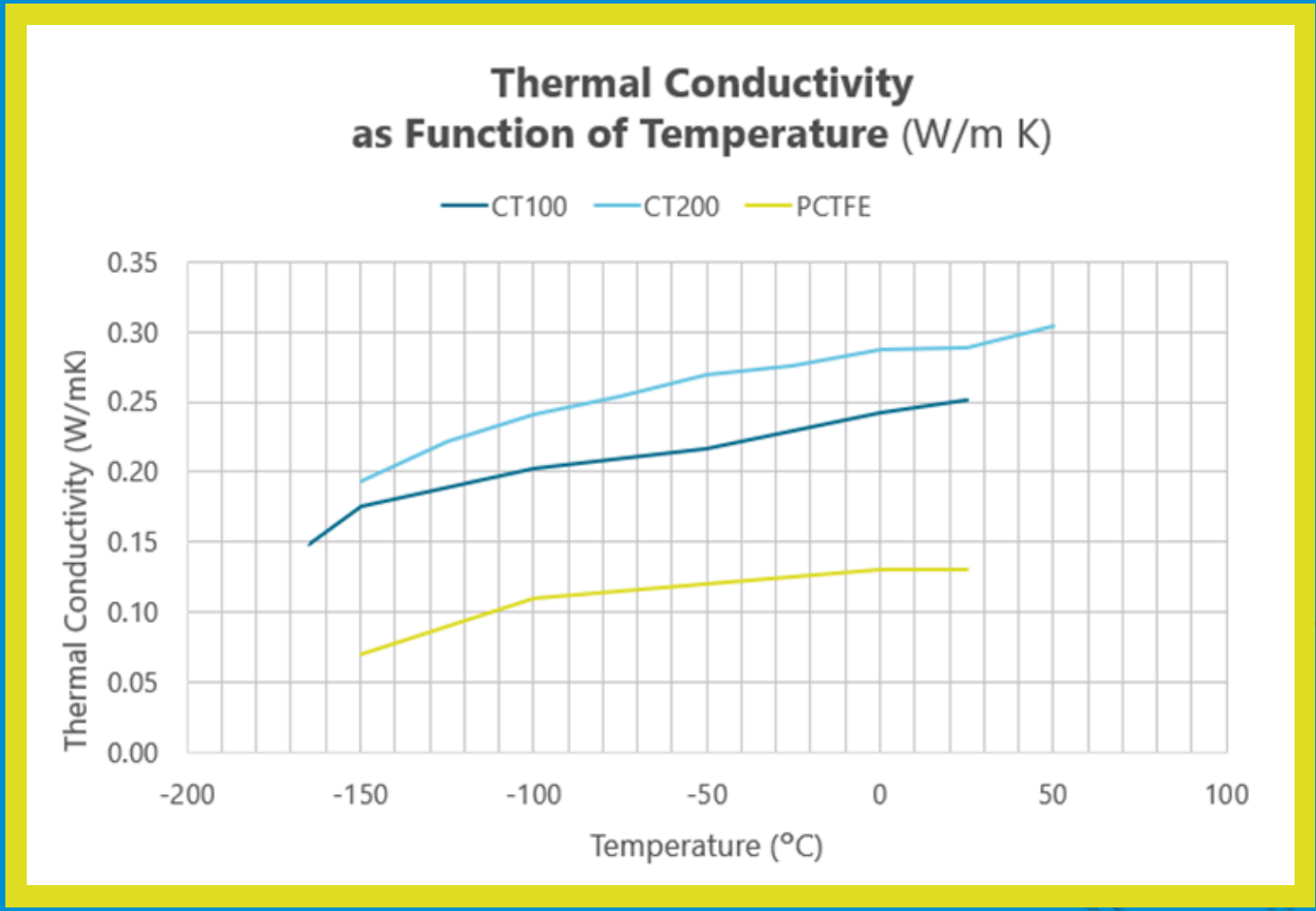
- Thermal contraction should be accounted for as this can affect tolerances and sealing interfaces.

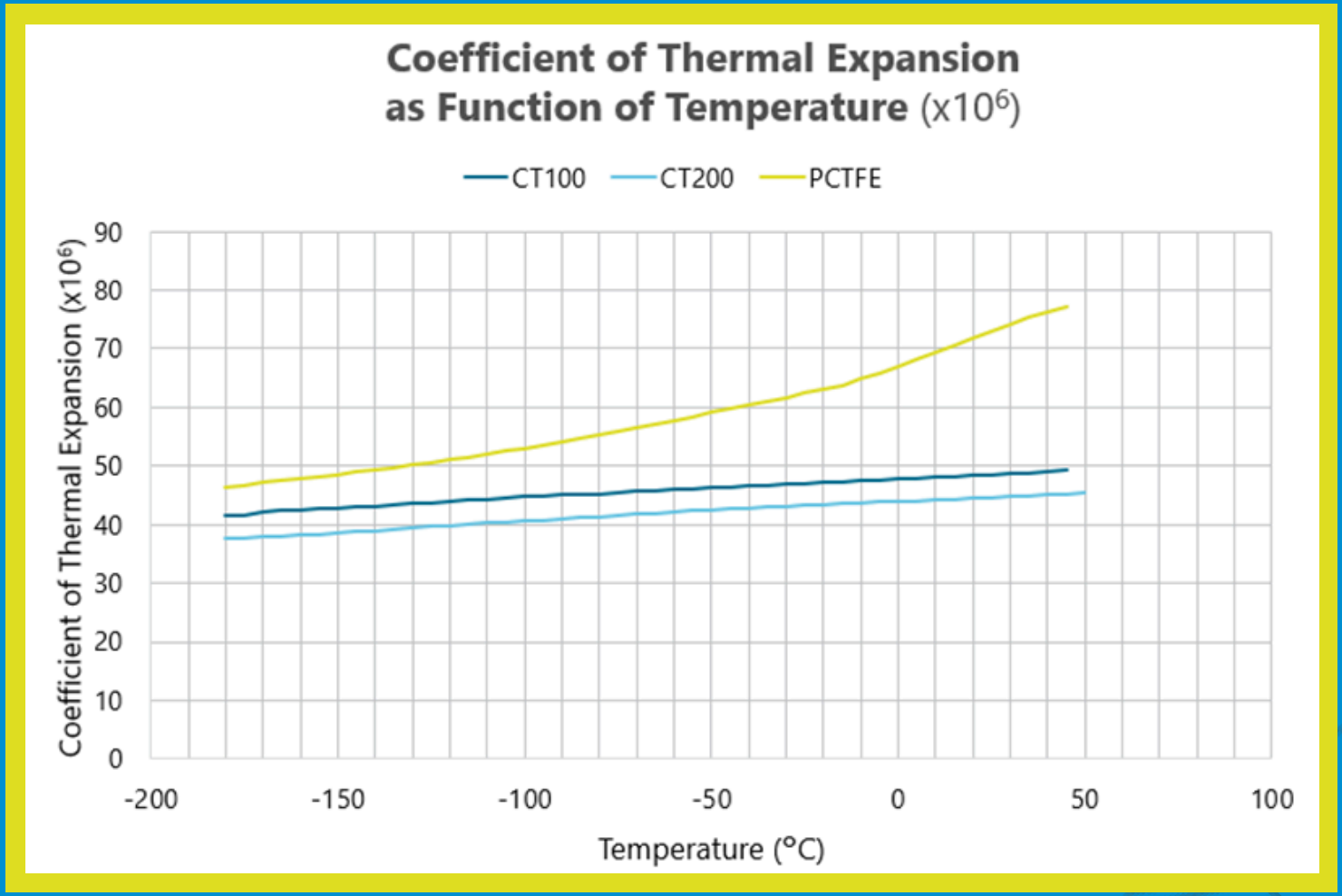
Thermal and Chemical Resistance

- CT Polymers offer excellent chemical resistance to cryogenic fluids like liquid nitrogen and hydrogen.
- Be sure to confirm chemical compatibility in the operating environment.
- CT Polymers has high thermal conductivity, which helps reduce heat transfer and maintain cryogenic conditions. It also ensures faster temperature equalisation, maintaining seal integrity. This is important for valves with rapid cycling or emergency shut-off.
- Be sure to confirm thermal cycling stability between ambient and cryogenic temperatures.



Structural Design

- The design must accommodate the differential in thermal expansion between CT Polymer and the counter face to avoid stress build up or cracking. This should reduce the shrinkage risk.
- Refer to shrinkage data for CT grades. (see below)
- Perform cryogenic cycling tests to confirm seal integrity.



Mould Shrinkage Data

VICTREX CT™ 100 Conditions:

ISO 294-4, 395°C nozzle, 185°C tool

Along Flow	0.9%
Across Flow	1.3%

VICTREX CT™ 200 Conditions:

ISO 294-4, 385°C nozzle, 180°C tool

Along Flow	1.09%
Across Flow	1.50%

Machineability and Assembly

- CT Polymer has good machinability; care must be taken to avoid introducing stress concentrations or microcracks during fabrication. Avoid sharp corners; use generous radii to reduce stress concentration.
- Precision machining is recommended for CT Polymer.
- Surface Finish: Ensure smooth metallic counter faces to minimise wear.
- Anneal after machining to relieve stress and improve dimensional stability.
- Ensure clean, dry assembly to prevent contamination in cryogenic service.

Standards and Compliance

- Refer to standards like Shell MESC SPE 77/200 and 77/302.
- Ensure compliance with industry specific safety and performance regulations, especially in hydrogen or LNG applications
- Always verify material performance in application conditions.

Partner with Victrex for Your Cryogenic Applications

Contact our experts to discuss the benefits of VICTREX CT™ Polymers. Learn how they can help address challenges and improve sealing performance in harsh environments.

Ready to Advance Your Cryogenic Applications?

Contact Us

A WORLD LEADER IN PEEK AND PAEK POLYMER SOLUTIONS

Victrex is an innovative world leader in high performance polymer solutions, focused on the strategic markets of automotive, aerospace, energy (including manufacturing & engineering), electronics and medical. Every day, millions of people use products and applications, which contain our materials – from smart phones, aeroplanes and cars to oil and gas operations and medical devices. With over 40 years' experience, we develop world leading solutions in PEEK and PAEK-based polymers, semi-finished and finished parts which shape future performance for our customers and our markets, and drive value for our shareholders. Find out more at www.victrex.com

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