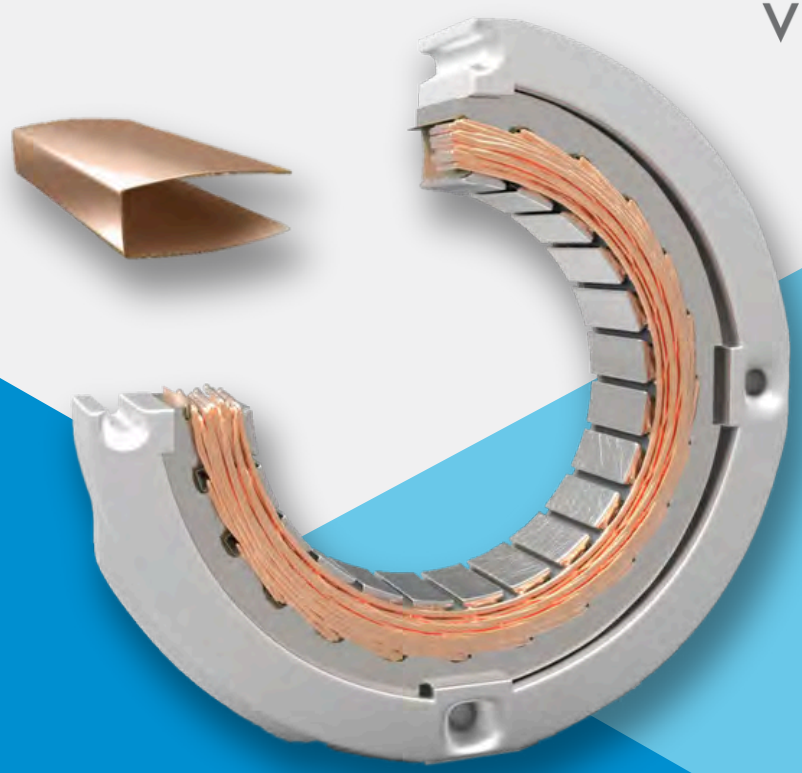
victrex



VICTREX™ PEEK-BASED

APTIV XPI™ PEEK FILM SLOT LINERS

ENHANCING THERMAL MANAGEMENT, EFFICIENCY AND RELIABILITY IN HIGH-VOLTAGE ELECTRIC MOTORS

EVOLVING DYNAMICS

Key trends in e-mobility

- The move to electrification in the automotive industry requires new approaches in design and material selection, driven by the need for increasing vehicle range, reducing cost, enhancing driving experience and faster charging – all without compromising on reliability and safety.
- As a result, electric drives must provide a higher ratio (relative to Peak ratings) of continuous torque and power, and greater efficiency.

GREATER POWER DENSITY

LONGER RANGE

FASTER CHARGING

RELIABLE PERFORMANCE

COMPLEX E-MOTOR REQUIREMENTS NEED WORLD CLASS CAPABILITIES

E-Motor design needs to address multiple engineering, manufacturing and cost challenges

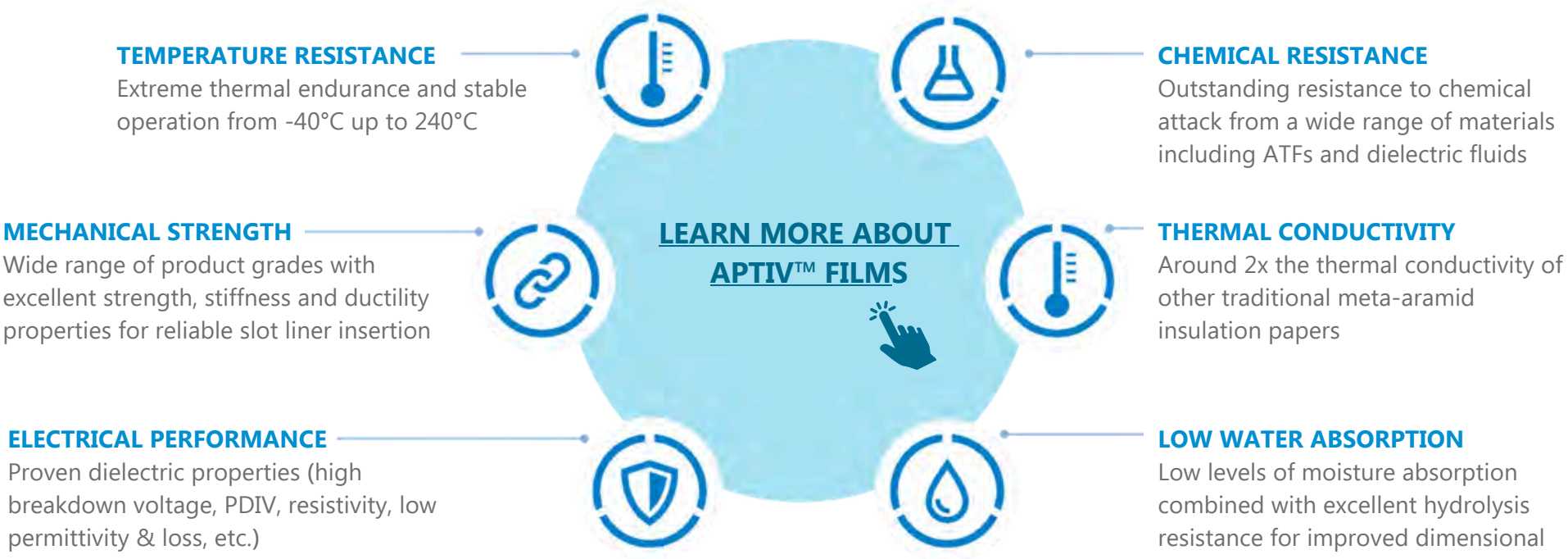
- **ENSURING EFFECTIVE THERMAL MANAGEMENT**
  to maintain maximum continuous torque and optimise efficiency
- **MAXIMISING ELECTRICAL PERFORMANCE**
  to support high-voltage systems of 800V and beyond
- **REDUCING E-MOTOR SIZE AND WEIGHT**
  for design flexibility and cost optimisation
- **SUPPORTING HIGH-VOLUME AND RELIABLE QUALITY E-MOTOR PRODUCTION**
  through tolerance to robust manufacturing processes
- **ENABLING TOTAL COST-EFFECTIVENESS**
  to ensure competitiveness in the dynamic automotive sector

PEEK INTRODUCTION

COMBINING PEEK VERSATILITY AND HIGH PERFORMANCE IN A THIN-FILM FORMAT

INTRODUCING THERMOPLASTIC PEEK-BASED APTIV™ FILM

APTIV films provide durability and reliability in the most demanding application environments. They incorporate all of the outstanding properties of VICTREX™ PEEK (PolyEtherEtherKetone) polymer in a thin film format. Their balance of properties make them amongst the highest-performing, most versatile thermoplastic films on the market. When used as stator slot liner insulation, APTIV XPI film enables excellent thermal management as well as high electrical performance and increased copper fill factor resulting in enhanced e-motor efficiency.



MATERIAL DATA

MATERIAL MATTERS

Assessing slot liner options for high-voltage e-motors

PROPERTIES / RELEVANCE		Meta-Aramid Paper	Meta-Aramid Laminate (NKN)	PEEK-based APTIV XPI film
Thermal Management	Thermal Conductivity	★★	★★	★★★★
	RTI (Electrical)	★★★	★★★	★★★★
	Thermal Class	★★★★	★★★★	★★★★
Electrical Performance	Partial Discharge Inception Voltage (PDIV)	★★★★	★★★★	★★★★
	Breakdown Voltage (BDV)	★★	★★★	★★★★
Chemical Resistance	Ageing in Automotive Transmission Fluids (ATF)	★★	★★	★★★★
Dimensional Stability	Moisture Uptake	★★	★★	★★★★
Power Density	Copper Fill Factor	★★★	★★★	★★★★

★ not favourable ★★★★ very favourable

Based on Victrex internal assessment

MATERIAL DATA

PERFORMANCE WHERE IT'S NEEDED

EXPLORING KEY MATERIAL DATA

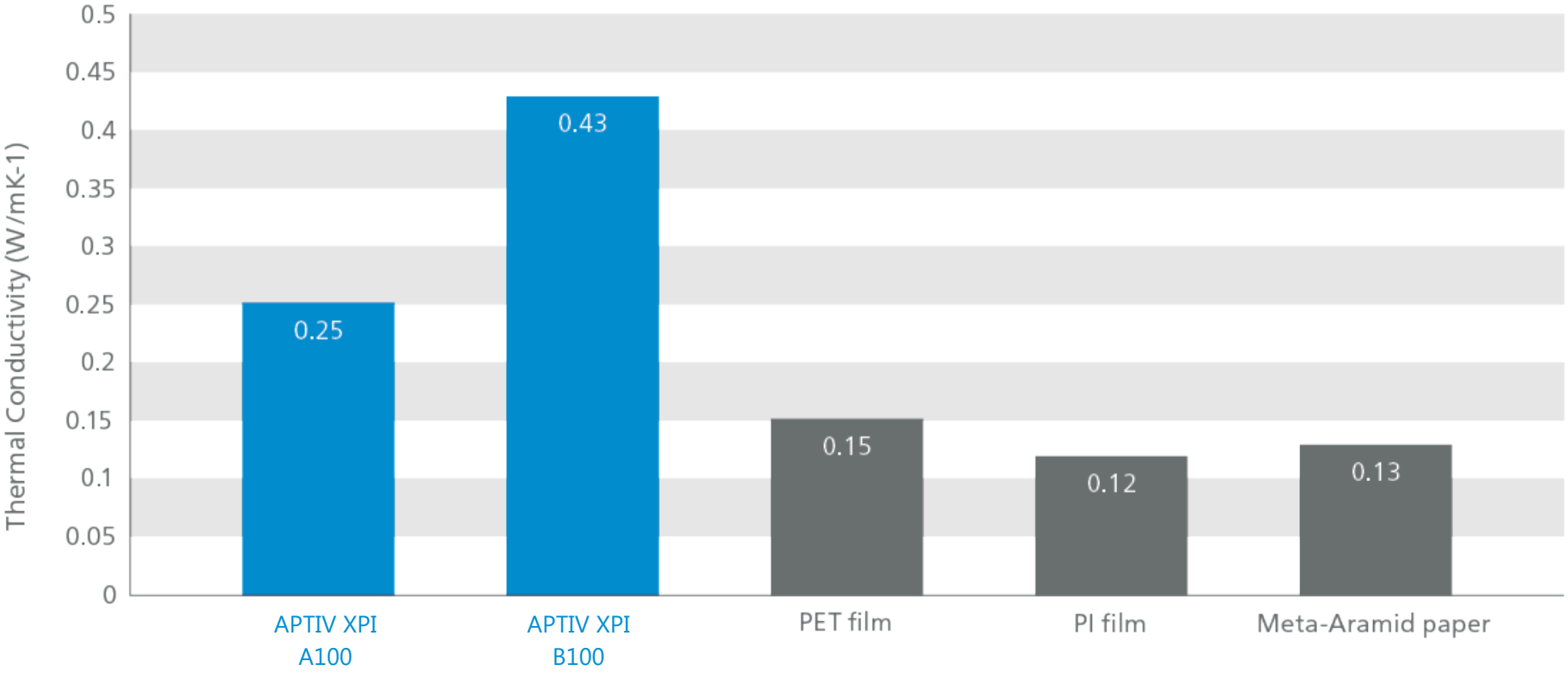
	CONDITIONS	TEST METHOD	UNITS	TYPICAL VALUE	
MECHANICAL DATA				APTIV XPI™ A100	APTIV XPI™ B100
Tensile Strength	Yield, 23°C	ISO 527	MPa	130	100
Tensile Elongation	Break, 23°C	ISO 527	%	>150	>100
Tear Strength	At 23°C	ISO 6383-1	N/mm	4	4,4
ELECTRICAL PROPERTIES				APTIV XPI™ A100	APTIV XPI™ B100
Dielectric Strength	23°C	ASTM D149	kV / mm	189	200
Dielectric Constant	23°C	ASTM D150	N/A	3,5	3,6
Loss Tangent	23°C	ASTM D150	N/A	0,002	0,001
Volume Resistivity	23°C	ASTM D257	Ohm cm	4.00E +16	1.00E +16
Partial Discharge Inception Voltage (PDIV)	23°C	IEC 60270	V_{peak}	1700*	1450**
Partial Discharge Inception Voltage (PDIV)	180°C	IEC 60270	V_{peak}	1050*	1000**

* tests performed on 150 µm thick film samples
** tests performed on 125 µm thick film samples

MATERIAL DATA

COOL FACTOR

APTIV XPI film steals the spotlight vs. traditional laminates in e-motor thermal dynamics



EXPERT VIEW

Taming the Temperature: Elevating e-motor performance with advanced thermal management

As BEV e-motors push beyond 800V and become increasingly power dense, thermal management becomes even more important. APTIV XPI film slot liners offer twice the thermal conductivity of traditional materials and can be applied in a thinner format which, in combination, can significantly reduce thermal resistance.
This enables optimum e-motor performance, through improved thermal efficiency, and long-term endurance in demanding environments

Colin Rimmer
Strategic Technology Manager
Victrex

KEY BENEFITS

TAMING THE TEMPERATURE

Optimising thermal management with APTIV XPI™ film slot liners

In the insulation application of slot liners for high-performance e-motors, specifically Permanent Magnet Synchronous Machines, when compared to traditional slot liner/paper, insulations APTIV XPI film has been found to offer

- **EXCELLENT THERMAL CONDUCTIVITY**
  ca. 2x the thermal conductivity of traditional meta-aramid insulation enabling reducing stator winding temperature.

- **HIGH-TEMPERATURE RESISTANCE**
  Extreme thermal endurance and stable operation from -40°C up to 240°C

- **TOP THERMAL INSULATION DURABILITY**
  supporting reliable insulation performance over the complete service life

- **LEADING CHEMICAL RESISTANCE**
  Outstanding resistance to chemical attack from a wide range of materials including ATFs and dielectric fluids

KEY BENEFITS

COMPARING SLOT LINER MATERIALS

In the insulation application of slot liners for high-performance e-motors, specifically Permanent Magnet Synchronous Machines, when compared to traditional slot liner/paper insulations, APTIV XPI film has been found to offer:

- **2x thermal conductivity improving thermal management**
- **Higher dielectric strength**
- **Better heat resistance and long term endurance**

  240°C for APTIV film vs. 180°C for PET paper laminates or 220°C for Meta-Aramid paper (single layer)
- **Improved retention of electrical properties**

  In elevated temperature environments cooled by ATF
- **Available in thinner ‘fit for purpose’ formats**

  (150 µm and below)

EXPERT VIEW

APTIV XPI FILM SLOT LINERS CAN ENABLE REDUCED TOTAL E-MOTOR COST

Designing e-motors with PEEK-based APTIV XPI film can deliver material savings by enabling smaller, more compact designs that still deliver at least the same continuous power.

James Bonnett
Global Program Leader E-Mobility
at Victrex

KEY BENEFITS

CUTTING WEIGHT & COST

Lighter and leaner e-motor designs with APTIV XPI film slot liners

Slimming down weight and scaling up savings, APTIV XPI film unleashes efficiency for a budget-friendly and lightweight revolution in electric motor innovation when compared to Meta-Aramid paper or laminate slot liners.

TOTAL COST REDUCTION

Opportunity to reduce axial length by up to 5% and reduce e-motor bill of material costs* through electrical steel & rare earth magnet reductions

WEIGHT REDUCTION

Can contribute to overall e-motor weight reduction by up to 5% due to reduced electrical steel and rare earth magnets

E-MOTOR SIZE REDUCTION

Can support overall e-motor size reduction by up to 7% due to reduced electrical steel and rare earth magnets

eDRIVE Engineering Services

* Saving based on study by Newcastle Uni & JLR on an 80 kW Distributed winding style PMSM.

MATERIAL SELECTION AT YOUR FINGERTIPS TO ACCELERATE YOUR DEVELOPMENT

Automotive e-motor design engineers increasingly look for relevant data for rapid material evaluation and accelerate time to market. Furthermore, OEMs and Tiers look to utilise materials that minimise waste, improve quality and maximise reliability. Victrex recognises these challenges and APTIV XPI slot liners can help to support.

With VICTREX™ PEEK products being included in the ANSYS MotorCAD material selection database, design options are right at your fingertips for ease of evaluation

Ansys

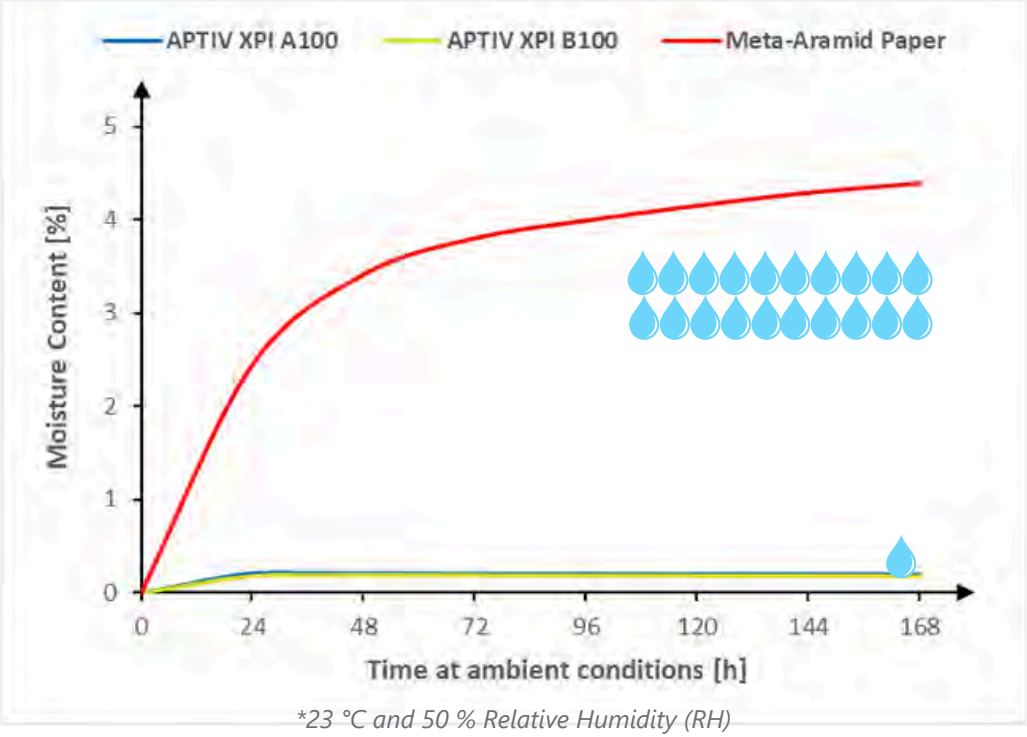
Motor Design Limited

MANUFACTURING PRODUCTIVITY & SAFETY

SUPPORTING MANUFACTURING QUALITY & EFFICIENCY

- Compared to traditional insulation papers, APTIV XPI film helps reduce dust particle formation and offers the potential for reduced equipment invest, maintenance cost and machine downtime while also improving product quality and workforce safety.

- APTIV XPI film inherently has very low moisture uptake, helping to reduce storage & conditioning costs, and maintain reliable product quality and robust processability



23 °C and 50 % Relative Humidity (RH)

APTIV XPI film offers 20x less moisture uptake vs. Meta-Aramid Paper

- The absorption of moisture in meta-aramid can result in changes to its dimensions. For example, in a 96% RH environment, changes of >3.5% in thickness, >2% in cross direction and >1% in machine direction are possible

- Such changes may lead to problems in the processes of folding and insertion of the slot liner into the stator

- APTIV PEEK polymer film absorbs up to 20 times less moisture, supporting reliable insertion process and reducing risk of dimensional changes

WHAT OUR CUSTOMERS SAY

“Equipmake is developing leading-edge high-performance electric motors for the automotive and aerospace industries, with a heavy focus on improving the cooling systems.
The use of Victrex’s APTIV™ film for the slot liner material has enabled us to improve thermal management.”

Ian Foley,
Managing Director, Equipmake

Equipmake

SUSTAINABILITY

SUPPORTING NET ZERO EMISSION GOALS THROUGHOUT THE SUPPLY CHAIN WITH APTIV XPI FILM SLOT LINERS

- Reducing the potential to create dust for cleaner processing versus traditional slot liner paper laminate insulation
- PEEK is fully recyclable, enhancing the potential for life time circularity of e-motors
- Growing number of accreditations from leading sustainability programs including

SCIENCE BASED TARGETS

Commitment to the science-based emission reduction targets

NQC | SUPPLIER ASSURANCE

The most widely adopted Automotive Supplier Assurance standard

MSCI ESG RATINGS A

A key ESG rating agency for investors & listed companies
A Rating

Committed to Apple's Supplier Clean Energy program

FTSE Russell

Inclusion in FTSE Russell Green Revenues Index

Sedex Member

Committed to an ethical and sustainable supply chain

CDP
DRIVING SUSTAINABLE ECONOMIES

Climate change assessment, B
Water Security, C

SUSTAINABILITY

VICTREX IS COMMITTED TO SUSTAINABILITY

52% of revenues from sustainable products (products offering a quantifiable environmental or societal benefit)

88% of R&D project investment focused on sustainable products

100% Renewable electricity across all Victrex global locations

38% Reduction in hazardous waste disposed to landfill (after treatment) vs FY2023

4% Reduction in Scope 1, 2 CO_2 emissions vs FY2023

Aligned to UN Sustainable Development Goals 2030

- Decarbonisation: carbon net zero emissions by 2050 aligned to SBTi (Scope 1, 2 & 3)
- Increase the use of sustainable products which support CO_2 reduction & clinical benefit
- Enhance circularity of our products and recycling rates
- Minimise resources (Carbon, Waste and Water) used in our operations
- Further inspire our employees and communities to positively impact sustainability

LEARN MORE ABOUT OUR SUSTAINABILITY STRATEGY

THE VICTREX DIFFERENCE

WHY VICTREX?

From the commercialisation of PEEK over 40 years ago, Victrex has continually pioneered new PAEK-based polymer solutions that have transformed markets, delivering global impact in the toughest environments.

SUPPORTING OUR CUSTOMERS' PRODUCTIVITY

- Custom formulations optimised for your specific requirements
- Expert 'on-site or remote' processing support

ACCELERATING INNOVATION

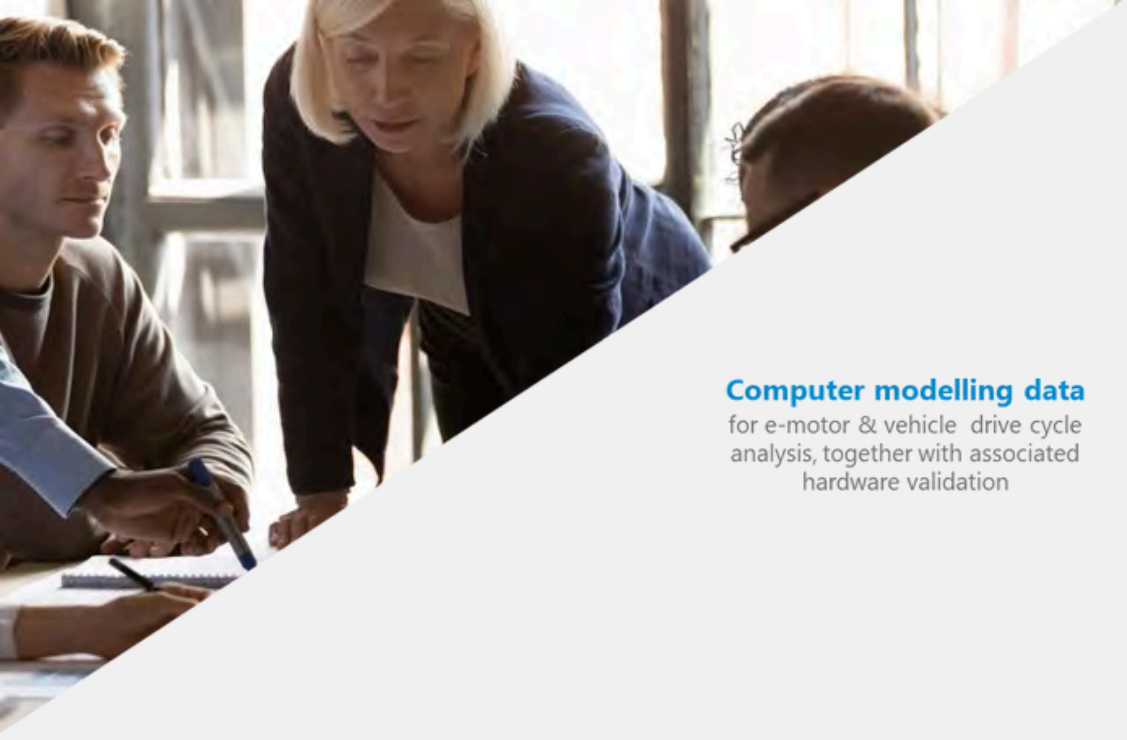
- Rapid response through deep automotive sector market insight
- Faster innovation and product scale up through PEEK-dedicated R&D and manufacturing facilities.

#1

PEEK EXPERTS

40+

YEARS OF EXPERIENCE

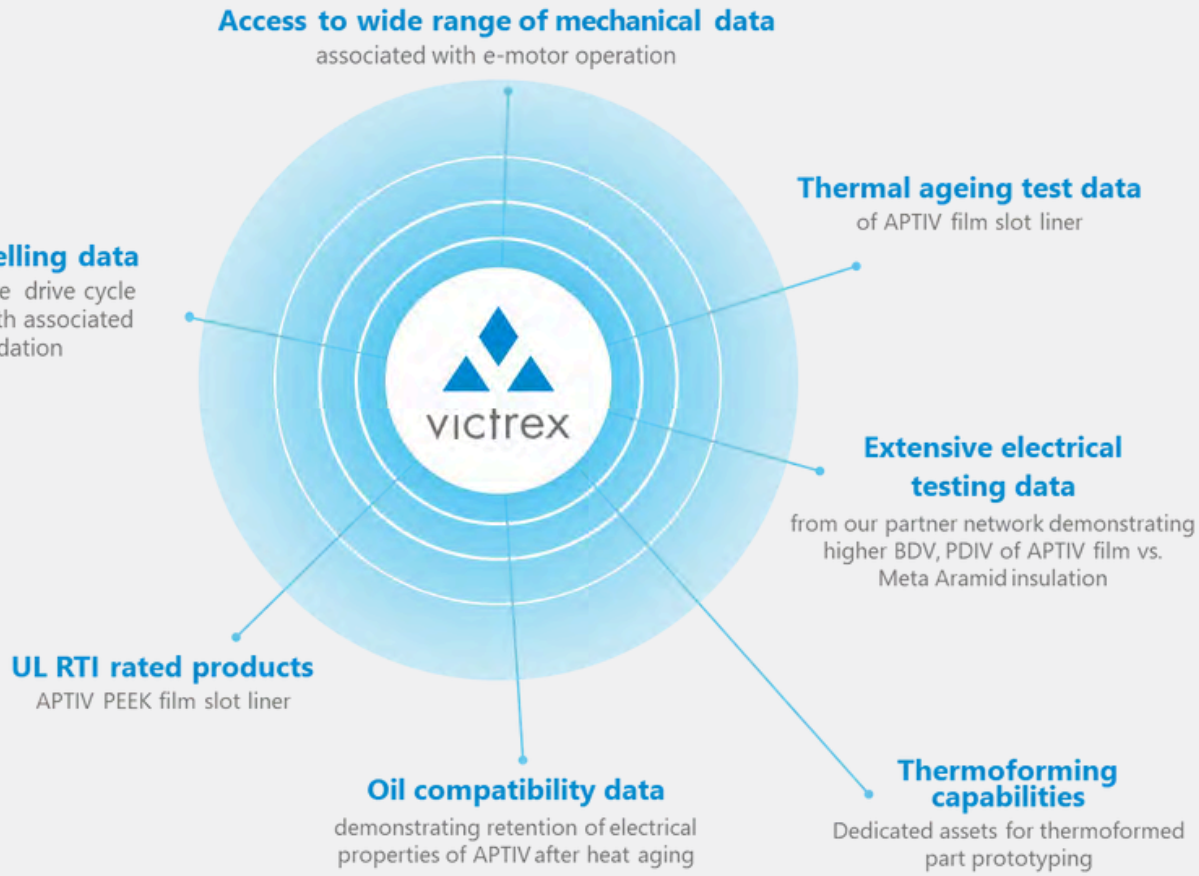


THE VICTREX DIFFERENCE

LEVERAGING THE VICTREX ECOSYSTEM

Beyond offering an innovative high-performance product, Victrex is collaborating with a network of partners.

In anticipating customer needs, we have been doing extensive work to underpin the value of APTIV Film slot liners. We partner with our customers to reduce risk, give them peace of mind and help accelerate their time to market.



THE VICTREX E-MOBILITY ECOSYSTEM
Watch the 90 second video here

Dr. David Simkin
Head of Winding Centre of Excellence
WMG Group @ Warwick University

THE VICTREX DIFFERENCE

ENSURING SECURITY OF SUPPLY

- Upstream integration enabling greater control of formulating flexibility & supply
- Global facilities providing short lead times and strengthening overall logistics
- Strategic commitment to supply chain security supported through Class A certified Integrated Business Planning
- #1 global PEEK production capacity – Invested and ready for growth now

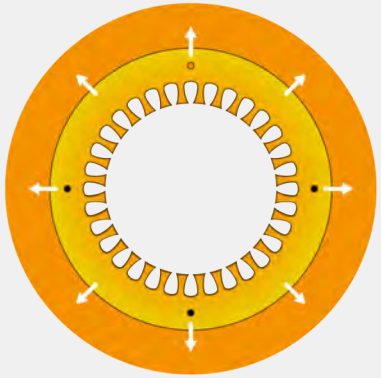
VICTREX E-MOTOR SOLUTIONS

WE HELP YOU ADVANCE SUSTAINABLE MOBILITY

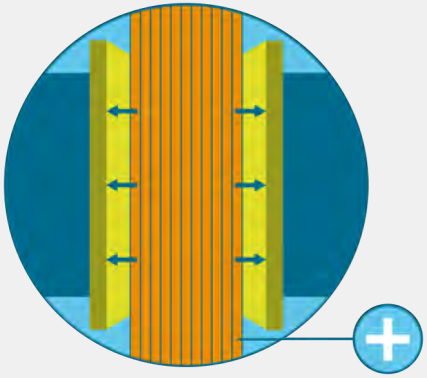
PEEK-based APTIV XPI film slot liners offer enhanced reliability and efficiency, as well as range and cost benefits in high-voltage e-motors to improve e-motor performance.

Combined with Victrex's unmatched PEEK experience, security of supply and our network of e-mobility partners, we help our customers advance sustainable mobility.

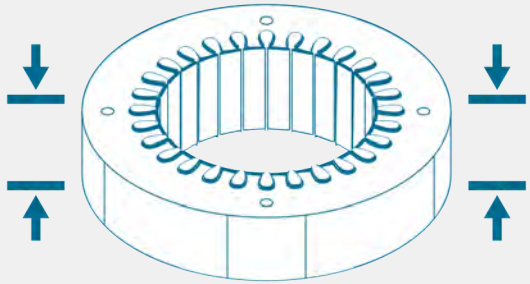
THERMAL MANAGEMENT



POWER DENSITY



COST-EFFECTIVENESS

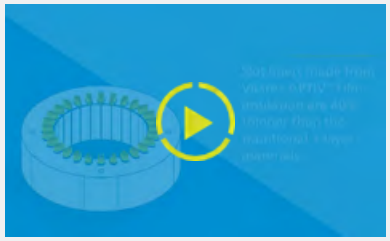


Experience the Victrex advantage and contact us now to discuss how we can support your next development and help you advance your e-motor efficiency.

CONTACT OUR E-MOBILITY TEAM DIRECTLY!

YOU MAY ALSO BE INTERESTED IN

VIDEO



E-motor slot liners using PEEK-based APTIV film for advanced electrical insulation solutions

WEBINAR

The impact of advanced PEEK slot liner insulation on high power density e-motors

VIDEO

VICTREX XPI Polymer for high-performance magnet wire Coating in high-voltage electric motors

victrex

MORE INFORMATION AT YOUR FINGERTIPS...

About Victrex

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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