

# APTIV™ Films

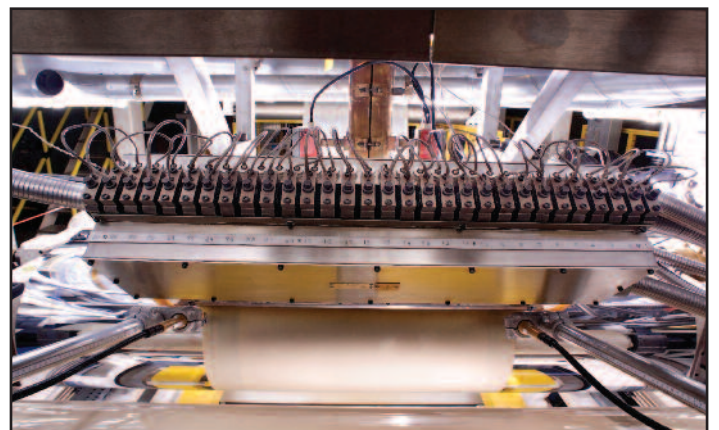
VICTREX™ PEEK FILM TECHNOLOGY  
FOR UNMATCHED VERSATILITY AND HIGH PERFORMANCE



# Material of choice...



Victrex APTIV™ films provide all of the outstanding properties of VICTREX PEEK polymer in a thin film format. Manufactured to exacting quality standards on state-of-the-art equipment, APTIV films provide a balance of properties that make it the highest performing, most versatile thermoplastic film available. The design freedom and ease of processing offered by using Victrex APTIV film helps OEMs, designers and processors achieve enhanced product performance, reduced systems cost, increased functionality, and product differentiation.



# ...for performance

## Benefits

APTIV film's versatility and high performance satisfy the increasing demand for higher temperature performance, lightweight, durability, low cost and eco-friendly application design in a broad range of markets including electronics, acoustics, aerospace, automotive, industrial, oil and gas and alternative energy.

- ▲ Reduced weight, low specific gravity and very low thicknesses.
- ▲ Thin, flexible format to facilitate miniaturisation.
- ▲ Longevity: toughness, durability and reliability to enhance performance and extend application lifetime.
- ▲ Lower cost: streamlined processing and recyclability lead to reduced overall systems cost.
- ▲ Versatility: can easily facilitate a broad range of secondary operations, including thermoforming, lamination and metallisation.

## Key Features

### ▲ High Heat Resistance

APTIV film has a RTI rating of 220°C (428°F) for mechanical use without impact and 200°C (392°F) for electrical use for 25–125 micron films, and is capable of withstanding lead-free solder processing temperatures of up to 300°C (572°F).

### ▲ Excellent Wear Properties

Inherently lubricious, has a very smooth surface finish and low particulation. Limiting pressure velocity Lpv rating is 145 MPa.m/min (69,000 psi.ft/min) without the need for lubricants.

### ▲ Low Moisture Absorption

Resists moisture that can adversely affect electrical, dimensional and mechanical properties of other materials.

### ▲ Purity

Exceptionally low outgassing and extractables.

### ▲ Outstanding Acoustic Properties

Excellent response, low distortion, high internal damping, low ringing.

### ▲ Broad Chemical Resistance

Insoluble in all common solvents. Excellent resistance to acids, bases, oxidizing agents, hydrocarbons, salts and steam. Superior chemical resistance than many exotic metals. Properties unaffected by exposure to steam at 200°C (392°F) after 2,000 hours.

### ▲ Low Smoke and Toxic Gas Emission

Good flame resistance without the use of flame retardant additives and low toxicity of combustion gases. Inherently halogen-free in accordance with IEC 61249-2-21.

### ▲ Environmentally Friendly

Lightweight, recyclable, halogen-free, withstands lead-free soldering process temperatures and is RoHS compliant.

### ▲ High Strength and Toughness

Highest stiffness and resistance to cyclic fatigue of any thermoplastic. Strength is maintained well over the glass transition temperature ( $T_g$ ). Excellent tear strength, puncture resistance and acoustic fatigue properties.

### ▲ Electrical Stability

Very stable dielectric properties over a wide range of temperatures, frequencies and humidities.

### ▲ FDA Food Contact Certified

APTIV film grades 1000, 1100, 1300, 2000 and 2100 may be safely used for repeated food contact. They comply with the compositional requirements of FDA 21 CFR 177.2415, Commission Directive 1935/2004/EC and 2002/72/EC and the amendments up to 2005/79/EC.

## The APTIV Film Advantage

- ▲ Extremely tight thickness tolerance – extruding equipment has world class process control and is dedicated to production of VICTREX PEEK film.
- ▲ Wide film widths up to 1.45 meters (57 in).
- ▲ Broad thickness range – from 6 to 750 microns.
- ▲ Dedicated manufacturing – part of Victrex's fully integrated supply chain to guarantee material quality, supply, consistency and performance.
- ▲ Design flexibility – readily accepts a wide range of secondary conversion processes.
- ▲ Unique combination of performance properties available in a film.
- ▲ Plasma surface treatment that raises surface energy to enhance adhesion, metallisation and printability.
- ▲ Global technical, sales and marketing support.
- ▲ Radiation Resistance  
Demonstrates excellent resistance to gamma radiation without embrittlement.
- ▲ Hydrolysis Resistance  
Exceptional stability and retention of mechanical properties when exposed to high temperature, humid environments, including steam.



# Markets...

## Electronics

- ▲ CD and DVD motor washers
- ▲ Speaker cones and voice coils
- ▲ Circuit board substrates
- ▲ Solder mask tape
- ▲ High energy capacitors



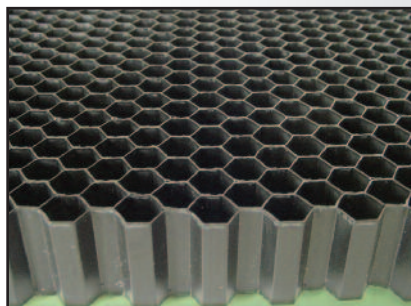
## Automotive

- ▲ Gaskets
- ▲ Thrust washers
- ▲ Alternator insulation
- ▲ High temperature circuit boards
- ▲ Bearings



## Aerospace

- ▲ Insulation films
- ▲ Thermoformed components
- ▲ Carbon fibre composites
- ▲ Adhesive tapes



## Energy

- ▲ Oil and gas cable wrap
- ▲ RFID tags
- ▲ Magnetic wire insulation
- ▲ Pressure sensors



## Food and Medical

- ▲ Process belts
- ▲ Medical labels
- ▲ Membrane switches
- ▲ Specialised packaging



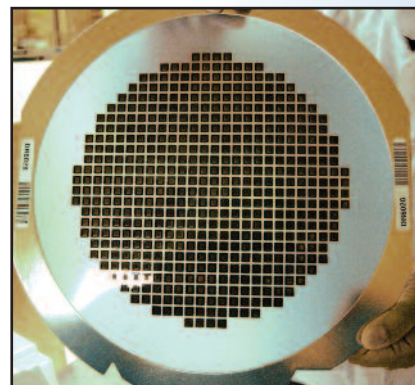
## Industrial

- ▲ Pressure sensors
- ▲ Flexible film heaters
- ▲ Belting
- ▲ High performance labels



## Semiconductor

- ▲ LCD glass polish frames
- ▲ Silicon wafer carriers
- ▲ Wafer and glass transport tapes



# Material Versatility...

## Film Grades

APTIV film is available in several grades according to the specific needs of the end use application. Within each grade a broad range of thicknesses are available from 6 to 750 microns (0.25 to 30 mils). The standard width of APTIV film is 610 mm (24 in), although some films can be provided in widths up to 1450 mm (57 in). On request, the stock rolls of film can be further slit by Victrex to 50 mm (2 in) width. Matte/Gloss and Gloss/Gloss surface finishes are standard. Other surface finishes may be available upon request.

### 1000 Series

APTIV 1000 series films are unfilled semi-crystalline films. Available in thicknesses from 8 to 750 microns, they are typically the mostly commonly used grades in the product range.

### 1100 Series

APTIV 1100 series are mineral-filled semi-crystalline films with the filler content being available at two loadings according to the application needs. The films are available in thicknesses from 12 microns upward.

The film is typically specified where either a higher modulus or lower coefficient of thermal expansion is required.

### 1300 Black

APTIV 1300 Black is a cosmetic grade unfilled semi-crystalline film which provides the same properties as the APTIV 1000 series natural colour film. It is a suitable option when dark colour is a design requirement for applications such as acoustic speakers. Thicknesses range from 50 to 100 microns.

### 2000 Series

APTIV 2000 series films are unfilled amorphous films available in thicknesses from 6 microns up to 300 microns. The 2000 series of films are typically selected for processing to the semi-crystalline state using a thermoforming process, or where ductility or a level of optical clarity are required. When the amorphous film is subjected to temperatures above the glass transition temperature ( $T_g$ ) of VICTREX PEEK polymer (143°C/289°F), the amorphous film will revert to the semi-crystalline form. This property is particularly advantageous when thermoforming parts from APTIV film.

### 2100 Series

APTIV 2100 series are mineral-filled amorphous films. Thicknesses are available from 25 microns upward. The film is typically specified where either a higher modulus or lower coefficient of thermal expansion is required and are often processed to the semi-crystalline form using a thermoforming process.

## Secondary Processes

APTIV film can be subjected to a wide range of secondary process operations:

- ▲ Plasma surface treatment for the promotion of adhesion.
- ▲ Metallisation using a variety of deposition and lamination processes.
- ▲ Thermoforming into highly detailed shaped parts.
- ▲ Adhesiveless heat lamination to other polymers and metals.
- ▲ Application of specialised coatings.

These secondary processes allow designers and engineers to obtain the benefits of APTIV film properties in a variety of formats. (See pages 10 and 11 for further details.)

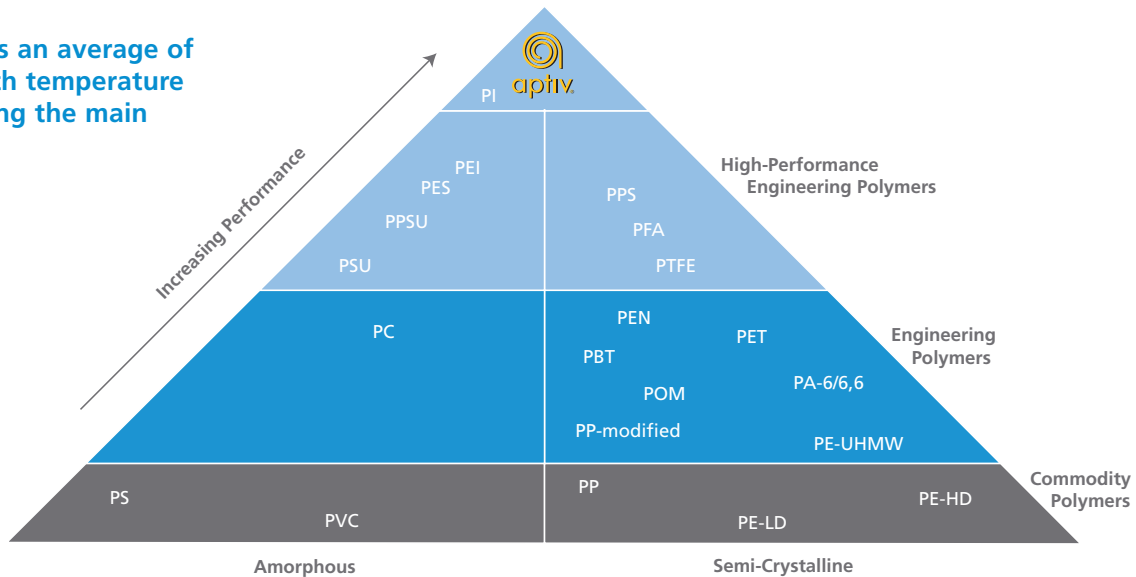
## APTIV Film – Comparison with Competitive Films

	Mechanical Properties at 200°C (392°F)	Low Moisture Absorption	Chemical Resistance	Abrasion/ Wear Resistance	Radiation Resistance	Low Outgassing & Extractables
Victrex APTIV film	Very Good	Very Good	Very Good	Excellent	Excellent	Excellent
Polyimide (PI)	Very Good	Fair	Poor	Good	Very Good	Good
Polyetherimide (PEI)	Good	Fair	Fair	Fair	Good	Good
Polytetrafluoroethylene (PTFE)	Poor	Excellent	Excellent	Poor	Poor	Very Good

	Basic Character	Low Permeation Properties	Recyclable	Dielectric Properties	RTI Rating	Flame Resistance
Victrex APTIV film	Melt Processable	Very Good	Yes	Very Good	220°C (428°F)	Very Good
Polyimide (PI)	Non Melt Processable	Very Good	No	Very Good	200°C (392°F)	Excellent
Polyetherimide (PEI)	Melt Processable	Fair	Yes	Good	180°C (356°F)	Excellent
Polytetrafluoroethylene (PTFE)	Limited Melt Processable	Good	Limited	Excellent	180°C (356°F)	Excellent

# A Unique Combination of Properties...

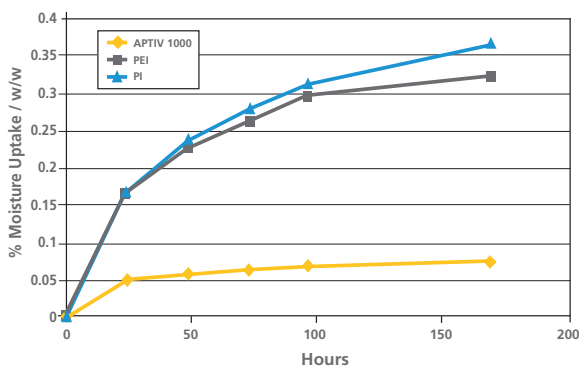
Performance is an average of properties with temperature resistance being the main determinant



## Moisture Uptake

Under general atmospheric conditions of 50% relative humidity (RH), APTIV 1000 film shows low moisture absorption. As a result APTIV 1000 film exhibits stable mechanical, dielectric and dimensional properties.

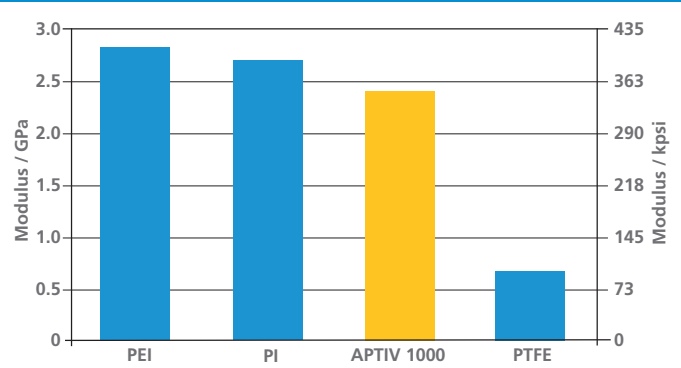
### Moisture Uptake at 50% RH, 23°C (73°F)



## Tensile Modulus

APTIV 1000 film has excellent tensile modulus. Further enhanced mechanical properties, if required, can be achieved by using the mineral-filled APTIV grades.

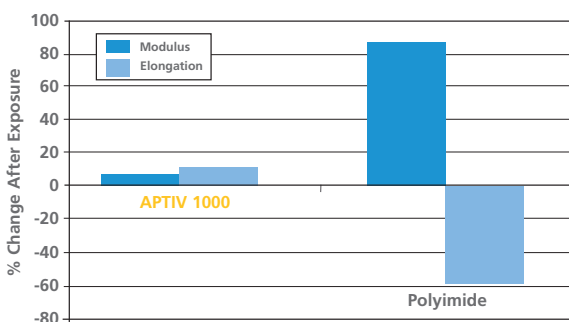
### Tensile Modulus at 23°C (73°F)



## Hydrolysis Resistance

APTIV 1000 film demonstrates exceptional stability in mechanical properties when exposed to a high temperature and high humidity environment. This results in excellent retention and minimal variability in the mechanical performance of the finished product.

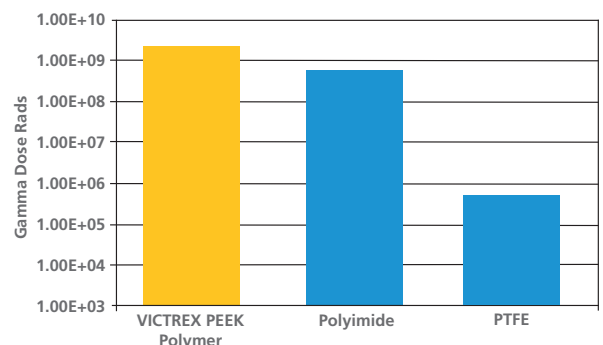
### Hydrolysis Resistance [5 days at 150°C (302°F), 100% RH]



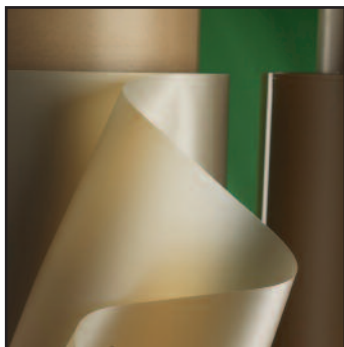
## Radiation Resistance

Considering the oxidative gamma radiation dose above which significant deterioration of flexural properties starts to occur, VICTREX PEEK polymer exhibits excellent resistance to radiation.

### Radiation Resistance\*



\* Measured on tensile bars.



APTIV film has a unique combination of properties providing high temperature performance, mechanical strength, chemical resistance, electrical insulation, wear and abrasion resistance, and low moisture absorption in a versatile film format.

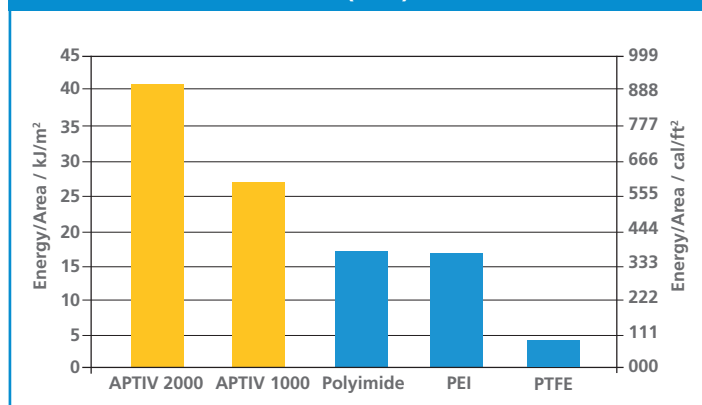
### Puncture Resistance

Both APTIV 1000 and 2000 film grades demonstrate excellent puncture resistance compared with other high temperature polymers.

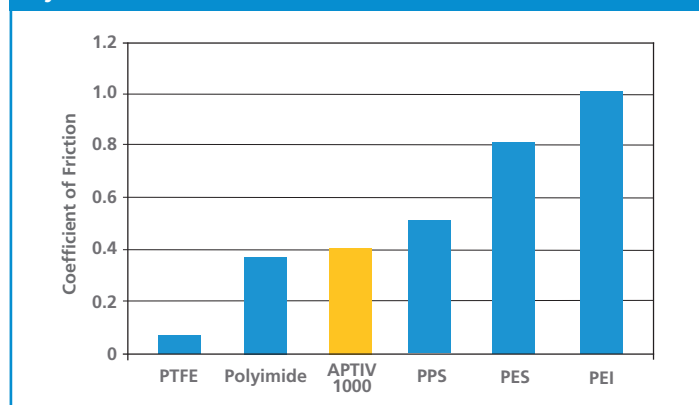
### Dynamic Coefficient of Friction

APTIV 1000 film has very good low dynamic coefficient of friction compared to other engineering polymers, making it an ideal choice for wear applications. APTIV 1000 film combines very low particle generation with excellent abrasion resistance.

Puncture Resistance at 23°C (73°F)



Dynamic Coefficient of Friction



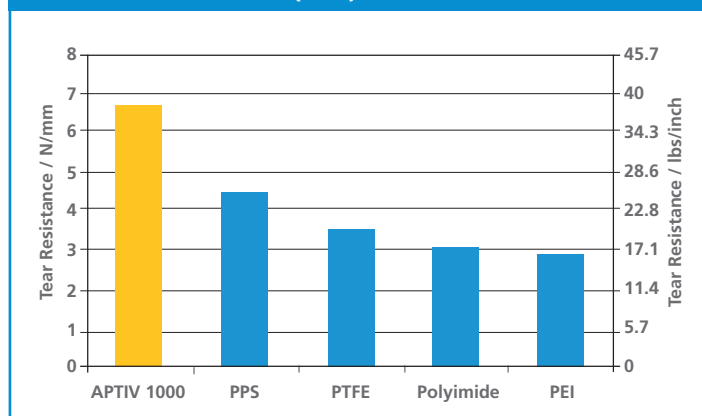
### Tear Resistance

APTIV 1000 film has excellent tear resistance properties combining strength from the crystalline phase and ductility from the amorphous phase.

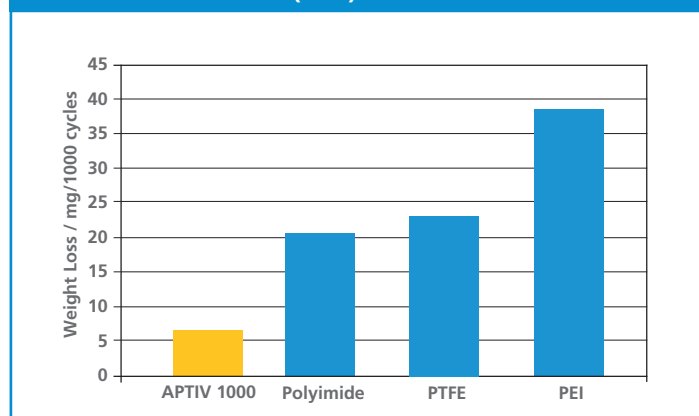
### Abrasion Resistance

APTIV 1000 film exhibits excellent abrasion resistance. The graph below shows the very low wear rate of APTIV 1000 under abrasive load when compared with other films.

Tear Resistance at 23°C (73°F)

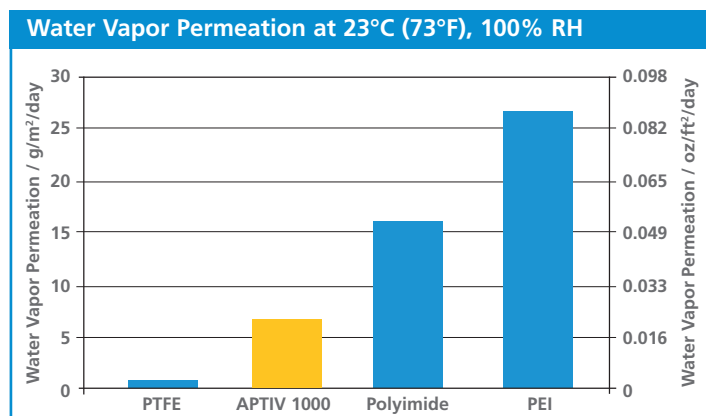


Taber Abrasion at 23°C (73°F)



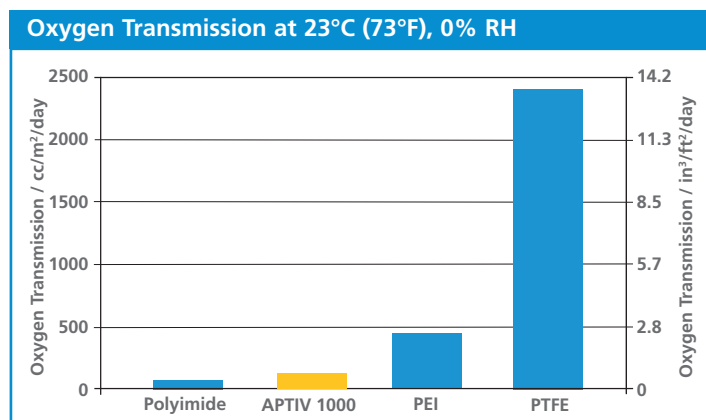
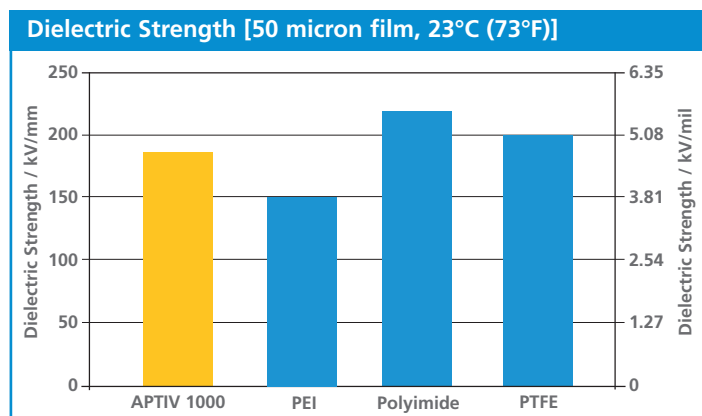
## Gas Permeation

APTIV 1000 film has very good resistance to gas permeation including oxygen and water vapor. It can also be metallised or coated with other suitable barrier material to further reduce the gas permeation if required.



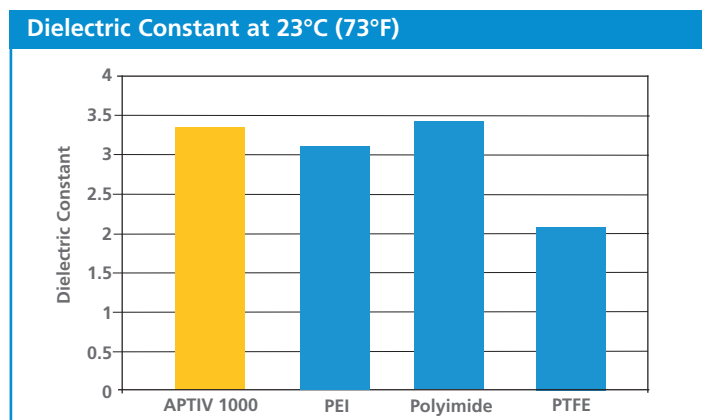
## Dielectric Strength

APTIV 1000 film has very good dielectric strength properties allowing it to be used in a variety of electrical insulation applications.



## Dielectric Constant

APTIV 1000 has very good dielectric properties for use in electrically insulative applications.



## Properties of APTIV Film Grades\*

Property	Test Method	Test Condition	Units	APTIV 1000	APTIV 2000	APTIV 1102
Tensile Modulus	ISO 527	23°C (73°F)	GPa (kpsi)	2.4 (384)	1.8 (261)	4.8 (696)
Tensile Strength (at break)	ISO 527	23°C (73°F)	MPa (kpsi)	120 (17.4)	120 (17.4)	100 (14.5)
Tensile Elongation (at break)	ISO 527	23°C (73°F)	%	>150	>200	>100
Puncture Strength	Def Stan 81-75	23°C (73°F)	kJ/m² (cal/ft²)	26 (577)	40 (888)	5 (111)
Tear Strength	ISO 6383-1	23°C (73°F)	N/mm (lb/in)	6.7(38)	6.3 (36)	4.4 (25)
Shrinkage	TM-VX-84	200°C (392°F)	%	<2	5-8	<1
Dielectric Strength (50 microns)	ASTM D149 1/4 inch electrode	23°C (73°F)	kV/mm (V/mil)	190 (4826)	190 (4826)	200 (5080)
Water Absorption (50%RH)	ISO 62	23°C (73°F), 24h	%	0.04	0.21	0.08
Specific Gravity	ISO 1183	23°C (73°F)		1.30	1.26	1.45
Coefficient of Linear Thermal Expansion	ASTM D696	MD, below Tg	ppm	47	60	35
Dielectric Constant	ASTM D150	23°C (73°F), 10 MHz		3.5	3.3	3.6
Loss Tangent	ASTM D150	23°C (73°F), 10 MHz		0.002	0.003	0.001

\* Testing on 50 micron films unless indicated. Mechanical properties are quoted in the machine direction (MD) where applicable.



# Application Case Studies...

## Aerospace Insulation Systems

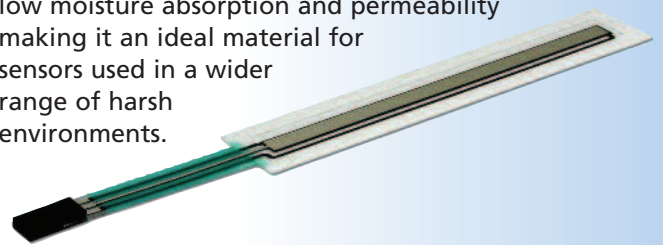
Commercial aircraft producers and insulation manufacturers are actively developing new lightweight thermal acoustic blanket (TAB) insulation systems constructed with APTIV PEEK polymer-based covering film. The APTIV film-based covering films provide an insulation solution that meets the FAA's performance requirements while giving the airlines a lighter weight solution versus traditional covering films.

APTIV film-based cover film laminates meet FAA FAR 25.856(a) radiant panel testing which mandates the improved resistance to flame propagation for thermal and acoustic insulation blankets. Cover films can also be laminated to specialised burn-through barrier systems that meet FAA FAR 25.856(b).



## Flexible Film Sensors

APTIV film has been selected for a variety of flexible film sensors for its ability to withstand the exacting demands of this application. APTIV film increases the reliability of the sensors ensuring they don't fail while delivering the best combination of friction and wear properties combined with high heat resistance, chemical and radiation resistance, purity and electric insulation. In addition, the film is hydrolytically stable with very low moisture absorption and permeability making it an ideal material for sensors used in a wider range of harsh environments.



## Mobile Phone Speaker Diaphragms

APTIV film is frequently chosen to meet the increasing demands of the mobile phone speaker diaphragm application which requires diaphragms to handle extremely high power inputs which produce increasingly high temperatures while producing excellent sound quality in smaller and smaller packages. APTIV films provide a significant improvement in processability, acoustic performance – especially in low frequency response, durability, high temperature performance exceeding 220°C (428°F), chemical resistance, tear resistance and fatigue resistance versus other high performance films on the market.



## Hot Wrapped Electrical Insulation

Unlike traditional polyimide (PI) insulation which requires an adhesive layer, APTIV film can be directly heat laminated around copper wire to make an adhesive-less, completely sealed, highly durable insulation layer. The elimination of adhesives allows for a thinner insulation wrap leading to improved thermal conductivity. It was selected to replace PI for the manufacture of high efficiency flat wire motor coils because it resists the high strain bending process which caused other materials to delaminate and fail thus increasing product reliability and manufacturing yield. Its outstanding electrical insulation properties and enhanced chemical and hydrolysis resistance improve operation in harsh environments.



## Medical Equipment Laser Marked Labels

When labels fade or fall off equipment they are unreadable. APTIV film reduces the risk of this product failure. As such it has been specified for highly durable laser markable medical labels because of its excellent resistance to aggressive cleaning and disinfecting agents used in demanding surgical environments. APTIV film labels can be readily printed using laser marking as well as a number of other conventional printing techniques.



## Heat Exchanger

By replacing metal in its spiral plate heat exchangers with APTIV film, the manufacturer was able to enhance the design of the exchanger, reduce weight, improve performance and reduce overall systems cost. In this design, APTIV film provides the right combination of high temperature performance and chemical resistance. It provides an effective barrier against many liquids and gases, is halogen-free, and withstands lead-free soldering process temperatures.



# Versatility and Flexibility...

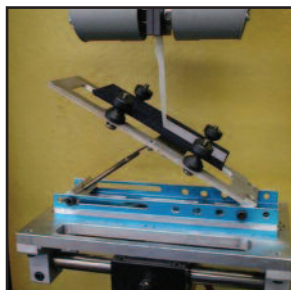
## Secondary Processes

Victrex APTIV film facilitates a wide range of secondary processes which allow designers and engineers to obtain the performance properties of APTIV film in a variety of forms. In addition to in-house capabilities, which include prototype-scale thermoforming and lamination along with slitting and surface treatment, Victrex has a global network of conversion partners who are expert in the use of APTIV film to assist with various operations, including:

- ▲ Adhesion
- ▲ Surface treatments
- ▲ Coatings
- ▲ Speciality slitting
- ▲ Die cutting and stamping
- ▲ Thermal lamination
- ▲ Heat welding and heat sealing
- ▲ Thermoforming
- ▲ Printing
- ▲ Metallisation
- ▲ Vacuum lamination
- ▲ Laser marking, welding, and machining

### Adhesion

APTIV film can be bonded to a broad range of substrates using a variety of adhesives, as selected by our customers. Surface preparation may be required including mechanical abrasion, or plasma treatment, in order to achieve the best results.



### Surface Treatments

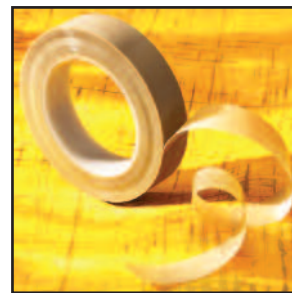
The APTIV film production facility allows for the option of atmospheric plasma technology for treating the surface of the film — this raises the surface energy to enhance adhesion, metallisation and printability.

Other traditional surface treatment operations can also be used on APTIV film including corona discharge treatment, flame treatment, mechanical abrasion and chemical etching.



### Coatings

Using conventional coating equipment, APTIV film can be coated with a range of materials, such as silicone and acrylic adhesive pressure sensitive tapes, B-stage heat activated adhesives, hard coats and printable top coats for labels.



### Speciality Slitting

Victrex has in-house slitting and rewinding capability to slit rolls of APTIV film, in thicknesses as low as 6 microns (0.25 mil) and into custom widths, down to 50 mm (2 in).



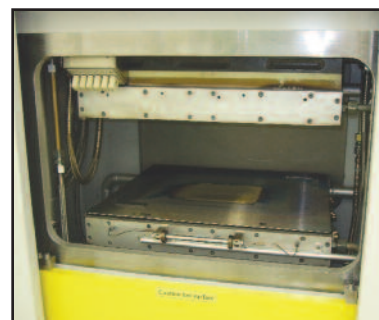
### Die Cutting and Stamping

APTIV film can be die cut to provide customers with a complete range of unique shapes and sizes of washers, gaskets and parts for use in their products. The majority of processors will use mechanical methods, although laser cutting and water jet methods have been demonstrated with APTIV film.



### Thermal Lamination

APTIV film is thermoplastic in nature and can be thermally laminated to a variety of substrates such as metals, fabrics and other reinforced and non-reinforced polymer films, using batch presses and roll-to-roll processes. An in-house high temperature vacuum laminating press system allows bonding of the APTIV film to the substrate without the use of adhesives. The versatility to produce multi-layer substrates incorporating APTIV film allows engineers to develop solutions tailored to their specific needs.



### Heat Welding and Sealing

APTIV film can be heat welded to itself using several joining techniques including the use of heated anvils, ultrasonic equipment or lasers. Being thermoplastic, joining can be achieved by bringing APTIV film close to (or marginally beyond) its melting point while applying pressure and then allowing it to cool.



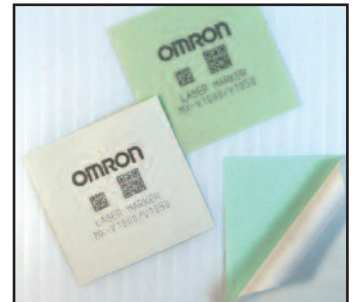
### Thermoforming

Unlike thermoset materials, being thermoplastic in nature, both amorphous or crystalline grades of APTIV film can be shaped into a variety of parts using thermoforming processes. Victrex has an APTIV film prototype thermoforming facility, located in our Asia Innovation and Technology Centre (AITC) in Shanghai, China. The centre supports APTIV film customers across the world with material selection, prototyping, testing and analysis, and customised training.



### Laser Marking, Welding, and Machining

APTIV film can be marked using laser technology to produce a good contrast print onto the surface of the film. Laser technology can also be used to cut or remove a partial layer from the film substrate. Laser welding of APTIV film is also possible.

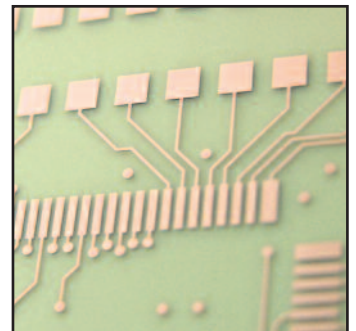


### Printing

APTIV film is receptive to printing by normal methods such as screen printing, transfer printing and ink jet printing. It is suggested that surface treatment of the film be considered to ensure good wetting and adhesion of the printing media to the surface of the film which results in the highest print quality.

### Metallisation and Specialised Coatings

APTIV film can be metallised with a variety of processes including vacuum deposition, sputtering, electroless deposition and direct thermal bonding of metal foils. Numerous metals can be bound to APTIV film without adhesives, the most common being aluminium and copper.



## Conclusion

Victrex APTIV film provides unrivaled versatility and performance for engineers and designers to use in high performance applications. APTIV film is a technology enabler to facilitate meeting the demand of reduced systems cost and improved product performance while also providing increased design freedom, and ease of processing to achieve product differentiation.





Based in the UK, Victrex is an innovative and world leading global provider of high-performance polymer solutions for the aerospace, automotive, electronics, energy and medical industries. Every day, millions of people rely on products and applications containing our polymers – from smart phones, aircraft and cars all the way to medical devices and oil and gas installations. With over 35 years' experience, we provide cutting-edge technological solutions that shape future performance for our customers and markets and drive value for our shareholders.

[www.victrex.com](http://www.victrex.com)

#### World Headquarters

Victrex plc  
Hillhouse International  
Thornton Cleveleys  
Lancashire  
FY5 4QD  
United Kingdom  
  
TEL +44 (0)1253 897700  
FAX +44 (0)1253 897701  
MAIL [victrexplc@victrex.com](mailto:victrexplc@victrex.com)

#### Americas

Victrex USA Inc  
300 Conshohocken State Road  
Suite 120  
West Conshohocken  
PA 19428  
USA  
  
TEL +1 800-VICTREX  
TEL +1 484-342-6001  
FAX +1 484-342-6002  
MAIL [americas@victrex.com](mailto:americas@victrex.com)

#### Europe

Victrex Europa GmbH  
Langgasse 16  
65719 Hofheim/Ts.  
Germany  
  
TEL +49 (0)6192 96490  
FAX +49 (0)6192 964948  
MAIL [customerservice@victrex.com](mailto:customerservice@victrex.com)

#### Japan

Victrex Japan Inc  
Mita Kokusai Building Annex  
4-28, Mita 1-chome  
Minato-ku  
Tokyo 108-0073  
Japan  
  
TEL +81 (0)3 5427 4650  
FAX +81 (0)3 5427 4651  
MAIL [japansales@victrex.com](mailto:japansales@victrex.com)

#### Asia Pacific

Victrex High Performance  
Materials (Shanghai) Co Ltd  
Part B Building G  
No. 1688 Zhuanxing Road  
Xinzhuang Industry Park  
Shanghai 201108  
China  
  
TEL +86 (0)21-6113 6900  
FAX +86 (0)21-6113 6901  
MAIL [scsales@victrex.com](mailto:scsales@victrex.com)

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