



aptiv™

VICTREX® PEEK™ FILM TECHNOLOGY



Versatility and Performance

Material of choice...

Victrex APTIV™ films offer a unique combination of properties, providing an unrivaled material solution for engineers and designers for use in high performance applications. It is the most versatile and high performing thermoplastic film available and has a proven track record of success in demanding applications in a broad range of industries and markets including electronic, acoustics, aerospace, automotive, industrial, oil and gas, chemical processing and many more.

APTIV film is produced from VICTREX® PEEK™ polymer and provides all of the properties of VICTREX PEEK polymer in a flexible format. APTIV film is a technology enabler for processors, designers and end users providing a high performance solution to facilitate meeting demands for reduced systems cost and improved product performance, including durability, reliability, miniaturization, and increased functionality. The increased design freedom offered by using APTIV film, and the ease of processing, allows customers and end users to enhance their own products' performance and differentiation.

APTIV film is produced by Victrex in one of the most technologically advanced film extrusion facilities in the world. Dedicated to the production of APTIV film, and part of Victrex's fully integrated supply chain for VICTREX PEEK polymer, Victrex's manufacturing capabilities guarantee material quality, supply, consistency and performance.

Victrex is an innovative world leader in high performance materials whose team of dedicated market development, sales, and technical support professionals have a long history — over 20 years — of working in partnership with customers around the world to develop new applications through product and technology innovation.



...for performance

Benefits

APTIV films provide many benefits for OEMs, designers and processors. Its versatility and high performance satisfy the increasing demand for lighter weight, durable, lower cost and eco-friendly application design. APTIV film offers the performance properties of VICTREX PEEK polymer in a film format to meet these challenges. Benefits include; light weight (low specific gravity and very low thicknesses available), facilitate miniaturization, longevity, durability, reliability and toughness; and streamlined processing to reduce overall systems cost, all using an eco-friendly and recyclable material.

Key Features

- ▲ **High Heat Resistance**
APTIV film has a UL 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 (1-5 mil), and is capable of withstanding lead free solder processing temperatures of up to 300°C.
- ▲ **Excellent Wear Properties**
Inherently lubricious and has a very smooth surface finish and low particulation. Lpv rating is 145 MPa-m/min (69,000 psi-ft/min) without the presence of lubricants.
- ▲ **Low Moisture Absorption**
Resists moisture that can adversely affect electrical and dimensional properties.
- ▲ **Purity**
Exceptionally low outgassing and extractables.
- ▲ **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.

The APTIV Film Advantage

- Tight Thickness Tolerances — extruding equipment has world class process control.
- Wide Film Widths up to 1.5 meters.
- Broad Thickness Range — from 6 to 750 microns.
- Dedicated Manufacturing — part of Victrex's fully integrated supply chain.
- Design Flexibility — easy to process.
- Global Technical, Sales and Marketing Support.

- ▲ **Environmentally Friendly**
Light weight, recyclable, halogen free, withstands lead free soldering process temperatures, is RoHS compliant and can be used to manufacture products compliant with the same directive.
- ▲ **High Strength and Toughness**
Highest stiffness and resistance to cyclic fatigue of any thermoplastic. Strength is maintained well over the glass transition temperature (Tg). Excellent tear strength, puncture resistance and acoustic properties.
- ▲ **Electrical Stability**
Very stable dielectric properties over a wide range of temperatures, frequencies and humidities.
- ▲ **Radiation Resistance**
Withstands over 10⁹ rads exposure without embrittlement.
- ▲ **Low Smoke and Toxic Gas Emission**
Good flammability without the use of flame retardants, low toxicity of combustion gases. Inherently halogen free in accordance with IEC 61249-2-21.
- ▲ **FDA Food Contact and Dairy 3A Certified**
APTIV film grades 1000, 1100, 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 Commission Directive 2002/72/EC, and the amendments up to 2005/79/EC.
- ▲ **Excellent Barrier Properties**
Provides an effective barrier against many liquids and gases.

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. The standard width of APTIV film is 610 mm, although some films can be provided in widths up to 1500 mm. The stock rolls of film can be further slit down to widths of as low as 45 mm. Matte/Gloss and Gloss/Gloss surface finishes of APTIV film are standard. Other surface finishes are available upon request.

1000 Series

APTIV 1000 series films are unfilled semi-crystalline films. Available in thicknesses from 12 microns upwards, they are typically the mostly commonly used grade in the product range.

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 semi-crystalline nature using a thin gauge thermoforming process, and where either ductility or a level of optical clarity are required. If, in applications, or

processing, temperatures above the glass transition temperature (T_g) of VICTREX PEEK (143°C/289°F) are experienced, then the amorphous film will revert to the semi-crystalline form. This property is particularly advantageous when thermoforming parts from APTIV film.

1100 Series

APTIV 1100 series are mineral filled semi-crystalline films with the filler content being available at several loadings according to the application needs. The films are available in thicknesses from 12 microns upwards. The film is typically specified where either a higher modulus or lower coefficient of thermal expansion is required, than is offered by the 1000 series of APTIV film, in the application.

2100 Series

APTIV 2100 series are mineral filled amorphous films with the filler content being available at several loadings according to the application needs. The films are available in thicknesses from 12 microns upwards. The film is typically specified for processing to the semi-crystalline form using a thin gauge thermoforming process where either a higher modulus or lower coefficient of

thermal expansion is required, than is offered by the 2000 series of APTIV film, in the application. If, in applications, or processing, temperatures above the glass transition temperature (T_g) of VICTREX PEEK (143°C/289°F) are experienced, then the amorphous film will revert to the semi-crystalline form. This property is particularly advantageous when thermoforming parts from APTIV film.

Secondary Processes

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

- Surface treatment for the promotion of adhesion
- Metallization using a variety of deposition and lamination processes
- Thermoforming into shaped parts with thin walls
- Lamination to other polymers and metals
- Application of specialized coatings

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

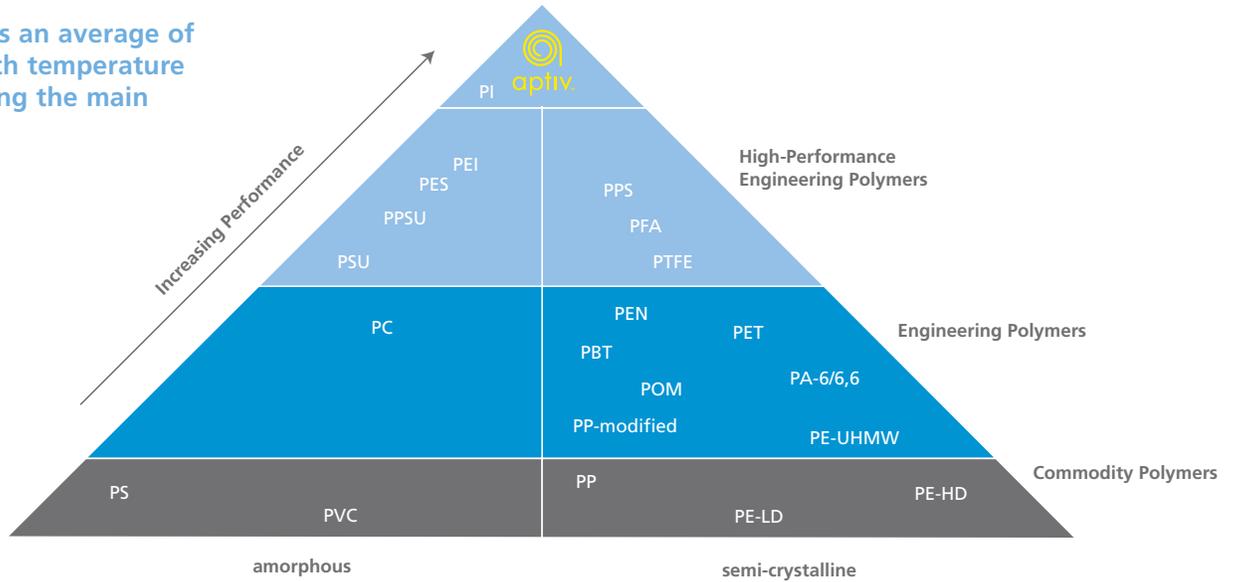
APTIV Film – Comparison with Competitive Films

	Mechanical Properties at 200°C	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	Permeation Properties	Recyclable	Dielectric Properties	RTI Rating	Flammability
Victrex APTIV film	Melt Processible	Very Good	Yes	Very Good	220°C	Very Good
Polyimide (PI)	Not Melt Processible	Very Good	No	Very Good	200°C	Excellent
Polyetherimide (PEI)	Melt Processible	Fair	Yes	Good	180°C	Excellent
Polytetrafluoroethylene (PTFE)	Limited Melt Processibility	Good	Limited	Excellent	180°C	Excellent

APTIV Film Performance

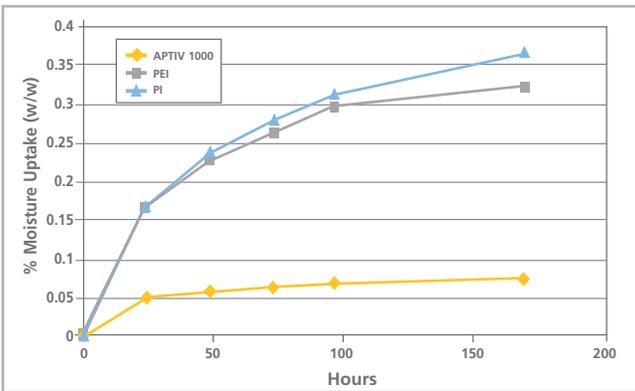
Performance is an average of properties with temperature resistance being the main determinant



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 dielectric properties under these conditions.

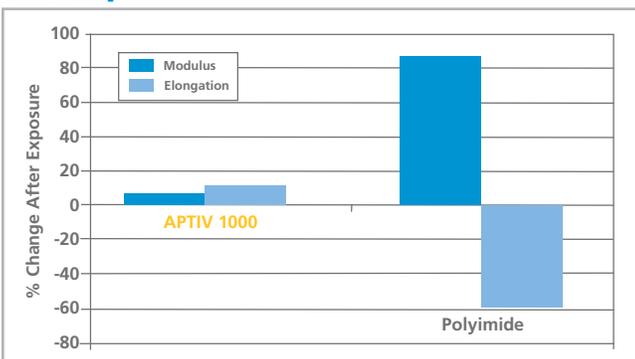
Figure 1: Moisture Uptake @ 50% RH, 23°C (73°F)



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 made using APTIV 1000 film.

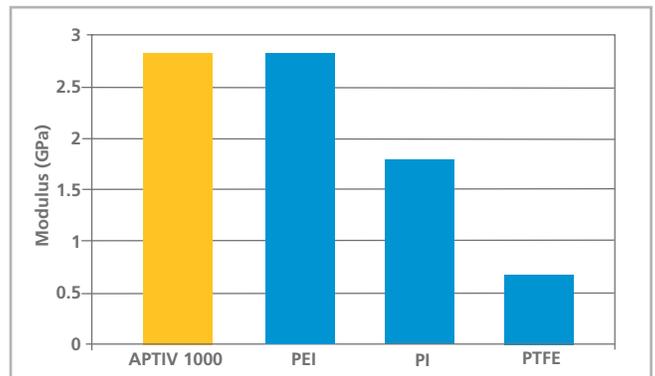
Figure 2: Hydrolysis Resistance [5 days @ 150°C (302°F), 100% RH]



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.

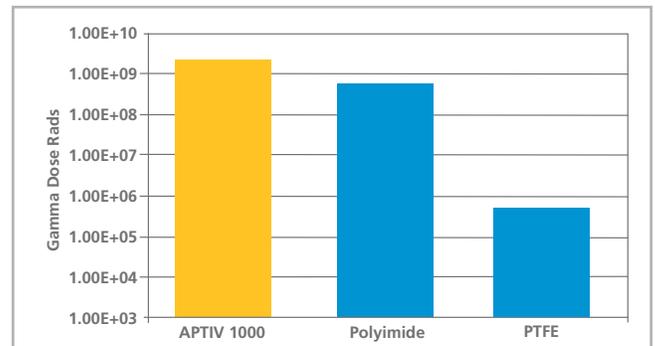
Figure 3: Tensile Modulus @ 23°C (73°F)



Radiation Resistance

The oxidative gamma radiation dose above which significant deterioration of flexural properties occurs. APTIV 1000 film exhibits excellent resistance to radiation

Figure 4: Radiation Resistance



A Unique Combination of Properties...

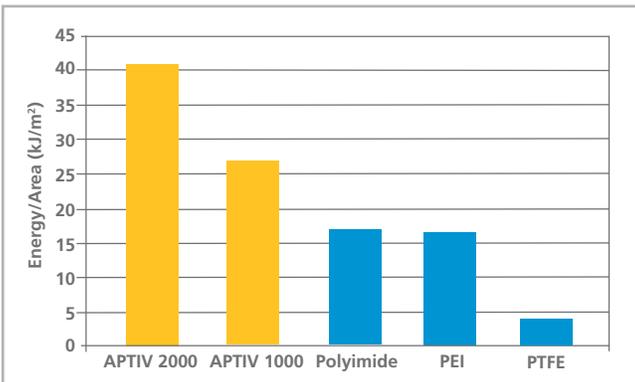


APTIV film has a unique combination of properties providing high temperature performance, mechanical strength, chemical resistance, electrical insulation, wear and abrasion resistance, and low moisture absorption in a versatile film format.

Puncture Resistance

Both APTIV 1000 and 2000 film grades demonstrate excellent puncture resistance properties as both a semi-crystalline film or amorphous film.

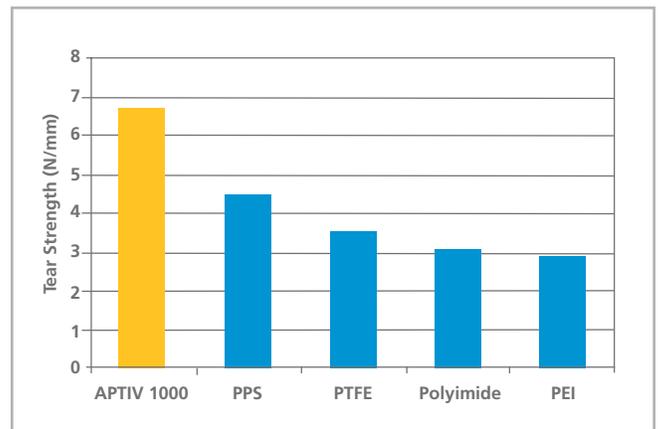
Figure 5: Puncture Resistance at 23°C (73°F)



Tear Strength

APTIV 1000 film has excellent tear strength properties as a semi-crystalline film, combining the crystalline strength with the ductility of the amorphous phase.

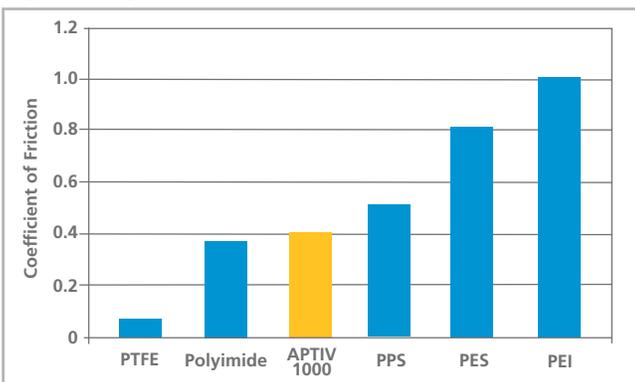
Figure 7: Tear Resistance at 23°C (73°F)



Dynamic Coefficient of Friction

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

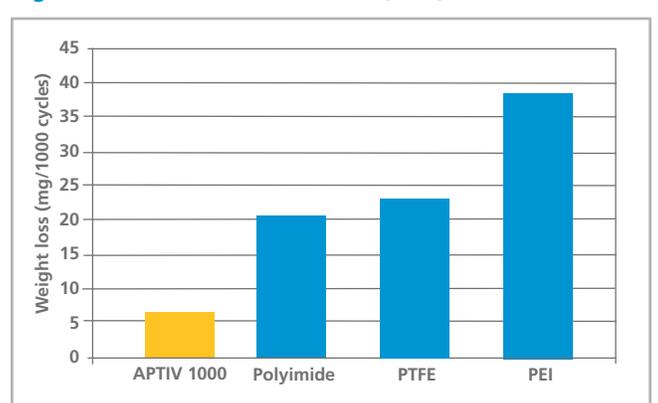
Figure 6: Dynamic Coefficient of Friction



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.

Figure 8: Taber Abrasion at 23°C (73°F)



Gas Permeation

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

Figure 9: Water Vapor Permeation at 23°F (73°F), 100% RH

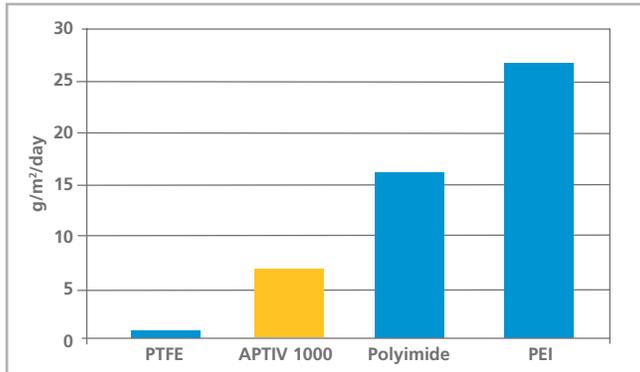
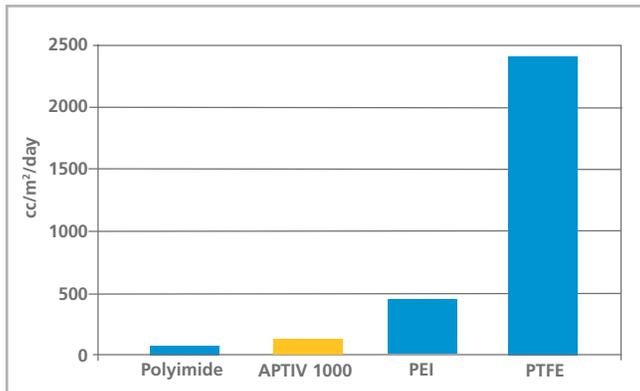


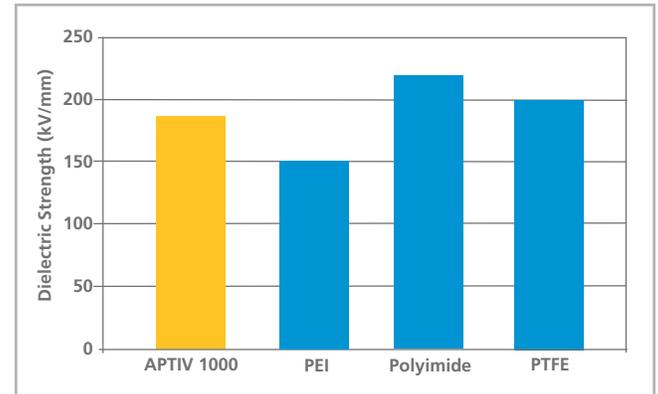
Figure 10: Oxygen Transmission at 23°C (73°F), 0% RH



Dielectric Strength

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

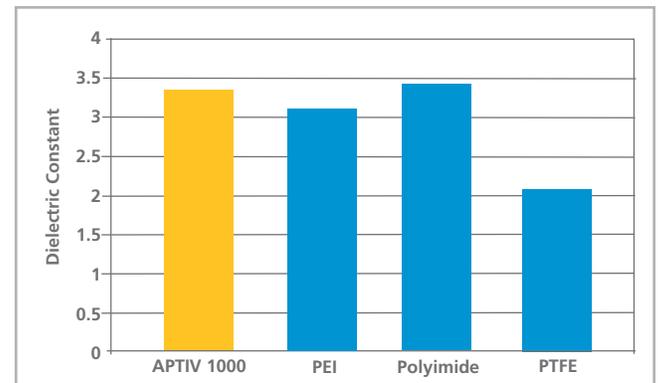
Figure 11: Dielectric Strength [50 micron film, 23°C (73°F)]



Dielectric Constant

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

Figure 12: Dielectric Constant at 23°C (73°F)



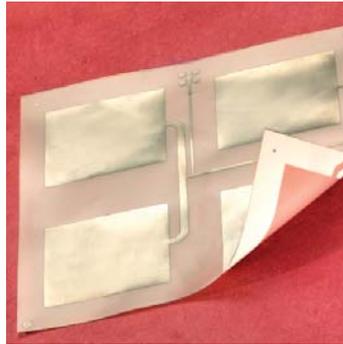
Properties of APTIV Film Grades

Property	Test Method	Test Condition	Units	APTIV 1000	APTIV 2000	APTIV 1102
Tensile Modulus	ISO 527	23°C	GPa (kpsi)	2.8 (406)	1.8 (261)	4.8 (696)
Tensile Strength (at break)	ISO 527	23°C	MPa (kpsi)	120 (17.4)	120 (17.4)	100 (14.5)
Tensile Elongation (at break)	ISO 527	23°C	%	>150	>200	>100
Puncture Strength	Def Stan 81-75	23°C	kJ/m ²	26	40	5
Tear Strength	ISO 6383-1	23°C	N/mm	6.7	6.3	4.4
Shrinkage	TM-VX-84	200°C	%	<2	5-8	<1
Dielectric Strength (50 microns)	ASTM D149	23°C, 1/4 inch electrode	kV/mm (V/mil)	190 (4826)	190 (4826)	200 (5080)
Water Absorption (50%RH)	ISO 62	23°C, 24h	%	0.04	0.21	0.08
Specific Gravity	ISO 1183	23°C		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, 10 MHz		3.5	3.3	3.6
Loss Tangent	ASTM D150	23°C, 10 MHz		0.002	0.003	0.001

Applications...

Applications

- ▲ Aerospace film applications
- ▲ Composite film layers
- ▲ Dry transformer insulation
- ▲ Electrical and magnet wire insulation
- ▲ Flexible film heaters
- ▲ High performance gaskets
- ▲ High temperature labels
- ▲ Industrial slot liners
- ▲ Electric motor washers
- ▲ Pressure sensitive adhesive tapes
- ▲ Printed circuit substrates
- ▲ Speaker diaphragms and voice coils
- ▲ Specialty laminates
- ▲ Thermoformed structures
- ▲ Capacitors
- ▲ Specialty Packaging
- ▲ Pressure Sensors



Thin Film Antennas

TennVac uses a unique Physical Vapor Deposition (PVD) process to selectively place a metallized antenna pattern directly onto APTIV film. Thin film antennas are used in a wide variety of electronic applications such as wireless LAN, Blue Tooth, GPS, RFID, Microwave, etc. to receive signals of various frequencies.

Using the PVD process, TennVac can take the APTIV film with an adhesive backing, metallize it with an antenna pattern, and stamp it to whatever shape is required. TennVac customers can then place the metallized adhesive film antenna directly onto the device housing.

Because the PVD process is done in an air-free environment, TennVac is able to apply multiple metal layers in a single application, without any concern about oxidation on the inner layers. This enables TennVac to determine location, thickness and types of metals used based on the requirements of the antenna, not the constraints of the process. This means customers can utilize highly conductive metals, such as copper, for an inner layer in combination with a more rugged layer that can be soldered such as tin.

The PVD process provides RF engineers with maximum flexibility to locate the antenna in the most advantageous location within their system's housing.



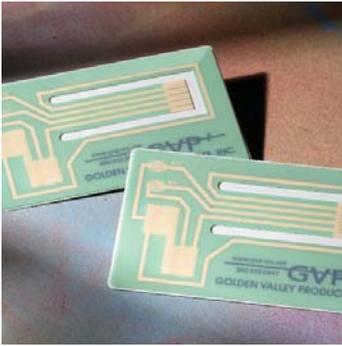
Diaphragm Liner for Back Pressure Regulator

When CIRCOR Instrumentation Technologies (CIT), a leading provider of fluid process instrumentation, encountered a sampling system application with ambient temperatures up to 260°C (500°F), it replaced the PTFE liner in a BP-3 series GO back pressure regulator with APTIV film because of its high temperature capabilities. GO back pressure regulators are used to maintain a constant pressure in an analyzer.

In this application, a sampling system application with ambient temperatures up to 260°C (500°F), the PTFE migrated toward one of the internal ports of the back pressure regulator. When this happened, flow was restricted through the unit.

Unlike PTFE, APTIV film does not have a tendency to cold-flow or creep. It does not migrate toward the internal port and thus has provided an excellent solution for this application.

APTIV film is used as a barrier between sample process media and the backing of the diaphragm which in this particular application was stainless steel.



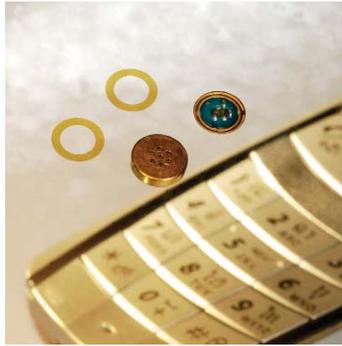
Membrane Switch Panels and Sensors

When Golden Valley Products, Inc. (GVP) wanted a material that would provide an effective barrier for its specialty membrane switches against moisture, chemicals and high temperatures, it chose APTIV film. The film has a better moisture resistance than polyester and polyimide, and has a higher operating temperature and better chemical resistance than polyester and polyimide films. GVP also engineers APTIV film into its specialty printed circuit sensors and thin-film potentiometers.

Since GVP prints a very sensitive conductive silver ink onto the film, it wanted to make sure that outside elements such as moisture can't get into the silver and corrode it.

Maintaining that barrier is extremely important for equipment such as insulin or med-infusion pumps where a switch malfunction is not an option. GVP uses APTIV film in its membrane switch designs when the requirements call for the utmost protection and reliability.

Complex membrane switch designs can have numerous layers. For its standard membrane switch panels, GVP uses a pressure sensitive adhesive to join the layers. For applications where it's imperative that a membrane switch be protected, GVP uses APTIV film. It creates a more durable barrier against moisture, heat, and chemicals than a typical polyester or polyimide switch construction.



Microphone Spacer Film for Mobile Phones

Ole Wolff-Seokang, a manufacturer of condenser microphones for mobile phones using Surface Mounted Device (SMD) methods, switched to APTIV film for the microphone's spacer film because of its superior temperature resistance and dielectric constant.

During SMD processing, the microphones are attached to a board while going through solder re-flow. This process requires the microphones to withstand very high temperatures. Previously, the company used PET for the spacer material but, because PET has lower heat resistance, it caused the microphones to melt and deform.

With a melt temperature of 343°C (649°F), APTIV film meets all the requirements. Not only does it offer higher heat resistance, but also electrical insulation, chemical resistance and outstanding physical properties.

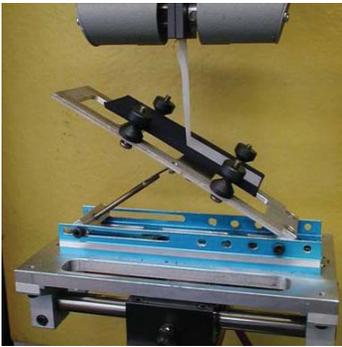
SMD-type microphones are twice as expensive as common solder-type microphones. By using APTIV film for the spacers, Ole Wolff-Seokang is able to cost effectively produce its SMD microphones.



Versatility and Flexibility...

Secondary Processes

Victrex APTIV film can be easily subjected to a range of secondary process operations which allow designers and engineers to obtain the benefits of APTIV film properties in a variety of forms. The following list is a short summary of each of the secondary operations that can be performed with APTIV film. More detailed guides are available for many of the secondary operations on the APTIV website or by contacting Victrex directly.



Adhesion

APTIV film can be adhered to a range of substrates using several types of adhesive systems. Customers will need to select the most appropriate adhesive for the service environment that the adhesive will be exposed to. A list of suggested adhesives is available from Victrex. In the majority of cases, pre-treatment of the surface of the APTIV film is required to achieve good wetting of the adhesive onto the PEEK substrate. The types of surface treatments are listed below.



Photo Courtesy of Enercon Industries

Surface Treatments

The APTIV film production facility incorporates atmospheric plasma technology for treating the surface of the film — this raises the surface energy allowing adhesives, inks and

dyes and other materials applied to the APTIV film surface to wet the surface of the film and achieve excellent bonding. The plasma treatment chosen by Victrex provides a higher surface energy level (over 55 dynes/cm) and longer lasting treatment life than traditional corona treatments without the risk of pin-holing and/or backside treatment, which are unwanted side effects of corona treatment especially on very thin films. Our testing of the effects of plasma treatment on the surface energy of APTIV film include aging/decay tests over a 12-month period and we would confidently expect plasma treated film to offer the enhanced surface energy levels for up to 6 months from treatment date.

Other traditional surface treatment operations can also be used on APTIV film such as corona discharge treatment, flame treatment, mechanical abrasion and chemical etching. The list of possible techniques are found in the Surface Treatment Guide available on the APTIV website or by contacting Victrex directly.



Photo Courtesy of Covalence Adhesives

Coatings

APTIV film can be coated with a range of materials to perform specific functional needs for the end user. Conventional coating equipment can be used for APTIV film. For example, pressure sensitive adhesives are being coated onto an APTIV film backing for pressure sensitive tapes. These PSA tapes are available with either an acrylic or silicone high temperature adhesive for a variety of application uses. Combining the excellent property combination of APTIV film with a customer's specialized coating material may allow development of new applications not previously possible. Other

available coatings include B-stage heat activated adhesives, hard coats and printable top coats.

Slitting

APTIV film rolls can be slit into custom widths to suit the needs of end users. Victrex has incorporated a state-of-the-art slitter rewinder into the APTIV production facility to provide customers with slit widths down to 45 mm. Customers can also use their own in-house slitting equipment or local converters for such operations.



Die Cutting and Stamping

APTIV film can be die cut to provide customers with a complete range of shapes and sizes of washers, gaskets and parts for use in their products. The majority of processors will use a mechanical method, though laser cutting and ultrasonic methods have been demonstrated with APTIV film. Regional and local conversion partners can also provide this service to end users.



Thermal Lamination

APTIV film is thermoplastic in nature and can be thermally laminated to a variety of substrates using batch presses and roll-to-roll processes. In many cases, the APTIV film can be bonded to substrates without

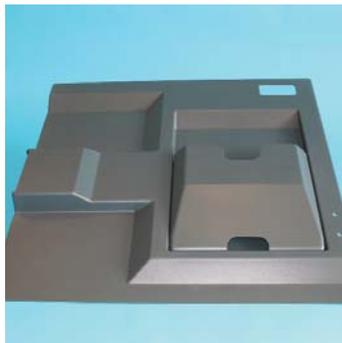
the use of an adhesive layer. APTIV film has successfully been laminated to metal foils of copper, steel and aluminum. It is also possible to laminate APTIV film to other polymer substrates. The versatility to produce multi-layer substrates incorporating APTIV film allows engineers to develop solutions tailored to their specific needs. More details of the conditions can be found in the Thermal Lamination Guide available on the APTIV website or by contacting Victrex directly.



Photo Courtesy of RDM Test Equipment Co.

Heat Welding and Heat Sealing

APTIV film can be heat welded to itself with several joining techniques. The joining can be achieved by bringing the APTIV film close to its melting point while applying a joining pressure. The heat welding can be achieved by the use of thermally heated anvils, the use of ultrasonic welding tools and laser welding equipment. More details of the conditions can be found in the Thermal Lamination Guide available on the APTIV website, by contacting Victrex directly or by contacting one of Victrex's supply chain partners who can assist with the joining of APTIV films.



Thermoforming

Being a thermoplastic material affords APTIV film a key advantage over thermoset films. It allows the film to be shaped into a variety of parts using thermoforming processes. The thermoformer can start with either the amorphous or crystalline grades of APTIV film and use the appropriate process conditions to shape the part. Parts ranging from a thickness of 6 microns up to 600 microns have been thermoformed, and thicker parts are also possible. More details of the conditions can be found in the Thermoforming Guide available on the APTIV website or by contacting Victrex directly.



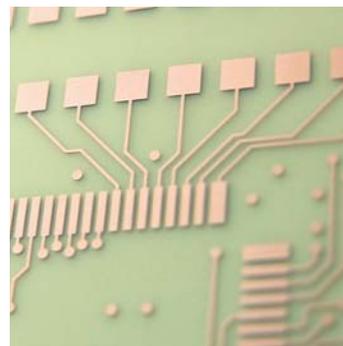
Laser Marking, Laser Ablation and Laser Machining

APTIV film can be marked using laser technology to produce a good contrast print onto the surface of the film. The same

laser technology with a higher level of control can also be used to remove a partial layer from the film substrate. Regional and local conversion partners are also capable of providing this service to end users.

Printing

APTIV film is receptive to being printed on by normal methods such as screen printing, transfer printing and ink-jet printing. It is recommended that the surface of the film should be plasma treated prior to the printing process to ensure good wetting and good adhesion of the printing media to the surface of the film.



Metallization

APTIV film can be metallized with a variety of processes including vacuum deposition, sputtering, electroless deposition and direct thermal bonding of metal foils. Numerous metals can be applied to APTIV film, the most typical being aluminum, copper, tin, and more specialized coatings such as indium tin oxide. Vacuum plasma systems can apply a range of other materials onto APTIV film to provide the appropriate functionality for the end user. Similarly, a sputtering technique for applying thicker layers of metals to APTIV film can also be used. Direct thermal bonding is detailed in the Thermal Lamination Guide available on the APTIV website, by contacting Victrex directly.

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.



www.aptivfilms.com

Victrex plc is the leading global manufacturer of Polyaryletherketones, high-end polymers, which are sold under the brand names VICTREX® PEEK™, VICTREX® PEEK-HT™, APTIV™ and VICOTE®. With production facilities in the UK backed by sales and distribution centers serving more than 30 countries worldwide, our global market development, sales, and technical support services work hand-in-hand with customers offering practical assistance in the areas of processing, design and application development. Contact us today to find out how we can help you.



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- Distributors
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