SOLVAY

asking more from chemistry®

High-Performance Polymers for

Automotive

SPECIALTY POLYMERS

High-Performance Polymers for Next-Generation Performance

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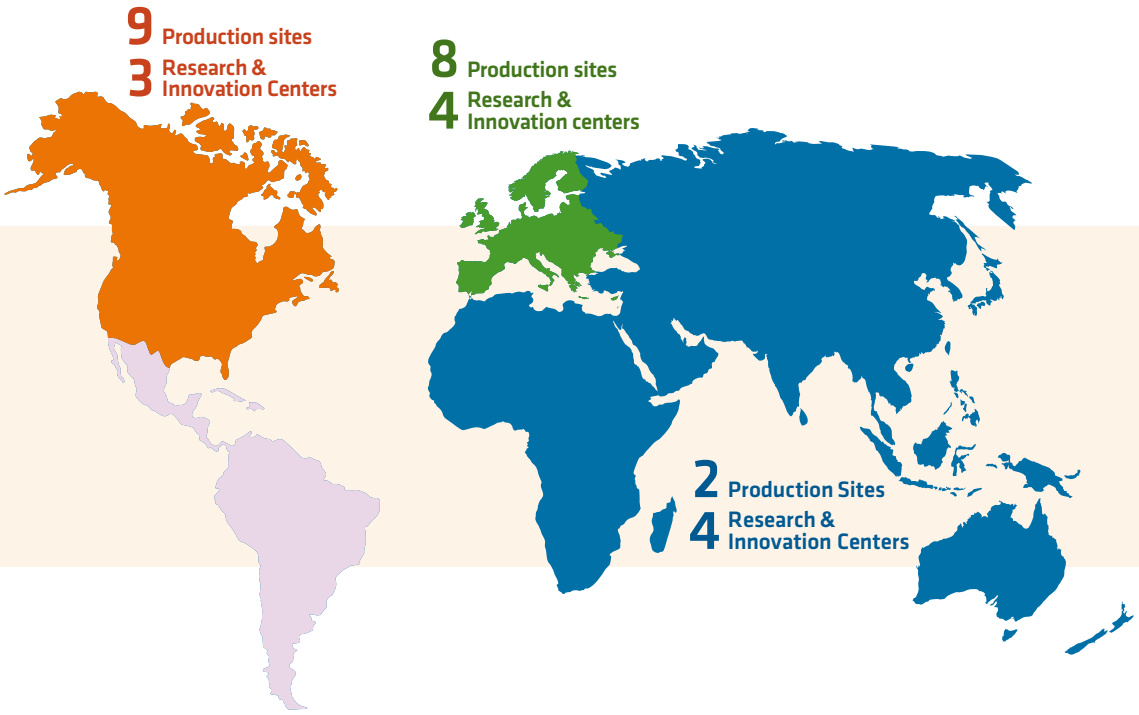
World Leader in Specialty Polymers

Solvay offers the industry's broadest portfolio of high-performance polymers, fluids and elastomers. These materials are designed to meet the critical requirements that engineers face every day when designing components for Automotive, Aerospace, Healthcare, Batteries, Smart Devices, Consumer, Industrial, and Energy Production and Storage.

Our production and Research & Innovation (R&I) sites are located strategically around the world to provide you with responsive technical support and customer service.

Specialty Polymers at a Glance



Multiple End Markets


Aircraft


Alternative Energy


Automotive


Construction


Consumer Goods


Electrical / Electronics


Healthcare


Industrial


Membranes

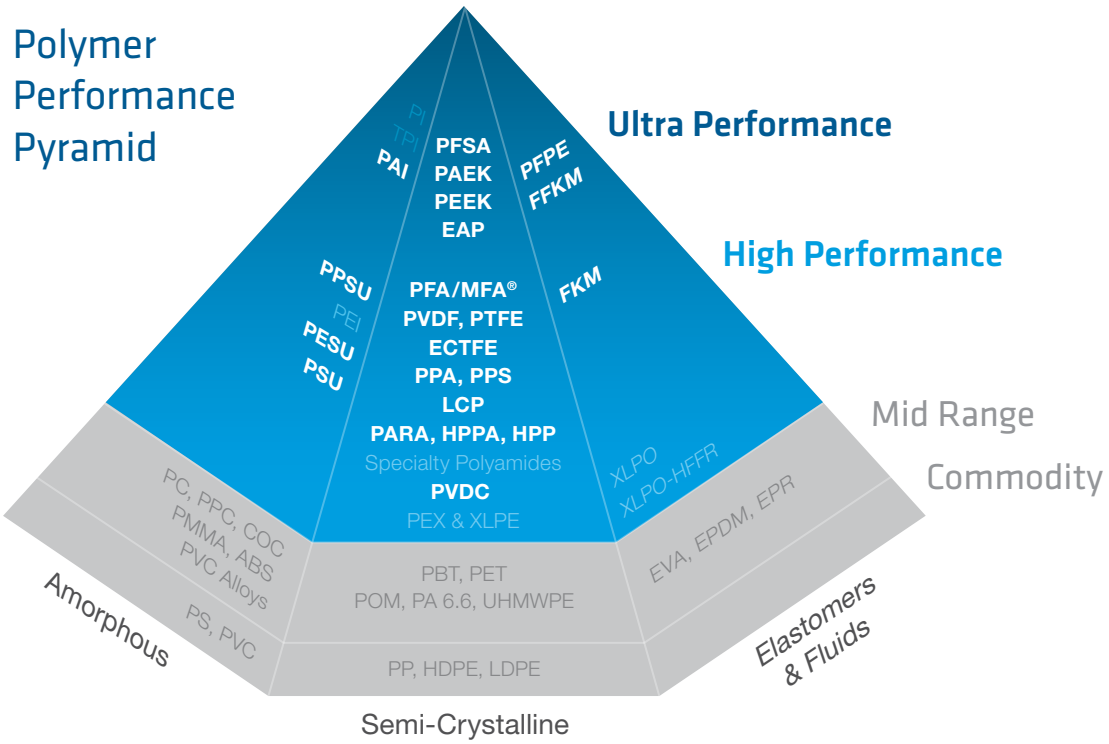

Oil & Gas


Smart Devices

Business Strengths

50+ Proprietary technologies
1,500+ Products
3,300+ Patents in force
340+ Commercial employees
3,000+ Employees worldwide
4,000+ Customers
550+ R&I specialists

Specialty Polymers Portfolio



Solvay's specialty polymers are designated in bold type

	Aromatic Polymers						Fluoropolymers					High Barrier Polymers
	LCP	PPA	PEEK	PAI	PSU	PPS	PTFE	PVDF	PFA	FKM	PFPE	PVDC
Advanced transportation	●	●	●	●	●	●	●	●	●	●	●	
Automotive		●	●	●	●	●	●	●	●	●	●	
Healthcare		●	●		●		●					●
Renewable energy			●		●	●		●		●	●	
Oil & gas		●	●	●		●		●	●	●	●	
Smart devices	●	●	●		●	●		●		●	●	
Water purification					●			●				

● *Currently produced in Asia* ● *On-going investments in Asia* ● *Not produced in Asia*

Advanced Lightweighting Solutions

- TegraLite™ Lightweighting Solutions
  - TegraCore™ PPSU Structural Foam
  - 3D Foams
  - Films
  - Composites
  - Solef® 80 000 e-PVDF
  - Virantage® PESU Toughenners

Biomaterials for Implantable Devices

- Solviva® Biomaterials
  - Eviva® PSU
  - Proniva® SRP
  - Veriva® PPSU
  - Zeniva® PEEK

Films

- Ajedium™ Films

Fluorinated Elastomers

- Tecnoflon® FKM & PFR FFKM
  - Base Resistant
  - Ionic Curable
  - Low Temperature
  - Peroxide Curable
  - PFR FFKM perfluoroelastomers

Fluorinated Fluids

- Fomblin® HC PFPE
- Fomblin® PFPE Lubricants
- Galden® PFPE
- Solvera® PFPE

Fluoropolymers

- Algoflon® PTFE
  - Dispersions
  - Fine Coagulated Powders
  - Granulars
  - Micronized Powders
- Halar® ECTFE
- Hyflon® PFA & MFA®
- Polymist® PTFE Micronized Powders
- Solef® PVDF

Fluoropolymer Coatings

- Halar® ECTFE
- Hyflon® PFA & MFA®
- Hylar® PVDF
- Hylar® 5000 for Architectural Coatings

Functional Fluids

- Fluorolink® PFPE
- Fomblin® PFPE Functional

Liquid Crystal Polymers

- Xydar® LCP

Polyamide-Imides

- Torlon® PAI

Polyamides, Aromatic

- Amodel® PPA
- Ixef® PARA
- Kalix® HPPA
- Omnix® HPPA

Polyesters, High-Performance

- Lavanta® HPP

Polyketones, Aromatic

- AvaSpire® PAEK
- KetaSpire® PEEK

Polymer Processing Aids

- Solef® 11010 PVDF
- Tecnoflon® NM FKM

Polyphenylene

- PrimoSpire® SRP

Polyphenylene Sulfide

- Ryton® PPS

Polyvinylidene Chloride

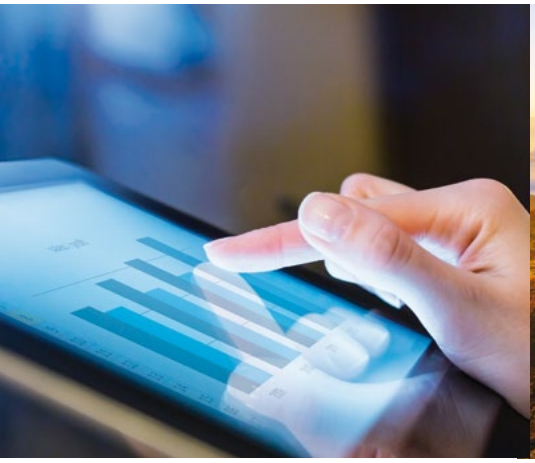
- Diofan® PVDC
- Ixan® PVDC Extrusion Resins
- Ixan® PVDC Soluble Powders

Specialty Materials

- Aquivion® PFSA
- EpiSpire® HTS
- Hyflon® AD
- Long Fiber Compounds
- Solvene® EAP
- Torlon® AI for Coatings

Sulfone Polymers

- Acudel® modified PPSU
- Radel® PPSU
- Udel® PSU
- Veradel® PESU



High-Performance Polymers for Automotive

Global automotive OEMs face the challenge of meeting upcoming CO_2 and tailpipe emissions standards. In order to address these challenges, OEMs are focused on improving powertrain efficiency through engine down-sizing and transmission down-speeding, increasing the electrification of their vehicles, lightweighting, and reducing fuel consumption.

Specialty Polymers is focused on these CO_2 and emissions reduction technologies by offering high-performance polymers that offer heat and chemical resistance as well as dimensional stability.

Our products are widely considered for the following solutions:

- Thermal and air management
- Transmission and launch devices
- Electronics and lighting
- Traction motors and power electronics
- Fuel and SCR systems
- Structural and semi-structural, lightweighting
- Chassis, braking and steering

Application Matrix

Application	Ixef® PARA	Amodel® PPA	Ryton® PPS	Veradel® PESU	KetaSpire® PEEK	Torlon® PAI	Solef® PVDF	Hyflon® PFA	Tecnoflon® FKM	Fomblin® PFPE
Thermal and air management	●	●	●	●	●	●	●	●	●	●
Transmission and launch devices	●	●	●	●	●	●			●	●
Electronics and lighting	●	●	●	●	●	●		●	●	●
Traction motors and power electronics	●	●	●	●	●	●	●	●	●	●
Fuel and SCR systems		●	●		●			●	●	●
Structural and semi-structural, lightweighting	●	●	●		●				●	●
Chassis, braking and steering	●	●	●	●	●	●	●		●	●

Thermal Management Systems

Amodel® PPA and Ryton® PPS have replaced die-cast aluminum in engine cooling systems for over 20 years. Both materials are routinely used in under-the-hood applications where resistance to heat, humidity and automotive fluids are major considerations.

Performance Advantages

- Long-term retention of mechanical properties in high heat
- Exceptional resistance to coolant (glycols)
- Low moisture absorption for dimensional stability
- No parting-line design possible

Typical Applications

- Thermostat housings
- Water inlet/outlet valves
- E-water pumps
- Water pump impellers
- Heater cores and end caps

Application	Amodel® PPA	Ryton® PPS	Veradel® PESU	KetaSpire® PEEK	Solef® PVDF	Fomblin® PFPE
Thermal management modules	●	●	●	●	●	●
Water inlet/outlet valves	●	●				●
Electric water pumps	●	●		●		●
Mechanical water pumps	●	●		●		●
Thermostat housings	●	●		●		●
Heater cores and end caps	●	●				●

Amodel® PPA (polyphthalamide)

Amodel® PPA offers excellent dimensional stability in corrosive, high-temperature environments along with better fatigue and impact resistance compared to standard polyamide, superior strength at 130 °C (266 °F) after prolonged exposure to engine coolants, and faster molding cycle times.

KetaSpire® PEEK (polyetheretherketone)

KetaSpire® PEEK combines exceptional strength, stiffness, chemical resistance and fatigue resistance with continuous-use up to 240 °C (464 °F), enabling it to replace metal in some of the most severe end-use environments.

Ryton® PPS (polyphenylene sulfide)

Ryton® PPS offer a unique combination of properties and an excellent cost-performance balance. Key properties include thermal stability, dimensional stability, chemical resistance and inherent flame retardancy.

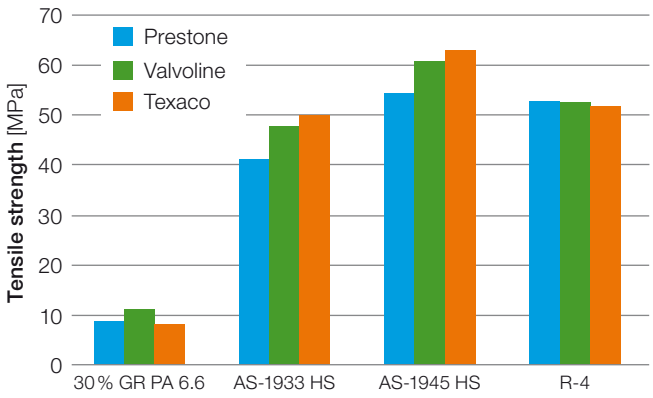
Fomblin® PFPE (perfluoropolyether)

Fomblin® PFPE is the ideal lubrication solution for the automotive industry, meeting lubrication challenges by providing the best possible performance for demanding applications. It is used as neat oil, formulated into greases, or deposited on the part through suitable carriers.

Retention of Mechanical Properties

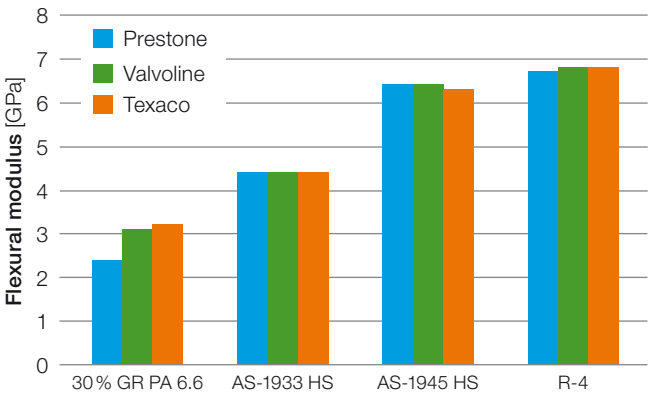
Tensile strength

After 5,000 hours exposure at 120 °C (248 °F) in 50/50 glycol/ether



Flexural modulus

After 5,000 hours exposure at 120 °C (248 °F) in 50/50 glycol/water



Typical Applications

Thermostat Housing

- High retention of mechanical properties at 130 °C (266 °F) in engine coolant
- No parting-line to prevent leakage risk
- High weldline strength

Impeller

- Dimensional stability
- High retention of mechanical properties > 130 °C (266 °F) in engine coolant
- Excellent resistance to glycol

E-water Pump

- Better dimensional stability than PA 6.6
- Continuous-use temperature 130 °C (266 °F) in glycol/water
- Fatigue resistance
- Easy welding

Amodel® PPA

Amodel® PPA offers excellent dimensional stability in corrosive, high temperature environments along with better fatigue and impact resistance, superior strength at 130 °C (266 °F) after prolonged exposure to engine coolants, and faster molding cycle times.

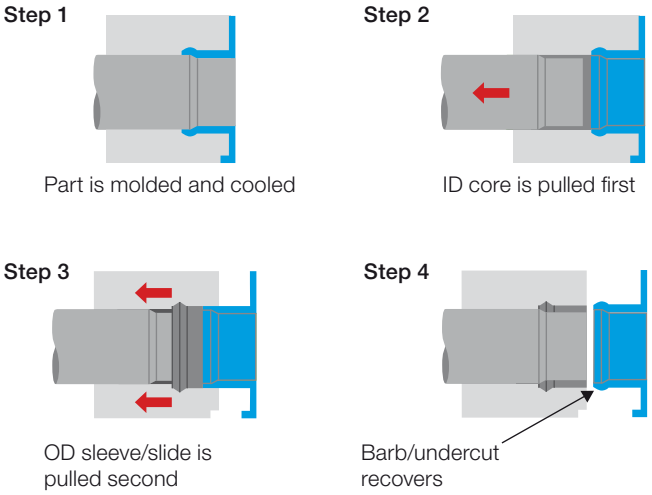
Key Features

- Retains mechanical properties in high heat
- Excellent resistance to coolants
- Dimensional stability
- Corrosion protection for metal inserts
- Under-cut designs possible

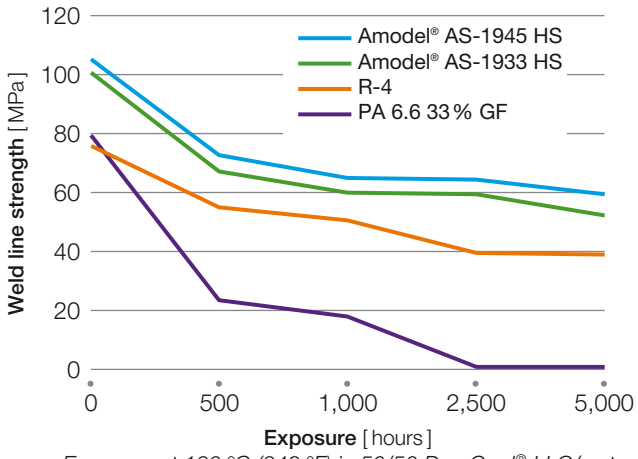
Undercut Designs

Amodel® AS grades are unique among high-performance plastics in their ability to mold undercut designs. Simplified mold designs can reduce tooling costs associated with parting lines.

Undercut design and processing



Weld-line strength after prolonged exposure to long-life coolant



Exposure at 120 °C (248 °F) in 50/50 Dex-Cool® LLC/water

Glycol-resistant Amodel® PPA grades

High Elongation

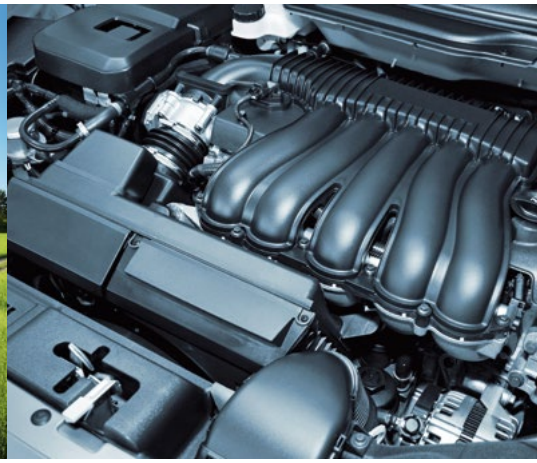
AS-1933 HS **AS-1945 HS**	High elongation, dimensional stability

Thermal Stability

A-8930 HS **A-8940 HS** **A-8950 HS**	High heat resistance, high strength, dimensional stability

Electrical Friendly

AE-8930 **AE-8935** **AE-8940**	High heat resistance, high strength, anti-corrosion to metal insert



Air Management Systems

Engine downsizing driven by emission legislations has placed high-temperature demands on air induction components. Solvay's broad range of specialty polymers can help you meet next-generation requirements of hot-side air induction components.

Performance Advantages

- Light weight for improved fuel efficiency
- Excellent dimensional stability
- High-temperature resistance
- Highly resistant to all automotive fluids

Typical Applications

- Turbocharger actuators
- Turbocharger by-pass valves
- Turbocharger hoses
- CAC housings
- Exhaust gas recirculation systems
- Electronic controlled throttle valves
- Hot air ducts

Applications	Amodel® PPA	Ryton® PPS	KetaSpire® PEEK	Torlon® PAI	Tecnoflon® FKM
Turbocharger actuators	●	●	●	●	●
Turbocharger by-pass valves	●	●	●		●
Turbocharger hoses					●
CAC housings	●	●	●		●
Exhaust gas recirculation systems	●	●	●	●	●
Electronic controlled throttle valves	●	●	●		●
Hot air ducts	●	●	●		●

Amodel® PPA

Amodel® PPA retains its high mechanical properties up to 230 °C (446 °F) and offers excellent chemical resistance to acidic condensates to meet the requirement of next generation air induction system.

Ryton® PPS

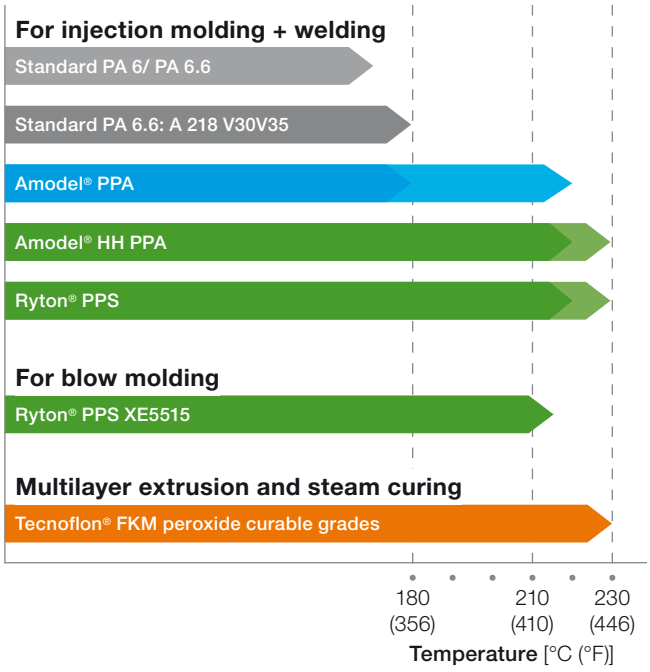
Ryton® PPS offer a unique combination of properties. Key properties include thermal stability, dimensional stability, chemical resistance and inherent flame retardancy.

KetaSpire® PEEK

KetaSpire® PEEK combines exceptional strength, stiffness, chemical resistance and fatigue resistance with continuous-use up to 240 °C (464 °F), enabling it to replace metal in some of the most severe end-use environments.

Tecnoflon® FKM (fluoroelastomers)

Tecnoflon® FKM offers a broad range of temperature resistance capabilities from –40 to 250 °C (–40 to 482 °F) at air section. Through our unique production technology, Tecnoflon® FKM eliminates costly processing steps, produces higher yields and increases cost efficiency.



Typical Properties for Air Induction Polymers

Grade	Tensile Strength [GPa]	Elongation [%]	Impact Strength [kJ/m²]	HDT [°C]	Density
Amodel® PPA					
A-1133 HS	13.4	2.5	9.5	280	1.48
AS-4145 HS	16.1	2.2	10.0	298	1.55
A-1145 HS	16.8	2.6	10.3	281	1.59
A-4133 HS	12.8	2.0	9.2	297	1.47
A-4145 HH	16.4	1.8	11.0	297	1.57
Ryton® PPS					
XE-5515	5.8	2.9	10.0	190	1.42

Grade	Mechanical Strength	Heat Resistance	Chemical Resistance	Dimensional Stability	Fatigue Resistance
Tecnoflon® FKM					
P 459/P 959	+++	+++	+++	+++	++
P 549L	+++	+++	+++	+++	+++
P 457/P 757	+++	+++	++	+++	++
PX 647	+++	+++	++	+++	+++
AEM	++	+	+	++	++
VMQ	–	++	–	+	+

+++ Excellent, ++ Very good, + Good, – Poor

Typical Applications

CAC Housing

- High heat resistance
- >50 % retention of mechanical strength after heat aging
- Chemical resistance to acidic condensates
- Weld-line strength (before/after heat aging)

EGR Valve

- Dimensional stability
- Low CLTE
- Heat resistance
- Chemical resistance

Turbocharger Hose

- Chemical resistance to acidic condensates
- High heat resistance
- High tear strength
- Fatigue resistance
- Silicone bonding
- Good processability

High Heat Amodel® PPA

Amodel® PPA offers excellent dimensional stability incorrosive, high temperature environments along with better fatigue and impact resistance, superior strength up to 230 °C (446 °F) exposure to hot air.

Key Features

- Retains mechanical properties in high heat
- Excellent resistance to acidic condensates
- Dimensional stability
- Good fatigue resistance

Typical Applications

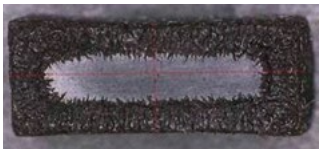
- CAC housings
- Throttle bodies
- EGR valves
- Hot air ducts

Structural Strength

A-4145 HH	High heat resistance, high mechanical strength, dimensional stability

Tensile bar cross section

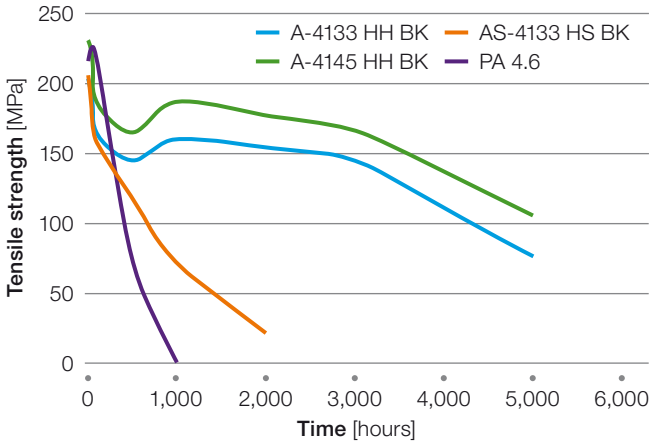
after 2,000 hours aging at 230 °C (446 °F)



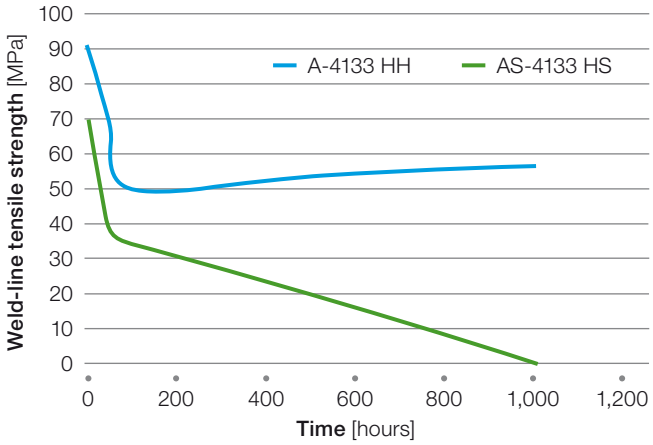
Amodel® PPA, AS grade

Amodel® PPA, HH grade

Retention of tensile strength at 230 °C (446 °F)



Retention of weld-line strength at 230 °C (446 °F)



Tecnoflon® FKM

Tecnoflon® FKM's unique polymerization technology makes it possible to meet requirements for excellent resistance to heat and chemicals. Only fluorinated elastomers can deliver this high level of performance.

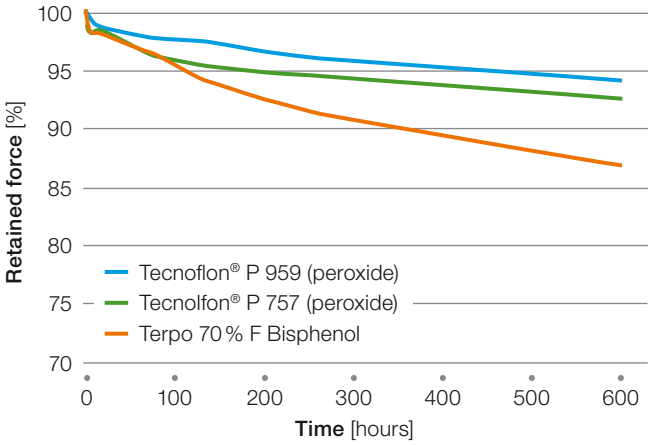
Key Features

- Resistance to conventional and bio fuels
- Engine and gear box oil resistance
- Resistance to engine coolants
- Outstanding range of thermal properties, from –45 to 250 °C (–49 to 482 °F)
- Long-term sealing, very low compression set

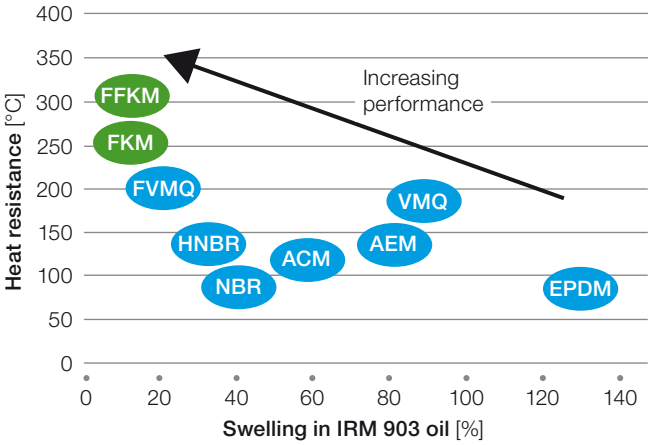
Typical Applications

- Gaskets
- Seals
- O-rings
- Fuel line hoses
- Turbocharger hoses

CSR retained force (F/F0) in total MA4 LUB at 150 °C (302 °F)



Rubber classification according to ASTM D2000



Tecnoflon® FKM grades

FOR 5312K	Medium-high viscosity copolymer, superior mold flow and release, high elongation and excellent hot tear strength. Suitable for compression molding of metal bonded and complicated shapes.
FOR 7380K	Medium-low viscosity molded goods terpolymer with superior rubber to metal bonding, good scorch safety and excellent hot tear strength.
P 459/P 959	Low and medium viscosity peroxide curable polymers with 70 % fluorine. Best-in-class for chemical and fuel resistance.
PL 458/PL 958	Low and medium viscosity peroxide curable polymers with 66 % fluorine with TR_{10} of –24 °C (–11 °F). Best-in-class for chemical and fuel resistance.
PL 455/PL 855	Low and medium viscosity peroxide curable polymers with 64 % fluorine with TR_{10} of –30 °C (–22 °F).
VPL 55540/VPL 85540	Low and medium-low viscosity peroxide curable grades with outstanding low temperature behavior (TR_{10} = –40 °C (–40 °F)) and chemical resistance. Easy processing and low fuel permeability.

Fuel and SCR Systems

The race to reduce evaporative emissions along with changes in fuel formulations have sparked a strong interest in higher performing plastics for use in automotive and other fuel burning engines.

Performance Advantages

- Ultra-low permeation
- Biodiesel and flex fuel compatibility
- Long-term fuel resistance from –40 to 125 °C (–40 to 257 °F)
- Continous use from 120 – 175 °C (248 – 347 °F)
- Electrostatic dissipation
- Resistance to automotive fluids, cleaners and road salts

Typical Applications

- SCR module housings and connectors
- Fuel flanges
- Rollover valves
- Quick connects
- Filter housings
- Fuel rails
- Fuel delivery modules
- Fuel hoses
- Fuel pumps

Application	Amodel® PPA	Ryton® PPS	KetaSpire® PEEK	Tecnoflon® FKM
SCR modules	●		●	
Fuel flanges	●	●		
Quick connects	●			●
Fuel rails	●			
Fuel hoses				●
Fuel pumps	●	●	●	●

Amodel® PPA

Amodel® PPA is compatible with a wide variety of fuel blends and thrives in the hotter, confined and stressed environments of today's down-sized engines.

Ryton® PPS

The chemical resistance of Ryton® PPS is exceptional, even at elevated temperatures. There are no known solvents below 200 °C (392 °F).

Tecnoflon® FKM

Tecnoflon® FKM's unique polymerization technology makes it possible to meet requirements for excellent resistance to heat and chemicals. Only fluorinated elastomers can deliver this high level of performance.

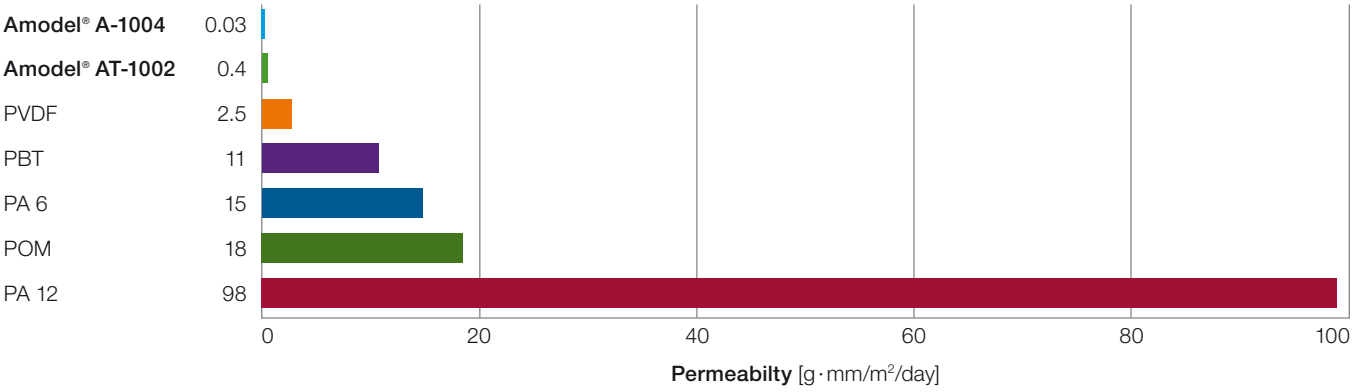
Superior Compatibility

The compatibility of Amodel® PPA with many current and potential future fuel blends was evaluated in extensive laboratory testing. This included exposure to bio-diesel, diesel, and diesel with aggressive water for 6,000 hours at 125 °C (257 °F) (to simulate under-the-hood conditions) and exposure to fuel C, flex fuels, and auto-oxidized fuels for 5,000 hours at 60 °C (140 °F) (to simulate fuel tank conditions).

Amodel® PPA showed low weight gain, little dimensional change, and excellent retention of mechanical properties over the range of fuels and temperatures evaluated.

Average permeability rates over 28 days

CE10 Fuel (90 % Fuel C, 10 % Ethanol) at 60 °C (140 °F)



Chemical resistance

Chemical	Test Conditions	Amodel® AT-1002	POM	PA 6.6
Hydrochloric acid, 5–10 %	23 °C (74 °F), 1,000 hrs	Excellent	Poor	Poor
Hydrofluoric acid, 1–5 %	23 °C (74 °F), 1,000 hrs	Good	Poor	Poor
Nitric acid, 5–10 %	23 °C (74 °F), 1,000 hrs	Excellent	Poor	Poor
Sulfuric acid, 5–10 %	23 °C (74 °F), 1,000 hrs	Excellent	Poor	Good
Sulfuric acid, 30–36 %	23 °C (74 °F), 1,000 hrs	Excellent	Poor	Poor
Sulfuric acid, 30–36 %	40 °C (104 °F), 200 hrs	Excellent	Poor	Poor
Zinc chloride, 50 %	23 °C (74 °F), 200 hrs	Excellent	Poor	Poor

Excellent: >85 % retention of tensile strength, no chemical attack and no stress cracking
Good: >50 % retention of tensile strength, no chemical attack and no stress cracking
Poor: chemical attack and stress cracking

Grade	Mechanical Strength	Heat Resistance	Fuel Resistance	Fuel Permeability	Fatigue Resistance
Tecnoflon® FKM					
P 459/P 959	+++	+++	+++	+++	–
FOR 4391	++	+++	+++	+++	–
VPL 85540	++	+++	+++	+++	+++
PL 855	+++	+++	++	+	++
AEM	++	+	+	N/A	++
VMQ	–	++	–	–	+++

+++ Excellent, **++** Very good, **+** Good, **–** Poor, **N/A** Not applicable

Typical Applications

Fuel Injector O-rings

- Excellent low temperature resistance
- Outstanding chemical resistance
- Excellent C-set and sealing force retention
- Outstanding processability
- Excellent tear strength at high temperature

Available Grades

VPL 85730/VPL 45730	TR_{10} –30 °C (–22 °F)
VPL 45535	TR_{10} –35 °C (–31 °F)
VPL 85540/VPL 55540	TR_{10} –40 °C (–40 °F)

Fuel Hose

- Excellent fuel/bio-fuel resistance
- Lowest fuel permeation rate
- Extrusion processing
- Fatigue resistance
- ECO bonding
- Good mechanical properties

Available Grades

P 959/P 459 70 % fluorine	Best fuel/bio-fuel resistance

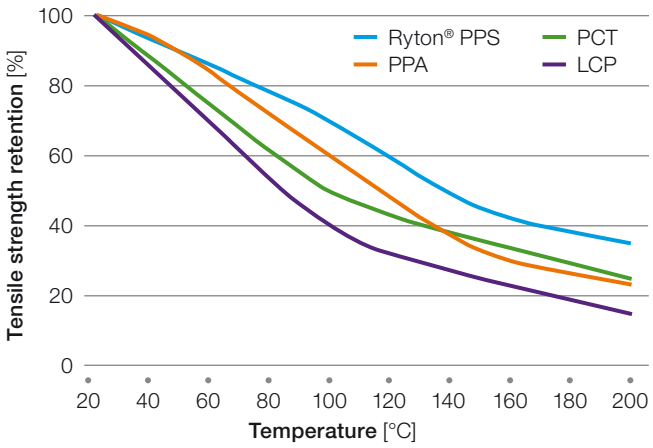
Ryton® PPS

Ryton® PPS compounds offer an unique combination of properties and a cost/performance balance unmatched by other engineering thermoplastics. Key properties include thermal stability, dimensional stability, chemical resistance and inherent flame retardancy.

Performance Advantages

- Long term heat resistance up to 200 °C
- Mold complex parts with tight tolerances
- Low to no moisture absorption
- Broad chemical resistance
- Inherent flame retardancy

Performance at high temperature



Ryton® PPS melt-processable grades

Glass Fiber and Mineral Filled Compounds

BR111/ BR111BL	Creep resistance, high modulus, dimensional stability
R-7-120BL/ R-7-120NA	Arc resistance, dimensional stability
R-7-220BL	Hydrolytic stability, creep resistance, high modulus, dimensional stability

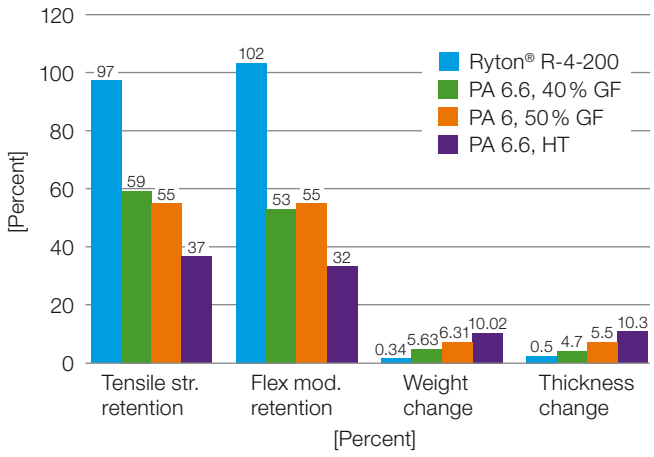
40% Glass Fiber Reinforced Compounds

BR42B	Low friction, high wear resistance
R-4-200BL/ R-4-200NA	Enhanced strength and toughness
R-4-220BL/ R-4-220NA	Exceptional resistance to hot water and engine coolants
R-4-230BL/ R-4-230NA	Low flash, high flow, good strength

Alloy Compounds

XE4050BL	High impact strength, good thermal stability
XE5030BL	High impact strength, high flow, good thermal stability
XE5515BL	Blow molding and extrusion
XK2340	High strength, exceptionally high flow, precision molding

Immersion in M30 fuel at 60 °C (140 °F), 2,000 h
(M30: 30 % methanol fuel)



Electronics and Lighting

Increased system complexity, higher operating and processing temperatures, reduced weight allowances, and over-crowded engines have made material selection a critical factor. Solvay's broad selection of high-performance plastics can help you meet these challenges.

Performance Advantages

- High strength and stiffness for good pin retention
- Withstands SMT processing up to 280 °C (536 °F)
- Low moisture absorption prevents blistering
- High flow for thin-wall designs
- Continuous use from –40 to 240 °C (–40 to 464 °F) for 5,000 hours
- Excellent electrical insulating properties
- Excellent dimensional stability

Typical Applications

- Motor end caps
- Sensors
- ECU housings
- Bobbins and solenoids
- Connectors
- Circuit protection/relays
- Actuator housings
- Li-Ion battery systems
- Fuse boxes

Application	Ixef® PARA	Amodel® PPA	Ryton® PPS	Veradel® PESU	Udel® PSU	KetaSpire® PEEK
Motor end caps		●	●			●
Sensors		●	●	●	●	●
ECU housings		●	●			●
Bobbins and solenoids		●	●	●	●	●
Connectors	●	●	●		●	●
Actuator housings	●	●				●
Li-Ion battery systems	●	●				●
Fuse boxes				●	●	●

Amodel® PPA

Amodel® PPA is compatible with lead-free surface-mount technology (SMT) processing and highly resistant to many commonly used electronic cleaning agents, fuels and automotive fluids. Grades with high strength and high elongation are well-suited for snap-fit designs.

Ryton® PPS

Due to the inherent thermal stability of PPS, the dielectric properties of Ryton® PPS compounds remain stable over a wide range of temperatures and frequencies.

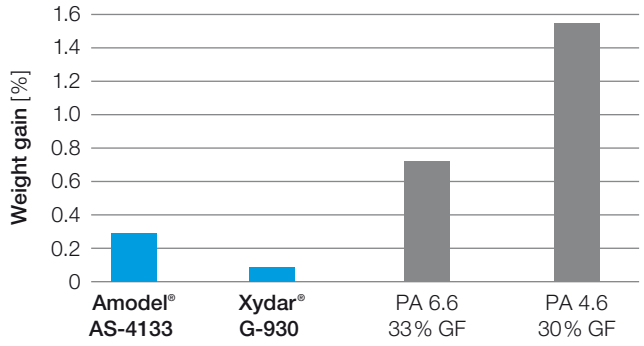
Udel® PSU and Veradel® PESU (polysulfone and polyethersulfone)

Sulfone polymers retain their mechanical strength in some of the toughest environments. Unfilled grades offer excellent ductility and are available in a range of transparent colors. Udel® PSU has an HDT of 174 °C (345 °F) and provides excellent dimensional and hydrolytic stability. Veradel® PESU has an HDT of 204 °C (399 °F) and offers better chemical resistance than Udel® PSU resins.

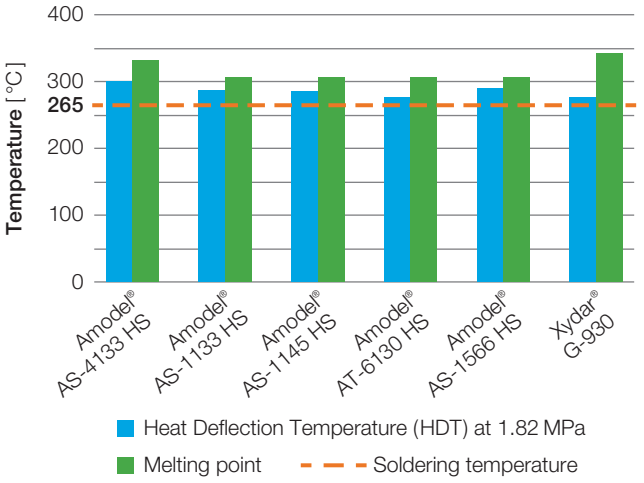
Lower Moisture Prevents Blistering

Blistering is primarily caused by water vaporizing during SMT processing. Amodel® PPA absorbs significantly less moisture than standard polyamides, making it an excellent candidate for SMT processing up to 280 °C (536 °F).

Water absorption



Reliable high-temperature performance



Better Mechanical Properties and Faster Cycle Times

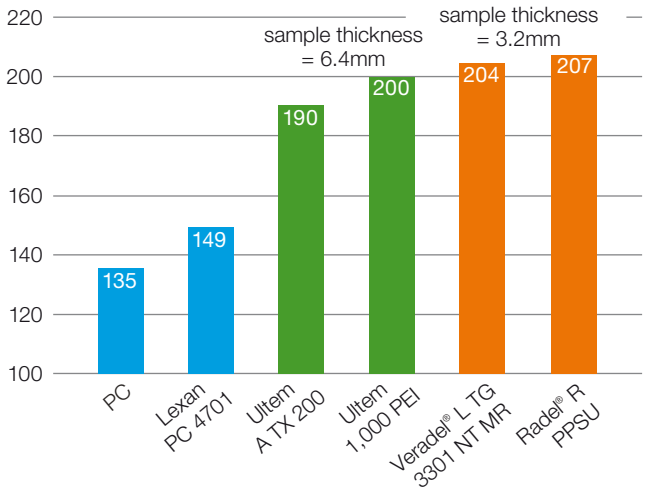
Amodel® PPA delivers strength, toughness and impact resistance along with low moisture absorption, high HDT and faster injection molding cycle times.

One-minute solder dip test

Polymer	250 °C (482 °F)	260 °C (500 °F)	270 °C (518 °F)	280 °C (536 °F)
Amodel® PPA	OK	OK	OK	OK
Xydar® LCP	OK	OK	OK	OK
Ryton® PPS	OK	OK	OK	OK
PCT	OK	Blisters	Blisters	Blisters
PA 4.6	OK	Blisters	Blisters	Blisters

Test bars conditioned at 23 °C (74 °F) in 50 % relative humidity for 48 hours.

Heat deflection temperature



Veradel® has better thermal performance in lower thickness.

Typical Applications

Motor End Cap

- Flatness
- Dimensional stability
- Thermal cycling from –40 to 150 °C (–40 to 302 °F)
- 1,000 hrs/180 °C (356 °F) heat aging
- Resistant to road salt
- Creep resistant
- 30 % weight reduction

ECU Housing

- USCAR PF1 Class 4
- Balance of strength and toughness
- High dielectric strength
- High comparative tracking index
- Excellent insulating capability
- Compatible with lead-free soldering reflow
- High temperature resistant to 190 °C (374 °F)

Lighting

- High heat resistance
- Class A surface finish
- Inherently flame retardant
- Platable

Amodel® AE Grades

Eliminates Corrosion of Metal Inserts

Sensors, solenoids and connectors use molded components that are in direct contact with conductive metal inserts. Traditional CuI/KI heat stabilizers in polyamides can sensitize an application to galvanic corrosion and ionic migration which can cause the failure mode of intermittent, erratic or loss of component electrical function. AE grades eliminate this sensitivity.

Components made from products in the Amodel® AE-8900 series provide high-voltage resistance and retain dielectric properties at elevated temperatures. They also extend the performance envelope beyond the Amodel® AE-1100 and AE-4100 series by delivering greater resistance to automotive fluids, enhanced thermal properties, higher mechanical strength and lower moisture absorption.

Reduces Ionic Migration

Ionic migration is an electrochemical process where metal on an insulating material in high humidity and under an applied electric field leaves its initial location in ionic form and re-deposits somewhere else. Such migration can reduce isolation gaps and ultimately lead to an electrical short circuit.

Solves Galvanic Corrosion

Galvanic corrosion is an electrochemical process in which one metal corrodes preferentially to another when both metals are in electrical contact, in the presence of an electrolyte. It is similar to ionic migration without needing an electrical field. This type of corrosion can lead to loss of electrical performance.

Performance Advantages

- Solution for miniaturization and high pin densities
- Water moldable to “Green” option
- Excellent dielectric performance of 600V CTI at 150 °C (302 °F)
- Suitable for lead-free soldering
- High HDT, blister free, dimensional stability

Amodel® AE Grades

AE-4133

- Hot-water moldable
- Fast cycling
- High HDT for soldering process

AE-89xx series

- Highest retention of mechanical properties
- Best retention of dielectric properties at 150 °C (302 °F)

Transmissions and Launch Devices

Smaller, more complex transmissions must deliver higher performance and better fuel economy, yet cost less to manufacture. Solvay's broad selection of high-performance plastics can help you meet these challenges.

Better than Metal

- Light weight for improved fuel efficiency
- Parts consolidation for lower manufacturing and assembly costs
- Noise and vibration dampening
- Compatible with transmission fluids
- Abrasion and corrosion resistance
- High-temperature wear resistance in dry and lubricated environments

Transmission & Launch Devices

- Dual clutch (DCT)
- Automated manual (AMT)
- Continuously variable (CVT)
- Automatic (AT)
- Torque convertor
- Dual mass flywheel
- Power takeoff
- Clutch cylinder

Application	Ixef® PARA	Amodel® PPA	Ryton® PPS	KetaSpire® PEEK	AvaSpire® PAEK	Torlon® PAI	Tecnoflon® FKM
Thrust washers		●	●	●	●	●	
Seal rings				●		●	●
Check balls				●		●	
Shift forks		●		●	●	●	
Bearing cages		●		●	●		
Hydraulic pistons		●	●	●	●		
Shaft seals				●			●
Bonded pistons	●						●
Clutch cylinders	●	●					

Torlon® PAI (polyamide-imide)

Torlon® PAI provides exceptional wear resistance in both dry and lubricated environments and retains its toughness, high strength and high stiffness up to 275 °C (525 °F). It exhibits outstanding creep and chemical resistance – including strong acids and most organics – and is ideally suited for harsh environments.

KetaSpire® PEEK

KetaSpire® PEEK combines exceptional strength, stiffness, chemical resistance and fatigue resistance with continuous-use up to 240 °C (464 °F), enabling it to replace metal in some of the most severe end-use environments.

Tecnoflon® FKM

Tecnoflon® FKM offers a broad range of temperature resistance capabilities from –40 to 250 °C (–40 to 482 °F) at air section. Through our unique production technology, Tecnoflon® FKM eliminates costly processing steps, produces higher yields and increases cost efficiency.

Amodel® PPA

Amodel® PPA is stronger, stiffer and has higher thermal capabilities than standard nylons. It is less sensitive to moisture and retains excellent mechanical properties – including fatigue and creep resistance – when exposed to a wide range of operating temperatures, high humidity and aggressive chemicals.

Wear-resistant Polymers for Transmissions and Launch Devices

		Dry	Lubricated	Seal Rings	Thrust Washers	Check Balls
Torlon® PAI						
4203L	Unfilled, high elongation	–	●	● *Small rings, high elongation*	● *High lubrication*	● *Compressive properties*
4301	High compressive strength	●	●	●	●	
4275	Designed for high speeds	●	●	● *Best balance of properties*	●	
4630	Excellent wear resistance	● *Best performance at high velocity, low pressure*	●	●	●	
4645	Excellent wear resistance		● *Best performance at high velocity, low pressure*	●	●	
KetaSpire® PEEK						
KT-820 SL31	Very good wear resistance	●	●	●	●	
KT-820 SL45	Very good wear resistance		●	●	●	
AvaSpire® PAEK						
AV-755 SL45	Very good wear resistance, more cost effective than PEEK		●	●	● *Large rings*	
Amodel® PPA						
AT-6130 HS	Good wear resistance, most cost effective		●		●	

Typical Applications

Seal Rings

- Excellent sealing and conformability
- High ductility for easier installation of small rings
- Molded-in joint geometries provide cost savings
- Excellent wear properties in dry and lubricated environments

Thrust Washers, Thrust Bearings, Needle Bearing Replacements

- Low creep
- High compressive strength
- Low coefficient of friction
- Excellent wear properties in dry and lubricated environments
- Suitable for very high pressures and velocities
- Molded-in oil grooves eliminate secondary machining costs

Check Balls

- Excellent sealing and conformability
- High compressive strength
- Low creep
- Lighter than metal for quicker response
- Non-destructive to metal seat
- Noise reduction

Torlon® PAI

Torlon® PAI offers the highest strength and stiffness of any thermoplastic up to 275 °C (527 °F). Its outstanding wear, creep and chemical resistance make it ideal for severe service environments.

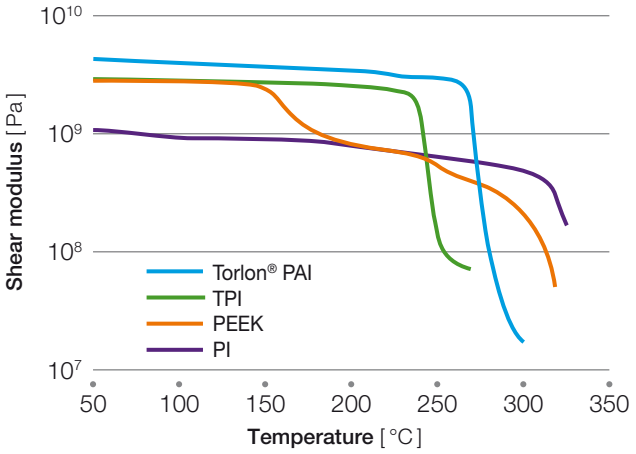
Key Features

- Very high strength and stiffness to 275 °C (527 °F)
- Superior toughness from cryogenic to 275 °C (527 °F)
- Exceptional wear resistance
- Resistant to strong acids and most organics
- Inherent flame resistance
- Low CLTE

High-strength grades deliver metal-like performance and are routinely specified for precision components used in repetitive-use, load-bearing operations. Glass fiber and carbon fiber filled grades retain their strength and stiffness at high temperatures with the added benefit of low creep and excellent fatigue resistance.

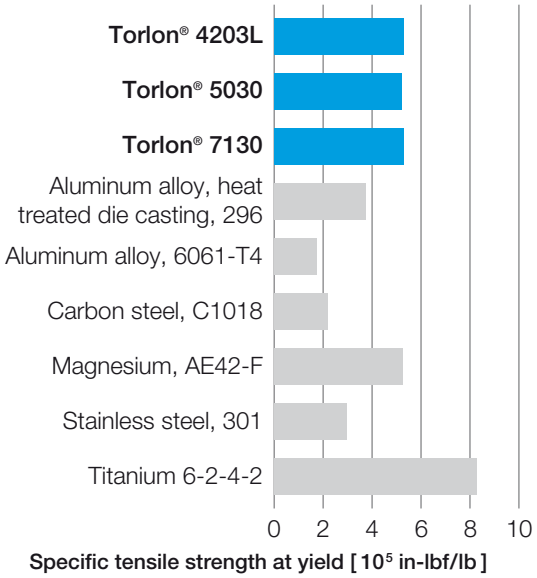
Wear-resistant grades offer select combinations of mechanical and tribological properties. Their inherent heat and chemical resistance, makes them an effective alternative to metal in high-temperature friction and wear applications – even when lubrication is marginal or non-existent. Select grades can perform in lubricated environments at exceptionally high pressures and velocities (PV).

Mechanical performance at high temperature(1)

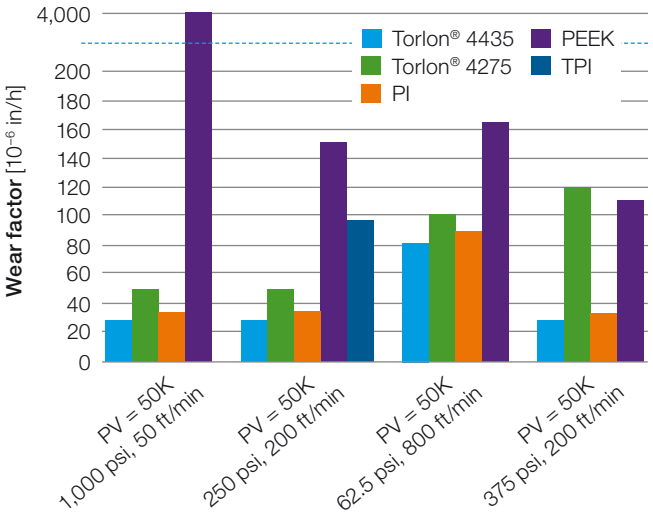


(1)Data generated by Dynamic Mechanical Thermal Analysis (DMTA).

Specific tensile strength comparison to metal



Torlon® PAI vs. other wear-resistant polymers



Traction Motors and Power Electronics

Hybrids, Plug in Hybrids, Battery Electric Vehicle, Fuel Cell Vehicles

As the most critical component of electrified powertrain in electric vehicles, lithium-ion batteries are the key for the xEV performance. A safe, robust battery (module) pack can help ensure the safety and durability of the xEVs.

Improved Battery Performance

- Higher energy density for better mileage
- Higher power density to achieve excellent drivability and fast charge
- Longer lasting to extend vehicle's service life
- Safer under critical operation conditions

Durable and Safe Battery packs

- Outstanding mechanical properties
- High safety under extreme conditions
- Efficient cooling system of packs
- Light weight

Application	Amodel® PPA	Solef® PVDF	Galden® PFPE
Binders for electrodes		●	
Separator coatings		●	
Battery pack casings	●		
Battery pack cooling systems			●

Solef® PVDF (polyvinylidene fluoride)

Binders for Electrodes

Solef® PVDF provides the outstanding binding function among the electrode active materials as well as with the current collecting substrate, which can be realized by only very low usage amount. Very high electrochemical stability up to 5V due to its exceptional chemical stability.

Separator Coatings

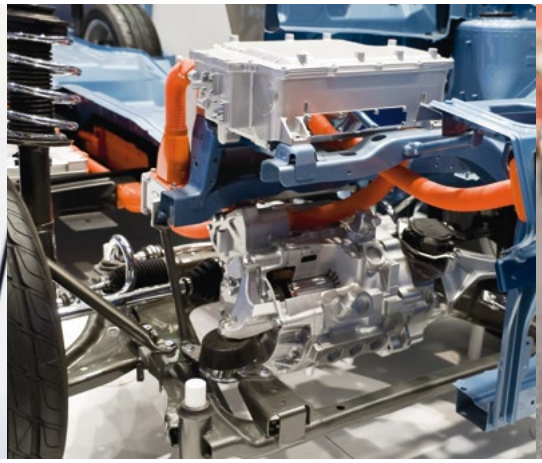
Both suspension and emulsion grades of Solef® PVDF provide excellent adhesion and pore forming properties with or without ceramic on various separator substrate. It also provides remarkable chemical resistance in electrolytes and high electrochemical stability at high voltage.

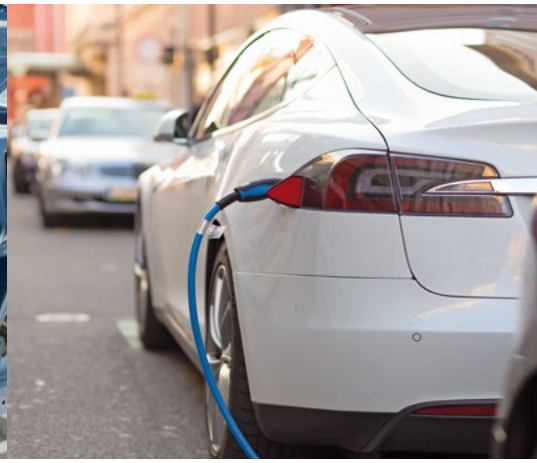
Amodel® PPA

Amodel® PPA is stronger, stiffer and has higher thermal capabilities than standard nylons. It is less sensitive to moisture and retains excellent mechanical properties – including fatigue and creep resistance – when exposed to wide range of operating temperatures, high humidity and aggressive chemicals.

Galden® PFPE (perfluoropolyether)

Galden® PFPE is an inert, dielectric, high-performance heat transfer fluid that allows precise control of the battery pack temperature.





Solef® PVDF Binders for Durable, High Performance Batteries

Adding a small amount of Solef® PVDF can significantly improve battery pack performance while reducing cost. A reduction of binder concentration that corresponds to higher amount of active material will reduce cost at the cell level which translates to a significant savings on the EV battery pack. Cost savings are realized by both battery relative capacity and increased lifetime. Solvay is using its in-depth knowledge of fluoromaterials to increase the stability and lifetime of these polymeric binders to the Li-Ion cells.

Solef® 5130 and Solef® 5120 are third generation binders that combine high adhesion and good processability for increased battery performance.

Solvay is the only PVDF supplier that uses both emulsion and suspension polymerization technologies, thereby producing a broader PVDF portfolio for anode, cathode and separator applications in Li-Ion batteries.

PVDF grades for binder

Solef® 6010	PVDF standard homopolymer	Standard for cathode and anode	1st Generation
Solef® 6020	PVDF homopolymer with high MW	Improved binder for cathode and anode	2nd Generation
Solef® 5130	Modified PVDF, high viscosity	New grade for cathode and anode with highest performances	3rd Generation
Solef® 21216	PVDF-HFP flexible copolymer	Acetone-based processing, high thickness electrodes	Flexible Binder
Solef® Flex PVDF	Experimental PVDF-based material	Flexible electrodes, conformable (shaped) cells	Flexible Binder, High Adhesion
Solef® 5120	Modified PVDF, medium viscosity	New grade for cathode and anode with high performance	

Solef® PVDF for High-Performance, Safe Separators

To reinforce the safety and the performance of the Li-Ion batteries, surface coatings with ceramics have become more popular in the industry, especially for xEVs.

Solvay provides various grades of Solef® PVDF based on our expertise in fluorinated polymers and in-depth knowledge of separator coatings.

Solef® PVDF's intrinsic chemical/electrochemical stability combined with Solvay's cutting edge technology ensures the excellent adhesion and cohesion among ceramic particles and separator substrates. The coated layers containing ceramic particles promote battery safety in critical conditions, especially at high temperatures. They also improve overall power performance and extend product life thanks to the laminating effects with electrodes.

Both suspension and emulsion grades of Solef® PVDF can be supplied to the customers to comply with different processing conditions, technologies and specific requirements.

Amodel® PPA and Galden® PFPE for Electric Vehicle Battery Packs

Amodel® PPA is a lightweight alternative to metal that withstands the harsh operating conditions of xEV battery packs. The material's high thermal stability makes it particularly suited for thermal insulation between inside and outside the packs. Its broad chemical resistance provides extra protection in extreme conditions, such as leakage of carbonate-based electrolytes.

Thermal management is a critical requirement for battery packs, enabling them to work safely and efficiently in confined, high heat conditions. Liquid cooling systems, which are today's most efficient battery pack cooling systems, benefit from Galden® PFPE's high thermal conductivity, low electrical conductivity, low viscosity and broad chemical resistance. PFPE also enables OEMs to precisely control the operating temperature within the battery pack.

Structural and Semi-Structural Lightweighting

Solvay's Long Fiber Thermoplastics (LFT) products target challenging metal replacement applications and semi-structural applications, opening new opportunities in terms of weight reduction, function integration and per part costs.

Exceptional performances of LFT products result from the creation of a unique 3-D entangled long glass fiber skeleton inside the molded part. Solvay's LFT compounds differ by the type of polymer resin used as well as the quantity of fiber reinforcement. They are available under the brands **Omnix® LF, Amodel® LF, Ixef® LF and Ryton® LF.**

Performance Advantages

- Combination of high stiffness and outstanding impact strength
- Excellent retention of mechanical performance at high temperature
- Extremely low tendency to creep under high permanent loading
- Outstanding fatigue resistance
- Isotropic mold shrinkage
- High dimensional stability/low warpage
- High shear strength and high burst pressure
- Excellent surface finish

Typical Applications

- Gears and bearings
- Sunroofs
- Brackets and mounts
- Electrical battery housings
- Thermal management components
- Braking system elements
- Pump and EGR systems

Application	Ixef® LF PARA	Amodel® LF PPA	Ryton® LF PPS	Omnix® LF HPPA
Gears & bearings	●	●	●	●
Sunroofs	●	●	●	●
Electrical battery housings		●	●	
Thermal management		●	●	
Pump and EGR systems		●	●	

Typical Applications

Gear

- Isotropic behavior and dimensional stability
- Wear performance
- Low noise generation
- High stiffness in a wide T range
- Fatigue performance

Sunroof

- High strength and stiffness
- Dimensional stability
- Fatigue resistance

BMW M4 GTS Hood

- Rapid cure thermoset resin system SolvaLite™ 760
- DMA E' onset T_g of 135 °C
- Superior toughness
- Successful head impact crash and functional tests
- 40 % weight reduction over traditional materials
- Class-A finish
- Compatible with existing metal stamping assets for composite production

SOLVAY

asking more from chemistry®

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