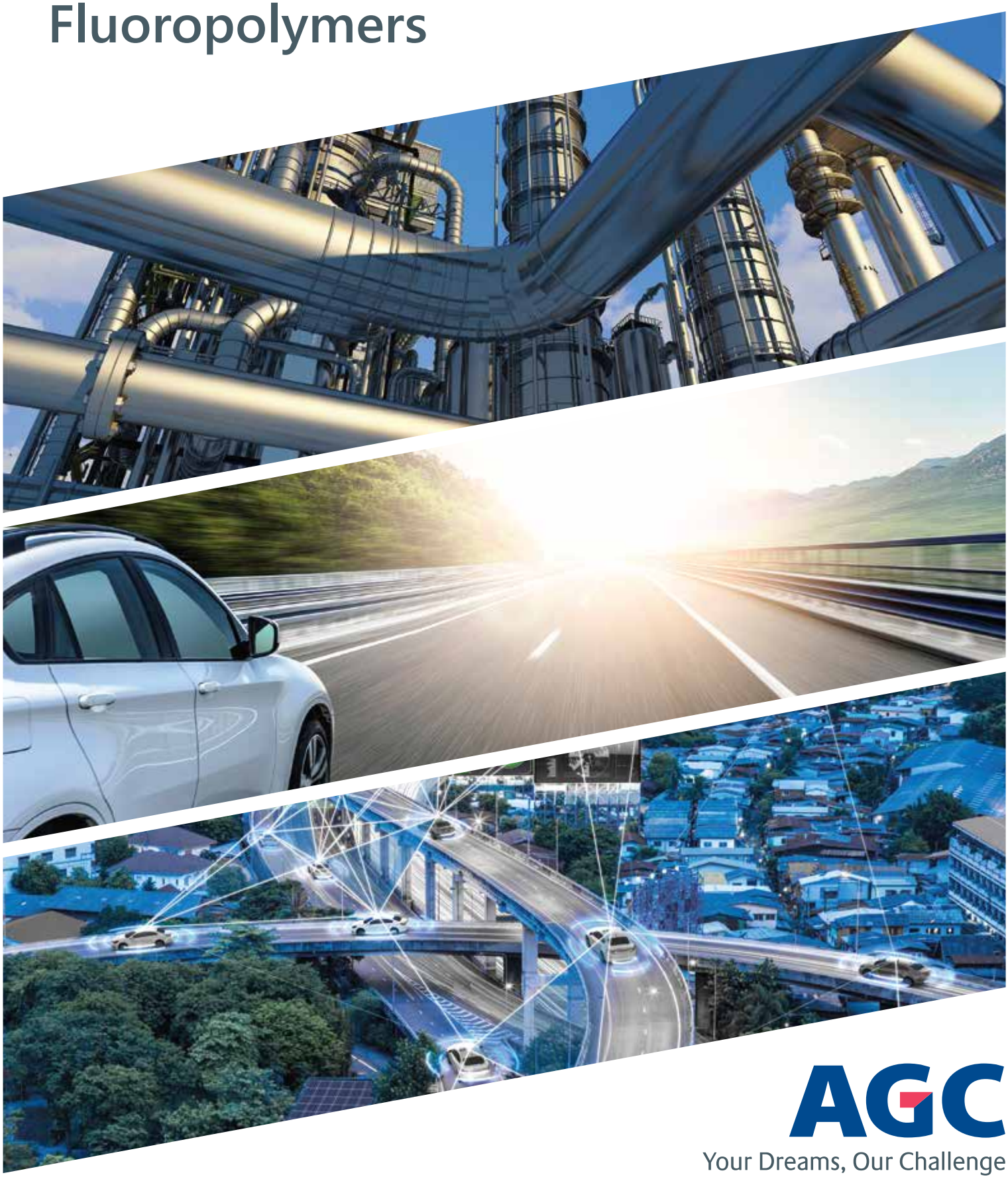
Fluon®

High Performance Fluoropolymers

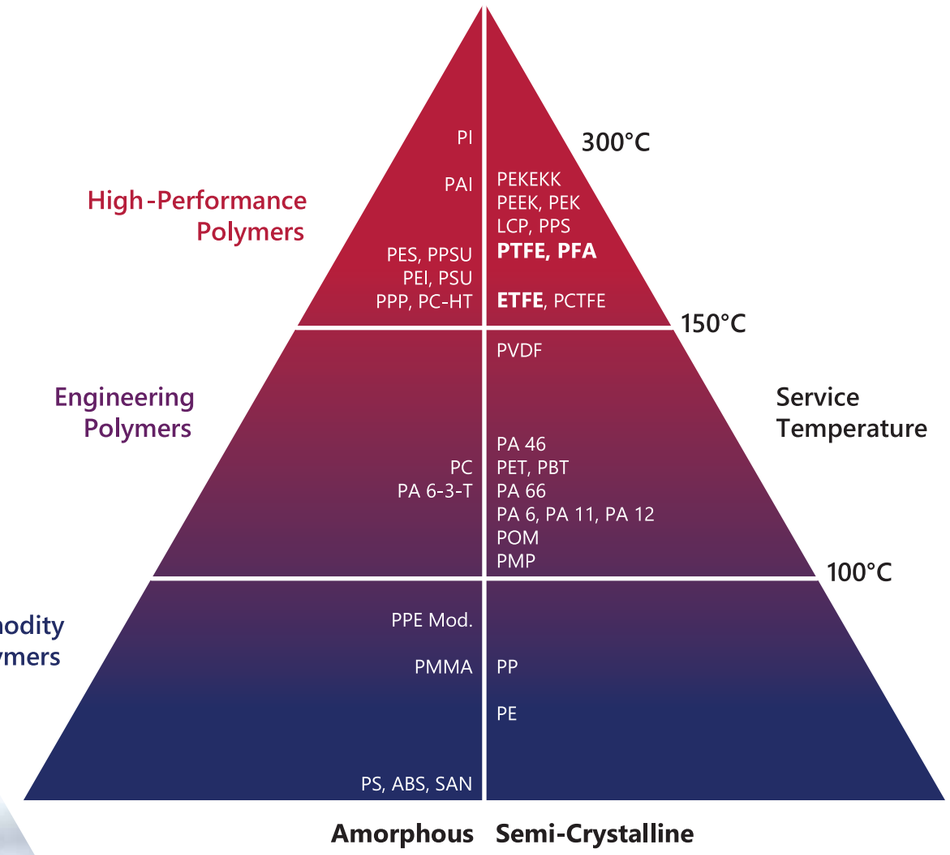


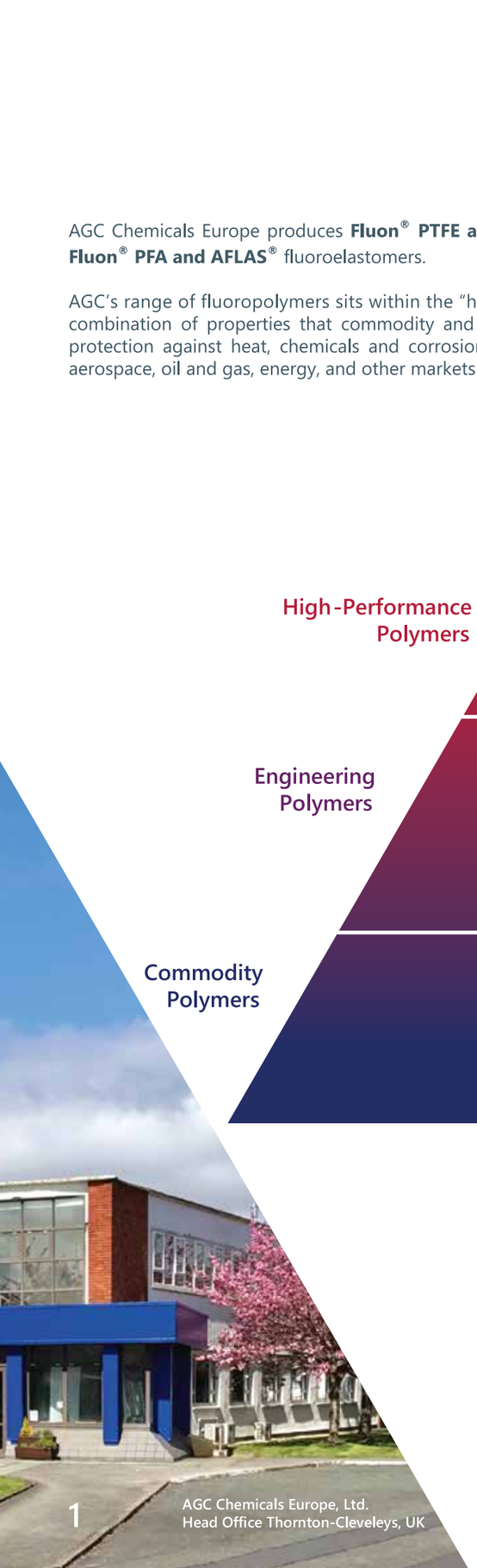
AGC

Your Dreams, Our Challenge

AGC Chemicals Europe produces **Fluon® PTFE and Fluon® ETFE** and markets other fluorinated products, including **Fluon® PFA and AFLAS®** fluoroelastomers.

AGC's range of fluoropolymers sits within the "high-performance" region of the polymer triangle since they offer a combination of properties that commodity and engineering polymers cannot. The product range offers excellent protection against heat, chemicals and corrosion, and has a broad base of applications in industrial, automotive, aerospace, oil and gas, energy, and other markets where long-lasting high performance is necessary.





AGC Chemicals Europe, Ltd.
Head Office Thornton-Cleveleys, UK

The table below provides a list of typical properties of the three fluoropolymer types that AGC manufactures. Values are general and vary depending on the specific grade of material. These should only be used as an approximate guide.

Mechanical Properties	Units	PTFE	PFA	ETFE
Specific Gravity		2.1 – 2.2	2.1 – 2.2	1.73 – 1.75
Tensile Strength	MPa	20 – 39	20 – 39	40 – 54
Elongation	%	230 – 600	340 – 400	350 – 450
Flexural Modulus	MPa	400 – 600	530 – 630	850 – 1000
Flex Life (MIT)	cycles	> 10^6	1.8 – 50 x 10^4	10 – 30 x 10^3
Impact Strength	J/m	180	no break	no break
Hardness	Rockwell	18 – 20	50	50 – 58
Dynamic Coefficient of Friction	<3 m/min	0.09	0.20	0.20
Thermal Properties				
Melting Point	°C	327	305	260
Upper Service Temperature (20,000h)	°C	260	260	150
Linear Thermal Expansion Coefficient	10^{-5}/°C	9 – 11	11 – 13	9 – 14
Heat Distortion Temperature 4.6 kg/cm²	°C	120	70	80
Heat Distortion Temperature 18.5 kg/cm²	°C	50	50	50
UL94 Flame Rating		V-0	V-0	V-0
Limiting Oxygen Index	%	> 95	> 95	30 – 36
Heat of Combustion	MJ/kg	5.1	5.3	13.7
Electrical Properties				
Dielectric Constant	1 MHz	2.1	2.1	2.6
Dissipation Factor	1 MHz	< 0.0001	0.0001	0.007
Arc Resistance	sec	> 300	> 180	122
Volume Resistivity	ohm.cm	> 10^{18}	> 10^{18}	> 10^{17}
Surface Resistivity	ohm/sq	> 10^{18}	> 10^{17}	> 10^{15}
General Properties				
Weather Resistance (Florida Exposure)	Years unaffected	20	10	15
Chemical / Solvent Resistance		excellent	excellent	excellent
Water Absorption	%	< 0.01	< 0.03	< 0.03

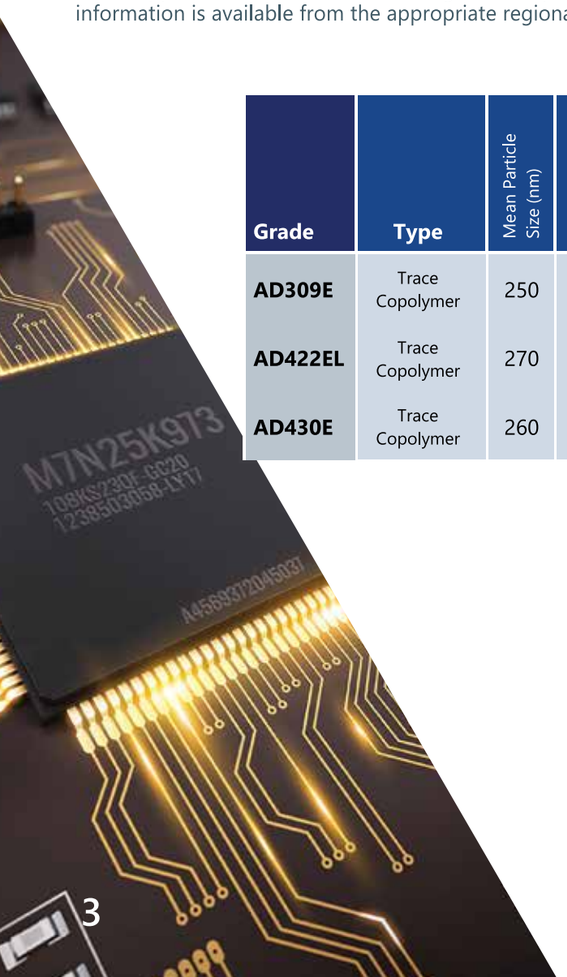
Polytetrafluoroethylene (PTFE) is a synthetic fluoropolymer used globally in thousands of applications ranging from industrial to surgical uses.

AGC Chemicals manufactures **Fluon® PTFE**, which offers exceptional performance in:

- Chemical resistance and inertness
- High service temperature resistance, up to 260°C (500°F)
- Cryogenic temperature flexibility, down to -200°C (-420°F)
- Electrical insulation
- Water and oil repellence
- Low friction
- Non-stick
- UV resistance
- No aging

High performance **Fluon® Aqueous Dispersions**, which are milky white dispersions of PTFE particles in water, stabilised by wetting agents, have been developed for use as a base coat, binder and top coat applications. They are also used to coat metal, impregnate glasscloth and fabric, as well as packings, and for coagulation withpigments or fillers for use in applications such as filled bearings. The dispersion product range is under continuous development and the latest information is available from the appropriate regional sales office.

Grade	Type	Mean Particle Size (nm)	Critical Film Thickness (µm)	Surfactant Type	Surfactant Content (wt% on PTFE)	Solids content (% PTFE)	Viscosity at 23°C (cP)	Applications
AD309E	Trace Copolymer	250	20	non-ionic	5.5	60	15	Fibre coating, glass cloth, aramid, and impregnation
AD422EL	Trace Copolymer	270	10	non-ionic	6.0	59	15	Metal coating
AD430E	Trace Copolymer	260	15	non-ionic	6.0	59	15	Impregnation and metal coating



Fluon® Coagulated Dispersions, also known as “fine powder”, have been developed for paste extrusion into pressure hoses (e.g. hydraulic systems), tubes, pipe liners, electrical wire insulation and tape. Fluon® CD grades are also used to make filtration membranes and technical fibres for textiles and industrial applications.

Grade	SSG	Extrusion Pressure (MPa)*	Mean Particle Size (µm)	Reduction Ratio Range	Bulk Density (g/l)	Applications
Trace Copolymer						
CD086EL	2.15	28	475	100 – 500:1	470	High performance hose, gaskets
CD086EH	2.15	35	475	100 – 500:1	470	High performance hose, gaskets
CD090E	2.19	40	600	400 – 4000:1	500	Wire coating, small-diameter transparent tubing
CD097E	2.18	34	580	100 – 4000:1	510	Wire coating, heat shrink tubing
Homopolymer						
CD122E	2.16	50	500	15 – 300:1	545	Electrical tape, fibres, large-diameter pipeliners
CD123E	2.16	43	530	15 – 300:1	545	Electrical tape, medium-diameter pipeliners
CD127E	2.16	35	530	25 – 400:1	545	Electrical tape, small-diameter pipeliners
CD141E	2.18	30	550	25 – 700:1	570	Low-density threadseal tape, tube, anti-drip additives for thermoplastics

** Extrusion Pressure is measured in accordance with ISO 12086-2*
Reduction ratio is 1600:1 for CD090E and CD097E; for all other CD grades it is 400:1

Fluon® Granular PTFE is used in the form of pre-sintered powder for ram extrusion, as a feedstock for filled compounds, and in theform of non-free-flow powder for moulding various products and stock shapes, such as tubes, rod and sheet where high mechanical and electrical performance are required.

Grade	Type	Bulk Density (g/l)	Mean Particle Size (µm)	Preform Pressure (MPa)	Shrinkage (%)	Ultimate Tensile Strength (MPa)	Elongation to Break (%)	Applications
G163	Fine powder	325	37	16	5	40	380	Blending with fillers Billets for skived tape
G201	Presintered for extrusion	650	600	extrusion only	12	22	330	Ram extrusion of small sections

Fluon® Lubricant Micropowders are manufactured from virgin PTFE feedstock and are used either as dry lubricants or as additives in other materials such as plastic compounds, rubbers, fluoroelastomers, inks, paint, oils and greases. They also give enhanced lubricity, non-stick properties and reduce friction, all of which are important in a wide range of applications.

Applications

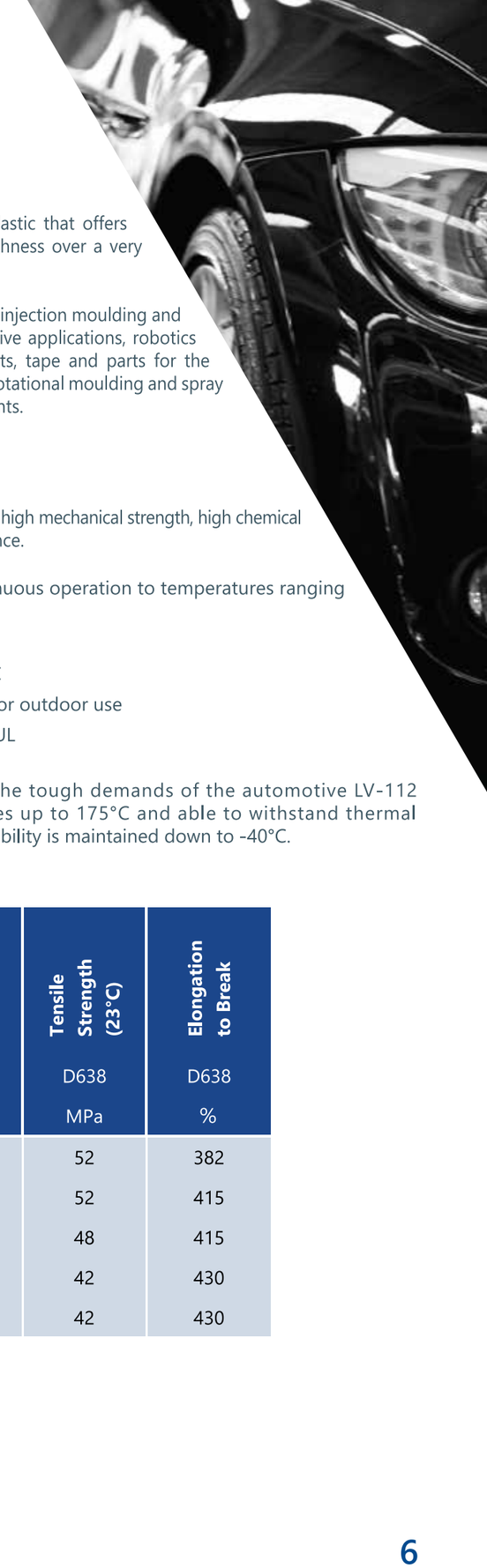
- Additive in gravure and flexographic printing inks
- General purpose lubricant
- Friction reducing additive in thermoplastics
- Modifier in industrial oils and greases
- Food contact coatings

Grade	Bulk Density (g/l)	Particle Size – Laser Diffraction D50 (µm)	Surface Area (m^2/g)	FDA Composition Approval	Thermoplastics	Elastomers	Oils and Greases	Inks and Industrial Finishes	General Purpose	Notes
FL1650Z	440	40	1.5	yes	✓	✓				High thermal stability
FL1690Z	440	40	1.5	yes	✓	✓			✓	High thermal stability
FL1700Z	570	15	7	no		✓	✓	✓		Friable to sub-micron
FL1700HTZ	620	18	6.5	yes			✓†			
FL1710Z	500	5	4	no				✓		
FL1730HZ	480	4	4	no				✓		

† *FL1700HTZ is specifically designed to be used in drinking water applications*

All **Fluon® PTFE grades** are manufactured without the use of perfluorooctanoic acid (PFOA) and its salts. PTFE lubricant grades suffixed with a Z comply with EU POP regulation 2020/784.

Fluon® ETFE



Fluon® ETFE (ethylene tetrafluoroethylene) is a fluorine-based thermoplastic that offers impressive corrosion resistance, chemical inertness and mechanical toughness over a very wide temperature range.

Available in pellet form, Fluon® ETFE resins can be processed by extrusion, injection moulding and blow moulding. Applications include wire and cable coating for automotive applications, robotics and electronic equipment, tubes, technical and architectural films, sheets, tape and parts for the semi-conductor industry. The product is also available in powder form for rotational moulding and spray coating to achieve chemically-resistant coatings for aggressive environments.

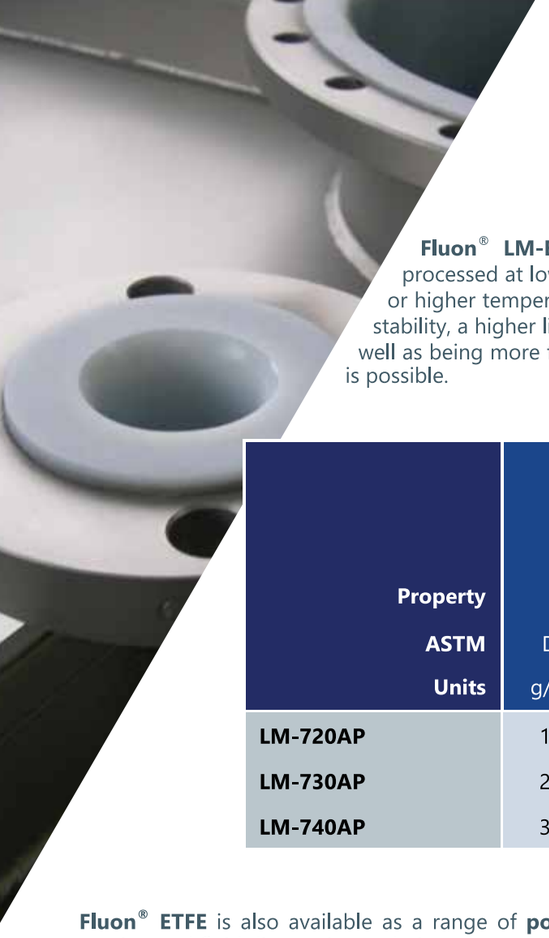
Fluon® ETFE Resins

Fluon® ETFE resins offer excellent processability and heat resistance as well as high mechanical strength, high chemical resistance, superior thermal and electrical properties and radiation resistance.

- Mechanical and electrical properties are maintained during continuous operation to temperatures ranging from -200°C up to +150°C
- No breakage by impact at room temperature
- Low-temperature impact resistance is guaranteed to at least -80°C
- Highly resistant to ultra-violet light, making them highly suitable for outdoor use
- With low smoke and flame characteristics, ETFE is rated 94V-0 by UL

Fluon® C-88AXMP-HT has been specifically designed to meet the tough demands of the automotive LV-112 stress crack test, cable of continuous operation at temperatures up to 175°C and able to withstand thermal overload, maintaining physical integrity for six hours at 250°C. Flexibility is maintained down to -40°C.

Property	MFR (297°C; 47N)	Specific Gravity	Melting Point	Tensile Strength (23°C)	Elongation to Break
ASTM	D3159	D792	-	D638	D638
Units	g/10 min	-	°C	MPa	%
C-55AP	3.9 – 8.0	1.74	265	52	382
C-55AXP	3.9 – 8.0	1.73	258	52	415
C-88AXP	9 – 12	1.73	260	48	415
C-88AXMP	24 – 43	1.73	260	42	430
C-88AXMP-HT	20 – 37	1.73	254	42	430



Fluon® LM-ETFE Resins have a lower melting point, meaning they can be processed at lower temperatures than conventional ETFE, or if processed at standard or higher temperatures can give increased production rates. They have better thermal stability, a higher limiting oxygen index, improved resistance to heat and stress crack, as well as being more flexible and transparent than standard ETFE. Continuous use at 180°C is possible.

Property	MFR (297°C; 47N)	Specific Gravity	Melting Point	Tensile Strength (23°C)	Elongation to Break
ASTM	D3159	D792	-	D638	D638
Units	g/10 min	-	°C	MPa	%
LM-720AP	10 – 20	1.78	225	43	380
LM-730AP	20 – 30	1.78	225	40	400
LM-740AP	30 – 40	1.78	225	38	420

Fluon® ETFE is also available as a range of **powder** products, suitable for rotational lining, electrostatic powder coating and fluid dip coating techniques.

With conventional resins, lining of complex geometries, for example where flanges exist such as in chemical reaction vessels, would normally require thermoplastic welding, which can introduce weld lines that could act as failure points in service. Used in coating systems, Fluon® ETFE powders provide all the usual benefits of ETFE, as well as seamless coverage around complex geometries and excellent adhesion to the substrate, especially in combination with our primer.

Grade	Particle Size (µm)	Application Thickness	FDA	Electrostatic Spray Coating	Rotolining	Fluid Dip Coating	Applications
Z-8820X	20 – 30	50 – 120 µm	✓	✓		✓	Thin coatings Non-stick for cookware Top coat for ZL520/521N
ZL-520N	70 – 80	up to 800 µm		✓			Corrosion resistance (20% carbon fibre added)
ZL-521N	50 – 60	up to 800 µm		✓			Top coat for ZL520N (5% carbon fibre added)
TL-581	250 – 300	2 – 5 mm	✓		✓		Corrosion protection for severe conditions
TL-081	80 – 150	up to 800 µm	✓	✓		✓	Reactors, vessels, tanks, pipeliners, pump housings
LM-2150	60 – 70	up to 800 µm	✓	✓			Non-stick anti-corrosion coatings
CP-801XGN	50 – 150	up to 800 µm		✓			Anti-corrosion coatings for FM semicon ducting

Fluon® PFA

Fluon® PFA is a copolymer of tetrafluoroethylene (C_2F_4) and perfluoroalkoxyethylene. It is classed as a fully fluorinated material, as in the basic structure of Fluon® PFA the carbon backbone is completely protected by fluorine atoms.

Available in pellet form, Fluon® PFA resins can be processed by extrusion, injection moulding compression moulding, transfer moulding and blow moulding. Applications include wire and cable coating for automotive applications, robotics and electronic equipment, tubes, technical films, sheets, and parts for the semi-conductor industry. The product is also available in powder form for rotational moulding and spray coating to achieve chemically-resistant coatings for aggressive environments.

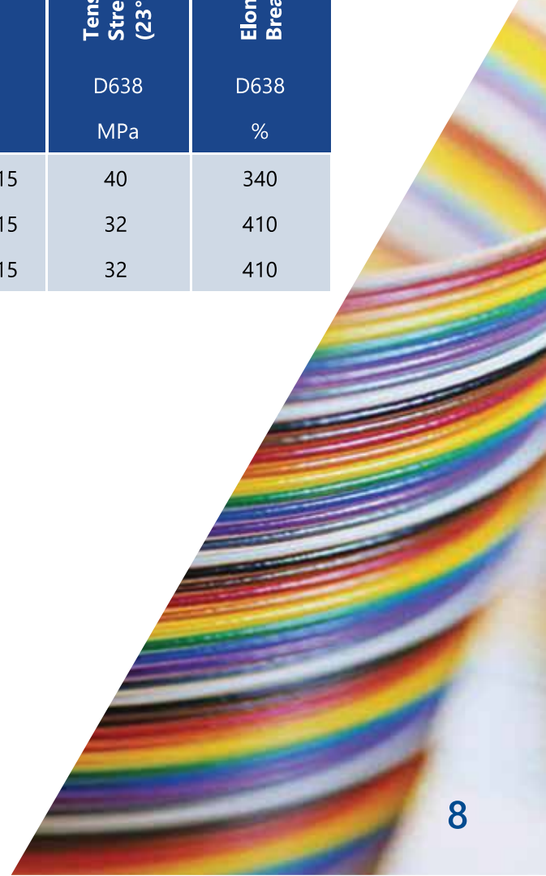
Fluon® PFA Resins

PFA possesses many of the key chemical and electrical properties of PTFE, and like ETFE, Fluon® PFA has excellent mechanical, and surface properties, but it can operate over a wider temperature range, maintaining its performance all the way from -200°C to 260°C. With a Limiting Oxygen Index (LOI) of more than 95%, Fluon® PFA is virtually non-flammable.

Similar to PTFE, PFA offers many desirable properties, including low friction, non-stick, and water and oil repellency.

Fluon® PFA offers excellent dielectric properties, which make it ideal for electrical insulating applications including wire and cable, sensors, antennae, and circuit boards.

Property	MFR (372°C; 49N)	Specific Gravity	Melting Point	Tensile Strength (23°C)	Elongation to Break
ASTM	D3307	D792	-	D638	D638
Units	g/10 min	-	°C	MPa	%
P-66P	1 – 3	2.142	305 – 315	40	340
P-63P	7 – 18	2.155	305 – 315	32	410
P-62XP	23 – 36	2.156	305 – 315	32	410



The **Fluon+™** brand launched by AGC Chemicals in 2019, is a unique product range based on AGC's functional fluoropolymertechnology. Fluon+™ products offer benefits in a variety of systems using technology to promote chemical bonding to non-fluorinated materials.

Chemically-reactive or otherwise functionalised materials and polymers such as Fluon+™ are often the base for further, specific modifications. The first well-established uses of Fluon+™ are in multi-layer fuel hoses, utilising its ability to form strong chemical bonds with polyamide.

Fluon+™ based on ETFE (LH and AH grades) and PFA (EA-2000) is available in granular form for film, extrusion and compounding applications, and in 20 – 50 µm powder for special compounding and coating. EA-2000 is also available as a fine powder with a 2 – 3 µm particle size.

Fluon+™ ETFE AH & LH (Adhesive) Resins for Co-extrusion

Engineered to provide enhanced adhesion when bonding with polyamides (PA), EVOH and other polymers†. Ideal for co-extrusion applications, such as fuel hoses where ETFE barrier properties are crucial. Also available in anti-static form. Fluon+™ AH ETFE is used in the SUNBESTA® fuel hose system.

†a co-extruded tie layer may be required for simple polyolefins such as PE and PP

Fluon+™ ETFE and PFA Melt Processable Compounds

Compound grades are used when improved properties over standard ETFE and PFA resins are needed. A variety of filled grades are available incorporating added materials such as glass fibres, carbon fibres, or carbon powder, and offer additional benefits such as increased tensile strength, abrasion resistance, impact resistance, flexural strength and electrical conductivity.

Fluon+™ for Composites

Using polymers enhanced with functional groups is a common technology in the composites industry. There are various reasons:

- Allow fibre-matrix adhesion
- Improve mechanical properties of matrix materials
- Allow new composite design

Based on its long experience in modifying fluoropolymers, AGC has extended this technology for use in thermoplastic or resin-based composites. There are multiple options to use Fluon+™ for the optimisation of composite systems:

Use	Matrix	Blend	Film	Adhesive
Wear performance	✓	✓	✓	
Chemical resistance	✓	✓	✓	✓
Flame retardance	✓		✓	
Low water adsorption	✓	✓	✓	
Vibration damping	✓			
Impact strength		✓		
Prevent galvanic corrosion				✓

Typical properties of Fluon+™

			ETFE			PFA
Property	**Test Method**	**Units**	**LH-8000**	**AH-2000**	**AH-3000L-CH1**	**EA-2000**
Adhesive			y	y	y	y
Antistatic					y	
MFR	ASTM D3159 (297°C; 47N)	g/10 min	78	25	7	10 – 30*
Specific Gravity	ASTM D792	-	1.75	1.78	1.77	2.14
Melting Point	AGC DSC	°C	180	240	236	298
Tensile Strength (23°C)	ASTM D638	MPa	44	49	29	40
Elongation to Break	ASTM D638	%	417	425	433	330
Flexural Modulus	ASTM D790	MPa	959	793	1221	580
MIT (Flex Life)	ASTM D2176	Cycles	1×10^5	1×10^5		1×10^5
Izod Impact (23°C)	ASTM D259	J/m	No break	No break		No break

** MFR Fluon+™ EA-2000 measured to D3307 (372°C; 49N)*

Fluon+™ MPC AR Series

Fluon+™ AR series is a range of modified ETFE offering all the benefits of ETFE but with enhanced flexibility and the capability to be crosslinked using e-beam irradiation. They can be processed using conventional thermoplastic techniques as with Fluon® ETFE.

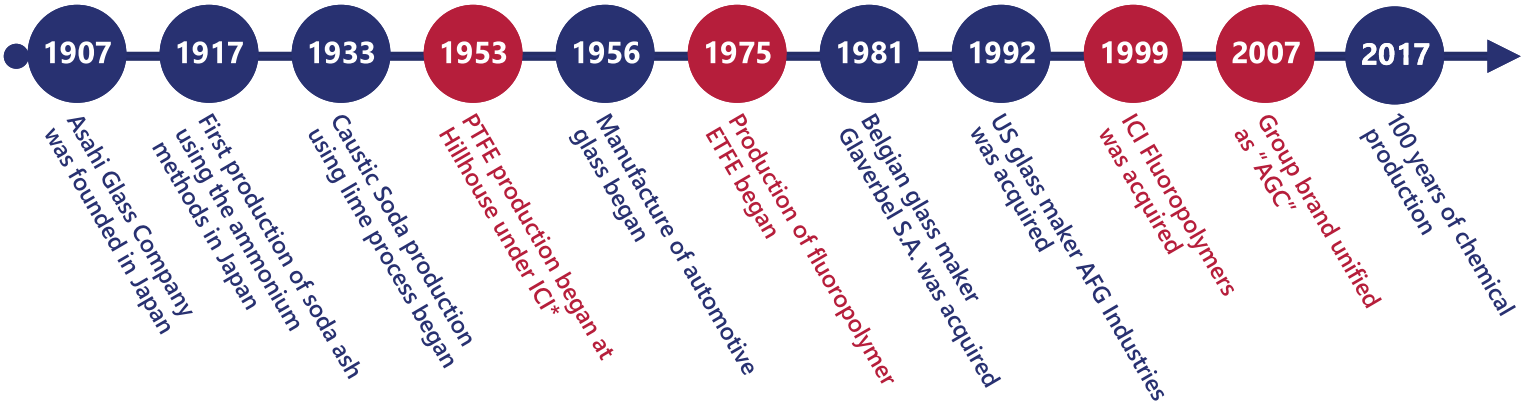
Property	**e-Beam Dose**	**MFR (297°C; 47N)**	**Melting Point**	**Tensile Strength (23°C)**	**Elongation to Break**	**Flexural Modulus**	**Hardness Shore D**
ASTM	-	D3159	-	D638	D638	D790	D2240
Units	kGy	g/10 min	°C	MPa	%	MPa	-
AR-8018TD	0	22	270	22	360	410	53
	100	-	-	33	400	500	53
AR-3300P	0	7	225	11	290	96	49
	120	-	-	24	294	121	51

The **AGC Group** is one of the world's leading manufacturers of glass, chemicals, electronic materials and ceramics and the world's largest producer of automotive and flat glass, ETFE fluoroplastics and ion exchange membranes.

The chemicals activity first began over 100 years ago, with the in-house production of soda ash, a raw ingredient in flat glass.

The chemicals division, now known as 'AGC Chemicals', a leading fluoropolymer manufacturer is guided by the mission statement, "Chemistry for a Blue Planet". AGC Chemicals continuously provides a wide variety of products, which are useful for a fulfilling, safe and comfortable society and environment, from basic chemicals to fluorine-based high-performance materials.

With its headquarters in the UK, the European subsidiary, AGC Chemicals Europe, has been manufacturing PTFE for over 60 years at its Hillhouse site. ETFE production began in Japan in 1975 and the Hillhouse ETFE plant opened in 2007.



* ICI = Imperial Chemical Industries

Your Dreams, Our Challenge

In 2018, AGC Group's new brand statement "Your Dreams, Our Challenge" was created to fulfil its mission under the group vision "Look Beyond". Since its foundation, the AGC Group has always taken up new challenges to make people's lives better.

AGC's unique materials, solutions and reliable partnerships have facilitated leading innovations across diverse industries and markets. Today, by working with others to combine knowledge and advanced technology, the Group helps make ever greater achievements possible and bring bolder ideas to life.

AGC

If you have an application that you think would benefit from using Fluon® PTFE, PFA, ETFE, or our Fluon+™ functional fluoropolymers, please contact:

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