

AGC

Your Dreams, Our Challenge



AFLAS[®]

FLUROELASTOMERS

High-Function
Fluoroelastomer



Chemistry
for a Blue Planet
AGC Chemicals



As a leading manufacturer of various fluorochemical products, AGC keep asking ourselves this question:
What could we do to contribute to creating a more fulfilling society and making people's lives more comfortable while protecting the global environment?
One of the answers that AGC has come up with is AFLAS®.

It is high-performance fluoroelastomer that is superior to conventional rubber products in terms of thermal resistance, chemical resistance, strength, etc. and is commonly used to make sealing, hose, and covering materials.
Its wide-ranging applications include underground resource mining without environmental pollution, highly reliable production equipment and facilities, enhancement of the energy-saving performance of vehicles, enabling our track record to continuously increase.
One's choice to use AFLAS® signifies their prioritization of a sense of security, safety, and quality as well as being future-minded. With AFLAS®, more can be accomplished.



AFLAS® is AGC's collective brand of high-performance fluoroelastomer products FEPM and FFKM.



*The photo is a sample image.

Fluoroelastomer is a general term that refers to any synthetic rubber that contains fluorine in its molecular structure. Compared to silicone and other synthetic rubber, it shows superior characteristics in terms of thermal resistance, chemical resistance, electric insulation, steam resistance, etc. and therefore has been used in a growing number of industries where the parts and products are subjected to harsh operating conditions. FKM, FEPM, and FFKM* are common fluoroelastomers that have unique characteristics respectively. AGC's AFLAS® includes especially high-functioning FEPMs and FFKMs in its product range.

* FKM: Vinylidene fluoride-based elastomers, FEPM: Tetrafluoroethylene-propylene-based elastomers, FFKM: Tetrafluoroethylene-perfluorovinyl ether-based elastomers

■ Types of fluoroelastomer and the position of AFLAS®

| | | | | |
|-----------------|-------------|--|---|--|
| Fluoroelastomer | AFLAS® FFKM | AFLAS® PM-1100 AFLAS® PM-3000 AFLAS® CP-4000 | -(CF ₂ CF ₂) _a -(CF ₂ CFORf) _b -(vulcanized part)- | |
| | AFLAS® FEPM | AFLAS® 100 AFLAS® 150 AFLAS® 400 AFLAS® 600 | -(CF ₂ CF ₂) _a -(CH ₂ CHCH ₂) _b - | |
| | FKM | Ternary Binary | -(CF ₂ CF ₂) _a -(CH ₂ CHCH ₂) _b -(CF ₂ CH ₂) _c - -(CF ₂ CF ₂) _a -(CF ₂ CF ₂) _b -(CF ₂ CH ₂) _c - -(CF ₂ CF ₂) _a -(CF ₂ CH ₂) _b - | |

FKM was the fluoroelastomer that was developed first, which offers a good balance between performance and cost. As for FFKM, it offers superb performance but is proportionately more costly, so it's targeted for special applications. Meanwhile, the AFLAS® FEPM product series, which AGC first introduced to the market in the 1970s, has been able to successfully expand the possibilities of what fluoroelastomers can do, with its cost competitiveness and excellent thermal resistance, chemical resistance, electric insulation, etc. that nearly match those of FFKM. In 2017, AGC debuted the AFLAS® FFKM series that was created based on the technical know-how that AGC gained from FEPM, which allows AGC to meet the ever more advanced needs of various industries.



AFLAS®
FLUROELASTOMERS
FEPM SERIES

AFLAS® FEPM is a fluoroelastomer product series that is mainly composed of alternating copolymers of tetrafluoroethylene and propylene. The thermal and chemical stability of the polymers are achieved by the structure where almost all propylene units are positioned between the adjacent tetrafluoroethylene units on both sides. The product series has a track record of being successfully used in various fields for over 40 years, and also is known for its stable quality and reliability.



Fluoroelastomers with excellent thermal, oil, and chemical resistance that has a successful track record of use in various industries.

■ Grade

| | | | | |
|---|---|---|--|--|
| <p>AFLAS® 100S/100H</p> | <p>AFLAS® 150E/150P</p> | <p>AFLAS® 600X</p> | <p>AFLAS® 400E</p> | <p>AFLAS® 150CS/150C</p> |
| <p>■ Main applications</p> <ul style="list-style-type: none"> Sealing material Oil seal Packer element ESP protective coverings | <p>■ Main applications</p> <ul style="list-style-type: none"> Wire and cable insulation Tube Sealing material | <p>■ Main applications</p> <ul style="list-style-type: none"> Sealing material | <p>■ Main applications</p> <ul style="list-style-type: none"> For extrusion processing Wire and cable insulation Tube | <p>■ Main applications</p> <ul style="list-style-type: none"> Wire and cable insulation Heat-shrink tube Resin improvement material |
| <p>This is the grade with the highest molecular weight. It is also used to make various parts in the oil exploration and production industry due to its high strength and elongation as well as resistance to H₂S gas and ability to be uniformly vulcanization-molded to make even large parts. The vulcanization speed can be adjusted by blending 100S and 100H together.</p> | <p>150E is a grade that is suitable for extrusion molding and has excellent electric insulation, thermal resistance, and chemical resistance. It is widely used to make coatings for heat-resistant electric wires, i.e., electric wiring around steel and glass furnaces, power cables for mobile objects, electric wires for home appliances and water heaters, etc. 150P is suitable for injection molding, transfer molding, and profile extrusion molding.</p> | <p>Excellent vulcanization speed and density have been achieved while maintaining high durability that is equivalent to conventional products. Compression set and mold release properties have been significantly improved. White compounds are also possible.</p> | <p>Continuous vulcanization is made possible with an improved crosslinking rate, while maintaining the resistance characteristics that are equivalent to those of conventional products. Excellent extrudability can be achieved. White compounds are also possible.</p> | <p>This is a grade that is suitable for extrusion molding for electron beam crosslinking. It is widely used to make coatings for heat-resistant electric wires because of its superb electric insulation, thermal resistance, and chemical resistance. It also has a strong track record as a material to improve the flexibility and thermal resistance of fluoroplastics and to make heat-shrink tubing.</p> |

■ Characteristics of FEPM



Flame retardance: It burns when put into a flame but stops burning when removed from the flame.
Chemical resistance: It hardly deteriorates when exposed to a high-temperature strong acid or base.
Thermal resistance: It has sufficient thermal resistance as long as the continuous-use temperature does not exceed 200°C, and the short-time use temperature is kept between 230 and 250°C.
Low odor-adhesiveness: With its very low odor-adhesiveness compared to other rubber materials, it is suitable for making gaskets and packing that will be used between piping parts at production lines, where any residual or adhesion of odor to products, etc. should be avoided.
Oil resistance / amine resistance: It exhibits excellent oil resistance to engine oil, gear oil, etc. that contain large amounts of amine additives.
Durability / strength: It is a material of high hardness and elongation that can be used under high-temperature and high-pressure conditions without issue. (Even if material has high-strength, it might crack in a high-pressure environment unless it has proper extensibility.)
Electric insulation: It has high electric insulation of 3×10¹⁰Ω·cm in terms of volume resistivity.
Steam resistance: It can withstand being exposed to 250°C steam.
Low-temperature property: It has a low brittle temperature and has excellent overall strength when used in a low-temperature environment.

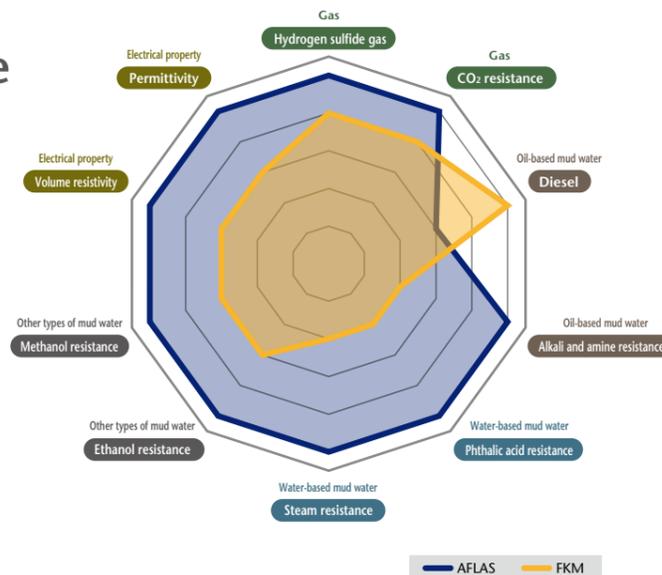
Resource recovery



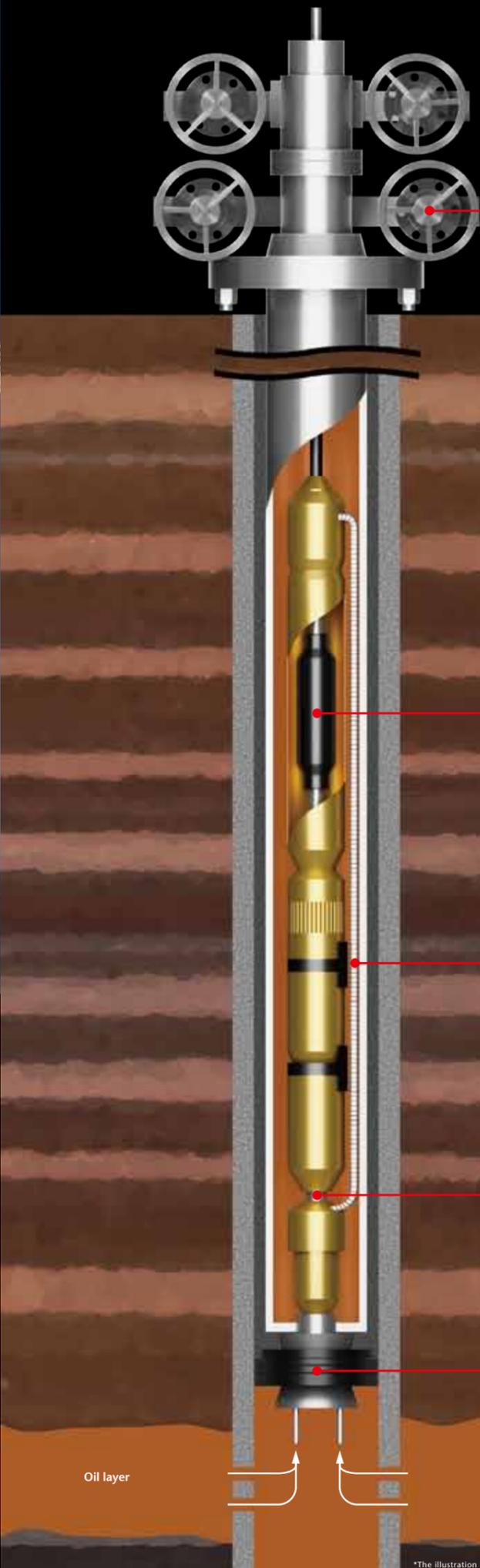
*The photo is a sample image.

It ensures safety and protects the natural environment while functioning properly under the harshest conditions at production sites.

The frontier of resource development is now widen into the unknown realms of the deep sea, the high-temperature and high-pressure layers of earth, etc. With such trends emerging, the technical requirements of digging equipment, etc. are becoming increasingly demanding. For example, the tip of an oil-well drilling machine must be made of material that has high thermal and pressure resistance, as it is constantly exposed to hydrogen sulfide and other corrosive gas and steam that are emitted in the ground as well as to the drilling oil that is supplied from above ground. The AFLAS® FEPM series is capable of meeting all these stringent requirements and has been widely used to make sealing and protective covering materials. It makes a significant contribution to oilfield development around the world.



*ESP = Electric Submersible Pump



Gasket / packing / O-ring

O-rings that are used in oil- and gas-well drilling machinery must have high blister resistance. RGD* is one of the test methods for gauging this specific performance metric. AFLAS® has passed major RGD testing requirements.

Recommended grades: AFLAS® 100S, 100H, 600X

Protective covers

It protects the motors that are the crucial parts of ESP* systems from oil, H₂S gas, etc.
*ESP System (Electric Submersible Pumps): It is the method of oil extraction, in which a multi-stage turbine pump accompanied by a small motor is installed at the lower end of the tubing.

Proven operating conditions: 204°C / 400°F, 2,000 psi
Recommended grades: AFLAS® 100S, 100H

Multi-layer power cable

It is for supplying electric power to the motors inside ESP systems. Unlike regular cables, a covering made of PI, AFLAS, alloy, etc. is placed around the core wire for protection against any corrosive environment.

Proven operating conditions: 204°C / 400°F, 5kv high voltage
Recommended grades: AFLAS® 150E, 150CS, 400E

Packer element

AFLAS® tightly seals the space between the casing and the tubing so as to allow the fluid coming into the casing below to flow into the tubing.
*Metal or spring reinforcement may be needed in some cases.

Proven operating conditions: 204°C / 400°F, 10,000 psi*
Recommended grades: AFLAS® 100S, 100H

*The illustration is a sample image.

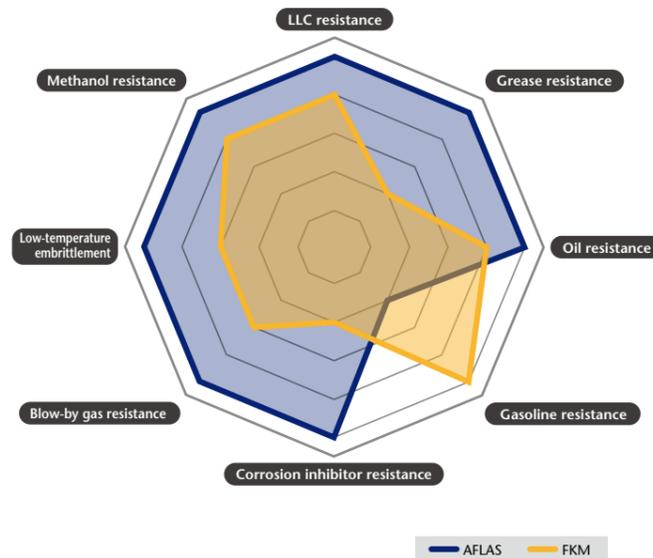
Transport machinery / heavy machinery



*The photo is a sample image.

It contributes to natural resource conservation and environmental protection by generating the potential of vehicles and heavy machinery.

Vehicles and heavy machinery of today are quite safe and friendly to both the environment and humans alike. Although such high-level performance is a common requirement, it can only be achieved by meeting strict technical requirements, one by one. Engine lubricant and fuel products are intrinsic parts of this technological progress. A wide variety of chemicals and additives are often incorporated to enhance product performance. However, they could also deteriorate or otherwise negatively affect the seals and hoses that are made of elastomers. This sort of issue is however resolved in the case of the AFLAS® FEPM series, as it offers superior chemical resistance and increases the longevity of vehicles and heavy machinery, although it's not necessarily evident upon the surface.



Cylinder-head gasket

As AFLAS® is resistant to both engine oil and coolant, it is used for metal gaskets that consist of metal sheets with rubber coating applied on top.

Recommended grades:
Please send an inquiry through the AFLAS® website.



Oil cooler hose / turbocharger hose

Due to today's more stringent regulation on exhaust gas emissions, it has become necessary for diesel engines to return the fuel gas and oil mist that leak from the cylinder blocks back into the intake passage system. Due to this technical requirement, the gas containing oil mist now passes through the hose that runs between the turbocharger and the intercooler. AFLAS® is the optimal choice of material to make such hoses as it has high resistance to the additives that are contained in the oil.

Recommended grades: AFLAS®150E, 400E

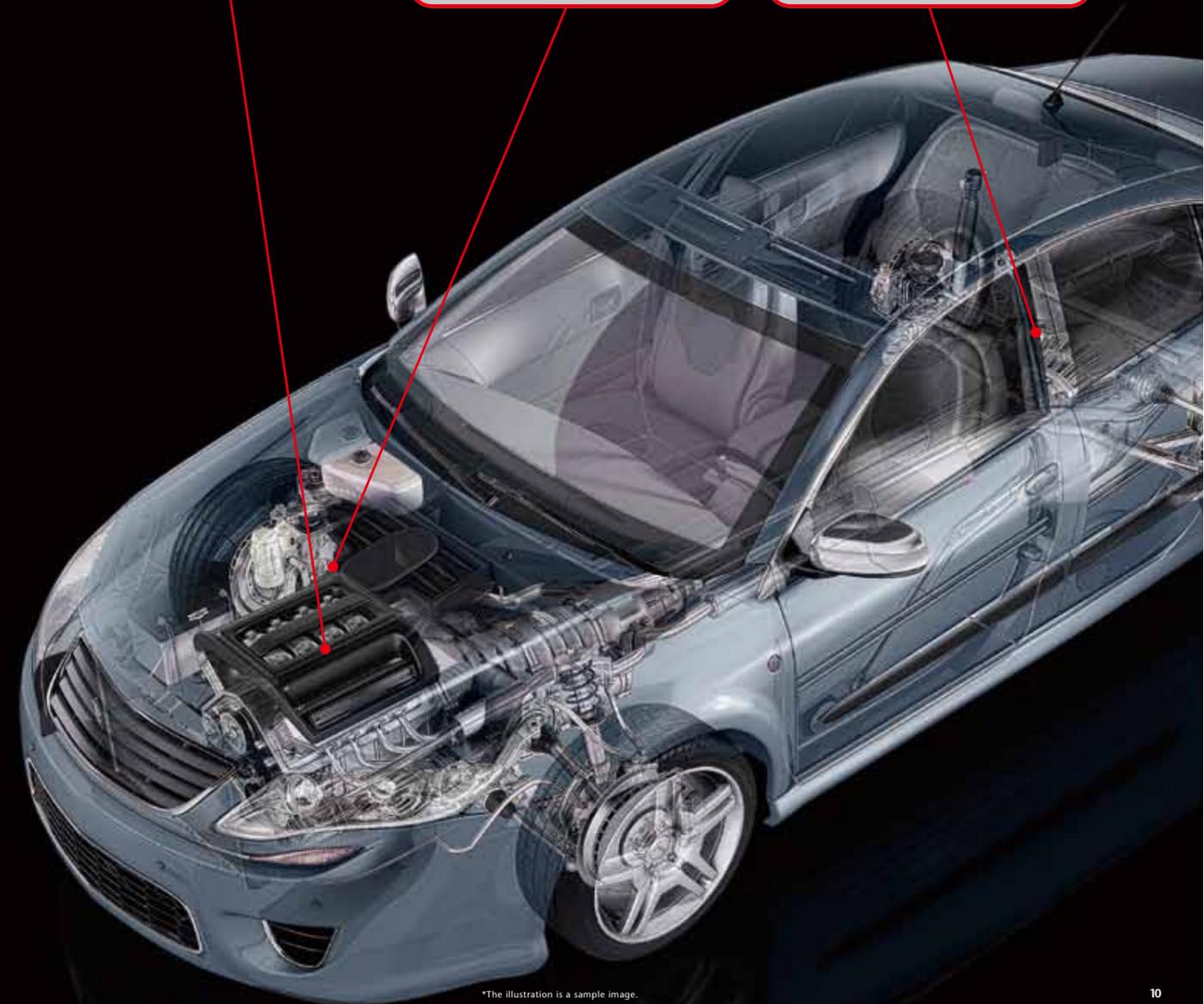


Oil seal / pinion shaft seal

The lubricants that are used in automobiles, such as engine oil, transmission oil, and brake fluid, contain large amounts of various dispersants and antioxidants. AFLAS® is resistant to such amine compounds in addition to being highly resistant to heat, which is an advantage of fluoroelastomers. Because such features deliver customer value, AFLAS® has been used in many automotive oil products* as an oil seal material.

*AFLAS® has been adopted in a growing number of automotive oil products that are used in construction machinery, trucks, etc., the operating conditions of which are far more demanding compared to regular cars.

Recommended grade: AFLAS®100S



*The illustration is a sample image.

Wire and cable insulation

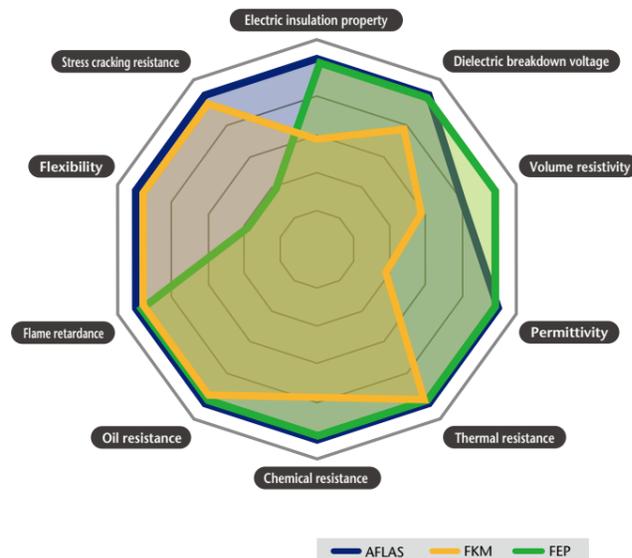


*The photo is a sample image.

It protects electric wires that are vital to the operation of various electric equipment, from large-scale facilities to home appliances.

Green vehicles (HVs, PHVs, EVs, etc.) and railroad vehicles are thought to be friendly to the global environment due to their low CO₂ emissions. However, the electric wires and power cables that sustain their operation are used under more demanding conditions, partly due to those vehicles becoming lighter in weight.

The AFLAS® FEPM series offers high resistance to both external and internal heat along with flexibility that provides improved installation of wiring, in addition to superb electric insulation that is a mandatory feature of electric wire coating material. Its track record of use in various applications is ever-improving, ranging from vehicles and large machinery to home appliances.



Electric wire coverings

Although fluoroplastics are excellent in electric insulation, they lack flexibility. As a result, they often lead to wiring routing issues. Meanwhile, as AFLAS® offers flexibility, it has been used as thin wire material in a wide variety of applications, from automobiles to home electronics and gas appliances, etc. It is also used as thick wire material around blast furnaces, etc.

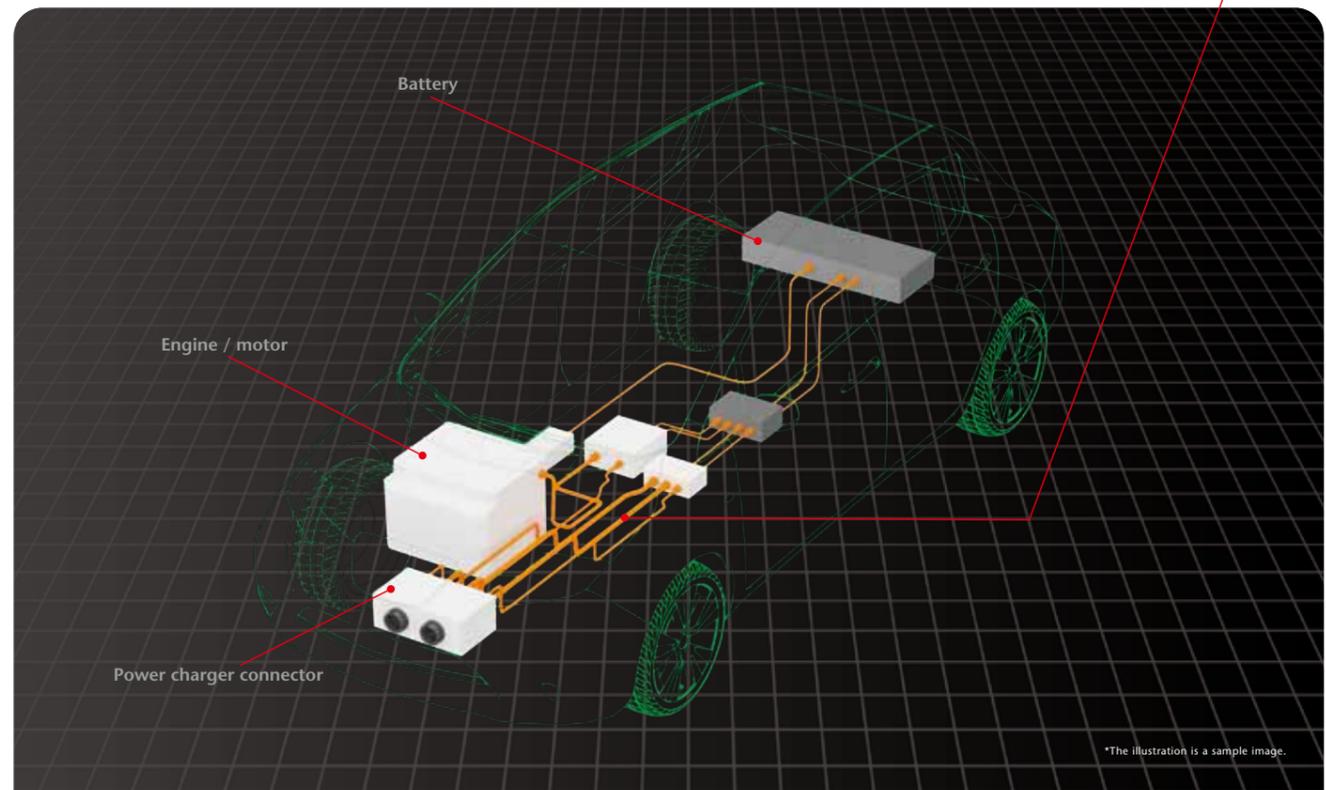
Recommended grades: AFLAS® 150E, 400E (steam crosslinking), 150CS (electron beam crosslinking)
 Proven operating conditions: Temperature range of -60 to 200°C, UL VW-1-certified



Power cable coverings

In order to reduce the weight of an electric wire, the diameter of its electric conductor has to be reduced. However, if the electric conductors are made thinner, the amount of electrical resistance will increase, which in turn requires higher thermal resistance to cope with more internally generated heat. As AFLAS® is valued as insulating material that satisfies all these tough requirements, it has been used to make power cable coverings in bullet trains and electric cars.

Recommended grades: AFLAS® 150E, 400E (steam crosslinking), 150CS (electron beam crosslinking)
 Proven operating conditions: Temperature range of -60 to 200°C, UL VW-1-certified



*The illustration is a sample image.

High-voltage power distribution system for EVs, HVs, and PHVs

Power cables are crucial for supplying power to batteries and motors in a reliable manner. In the latest models of EVs, HVs, and PHVs, lightness is a standard requirement for energy- and space-saving, in addition to sturdiness and electric insulation. Given its high thermal resistance, superb electric insulation, and low specific gravity, AFLAS® is an optimal material for making electric wire coverings for these applications.

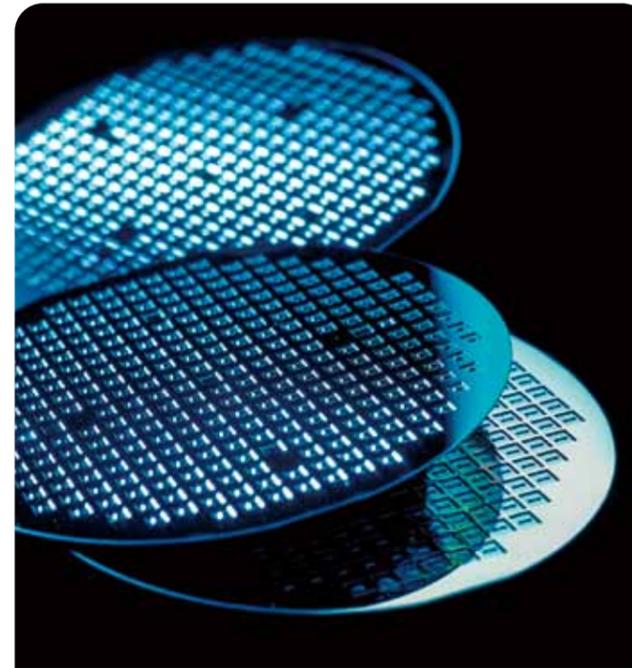
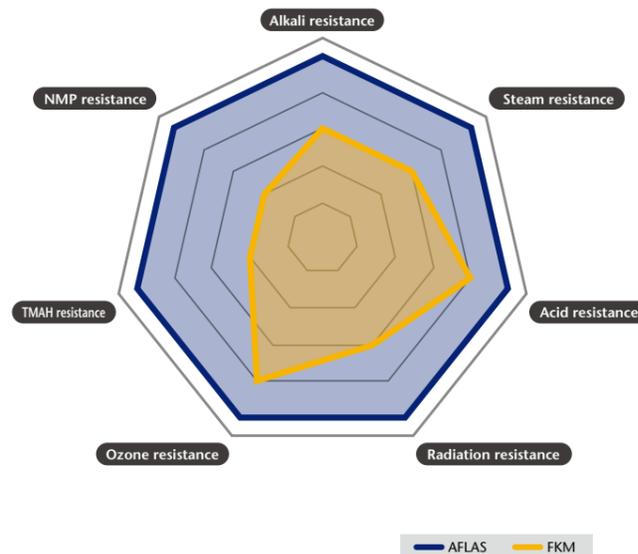
Electronics, chemical, pharmaceutical, food, and space industries



*The photo is a sample image.

Its excellent characteristics are highly valued in various manufacturing operations and extreme environments.

As the AFLAS® FEPM series offers superb thermal resistance and durability among other excellent features, it has been used in an ever-increasing number of applications including various infrastructures, factories, etc. For example, due to its low odor-adsorption characteristics, it is used to make packings, and other similar components in food manufacturing. As it is also highly resistant to both chemicals and steam, its use has become widespread as sealing material that is incorporated into chemical plants, replacing FKM. It has also been adopted in a growing number of fields where only highly reliable products are accepted, such as in space stations and satellites, because of its superb radiation and ozone resistance.

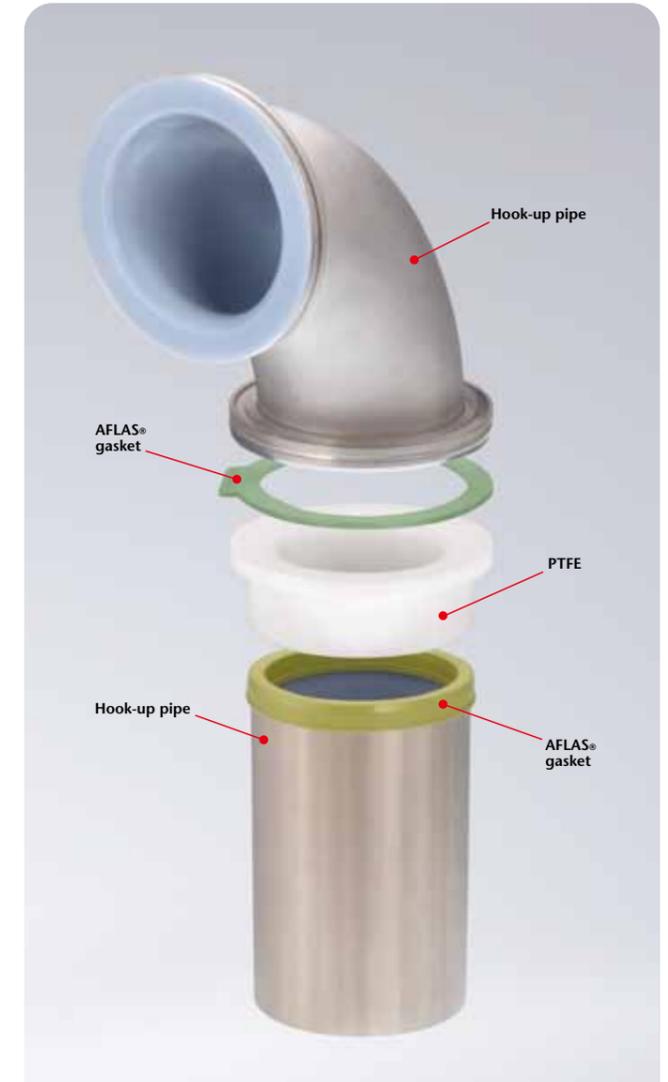


Sealing for semiconductor applications

FKM is suitable for making sealing to be used in semiconductor production lines. However, it can be replaced by AFLAS® FEPM which will lead to cost reduction, depending on the types of gas* and chemicals to be used.

*AFLAS® FEPM shows excellent plasma resistance properties in an atmosphere rich in O₂ and CF₄+O₂ plasma.

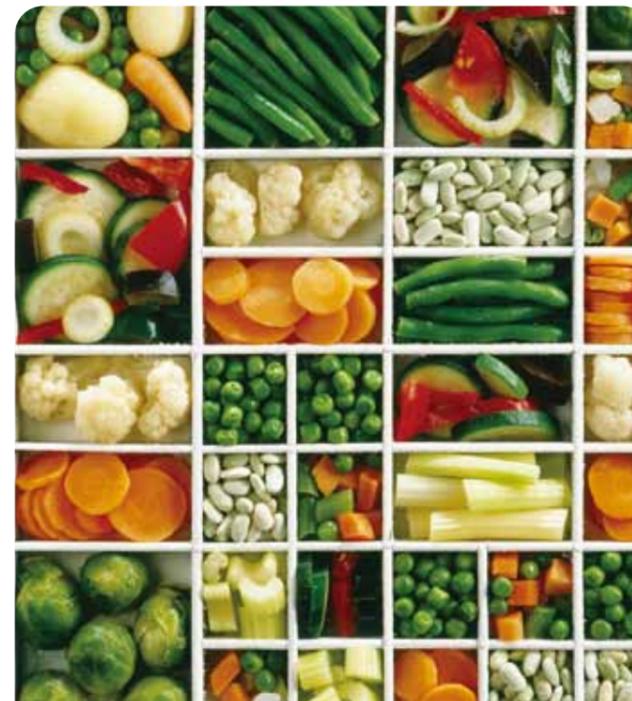
Recommended grades: AFLAS® 100S/600X



Packing for hook-up pipes

Because of its high flame retardance, AFLAS® is widely used to make packings that are inserted between hook-up pipes that connect ducts at semiconductor fabrication plants.

Recommended grades: AFLAS® 100S/600X

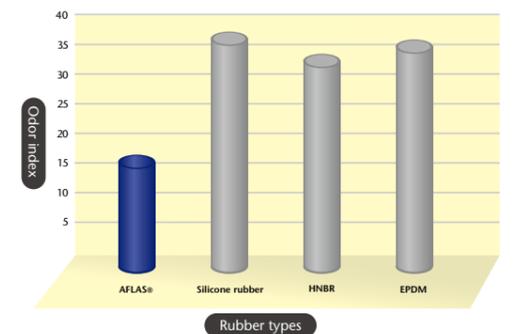


Sealing for food applications

AFLAS® does not absorb odors and has high resistance to various chemicals, steam, ultraviolet radiation, etc. that are used for sterilization and antiseptic purposes. Therefore, it is suitable for making packings, etc. used in food and beverage production lines where any transfer of odors should be avoided.

Recommended grade: AFLAS® 600X

Low odor adsorption is proven based on odor index equivalent value.



"Odor index equivalent values" are numerical data indicating odor intensity after correcting for human olfactory sensitivity (i.e., threshold correction). For example, an odor index of '10' means that, the odor becomes unnoticeable if it is diluted tenfold. Likewise, odor indexes of '20' and '30' refer to odor intensity levels that become insensible if diluted 100 times and 1000 times, respectively.

*The data shown in the graph were measured after immersing the test objects in a commercially available 80°C orange-flavored beverage (30% pure orange juice) for 24 hours 30% orange juice with 80°C for 24 hours and then washing them in running water for 30 minutes.

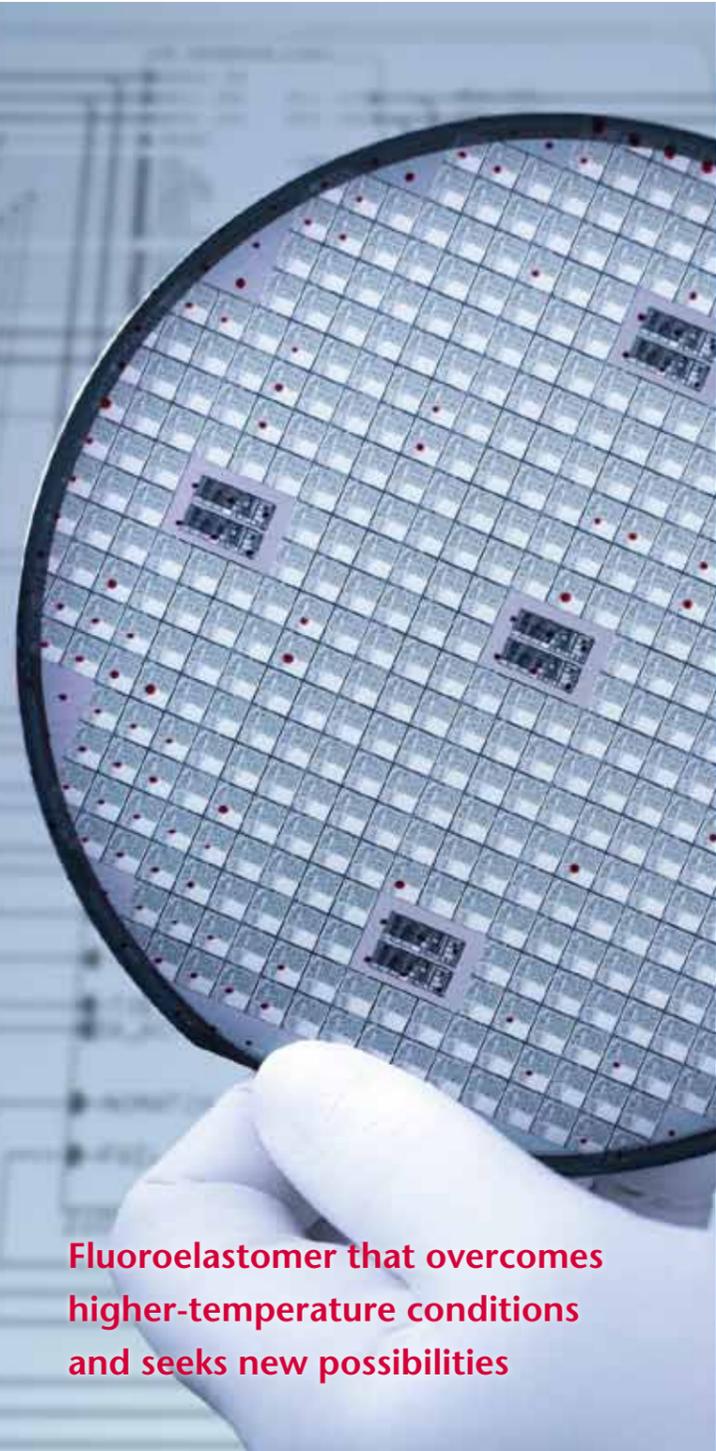
*The photo is a sample image.



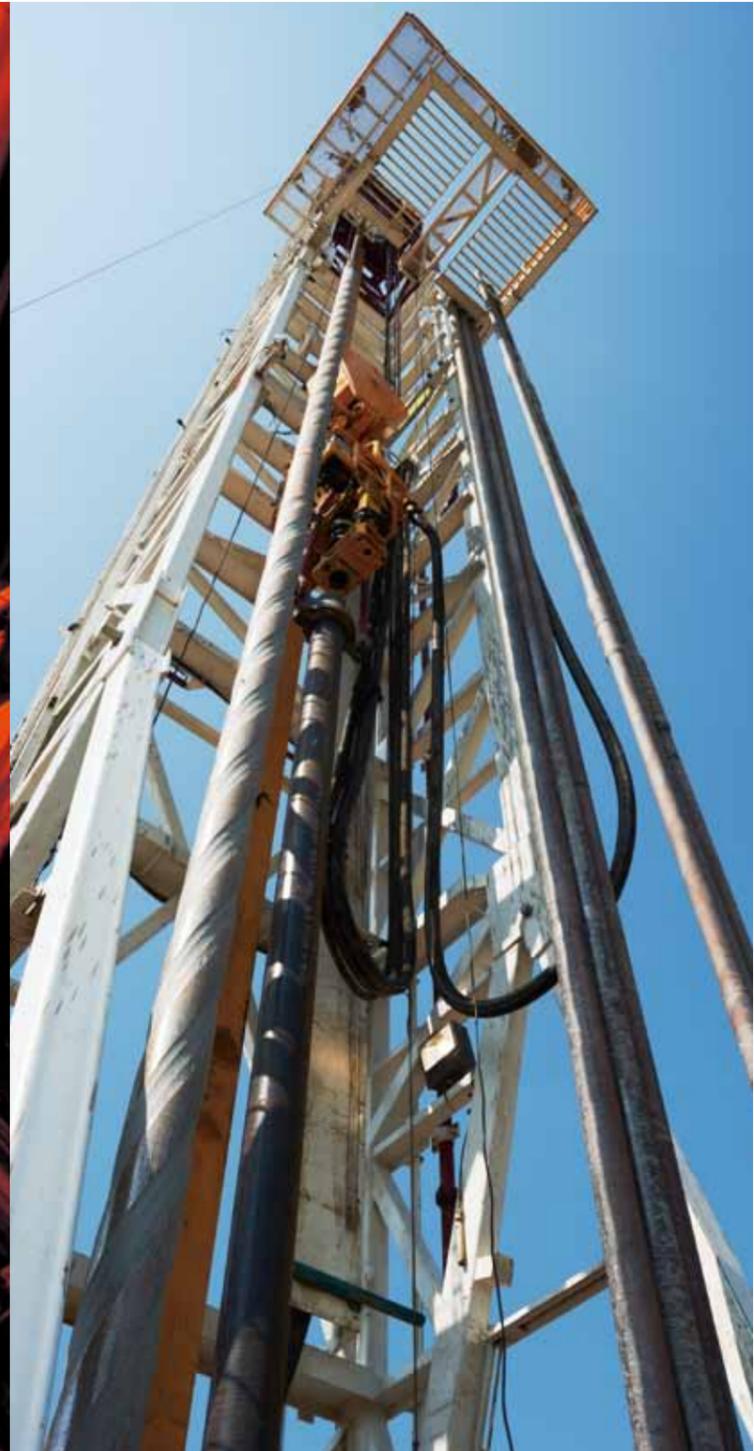
AFLAS®

FLUROELASTOMERS
FFKM SERIES

AFLAS® FFKM is a fully fluorinated rubber copolymer product series that is mainly composed of tetrafluoroethylene (C₂F₄) and perfluoroalkylvinyl ether (C₂F₃-ORf). It has characteristics that are superior to those of partially fluorinated fluoroelastomer (FKM/FEPM) in terms of thermal resistance, chemical resistance, solvent resistance, ozone resistance, etc., and can meet heavy-duty operating conditions such as high temperature and high pressure. Since being introduced to the market in 2017, it has been used in a wide variety of applications as high-performance sealing material.



Fluoroelastomer that overcomes higher-temperature conditions and seeks new possibilities



Grade

**AFLAS®
PM-1100**

Main applications

Chemical processing industry
Oil and gas industry

It has sufficient thermal resistance as long as the continuous-use temperature does not exceed 230°C, and the short-term use temperature does not exceed 250°C.

**AFLAS®
PM-3000**

Main applications

Chemical processing industry
Oil and gas industry

Sealing for semiconductor manufacturing equipment

It offers improved thermal resistance while maintaining the same levels of excellent strength and chemical resistance. It has sufficient thermal resistance as long as the continuous-use temperature does not exceed 250°C, and the short-term use temperature does not exceed 270°C.

**AFLAS®
CP-4000**

Main applications

Chemical processing industry
Oil and gas industry

Sealing for semiconductor manufacturing equipment

It offers improved thermal resistance while maintaining the same levels of excellent mechanical strength and chemical resistance. It has sufficient thermal resistance as long as the continuous-use temperature does not exceed 280°C, and the short-term use temperature does not exceed 300°C.

AFLAS® CBseries *Includes under-development grades

**AFLAS®
CB-099**

It's a black compound with thermal resistance of 230°C and hardness of 70° to 75°.

**AFLAS®
CB-097**

It's a black compound with thermal resistance of 250°C and hardness of 70° to 75°.

**AFLAS®
CB-046**

It's a black compound with thermal resistance of 300°C and hardness of 70° to 75°.

AFLAS® FFKM product range by their heat-resisting temperatures

| Thermal resistance | | | |
|-------------------------|-------------------------|-------------------------|-------------------------|
| 230°C | 250°C | 280°C | 300°C |
| PM-1100 Raw rubber | PM-3000 Raw rubber | CP-4000 Pre-compound | |
| CB-099 Full compound | CB-097 Full compound | | CB-046 Full compound |

Characteristics of FFKM



Chemical resistance: It has significantly high resistance to high-temperature and highly active acids, alkalis, hydrogen sulfide, etc.

Thermal resistance: It has sufficient thermal resistance as long as the continuous-use temperature is kept between 200 and 280°C, and the short-term use temperature is maintained between 280 and 300°C.

Oil resistance / solvent resistance: It has significantly high resistance to oil and solvents.

Durability / strength: It has a superb compression set and also an excellent mechanical strength of over 20 MPa.

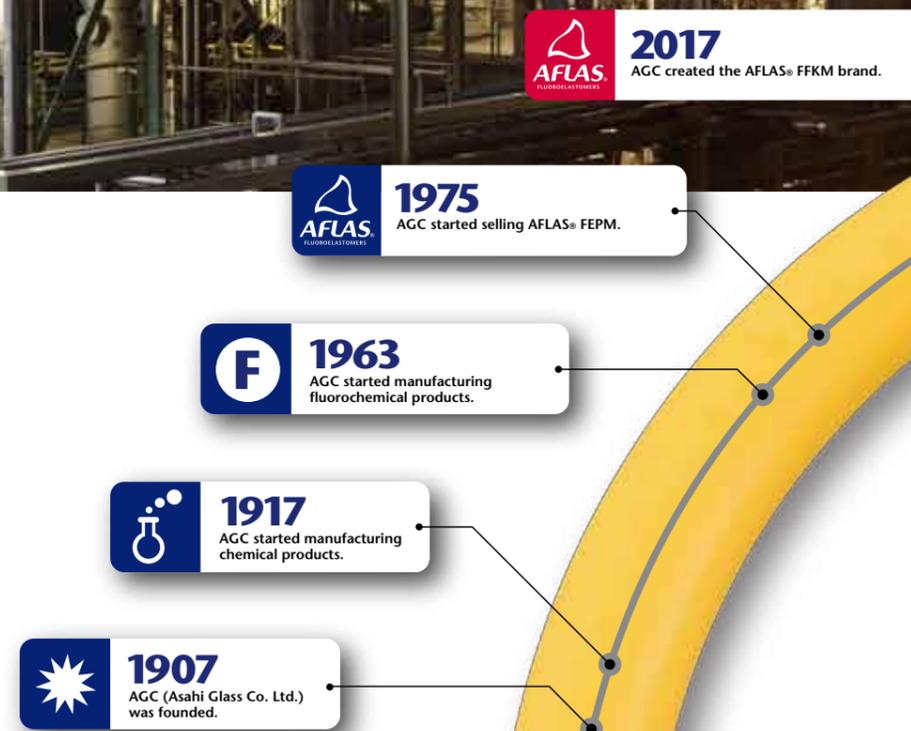
Ozone resistance: Its physical properties do not change even after being exposed to 50 ppm ozone at 40°C for a month.



AGC's AFLAS® manufacturing system ensures steady supply

Its plants in Japan utilize cutting-edge fluorochemical technology and deliver high-quality products.

With roughly 100 years of experience in chemical production and around 50 years of experience with fluorochemical products, AGC has been a leading developer and manufacturer of high-performance fluoroelastomers from an early stage, while leveraging its technical competency and delivering superb results. In 1975, AGC started marketing AFLAS® FEPM, catering to the wide-ranging needs of various industries. In 2017, AGC introduced AFLAS® FFKM to the market and has constantly been taking on different challenges to cultivate new possibilities for fluoroelastomers. It is also noteworthy that all products that belong to the AFLAS® series are made in Japan. Being integratedly produced at AGC's dedicated plants in Japan under meticulous quality control, AFLAS® products can be securely supplied to every corner of the world.



Notice

- 1) The statements and data given in this publication are believed to be accurate. They are presented without any guarantee or warranty, express or implied. Statements or suggestions regarding the use of these products are made without representation or warranty that any such use is free of patent infringement and are not recommendations to infringe any patent. The user should not assume that all safety measures are indicated.
- 2) Please refer to the SDS (Safety Data Sheet) for safety and details.
- 3) This product is not designed for use in the implantation of the human body or for medical applications that come in contact with body fluid or body tissues, AGC Inc. carries out no test as to the fitness of the product for any medical applications.
- 4) The contents are subject to change without prior notice.

Manufacturer/distributor

AGC Chemicals Company

AGC Inc.

Shin-Marunouchi Bldg., 1-5-1 Marunouchi,
Chiyoda-ku, Tokyo 100-8405
Tel +81-3-3218-5875 Fax +81-3-3218-7856
www.agc.com
AFLAS®Website www.aflas.jp/english/

AGC Chemicals Americas, Inc.

55 East Uwchlan Ave., Suite 201, Exton, PA 19341, USA
Tel +1 610 423 4300 Fax +1 610 423 4301
www.agcchem.com

AGC Asia Pacific Pte. Ltd.

460 Alexandra Road, #32-01 mTower, 119963, Singapore
Tel +65 6273 5656 Fax +65 6276 8783
<http://agc-asiapacific.com>

AGC Chemicals Europe, Ltd.

Hillhouse International, Fleetwood Road North,
Thornton-Cleveleys, FY5 4QD, UK
Tel +44 1253 209600
www.agcce.com

AGC Chemicals Trading (Shanghai) Inc.

4008/09,F40,T1 Raffles City Changning No.1133 Changning Road,
Shanghai, 200051, China
Tel +86 21 6386 2211 Fax +86 21 6386 5377
www.agc-chemicals.com