<u>Bearing material & sliding material</u>

Application Number: Transportation (annex E.2.10), Electronics and semiconductors (annex E.2.11), Energy sector (annex E2.12)
Application Name: Bearing material and sliding material

Materials used in these products are PTFE (CAS No. 9002-84-0) alone, or inorganic and organic materials blended as a filler. *6)

Subject to use: Bearings and sliding members *4), *5)

Main fillers: There are glass fibers, carbon/graphite, carbon fibers, molybdenum disulfide, bronze, etc. *2), *3), *6)

Chemicals used: Chemicals, oilless *2), *7)

Use conditions: High temperature, high pressure, high speed. *2), *3)

Essential conditions: To have a low friction coefficient. *1)

Creep resistance, wear resistance, friction coefficient stability, seizure resistance, *2), *3) non-adhesiveness, and self-lubricity *2)

Reference materials

*1) Sumitomo Chemical Co., Ltd., Super Engineering Plastic “Sliding properties of Sumiploy”

*2) Valqua, Ltd., Research Department, Rubber Laboratory, Takaharu IKEDA “High-performance sliding material VALFLON® sliding material series with filler”

*3) Mitsubishi Cable Industries Review 101, April, 2004 “Influence of filler on friction and wear behavior of tetrafluoroethylene resin”

*4) IIDA Co., Ltd. “Possibility of non-grease resin bearings and resin gears by resin cutting”

*5) SAINT-GOBAIN “https://www.bearings.saint-gobain.com/ja/applications/norglide-ptfe-bearings-seat-frames”

*6) Valqua, Ltd., Valqua Technology News Spring 2017 “Types and Application of Filler-added PTFE Materials”

*7) Toray Industries, Inc. “https://www.toray.jp/mf/product/toyoflon/use.html”

A material that satisfies all of the above-described specification conditions is PTFE.

Other resins have been exemplified as other materials for bearing and sliding materials, but no substitutes for the bearing and sliding materials specifically shown in the following fields have been found.

<Comparison in chemical resistance between PTFE alone and other resins>

Table 2 Chemical and solvent resistance of various plastics and rubbers*

Chemicals and solvents (concentration %) \ Materials	Polyethylene	Polypropylene	Poly-4-methylpentene	Polyvinyl chloride		Polymethyl methacrylate	Polystyrene	Polyvinylidene chloride	Tetrafluoroethylene	Silicone rubber	Fluororubber
				Soft	Hard						
Hydrochloric acid (10)	◎	◎	◎	○	◎	○		◎	◎	○	◎
(38)	◎	◎	◎	△	◎	○		◎	◎	×	◎
Nitric acid (30)	○	○	○	△	○	×	×	○	◎		◎
Sulfuric acid (10)	◎	◎	◎	◎	◎	◎	◎	◎	◎		◎
(98)	△	△	△	×	△	×	×	×	◎	×	◎
Formic acid (90)	◎	◎	◎	×	○	×		○	◎	○	△
Acetic acid (10)	◎	◎	◎	○	◎	○		○	◎	○	○
(100)	△	△	◎	×	△	×		×	◎	○	○
Aqueous ammonia	◎	◎	◎	○	◎	○		◎	◎	◎	◎
Sodium hydroxide (10)	◎	◎	◎	○	◎	○	◎	◎	◎	×	○
Ethanolamine	○	○	○	×	×				◎	○	×
Ethylene diamine	○	○	○	×	×	×			◎	◎	×
Pyridine				×	×	×			◎		×
Methanol	○	○	○	×	○	×		△	◎	○	○
Ethanol	○	○	○	×	○	×		○	◎	○	◎
Isopropanol	◎	◎	◎	×	○	×		○	◎	◎	◎
Ethylene glycol	◎	◎	◎	×	△				◎	◎	◎
Diethyl ether	×	△	×△	×	△			×	○	×	×
Diisopropyl ether	○	○	○	×	△	×			◎		×
Dioxane				×	×					△	×
Formaldehyde (40)	○	◎	◎	○	○	○		○	◎		◎
Acetone	△	△	△	×	×	×	×	×	◎	○△	×
Methyl ethyl ketone	△×	△	△	×	×	×	×	×	◎	△	×
Ethyl acetate	△	△	△	×	×	△		×	◎	△	×
Butyl acetate	△	△	△	×	×	×	×	×	◎	×	×
Hexane	×	△	×△	×	○	△			◎	×	◎
Isooctane	△			×	×	△			◎	×	◎
Benzene	△	△	△	×	×	△	×	×	◎	△	○
Toluene	△	△	△	×	×	△		×	○	×	○
Methylene chloride	×	△	×△	×	×	×	×	×	◎	×	○
Chloroform	×	×	×	×	×	×	×	×	○	×	○
Carbon tetrachloride	×	△	×△	×	×	×	×	×	◎○	×	◎
Chlorine gas	△	△	△	△	○	○	◎	○	○		◎
Ammonia gas	◎			△	○			×	◎	◎	×
Ozone	△			○	○	△		◎	◎	◎	◎
Potassium permanganate (5)	◎	◎	◎	○	◎			◎	◎		
Sodium hypochlorite (5)	◎	◎	◎	○	◎	○		◎	◎	◎	◎

Resistance to inorganic chemicals was determined by focusing on change in the appearance of a sample, the degree of contamination of a liquid, and change in physical properties.
◎=Excellent: There is no or little influence. O=Good: Although there is some influence, it can be used sufficiently depending on the conditions. △=Available: It should be used as little as possible.
X=Unavailable: Not suitable for use due to violent influence.

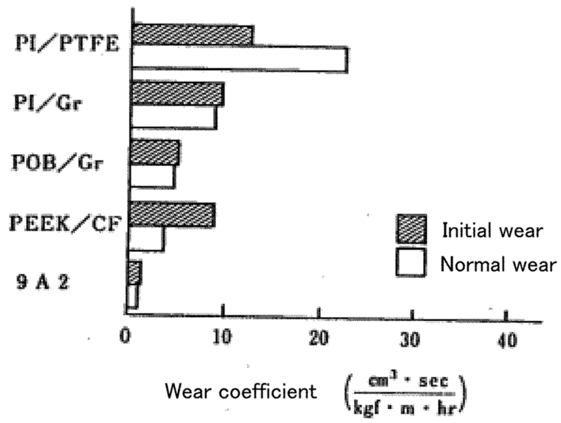
The resistance to organic oils and solvents was measured by immersing a sample at room temperature for 48 hours, measuring a weight change rate, and performing classification as follows.
Weight change rate=10% or less for ◎, 11% to 30% for O, 31% to 100% for △, and 101% or more for X

* Extracted and cited from Literature 1) and 2).

The table shows results at normal temperature. The resistance decreases at high temperatures. In some cases, samples cannot be used at high temperatures even though these can be used at room temperature.

Reference materials

*13) National Research and Development Agency, the Japan Science and Technology Agency, Masahiro NATSUME, School of Agricultural Science, Nagoya University “Chemical and solvent resistance of plastic experimental instruments”)



[Sliding conditions] Pin-disk type
Mating material: SS41 Hard chrome plating
$P = 10 kgf/cm^2$, $V = 4.0 m/sec.$
In air, Normal temperature

Fig. 5 Example of high PV value wear test data

*2) Valqua, Ltd., Research Department, Rubber Laboratory, Takaharu IKEDA "High-performance sliding material VALFLON® sliding material series with filler"

(9A2 is PTFE+filler.)

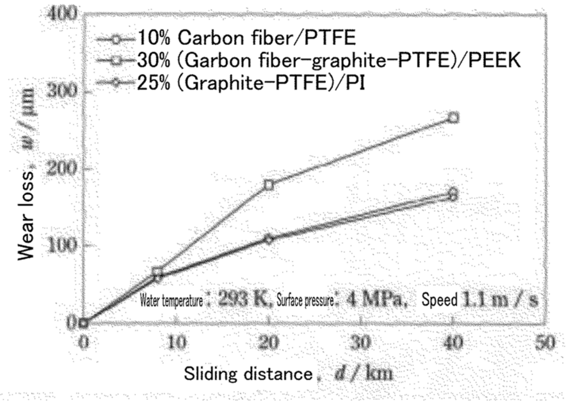


Fig. 14 Relationship between sliding distance and wear loss of various materials in water

*2) Valqua, Ltd., Research Department, Rubber Laboratory, Takaharu IKEDA "High-performance sliding material VALFLON® sliding material series with filler"

Table 4 Valflon® Sliding material property table

Item		Measurement method (ASTM etc.)	Unit	Valflon® 2N0	Valflon® 2T9	Valflon® 9A1	Valflon® 9A2	Valflon® 9B1	Valflon® 9A4	Valflon® 3U8
Color		————	————	White	Yellowish white	Yellowish white	Yellowish white	Black	Black	Dark brown
Specific gravity		D792	————	2.24	2.18	1.97	1.97	2.05	1.97	2.66
Hardness		D2240	Durometer "D"	65	71	65	65	62	66	73
Tensile strength		D1457 25℃	kgf/cm^2 (CD-direction)	170	110	150	100	180	100	190
Elongation		D1457 25℃	% (CD-direction)	280	270	250	170	280	90	240
Compression creep	60min	D621 25℃ $140kgf/cm^2$	% (MD-direction)	8.7	7.3	4.9	4.8	5.9	3.7	5.1
	24hr			12.5	9.5	8.0	7.0	7.0	4.5	6.9
	Permanent deformation (after 24 hrs)			7.5	5.8	4.1	3.5	2.9	1.7	3.6
Compression strength	0.2% Offset	D695 25℃	kgf/cm^2 (MD-direction)	87	90	110	110	110	120	110
	1% Distortion			75	100	100	100	77	110	110
	Modulus of elasticity			9100	13900	11400	11400	8100	13500	13600
Friction and wear properties with respect to copper material	Wear coefficient	$P=6kgf/cm^2$ $V=0.5m/s$ With respect to SS41 (using Matsubara-type tester), in air, normal temperature	$\frac{cm^3 \cdot s}{kgf \cdot m \cdot hr}$	6.1×10^{-6}	5.0×10^{-6}	1.3×10^{-6}	2.2×10^{-6}	3.9×10^{-6}	1.8×10^{-6}	0.9×10^{-6}
	Friction coefficient		————	0.40	0.40	0.20	0.21	0.17	0.27	0.27
	Aggressiveness		mg/km	0.01 Or less	0.01 Or less	0.01 Or less	0.01 Or less	0.01 Or less	0.01 Or less	0.01 Or less

Notes) 1. Values in this table represent an example of in-house measurement values and are not standard values.
2. There are some differences from the values in catalogs and literature so far, which is due to differences in molding conditions and measurement methods.

*2) Valqua, Ltd., Research Department, Rubber Laboratory, Takaharu IKEDA "High-performance sliding material VALFLON® sliding material series with filler"

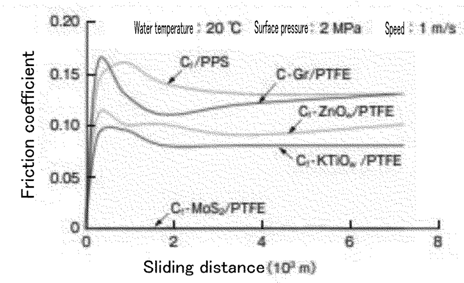


Fig. 3Comparison of friction coefficients between C_1–MOS_2/PTFE and other bearing materials: C_1–MOS_2/PTFE has a significantly small friction coefficient compared to other bearing materials.

Comparison of friction coefficients of C_1-MoS_2/PTFE and other bearing materials

*9) Toshiba Corporation, Toshiba Review Vol. 69 No. 12 (2014) "Water-lubricated bearing material with excellent wear resistance and low friction"

One of the reasons why PTFE-containing sliding materials are selected in various fields is that they have low frictional resistance and high elongation, which reduces the risk of damage during installation, vibration, and impact. In addition, they are considered to have great advantages such as absence of unpleasant "squeaking", "creaking", and the like. *2)

In this manner, if it becomes not possible for PTFE to be used, this will have a great impact on the automotive field, the electronic and semiconductor fields, and the energy field. For example, PTFE-containing bearing and sliding materials are used as follows.

· The materials are used in car power steering, car air conditioners, and the like. Toyota Motor Corporation, the world's number one seller, will have sales of 371,542,980,000 yen in 2022, and there will be a great economic impact on its 375,235 employees. *8)

· The materials are used as water-lubricated bearing materials for water turbine bearings in hydroelectric power generation. *9) In Norway, the largest hydroelectric country in Europe, 93% of domestic electricity comes from hydroelectric power generation (2019), which supports various industries. In addition, the GDP in 2021 will be 444.5 billion dollars, and there will be a great impact on the economy and livelihoods. *10)

· In the semiconductor field, the materials are used in high-purity solvent treatment systems to keep components free from corrosion and impurities. *11) The global semiconductor shipment value in 2021 will be 9,499.9 billion yen, and there will be a great impact on the global economy and information communication. *12)

Accordingly, it is essential that PTFE is used, and this enables environmental protection and economic sustainability.

Based on the above, permanent exemption for these uses is proposed.

Reference materials

*8) Toyota Motor Corporation, Summary of Financial Results ended in March 2023 (April 1, 2022 to March 31, 2023)

*9) Toshiba Corporation, Toshiba Review Vol. 69 No. 12 (2014) “Water-lubricated bearing material with excellent wear resistance and low friction”

*10) Ministry of Foreign Affairs of Japan, Basic Data of the Kingdom of Norway

*11) CHEMOURS.COM “Teflon™ Fluororesin in Semiconductor Manufacturing”

*12) Japan Ministry of Internal Affairs and Communications, Policy White Paper, 2022 Edition, Summary of Current Status Report on Information Communication