ARFLON

Structure•Properties•Applications

Fluoropolymer materials for self-lubricating parts, mechanical sealing, and dielectric applications

Produced by OOO «NPP «Arflon»

GENERAL CHARACTERISTICS OF MATERIALS UNDER BRAND ARFLON

Materials under tradename ARFLON are fluoropolymer materials obtained by preliminary compacting pure PTFE powder with various organic and inorganic fillers with subsequent thermal or high-temperature physico-chemical treatment.

Due to application of novel modification techniques, the ARFLON materials possess high homogeneity of structure and are free of porosity, the features intrinsic to common PTFE, both unfilled and filled. We also produce filled ARFLON materials featuring strong adhesion between filler and matrix.

ARFLON materials can be used for mechanical sealing, self-lubricating, dielectric and structural parts operating in a moderate load, up to 300 °C) in neutral and chemically and biologically aggressive environment, under exposure of UV and ionizing radiation. Radiation stability of ARFLON is in wide temperature range from −196 to +260 °C (under materials is enhanced by 100–250 times with respect to PTFE.

Special-grade ARFLON materials dedicated for sliding contacts (slider bearings, sealing rings, gland seals, piston seals, wear bands, etc.) demonstrate extremely high wear resistance (at $V < 2$ m/s up under dry conditions PV factor is up to 10 MPa·m/s; at $V < 5$ m/s under lubrication conditions PV factor is up to 25 MPa×m/s), low coefficient of friction, low creep and enlarged thermal conductivity.

Characteristics of ARFLON materials provide high reliability and long life for sliding parts and overtop counterparts used in world’s practice.

ARFLON MATERIALS OBTAINED BY COMPACTION AND THERMAL SINTERING OF PTFE POWDER, BOTH FILLED AND UNFILLED

Material grade	Description	Material shape	Properties	Replaced materials (counterpart)	Advantages over replaced materials	Applications
ARFLON A	Unfilled PTFE. Obtained by compaction and thermal sintering of PTFE powder according to international standatds (ISO, ASTM). Milky white color	Sheets, tubes, rods, roll, film	Similar to fluoroplast-4	Fluoroplast-4, Teflon® PTFE, Polyflon, Algoflon, Fluon, Soreflon, Gostaflon TF	As compared to domestic grades, possesses higher quality guaranteed by conformance to international standards (ISO, ASTM)	Sealing and tribological parts operating at low pressure (up to 50 kg/cm^2) and temperature (up to 100 °C), also in aggressive environment. Parts with enhanced chemical stability and biological inertness (chemical vessels, blood vessels, implants). Dielectric parts.
ARFLON C20	Filled PTFE obtained by compaction and thermal sintering of a blend of powders: 80% PTFE and 20% carbon black. Charcoal color	Sheets, tubes, rods, roll	Similar to fluoroplast-4, but with enhanced wear resistance and reduced creep	Filled PTFE of F4K20, F4K15M5 grades	Significantly reduced wear of countersurface, the parts obtained by machining have clean smooth surface	Sealing and tribological parts operating at moderate pressure (up to 120 kg/cm^2) and temperature (up to 180 °C), also in aggressive environment (except for liquid oxygen)
ARFLON B40G10	Filled PTFE obtained by compaction and thermal sintering of a blend of powders: 50% PTFE, 40% bronze, and 10% graphite. Dark brown color	Sheets, tubes, rods, roll	Similar to fluoroplast-4, but with enhanced rigidity, hardness, wear resistance and reduced creep	Filled PTFE of F4K20, F4K15M5, AFG-80VS, AFGM, F4Br40 grades	Puts together the properties of two self-lubricating fillers: graphite and bronze	Slider bearings and mechanical sealings operating at moderate pressure (up to 120 kg/cm^2) and temperature (up to 180 °C)
ARFLON CF20 and CF15	Filled PTFE obtained by compaction and thermal sintering of a blend of powders: 80 or 85% PTFE and 20 or 15% carbon fiber. Charcoal color	Sheets, tubes, rods, roll	Similar to fluoroplast-4, but with enhanced rigidity, wear resistance and reduced creep	Filled PTFE of F4UV15, F4UV20, flubon20 grades	Quality guaranteed by conformance to international standards (ISO, ASTM)	Slider bearings and mechanical sealings operating at moderate pressure (up to 120 kg/cm^2) and temperature (up to 180 °C), also in aggressive environment (except for liquid oxygen)
ARFLON GF25, GF20, GF15	Filled PTFE obtained by compaction and thermal sintering of a blend of powders: 75 or 80 or 85% PTFE and 25 or 20 or 15% fiberglass. Light-yellow color	Sheets, tubes, rods, roll	Similar to fluoroplast-4, but with enhanced rigidity, hardness, wear resistance and reduced thermal expansion and creep	Filled PTFE of F4S15, F4S20 grades	Quality guaranteed by conformance to international standards (ISO, ASTM)	Sealing and tribological parts operating at moderate pressure (up to 120 kg/cm^2) and temperature (up to 180 °C), also in aggressive environment (except for hydrofluoric acid and strong alkali at elevated temperature). Cryogenic mechanical sealings. Dielectric parts.

ARFLON MATERIALS OBTAINED BY COMPACTION AND PHYSICAL CROSS-LINKING OF UNFILLED AND FILLED PTFE POWDERS

Material grade	Description	Material shape	Properties	Replaced materials (counterpart)	Advantages over replaced materials	Applications
ARFLON AR100	Unfilled PTFE. Obtained by compaction and PCL of PTFE powder. TU 20.16.30-002-06335753-2017 White translucent color	Sheets, tubes, rods, roll, film	Similar to F4 and ARFLON A, but with enhanced wear resistance, thermal stability, and reduced creep	F4, Teflon® PTFE, Polyflon, Algoflon, Fluon, Soreflon, Gostaflon TF Teflon® NXT 70, NXT 75, NXT 85 (manufactured by DuPont, U.S.) Dyneon TFM1700, TFM1705, TFM1600, TFM1605 (manufactured by 3M, U.S.–Germany)	Puts together all best properties of unfilled PTFE with significant reduction of wear rate by 3–5 times and creep reduced by 2–3 times	Parts for mechanical sealing and tribological purposes operating at moderate pressure (up to 120 kg/cm^2) and temperature (up to 180 °C), also in highly aggressive environment (concentrated and diluted acids and alkali, hydrogen sulfide, hydrofluoric acid, hydrocarbons, liquid oxygen, solvents, sea water, etc.). Parts with high chemical resistanse and biological inertness (chemical vessels, blood vessels, implants, prosthetic devices). Dielectric parts.
ARFLON AR200	Unfilled PTFE. Obtained by compaction and PCL of PTFE powder. TU 20.16.30-002-06335753-2017 White translucent color	Sheets, tubes, rods, roll, film	Similar to ARFLON AR100, but with enhanced wear resistance, radiation and thermal stability, rigidity, hardness, reduced creep and friction at $V > 0.5$ m/s	F4K20, F4K15M5, F4S15, F4UV15, F4UV20, Caprolon, UHMWPE Teflon® NXT 70, NXT 75, NXT 85 (manufactured by DuPont, U.S.) Dyneon TFM1700, TFM1705, TFM1600, TFM1605 (manufactured by 3M, U.S.–Germany) ZX-100K, ZX-530, PEEK (Manufactured by Zedex, Germany) MSM (manufactured by Maurer, Germany)	Puts together all best properties of ARFLON AR100 with significant reduction of wear, up to 10-fold as compared with best filled PTFE, and up to 10000-fold as compared to unfilled PTFE. Creep is reduced by 2-3 times as compared with filled PTFE, Caprolon, and others, and by 10 times as compared to unfilled PTFE. Radiation stability is enhanced by 100–300 times as compared with PTFE. As compared to PEEK and ZX-530, *PV* factor and friction coefficient are significantly reduced. As compared to ZX-100K and MSM, thermal stability and operation temperature are significantly enhanced.	Parts for mechanical sealing and tribological purposes operating at elevated pressure (up to 200 kg/cm^2) and temperature (up to 200 °C), also in highly aggressive environment (concentrated and diluted acids and alkali, hydrogen sulfide, hydrofluoric acid, hydrocarbons, liquid oxygen, solvents, seawater, etc.). Parts with high chemical stability and biological inertness (chemical vessels, blood vessels, implants, prosthetic devices). Dielectric parts.
ARFLON AR201	Filled PTFE obtained by compaction and PCL TU 20.16.30-002-06335753-2017 Black color	Sheets, tubes, rods, roll	Similar to ARFLON AR100, but with enhanced thermal conductivity and reduced friction	F4K20, F4K15M5, F4S15, F4UV15, F4UV20, Fluvis Filled PTFE of G412, G414, G483, G410, G415, G430, G450, G451, G452, G456, G463, G453, G472 grades (manufactured by Guarniflon S.p.A, Italy) Fluon PB2015, RB2015 (manufactured	Puts together advantages of AR200 with enhanced radiation stability, electric and thermal conductivity.	Parts for mechanical sealing and tribological purposes operating at high pressure (up to 250 kg/cm^2) and temperature (up to 260 °C), also in aggressive environment (concentrated and diluted acids and alkali, hydrogen sulfide, hydrocarbons, liquid oxygen, solvents, seawater, etc.), except for liquid oxygen.

				by Asahi Glass, Japan–U.K.) Filled PTFE Dyneon 1191N, FC15025, PDR 06014, TF6302, 310192004, TF3215, TF3215S, TF3235, TF3236, TF4212, TF4215, TF4216, TF4303, TF 6262, TF6302 (manufactured by 3M, U.S.–Germany)		
ARFLON AR202	Filled PTFE obtained by compaction and PCL TU 20.16.30-002-06335753-2017 Black color	Sheets, tubes, rods, roll	Similar to ARFLON AR200, but with enhanced thermal conductivity	F4K20, F4K15M5, F4S15, F4UV15, F4UV20, Fluvis Filled PTFE of G412, G414, G483, G410, G415, G430, G450, G451, G452, G456, G463, G453, G472 grades (manufactured by Guarniflon S.p.A, Italy) Fluon PB2015, RB2015 (manufactured by Asahi Glass, Japan–U.K.) Filled PTFE Dyneon 1191N, FC15025, PDR 06014, TF6302, 310192004, TF3215, TF3215S, TF3235, TF3236, TF4212, TF4215, TF4216, TF4303, TF 6262, TF6302 (manufactured by 3M, U.S.–Germany)	Combines advantages of AR200 with enhanced radiation stability, electric and thermal conductivity.	Parts for mechanical sealing and tribological purposes operating at high pressure (up to 250 kg/cm^2) and temperature (up to 260 °C), also in aggressive environment (concentrated and diluted acids and alkali, hydrogen sulfide, hydrocarbons, liquid oxygen, solvents, seawater, etc.), except for liquid oxygen.
ARFLON AR215	Filled PTFE obtained by compaction and PCL TU 20.16.30-002-06335753-2017 Dark brown color	Sheets, tubes, rods, roll	Similar to ARFLON AR200, but with enhanced wear resistance, thermal stability, thermal conductivity, rigidity, hardness, reduced friction, thermal expansion and creep	F4K20, F4K15M5, F4S15, F4UV15, F4UV20, Fluvis, Superfluvis, F4Br40, PEEK, Caprolon, polyurethanes Filled PTFE of G401, G402, G403, G404, G405, G406, G513, G416, G417, G425, G427, G428, G429, G458, G459. G464, G473, G476. G488, G506, G548 grades (manufactured by Guarniflon S.p.A, Italy) Fluon PA1015Z, PA1020Z, PA1025Z, RB1015S, RB1020S, RB1025S, PB3060, PB3360T (manufactured by Asahi Glass, Japan–U.K.) Filled PTFE Dyneon 1174N, FB01N, FC100151000, FC16863, FC18050, PDR010031, PDR05017, PDR010031, PDR 05017, TF3406, TF3105, TF4103, TF4104, TF4105, TF4705, TF6103N, TF6105N, TF6404, TF4105, TF6406, TF8615 (manufactured by 3M, U.S.–Germany)	Combines advantages of AR200 with significantly improved mechanical and tribological characteristics, enhanced radiation stability, electric and thermal conductivity.	High-quality material for tribocontacts and mechanical sealings operating at high pressure (up to 250 kg/cm^2) and temperature (up to 260 °C).
ARFLON AR204	Filled PTFE obtained by compaction and PCL TU 20.16.30-002-06335753-2017 Black color	Sheets, tubes, rods, roll	Similar to ARFLON AR200, but with enhanced wear resistance, thermal stability, thermal conductivity, rigidity, hardness, reduced	F4K20, F4K15M5, F4UV15, F4UV20, Fluvis, Superfluvis, F4Br40, PEEK, Caprolon, polyurethanes Filled PTFE of G412, G414, G483, G410, G415, G430, G450, G451, G452, G456, G463, G453, G472 grades	Combines advantages of AR215 with enhanced chemical stability	High-quality material for tribocontacts and mechanical sealings operating at high pressure (up to 250 kg/cm^2) and temperature (up to 260 °C), also in aggressive environment, except for liquid oxygen.

			friction, thermal expansion, and creep	(manufactured by Guarniflon S.p.A, Italy) Fluon PB2015, RB2015 (manufactured by Asahi Glass, Japan–U.K.) Filled PTFE Dyneon 1191N, FC15025, PDR 06014, TF6302, 310192004, TF3215, TF3215S, TF3235, TF3236, TF4212, TF4215, TF4216, TF4303, TF 6262, TF6302 (manufactured by 3M, U.S.–Germany)		
ARFLON AR203	Filled PTFE obtained by compaction and PCL TU 20.16.30-002-06335753-2017 Dark brown color	Sheets, tubes, rods, roll	Similar to ARFLON AR200, including dielectric characteristics, but with enhanced rigidity, hardness, reduced thermal expansion and creep	F4K20, F4K15M5, F4S15, F4S25 Filled PTFE of G401, G402, G403, G404, G405, G406, G513, G416, G417, G425, G427, G428, G429, G458, G459. G464, G473, G476. G488, G506, G548 grades (manufactured by Guarniflon S.p.A, Italy) Fluon PA1015Z, PA1020Z, PA1025Z, RB1015S, RB1020S, RB1025S, PB3060, PB3360T (manufactured by Asahi Glass, Japan–U.K.) Filled PTFE Dyneon 1174N, FB01N, FC100151000, FC16863, FC18050, PDR010031, PDR05017, PDR010031, PDR 05017, TF3406, TF3105, TF4103, TF4104, TF4105, TF4705, TF6103N, TF6105N, TF6404, TF4105, TF6406, TF8615 (manufactured by 3M, U.S.–Germany)	Combines advantages of AR200, including excellent dielectric characteristics, with improved mechanical characteristics and enhanced radiation stability.	High-quality material for tribocontacts and mechanical sealings operating at high pressure (up to 250 kg/cm^2) and temperature (up to 260 °C), also in aggressive environment, except for hydrofluoric acid and strong alkali at elevated temperature. Dielectric parts and cryogenic parts

STRUCTURAL FEATURES OF ARFLON MATERIALS OBTAINED BY PCL METHOD

Unfilled ARFLON materials obtained by physical cross-linking (PCL), AR100 and AR200, are PTFE with modified structure. These ARFLON grades exhibit spherolite packing of macromolecules instead of lamellar packing typical for ordinary PTFE. Spherolite packing provides improvement of mechanical, viscoelastic, and tribological characteristics.

Filled ARFLON materials obtained by PCL method exhibit strong chemical bonding between dispersed particles and PTFE macromolecules, and also axiolite structure, where filler particles are located at the center, and macromolecules are arranged radially with respect to the center of axiolite. In common thermally sintered filled PTFE filler particles are not bonded with macromolucules and are not wetted by them due to incompatibility of surface energies, while the structure of polymer matrix remains lamellar as in unfilled sintered PTFE. PCL method provides significant improvement of mechanical, viscoelastic and tribological properties of filled PTFE.

GENERAL DESCRIPTION OF ARFLON MATERIALS OBTAINED BY PCL METHOD

Unfilled AR100 and AR200 materials obtained by PCL method exhibit better performance characteristics as compared to ordinary PTFE. In passing from AR100 to AR200 density, Young modulus, hardness, stress at given strain increase, while wear rate, strain at given stress, creep rate and porosity decrease. Use of AR100 and AR200 makes it possible to increase significantly ultimate values of mechanical stress at elevated temperatures, and also ultimate values of sliding pressure and velocity in tribocontacts. The decrease in porosity increases average values of breakdown voltage. ARFLON of AR200 grade surpasses conventional filled PTFE grades, such as F4K20, F4K15M5, F4S15, F4UV15, F4KS2, AFG20VS, and others, with respect of creep, strain and strength characteristics, especially at elevated temperatures, and also by stability of characteristics under exposure by ionizing radiation.

Filling provides additional advantages to ARFLON materials. Filled ARFLON obtained by PCL method exhibit enhanced wear resistance, thermal stability, thermal conductivity, rigidity, hardness, and reduced friction, thermal expansion and creep. This provides further increase in ultimate mechanical stress (especially at elevated temperatures) and ultimate sliding pressure and velocity in tribocontacts.

FIELD OF APPLICATION OF ARFLON MATERIALS OBTAINED BY PCL METHOD

ARFLON materials can be used in the fields where unfilled and filled PTFE materials are currently used: as structural materials, mechanical sealings, self-lubricating parts, and dielectric materials, and also in the field where these materials could not previously be used due to restrictions on the operating conditions (pressure, temperature, absorbed radiation dose, etc.).

ARFLON materials can successfully replace such materials as Caprolon, UHMWPE, polyurethanes, and a wide range of sealing and tribological materials: MSM (Maurer, Germany), ZX100K, ZX530 (Zedex, Germany), and others.

The absence of fillers provides flexibility of applications for AR100 и AR200 grades, because the fillers restrict applicability of material due to deterioration of chemical and corrosion resistance, dielectric properties, abrasion of countersurface, moisture absorpstion, inhomogeneity and porosity of structure, etc.

When these restrictions are absent, the use of filled ARFLON grades provides additional increase in the life cycle of parts due to better mechanical and tribological characteristics.

GENERAL CHARACTERISTICS OF UNFILLED ARFLON MATERIALS OBTAINED BY PCL MATHOD AS COMPARED TO SINTERED PTFE

No.	Property	Material grade			
		PTFE	AR100	AR101	AR200
1	Density according to GOST 15139 at 20±2 °C, g/cm³	2.140-2.180	2.185-2.195	2.190-2.205	2.195-2.215
2	Young modulus under compression according to GOST 9550, MPa				
	20 °C	250-400	450-500	550-600	600-700
	100 °C	150-160	230-260	270-290	280-330
	150 °C	30-40	70-85	120-140	150-170
	200 °C	20-25	60-80	100-120	120-130
	250 °C	10-15	40-50	60-70	70-80
3	Young modulus under tension according to GOST 9550, MPa				
	20 °C	250-350	400-450	500-550	500-600
	100 °C	135-145	200-220	230-250	230-250
	150 °C	25-35	90-100	100-110	110-130
	200 °C	15-20	50-60	60-70	70-80
4	Stress at 10% strain under compression according to GOST 4651, MPa				
	20 °C	12	19	22	25
	100 °C	4.1	12	14	16
	150 °C	3.5	8	10	11
	200 °C	2.4	5	7	9
	250 °C	1.6	3	5	7
5	Stress at 10% strain under tension according to GOST 4651, MPa				
	20 °C	6	10	13	14
	100 °C	3.5	7	8	11
	150 °C	2.5	5.5	5.5	7
	200 °C	2	3.5	4	5
6	Creep at 14 MPa under compression at 20 °C for 24 h, %:				
	– total	16	12	10	8
	– irreversible	12	2	1	0.2
7	Creep at 12 MPa under tension at 20 °C for 100 h, %				
	– total	300	20	4	2
	– irreversible	180	4	1	0.1
8	Creep at 0.5 MPa under tension at 250 °C for 24 h, %				
	– total	20	5	3	2
	– irreversible	14	1	0.5	0.2

9	Tensile strength according to GOST 11262, MPa 20 °C 100 °C 150 °C 200 °C	 20-30 13-15 8-10 6-8	 15-17 10-12 10-12 6-8	 13-15 10-12 10-12 6-8	 12-15 11-13 7-8 5-7
10	True tensile strength (load normalized to the actual sample cross section at the moment of breakage), MPa	120-130	120-130	115-125	100-110
11	Elongation at brake according to GOST 11262, % 20 °C 100 °C 150 °C 200 °C	 400-550 400-500 400-500 400-500	 350-470 350-400 350-400 300-350	 200-300 300-400 300-350 300-350	 80-150 200-250 200-250 200-250
12	Dynamic coefficient of friction (dry sliding of pin against metal disk without cooling of contact area): – P=2.5 МПа, V=1 м/с, Ra=0.3, HRc 45 – P=10 МПа, V=1 м/с, Ra=0.3, HRc 45	 0.22 0.20	 0.22 0.20	 0.20 0.18	 0.20 0.18
13	Linear wear rate (dry sliding of pin against metal disk without cooling of contact area), μm/km: – *P* = 2.5 MPa, *V* = 1 m/s, Ra = 0.3, HRc 45 – *P* = 10 MPa, *V* = 1 m/s, Ra = 0.3, HRc 45	 5×10^3 $>10^4$	 0.5×10^3 $(1\text{-}2)\times10^3$	 0.5-1 1-2	 0.1-0.3 1-2
14	Wear rate (dry sliding of pin against metal disk without cooling of contact area), $mm^3/(N\cdot m)$: – *P* = 2.5 MPa, *V* = 1 m/s, Ra = 0.3, HRc 45 – *P* = 10 MPa, *V* = 1 m/s, Ra = 0.3, HRc 45	 10^{-3} -	 $(0.3\text{-}0.5)\times10^{-6}$ $(1\text{-}2)\times10^{-6}$	 $(0.5\text{-}1)\times10^{-9}$ $(0.5\text{-}1)\times10^{-9}$	 10^{-9} 10^{-9}
15	Stretching void index, SVI ASTM D4895-04	<300	<100	<60	<50
16	Brinell hardness, MPa D2240 – 05	25-28	30-35	38-40	40-42
17	Shore hardness D2240 – 05	58-60	59-60	60-61	61
18	Heat ageing in air at 250 ºC for 1000 h: – change in tensile strength, %, maximum – change in the elongation at break, %, maximum	 10 30	 10 30	 10 30	 10 30

19	Melting temperature, ºC ASTM D 4591	327	320	315	312
20	Heat of fusion/crystallization, J/g ASTM D 4591	25-30	30-35	35-40	35-40
21	Linear thermal expansion coefficient, 10^{-5}, K^{-1} -60 20 100 150 200 250	 9 12 12 17 20 24	 9 11 11 16 19 23	 8 10 10 15 18 22	 8 10 11 15 18 21
22	Moisture absorption after 1000 hours in water at 60 ºC, %, maximum GOST 4650	0.05	0.05	0.05	0.05
23	Dielectric coefficient at 10^9 Hz	2.1 – 2.2	2.1 – 2.2	2.1 – 2.2	2.1 – 2.2
24	Dielectric loss tangent at 10^9 Hz	$(1 – 3)\times10^{-4}$	$(1 – 3)\times10^{-4}$	$(1 – 3)\times10^{-4}$	$(1 – 3)\times10^{-4}$
25	Dielectric strength at constant voltage (sample thickness 0.100±0.005 mm), kV/mm	>25	>50	>50	>70
26	Integral optical transmission coefficient in the region 400–800 nm for 100 μm film, %	≥40	≥50	≥60	≥80
27	Gas release, % GOST R 50109	≤0.01	≤0.01	≤0.01	≤0.01
28	Corrosion resistance, GOST 9902	Applicability up to 250 ºC in contact with stainless steel. chrome-plated structural steel, and titanium alloys.	Applicability up to 250 ºC in contact with stainless steel. chrome-plated structural steel, and titanium alloys.	Applicability up to 250 ºC in contact with stainless steel. chrome-plated structural steel, and titanium alloys.	Applicability up to 250 ºC in contact with stainless steel. chrome-plated structural steel, and titanium alloys.
29	Radiation stability, kGy, GOST 9.706, group IV	10	500	1000	2000

GENERAL CHARACTERISTICS OF FILLED ARFLON MATERIALS OBTAINED BY PCL METHOD AS COMPARED TO SINTERED FILLED PTFE

No.	Property	Material grade					
		Thermal sintering			PCL		
		F4K15M5	F4S15	F4UV15	AR203	AR204	AR215
1	Young nodulus under compression according to GOST 9550, MPa 20 °C 150 °C 200 °C 250 °C	 650-750 75-85 60-70 30-40	 550-700 70-80 60-70 30-40	 700-800 100-120 60-70 30-40	 800-900 350-400 230-250 150-170	 1000-1100 460-500 260-300 220-230	 1300-1400 480-520 350-370 250-280
2	Stress at 10% strain under compression according to GOST 4651, MPa 20 °C 150 °C 200 °C 250 °C	 21 6.5 5.6 2.5	 21 7.0 5.7 3.0	 22 7.3 5.9 3.2	 28 14 9.8 8.4	 36 17 14.9 9.9	 38 18 15.0 11.9
3	Creep at 25 MPa under compression for 1 h, %: – total 20 °C 150 °C 200 °C – irreversible 20 °C 150 °C 200 °C	 25 33 40 20 25 29	 22 30 40 18 24 30	 20 30 56 14 22 40	 5 12 22 2.4 4.4 9.5	 4.5 7 16 1.7 2.1 4.0	 4.1 5.9 15 1.0 1.5 3.2
4	Tensile strength at 20 ºC according to GOST 11262, MPa	>15	>15	>15	>15	>15	>15
5	Elongation at brake at 20 ºC according to GOST 11262, %	>100	>150	>100	>100	>100	>50
6	Dynamic coefficient of friction (dry sliding of pin against metal disk without cooling of contact area at P = 2.5 MPa, V =1 m/s, Ra = 0.3, HRc 45)	0.25-0.38	0.25-0.30	0.24-0.26	0.14-0.16	0.14-0.18	0.18-0.20
7	Linear wear rate (dry sliding of pin against metal disk without cooling of contact area at P = 2.5 MPa, V =1 m/s, Ra = 0.3, HRc 45), μm/km	5-10	3-5	2-3	0.3	<0.1	<0.1
8	Brinell hardness, MPa, D2240 – 05	28-30	28-30	30-32	42-45	55-58	70-75
9	Thermal conductivity, W/(m·K)	0.34	0.28	0.35	0.35	0.38	0.45
10	Melting temperature, ºC ASTM D 4591	329	328	328	310	308	307
11	Heat of fusion/crystallization, J/g, ASTM D 4591	24	25	20	35-40	35-40	35-40
12	Radiation stability, kGy, GOST 9.706, group IV	1	1	1	2500	2500	2500

CHARACTERISTICS OF TEFLON PTFE, PEEK AND ARFLON AR200

No.	Property	Standard	Units	PTFE	PEEK	AR200
1	Density	ISO 12086	g/cm^3	2.14-2.17	1.31	2.19-2.20
2	Maximum operating temperature	-	°C	260	250	260
3	Minimum operating temperature	-	°C	-200		-200
4	Brinell hardness	DIN 53 456	N/mm^2	28-32	170	38-40
5	Shore hardness	DIN 53 505	Sh. D	58	>80	60
6	Tensile strength (23°C)	DIN 53 455	N/mm^2	20-30	75-97	15-16
7	Elongation at break (23°C)	DIN 53 455	%	300-500	20	100-150
8	Young modulus under tension (23°C)	DIN 53 457	N/mm^2	250-350	2300-4300	450-550
9	Flexural modulus	DIN EN ISO 178	MPa	600-800	3600-4100	800-1000
10	Thermal expansion coefficient (20-150°C)	-	$1/K, 10^{-5}$	10-15	5	9-12
11	Thermal expansion coefficient (150-260°C)	-	$1/K, 10^{-5}$	15-20	6	13-18
12	Thermal conductivity (23°C)	DIN 52 612	$W/K \times m$	0.25	0.25	0.25
13	Creep at 15 MPa for 24 h (23°C)	ASTM-D621	%	16-18		7-9
14	Creep at 4 MPa for 24 h (260°C)	ASTM-D621	%	30-33		4-5
15	Stress at 1% strain (23°C)	DIN 53 454	N/mm^2	3-4		7-8
16	*PV* factor 3 m/min	-	$\frac{N \times m}{mm^2 \times min}$	<1	20-30	30-35
17	*PV* factor 30 m/min	-	$\frac{N \times m}{mm^2 \times min}$	<1	10-15	250-300
18	*PV* factor 300 m/min	-	$\frac{N \times m}{mm^2 \times min}$	<1	5-10	50-100
19	Coefficient of friction (static)	-		0.05-0.10	0.25-0.34	0.08-0.12
20	Coefficient of friction (dynamic)	-		0.22-0.27	0.22-0.25	0.19-0.22
21	Wear rate, 10^{-8} (20-100°C)	-	$\frac{cm^3 \times min}{kg \times m \times h}$	10^4	20-60	1-3

COMPARIZON OF TEFLON PTFE, PEEK AND ARFLON AR200

1. AR200 material possesses significantly better tribological characteristics as compared to PEEK and especially PTFE.

PV factor describes ultimate conditions for polymer operating in a tribocontact. At given sliding velocity *V* (m/s) PV_f factor gives ultimate load (or pressure) $P_{\max}$ for tribocontact:

$$P_{\max} = \frac{PV_f}{V}$$

As can be seen from the table, at all sliding velocities from 3 m/min to 300 m/min the values of PV_f factor for AR200 are always higher as compared to PEEK. AR200 is better than PEEK in this respect by 20–30 times at V = 30 and 300 m/min. For PTFE PV_f factor is much lower than that of AR200 and PEEK. For this reason PTFE is used for frictional parts only when filled with fiberglass, carbon fiber, graphite, coke, carbon black, bronze, and other fillers decreasing its wear rate. PTFE itself has very high creep restricting ultimate pressure in the tribocontact and high wear rate restricting ultimate sliding speed. This results in very low values of PV_f factor (below 1), 100–200 times lower than that of AR200 (see table). PEEK has PV_f factor that is higher than PV_f factor of PTFE, but much lower than PV_f factor of AR200. A drawback of PEEK is an increase in the wear rate with sliding speed. For this reason an increase in the sliding speed from 3 to 300 m/min decreases the ultimate pressure in the tribocontact by 5–6 times.

PEEK also have higher coefficient of friction than PTFE and AR200. So, the self-lubricating ability of the latters is higher as compared to PEEK.

As demonstrated in table, wear resistance of AR200 is about 20 times higher than that of PEEK due to higher self-lubricating properties of AR200. Wear resistance of PTFE is 10000 lower than that of AR200 and 500-1000 times lower than that of PEEK.

Thus, at both low and high sliding speed AR200 demonstrate better tribological characteristics than PEEK and PTFE. Use of AR200 in frictional parts provides higher reliability and longer life cycle and also possibility to enhance technical characteristics, such as ultimate temperature, pressure and sliding velocity.

2. From the viewpoint of mechanical properties PEEK is more rigid and hard material than AR200 and PTFE. As demonstrated in table, PEEK have higher Young modulus, hardness, and tensile strength. Meanwhile PEEK have elongation at break much lower than that of PTFE and AR200. Due to its brittleness and low plasticity, to apply PEEK for mechanical sealing we need precision machining (fitting) of interfacing surfaces and can not fabricate thin-walled parts (or sharp edges). So AR200 is the best choice for thin-walled parts and mechanical sealings.

3. Creep under static load of AR200 (15 MPa for 24 h at 23 °C and 4 MPa for 24 h at 260 °C) is lower than that of PEEK. This indicates that

long-range creep of AR200 is much better than that of PEEK. For this reason the expected lifetime of AR200 in mechanical sealing or tribocouple at elevated temperatures is higher than that of PEEK.

4. PEEK has lower coefficient of thermal expansion as compared to AR200 and PTFE. This does not affect directly the life cycle but shoud be taken into account in designing the parts and assemblies.

ARFON materials are developed and produced by OOO «NPP «Arflon» using domestic raw materials

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