DAIKIN

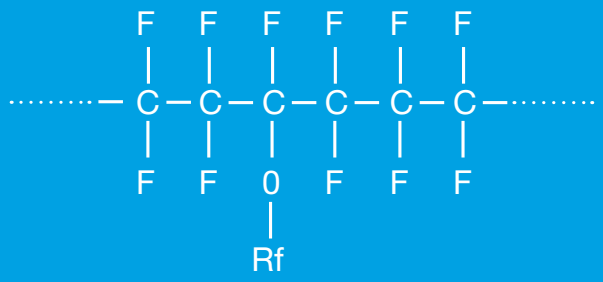
PRODUCT INFORMATION

(except for U.S.A.)

NEOFLON PFA

Introduction:

NEOFLON PFA is a copolymer of tetrafluoroethylene and perfluoroalkyl vinyl ether, NEOFLON PFA is a compound of carbon atoms and fluorine atoms in which a perfluoroalkoxy radical is bonded to the carbon chain in the following molecular structure.



NEOFLON PFA has better mechanical strength at high temperatures than NEOFLON FEP, and has excellent moldability for easy of processing by extrusion, compression, blow, transfer, and injection molding methods. Due to the high bonding strength of the carbon, fluorine and oxygen atoms, NEOFLON PFA demonstrates nearly the same outstanding capabilities as PTFE in temperatures ranging -200°C~+260°C. NEOFLON PFA has excellent transparency for use in melt-flow processing.

1. NEOFLON PFA Features

1-1 Moldability

While maintaining the outstanding characteristics of PTFE, NEOFLON PFA is a fluoropolymer resin with good melt flowability, which can be processed similar to other thermoplastic resins.

1-2 Corrosion-resistance

NEOFLON PFA is not effected by most chemicals.

1-3 Retention of mechanical strength through a wide temperature range

From-200℃ up to +260℃, PFA maintains its flexibility without a loss of toughness. The maximum continuous use temperature for PFA is 260℃ (500° F). This is the highest temperature for continuous use of any fluoropolymer resins.

1-4 Electrical characteristics

- Low, stable dielectric constant throughout a wide frequency range
- Extremely low, stable dissipation factor throughout a wide temperature and frequency range
- High volume resistivity
- Extremely high dielectric breakdown strength

1-5 Flame resistant

NEOFLON PFA has excellent flame resistance.

1-6 Weatherability

Even after long exposure to the elements, PFA's properties will not change.

1-7 Non-sticking and low friction

PFA is inherently noncohesive and it is extremely repellant of water, oil and other substances. Furthermore, its surface is characteristically slippery.

2. NEOFLON PFA Grades The details of features' for the semiconductor grade PFA is referred to the thechechnical data of SH series, EG-68

Table 1 NEOFLON PFA Grades and Properties

Item / Grade	Appearance	Apparent★1 specific gravity (g/ml)	Melt flow rate ★2 372℃, 5000g (g/10min)	Molding methods	Features
AP-201	Semi-translucent, milky white pellets	1.0~1.4	20~30	Injection molding Extrusion molding	Suitable for complex and small shapes, injection molding forms and thin electric wire coatings
AP-210	Semi-translucent, milky white pellets	1.0~1.4	10~17	Injection molding Extrusion molding	Suitable for complicated injection molding forms and for electrical wire coatings
AP-230	Semi-translucent, milky white pellets	1.0~1.4	1.5~2.5	Extrusion molding Transfer molding Compression molding	Suitable for linings

Special colored pellets for NEOFLON PFA are available for use as coloring agents.
Available colors are: white, red, orange, yellow, green, blue, purple, brown, gray, and black.
★1 Test method: JIS K6891
★2 Test method: ASTM D1238

Table 2 NEOFLON PFA-SH Grades and Properties(High-Purity PFA in semiconductor) *1

Item / Grade	Appearance	Apparent specific gravity (g/ml)	Melt flow rate 372℃, 5000g (g/10min)	Density (25℃)	Features	Packaging unit (kg)
AP-201SH	Semi-translucent, milky white pellets	1.0~1.4	20~30	Ca.2.15	Suitable for complex and small shapes,	25
AP-211SH	Semi-translucent, milky white pellets	1.0~1.4	10~18	Ca.2.15	Improved flexural life cycles and excellent stress crack resistan suitable for the fittings and the pomp parts	25
AP-215SH	Semi-translucent, milky white pellets	1.0~1.4	10~18	Ca.2.15	High MFR and suitable for injection molding of wafer baskets	25
AP-231SH	Semi-translucent, milky white pellets	1.0~1.4	1.5~2.5	Ca.2.15	Improved flexural life cycles and excellend stress crack resistan suitable for extrusion molding and transfer molding	25

Notice)*1 SH Series hes stable polymer ends to reduce the level of extractable fluoride ions.

3. NEOFLON PFA Properties

3-1 Physical properties

Table2 NEOFLON PFA Physical Properties

	Unit	NEOFLON PFA	NEOFLON FEP	Test metho
Specific gravity		2.14～2.16	2.12～2.17	ASTM D 79
Contact angle(for water)	Degree	115	114	—
Water absorption	%	<0.01	<0.01	ASTM D 57

3-2 Thermal properties

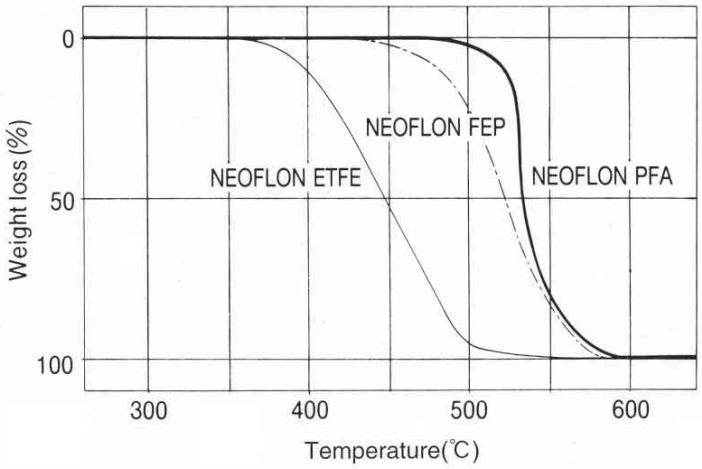
Table3 NEOFLON PFA Thermal Properties

	Unit	NEOFLON PFA	NEOFLON FI
Melt viscosity at 380℃	P	$(2\sim25)\times10^{4}$	$(5\sim60)\times1$
Specific heat	J/g/℃	1.05	1.17
Melting point*1	℃	300～310	265～275
Coefficient thermal conductivity*2	J/s·℃·cm	2.6×10^{-3}	2.5×10^{-3}
Coefficient of		12×10^{-5}	$(8\sim15)\times1$
Linear Thermal Expansion*3	1/℃	(+20～+100℃)	(−50～+100

*1 Test method: DSC(10℃/min) ASTM D4591
*2 Test method: ASTM C177
*3 Test method: ASTM D696

Fig.1 is comparison of the results of a thermal gravity analysis (TGA) for NEOFLON PFA, NEOFLON ETFE and NEOFLON FEP.

Fig.1 Heat-weight Reduction Curve (TGA)



3-3 Flammability

NEOFLON PFA has excellent flame resistance similar to PTFE and NEOFLON FEP. It produces less smoke than ethylene tetrafluoroethylene copolymer (ETFE) or polyvinylidene fluoride (PVdF). It is noncombustible at a marginal oxygen index (the concentration of oxygen required for sustained combustion) less than 95 vol%.

Table 4 Flammability

	UL test		ASTM test
	UL 94 flame class	Sample thickness (mm)	Oxygen index (vol%)
NEOFLON PFA	V-0	1.57	>95
NEOFLON FEP	V-0	1.57	>95
NEOFLON ETFE	V-0	1.57	31

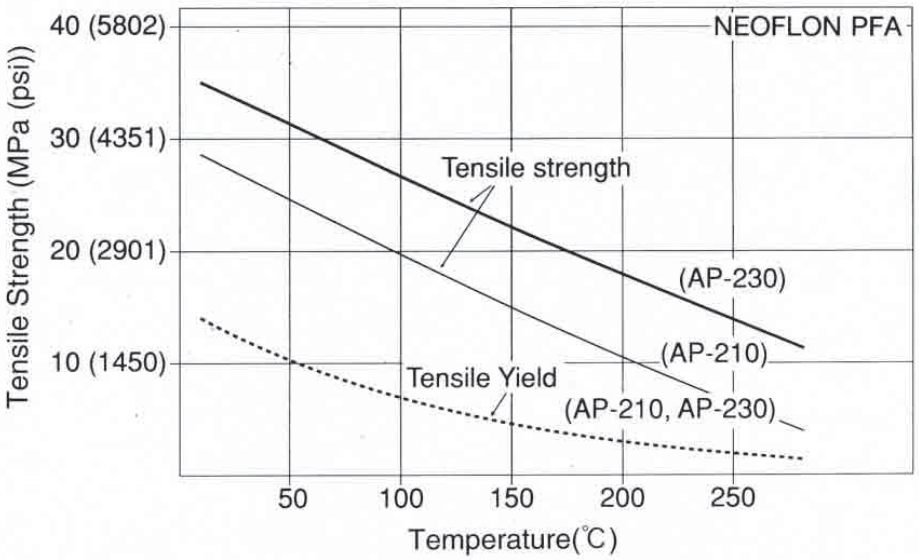
3-4 Mechanical properties

NEOFLON PFA has superior mechanical strength particularly at high temperatures, and can be used over a wide temperature range (-200～+250℃) (-320～+250°F).
Table 5 shows the mechanical properties of NEOFLON PFA. Fig.2～5 show the relationship between temperature and tensile strength, elongation, deformation, and hardness, respectively.

Table 5 NEOFLON PFA Mechanical Properties

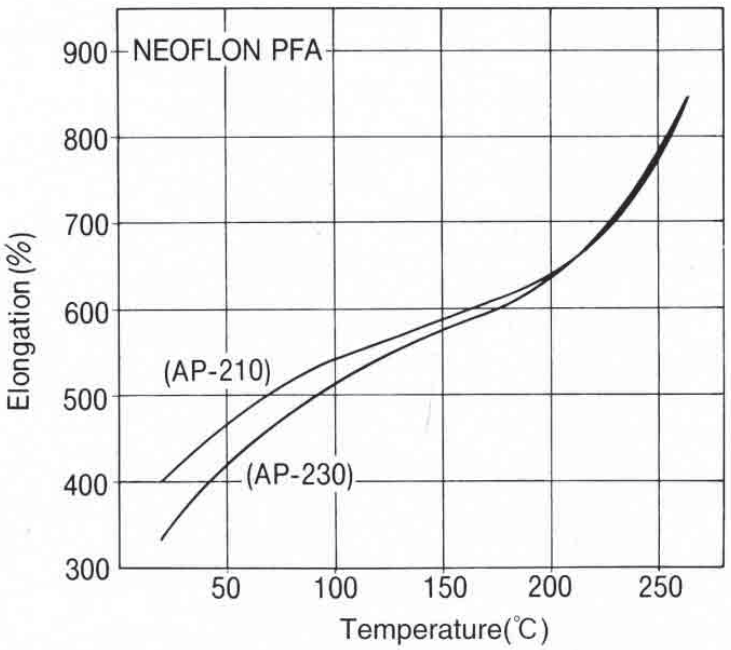
	Unit	NEOFLON PFA			PTFE	Test method
		AP-201	AP-210	AP-230		
Tensile strength	MPa	24.5～29.4	25.4～30.4	30.4～34.3	24.5～44.1	JIS K 6891
Elongation	%	350～450	350～450	300～400	200～400	
Flexural strength		No break	No break	No break	No break	ASTM D 790
Flexural modulus	MPa	$(5.8～6.9)\times10^2$	$(5.8～6.9)\times10^2$	$(5.8～6.9)\times10^2$	$(4.9～5.8)\times10^2$	
Compressive strength						
1% deformation	MPa	4.9～5.9	4.9～5.9	4.9～5.9	4.9～5.9	ASTM D 695
25% deformation	MPa	31.4～33.3	31.4～33.3	31.4～33.3	27.5～30.4	
Compressive modulus	MPa	$(4.9～5.9)\times10^2$	$(4.9～5.9)\times10^2$	$(4.9～5.9)\times10^2$	$(4.9～5.9)\times10^2$	
Hardness	Shore	D60～D70	D60～D70	D60～D70	D50～D65	Durometer
Deformation under load						
Compressive creep 25℃(77°F)・13.7MPa(2000psi)	%	2.5～3.0	2.5～3.0	2.5～3.0	9.0～10.0	
100℃(212°F)・6.9MPa(1000psi)	%	2.0～3.0	2.0～3.0	2.0～3.0	4.5～5.5	ASTM D 621
Total deformation 25℃・13.7MPa(2000psi)	%	8.0～9.0	8.0～9.0	8.0～9.0	14.5～15.5	
100℃・6.9MPa(1000psi)	%	8.5～9.5	8.5～9.5	8.5～9.5	14.0～15.0	
Impact strength (Izod)	N・m/m	No break	No break	No break	160.1	ASTM D 256
Coefficient of friction (static friction coefficient)	Coated-steel surface	0.04～0.05	0.04～0.05	0.04～0.05	0.02	

Fig. 2 Tensile Strength vs Temperature



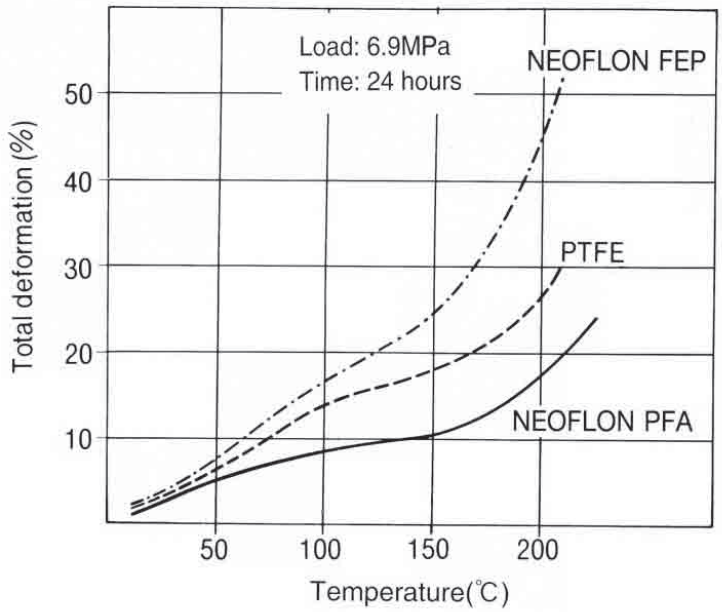
Test method: JIS K 6891

Fig. 3 Elongation vs Temperature



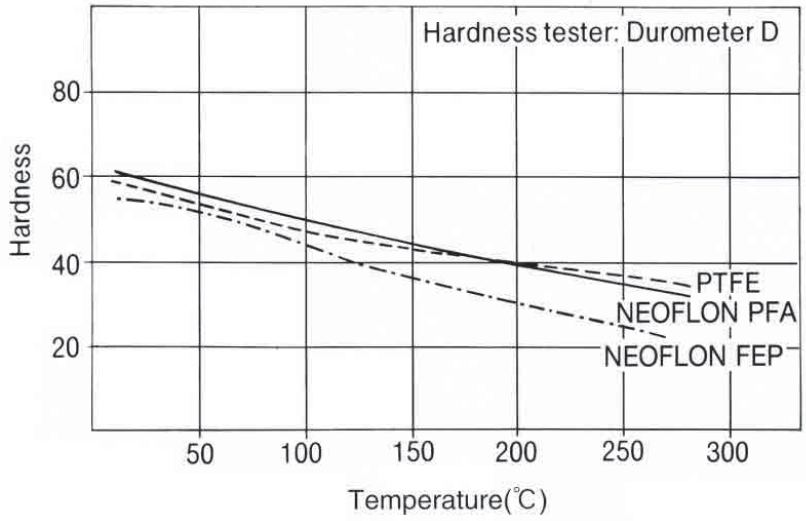
Test method: JIS K 6891

Fig. 4 Percent Load Deformation vs Temperature



Test method: ASTM D 621

Fig. 5 Hardness vs Temperature



Test method: JIS K 7215

3-5 Chemical properties

Any weight change of NEOFLON PFA after immersion in a variety of organic and inorganic chemicals. The results were compared with those resulting from the same test on NEOFLON FEP and NEOFLON ETFE. Although NEOFLON PFA was demonstrated to be slightly effected by chloride solvents, it is not change of weight loss by acid, and alkalis.

Table 6 Percent Weight Change after Immersion in Chemicals

	mass change(%)		
Chemicals	NEOFLON PFA	NEOFLON FEP	NEOFLON ETFE
Hydrochloric acid(35%)	0.0	0.0	0.0
Sulfuric acid(95%)	0.0	0.0	0.0
Nitric acid(60%)	0.0	0.0	+0.2
Fluoric acid(50%)	0.0	0.0	0.0
Acetic acid(50%)	0.0	0.0	+0.2
Sodium hydroxide(50%)	0.0	0.0	0.0
Ammonia hydroxide(28%)	0.0	0.0	0.0
Sodium chloride(30%)	0.0	0.0	0.0
Methyl alcohol	0.0	+0.1	+0.5
Ethyl alcohol	+0.1	+0.1	+0.7
Acetone	+0.4	+0.3	+3.5
Carbon tetrachloride	+2.3	+1.9	+6.0
Chloroform	+1.6	+1.6	+6.8
Toluene	+0.5	+0.5	+2.8
Xylene	+0.4	+0.4	+2.2
Benzene	+0.7	+0.7	+3.4
n-Hexane	+0.7	+0.6	+1.1
Methyl ethyl ketone	+0.4	+0.4	+3.7
Ethyl acetate	+0.6	+0.6	+4.0
Aniline	+0.1	+0.1	+0.6
Diethylamine	+0.6	+0.6	+2.4
Phenol	+0.1	+0.1	+0.4

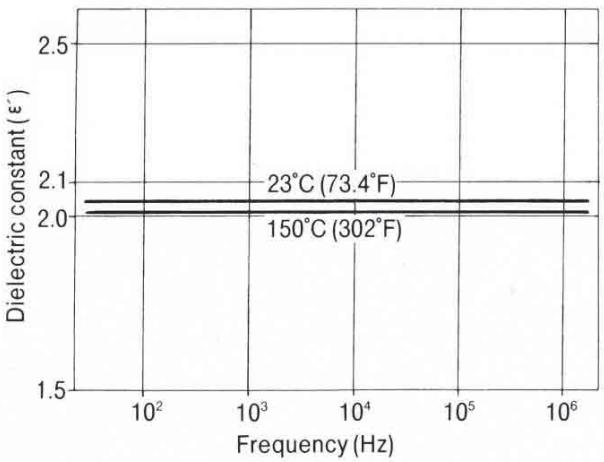
Note: Immersing conditions
:For days at 75～80℃(167～176°F) In case of Fluoric acid and Ammonia hydroxide, immersing conditions are for 7 days at room temperature.

3-6 Electrical properties

NEOFLON PFA possesses extremely low intermolecular polarity, and exhibits a consistently low dielectric constant and dissipation factor across a wide temperature and frequency range.

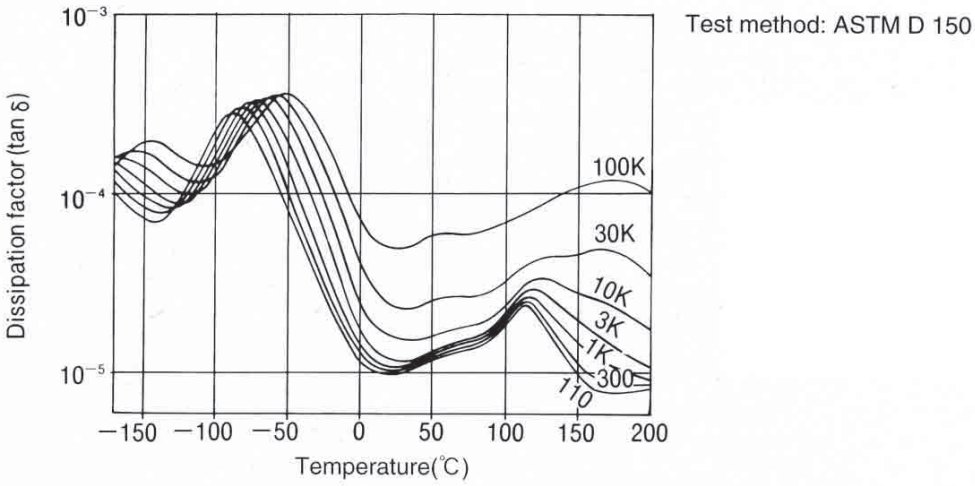
1) Dielectric constant

Fig. 6 Dielectric Constant vs Frequency



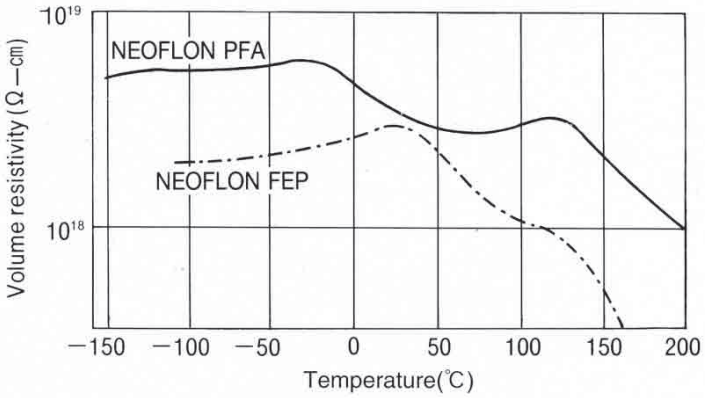
2) Dissipation factor

Fig. 7 Dissipation Factor vs Temperature at Various Frequencies



3) Volume resistivity

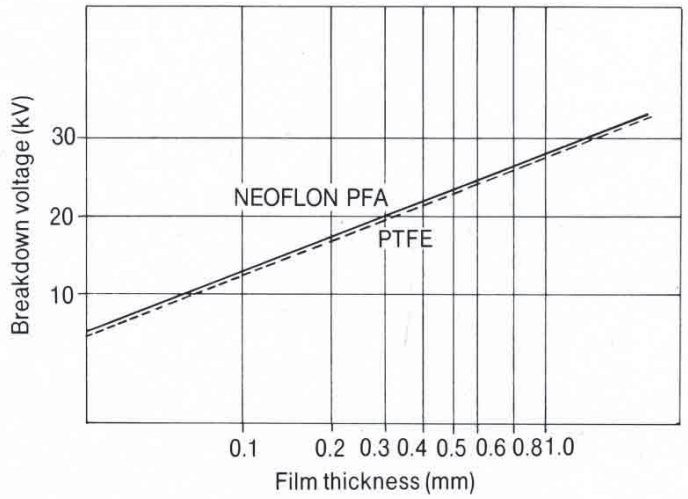
Fig.8 Volume Resistivity vs Temperature



Test method: ASTM D 257

4) Breakdown voltage

Fig. 9 Breakdown Voltage vs Film Thickness



Test method: ASTM D 149

3-7 Gas and moisture permeability

Table 7 Moisture Permeability and Coefficient of Gas Permeability of NEOFLON PFA

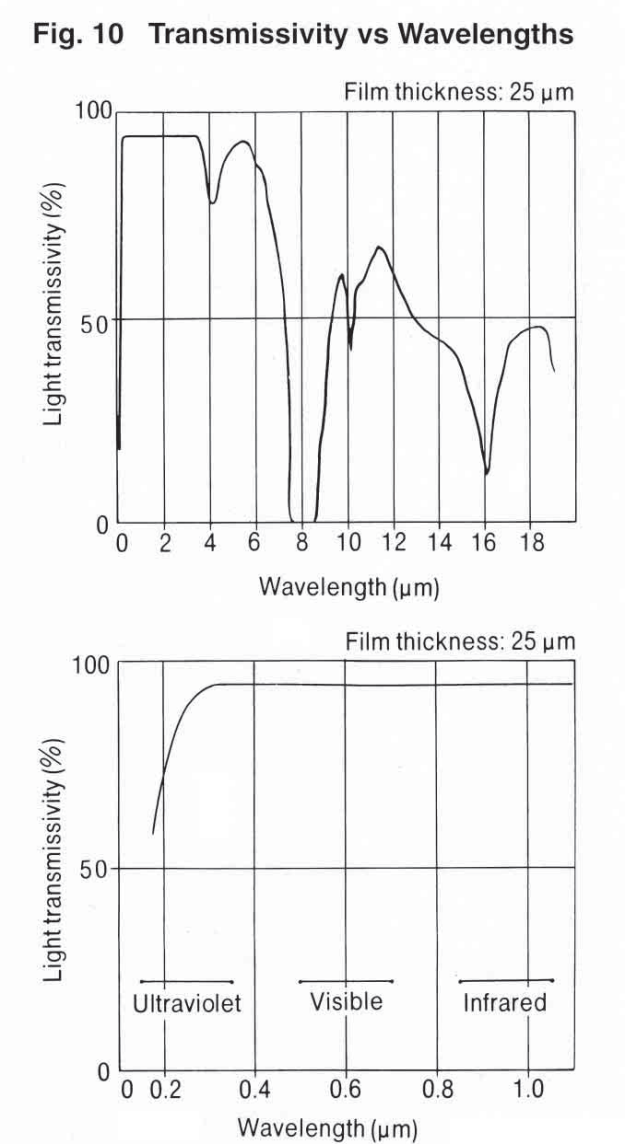
	NEOFLON PFA	NEOFLON FEP
Nitrogen $\left(\frac{cm^3 \cdot cm}{cm^2 \cdot s \cdot atm}\right)$	1.4×10^{-8}	1.2×10^{-8}
Oxygen $\left(\frac{cm^3 \cdot cm}{cm^2 \cdot s \cdot atm}\right)$	4.8×10^{-8}	3.7×10^{-8}
Moisture permeability (film thickness: 45 μm $\left(\frac{g}{m^2 \cdot 24h}\right)$	3.1	2.0

Test method: ASTM D 1434, JIS Z0208

3-8 Light transmissivity

Figs. 10 below show the light transmissivity of NEOFLON PFA. The lower figure is an enlargement of the 1.0 μm range wavelength transmissivity shown in the upper figure.

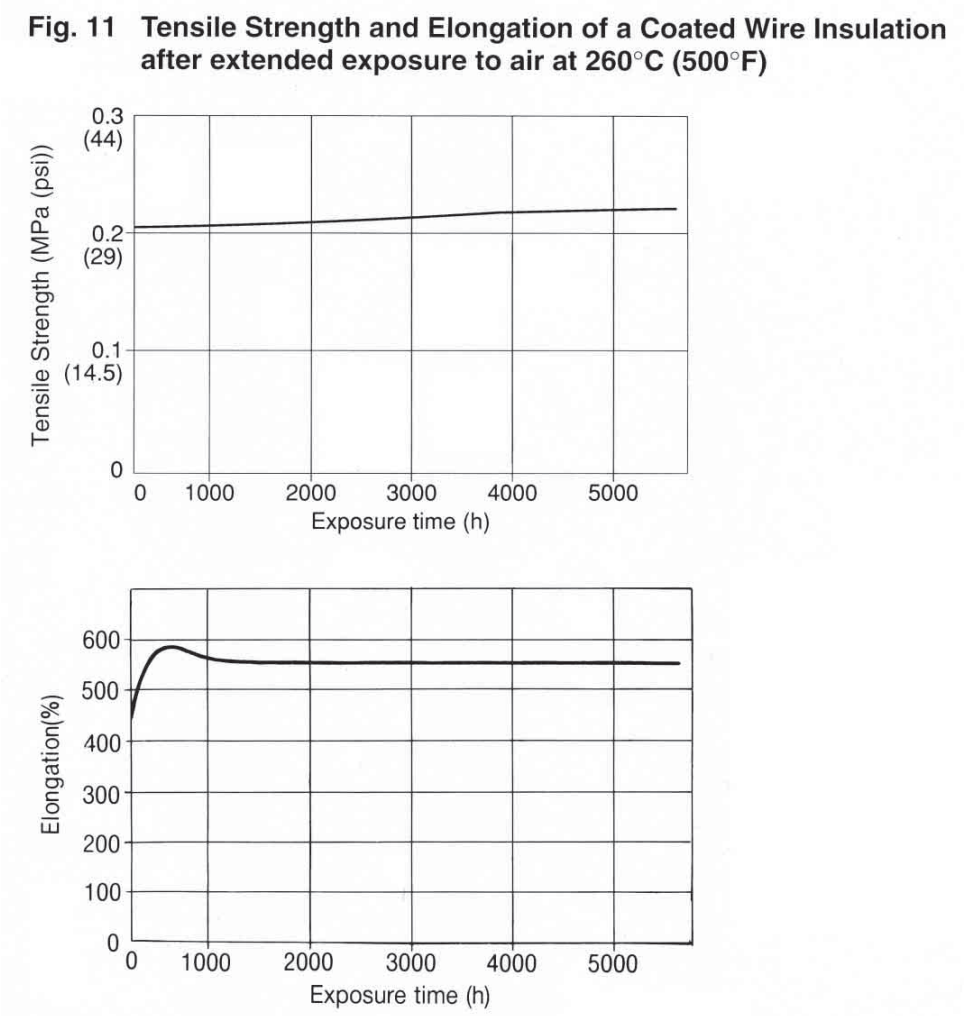
Fig. 10 Transmissivity vs Wavelengths



3-9 Heat aging resistance

NEOFLON PFA exhibits excellent heat resistance, and meintains mechanical properties after extended exposure to high temperatures in air. Fig. 11 below shows the tensile strength and elongation of a coated wire insulation after extended exposure to air at 260℃

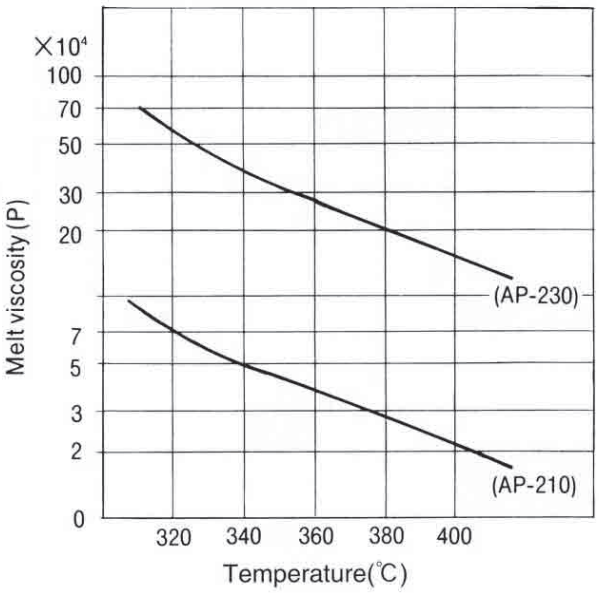
Fig. 11 Tensile Strength and Elongation of a Coated Wire Insulation after extended exposure to air at 260°C (500°F)



4. Processing of NEOFLON PFA

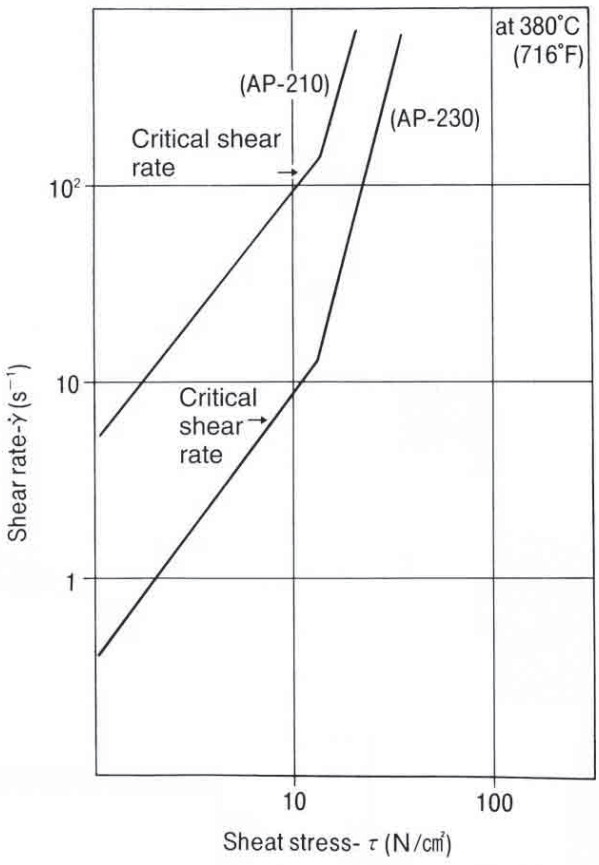
NEOFLON PFA has a good melt flow processability and excellent thermal stability.
NEOFLON PFA can, be molded by the same injection, extrusion, blowing, and compression molding processes used for other thermoplastic resins. NEOFLON PFA AP-201 in particular has a low viscosity and is suitable for use in molding complex shapes. NEOFLON PFA AP-230 is particularly suited for use in corrosion resistant linings requiring stress crack resistance. The mold temperature range for both AP-210 and AP-230 is 350℃～380℃ (662～770°F). Molding conditions must be selected according to the specific molding method used and the shape the final product.
The molding speed in injection molding must be less than the critical shear rate or melt fracture will occur, resulting in a rough surface on the molded part.
Fig. 12 shows the relationship between temperature and melt viscosity.
Fig. 13 shows the relationship between shear stress and shear speed.

Fig. 12 Melt Viscosity vs Temperature



Test method: JIS K 7210
Nozzle Dia.: 2mm
Length: 8mm
Pressure: 0.7MPa

Fig. 13 Shear Rate vs Shear Stress



Test method: JIS K 7210
Pressure: 0.7~3.9MPa
Nozzle Dia.: 1mm
Length: 1, 2, 10mm

When molding NEOFLON PFA, using injection, extrusion, or blow molding machines, a highly corrosive resistant material should be used to coat all surfaces which will directly in contact with the molding resin. NEOFLON PFA will begin to decompose at 380℃(788°F). Extended use of such high temperatures should be avoided.

4-1 Injection molding

Molding of semi-conductor manufacturing equipment, instruments for physics, chemistry and other sciences, and electronics and electrical parts is possible by this method.
Normal screw-type injection molding machines are used.
In order to reduce molding deformation, the sprue, runner, and gate should be slightly large and as short as possible, and the mold cavity should be nearly round in cross-section. A hard chromium-plated mold should be used, and it must be heated to between 150～200℃(302～392°F).
The following table shows a typical set of injection molding conditions.

Table 8 Injection Molding Conditions

	Small wafer basket	Flat sheet(thickeness:2mm
Cylinder temperature(℃)		
(rear)	(350)	(360)
(middle)	(370)	(390)
(front)	(380)	(400)
(nozzle)	(380)	(400)
Mold temperature(℃)	(200)	(200)
Screw speed(rpm)	180	180
Injection pressure(MPa(psi))	29.4~68.6 (4264~9950)	29.4~68.6 (4264~9950)
Holding pressure(MPa(psi))	44.1(6396)	44.1(6396)
Holding time(s.)	20	20
Injection rate(flow valve scale)	0.95	0.95
Cooling time (s.)	60	60
Molding cycle time (s./cycle)	120	120

Injection molding machine:
Model N-65,3oz.,product of Japan Steel Works, Ltd.
cylinder: type C, 42mm in diameter
screw:42mm in diameter

4-2 Extrusion molding

Coated electrical wiring, pipe, tubing film monofilament, and similar products can be produced by extrusion molding.
Extruder cylinders usually have a diameter from 30～65mm, with a screw L/D ratio of 2.0～24 Rapid compression screw type units with a compression ratio of 2.5～3.0 are used. Table 10 shows typical extrusion molding conditions.

4-3 Compression molding

Processing of molded sheet products with thickness of 1-2mm is possible by using presses equipped with both electrically heating panels capable of heating to 360(680°F) and with water cooling panels. Processing is also possible with presses in which these panels are separated. The molds are usually carbon steel with a hard chromium plating. If the molded product adheres to the mold surface and is not easily release, line the mold with aluminum foil.
Table 9 shows typical compression molding conditions.

Table 9 Compression Molding Conditions

	Condition
(Molding 120 diameter×2t(mm))	
Mold and materials	
temperature	350℃
heating time	30min
pressure	4.9MPa
cooling method	water cooling(rapid quenching)

5. Typical applications

NEOFLON PFA is a fluoropolymer resin with superior flow charactisics. It is used in a wide range of fields, including chemicals and electronics. Table 11 shows the major application of NEOFLON PFA.

Table 10 Extrusion Molding Conditions

	Tubing	Coated wire	
grade	AP-230	AP-210	Ap-210
Molded product	Tubing I.D.8.5 Tubing O.D.10.5 Tubing thickness 1.0	Core: T.A.(single wire) Core diameter: 0.4mm Coating thickness: 0.15mm	Core: T.A.(single wire) Core diameter: 0.7mm Coating thickness: 0.3mm
Extruder			
barrel diameter	25	30	30
screw L/D	20	22	22
compression ratio	2.8	2.8	2.8
screw type	Gradual transition	Rapid transition	Rapid transition
Die die I.D./tip O.D.	8.5/4.5	7/4	13/7
Temprature(℃)			
rear	350	360	360
middle		380	380
front	380	390	390
Die head	400	410	410
tip	420	410	410
Screw speed(rpm)	14	8	40
Draw-down ratio	1.36	100	100
Insulating speed(m/min.)	0.5	55	50

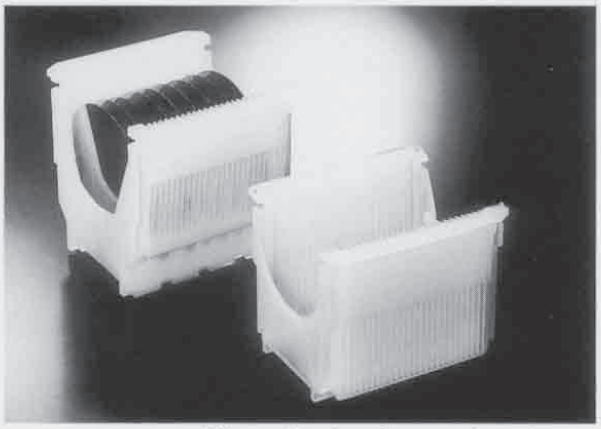
Table 11 Major applications

	Major applications	Useful characteristics
Containers, Equipment	Water baskets Containers for chemistry Large vessels, both round and square	Corrosion resistant heat resistant non-sticking
Pipe, Tubing	Heat-shrinkable tubes, flexible tubes bellows, expansion joints heat exchanger pipes, wire and cable conduit	Corrosion resistant heat resistant non-sticking
Linings	Valves, pipe and joint linings linings for pumps and tanks	Corrosion resistant heat resistant non-sticking
Electrical wire, Cable	Wiring for machinery and other equipment heat-resistant wiring coaxial cable jackets	Electrical characteristics heat resistance non-flammable
Electronic parts, Electrical parts	Flat cable connectors, sockets	Electrical characteristics heat resistance non-flammable
Film, Sheet	PTFE adhesive sheet lining release film electrical insulating tape	Mold releaseability heat seal corrosion resistance electrical characteristics
Monofilament	Screen filters demisters	Corrosion resistance heat resistance weather resistance

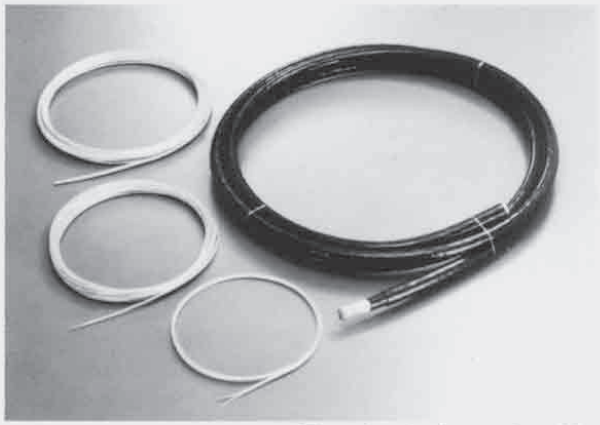
6. NEOFLON PFA Grades and Packaging

Type	Color	Packaging unit
AP-201 AP-210 AP-230	Translucent milky white	25kg
Color pellets(AP-210)	White, red, orange, yellow, green, blue, purple, brown, gray, black	10kg

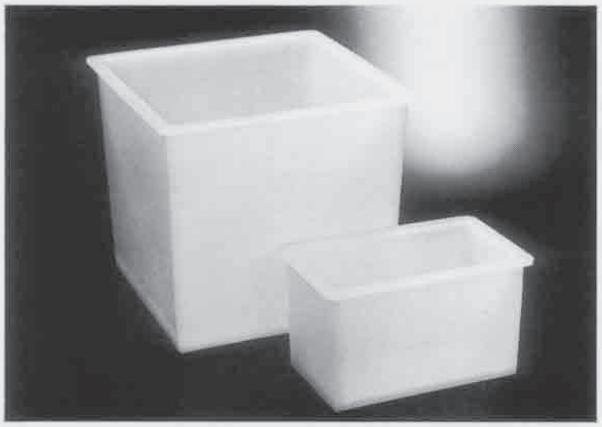
Molded parts by injection molding



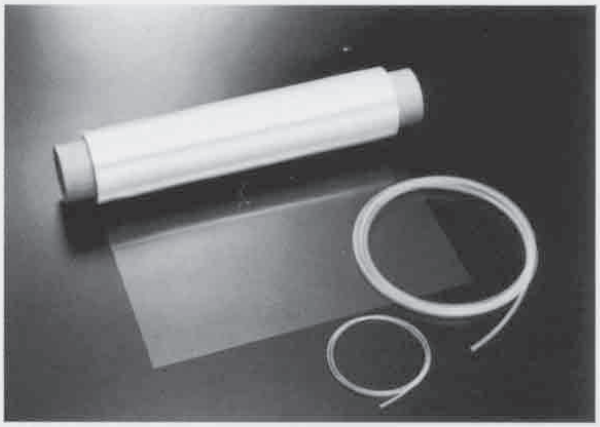
Wafer basket for semiconductor



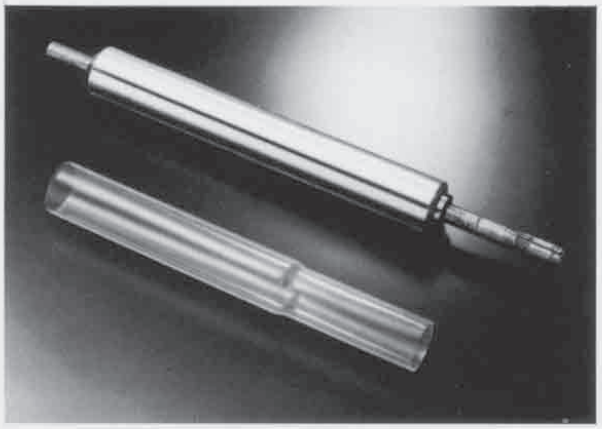
Electrical wire and cable



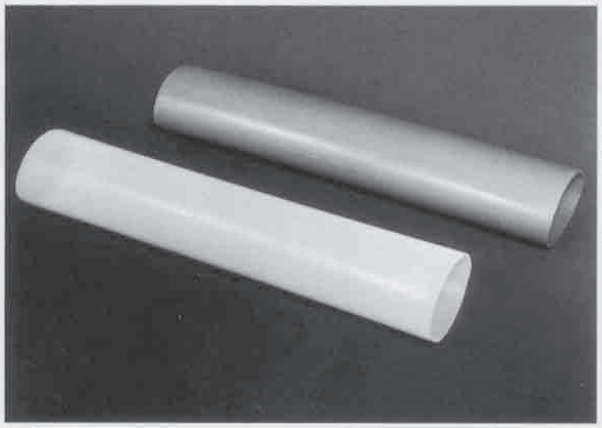
Tank



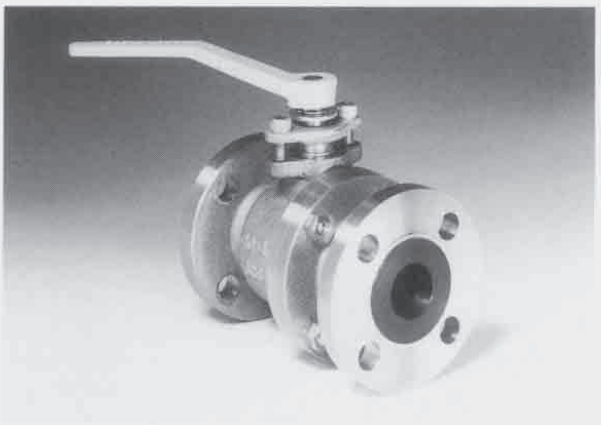
Film and tubing



Heat-shrinkable tube



Pipe for lining



Lining for ballvalve

Caution on handling

The following points should be followed to ensure safety when handling NEOFLON PFA:

WARNING: VAPORS HARMFUL IF INHALED.
The work area should be adequately ventilated at all times, because HF, COF_2 begin to be produced at approximately higher than 260°C and the volume increases at approximately 400°C. If PFA is incinerated, the acidic gases must be removed by alkaline scrubbing techniques.

- Personnel should be cautioned against inhaling the fumes liberated during processing and provided with suitable protective equipment.
- Smoking should be prohibited in work areas, since smoking fluoropolymer contaminated tobacco may result in inhalation of decomposed gas. Do not bring tobacco in the work area.
- Avoid breathing dust and contact with eyes.
- Wash hands and face after handing.
- Waste generated during processing should be treated by waste treatment specialists and/or licensed waste contactor disposed of in accordance with federal, state and local waste disposal regulations.
- Read the „Material Safety Date Sheet“ before use.

- DAIKIN INDUSTRIES, LTD. and DAIKIN AMERICA.INC. have obtained the ISO 14001 (*1) certification which is an International Standard concerning the environmental management system. DAIKIN INDUSTRIES, LTD has obtained the ISO 9001 (*2) and DAIKIN AMERICA. INC has obtained the ISO 9002 (*3).

*1. ISO 14001 is a standard established by the ISO (International Organization for Standardization) which applies to environmental preservation activities. Activities, products and services of our fuorochemicals plant have been certified as being environmentally sound by an internationally recognized certification body.

*2. ISO 9001-2000 is a certification system for quality control established by the ISO which certifies our quality control system concerning our products.

*3. ISO 9002-1994 is a plant certification system for quality control established by the ISO which certifies our quality control system concerning manufacture and inspection of the products manufactured at our plant (division).

IMPORTANT NOTICE: The information contained herein is based on technical data and tests we believe to be reliable and is intended for use by persons having technical knowledge and skill, solely at their own discretion and risk. Since conditions of use are outside of our control, we assume no responsibility for results obtained or damages incurred through application of the data given; and the publication of the information herein shall not be understood as permission or recommendation for the use of our fluorocarbon compounds in violation of any patent or otherwise. We only warrant that the product conforms to description and specification, and our only obligation shall be to replace goods shown to be defective or refund the original purchase price thereof.

MEDICAL USE: This product is not specifically designed or manufactured for use in implantable medical and/or dental devices. We have not tested it for such application and will only sell it for such use pursuant to contract containing specific terms and conditions required by us.

DAIKIN INDUSTRIES, LTD.
Umeda Center Bldg., 2-4-12,
Nakazaki-Nishi, Kita-ku,
Osaka 530-8323,
Japan
Phone: +81-6-6374-9300
Fax: +81-6-6373-4281

www.daikinchemicals.com

DAIKIN AMERICA, INC.
20 Olympic Drive
Orangeburg, NY 10962,
U.S.A.
Phone: +1-845-365-9500
Toll-Free: +1-800-365-9570
Fax: +1-845-365-9598

www.daikin-america.com

DAIKIN CHEMICAL EUROPE GmbH
Am Wehrhahn 50
40211 Düsseldorf,
Germany
Phone: +49-211-179225-0
Fax: +49-211-1640732

www.daikinchem.de

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