DAIKIN

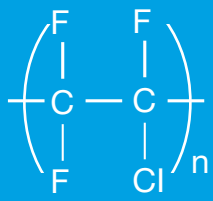
PRODUCT INFORMATION

(except for U.S.A.)

NEOFLON
PCTFE MOLDING POWDER

Introduction:

NEOFLON PCTFE is a homopolymer of chlorotrifluoroethylene, characterized by the chemical formula.



The addition of the one chlorine bond to fluorocarbon contributes to lower the melt viscosity to permit extrusion molding. It also contributes to the transparency, the exceptional flow, and the rigidity characteristics of the polymer. Therefore, NEOFLON PCTFE has unique properties. Its resistance to cold flow, dimensional stability, rigidity, low gas permeability, and low moisture absorption are superior to other fluoropolymers.

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1. Features

NEOFLON PCTFE is a high performance thermoplastic. Chlorine and fluorine in the molecule contribute to the combination of outstanding properties and good melt-flow processability.
Features of NEOFLON PCTFE has high compressive strength and low deformation under load.
In particular, its cold-flow characteristic is lower than other fluoropolymers and it does not deform under load at room temperature.
In addition, PCTFE retains its excellent properties over a wide thermal range.

Zero strength time (ZST)
The ZST is a test method to check the molecular weight of the PCTFE molding materials and the molded parts. It will give both the molder and customer a good indication of the quality of molded parts.
This method is described in detail in ASTM D1430-89.
The ZST of the M-300 series is 200 to 300 seconds, while that of M-400H is 301 to 450 seconds because of a higher molecular weight grade.

Crystallinity
NEOFLON PCTFE is a crystalline polymer.
The degree and kind of crystallinity may be controlled by its thermal history, especially the cooling speed during processing.
In general, its range may be approximately from 40% to 80%, but it is never completely crystalline or amorphous. Molded PCTFE with high crystallinity is a dense material which has high mechanical strength and low elongation. On the other hand, the amorphous rich PCTFE moldings are optically clear, more elastic, and have a lower density.
Although the rapid-cooling procedure is only applied for thin-wall tubings and sheets, heavy wall products should be cooled slowly to prevent cracks or voids.
Long chain molecules in high molecular weight PCTFE are slow to develop crystal nuclei and may prevent rearrangement into large spherulites.

2. Grades

NEOFLON PCTFE molding materials contain no plasticizers, fillers, or other additives.
They are available in the following series:
M-300 series (M-300, M-300H, M-300P)
—ASTM D 1430 Type 1, Grade 2
M-400H—ASTM D1430 Type 1, Grade 3

Material grade
Each type is available in either powder or pellet form.
The M-300series consists of molding materials for general purpose applications.
M-400H consists of molding materials of a high molecular weight which are suitable for applications requiring mechanical toughness or stress-crack resistance.

Table 1 Grades of NEOFLON PCTFE

Product no.	Apparent density (g/ml) (approx.)	*Flow value (ml/s)	**Z.S.T. (s)	Description	Processing methods	Uses
M-300	0.60	1~3 x 10^{-3}	200~300	Powders (10~60 meshes)	Compression	Sheets
M-300H***	1.00	1~3 x 10^{-3}	200~300	Granular powders	Compression Extrusion	Sheets Rods Tubing
M-300P*** M-300PL	1.20	1~3 x 10^{-3}	200~300	Pellets	Extrusion Injection	Rods Small parts
M-400H***	1.00	0.5~0.8 x 10^{-3}	301~450	Granular powders	Compression Extrusion	Sheets Rods

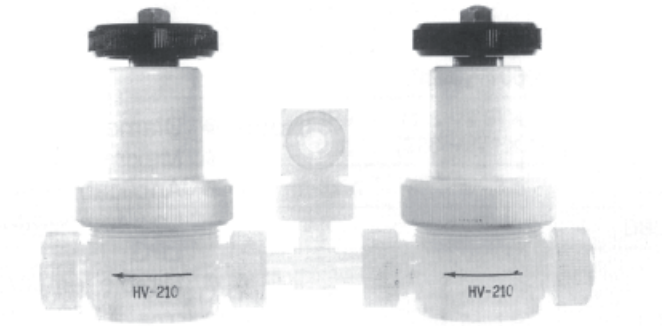
Note: * Measured by flow tester at 230°C, under load 100MPa (nozzle size 1 mm dia, 1mm length)
** ASTM D 1430, zero strength time at 250°C
*** Recognized by Underwriters' Laboratories, Inc.

3. Applications

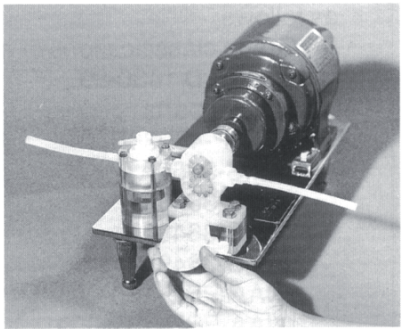
The unique balance of properties exhibited by NEOFLON PCTFE suits it to many applications where usual other materials are unsatisfactory.

- Chemical field
  Seals and gaskets
  Valve and pump parts — diaphragms, impellers, seats, and plugs
  Translucent tubing, sight glasses, and flowmeter tubes
  Heavy-wall solid pipe and fittings
  Gears, cams, and bearings
  Laboratory ware
  Coatings for pipes, fittings, valves, heat exchangers, pumps, tanks, reaction vessels, autoclaves, drums, and containers
  Anti-sticking surfaces — rolles on textile
  Anti-sticking surfaces — rollers on textile
  Machines, suction boxes, molds for plastics, and equipment for the processing of toffee, dough, chocolate, and other foodstuff
  Thin-walled articles — jackets, bellow, diaphragms, films, and various laboratory instruments
- Electrical field
  Molded components, terminal boards, coil forms, printed circuit boards, connector covers, radome covers, tube sockets, wire coatings, jackets, potentiometers, and switches

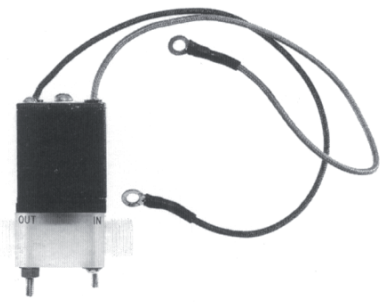
Molded products made from NEOFLON PCTFE



Reaction equipment and piping connector for anhydrous hydrogen fluoride made from NEOFLON PCTFE



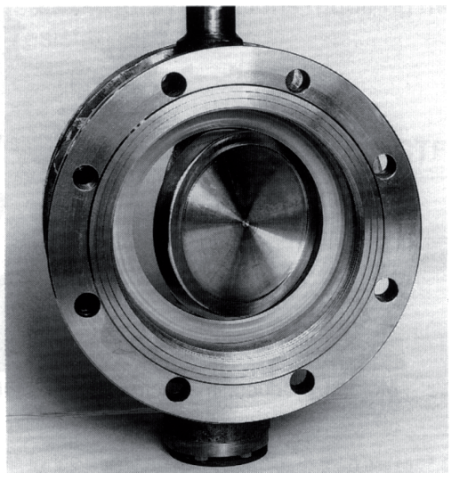
Gear pump made from NEOFLON PCTFE



Solenoid valve component machined made from NEOFLON PCTFE

Butterfly valves for cryogenic applications
(NEOFLON PCTFE is used.)

Butterfly valves for cryogenic applications were developed for large pipes which are used to transport cryogenic fluids.They are mainly used in storage and transport bases of liquefied natural gas or in its transport ship. NEOFLON PCTFE which is characterized by its excellent stability at low temperatures, is used for the seat of the valve for safety, and at the sealing area for easy operation, making highly reliable sealing performance possible. Because NEOFLON PCTFE has high mechanical strength and a low shrinkage rate at low temperatures, it is widely used for low-temperature machineries, equipment, etc.



(Note)
- Diameter 80~700 mm (standard)
- Maximum pressure 1MPaG
- (Applicable materials
  Low-temperature fluids and gases, such as LNG · LO_2 · LN_2 · LH_2 · LPG)
- (Usable temperature
  -250°~normal temperature)

As a guide, the main application specifications relative to PCTFE are as follows:

- Grade classifications of molding materials
  ASTM D 1430-89
- Molded parts
  MIL-P-46036B
  AMS-3650A
  AMS-3646A
  AMS-3648A
  AMS-3649B
  NAA-PBU-130-005
  NAA-PUB-130-009

4. Properties

4-1 Physical Properties

Resistance to Stress-Cracking

As M-400H consists of higher molecular weight polymers than those of the M-300 series, M-400H is suitable for use in applications requiring stress-crack resistance.

Table 2 Typical Physical Properties of NEOFLON PCTFE

Property	Test method (ASTM)	Units	NEOFLON PCTFE	
			M-300H	M-400H
Specific gravity	D-792		2.11~2.16	2.11~2.16
Zero strength time	D-1430	s	200~300	350~450
Tensile strength	D-638	MPa	31.4~37.2	33.3~39.2
Elongation	D-638	%	50~200	100~250
Tensile modulus of elasticity	D-638	MPa	$(1.3\sim1.5)\times10^4$	$(1.2\sim1.4)\times10^4$
Compression strength	D-695			
	0.2% off set	MPa	39~44	36~41
	1% strain	MPa	12~14	11~13
Compression modulus of elasticity	D-695	MPa	$(1.4\sim1.6)\times10^3$	$(1.2\sim1.4)\times10^3$
Flexural strength	D-790	MPa	68~73	66~71
Flexural modulus elasticity	D-790	MPa	$(1.6\sim1.9)\times10^3$	$(1.4\sim1.7)\times10^3$
Impact strength	D-256	J/m	133~144	133~144
Hardness(Shore:durometer)			D80	D80
Deformation under load	D-621			
24 h/686N	25°C	%	≤0.2	≤0.2
	80°C		1.7~1.9	1.4~1.6
	100°C		7.0~9.0	4.5~6.5

Tensile Properties

The tensile test is conducted by using the JIS K6251 Dumbbell #3 specimen which is illustrated below.

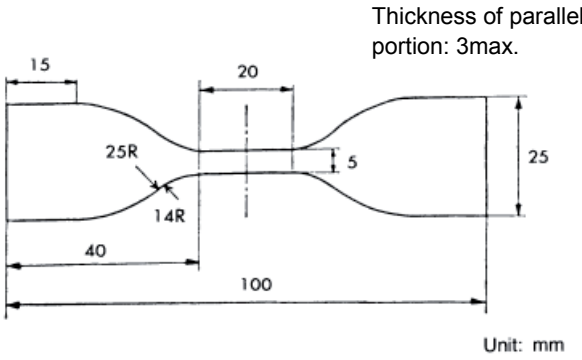


Fig.1 Tensile Strength (at break point) at Various Temperatures

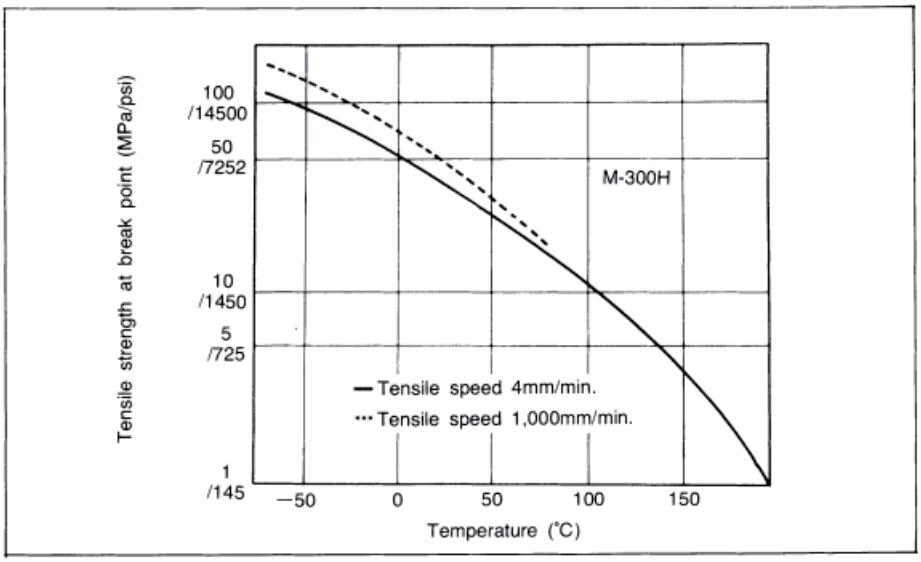


Fig.2 Tensile Modulus of Elasticity at Various Temperatures

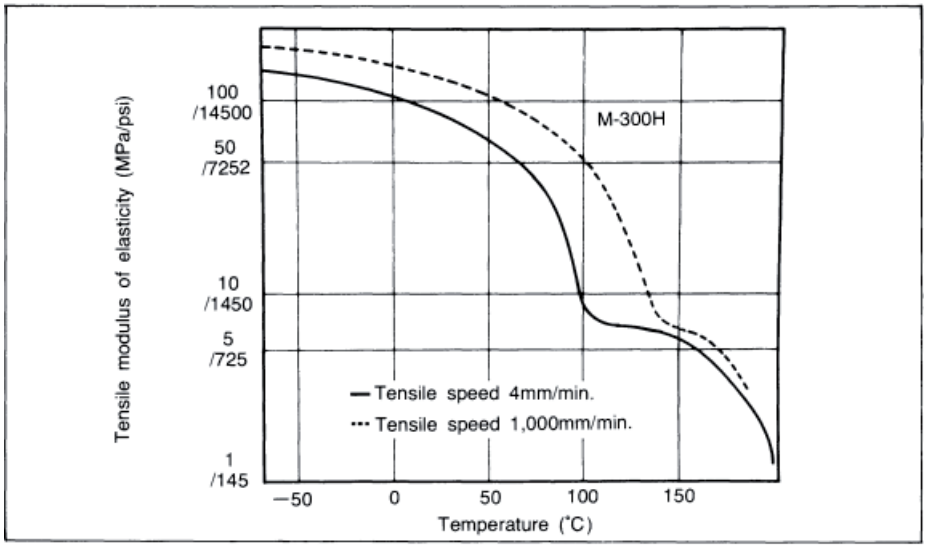
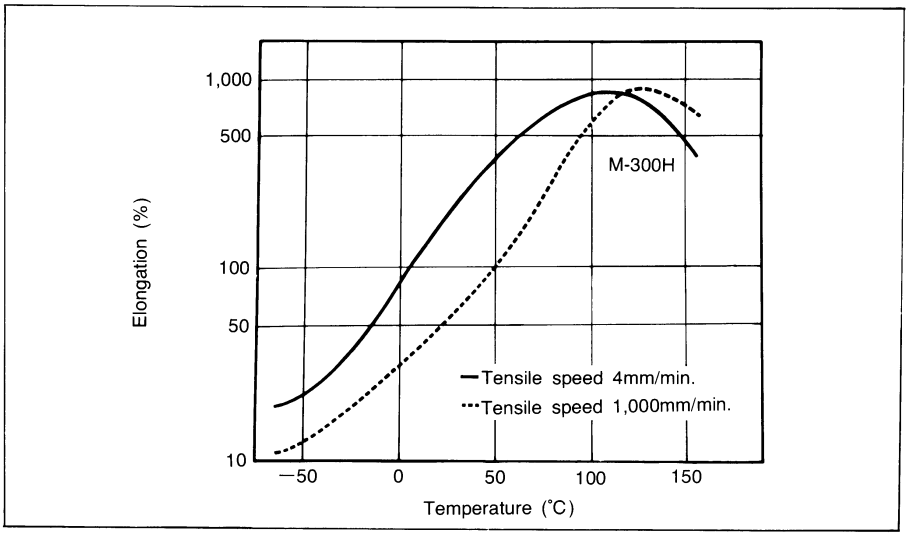
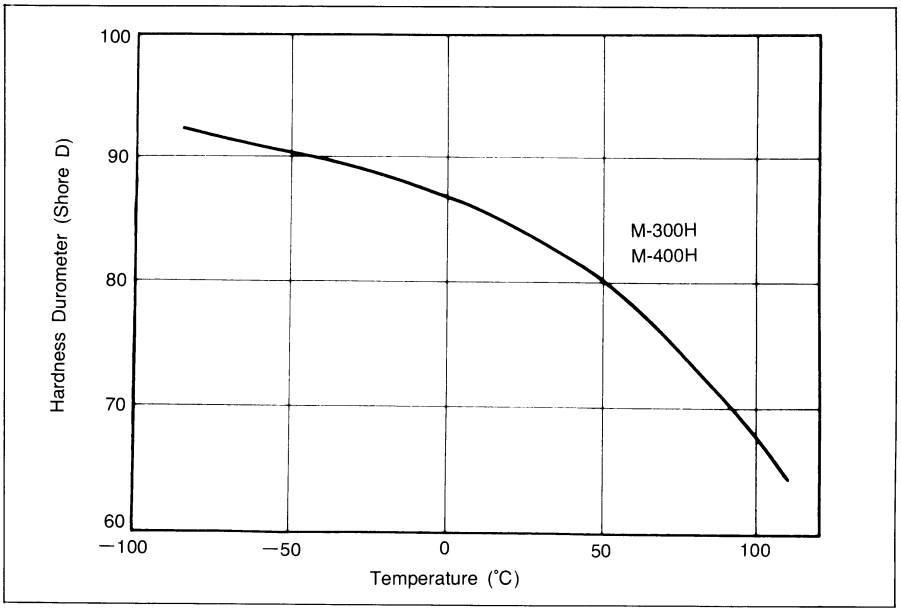


Fig.3 Elongation at Various Temperatures



Hardness

Fig.4 Effect of Temperature on the Hardness of the NEOFLON PCTFE Moldings



Compression Properties

Fig.5 Stress-Strain Curves (Compression method)

Test condition:

1. Compression speed 1mm/min.
2. Size of the specimen dia.12.7mm × height 25.4mm (M-300H,M-400H molded by compression molding)
3. Temperature 23°C

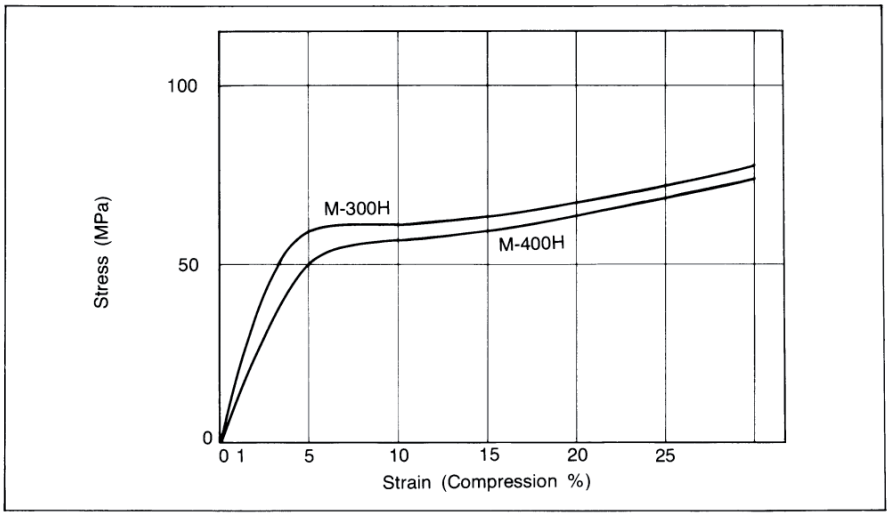
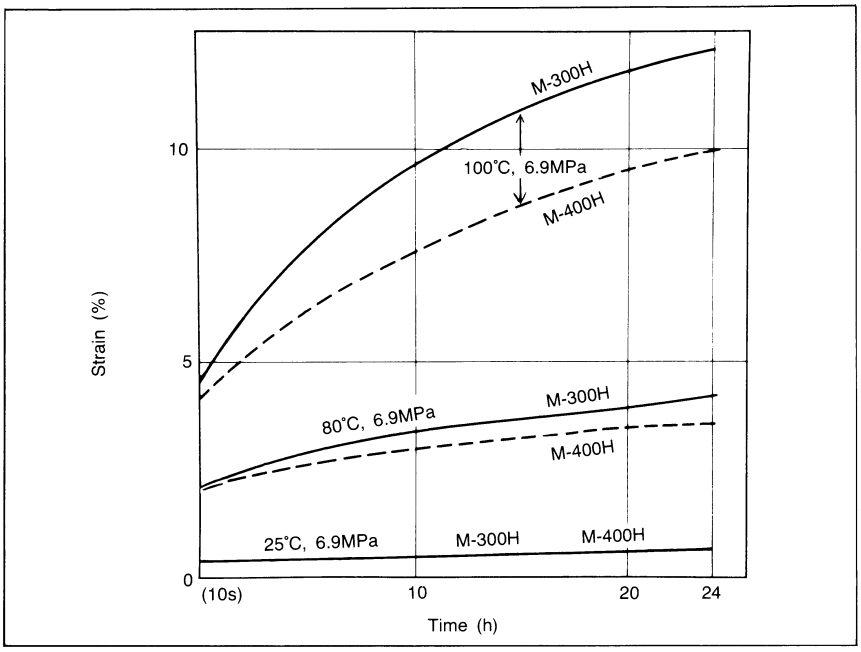


Fig.6 Creep Curves

Test condition:

Size of the specimen dia.11.3mmXheight 10mm (M-300H, M-400H molded by compression molding)



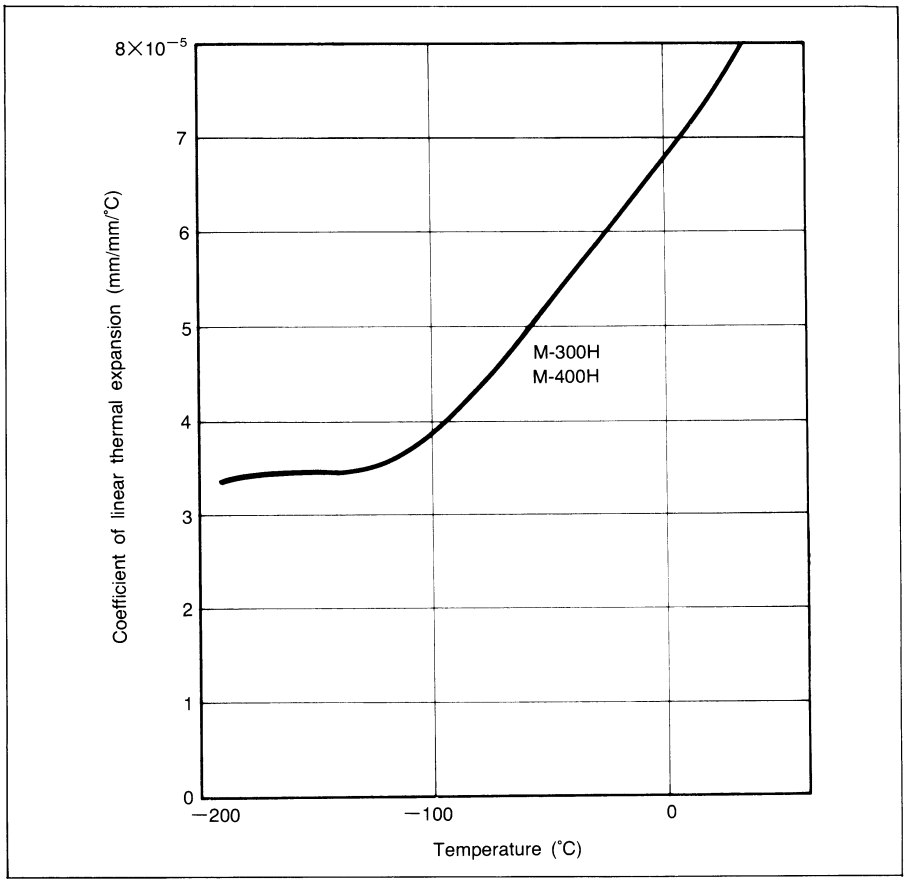
4-2 Thermal Properties

Table 3 Thermal Properties of NEOFLON PCTFE

Property	Test method (ASTM)	Units	NEOFLON PCTFE (typical value)
Specific heat		10^3J/Kg·K	0.9
Melting point		°C	210~212
Heat deflection temperature	D-648	°C	126
Thermal conductivity	C-177	W/m·K	0.21
Thermal expansion	D-696		
+30~–30°C		Cm/cm/°C	$7.0X10^{-5}$
–30~–100°C			$5.1X10^{-5}$
–100~–190°C			$3.6X10^{-5}$
Flammability	D-635		Non-flammable

Fig. 7 Coefficient of Linear Thermal Expansion at Various Temperature

Size of the specimen dia.7mm × length 10mm
(M-300H and M-400H molded by compression molding)



4-3 Chemical Properties

Due to its molecular structure, NEOFLON PCTFE possesses excellent chemical resistance, with the exception of some highly halogenated hydrocarbons and aromatic solvents.
The following table shows the effect of chemicals on PCTFE at various temperatures:

Table 4 Immersion Test (for 7 days)

	Conc. (%)	Temp. (°C)	Weight change (%)
Hydrochloric acid	10	25	0.0
Sulfuric acid	96	70	0.0
Nitric acid	70	70	0.0
Fluoric acid	50	25	0.0
Acetic acid	50	175	0.1
Chromic acid	50	175	0.0
Acetic acid anhydride		70	+0.1
Caustic soda	50	b.p.	+0.1
Aqueous ammonia		25	0.0
Potassium bichromate	Saturation	175	0.0
Sodium chloride	Saturation	175	0.0
Methyl alcohol		25	0.0
Ethyl alcohol		80	+0.2
Acetone		25	+0.1
Carbon tetrachloride		70	+9.7
Chloroform		90	+8.5
Trichloethylene		80	+9.2
Toluene		110	+5.0
Xylene		90	+6.5
Benzene		90	+7.0
n-Hexane		90	+4.5
Methylethylketone		90	+4.6
Aniline		70	0.0
Ethyl acetate		70	+6.5
Ether		25	+3.8
Dioxan		90	+5.7
Diethylamine		25	+1.9
Formaldehyde		135	+0.7
Phenol		70	0.0

4-4 Electrical Properties

NEOFLON PCTFE possesses excellent electrical properties; however, unlike PTFE, it will polarize because it contains chlorine atoms and fluorine atoms. Breakdown voltage, dielectric constant, dissipation factor, arc resistance of NEOFLON PCTFE and various factors which affect these properties are described below.

Table 5 Electrical Properties of NEOFLON PCTFE

Properties	Test method (ASTM)	Unit	NEOFLON PCTFE (typical value)
Dielectric constant 10^3HZ	D-150		2.6
Dielectric dissipation factor 10^3HZ	D-150		0.02
Dielectric strength Short time 4 mils thickness 68 mils thickness	D-149	Volt/Mil	 3000 500
Arc resistance	D-495	s	360
Volume resistivity 50% R.H.	D-257	Ω-cm	$2X10^{17}$
Surface resistivity 100% R.H.	D-257	Ω-cm	$1X10^{15}$

Fig. 8 Dielectric Constant at Various Frequencies

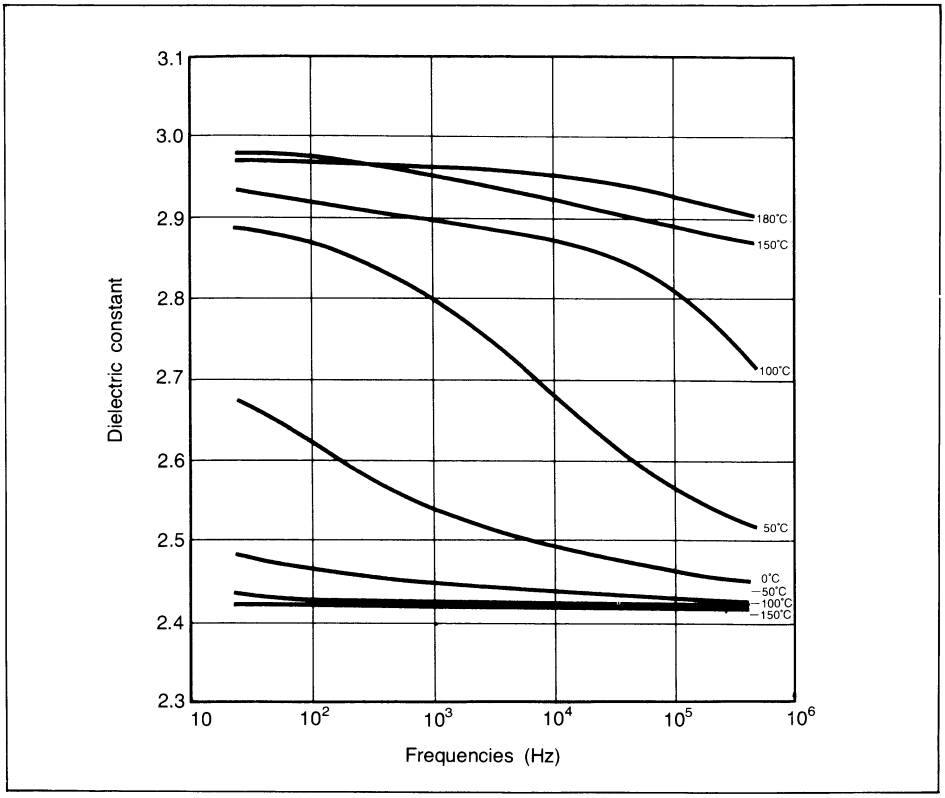


Fig. 9 Dielectric Constant at Various Temperatures

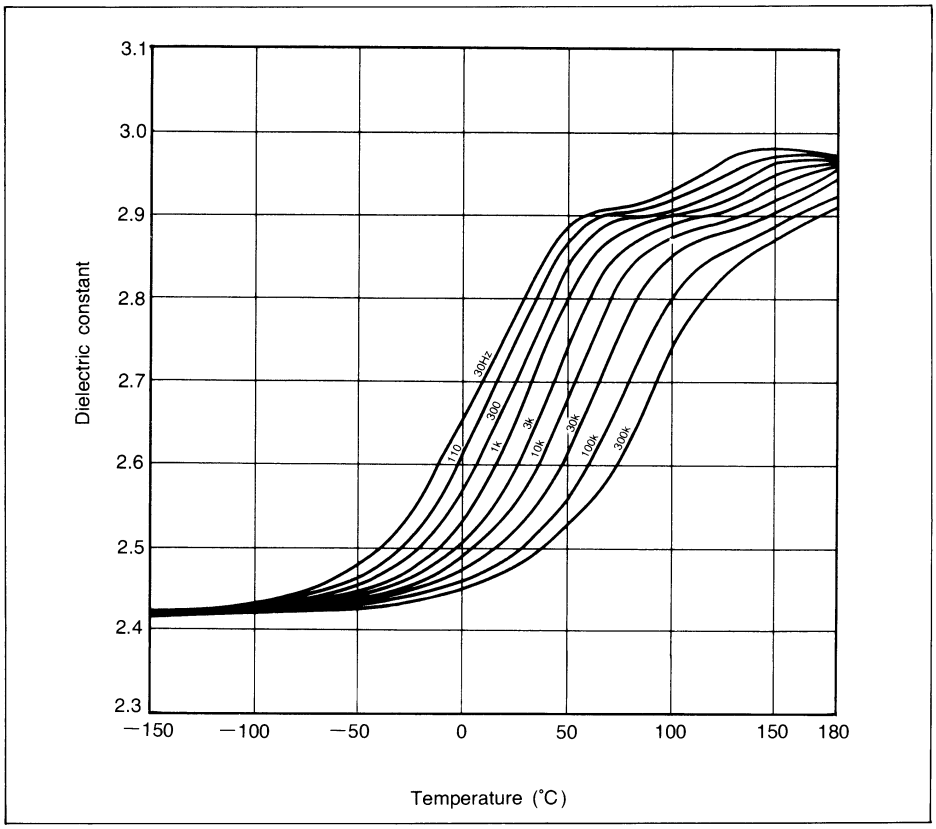


Fig. 10 Dielectric Dissipation Factor at Various Temperature

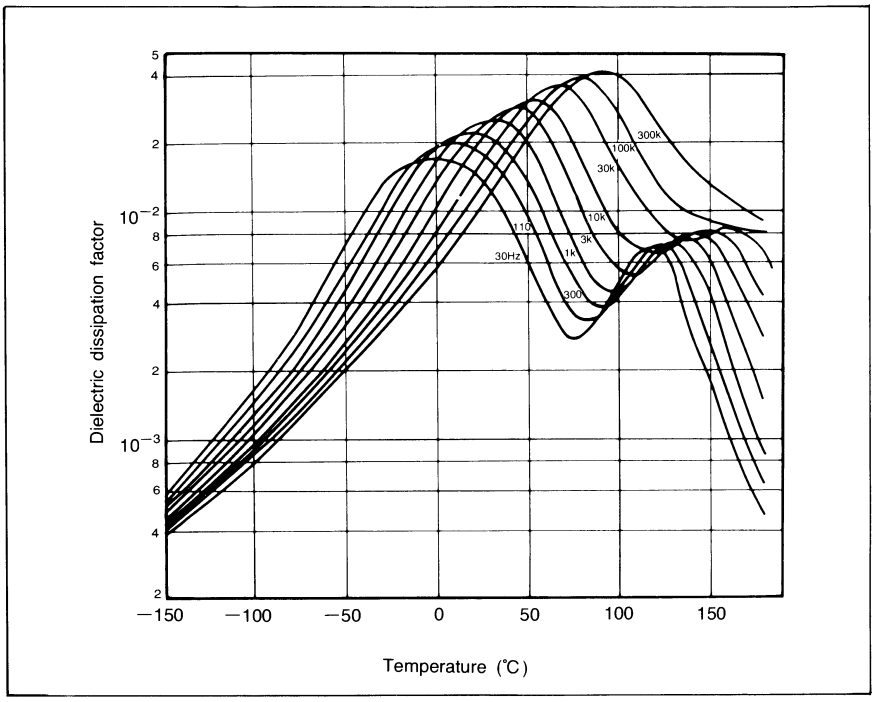


Fig. 11 Dielectric Strength at Various Thicknesses

Test conditions:

Shape of electrode	2 disc electrodes (diameter 25mm) with rounded edge of 2.5mm radius, 500g
Methods of impressing voltage	1,000V/s. (continuous rise)
Atmosphere	Silicon oil (Toshiba TSF433), 25°C
Power source	AC60Hz

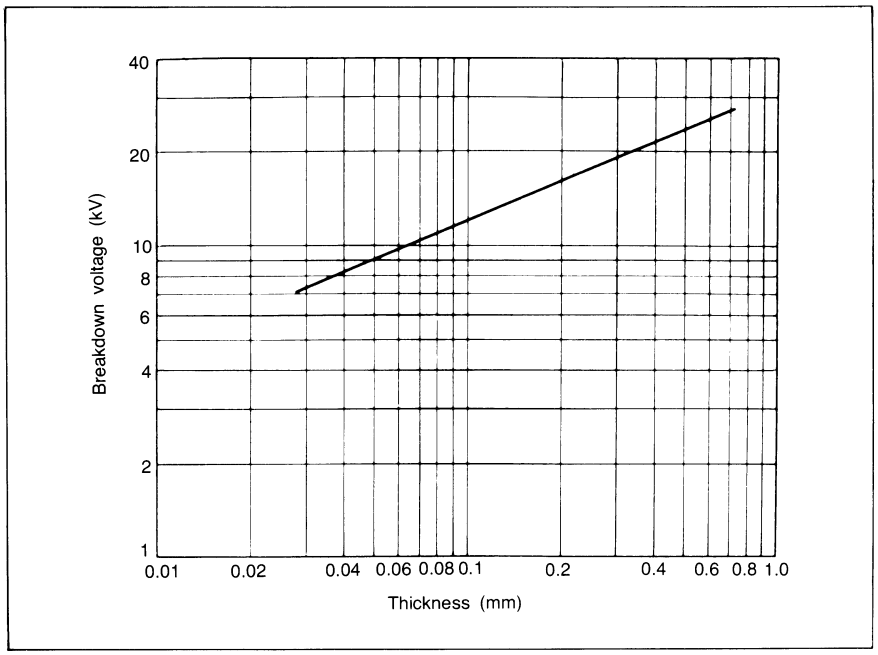
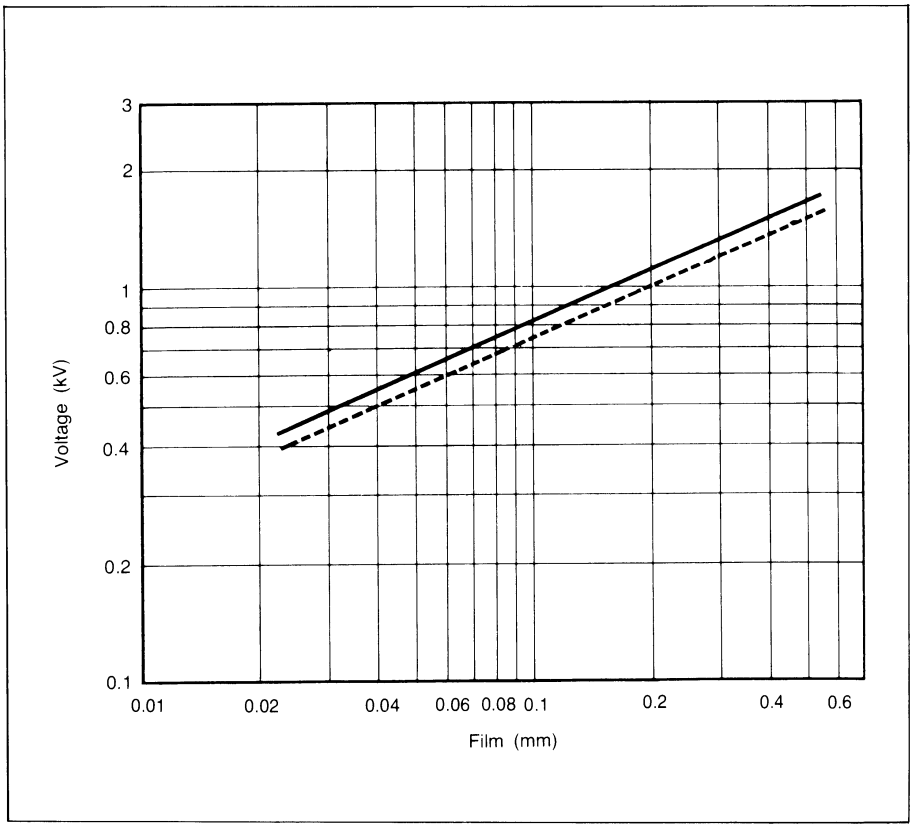


Fig. 12 Arc Resistance

Testconditions:

Shape of electrode	2 disc electrodes (diameter 25mm)with rounded edge of 2.5mm radius, 500g
Atmosphere	Dry (P_2O_5) air 23°C
Power source	AC60Hz



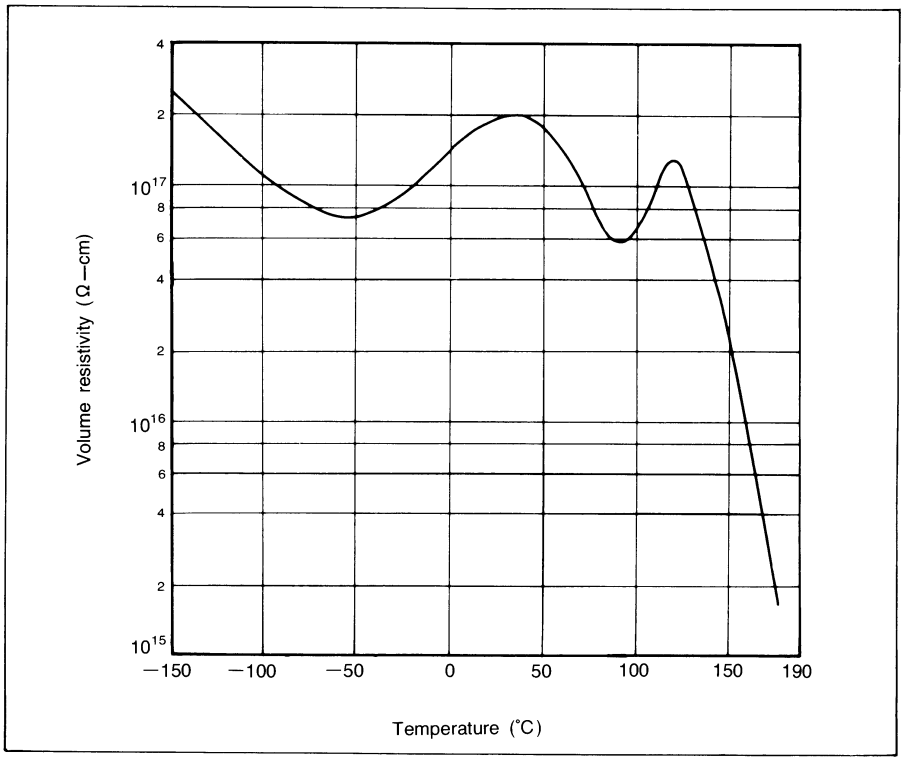
Thus, the following empirical formulas can be obtained:

Occurrence voltage $V_t=4570\sqrt{\frac{t}{\varepsilon'}}$

Disappearance voltage $V_f=4210\sqrt{\frac{t}{\varepsilon'}}$

V_t : Voltage at corona occurrence (V)
V_f : Voltage at corona disappearance (V)
t : Thickness of sample (mm)
ε' : Dielectric constant of sample

Fig. 13 Volume Resistivity at Various Temperatures



4-5 Other Properties

1) Gas permeability

NEOFLON PCTFE has extremely low gas permeability.

		NEOFLON PCTFE	FEP
Gas permeability constant	N_2 cm^3, cm/cm^2, s, atm	$1.8X10^{-11}$	$1.2X10^{-8}$
	O_2 cm^3, cm/cm^2, s, atm	$1.5X10^{-10}$	$3.7X10^{-8}$
	H_2 cm^3, cm/cm^2, s, atm	$5.6X10^{-9}$	$1.1X10^{-7}$
	CO_2 cm^3, cm/cm^2, s, atm	$2.9X10^{-10}$	$9.7X10^{-8}$
	CH_4 cm^3, cm/cm^2, s, atm		$6.6X10^{-9}$

2) Moisture resistance

NEOFLON PCTFE essentially does not absorb moisture.
Its dimensional stability is not affected by direct contact with water or high humidity; therefore, NEOFLON PCTFE retains its excellent electrical properties in a high humidity environment.

		NEOFLON PCTFE	FEP
Moisture permeability constant	g/m, 24 h	0.2	1.6
Water absorption	%, 24 h	0.00	<0.01
	% by weight, 168 h	0.0	

5. Processing and Fabrication

NEOFLON PCTFE molding materials are supplied in both powder and pellet form for melt flow processes of extrusion, injection and compression molding. Compression molding is popular and the best method for producing parts of NEOFLON PCTFE without reducing the quality of the finished part.
Because of the high melting temperature of this material, in many cases, it may be necessary to process near the decomposition temperature (approx.350°C (662°F) or above).

5-1 Compression Molding

1) Transparent sheets

M-300 is used for the molding of transparent sheets. The powder is placed in a pile on the center of a ferro-type plate, and heated to 250~300°C (482~527°F) between the platens of the press.
The appropriate gauge block is placed on the side of the ferro-type plate. When the polymer reaches the desired state, another ferro-type plate is placed on the top of the powder and a pressure of 2.0~9.8MPa (290~1400psi.) is applied. After holding for a while, the assembly is transferred to cool press platens and quenched under 2.0~9.8MPa (290~1400psi.).

2) Heavy wall articles

Both the M-300H and the M-400H are used for molding heavy wall parts, such as sheets, rods, and sleeves.
M-300 and M-300H are used for compression molding of heavy shaped articles. The powder is heated at a temperature of 260~300°C (500~572°F) in a mold until it reaches molten state.
Then a pressure of 3.9~9.8MPa (570~1400psi.) is applied slowly. The assembly is then transferred to a cool press and cooled under pressure of 9.8~49.0MPa (1400~7000psi.) slowly.

5-2 Extrusion Molding

M-300H, M-300P and M-400H are used for molding rods, tubings, and films by the conventional extrusion process.
The recommended grads in each application are as follows:
Rods —M-300 series and M-400H
Tubings —M-300 series
Films —M-300 series
Suggested operating conditions are:
Extruder
Barrel dia. 25~50mm
L/D 20~25
Screw
Gradual transition metering type
Compression ratio 2.5~3.0
Operating temperature

	(M-300H)	(M-400H)
Barrel(rear)	230°C	230°C
(center)	280°C	280°C
(front)	290°C	295°C
Adapter	295°C	300°C
Die head	310°C	315°C
Die tip	320°C	325°C

Screw speed 10~15rpm

5-3 Machining

NEOFLON PCTFE has good machining properties for sawing, turning, drilling, milling, and cutting, because of its high melt temperature.
Desirable parts may be easily obtained by machining the standard stock, such as sheets, rods, shaped pieces, etc.
The PCTFE molded parts can be buffed and polished with general paste.

5-4 Heat Sealing

NEOFLON PCTFE films and sheets may be heat-sealed under certain conditions.

Heating temperature
260~280°C

Heating time
Approx. 10minutes for every 2mm sheet (thickness).

Operating pressure
Approx. 6.9MPa

Cooling rate
Repid cooling (250°C/30min.)

Caution on handling

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

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 then 120°C and the volume increases at approximately 265°C. If PCTFE 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).

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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.

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