PRODUCT INFORMATION

(except for U.S.A)

POLYFLON™
PTFE MOLDING POWDER

Introduction:

The M-111, M-112 and M-139 grades of NEW POLYFLON PTFE are new generation high reliability PTFE products which greatly improved on the performance of conventional PTFE (M-12, M-18, M-390 series). While possessing the same excellent characteristics of conventional PTFE such as heat and chemical resistance, these new materials also have improved creep resistance and weldability. In addition they have greater durability under severe conditions when used in applications such as packing, gaskets and linings. Excellent secondary processing characteristics also allow them to be used for a large range of new applications. The M-112 grade has particularly good flexural endurance resistance.

TM: DAIKIN INDUSTRIES trade mark for its fluoroplastics

1. Powder Grades and Molding Methods

The basic types of POLYFLON PTFE molding powders are those for compression molding and ram extrusion molding.
The following grades are available in order to suit various molding methods.

Table 1 Powder Grades and Molding Methods POLYFLON PTFE Molding Powders

Grade	Compression molding	Automatic compression molding	Isostatic molding	Ram extrusion molding
M-12	Adequate			
M-18	Adequate			
M-391S	Excellent	Adequate	Excellent	
M-392	Excellent	Excellent	Adequate	Excellent
M-393	Excellent	Excellent		Excellent
M-111	Adequate			
M-139	Excellent	Excellent	Adequate	
M-112	Adequate			

Note: Grades of filled molding powders are also available.
*: Recognized by Underwriters Laboratories Inc.

2. Molding Powders for Compression Molding

2-1 Powder properties

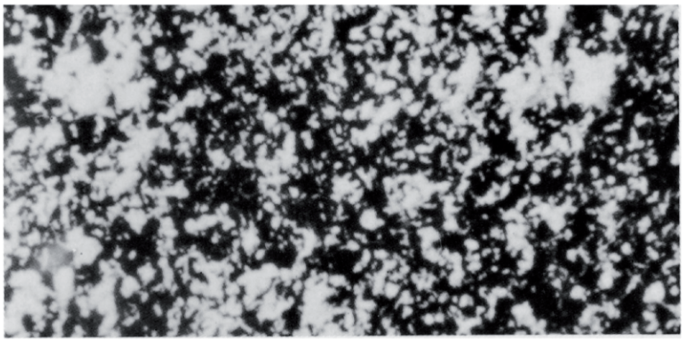
The properties of POLYFLON PTFE molding powders used for compression molding are shown in Table 2, and microphotographs of the powders are shown on the next page.

Table 2 Properties of Molding Powders for Compression Molding

	Grade	Average particle size (μm)	Apparent density approx. (g/l)	Flowability
POLYFLON PTFE	M-12	50	290	Poor
	M-18	40	450	Poor
	M-391S	350	790	Good
	M-392	400	870	Excellent
	M-393	500	930	Excellent
★ NEW POLYFLON PTFE	M-111	40	400	Poor
	M-139	400	900	Excellent
	M-112	40	400	Poor

★ NEW POLYFLON PTFE is a tetrafluoroethylene polymer and is a small amount of chemical (less than 1 mass%) which is thermally and chemically stable. Compared with conventional PTFE products, NEW POLYFLON PTFE has the following advantages.

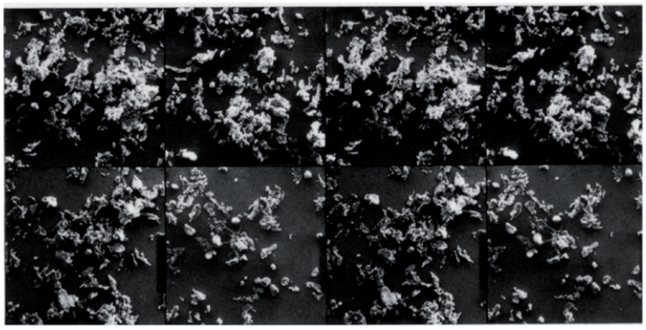
(1) Excellent creep resistance
(2) Large tensile elongation
(3) Excellent electrical insulation
(4) Well-suited to secondary processes such as welding, folding, drawing and stretching
(5) M-112 has several times longer flexural life than conventional PTFE



M-12

Magnified 20X

1mm

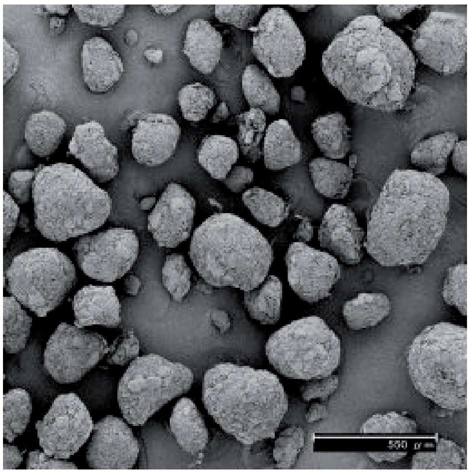


M-18

Magnified 20X

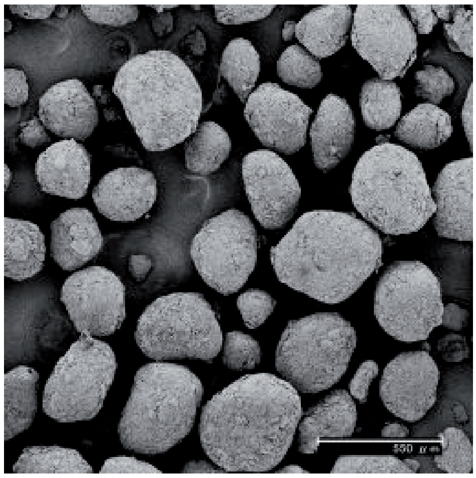
1mm

M-391S



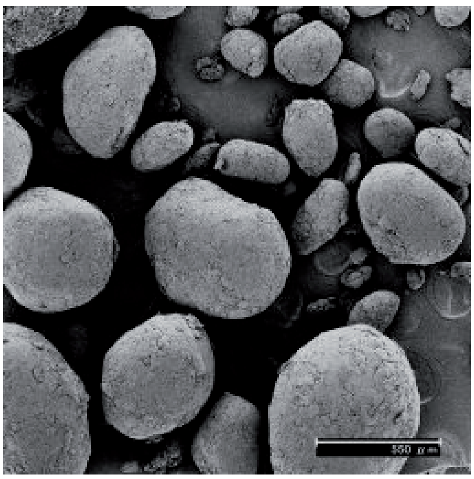
scale 550 μm

M-392



scale 550 μm

M-393



scale 550 μm

2-2 Properties of molded products

The properties of products molded from POLYFLON PTFE molding powders are shown in Table 3. One characteristic of these products is the excellent, smooth surface.

Table 3 Properties of Products Molded from POLYFLON PTFE Molding Powder

	Test condition	M-12	M-18	M-111	M-112
Specific gravity*1		2.17	2.17	2.17	2.15
Tensile strength (MPa(psi))*1		46 (6670)	45 (6525)	43.5 (6345)	44.5 (6485)
Elongation (%)*1		370	360	450	420
Dieiectric strength (kV/0.1mm)*1		12	11	13.5	13.0
Surface roughness (μm)*2		Ha 0.5~1.0	Ha 0.7~1.3	Ha 0.5~1.2	Ha 0.5~1.2
Hardness (Shore)	Durometer	D52~D62	D52~D62	D52~D62	D52~D62
Compressive strength*3	0.2% off set	7.5 (1088)	7.5 (1088)	8.7 (1270)	7.7 (1130)
(MPa(psi))	1% strain	5.0 (725)	5.0 (725)	5.9 (857)	4.7 (685)
	25% strain	30 (4350)	30 (4350)	28.6 (4170)	28.3 (4130)
Deformation under load*4	1000 p.s.i., 100°C, 24h	13.3	13.3	8.0	9.5
(%)	2000 p.s.i., 24°C, 24h	14.0	14.0	10.6	12.9
Compression set (%)*4	1000 p.s.i., 100°C, 24h	4.6	4.6	3.0	4.0
	2000 p.s.i., 24°C, 24h	7.0	7.0	3.0	4.8

	Test condition	M-139	M-391S	M-392	M-393
Specific gravity*1		2.17	2.17	2.17	2.17
Tensile strength (MPa(psi))*1		37 (5400)	43 (6525)	40 (6090)	36 (5655)
Elongation (%)*1		390	380	350	330
Dieiectric strength (kV/0.1mm)*1		9.0	8	60	3.0
Surface roughness (μm)*2		Ha 1.5~2.5	Ha 1.9~2.5	Ha 2.1~2.7	Ha 2.4~3.2
Hardness (Shore)	Durometer	D52~D62	D52~D62	D52~D62	D52~D62
Compressive strength*3	0.2% off set	8.7 (1270)	7.3 (1059)	7.3 (1059)	7.3 (1059)
(MPa(psi))	1% strain	5.9 (857)	4.8 (696)	4.8 (696)	4.8 (696)
	25% strain	28.6 (4170)	30 (4350)	30 (4350)	30 (4350)
Deformation under load*4	1000 p.s.i., 100°C, 24h	8.0	13.8	13.8	13.8
(%)	2000 p.s.i., 24°C, 24h	10.6	14.8	14.8	14.8
Compression set (%)*4	1000 p.s.i., 100°C, 24h	3.0	4.7	4.7	4.7
	2000 p.s.i., 24°C, 24h	3.0	7.9	7.9	7.9

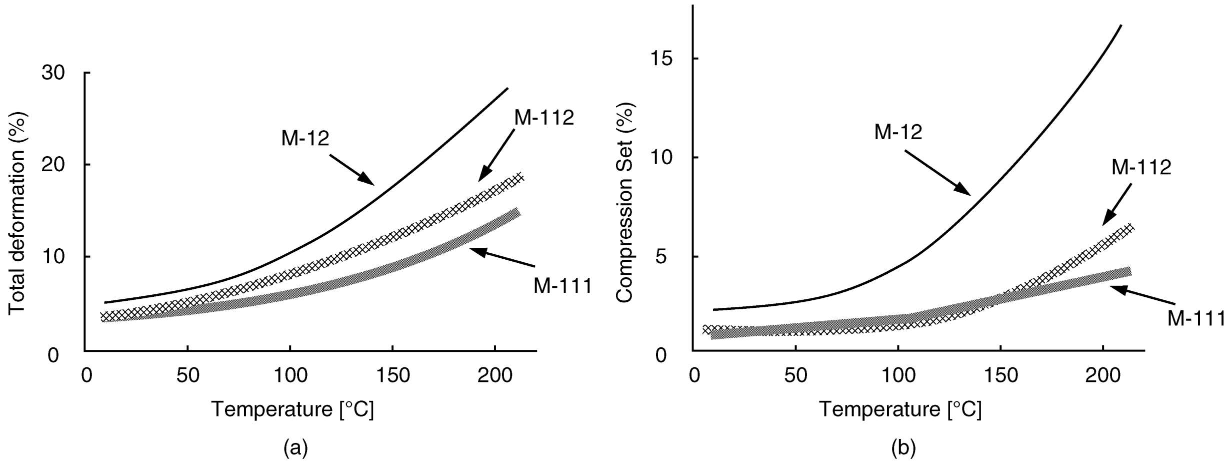
Notes: *1 Measurement method: JIS K 6891
*2 Average roughness measured at the centerline of the surface of a free-baked molded article
*3 Measurement method: JIS K 695
*4 Measurement method: ASTM D 621

(1) Creep resistance

Both of the M-111 and M-112 grades of NEW POLYFLON PTFE powder have better creep resistance than conventional PTFE. Figure 8 shows the total deformation (a) and compression set (b) at different temperatures under the load of 6.9 MPa.

The conventional PTFE exhibited extreme deformation at high temperatures, whereas both M-111 and M-112 exhibit less deformation. Accordingly, articles molded from M-111 and M-112 can be used under conditions of greater severity than can the conventional articles. This advantage is maintained even after compounding with inorganic filler. Figure 9 shows the compressive properties on compound.

Fig. 1 Total deformation (a) and Compression Set (b) at different temperature.



Conditions: According to ASTM D621 (Load at 6.9 MPa)

Sample Specimen : 10mm diameter × 20mm length

Total defomation: $(H_0-H_1)/H_0$

Compression set: $(H_0-H_2)/H_0$

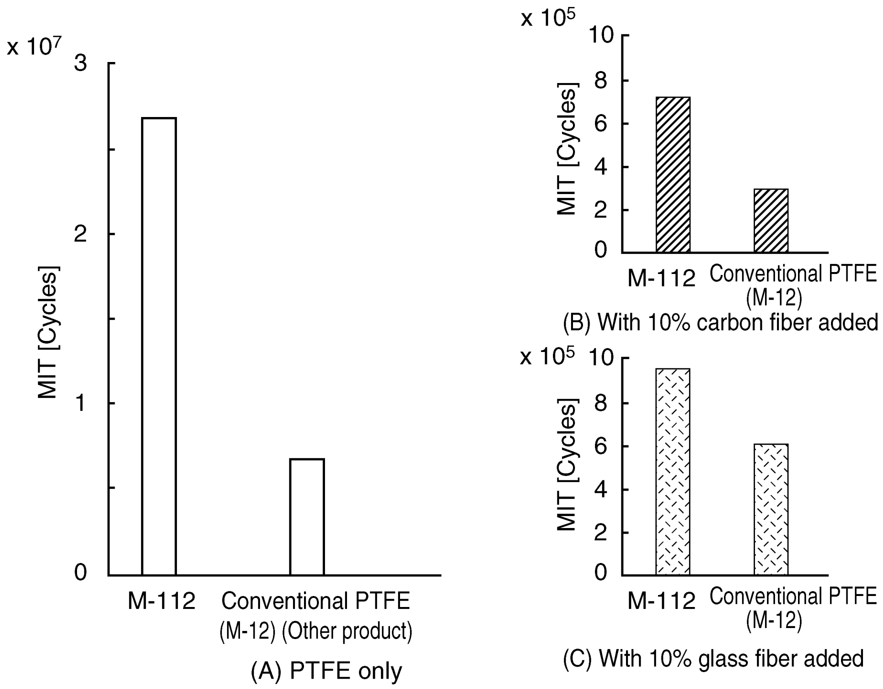
Here H_0: Original Height

H_1: Height after load applied for 24 hourse at test temperature.

H_2: Height after load removed and 24 hourse rest at test temperature.

(2) Flexural fatigue resistance
The M-112 grade of NEW POLYFLON PTFE powder has particularly good flexural fatigue resistance. Compared to conventional PTFE, MIT tests show that M-112 has several times longer flexural life as that of conventional grades. Even after the addition of inorganic fibers, the flexural fatigue resistance is better than that of conventional PTFE. Because of this, M-112 can be used in dynamic applications which require a higher degree of reliability.

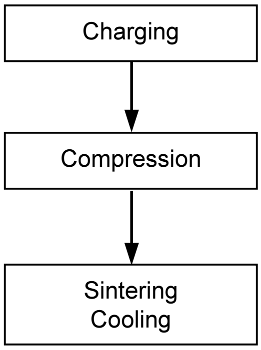
Fig. 2 MIT test results (According to ASTM D2178)



Film thickness: (A) 0.5 mm; (B), (C): 0.3 mm

2-3 Compression molding process for molding powders

Compression molding is the most basic method of PTFE molding. Articles with simple shapes, such as sheets, blocks, sleeves, etc; are molded by this method. The principles of the compression molding method are as follows.



- Charging: The mold is uniformly charged with powder.
- Compression: The powder is compressed a pressure of 10~100 MPa at room temperature.
- Sintering / Cooling: Sintering is done at 360~380°C (680~716°F) and then cooled.

Compression molding methods are divided into several classifications, including ordinary compression molding, automatic compression molding, and isostatic molding. The mechanical processes for these main methods are outlined in Table 4.

Table 4 Classification of Compression Molding Methods

Molding method	Charging	Compression	Sintering
Ordinary compression molding			
Free baking	Manual	Press	Sinter, then cool slowly
Hot coining	Manual	Press	Sinter, then water quench under pressure
Automatic compression molding	Manual or Automatic	Automatic press	Sinter, then cool slowly
Isostatic molding	Manual	Fluid pressure	Sinter, then cool slowly

(A) Ordinary compression method

This method utilizes a mold, a press, and a sintering oven, is the simplest method of PTFE molding. Products from several grams to several hundred kilograms are molded by this method.

(1) Molding material

The various applications are shown in Table 5.

Table 5 Applications POLYFLON PTFE Molding Powders

Grade	Shape of article
M-12	Blocks for film fabricaiton Thin sheets
M-18	Large blocks for sheet fabrication Thin sheet Base powder for filled PTFE molding powders
M-392	Sleeves for semi-finished products Small blocks
M-391S	Sleeves for ordinary material fabrication Small blocks

(2) Mold and mold charge
The dimensions (diameter and height) of the mold to be used in compression molding must be determined after considering the apparent package density of the powder and the percentage of change (expansion/shrinkage) that will occur in the molding.
The molds ordinarily used are constructed of chrome plated carbon steel, or polished stainless steel.
In order to decrease the amount of friction between the surface of the mold and the PTFE as much as possible, the surface must be smoothed by honing, etc.
The clearance between the male and female portions of the mold should generally be about 0.1% of the diameter of the female portion.
Relatively soft metals, such as brass, etc., are sometimes used to cover the punch in order to protect the mold.
The density of the powder varies according to the quantity of the charge but can be roughly expressed as shown in table 6.

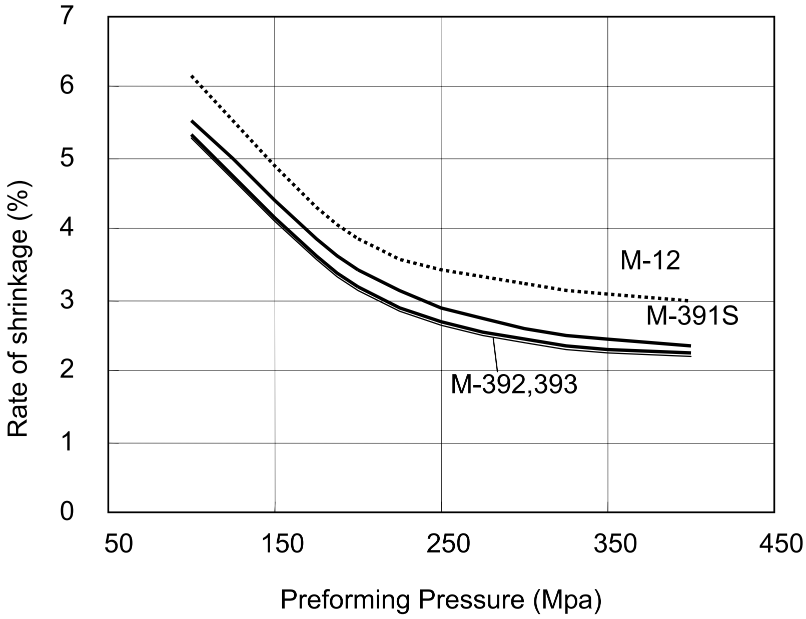
Table 6 Apparent Package Density of the Powder

Grade	M-12	M-18	M-391S	M-392	M-393
Apparent package density (g/l)	400	700	850	900	950

Note: The above figures correspond to a 2 kg charge in a mold with a diameter of 100 mm.

Powder which has been compressed and solidified in a mold is called a preform. The dimensions of this preform are nearly the same as those of the mold. The sintering process which follows causes the preform to expand in the machine direction, and shrink in the cross-direction.
The relationship of the molding pressure and the rate of change in dimensions (rate of expansion/shrinkage) is shown in Fig.3.

Fig. 3 Preforming Pressure and Rate of shrinkage



Dimensions:	50 (O.D.) ×50 (H) mm
Preforming pressure:	10~40Mpa
Dwell period:	5min (double ended pressing)
Heating rate:	50°C/h
Sintering period:	365°C for 5h
Cooling rate:	50°C/h

Any lumps formed in the powder during transport or storage must be removed prior to charging, and the powder must be uniformly charged into the mold. It is also important that the following precautions be taken at this time in order to minimize the contamination of the powder.

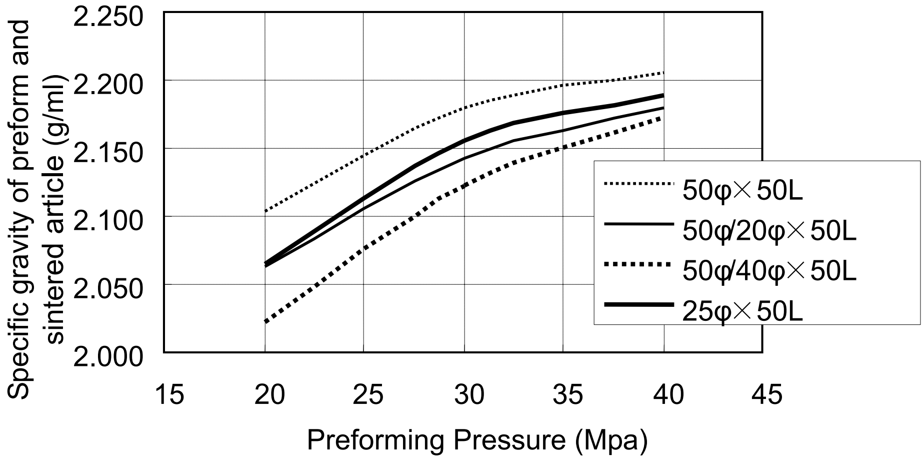
- Dust-proofing of the molding room (installation and maintenance of dustproofing equipment)
- Maintenance of molding equipment (press, molds, etc.)
- Training of operators (improvement of product-quality consciousness)

(3) Molding pressure

This is determined by considering the relationship of the molding pressure and specific gravity (preform and sintered article) as shown in Fig.4.

Because, the molding pressure varies according to several factors, including the shape of the article (the pressure loss inside the mold increases or decreases in accordance with this shape), the temperature of the powder, etc., the pressure which brings the specific gravity of the preform close to the true specific gravity (approx. 2.17) is considered the best.

Fig. 4 M-392 Preforming Pressure and Specific Gravity of Preform and Sintered Article



Molding conditions
Dimensions: 50 (Dia.) × 50 (H) mm
Molding temperature: 23~25°C (73~77°F)
Holding time of pressure: 5 min
Dwell period: 5 min (double ended pressing)
Molding temperature: 25°C

When molding large articles (blocks larger than 100 mm in diameter), the molding pressure should be slightly lower than that for small articles. The proper range is as shown in Table 7.

Table 7 Molding Pressure for POLYFLON PTFE

Grade	M-12	M-18	M-392
Proper range of molding pressure (Mpa (psi))	15~25 (2175~3625)	15~25 (2175~3625)	20~30 (2900~4350)

The molding pressure influences the quality of the molded product. Fig.5 and Fig.6 show the relationship of molding pressure and tensile properties. Fig.7 shows the relationship of molding pressure and dielectric strength.

Fig. 5 Relationship of Preform density and Tensile Properties

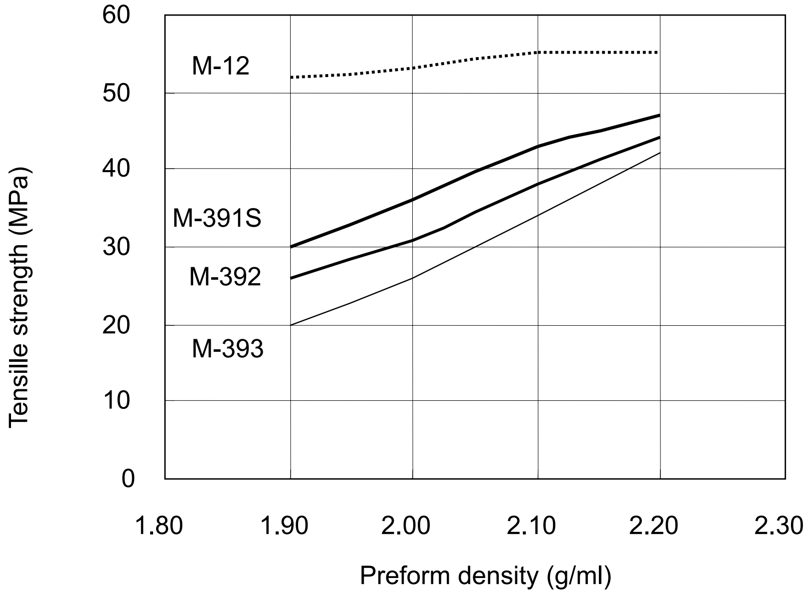
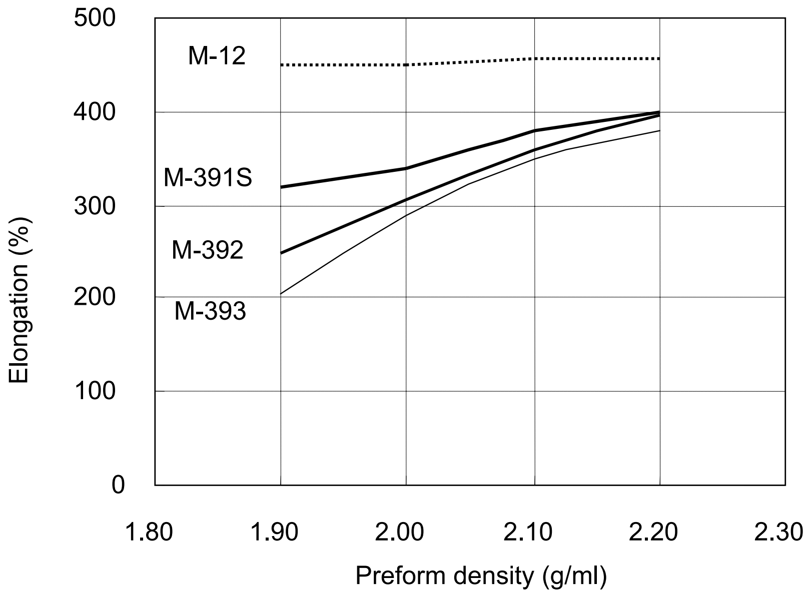


Fig. 6 Relationship of preform density and Elongation Propreties



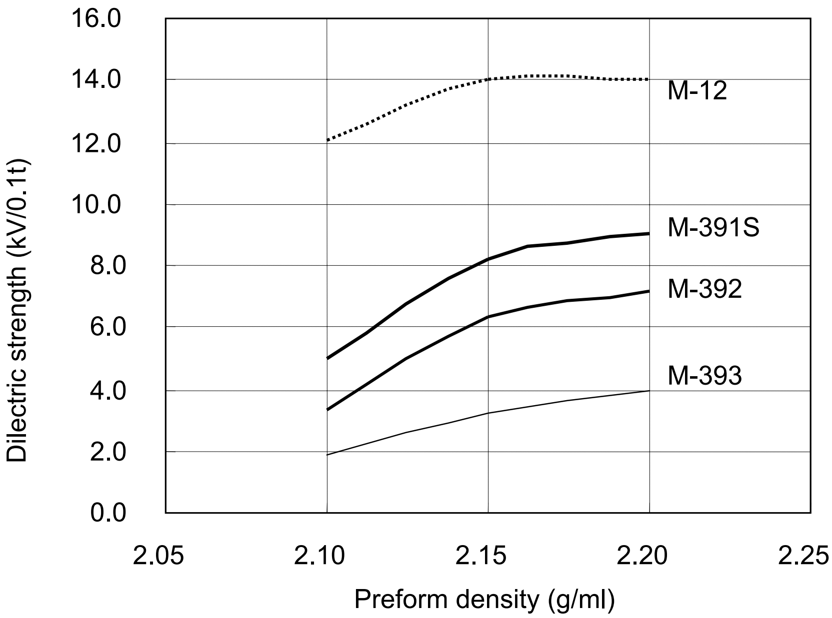
Molding conditions

Dimensions:	50 (O.D.) ×50 (H) mm
Preforming pressure:	10~50MPa
Dwell period:	5 min
Heating rate:	50°C/h
Sintreing period:	5hrs at 365°C
Cooling rate:	50°C/h

Test specimens for tensile properties were punched according to the No. 3 Dumbbell type of test method JIS K 6301 from skived film 0.3 mm in thickness.

Test speciments for dielectric strength were skived to films of 0.1 mm in thickness.

Fig. 7 Relationship of Preform density and Dielectric Strength

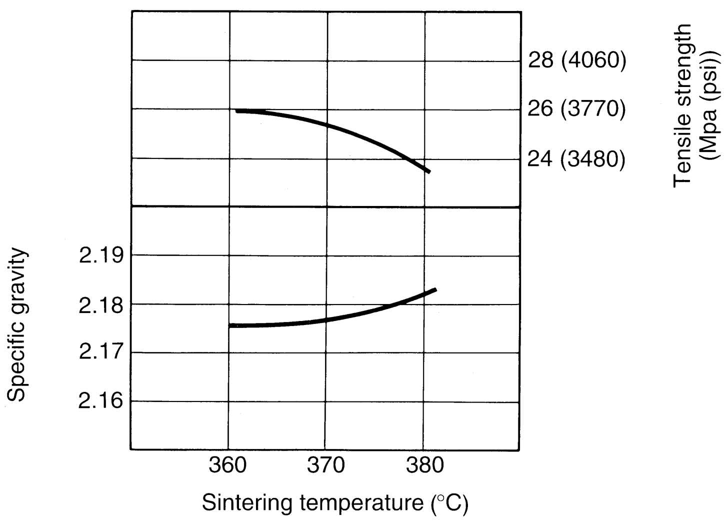


(4) Sintering conditions

A sintering temperature of 360~380°C (680~716°F) is appropriate. The minimum sintering time is one hour, plus one hour for each 10 mm thickness.

The heat stability of grade M-12 is good. If necessary to sinter a large article for a long period of time, it should be sintered at a temperature below 370°C (698°F). For example, one hour is ordinarily sufficient for a 1 mm sheet; however, as shown in Fig.8, when sintering for an especially long time (7 hours) at 380°C (716°F), a slight decrease in tensile strength and increase in specific gravity can be seen. Special attention must be paid to this point when tetrafluoro-ethylene resin is fabricated.

Fig. 8 7-hour Sintering: Sintering Temperature and Product Quality



Also the heating rate or cooling rate must be slowed as the size of the article increases. Table 8 shows several examples of sintering cycles appropriate to various sizes.

Table 8 Examples of POLYFLON PTFE Sintering Conditions

Preform size		Sintering cycle		
Size (mm) (dia. × length) (O.D./I.D.) × (L)	Weight (kg)	Heating rate	Sintering	Cooling rate
50 × 50	0.2	50°C/h	5h at 370°C	50°C/h
100 × 100	1.7	30°C/h	10h at 370°C	30°C/h
174/52 × 130	6.0	30°C/h	12h at 370°C	30°C/h
420/150 × 600	150	50°C/h 25°C→150°C 3h at 150°C 25°C/h 150°C→250°C 3h at 250°C 15°C/h 250°C→315°C 5h at 315°C 10°C/h 315°C→365°C	20h at 365°C	10°C/hr 365°C→315°C 10hr at 315°C 10°C/hr 315°C→250°C 25°C/hr 250°C→100°C
420/150 × 1200	300	50°C/h 25°C→150°C 5h at 150°C 25°C/h 150°C→250°C 5h at 250°C 15°C/h 250°C→315°C 5h at 315°C 10°C/h 315°C→365°C	30h at 365°C	10°C/h 365°C→315°C 13h at 315°C 10°C/h 315°C→250°C 25°C/h 250°C→100°C

Notes: * Preforming pressure: 15 MPa (2175 psi) (double ended pressing)
Ram speed: 40 to 60 mm/min (pressure applied in 4 stages)
Dwell time: 30 min or more

** Preforming pressure: 15 MPa (2175 psi) (double ended pressing)
Ram speed: 40 to 60 mm/min (pressure applied in 4 or 5 stages)
Dwell time: 45 min or more
For sintering, set the article vertically on a stand provided with a ventilation opening in the center (so that air is allowed to pass through the center of the article) to assist the interior heating rate of the article.

(B) Automatic compression molding

Automatic compression molding is an automatic charging and compression process, suitable for the mass production of small molded articles.

(1) Powder

Since the powder is automatically charged in this molding method, a powder with good flowability is requires.
POLYFLON PTFE M-391S, M-392, M-393 grades are ideal for use in automatic compression molding because of their superior flowability. Moreover, the quality of articles molded from these grades and the smoothness of their surfaces are excellent.

Table 9 Powders Used for Automatic Compression Molding

Grade	M-391S	M-392	M-393
Apparent density (g/l)	790	870	930
Average particle diameter (μm)	350	400	500
Flowability	Good	Excellent	Excellent
Surface roughness of molded articles (μm)	Ha 1.9~2.5	Ha 2.1~2.7	Ha 2.4~3.2

Note: Free-flow type molding powders containing fillers (MGF) are also available.

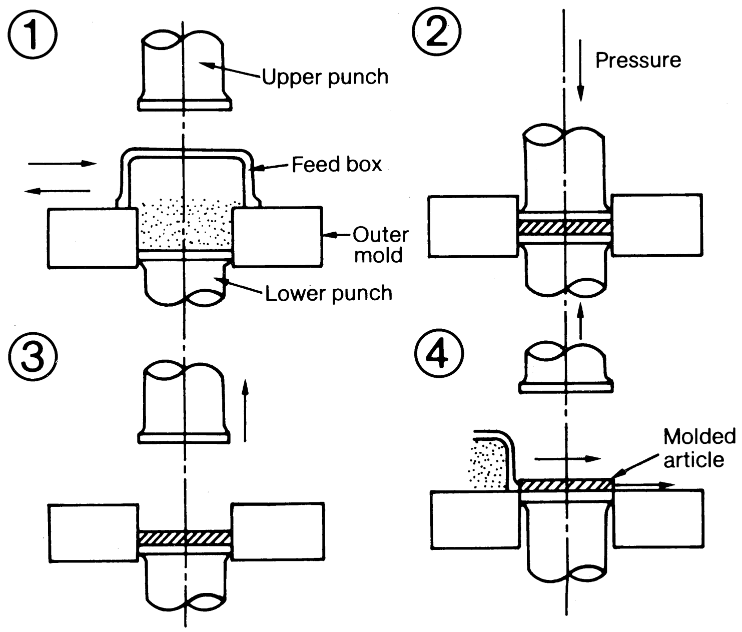
(2) Powder charging

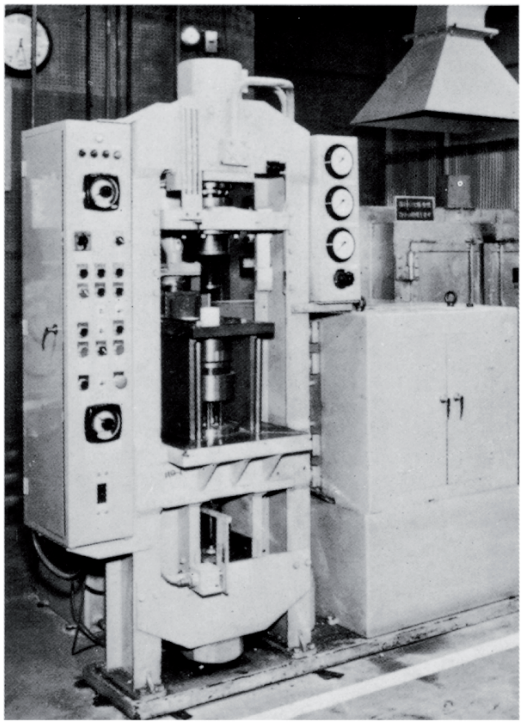
What is presently called automatic compression molding is actually automatic preforming. A fixed quantity of powder is automatically charged into the cavity of a mold. As soon as this is done, a ram is lowered and the powder is compressed. In the second half of the process, a lower ram is raised and the material is pressed from both directions. After this pressure has been maintained for a fixed period of time, the upper ram is retrieved and the compressed preform is extruded by the raising action of the lower ram. This operation automatically takes place according to a preset operating cycle. A diagram illustrating the procedure for automatic compression molding is shown in Fig.9.

Even powders with good flowability tend to aggregate at high temperatures. This may cause the formation of a bridge in the hopper or partial lumping in the feed box, resulting in uneven charges in the mold cavity, or variations in each charge.

For this reason, the molding room (molding equipment) and the powder used for automatic compression molding should be maintained at 23~25°C (73.4~77°F)

Fig. 9 Automatic Compression Molding Diagram

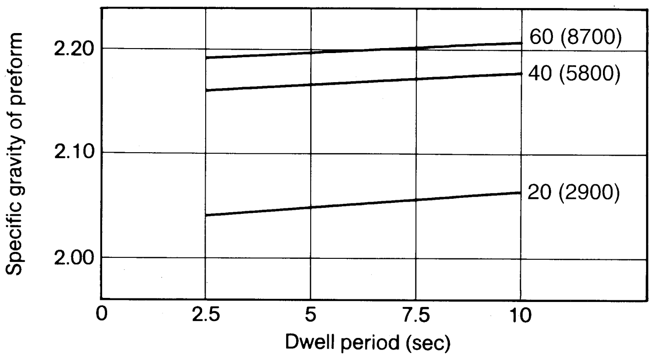




Automatic compression molding machine

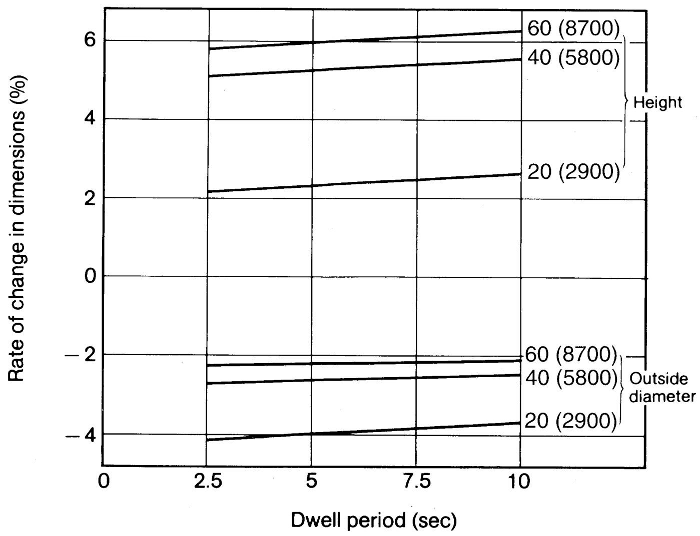
(3) Compression
Since the powder is compressed for a very short time in the automatic molding process, a higher pressure is used than in ordinary compression molding. The relationship of the molding pressure/dwell period of the M-392 grade and the specific gravity of the preform, the rate of change in dimensions, the tensile strength, and elongation is shown in Fig.10~13.

Fig.10 Relationship of Molding Pressure/Dwell Period and Specific Gravity of Preform



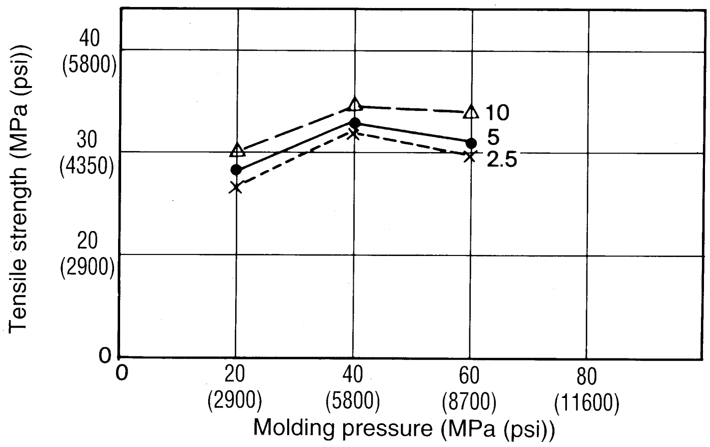
Note: The numbers in the graph indicate the molding pressure (Mpa (psi)).
Dimensions of the molded article: 64 (O.D.) × 52 (I.D.) × 15 (Length) mm

Fig.11 Relationship of Molding Pressure/Dwell Period and Rate of Change in Dimensions



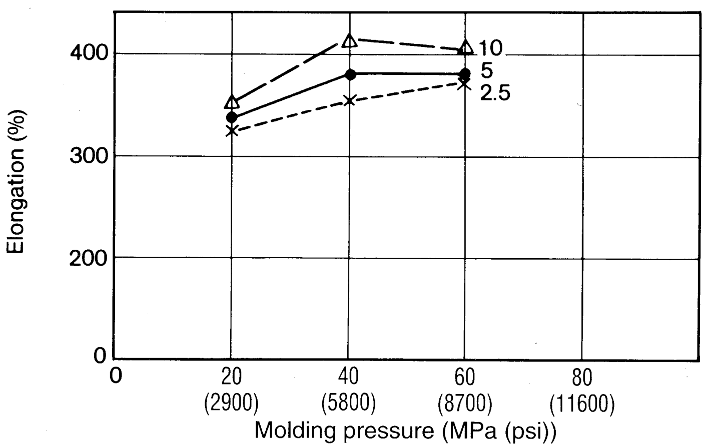
Note: The numbers in the graph indicate the molding pressure (Mpa (psi))
Dimensions of the molded article.
64 (O.D.) × 52 (I.D.) × 15 (H) mm
Sintering conditions: Heating rate 100°C/h, 370°C (698°F) maintained for 3 h
Cooling rate 100°C/h

Fig.12 Relationship of Molding Pressure/Dwell Period and Tensile Strength



Note: The numbers in the graph indicate the dwell period (s)

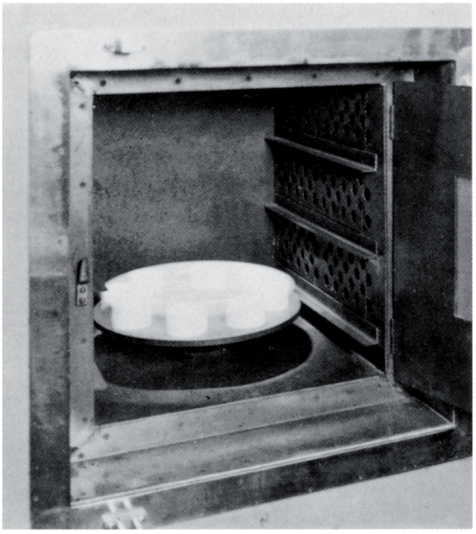
Fig.13 Relationship of Molding Pressure/Dwell Period and Elongation



Note: The numbers in the graph indicate the dwell period (s)

The molding pressure for automatic compression molding is determined by considering the relationship of the molding pressure, the specific gravity of the preform, and the specific gravity of the molded product, in the same manner as is done for ordinary compression molding. The pressure applied, however, is higher than ordinary compression molding. Grade M-392 are generally compressed at 50~70 MPa (7250~10150 psi).

(4) Sintering conditions
The sintering conditions for automatic compression molding do not differ very much from those for ordinary compression molding. However, because the molded articles are smaller in size and are often made into finished products without any secondary processing (machining etc.), further it is necessary to minimize any changes in dimensions or shape in the sintering. For this reason, improvements are now being made in sintering methods, and the use of rotary-type sintering ovens and continuous-type sintering ovens are being introduced.


Rotary-type sintering oven

(C) Isostatic molding
In isostatic molding, hydraulic pressure (water, oil) is exerted on an elastic structure, such as rubber, etc., through which pressure is applied to the powder. Thin-wall pipes with large diameters, beaker-shaped containers and bottles, piping parts, and other articles with complex shapes can be molded by this method.

(1) Powder
The powder used for isostatic molding must be easy to handle and must be capable of producing articles whose characteristics are good, even though relatively low pressure is applied. The grades of POLYFLON PTFE used for isostatic molding are shown in Table 10.

Table 10 Grades of Powder Used for Isostatic Molding

Grade	M-12	M-18	M-392
Apparent density (g/l)	290	450	870
Average particle diameter (μm)	50	40	400
Handling properties	Poor	Poor	Excellent
Surface roughness of molded articles (μm)	Ha 0.5~1.0	Ha 0.7~1.3	Ha 2.0~2.8

(2) Compression

Isostatic molding is a method of molding thin, hollow articles by distributing the molding pressure as uniformly as possible.
Fig.14 illustrates the isostatic molding process for a beaker article.
The basic principles are as follows (dry bag method).

In another form of the isostatic molding method, a rubber mold is charged with powder, and then placed in a pressure-resistant vessel. Pressure is then applied to the vessel. This is called the “wet bag method,” and is shown in Fig.15.

Fig. 14 Principles of Isostatic Molding (Dry Bag Method)

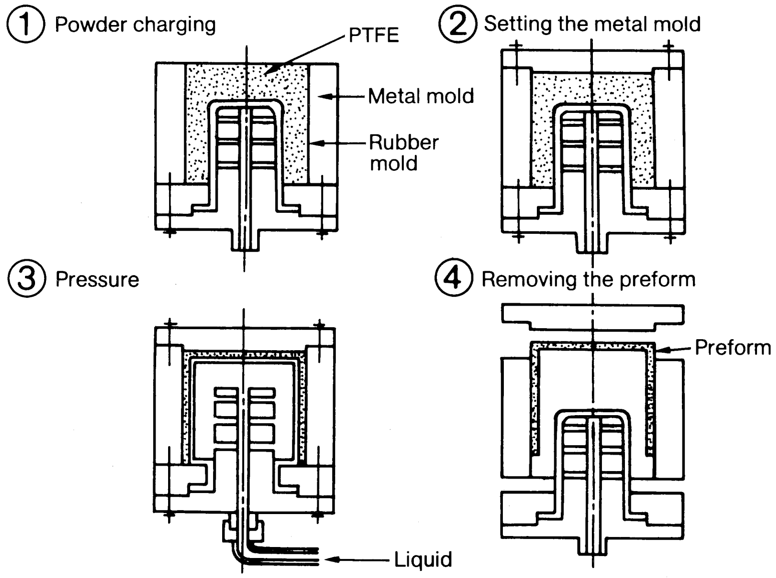
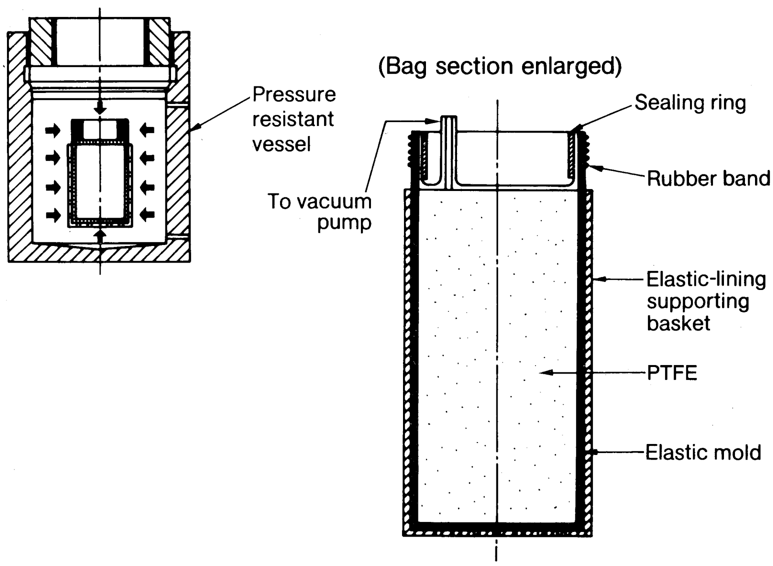


Fig.15 The Wet Bag Method



The molding pressure used is ordinarily 15~30 MPa.
In both of these methods, the surfaces which are pressed by the rubber mold become rough, and must be finished by machining whenever necessary.
Applying an even distribution of pressure is difficult not only in the preforming of hollow articles; in the preforming of large thin sheets, etc., this is also extremely difficult. Excessive pressure is sometimes applied to certain parts of the sheet, causing these areas to become transparent. Even if the pressure is not severe, it may cause the sheet to warp or bend during sintering. Therefore, after the powder is charged, a thin metal panel should be placed on it in order to ensure a flat preform surface. Then, a rubber sheet approximately 10 mm thick should be laid on the metal panel. The plunger should then be placed on top of the rubber sheet, and pressure applied. A preform with good pressure distribution is produced, and distortions caused by sintering are kept to a minimnum. The thinner the sheet to be molded, the softer the rubber sheet. The appropriate rubber-sheet hardness for the molding of a sheet 300 mm × 300 mm are as follows.

Relationship of Sheet Thickenss and Rubber Hardness
Sheet size: 310 × 310 mm
Powder: M-12
Molding pressure: 15 MPa

Sheet thickness (mm)	Rubber hardness (Shore A)
2.0 or more	A75
1.5 or more	A60
1.0 or more	A50

(3) Sintering conditions
The sintering conditions for isostatic molding are the same as those for ordinary compression molding. In isostatic molding, however, because the articles often have complex shapes which may easily be deformed during sintering, correction devices, such as metal cores and outer sleeves, and a rotary-type sintering oven are used.

3. Ram Extrusion Molding

In ram extrusion molding, the molding powder is pressure-inserted intermittently into the heated die. The preforming, sintering, and cooling processes then occur consecutively inside the die. Articles such as cylindrical rods and pipes are produced in high efficiency by this method.

3-1 Ram extrusion molding powder

In ram extrusion molding, selecting the correct molding powder is a very important factor in assuring product quality (stability), continuous productivity, etc.
POLYFLON PTFE M-392 and M-393 have been subjected to various practical tests over long periods of time. These grades have thus been developed exclusively for use in ram extrusion molding.

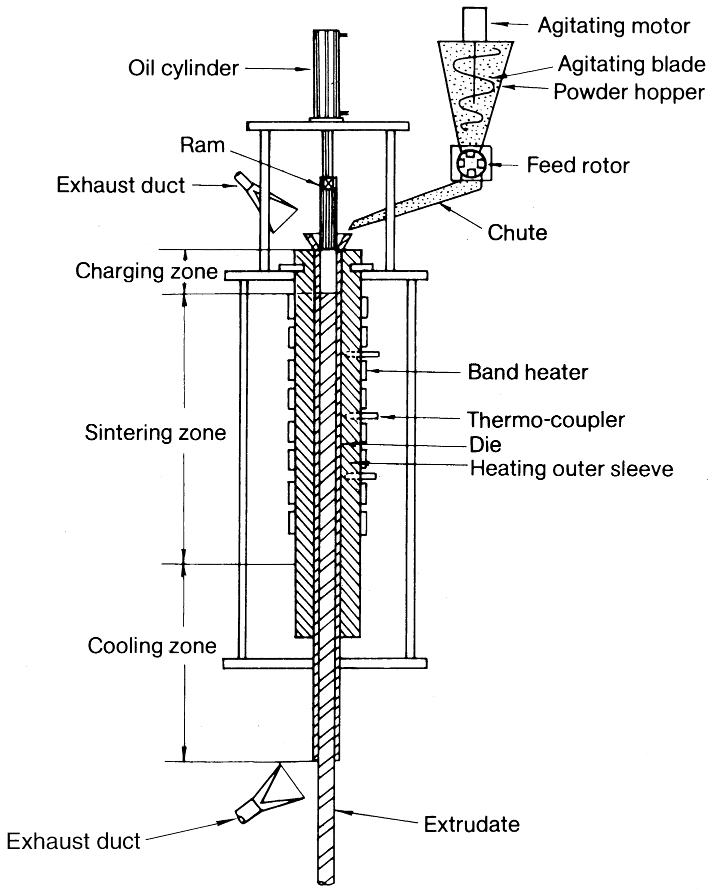
3-2 Ram extruder

There are two types of ram extruders: a horizontal type and a vertical type. The vertical type is shown in Fig.16.
The main components of the ram extruder are a ram which moves in a reciprocal motion, a die which contains a heating apparatus, and a molding powder supply device. The ram extruder can be operated automatically.

A settled quantity of molding powder is injected into the upper end of the die from the hopper. This molding powder is intermittently pressure-inserted into the die by the reciprocal motion of the ram. The charged molding powder is then compressed by the forward motion of the ram. This primary compressed molding block is sent next to the sintering zone by the repetition of the vertical movement (horizontal movement in the horizontal-type extruder) of the ram. In this zone, the article is heated to a maximum temperature of approximately 400°C (752°F) and sintering is done for a fixed period of time. After sintering is completed, the article passes through the cooling zone, and is then extruded out the other end of the die as a finished product.
The procedure in ram extrusion, therefore, consists of a consecutive process of charging, compressing, sintering, and cooling the molding powder. In this method the frictional force created by the thermal expansion which occurs mainly when the resin proceeds through the charging and sintering zones of the mold maintains the preforming pressure.
Cylindrical rods and rods of various shapes can be molded by this method.

By another charging method the molding powder, multiple extrusion (in which several rods are produced at the same time by one extruder) can be done.
The main components of the ram extruder are described in the following sections.
By attaching a mandrel to the center of the die, pipes can also be molded. For this, the molding powder must be uniformly inserted.

Fig. 16 Ram Extruder



(1) Ram

The ram moves in a reciprocal motion and pressure-inserts the molding powder intermittently into the die. It is driven by oil or pressure.

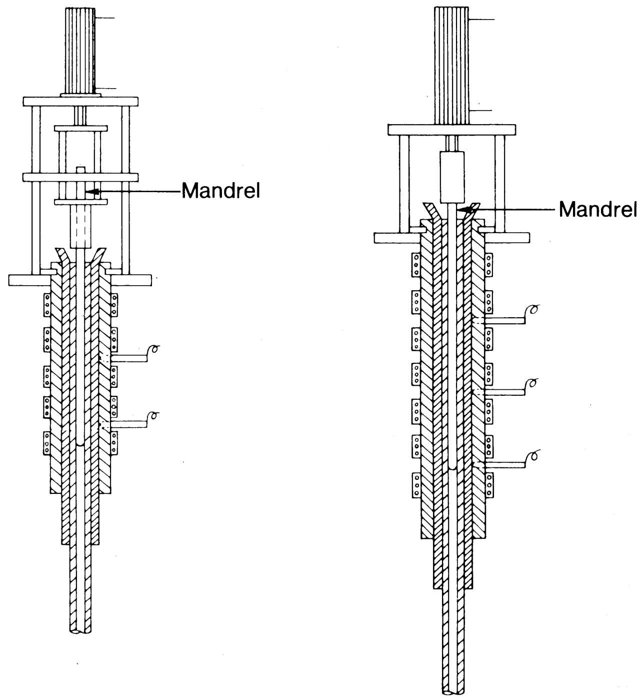
The outside diameter of the ram is 0.15~0.30 mm smaller than the inside diameter of the die. Ordinarily, rams constructed of steel with hard chrome plating are used.

(2) Die

The die is divided into 3 zones: the charging zone, the sintering zone, and the cooling zone. The length of each zone is determined by the size and the shape of the final product.

The die usually consists of a stainless-steel pipe with a wall thickness of approximately 2.5 mm, and is placed in a heated outer sleeve of approximately 25 mm. The inside diameter of a die for the molding of cylindrical rods is 1.14 times the outside diameter of the rod, and for pipes is 1.11 times the outside diameter of the finished pipe. The molding pressure for the ram extrusion method is generated by the frictional force created by the movement of the resin along the inside wall of the charging and sintering zones of the die. This frictional force, in both the charging and sintering zones, appears as stress in the direction perpendicular to that of the extrusion pressure. Therefore, the degree to which the inner wall of the die is polished becomes a very important factor. The die is heated by a band heater through the outer sleeve. The temperature of the die is controlled by an automatic temperature control device.

Fig. 17   Pipe Extruder



Fixed mandrel   Drive mandrel

(3) Mandrel
A mandrel is used for the extrusion of pipes and other hollow articles. There are two types of mandrels: in one type, the ram and the mandrel are connected, and they reciprocate together (drive-mandrel type); in the other type, the mandrel is fixed, and only the ram reciprocates (fixed-mandrel type).

(4) Molding-powder supply unit
There are three type of molding powder supply units: the rotary-feed type shown in Fig.17, a shuttle-box type, and a type that uses a vibrator and a scale to supply a fixed quantity of molding powder.
POLYFLON PTFE molding powders have a general tendency to become fibrous from shearing force and friction.
Because of this, a bridging phenomenon may occur and cause an uneven powder supply. It is necessary, therefore, to select a supply system that will minimize friction in the supply of POLYFLON PTFE, and to keep the temperature of the powder below 23~25°C.

3-3 Molding defects and their appropriate counter-measures

Defects which may occur in ram extrusion molding and the appropriate countermeasures to prevent them are shown in Table 15. Of special note is the fact that PTFE undergoes volume changes (approx.1%) due to secondary transition at about 20°C. If extrusion molding is done below this transition temperature, various problems may result. These problems include poorer cohesive properties of the resin block with each successive charge, and deviations in the molding pressure, decreasing the quality of the molded articles.
Therefore, it is recommended the temperature of the powder, and of the molding room, be maintained at 23~25°C.

Table 11 Causes of Defects in Ram Extrusion Molding and Their Appropriate Countermeasures

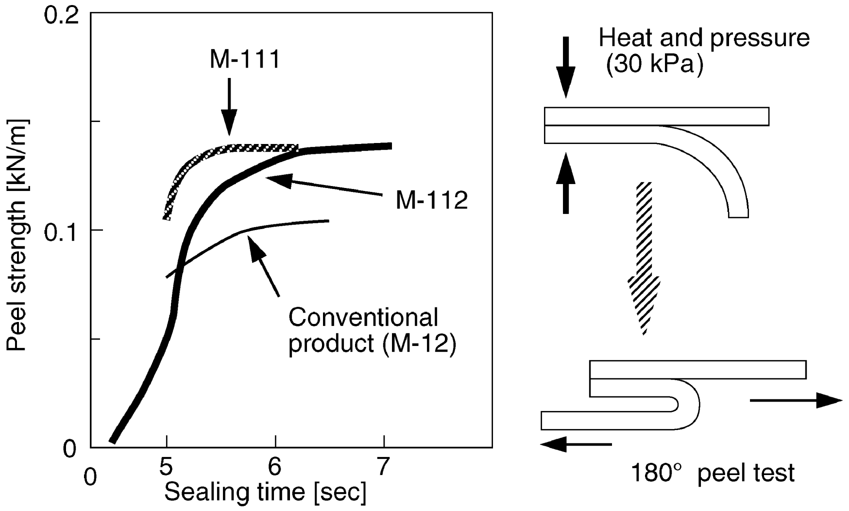
Defect	Cause	Countermeasure
Insufficient cohesion of joining surfaces between charges, or formation of chips	Temperature of molding powder is too low	Regulate the condition of the molding powder before use
	Extrusion pressure is too high	Decrease the sintering temperature and the pressure, or shorten the cycle and decrease the pressure
A spongy condition in molded articles	Insufficient pressure, of insufficient sintering	Lengthen the cycle(increase the the pressure)
Unsatisfactory surface finish	Article surface is over-sintered	Shorten the cycle, lower the sintering temperature(reduce the pressure)
	Foreign matter adhering to interior surface of die	Clean the mold
Voids	Air exists inside the primary molded article	Decrease ram speed
Warping	Uneven temperature surrounding the molded article as it is extruded from the die	Make the temperature of the fabrication room uniform
	Uneven charging	Make the molding powder charges uniform
Contamination	Contamination by dust or oil	Clean equipment and surroundings
	Foregin (decomposed) matter adhering to interior surface of die	Polish the interior surface of the die before use

4. NEW POLYFLON PTFE Secondary Processing Performance

4-1 Thermal fusibility

Skived films of the M-111 and M-112 grades of NEW POLYFLON PTFE can be thermally fused with ease using a heat sealer.
Furthermore, the sealing strengths obtained are stronger than those for conventional products.

Fig.18 Peel test for sealed article (Film thickness 100 μm)



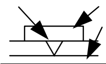
Weld time and ultimate temperature for sealing equipment

Weld time (sec.)	4	5	6	7
Ultimate temperature (°C)	310	340	380	410

4-2 Weld processability

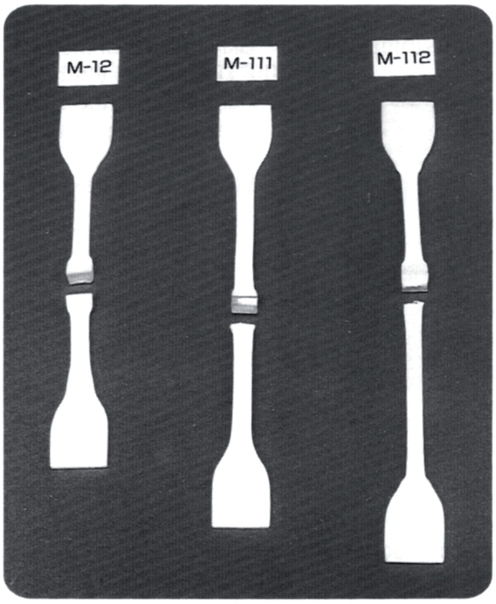
Articles molded from the M-111 and M-112 grades of NEW POLYFLON PTFE powder have more stable weldability and higher tensile elongation than conventional PTFE. In addition, they are easier to work, with less thermal refining necessary compared to conventional products.

Welding strength and elongation for PTFE sheet linings

Welding method	M-111		M-112		Conventional PTFE	
	Strength at break KN/m	Elongation %	Strength at break KN/m	Elongation %	Strength at break KN/m	Elongation %
PFA M-111/M-112 	45 [60]	190	41 [50]	210	44 [50]	45

Values in square brackets are welding efficiency (%).
Sheet thickness: 3 mm^t

Results of tensile tests carried out for pre-welded products show that fissures occur in conventional PTFE at the welded sections, whereas M-111 and M-112 break in places next to the welded sections.

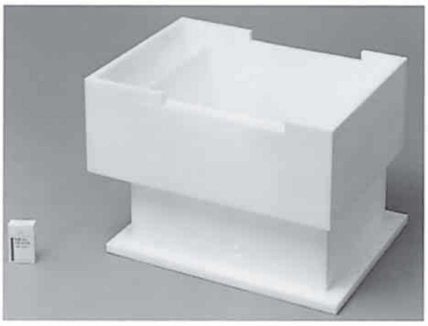


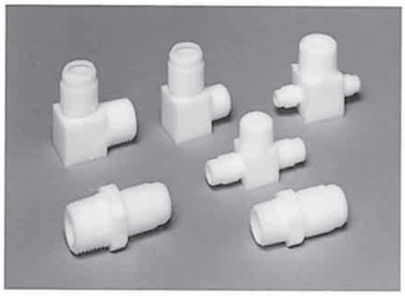
5. Applications

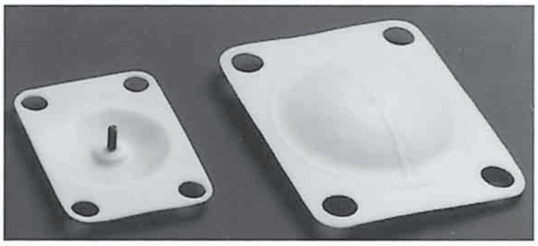
Chemical, Mechanical	Packings, gaskets, diaphragms, bellows, corrosion-resistant linings, piping components, pump parts, O-rings, V-rings
Electrical, Others	Insulating tape, insulating sleeves, terminals, connectors, sockets, spacers, electronic parts, laboratory equipment

5-1 Examples of Processing Applications

Application	Applicable grade	Features	
		Physical properties	Processability
Gaskets, seals	M-111, M-112	Creep resistance	Formability
Ball valve seats	M-111	Creep resistance	
Tees and elbows	M-111, M-112	Crack resistance Creep resistance	
Automotive parts Power steering seals A/T seals Air conditioner seals Others	M-111, M-112	Creep resistance Flexural fatigue resistance Wear resistance	
Bellows	M-112	Flexural fatigue resistance	
Diaphragms	M-112	Flexural fatigue resistance	Formability
Sheet linings	M-111, M-112	Low chemical permiation	Weldability, formability and flange processing ability
Containers	M-111, M-112	Low chemical permiation	Welding, crack resistance during molding
Chemical bags	M-111, M-112	Low chemical permiation Transparency	Heat sealing ability
Medicine containers	M-111, M-112		Blow molding ability
Metal insert molded parts Butterfly valves Impellers Casings Magnetic pumps Stirrer Other	M-111, M-112	Stress cracking resistance	Crack resistance during molding, fusibility
Electric insulation films	M-111, M-112	Surface smoothness High dielectric breakdown voltage	High stretchability (forms thin films)
Mold release films	M-111, M-112		
Base powders	M-111, M-112	(Compounds) Creep resistance Flexural fatigue resistance	Compatibility with filler








DAIKIN INDUSTRIES

Caution on handling

WARNING:VAPORS HARMFUL IF INHALED.POLYFLON PTFE is inert under normal temperature of use (260°C).
However, when POLYFLON PTFE is heated to processing temperature (350~380°C), it may produce harmful vapors,including toxic gases.
These harmful vapors include hydrogen fluoride (HF) and chloride (HCl).
Therefore, adequate exhaust should be installed as a precautionary measure to remove the gases released from POLYFLON PTFE in work areas during the molding process.
Tobacco contaminated with POLYFLON PTFE may result in the inhalation of toxic gases. Therefore, do not smoke in work areas.
Wash hands and face after handling to avoid contamination of tobacco with POLYFLON PTFE.
Instructions on first-aid treatment, proper handling, and storage requirements can be found on the Material Safety Data Sheet for POLYFLON PTFE.
Please follow all federal, states and local requirements for disposal.

• 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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