ENGINEERING PLASTICS HANDBOOK

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ENGINEERING PLASTICS
HANDBOOK

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1. Plastics

1.1 Advantages and disadvantages of plastics

Advantages of plastics

The following summarizes the advantages of plastics:

(1) Lightweight. (Some are light enough to float on water)
(2) Usually transparent with high refraction index. Easy coloring by blending pigments.
(3) Vibration and sound are not easily conducted but absorbed. (Viscoelastic property)
(4) Often slippery with a small friction coefficient. Non-viscous plastics are also available.
(5) Often exhibits excellent flexibility.
(6) Heat is not easily conducted.
(7) Excellent electric insulation property. Dielectric substance. Transparent to radio waves.
(8) Impervious to water. Often exhibits high tolerance against acid and alkali.
(9) Some plastics are permeable to gasses while preventing liquid to pass through.
(10) Surface is treatable. (Plating, painting, metallicon, adhesives, etc.)
(11) Easily formed; suitable for mass production.

Disadvantages of plastics

The following summarizes the disadvantages of plastics:

(1) Lower strength than steel. Some have superior specific strength (strength/specific weight).
(2) Rigidity (Young's modulus) is smaller than metal. Some have comparable specific rigidity (Young's modulus/specific weight). (e.g. carbon fiber reinforced plastics).
(3) Low surface hardness, vulnerable against scratches. (Surface hardening treatment is available).
(4) Larger thermal expansion than metal.
(5) Low heat resistance with potential thermal deformation, degradation and decomposition (Some have high heat resistance such as polyimide).
(6) Some are vulnerable to organic solvent and oil, resulting in swelling, melting and cracking.
(7) Some may deteriorate from ultraviolet rays and oxygen.
(8) Highly sensitive to temperature; physical property is governed by temperature and frequency. Subject to creep and stress relaxation phenomena. (Viscoelastic property).
(9) Potential shrinkage immediately after molding and temporal variation over time.
(10) Persistent as waste resulting in high cost of disposal. (Recycling is available).

1.2 Classification of plastics

1.2.1 Classification by chemical structure and processing characteristics

Plastics are broadly classified into thermoplastic resin and thermo hardening resin based on the chemical structure and processing characteristics and the thermoplastic resin is further classified into crystalline and amorphous (non-crystalline) plastic. (**Table 1.1**)

(1) Thermoplastic resin

Softens and melts when heated and solidifies when cooled; this melting and solidifying by heating and cooling can be reversibly repeated.

a) Crystalline resin

Crystallizes when appropriate conditions are given. In general, no resins are 100% crystallized, but rather, crystalline, semi crystalline and amorphous substances are locally formed and the formation of crystalline organization, such as degree of crystallinity, crystal size, degree of orientation of crystals, depending on the conditions, such as the forming process, during which crystalline substances are formed.

The typical relation between the mechanical strength and temperature is shown in **Fig. 1.1**. This can be easily understood if you consider that Tg (glass-transition point) is the temperature that amorphous substance is softened and Tm (melting point) is the temperature that crystalline substance is also softened.

b) Amorphous resin

The substance that cannot take a crystalline state. **Fig. 1.2** shows the relation between the mechanical strength and temperature. Its change of strength due to temperature is smaller than crystalline resin.

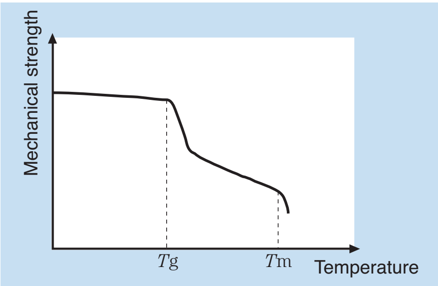

Fig. 1.1

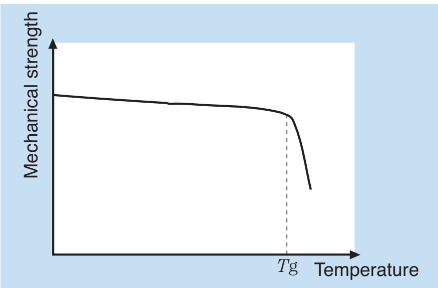

Fig. 1.2

(2) Thermo hardening resin

Hardens with heat or a hardening agent. It is composed of relatively low molecular-mass material before hardening which is hardened by a chemical reaction from heat or a hardening agent to become insoluble resin with a three-dimensional network molecular structure. Therefore, different from thermoplastic resin, its melting and solidification process is irreversible and it is not soluble once hardened.

The relation between the mechanical strength and temperature is shown in **Fig. 1.3**. Its reduction in strength due to temperature is smaller compared with thermoplastic resin. Although there is no melting point, it decomposes over Td (thermal decomposition temperature).

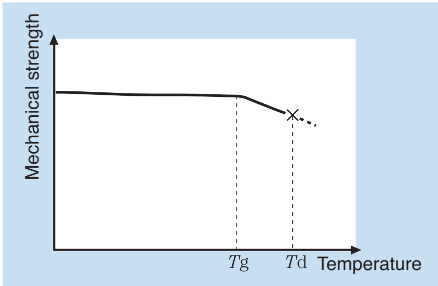

Fig. 1.3

1.2.2 Classification by performance

Plastics may be classified into general purpose resins and engineering plastics by performance, versatility (availability, price and production volume), etc. The definition of enterprise plastics, sometimes also called as highly functional resins, is not yet standardized, however, it is generally defined as the "general name for plastics used mainly as an alternative to metals in industrial fields such as components and housings of machinery and equipment."

Engineering plastics may also be further classified into general engineering plastics, high engineering plastics and super engineering plastics (specialized engineering plastics). **Table 1.2** shows an example. However, this classification is not explicit or primary and other classifications are also often used.

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Table 1.1 Classification of plastics by chemical structure and processing characteristics and relation with BEAREE resins

<table>
<tr><th colspan="3">Classification</th><th>Name of plastics</th><th>Acronym</th><th>Name of engineering plastic material</th></tr>
<tr><td rowspan="30">Plastics</td><td rowspan="25">Thermoplasticity</td><td rowspan="14">Crystalline property</td><td>Aromatic polyester</td><td>ARP</td><td>BEAREE LC</td></tr>
<tr><td>Polyetheretherketone</td><td>PEEK</td><td rowspan="2">BEAREE PK</td></tr>
<tr><td>Polyetherketone</td><td>PEK</td></tr>
<tr><td>Polyethernitrile</td><td>PEN</td><td>BEAREE TP</td></tr>
<tr><td>Fluoro resin (tetrafluoroethylene)</td><td>PTFE</td><td>BEAREE FL</td></tr>
<tr><td rowspan="3">Fusible fluoro resin
(other than tetrafluoroethylene)</td><td>PFA</td><td rowspan="3">BEAREE FE</td></tr>
<tr><td>ETFE</td></tr>
<tr><td>FEP</td></tr>
<tr><td>Polyphenylene sulfide</td><td>PPS</td><td>BEAREE AS</td></tr>
<tr><td>Polyacetal</td><td>POM</td><td>BEAREE DM</td></tr>
<tr><td>Polyethylene terephthalate</td><td>PET</td><td>BEAREE ET</td></tr>
<tr><td>Polybuthylene terephthalate</td><td>PBT</td><td>BEAREE PB</td></tr>
<tr><td>Polyamide</td><td>PA</td><td>BEAREE NY</td></tr>
<tr><td>Polyethylene</td><td>PE</td><td rowspan="3">BEAREE UH</td></tr>
<tr><td rowspan="11">Amorphous property</td><td>Polypropylene</td><td>PP</td></tr>
<tr><td>Other polyolefin</td><td>PO</td></tr>
<tr><td>Polyetherimide</td><td>PEI</td><td>BEAREE EI</td></tr>
<tr><td>Polyethersulfone</td><td>PES</td><td>BEAREE ES</td></tr>
<tr><td>Thermoplastic polyimide (can be crystalline)</td><td>TPI</td><td>BEAREE PI</td></tr>
<tr><td>Polyamideimide</td><td>PAI</td><td>BEAREE AI</td></tr>
<tr><td>Polysulfone</td><td>PSF, PSU</td><td>BEAREE SU</td></tr>
<tr><td>Polyphenylene oxide</td><td>PPO</td><td>BEAREE PD</td></tr>
<tr><td>Polycarbonate</td><td>PC</td><td>BEAREE PC</td></tr>
<tr><td>Polyarylate</td><td>PAR</td><td>BEAREE RA</td></tr>
<tr><td>Polyvinyl chloride</td><td>PVC</td><td></td></tr>
<tr><td colspan="2" rowspan="5">Thermo hardening</td><td>Polystyrene</td><td>PS</td><td></td></tr>
<tr><td>ABS resin</td><td>ABS</td><td></td></tr>
<tr><td>Methacryl resin</td><td>PMMA</td><td></td></tr>
<tr><td>Polyimide</td><td>PI</td><td>BEAREE PI</td></tr>
<tr><td>Epoxy resin</td><td>EP</td><td>BEAREE EP</td></tr>
<tr><td colspan="2"></td><td>Phenolic resin</td><td>PF</td><td>BEAREE PF</td></tr>
<tr><td colspan="3"></td><td>Melamine resin</td><td>MF</td><td></td></tr>
<tr><td colspan="3"></td><td>Urea resin</td><td>UF</td><td></td></tr>
</table>

Table 1.2 Classification of plastics by performance and versatility and relation with BEAREE resins

Classification			Name of plastics	Acronym	Name of engineering plastic material
Plastics	Engineering plastics	Super engineering plastics	Aromatic polyester	ARP	**BEAREE LC**
			Polyetheretherketone	PEEK	**BEAREE PK**
			Polyetherketone	PEK	
			Polyethernitrile	PEN	**BEAREE TP**
			Polyetherimide	PEI	**BEAREE EI**
			Polyethersulfone	PES	**BEAREE ES**
			Fluoro resin (tetrafluoroethylene)	PTFE	**BEAREE FL**
			Fusible fluoro resin (other than tetrafluoroethylene)	PFA	**BEAREE FE**
				ETFE	
				FEP	
			Thermoplastic polyimide	TPI	**BEAREE PI**
			Thermo hardening polyimide	PI	
			Polyamideimide	PAI	**BEAREE AI**
		High engineering plastics	Polyphenylene sulfide	PPS	**BEAREE AS**
			Polysulfone	PSF，PUS	**BEAREE SU**
		General engineering plastics	Polyacetal	POM	**BEAREE DM**
			Polyphenylene oxide	PPO，PPE	**BEAREE PD**
			Polyethylene terephthalate	PET	**BEAREE ET**
			Polybuthylene terephthalate	PBT	**BEAREE PB**
			Polycarbonate	PC	**BEAREE PC**
			Polyamide	PA	**BEAREE NY**
			Polyarylate	PAR	**BEAREE RA**
			Epoxy resin	EP	**BEAREE EP**
			Polyethylene	PE	**BEAREE UH**
	General purpose plastics		Polypropylene	PP	
			Polyolefin	PO	
			Polyvinyl chloride	PVC	
			Polystyrene	PS	
			ABS resin	ABS	
			Methacryl resin	PMMA	
			Phenolic resin	PF	**BEAREE PF**
			Melamine resin	MF	
			Urea resin	UF	

1.3 Main features of plastics

1) Aromatic polyester (ARP)

Most of this type are called liquid crystal polymer and have high mechanical strength, particularly, high rigidity even without filling materials because of their self reinforcing property (reinforcing effect similar to filling material derived from the liquid crystal molecular orientation). In addition, some of them have the highest heat resistance among all the thermoplastic resins.

The material organization is anisotropic with a very small thermal expansion coefficient, similar to metals, in the flowing direction as well as a very small shrinking percentage, almost zero, however, in the direction perpendicular to the flowing direction, the mechanical strength is reduced with a larger thermal expansion coefficient and shrinking percentage.

2) Polyetheretherketone (PEEK)

It has the highest heat resistance among thermal plastic resins with 240˚C of continuous operating temperature and 300˚C of short-term heat resistance temperature. Self lubricates and excels particularly in impact resistance, fatigue resistance, radiation resistance and chemical resistance (except strong sulfuric acid), as well as electric insulation and flame resistance.

It exhibits fast crystalline formation speed and low weld strength in molded articles. Also, its wettability as a filling agent is inferior with little reinforcing effect. Since it shows large dimensional variation in its crystalline process and large shrinking percentage during the forming process, it is not suitable for precision components.

3) Polyetherimide (PEI)

Its heat-resistant temperature is a little inferior to polyimide and polyamideimide; however it is short-term heat resistant to 200˚C and 170˚C in long-term heat resistance, and exhibits excellent mechanical strength, electric characteristics and flame resistance. With stable strength and a thermal expansion coefficient up to approximately 200˚C, as amorphous resin, as well as have a good forming property, it is used as heat-resistant structural material and because of its excellent environmental properties (impact from temperature, humidity, etc.) it is also used for precision machines. Another noteworthy property is only a small amount of smoke is generated during combustion, with which its use is being studied in the aviation industry.

As a sliding material, it has a large friction coefficient (about 0.4) and inferior wear resistance. Its chemical resistance is superior compared with polyethersulfone, which shows similar heat resistance, however, it is a little more expensive.

4) Polyethersulfone (PES)

It is an amorphous resin having similar heat resistance as polyetherimide (PEI), with superior hydrolysis resistance, creep resistance, strength against temperature, dimension stability and flame resistance.

It is used as the material for medical equipment and kitchen appliances due to its superior hydrolysis resistance, as the heat resistant and load resistant material due to its superior creep resistance in high temperature up to 180°C, and as the material for precision components due to its dimension stability. Its melt fluidity is not as good as PEI, however, its moldability is good. Although its friction coefficient is large (about 0.4), it can be improved with solid lubricant, etc. so it can be used as structure material and sliding material.

It's weak point is its inferior chemical resistance.

5) Fluoro resin

There are different types of fluoro resins other than tetrafluoroethylene (PTFE), which is the main constituent of BEAREE (FL material). The following are the typical substances. They have a superior lubricating property although it is not as good as PTFE. In addition, they can be used for melt-molding (injection, extrusion molding, etc.). They are superior to PTFE in creep resistance and impact resistance and are harder than PTFE.

● **PFA (tetrafluoroethylene – perfluorovinylether copolymer resin)**

It has equivalent or superior non-viscosity to PTFE and has a continuous operating temperature of 260˚C, the same as PTFE. Its friction coefficient is larger than PTFE, however, it is the smallest among the fluoro resins with which melt-molding can be used.

The moldability is not as good and toxic gas may be generated during molding. It is also more expensive than PTFE.

● **ETFE (tetrafluoroethylene – ethylene copolymer resin)**

It is superior in moldability and adhesion strength of powder coating to the base material is particularly high. Although inferior to other fluoro resins, its chemical resistance is excellent. The friction coefficient is larger than PTFE and its continuous operating temperature is about 150˚C

● **FEP (tetrafluoroethylene – hexafluoropropylene copolymer resin)**

Its continuous operating temperature is 200˚C. It shows an excellent non-viscosity and is relatively inexpensive, however, it has a relatively larger friction coefficient.

6) Polyimide (TPI/PI)

There are two types, i.e. thermoplastic and thermo hardening. Thermoplastic polyimide becomes crystalline resin by the crystalline process (annealing) to obtain a nearly equivalent property as thermo hardened material. The polyimide is well known to have superior heat resistance. They have especially superior dimensional stability in high temperature, a high retention rate of mechanical strength and excellent wear resistance, as well as a stable friction coefficient. In addition, they have excellent radiation resistance, electric insulation and chemical resistance, however, they are affected by alkali.

7) Polyamideimide (PAI)

It is a resin which can be used for injection molding, while having excellent heat resistance, electric characteristics, chemical resistance (except alkali) and radiation resistance close to polyimide (PI).

In particular, it largely exceeds thermo hardened PI in tensile strength and impact resistance. Although it is inferior to PI in sliding property, it can be used as a sliding material by adding solid lubricant such as graphite.

It can be used for injection molding, however in order to obtain the complete physical property, long heat treatment after molding (post cure) is indispensable. In addition, due to its high melt viscosity, attention is required for weld strength of the molded product.

It has a disadvantage of a large water absorption rate and the heat resistant temperature decreases due to absorbed water.

8) Polyhpenylene sulfide (PPS)

It is a crystalline resin with very high heat resistance (continuous operating temperature of 240˚C) and high rigidity, as well as superior flame resistance, chemical resistance and electrical characteristics. It is relatively inexpensive for the excellent performance, thus it is a proven resin exhibiting superior cost performance.

It has very good melt fluidity, however, there are issues such as burrs from molding, gas burning and appearance of void due to generated gas, mold corrosion, etc. In addition, since the shrinking percentage can significantly vary depending on the difference of wall thickness, the dimension accuracy is critical.

Since the friction coefficient and wear resistance can be significantly improved by adding reinforcing material and lubricant, it is widely used as heat-resistant sliding material that can be used for injection molding.

Compared to polyetherimide, polyethersulfon, etc. its sliding property excels, however, since it is very brittle, it requires reinforcing with fiber reinforcing materials, etc, which results in an anisotropic property in dimension, strength, etc.

9) Polyacetal (POM: Polyoxymethylene)

It is a crystalline resin with balanced mechanical properties, particularly, superior fatigue resistance and creep resistance. It has a self lubricating property, superior wear resistance and dimension stability with a small water absorption rate.

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It has good resistance to oil and organic solvent, however, it is affected by strong acid and alkali. In addition, as it includes abundant oxygen in the molecule, it is difficult to give it flame retardancy. The continuous operating temperature range is about -40˚C to 120˚C.

It has excellent melt fluidity, however, filling materials used for property improvement potentially drives thermal decomposition. Therefore, selection of filling materials is very much restricted.

10) Polyhpenylene oxide (PPO)

PPO is originally a trademark of DuPont. It is also called modified PPE (polyphenylene ether). It has excellent electrical insulation over a wide temperature range with high mechanical strength.

It has excellent rigidity in high temperature compared with polyamide and polyacetal. Its chemical resistance is superior to polycarbonate (PC) and its shrinking percentage in molding is small similar to PC. Moldability and dimension stability are also excellent. Its small specific weight can also be cited as one of the features.

The sliding property is not good, so it is often used as structure material.

11) Polyethylene terephthalate (PET)

Basically, it has the same properties as polybuthylene terephthalate (PBT), however, it is less expensive than PBT with higher rigidity and superior heat resistance.

Currently, it is mainly used as film and PET bottles, however, research is underway to use it as an alternative material of polyphenylene sulfide by reinforcing it with glass fiber, etc.

12) Polybuthylene terephthalate (PBT)

It is a type of saturated polyester with thermalplasticity, similar to polyethylene terephthalate (PET). It possesses balanced mechanical properties, with low water absorption and self lubricating properties. It also has a large shrinking percentage during molding and inferior forming accuracy.

It is inferior in impact resistance compared with polyamide, however superior in flame retardancy compared with polyacetal with low moisture absorption. In addition, it excels in chemical resistance compared with polycarbonate and hydrolysis is less likely during molding compared with PET.

13) Polycarbonate (PC)

It is an amorphous resin and is transparent. It has a small water absorption rate, shrinking percentage and excellent dimension stability. It has good mechanical strength, particularly excellent impact and creep resistance, good electrical characteristics and weatherability, however, cracks may potentially result from strain of molding and is poor in chemical resistance.

14) Polyamide (PA)

It's general name “nylon” is very well known, however, it was originally DuPont’s product name. It has excellent mechanical strength, wear resistance (particularly, abrasive wear), moldability and is inexpensive, however, it has a large water absorption rate resulting in significant reduction of the physical property and dimensional variation due to water absorption, therefore, its operating environment is restricted.

11PA and 12PA with a reduced water absorption rate has a lower heat resistance temperature, and 46PA, 66PA and 6PA are superior in heat resistance, however their water absorption rate is high.

15) Polyethylene (PE)

It is an inexpensive material, classified into a few types by molecular weight and density. It has a number of excellent properties, such as a lubricating property (low friction coefficient), wear resistance, non-viscosity, electrical characteristics (low permittivity) and chemical resistance. It has one of the smallest specific weights among resins.

In particular, ultrahigh molecular weight PE excels in creep resistance and wear resistance (especially, abrasive wear), however, melt viscosity is very high making injection molding difficult.

On the other hand, some types can be used for injection molding, however, their wear resistance is significantly inferior compared with ultrahigh molecular weight PE. All types of PE have heat resistance of 80 to 100˚C and a shrinking percentage during molding and a very high thermal expansion coefficient, therefore, care must be taken if used for precision components. It also has very poor adhesiveness.

16) Epoxy resin (EP)

It has good heat resistance next to polyimide among thermo hardening resins (around 200˚C) with good physical properties for the low price, and therefore it is widely used. Excellent dimensional stability, electric insulation chemical resistance and adhesiveness, however, it is poor in toughness and impact strength due to a low extension property. Although it exhibits good moldability, melt viscosity is very small, therefore, it is difficult to eliminate burrs from being generated.

1.4 Relation of continuous heat resistant temperature and price of main plastics

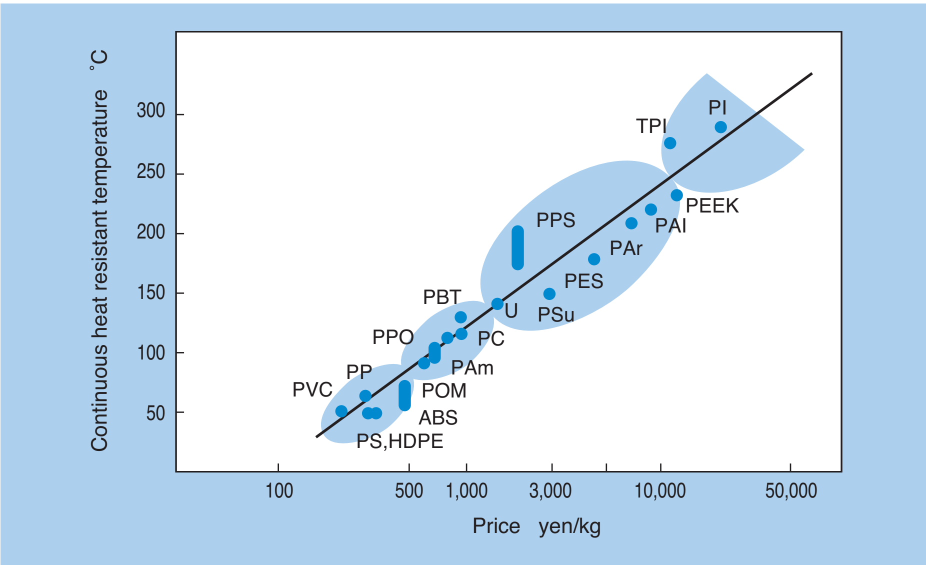

Fig. 1.4 Relation of continuous heat resistant temperature and price of main plastics

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2. Features and positioning of BEAREE resins

2.1 Typical grades of BEAREE resins and their features (Table 2.1)

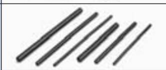
Table 2.1 Features of typical grades

[ ] : Forming method

Grade	Base resin	Features
BEAREE FL	Fluoro resin (tetrafluoroethylene)	Fluoro resin, which is the base resin of BEAREE FL, is an excellent resin for low friction, non-viscosity, heat resistance, chemical resistance and weatherability. BEAREE FL is a material with filling agents added for various applications based on this fluoro resin with superior properties. [Compression molding, extrusion molding, coating]
BEAREE FE	Fusible fluoro resin (other than tetrafluoroethylene) Fluorine oil	BEAREE FE has slightly lower properties than BEAREE FL, however, it has excellent moldability. It is also superior in low friction and wear resistance, suitable for non-viscous coating material and surface treatment material. [Injection molding, extrusion molding, coating, surface treatment]
BEAREE PI	Polyimide	This is a material with improved properties with a special filling agent added to polyimide, which is the highest heat-resistant resin. It has excellent heat resistance and strength. There are two types, thermo hardening and thermoplastic, which are to be selected based on applications. In product design, care should be taken for its high water absorption property. [Injection molding, extrusion molding, compression molding, coating]
BEAREE AI	Polyamideimide	It has lower heat resistance than BEAREE PI, however, it has excellent mechanical properties such as impact resistance and fatigue resistance. In product design, care should be taken for its high water absorption property. [Injection molding, extrusion molding]
BEAREE UH	Polyethylene	It has lower heat resistance than the material based on super engineering plastics, however, it is a material with excellent low friction, wear resistance, non-viscosity, chemical resistance, impact resistance and electrical characteristics, inherent from polyethylene. It is a material with a large shrinking percentage from forming and thermal expansion coefficient, and poor adhesiveness. [Injection molding, extrusion molding, compression molding]
BEAREE AS	Polyphenylene sulfide	It is a material most widely used based on polyphenylsulfide, excellent in heat resistance, chemical resistance, mechanical strength and moldability. It is excellent for volume production and cost performance. [Injection molding]
BEAREE LC	Aromatic polyester	Excels in heat resistance and mechanical strength (particularly, rigidity). Especially, the production design of liquid crystal polymer based material should take the anisotropic property of the material organization into consideration. [Injection molding]
BEAREE PK	Polyetheretherketone	It is a material based on polyetheretherketon which has excellent heat resistance similar to polyimide and chemical resistance, impact resistance, fatigue resistance and self lubricating property. It has properties similar to BEAREE PI and AI, however, with smaller water absorption. Product design should consider its large shrinking percentage from forming. [Injection molding, extrusion molding]
BEAREE NY	Polyamide	It is a material based on polyamide, which is a typical general purpose engineering plastic. It excels in impact resistance and wear resistance. Although it has lower heat resistance than super engineering plastics, it is more economical. In product design, care should be taken for its high water absorption property. [Injection molding]
BEAREE DM	Polyoxymethylene (Polyacetal)	It is a material based on polyoxymethylene, which has excellent fatigue resistance, creep resistance, wear resistance and dimensional stability. As it includes abundant oxygen in the molecule, it is difficult to give it flame retardancy. Similar to BEAREE NY, it is economical compared to the materials based on super engineering plastics. [Injection molding]
BEAREE ER	Elastomer (Sliding rubber)	BEAREE ER is based on elastomer. "Sliding rubber" is a material with both rubber elasticity and sliding property. It has excellent elasticity, heat resistance, low friction property, wear resistance and creep resistance.

2.2 Features and applications of various BEAREE resins

Table 2.2 Material for mechanical processing

Material name	Base resin	Features		Applications
BEAREE FL3000	PTFE		• Small deformation caused by compression load • Excellent friction and wear properties	• Sliding bearing • Valve seat • Piston ring
BEAREE FL3020	PTFE		• Small friction coefficient under high surface pressure • Excellent weatherability	• Sliding support
BEAREE FL3030	PTFE		• Less likely to cause damage to soft mating material such as SUS • Stable friction coefficient	• Sliding bearing / friction plate • Seal ring • Piston ring
BEAREE FL3040	PTFE		• Less likely to cause damage to soft mating material	• Piston ring • Piston cup seal
BEAREE FL3060	PTFE		• Excellent creep resistance	• M liner dedicated material
BEAREE FL3071	PTFE		• Excellent sliding performance and creep resistance	• Compressor seal
BEAREE FL3082	PTFE		• Very small deformation caused by compression load • Excellent friction/wear properties under high surface pressure and oil lubrication	• Piston ring • Sliding bearing
BEAREE FL3307	PTFE		• Excellent compression creep property	• Sliding area of machining tool
BEAREE FL3642	PTFE		• Approved by food related standards • Excellent wear resistance	• Sliding bearing • Seal
BEAREE FL3700	PTFE		• Excellent wear resistance in water • Excellent chemical resistance	• Bearings used in water • Bearings used in chemical solution
BEAREE FL3900	PTFE		• Electrically conductive (volume resistivity: 10Ωcm) • Excellent friction and wear properties	• Earth button • Brush
BEAREE UH3000	PE		• Excellent friction/wear properties in low PV value • Excellent impact resistance	• Sliding bearing • Washer • Seal ring
BEAREE UH3954	PE		• Antistatic effect • Low abrasive wear (wear from sand and paper)	• Noise prevention washer • Cassette shim
BEAREE FL9000 ❷	PTFE		• Suitable for low-speed/high-load	• Sliding bearing • Swinging bearing
BEAREE ER3000	E ❶		• Elastic body with low friction coefficient • Excellent sealability, chemical resistance, heat resistance, wear resistance, creep resistance and non-viscosity.	• Seal for food processing equipment • Sliding bearing
BEAREE ER3201	E ❶		• Elastic body with low friction coefficient • Excellent sealability and wear resistance	• O ring • Lip seal

❶ E: Elastomer ❷ BEAREE FL9000 is a material exclusively for tapes.

Table 2.3 Material for injection molding (1)

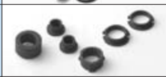
Material name	Base resin	Features		Applications
BEAREE PI 5001	PI		• Excellent wear resistance	• Sliding bearing • Washer • Piston ring
BEAREE PI 5010	PI		• Less likely to cause damage to soft mating material	• Sliding bearing • Thrust pad
BEAREE PI 5014	PI		• Less likely to cause damage to soft mating material • Sliding material for high temperature	• Bearing for fixing roller
BEAREE PI 5022	PI		• Moldability with high dimensional accuracy • Excellent strength as separation claw	• Separation claw • Electric/electronics component
BEAREE PI 5033	PI		• High mechanical strength	• Gear • Cage
BEAREE PI 5040	PI		• High rigidity and electrically conductive	• Gears • Insulating sleeve bearing
BEAREE AI 5003	PAI		• Excellent impact resistance • High mechanical strength	• Insulating material • Electric/electronics component
BEAREE UH5000	PE		• Excellent impact resistance • Strong against abrasive wear	• Sliding bearing
BEAREE AS5000	PPS		• Sliding material for high temperature • Large permissible surface pressure (P_{max}=5MPa) • Less likely to cause damage to soft mating material	• Sliding bearing • Friction plate • Reciprocating motion bearing
BEAREE AS5005	PPS		• Sliding material for high temperature • Large permissible surface pressure (P_{max}=5MPa) • Less likely to cause damage to soft mating material	• Sliding bearing
BEAREE AS5056	PPS		• Sliding material for high temperature	• Bearing for fixing roller
BEAREE AS5965	PPS		• Sliding material for high temperature	• Bearing for fixing roller
BEAREE FE5002	PFA		• Excellent non-viscosity	• Roller • Separation claw • Cage

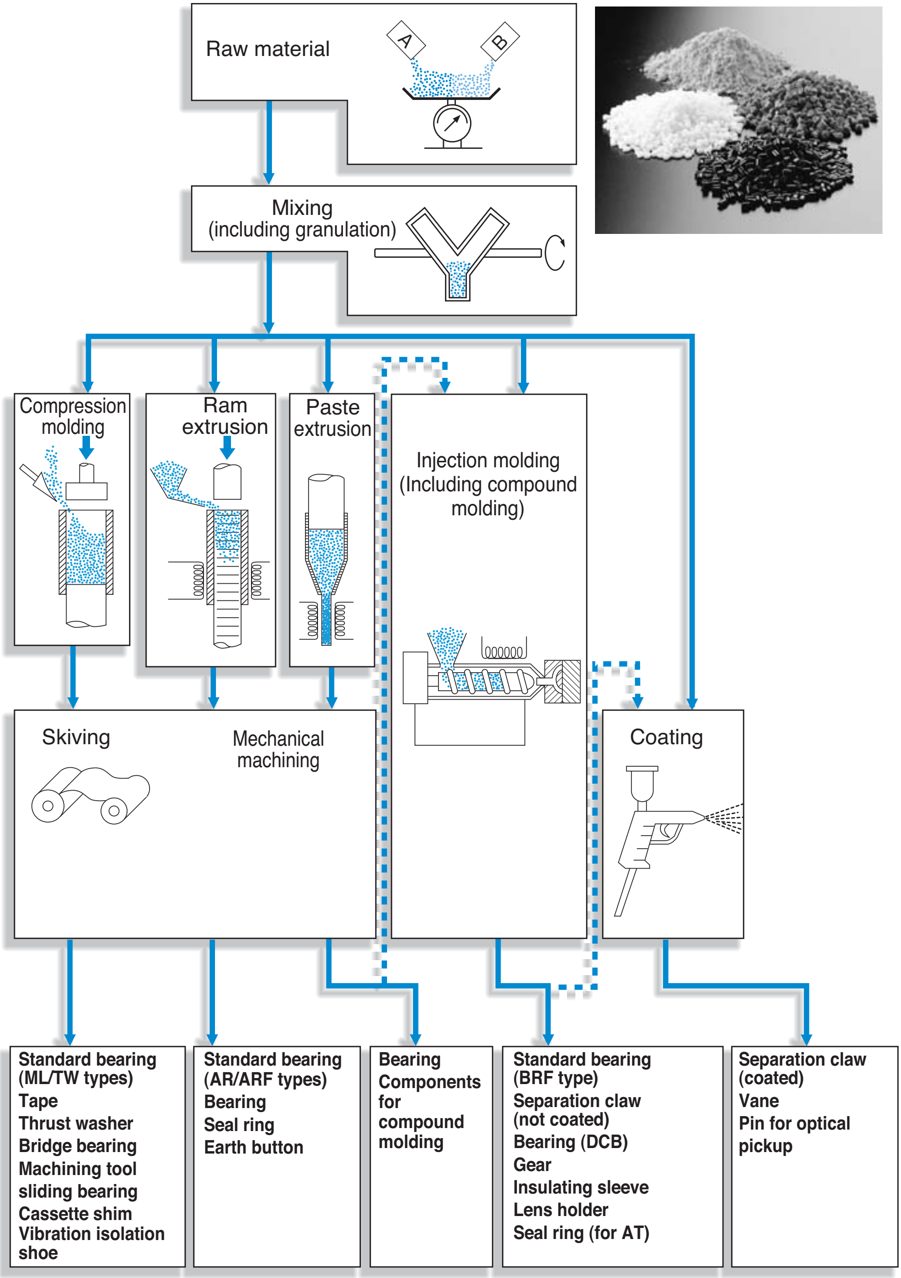
Table 2.3 Material for injection molding (2)

Material name	Base resin	Features		Applications
BEAREE AS5704	PPS		• Excellent wear resistance in water • Excellent chemical resistance	• Bearing used in water • Bearing used in chemical solution
BEAREE AS5912	PPS		• High modulus of elasticity	• Lens holder
BEAREE PK5900	PEEK		• Excellent wear resistance • Excellent impact resistance • Excellent wear resistance in oil and water	• Sliding bearing • Bearing used in oil • Bearing used in water
BEAREE PK5301	PEEK		• Excellent wear resistance, low friction property, chemical resistance and heat resistance • Excellent leak characteristics • Excellent friction property in water and excellent wear property	• Seal ring
BEAREE DM5030	POM		• Excellent wear resistance and a long-term stable low friction coefficient • Suitable for aluminum and copper materials	• Sliding bearing • Gear • Roller

Table 2.4 Coating material

Material name	Features		Applications
BEAREE FL7075		• Excellent friction and wear properties • Strong coating is possible	• Washer • Valve plate • Roller
BEAREE FE7010		• Thick and strong coating is possible	• Root pump rotor
BEAREE FE7030 **BEAREE FE7031**		• Excellent non-viscosity • Strong coating is possible	• Separation claw • Slide guide
BEAREE FE7092		• Excellent non-viscosity	• Separation claw
BEAREE FL7067		• Excellent friction property under high surface pressure and excellent wear property	• Sliding material for compressor • Hydraulic jack plate

3. Manufacturing process of key BEAREE products



One point advice
Brief knowledge about engineering plastics

Injection molding

●Principle of injection molding

The principle of injection molding is as follows: The material supplied to the hopper is sent to the front of the cylinder along with the rotation of the screw. Here, the material is softened while being heated by the heater and becomes fluid (plasticized state).

When the plasticized material in the cylinder is pushed out by the screw, the material is injected from the tip of the cylinder into the closed mold. When the material in the mold is cooled and solidified, the molded article is taken out by opening the mold. (**Fig. 1** shows the principle of screw type injection molding.)

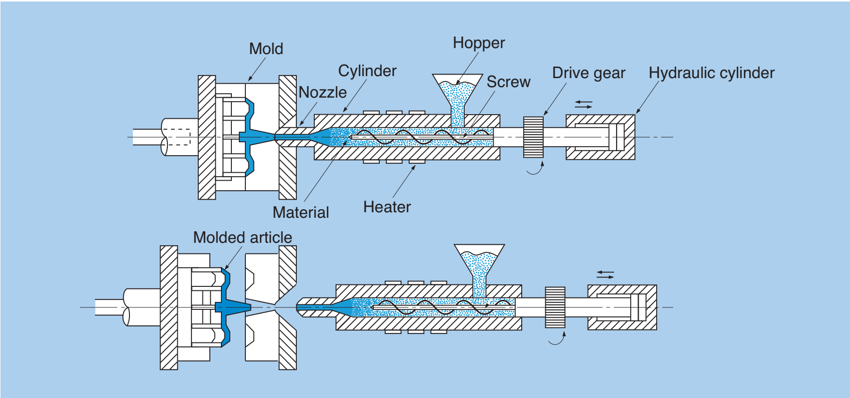


Fig. 1 Principle of screw type injection molding

●Mold of injection molding

Fig. 2 shows the structure of the typical mold for injection molding.

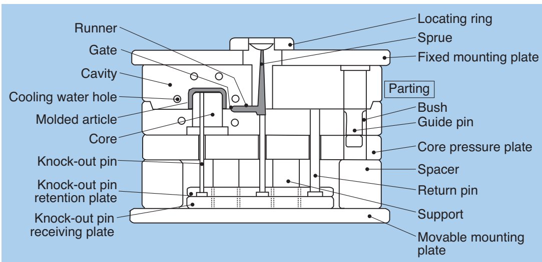


Fig. 2 Mold of injection molding

●Type of gate for injection molding

Figs. 3 to **5** indicate the types of standard gates.

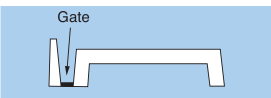


Fig. 3 Side gate

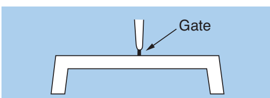


Fig. 4 Pin-point gate

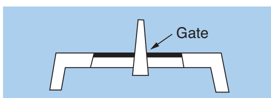


Fig. 5 Disk gate

4. Design of BEAREE resin bearings

4.1 Procedure of bearing selection

There are many types, models and dimensions for sliding bearings. It is important to select the most appropriate bearings for achieving the expected functions of the machines and devices.

While there are various selection procedures, the following figure shows the typical procedure.

Steps	Checkpoints
Verification of environmental conditions	● Function and structure of machines and devices ● Application area of bearings ● Mating material ● Bearing load (magnitude/direction) ● Sliding velocity ● Operating temperature (ambient temperature/increase in temperature) ● Atmosphere ● Flame retardancy
↓ Selection of bearing material	● Mating material ● Bearing load (magnitude/direction) ● Sliding velocity ● Operating temperature (ambient temperature/increase in temperature) ● Atmosphere ● Permissible surface pressure ● Estimate of wear amount
↓ Selection of bearing formats	● Function and structure of machines and devices ● Application area of bearings ● Permissible space for bearings ● Bearing load (magnitude/direction) ● Installation/removal
↓ Selection of bearing dimensions	● Design life of machines and devices ● Bearing load (magnitude/direction) ● Sliding velocity ● Operating temperature (ambient temperature/increase in temperature) ● Estimate of wear amoun ● Safety index ● Permissible space ● Fitting ● Bearing clearance
↓ Verification of handling methods	● Installation related dimension ● Assembly/disassembly procedure

4.2 Checkpoints of engineering plastic product operating conditions

Item	Verification content
1. Operating machine	
2. Application area	
3. Ambient temperature	Min. °C to max. °C
4. Ambient humidity	%
5. Ambient environment	Atmosphere, in water, in sea water, in oil
6. Type of load	Dynamic/static/impact/repetitive/other ( )
7. Load behavior	Rotating/swinging/reciprocating/other ( )
8. Operating time (lifetime)	h/d cycle/min (desirable life:)
9. Revolution speed	r/min
10. Speed	m/min
11. Load	Radial N {kgf} , Axial N {kgf}
12. Pressure (seal ring)	MPa {kgf/cm^2}
13. Lubrication	No, Yes ( )
14. Shaft (piston)	Dimension :
	Material :
	Hardness :
	Roughness :
15. Housing (cylinder)	Dimension :
	Material :
	Hardness :
	Roughness :

4.3 Design of bearings

For designing **NTN** Engineering Plastics sliding bearings, it is necessary to clearly understand various conditions such as operating temperature, load, sliding velocity, PV value, mating material, torque, accuracy, environment, behavior pattern and expected life.

4.3.1 Selection of bearing material (PV value)

When selecting bearing material, it is necessary to consider the permissible surface pressure and sliding velocity of bearing material, as well as to review operating temperature, mating material, lubricating conditions, etc.

PV value is a product of the surface pressure P and sliding velocity V, and is widely used to determine the possible operating range of bearing materials. However, because the surface pressure and sliding velocity also have permissible values, the operating range is determined as shown in **Fig. 4.1**.

4.3.2 Estimate of wear amount

The life of sliding bearings is determined by the wear of the sliding surface which prohibits use of the bearings.

The wear amount of sliding bearings depends on various operating conditions such as sliding velocity, surface pressure, operating patterns, lubricating conditions, surface roughness of the mating material and ambient temperature. In general, a guideline of wear amount is obtained from the following equation:

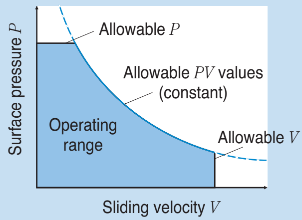
$$R = K \cdot P \cdot V \cdot T$$

Where,

R: Wear amount (mm)
K: Specific wear rate (mm^3/N·m)
P: Surface pressure MPa (N/mm^2)
V: Sliding velocity (m/min)
T: Time (min)

The wear of sliding bearings is affected by surface roughness of the mating material. Therefore, it needs to be finished at around 0.1 to 0.8 Ra.

In addition, the wear amount can be reduced by the hardness of the shaft, therefore, it is recommended to use HRC22 or better.



$PV \leqq$ Allowable PV values
$P \leqq$ Allowable surface pressure
$PV \leqq$ Allowable sliding velocity V
Equation of surface pressure P and sliding velocity V

$P = Fr/d \leqq \cdot l$
$V = \pi \cdot d \cdot n \times 10^{-3}$

P : Operating surface pressure MPa
Fr : Radial load N
d : Shaft diameter mm
l : Bearing width mm
V : Sliding velocity m/min
n : Shaft rotation speed rpm

Fig. 4.1 Allowable PV values

4.3.3 Housing fit and bearing clearance

Sliding bearings are usually used press fit into housing.

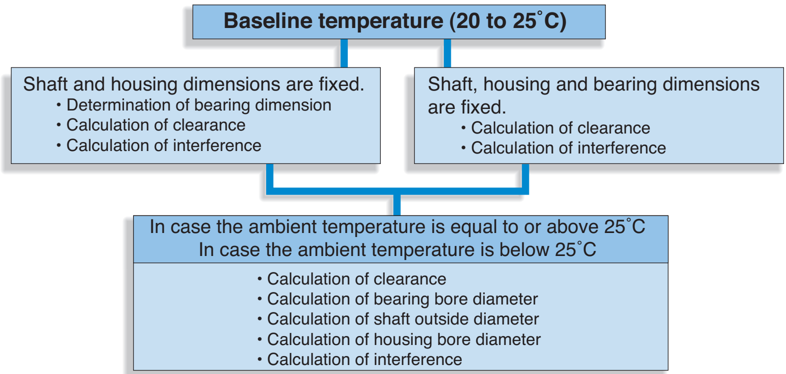
The recommended mounted clearance of bearings depends on the shaft diameter. The required minimum clearance is 2 to 7/1000 of the shaft diameter. When the operating temperature significantly varies, the clearance becomes smaller as the bearings expand. Therefore, the mounting clearance must be larger for that amount.

When bearing accuracy needs to be increased by reducing the clearance, the bore diameter can be worked by a lathe or reamer after the bearings are installed into the housing.

For standard sliding bearings, the bearing dimension table lists the recommended dimensions of the shafts and housings and mounting clearance after fitting. For housings of soft material or thinned-wall housings, the mounting clearance must be larger than the clearance listed in the dimension table. In addition, when they are used in low temperature, the press interference fit may become loose, therefore, bearings need to be locked by using a knock pin or key, or using adhesives.

● Calculation of clearance between the shaft and the bearing (excluding M liner bearings and MLE bearings)

The calculation procedures of the clearance between the shaft and the bearing are different for “baseline temperature”, “equal to or above 25˚C” and “equal to or below 20˚C”. **Fig. 4.2** shows the respective calculation procedures.



Remark: In general, the procedure for baseline temperature can be used for ambient temperature of 15 to 50˚C.

Fig. 4.2 Calculation procedure of clearance of the BEAREE sliding bearings

1. Calculation of clearance for baseline temperature (25˚C)

1) Interference

Max. : $F_H = D_H - H_L$

Min. : $F_L = D_L - H_H$

2) Bearing bore diameter reduction by interference

Max. : $E_{max} = \lambda \cdot F_H \ (\lambda = 1.0)$

Min. : $E_{min} = \lambda \cdot F_L \ (\lambda = 1.0)$

3) Bearing bore diameter dimension for installation at 25˚C

Max. : $d_{25H} = d_H - E_{min}$

Min. : $d_{25L} = d_L - E_{max}$

4) Mounted clearance for installation at 25˚C

Max. : $C_{max} = d_{25H} - S_L$

Min. : $C_{min} = d_{25L} - S_H$

Where,

S_H : Maximum dimension of shaft outside diameter
S_L : Minimum dimension of shaft outside diameter
H_H : Maximum dimension of housing bore diameter
H_L : Minimum dimension of housing bore diameter
d_H : Maximum dimension of bearing bore diameter
d_L : Minimum dimension of bearing bore diameter
D_H : Maximum dimension of bearing outside diameter
D_L : Minimum dimension of bearing outside diameter

Remarks

1. In general, the minimum clearance of sliding bearing of around 2 to 7/1000 of the shaft diameter is required, when used dry, to reduce the impact of heat.
2. Shrinking percentage due to interference should be usually 100%.

BEAREE FL3000 AR type sleeve bearing

Calculation for R-AR1010 is used.

Use the recommended values in the catalog for shaft and housing dimensions.

Shaft dimension:

$S_H = 10$, $S_L = 9.991$ from 10h6 $\left(^{0}_{-0.009}\right)$

Housing dimension:

$H_H = 14$, $H_L = 13.982$ from 14M7 $\left(^{0}_{-0.018}\right)$

Bearing bore diameter dimension:

$d_H = 10.24$, $d_L = 10.19$ from 10 $\left(^{+0.24}_{+0.19}\right)$

Bearing outside diameter dimension:

$D_H = 14.10$, $D_L = 14.05$ from 14 $\left(^{+0.10}_{+0.05}\right)$

Maximum interference:

$F_H = D_H - H_L = 14.10 - 13.982 = 0.118$

Minimum interference:

$F_L = D_L - H_H = 14.05 - 14.00 = 0.05$

Reduction of bearing bore diameter:

$E_{max} = F_H \times \lambda = 0.118 \times 1 = 0.118$

$E_{min} = F_L \times \lambda = 0.05 \times 1 = 0.05$

Bearing bore diameter dimension for installation at 25˚C:

$d_{25H} = d_H - E_{min} = 10.24 - 0.05 = 10.19$

$d_{25L} = d_L - E_{max} = 10.19 - 0.118 = 10.072$

Mounted clearance for installation at 25˚C:

$C_{max} = d_{25H} - S_L = 10.19 - 9.991 = 0.199 \fallingdotseq 0.20$

$C_{min} = d_{25L} - S_H = 10.072 - 10 = 0.072 \fallingdotseq 0.07$

4.2 Calculation of clearance for high temperature (T_H˚C) operation

1) Housing bore diameter dimensions

Max. : $HH_H = H_H \{1 + \alpha_1 (T_H - 25)\}$

Min. : $HH_L = H_L \{1 + \alpha_1 (T_H - 25)\}$

2) Shaft outside diameter dimensions

Max. : $SH_H = S_H \{1 + \alpha_2 (T_H - 25)\}$

Min. : $SH_L = S_L \{1 + \alpha_2 (T_H - 25)\}$

3) Mounted clearance

Max. :

$$CH_{max} = \sqrt{(H_H)^2 \{1+\alpha_1 (T_H-25)\}^2 - \{(H_H)^2 - (d_{25H})^2\} \{1+\alpha_3 (T_H-25)\}^2} - S_L \{1+\alpha_2 (T_H-25)\}$$

Min. :

$$CH_{min} = \sqrt{(H_L)^2 \{1+\alpha_1 (T_H-25)\}^2 - \{(H_L)^2 - (d_{25L})^2\} \{1+\alpha_3 (T_H-25)\}^2} - S_H \{1+\alpha_2 (T_H-25)\}$$

Where,

α_1 : Linear expansion coefficient of housing material at T_H˚C

α_2 : Linear expansion coefficient of shaft material at T_H˚C

α_3 : Linear expansion coefficient of bearing material at T_H˚C

4.3 Calculation of clearance for low temperature (T_L°C) operation

1) Housing bore diameter dimensions

Max. : $HL_H = H_H \{1 + \alpha_{11} (T_L - 25)\}$

Min. : $HL_L = H_L \{1 + \alpha_{11} (T_L - 25)\}$

2) Shaft outside diameter dimensions

Max. : $SL_H = S_H \{1 + \alpha_{22} (T_L - 25)\}$

Min. : $SL_L = S_L \{1 + \alpha_{22} (T_L - 25)\}$

Reduction of bearing bore diameter:

Max. :

$$CL_{max} = \sqrt{(H_H)^2 \{1+\alpha_{11} (T_L-25)\}^2 - \{(H_H)^2 - (d_{25H})^2\} \{1+\alpha_{33} (T_L-25)\}^2} - S_L \{1+\alpha_{22} (T_L-25)\}$$

Min. :

$$CL_{min} = \sqrt{(H_L)^2 \{1+\alpha_{11} (T_L-25)\}^2 - \{(H_L)^2 - (d_{25L})^2\} \{1+\alpha_{33} (T_L-25)\}^2} - S_H \{1+\alpha_{22} (T_L-25)\}$$

Where,

α_{11} : Linear expansion coefficient of housing material at T_L˚C

α_{22} : Linear expansion coefficient of shaft material at T_L˚C

α_{33} : Linear expansion coefficient of bearing material at T_L˚C

4.3 Assembling method of bearings

Avoid hammering the bearing when pressing it into the housing.

Use a press arbor as depicted in **Fig. 4.3**, provide a guiding surface large enough for the opening of the housing, then by aligning the bearing and the housing bore diameter, push it down with a press. In addition, when they are used in low temperature, the press interference fit may become loose, therefore, bearings needs to be locked by using a knock pin or key, or using adhesives.

Remark: When installing large resin bearing, the bearing can be cooled down with dry ice for easy fitting.

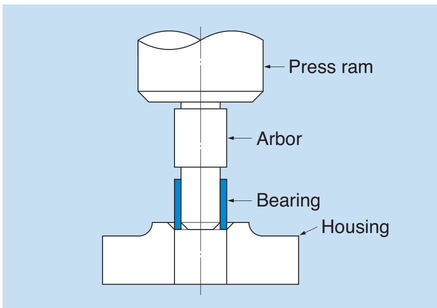


Fig. 4.3 Assembling method

5. BEAREE resin technical data

5.1 Wear properties

Table 5.1 Specific wear rate of BEAREE resin materials

Material name	Test condition						Specific wear rate $\times10^{-7}mm^3/N\cdot m$
	Test type	Mating material	Surface pressure MPa	Sliding velocity m/min	Lubrication	Ambient temperature m/min	
BEAREE FL3000	Thrust	SUJ2	0.2	128.0	No	Room temperature	1.0
BEAREE FL3030	Thrust	SUS304	1.95	32.0	No	Room temperature	1.6
BEAREE PI5001	Thrust	SUJ2	1.95	128.0	No	Room temperature	6.23
	Thrust	SUJ2	0.2	128.0	No	Room temperature	1.0
BEAREE PI5014	Radial	AS5052	0.3	9	No	250	9.5
BEAREE AS5056	Radial	Nickel plating (base SUM)	3	4.6	No	150	53
BEAREE PK5900	Thrust	SUS304	0.5	100.0	Yes	Room temperature	6.2
BEAREE DM5030	Thrust	SUJ2	0.3	32.0	No	Room temperature	1.5
	Thrust	A5056	0.3	32.0	No	Room temperature	5.0
BEAREE ER3000	Thrust	SUJ2	0.2	128.0	No	Room temperature	3.3
	Thrust	A2017	0.2	128.0	No	Room temperature	2.9
BEAREE FL7075	Thrust	SUS304	0.5	32.0	No	Room temperature	10.0
BEAREE FL7067	Thrust	ADC12	—	60	Oil	Room temperature	49

5.2 Friction properties

Table 5.2 Friction coefficient of BEAREE resin materials

Material name	Test condition						Specific wear rate $\times 10^{-7}mm^3/N \cdot m$
	Test type	Mating material	Surface pressure MPa	Sliding velocity m/min	Lubrication	Ambient temperature m/min	
BEAREE FL3000	Thrust	SUJ2	1.0	10.0	No	Room temperature	0.13
BEAREE FL3030	Thrust	SUS304	1.95	32.0	No	Room temperature	0.18
BEAREE PI5001	Thrust	SUJ2	1.0	10.0	No	Room temperature	0.3
	Thrust	SUJ2	0.5	128.0	No	Room temperature	0.1
BEAREE PI5014	Radial	AS5052	0.3	9	No	250	0.07
BEAREE AS5056	Radial	Nickel plating (base SUM)	3	4.6	No	150	0.07
BEAREE PK5900	Thrust	SUS304	1.0	10.0	Yes	Room temperature	0.28
BEAREE DM5030	Thrust	SUJ2	1.0	10.0	No	Room temperature	0.21
	Thrust	A5056	1.0	10.0	No	Room temperature	0.13
BEAREE ER3000	Thrust	SUJ2	0.3	1.0	No	Room temperature	0.28
	Thrust	SUS304	0.3	1.0	No	Room temperature	0.22
BEAREE FL7075	Thrust	A5056	0.2	2.4	No	Room temperature	0.13
BEAREE FL7067	Thrust	ADC12	—	60	Oil	Room temperature	0.03

5.3 Chemical characteristics

Table 5.3 Chemical characteristics of BEAREE resin materials

	Name of chemical	BEAREE FL	BEAREE FE	BEAREE PI	BEAREE AI	BEAREE UH	BEAREE AS	BEAREE LC	BEAREE PK	BEAREE NY	BEAREE DM	BEAREE ER3000 series
Acid	Strong sulfuric acid	◎	◎	×		○	○	◎	×	×	×	○
	15% acetic acid	◎	◎	△	◎	○	◎	◎	◎	×	×	×
	75% acetic acid	◎	◎	△	◎	×	◎	◎	◎	×	×	×
	Hydrochloric acid	△	△	◎	○	◎	◎	◎	◎	×	×	◎
	15% nitric acid	◎	◎	○		○	○	◎	◎	×	×	○
	70% nitric acid	◎	◎	△	×	×	×	◎	△	×	×	○
	Formic acid	◎	◎	△	×	◎	◎	◎	×	×	×	×
	85% phosphoric acid	◎	◎	△	◎	×	◎	◎	◎	×	×	○
	40% chromic acid	◎	◎			×	○	◎	○	×	×	○
	100% lactic acid	◎	◎	△	◎	◎	◎	◎	◎	×		◎
	Hydrogen peroxide	◎	◎			○	○	○	◎	×	○	◎
Alkali	30% ammonia water	◎	◎	△	○	◎	○	×	○	×	○	◎
	Ferric chloride	◎	◎	△	◎	◎	◎	◎		◎	○	◎
	Calcium chloride	◎	◎	◎	◎	◎	◎	◎	◎	○	○	◎
	Hydrosulfate	◎	◎	◎	◎	◎	◎	◎	◎	△	○	△
	Calcium hydroxide	◎	◎	◎	◎	◎	◎	×	◎	○	○	○
	Mineral water	◎	◎	◎	◎	◎	◎	◎	◎	○	○	◎
Solvent	Methyl alcohol	◎	◎	◎	◎	○	◎	◎	○	×	○	○
	Acetone	◎	◎	○	◎	×	◎	◎	◎	◎	○	×
	Benzene	◎	◎	○	◎	×	◎	◎	◎	◎	○	○
	Carbon tetrachloride	◎	◎	×	◎	×	◎	◎	◎	◎	○	○
	Ethyl ether	◎	◎	◎	◎	×	◎	◎	◎	◎	○	×
	Ethylene glycol	◎	◎	△	◎	◎	◎	◎	○	◎	○	◎
Oil	Diesel engine oil	◎	◎	◎	◎		◎	◎	◎	◎	○	○
	Lubricating oil	◎	◎	◎	◎	×	◎	◎	◎	◎	○	◎
	Animal oil, vegetal oil	◎	◎	◎	◎	◎	◎	◎	◎	◎	○	◎
	Kerosene (lamp oil)	◎	◎	◎	◎	◎	◎	◎	◎	◎	○	◎
	Naphtha	◎	◎	○	◎	×	◎	◎	○	◎	△	◎
Other	Nitrate ester	◎	◎	△	◎		○	○	◎	◎	○	×
	Hydrocarbon fuel	◎	◎	◎	◎	○	◎	◎	◎	◎	○	◎
	Fluorine gas	×	×	△	◎		×*	△	×	×		△
	Molten metallic sodium	×	×	×			×		×			
	Fluorocarbon 134a	◎	◎	◎	◎		◎	◎	◎	◎	○	×
	Liquid oxygen	◎	◎	○	◎	◎	◎	◎	○	◎		○
	Carbon dioxide	◎	◎	◎	◎	◎	◎	◎	◎	◎	○	○
	Nitrogen dioxide	◎	◎	△	◎	◎	◎	◎				◎

Code description: ◎ : Excellent, ○ : Good, △ : Fair, × : nappropriate, * : High temperature/high pressure
Remark: This table is only a guideline. The characteristics may vary depending on the grades.

5.4 Typical characteristics

Table 5.4 Material for mechanical processing

Material name	Specific gravity	Compression creep %	Hardness ❶	Tensile strength MPa	Elongation %	Bend strength MPa	Flexural modulus MPa	Water absorption rate %	Linear expansion coefficient ❷ $\times10^{-5}$/°C	Operating temperature limit ˚C
BEAREE FL3000	2.28	8.1	66	15	200	—	—	0.03	8.3	260
BEAREE FL3020	2.23	7.0	64	22	250	—	—	0.03	—	260
BEAREE FL3030	1.98	5.0	62	12	170	—	—	0.09	9.0	260
BEAREE FL3040	2.19	6.0	63	14	170	—	—	0.02	8.5	260
BEAREE FL3060 ❸	3.80	3.2	70	10	100	—	—	0.09	6.8	260
BEAREE FL3071	2.09	7.8	68	17	230	—	—	—	6.1	260
BEAREE FL3082	2.15	2.5	66	18	254	—	—	—	11.5	260
BEAREE FL3307	3.39	4.0	67	17	160	—	—	—	9.9	260
BEAREE FL3642	2.02	8.4	64	20	230	—	—	0.02	7.0	260
BEAREE FL3700	2.10	3.0	70	16	130	—	—	0.07	7.2	260
BEAREE FL3900	2.07	1.4	70	14	30	—	—	—	8.7	260
BEAREE UH3000	0.94	11.0	65	20	200	20	610	0.01	20.0	80
BEAREE UH3954	0.94	10.0	65	40	200	—	—	0.01	17.0	80
BEAREE FL9000 ❹	4.25	—	—	46	15	—	—	—	1.9	260
BEAREE ER3000	1.78	—	Hs70,80,90	10	290	—	—	0.05	10.0	230
BEAREE ER3201	1.30	—	Hs70	15	500	—	—	—	—	—

❶ Hardness: No mark indicates durometer, Hs indicates rubber hardness and the rest indicates Rockwell scale
❷ Linear expansion coefficient: average linear expansion coefficient in the range of room temperature to 150˚C.
❸ BEAREE FL3060 is the ML dedicated material.
❹ BEAREE FL9000 is the tape dedicated material.

Remark: These values indicate the typical test results.

Table 5.5 Material for injection molding (1)

Material name	Specific gravity	Compression creep %	❶ Hardness	Tensile strength MPa	Elongation %	Bend strength MPa	Flexural modulus MPa	Water absorption rate %	Linear ❷ expansion coefficient ×10⁻⁵/°C	Operating temperature limit °C
BEAREE PI5001	1.49	—	M94	67	1.3	108	8 500	0.10	2.2	240
BEAREE PI5010	1.46	<0.2	M70	76	7	116	3 700	0.25	4.5	240
BEAREE PI5014	1.52	—	R107	56.2	1.6	82.4	3 540	0.12	6.0	240
BEAREE PI5022	1.80	—	M107	138	1	190	14 100	0.3	3.4	240(300) ❸
BEAREE PI5033	1.63	—	M97	118	1.3	216	11 300	0.3	4.9	240
BEAREE PI5040	1.43	<0.2	M99	230	2	360	21 000	0.25	0.4	240
BEAREE AI5003	1.40	<0.2	E91	190	12	220	4 700	0.28	4.0	250
BEAREE UH5000	0.94	11.0	R60	41	10	41	1 600	0.01	17.0	80
BEAREE AS5000	1.53	0.3	80	51	3	61	—	0.05	8.1	230
BEAREE AS5005	1.55	0.3	81	51	3	61	—	0.03	7.0	230
BEAREE AS5056	1.58	—	R102	58	4	96	4 700	—	8.7	230
BEAREE AS5965	1.62	—	R112	43	2.9	67	5 300	—	7.3	230
BEAREE AS5040	1.66	—	R120	177	1.7	235	—	0.01	1.8	230
BEAREE AS5302	1.44	—	M88	65	1.6	119	4 730	—	6.1	230

❶ Hardness: No mark indicates durometer, Hs indicates rubber hardness and the rest indicates Rockwell scale
❷ Linear expansion coefficient: average linear expansion coefficient in the range of room temperature to 150°C.
❸ Within operating temperature limit ( ): crystalline treated material.
Remark: These values indicate the typical test results.

5

Table 5.5 Material for injection molding (2)

Material name	Specific gravity	Compre-ssion creep %	❶ Hardness	Tensile strength MPa	Elongation %	Bend strength MPa	Flexural modulus MPa	Water absorption rate %	Linear ❷ expansion coefficient $\times 10^{-5}$/°C	Operating temperature limit °C
BEAREE AS5704	1.64	—	R112	54	0.7	103	10 000	0.04	4.5	230
BEAREE AS5912	1.57	—	—	137	1	167	26 500	—	1.2	230
BEAREE PK5900	1.39	—	R118	126	2	207	7 400	—	4.4	250
BEAREE PK5301	1.43	—	R117	82	3.5	153	7 800	—	6.2	250
BEAREE DM5030	1.42	—	—	50	35	80	2 650	—	—	100

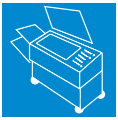
❶ Hardness: No mark indicates durometer, Hs indicates rubber hardness and the rest indicates Rockwell scale
❷ Linear expansion coefficient: average linear expansion coefficient in the range of room temperature to 150°C.
Remark: These values indicate the typical test results.

Table 5.6 Coating material

Material name	Film thickness μm	Adhesion strength				Continuous operating temperature °C	Baking temperature °C	Coating method	
		Crosscut test	Pencil hardness		Drawing test			Spray coating	Powder coating
			Dented	Broken					
BEAREE FL7075	10～30	100/100	H	3H	5	180	230	○	
BEAREE FE7010	500～1 000	100/100	6H	—	5	180	315		○
BEAREE FE7030 **BEAREE FE7031**	10～20	100/100	3H	5H	5	180	230	○	
BEAREE FE7092	10～20	100/100	B	H	4	330	370	○	
BEAREE FL7067	10～30	100/100	H	—	5	220	230	○	

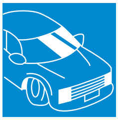
Remark: These values indicate the typical test results.

6. Applications of BEAREE products



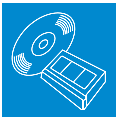
Office/information equipment

Resin materials in precision components such as bearings and gears contribute to improvement of reliability, quietness, lightweight and compactness of OA equipment.



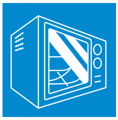
Automotive/electric equipment

Superior materials selected depending on applications such as seal materials that have advantages over aluminum contribute to vehicle performance and CAFE compliance.



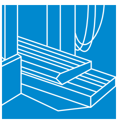
AV equipment

Resin products of high precision in micron (1/1000) order and excellent sliding properties satisfy all the functions required for AV equipment.



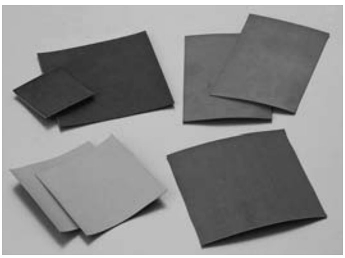
Home/electric appliances

Air conditioning, microwave ovens, refrigerators, etc. provide unique performance under tough conditions, in hidden places, lightly, quietly and cleanly.



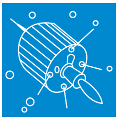
Machining tools

The materials used in sliding areas of machining tables have unparalleled high speed sliding performance. The evolution of material technology will further advance these characteristics.



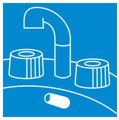
Civil/construction

Sliding materials of Engineering Plastics are used to withstand earthquakes and typhoons and to absorb the impact of thermal expansion.



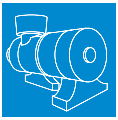
Aerospace equipment

The materials are used in aerospace equipment where high reliability is required. The characteristics in vacuum and ultra low temperature (-235°C) are proven for applications in space and liquid fuels.



Equipment for water section

Engineering Plastics products are used in familiar places such as faucets, showers and water purifiers. They support our comfortable lives.

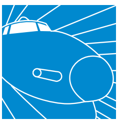


Chemical equipment

Engineering plastics with the highest chemical resistance among all resins play an important role in bearings and seals in chemical equipment.

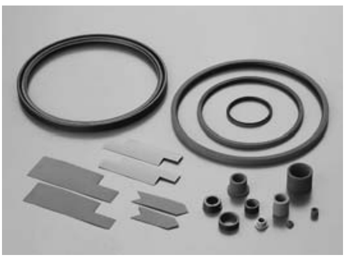
Food processing equipment / vending machines

For food processing equipment, sanitary safety with rustless materials is of utmost importance. Engineering Plastics products with materials approved by food related standards are used. They are used in vending machines which require no maintenance with their advantages in reliability.



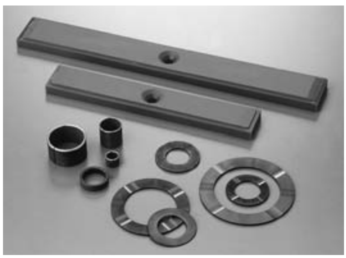
Transportation system

Key areas of transportation system such as the seals for axle shafts of Shinkansen trains, automatic wicket and ticket machines are supported by the sliding performance of Engineering Plastics products.



Construction machinery

Resin products can maintain the functions even under tough conditions. They have demonstrated results in rotational and sliding parts of civil/construction machinery.



7. Introduction of products by applications

7.1 Sliding material for food processing equipment

No materials have fully satisfied the functional requirements as sliding material for food processing equipment.

For example, ultrahigh molecular weight polyethylene has a limited allowable temperature range and unfilled fluoro resin has poor wear resistance.

Also, carbon based materials have a high friction coefficient and unfavorable color.

Fluoro resin series “BEAREE FL3642” developed by **NTN** is an epoch-making material that has overcome these issues.

■ Approved by the Synthetic Resin Equipment and Container Packaging Standard Test (Japan Food Research Laboratory)

Photo 7.1 BEAREE FL3642 product

<Features>

1. Low friction coefficient without lubrication.
2. Excellent wear resistance.
3. High allowable *PV* value.
4. Unlikely stick-slip because of an extremely low friction coefficient at the start and very low speed operation.
5. Good compatibility with mild steel and stainless steel.
6. Clean-looking light yellow.
7. Insusceptible to acid, alkali and solvent.

<Applications>

- Food processing equipment
- Drug manufacturing equipment
- Vending machines for food and drink

◆Test condition: Thrust tester
Surface pressure: 0.98MPa
Circumferential velocity: 32 m/min
Mating material: SUS304
Lubrication: Dry, water
Time: 50 h

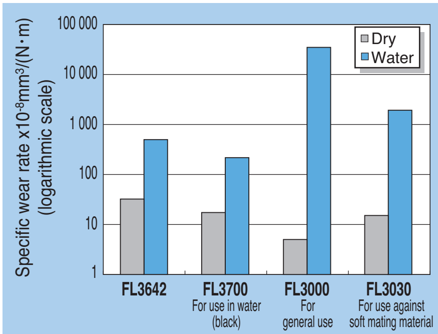


Fig 7.1 Comparison of specific wear rate of FL3642 and our other materials

In addition to BEAREE FL3642, other materials approved by the standard test are also available.

Select the materials based on the applications.

Table 7.1 Typical materials approved by the Synthetic resin equipment and container packaging standard test

Material name	Color	Applications
BEAREE FL3040	Black	For use against soft mating materials
BEAREE FL3700	Black	For use in water
BEAREE UH3000	White	For excellent friction and wear resistance with low *PV* value
BEAREE AS5000	Light brown	For injection molding/volume production

Photo 7.2 Products for food processing equipment

7.2 Sliding material for use in water (chemicals)

Materials with excellent properties in atmosphere (dry) may exhibit disadvantages such as fast wear and/or damage to the mating materials when used in water/chemical. We have materials to solve these problems appropriate to various conditions.

<Applications>

- Bearings for use in water (sea water)
- Bearings for chemical pumps
- Vanes, rotors, casings for vane pumps
- Bearings for sewage treatment equipment

Table 7.2 Allowable surface pressure and machining methods

Material name	Base resin	Allowable surface pressure P MPa	Machining method
BEAREE FL3700	PTFE	3	Mechanical machining
BEAREE AS5704	PPS	5	Injection molding

Photo 7.3 Products for use in water (chemical)

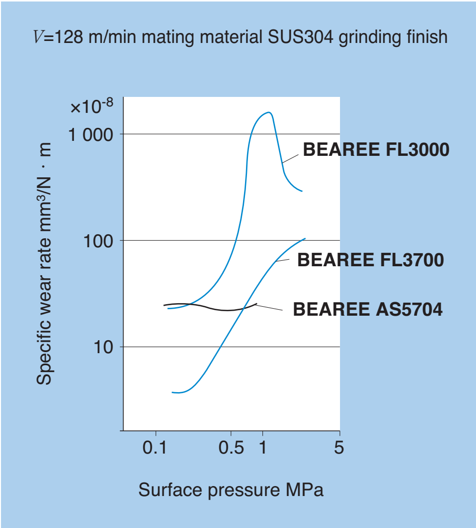


Fig 7.2 Thrust in-water wear test

7.3 Conductive (antistatic) sliding material

It has conductivity in addition to excellent friction/wear properties. It is possible to eliminate the need for grounding by using it as the bearing material at the locations where an antistatic property is required.

Compared to the conventional carbon-based brush materials, it is less likely to crack or chip and is quiet in sliding motion.

<Applications>

- Sliding components and grounding materials for computer-related equipment.
- Bearings and gears for copiers, printers, facsimile equipment.

Photo 7.4 Conductive bearings and gears

Table 7.3 Volume resistivity and main applications

Material name	Volume resistivity Ω•cm	Main applications
BEAREE 3900	10	Ground button for disk drive
BEAREE PI5040	1×10^5	Gear
BEAREE AS5965	1×10^3	Bearing
BEAREE AS5963	3.3×10^3	Insulating sleeve
BEAREE NY5910	10	Gear

Photo 7.5 Ground buttons for disk drive

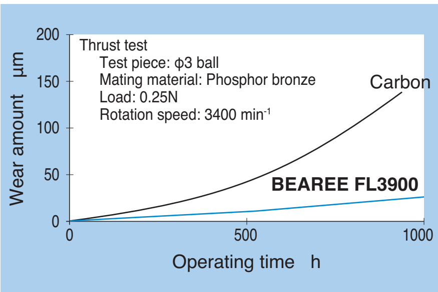


Fig 7.3 Comparison of wear between BEAREE FL3900 and carbon

7.4 Sliding material for high surface pressure

In general, resin materials have a lower allowable surface pressure compared with metallic materials, however, they can be used under high surface pressure by adhering them to back metal, adding reinforcing material, selecting high allowable surface pressure materials, etc.

1. BEAREE PI5001

BEAREE PI5001, which uses polyimide series resin, can be used up to the allowable surface pressure of 50 MPa.

Table 7.4 Allowable surface pressure and machining methods

Material name	Allowable surface pressure MPa	Machining method
BEAREE PI5001	50	Injection molding

<Applications>

- Oilless pillow block, anchor bearing for buoy, transmission thrust bearing

2. BEAREE FL9000

It can be used for high surface pressure up to 100 MPa and low speed applications. This material has a structure to prevent creep of resin from bronze wire fabric. Therefore, it can be used under high surface pressure.

Fig. 7.4 shows the cross section of this structure. Its thin structure of 0.5 mm allows for a compact design. It is recommended to adhere it to solid backing material such as metal when used under surface pressure of 40 MPa or more.

Table 7.5 Allowable surface pressure and structure

Material name	Allowable surface pressure MPa	Structure
BEAREE FL9000	100	PTFE with metallic wire fabric

<Applications>

- Oilless ball sliding bearing, king pin bearing, crane, shock absorber, door hinge

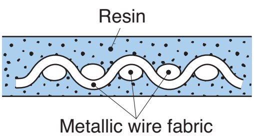


Fig 7.4 Structure of FL9000

Photo 7.6 High surface pressure bearings

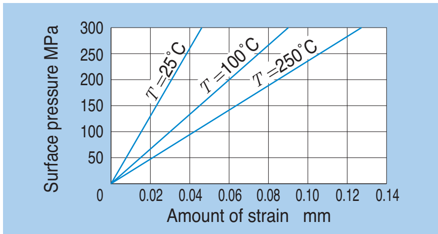


Fig 7.5 Strain due to load (surface pressure) (compression strain)

(Note) The strain is measured by applying the load for 60 minutes on BEAREE FL9000 placed between two steel plates. When BEAREE FL9000 is adhered to the base material, it is further reduced.

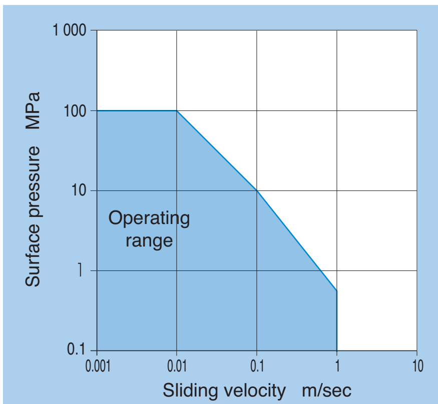


Fig 7.6 Allowable *PV* values of BEAREE FL9000

7.5 Material for resin gears

Resin gears show excellent qualities in being lightweight, no lubrication, low noise, corrosion resistance and volume production, which enable them to be used in broad applications. **NTN** provides a wide range of Engineering Plastics materials for gears from super engineering plastics to general-purpose engineering plastics for various applications, from which the users can select the most appropriate materials.

<Features>

1. High strength and long life.
2. Excellent sliding performance.
3. Excellent heat resistance.

■ Typical shape

Type: Spur gear, helical gear
Module: 0.8 – 1.5
Pitch circle diameter: 15 – 60 mm

A With locking mechanism (D-shape hole)
B With locking mechanism (key))
C Idle gear (gear itself slides)
D Idle gear (compound type with the shaft side made of sliding material)
E Two-stage gear
F Two-stage gear

Photo 7.7 Gear products

Table 7.6 Gear materials and their features

Material name	Base resin	Performance assessment: Heat resistance	Sliding performance	Strength	Conductivity	Main applications
BEAREE PI 5030	PI	◎		◎		Drive gear (fixed part)
BEAREE PI 5033		◎		◎		Drive gear (fixed part)
BEAREE AI 5003	PAI	◎	○	◎		Drive and idle gear (fixed part)
BEAREE AS5040	PPS	○		◎		Drive gear (fixed part)
BEAREE AS5044		○		◎		Drive gear (fixed part)
BEAREE AS5057		○	○	○		Idle gear (fixed part)

◎ : Excellent ○ : Good
* Select the material based on operating conditions, mating gear material, life, accuracy, etc.

7.6 Sliding material dedicated for machining tools

BEAREE FL3307, with improvement of wear resistance, creep resistance and heat conductivity based on fluoro resins of a low friction coefficient, is the sliding material dedicated for machining tools with the smallest friction coefficient under oil lubrication.

<Features>

1. Smallest friction coefficient under oil lubrication.
2. Stick-slip is unlikely.
3. Galling and seizure are unlikely.
4. Small compression strain.
5. Unlikely oil shortage at the start-up, making it appropriate for frequent start/stop.
6. Small friction coefficient and long life.

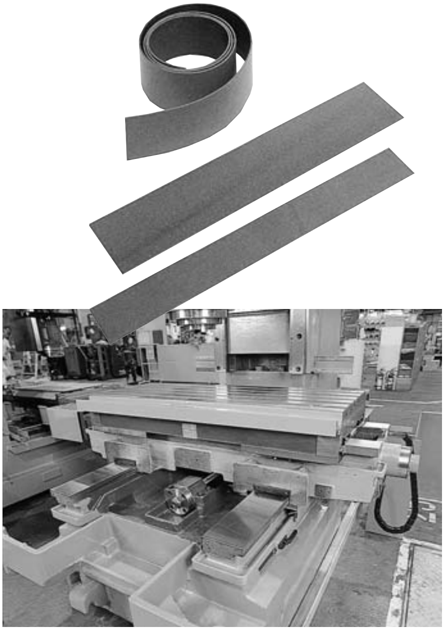


Photo 7.8 Sliding part of machining tool bed

[Test condition]
Test equipment: Creep tester (JIS)
Test piece dimension: 12.7×12.7×0.76mm
Load direction: Direction of thickness
Load duration: 24 hr
Surface pressure: 13.7MPa
Test temperature: Room temperature

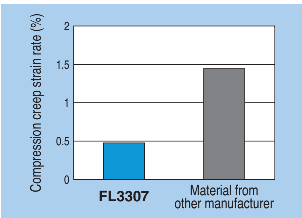


Fig 7.7 Creep strain rate

[Test condition]
Test equipment:
NTN-made reciprocating friction/wear testing equipment
Mating material: Meehanite metal
Surface roughness: Ra 0.25
Surface pressure: 0.49MPa
Travel distance: ±100mm
Lubricating oil: Tonna oil T68
Test temperature: Room temperature

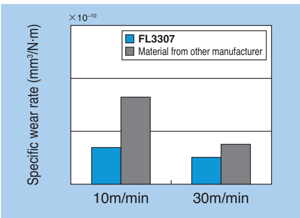


Fig 7.8 Wear amount

[Test condition]
Test equipment:
NTN-made reciprocating friction/wear testing equipment
Sliding velocity: 50 m/min
Travel distance: ±100mm
Mating material: Meehanite metal
Surface roughness: Ra 0.25
Lubricating oil: Tonna oil T68
Test temperature: Room temperature

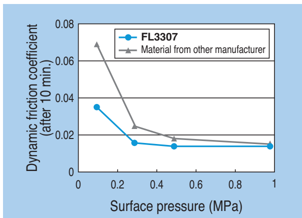


Fig 7.9 Dynamic friction coefficient

Refer to P. 58 for standard dimensions.

7.7 Material for separation claw

With copiers and printers, the toner image adhered onto the paper is heated and pressed by the roller for fixing. For scraping off the paper which is stuck on the roller, separation claws with sharp tips are used.

The separation claw is required to have rigidity in high temperature, sliding performance to avoid damage to the mating roller and non-viscosity against the melt toner.

NTN Engineering Plastics provides the appropriate claw material for the operating temperature and coating material.

<Features>

1. Excellent mechanical strength and heat resistance.
2. Good fluidity and excellent molding of the shape of claw tips
3. Excellent impact resistance
4. Excellent friction and wear properties

Photo 7.9 Material for separation claw

Table 7.7 Combination of separation claw material and recommended coating material

Material name	Heat resistance temperature, ˚C	Recommended coating material	Applications
BEAREE PI 5022	300	**BEAREE FE7092**	Claws on the fixed part, high functionality
BEAREE AI 5003	230	**BEAREE FE7030, FE7031**	Claws on photoreceptive drum
BEAREE FE5002	200	No coating is required	Claws on the fixed part, high functionality, inexpensive

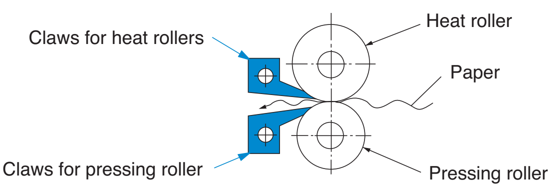


Fig 7.10 Applications of separation claws

7.8 Seal material for sliding

NTN Engineering Plastics material is a material with excellent sealability for gas and liquid, as well as wear resistance and a low friction property.

<Features>

1. High fitting and sealing properties.
2. Low friction coefficient and excellent wear resistance.
3. High self lubricating property requiring no lubricating oil.
4. Excellent chemical resistance allows use in special environments.
   (Refer to **Table 5.3** in page 24, for chemical resistance.)

Photo 7.10 Different types of seal rings

Table 7.8 Selection of materials based on the mating materials and environment and their applications

Material name	Mating material			Environment			Elongation	Machining method	Applications (examples)
	Mild steel	Cast iron	Alumi-num	Dry	Oil	Water	%		
BEAREE FL3000	○	○	×	○	○	△	200	Mechanical machining	General use, power steering, automatic transmission
BEAREE FL3030	○	○	○	○	○	×	170	Mechanical machining	Air suspension Air compressor
BEAREE FL3071	○	○	○	△	○	△	230	Mechanical machining	Car air conditioning Automatic transmission
BEAREE FL3082	○	○	×	△	○	△	254	Mechanical machining	Power steering
BEAREE AS5302	○	○	○	△	○	△	1.6	Injection molding	Scroll compressor
BEAREE PK5301	○	○	○	△	○	○	2.5	Injection molding	Automatic transmission
BEAREE PK5900	○	○	×	×	○	○	2.0	Injection molding	Automatic transmission

○ : Good △ : Fair × : Inappropriate

7.9 Coating material

BEAREE coating material forms a solid film, and because it is thin and uniform, it can be used in those places where thermal expansion may become an issue or high accuracy is required. It can be used taking advantage of its high wear resistance and non-viscosity.

Depending on the type of the material, different coating methods can be used such as spray coating and powder coating.

<Features>

1. Excellent friction and wear resistance.
2. Excellent non-viscosity.
3. Excellent heat resistance.
4. Excellent chemical resistance.

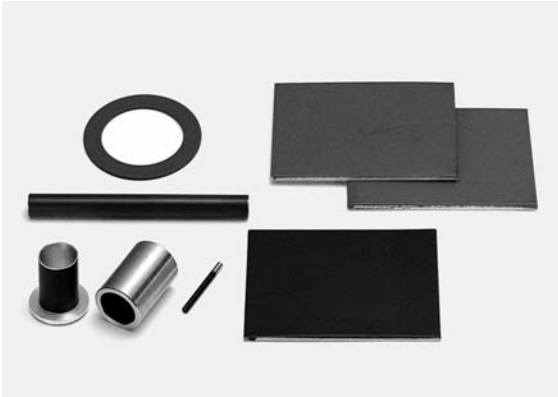


Photo 7.11 Coating products

7

Table 7.9 Coating materials and features

Material name	Features				Baking temperature ˚C	Film thickness μm	Applications
	Low friction coefficient	Wear resistance	Non-viscosity	Other			
BEAREE FL7060	○	○		Excellent under low surface pressure	230	10～30	Guide pin
BEAREE FL7075	○	○		General purpose	230	10～30	Piston, washer, vane
BEAREE FE7010		○		Thick film, for high surface pressure	315	500～1000	Supercharger rotor
BEAREE FL7067	○	○		For high surface pressure	230	10～40	High surface pressure sliding part
BEAREE FE7030			○		230	10～30	Slide guide, separation claw
BEAREE FE7092			○		370	10～30	Separation claw

＊ Coating can be applied to resins, in addition to metals, however, the material must withstand the baking temperature of coating.

7.10 Fluorine based sliding rubber

It is a material that holds both elasticity of rubber and the sliding property of fluoro resin. It has the following excellent features:

<Features>

1. Excellent sealability due to its elasticity.
2. Excellent chemical resistance. (Refer to **Table 6.3** in page 28)
3. Excellent heat resistance. (Continuous operating temperature of 230˚C)
4. Low friction coefficient and excellent wear resistance.
5. Excellent creep resistance
6. Excellent non-viscosity.
7. Can be used for food related applications.

Photo 7.12 Sliding rubber products

<Applications>

- O ring
- V ring
- Bearing
- Mechanical seal

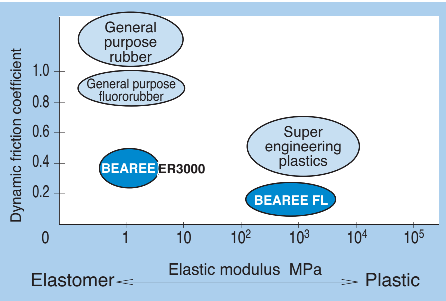


Fig 7.12 Position of BEAREE ER3000 as sliding material

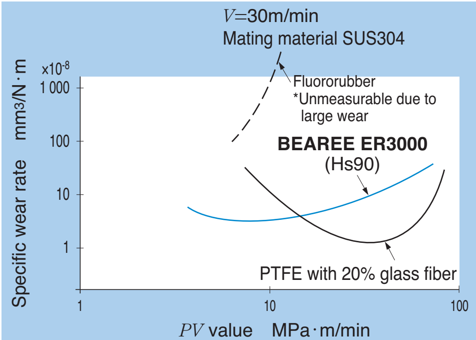


Fig 7.13 *PV* value and specific wear rate

Table 7.10 Features and applications

Material name	Hardness	Color	Features	Applications
BEAREE ER 3000	Hs 70	Black	Wear resistance	Bearing
	Hs 80			
	Hs 90			

7.11 NBR Series sliding rubber

NBR rubber, with its poor sliding property, requires lubrication such as grease, however, BEAREE ER3201 s a new rubber material with low friction and excellent wear properties using NBR as the base material.

It can be used for a dynamic seal with no lubrication, providing lower friction and higher durability compared to the conventional NBR rubber seals.

Photo 7.13 Sliding rubber products

<Features>

1. Low friction, low wear and good seal properties.
2. Low friction, low wear and good sealing properties.
3. Non-viscosity to prevent adherence.
4. Excellent applicability.

<Applications>

- O ring/V ring/Different types of seals

We have conducted comparison tests of ER 3201 and general-purpose NBR using the tester in the right figure.

O ring shape : P10
Traveling direction : Reciprocating
Stroke : ±2mm
Air pressure : 0, 0.2, 0.45 MPa
Frequency : 5 Hz
Testing time : 100 h
Grease application : No
Housing material : SUS304

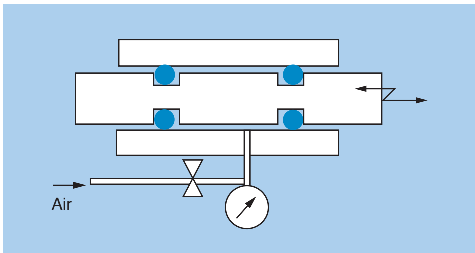


Table 7.12 Sealing property of traveling O ring and presence of cracks

Test piece	Test condition	Assessment after test		
	Air pressure	Sealing property	Presence of cracks	Photo observation
ER3201	0.0MPa	–	No	
	0.2MPa	Air leak	No	
	0.45MPa	Air leak	No	
General-purpose NBR	0.0MPa	–	Yes	
	0.2MPa	No air leak	Yes	
	0.45MPa	No air leak	Yes	

Table 7.11 General properties of ER3201

Item	Test method	SI unit	ER3201	General-purpose rubber (1 Class A)
Hardness	JIS-K6253	JIS-A	70±5	70±5
Specific gravity	JIS-K6301	—	1.3	—
Tensile strength	JIS-K6251	MPa	15	9.8 or above
Elongation percentage	JIS-K6251	%	500	250 or above
Tear strength	JIS-K6252	N/mm	35	—
Permanent elongation percentage	JIS-K6301	%	15	—
Permanent compression strain rate (100˚C×22h)	JIS-K6262	%	10	—
Ozone resistant property (40˚C, 50pphm, 42days)	JIS-K6259	—	No cracks	—

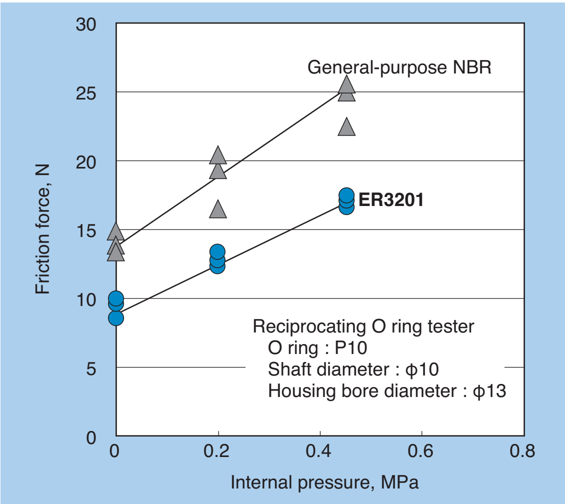


Fig 7.14 Relation between internal pressure and friction force at reciprocating O ring

7.12 Resin rolling bearing

General bearings cannot be used in special environments (in water, in chemicals, etc.), however, resin rolling bearings can be used with no lubrication and in lower torque than sliding bearings, since they use material with corrosion resistance and a self lubricating property for inner/outer rings, balls and cages. However, since the inner/outer rings are made of resin, the load capacity and rotational speed are for low range applications.

Photo 7.14 Bearings for corrosion environment

Table 7.13

	Inner/outer rings	Ball	Cage
Bearings for corrosion environment	**BEAREE PK5031**	Ceramic	66 nylon with glass reinforced fiber or BEAREE FL3700 (PTFE Series)

<Application record>

- Film developing machine (#6202, 6203 types)
  Operating conditions: Radial load: Max 9.3N, rotational speed: 1000 rpm, environment: development agent of PH 0.9 -12
- Aluminum foil chemical conversion line (UC205, 206 types)
  Operating conditions: Radial load: 127 – 147 N, rotational speed: 1 rpm, environment: acid, water vapor
- Photomagnetic disk sputtering equipment (ϕ20×ϕ25×4)
  Operating conditions: Radial load: 9.8 N, rotational speed: 120 rpm, environment: vacuum
- Hard disk cleaning equipment
  Operating conditions: Radial load: 19.6 N, rotational speed: max 400 rpm, environment: pure water

7.13 Miniature resin sliding screw

BEAREE AS5000 is adopted as the nut material of the sliding screw, therefore, it can be used in a wide range of temperatures without lubrication. And since the screw shaft is made of SUS304, it provides excellent corrosion resistance and is usable in special environments such as in water.

However, different from ball screws, it cannot be used for accurate positioning and for high load, but it is usable as the feeding mechanism of various machines.

The standard dimensions are screw shaft nominal outside diameter of ϕ4 · 6 · 8 · 10 · 12 mm with lead of 1 and 2 mm. In addition, the leads of three times the shaft diameter are added for screw shaft nominal outside diameter of ϕ6 · 8 · 10 · 12mm as high leads.

Photo 7.15 Miniature resin sliding screws

<Features>

1. Can be used in a wide range of environments. (no lubrication, corrosion resistance)
2. Low noise compared to ball screws.
3. High screw efficiency due to low friction resin nuts.

<Applications>

- Actuator, measurement equipment, semiconductor manufacturing devices, medical devices, automatic control equipment, etc.

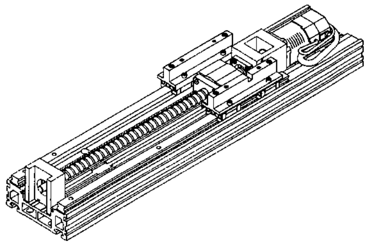


Fig. 7.15 An example of actuator application

Table 7.14 Reference: General features of various feed screws

	Grease	Guideline of operating ambient temperature	Corrosion resistance	Screw accuracy	Screw efficiency	Operating performance: High speed	Operating performance: Load resistance	Operating performance: Operating noise	Remarks
NTN resin sliding screw	Not required	❶ −40～+130˚C	○	○	○	○	▲	○	Applicable in the areas where general-purpose engineering plastic sliding screws were not conventionally usable.
General-purpose engineering plastic sliding screw	(Not required)	❷ −20～+50˚C	▲	▲～○	▲～○	▲	×	○	Oil impregnated polyacetal is common. Limited to low-load applications.
Metallic sliding screw	Required	❷ −20～+80˚C	×	×～◎	×～○	×～▲	◎	○	Performance is significantly affected by the lubricating agent used. Suitable for low-speed/high-load application.
Ball screw	Required	❷ −20～+80˚C	×	○～◎	◎	◎	○	▲	Expensive.

❶ Assuming operating heat generation of up to 100˚C and **NTN** resin sliding screw resin nut operating temperature limit of 230˚C, the operating ambient temperature is set to 230˚C-100˚C=130˚C for the high temperature side. In case the operating heat generation is lower, it may be used up to around 230˚C. However, it is necessary to confirm/set the initial clearance so that the axial clearance does not become negative at the operating temperature.
❷ Various references have been considered.

Refer to P. 56 for standard dimensions.

7.14 Compound products

By combining BEAREE group materials with other materials, you can take advantages of their features.

<Features>

1. Allowable surface pressure can be improved.
2. Reinforcing materials can be chosen depending on applications.
3. Weight can be reduced.
4. Thermal expansion can be reduced.
5. Machining accuracy can be improved.
6. Compact design can be achieved by integrating with mating housing.
7. Number of components can be reduced.

■ Examples of applications

Copier fixing roller bearing, pressure roller bearing, carriage bearing, mirror slide bearing, recorder sliding bearing, seal rings for automotive application, elevator door guide shoe

■ Examples of compound materials

- BEAREE material + rubber
- BEAREE material + rubber + metal
- BEAREE material + metal
- BEAREE material + general-purpose engineering plastic + metal

Photo 7.16 Compound products

8. Introduction of standard products

8.1 Sliding bearing

The following 6 types of standard products are available for a wide range of applications.

ARE, AR type [sleeve bearing]

The ARE type is a product which achieved zero environmental emission by the auto mold approach based on BEAREE FL3000. The performance is equivalent to the AR type. The bore diameters of 3 mm to 12 mm are standardized. The AR type is a product worked from rod or pipe shaped BEAREE FL3000 material. These bearings can only receive radial loads. The bore diameters of 15 mm to 50 mm are standardized.

ARF type [sleeve bearing with flange]

The ARE type is a flanged version of the AR type which can also receive axial loads. The bore diameters of 3 mm to 50 mm are standardized.

BRF type [sleeve bearing with flange]

The BRF type is a product produced with an injection mold of AS5005 material.

These bearings are flanged and can receive radial loads and axial loads.

The bore diameters of 3 mm to 25 mm are standardized. These bearings can be designed lighter and more compact than the ARF type.

TW type [thrust washer]

The TW type is a thrust washer worked out from BEAREE FL3000 tape. The thickness of 0.8 mm and bore diameters of 6 mm to 50 mm are standardized.

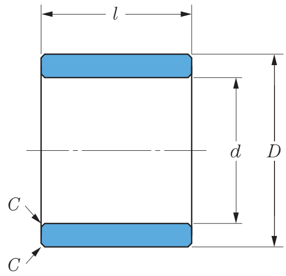
ML type [M liner bearing]

The ML type is a winding bush where BEAREE FL3060 tape is adhered to the inner surface of the steel plate which is galvanized for rust prevention. These bearings withstand higher surface pressure than the AR and ARF types and its thinness allows for a compact design. The bore diameters are standardized for 3 mm to 70 mm and several widths are standardized for each bore diameter dimension.

MLE type [MLE bearing]

The MLE type is three-layer structured lead-free bearings with tetrafluoroethylene resin with a special filling agent impregnated into porous sintered layer which is made by sintering bronze powder onto the backing steel plate. Bearing MLE for radial loads, flanged bearing MLEF for radial loads and axial loads, and bearing MLEW for thrust loads are standardized.

ARE type
AR type
Sleeve bearing



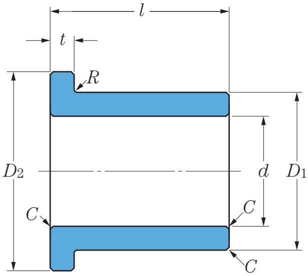
Dimension measurement temperature 25˚C

Bearing number	Dimension mm							Recommended dimensions mm				Minimum mounting clearance mm
	d	tolerance	*D*	tolerance	*l*	tolerance	*C*	Shaft h6		Housing M7		
R-ARE0305	3	+0.21/+0.16	6	+0.09/+0.04	5	0/-0.20	0.3	3	0/-0.006	6	0/-0 012	0.06
R-ARE0406	4	+0.21/+0.16	7	+0.09/+0.04	6	0/-0.20	0.3	4	0/-0.006	7	0/-0.015	0.06
R-ARE0506	5	+0.21/+0.16	8	+0.09/+0.04	6	0/-0.20	0.3	5	0/-0.008	8	0/-0.015	0.06
R-ARE0608	6	+0.21/+0.16	9	+0.09/+0.04	8	0/-0.20	0.3	6	0/-0.008	9	0/-0.015	0.06
R-ARE0708	7	+0.23/+0.18	11	+0.10/+0.05	8	0/-0.20	0.5	7	0/-0.009	11	0/-0.018	0.06
R-ARE0808	8	+0.23/+0.18	12	+0.10/+0.05	8	0/-0.20	0.5	8	0/-0.009	12	0/-0.018	0.06
R-ARE0910	9	+0.23/+0.18	13	+0.10/+0.05	10	0/-0.25	0.5	9	0/-0.009	13	0./-0.018	0.06
R-ARE1010	10	+0.24/+0.19	14	+0.10/+0.05	10	0/-0.25	0.5	10	0/-0.009	14	0/-0.018	0.07
R-ARE1210	12	+0.24/+0.19	16	+0.10/+0.05	10	0/-0.25	0.5	12	0/-0.011	16	0/-0.018	0.07
R-AR1515	15	+0.27/+0.20	21	+0.10/+0.05	15	0/-0.25	0.5	15	0/-0.011	21	0/-0.021	0.08
R-AR1715	17	+0.27/+0.20	23	+0.10/+0.05	15	0/-0.25	0.5	17	0/-0.011	23	0/-0.021	0.08
R-AR1815	18	+0.27/+0.20	24	+0.10/+0.05	15	0/-0.25	0.5	18	0/-0.011	24	0/-0.021	0.08
R-AR2020	20	+0.33/+0.21	26	+0.11/+0.06	20	0/-0.25	0.8	20	0/-0.013	26	0/-0.021	0.08
R-AR2220	22	+0.33/+0.21	28	+0.11/+0.06	20	0/-0.25	0.8	22	0/-0.013	28	0/-0.021	0.08
R-AR2525	25	+0.33/+0.21	31	+0.11/+0.06	25	0/-0.25	0.8	25	0/-0.013	31	0/-0.025	0.08
R-AR2830	28	+0.33/+0.21	34	+0.11/+0.06	30	0/-0.25	0.8	28	0/-0.013	34	0/-0.025	0.08
R-AR3030	30	+0.33/+0.21	36	+0.11/+0.06	30	0/-0.25	0.8	30	0/-0.013	36	0/-0.025	0.08
R-AR3230	32	+0.38/+0.22	40	+0.11/+0.06	30	0/-0.25	1.0	32	0/-0.016	40	0/-0.025	0.09
R-AR3535	35	+0.38/+0.22	43	+0.11/+0.06	35	0/-0.25	1.0	35	0/-0.016	43	0/-0.025	0.09
R-AR4040	40	+0.38/+0.22	48	+0.11/+0.06	40	0/-0.25	1.0	40	0/-0.016	48	0/-0.025	0.09
R-AR4550	45	+0.39/+0.23	53	+0.11/+0.06	50	0/-0.25	1.0	45	0/-0.016	53	0/-0.030	0.09
R-AR5050	50	+0.39/+0.23	60	+0.11/+0.06	50	0/-0.25	1.0	50	0/-0.016	60	0/-0.030	0.09

Remark 1. Use $1.0\times10^{-7} mm^3/N\cdot m$ as a guideline for the specific wear rate K.

ARF type

Sleeve bearing with flange



Dimension measurement temperature 25˚C

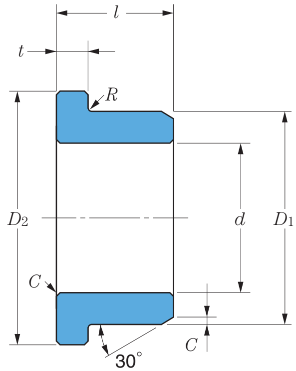
Bearing number	Dimension mm									Recommended dimensions mm		Minimum mounting clearance mm
	d	tolerance	D_1	tolerance	l	tolerance	D_2	t	tolerance	Shaft h6	Housing M7	
R-ARF0305	3	+0.21 / +0.16	6	+0.09 / +0.04	5	0 / -0.20	9	1.5	+0.10 / 0	3 0 / -0.006	6 0 / -0.012	0.06
R-ARF0406	4	+0.21 / +0.16	7	+0.09 / +0.04	6	0 / -0.20	9	1.5	+0.10 / 0	4 0 / -0.008	7 0 / -0.015	0.06
R-ARF0508	5	+0.21 / +0.16	8	+0.09 / +0.04	8	0 / -0.20	11	1.5	+0.10 / 0	5 0 / -0.008	8 0 / -0.015	0.06
R-ARF0608	6	+0.21 / +0.16	9	+0.09 / +0.04	8	0 / -0.20	12	1.5	+0.10 / 0	6 0 / -0.008	9 0 / -0.015	0.06
R-ARF0710	7	+0.23 / +0.18	11	+0.10 / +0.05	10	0 / -0.25	15	2	+0.10 / 0	7 0 / -0.009	11 0 / -0.018	0.06
R-ARF0810	8	+0.23 / +0.18	12	+0.10 / +0.05	10	0 / -0.25	16	2	+0.10 / 0	8 0 / -0.009	12 0 / -0.018	0.06
R-ARF0910	9	+0.23 / +0.18	13	+0.10 / +0.05	10	0 / -0.25	17	2	+0.10 / 0	9 0 / -0.009	13 0 / -0.018	0.06
R-ARF1015	10	+0.24 / +0.19	14	+0.10 / +0.05	15	0 / -0.25	18	2	+0.10 / 0	10 0 / -0.009	14 0 / -0.018	0.07
R-ARF1215	12	+0.24 / +0.19	16	+0.10 / +0.05	15	0 / -0.25	20	2	+0.10 / 0	12 0 / -0.011	16 0 / -0.018	0.07
R-ARF1520	15	+0.27 / +0.20	21	+0.10 / +0.05	20	0 / -0.25	27	3	+0.10 / 0	15 0 / -0.011	21 0 / -0.021	0.08
R-ARF1720	17	+0.27 / +0.20	23	+0.10 / +0.05	20	0 / -0.25	29	3	+0.10 / 0	17 0 / -0.011	23 0 / -0.021	0.08
R-ARF1820	18	+0.27 / +0.20	24	+0.10 / +0.05	20	0 / -0.25	30	3	+0.10 / 0	18 0 / -0.011	24 0 / -0.021	0.08
R-ARF2025	20	+0.33 / +0.21	26	+0.11 / +0.06	25	0 / -0.25	32	3	+0.10 / 0	20 0 / -0.013	26 0 / -0.021	0.08
R-ARF2225	22	+0.33 / +0.21	28	+0.11 / +0.06	25	0 / -0.25	34	3	+0.10 / 0	22 0 / -0.013	28 0 / -0.021	0.08
R-ARF2530	25	+0.33 / +0.21	31	+0.11 / +0.06	30	0 / -0.25	37	3	+0.10 / 0	25 0 / -0.013	31 0 / -0.025	0.08
R-ARF2830	28	+0.33 / +0.21	34	+0.11 / +0.06	30	0 / -0.25	40	3	+0.10 / -0.05	28 0 / -0.013	34 0 / -0.025	0.08
R-ARF3035	30	+0.33 / +0.21	36	+0.11 / +0.06	35	0 / -0.25	42	3	+0.10 / -0.05	30 0 / -0.013	36 0 / -0.025	0.08
R-ARF3235	32	+0.38 / +0.22	40	+0.11 / +0.06	35	0 / -0.25	48	4	+0.10 / -0.05	32 0 / -0.016	40 0 / -0.025	0.09
R-ARF3540	35	+0.38 / +0.22	43	+0.11 / +0.06	40	0 / -0.25	51	4	+0.10 / -0.05	35 0 / -0.016	43 0 / -0.025	0.09
R-ARF4045	40	+0.38 / +0.22	48	+0.11 / +0.06	45	0 / -0.25	56	4	+0.10 / -0.05	40 0 / -0.016	48 0 / -0.025	0.09
R-ARF4550	45	+0.39 / +0.23	53	+0.11 / +0.06	50	0 / -0.25	61	4	+0.10 / -0.05	45 0 / -0.016	53 0 / -0.030	0.09
R-ARF5060	50	+0.39 / +0.23	60	+0.11 / +0.06	60	0 / -0.25	70	5	+0.10 / -0.05	50 0 / -0.016	60 0 / -0.030	0.09

Remarks
1. The corner R inside flange area is 0.2 mm or less.
2. Chamfering C dimension is the same as the AR type if the bore diameter is the same.
3. Minimum mounting clearance is the value when mounted on M7 ultra hard housing.
4. Use $1.0\times10^{-7}mm^3/N\cdot m$ as a guideline for the specific wear rate K.

8

BRF type

Sleeve bearing with flange



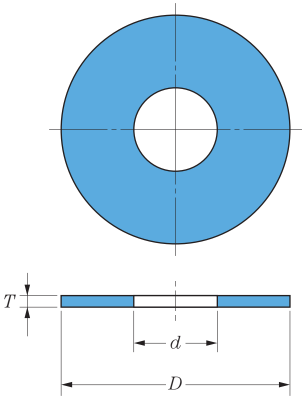
Dimension measurement temperature 25°C

Bearing number	Dimension mm					Recommended dimensions mm		Minimum mounting clearance mm
	d olerance	D_1 olerance	l olerance	D_2	t olerance	Shaft h7	Housing H7	
R-BRF0304	$3^{+0.21}_{+0.16}$	$6^{+0.11}_{+0.06}$	4 ±0.2	9	1.5±0.1	$3^{0}_{-0.010}$	$6^{+0.012}_{0}$	0.05
R-BRF0404	$4^{+0.22}_{+0.17}$	$7^{+0.12}_{+0.06}$	4 ±0.2	10	1.5±0.1	$4^{0}_{-0.012}$	$7^{+0.015}_{0}$	0.05
R-BRF0505	$5^{+0.22}_{+0.17}$	$8^{+0.12}_{+0.06}$	5 ±0.2	11	1.5±0.1	$5^{0}_{-0.012}$	$8^{+0.015}_{0}$	0.05
R-BRF0605	$6^{+0.22}_{+0.17}$	$9^{+0.12}_{+0.06}$	5 ±0.2	12	1.5±0.1	$6^{0}_{-0.012}$	$9^{+0.015}_{0}$	0.05
R-BRF0806	$8^{+0.26}_{+0.20}$	$12^{+0.14}_{+0.07}$	6 ±0.2	15	2 ±0.1	$8^{0}_{-0.015}$	$12^{+0.018}_{0}$	0.06
R-BRF1008	$10^{+0.27}_{+0.21}$	$14^{+0.14}_{+0.07}$	8 ±0.2	17	2 ±0.1	$10^{0}_{-0.015}$	$14^{+0.018}_{0}$	0.07
R-BRF1208	$12^{+0.28}_{+0.21}$	$16^{+0.14}_{+0.07}$	8 ±0.2	19	2 ±0.1	$12^{0}_{-0.018}$	$16^{+0.018}_{0}$	0.07
R-BRF1510	$15^{+0.30}_{+0.23}$	$21^{+0.15}_{+0.07}$	10 ±0.2	24	3 ±0.1	$15^{0}_{-0.018}$	$21^{+0.021}_{0}$	0.08
R-BRF2012	$20^{+0.31}_{+0.23}$	$26^{+0.15}_{+0.07}$	12 ±0.2	29	3 ±0.1	$20^{0}_{-0.021}$	$26^{+0.021}_{0}$	0.08
R-BRF2515	$25^{+0.32}_{+0.24}$	$31^{+0.16}_{+0.08}$	15 ±0.2	34	3 ±0.1	$25^{0}_{-0.021}$	$31^{+0.025}_{0}$	0.08

Remarks 1. Chamfer C dimension is 0.3 mm when bore diameter is 6 mm or less and 0.5 mm when it is 8 mm or more.
2. The corner R inside flange area is 0.2 mm or less.
3. Use $1.5\times10^{-7}mm^3/N\cdot m$ as a guideline for the specific wear rate K.

TW type

Thrust washer



Dimension measurement temperature 25˚C

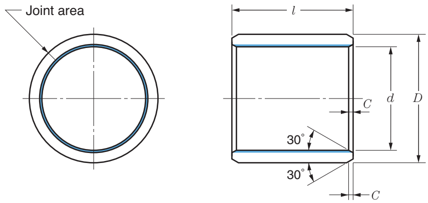
Bearing number	Dimension mm		
	d +0.25 / 0	*D* 0 / -0.25	*T* ±0.06
R-TW0613	6.2	12.8	0.8
R-TW0715	7.2	14.8	0.8
R-TW0815	8.2	14.8	0.8
R-TW0920	9.2	19.8	0.8
R-TW1020	10.2	19.8	0.8
R-TW1225	12.2	24.7	0.8
R-TW1530	15.3	29.7	0.8
R-TW1735	17.3	34.6	0.8
R-TW1835	18.3	34.6	0.8
R-TW2040	20.4	39.6	0.8
R-TW2245	22.4	44.5	0.8
R-TW2550	25.4	49.5	0.8
R-TW2855	28.4	54.4	0.8
R-TW3060	30.4	59.4	0.8
R-TW3260	32.4	59.4	0.8
R-TW3565	35.6	64.3	0.8
R-TW4070	40.6	69.3	0.8
R-TW4575	45.6	74.2	0.8
R-TW5080	50.8	79.2	0.8

Remarks 1. Use $1.0\times10^{-7}mm^3/N\cdot m$ as a guideline for the specific wear rate K.

8

ML type

M liner bearing



Bore diameter d	Outside diameter D	Bearing number									
		Length l (tolerance $^{0}_{-0.25}$) mm									
mm	mm	3	4	5	6	7	8	10	12	15	20
3	5	**R-ML0303**	**R-ML0304**	**R-ML0305**	**R-ML0306**						
4	6		**R-ML0404**		**R-ML0406**		**R-ML0408**				
5	7		**R-ML0504**	**R-ML0505**	**R-ML0506**		**R-ML0508**				
6	8			**R-ML0605**	**R-ML0606**	**R-ML0607**	**R-ML0608**	**R-ML0610**			
7	9			**R-ML0705**		**R-ML0707**		**R-ML0710**	**R-ML0712**		
8	10				**R-ML0806**		**R-ML0808**	**R-ML0810**	**R-ML0812**		
9	11							**R-ML0910**			
10	12				**R-ML1006**	**R-ML1007**	**R-ML1008**	**R-ML1010**	**R-ML1012**	**R-ML1015**	**R-ML1020**
12	14				**R-ML1206**		**R-ML1208**	**R-ML1210**	**R-ML1212**	**R-ML1215**	**R-ML1220**
13	15									**R-ML1315**	
14	16							**R-ML1410**	**R-ML1412**	**R-ML1415**	**R-ML1420**
15	17							**R-ML1510**	**R-ML1512**	**R-ML1515**	**R-ML1520**
16	18							**R-ML1610**	**R-ML1612**	**R-ML1615**	**R-ML1620**
17	19									**R-ML1715**	
18	20							**R-ML1810**	**R-ML1812**	**R-ML1815**	**R-ML1820**
19	22									**R-ML1915**	
20	23							**R-ML2010**	**R-ML2012**	**R-ML2015**	**R-ML2020**
22	25							**R-ML2210**	**R-ML2212**	**R-ML2215**	**R-ML2220**
24	27									**R-ML2415**	**R-ML2420**
25	28							**R-ML2510**	**R-ML2512**	**R-ML2515**	**R-ML2520**
26	30										**R-ML2620**
28	32								**R-ML2812**	**R-ML2815**	**R-ML2820**
30	34								**R-ML3012**	**R-ML3015**	**R-ML3020**
31	35										
32	36										**R-ML3220**
35	39								**R-ML3512**		**R-ML3520**
38	42										**R-ML3820**
40	44								**R-ML4012**		**R-ML4020**
45	50										**R-ML4520**
50	55							**R-ML5010**			**R-ML5020**
55	60										
60	65										
65	70										
70	75										

Remarks 1. Use $1.2\times10^{-7}mm^3/N\cdot m$ as a guideline for the specific wear rate K.

8

▼ Indication of product number

R-ML○○○○
- R-ML — Type code
- first ○○ — Bore diameter dimension
- last ○○ — Length dimension

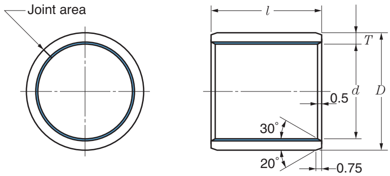
Dimension measurement temperature 25˚C

Bearing number Length l (tolerance $^{0}_{-0.25}$) mm 25	30	40	50	60	80	Dimension C mm	Recommended dimensions mm Shaft h7	Housing H7	Mounting clearance mm (When mounted on H7 ultra hard housing) Min.	Max.
						0.3	3 $^{0}_{-0.010}$	5 $^{+0.012}_{0}$	0.025	0.075
						0.5	4 $^{0}_{-0.012}$	6 $^{+0.012}_{0}$	0.025	0.085
						0.5	5 $^{0}_{-0.012}$	7 $^{+0.015}_{0}$	0.025	0.095
						0.5	6 $^{0}_{-0.012}$	8 $^{+0.015}_{0}$	0.025	0.095
						0.5	7 $^{0}_{-0.015}$	9 $^{+0.015}_{0}$	0.025	0.100
						0.5	8 $^{0}_{-0.015}$	10 $^{+0.015}_{0}$	0.025	0.100
						0.5	9 $^{0}_{-0.015}$	11 $^{+0.018}_{0}$	0.025	0.100
						0.5	10 $^{0}_{-0.015}$	12 $^{+0.018}_{0}$	0.025	0.100
						0.5	12 $^{0}_{-0.018}$	14 $^{+0.018}_{0}$	0.025	0.115
						0.5	13 $^{0}_{-0.018}$	15 $^{+0.018}_{0}$	0.025	0.115
						0.5	14 $^{0}_{-0.018}$	16 $^{+0.018}_{0}$	0.025	0.115
R-ML1525						0.5	15 $^{0}_{-0.018}$	17 $^{+0.018}_{0}$	0.025	0.115
R-ML1625						0.5	16 $^{0}_{-0.018}$	18 $^{+0.018}_{0}$	0.025	0.115
						0.5	17 $^{0}_{-0.018}$	19 $^{+0.021}_{0}$	0.025	0.115
R-ML1825						0.5	18 $^{0}_{-0.018}$	20 $^{+0.021}_{0}$	0.025	0.115
						0.7	19 $^{0}_{-0.021}$	22 $^{+0.021}_{0}$	0.025	0.130
R-ML2025	**R-ML2030**					0.7	20 $^{0}_{-0.021}$	23 $^{+0.021}_{0}$	0.025	0.130
R-ML2225						0.7	22 $^{0}_{-0.021}$	25 $^{+0.021}_{0}$	0.025	0.130
R-ML2425	**R-ML2430**					0.7	24 $^{0}_{-0.021}$	27 $^{+0.021}_{0}$	0.025	0.130
R-ML2525	**R-ML2530**					0.7	25 $^{0}_{-0.021}$	28 $^{+0.021}_{0}$	0.025	0.130
R-ML2625	**R-ML2630**					0.9	26 $^{0}_{-0.021}$	30 $^{+0.021}_{0}$	0.025	0.130
	R-ML2830					0.9	28 $^{0}_{-0.021}$	32 $^{+0.025}_{0}$	0.025	0.135
R-ML3025	**R-ML3030**	**R-ML3040**				0.9	30 $^{0}_{-0.021}$	34 $^{+0.025}_{0}$	0.025	0.135
R-ML3125		**R-ML3140**				0.9	31 $^{0}_{-0.025}$	35 $^{+0.025}_{0}$	0.035	0.165
R-ML3225	**R-ML3230**	**R-ML3240**				0.9	32 $^{0}_{-0.025}$	36 $^{+0.025}_{0}$	0.035	0.165
R-ML3525	**R-ML3530**	**R-ML3540**	**R-ML3550**			0.9	35 $^{0}_{-0.025}$	39 $^{+0.025}_{0}$	0.035	0.165
		R-ML3840				0.9	38 $^{0}_{-0.025}$	42 $^{+0.025}_{0}$	0.035	0.165
R-ML4025	**R-ML4030**	**R-ML4040**	**R-ML4050**			0.9	40 $^{0}_{-0.025}$	44 $^{+0.025}_{0}$	0.035	0.165
R-ML4525	**R-ML4530**	**R-ML4540**	**R-ML4550**			1.1	45 $^{0}_{-0.025}$	50 $^{+0.025}_{0}$	0.035	0.165
	R-ML5030	**R-ML5040**	**R-ML5050**	**R-ML5060**		1.1	50 $^{0}_{-0.025}$	55 $^{+0.030}_{0}$	0.035	0.165
	R-ML5530	**R-ML5540**		**R-ML5560**		1.1	55 $^{0}_{-0.030}$	60 $^{+0.030}_{0}$	0.045	0.195
	R-ML6030	**R-ML6040**		**R-ML6060**		1.1	60 $^{0}_{-0.030}$	65 $^{+0.030}_{0}$	0.045	0.195
	R-ML6530	**R-ML6540**		**R-ML6560**		1.1	65 $^{0}_{-0.030}$	70 $^{+0.030}_{0}$	0.045	0.195
		R-ML7040		**R-ML7060**	**R-ML7080**	1.1	70 $^{0}_{-0.030}$	75 $^{+0.030}_{0}$	0.045	0.195

8

MLE type

MLE bearing



* Note: Chamfering dimension of bushes with an outside diameter of 10 mm or less, or length of 7 mm or less is different from the figure, only eliminating burrs.

Bore diameter *d*	Outside diameter *D*	Length l $^{0}_{-0.4}$ mm											
		3	4	5	6	7	8	10	12	15	20	25	30
3	5												
4	6		MLE0404		MLE0406		MLE0408						
5	7		MLE0504	MLE0505	MLE0506		MLE0508						
6	8			MLE0605	MLE0606	MLE0607	MLE0608	MLE0610					
7	9			MLE0705		MLE0707		MLE0710	MLE0712				
8	10			MLE0805	MLE0806	MLE0807	MLE0808	MLE0810	MLE0812				
9	11					MLE0907		MLE0910					
10	12				MLE1006	MLE1007	MLE1008	MLE1010	MLE1012	MLE1015	MLE1020		
12	14				MLE1206		MLE1208	MLE1210	MLE1212	MLE1215	MLE1220		
13	15						MLE1308	MLE1310	MLE1315				
14	16							MLE1410	MLE1412	MLE1415	MLE1420		
15	17						MLE1508	MLE1510	MLE1512	MLE1515	MLE1520	MLE1525	
16	18							MLE1610	MLE1612	MLE1615	MLE1620	MLE1625	
17	19									MLE1715	MLE1720		
18	20							MLE1810	MLE1812	MLE1815	MLE1820	MLE1825	
19	22							MLE1910		MLE1915			
20	23							MLE2010	MLE2012	MLE2015	MLE2020	MLE2025	MLE2030
22	25							MLE2210	MLE2212	MLE2215	MLE2220	MLE2225	MLE2230
24	27							MLE2410		MLE2415		MLE2425	MLE2430
25	28							MLE2510	MLE2512	MLE2515	MLE2520	MLE2525	MLE2530
26	30												MLE2630
28	32							MLE2810	MLE2812		MLE2820	MLE2825	MLE2830
30	34							MLE3010	MLE3012	MLE3015	MLE3020	MLE3025	MLE3030
31	35									MLE3115			
32	36										MLE3220	MLE3225	MLE3230
35	39								MLE3512	MLE3515	MLE3520	MLE3525	MLE3530
38	42										MLE3820	MLE3825	
40	44								MLE4012	MLE4015	MLE4020	MLE4025	MLE4030
45	50										MLE4520	MLE4525	MLE4530
50	55								MLE5012	MLE5015	MLE5020	MLE5025	MLE5030
55	60											MLE5525	MLE5530
60	65										MLE6020		MLE6030
65	70									MLE6515			MLE6530
70	75									MLE7015	MLE7020		MLE7030
75	80										MLE7520		MLE7530
80	85									MLE8015	MLE8020		MLE8030
85	90												MLE8530
90	95										MLE9020		
95	100												MLE9530
100	105												MLE10030
105	110												
110	115										MLE11020		MLE11030
120	125												
130	135										MLE13020		
140	145												
150	155												
160	165												

Remarks 1. The minimum clearance when using the recommended shaft and housing is 0.025 mm.
2. Use 1.7×10^{-7} mm^3/N·m as a guideline for the specific wear rate K.

8

▼ Indication of product number

R-MLE○○○○

- ○○ (last two): Length dimension
- ○○ (first two): Bore diameter dimension
- MLE: Type code

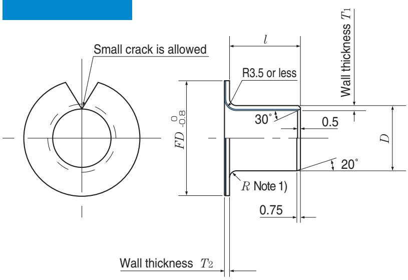
Dimension measurement temperature 25˚C

Length l $^{0}_{-0.4}$ mm									Wall thickness T	Recommended shaft d_a	Recommended housing bore diameter D_a
35	40	50	60	70	80	90	95	100			
										$3^{-0.025}_{-0.035}$	5 (H7)$^{+0.012}_{0}$
										$4^{-0.025}_{-0.037}$	6 (H7)$^{+0.012}_{0}$
										$5^{-0.025}_{-0.037}$	7 (H7)$^{+0.015}_{0}$
										$6^{-0.025}_{-0.037}$	8 (H7)$^{+0.015}_{0}$
										$7^{-0.025}_{-0.040}$	9 (H7)$^{+0.015}_{0}$
										$8^{-0.025}_{-0.040}$	10 (H7)$^{+0.015}_{0}$
										$9^{-0.025}_{-0.040}$	11 (H7)$^{+0.018}_{0}$
									$1.0^{0}_{-0.025}$	$10^{-0.025}_{-0.040}$	12 (H7)$^{+0.018}_{0}$
										$12^{-0.025}_{-0.043}$	14 (H7)$^{+0.018}_{0}$
										$13^{-0.025}_{-0.043}$	15 (H7)$^{+0.018}_{0}$
										$14^{-0.025}_{-0.043}$	16 (H7)$^{+0.018}_{0}$
										$15^{-0.025}_{-0.043}$	17 (H7)$^{+0.018}_{0}$
										$16^{-0.025}_{-0.043}$	18 (H7)$^{+0.018}_{0}$
										$17^{-0.025}_{-0.043}$	19 (H7)$^{+0.021}_{0}$
										$18^{-0.025}_{-0.043}$	20 (H7)$^{+0.021}_{0}$
										$19^{-0.025}_{-0.046}$	22 (H7)$^{+0.021}_{0}$
										$20^{-0.025}_{-0.046}$	23 (H7)$^{+0.021}_{0}$
									$1.5^{0}_{-0.030}$	$22^{-0.025}_{-0.046}$	25 (H7)$^{+0.021}_{0}$
										$24^{-0.025}_{-0.046}$	27 (H7)$^{+0.021}_{0}$
MLE2535	MLE2540									$25^{-0.025}_{-0.046}$	28 (H7)$^{+0.021}_{0}$
										$26^{-0.025}_{-0.046}$	30 (H7)$^{+0.021}_{0}$
										$28^{-0.025}_{-0.046}$	32 (H7)$^{+0.025}_{0}$
MLE3035	MLE3040									$30^{-0.025}_{-0.046}$	34 (H7)$^{+0.025}_{0}$
	MLE3140									$31^{-0.025}_{-0.050}$	35 (H7)$^{+0.025}_{0}$
MLE3235	MLE3240	MLE3250							$2.0^{0}_{-0.030}$	$32^{-0.025}_{-0.050}$	36 (H7)$^{+0.025}_{0}$
MLE3535	MLE3540	MLE3550								$35^{-0.025}_{-0.050}$	39 (H7)$^{+0.025}_{0}$
	MLE3840									$38^{-0.025}_{-0.050}$	42 (H7)$^{+0.025}_{0}$
MLE4035	MLE4040	MLE4050								$40^{-0.025}_{-0.050}$	44 (H7)$^{+0.025}_{0}$
MLE4535	MLE4540	MLE4550								$45^{-0.025}_{-0.050}$	50 (H7)$^{+0.025}_{0}$
MLE5035	MLE5040	MLE5050	MLE5060		MLE5080				$2.5^{0}_{-0.040}$	$50^{-0.025}_{-0.050}$	55 (H7)$^{+0.030}_{0}$
MLE5535	MLE5540		MLE5560							$55^{-0.025}_{-0.055}$	60 (H7)$^{+0.030}_{0}$
MLE6035	MLE6040	MLE6050	MLE6060	MLE6070						$60^{-0.025}_{-0.055}$	65 (H7)$^{+0.030}_{0}$
	MLE6540	MLE6550	MLE6560	MLE6570						$65^{+0.035}_{+0.005}$	70 (H7)$^{+0.030}_{0}$
MLE7035	MLE7040	MLE7050	MLE7060		MLE7080					$70^{+0.035}_{+0.005}$	75 (H7)$^{+0.030}_{0}$
MLE7535	MLE7540	MLE7550	MLE7560		MLE7580					$75^{+0.035}_{+0.005}$	80 (H7)$^{+0.030}_{0}$
	MLE8040	MLE8050	MLE8060		MLE8080					$80^{+0.035}_{+0.005}$	85 (H7)$^{+0.035}_{0}$
	MLE8540	MLE8550	MLE8560		MLE8580					$85^{+0.035}_{0}$	90 (H7)$^{+0.035}_{0}$
MLE9035	MLE9040	MLE9050	MLE9060			MLE9090				$90^{+0.035}_{0}$	95 (H7)$^{+0.035}_{0}$
	MLE9540									$95^{+0.035}_{0}$	100 (H7)$^{+0.035}_{0}$
MLE10035	MLE10040	MLE10050		MLE10070			MLE10095		$2.47^{0}_{-0.050}$	$100^{+0.035}_{0}$	105 (H7)$^{+0.035}_{0}$
		MLE10550					MLE10595			$105^{+0.035}_{0}$	110 (H7)$^{+0.035}_{0}$
MLE11035	MLE11040	MLE11050	MLE11060	MLE11070			MLE11095			$110^{+0.035}_{0}$	115 (H7)$^{+0.035}_{0}$
	MLE12040	MLE12050	MLE12060	MLE12070			MLE12095			$120^{+0.035}_{0}$	125 (H7)$^{+0.040}_{0}$
		MLE13050			MLE13080					$130^{+0.035}_{-0.005}$	135 (H7)$^{+0.040}_{0}$
		MLE14050		MLE14070	MLE14080			MLE140100		$140^{+0.035}_{-0.005}$	145 (H7)$^{+0.040}_{0}$
	MLE15040	MLE15050			MLE15080			MLE150100		$150^{+0.035}_{-0.005}$	155 (H7)$^{+0.040}_{0}$
		MLE16050			MLE16080			MLE160100		$160^{+0.035}_{-0.005}$	165 (H7)$^{+0.040}_{0}$

8

MLEF type

MLE bearing



Note 1) R dimension in the above figure is 0.75 or less when the wall thickness T_1=0 and 1.0 or less when the wall thickness T_1=1.5 or more.
2) Chamfering dimension of bushes with an outside diameter of 10 mm or less, or length of 0.28in or less is different from the figure, only eliminating burrs.

▼ Indication of product number

R-MLEF○○○○
- Length dimension
- Bore diameter dimension
- Type code

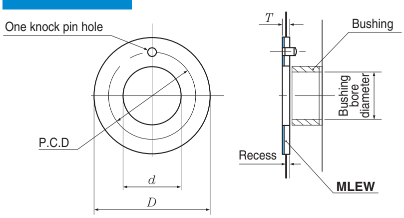
Bore diameter d	Outside diameter D	Flange outside diameter FD	Length l $^{0}_{-0.4}$ mm 4	5	6	7	8	10
5	7	10	MLEF0504	MLEF0505				
6	8	12		MLEF0605	MLEF0606	MLEF0607	MLEF0608	MLEF0610
7	9	13						
8	10	15			MLEF0806		MLEF0808	MLEF0810
10	12	18			MLEF1006		MLEF1008	MLEF1010
12	14	20			MLEF1206		MLEF1208	MLEF1210
14	16	22						MLEF1410
15	17	23						MLEF1510
16	18	24						MLEF1610
18	20	26						MLEF1810
20	23	31						MLEF2010
22	25	33						MLEF2210
24	27	35						
25	28	36						MLEF2510
26	30	38						
28	32	40						
30	34	42						
31	35	45						
32	36	46						
35	39	49						
38	42	52						
40	44	54						
45	50	60						
50	55	65						
55	60	70						
60	65	75						

Remarks 1. The minimum clearance when using recommended the shaft and housing (ultra hard) is 0.025 mm.
2. Use 1.7×10^{-7}mm^3/N·m as a guideline for the specific wear rate K.

8

MLEW type

MLE bearing



▼ Indication of product number

R-MLEW○○
- Bush bore diameter
- Type code

Bore diameter ofbush to be combined	Bearing number	Bore diameter d mm	Outside diameter D mm	Wall thickness T mm
6	MLEW06	8 $^{+0.25}_{0}$	16 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
8	MLEW08	10 $^{+0.25}_{0}$	18 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
10	MLEW10	12 $^{+0.25}_{0}$	24 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
12	MLEW12	14 $^{+0.25}_{0}$	26 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
14	MLEW14	16 $^{+0.25}_{0}$	30 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
16	MLEW16	18 $^{+0.25}_{0}$	32 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
18	MLEW18	20 $^{+0.25}_{0}$	36 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
20	MLEW20	22 $^{+0.25}_{0}$	38 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
22	MLEW22	24 $^{+0.25}_{0}$	42 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
24	MLEW24	26 $^{+0.25}_{0}$	44 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
25	MLEW25	28 $^{+0.25}_{0}$	48 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
30	MLEW30	32 $^{+0.25}_{0}$	54 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
35	MLEW35	38 $^{+0.25}_{0}$	62 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
40	MLEW40	42 $^{+0.25}_{0}$	66 $^{0}_{-0.25}$	1.5 $^{-0.03}_{-0.08}$
45	MLEW45	48 $^{+0.25}_{0}$	74 $^{0}_{-0.25}$	2.0 $^{-0.03}_{-0.08}$
50	MLEW50	52 $^{+0.25}_{0}$	78 $^{0}_{-0.25}$	2.0 $^{-0.03}_{-0.08}$

Remarks 1. Use 1.7×10^{-7}mm^3/N·m as a guideline for the specific wear rate K.

Dimension measurement temperature 25˚C

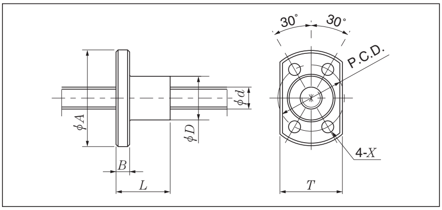
Length l $^{0}_{-0.4}$ mm								Wall thickness		Recommended shaft da	Recommended housing bore diameter Da
12	15	20	25	30	40	50	60	T_1	T_2		
								$1.0^{0}_{-0.025}$	$^{0}_{-0.2}$	$5^{-0.025}_{-0.037}$	7 (H7)$^{+0.015}_{0}$
										$6^{-0.025}_{-0.037}$	8 (H7)$^{+0.015}_{0}$
MLEF0712										$7^{-0.025}_{-0.040}$	9 (H7)$^{+0.015}_{0}$
MLEF0812										$8^{-0.025}_{-0.040}$	10 (H7)$^{+0.015}_{0}$
MLEF1012	MLEF1015									$10^{-0.025}_{-0.040}$	12 (H7)$^{+0.018}_{0}$
MLEF1212	MLEF1215	MLEF1220								$12^{-0.025}_{-0.043}$	14 (H7)$^{+0.018}_{0}$
MLEF1412	MLEF1415	MLEF1420								$14^{-0.025}_{-0.043}$	16 (H7)$^{+0.018}_{0}$
MLEF1512	MLEF1515	MLEF1520	MLEF1525							$15^{-0.025}_{-0.043}$	17 (H7)$^{+0.018}_{0}$
MLEF1612	MLEF1615	MLEF1620	MLEF1625							$16^{-0.025}_{-0.043}$	18 (H7)$^{+0.018}_{0}$
MLEF1812	MLEF1815	MLEF1820	MLEF1825							$18^{-0.025}_{-0.043}$	20 (H7)$^{+0.021}_{0}$
MLEF2012	MLEF2015	MLEF2020	MLEF2025	MLEF2030				$1.5^{0}_{-0.030}$	$^{0}_{-0.2}$	$20^{-0.025}_{-0.046}$	23 (H7)$^{+0.021}_{0}$
MLEF2212	MLEF2215	MLEF2220	MLEF2225							$22^{-0.025}_{-0.046}$	25 (H7)$^{+0.021}_{0}$
				MLEF2430						$24^{-0.025}_{-0.046}$	27 (H7)$^{+0.021}_{0}$
MLEF2512	MLEF2515	MLEF2520	MLEF2525	MLEF2530						$25^{-0.025}_{-0.046}$	28 (H7)$^{+0.021}_{0}$
	MLEF2615	MLEF2620						$2.0^{0}_{-0.030}$	$^{0}_{-0.2}$	$26^{-0.025}_{-0.046}$	30 (H7)$^{+0.021}_{0}$
				MLEF2830						$28^{-0.025}_{-0.046}$	32 (H7)$^{+0.025}_{0}$
MLEF3012	MLEF3015	MLEF3020	MLEF3025	MLEF3030	MLEF3040					$30^{-0.025}_{-0.046}$	34 (H7)$^{+0.025}_{0}$
			MLEF3125							$31^{-0.025}_{-0.050}$	35 (H7)$^{+0.025}_{0}$
				MLEF3230						$32^{-0.025}_{-0.050}$	36 (H7)$^{+0.025}_{0}$
MLEF3512		MLEF3520	MLEF3525	MLEF3530	MLEF3540	MLEF3550				$35^{-0.025}_{-0.050}$	39 (H7)$^{+0.025}_{0}$
					MLEF3840					$38^{-0.025}_{-0.050}$	42 (H7)$^{+0.025}_{0}$
MLEF4012		MLEF4020		MLEF4030	MLEF4040	MLEF4050				$40^{-0.025}_{-0.050}$	44 (H7)$^{+0.025}_{0}$
			MLEF4525		MLEF4540	MLEF4550		$2.5^{0}_{-0.040}$	$^{0}_{-0.3}$	$45^{-0.025}_{-0.050}$	50 (H7)$^{+0.025}_{0}$
		MLEF5020		MLEF5030	MLEF5040		MLEF5060			$50^{-0.025}_{-0.050}$	55 (H7)$^{+0.030}_{0}$
							MLEF5560			$55^{-0.025}_{-0.055}$	60 (H7)$^{+0.030}_{0}$
				MLEF6030	MLEF6040		MLEF6060			$60^{-0.025}_{-0.055}$	65 (H7)$^{+0.030}_{0}$

Dimension measurement temperature 25˚C

Knock pin hole diameter mm	Knock pin position P.C.D mm	Depth of housing recess mm
1.100～1.300	12 ±0.12	0.95～1.20
1.100～1.300	14 ±0.12	0.95～1.20
1.625～1.875	18 ±0.12	0.95～1.20
2.125～2.375	20 ±0.12	0.95～1.20
2.125～2.375	23 ±0.12	0.95～1.20
2.125～2.375	25 ±0.12	0.95～1.20
3.125～3.375	28 ±0.12	0.95～1.20
3.125～3.375	30 ±0.12	0.95～1.20
3.125～3.375	33 ±0.12	0.95～1.20
3.125～3.375	35 ±0.12	0.95～1.20
4.125～4.375	38 ±0.12	0.95～1.20
4.125～4.375	43 ±0.12	0.95～1.20
4.125～4.375	50 ±0.12	0.95～1.20
4.125～4.375	54 ±0.12	0.95～1.20
4.125～4.375	61 ±0.12	1.45～1.70
4.125～4.375	65 ±0.12	1.45～1.70

8.2 Miniature resin sliding screw

It is the type of low-noise sliding screws which can be used in a broad range of environments by the combination of BEAREE AS5000 nuts and stainless steel (SUS304) screw shafts.



R - MSS 06 18 □

- □ Nut material code
  Y: BEAREE AS5000
- 18: Screw shaft, nominal lead, mm
- 06: Screw shaft, nominal outside diameter, mm
- MSS: Miniature resin sliding screw
- R: **NTN** Engineering Plastics Corp. product

Nut material: **BEAREE AS5000**

mm

<table>
<tr><th rowspan="3">Part number</th><th colspan="2">Screw shaft</th><th colspan="9">Resin nut</th><th rowspan="3">① Standard shaft length</th></tr>
<tr><th rowspan="2">Nominal diameter d</th><th rowspan="2">Nominal lead</th><th rowspan="2">Outside diameter D 0 -0.2</th><th rowspan="2">Length L</th><th colspan="2">Flange</th><th colspan="3">Hole for mounting</th><th rowspan="2">Width across flats T</th><th rowspan="2">Pitch</th></tr>
<tr><th>A</th><th>B</th><th>P.C.D</th><th>Hole diameter X</th><th>Number of holes</th></tr>
<tr><td>R-MSS0401Y</td><td rowspan="2">4</td><td>1</td><td rowspan="2">10</td><td rowspan="2">11.5</td><td rowspan="2">23</td><td rowspan="6">3.5</td><td rowspan="2">15</td><td rowspan="2">2.9</td><td rowspan="16">4</td><td rowspan="2">15</td><td>1</td><td rowspan="2">200</td></tr>
<tr><td>R-MSS0402Y</td><td>2</td><td>2</td></tr>
<tr><td>R-MSS0601Y</td><td rowspan="4">6</td><td>1</td><td rowspan="4">12</td><td rowspan="4">14.5</td><td rowspan="4">26</td><td rowspan="4">18</td><td rowspan="8">3.4</td><td rowspan="4">17</td><td rowspan="2">1</td><td rowspan="6">300</td></tr>
<tr><td>R-MSS0602Y</td><td>2</td></tr>
<tr><td>R-MSS0609Y</td><td>9</td><td rowspan="2">4</td></tr>
<tr><td>R-MSS0618Y</td><td>18</td></tr>
<tr><td>R-MSS0801Y</td><td rowspan="4">8</td><td>1</td><td rowspan="4">14</td><td rowspan="4">18</td><td rowspan="4">29</td><td rowspan="4">4</td><td rowspan="4">21</td><td rowspan="4">18</td><td rowspan="2">1</td></tr>
<tr><td>R-MSS0802Y</td><td>2</td></tr>
<tr><td>R-MSS0812Y</td><td>12</td><td>4</td><td rowspan="2">400</td></tr>
<tr><td>R-MSS0824Y</td><td>24</td><td>6</td></tr>
<tr><td>R-MSS1002Y</td><td rowspan="3">10</td><td>2</td><td rowspan="3">16</td><td rowspan="3">22</td><td rowspan="3">33</td><td rowspan="6">5</td><td rowspan="3">24</td><td rowspan="6">4.5</td><td rowspan="3">21</td><td>1</td><td>300</td></tr>
<tr><td>R-MSS1015Y</td><td>15</td><td>4</td><td rowspan="2">450</td></tr>
<tr><td>R-MSS1030Y</td><td>30</td><td>6</td></tr>
<tr><td>R-MSS1202Y</td><td rowspan="3">12</td><td>2</td><td rowspan="3">18</td><td rowspan="3">25</td><td rowspan="3">35</td><td rowspan="3">26</td><td rowspan="3">22</td><td>1</td><td>300</td></tr>
<tr><td>R-MSS1218Y</td><td>18</td><td rowspan="2">6</td><td rowspan="2">500</td></tr>
<tr><td>R-MSS1236Y</td><td>36</td></tr>
</table>

① Standard shaft end of the screw is not machined (flush cut). However, machining of shaft end can be made by request.

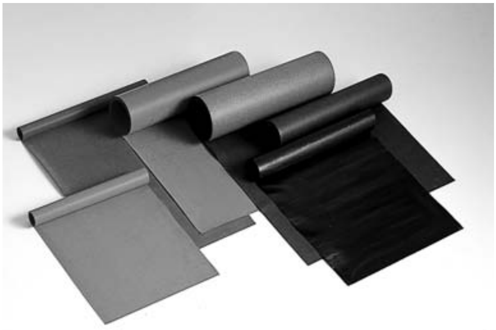
8

8.3 BEAREE resin material

NTN Engineering Plastics products are widely used in mechanical, electrical and chemical industries, as well as other industrial fields. We provide sheet, rod and pipe materials made by fluoro resin (BEAREE FL3000, BEAREE FL3030, BEAREE FL3700 and BEAREE FL3307) and ultra high molecular weight polyethylene resin (BEAREE UH3000), which are typical engineering plastic materials.

Sheet material

Sheet material is skived from large billet material made by compression molding.
In order to use the material by bonding, the surface must be treated through the preparation process for bonding (TOS: Treatment of Surface). However, BEAREE UH3954 is not treatable for bonding. BEAREE FL3307 is standardized for the treatment for bonding.



Rod material

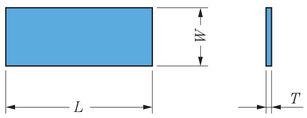
It is formed by ram extrusion in a round rod shape.
It can be machined to the requested shape by the turning or milling process.

Pipe material

It is the material formed by ram extrusion in a round pipe.
It can be machined to the requested shape by the turning or milling process.

8

Sheet material



R-T □×□×M□ □ T0

- Supplementary code (T0 for treatment of surface (TOS), no code for no treatment)
- Material code
  - No code : BEAREE FL3000
  - B : BEAREE FL3020
  - J : BEAREE FL3030
  - W : BEAREE FL3700
  - TA : BEAREE FL3307
  - Q : BEAREE UH3954
- Length code (unit length of 1 m)
- Width code 300 (500 only for BEAREE FL3020)
- Thickness code (thickness dimension)
- Material code (Sheet)

Unit: mm

Dimension			Material					
Thickness (*T*)	Width (*W*)	Maximum continuous length* (*L*) m	BEAREE FL3000	BEAREE FL3020	BEAREE FL3030	BEAREE FL3700	BEAREE FL3307	BEAREE UH3954
0.1±0.02	300^{+30}_{0} (500^{+30}_{0} for BEAREE FL3020)	10						○
0.2±0.02								○
0.3±0.03			○	○	○	○		○
0.4±0.04			○	○	○	○		○
0.5±0.05			○	○	○	○		○
0.6±0.06			○	○	○	○	○	
0.8±0.06			○	○	○	○	○	○
1 ±0.1			○	○	○	○	○	○
1.2±0.1		5	○	○	○	○	○	
1.5±0.1			○	○	○	○	○	
2 ±0.2			○	○	○	○	○	
2.5±0.2		1	○	○	○	○	○	
3 ±0.3			○	○	○	○	○	
4 ±0.3			○	○	○	○	○	
5 ±0.4			○	○	○	○	○	
6 ±0.5			○	○	○	○	○	

○ mark indicates availability.
Contact us for draw-formed product application.

*Length code for 1 m is M1.

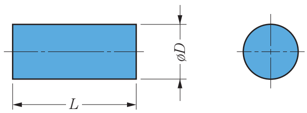
One point advice
Brief knowledge about engineering plastics

Treatment of Surface (TOS)

PTFE, which is the main ingredient of BEAREE FL, has excellent non-viscosity, which makes it, in general, not bondable. Accordingly, the BEAREE FL material surface needs to be treated by etching, using ammonia solution, etc. which contains metallic sodium, in order to make it bondable.
This process is called treatment of surface (TOS).

8

Rod material



R-R□×M1□

- Material code
  - No code : BEAREE FL3000
  - J : BEAREE FL3030
  - W : BEAREE FL3700
  - HA : BEAREE UH3000
- Length code (unit length of 1 m)
- Outside diameter code (Outside diameter dimension)
- Material code (Rod)

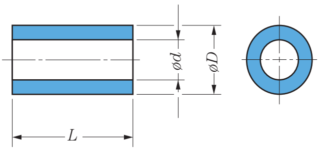
Unit: mm

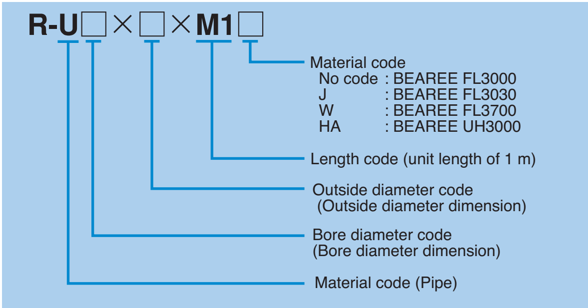
Dimension		Material			
Outside diameter (*ϕD*)	Length (*L*)	**BEAREE FL 3000**	**BEAREE FL 3030**	**BEAREE FL 3700**	**BEAREE UH 3000**
8		○		○	
9		○	○	○	
11		○		○	
12		○		○	
13				○	
15		○		○	
17		○	○	○	○
19	1 000*	○		○	
20		○		○	○
21		○	○		○
23		○		○	
28		○		○	
29		○			
33		○		○	
37		○		○	

○ mark indicates availability.
Contact us for draw-formed product application.

*Length code for 1000 mm is M1.

Pipe material





Unit: mm

Dimension			Material			
Bore diameter (ϕd)	Outside diameter (ϕD)	Length (L)	**BEAREE FL 3000**	**BEAREE FL 3030**	**BEAREE FL 3700**	**BEAREE UH 3000**
7	22	1 000*		○		
9	19		○		○	
12	20		○		○	
13	21					○
13	28		○		○	
14	23		○	○	○	
14	25		○		○	
15	20				○	
15	23		○			
15	33				○	
16	26		○			
16	28				○	
16	30		○			
17	26			○		
18	26		○		○	
19	33		○		○	○
21	38		○		○	
21	42				○	
21	45					○
22	31			○		
22	32			○	○	
27	42		○		○	
28	37		○		○	
32	41		○			
34	44		○		○	

○ mark indicates availability. ∗Length code for 1000 mm is M1.
The material dimensions do not include lathe turning margin.

9. Naming of engineering plastics

9.1 Material name

Convention of material name

The material name consists of base material code and supplementary code. Its convention is as follows:

Example:

FL 3 0 00

- 00 — Suffix
- 0 — Material property code
- 3 — Processing code
- FL — Material code

Material code

It is the code that indicates the base material of engineering plastics and is expressed by two alphabet characters.

Resin name	Resin material acronym	Base material code
Tetrafluoroethylene	TFE	FL
Other fluoro resin	PFA, ETFE	FE
Polyimide	PI	PI
Polyamideimide	PAI	AI
Polyetherimide	PEI	EI
Polyolefin	PO, PE, PP	UH
Polyarylenesulfide	PAS, PPS	AS
Polyester	ARP	LC
Polyethylene terephthalate	PET	ET
Polybuthylene terephthalate	PBT	PB
Polyetherketone	PEEK, PEK	PK
Polyethersulfone	PES	ES
Polyamide	PA	NY
Polycarbonate	PC	CB
Polysulfone	PSU	SU
Polyphenyleneoxide	PPO	PD
Polyacetal	POM	DM
Polyarylate	PAR	RA
Epoxy	EP	EP
Phenol	PF	PF
Other thermalplastic resin	TP	TP
Other thermal hardening resin	TSP	SP
Elastomer (rubber)	E	ER
Other		ZA

Processing code

It is the code that indicates the processing series material and is expressed by one digit.

Processing series		Processing series code	Remarks
Compression molding	Compression molding Ram extrusion Paste extrusion	3	" 2 " is used for ultra heat resistance ❶ resin.
Injection molding	Injection molding Melt extrusion	5	
Coating	Coating	7	
Other		9	

❶ Continuous operating temperature of 300˚C or more

Material property code

It is the code that indicates operating properties of the material and is expressed by one digit.

Material property code	Property	Material property code	Property
0	General purpose property material	5	—
1	General purpose property material	6	Material for food use
2	—	7	Material for use in water
3	Material for oil lubrication	8	Material for use in vacuum
4	—	9	Conductive material

Suffix

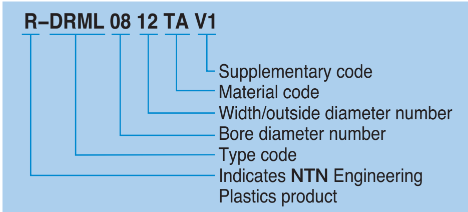
Classification code determined by the filling agent and blending and is expressed by two digits.

8

9.2 Product name

9.2.1 Standard product

The standard products are a series of products designed under a specified design standard and their naming convention is as follows:



(1) Type code

The type codes and standard materials of the standard products are shown in **Table 9.1**.

Table 9.1 Type code and standard material of standard products

Type	Classification	Type code	Standard material
Solid sleeve bearing	Cylindrical	AR	**BEAREE FL3000**
	Flanged cylindrical	ARF	**BEAREE FL3000**
	Flanged cylindrical	BRF	**BEAREE AS5005**
Thrust washer	Disc	TW	**BEAREE FL3000**
Winding bush with slit	Cylindrical	ML	**BEAREE FL3060**
	Cylindrical (inch)	DRML	**BEAREE FL3060**
MLE bearing	Cylindrical	MLE	**BEAREE FL7023**
	Flanged cylindrical	MLEF	**BEAREE FL7023**
	Disc	MLEW	**BEAREE FL7023**
Sliding screw	Sliding screw	MSS	**BEAREE AS5000**

(2) Bore diameter number

The bore diameter number is indicated by an integer, rounding down the decimals of the bore diameter dimension (mm). However, for the type code DRML, it is indicated by an integer as a multiple of 1/16 inch of the nominal dimension of the applicable shaft diameter.

For sliding screws, the nominal diameter dimension of the screw shaft is indicated by an integer.

(3) Width/outside diameter number

The width/outside diameter number is indicated by an integer, rounding up the decimals of the width/outside diameter dimension (mm).

For thrust washers, it is indicated by the outside diameter dimension and for others, by the width dimension. However, for the type code DRML, it is indicated by an integer as a multiple of 1/16 inch of the width dimension.

For sliding screws, it is indicated by an integer of the nominal lead of the screw.

For sliding rubber O rings, the nominal number determined by JIS B2401 is used as is. (The width/outside diameter numbers are omitted.)

(4) Material code

The materials and their codes used for the standard products are shown in **Table 9.2**.

However, when standard materials of each type (**Table 9.1**) are used, the material codes are omitted.

Table 9.2 Material codes of standard products, non-standard products and raw materials

Category	Material name	Code
The base material is tetrafluoroethylene	**BEAREE FL3000**	L
	BEAREE FL3020	B
	BEAREE FL3030	J
	BEAREE FL3700	W
	BEAREE FL3040	D
	BEAREE FL3304	T
	BEAREE FL3305	TA
	BEAREE FL9000	S
	Other	F
Injection molding	**BEAREE AS5000**	Y
	BEAREE AS5010, AS5030 **BEAREE AS5031, AS5040**	R
	Other	Z
Coating	**BEAREE FL7075**	C
	Other	K
	BEAREE UH3954	Q
The base material is polyethylene	**BEAREE UH3000**	HA
	Other	H
The base material is polyimide or polyamideimide	**BEAREE PI2030**	P
	BEAREE PI5000	G
	BEAREE AI5003	E
	Other	M
Other	Not any of the above	V

(5) Supplementary code

The different surface treatments and dimension tolerances are indicated with supplementary code shown in **Table 9.3**.

Table 9.3 Supplementary codes for standard products and raw materials

Code	Application
TO	Standard product: TOS of outside diameter of AR and ARF; one-sided TOS of TW Raw material: TOS of tape, sheet, tube, rod
T_n (n=1, 2…)	Surface treatment not included in the definition of the above TO such as TOS of bore diameter of AR and ARF (including those with adhesive tape)
V_n (n=1, 2…)	Winding bush with slit (ML) with the same bore diameter number and width/outside diameter number and different dimension tolerance

9.2.2 Non-standard product

Products that are not standard products, raw materials or prototypes.

The naming convention of the non-standard products is shown on the right.

(1) Type codes of non-standard products are shown in Table 9.4.

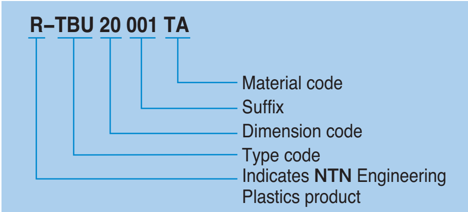


Table 9.4 Type codes of non-standard products

Classification	Type code	Remark
Built-in Bearing	MPB	
Bush with shell	SBU	Bush is pressed in or bonded to the metallic outer ring
	SBT	Bush is pressed in or bonded to the metallic material outside diameter
Claw/scraper	TME	
TLB Mirror slide	TLB	Insert is bonded into the metallic outer ring
	TLT	Tape is adhered to metallic material outside diameter, ball bush, rod end
Tape	TAP	General tape
	CUW	For curtain wall
	LTP	Insert
	CSS	Cassette shim
	TAT	Other standard products (TOS, holes, etc.), not included in the above classification, width 6 mm or less
Pin	PIN	Coated rod-like material, rod-like formed material
Compound product	DCB	Radial type, rotation type
	DCT	Variant (vane blade, rubber + BEAREE, etc.)
Bush	TBU	Straight (cylindrical) bush
	TBF	Flanged bush (including both flanges)
	TBT	TOS, split, additional processing, etc.
Roller	ROL	
Washer (wall thickness is greater than width)	WAS	General washer
	WAT	Eccentric, ring washer, packing
Surface treatment	ETC	Surface treatment only to the customer supplied material, etc.
Unit bearing	UNT	Bush, etc. are integrated into the bearing box as a unit or its bearing only
Ass'y product	ASY	Product consisting of multiple components (compound product with bonding and pressing; different from - DCB, TLB -)

Classification	Type code	Remark
Seal	CSL	Cup seal
	LSL	Lip seal
	PSL	Piston seal ring
	RDR	Rider ring
	SSL	Slipper seal
	ROG	O ring
	DRG	D ring
	SRG	Square ring
	VPA	V packing (includes back-up ring)
	CAS	Cartridge seal
	SLT	Other variant seal
Slider	SLD	Slider
	SGP	Guide piece
	SVL	Valve slider
	SLW	Wiper
Insulated/heat resistant products	HIS	Heat resistant sleeve
	HIT	Insulating/heat resistant product other than HIS, gear
Gears	GER	Gear, sprocket, toothed pulley
Damper	DAM	Mechanical damper, air damper
Pad	RPD	Pad for rotation
	LPD	Pad for linear motion
	SPD	Slow-motion shim
Retainer for bearing	RTR	
Winding bush with slit	MLT	Products whose type numbers are not registered as a standard product
Material	MAT	Sale of raw material and other material specified by Export Trade Control Order and U.S. Export Administration Regulations
Sliding screw	MST	Products whose type number is not registered as a standard product
Sliding damper unit	SSB	Base-isolated slide damper
Boot	BOT	Joint boot
Resin rolling bearing	PB	Resin bearing using rolling elements
Other than above	XXX	

(2) Dimension code

Typical dimension of the products is indicated by two digits.

The indication of dimensions for each type is shown in **Table 9.5**.

(3) Suffix

Suffix is indicated by 3 digits.

Products with the same dimension should have different suffix if the material is different.

(4) Material code

The materials and their codes used for the non-standard products are shown in **Table 9.2**.

However, when standard materials of each type (**Table 9.1**) are used, the material codes are omitted.

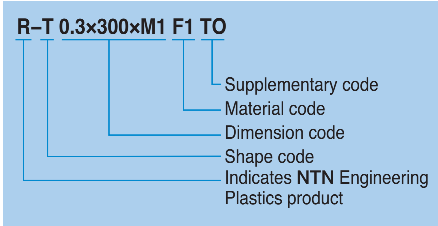
Table 9.5 Codes by non-standard product type

Type code	Indicated dimension	Type code	Indicated dimension
MPB	Bore diameter	SSL	Bore diameter and outside diameter
SBU	Bore diameter	ROG	Bore diameter
SBT	Outside diameter	DRG	Bore diameter
TME	Dimension from tip to hole and shaft	SRG	Bore diameter
TLB	Bore diameter	VPA	Bore diameter
TLT	Outside diameter	CAS	Bore diameter
TAP	Thickness	SLT	Bore diameter
CUW	Thickness	SLD	Bore diameter
LTP	Thickness	SGP	Bore diameter
CSS	Thickness	SVL	Bore diameter
TAT	Thickness	SLW	Thickness
PIN	Outside diameter	HIS	Bore diameter
DCB	Bore diameter	HIT	Bore diameter
DCT	Bore diameter	GER	Outside diameter
TBU	Bore diameter	DAM	Bore diameter
TBF	Bore diameter	RPD	Thickness
TBT	Bore diameter	LPD	Thickness
ROL	Bore diameter	SPD	Thickness
WAS	Bore diameter	RTR	Bore diameter
WAT	Bore diameter	MLT	Bore diameter
ETC	Bore diameter		Bore diameter (tube material)
UNT	Bore diameter	MAT	Outside diameter (rod material)
ASY	Bore diameter		Thickness; Corresponds to U.S. Export Administration Regulations. Raw material.
CSL	Outside diameter	MST	Screw outside diameter
LSL	Bore diameter and outside diameter	SSB	Outside diameter
PSL	Outside diameter	XXX	Bore diameter
RDR	Outside diameter	PB	Nominal number specified by JISB1513
		BOT	Dimension of mounting length with shaft

Remarks
1. Bore diameter is indicated by an integer, rounding down decimals. Less than 1 and 100 or more are indicated by 00.
2. Outside diameter is indicated by an integer, rounding up decimals. Less than 1 and 100 or more are indicated by 00.
3. Thickness is indicated by rounding up the second decimal place. Less than 0.1 and 10 or more are indicated by .00. (Thickness of 0.55→06, thickness of 1.5→15)
4. If the above dimension does not exist in the product line, it is indicated by 00.
5. Dimension from the tip to the hole or shaft of TME is to be rounded off.
6. Dimension of mounting length with the BOT shaft is indicated by an integer, rounding up decimals. Less than 1 and 100 or more are indicated by 00.
7. When registering raw materials corresponding to the U.S. Export Administration Regulations with MAT, it is indicated by 00.

9.2.3 Raw material

Raw materials are the collective name for fixed size tape material, sheet material, rod material and tube material and their naming convention is as shown on the right.



(1) Shape code

The shape codes of the raw materials are shown in **Table 9.6**.

(2) Dimension code

The dimension codes of the raw materials are shown in **Table 9.6**.

Table 9.6 Shape code and dimension code of raw materials

Classification	Catalog classification	Shape code	Dimension code
Tape	Sheet	T	(thickness) x (width) x (length)
Sheet	—	S	(thickness) x (width) x (length)
Rod	Rod	R	(Outside diameter) x (Length)
Tube	Pipe	U	(Bore diameter) x (Outside diameter) x (Length)

Remarks
Dimension codes are an indication of nominal dimensions (mm) in numerical codes, rounding down the second decimal place.
When nominal dimension is 1000 mm or more and metric, it is indicated by the metric unit and M is placed before the nominal number.
e.g. Length 2000 mm → M2
However, if a fraction of 1000 mm exists, it is indicated by the unit of mm.
e.g. Length 1500 mm → 1500

(3) Material code

The codes in **Table 9.2** and **9.7** are used as material codes.

However, when FL3000 is used, the material code is omitted.

In addition, the code of "Others" in Exhibit 1.1 and any codes to include more than one material should not be used.

(4) Supplementary code

The different surface treatments and dimension tolerances are indicated with supplementary code shown in **Table 9.3**.

Table 9.7 Material codes of raw materials

Category	Material name	Code
The base material is tetrafluoroethylene	**BEAREE FL3900**	F1
	BEAREE FL3075	F2
	BEAREE FL3800	F5
	BEAREE FL3070	F7
	BEAREE FL3642	F8
	BEAREE FL3060	F11
	BEAREE FL3307	F12
	BEAREE FL3308	F13
	BEAREE FL3082	F15
	BEAREE FL3071	F16
The base material is polyimide or polyamideimide	**BEAREE PI5010**	P1 ❶

❶ Not to be applied for new ones.

9.2.4 Prototype

The naming convention of prototypes should be as shown on the right.

(1) Type code

The type codes of the prototypes are shown in **Table 9.4**.

(2) Suffix-1

Suffix-1 is indicated by 4 digits and set when prototypes are entered for the new prototyping plan.

The given number should be uniquely used throughout the case until it is completed.

(3) Suffix-2

Suffix-2 is set every time the design changes and is indicated by 2 digits.

Design change means changes in material, dimension, dimensional tolerance, shape, etc.

R–Z–SBU 0001–01

- 01: Suffix-2
- 0001: Suffix-1
- SBU: Type code
- Z: Prototype code
- R: Indicates **NTN** Engineering Plastics product

One point advice
Brief knowledge about engineering plastics

●*History of NTN Engineering Plastics Corp.*

1965	Oct	Established Toyo Bearing Rulon Co., Ltd. as a joint venture of **NTN** Corporation and Dixon Corp. of the U.S.A.
1967	Jan	Constructed new molding/machinery factory in **NTN**'s Kuwana Works.
1968	Jan	Established integrated production system from material to machining.
1970		Started production of bearings and gears for copiers.
1973		Started production of automotive components.
1978	Jun	Volume production of claws for copiers by injection molding.
1981	Jul	Constructed new factory in Toincho Inabe-gun, Mie-ken.
1985	Apr	Registered trademark "**BEAREE**", enhanced overseas sales.
1989	Oct	Changed the company name to "**NTN** Rulon Co., Ltd."
1991	Apr	Changed the company name to "**NTN** Engineering Plastics Corp. (terminated tie-up with Dixon Corp.)
1993	Apr	Unified the trademarks of engineering plastic materials to "**BEAREE**".
1998	May	Received "ISO9001" certification
1999	Nov	Received "ISO14001" certification
2003	Mar	Established production of variant products by automatic powder molding