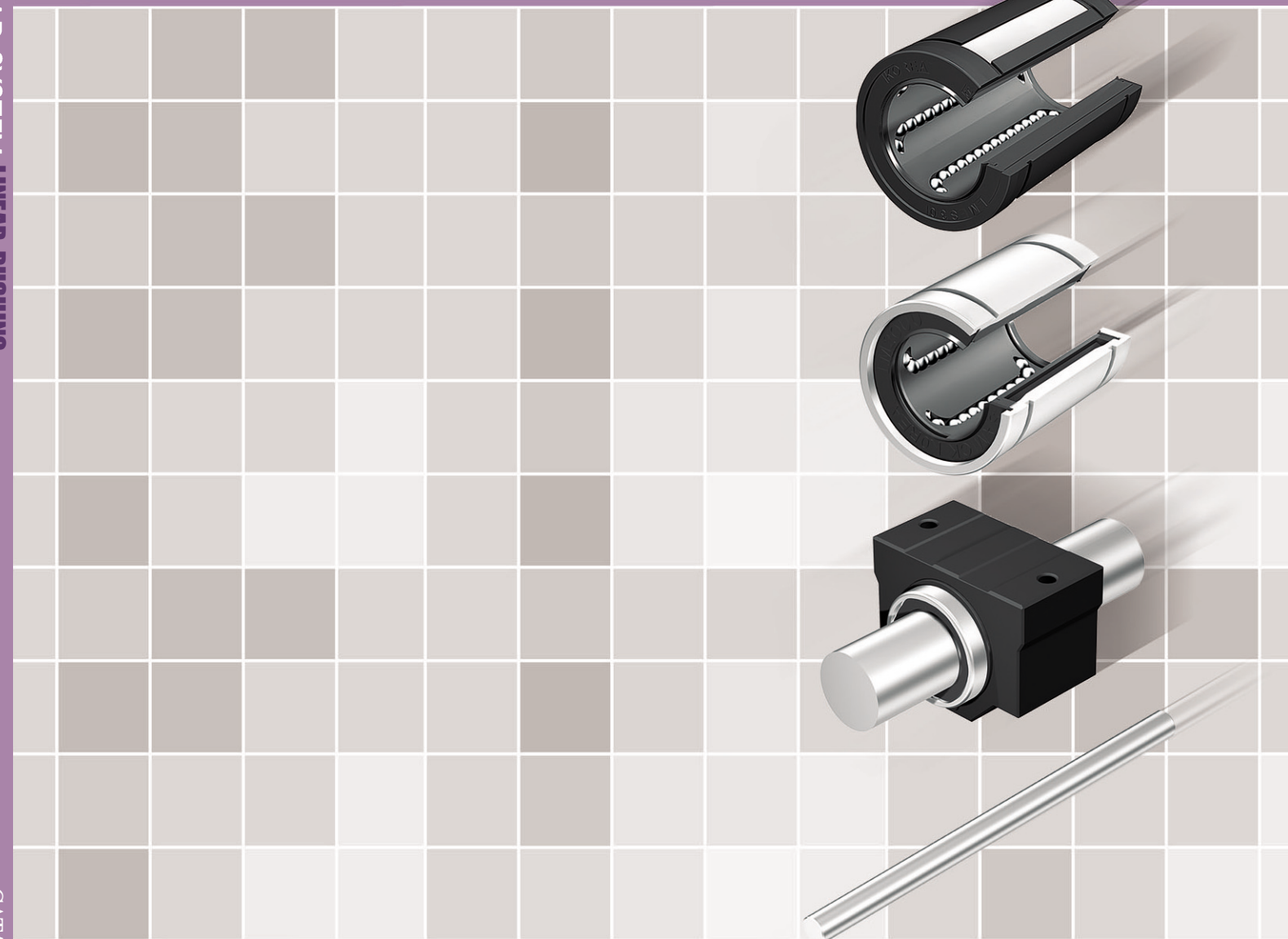


THE PRINCIPLE OF LINEAR SYSTEM

# LINEAR BUSHING

by SAMICK the Linear Instinct



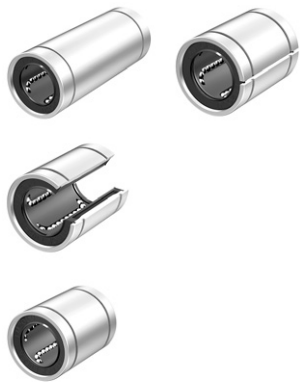
CATALOG NO. 0801E



### Self-Aligning Linear Bushing

- Up to 3 times higher load capacity and 27 times longer travel life compared to a standard linear bushing
- Interchangeable with standard linear bushing
- Travel speeds up to 10ft/s (3m/s)
- Smooth operation and reduced maintenance as a result of self-aligning Ball plates ( $\pm 0.5^\circ$ )
- Anti-Rusting: Nickel or Chrome plating, Raydent treatment of ball plate, Stainless-steel ball plate (Under LMES12, LMBS8), Stainless-steel ball

LMES, LMES\_OP: European standard(mm), p29  
LMBS, LMBS\_OP: American standard(inch), p31



### Standard Linear Bushing

- Allowed Max. 7650N the basic dynamic load rating
- Shaft diameter from 60mm to 5mm
- Provide low friction on high-speed movement
- Can be selected resin retainer (standard), and steel retainer (for high temperature & vacuum)
- Corrosion-resisting: the nickel-plated, Raydent treatment of Outer-sleeves, stainless steel ball

LM, LM\_OP, LM\_AJ, LM\_L: Asian standard, p46  
LME, LME\_OP, LME\_AJ, LME\_L: European standard, p66



### Flanged type Linear Bushing

- With a variety of design and ease of installation
- Used in case of passing the load of moving body directly to the Linear Bushing
- Installed without housing
- Can be selected resin retainer (standard), and steel retainer (for high temperature & vacuum)
- Corrosion-resisting: the nickel-plated, Raydent treatment of Outer-sleeves, stainless steel ball

LMF\_(L), LMK\_(L), LMH\_(L): Asian standard, p50  
LMEF\_(L), LMEK\_(L): European standard, p70



### Pilot Flanged type Linear Bushing

- With a variety of design and ease of installation
- When the load of moving body passed directly to the Linear Bushing, the Pilot Flange can get more stable movement and being the most suitable for moment load
- Installed without housing
- Can be selected resin retainer (standard), and steel retainer (for high temperature & vacuum)
- Corrosion-resisting: the nickel-plated, Raydent treatment of Outer-sleeves, stainless steel ball

LMFP\_(L), LMK\_P(L), LMHP\_(L): Asian standard, p56  
LMEFP\_(L), LMEK\_P(L): European standard, p70



### Middle Pilot Flanged type Linear Bushing

- With a variety of design and ease of installation
- When the load of moving body passed directly to the Linear Bushing, the Pilot Flange can get more stable movement and being the most suitable for moment load
- Installed without housing
- Can be selected resin retainer (standard), and steel retainer (for high temperature & vacuum)
- Corrosion-resisting: the nickel-plated, Raydent treatment of Outer-sleeves, stainless steel ball

LMFM, LMKM, LMHM: Asian standard, p62  
LMEFM, LMEKM: European standard, p78



### Aluminum Case Unit

- Combination product with Aluminum housing and standard or Self-Aligning linear bushing
- Aluminum housing with a high precision and lightweight
- Abnormal variant does not occur within reasonable load
- Minimized surface scratch

SC, SC\_V, SC-W, SCJ: Asian standard, p82  
SCE, SCE\_V, SCE\_W: European standard, p89



### Aluminum Case Unit (Open type)

- Integration of open type aluminum housing and open type linear bushing
- Aluminum housing with a high hardness and lightweight
- Combined with support rail

SBR, TBR: Asian, European standard, p87



### Shaft Rail Unit

- Integration of aluminum rail and shaft
- Combined with open type Aluminum Case Unit

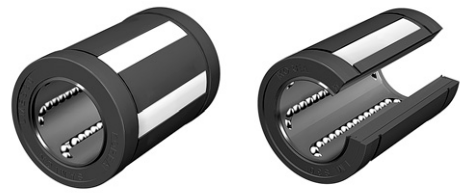
SBS, TBS: Asian, European standard, p96



### Shaft / Shaft Support

- High carbon bearing steel shaft (Surface treatment and chamfering is possible)
- Aluminum shaft support

SF: Shaft, Asian, European standard, p98  
SK: Shaft support, Asian, European standard, p98



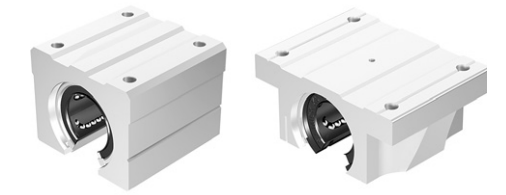
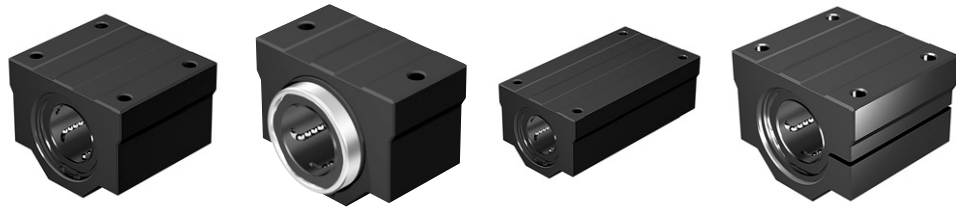
### | PART NUMBER NOTATION |

<b>Self-Aligning Linear Bushing</b>	LM	ES	16	UU	OP	-	N	S
Samick Linear Bushing								
Standards	Metric series (mm) : ES Inch series (inch) : BS							
Nominal Shaft Diameter	Metric (mm) : 10~50mm Inch Series : #4~#32							
Seal	No Seal : Blank One Side Seal : U Both Side Seal : UU							
Type	Standard type : Blank Open type (for support rail) : OP							
Corrosion resistance type	No-plating (Standard) : Blank Ball plate nickel plating : N Stainless steel ball plating : M Ball plate Chrome plating : C							
Ball type (by corrosion resistance)	High carbon bearing steel ball (standard) : Blank Stainless steel ball : S							



### | PART NUMBER NOTATION |

<b>Linear Bushing</b>	LM	E	F	P	20	L	UU	OP	-	A	N	S
Samick Linear Bushing												
Standards(Asia, Europe)	Asian Standard : Blank / European Standard : E											
Flange option	Standard : Blank Circular type : F Square type : K Oval type : H											
Flange Location	Standard : Blank Pilot : P Middle : M											
Nominal Shaft Diameter	Standard : 5 ~ 60mm Flange type : 6 ~ 60mm											
Length	Standard : Blank Long : L											
Seal	No Seal : Blank One Side Seal : U Both Side Seal : UU											
Sloting Type	Standard type : Blank Open type : OP Adjustable type : AJ											
Retainer (by application temperature)	Resin retainer (Standard) : Blank Steel retainer(High temperature) : A											
Outer-sleeves (by corrosion resistance)	No plating(Standard) : Blank Electroless nickel plating : N Raydent treatment : R											
Ball type (by corrosion resistance)	High carbon bearing steel ball (standard) : Blank Stainless steel ball : S											



### | PART NUMBER NOTATION |

Aluminum Case Unit	SC	E	J	20	W	UU	-	A	N	S
Samick Aluminum Case Unit (with Standard Linear Bushing)										
<b>Standards (Asia, Europe)</b>										
Asian Standard : blank European Standard : E										
<b>Clearance adjustable type*</b>										
Standard : blank Clearance adjustable type (Asian standard only) : J										
<b>Nominal Shaft Diameter</b>										
Metric series (mm) : 8~50mm										
<b>Case unit length</b>										
Standard : blank Compact type : V Long type : W										
<b>Seal</b>										
No Seal : Blank One Side Seal : U Both Side Seal : UU										
<b>Retainer (by application temperature)**</b>										
Resin retainer (Standard) : Blank Steel retainer(High temperature) : A										
<b>Outer-sleeves (by corrosion resistance)</b>										
No plating(Standard) : Blank Electroless nickel plating : N Raydent treatment : R										
<b>Ball type (by corrosion resistance)</b>										
High carbon bearing steel ball (standard) : Blank Stainless steel ball : S										

\* Clearance adjustable type aluminum housing unit applies only to the Asian standard and the Nominal Shaft Diameter Selection is possible between 10mm to 50mm  
 \*\* Steel retainer applies only to Asian standard and European standard  
 \*\*\* It can combine with self-aligning linear bushing (SCE type)

### | PART NUMBER NOTATION |

Aluminum Case Unit (Open type)	SBR	20	UU	-	A	N	S
Samick open type Aluminum Case Unit							
Open type Aluminum Case Unit(Standard type) : SBR Open type Aluminum Case Unit(Clearance adjustable type) : TBR							
<b>Nominal Shaft Diameter*</b>							
16~50mm							
<b>Seal</b>							
No Seal : Blank One Side Seal : U Both Side Seal : UU							
<b>Retainer (by application temperature)**</b>							
Resin retainer (Standard) : Blank Steel retainer(High temperature) : A							
<b>Outer-sleeves (by corrosion resistance)</b>							
No plating(Standard) : Blank Electroless nickel plating : N Raydent treatment : R							
<b>Ball type (by corrosion resistance)</b>							
High carbon bearing steel ball (standard) : Blank Stainless steel ball : S							

\* SBR's nominal shaft diameter: 16~50mm, TBR's nominal shaft diameter: 16~50mm  
 \*\* By default, open type case unit cannot combine with a self-aligning linear bushing but some of the model is available with self-aligning linear bushing. Please contact Samick.



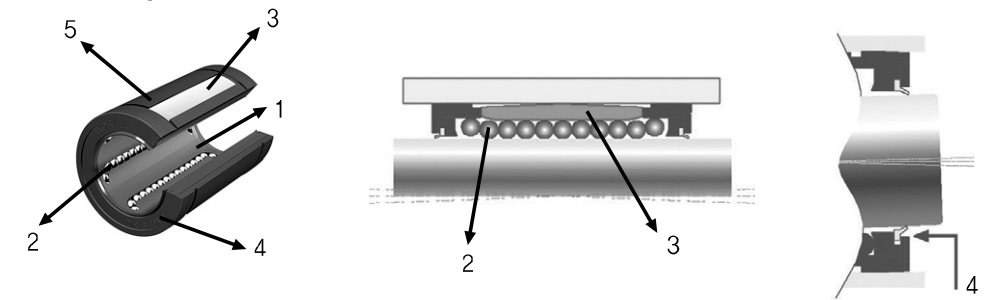
| PART NUMBER NOTATION |

<b>Support Rail Unit</b>	<b>SBS</b>	<b>C</b>	<b>g6</b>	<b>30</b>	<b>-</b>	<b>1000</b>	<b>L</b>
<b>Samick Support Rail Unit</b>							
Support Rail Unit for SBR : SBS Support Rail Unit for TBR : TBS							
<b>Shaft (by corrosion resistance)</b>							
No plating (Standard) : Blank Chrome plated shaft : C Nickel plated shaft : N Raydent treated shaft : R							
<b>Shaft tolerance</b>							
Asian standard g6 tolerance shaft : blank European standard h6 tolerance shaft : h6							
<b>Shaft Diameter</b>							
<b>Shaft Length</b> 100~3000mm							

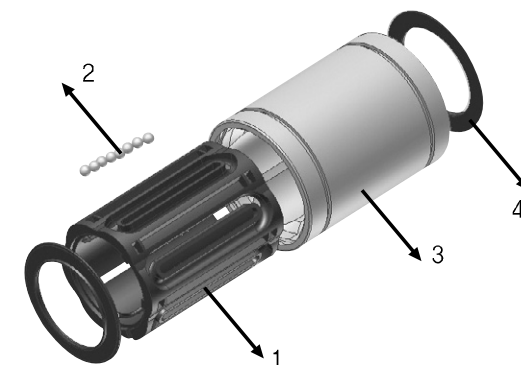
<b>Shaft</b>	<b>SF</b>	<b>C</b>	<b>g6</b>	<b>30</b>	<b>-</b>	<b>1000</b>	<b>L</b>
<b>Samick LM Shaft</b>							
<b>Corrosion resistance treatment</b>							
No plating (Standard) : Blank Chrome plated shaft : C Nickel plated shaft (Length Max 1m) : N Raydent treated shaft : R							
<b>Shaft tolerance</b>							
Asian standard g6 tolerance : Blank European standard h6 tolerance : h6							
<b>Shaft Diameter</b> 5~80mm							
<b>Shaft Length</b> 100~3000mm							

<b>Shaft Support</b>	<b>SK</b>	<b>20</b>
<b>Samick Shaft Support (Aluminum)</b>		
<b>Shaft Diameter</b>	6~40mm	

| Structure and Special Feature |



Part	Material	Special features and function
<b>1 Retainer</b>	- POM	- Guide ball's Motion - An essential element of unlimited linear stroke
<b>2 Ball</b>	- High carbon bearing steel - Stainless steel - Ceramic	- the support of the load by direct contact between shaft and ball plate - An essential element for low friction, high load capacity, high precision and high speed stroke
<b>3 Ball plate</b>	- High carbon bearing steel - Stainless steel * available Corrosion resistance plating	- Direct contact with the ball to hold the load - Stand on a high load with the specially designed ball groove. - A key part of the self-aligning
<b>4 Rubber Seal</b>	- NBR * optional item	- Direct contact with shaft - Blocking a foreign substance from outside - Blocking outflow of lubricant by sealing linear bushing - An floating seal to facilitate self-aligning
<b>5 Outer Sleeve</b>	- POM	- Support ball plate - Possible to run with highspeed and reduce the inertia force & noise because of low friction with lightweight



Part	Material	Special features and function
<b>1 Retainer</b>	- POM - Stainless Steel	- Guide ball's Motion - An essential element of unlimited linear stroke
<b>2 Ball</b>	- High carbon bearing steel - Stainless steel - Ceramic	- the support of the load by direct contact between shaft and ball plate - An essential element for low friction, high load capacity, high precision and high speed stroke
<b>3 Outer Sleeve</b>	- High carbon bearing steel - Stainless steel * available Corrosion resistance plating	- Direct contact with the ball to the receiving portion of the load - Direct contact part to housing - An essential element for high load capacity - Interchangeability
<b>4 Rubber Seal</b>	- NBR * optional item	- Blocking a foreign substance from outside - Blocking outflow of lubricant by sealing linear bushing

## ∴ Load Rating and Service Life of Linear Motion System

When determine a model that would best suit for service conditions of a linear motion system, the load rating and travel life of the model must be considered. To consider the load rating, you should know the static safety factor of the model, which is calculated based on the basic static load rating. The service life can be assessed by calculating the nominal life, based on the basic dynamic load rating, and you need to check if the values thus obtained meet your requirements.

### Basic static load rating

There are two basic load ratings of a linear motion system: basic static load rating (C<sub>0</sub>), which sets the static load allowance limit, and basic dynamic load rating(C), which is using for calculating travel life.

### Basic Static Load Rating (C<sub>0</sub>)

If a linear motion system, whether at rest or in motion, receives an excessive load or large impact, a local permanent deformation develops the raceway and rolling elements. And if the magnitude of the permanent deformation exceeds a certain limit, it hinders the smooth motion of the linear motion system. The basic static load rating refers to a static load in a given direction with given magnitude, which total permanent deformation of rolling elements and raceway at the contact area is approximately 0.0001 of the rolling element diameter. In a linear motion system, the basic static load rating is defined as the radial load. Thus, the limit of static load allowance is the basic static load rating. For the rating values of individual linear motion systems, see the respective specification table in this catalog.

### Static Safety Factor (f<sub>s</sub>)

A linear motion system may possibly receive an unpredictable external force due to the vibration or impact while it is at rest or in motion, or inertia as a result of starting and stopping. It is, therefore, necessary to consider the static safety factor against operating loads. The static safety factor(f<sub>s</sub>) indicates the ratio of a linear motion system load carrying capacity (basic static load rating, C<sub>0</sub>) to the load exerted there on.

$$f_s = \frac{C_0}{P} \quad \text{or} \quad f_s = \frac{M_b}{M}$$

- f<sub>s</sub> : Static safety factor
- C<sub>0</sub> : Basic static load rating (N)
- M<sub>b</sub> : Static permissible moment (N · mm)
- P : Calculated load (N)
- M : Calculated moment (N · mm)

To calculate a load exerted on the linear motion system, the mean load for calculating the service life and the maximum load for calculating the static safety factor must be obtained in advance. A system can receive unexpected excessive load when it is subject to frequent starts and stops, placed under machining loads, or when the severe moment is applied by overhanging loads. When selecting the correct type of a linear motion system for your application, be sure that the type you are considering can bear the maximum possible load when stopped and in operation. The table below specifies the standard values for the static safety factors.

Machine used	Loading conditions	f <sub>s</sub> lower limit
Ordinary Industrial Machine	Receives no vibration or impact	1.0 ~ 1.3
	Receives vibration or impact	2.0 ~ 3.0
Machine tool	Receives no vibration or impact	1.0 ~ 1.5
	Receives vibration or impact	2.5 ~ 7.0

For large radial loads	$\frac{f_H \cdot f_T \cdot f_C \cdot C_0}{P} \geq f_s$
------------------------	--

- C<sub>0</sub> : Basic static load rating (N)
- f<sub>H</sub> : Hardness factor
- f<sub>C</sub> : Contact factor
- P : Calculated load (N)
- f<sub>T</sub> : Temperature factor

### Basic Dynamic Load Rating (C)

The basic dynamic load rating (C) refers to a load in a given direction with given magnitude such that when identical linear motion systems in a group are interlocked with one another under the same conditions, the nominal life (L) of the systems is 50km (L=50km) if the systems use balls, and 100km(L=100km) if they use rollers. The basic dynamic load rating (C) is used to calculate the service life of a set of linear motion systems, which are interlocked with one another in response to a load. For rating values of individual linear motion systems, see the respective specification tables in this catalog.

### Nominal Life

The service lives of linear motion systems more or less vary from system to system even if they are manufactured to the same specifications and remain in service under the same operating conditions. Hence a guideline for determining the service life of a linear motion system is given based on nominal life, which is defined as follows. The nominal life refers to the total running distance that 90% of identical linear motion systems in a group, when interlocked with one another under the same conditions, can achieve without flaking develops. The nominal life (L) of a linear motion system can be obtained from the basic dynamic load rating (C) and load imposed (P) using the following equations.

For linear motion system with balls	For a linear motion system with rollers
$L = \left(\frac{C}{P}\right)^3 \times 50$	$L = \left(\frac{C}{P}\right)^3 \times 100$
$L_{100} = \left(\frac{C_{100}}{P}\right)^3 \times 100$	
$\ast C_{100} = \left(\frac{C}{1.26}\right)$	
L : Nominal life of 50km	L : Nominal life of 100km
L <sub>100</sub> : Nominal life of 100km	
C : Basic dynamic load rating of 50km	
C <sub>100</sub> : Basic dynamic load rating of 100km	
P : Applied load	

The travel life of the Linear Bushing can be obtained using the following equation

$$L = \left( \frac{f_H \times f_T \times f_c}{f_w} \times \frac{C}{P} \right)^3 \times 50$$

$$L_{100} = \left( \frac{f_H \times f_T \times f_c}{f_w} \times \frac{C_{100}}{P} \right)^3 \times 100$$

**L** : Nominal life of 50km      **L<sub>100</sub>** : Nominal life of 100km  
**C** : Basic dynamic load rating of 50km      **C<sub>100</sub>** : Basic dynamic load rating of 100km  
**P** : Applied load      **f<sub>H</sub>** : Hardness factor (see Fig 1)  
**f<sub>T</sub>** : Temperature (see Fig 2)      **f<sub>c</sub>** : Contact factor (see Table)  
**f<sub>w</sub>** : Load factor (see Table)

Once nominal life L is obtained using this equation, the Linear Bushing service life can be calculated using the following equation, if the stroke length and the number of reciprocating cycles are constant

$$L_h = \frac{L \times 10^6}{2 \times l_s \times N_s \times 60}$$

**L<sub>h</sub>** : Travel life in hours      **l<sub>s</sub>** : Stroke  
**N<sub>s</sub>** : Number of strokes per minute

## Factors that affect the travel life

### Hardness factor (f<sub>H</sub>)

To ensure achievement of the optimum load rating of the Linear Bushing, the raceway hardness must be 58 to 64 HRC. At hardness below this range, the basic dynamic and static load ratings decrease. The ratings must therefore be multiplied by the respective hardness factors (f<sub>H</sub>).

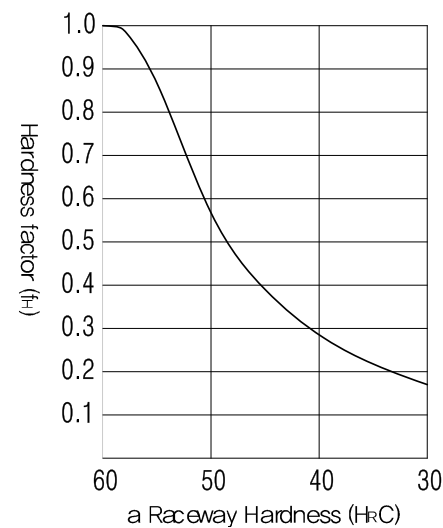


Fig1 Hardness factor (f<sub>H</sub>)

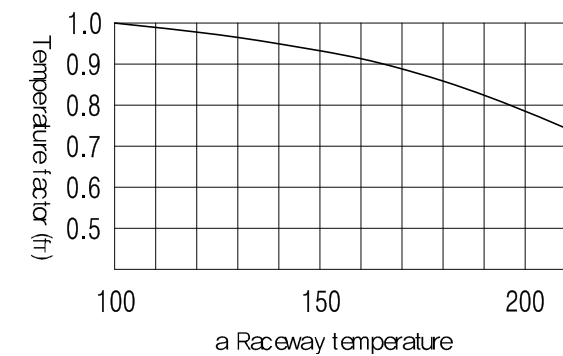


Fig2 Temperature factor (f<sub>T</sub>)

### Temperature factor (f<sub>T</sub>)

For Linear Bushings used at ambient temperatures over 100°C, a temperature factor corresponding to the ambient temperature, selected from the diagram, must be taken into consideration. For higher than 80°C application, the seals, end plates and retainer must be changed for high temperature specifications (Temperature range: 20°C ~ 80°C). In addition, please note that the selected Linear Bushing itself must be a model with high-temperature specifications.

### Contact factor (f<sub>c</sub>)

When multiple Linear Bushings are used laid over one another, moments and mounting-surface precision will affect operation, making it difficult to achieve uniform load distribution. For Linear Bushings used laid over one another, multiply the basic load rating (C or C<sub>0</sub>) by a contact factor selected from the table below.

Number of linear bushings on a shaft	Contact factor (f <sub>c</sub> )
2	0.81
3	0.72
4	0.66
5	0.61
Over 6	0.60
In normal use	1.0

### Load factor (f<sub>w</sub>)

In general, machines in reciprocal motion are likely to cause vibration and impact during operation, and it is particularly difficult to determine the magnitude of vibration that develops during high-speed operation, as well as that of impact during repeated starting and stopping in normal use. Therefore, where the effects of speed and vibration are estimated to be significant, divide the basic dynamic load rating (C) by a load factor selected from the table below.

Operating conditions		Load factor (f <sub>w</sub> )
Load conditions	Speed	
No impact and vibration	Under 15m/min	1.0~1.5
Slight impact and vibration	Under 60m/min	1.5~2.0
Considerable impact and vibration	Over 60m/min	2.0~4.0

## ∴ Load Consideration

When designing a linear motion system, it is necessary to consider how the variables of operation will affect performance. The following examples demonstrate how the position of the load and the center of gravity can influence the product selection. When evaluating your application, review each of the forces acting on your system and determine the product best for your needs.

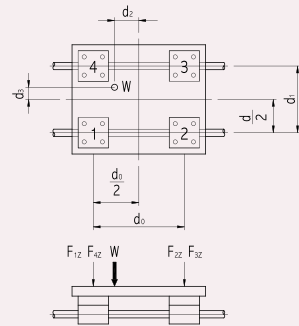
**Horizontal Application** | At the time of movement with uniform velocity or at the time of stop

$$F_{1z} = \frac{W}{4} + \left(\frac{W}{2} \cdot \frac{d_2}{d_0}\right) - \left(\frac{W}{2} \cdot \frac{d_3}{d_1}\right)$$

$$F_{2z} = \frac{W}{4} - \left(\frac{W}{2} \cdot \frac{d_2}{d_0}\right) - \left(\frac{W}{2} \cdot \frac{d_3}{d_1}\right)$$

$$F_{3z} = \frac{W}{4} - \left(\frac{W}{2} \cdot \frac{d_2}{d_0}\right) + \left(\frac{W}{2} \cdot \frac{d_3}{d_1}\right)$$

$$F_{4z} = \frac{W}{4} + \left(\frac{W}{2} \cdot \frac{d_2}{d_0}\right) + \left(\frac{W}{2} \cdot \frac{d_3}{d_1}\right)$$



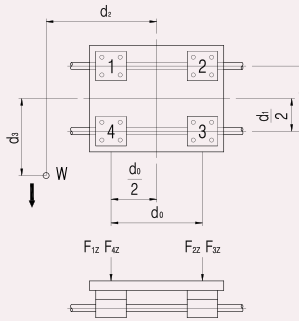
**Horizontal Application** | At the time of movement with uniform velocity or at the time of stop

$$F_{1z} = \frac{W}{4} + \left(\frac{W}{2} \cdot \frac{d_2}{d_0}\right) - \left(\frac{W}{2} \cdot \frac{d_3}{d_1}\right)$$

$$F_{2z} = \frac{W}{4} - \left(\frac{W}{2} \cdot \frac{d_2}{d_0}\right) - \left(\frac{W}{2} \cdot \frac{d_3}{d_1}\right)$$

$$F_{3z} = \frac{W}{4} - \left(\frac{W}{2} \cdot \frac{d_2}{d_0}\right) + \left(\frac{W}{2} \cdot \frac{d_3}{d_1}\right)$$

$$F_{4z} = \frac{W}{4} + \left(\frac{W}{2} \cdot \frac{d_2}{d_0}\right) + \left(\frac{W}{2} \cdot \frac{d_3}{d_1}\right)$$

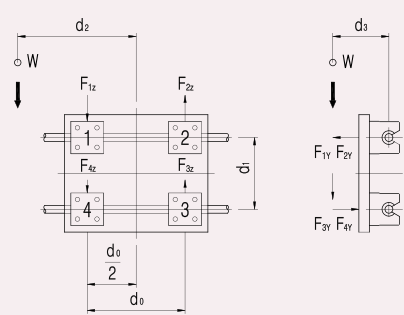


**Side Mounted Application** | At the time of movement with uniform velocity or at the time of stop

$$F_{1y} \sim F_{3y} = \frac{W}{2} \cdot \frac{d_3}{d_0}$$

$$F_{1z} = F_{3z} = \frac{W}{4} + \left(\frac{W}{2} \cdot \frac{d_2}{d_0}\right)$$

$$F_{2z} = F_{4z} = \frac{W}{4} - \left(\frac{W}{2} \cdot \frac{d_2}{d_0}\right)$$



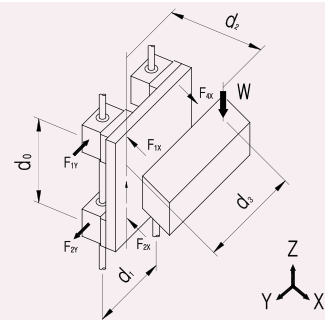
**Vertical Application** | At the time of movement with uniform velocity or at the time of stop.  
At the time of start and stop, the load varies because of inertia

$$F_{1x} \sim F_{3x} = \frac{W}{2} \cdot \frac{d_2}{d_0}$$

$$F_{1y} \sim F_{3y} = \frac{W}{2} \cdot \frac{d_3}{d_0}$$

$$F_{1x} + F_{3x} \sim F_{2x} + F_{4x}$$

$$F_{1y} + F_{3y} \sim F_{2y} + F_{4y}$$



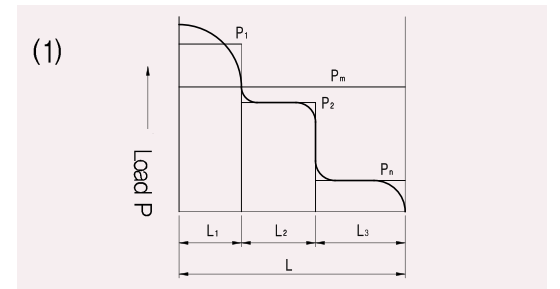
## ∴ Mean Effective Load at Varying Load

The load acting on a linear system changes depending on the application, for example, when the linear system starts or stops reciprocating motion, while it is operating at a fixed speed, and according to whether the linear system carries work or not. For a fluctuating load, it is important to obtain the mean effective load.

**For stepped load according to the travelling distance**

$$P_m = \sqrt{\frac{1}{L} (P_1^3 \cdot L_1 + P_2^3 \cdot L_2 + \dots + P_n^3 \cdot L_n)} \quad \dots \dots \dots (1)$$

- $P_m$  : mean effective load in fluctuation (N)
- $P_n$  : floating load (N)
- $L$  : Total traveling distance (mm)
- $L_n$  : Traveling distance with carrying  $P_n$  (mm)

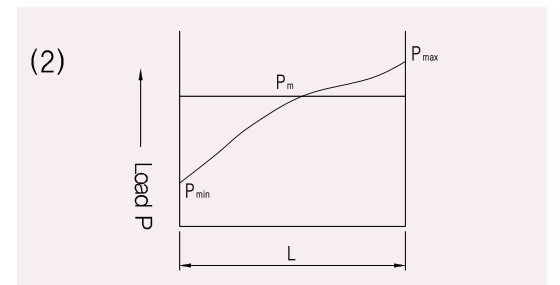


For loads that changes step wisely

**For almost linearly varying load**

$$P_m \cong \frac{1}{3} (P_{min} + 2 \cdot P_{max}) \quad \dots \dots \dots (2)$$

- $P_m$  : mean effective load in fluctuation (N)
- $P_{min}$  : Minimum value of fluctuating load (N)
- $P_{max}$  : Maximum value of fluctuating load (N)

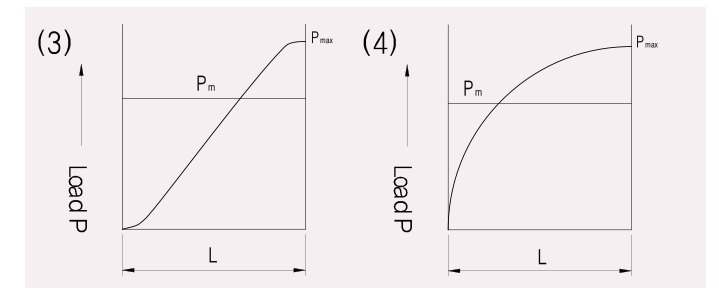


For loads that changes monotonously

**When the load draws a sine curve**

$$P_m \cong 0.65 P_{max} \quad \dots \dots \dots (3)$$

$$P_m \cong 0.75 P_{max} \quad \dots \dots \dots (4)$$



For loads that changes sinusoid ally



## High Capacity Self-Aligning Linear Bushing - SUPERBALL

### Higher Load Ratings and Travel Life

Specially designed ball plate is made of Hardened steel, and the precisely ground groove is slightly larger than the ball size, which provides greater contact area between the ball and the ball plate. In addition, this design provides 3 times higher load ratings and 27 times longer travel life compared to conventional Linear Bushing.

### Self-Alignment

Ball plate has a convex shape to provide a pivot point at the center, which allows Self Alignment up to 0.5°. This Self Alignment capability eliminates any possibility of edge pressure caused by inaccurate machining, errors on mounting, or shaft deflection. Moreover, it obtains uniform load distribution and low friction motion.

### Smooth and Silent Running

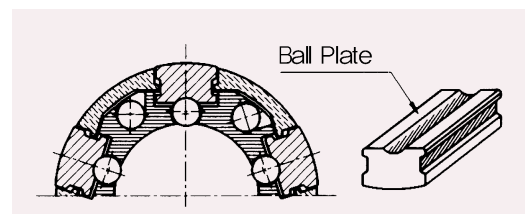
SUPERBALL has extremely smooth running due to the uniquely designed ball retainer and the outer sleeve. They are made of Engineering Polymer, which has light weight, low friction, and high wear-resistance. Due to them, the smooth and silent running can be obtained.

### Clearance Adjustment

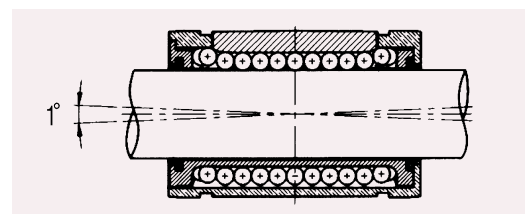
SUPERBALL's ball plates are designed to float in the outer sleeve. This allows clearance between the balls and shaft to be adjusted for the best application environment by using with the housing.

### Interchangeability

SUPERBALL is designed to be fully Interchangeable with conventional linear bushing.



Cross-section of SUPERBALL



SUPERBALL's self-alignment feature

## Cost Effectiveness

### Lower cost on installation

Self-Alignment feature can compensate the inaccurate machining of the base, so less installation time and cost can be obtained

### Higher load rating and longer travel life

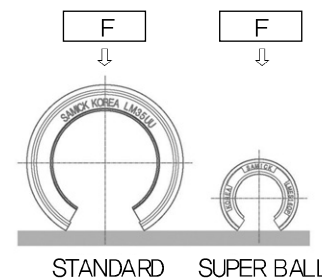
Compared to the same size conventional linear bushings, SUPERBALL will offer higher load rating and longer travel life.

### Reduction of material cost

SUPERBALL's higher load rating enables the use of smaller components, and reducing material cost.

### Energy saving

SUPERBALL is designed with lightweight, lower inertia, and low friction, so it enables the moving parts to have rapid motion with lower driving power.



STANDARD SUPER BALL

## Load Ratings and Travel Life

SUPERBALL's load ratings give an influence to travel life with load direction, ball circuit orientation, and hardness of the shaft.

No. of Ball Row	Orientation of Balls		
	4 Row	5 Row	6 Row
Max. Load			
Equation	$F = 1.41 \times C$	$F = 1.46 \times C$	$F = 1.26 \times C$
Min. Load			
Equation	$F = C$	$F = C$	$F = C$

### Basic Dynamic load rating(C) and travel life

The travel life of a Linear Bushing is determined largely by the quality of the shaft. The Basic Dynamic load rating is maximum continuous load that can be applied to the Linear Bushing with 90% of reliability achieving after 50km operation under normal conditions. The nominal travel life can be calculated by follow equation.

$$L = \left[ \frac{C}{P} \right]^3 \times 50$$

$$L_{100} = \left[ \frac{C_{100}}{P} \right]^3 \times 100$$

L : Nominal life(basis:50km, unit: Km)  
 L<sub>100</sub> : Nominal life(basis:100km, unit: Km)  
 C : Basic dynamic load rating(basis:50km, unit: N)  
 C<sub>100</sub> : Basic dynamic load rating(basis:100km, unit: N)  
 P : Applied load

Practically, other factors will affect the life as follows

$$L = \left[ \frac{f_H \times f_T \times f_C}{f_W} \times \frac{C}{P} \right]^3 \times 50$$

$$L_{100} = \left[ \frac{f_H \times f_T \times f_C}{f_W} \times \frac{C_{100}}{P} \right]^3 \times 100$$

f<sub>w</sub> : Load factor  
 f<sub>H</sub> : Hardness factor  
 f<sub>T</sub> : Temperature factor  
 f<sub>C</sub> : Contact factor

From the above equations, the stroke and frequency are constant, the Travel Life can be calculated by following equation

$$L_h = \frac{L \times 10^6}{2 \times l_s \times N_k \times 60}$$

$L_h$  : Travel life (hour)  
 $l_s$  : Stroke (mm)  
 $N_k$  : Number of strokes per minute (cpm)

## Examples of Calculation and Choosing a proper SUPERBALL

The Maximum applied load and the travel life are the most important factor for choosing a proper Linear Bushing size. Below are the sample calculation of the expecting travel life and choosing of proper Linear Bushing size.

〈Working conditions〉			
- Applied load	: 250N(P)	- Stroke	: 250mm (l <sub>s</sub> )
- Number of strokes per minutes	: 60(N <sub>k</sub> )	- Shaft Hardness	: HRC60 (f <sub>H</sub> = 1.0)
- Operating speed	: 30m/min		

$$\begin{aligned} \text{Operating Speed } V &= 2 \times l_s \times N_k \\ &= 2 \times 250 \times 60 \\ &= 30000 \text{ mm/min } (f_w = 1.6) \end{aligned}$$

Other factors (f<sub>c</sub>, f<sub>r</sub>) are considered as 1.0

### Calculation of expected travel life

Since, basic dynamic load rating is based on travel life of 50km and assuming all other factors as 1.0, you can choose the Linear Bushing size that you can expected Travel life. Let's try LMES20UU with the above working conditions

$$L = \left[ \frac{1.0 \times 1.0 \times 1.0}{1.6} \times \frac{2,580}{250} \right]^3 \times 50$$

$$\approx 13,417 \text{ km}$$

$$L_h = \frac{13,417 \times 10^6}{2 \times 0.250 \times 60 \times 60}$$

$$\approx 7,454 \text{ hours}$$

### Choosing proper Linear Bushing

Let's assume our design travel life is 15,000hours,

$$L = 15,000 \times 2 \times 250 \times 10^{-6} \times 60 \times 60 = 27,000 \text{ km}$$

$$C = \frac{250 \times 1.6}{1.0 \times 1.0 \times 1.0} \times \sqrt[3]{\frac{27,000}{50}} = 3,257 \text{ N}$$

Therefore, the proper SUPERBALL for above condition is LMES25UU which has 3800N as the Basic dynamic load rating.

## Housing and Shaft

### Housing

For SUPERBALL's application, Housing is required. Tolerance of Housing bore will affect the life and the accuracy of application. See the below Table However, if the tolerance of housing is H7, tight fitting can be occurred at both ends of outer- sleeves in case of LMES type

Table9. Housing and tight fitting

Part number(mm)	LMES10	LMES12	LMES16	LMES20	LMES25	LMES30	LMES40	LMES50	
Inner diameter(mm)	19	22	26	32	40	47	62	75	
Tolerance(H7)		+0.021 0			+0.025 0		+0.030 0		
Part number(Inch)	LMBS4	LMBS6	LMBS8	LMBS10	LMBS12	LMBS16	LMBS20	LMBS24	LMBS32
Inner diameter(Inch)	0.5	0.625	0.875	1.125	1.25	1.5625	2	2.375	3
Tolerance(H7)	0 +0.007	0 +0.007	0 +0.008	0 +0.008	0 +0.010	0 +0.010	0 +0.012	0 +0.012	0 +0.012

### Shaft

Because the balls in SAMICK SUPERBALL as rolling elements are running directly on the shaft surface, the hardness, surface finish, and tolerance of shaft will largely affect on the traveling performance of SUPERBALL. The shaft must be manufactured with following conditions:

#### 1) Hardness

The hardness must be HRC 58 to 64. The shaft with hardness less than HRC58 will lead decreasing of travel life and permissible load.

#### 2) Surface Finishing

The surface finishing must be 1.6S or better for smooth operation.

#### 3) Tolerance

The correct tolerance of the shaft diameter is recommended. See the below table.

Table10. Shaft and tight fitting

Part number(mm)	LMES10	LMES12	LMES16	LMES20	LMES25	LMES30	LMES40	LMES50	
diameter(mm)	10	12	16	20	25	30	40	50	
Tolerance(h6)	0 -0.009	0 -0.011	0 -0.011	0 -0.013	0 -0.013	0 -0.013	0 -0.016	0 -0.016	
Part number(Inch)	LMBS4	LMBS6	LMBS8	LMBS10	LMBS12	LMBS16	LMBS20	LMBS24	LMBS32
diameter(Inch)	0.25	0.375	0.500	0.625	0.750	1.000	1.250	1.500	2.000
Part number(g6)	-0.0002 -0.0006	-0.0002 -0.0006	-0.0002 -0.0007	-0.0002 -0.0007	-0.0003 -0.0008	-0.0003 -0.0008	-0.0004 -0.0010	-0.0004 -0.0010	-0.0004 -0.0012

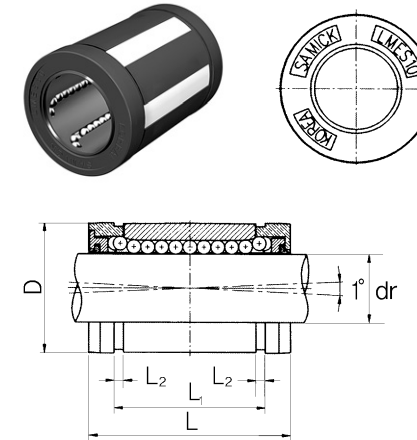


## Part Number Notation

<b>Self-Aligning Linear Bushing</b>	LM	ES	16	UU	OP	-	N	S
<b>Samick Linear Bushing</b>								
<b>Standards</b>	Metric series (mm) : ES Inch series (inch) : BS							
<b>Nominal Shaft Diameter</b>	Metric series (mm) : 10~50mm Inch Series : #4~#32							
<b>Seal</b>	No Seal : Blank One Side Seal : U Both Side Seal : UU							
<b>Type</b>	Standard type : Blank Open type (for support rail) : OP							
<b>Corrosion resistance type</b>	No-plating (Standard) : Blank Ball plate nickel plating : N Stainless steel ball plate : M* Ball plate Chrome plating : C							
<b>Ball type (by corrosion resistance)</b>	High carbon bearing steel ball (standard) : Blank Stainless steel ball : S							

\* LMES10, LMES12 and LMBS4, LMBS6, LMBS8 only with stainless steel ball plate

## LMES Self-Aligning Linear Bushing



<b>Self-Aligning linear Bushing</b>	LMES	20	UU	-	N	S
<b>Nominal Shaft Diameter</b>						
<b>Seal</b>	No Seal : Blank One Side Seal : U Both Side Seal : UU					
<b>Corrosion resistance type</b>	No-plating (Standard) : Blank Ball plate nickel plating : N Ball plate Chrome plating : C Stainless steel ball plate : M****					
<b>Ball type (by corrosion resistance)</b>	High carbon bearing steel ball (standard) : Blank Stainless steel ball : S					

PART NUMBER	DIAMETER		D*	L ±0.2	L <sub>1</sub> ±0.2	L <sub>2</sub> mm	BASIC LOAD RATING(N)		NO. OF BALL CIRCUIT	WEIGHT (g)
	dr.	TOLERANCE					DYNAMIC**C	STATIC**C <sub>0</sub>		
LMES10	10	+0.008	19	29	21.7	1.35	750	550	5	17
LMES12	12	0	22	32	22.7	1.35	1230	1100	5	23
LMES16	16	+0.009	26	36	24.7	1.35	1550	1250	5	28
LMES20	20	+0.001	32	45	31.3	1.65	2580	1670	6	61
LMES25	25	+0.011	40	58	43.8	1.9	3800	2750	6	122
LMES30	30	+0.001	47	68	51.8	1.9	4710	2800	6	185
LMES40	40	+0.013	62	80	60.4	2.2	6500	5720	6	360
LMES50	50	+0.002	75	100	77.4	2.7	11460	7940	6	580

\* Based on nominal housing bore

\*\* Dynamic load rating is based on the nominal life of 50km. In case of 100km, C on the table need to be divided by 1.26

Ex) LM12 s 50km basis dynamic load rating C = 410N

LM12 s 100km basis dynamic load rating C<sub>100</sub> = 410 / 1.26 = 325.40N

\*\*\* Dimension : mm

\*\*\*\* LMES10, LMES12 only with stainless steel ball plate

# :: SAMICK LINEAR BUSHING

SAMICK Linear Bushing, LM type is the linear motion system with unlimited stroke by applying with LM shaft. Because of the point contact between Balls and LM shaft, minimum friction can be acquired and that can give you the high precision motion. SAMICK Linear Bushing serves the alignment of the balls toward the LM Shaft by the single Retainer and cylindrical shape of Raceway. Outer Sleeve is made of high-carbon Chromium Bearing Steel, and inner and outer grinding processes are applied after Heat treatment.

## Interchangeability

The Dimensions of SAMICK Linear Bushing are standardized to have full interchangeability. LM shaft is provided with the cylindrical grinding to have high precision fitting clearance.

## Rigid Outer Sleeve

Hardened and Precisely ground Outer Sleeve is made of Bearing steel, and can be direct assembled with the needle bearing on outer surface.

## High precision Retainer

The single body retainer guides 4~6 ball circuits, and it makes the precision guiding against the balls moving direction and smooth motion.

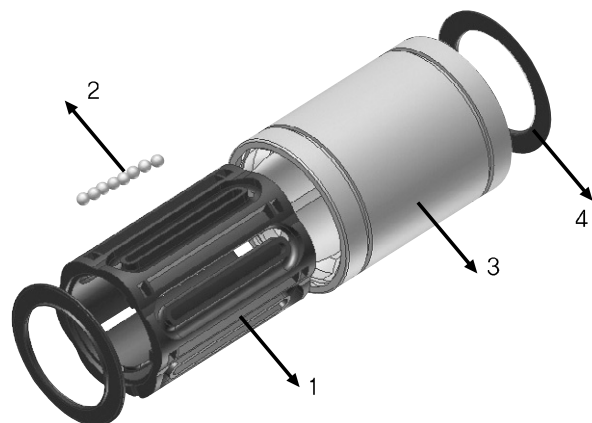
## LM Case Unit

LM Case Unit, SC type is consist of the light Aluminum case and LM type Linear Bushing, so the assembly can be finished by simple bolting. Longer life can be obtained by adjusting the Ball circuit orientation of Linear Bushing against the direction of load.

## Application

SAMICK Linear Bushing are widely used in Precision equipments: Computer and peripheral equipments, Measuring equipments, Auto recording equipments, and 3D measuring equipments, and Linear Motion systems in Machine for Mass Production: Multi-Axis Drilling machines, Punching Press, Tool Grinders, Auto-Gas cutters, printing machines, card selectors, food packing machines, and etc.

# :: Structure



part	Material
1 Retainer	- POM - Stainless Steel
2 Ball	- High carbon bearing steel - Stainless steel - Ceramic
3 Outer-sleeve	- High carbon bearing steel ※ available Corrosion resistance plating
4 Rubber Seal	- NBR (Acrylonitrile Butadiene Rubber)* ※ optional item



## | PART NUMBER NOTATION |

Linear Bushing	LM	E	F	P	20	L	UU	OP	-	A	N	S
<b>Samick Linear Bushing</b>												
<b>Standards(Asia, Europe)</b>												
Asian Standard : Blank / European Standard : E												
<b>Flange option</b>												
Standard : Blank Circular type : F Square type : K Oval type : H												
<b>Flange Location</b>												
Standard : Blank Pilot : P Middle : M												
<b>Nominal Shaft Diameter</b>												
Standard : 5 ~ 60mm Flange type : 6 ~ 60mm												
<b>Length</b>												
Standard : Blank Long : L												
<b>Seal</b>												
No Seal : Blank One Side Seal : U Both Side Seal : UU												
<b>Sloting Type</b>												
Standard type : Blank Open type : OP Adjustable type : AJ												
<b>Retainer (by application temperature)</b>												
Resin retainer (Standard) : Blank Steel retainer(High temperature) : A												
<b>Outer-sleeves (by corrosion resistance)</b>												
No plating(Standard) : Blank Electroless nickel plating : N Raydent treatment : R												
<b>Ball type (by corrosion resistance)</b>												
High carbon bearing steel ball (standard) : Blank Stainless steel ball : S												

# ∴ Load rating and Travel Life

The Load rating of SAMICK Linear Bushing can be affected by the balls orientation against the Load. The Basic Load rating in the table is the Load rating of Linear Bushing when 1 (one) Ball circuit are just beneath the load. As shown in Table, if the Ball are located on symmetrical position against the Load, the Load rating will be increased and the travel life will be extended.

## Load ratings and Orientation of Bals

No. of Ball Row	Orientation of Bals		
	4 Row	5 Row	6 Row
Max. Load			
Equation	$F = 1.41 \times C$	$F = 1.46 \times C$	$F = 1.26 \times C$
Min. Load			
Equation	$F = C$	$F = C$	$F = C$

## Basic Dynamic load rating(C) and travel life

The travel life of a Linear Bushing is determined largely by the quality of the shaft. The Basic Dynamic load rating is maximum continuous load that can be applied to the Linear Bushing with 90% of reliability achieving after 50km traveling under normal conditions. The nominal travel life can be calculated by follow equation.

$$L = \left[ \frac{C}{P} \right]^3 \times 50$$

$$L_{100} = \left[ \frac{C_{100}}{P} \right]^3 \times 100$$

$L$  : Nominal life (basis:50km, unit: Km)  
 $L_{100}$  : Nominal life (basis:50km, unit: Km)  
 $C$  : Basic dynamic load rating(basis:50km, unit: N)  
 $C_{100}$  : Basic dynamic load rating(basis:10km, unit: N)  
 $P$  : Applied load

Practically, other factors (Hardness factor, Load factor, Contact factor, etc) will affect the life as follows

$$L = \left[ \frac{f_H \times f_T \times f_C}{f_W} \times \frac{C}{P} \right]^3 \times 50$$

$$L_{100} = \left[ \frac{f_H \times f_T \times f_C}{f_W} \times \frac{C_{100}}{P} \right]^3 \times 100$$

$f_W$  : Load factor  
 $f_H$  : Hardness factor  
 $f_T$  : Temperature factor  
 $f_C$  : Contact factor

## Equivalent factor and Travel life

If a Linear Bushing or two Linear Bushings laid beside one another on one shaft, and the moment load is applied, calculate the Equivalent load.

$$P_U \cong K \cdot M$$

$P_U$  : Equivalent Load when the moment applied  
 $K$  : Equivalent factor(see Table below)  
 $M$  : Applied Moment where  $P_V$  should be up to Basic load rating( $C_0$ )

If the moment load and the radial load are applied, the travel life can be calculated by the sum of the moment load and the radial load. From the above equations, the stroke and frequency are constant; the travel life can be calculated by following equation

$$L_h = \left[ \frac{L \times 10^6}{2 \times l_s \times N_s \times 60} \right]$$

$L_h$  : travel life(hr)  
 $l_s$  : Stroke(mm)  
 $N_s$  : Number of stroke per minute (cpm)

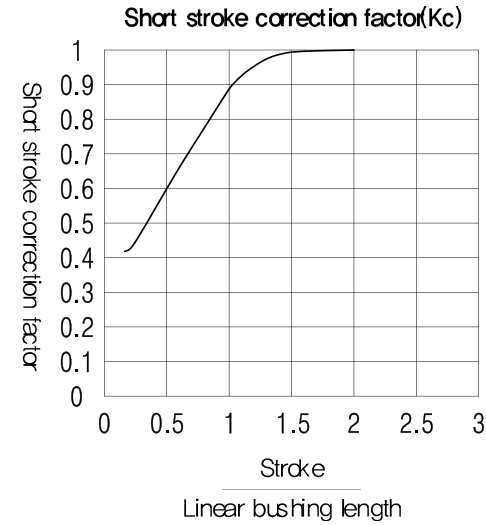
## Equivalent factor for Linear Bushing

Equivalent factor (K)							
P/N	1EA	2EA	P/N	1EA	P/N	1EA	2EA
LM 5	1.253	0.178	LM 5L	0.223	LME 5	0.669	0.123
LM 6	0.553	0.162	LM 6L	0.201	LME 8	0.514	0.116
LM 8S	0.708	0.166	LM 8L	0.151	LME 12	0.389	0.090
LM 8	0.442	0.128	LM 10L	0.118	LME 16	0.343	0.081
LM 10	0.389	0.101	LM 12L	0.113	LME 20	0.291	0.063
LM 12	0.389	0.097	LM 13L	0.107	LME 25	0.209	0.052
LM 13	0.343	0.093	LM 16L	0.096	LME 30	0.167	0.045
LM 16	0.279	0.084	LM 20L	0.082	LME 40	0.127	0.039
LM 20	0.257	0.071	LM 25L	0.060	LME 50	0.105	0.031
LM 25	0.163	0.054	LM 30L	0.053	LME 60	0.098	0.024
LM 30	0.153	0.049	LM 35L	0.050			
LM 35	0.143	0.045	LM 40L	0.043			
LM 40	0.117	0.040	LM 50L	0.034			
LM 50	0.096	0.032	LM 60L	0.031			
LM 60	0.098	0.028					

Note 1) The equivalent factor for LMF/K/H, LMFP/KP/H and SC types are same as LM type.  
 Note 2) The equivalent factor for LMF-L, LMK-L, LMH-L and SCW types are same as LM-L type.  
 Note 3) The equivalent factor for LMEF/K/H and SCE types are same as LME type.

### Short stroke Applications

In applications when the stroke is short, the life of the shaft is shorter than that of the Linear Bushing. In short stroke applications, the required dynamic load rating must be multiplied by the shot stroke correction factor (Kc) found on Fig right side.



## ❖ Lubrication and Friction

Linear Bushing is used with grease lubrication or oil lubrication but in some case, it is used without any lubrication.

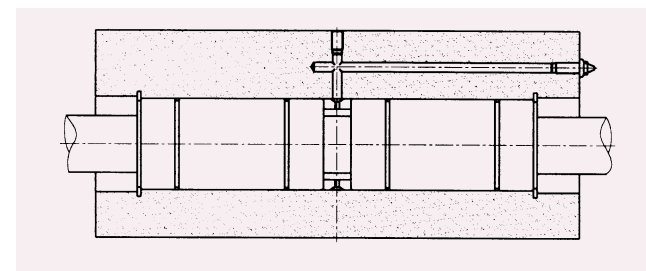
### Grease Lubrication

Before applying the grease, the anticorrosive oil must be removed by kerosene or organic solvent, and applying the grease after drying. Must Applying grease directly on the ball for both side sealed type (UU), and applying same as above or applying on the shaft for without sealed type. Lithium soap radical of viscosity mark (JIS No. 2) is recommended for use.

### Oil Lubrication

Operating Temp.	Viscosity
-30°C ~ 50°C	VG 15 ~ 46
50°C ~ 80°C	VG 46 ~ 100

There is no need to remove anticorrosive oil when oil is used for lubrication. ISO viscosity grade VG15~100 oil is usually used according to the temperature. The turbine oil, machine oil, and spindle oil are usually used as lubrication oil. Drop the oil on the shaft for lubrication, or supply it through an oil hole provided on the housing (Fig 6). However, dropping lubrication is not used in both seal type because the seal remove oil, because. Contact SAMICK for Linear Bushing with lubrication hole for user's demands.



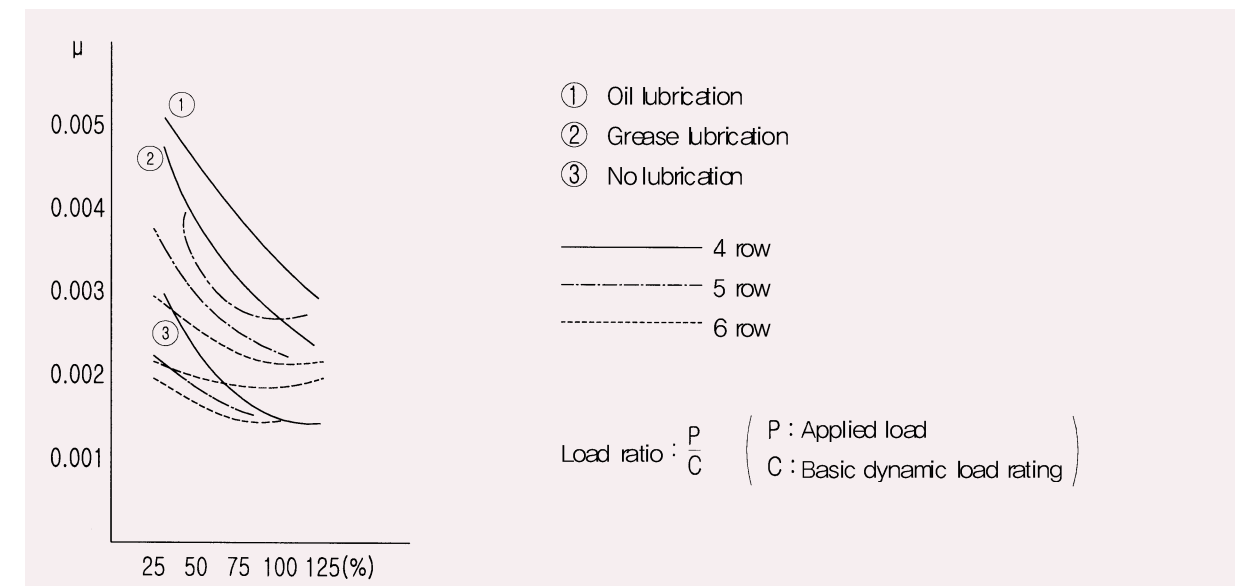
### Coefficient of Friction

Linear Bushing has balls as rolling elements, so it gives rise to reduces the frictional resistance. Static friction, in particular, is very low, and there is just little difference between static and dynamic friction, so, that stick-slip does not occur. Such low friction makes submicron feeding possible. The normal friction coefficient is on Fig below, and the Friction resistance can be calculated by following equation.

$$F = \mu \cdot P + f_s$$

F	: Friction resistance force	(N)
f <sub>s</sub>	: Resistant of Seal (0.3 ~ 2.4N)	
P	: Applied External load (Perpendicular Load against shaft core)	(N)
μ	: Friction Coefficient(Static or Dynamic)	

### Coefficient of Kinetic Friction



Coefficient of Kinetic Friction

# Installation Guide

Recommended Tolerance of Housing bore for SAMICK Linear Bushing are in Table. Normal fit is standard, but for without clearance, pressed fit is also available.

Type		Case	
Part number	Grade	Normal fit	Pressed fit
LM	Higher(H)	H7	J7
LME	—	H7	K6, J6
LMF / FP LMK / KP LMH / HP LM_L LMF / FP_L LMK / KP_L LMH / HP_L LMFM	—	H7	J7

## Clearance of Outer sleeve and Shaft

Normal fit is standard for using of Linear Bushing with LM shaft. And, for without clearance, tight fit is available. Next table shows outer diameter tolerance of shaft.

Type		LM Shaft	
Part number	Grade	Normal fit	Tight fit
LM	Higher(H)	f6, g6	h6
LME	—	h7	K6
LMF / FP LMK / KP LMH / HP LM_L LMF / FP_L LMK / KP_L LMH / HP_L LMFM	—	f6, g6	h6

Negative diametric clearance should not exceed what is specified in the dimension table.

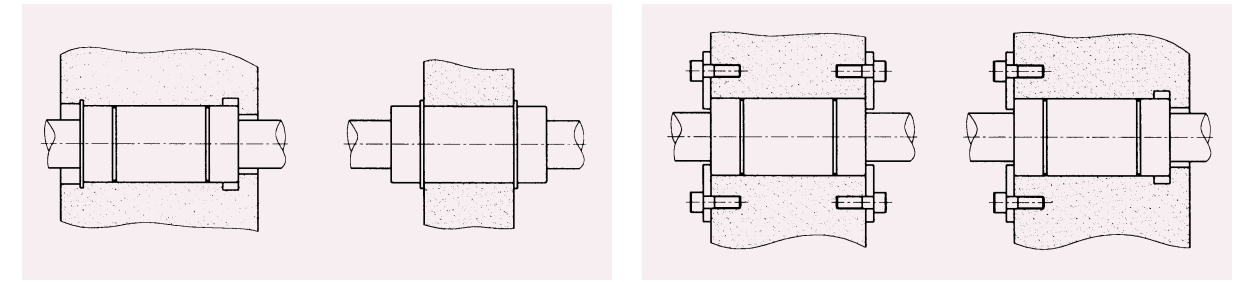
Radical Clearance(μm)															
Type \ Dr.	5	6	8S	8	10	12	13	16	20	25	30	35	40	50	60
LM(μm)	-3	-5	-5	-5	-5	-5	-7	-7	-9	-9	-9	-13	-13	-13	-16
LME(μm)	-5			-5		-7		-7	-9	-9	-9		-13	-13	-16

## Mounting

High holding strength toward LM shaft direction is not required, but just press fit only for mounting is not recommended.

### Standard type

Feasible mounting methods are illustrated in Fig 8 and Fig 9. At this moment, fix the linear bushing with retaining rings and cover plates



Mounting with retaining rings

Mounting with cover plates

### Retaining ring for Mounting

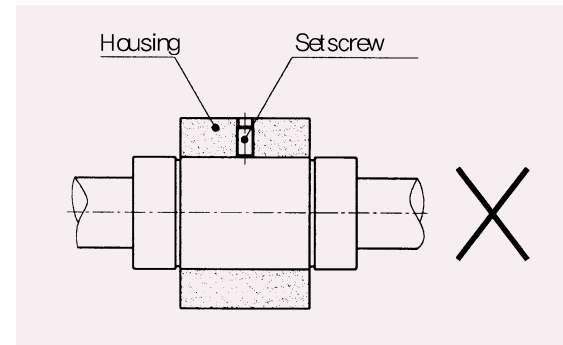
Retaining ring for LM type SAMICK Linear Bushing are used for mounting as shown in the table below

Part number	Retaining ring(mm)			
	External (for Shaft)		Internal(for Bore)	
	C type	Needle type	C type	Needle type
LM 5	10	10	10	10
LM 6	12	12	12	12
LM 8	—	15	15	15
LM 8S	—	15	15	15
LM 10	19	19	19	19
LM 12	21	21	21	21
LM 13	23	22	23	—
LM 16	28	—	28	28
LM 20	32	—	32	32
LM 25	40	40	40	40
LM 30	45	45	45	45
LM 35	52	52	52	52
LM 40	—	60	60	60
LM 50	—	80	80	80
LM 60	—	90	90	90

Note) The information in the table are common for LM and LM-L type

**Setscrew mounting prohibited**

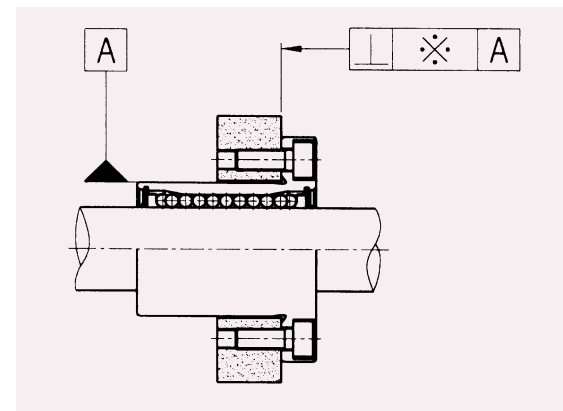
Mounting a Linear Bushing with a set screw as show in Figure will cause deformation of the outer sleeve and should be avoided.



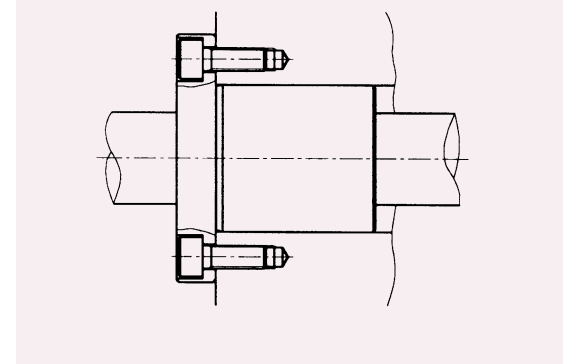
Mounting with setscrew

**Flanged type**

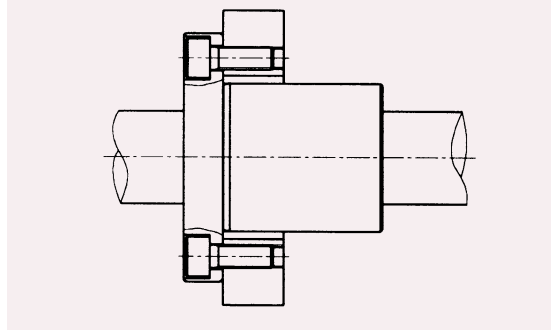
Mounting for LMF, LMK, LMH (included long type), only mounting the flange with mounting bolt can be all of mounting because of its single body shape. Geometric Dimensional Tolerance should be considered when the Outer Sleeve is the datum for installation.



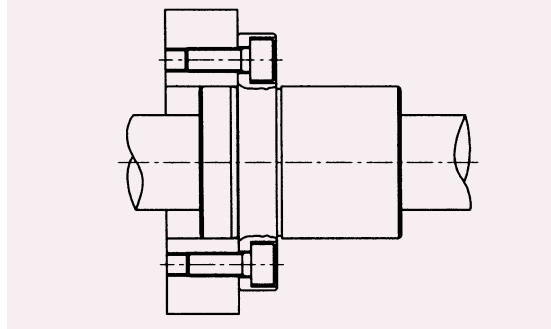
• Mounting with datum from Outer Sleeve



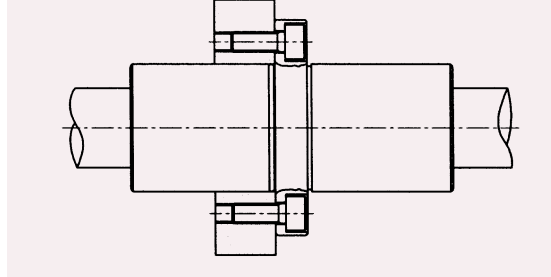
• Mounting of Flange with mounting bolt



• Mounting of Pilot flanged type



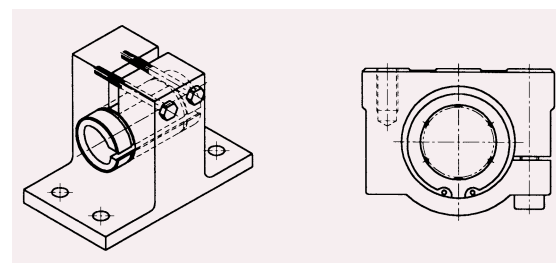
• Mounting of Middle flanged type



Flanged type mounting

**Mounting of Adjustable type**

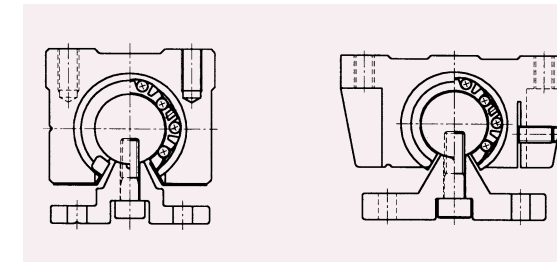
Adjustment of clearance for Adjustable type (AJ) and LM shaft can be obtained by assembling with the adjustable type Housing. In this case, the slotted side of Linear Bushing should be located at 90° of open side of Housing for equivalent deformation against radial direction.



Mounting of adjustable type

**Mounting of Open type**

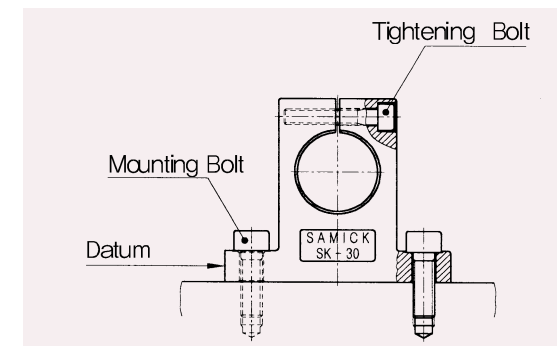
Open type(...OP) also can be used with clearance adjustable housing as shown on Figure. Light pre-load is applied for normal using, but heavy pre-load should be avoided.



Mounting of Open type

**Mounting of Shaft support**

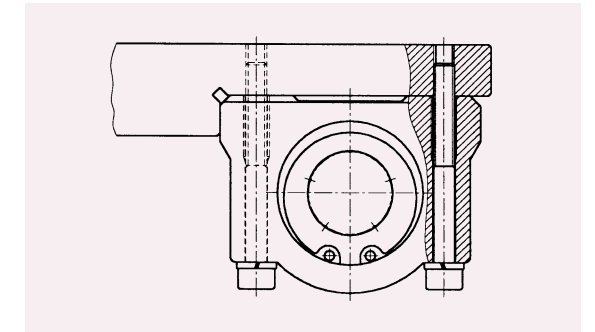
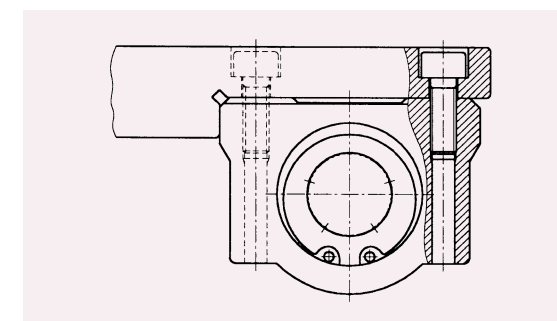
Shaft support, SK can be mounted with mounting bolt for table, and LM shaft can be mounted with tightening bolt



Mounting of Shaft support

**Mounting of LM Case Unit**

Mounting of SC type Both side mounting of SC(E), SC(E)\_W, SC(E)\_V type from the top and the bottom side with mounting bolt are both available, and it gives you minimum mounting time.

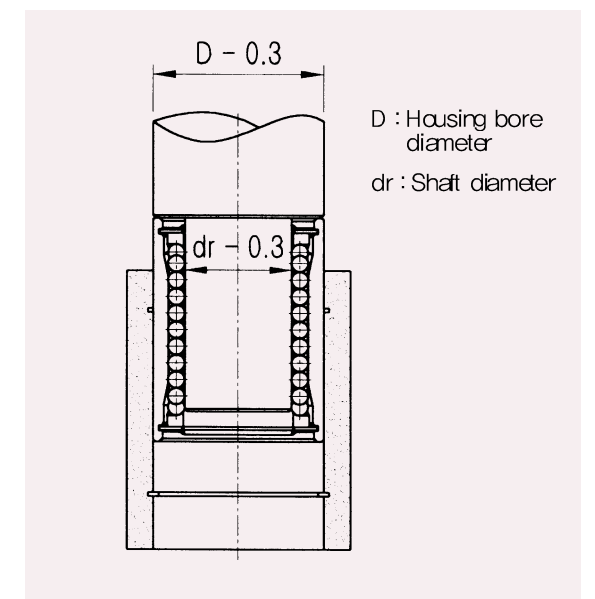


Mounting of Case unit

**Application Tips**

**Mounting of Linear Bushing**

For mounting of standard type SAMICK Linear Bushing into the Housing, a jig should be used to avoid direct hitting on the outer sleeve or seal when installing. See Below.

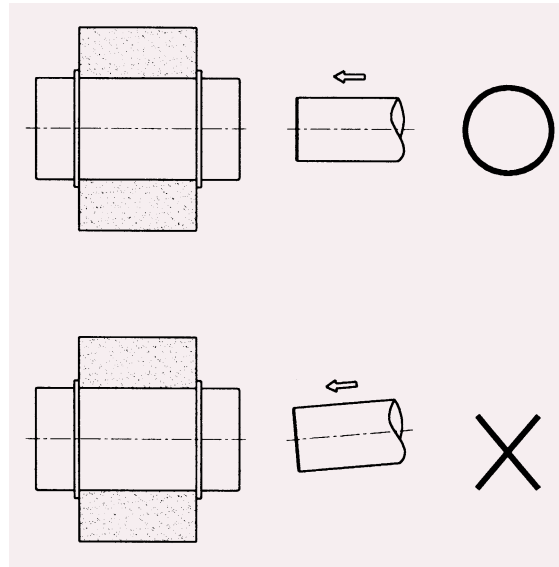


Mounting into housing



**Insertion of Shaft**

Care must be taken to align the bushing and the shaft when inserting a shaft into a linear bushing. If the shaft is inserted with slanted, balls may depart from the damaged or deformed retainer.



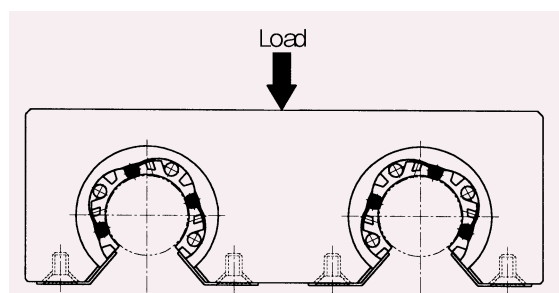
Insertion of shaft into Linear Bearing

**When Moment loads applied**

External loads should be distributed uniformly on a Linear Bushing. When moment loads are applied, two or more Linear Bushings should be used on one LM shaft, and the distance between two Linear Bushings should have enough distance. When the moment loads are applied, calculate the equivalent load and choose the proper Linear Bushing.

**Mounting of open type Linear Bushing with three ball rows**

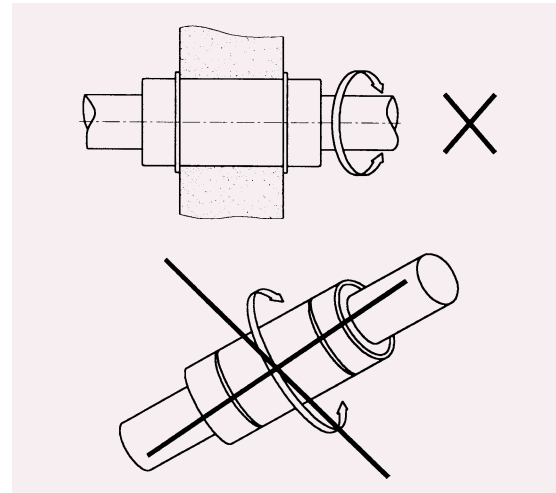
Please mount the open type Linear Bushings with three ball circuit as same as Figure for considering of load distribution.



Installation example of LM12, LM13

**The Rotational Motion Prohibited**

Linear Bushing is not suitable for rotational motion. If the Linear Bushing is exposed to rotational motion it may lead unexpected accidents.



The Rotational Motion Prohibited

45  
ASIAN Standard

## :: SAMICK Support Rail Unit

SAMICK Support Rail Unit is assembled of Support Rail, LM Shaft, and Open type Linear Bushing Case. All components are standardized for providing interchangeability, and less cost and designing time.



Support Rail Unit	SBS	C	h6	30	-	1000	L
<b>SAMICK Support Rail Unit</b>							
Support Rail Unit for SBR : SBS Support Rail Unit for TBR : TBS							
<b>Shaft(by corrosion resistance)</b>							
No plating (Standard) : Blank Chrome plated shaft : C Nickel plated shaft : N Raydent treated shaft : R							
<b>Shaft tolerance</b>							
Asian standard g6 tolerance shaft : blank European standard h6 tolerance shaft : h6							
<b>Shaft Diameter</b>							
16~50mm							
<b>Shaft Length</b>							
100~3000mm							

## :: SAMICK LM Shaft

SAMICK supply precision LM shaft for SAMICK Linear Bushing. The hardness, surface finishing, and tolerance of shaft must be considered for choosing the proper shaft because the balls are running directly on the shaft surface. Shaft dimensions are as follows

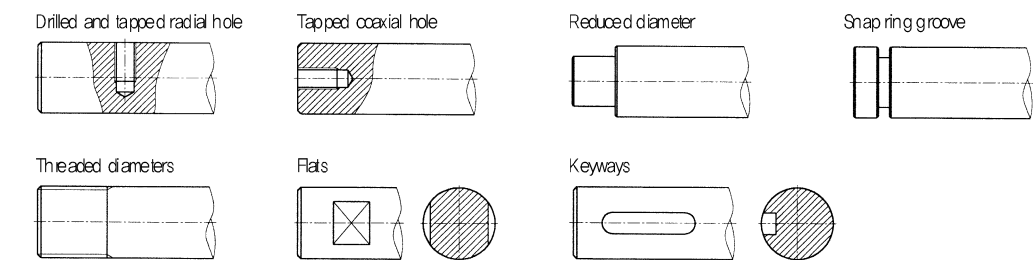
- Material : High carbon chromium bearing steel
- Hardness : Hrc58 ~ 64
- Hardened depth : 0.8 ~ 2.5mm
- Surface finishing : 0.8S ~ 1.6S
- Straightness : 0.05mm / 300mm

LM Shaft	SF	C	h6	30	-	1000	L
<b>SAMICK Support Rail Unit</b>							
<b>Shaft(by corrosion resistance)</b>							
No plating (Standard) : Blank Chrome plated shaft : C Nickel plated shaft : N Raydent treated shaft : R							
<b>Shaft tolerance</b>							
Asian standard g6 tolerance shaft : blank European standard h6 tolerance shaft : h6							
<b>Shaft Diameter</b>							
5~80mm							
<b>Shaft Length</b>							
100~3000mm							

### Shaft Special Machining

SAMICK also supply specially machined shaft as shown in the below figure. The drilled and tapped holes on LM shaft for mounting on the Support Rail are also available.

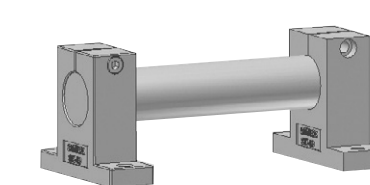
#### (Example of machining)



## :: SAMICK Shaft Support

Support for Shaft ends, SAMICK Shaft Support is made of aluminum with compact design, and able to fix the LM shaft by tightening bolt at the axial direction slot.

Shaft Support	SK	20
<b>SAMICK Shaft Support (Aluminum)</b>		
<b>LM Shaft diameter</b>		
6~40mm		



## Hardness Conversion Table

Rockwell C Scale H <sub>C</sub>	Vickers' Hardness H <sub>v</sub>	Briene II Hardness H <sub>b</sub>		Rockwell Hardness		Shore Hardness H <sub>s</sub>
		Standard Ball	Tungsten Carbon Ball	H <sub>A</sub> A Scale	H <sub>B</sub> B Scale	
68	940	-	-	85.6	-	97
67	900	-	-	85.0	-	95
66	865	-	-	84.5	-	92
65	832	-	739	83.9	-	91
64	800	-	722	83.4	-	88
63	772	-	705	82.8	-	87
62	746	-	688	82.3	-	85
61	720	-	670	81.8	-	83
60	697	-	654	81.2	-	81
59	674	-	634	80.7	-	80
58	653	-	615	80.1	-	78
57	633	-	595	79.6	-	76
56	613	-	577	79.0	-	75
55	595	-	560	78.5	-	74
54	577	-	543	78.0	-	72
53	560	-	525	77.4	-	71
52	544	500	512	76.8	-	69
51	528	487	496	76.3	-	68
50	513	475	481	75.9	-	67
49	498	464	469	75.2	-	66
48	484	451	455	74.7	-	64
47	471	442	443	74.1	-	63
46	458	432	432	73.6	-	62
45	446	421	421	73.0	-	60
44	434	409	409	72.5	-	58
43	423	400	400	72.0	-	57
42	412	390	390	71.5	-	56
41	402	381	381	70.9	-	55
40	392	371	371	70.4	-	54
39	382	362	362	69.9	-	52
38	372	353	353	69.4	-	51
37	363	344	344	68.9	-	50
36	354	336	336	68.4	(109.0)	49
35	345	327	327	67.9	108.5	48
34	336	319	319	67.4	108.0	47
33	327	311	311	66.8	107.5	46
32	318	301	301	66.3	107.0	44
31	310	294	294	65.8	106.0	43
30	302	286	286	65.3	105.5	42
29	294	279	279	64.7	104.5	41
28	286	271	271	64.3	104.0	41
27	279	264	264	63.8	103.0	40
26	272	258	258	63.3	102.5	38
25	266	253	253	62.8	101.5	38
24	260	247	247	62.4	101.0	37
23	254	243	243	62.0	100.0	36
22	248	237	237	61.5	99.0	35
21	243	231	231	61.0	98.5	35
20	238	226	226	60.5	97.8	34
(18)	230	219	219	-	96.7	33
(16)	222	212	212	-	95.5	32
(14)	213	203	203	-	93.9	31
(12)	204	194	194	-	92.3	29
(10)	196	187	187	-	90.7	28
(8)	188	179	179	-	89.5	27
(6)	180	171	171	-	87.1	26
(4)	173	165	165	-	85.5	25
(2)	166	158	158	-	83.5	24
0	160	152	152	-	81.7	24

### Fitting Tolerances for Shaft and Housing Bore Diameter (Metric Series)

Nominal Diameter (mm)	Tolerance of Shaft Diameter																		Tolerance of Housing Bore Diameter																																															
	f						g						h						js						j						k						H						JS						J						K						M					
	f5	f6	f7	f8	f9	f10	g5	g6	g7	g8	g9	g10	h5	h6	h7	h8	js5	js6	js7	j5	j6	j7	k5	k6	k7	H5	H6	H7	H8	JS5	JS6	JS7	JS8	J5	J6	J7	J8	K5	K6	K7	K8	M5	M6	M7	M8																					
3	-6	-10	-12	-16	-18	-22	-2	-6	-8	-12	-16	-4	-6	-10	-14	±2	±3	±5	+2	+4	+6	+8	+4	+6	+10	+4	+6	+10	+14	±2	±3	±5	±7	+2	+4	+6	+8	+6	+8	+10	+14	±2	±3	±5	±7	+2	+4	+6	+8																	
6	-10	-15	-18	-22	-28	-34	-4	-8	-12	-16	-20	-5	-8	-12	-18	±2.5	±4	±5	+3	+6	+8	+10	+6	+9	+13	+5	+8	+12	+18	±2.5	±4	±6	±9	+5	+6	+8	+10	+7	+10	+14	+18	+5	+6	+8	+10	+6	+8	+10	+14																	
10	-16	-24	-27	-34	-42	-50	-6	-12	-17	-24	-30	-7	-11	-15	-22	±3	±4.5	±7	+4	+7	+10	+16	+7	+10	+16	+6	+9	+15	+22	±3	±4.5	±7	±11	+5	+8	+12	+20	+8	+12	+18	+28	+6	+9	+14	+22	+8	+12	+18	+28																	
14	-20	-28	-33	-41	-50	-60	-8	-14	-20	-28	-36	-9	-13	-18	-27	±4	±5.5	±9	+5	+8	+12	+19	+9	+12	+19	+8	+11	+18	+27	±4	±5.5	±9	±13	+6	+10	+15	+27	+9	+13	+19	+30	+7	+10	+15	+27	+9	+13	+19	+30																	
18	-25	-33	-39	-48	-58	-70	-10	-18	-26	-36	-46	-11	-16	-21	-33	±4.5	±6.5	±10	+5	+9	+13	+23	+9	+15	+23	+9	+13	+21	+33	±4.5	±6.5	±10	±16	+8	+12	+18	+33	+10	+14	+20	+33	+8	+11	+16	+27	+10	+14	+20	+33																	
24	-30	-39	-47	-58	-70	-84	-12	-22	-32	-44	-58	-13	-19	-25	-39	±5.5	±8	±12	+6	+11	+15	+27	+11	+18	+27	+11	+16	+25	+39	±5.5	±8	±12	±19	+10	+14	+20	+39	+11	+15	+21	+39	+11	+15	+21	+39	+11	+15	+21	+39																	
30	-36	-45	-54	-66	-80	-96	-15	-27	-39	-54	-72	-16	-23	-30	-46	±6.5	±9.5	±15	+6	+12	+18	+32	+13	+21	+32	+13	+19	+30	+46	±6.5	±9.5	±15	±23	+13	+18	+24	+46	+13	+18	+24	+46	+13	+18	+24	+46	+13	+18	+24	+46																	
40	-45	-56	-67	-81	-98	-118	-20	-36	-51	-70	-93	-19	-27	-35	-54	±7.5	±11	±17	+6	+13	+20	+38	+15	+25	+38	+15	+22	+35	+54	±7.5	±11	±17	±27	+16	+22	+30	+54	+15	+22	+30	+54	+15	+22	+30	+54	+15	+22	+30	+54																	
50	-54	-66	-80	-98	-120	-147	-27	-48	-69	-96	-126	-25	-35	-45	-66	±9	±14	±21	+7	+14	+21	+43	+18	+28	+43	+18	+25	+40	+63	±9	±14	±21	±31	+18	+25	+34	+63	+18	+25	+34	+63	+18	+25	+34	+63	+18	+25	+34	+63																	
65	-66	-81	-98	-120	-147	-180	-36	-63	-93	-126	-168	-35	-48	-63	-93	±10	±15	±23	+8	+16	+24	+51	+20	+32	+51	+20	+28	+46	+72	±10	±15	±23	±35	+20	+28	+38	+72	+20	+28	+38	+72	+20	+28	+38	+72	+20	+28	+38	+72																	
80	-81	-98	-120	-147	-180	-225	-48	-84	-126	-168	-225	-40	-56	-75	-112	±11	±17	±27	+9	+18	+27	+63	+22	+35	+63	+22	+30	+48	+84	±11	±17	±27	±41	+22	+30	+42	+84	+22	+30	+42	+84	+22	+30	+42	+84	+22	+30	+42	+84																	
100	-98	-120	-147	-180	-225	-280	-60	-108	-162	-216	-288	-50	-70	-93	-140	±12	±19	±30	+10	+20	+30	+84	+25	+38	+84	+25	+35	+54	+108	±12	±19	±30	±45	+25	+35	+48	+108	+25	+35	+48	+108	+25	+35	+48	+108	+25	+35	+48	+108																	
120	-120	-147	-180	-225	-280	-360	-72	-126	-189	-252	-360	-60	-84	-112	-168	±13	±21	±33	+11	+22	+33	+108	+30	+45	+108	+30	+42	+63	+144	±13	±21	±33	±51	+30	+42	+57	+144	+30	+42	+57	+144	+30	+42	+57	+144	+30	+42	+57	+144																	
140	-147	-180	-225	-280	-360	-450	-90	-156	-234	-324	-450	-70	-98	-132	-210	±14	±23	±36	+12	+24	+36	+126	+35	+51	+126	+35	+48	+72	+180	±14	±23	±36	±63	+35	+48	+66	+180	+35	+48	+66	+180	+35	+48	+66	+180	+35	+48	+66	+180																	
160	-180	-225	-280	-360	-450	-560	-108	-189	-282	-384	-560	-84	-118	-162	-252	±15	±27	±42	+13	+27	+42	+156	+40	+60	+156	+40	+54	+84	+210	±15	±27	±42	±84	+40	+54	+75	+210	+40	+54	+75	+210	+40	+54	+75	+210	+40	+54	+75	+210																	
180	-225	-280	-360	-450	-560	-720	-132	-234	-351	-468	-720	-100	-140	-198	-300	±16	±30	±45	+14	+30	+45	+180	+45	+66	+180	+45	+60	+90	+252	±16	±30	±45	±108	+45	+60	+84	+252	+45	+60	+84	+252	+45	+60	+84	+252	+45	+60	+84	+252																	

## Fitting Tolerances for Shaft and Housing Bore Diameter (Inch Series)

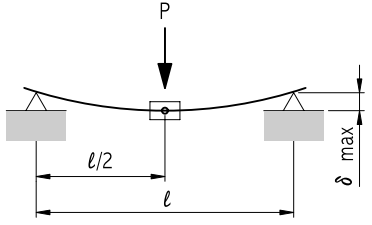
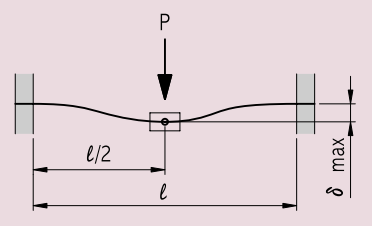
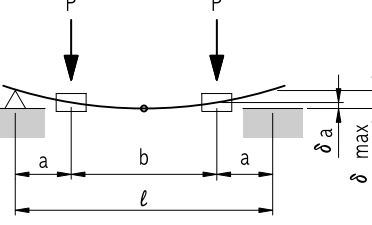
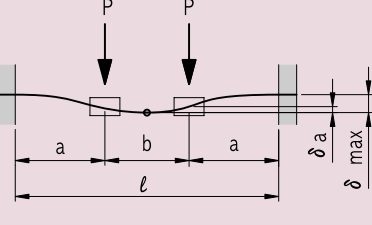
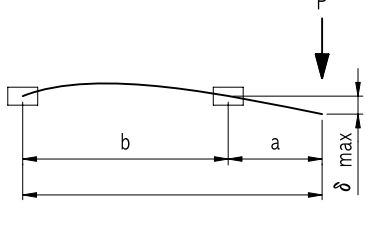
## ●● Tolerance of housing bore

	SIZE		H5		H6		H7		H8	
	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm
OVER BELOW	0.1181 0.2362	3 6	0.0002 0	0.005 0	0.0003 0	0.008 0	0.0004 0	0.012 0	0.0007 0	0.018 0
OVER BELOW	0.2362 0.3937	6 10	0.0002 0	0.006 0	0.0003 0	0.009 0	0.0003 0	0.015 0	0.0008 0	0.022 0
OVER BELOW	0.3937 0.7087	10 18	0.0003 0	0.008 0	0.004 0	0.011 0	0.0007 0	0.018 0	0.0010 0	0.027 0
OVER BELOW	0.7087 1.1811	18 30	0.0003 0	0.009 0	0.0005 0	0.013 0	0.0008 0	0.021 0	0.0013 0	0.033 0
OVER BELOW	1.1811 1.9685	30 50	0.0004 0	0.011 0	0.0006 0	0.016 0	0.0009 0	0.025 0	0.0015 0	0.039 0
OVER BELOW	1.9685 3.1496	50 80	0.0005 0	0.013 0	0.007 0	0.019 0	0.0011 0	0.030 0	0.0018 0	0.046 0
OVER BELOW	3.1496 4.7244	80 120	0.0005 0	0.015 0	0.008 0	0.022 0	0.0013 0	0.035 0	0.0021 0	0.054 0

## ●● Tolerance of shaft

	SIZE		g5		g6		g7		h5		h6		h7	
	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm
OVER BELOW	0.1181 0.2362	3 6	-0.0001 -0.0003	-0.004 -0.009	-0.0001 -0.0004	-0.004 -0.012	-0.0001 -0.0006	-0.004 -0.016	0 -0.0002	0 -0.005	0 -0.0003	0 -0.008	0 -0.0004	0 -0.012
OVER BELOW	0.2362 0.3937	6 10	-0.0002 -0.0004	-0.005 -0.011	-0.0002 -0.0005	-0.005 -0.014	-0.0002 -0.0007	-0.005 -0.020	0 -0.0002	0 -0.006	0 -0.0003	0 -0.009	0 -0.0006	0 -0.015
OVER BELOW	0.3937 0.7087	10 18	-0.0002 -0.0005	-0.006 -0.014	-0.0002 -0.0006	-0.006 -0.017	-0.0002 -0.0009	-0.006 -0.024	0 -0.0003	0 -0.008	0 -0.0004	0 -0.011	0 -0.0007	0 -0.018
OVER BELOW	0.7087 1.1811	18 30	-0.0002 -0.0006	-0.007 -0.016	-0.0002 -0.0007	-0.007 -0.020	-0.0002 -0.0011	-0.007 -0.028	0 -0.0003	0 -0.009	0 -0.0005	0 -0.013	0 -0.0008	0 -0.021
OVER BELOW	1.1811 1.9685	30 50	-0.0003 -0.0007	-0.009 -0.020	-0.0003 -0.0009	-0.009 -0.025	-0.0003 -0.0013	-0.009 -0.034	0 -0.0004	0 -0.011	0 -0.0006	0 -0.016	0 -0.0009	0 -0.025
OVER BELOW	1.9685 3.1496	50 80	-0.0004 -0.0009	-0.010 -0.023	-0.0004 -0.0011	-0.010 -0.029	-0.0004 -0.0015	-0.010 -0.04	0 -0.0005	0 -0.013	0 -0.0007	0 -0.019	0 -0.011	0 -0.030
OVER BELOW	3.1496 4.7244	80 120	-0.0004 -0.0010	-0.012 -0.027	-0.0004 -0.0013	-0.012 -0.034	-0.0004 -0.0018	-0.012 -0.047	0 -0.0006	0 -0.015	0 -0.0008	0 -0.022	0 -0.0013	0 -0.035

## ●● Equations for shaft deflection amount calculation

Variations of support and Load	Equation for Deflection Amount (mm)
	$\delta_{\max} = \frac{P \cdot l^3}{48 \cdot E \cdot I} = 2.021 \times 10^{-6} \frac{P \cdot l^3}{d^4}$
	$\delta_{\max} = \frac{P \cdot l^3}{192 \cdot E \cdot I} = 5.053 \times 10^{-6} \frac{P \cdot l^3}{d^4}$
	$\delta_a = \frac{P \cdot a^2}{6 \cdot E \cdot I} (2a+3b) = 1.617 \times 10^{-4} \frac{P \cdot a^2(2a+3b)}{d^4}$ $\delta_{\max} = \frac{P \cdot a^2}{24 \cdot E \cdot I} (3l-4a^2) = 4.042 \times 10^{-5} \frac{P \cdot a \cdot (3l-4a^2)}{d^4}$
	$\delta_a = \frac{P \cdot a^3}{6 \cdot E \cdot I} (2 - \frac{3a}{l}) = 1.617 \times 10^{-4} \frac{P \cdot a^3}{d^4} (2 - \frac{3a}{l})$ $\delta_{\max} = \frac{P \cdot a^2}{24 \cdot E \cdot I} (2a+3b) = 4.042 \times 10^{-5} \frac{P \cdot a^2(2a+3b)}{d^4}$
	$\delta_{\max} = \frac{P \cdot a^2 l}{3 \cdot E \cdot I} = 3.234 \times 10^{-4} \frac{P \cdot a^2 l}{d^4}$

E : Modulus of Longitudinal Elasticity  $2.1 \times 10^4$ (kgf/mm<sup>2</sup>)  
 P : Applying Load (kgf)  
 I : Geometrical Moment of Inertia(mm<sup>4</sup>) ; I =  $\pi d^4 / 64$ , Hallow shaft : I =  $\pi (d^4 - d_i^4) / 64$   
 d<sub>i</sub> : Shaft inner-diameter(mm), d : Shaft Outer-diameter (mm)