ST

LM Stroke Models ST, ST-B and STI

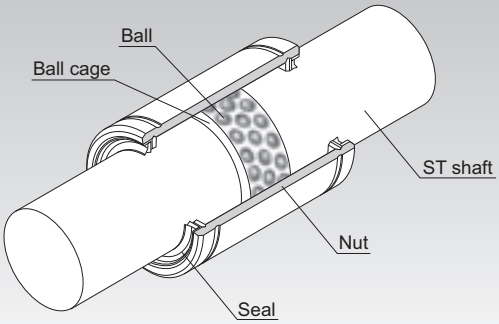


Fig.1 Structure of LM Stroke Model ST

Structure and Features

Model ST has a ball cage and balls both incorporated into a precision-ground cylindrical nut as shown in Fig.1. The balls are arranged in zigzags so as to evenly receive a load. The ball cage is a drilled cage made of a light alloy with high rigidity, and is capable of high-speed motion. A thrust ring and a snap ring are installed on both sides of the inner surface of the nut to prevent the ball cage from overshooting.

This structure allows rotational motion, reciprocal motion, and complex motion with a small friction coefficient. The Model ST has a stroke length up to twice the range within which the ball cage can travel.

Since high accuracy can be obtained at a low price, this model is used in a broad array of applications such as press die settings, ink roll units of printing machines, workpiece chuck units of punching presses, press feeders, work heads of electric discharge machines, wound roll correctors, spinning and weaving machines, distortion measuring equipment, spindles of optical measuring instruments, and photocopiers.

[Minimal Friction Coefficient]
The balls and the ball raceway are in point contact, which causes the smallest rolling loss, and the balls are individually retained in the ball cage. This allows for rolling motion with a minimal friction coefficient (μ=0.0006 to 0.0012).

[Compact Design]
Since it consists only of a thin nut and balls, the outer diameter of the bearing is minimized and a light, space-saving, compact design is achieved.

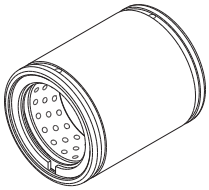
[High Accuracy at a Low Price]
A highly accurate slide unit can be produced at a low price.

Types and Features

Light Load Type Model ST

Specification Table⇒A5-10

Model ST is a light load type that allows for a long stroke.
Shaft diameter: 6 to 100 mm
In addition, a type with a seal is available (Model ST-UU).

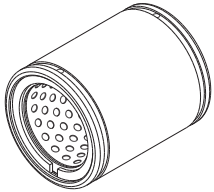


Model ST

Medium Load Type Model ST-B

Specification Table⇒A5-10

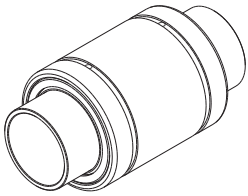
It is a medium-load type with the same dimensions as the Model ST, a greater number of balls, and a rated load twice that of the Model ST.
Shaft diameter: 8 to 100 mm
In addition, a type with a seal is available (Model ST-UUB).



Model ST-B

Inner Ring Type Model STI

If the LM shaft cannot be hard quenched, STI allows an inner ring to be incorporated. The inner ring is available build-to-order.



Model STI

Rated Load and Nominal Life

[Load Rating]
The basic load ratings for model ST are indicated in the respective specification tables.

[Calculating the Nominal Life]
The nominal life of model ST is obtained using the following equation.

$$L_{10} = \left(\frac{C}{P_C}\right)^3 \times 10^6 \quad \cdots\cdots\cdots (1)$$

L_{10} : Nominal life (rev.)
(The total number of revolutions that 90% of a group of identical LM strokes independently operating under the same conditions can achieve without showing flaking)
C : Basic dynamic load rating (N)
P_C : Calculated radial load (N)

[Calculating the Modified Nominal Life]
During use, an LM stroke may be subjected to vibrations and shocks as well as fluctuating loads, which are difficult to detect. In addition, the hardness of the raceways, the operating temperature, and having LM strokes arranged in close contact will have a decisive impact on the service life. Taking these factors into account, the modified nominal life (L_{10m}) can be calculated according to the following formula (2).

●Modified factor α

$$\alpha = \frac{f_H \cdot f_T \cdot f_C}{f_W}$$

α : Modified factor
f_H : Hardness factor (see Fig.2 on A5-6)
f_T : Temperature factor (see Fig.3 on A5-6)
f_C : Contact factor (see Table1 on A5-7)
f_W : Load factor (see Table 2 on A5-7)

●Modified nominal life L_{10m}

$$L_{10m} = \left(\alpha \times \frac{C}{P_C}\right)^3 \times 10^6 \quad \cdots\cdots\cdots (2)$$

L_{10m} : Modified nominal life (rev.)
C : Basic dynamic load rating (N)
P_C : Calculated radial load (N)

● When a Moment Load is Applied to a Single Nut

When a moment load is applied to a single nut, calculate the equivalent radial load from the moment.

$$P_u = K \cdot M$$

P_u : Equivalent radial load (with moment load) (N)
K : Equivalent factor (see Table3 to Table4 on A5-7)
M : Applied moment (N·mm)
P_u is assumed to be within the Basic Static Load Rating (C_0).

● When a Moment Load and a Radial Load are Simultaneously Applied

When a moment and a radial load are applied simultaneously, calculated the service life based on the sum of the radial load and the equivalent radial load.

[Calculating the Service Life Time]

When the nominal life (L_{10}) has been obtained, if the number of revolutions per minute and the number of reciprocations per minute are constant, the service life time is obtained using the following formulas.

● For Rotating Motion or Complex Motion

$$L_h = \frac{L_{10}}{60\sqrt{(dm \cdot n)^2 + (10 \times \alpha \cdot \ell_s \cdot n_1)^2} / (\pi \cdot dm)}$$

● For Reciprocating Motion

$$L_h = \frac{L_{10}}{60 \times 10 \times \alpha \cdot \ell_s \cdot n_1 / (\pi \cdot dm)}$$

L_h : Service life time (h)
n : Revolutions per minute (min^{-1})
n_1 : Number of reciprocations per minute (min^{-1})
ℓ_s : Stroke length (mm)
dm : Pitch circle diameter (mm)
(dm≒1.15×dr)
dr : Ball inscribed bore diameter (mm)
α : Factor for cage material
(α=0.7)

[Tolerance Value in Rotation and Reciprocating Speed]
The permissible speed limit of model ST is obtained using the following equation.

$$DN \geqq dm \cdot n + 10 \times \ell_s \cdot n_1$$

For the DN value above, the following value applies as a standard value.
For oil lubrication DN=600000
For grease lubrication DN=300000
However, the following points must be taken into account.
n ≦5000
$\ell_s \cdot n_1$ ≦50000

● f_H: Hardness Factor

To maximize the load capacity of model ST, the hardness of the raceways needs to be between 58 to 64 HRC.
If the hardness is lower than this range, the basic dynamic load rating and the basic static load rating decrease. Therefore, it is necessary to multiply each rating by the respective hardness factor (f_H).
Normally, f_H=1.0 since model ST has sufficient hardness.

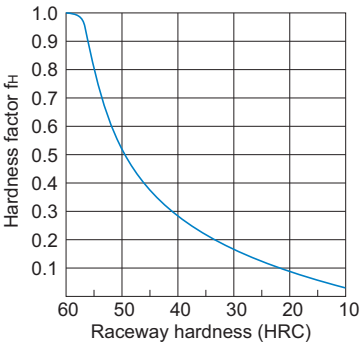


Fig.2 Hardness Factor (f_H)

● f_T: Temperature Factor

If the temperature of the environment surrounding the operating model ST exceeds 100℃, take into account the adverse effect of the high temperature and multiply the basic load ratings by the temperature factor indicated in Fig.3.
Note: If the environment temperature exceeds 80℃, contact THK.

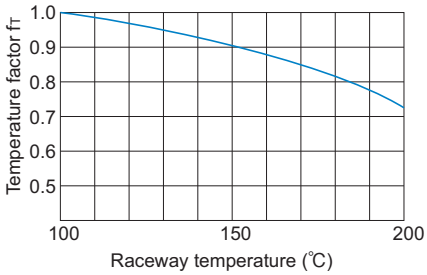


Fig.3 Temperature Factor (f_T)

● f_c: Contact Factor

When multiple nuts of model ST are used in close contact with each other, their linear motion is affected by moments and mounting accuracy, making it difficult to achieve uniform load distribution. In such applications, multiply the basic load rating (C) and (C_0) by the corresponding contact factor in Table1.

Note: If uneven load distribution is expected in a large machine, take into account the respective contact factor indicated in table 1.

Table1 Contact Factor (f_c)

Number of nuts in close contact with each other	Contact factor f_c
2	0.81
3	0.72
4	0.66
5	0.61
Normal use	1

● f_w: Load Factor

In general, reciprocating machines tend to experience vibrations or impacts during operation, and it is extremely difficult to accurately determine the vibrations generated during high-speed operation and impacts during frequent starts and stops. Therefore, when speed and vibrations have a significant influence, divide the basic dynamic load rating (C) by the corresponding load factor in Table 2, which has been empirically obtained.

Table 2 Load Factor (f_w)

Vibrations/ impact	Speed (V)	f_w
Faint	Very low V≦0.25m/s	1 to 1.2
Weak	Slow 0.25<V≦1m/s	1.2 to 1.5
Medium	Medium 1<V≦2m/s	1.5 to 2
Strong	High V>2m/s	2 to 3.5

Table of Equivalent Factors

Table3 Equivalent Factor of Model ST

Model No.	Equivalent factor: K
	Single nut
ST 6	0.726
ST 8	0.721
ST 10	0.489
ST 12	0.421
ST 16	0.408
ST 20	0.419
ST 25	0.42
ST 30	0.28
ST 35	0.285
ST 40	0.252
ST 45	0.251
ST 50	0.207
ST 55	0.206
ST 60	0.206
ST 70	0.206
ST 80	0.186
ST 90	0.185
ST 100	0.185

Table4 Equivalent Factor of Model ST-B

Model No.	Equivalent factor: K
	Single nut
ST 8B	0.444
ST 10B	0.301
ST 12B	0.259
ST 16B	0.251
ST 20B	0.258
ST 25B	0.257
ST 30B	0.171
ST 35B	0.175
ST 40B	0.154
ST 45B	0.154
ST 50B	0.127
ST 55B	0.127
ST 60B	0.127
ST 70B	0.127
ST 80B	0.114
ST 90B	0.114
ST 100B	0.114

Accuracy Standards

The tolerance value in inscribed bore diameter (dr), nut outer diameter (D) and nut length (L) is indicated in the corresponding specification table.
The end of the nut may be deformed due to tension of the snap ring. Therefore, when measuring the nut outer diameter, it is necessary to calculate the measurement range using the following equation, and obtain the average diameter value within the range.
The tolerance value in the nut outer diameter is equal to the calculated average value of the maximum diameter and the minimum diameter obtained through two-point measurement of the outer diameter.

$$W = 4 + \frac{L}{8}$$

W : Length out of the measurement range (mm)
L : Nut length (mm)

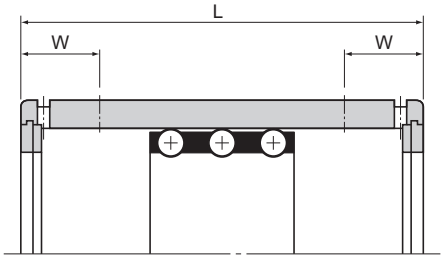


Fig.4 Measurement Range of the Nut

Fit

In theory, the ball cage of model ST moves in the same direction as the ST shaft by 1/2 of the shaft (or nut). However, to minimize the travel distance error caused by uneven load distribution or vibrations, it is necessary to reduce the clearance. If high accuracy is required or if the LM Stroke is used on a vertical shaft, we recommend setting the radial clearance between -10 and 0μm.

Item	Normal conditions	Vertical shaft or high accuracy
ST shaft	k5, m5	n5, p5
Housing	H6, H7	J6, J7

ST Shaft

With the ST shaft, used in model ST, balls roll directly on the shaft surface. Therefore, it is necessary to pay much attention to the hardness, surface roughness and dimensional accuracy when manufacturing it.
Since the hardness of the ST shaft has especially large impact on the service life, use much care in selecting a material and heat treatment method.
THK also manufactures high-quality ST shafts. Contact us for details.

[Material]
Generally, the following materials are used as suitable for surface hardening through induction-hardening.
- SUJ2 (JIS G 4805: high-carbon chromium bearing steel)
- SK3 to 6 (JIS G 4401: carbon tool steel)
- S55C (JIS G 4051: carbon steel for machine structural use)

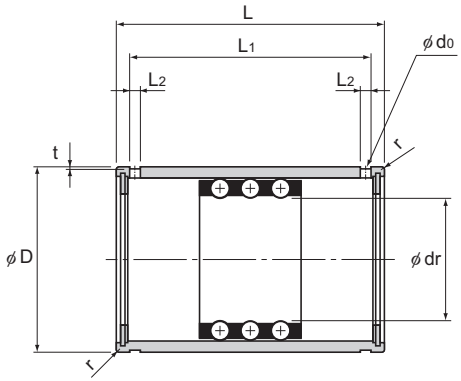
[Hardness]
We recommend surface hardness of 58 HRC (≒653 HV) or higher. The depth of the hardened layer is determined by the shaft diameter; we recommend approximately 2 mm for general use.
The ST shaft can have a hardened inner ring attached on the shaft raceway.

[Surface Roughness]
To achieve smooth motion, the surface is normally finished to Ra0.40 or less. If higher wear resistance is required, finish the surface to Ra0.20 or less.

Installation of the ST Shaft

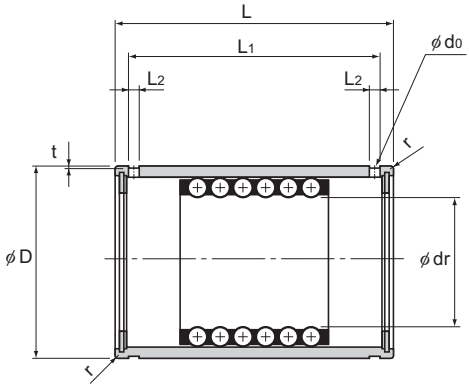
To install the ST shaft, drive it in to the designated depth. If the clearance is negative, a large driving force is required. However, do not forcibly hammer the shaft. Instead, apply a lubricant on the ST shaft first, and then gradually drive it in with a slight back action.

Models ST / ST-B



Model ST
(For light load)

Model No.	Maximum stroke	Main dimensions			
		Inscribed bore diameter		Outer diameter	
		dr	Tolerance	D	Tolerance
ST 6	14	6	+0.018 +0.010	12	0 –0.008
ST 8 ST 8B	24 8	8	+0.022 +0.013	15	
ST 10 ST 10B	30 8	10		19	0 –0.009
ST 12 ST 12B	32 8	12	+0.027 +0.016	23	
ST 16 ST 16B	40 16	16		28	
ST 20 ST 20B	54 28	20	+0.033 +0.020	32	0 –0.011
ST 25 ST 25B	54 28	25		37	
ST 30 ST 30B	82 44	30		45	
ST 35 ST 35B	92 54	35	+0.041 +0.025	52	0 –0.013

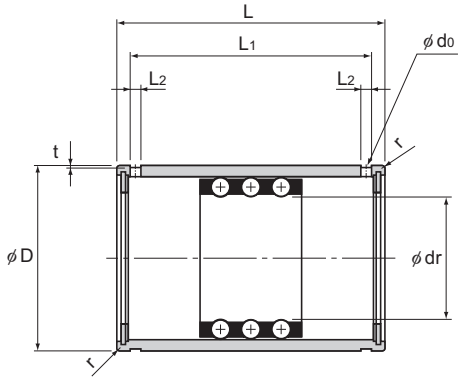


Model ST-B
(For medium load)

Unit: mm

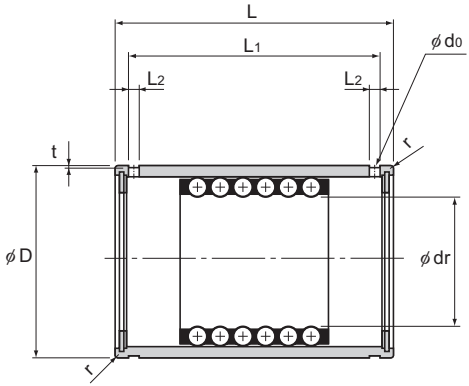
	Length							Basic dynamic load rating	Basic static load rating	Mass
	L	Tolerance	L_1	L_2	t	d_0	r	C kN	C_0 kN	g
	19	0 −0.2	13.5	1.1	0.25	—	0.3	0.98	0.23	8
	24		20.1	1.5	0.5	1.5	0.5	0.98 2.06	0.27 0.55	16.4 17.6
	30		25.7	1.5	0.5	1.5	0.5	2.35 4.61	0.62 1.27	31.5 34.5
	32		27.5	1.5	0.5	1.5	0.5	4.02 8.14	1.08 2.25	47 53.5
	37		32.1	1.5	0.5	1.5	0.5	4.02 8.04	1.27 2.65	77 85
	45		39.8	2	0.5	2	0.5	4.12 8.33	1.57 3.24	109 120
	45	0 −0.3	39.8	2	0.5	2	1	4.12 8.14	1.76 3.63	128 142
	65		58.5	2.5	0.5	2.5	1	9.31 18.7	4.12 8.14	240 275
	70		63.5	2.5	0.7	2.5	1.5	9.41 18.7	4.51 9.02	370 410

Models ST / ST-B



Model ST
(For light load)

Model No.	Maximum stroke	Main dimensions			
		Inscribed bore diameter		Outer diameter	
		dr	Tolerance	D	Tolerance
ST 40 ST 40B	108 66	40	+0.041 +0.025	60	0 –0.013
ST 45 ST 45B	108 66	45		65	
ST 50 ST 50B	138 88	50		72	
ST 55 ST 55B	138 88	55	+0.049 +0.030	80	
ST 60 ST 60B	138 88	60		85	0 –0.015
ST 70 ST 70B	138 88	70		95	
ST 80 ST 80B	132 76	80		110	
ST 90 ST 90B	132 76	90	+0.058 +0.036	120	
ST 100 ST 100B	132 76	100		130	0 –0.018

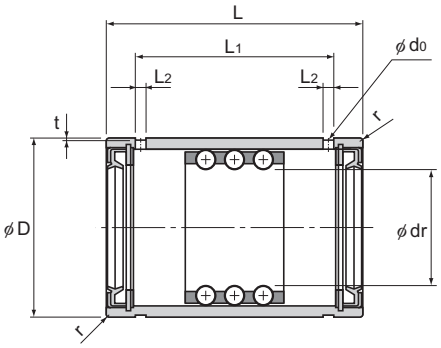


Model ST-B
(For medium load)

Unit: mm

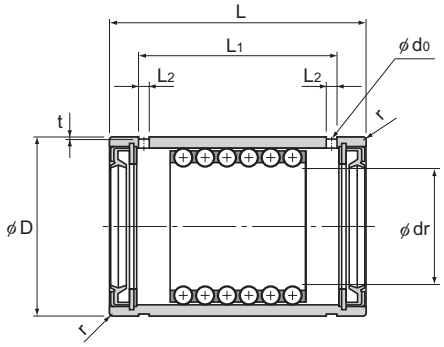
	Length							Basic dynamic load rating	Basic static load rating	Mass
	L	Tolerance	L_1	L_2	t	d_0	r	C kN	C_0 kN	g
	80	0 –0.3	73.3	2.5	0.7	2.5	1.5	12.5 25	6.18 12.4	570 635
	80		73.3	2.5	0.7	2.5	1.5	12.6 25.2	6.76 13.5	625 695
	100		92.4	3	1	3	1.5	16.3 32.5	8.82 17.7	910 1020
	100		92.4	3	1	3	2	16.6 33	9.71 19.3	1270 1380
	100		92.4	3	1	3	2	16.8 33.6	10.5 21	1360 1480
	100	0 –0.4	92.4	3	1	3	2	16.9 33.8	11.7 23.3	1530 1670
	100		92	3	1.5	3	2	21.3 42.5	15.3 30.6	2220 2430
	100		92	3	1.5	3	2	21.7 43.3	16.9 33.7	2440 2670
	100		92	3	1.5	3	2	22 43.9	18.3 36.8	2670 2910

Models ST···UU/ST···UUB



Model ST···UU
(For light load)

Model No.	Maximum stroke	Main dimensions			
		Inscribed bore diameter		Outer diameter	
		dr	Tolerance	D	Tolerance
ST 8UU	14	8	+0.022 +0.013	15	0 –0.008
ST 10UU	16	10		19	0 –0.009
ST 12UU	17	12	+0.027 +0.016	23	
ST 16UU	24	16		28	
ST 20UU ST 20UUB	32 12	20	+0.033 +0.020	32	0 –0.011
ST 25UU ST 25UUB	32 12	25		37	
ST 30UU ST 30UUB	65 27	30		45	
ST 35UU ST 35UUB	75 37	35	+0.041 +0.025	52	0 –0.013
ST 40UU ST 40UUB	91 49	40		60	
ST 45UU ST 45UUB	91 49	45		65	

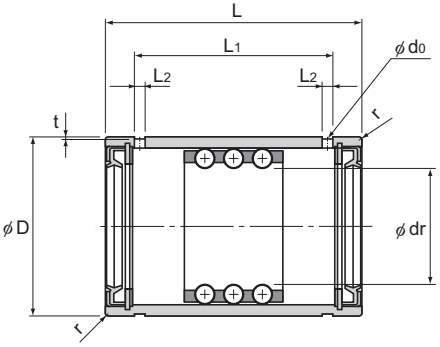


Model ST···UUB
(For medium load)

Unit: mm

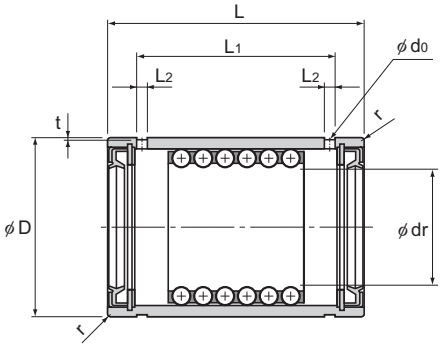
	Length							Basic dynamic load rating	Basic static load rating	Mass
	L	Tolerance	L_1	L_2	t	d_0	r	C kN	C_0 kN	g
	24	0 –0.2	15.3	1.5	0.5	1.5	0.5	0.98	0.27	17
	30		18.5	1.5	0.5	1.5	0.5	2.35	0.62	31
	32		20.1	1.5	0.5	1.5	0.5	4.02	1.08	49
	37		24.1	1.5	0.5	1.5	0.5	4.02	1.27	80
	45		30.8	2	0.5	2	0.5	4.12 8.33	1.57 3.24	112 125
	45	0 –0.3	30.8	2	0.5	2	1	4.12 8.14	1.76 3.63	132 145
	65		50.1	2.5	0.5	2.5	1	9.31 18.7	4.12 8.14	245 280
	70		55.1	2.5	0.7	2.5	1.5	9.41 18.7	4.51 9.02	375 420
	80		64.9	2.5	0.7	2.5	1.5	12.5 25	6.18 12.4	580 640
	80		64.9	2.5	0.7	2.5	1.5	12.6 25.2	6.76 13.5	635 705

Models ST···UU/ST···UUB



Model ST···UU
(For light load)

Model No.	Maximum stroke	Main dimensions			
		Inscribed bore diameter		Outer diameter	
		dr	Tolerance	D	Tolerance
ST 50UU ST 50UUB	120 70	50	+0.041 +0.025	72	0 –0.013
ST 55UU ST 55UUB	120 70	55	+0.049 +0.030	80	
ST 60UU ST 60UUB	120 70	60		85	0 –0.015
ST 70UU ST 70UUB	120 70	70		95	
ST 80UU ST 80UUB	114 58	80		110	
ST 90UU ST 90UUB	114 58	90	+0.058 +0.036	120	
ST 100UU ST 100UUB	114 58	100		130	0 –0.018



Model ST···UUB
(For medium load)

Unit: mm

	Length		L_1	L_2	t	d_0	r	Basic dynamic load rating C kN	Basic static load rating C_0 kN	Mass g
	L	Tolerance								
	100	0 –0.3	83.4	3	1	3	1.5	16.3 32.5	8.82 17.7	920 1030
	100		83.4	3	1	3	2	16.6 33	9.71 19.3	1280 1400
	100		83.4	3	1	3	2	16.8 33.6	10.5 21	1370 1490
	100	0 –0.4	83.4	3	1	3	2	16.9 33.8	11.7 23.3	1540 1680
	100		83	3	1.5	3	2	21.3 42.5	15.3 30.6	2240 2450
	100		83	3	1.5	3	2	21.7 43.3	16.9 33.7	2470 2700
	100		83	3	1.5	3	2	22 43.9	18.3 36.8	2700 2940