THK

General Catalog

Linear Motion Systems

A Technical Descriptions of the Products

PRODUCTS INFORMATION

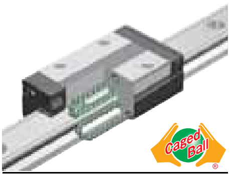
THK develops and provides a large number of linear motion systems products, including LM Guides, Ball Screws and Actuators. All of these are used in various types of industrial equipment such as machine tools, semiconductor manufacturing machines and industrial robots.
To respond to diversifying requirements, THK has been enhancing its high-performance and high-quality products that can be used in widely varying operating environments.
Select the most suitable product from our broad array of product lineups that respond to various applications.

Caged Ball LM Guide

Global standard size
SHS **A-136**

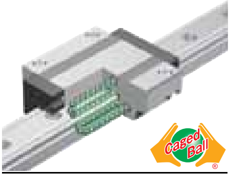
Model No.: SHS15 to 65

Radial Type
SSR **A-142**



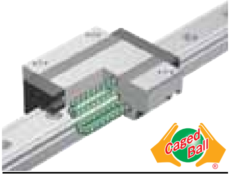
Model No.: SSR15 to 35

Ultra-heavy Load
SNR **A-148**



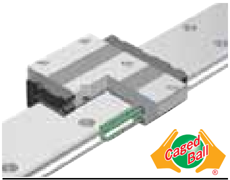
Model No.: SNR25 to 85

Ultra-heavy Load
SNS **A-148**



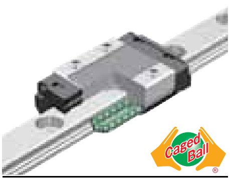
Model No.: SNS25 to 85

Wide Rail
SHW **A-156**



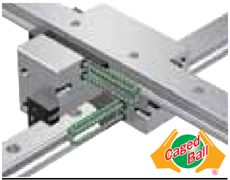
Model No.: SHW12 to 50

Miniature
SRS **A-160**



Model No.: SRS7 to 25

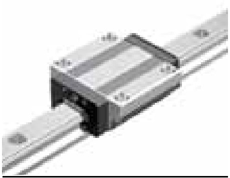
Cross LM Guide
SCR **A-166**



Model No.: SCR15 to 65

LM Guide

Global standard size
HSR **A-170**



Model No.:HSR8 to 150

Radial Type
SR **A-178**

Model No.: SR15 to 150

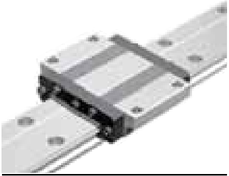
Ultra-heavy Load Type
NR **A-186**

Model No.: NR25 to 100

Ultra-heavy Load Type
NRS **A-186**

Model No.: NRS25 to 100

Wide Rail
HRW **A-194**



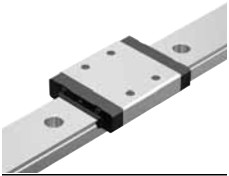
Model No.: HRW12 to 60

LM Guide

Miniature
RSR **A-200**

Model No.: RSR3 to 20

Miniature
RSR-W **A-200**



Model No.: RSR-W3 to 20

Miniature (Low Cost Type)
RSR-Z **A-208**

Model No.: RSR-Z7 to 15

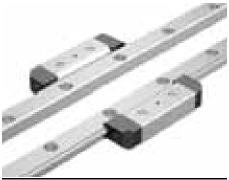
Miniature (Attached with Retainer)
RSH **A-214**

Model No.: RSH7 to 12

Miniature (Attached with Retainer)
RSH-Z **A-218**

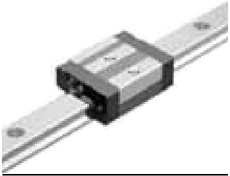
Model No.: RSH-Z 7 to 15

Separate Type
HR **A-224**



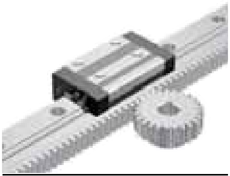
Model No.: HR918 to 60125

Separate Type
GSR **A-230**



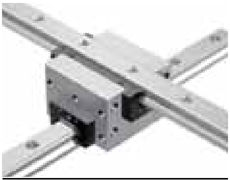
Model No.: GSR15 to 35

Separate Type
GSR-R **A-236**



Model No.: GSR-R25 to 35

Cross LM Guide
CSR **A-244**



Model No.: CSR15 to 45

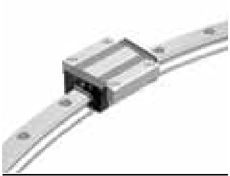
Miniature Cross Guide
MX **A-248**

Model No.: MX5 to 7

Structural Member Rail
JR **A-252**

Model No.: JR25 to 55

R Guide
HCR **A-258**



Model No.: HCR12 to 65

Straight-Curved Guide
HMG **A-262**

Model No.: HMG15 to 65

Self-aligning
NSR-TBC **A-268**

Model No.: NSR-TBC20 to 70

High Temperature
HSR-M1 **A-272**

Model No.: HSR-M1 15 to 35

High Temperature
SR-M1 **A-280**

Model No.: SR-M1 15 to 35

LM Guide

High Temperature
RSR-M1 A-286

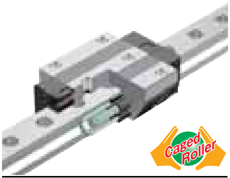
Model No.: RSR-M1 9 to 20

High Corrosion Resistance
HSR-M2 A-292

Model No.: HSR-M2 15 to 25

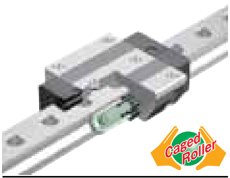
Caged Roller LM Guide

Ultra-high Rigidity
SRG A-300



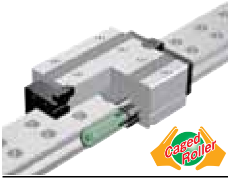
Model No.: SRG15 to 65

Ultra-high Rigidity (Low Center of Gravity)
SRN A-306



Model No.: SRN35 to 65

Ultra-high Rigidity (Wide)
SRW A-312



Model No.: SRW70 to 100

LM Guide Actuator

KR A-386

Model No.: KR15 to 65
Lead: 1 to 25

Caged Ball LM Guide Actuator

SKR A-416

Model No.: SKR33 to 46
Lead: 6 to 20

LM Actuator

Ball Screw Drive Type
GL A-438

Model No.: GL15/20
Lead: 5 to 40

Belt Drive Type
GL A-438

Model No.: GL15/20

High Torque Type Ball Spline

LBS A-484

Shaft diameter: ϕ6 to 100

LBST A-484

Shaft diameter: ϕ20 to 150

LBF A-484

Shaft diameter: ϕ15 to 100

LBR A-484

Shaft diameter: ϕ15 to 100

LBH A-484

Shaft diameter: ϕ15 to 50

Medium Torque Type Ball Spline

LT A-490

Shaft diameter: ϕ4 to 100

LF A-490

Shaft diameter: ϕ6 to 50

Rotary Ball Spline

LBG A-496

Shaft diameter: φ20 to 85

LBGT A-496

Shaft diameter: φ20 to 85

LTR A-500

Shaft diameter: φ16 to 60

LTR-A A-500

Shaft diameter: φ8 to 40

Spline Nut

DPM A-514

Model No.: DPM1220 to 5080

DP A-514

Model No.: DP12 to 50

Linear Bushing

LM A-524

Shaft diameter: φ3 to 60

LM-GA A-524

Shaft diameter: φ6 to 120

LM-MG A-524

Shaft diameter: φ3 to 40

LM-L A-524

Shaft diameter: φ3 to 60

LME A-524

Shaft diameter: φ5 to 80

LMF A-524

Shaft diameter: φ6 to 60

LMF-M A-524

Shaft diameter: φ6 to 30

LMF-L A-524

Shaft diameter: φ6 to 60

LMF-ML A-524

Shaft diameter: φ6 to 30

LMK A-524

Shaft diameter: φ6 to 60

Linear Bushing

LMK-M **A-524**

Shaft diameter: φ6 to 30

LMK-L **A-524**

Shaft diameter: φ6 to 60

LMK-ML **A-524**

Shaft diameter: φ6 to 30

LMH **A-524**

Shaft diameter: φ6 to 30

Linear Bushing

LMH-L **A-524**

Shaft diameter: φ6 to 30

SC **A-524**

Shaft diameter: φ6 to 50

SL **A-524**

Shaft diameter: φ6 to 30

SH **A-524**

Shaft diameter: φ3 to 20

SH-L **A-524**

Shaft diameter: φ3 to 20

LM Shaft End Support

SK **A-524**

Shaft diameter: φ10 to 40

Standard LM Shafts

SF **A-524**

Shaft diameter: φ3 to 100

LM Stroke

ST **A-554**

Shaft diameter: φ6 to 100

ST-B **A-554**

Shaft diameter: φ8 to 100

STI **A-554**

Shaft diameter: φ6 to 100

Miniature Stroke

MST **A-560**

Shaft diameter: φ3 to 6

Die-setting Ball Cage

KS **A-562**

Shaft diameter: φ19 to 38

Die-setting Ball Cage

BS A-562

Shaft diameter: ϕ19 to 38

Precision Linear Pack

ER A-566

Model No.: ER513 to 1025

Cross Roller Guide

VR A-572

Model No.: VR1 to 18

Ball Guide

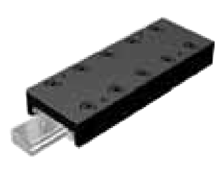
With Ball Cage

VB A-572

Model No.: VB1 to 15

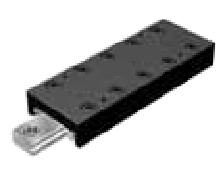
Cross Roller Table

VRT A-586



Model No.: VRT1025 to 3205

VRT-A A-586



Model No.: VRT1025A to 3205A

VRU A-586

Model No.: VRU1025 to 91010

Linear Ball Slide

LSP A-594

Model No.: LSP1340 to 25150

LS A-594

Model No.: LS827 to 1077

LSC A-594

Model No.: LSC1015 to 1550

Unit Base

LSC A-594

Model No.: LSC1515B to 1550B

LM Roller

LR A-604

Model No.: LR4095 to 50130

LR-Z A-604

Model No.: LR1547Z to 3275Z

LRA A-604

Model No.: LRA4095 to 50130

LRA-Z A-604

Model No.: LRA1547Z to 3275Z

LRB A-604

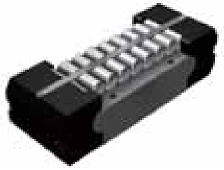
Model No.: LRB4095 to 50130

LM Roller

LRB-Z **A-604**

Model No.: LRB1547Z to 3275Z

LRU **A-604**



Model No.: LRU22.2 to 76.2

LM Roller (Options)

Fixture Model
SM **A-618**

Model No.: SM15 to 50

Fixture Model
SMB **A-618**

Model No.: SMB15 to 50

Fixture Model
SE **A-618**

Model No.: SE15 to 50

Fixture Model
SEB **A-618**

Model No.: SEB15 to 50

Spring Pad
PA **A-617**

Model No.: PA15 to 50

Flat Roller

FT **A-622**

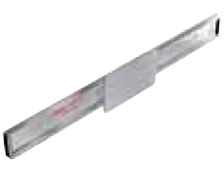
Width: 10 to 60
Length: 32 to 500

FTW **A-622**

Width: 30 to 70
Length: 150 to 500

Slide Pack

FBW **A-636**



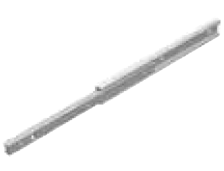
Rail length: 160 to 1800

Slide Rail

FBL **A-646**

Rail length: 200 to 2160

E15/20 **A-646**



Rail length: 50 to 300

D20 **A-646**

Rail length: 80 to 300

Precision, Caged Ball Screw

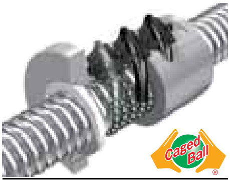
High Speed Ball Screw
SBN **A-748**

Shaft diameter: ϕ32 to 50
Lead: 10 to 20

High Speed Ball Screw
SBK **A-748**

Shaft diameter: ϕ36 to 55
Lead: 20 to 36

High Load Ball Screw
HBN **A-748**



Shaft diameter: ϕ32 to 63
Lead: 10 to 20

Standard-Stock Precision Ball Screw

BIF A-754

Shaft diameter: ϕ16 to 50
Lead: 5 to 12

BNFN A-754

Shaft diameter: ϕ16 to 50
Lead: 5 to 12

MDK A-754

Shaft diameter: ϕ4 to 14
Lead: 1 to 5

MBF A-754

Shaft diameter: ϕ4 to 14
Lead: 1 to 4

BNF A-754

Shaft diameter: ϕ16 to 50
Lead: 5 to 12

Standard Ball Screw assembly

BNK A-760

Shaft diameter: ϕ4 to 25
Lead: 1 to 20

Precision Ball Screw

BIF A-764

Shaft diameter: ϕ16 to 50
Lead: 5 to 12

DIK A-764

Shaft diameter: ϕ14 to 63
Lead: 4 to 16

BNFN A-764

Shaft diameter: ϕ16 to 100
Lead: 4 to 20

DKN A-764

Shaft diameter: ϕ40 to 63
Lead: 20

BLW A-764

Shaft diameter: ϕ15 to 50
Lead: 10 to 50

BNF A-764

Shaft diameter: ϕ16 to 100
Lead: 4 to 20

DK A-764

Shaft diameter: ϕ14 to 63
Lead: 4 to 20

MDK A-764

Shaft diameter: ϕ4 to 14
Lead: 1 to 5

BLK A-764

Shaft diameter: ϕ15 to 50
Lead: 10 to 50

WGF A-764

Shaft diameter: ϕ8 to 50
Lead: 12 to 100

Precision Ball Screw

BNT A-764

Shaft diameter: ϕ14 to 45
Lead: 4 to 12

Precision Rotary Ball Screw

DIR A-772

Shaft diameter: ϕ16 to 40
Lead: 5 to 12

BLR A-772

Shaft diameter: ϕ16 to 50
Lead: 16 to 50

Precision Ball Screw/Spline

BNS-A A-780

Shaft diameter: ϕ8 to 40
Lead: 12 to 40

BNS A-780

Shaft diameter: ϕ16 to 50
Lead: 16 to 50

NS-A A-780

Shaft diameter: ϕ8 to 40
Lead: 12 to 40

NS A-780

Shaft diameter: ϕ16 to 50
Lead: 16 to 50

Rolled Ball Screw

Constant Pressure Preload

JPF A-790

Shaft diameter: ϕ14 to 40
Lead: 4 to 10

BTK A-790

Shaft diameter: ϕ10 to 50
Lead: 4 to 16

MTF A-790

Shaft diameter: ϕ6 to 12
Lead: 1 to 2

BLK A-790

Shaft diameter: ϕ15 to 50
Lead: 10 to 50

WTF A-790

Shaft diameter: ϕ15 to 50
Lead: 20 to 100

CNF A-790

Shaft diameter: ϕ15 to 30
Lead: 30 to 60

BNT A-790

Shaft diameter: ϕ14 to 45
Lead: 4 to 12

Rolled Rotary Ball Screw

BLR A-796

Shaft diameter: ϕ16 to 50
Lead: 16 to 50

Lead Screw Nut

DCM A-830

Shaft diameter: ϕ12 to 50

Lead Screw Nut

DC A-830

Shaft diameter: ϕ12 to 50

Change Nut

DCMA A-842

Model No.: DCMA15T to 50

DCMB A-842

Model No.: DCMB8T to 50

Cross-Roller Ring

Integrated Inner/Outer Ring Type

RU A-854

Inner diameter: ϕ20 to 350

Separable Outer Ring Type

RB A-854

Inner diameter: ϕ20 to 1250

Two-piece Inner Ring

RE A-854

Inner diameter: ϕ20 to 600

RB-USP A-854

Inner diameter: ϕ100 to 600

RE-USP A-854

Inner diameter: ϕ100 to 600

Separable Outer Ring Type

RA A-854

Inner diameter: ϕ50 to 200

Separable Outer Ring Type

RA-C A-854

Inner diameter: ϕ50 to 200

Cam Follower

Popular Type

CF A-880

Stud diameter: ϕ5 to 30

With a Hexagon Socket

CF-A A-880

Stud diameter: ϕ3 to 30

Containing Thrust Balls

CFN-R-A A-880

Stud diameter: ϕ5 to 12

Eccentric Cam Follower with Hexagon Socket

CFH-A A-880

Stud diameter: ϕ6 to 30

With a Tapped Hole for Greasing

CFT A-880

Stud diameter: ϕ6 to 30

Roller Follower

Separable Type

NAST A-896

Inner diameter: ϕ6 to 50

Roller Follower

Separable Type
RNAST **A-896**

Inner diameter: ϕ7 to 60

Non-separable Type
NART **A-896**

Inner diameter: ϕ5 to 50

Spherical Plain Bearing

Double-split Outer Ring
SB **A-910**

Inner diameter: ϕ12 to 65

Single-split Outer Ring
SA1 **A-910**

Inner diameter: ϕ12 to 70

Link Ball

AL **A-922**

Shank thread diameter:
M4 to M10

BL **A-922**

Shank thread diameter:
M6 to M16

RBL **A-922**

Shank thread diameter:
M5 to M22

RBI **A-922**

Shank thread diameter:
M5 to M22

TBS **A-922**

Shank thread diameter:
M6 to M12

Rod End

Female Threading Type
PHS **A-942**

Spherical inner ring: ϕ5 to 30

Die Cast, Low Price Type
RBH **A-942**

Spherical inner ring: ϕ5 to 22

No Lubrication Type
NHS-T **A-942**

Spherical inner ring: ϕ3 to 22

Male Threading Type
POS **A-942**

Spherical inner ring: ϕ5 to 30

No Lubrication, Male Threading Type
NOS-T **A-942**

Spherical inner ring: ϕ3 to 22

Standard Type
PB **A-942**

Spherical inner ring: ϕ5 to 30

Die Cast Type
PBA **A-942**

Spherical inner ring: ϕ5 to 22

Rod End

No Lubrication Type
NB-T A-942

Spherical inner ring: ϕ14 to 22

No Lubrication Type
HB A-942

Spherical inner ring: ϕ5 to 12

Lubrication-free, Corrosion-resistant Type
HS A-942

Spherical inner ring: ϕ5 to 12

Accessories for Lubrication

Grease Gun Unit
MG70 A-970

For a 70-g bellows cartridge

Accessories for Lubrication
Special Plumbing Fixtures A-970

Available in various types

Accessories for Lubrication
Grease Nipple A-970

Available in various types

Original Grease
AFA A-959

Base oil: High-grade synthetic oil
Consistency enhancer: Urea-based

Original Grease
AFB-LF A-960

Base oil: Refined mineral oil
Consistency enhancer: Lithium-based

Original Grease
AFC A-961

Base oil: High-grade synthetic oil
Consistency enhancer: Urea-based

Original Grease
AFE-CA A-963

Base oil: High-grade synthetic oil
Consistency enhancer: Urea-based

Original Grease
AFF A-965

Base oil: High-grade synthetic oil
Consistency enhancer: Lithium-based

Original Grease
AFG A-968

Base oil: High-grade synthetic oil
Consistency enhancer: Urea-based

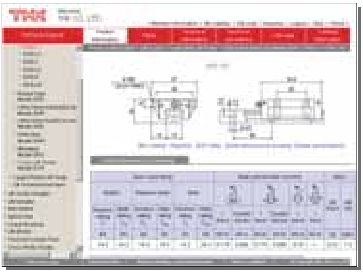
THK Technical Support Site

The THK Technical Support Site lets you access product information and technical support online. You will also find a search feature for locating desired products and a calculation feature for calculating service life. 2D CAD and 3D CAD data are also downloadable.

http://www.thk.com/ ◄ **Enter here.**

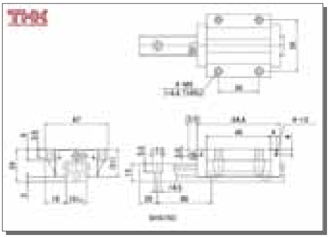
Product Information

View information on our products.
Search by model number, description, or any other criteria.



Detailed Dimensional Drawings

Check detailed product dimensions according to model number.



Detailed Specifications

Check detailed product specifications according to model number.

Available in 3 languages: Japanese,English,and German

Technical Information

View technical information, from application examples to research papers.

FAQ

View inquiries relating to products.
You can search by an entire inquiry or answer.

Technical Calculation

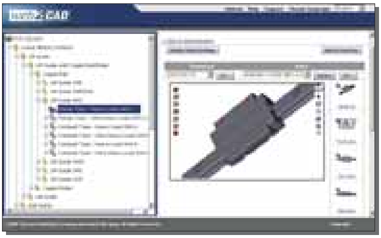
Rated life (service life time) can be calculated simply by entering model number, application criteria, etc.

2D CAD Data Downloads

Approximately 4,000 downloadables of 2D CAD data (DXF files) are available.

3D CAD Data Downloads

Find 3D CAD data matching your specifications, from rail lengths to installation of option items.



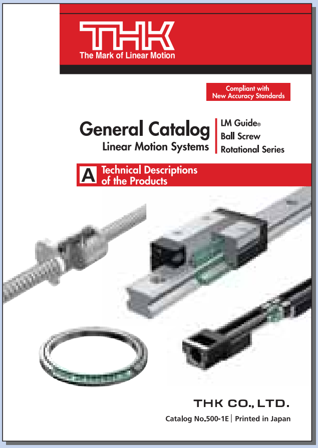
Catalog Information

Order any of a variety of catalogs.
You can also view in PDF format.

◆No user registration required to access Product Information or 2D CAD Data Downloads.
◆To access other services, (free) user registration is required.
◆Use of all services is free.

Guide to the General Catalog

The THK General Catalog is in two volumes, A Technical Descriptions of the Products, and B Product Specifications.

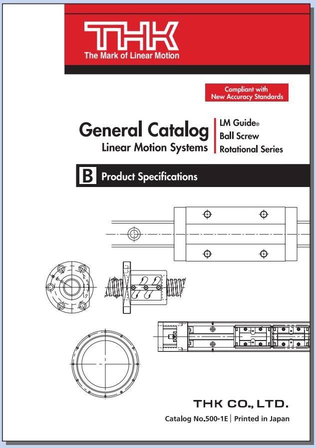

THK
The Mark of Linear Motion
Compliant with New Accuracy Standards
General Catalog
Linear Motion Systems
LM Guide®
Ball Screw
Rotational Series
A Technical Descriptions of the Products
THK CO., LTD.
Catalog No.500-1E | Printed in Japan

A Product Technical Descriptions

A Technical Descriptions of the Products mainly contains product

- Features and Structure
- Point of Selection
- Point of Design
- Mounting Procedure and Maintenance
- Options
- Precautions on Use

■Point of Selection include test data and service life calculation formulas for use when considering technical features in detail. Further, information relating generally to lubrication and grease-type products in special environments can be found conveniently together in Accessories for Lubrication


THK
The Mark of Linear Motion
Compliant with New Accuracy Standards
General Catalog
Linear Motion Systems
LM Guide®
Ball Screw
Rotational Series
B Product Specifications
THK CO., LTD.
Catalog No.500-1E | Printed in Japan

B Product Specifications

B Product Specifications contains dimensional drawings and tables according to product and model number.

All information containing product dimensional elements is given.

With two volumes, you can compare a page of product technical information with the product's dimensional drawings and tables to aid when considering specifications.

We at THK are sure you will be pleased in finding products among our abundant selection in the General Catalog that fit your needs.

General Table of Contents

THK General Catalog

THK General Catalog

General Table of Contents

Dimensions of Each Model with an Option Attached

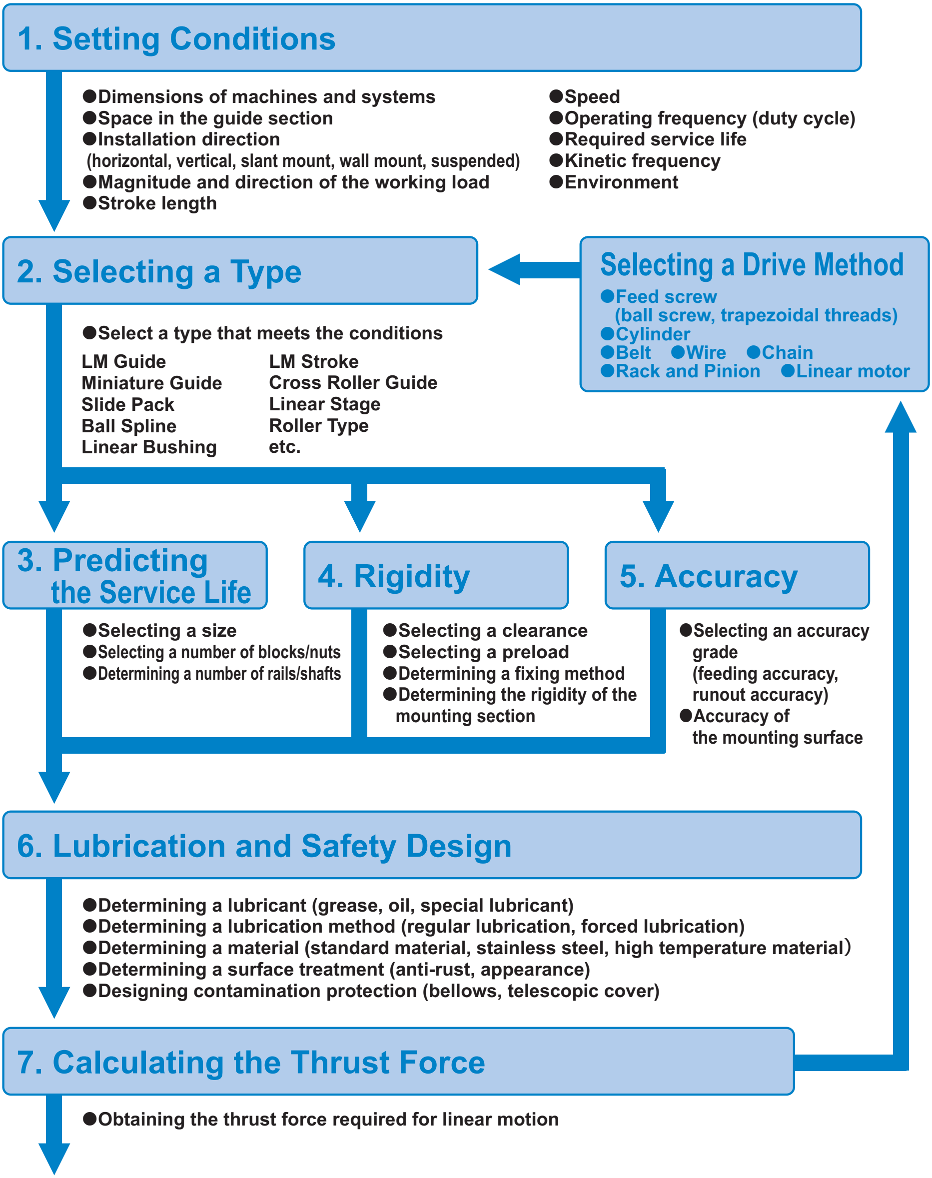
Features and Types

General Description

THK General Catalog

A Technical Descriptions of the Products

Selection Flow Chart



1. Setting Conditions

- ●Dimensions of machines and systems
- ●Space in the guide section
- ●Installation direction
  (horizontal, vertical, slant mount, wall mount, suspended)
- ●Magnitude and direction of the working load
- ●Stroke length
- ●Speed
- ●Operating frequency (duty cycle)
- ●Required service life
- ●Kinetic frequency
- ●Environment

2. Selecting a Type

●Select a type that meets the conditions

LM Guide
Miniature Guide
Slide Pack
Ball Spline
Linear Bushing
LM Stroke
Cross Roller Guide
Linear Stage
Roller Type
etc.

Selecting a Drive Method

- ●Feed screw
  (ball screw, trapezoidal threads)
- ●Cylinder
- ●Belt
- ●Wire
- ●Chain
- ●Rack and Pinion
- ●Linear motor

3. Predicting the Service Life

- ●Selecting a size
- ●Selecting a number of blocks/nuts
- ●Determining a number of rails/shafts

4. Rigidity

- ●Selecting a clearance
- ●Selecting a preload
- ●Determining a fixing method
- ●Determining the rigidity of the mounting section

5. Accuracy

- ●Selecting an accuracy grade
  (feeding accuracy, runout accuracy)
- ●Accuracy of the mounting surface

6. Lubrication and Safety Design

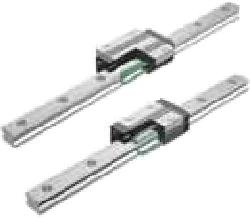
- ●Determining a lubricant (grease, oil, special lubricant)
- ●Determining a lubrication method (regular lubrication, forced lubrication)
- ●Determining a material (standard material, stainless steel, high temperature material)
- ●Determining a surface treatment (anti-rust, appearance)
- ●Designing contamination protection (bellows, telescopic cover)

7. Calculating the Thrust Force

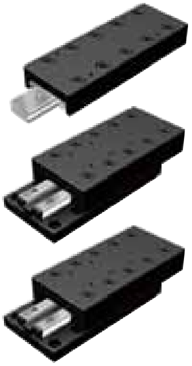
- ●Obtaining the thrust force required for linear motion

Selection Completed

Types and Features of LM Systems

Type	LM Guide	Ball Spline	Linear Bushing
Appearance			
Features	- Ideal Four Raceway, Circular-Arc Groove, Two-Point Contact Structure - Superb error-absorbing capability with the DF design - Accuracy Averaging Effect by Absorbing Mounting Surface Error - Large Permissible Load and High Rigidity - Low Friction Coefficient	- Large torque load capacity - Optimal for torque-transmitting mechanisms and locations where torque and radial load are simultaneously applied - No angular backlash - Ball Retaining Type	- Interchangeable type - LM system capable of performing infinite linear motion at low price
Stroke	Infinite stroke	Infinite stroke	Infinite stroke
Major Applications	- Surface grinder - Electric discharge machine - High-speed transfer equipment - NC lathe - Injection molding machine - Woodworking machine - Semiconductor manufacturing equipment - Inspection equipment - Food-related machine - Medical equipment	- Z axis of assembly robot - Automatic loader - Transfer machine - Automatic conveyance system - Wire winder - Spindle drive shaft of grinding machine - Steering of construction vehicle - Blood test equipment - ATC - Golf training machine	- Measuring instruments - Digital 3D measuring instrument - Printing machine - OA equipment - Automatic vending machine - Medical equipment - Food packaging machine
Page introducing the product	A-25 onward	A-447 onward	A-523 onward

Type	LM Stroke	Precision Linear Pack	Cross Roller Guide
Appearance			
Features	• Capable of performing rotary motion, straight motion and complex motion • Capable of performing rolling motion with an extremely small friction coefficient • Low cost	• Ultra-thin lightweight type • Reduced design and assembly costs	• Long service life, high rigidity • Easy clearance adjustment type
Stroke	Finite stroke	Infinite stroke	Finite stroke
Major Applications	• Press die setting • Ink roll unit of printing machine • Optical measuring instrument • Spindle • Solenoid valve guide • Press post guide • Load cell • Photocopiers • Inspection machines	• Magnetic disc device • Electronic equipment • Semiconductor manufacturing equipment • Medical equipment • Measuring equipment • Plotting machine • Photocopier	• Measuring instruments • Insertion machine • Printed circuit board drilling machine • Inspection equipment • Small stage • Handling mechanism • Automatic lathe • Tool grinder • Internal grinding machine • Small surface grinding machine
Page introducing the product	A-553 onward	A-565 onward	A-571 onward

Type	Cross Roller Table	Linear Ball Slide	LM Roller
Appearance			
Features	• Easily installable unit type • Allows selection of diverse uses	• Easily installable unit type • Lightweight and Compact • Capable of performing rolling motion with an extremely small friction coefficient • Capable of operating without lubrication • Low cost	• Compact, large load capacity type • Self skewing-adjusting type
Stroke	Finite stroke	Finite stroke	Infinite stroke
Major Applications	• Measuring equipment stage • Optical stage • Tool grinder • Printed circuit board drilling machine • Medical equipment • Automatic lathe • Tool grinder • Internal grinding machine • Small surface grinding machine	• Small electronic part assembly machine • Handler • Automatic recorder • Measuring equipment stage • Optical stage • Medical equipment	• Precision press ram guide • Press metal mold exchanger • Heavy load conveyor systems • Vendor machine
Page introducing the product	A-585 onward	A-593 onward	A-603 onward

Type	Flat Roller	Slide Pack	Slide Rail
Appearance			
Features	• Large Load Capacity • Combined accuracy of 90° V-shape surface and flat surface available as standard	• Interchangeable type • Low-cost, simple type	• Thin, compact design • Low-cost, simple type • High strength, high durability
Stroke	Finite stroke	Infinite stroke	Finite stroke
Major Applications	• Planer • Horizontal milling machine • Roll grinding machine • Surface grinder • Cylindrical grinder • Optical measuring instrument	• Amusement machine • High-grade furniture • Light and heavy doors • Tool cabinet • Kitchen fitments • Automatic feeder • Computer peripherals • Photocopier • Medical equipment • Office equipment	• Amusement machine • High-grade furniture • Light and heavy doors • Office equipment • Store fixture • Stocker
Page introducing the product	A-621 onward	A-635 onward	A-645 onward

Load Rating

Service Life of an LM System

When an LM system rolls under a load, its raceway and rolling elements (balls or rollers) constantly receive repetitive stress. If a limit is reached, the raceway fractures from fatigue and part of the surface exfoliates like scales. This phenomenon is called flaking.
The service life of an LM system refers to the total travel distance until the first event of flaking occurs due to rolling fatigue of the material on the raceway or the rolling element.

Nominal Life

The service life of an LM system is subject to slight variations even under the same operating conditions. Therefore, it is necessary to use the nominal life defined below as a reference value for obtaining the service life of the LM system.
The nominal life means the total travel distance that 90% of a group of identical LM system units can achieve without flaking.

Basic Load Rating

An LM system has two types of basic load ratings: basic dynamic load rating (C), which is used to calculate the service life, and basic static load rating (C_0), which defines the static permissible limit.

Basic Dynamic Load Rating C

The basic dynamic load rating (C) indicates the load with constant direction and magnitude, under which the rated life (L) is L = 50 km for an LM system using balls, or L = 100 km for an LM system using rollers, when a group of identical LM system units independently operate under the same conditions.
The basic dynamic load rating (C) is used to calculate the service life when an LM system operates under a load.

Specific values of each LM system model are indicated in the specification table for the corresponding model number.

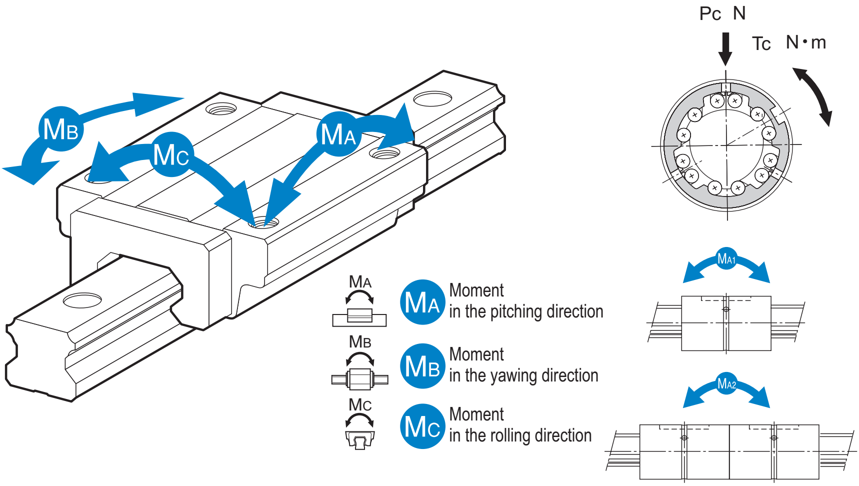
Basic Static Load Rating C_0

If an LM system receives an excessively large load or a large impact when it is stationary or operative, permanent deformation occurs between the raceway and the rolling element. If the permanent deformation exceeds a certain limit, it will prevent the LM system from performing smooth motion.
The basic static load rating is a static load with a constant direction and magnitude whereby the sum of the permanent deformation of the rolling element and that of the raceway on the contact area under the maximum stress is 0.0001 times the rolling element diameter. With an LM system, the basic static load rating is defined for the radial load.
Therefore, the basic static load rating is considered the limit of the static permissible load.

Specific values of each LM system model are indicated in the specification table for the corresponding model number.

Static Permissible Moment M_0

When an LM system receives a moment, the rolling elements on both ends receive the maximum stress due to uneven distribution of the stress on the rolling elements within the LM system.
The permissible static moment (M_0) means the moment with constant direction and magnitude, under which the sum of the permanent deformation of the rolling element and the permanent deformation of the raceway accounts for 0.0001 times of the rolling element's diameter in the contact area where the maximum stress is applied.
With an LM system, the static permissible moment is defined in three directions: M_A, M_B and M_C.
Thus, the static permissible moment is considered the limit of the static moment applied.



P_C : Radial load
T_C : Moment in the torque direction
M_{A1} : Moment in the pitching direction
M_{A2} : Moment in the pitching direction

The specific static permissible moment value of each LM system model is provided in the section on the permissible moments of each model.

Static Safety Factor f_S

The Linear Motion system may receive an unexpected external force while it is stationary or operative due to the generation of an inertia caused by vibrations and impact or start and stop. It is necessary to consider a static safety factor against such a working load.

[Static Safety Factor f_S]

The static safety factor (f_S) is determined by the ratio of the load capacity (basic static load rating C_0) of an LM system to the load applied on the LM system.

$$f_S = \frac{f_C \cdot C_0}{P} \quad \text{or} \quad f_S = \frac{f_C \cdot M_0}{M} \quad \cdots\cdots\cdots \ (1)$$

f_S : Static safety factor
f_C : Contact factor (see Table2 on A-11)
C_0 : Basic static load rating
M_0 : Static permissible moment (M_A, M_B and M_C)
P : Calculated load
M : Calculated moment

[Measure of Static Safety Factor]

Refer to the static safety factor in Table1 as a measure of the lower limit under the service conditions.

Table1 Measure of Static Safety Factor

Kinetic conditions	Load conditions	Lower limit of f_S
Constantly stationary	Impact is small, and deflection of the shaft is also small	1.0 to 1.3
	Impact is present, and a twisting load is applied	2.0 to 3.0
Normal motion	A normal load is applied, and the deflection of the shaft is small	1.0 to 1.5
	Impact is present, and a twisting load is applied	2.5 to 7.0

Life Calculation Formula

The nominal life (L) of an LM system is obtained from the following equation using the basic dynamic load rating (C) and the applied load (P).

[LM System Using Balls]

$$L = \left(\frac{C}{P}\right)^{3} \times 50 \quad \cdots\cdots\cdots \quad (2)$$

[LM System Using Rollers]

$$L = \left(\frac{C}{P}\right)^{\frac{10}{3}} \times 100 \quad \cdots\cdots\cdots \quad (3)$$

L : Nominal life (km)
C : Basic dynamic load rating (N)
P : Applied load (N)

In most cases, it is difficult to calculate a load applied on an LM system.
In actual use, most LM systems receive vibrations and impact during operation, and fluctuation of the loads applied on them is assumed. In addition, the hardness of the raceway and the temperature of the LM system unit greatly affect the service life.
With these conditions considered, the practical service life calculation formulas (2) and (3) should be as follows.

[LM System Using Balls]

$$L = \left(\frac{f_H \cdot f_T \cdot f_C}{f_W} \times \frac{C}{P}\right)^{3} \times 50 \quad \cdots\cdots\cdots \quad (4)$$

[LM System Using Rollers]

$$L = \left(\frac{f_H \cdot f_T \cdot f_C}{f_W} \times \frac{C}{P}\right)^{\frac{10}{3}} \times 100 \quad \cdots\cdots\cdots \quad (5)$$

L : Nominal life (km)
C : Basic dynamic load rating (N)
P : Applied load (N)
f_H : Hardness factor (see Fig.1 on A-11)
f_T : Temperature factor (see Fig.2 on A-11)
f_C : Contact factor (see Table2 on A-11)
f_W : Load factor (see Table3 on A-12)

● f_H: Hardness Factor

To maximize the load capacity of the LM system, the hardness of the raceways needs to be between 58 and 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).

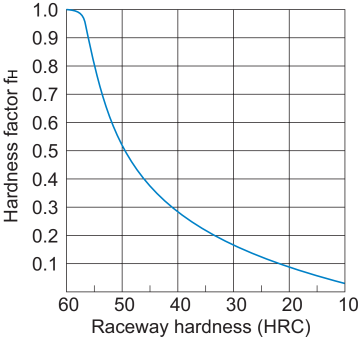


Fig.1 Hardness Factor (f_H)

● f_T:Temperature Factor

If the temperature of the environment surrounding the operating LM System 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.2.

In addition, the LM system must be of high temperature type.

Note) If the temperature of the service environment exceeds 80 ℃ , it is necessary to change the materials of the seal and end plate to high-temperature materials.

Note) If the temperature of the environment exceeds 120℃, it is necessary to provide dimensional stabilization.

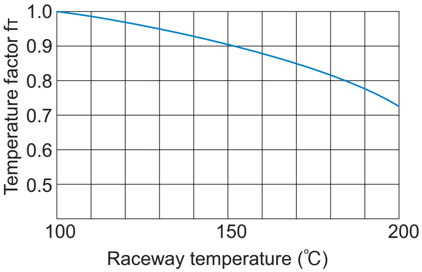


Fig.2 Temperature Factor (f_T)

● f_C: Contact Factor

If multiple LM Guide blocks are closely arranged with each other, it is difficult to achieve uniform load distribution due to a moment load and the accuracy of the mounting surface. In such applications, multiply basic load ratings “C” and “C_0” by the corresponding contact factors in Table2.

Note) If uneven load distribution is expected in a large machine, take into account the respective contact factor indicated in Table2.

Table2 Contact Factor (f_C)

Number of blocks used in close contact	Contact factor f_C
2	0.81
3	0.72
4	0.66
5	0.61
6 or greater	0.6
Normal use	1

● f_W: Load Factor

In general, reciprocating machines tend to involve vibrations or impact during operation. It is extremely difficult to accurately determine vibrations generated during high-speed operation and impact during frequent start and stop. 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 Table3, which contains empirically obtained data.

Table3 Load Factor (f_W)

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

Rigidity

When using an LM system, it is necessary to select a type and a clearance (preload) that meet the service conditions in order to achieve the required rigidity of the machine/equipment.

Selecting a Clearance/Preload for an LM System

Since clearances and preloads of LM systems are standardized for different models, you can select a clearance and a preload according to the service conditions.
For separate-type models, THK cannot adjust their clearances at shipment. Therefore, the user must adjust the clearance when installing the product.
Determine a clearance/preload while referring to the following section.

Clearance and Preload

[Clearance (internal clearance)]
Clearance of an LM system is a play between the block (nut), the rail (shaft) and the ball (or roller). The sum of vertical clearances is called radial clearance, and the sum of circumferential clearances is called angular backlash (clearance in the rotational direction).

(1) Radial clearance
With the LM Guide, a radial clearance refers to the value of a movement of the block center when the LM block is gently moved vertically with constant force applied in the center of the fixed LM rail in the longitudinal direction.

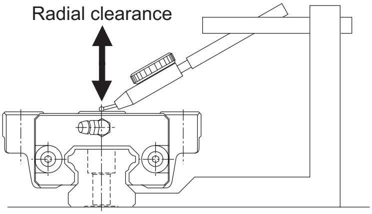


Fig.3 Radial clearance of the LM Guide

(2) Angular backlash (clearance in the rotational direction)
With the Ball Spline, angular backlash (clearance in the rotational direction) refers to the value of a rotational motion of the nut when the nut is gently rotated forward and backward with constant force with the spline shaft fixed.

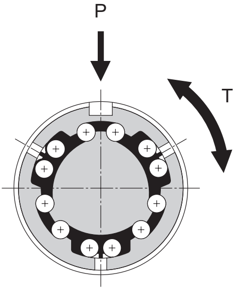


Fig.4 Angular backlash of the Ball Spline

[Preload]

Preload is a load that is preliminarily applied to the rolling elements in order to eliminate a clearance of an LM system and increase its rigidity. A negative clearance indication (negative value) of an LM system means that a preload is provided.

Table4 Examples of Radial Clearances for LM Guide Model HSR

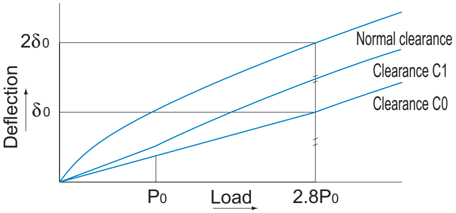
Unit: μm

Indication symbol	Normal	Light preload	Medium preload
Model No.	No Symbol	C1	C0
HSR 15	−4 to +2	−12 to −4	—
HSR 20	−5 to +2	−14 to −5	−23 to −14
HSR 25	−6 to +3	−16 to −6	−26 to −16
HSR 30	−7 to +4	−19 to −7	−31 to −19
HSR 35	−8 to +4	−22 to −8	−35 to −22

For specific clearances and preloads, see the section concerning the corresponding model.

Preload and Rigidity

Providing a preload to an LM system will increase the rigidity according to the amount of the preload. Fig.5 shows deflection of clearances (normal clearance, clearance C1 and clearance C0) (with LM Guide model HSR).



P0: Applied preload

Fig.5 Rigidity Data

Thus, a preload has an effect of up to approximately 2.8 times greater than the applied preload itself. The deflection with a preload under a given load is smaller, and the rigidity is much greater, than that without a preload.

Fig.6 shows how the radial deflection of an LM Guide changes with a preload. As indicated in Fig.6, when an LM Guide block receives a radial load of 2.45 kN, the radial deflection is 9μm if the radial clearance is zero (normal clearance) or 2μm if it the radial clearance is -30μm (clearance C0), thus increasing the rigidity by 4.5 times.

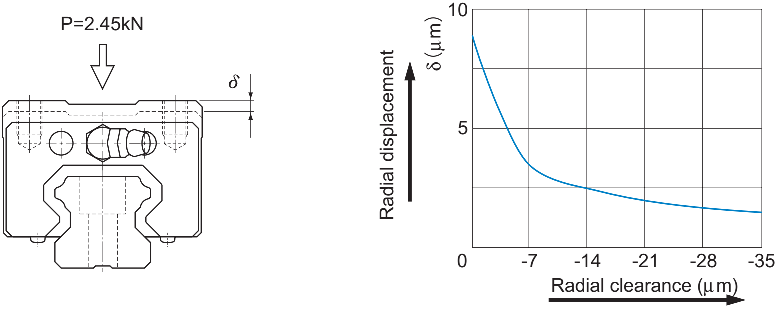


Fig.6 Radial Clearance and Deflection

For selecting a specific clearance, see the section concerning selection of a radial clearance for the corresponding LM system model.

Friction coefficient

Since an LM system makes rolling motion via its rolling elements such as balls and rollers between the raceways, its frictional resistance is 1/20 to 1/40 smaller than a sliding guide. Its static friction is especially small and almost the same as dynamic friction, preventing the system from experiencing "stick-slip." Therefore, the system is capable of being fed by the submicron distance.

The frictional resistance of an LM system varies according to the type of the LM system, preload, viscosity resistance of the lubricant and the load applied on the LM system.

In particular, when a moment is given or a preload is applied to increase rigidity, the frictional resistance increases.

Normal friction coefficient by LM systems are indicated in Table5.

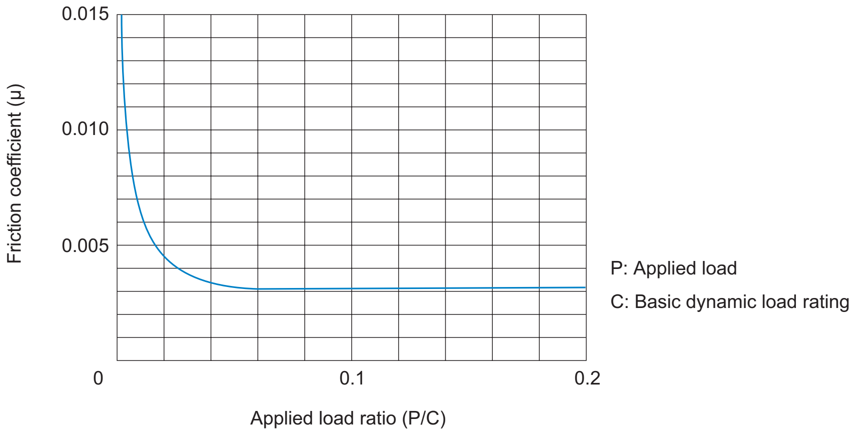


Fig.7 Relationship between Applied Load Ratio and Frictional Resistance

Table5 Frictional Resistances (μ) of LM Systems

Types of LM systems	Representative types	Frictional resistance (μ)
LM Guide	SSR, SHS, SNR/SNS, SRS, RSR, HSR, NR/NRS	0.002 to 0.003
	SRG, SRN	0.001 to 0.002
Ball Spline	LBS, LBF, LT, LF	0.002 to 0.003
Linear Bushing	LM, LMK, LMF, SC	0.001 to 0.003
LM Stroke	MST, ST	0.0006 to 0.0012
LM Roller	LR, LRA	0.005 to 0.01
Flat Roller	FT, FTW	0.001 to 0.0025
Cross-roller Guide/Cross-roller Table	VR, VRU, VRT	0.001 to 0.0025
Linear Ball Slide	LS	0.0006 to 0.0012
Cam Follower/Roller Follower	CF, NAST	0.0015 to 0.0025

Accuracy

The motion accuracy of an LM system is defined in running accuracy for models that are fixed on the flat surface and in runout accuracy for models whose shafts are supported, and accuracy grades are established for each of them.
For details, see the page concerning the corresponding model.

Lubrication

When using an LM system, it is necessary to provide effective lubrication. Using the product without lubrication may increase wear of the rolling elements or shorten the service life.
A lubricant has the following effects.

1. Minimizes friction in moving elements to prevent seizure and reduce wear.
2. Forms an oil film on the raceway to decrease stress acting on the surface and extend rolling fatigue life.
3. Covers the metal surface to prevent rust formation.

To fully bring out an LM system's functions, it is necessary to provide lubrication according to the conditions.
Even with an LM system with seals, the internal lubricant gradually seeps out during operation. Therefore, the system needs to be lubricated at an appropriate interval according to the conditions.

[Types of Lubricants]

LM systems mainly use grease or sliding surface oil for their lubricants.
The requirements that lubricants need to satisfy generally consist of the following.

(1) High oil film strength
(2) Low friction
(3) High wear resistance
(4) High thermal stability
(5) Non-corrosive
(6) Highly anti-corrosive
(7) Minimal dust/water content
(8) Consistency of grease must not be altered to a significant extent even after it is repeatedly stirred.

Lubricants that meet these requirements include the following products.

Table6 Lubricants for General Use

Lubricant	Type	Brand name
Oil	Sliding surface oil or turbine oil ISOVG32 to 68	Super Multi 32 to 68 (Idemitsu) Vactra No.2S (ExxonMobile) DT Oil (ExxonMobile) Tonner Oil (Showa Shell Sekiyu) or equivalent

Table7 Lubricants Used under Special Environments

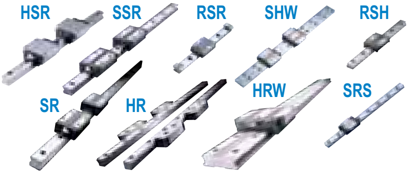
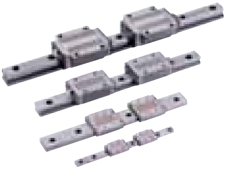
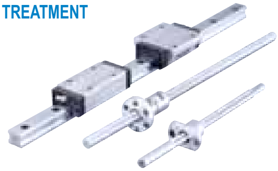
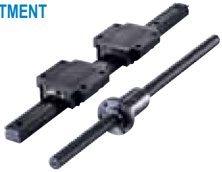
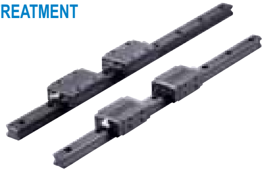
Service environment	Lubricant characteristics	Brand name
High-speed moving parts	Grease with low torque and low heat generation	AFG Grease(THK) see A-968 AFA Grease(THK) see A-959 NBU15(NOK Kluba) Multemp (Kyodo Yushi) or equivalent
Vacuum	Fluorine based vacuum grease or oil (vapor pressure varies by brand) Note 1	Fomblin Grease (Solvay Solexis) Fomblin Oil (Solvay Solexis) Barrierta IEL/V (NOK Kluba) Isoflex(NOK Kluba) Krytox (Dupont)
Clean room	Grease with very low dust generation	AFE-CA Grease(THK) see A-963 (The above vacuum grease products also applicable) AFF Grease(THK) see A-965
Environments subject to microvibrations or microstrokes, which may cause fretting corrosion	Grease that easily forms an oil film and has high fretting resistance	AFC Grease(THK) see A-961
Environments subject to a spattering coolant such as machine tools	Highly anti-corrosive, refined mineral oil or synthetic oil that forms a strong oil film and is not easily emulsified or washed away by coolant Water-resistant grease Note 2	Super Multi 68 (Idemitsu) Vactra No.2S (ExxonMobile) or equivalent

Note1) When using a vacuum grease, be sure that some brands have starting resistances several times greater than ordinary lithium-based greases.
Note2) In an environment subject to a spattering water-soluble coolant, some brands of intermediate viscosity significantly decrease their lubricity or do not properly form an oil film. Check the compatibility between the lubricant and the coolant.
Note3) Do not mix greases with different physical properties.
Note4) For THK original grease products, see A-958.

Safety Design

LM systems are used in various environments. If using an LM system in a special environment such as vacuum, anti corrosion, high temperature and low temperature, it is necessary to select a material and surface treatment that suit the service environment.

To support use in various special environments, THK offers the following materials and surface treatments for LM systems.

	Description	Model No.	Features/Capabilities
Material	Martensite stainless steel	HSR SSR RSR SHW RSH SR HR HRW SRS 	Anti-rust property ★★★★★
	Martensite stainless steel	SR-M1 HSR-M1 RSR-M1 	High temperature support ★★★★★ * up to 150℃
	Austenite stainless steel	HSR-M2 	Anti-rust property ★★★★★
Surface Treatment	AP-HC	THK AP-HC TREATMENT 	Low dust generation ★★★★★ Anti-rust property ★★★ Surface hardness ★★★★★
	AP-C	THK AP-C TREATMENT 	Anti-rust property ★★★★
	AP-CF	THK AP-CF TREATMENT 	Anti-rust property ★★★★★

* If you desire a surface treatment other than the above, contact THK.

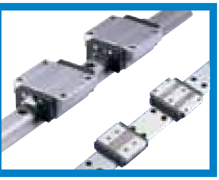
Determining a Material

In normal service conditions, LM systems use a type of steel that suits LM systems. If using an LM system in a special environment, it is necessary to select a material that suits the service environment.
For locations that require high corrosion resistance, a stainless steel material is used.

Material Specifications

Stainless Steel LM Systems

●Material···martensite stainless steel/austenite stainless steel



For use in environments where corrosion resistance is required, some LM system models can use martensite stainless steel.
If the model number of an LM system contains symbol M, it means that the model is made of stainless steel. See the section concerning the corresponding model.

Model number coding

HSR25 A 2 QZ UU C0 M +1200L P M -Ⅱ

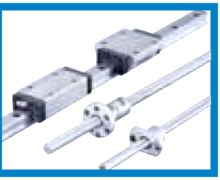
Model number
Type of LM block
No. of LM blocks used on the same rail
With QZ Lubricator
Dust prevention accessory symbol
Radial clearance symbol
Stainless steel LM block
LM rail length (in mm)
Accuracy symbol
Stainless steel LM rail
Symbol for No. of rails used on the same plane

Surface Treatment

The surfaces of the rails and shafts of LM systems can be treated for anti-corrosive or aesthetic purposes.
THK offers THK-AP treatment, which is the optimum surface treatment for LM systems.
The THK-AP treatment consists of the following 3 types.

AP-HC

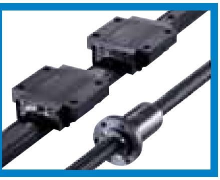
- **Surface treatment…industrial-use hard chrome plating**
- **Film hardness…750 Hv or higher**



Equivalent to industrial-use hard chrome plating, AP-HC achieves almost the same level of corrosion resistance as martensite stainless steel. In addition, it is highly wear resistant since the film hardness is extremely high, 750 Hv or higher.

AP-C

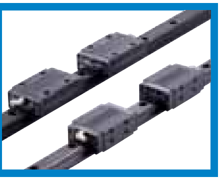
- **Surface treatment…industrial-use black chrome coating**



A type of industrial-use black chrome coating designed to increase corrosion resistance. It achieves lower cost and higher corrosion resistance than martensite stainless steel.

AP-CF

- **Surface treatment…industrial-use black chrome coating**
  /special fluorocarbon resin coating



A compound surface treatment that combines black chrome coating and special fluorine resin coating and is suitable for applications requiring high corrosion resistance.
In addition to the above treatments, other surface treatments are sometimes performed on areas other than the raceways, such as alkaline coloring treatment (black oxidizing) and color anodize treatment. However, some of them are not suitable for LM systems. For details, contact THK.
If using an LM system whose raceways are surface treated, set a higher safety factor.

Model number coding

SR15 V 2 F + 640L F

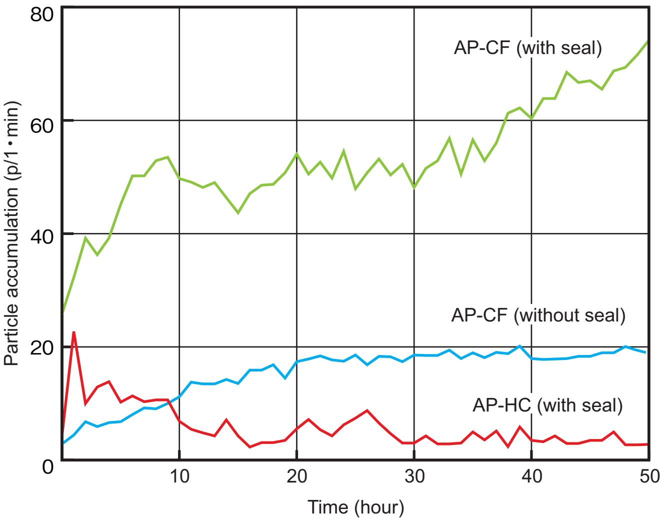
SR15: Model number
V: Type of LM block
2: No. of LM blocks used on the same rail
F: With surface treatment on the LM block
640L: LM rail length (in mm)
F: With surface treatment on the LM block

Note) Note that the inside of the mounting hole is not provided with surface treatment.

[Data on Comparison of Dust Generation with AP Treatment]

[Test conditions]

Item	Description
LM Guide model number	SSR20WF+280LF (AP-CF, without seal) SSR20UUF+280LF (AP-CF, with seal) SSR20WUUF+280LF (AP-HC, with seal)
Grease used	THK AFE-CA Grease
Grease quantity	1cc (per LM block)
Speed	30m/min(MAX)
Stroke	200mm
Flow rate during measurement	1ℓ/min
Clean room volume	1.7 liter (acrylic casing)
Measuring instrument	Dust counter
Measured particle diameter	0.3µm or more



THK AP-HC treatment provides high surface hardness and has high wear resistance. The high level of wear in the early stage in the graph above is considered to be due to the initial wear of the end seal.

Note) THK AP-HC treatment (equivalent to hard chrome plating)
THK AP-CF treatment (equivalent to black chrome plating + fluorine resin coating)

[Data on Comparison of Rust Prevention]

<Salt-water spray resistance cycle test>

Item	Description
Spray liquid	1% NaCl solution
cycles	Spraying for 6 hours, drying for 6 hours
Temperature conditions	35℃ during spraying
	60℃ during drying

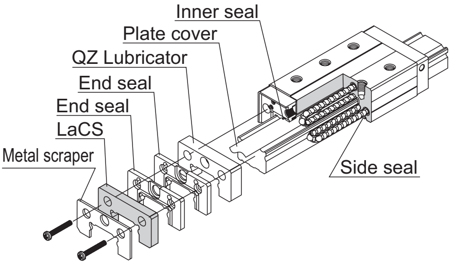
Specimen material Time		Austenite stainless steel	Martensite stainless steel	THK AP-HC	THK AP-C	THK AP-CF
Before test						
6 hours						
24 hours						
96 hours						
Test Result	Anti-rust property	◎	○	○	◎	◎
	Wear Resistance	○	◎	◎	△	○
	Surface hardness	△	◎	◎	△	△
	Adherence	—	—	◎	△	○
	Appearance	Metallic luster	Metallic luster	Metallic luster	Black luster	Black luster

Contamination Protection

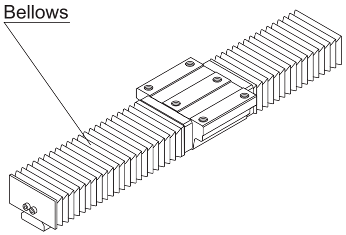
Contamination protection is the most important factor in using an LM system. Entrance of dust or other foreign material into the LM system will cause abnormal wear or shorten the service life.
Therefore, when entrance of dust or other foreign material is predicted, it is necessary to select a sealing device or contamination protection device that meets the service environment conditions.

(1) Dedicated seals for LM systems
For LM systems, seals made of special synthetic rubber with high wear resistance (e.g., Laminated Contact Scraper LaCS) and a wiper ring are available as contamination protection seals.
For locations with adverse service environments, dedicated bellows and dedicated covers are available for some models.
For details and symbols of these seals, see the section concerning options (contamination protection) for the corresponding model.
To provide contamination protection also for Ball Screws in service environments subject to cutting chips and cutting fluids, it is advisable to use a telescopic cover that covers the whole system and a large-size bellows.

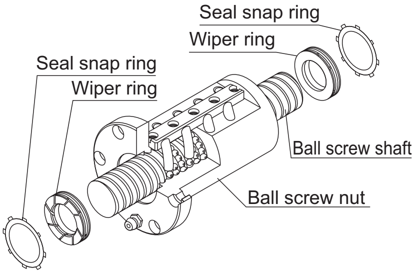
(2) Dedicated bellows
For LM Guides, standardized bellows are available.
THK manufactures dedicated bellows also for other LM systems such as Ball Screws and Ball Splines. Contact THK for details.



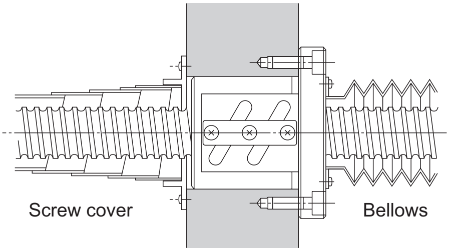
Contamination Protection Seal for the LM Guide



Dedicated Bellows for the LM Guide



Wiper Ring for the Ball Screw



Contamination Protection Cover for the Ball Screw

LM Guide®

THK General Catalog

LM Guide

THK General Catalog

A Technical Descriptions of the Products

Dimensions of Each Model with an Option Attached

B Product Specifications (Separate)

Dimensional Drawing, Dimensional Table

Caged Ball LM Guide

LM Guide

Caged Roller LM Guide

*** Please see the separate "B Product Specifications".**

Features of the LM Guide

Functions Required for Linear Guide Surface

- Large permissible load
- Highly rigid in all directions
- High positioning repeatability
- Running accuracy can be obtained easily
- High accuracy can be maintained over a long period

- Smooth motion with no clearance
- Superbly high speed
- Easy maintenance
- Can be used in various environments

Features of the LM Guide

- Large permissible load and high rigidity
- Accuracy averaging effect by absorbing mounting surface error
- Ideal four raceway, circular-arc groove, two point contact structure
- Superb error-absorbing capability with the DF design
- Low friction coefficient
- Wide array of options (QZ lubricator, Laminated contact scraper LaCS, etc.)

As a result, the following features are achieved.

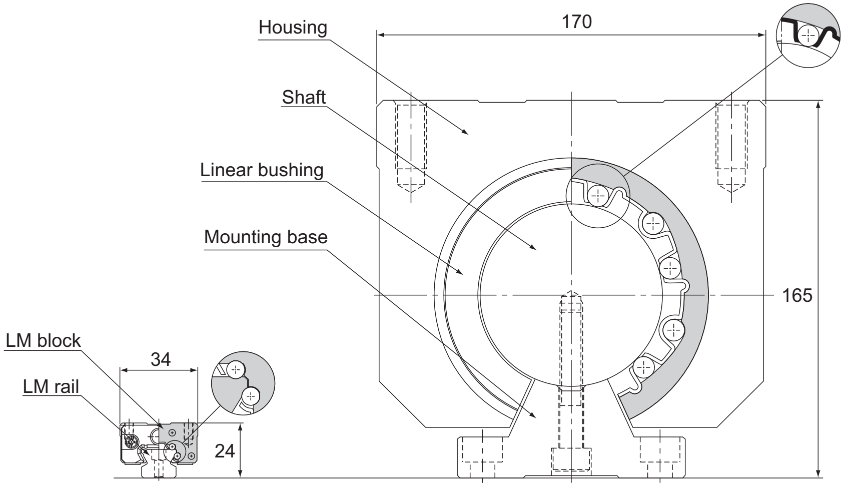
- Easy maintenance
- Improved productivity of the machine
- Substantial energy savings
- Low total cost
- Higher accuracy of the machine
- Higher efficiency in machine design

Large Permissible Load and High Rigidity

[Large Permissible Load]

The LM Guide has raceway grooves with a radius almost equal to the ball radius, which is significantly different from the linear bushing. As shown in Fig.1, which compares size between the LM Guide and the linear bushing with similar basic dynamic load ratings, the LM Guide is much smaller than the linear bushing, indicating that the LM Guide allows a significantly compact design.

The reason for this space saving is the greater difference in permissible load between the R-groove contact structure and the surface contact structure. The R-groove contact structure (radius: 52% of the ball radius) can bear a load per ball 13 times greater than the surface contact structure. Since service life is proportional to the cube of the permissible load, this increased ball-bearing load translates into a service life that is approximately 2,200 longer than the linear bushing.



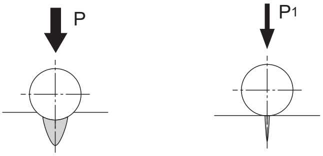
LM Guide model SSR15XW
Basic dynamic load rating: 14.7 kN

Linear Bushing model LM80 OP
Basic dynamic load rating: 7.35 kN

Fig.1 Comparison between the LM Guide and the Linear Bushing

Table1 Load Capacity per Ball (P and P_1)
Permissible contact surface pressure: 4,200 MPa

	R-groove (P)	Flat surface (P_1)	P/P_1
ϕ 3.175 (1/8´´)	0.90 kN	0.07 kN	13
ϕ 4.763 (3/16´´)	2.03 kN	0.16 kN	13
ϕ 6.350 (1/4´´)	3.61 kN	0.28 kN	13
ϕ 7.938 (5/16´´)	5.64 kN	0.44 kN	13
ϕ 11.906 (15/32´´)	12.68 kN	0.98 kN	13



R-groove **Flat surface**

Fig.2 Load Capacity per Ball

[High Rigidity]

The LM Guide is capable of bearing vertical and horizontal loads. Additionally, due to the circular-arc groove design, it is capable of carrying a preload as necessary to increase its rigidity.
When compared with a feed screw shaft system and a spindle in rigidity, the guide surface using an LM Guide has higher rigidity.

- **Example of comparing static rigidity between the LM Guide, a feed screw shaft system and a spindle**

(vertical machining center with the main shaft motor of 7.5 kW)

[Components]

LM Guide: SNR45LC/C0
(C0 clearance: preload = 8.05kN)
Ball Screw: BNFN4010-5/G0
(G0 clearance: preload = 2.64kN)
Spindle: general-purpose cutting spindle

Table2 Comparison of Static Rigidity

Unit: N/µm

Components	X-axis direction	Y-axis direction	Z-axis direction
LM Guide	—	2110	8700 (radial) 6730 (reverse radial)
Ball screw	330	—	—
Spindle	250	250	280

Note) The rigidity of the feed screw shaft system includes rigidity of the shaft end support bearing.

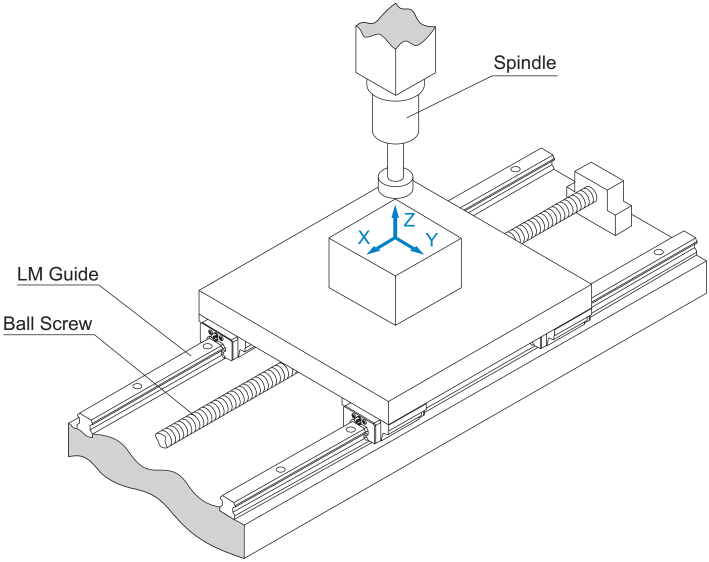
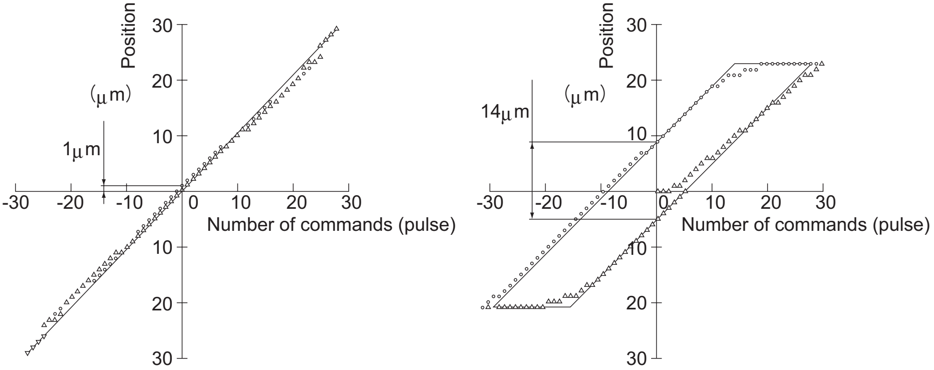


Fig.3

High Precision of Motion

[Small lost motion]

The LM Guide is provided with an ideal rolling mechanism. Therefore, the difference between dynamic and static friction is minimal and lost motion hardly occurs.



LM Guide model HSR45

Square slide + Turcite

(Measurements are taken with the single-axis table loaded with a 500-kg weight)

Fig.4 Comparison of Lost Motion between the LM Guide and a Slide Guide

Table3 Lost Motion Comparison

Unit: µm

Type	Clearance	Test method			
		As per JIS B 6330			Based on minimum unit feeding
		10mm/min	500mm/min	4000mm/min	
LM Guide (HSR45)	C1 clearance (see table below)	2.3	5.3	3.9	0
	C0 clearance (see table below)	3.6	4.4	3.1	1
Square slide + turcite	0.02mm	10.7	15	14.1	14
	0.005mm	8.7	13.1	12.1	13

Radial clearance of the LM Guide

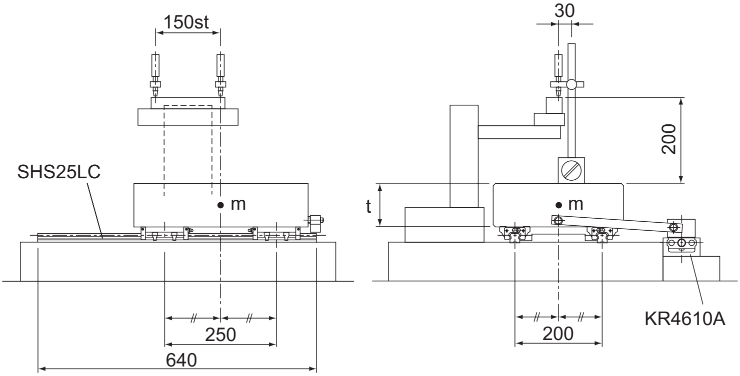
Unit: µm

Symbol	C1	C0
Radial clearance	–25 to –10	–40 to –25

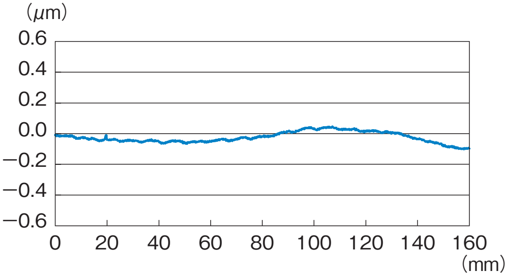
[High running accuracy]

Use of the LM Guide allows you to achieve high running accuracy.

[Measurement method]



Pitching accuracy



Yawing accuracy

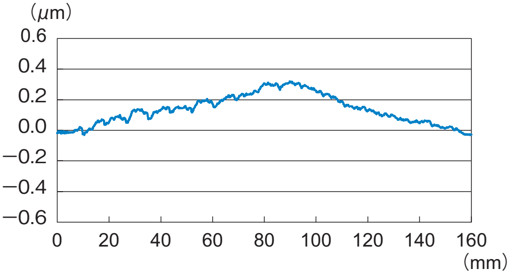


Fig.5 Dynamic Accuracy of a Single-axis Table

[High accuracy maintained over a long period]

As the LM Guide employs an ideal rolling mechanism, wear is negligible and high precision is maintained for long periods of time. As shown in Fig.6, when the LM Guide operates under both a preload and a normal load, more than 90% of the preload remains even after running 2,000 km.

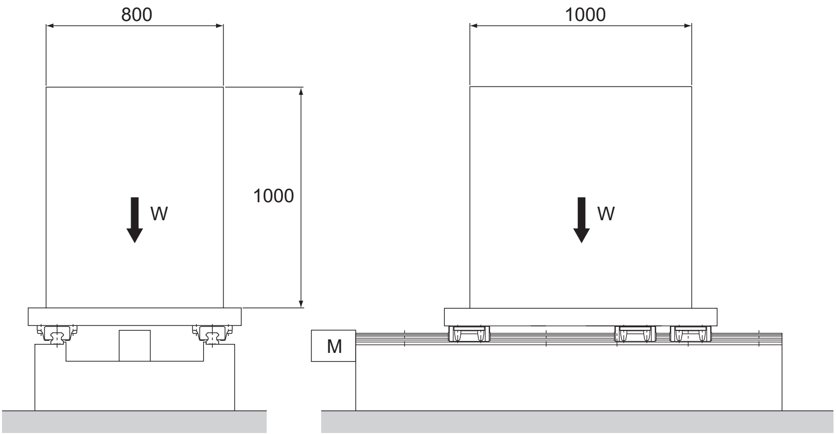


Fig.6 Condition

[Conditions]
Model No. : HSR65LA3SSC0 + 2565LP-Ⅱ
Radial clearance
: C0 (preload: 15.7 kN)
Stroke : 1,050mm
Speed : 15 m/min (stops 5 sec at both ends)
Acceleration/decelelation time in rapid motion
: 300 ms (acceleration: α = 0.833 m/s^2)
Mass : 6000kg
Drive : Ball Screws
Lubrication : Lithium soap-based grease No. 2
(greased every 100 km)

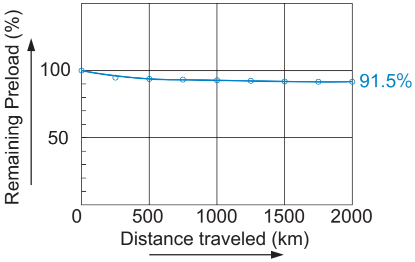


Fig.7 Distance Traveled and Remaining Preload

Accuracy Averaging Effect by Absorbing Mounting Surface Error

The LM Guide contains highly spherical balls and has a constrained structure with no clearance. In addition, it uses LM rails in parallel on multiple axes to form a guide system with multiple-axis configuration. Thus, the LM Guide is capable of absorbing misalignment in straightness, flatness or parallelism that would occur in the machining of the base to which the LM Guide is to be mounted or in the installation of the LM Guide by averaging these errors.

The magnitude of the averaging effect varies according to the length or size of the misalignment, the preload applied on the LM Guide and the number of axes in the multiple-axis configuration. When misalignment is given to one of the LM rails of the table as shown in Fig.8, the magnitude of misalignment and the actual dynamic accuracy of the table (straightness in the horizontal direction) are as shown in Fig.9.

By applying such characteristics obtained with the averaging effect, you can easily establish a guide system with high precision of motion.

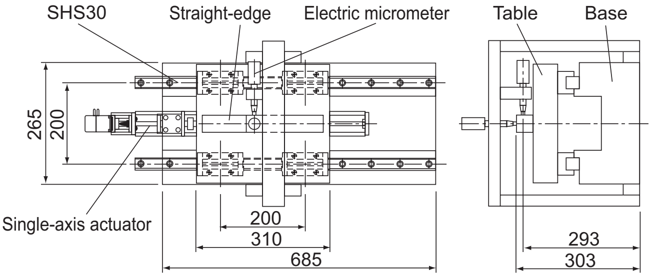
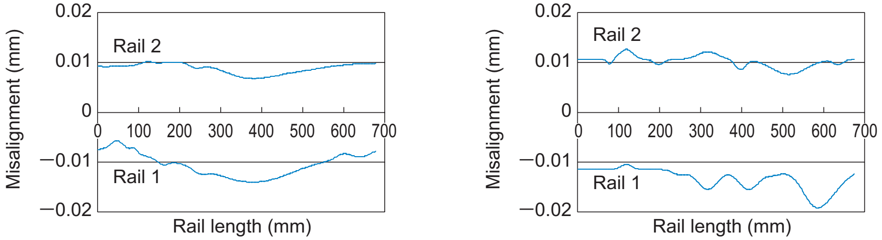
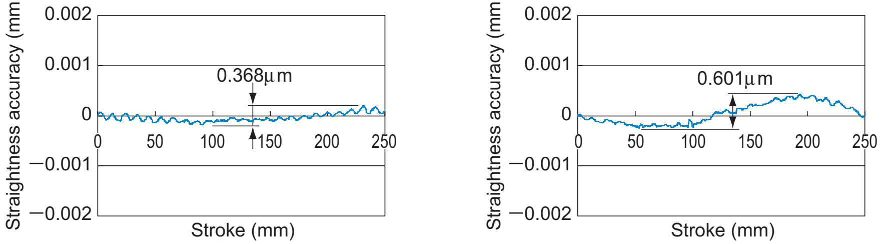


Fig.8



Misalignment curve (vertical)

Misalignment curve (horizontal)



Displacement of the table (vertical)

Displacement of the table (horizontal)

Fig.9

Even on a roughly milled mounting surface, the LM Guide drastically increases running accuracy of the top face of the table.

[Example of Installation]

When comparing the mounting surface accuracy (a) and the table running accuracy (b), the results are :

Vertical 92.5μm → 15μm = 1/6
Horizontal 28μm → 4μm = 1/7

Table4 Actual Measurement of Mounting-Surface Accuracy

Unit: μm

Direction	Mounting surface		Straightness	Average (a)
Vertical	Horizontal	A	80	92.5
		B	105	
Bottom surface	Side surface	C	40	28
		D	16	

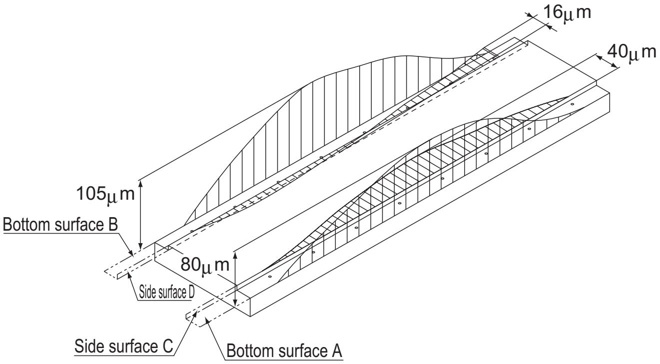


Fig.10 Surface Accuracy of the LM Guide Mounting Base (Milled Surface Only)

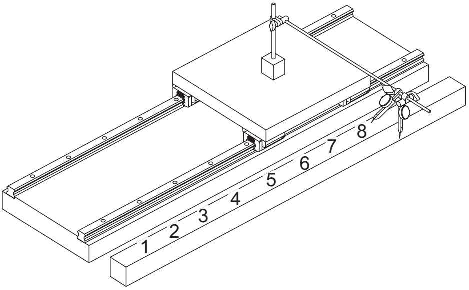


Fig.11 Running Accuracy After the LM Guide Is Mounted

Table5 Actual Measurement of Running Accuracy on the Table (Based on Measurement in Fig.10 and Fig.11)

Unit: μm

Direction	Measurement point								
	1	2	3	4	5	6	7	8	Straightness (b)
Vertical	0	+2	+8	+13	+15	+9	+5	0	15
Horizontal	0	+1	+2	+3	+2	+2	–1	0	4

Easy Maintenance

Unlike with sliding guides, the LM Guide does not incur abnormal wear. As a result, sliding surfaces do not need to be reconditioned, and precision needs not be altered. Regarding lubrication, sliding guides require forced circulation of a large amount of lubricant so as to maintain an oil film on the sliding surfaces, whereas the LM Guide only needs periodical replenishing of a small amount of grease or lubricant. Maintenance is that simple. This also helps keep the work environment clean.

Improved Productivity of the Machine

Since the LM Guide is superb in high speed, productivity of the machine is improved.

Table6 Examples of Using the LM Guide in High-speed Applications

Machine using the LM Guide	Place where the LM Guide is used	Speed (m/s)	Model No.
Durability test machine	X axis	5.0	SSR25XW
Pick-up robot	X axis	2.0	SSR25XW
	Z axis	3.0	SSR15XW
Injection molding machine	Automatic unloading unit	2.2	HSR30LR
Glass cutter	Cutter sliding unit	3.7	HSR25B
Inspection equipment	Work transfer unit	5.0	HRW27CA
Conveyance robot	Work transport unit	4.2	HSR25R
XY table	X-Y axis	2.3	RSR15WV

Substantial Energy Savings

As shown in Table7, the LM Guide has a substantial energy saving effect.

Table7 Comparative Data on Sliding and Rolling Characteristics

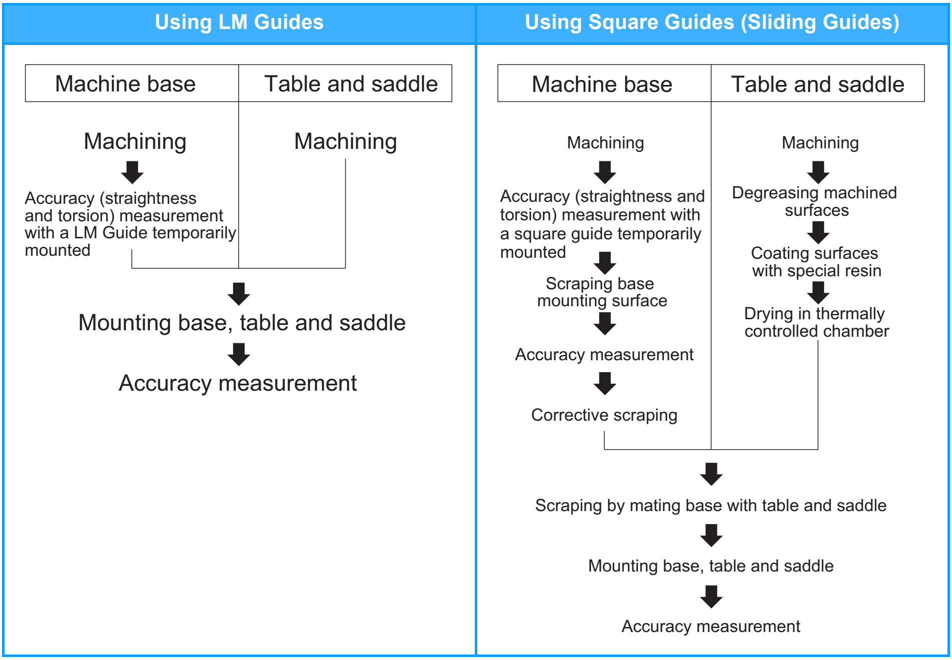
Machine Specifications		
Type of machine	Single-axis surface grinding machine (sliding guide)	Three-axis surface grinding machine (rolling guide)
Overall length × overall width	13m×3.2m	12.6m×2.6m
Total mass	17000kg	16000kg
Table mass	5000kg	5000kg
Grinding area	0.7m×5m	0.7m×5m
Table guide	Rolling through V-V guide	Rolling through LM Guide installation
No. of grinding stone axes	Single axis (5.5 kW)	Three axes (5.5 kW + 3.7 kW x 2) Grinding capacity: 3 times greater

Table Drive Specifications			Ratio
Motor used	38.05kW	3.7kW	10.3
Drive hydraulic pressure	Bore diameterϕ160×1.2MPa	Bore diameter ϕ 65×0.7MPa	—
Thrust	23600N	2270N	10.4
Electric Power consumption	38kWH	3.7kWH	10.3
Drive hydraulic pressure oil consumption	400ℓ/year	250ℓ/year	1.6
Lubricant consumption	60 ℓ/year (oil)	3.6 ℓ/year (grease)	16.7

Low Total Cost

Compared with a sliding guide, the LM Guide is easier to assemble and does not require highly skilled technicians to perform the adjustment work. Thus, the assembly man-hours for the LM Guide are reduced, and machines and systems incorporating the LM Guide can be produced at lower cost. The figure below shows an example of difference in the procedure of assembling a machining center between using siding guides and using LM Guides.
Normally, with a sliding guide, the surface on which the guide is installed must be given a very smooth finish by grinding. However, the LM Guide can offer high precision even if the surface is milled or planed. Using the LM Guide thus cuts down on machining man-hours and lowers machining costs as a whole.

[Assembly Procedure for a Machining Center]

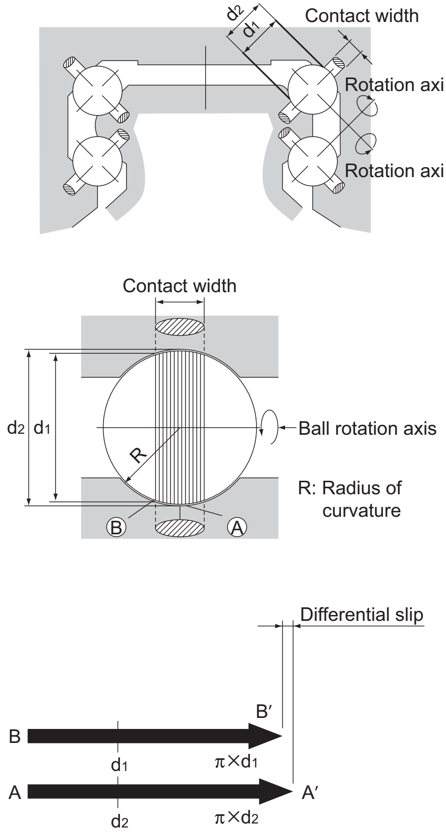
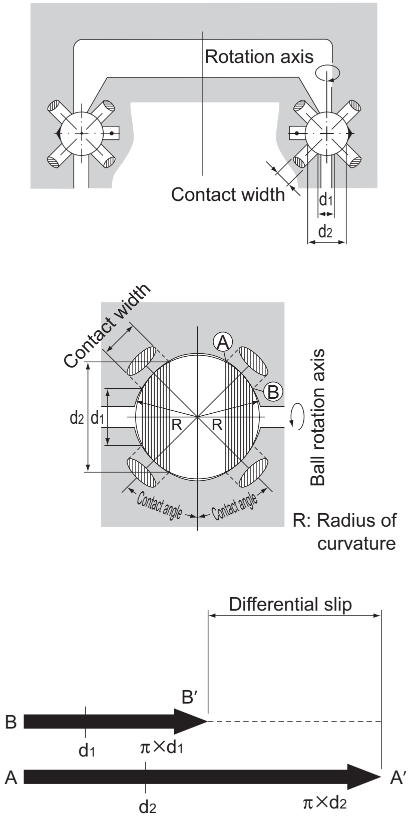


When extremely high precision is not required (e.g., running accuracy), the LM Guide can be attached to the steel plate even if the black scale on it is not removed.

Ideal Four Raceway, Circular-Arc Groove, Two-Point Contact Structure

The LM Guide has a self-adjusting capability that competitors' products do not have.
This feature is achieved with an ideal four raceway, circular-arc groove, two-point contact structure.

[Comparison of Characteristics between the LM Guide and Similar Products]

LM Guide: Four Raceway, Circular-arc Groove, Two-point Contact Structure	Other Product: Two-row, Gothic-arch Groove Four Point Contact Structure
LM Guide Model HSR  Fig.12	**Two-row Gothic-arch groove product**  Fig.13

As indicated in Fig.12 and Fig.13, when the ball rotates one revolution, the ball slips by the difference between the circumference of the diameter of inner surface (πd_1) and that of the outer contact diameter (πd_2). (This slip is called differential slip.) If the difference is large, the ball rotates while slipping, the friction coefficient increases more than 10 times and the friction resistance steeply increases.

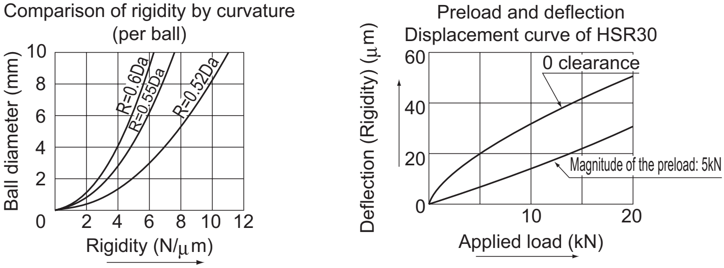
<table>
<tr><th>Four Raceway, Circular-Arc Groove,
Two-Point Contact Structure</th><th>Two-Row, Gothic-Arch Groove,
Four Point Contact Structure</th></tr>
<tr><td colspan="2">Smooth Motion</td></tr>
<tr><td>Since the ball contacts the groove at two points in the load direction as shown in Fig.12 and Fig.13 on A-39 even under a preload or a normal load, the difference between d_1 and d_2 is small and the differential slip is minimized to allow smooth rolling motion.</td><td>The difference between d_1 and d_2 in the contact area is large as shown in Fig.12 and Fig.13 on A-39. Therefore, if any of the following occurs, the ball will generate differential slip, causing friction almost as large as sliding resistance and shortening the service as a result of abnormal friction.
(1) A preload is applied.
(2) A lateral load is applied.
(3) The mounting parallelism between the two axes is poor.</td></tr>
<tr><td colspan="2">Accuracy and Rigidity of the Mounting Surface</td></tr>
<tr><td>In the ideal two-point contact structure, four rows of circular arc grooves are given appropriate contact angles. With this structure, a light distortion of the mounting surface would be absorbed within the LM block due to elastic deformation of the balls and moving of the contact points to allow unforced, smooth motion. This eliminates the need for a robust mounting base with high rigidity and accuracy for machinery such as a conveyance system.</td><td>With the Gothic-arch groove product, each ball contacts the groove at four points, preventing itself from being elastically deformed and the contact points from moving (i.e., no self-adjusting capability). Therefore, even a slight distortion of the mounting surface or an accuracy error of the rail bed cannot be absorbed and smooth motion cannot be achieved. Accordingly, it is necessary to machine a highly rigid mounting base with high precision and mount a high precision rail.</td></tr>
<tr><td colspan="2">Rigidity</td></tr>
<tr><td>With the two-point contact, even if a relatively large preload is applied, the rolling resistance does not abnormally increase and high rigidity is obtained.</td><td>Since differential slip occurs due to the four-point contact, a sufficient preload cannot be applied and high rigidity cannot be obtained.</td></tr>
<tr><td colspan="2">Load Rating</td></tr>
<tr><td>Since the curvature radius of the ball raceway is 51 to 52% of the ball diameter, a large rated load can be obtained.</td><td>Since the curvature radius of the gothic arch groove has to be 55 to 60% of the ball diameter, the rated load is reduced to approx. 50% of that of the circular arc groove.</td></tr>
<tr><td colspan="2">Difference in Rigidity</td></tr>
<tr><td colspan="2">As shown in Fig.14, the rigidity widely varies according to the difference in curvature radius or difference in preload.
Curvature radius and rigidity


Fig.14</td></tr>
<tr><td colspan="2">Difference in Service Life</td></tr>
<tr><td colspan="2">Since the load rating of the gothic arch groove is reduced to approx. 50% of that of the circular arc groove, the service life also decreases to 87.5%.</td></tr>
</table>

[Accuracy Error of the Mounting Surface and Test Data on Rolling Resistance]

The difference between the contact structures translates into a rolling resistance.
In the gothic arch groove contact structure, each ball contacts at four points and differential slip or spinning occurs if a preload is applied to increase rigidity or an error in the mounting precision is large. This sharply increases the rolling resistance and causes abnormal wear in an early stage.
The following are test data obtained by comparing an LM Guide having the four raceway, circular-arc groove two-point contact structure and a product having the two-row, Gothic-arch, four-point contact structure.

[Sample]

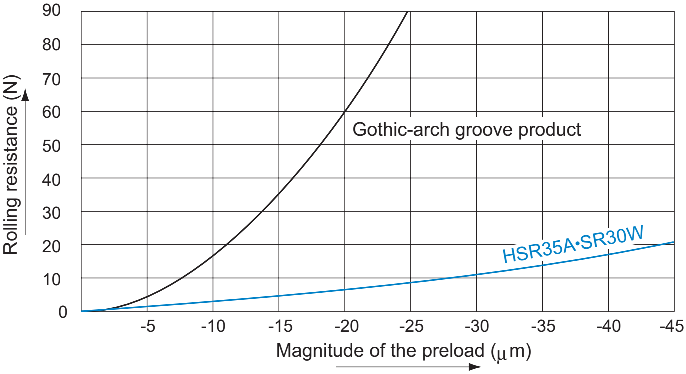
(1) LM Guide
SR30W (self-adjusting type) 2 sets
HSR35A (four-way equal-load type) 2 sets
(2) Two-row Gothic-arch groove product
Type with dimensions similar to HSR30 2 sets

[Conditions]

Radial clearance: ±0μm
Without seal
Without lubrication
Load: table mass of 30 kg

Data 1: Preload and rolling resistance

When a preload is applied, the rolling resistance of the Gothic-arch groove product steeply increases and differential slip occurs. Even under a preload, the rolling resistance of the LM Guide does not increase.



Data 2: Error in parallelism between two axes and rolling resistance

As shown in the Fig.15, part of the rails mounted in parallel is parallelly displaced and the rolling resistance at that point is measured.
With the Gothic-arch groove product, the rolling resistance is 34 N when the parallelistic error is 0.03 mm and 62 N when the error is 0.04 mm. These resistances are equivalent to the slip friction coefficients, indicating that the balls are in sliding contact with the groove.

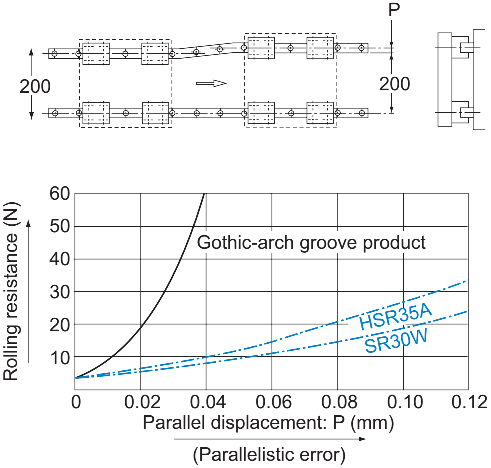
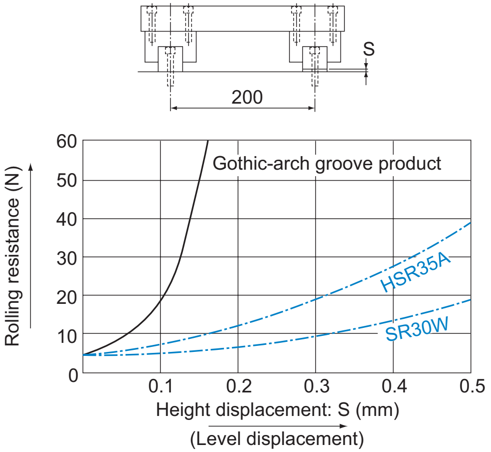


Fig.15

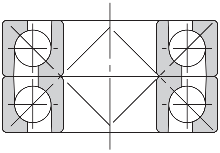
Data 3: Difference between the levels of the right and left rails and rolling resistance

The bottom of either rail is displaced by distance S so that there is a level difference between the two axes, and then rolling resistance is measured. If there is a level difference between the right and left rails, a moment acts on the LM block, and in the case of the Gothic-arch groove, spinning occurs. Even if the level difference between the two rails is as great as 0.3/200 mm, the LM Guide absorbs the error. This indicates that the LM Guide can operate normally even when such errors are present.

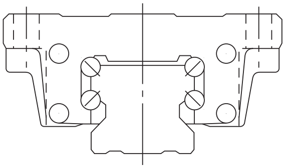


Superb Error-Absorbing Capability with the DF Design

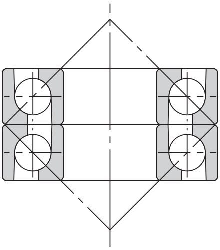
Since the LM Guide has a contact structure similar to the front-to-front mount of angular ball bearings, it has superb self-adjusting capability.



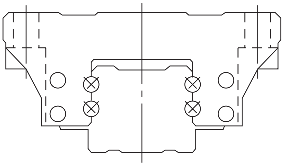
Angular Ball Bearings Mounted Front-to-front (DF type)



DF Type Four-row Angular Contact (LM Guide)

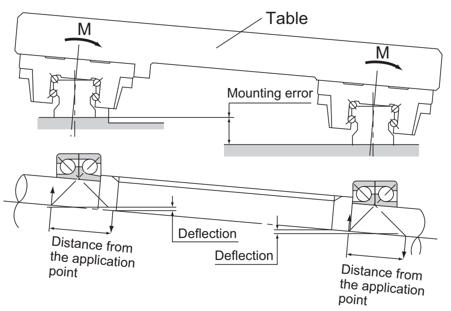
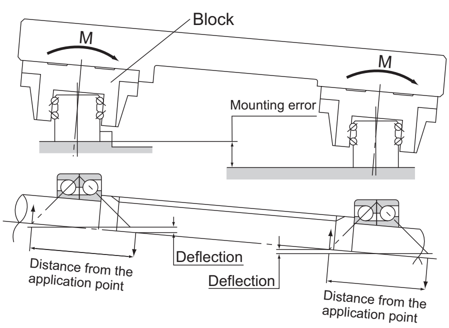


Angular Ball Bearings Mounted Back-to-back (DB type)



Four-row Gothic-arch Contact

An LM ball guide mounted on a plane receives a moment (M) due to an error in flatness or in level or a deflection of the table. Therefore, it is essential for the guide to have self-adjusting capability.

LM Guide Model HSR	Similar Product of a Competitor
	
Since the distance from the application point of the bearing is small, the internal load generated from a mounting error is small and the self-adjusting capability is large.	Since the distance from the application point of the bearing is large, the internal load generated from a mounting error is large and the self-adjusting capability is small. With an LM ball guide having angular ball bearings mounted back-to-back, if there is an error in flatness or a deflection in the table, the internal load applied to the block is approx. 6 times greater than that of the front-to-front mount structure and the service life is much shorter. In addition, the fluctuation in sliding resistance is greater.

Classification Table of the LM Guides

LM Guide

Ball Guide

Caged Ball Type

- Standard Type
  - **Model SHS**
    - Global Standard Size
  - **Model SSR**
    - Radial
  - **Model SNR**
    - Ultra-heavy Load
  - **Model SNS**
    - Ultra-heavy Load
- Wide Type
  - **Model SHW**
    - Low Center of Gravity
- Miniature Type
  - **Model SRS**
    - Lightweight and Compact
- Cross Type
  - **Model SCR**
    - 4-way Equal Load

Full-ball Type

- Standard Type
  - **Model HSR**
    - 4-way Equal Load
  - **Model SR**
    - Radial
  - **Model NSR-TBC**
    - Self-aligning
  - **Model NR**
    - Ultra-heavy Load
    - High Rigidity
  - **Model NRS**
    - Ultra-heavy Load
    - High Rigidity
- Miniature Type
  - **Model RSR**
    - Ultra Compact
  - **Model RSR-Z**
    - Ultra Compact
    - High Corrosion Resistance
  - **Model RSH**
    - Equipped with a Ball Retainer
  - **Model RSH-Z**
    - Equipped with a Ball Retainer
    - High Corrosion Resistance
- Wide Type
  - **Model HRW**
    - Wide Rail
    - 4-way Equal Load

Cross Type

Model CSR
4-way Equal Load

Model MX
Miniature Cross

Special Environment Types

Model HSR-M1
High Temperature
4-way Equal Load

Model SR-M1
High Temperature
Radial

Model HSR-M2
High Corrosion Resistance
4-way Equal Load

Model RSR-M1
High Temperature

R Guide Type

Model HCR

Straight-Curved Type

Model HMG

Separate Type

Model HR
Heavy Load

Model GSR
Interchangeable, Self-aligning

Model GSR-R
Interchangeable, Self-aligning
With Rack

Model JR Type

Model JR
Structural Member Rail
4-way Equal Load

Roller Guide

With a Caged Roller

Standard Type

Model SRG
Ultra-high Rigidity

Model SRN
Ultra-high Rigidity
Low Center of Gravity

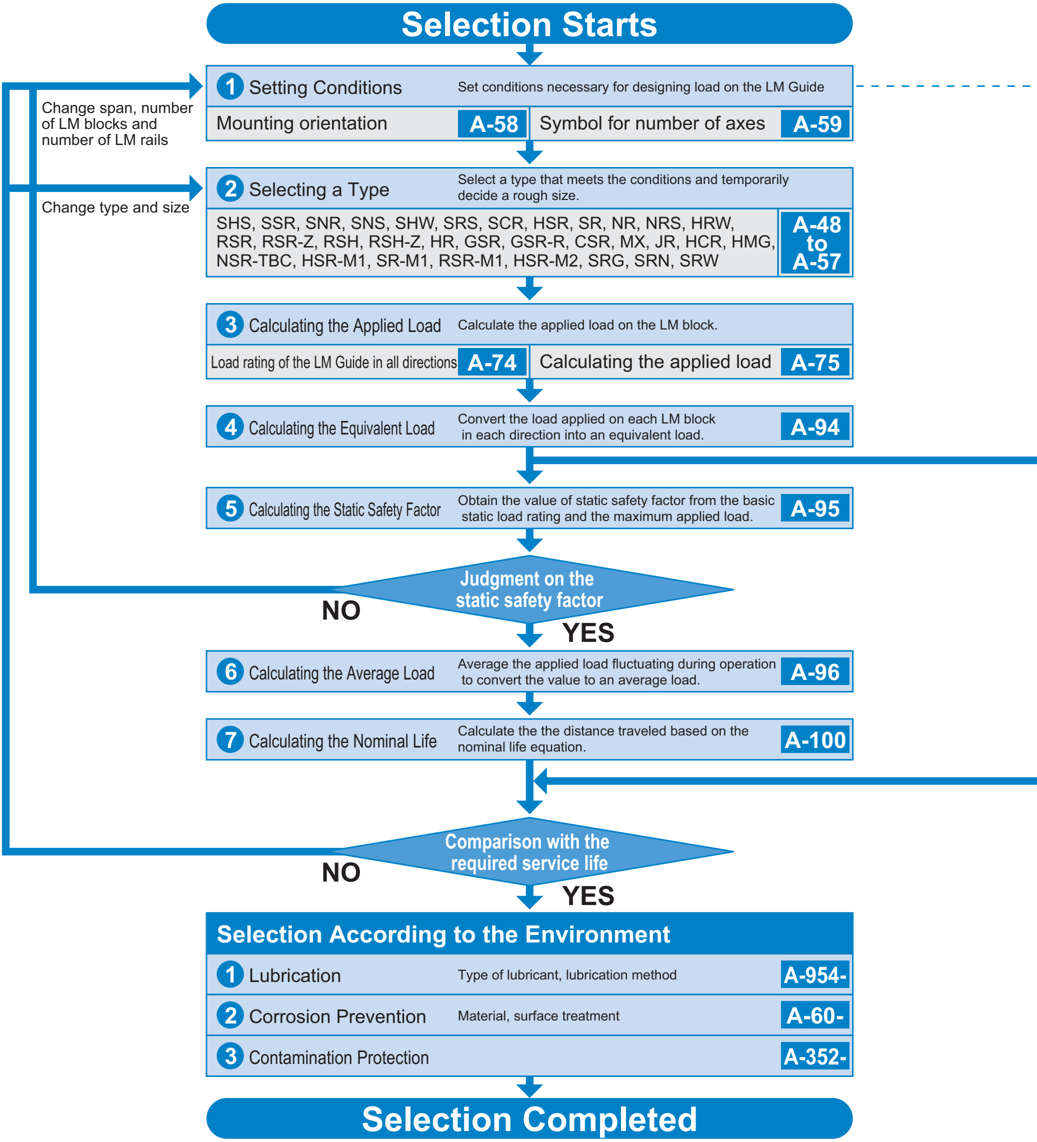
Wide Type

Model SRW
Ultra-high Rigidity

Flowchart for Selecting an LM Guide

[Steps for Selecting an LM Guide]

The following is a flowchart as a measuring stick for selecting an LM Guide.



Selection Starts

① Setting Conditions — Set conditions necessary for designing load on the LM Guide

Mounting orientation **A-58** | Symbol for number of axes **A-59**

Change span, number of LM blocks and number of LM rails

② Selecting a Type — Select a type that meets the conditions and temporarily decide a rough size.

SHS, SSR, SNR, SNS, SHW, SRS, SCR, HSR, SR, NR, NRS, HRW, RSR, RSR-Z, RSH, RSH-Z, HR, GSR, GSR-R, CSR, MX, JR, HCR, HMG, NSR-TBC, HSR-M1, SR-M1, RSR-M1, HSR-M2, SRG, SRN, SRW **A-48 to A-57**

Change type and size

③ Calculating the Applied Load — Calculate the applied load on the LM block.

Load rating of the LM Guide in all directions **A-74** | Calculating the applied load **A-75**

④ Calculating the Equivalent Load — Convert the load applied on each LM block in each direction into an equivalent load. **A-94**

⑤ Calculating the Static Safety Factor — Obtain the value of static safety factor from the basic static load rating and the maximum applied load. **A-95**

Judgment on the static safety factor — NO / YES

⑥ Calculating the Average Load — Average the applied load fluctuating during operation to convert the value to an average load. **A-96**

⑦ Calculating the Nominal Life — Calculate the the distance traveled based on the nominal life equation. **A-100**

Comparison with the required service life — NO / YES

Selection According to the Environment

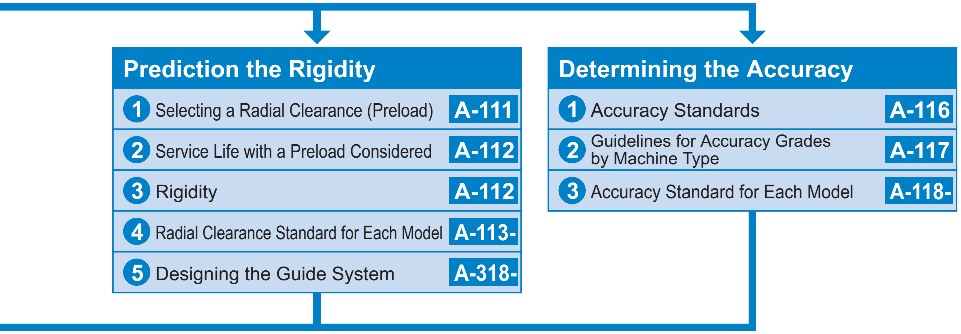
① Lubrication — Type of lubricant, lubrication method **A-954-**

② Corrosion Prevention — Material, surface treatment **A-60-**

③ Contamination Protection **A-352-**

Selection Completed

- Space in the guide section
- Dimensions (span, number of LM blocks, number of LM rails, thrust)
- Installation direction (horizontal, vertical, slant mount, wall mount, suspended)
- Magnitude, direction and position of the working load
- Operating frequency (duty cycle)
- Speed (acceleration)
- Stroke length
- Required service life
- Precision of motion
- Environment
- In a special environment (vacuum, clean room, high temperature, environment exposed to contaminated environment, etc.), it is necessary to take into account material, surface treatment, lubrication and contamination protection.



Prediction the Rigidity

1	Selecting a Radial Clearance (Preload)	A-111
2	Service Life with a Preload Considered	A-112
3	Rigidity	A-112
4	Radial Clearance Standard for Each Model	A-113-
5	Designing the Guide System	A-318-

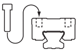
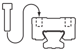
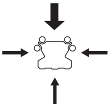
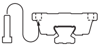
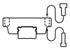
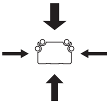
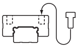
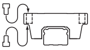
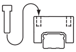
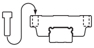
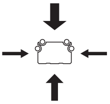
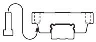
Determining the Accuracy

1	Accuracy Standards	A-116
2	Guidelines for Accuracy Grades by Machine Type	A-117
3	Accuracy Standard for Each Model	A-118-

Selecting a Type

Types of LM Guides

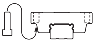
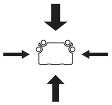
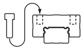
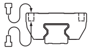
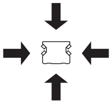
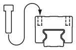
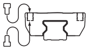
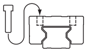
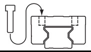
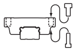
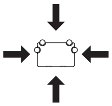
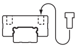
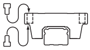
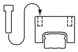
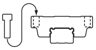
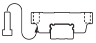
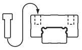
THK offers a wide array of types and dimensions with LM Guides as standard so that you can select the optimal product for any application. With the unit structure of each model, you can easily obtain high running accuracy with no clearance simply by mounting the product on a plane surface with bolts. We have a proven track record and know-how in extensive applications with LM Guides.

Classification		Type		Specification Table*	Load capacity diagram	Basic load rating (kN)	
						Basic dynamic load rating	Basic static load rating
Radial type	Caged Ball LM Guide		SSR-XW	▶**B-16**		14.7 to 64.6	16.5 to 71.6
			SSR-XV	▶**B-18**		9.1 to 21.7	9.7 to 22.5
			SSR-XTB	▶**B-20**		14.7 to 31.5	16.5 to 36.4
	Full-ball LM Guides		Model SR-W	▶**B-86**		9.51 to 411	19.3 to 537
			SR-M1W	▶**B-192**		9.51 to 41.7	19.3 to 77.2
			SR-V	▶**B-86**		5.39 to 23.8	11.1 to 44.1
			SR-M1V	▶**B-192**		5.39 to 23.8	11.1 to 44.1
			SR-TB	▶**B-88**		9.51 to 89.1	19.3 to 157
			SR-M1TB	▶**B-194**		9.51 to 41.7	19.3 to 77.2
			SR-SB	▶**B-88**		5.39 to 23.8	11.1 to 44.1
			SR- M1SB	▶**B-194**		5.39 to 23.8	11.1 to 44.1
	Caged Ball LM Guide - ultra-heavy load, high rigidity types		SNR-C	▶**B-30**		48 to 260	79 to 409
			SNR-LC	▶**B-30**		57 to 550	101 to 887
			SNR-R	▶**B-26**		48 to 260	79 to 409
			SNR-LR	▶**B-26**		57 to 550	101 to 887
			SNR-CH	▶**B-38**		90 to 177	144 to 292
			SNR-LCH	▶**B-38**		108 to 214	188 to 383
			SNR-RH	▶**B-34**		90 to 177	144 to 292
			SNR-LRH	▶**B-34**		108 to 214	188 to 383
	Full-ball LM Guide - ultra-heavy load, high rigidity types		NR-A	▶**B-98**		33 to 479	84.6 to 1040
			NR-LA	▶**B-98**		44 to 599	113 to 1300
			NR-B	▶**B-102**		33 to 479	84.6 to 1040

＊For specification tables for each model, please see the separate "B Product Specifications".

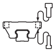
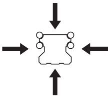
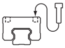
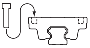
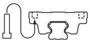
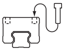
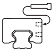
dammy

External dimensions (mm)		Features	Major application
Height	Width		
24 to 48	34 to 70	● Long service life, long-term maintenance-free operation ● Low dust generation, low noise, acceptable running sound ● Superbly high speed ● Smooth motion in all mounting orientations ● Thin, compact design, large radial load capacity ● Superb in planar running accuracy ● Superb capability of absorbing mounting error ● Stainless steel type also available as standard	● Surface grinder table ● Tool grinder table ● Electric discharge machine ● Printed circuit board drilling machine ● Chip mounter ● High-speed transfer equipment ● Traveling unit of robots ● Machining center ● NC lathe ● Five axis milling machine ● Conveyance system ● Mold guide of pressing machines ● Inspection equipment ● Testing machine ● Food-related machine ● Medical equipment ● 3D measuring instrument ● Packaging machine ● Injection molding machine ● Woodworking machine ● Ultra precision table ● Semiconductor/liquid crystal manufacturing equipment
24 to 33	34 to 48		
24 to 33	52 to 73		
24 to 135	34 to 250	● Thin, compact design, large radial load capacity ● Superb in planar running accuracy ● Superb capability of absorbing mounting error ● Stainless steel type also available as standard ● Type M1, achieving max service temperature of 150℃, also available	
24 to 48	34 to 70		
24 to 48	34 to 70		
24 to 48	34 to 70		
24 to 68	52 to 140		
24 to 48	52 to 100		
24 to 48	52 to 100		
24 to 48	52 to 100		
31 to 75	72 to 170	● Long service life, long-term maintenance-free operation ● Low dust generation, low noise, acceptable running sound ● Superbly high speed ● Smooth motion in all mounting orientations ● Ultra-heavy load capacity optimal for machine tools ● Thin, compact design, large radial load capacity ● High vibration resistance and impact resistance due to improved damping characteristics ● Superb in planar running accuracy	● Machining center ● NC lathe ● Grinding machine ● Five axis milling machine ● Jig borer ● Drilling machine ● NC milling machine ● Horizontal milling machine ● Mold processing machine ● Graphite working machine ● Electric discharge machine ● Wire-cut electric discharge machine
31 to 90	72 to 215		
31 to 75	50 to 126		
31 to 90	50 to 156		
48 to 70	100 to 140	● Long service life, long-term maintenance-free operation ● Low dust generation, low noise, acceptable running sound ● Superbly high speed ● Smooth motion in all mounting orientations ● Ultra-heavy load capacity optimal for machine tools ● Large radial load capacity ● High vibration resistance and impact resistance due to improved damping characteristics ● Superb in planar running accuracy ● Has dimensions almost the same as that of the full-ball type LM Guide model HSR, which is practically a global standard size	
48 to 70	100 to 140		
55 to 80	70 to 100		
55 to 80	70 to 100		
31 to 105	72 to 260	● Ultra-heavy load capacity optimal for machine tools ● High vibration resistance and impact resistance due to improved damping characteristics ● Thin, compact design, large radial load capacity ● Superb in planar running accuracy	
31 to 105	72 to 260		
31 to 105	72 to 260		

Classification		Type		Specification Table*	Load capacity diagram	Basic load rating (kN)	
						Basic dynamic load rating	Basic static load rating
Radial type	Full-ball LM Guide - ultra-heavy load, high rigidity types		NR-LB	▶B-102		44 to 599	113 to 1300
			NR-R	▶B-94		33 to 479	84.6 to 1040
			NR-LR	▶B-94		44 to 599	113 to 1300
4-way equal load type	Caged Roller LM Guide - super ultra-heavy-load, high rigidity types		SRG-A, C	▶B-208		11.3 to 131	25.8 to 266
			SRG-LA, LC	▶B-208		26.7 to 278	63.8 to 599
			SRG-R, V	▶B-210		11.3 to 131	25.8 to 266
			SRG-LR, LV	▶B-210		26.7 to 278	63.8 to 599
			SRN-C	▶B-214		59.1 to 131	119 to 266
			SRN-LC	▶B-214		76 to 278	165 to 599
			SRN-R	▶B-216		59.1 to 131	119 to 266
			SRN-LR	▶B-216		76 to 278	165 to 599
			SRW-LR	▶B-220		115 to 278	256 to 599
	Caged Ball LM Guide - ultra-heavy load, high rigidity types		SNS-C	▶B-32		37 to 199	61 to 315
			SNS-LC	▶B-32		44 to 422	78 to 679
			SNS-R	▶B-28		37 to 199	61 to 315
			SNS-LR	▶B-28		44 to 422	78 to 679
			SNS-CH	▶B-40		69 to 136	110 to 225
			SNS-LCH	▶B-40		83 to 164	144 to 295
			SNS-RH	▶B-36		69 to 136	110 to 225
			SNS-LRH	▶B-36		83 to 164	144 to 295
	Full-ball LM Guide - ultra-heavy load, high rigidity types		NRS-A	▶B-100		25.9 to 376	59.8 to 737
			NRS-LA	▶B-100		34.5 to 470	79.7 to 920
			NRS-B	▶B-104		25.9 to 376	59.8 to 737
			NRS-LB	▶B-104		34.5 to 470	79.7 to 920
			NRS-R	▶B-96		25.9 to 376	59.8 to 737
			NRS-LR	▶B-96		34.5 to 470	79.7 to 920

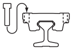
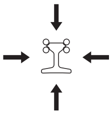
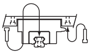
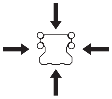
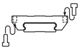
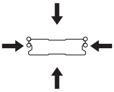
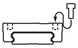
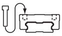
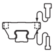
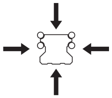
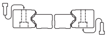
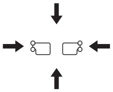
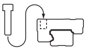
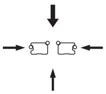
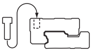
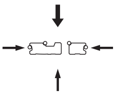
*For specification tables for each model, please see the separate "B Product Specifications".

External dimensions (mm)		Features	Major application
Height	Width		
31 to 105	72 to 260	● Ultra-heavy load capacity optimal for machine tools ● High vibration resistance and impact resistance due to improved damping characteristics ● Thin, compact design, large radial load capacity ● Superb in planar running accuracy	● Machining center ● NC lathe ● Grinding machine ● Five axis milling machine ● Jig borer ● Drilling machine ● NC milling machine ● Horizontal milling machine ● Mold processing machine ● Graphite working machine ● Electric discharge machine ● Wire-cut electric discharge machine
31 to 105	50 to 200		
31 to 105	50 to 200		
24 to 70	47 to 140	● Long service life, long-term maintenance-free operation ● Low noise, acceptable running sound ● Superbly high speed ● Smooth motion due to prevention of rollers from skewing ● Ultra-heavy load capacity optimal for machine tools	
30 to 90	63 to 170		
24 to 80	34 to 100		
30 to 90	44 to 126		
44 to 63	100 to 140	● Long service life, long-term maintenance-free operation ● Low noise, acceptable running sound ● Superbly high speed ● Smooth motion due to prevention of rollers from skewing ● Ultra-heavy load capacity optimal for machine tools ● Low center of gravity, ultra-high rigidity	
44 to 75	100 to 170		
44 to 63	70 to 100		
44 to 75	70 to 126		
70 to 100	135 to 200		
31 to 75	72 to 170	● Long service life, long-term maintenance-free operation ● Low dust generation, low noise, acceptable running sound ● Superbly high speed ● Smooth motion in all mounting orientations ● Ultra-heavy load capacity optimal for machine tools ● Thin, compact design, 4-way equal load ● High vibration resistance and impact resistance due to improved damping characteristics	
31 to 90	72 to 215		
31 to 75	50 to 126		
31 to 90	50 to 156		
48 to 70	100 to 140	● Long service life, long-term maintenance-free operation ● Low dust generation, low noise, acceptable running sound ● Superbly high speed ● Smooth motion in all mounting orientations ● Ultra-heavy load capacity optimal for machine tools ● 4-way equal load type ● High vibration resistance and impact resistance due to improved damping characteristics ● Has dimensions almost the same as that of the full-ball type LM Guide model HSR, which is practically a global standard size	
48 to 70	100 to 140		
55 to 80	70 to 100		
55 to 80	70 to 100		
31 to 105	72 to 260	● Ultra-heavy load capacity optimal for machine tools ● High vibration resistance and impact resistance due to improved damping characteristics ● Thin, compact design, 4-way equal load	
31 to 105	72 to 260		
31 to 105	72 to 260		
31 to 105	72 to 260		
31 to 105	50 to 200		
31 to 105	50 to 200		

Classification		Type		Specification Table*	Load capacity diagram	Basic load rating (kN)	
						Basic dynamic load rating	Basic static load rating
4-way equal load type	Caged Ball LM Guide - heavy-load, high rigidity types		SHS-C	▶B-6		14.2 to 205	24.2 to 320
			SHS-LC	▶B-6		17.2 to 253	31.9 to 408
			SHS-V	▶B-8		14.2 to 205	24.2 to 320
			SHS-LV	▶B-8		17.2 to 253	31.9 to 408
			SHS-R	▶B-10		14.2 to 128	24.2 to 197
			SHS-LR	▶B-10		36.8 to 161	64.7 to 259
	Full-ball LM Guide - heavy-load, high rigidity types		HSR-A	▶B-62		8.33 to 210	13.5 to 310
			HSR-M1A	▶B-182		8.33 to 37.3	13.5 to 61.1
			HSR-LA	▶B-62		21.3 to 282	31.8 to 412
			HSR-M1LA	▶B-182		21.3 to 50.2	31.8 to 81.5
			HSR-CA	▶B-76		13.8 to 210	23.8 to 310
			HSR-HA	▶B-76		21.3 to 518	31.8 to 728
			HSR-B	▶B-64		8.33 to 210	13.5 to 310
			HSR-M1B	▶B-184		8.33 to 37.3	13.5 to 61.1
			HSR-LB	▶B-64		21.3 to 282	31.8 to 412
			HSR-M1LB	▶B-184		21.3 to 50.2	31.8 to 81.5
			HSR-CB	▶B-78		13.8 to 210	23.8 to 310
			HSR-HB	▶B-78		21.3 to 518	31.8 to 728
			HSR-R	▶B-70		1.08 to 210	2.16 to 310
			HSR-M1R	▶B-186		8.33 to 37.3	13.5 to 61.1
			HSR-LR	▶B-70		21.3 to 282	31.8 to 412
			HSR-M1LR	▶B-186		21.3 to 50.2	31.8 to 81.5
			HSR-HR	▶B-80		351 to 518	506 to 728
	Full-ball LM Guide - side mount types		HSR-YR	▶B-74		8.33 to 141	13.5 to 215
			HSR-M1YR	▶B-188		8.33 to 37.3	13.5 to 61.1

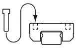
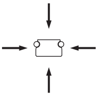
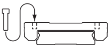
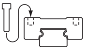
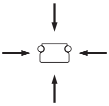
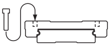
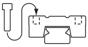
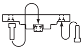
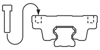
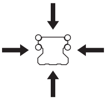
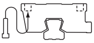
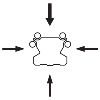
∗For specification tables for each model, please see the separate "B Product Specifications".

External dimensions (mm)		Features	Major application
Height	Width		
24 to 90	47 to 170	● Long service life, long-term maintenance-free operation ● Low dust generation, low noise, acceptable running sound ● Superbly high speed ● Smooth motion in all mounting orientations ● Heavy load, high rigidity ● Has dimensions almost the same as that of the full-ball type LM Guide model HSR, which is practically a global standard size ● Superb capability of absorbing mounting error	● Machining center ● NC lathe ● XYZ axes of heavy cutting machine tools ● Grinding head feeding axis of grinding machines ● Components requiring a heavy moment and high accuracy ● NC milling machine ● Horizontal milling machine ● Gantry five axis milling machine ● Z axis of electric discharge machines ● Wire-cut electric discharge machine ● Car elevator ● Food-related machine ● Testing machine ● Vehicle doors ● Printed circuit board drilling machine ● ATC ● Construction equipment ● Shield machine ● Semiconductor/liquid crystal manufacturing equipment
24 to 90	47 to 170		
24 to 90	34 to 126		
24 to 90	34 to 126		
28 to 80	34 to 100		
28 to 80	34 to 100		
24 to 110	47 to 215	● Heavy load, high rigidity ● Practically a global standard size ● Superb capability of absorbing mounting error ● Stainless steel type also available as standard ● Type M1, achieving max service temperature of 150℃, also available ● Type M2, with high corrosion resistance, also available (Basic dynamic load rating: 2.33 to 5.57 kN) (Basic static load rating: 2.03 to 5.16 kN)	
24 to 48	47 to 100		
30 to 110	63 to 215		
30 to 48	63 to 100		
30 to 110	63 to 215		
30 to 145	63 to 350		
24 to 110	47 to 215		
24 to 48	47 to 100		
30 to 110	63 to 215		
30 to 48	63 to 100		
30 to 110	63 to 215		
30 to 145	63 to 350		
11 to 110	16 to 156		
28 to 55	34 to 70		
30 to 110	44 to 156		
30 to 55	44 to 70		
120 to 145	250 to 266		
28 to 90	33.5 to 124.5	● Easy mounting and reduced mounting height when using 2 units opposed to each other since the side faces of the LM block have mounting holes ● Heavy load, high rigidity ● Superb capability of absorbing mounting error ● Stainless steel type also available as standard ● Type M1, achieving max service temperature of 150℃, also available	● Cross rails of gantry machine tools ● Z axis of woodworking machines ● Z axis of measuring instruments ● Components opposed to each other
28 to 55	33.5 to 69.5		

Classification		Type		Specification Table*	Load capacity diagram	Basic load rating (kN)	
						Basic dynamic load rating	Basic static load rating
4-way equal load type	Full-ball LM Guides - special LM rail types		JR-A	▶**B-164**		19.9 to 88.5	34.4 to 137
			JR-B	▶**B-164**		19.9 to 88.5	34.4 to 137
			JR-R	▶**B-164**		19.9 to 88.5	34.4 to 137
	Caged Ball Cross LM Guide		SCR	▶**B-56**		36.8 to 253	64.7 to 408
	Full-ball LM Guide - orthogonal type		CSR	▶**B-154**		8.33 to 80.4	13.5 to 127.5
	Caged Ball LM Guide - wide, low center of gravity types		SHW-CA	▶**B-44**		4.31 to 70.2	5.66 to 91.4
			SHW-CR, HR	▶**B-46**		4.31 to 70.2	5.66 to 91.4
	Full-ball LM Guide - wide, low center of gravity types		HRW-CA	▶**B-108**		4.31 to 63.8	81.4 to 102
			HRW-CR, LR	▶**B-110**		3.29 to 50.2	7.16 to 81.5
	Full-ball Straight - Curved Guide		HMG	▶**B-172**		2.56 to 66.2	Straight section 4.23 to 66.7 Curved section 0.44 to 36.2
	Full-ball LM Guide - separate types		HR, HR-T	▶**B-138**		1.57 to 141	3.04 to 206
Interchangeable designs			GSR-T	▶**B-146**		5.69 to 25.1	8.43 to 33.8
			GSR-V	▶**B-146**		4.31 to 10.29	5.59 to 12.65
	Full-ball LM Guides - LM rail-rack intergrated type		GSR-R	▶**B-150**		10.29 to 25.1	12.65 to 33.8

*For specification tables for each model, please see the separate "B Product Specifications".

External dimensions (mm)		Features	Major application
Height	Width		
61 to 114	70 to 140	● Since the central part of the LM rail is thinly structured, the LM Guide is capable of absorbing an error and achieving smooth motion if the parallelism between the two axes is poor ● Since the LM rail has a highly rigid sectional shape, it can be used as a structural member	● Automated warehouse ● Garage ● Gantry robot ● FMS traveling rail ● Lift ● Conveyance system ● Welding machine ● Lifter ● Crane ● Forklift ● Coating machine ● Shield machine ● Stage setting
61 to 114	70 to 140		
65 to 124	48 to 100		
70 to 180	88 to 226	● A compact XY structure is allowed due to an XY orthogonal, single-piece LM block ● Since a saddle-less structure is allowed, the machine can be lightweighted and compactly designed ● Long service life, long-term maintenance-free operation ● Low dust generation, low noise, acceptable running sound ● Superbly high speed	● Low center of gravity, precision XY table ● NC lathe ● Optical measuring instrument ● Automatic lathe ● Inspection equipment ● Cartesian coordinate robot ● Bonding machine ● Wire-cut electric discharge machine ● Hollow table ● Printed circuit board assembler ● Machine tool table ● Electric discharge machine ● XY axes of horizontal machining center
47 to 118	38.8 to 129.8	● A compact XY structure is allowed due to an XY orthogonal, single-piece LM block ● Since a saddle-less structure is allowed, the machine can be lightweighted and compactly designed	
12 to 50	40 to 162	● Long service life, long-term maintenance-free operation ● Low dust generation, low noise, acceptable running sound ● Superbly high speed ● Smooth motion in all mounting orientations ● Wide, low center of gravity, space saving structure ● Stainless steel type also available as standard	● Z axis of IC printed circuit board drilling machine ● Z axis of small electric discharge machine ● Loader ● Machining center ● NC lathe ● Robot ● Wire-cut electric discharge machine ● APC ● Semiconductor/liquid crystal manufacturing equipment ● Measuring instrument ● Wafer transfer equipment ● Construction equipment ● Railroad vehicle
12 to 50	30 to 130		
17 to 60	60 to 200	● 4-way equal load, thin and highly rigid ● Wide, low center of gravity, space saving structure ● Stainless steel type also available as standard	
12 to 50	30 to 130		
24 to 90	47 to 170	● Freedom of design ● Cost reduction through simplified structure	● Large swivel base ● Pendulum vehicle for railroad ● Pantagraph ● Control unit ● Optical measuring machine ● Tool grinder ● X-Ray machine ● CT scanner ● Medical equipment ● Stage setting ● Car elevator ● Amusement machine ● Turntable ● Tool changer
8.5 to 60	18 to 125	● Thin, high rigidity, space saving structure ● Interchangeable with Cross-Roller Guide ● Preload can be adjusted ● Stainless steel type also available as standard	● XYZ axes of electric discharge machine ● Precision table ● XZ axes of NC lathe ● Assembly robot ● Conveyance system ● Machining center ● Wire-cut electric discharge machine ● Tool changer ● Woodworking machine
20 to 38	32 to 68	● LM block and LM rail are both interchangeable ● Preload can be adjusted ● Capable of absorbing vertical level error and horizontal tolerance for parallelism	● Industrial robot ● Various conveyance systems ● Automated warehouse ● Palette changer ● ATC ● Door closing device ● Guide using an aluminum mold base ● Welding machine ● Coating machine ● Car washing machine
20 to 30	32 to 50		
30 to 38	59.91 to 80.18	● LM rail-rack integrated design eliminates assembly and adjustment work ● LM rail-rack integrated design enables a space-saving structure to be achieved ● Capable of supporting long strokes	

Classification		Type		Specification Table*	Load capacity diagram	Basic load rating (kN)	
						Basic dynamic load rating	Basic static load rating
Miniature types	Caged Ball LM Guides		SRS	▶B-50		1.51 to 16.5	1.29 to 20.2
			SRS-W	▶B-52		2.01 to 9.12	1.94 to 8.55
	Full-ball LM Guides		RSR, RSR-K, RSR-V	▶B-116		0.18 to 8.82	0.27 to 12.7
			RSR-M1V	▶B-198		1.47 to 8.82	2.25 to 12.7
			RSR-N	▶B-114		0.3 to 14.2	0.44 to 20.6
			RSR-M1N	▶B-198		2.6 to 14.2	3.96 to 20.6
			RSR-Z	▶B-122		0.88 to 4.41	1.37 to 6.57
	Full-ball LM Guide - wide types		RSR-W, WV	▶B-118		0.25 to 6.66	0.47 to 9.8
			RSR-M1WV	▶B-200		2.45 to 6.66	3.92 to 9.8
			RSR-WN	▶B-118		0.39 to 9.91	0.75 to 14.9
			RSR-M1WN	▶B-200		3.52 to 9.91	5.37 to 14.9
			RSR-WZ	▶B-124		1.37 to 6.66	2.16 to 9.8
	Full-ball LM Guide - ball-retaining plate types		RSH, RSH-K, RSH-V	▶B-128		0.88 to 2.65	1.37 to 4.02
			RSH-Z	▶B-132		0.88 to 4.41	1.37 to 6.57
	Full-ball LM Guide - orthogonal type		MX	▶B-160		0.59 to 2.04	1.1 to 3.21
Circular arc types	Full-ball LM Guides		HCR	▶B-168		4.7 to 141	8.53 to 215
Self-aligning types	Full-ball LM Guides		NSR-TBC	▶B-178		9.41 to 90.8	18.6 to 152

∗For specification tables for each model, please see the separate "B Product Specifications".

External dimensions (mm)		Features	Major application
Height	Width		
8 to 25	17 to 48	● Long service life, long-term maintenance-free operation ● Low dust generation, low noise, acceptable running sound ● Superbly high speed ● Smooth motion in all mounting orientations ● Stainless steel type also available as standard ● Lightweight and compact	● IC/LSI manufacturing machine ● Hard disc drive ● Slide unit of OA equipment ● Wafer transfer equipment ● Printed circuit board assembly table ● Medical equipment ● Electronic components of electron microscope ● Optical stage ● Stepper ● Plotting machine ● Feed mechanism of IC bonding machine ● Inspection equipment
9 to 16	25 to 60		
4 to 25	8 to 46	● Stainless steel type also available as standard ● Long type with increased load capacity also offered as standard ● Type M1, achieving max service temperature of 150℃, also available	● IC/LSI manufacturing machine ● Hard disc drive ● Slide unit of OA equipment ● Wafer transfer equipment ● Printed circuit board assembly table ● Medical equipment ● Electronic components of electron microscope ● Optical stage ● Stepper ● Plotting machine ● Feed mechanism of IC bonding machine ● Inspection equipment
10 to 25	20 to 46		
4 to 25	8 to 46		
10 to 25	20 to 46		
8 to 16	17 to 32		
4.5 to 16	12 to 60	● Stainless steel type also available as standard ● Long type with increased load capacity also offered as standard ● Type M1, achieving max service temperature of 150℃, also available	
12 to 16	30 to 60		
4.5 to 16	12 to 60		
12 to 16	30 to 60		
9 to 16	25 to 60		
8 to 13	17 to 27	● Equipped with a ball retainer ● Stainless steel type also available as standard	
8 to 16	17 to 32		
10 to 14.5	15.2 to 30.2	● A compact XY structure is allowed due to an XY orthogonal, single-piece LM block ● Stainless steel type also available as standard	● IC/LSI manufacturing machine ● Inspection equipment ● Slide unit of OA equipment ● Wafer transfer equipment ● Feed mechanism of IC bonding machine ● Printed circuit board assembly table ● Medical equipment ● Electronic components of electron microscope ● Optical stage
18 to 90	39 to 170	● Circular motion guide in a 4-way equal load design ● Highly accurate circular motion without play ● Allows an efficient design with the LM block placed in the loading point ● Large circular motion easily achieved	● Large swivel base ● Pendulum vehicle for railroad ● Pantagraph ● Control unit ● Optical measuring machine ● Tool grinder ● X-Ray machine ● CT scanner ● Medical equipment ● Stage setting ● Car elevator ● Amusement machine ● Turntable ● Tool changer
40 to 105	70 to 175	● Can be used in rough mount due to self-aligning on the fit surface of the case ● Preload can be adjusted ● Can be mounted on a black steel sheet	● XY axes of ordinary industrial machinery ● Various conveyance systems ● Automated warehouse ● Palette changer ● Automatic coating machine ● Various welding machines

Setting Conditions

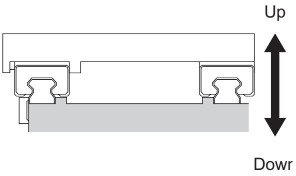
Conditions of the LM Guide

[Mounting Orientation]

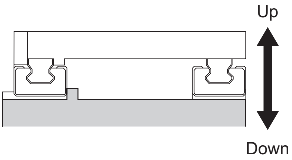
The LM Guide can be mounted in the following five orientations. If oil is to be used as a lubricant, it is necessary to change the lubrication routing and the related settings. When ordering an LM Guide, please specify the mounting orientation.

[Mounting Orientation]

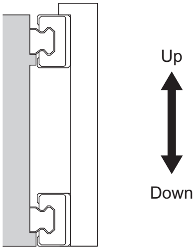
Horizontal (symbol: H)



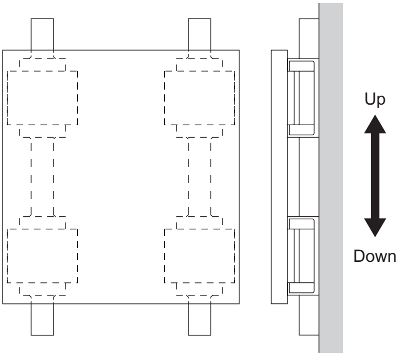
Inverted (symbol: R)



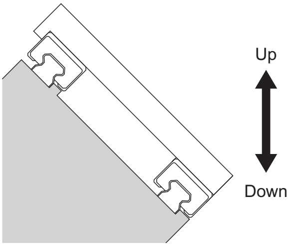
Wall mount (symbol: K)



Vertical (symbol: V)



Slant mount (symbol: T)



[Symbol for Number of Axes]

With the LM Guide, the normal and high-accuracy grades are interchangeable when two or more units of the LM Guide are used in combination on the same plane. However, when using two or more units of a model of precision or higher grade, or with a radial clearance of C1 or C0, specify the number of LM rails (symbol for number of axes) in advance.
(For accuracy standards and radial clearance standards, see A-118 and A-113, respectively.)

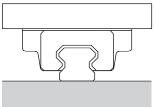
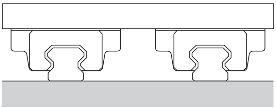
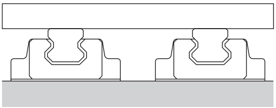
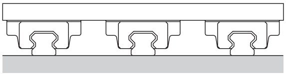
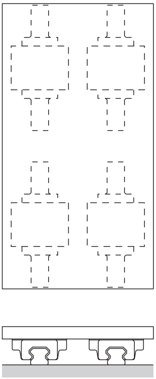
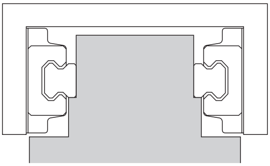
Model number coding

SHS25C2SSCO+1000LP -Ⅱ

Model number (details are given on the corresponding page of the model)

Symbol for number of axes
("II" indicates 2 axes. No symbol for a single axis)

[Symbol for Number of Axes]

Symbol for number of axes: none	Symbol for number of axes: Ⅱ	Symbol for number of axes: Ⅱ
Required number of axes: 1 	**Required number of axes: 2**  Note: When placing an order, specify the number in multiple of 2 axes.	**Required number of axes: 2**  Note: When placing an order, specify the number in multiple of 2 axes.
Symbol for number of axes: Ⅲ	**Symbol for number of axes: Ⅳ**	**Other**
Required number of axes: 3  Note: When placing an order, specify the number in multiple of 3 axes.	**Required number of axes: 4**  Note: When placing an order, specify the number in multiple of 4 axes.	**Required number of axes: 2**  Using 2 axes opposed to each other

[Service environment]

● Lubrication

When using an LM system, it is necessary to provide effective lubrication. Without lubrication, the rolling elements or the raceway may be worn faster and the service life may be shortened.

A lubricant has effects such as the following.

(1) Minimizes friction in moving elements to prevent seizure and reduce wear.

(2) Forms an oil film on the raceway to decrease stress acting on the surface and extend rolling fatigue life.

(3) Covers the metal surface to prevent rust formation.

To fully bring out an LM system's functions, it is necessary to provide lubrication according to the conditions.

Even with an LM system with seals, the internal lubricant gradually seeps out during operation. Therefore, the system needs to be lubricated at an appropriate interval according to the conditions.

● Corrosion Prevention

■Determining a Material

Any LM system requires a material that meets the environments. For use in environments where corrosion resistance is required, some LM system models can use martensite stainless steel.

(Martensite stainless steel can be used for LM Guide models SSR, SHW, SRS, HSR, SR, HRW, RSR, RSR-Z, RSH RSH-Z and HR.)

The HSR series includes HSR-M2, a highly corrosion resistant LM Guide using austenite stainless steel, which has high anti-corrosive effect. For details, see A-292.

■Surface Treatment

The surfaces of the rails and shafts of LM systems can be treated for anti-corrosive or aesthetic purposes.

THK offers THK-AP treatment, which is the optimum surface treatment for LM systems.

There are roughly three types of THK-AP treatment: AP-HC, AP-C, and AP-CF. (See A-20.)

● Contamination Protection

When foreign material enters an LM system, it will cause abnormal wear or shorten the service life, and it is necessary to prevent foreign material from entering the system. When entrance of dust or other foreign material is predicted, it is important to select an effective sealing device or dust-control device that meets the environment conditions.

THK offers contamination protection accessories for LM Guides by model number, such as end seals made of special synthetic rubber with high wear resistance, and side seals and inner seals for further increasing dust-prevention effect.

In addition, for locations with adverse environment, Laminated Contact Scraper LaCS and dedicated bellows are available by model number. Also, THK offers dedicated caps for LM rail mounting holes, designed to prevent cutting chips from entering the LM rail mounting holes.

When it is required to provide contamination protection for a Ball Screw in an environment exposed to cutting chips and moisture, we recommend using a telescopic cover that protects the whole system or a large bellows.

Clean Room

In a clean environment like clean rooms, generation of dust from the LM system has to be reduced and anti-rust oil cannot be used. Therefore, it is necessary to increase the corrosion resistance of the LM system. In addition, depending on the level of cleanliness, a dust collector is required.

Dust Generation from the LM System

■Measure to Prevent Dust Generation Resulting from Flying Grease

THK AFE-CA and AFF Grease

Use environmentally clean grease that produces little dust.

■Measure to Prevent Dust Generation Resulting from Metallic Abrasion Dust

Caged Ball LM Guide

Use the Caged Ball LM Guide, which has no friction between balls and generates little metallic abrasion dust, to allow generation of dust to be minimized.

Corrosion Prevention

■Material-based Measure

Stainless Steel LM Guide

This LM Guide uses martensite stainless steel, which has an anti-corrosion effect.

Highly Corrosion Resistant LM Guide

It uses austenite stainless steel, which has a high anti-corrosion effect, in its LM rail.

■Measure Through Surface Treatment

THK AP-HC, AP-C and AP-CF Treatment

The LM system is surface treated to increase corrosion resistance.

Caged Ball LM Guide

Supported models
SHS SSR SNR/SNS
SHW SRS SCR

Caged Roller LM Guide

Supported models
SRG SRN SRW

Stainless Steel LM Guide

Supported models
SSR SHW SRS HSR SR
HRW HR RSR RSH

Highly Corrosion Resistant LM Guide

Surface Treatment

Grease

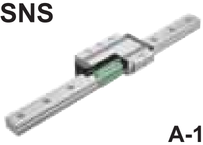
SHS

A-136

SSR

A-142

SNR/SNS

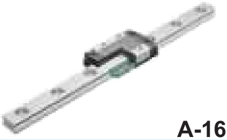


A-148

SHW

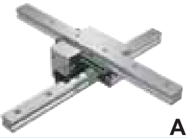
A-156

SRS



A-160

SCR



A-166

SRG

A-300

SRN

A-306

SRW

A-312

SSR

A-142

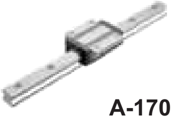
SHW

A-156

SRS

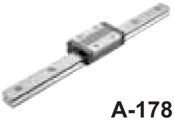
A-160

HSR



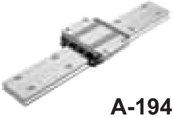
A-170

SR



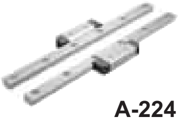
A-178

HRW



A-194

HR



A-224

RSR

A-200

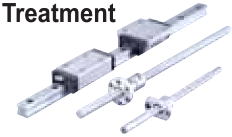
RSH

A-214

HSR-M2

A-292

THK AP-HC Treatment



A-20

THK AFE-CA Grease

A-963

THK AFF Grease

A-965

Vacuum

In a vacuum environment, measures to prevent gas from being emitted from a resin and grease from flying are required and anti-rust oil cannot be used. Therefore, it is necessary to select a product with high corrosion resistance.

■Measure to Prevent Emission of Gas from Resin

Stainless Steel LM Guide

It uses stainless steel in the endplate (ball circulation unit made of resin) of the LM block to reduce emission of gas.

■Measure to Prevent Grease from Evaporating

Vacuum Grease

If a general-purpose grease is used in a vacuum environment, oil contained in the grease evaporates and the grease looses lubricity. Therefore, use a vacuum grease that uses fluorine based oil, whose vapor pressure is low, as the base oil.

■Corrosion Prevention

Stainless Steel LM Guide

In a vacuum environment, use a stainless steel LM Guide, which is highly corrosion resistant.

High Temperature LM Guide

If high temperature is predicted due to baking, use a High Temperature LM Guide, which is highly resistant to heat and corrosion.

■Highly Corrosion Resistant LM Guide

This LM Guide uses austenite stainless steel, which has a high anti-corrosion effect, in the LM rail.

High Temperature LM Guide

Supported models HSR-M1 SR-M1 RSR-M1

Highly Corrosion Resistant LM Guide

Stainless Steel LM Guide

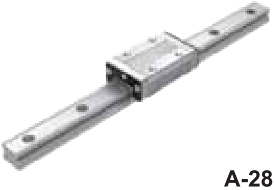
Supported models SSR SHW SRS HSR SR HRW HR RSR RSH

Vacuum Grease

HSR-M1

A-272

SR-M1



A-280

RSR-M1

A-286

HSR-M2

A-292

SSR

A-142

SHW

A-156

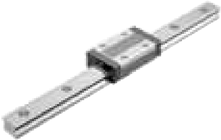
SRS

A-160

HSR

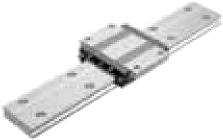
A-170

SR



A-178

HRW



A-194

HR

A-224

RSR

A-200

RSH

A-214

Corrosion Prevention

As with clean room applications, it is necessary to increase corrosion resistance through material selection and surface treatment.

■Material-based Measure

Stainless Steel LM Guide
This LM Guide uses martensite stainless steel, which has an anti-corrosion effect.

Highly Corrosion Resistant LM Guide
It uses austenite stainless steel, which has a high anti-corrosion effect, in its LM rail.

■Measure Through Surface Treatment

THK AP-HC, AP-C and AP-CF Treatment
The LM system is surface treated to increase corrosion resistance.

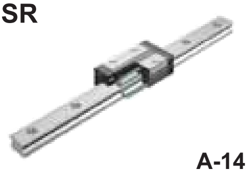
Stainless Steel LM Guide

Supported models: SSR SHW SRS HSR SR HRW HR RSR RSH

Highly Corrosion Resistant LM Guide

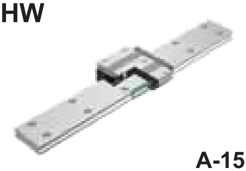
Surface Treatment

SSR



A-142

SHW

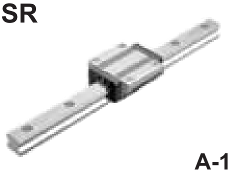


A-156

SRS

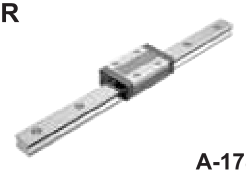
A-160

HSR



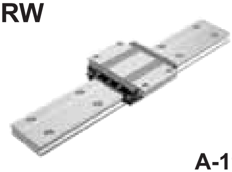
A-170

SR



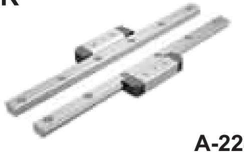
A-178

HRW



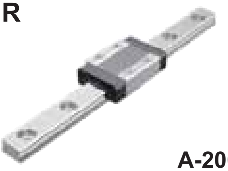
A-194

HR



A-224

RSR



A-200

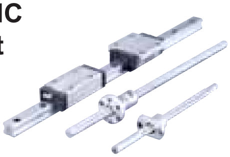
RSH

A-214

HSR-M2

A-292

THK AP-HC Treatment

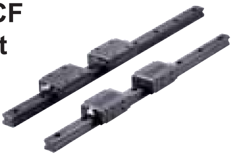


A-20

THK AP-C Treatment

A-20

THK AP-CF Treatment



A-20

High Speed

In a high speed environment, it is necessary to apply an optimum lubrication method that reduces heat generation during high speed operation and increases grease retention.

■Measures to Reduce Heat Generation

Caged Ball LM Guide

Use of a ball cage eliminates friction between balls to reduce heat generation. In addition, grease retention is increased, thus to achieve long service life and high speed operation.

High Speed Ball Screw with Ball Cage

Use of a ball cage and an ideal ball recirculation structure enables fast feeding, which conventional products have not achieved.

THK AFG Grease

It reduces heat generation in high speed operation and has superb lubricity.

■Measure to Improve Lubrication

QZ Lubricator

Since it supplements oil loss, the lubrication and maintenance interval can significantly be extended. It also applies the right amount of oil to the raceway, making itself an eco-friendly lubrication system that does not contaminate the surrounding area.

Caged Ball LM Guide

Supported models
SHS SSR SNR/SNS
SHW SRS SCR

Caged Roller LM Guide

Supported models
SRG SRN SRW

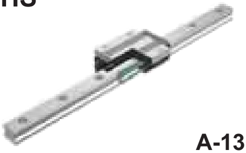
High Speed Ball Screw with Ball Cage

Supported models
SBK SBN

QZ Lubricator

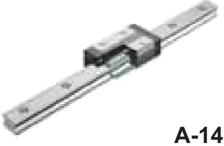
Grease

SHS



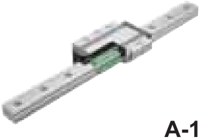
A-136

SSR



A-142

SNR/SNS



A-148

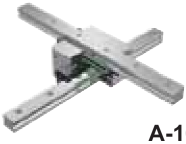
SHW

A-156

SRS

A-160

SCR



A-166

SRG

A-300

SRN

A-306

SRW

A-312

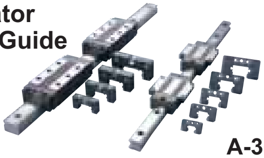
SBK

A-748

SBN

A-748

QZ Lubricator for the LM Guide



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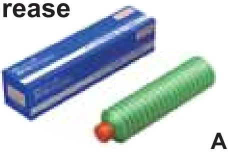
QZ Lubricator for the Ball Screw

A-817

THK AFG Grease



A-968

High Temperature

In a high temperature environment, dimensional alteration caused by heat is problematic. Use a High Temperature LM Guide, which is heat resistant and whose dimensions little change after being heated, and a high temperature grease.

■Heat Resistance

High Temperature LM Guide

It is an LM Guide that is highly resistant to heat and whose dimensions little change after being heated and cooled.

■Grease

High Temperature Grease

Use a high temperature grease with which the rolling resistance of the LM system little fluctuates even temperature changes from a normal to high range.

High Temperature LM Guide

Supported models HSR-M1 SR-M1 RSR-M1

High Temperature Grease

Low Temperature

Use an LM system whose resin component are little affected by low temperature, as a measure to increase corrosion resistance in transition from normal to low temperature, and a grease with a low rolling resistance fluctuation even at low temperature.

■Impact of Low Temperature on Resin Components

Stainless Steel LM Guide

The endplate (ball circulation path normally made of resin) of the LM block is made of stainless steel.

■Corrosion Prevention

Provide surface treatment to the LM system to increase its corrosion resistance.

■Grease

Use THK AFC Grease, with which the rolling resistance of the system little fluctuates even at low temperature.

Stainless Steel LM Guide

Supported models SSR SHW SRS HSR SR HRW HR RSR RSH

Surface Treatment

Grease

Micro Motion

Micro strokes cause oil film break and poor lubrication, resulting in early wear. In such cases, select a grease with which the oil film strength is high and an oil film can easily be formed.

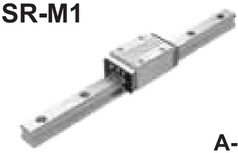
■Grease

THK AFC Grease

AFC Grease is a urea-based grease that excels in oil film strength and wear resistance.

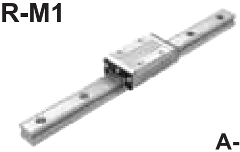
Grease

HSR-M1



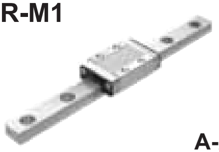
A-272

SR-M1



A-280

RSR-M1



A-286

SSR

A-142

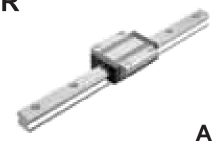
SHW

A-156

SRS

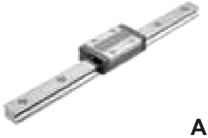
A-160

HSR



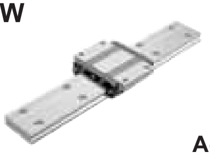
A-170

SR



A-178

HRW



A-194

HR

A-224

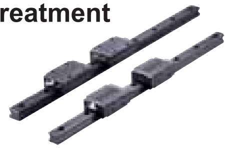
RSR

A-200

RSH

A-214

THK AP-CF Treatment



A-20

THK AFC Grease

A-961

THK AFC Grease

A-961

Foreign Matter

If foreign matter enters the LM system, it will cause abnormal wear and shorten the service life. Therefore, it is necessary to prevent such entrance of foreign matter.
Especially in an environment containing minute foreign matter or a water-soluble coolant that a telescopic cover or a bellows cannot remove, it is necessary to attach a contamination protection accessory capable of efficiently removing foreign matter.

■Metal Scraper

It is used to remove relatively large foreign objects such as cutting chips, spatter and sand or hard foreign matter that adhere to the LM rail.

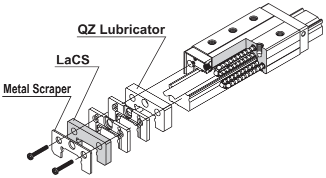
■Laminated Contact Scraper LaCS

Unlike a metal scraper, it removes foreign matter while it is in contact with the LM rail. Therefore, it demonstrates a high contamination protection effect against minute foreign matter, which has been difficult to remove with conventional metal scrapers.

■QZ Lubricator

QZ Lubricator is a lubrication system that feeds the right amount of lubricant by closely contacting its highly oil-impregnated fiber net to the ball raceway.

LM Guide
+Metal Scraper
+Laminated Contact Scraper LaCS
+QZ Lubricator

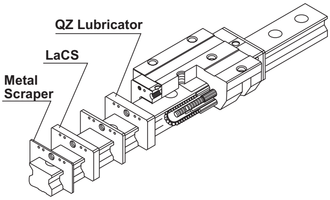


Supported models

Caged Ball LM Guide
SHS SSR SNR/SNS SHW SRS

Full Ball LM Guide
HSR NR/NRS

Caged Roller LM Guide
+Metal Scraper
+Laminated Contact Scraper LaCS
+QZ Lubricator



Supported models

SRG

Caged Ball LM Guide

SHS

A-136

SSR

A-142

SNR/SNS

A-148

SHW

A-156

SRS

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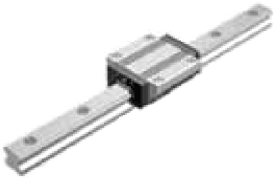
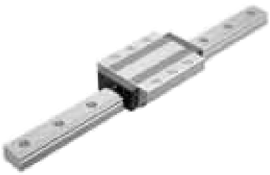
Full ball LM Guide

HSR



A-170

NR/NRS



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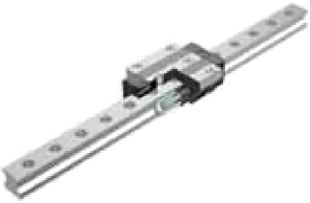
Caged Roller LM Guide

SRG



A-300

Calculating the Applied Load

The LM Guide is capable of receiving loads and moments in all directions that are generated due to the mounting orientation, alignment, gravity center position of a traveling object, thrust position and cutting resistance.

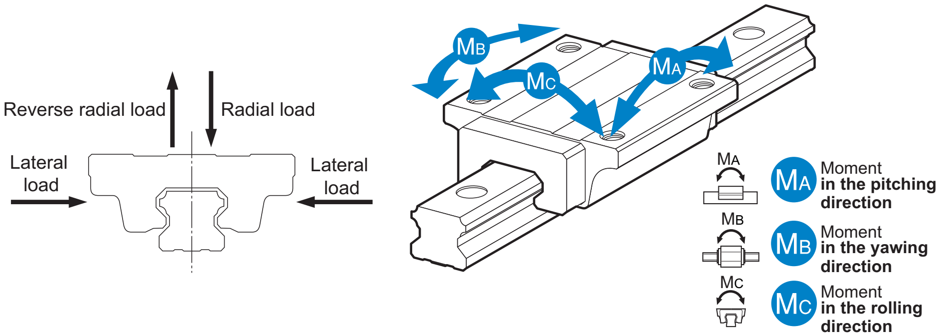
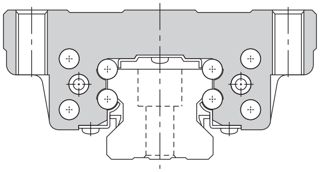
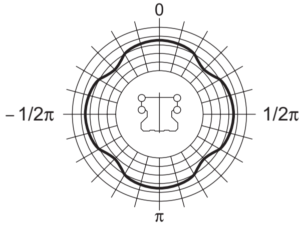
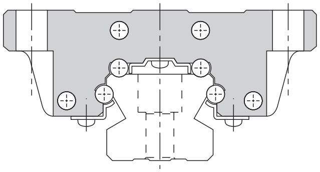
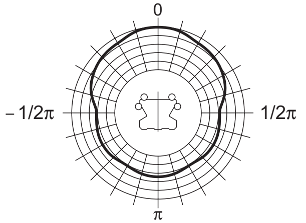


Fig.1 Directions of the Loads Applied on the LM Guide

Rated Load of an LM Guide in Each Direction

The LM Guide is categorized into roughly two types: the 4-way equal load type, which has the same rated load in the radial, reverse radial and lateral directions, and the radial type, which has a large rated load in the radial direction. With the radial type LM Guide, the rated load in the radial direction is different from that in the reverse radial and lateral directions. When such loads are applied, multiply the basic load rating by the corresponding factor. Those factors are specified in the respective sections.

[Rated Loads in All Directions]

Type	Load Distribution Curve
4-way Equal Load Type 	
Radial Type 	

Calculating an Applied Load

[Single-Axis Use]

● Moment Equivalence

When the installation space for the LM Guide is limited, you may have to use only one LM block, or double LM blocks closely contacting with each other. In such a setting, the load distribution is not uniform and, as a result, an excessive load is applied in localized areas (i.e., both ends) as shown in Fig.2. Continued use under such conditions may result in flaking in those areas, consequently shortening the service life. In such a case, calculate the actual load by multiplying the moment value by any one of the equivalent-moment factors specified in Table1 to Table9.

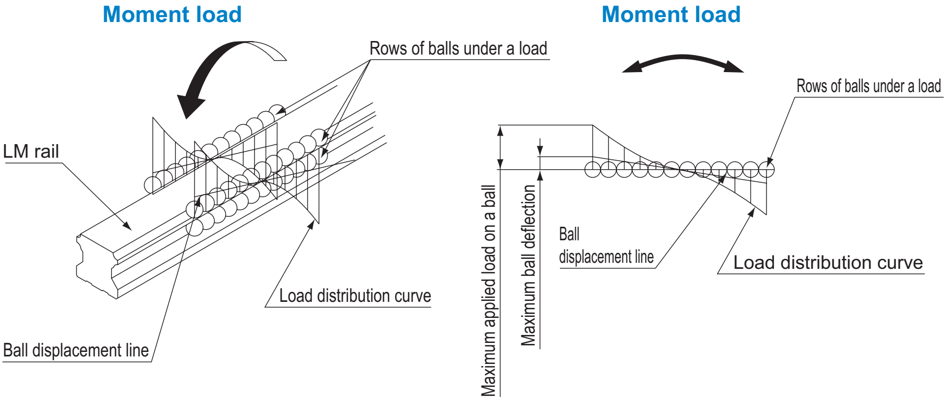


Fig.2 Ball Load when a Moment is Applied

An equivalent-load equation applicable when a moment acts on an LM Guide is shown below.

$$P = K \cdot M$$

P : Equivalent load per LM Guide (N)
K : Equivalent moment factor
M : Applied moment (N-mm)

● Equivalent Factor

Since the rated load is equivalent to the permissible moment, the equivalent factor to be multiplied when equalizing the M_A, M_B and M_C moments to the applied load per block is obtained by dividing the rated loads in the corresponding directions.

With those models other than 4-way equal load types, however, the load ratings in the 4 directions differ from each other. Therefore, the equivalent factor values for the M_A and M_C moments also differ depending on whether the direction is radial or reverse radial.

■Equivalent Factors for the M_A Moment

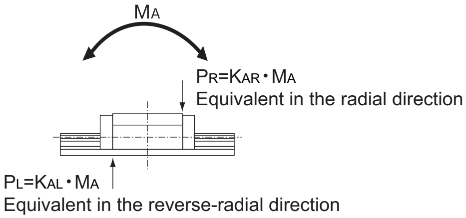


Fig.3 Equivalent Factors for the M_A Moment

Equivalent factors for the M_A Moment

- Equivalent factor in the radial direction $K_{AR}=\dfrac{C_0}{M_A}$
- Equivalent factor in the reverse radial direction $K_{AL}=\dfrac{C_{0L}}{M_A}$

$$\frac{C_0}{K_{AR} \cdot M_A}=\frac{C_{0L}}{K_{AL} \cdot M_A}=1$$

■Equivalent Factors for the M_B Moment

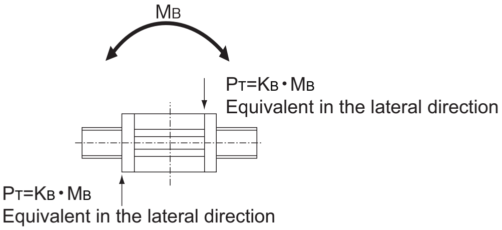


Fig.4 Equivalent Factors for the M_B Moment

Equivalent factors for the M_B Moment

- Equivalent factor in the lateral directions $K_B=\dfrac{C_{0T}}{M_B}$

$$\frac{C_{0T}}{K_B \cdot M_B}=1$$

■Equivalent Factors for the M_C Moment

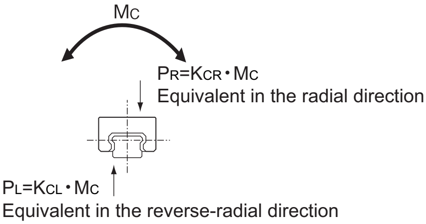


Fig.5 Equivalent Factors for the M_C Moment

Equivalent factors for the M_C Moment

- Equivalent factor in the radial direction $K_{CR}=\frac{C_0}{M_C}$
- Equivalent factor in the reverse radial direction $K_{CL}=\frac{C_{0L}}{M_C}$

$$\frac{C_0}{K_{CR} \cdot M_C}=\frac{C_{0L}}{K_{CL} \cdot M_C}=1$$

C_0	: Basic static load rating (radial direction)	(N)
C_{0L}	: Basic static load rating (reverse radial direction)	(N)
C_{0T}	: Basic static load rating (lateral direction)	(N)
P_R	: Calculated load (radial direction)	(N)
P_L	: Calculated load (reverse radial direction)	(N)
P_T	: Calculated load (lateral direction)	(N)

Table1 Equivalent Factors (Models SHS, SSR and SNR)

Model No.		Equivalent factor							
		K_{AR1}	K_{AL1}	K_{AR2}	K_{AL2}	K_{B1}	K_{B2}	K_{CR}	K_{CL}
SHS	15	1.38×10^{-1}		2.69×10^{-2}		1.38×10^{-1}	2.69×10^{-2}	1.50×10^{-1}	
	15L	1.07×10^{-1}		2.22×10^{-2}		1.07×10^{-1}	2.22×10^{-2}	1.50×10^{-1}	
	20	1.15×10^{-1}		2.18×10^{-2}		1.15×10^{-1}	2.18×10^{-2}	1.06×10^{-1}	
	20L	8.85×10^{-2}		1.79×10^{-2}		8.85×10^{-2}	1.79×10^{-2}	1.06×10^{-1}	
	25	9.25×10^{-2}		1.90×10^{-2}		9.25×10^{-2}	1.90×10^{-2}	9.29×10^{-2}	
	25L	7.62×10^{-2}		1.62×10^{-2}		7.62×10^{-2}	1.62×10^{-2}	9.29×10^{-2}	
	30	8.47×10^{-2}		1.63×10^{-2}		8.47×10^{-2}	1.63×10^{-2}	7.69×10^{-2}	
	30L	6.52×10^{-2}		1.34×10^{-2}		6.52×10^{-2}	1.34×10^{-2}	7.69×10^{-2}	
	35	6.95×10^{-2}		1.43×10^{-2}		6.95×10^{-2}	1.43×10^{-2}	6.29×10^{-2}	
	35L	5.43×10^{-2}		1.16×10^{-2}		5.43×10^{-2}	1.16×10^{-2}	6.29×10^{-2}	
	45	6.13×10^{-2}		1.24×10^{-2}		6.13×10^{-2}	1.24×10^{-2}	4.69×10^{-2}	
	45L	4.79×10^{-2}		1.02×10^{-2}		4.79×10^{-2}	1.02×10^{-2}	4.69×10^{-2}	
	55	4.97×10^{-2}		1.02×10^{-2}		4.97×10^{-2}	1.02×10^{-2}	4.02×10^{-2}	
	55L	3.88×10^{-2}		8.30×10^{-3}		3.88×10^{-2}	8.30×10^{-3}	4.02×10^{-2}	
	65	3.87×10^{-2}		7.91×10^{-3}		3.87×10^{-2}	7.91×10^{-3}	3.40×10^{-2}	
	65L	3.06×10^{-2}		6.51×10^{-3}		3.06×10^{-2}	6.51×10^{-3}	3.40×10^{-2}	
SSR	15XW (TB)	2.08×10^{-1}	1.04×10^{-1}	3.75×10^{-2}	1.87×10^{-2}	1.46×10^{-1}	2.59×10^{-2}	1.71×10^{-1}	8.57×10^{-2}
	15XV	3.19×10^{-1}	1.60×10^{-1}	5.03×10^{-2}	2.51×10^{-2}	2.20×10^{-1}	3.41×10^{-2}	1.71×10^{-1}	8.57×10^{-2}
	20XW (TB)	1.69×10^{-1}	8.46×10^{-2}	3.23×10^{-2}	1.62×10^{-2}	1.19×10^{-1}	2.25×10^{-2}	1.29×10^{-1}	6.44×10^{-2}
	20XV	2.75×10^{-1}	1.37×10^{-1}	4.28×10^{-2}	2.14×10^{-2}	1.89×10^{-1}	2.89×10^{-2}	1.29×10^{-1}	6.44×10^{-2}
	25XW (TB)	1.41×10^{-1}	7.05×10^{-2}	2.56×10^{-2}	1.28×10^{-2}	9.86×10^{-2}	1.77×10^{-2}	1.10×10^{-1}	5.51×10^{-2}
	25XV	2.15×10^{-1}	1.08×10^{-1}	3.40×10^{-2}	1.70×10^{-2}	1.48×10^{-1}	2.31×10^{-2}	1.10×10^{-1}	5.51×10^{-2}
	30XW	1.18×10^{-1}	5.91×10^{-2}	2.19×10^{-2}	1.10×10^{-2}	8.26×10^{-2}	1.52×10^{-2}	9.22×10^{-2}	4.61×10^{-2}
	35XW	1.01×10^{-1}	5.03×10^{-2}	1.92×10^{-2}	9.60×10^{-3}	7.04×10^{-2}	1.33×10^{-2}	7.64×10^{-2}	3.82×10^{-2}
SNR	25	1.16×10^{-1}	7.41×10^{-2}	2.18×10^{-2}	1.40×10^{-2}	7.02×10^{-2}	1.33×10^{-2}	9.09×10^{-2}	5.82×10^{-2}
	25L	8.79×10^{-2}	5.62×10^{-2}	1.82×10^{-2}	1.16×10^{-2}	5.41×10^{-2}	1.13×10^{-2}	9.09×10^{-2}	5.82×10^{-2}
	30	1.02×10^{-1}	6.51×10^{-2}	1.86×10^{-2}	1.19×10^{-2}	6.16×10^{-2}	1.13×10^{-2}	8.11×10^{-2}	5.19×10^{-2}
	30L	7.60×10^{-2}	4.87×10^{-2}	1.55×10^{-2}	9.93×10^{-3}	4.68×10^{-2}	9.58×10^{-3}	8.11×10^{-2}	5.19×10^{-2}
	35	8.92×10^{-2}	5.71×10^{-2}	1.67×10^{-2}	1.07×10^{-2}	5.40×10^{-2}	1.01×10^{-2}	6.73×10^{-2}	4.31×10^{-2}
	35L	7.01×10^{-2}	4.48×10^{-2}	1.37×10^{-2}	8.79×10^{-3}	4.27×10^{-2}	8.41×10^{-3}	6.73×10^{-2}	4.31×10^{-2}
	45	6.55×10^{-2}	4.19×10^{-2}	1.35×10^{-2}	8.62×10^{-3}	4.03×10^{-2}	8.32×10^{-3}	5.10×10^{-2}	3.27×10^{-2}
	45L	5.32×10^{-2}	3.41×10^{-2}	1.10×10^{-2}	7.01×10^{-3}	3.26×10^{-2}	6.73×10^{-3}	5.10×10^{-2}	3.27×10^{-2}
	55	5.85×10^{-2}	3.74×10^{-2}	1.13×10^{-2}	7.24×10^{-3}	3.56×10^{-2}	6.92×10^{-3}	4.36×10^{-2}	2.79×10^{-2}
	55L	4.55×10^{-2}	2.91×10^{-2}	9.36×10^{-3}	5.99×10^{-3}	2.79×10^{-2}	5.75×10^{-3}	4.36×10^{-2}	2.79×10^{-2}
	65	5.07×10^{-2}	3.25×10^{-2}	9.92×10^{-3}	6.35×10^{-3}	3.09×10^{-2}	6.06×10^{-3}	3.70×10^{-2}	2.37×10^{-2}
	65L	3.58×10^{-2}	2.29×10^{-2}	7.67×10^{-3}	4.91×10^{-3}	2.21×10^{-2}	4.75×10^{-3}	3.70×10^{-2}	2.37×10^{-2}
	85L	2.92×10^{-2}	1.87×10^{-2}	6.20×10^{-3}	4.00×10^{-3}	1.80×10^{-2}	3.80×10^{-3}	2.78×10^{-2}	1.78×10^{-2}

K_{AR1} : Equivalent factor in the M_A radial direction when one LM block is used

K_{AL1} : Equivalent factor in the M_A reverse radial direction when one LM block is used

K_{AR2} : Equivalent factor in the M_A radial direction when two LM blocks are used in close contact with each other

K_{AL2} : Equivalent factor in the M_A reverse radial direction when two LM blocks are used in close contact with each other

K_{B1} : M_B Equivalent factor when one LM block is used

K_{B2} : M_B Equivalent factor when two LM blocks are used in close contact with each other

K_{CR} : Equivalent factor in the M_C radial direction

K_{CL} : Equivalent factor in the M_C reverse radial direction

Table2 Equivalent Factors (Models SNS, SHW and SRS)

Model No.		Equivalent factor							
		K_{AR1}	K_{AL1}	K_{AR2}	K_{AL2}	K_{B1}	K_{B2}	K_{CR}	K_{CL}
SNS	25	1.12×10^{-1}	9.42×10^{-2}	2.11×10^{-2}	1.78×10^{-2}	1.02×10^{-1}	1.91×10^{-2}	9.41×10^{-2}	7.90×10^{-2}
	25L	8.52×10^{-2}	7.16×10^{-2}	1.77×10^{-2}	1.48×10^{-2}	7.73×10^{-2}	1.60×10^{-2}	9.41×10^{-2}	7.90×10^{-2}
	30	9.86×10^{-2}	8.28×10^{-2}	1.80×10^{-2}	1.51×10^{-2}	8.93×10^{-2}	1.63×10^{-2}	8.42×10^{-2}	7.07×10^{-2}
	30L	7.37×10^{-2}	6.19×10^{-2}	1.50×10^{-2}	1.26×10^{-2}	6.68×10^{-2}	1.36×10^{-2}	8.42×10^{-2}	7.07×10^{-2}
	35	8.64×10^{-2}	7.26×10^{-2}	1.61×10^{-2}	1.36×10^{-2}	7.83×10^{-2}	1.46×10^{-2}	7.01×10^{-2}	5.89×10^{-2}
	35L	6.80×10^{-2}	5.71×10^{-2}	1.33×10^{-2}	1.12×10^{-2}	6.17×10^{-2}	1.21×10^{-2}	7.01×10^{-2}	5.89×10^{-2}
	45	6.34×10^{-2}	5.33×10^{-2}	1.30×10^{-2}	1.10×10^{-2}	5.75×10^{-2}	1.18×10^{-2}	5.27×10^{-2}	4.43×10^{-2}
	45L	5.17×10^{-2}	4.34×10^{-2}	1.06×10^{-2}	8.94×10^{-3}	4.69×10^{-2}	9.64×10^{-3}	5.27×10^{-2}	4.43×10^{-2}
	55	5.67×10^{-2}	4.76×10^{-2}	1.10×10^{-2}	9.22×10^{-3}	5.14×10^{-2}	9.94×10^{-3}	4.52×10^{-2}	3.80×10^{-2}
	55L	4.42×10^{-2}	3.72×10^{-2}	9.09×10^{-3}	7.64×10^{-3}	4.01×10^{-2}	8.24×10^{-3}	4.52×10^{-2}	3.80×10^{-2}
	65	4.92×10^{-2}	4.13×10^{-2}	9.62×10^{-3}	8.08×10^{-3}	4.46×10^{-2}	8.71×10^{-3}	3.82×10^{-2}	3.21×10^{-2}
	65L	3.47×10^{-2}	2.92×10^{-2}	7.45×10^{-3}	6.26×10^{-3}	3.15×10^{-2}	6.75×10^{-3}	3.82×10^{-2}	3.21×10^{-2}
	85L	2.83×10^{-2}	2.38×10^{-2}	6.00×10^{-3}	5.10×10^{-3}	2.57×10^{-2}	5.50×10^{-3}	2.86×10^{-2}	2.40×10^{-2}
SHW	12	2.48×10^{-1}		4.69×10^{-2}		2.48×10^{-1}	4.69×10^{-2}	1.40×10^{-1}	
	12HR	1.70×10^{-1}		3.52×10^{-2}		1.70×10^{-1}	3.52×10^{-2}	1.40×10^{-1}	
	14	1.92×10^{-1}		3.80×10^{-2}		1.92×10^{-1}	3.80×10^{-2}	9.93×10^{-2}	
	17	1.72×10^{-1}		3.41×10^{-2}		1.72×10^{-1}	3.41×10^{-2}	6.21×10^{-2}	
	21	1.59×10^{-1}		2.95×10^{-2}		1.59×10^{-1}	2.95×10^{-2}	5.57×10^{-2}	
	27	1.21×10^{-1}		2.39×10^{-2}		1.21×10^{-1}	2.39×10^{-2}	4.99×10^{-2}	
	35	8.15×10^{-2}		1.64×10^{-2}		8.15×10^{-2}	1.64×10^{-2}	3.02×10^{-2}	
	50	6.22×10^{-2}		1.24×10^{-2}		6.22×10^{-2}	1.24×10^{-2}	2.30×10^{-2}	
SRS	7	4.19×10^{-1}		7.46×10^{-2}		4.18×10^{-1}	7.45×10^{-2}	2.58×10^{-1}	
	7W	3.01×10^{-1}		5.67×10^{-2}		3.00×10^{-1}	5.66×10^{-2}	1.36×10^{-1}	
	9	2.95×10^{-1}		5.26×10^{-2}		3.04×10^{-1}	5.40×10^{-2}	2.17×10^{-1}	
	9W	2.37×10^{-1}		4.25×10^{-2}		2.44×10^{-1}	4.37×10^{-2}	1.06×10^{-1}	
	12	2.94×10^{-1}		4.50×10^{-2}		2.94×10^{-1}	4.50×10^{-2}	1.53×10^{-1}	
	12W	2.00×10^{-1}		3.69×10^{-2}		2.00×10^{-1}	3.69×10^{-2}	7.97×10^{-2}	
	15	2.17×10^{-1}		3.69×10^{-2}		2.17×10^{-1}	3.69×10^{-2}	1.41×10^{-1}	
	15W	1.67×10^{-1}		2.94×10^{-2}		1.67×10^{-1}	2.94×10^{-2}	4.83×10^{-2}	
	20	1.80×10^{-1}		3.30×10^{-2}		1.86×10^{-1}	3.41×10^{-2}	9.34×10^{-2}	
	25	1.14×10^{-1}		2.17×10^{-2}		1.14×10^{-1}	2.17×10^{-2}	8.13×10^{-2}	

K_{AR1} : Equivalent factor in the M_A radial direction when one LM block is used

K_{AL1} : Equivalent factor in the M_A reverse radial direction when one LM block is used

K_{AR2} : Equivalent factor in the M_A radial direction when two LM blocks are used in close contact with each other

K_{AL2} : Equivalent factor in the M_A reverse radial direction when two LM blocks are used in close contact with each other

K_{B1} : M_B Equivalent factor when one LM block is used

K_{B2} : M_B Equivalent factor when two LM blocks are used in close contact with each other

K_{CR} : Equivalent factor in the M_C radial direction

K_{CL} : Equivalent factor in the M_C reverse radial direction

Table3 Equivalent Factors (Models SCR and HSR)

<table>
<tr><th colspan="2" rowspan="2">Model No.</th><th colspan="8">Equivalent factor</th></tr>
<tr><th>K_{AR1}</th><th>K_{AL1}</th><th>K_{AR2}</th><th>K_{AL2}</th><th>K_{B1}</th><th>K_{B2}</th><th>K_{CR}</th><th>K_{CL}</th></tr>
<tr><td rowspan="5">SCR</td><td>25</td><td colspan="2">9.25×10^{-2}</td><td colspan="2">1.90×10^{-2}</td><td>9.25×10^{-2}</td><td>1.90×10^{-2}</td><td colspan="2">9.29×10^{-2}</td></tr>
<tr><td>30</td><td colspan="2">8.47×10^{-2}</td><td colspan="2">1.63×10^{-2}</td><td>8.47×10^{-2}</td><td>1.63×10^{-2}</td><td colspan="2">7.69×10^{-2}</td></tr>
<tr><td>35</td><td colspan="2">6.95×10^{-2}</td><td colspan="2">1.43×10^{-2}</td><td>6.95×10^{-2}</td><td>1.43×10^{-2}</td><td colspan="2">6.29×10^{-2}</td></tr>
<tr><td>45</td><td colspan="2">6.13×10^{-2}</td><td colspan="2">1.24×10^{-2}</td><td>6.13×10^{-2}</td><td>1.24×10^{-2}</td><td colspan="2">4.69×10^{-2}</td></tr>
<tr><td>65</td><td colspan="2">3.87×10^{-2}</td><td colspan="2">7.91×10^{-3}</td><td>3.87×10^{-2}</td><td>7.91×10^{-3}</td><td colspan="2">3.40×10^{-2}</td></tr>
<tr><td rowspan="26">HSR</td><td>8</td><td colspan="2">4.39×10^{-1}</td><td colspan="2">6.75×10^{-2}</td><td>4.39×10^{-1}</td><td>6.75×10^{-2}</td><td colspan="2">2.97×10^{-1}</td></tr>
<tr><td>10</td><td colspan="2">3.09×10^{-1}</td><td colspan="2">5.33×10^{-2}</td><td>3.09×10^{-1}</td><td>5.33×10^{-2}</td><td colspan="2">2.35×10^{-1}</td></tr>
<tr><td>12</td><td colspan="2">2.08×10^{-1}</td><td colspan="2">3.74×10^{-2}</td><td>2.08×10^{-1}</td><td>3.74×10^{-2}</td><td colspan="2">1.91×10^{-1}</td></tr>
<tr><td>15</td><td colspan="2">1.68×10^{-1}</td><td colspan="2">2.95×10^{-2}</td><td>1.68×10^{-1}</td><td>2.95×10^{-2}</td><td colspan="2">1.60×10^{-1}</td></tr>
<tr><td>20</td><td colspan="2">1.25×10^{-1}</td><td colspan="2">2.28×10^{-2}</td><td>1.25×10^{-1}</td><td>2.28×10^{-2}</td><td colspan="2">1.18×10^{-1}</td></tr>
<tr><td>20L</td><td colspan="2">9.83×10^{-2}</td><td colspan="2">1.91×10^{-2}</td><td>9.83×10^{-2}</td><td>1.91×10^{-2}</td><td colspan="2">1.18×10^{-1}</td></tr>
<tr><td>25</td><td colspan="2">1.12×10^{-1}</td><td colspan="2">2.01×10^{-2}</td><td>1.12×10^{-1}</td><td>2.01×10^{-2}</td><td colspan="2">1.00×10^{-1}</td></tr>
<tr><td>25L</td><td colspan="2">8.66×10^{-2}</td><td colspan="2">1.68×10^{-2}</td><td>8.66×10^{-2}</td><td>1.68×10^{-2}</td><td colspan="2">1.00×10^{-1}</td></tr>
<tr><td>30</td><td colspan="2">8.93×10^{-2}</td><td colspan="2">1.73×10^{-2}</td><td>8.93×10^{-2}</td><td>1.73×10^{-2}</td><td colspan="2">8.31×10^{-2}</td></tr>
<tr><td>30L</td><td colspan="2">7.02×10^{-2}</td><td colspan="2">1.43×10^{-2}</td><td>7.02×10^{-2}</td><td>1.43×10^{-2}</td><td colspan="2">8.31×10^{-2}</td></tr>
<tr><td>35</td><td colspan="2">7.81×10^{-2}</td><td colspan="2">1.55×10^{-2}</td><td>7.81×10^{-2}</td><td>1.55×10^{-2}</td><td colspan="2">6.74×10^{-2}</td></tr>
<tr><td>35L</td><td colspan="2">6.15×10^{-2}</td><td colspan="2">1.28×10^{-2}</td><td>6.15×10^{-2}</td><td>1.28×10^{-2}</td><td colspan="2">6.74×10^{-2}</td></tr>
<tr><td>45</td><td colspan="2">6.71×10^{-2}</td><td colspan="2">1.21×10^{-2}</td><td>6.71×10^{-2}</td><td>1.21×10^{-2}</td><td colspan="2">5.22×10^{-2}</td></tr>
<tr><td>45L</td><td colspan="2">5.20×10^{-2}</td><td colspan="2">1.00×10^{-2}</td><td>5.20×10^{-2}</td><td>1.00×10^{-2}</td><td colspan="2">5.22×10^{-2}</td></tr>
<tr><td>55</td><td colspan="2">5.59×10^{-2}</td><td colspan="2">1.03×10^{-2}</td><td>5.59×10^{-2}</td><td>1.03×10^{-2}</td><td colspan="2">4.27×10^{-2}</td></tr>
<tr><td>55L</td><td colspan="2">4.33×10^{-2}</td><td colspan="2">8.56×10^{-3}</td><td>4.33×10^{-2}</td><td>8.56×10^{-3}</td><td colspan="2">4.27×10^{-2}</td></tr>
<tr><td>65</td><td colspan="2">4.47×10^{-2}</td><td colspan="2">9.13×10^{-3}</td><td>4.47×10^{-2}</td><td>9.13×10^{-3}</td><td colspan="2">3.69×10^{-2}</td></tr>
<tr><td>65L</td><td colspan="2">3.28×10^{-2}</td><td colspan="2">7.06×10^{-3}</td><td>3.28×10^{-2}</td><td>7.06×10^{-3}</td><td colspan="2">3.69×10^{-2}</td></tr>
<tr><td>85</td><td colspan="2">3.73×10^{-2}</td><td colspan="2">6.80×10^{-3}</td><td>3.73×10^{-2}</td><td>6.80×10^{-3}</td><td colspan="2">2.79×10^{-2}</td></tr>
<tr><td>85L</td><td colspan="2">2.89×10^{-2}</td><td colspan="2">5.68×10^{-3}</td><td>2.89×10^{-2}</td><td>5.68×10^{-3}</td><td colspan="2">2.79×10^{-2}</td></tr>
<tr><td>100</td><td colspan="2">2.60×10^{-2}</td><td colspan="2">5.15×10^{-3}</td><td>2.60×10^{-2}</td><td>5.15×10^{-3}</td><td colspan="2">2.25×10^{-2}</td></tr>
<tr><td>120</td><td colspan="2">2.36×10^{-2}</td><td colspan="2">4.72×10^{-3}</td><td>2.36×10^{-2}</td><td>4.72×10^{-3}</td><td colspan="2">1.97×10^{-2}</td></tr>
<tr><td>150</td><td colspan="2">2.17×10^{-2}</td><td colspan="2">4.35×10^{-3}</td><td>2.17×10^{-2}</td><td>4.35×10^{-3}</td><td colspan="2">1.61×10^{-2}</td></tr>
<tr><td>15M2A</td><td colspan="2">1.65×10^{-1}</td><td colspan="2">2.89×10^{-2}</td><td>1.65×10^{-1}</td><td>2.89×10^{-2}</td><td colspan="2">1.86×10^{-1}</td></tr>
<tr><td>20M2A</td><td colspan="2">1.23×10^{-1}</td><td colspan="2">2.23×10^{-2}</td><td>1.23×10^{-1}</td><td>2.23×10^{-2}</td><td colspan="2">1.34×10^{-1}</td></tr>
<tr><td>25M2A</td><td colspan="2">1.10×10^{-1}</td><td colspan="2">1.98×10^{-2}</td><td>1.10×10^{-1}</td><td>1.98×10^{-2}</td><td colspan="2">1.14×10^{-1}</td></tr>
</table>

K_{AR1} : Equivalent factor in the M_A radial direction when one LM block is used
K_{AL1} : Equivalent factor in the M_A reverse radial direction when one LM block is used
K_{AR2} : Equivalent factor in the M_A radial direction when two LM blocks are used in close contact with each other
K_{AL2} : Equivalent factor in the M_A reverse radial direction when two LM blocks are used in close contact with each other
K_{B1} : M_B Equivalent factor when one LM block is used
K_{B2} : M_B Equivalent factor when two LM blocks are used in close contact with each other
K_{CR} : Equivalent factor in the M_C radial direction
K_{CL} : Equivalent factor in the M_C reverse radial direction

Table4 Equivalent Factors (Models SR and NR)

Model No.		Equivalent factor							
		K_{AR1}	K_{AL1}	K_{AR2}	K_{AL2}	K_{B1}	K_{B2}	K_{CR}	K_{CL}
SR	15W (TB)	2.09×10^{-1}	1.04×10^{-1}	3.74×10^{-2}	1.87×10^{-2}	1.46×10^{-1}	2.58×10^{-2}	1.70×10^{-1}	8.48×10^{-2}
	15V (SB)	3.40×10^{-1}	1.70×10^{-1}	4.94×10^{-2}	2.47×10^{-2}	2.35×10^{-1}	3.32×10^{-2}	1.70×10^{-1}	8.48×10^{-2}
	20W (TB)	1.72×10^{-1}	8.61×10^{-2}	3.24×10^{-2}	1.62×10^{-2}	1.21×10^{-1}	2.25×10^{-2}	1.30×10^{-1}	6.49×10^{-2}
	20V (SB)	2.72×10^{-1}	1.36×10^{-1}	4.33×10^{-2}	2.16×10^{-2}	1.88×10^{-1}	2.94×10^{-2}	1.30×10^{-1}	6.49×10^{-2}
	25W (TB)	1.38×10^{-1}	6.89×10^{-2}	2.59×10^{-2}	1.30×10^{-2}	9.67×10^{-2}	1.80×10^{-2}	1.11×10^{-1}	5.55×10^{-2}
	25V (SB)	2.17×10^{-1}	1.09×10^{-1}	3.46×10^{-2}	1.73×10^{-2}	1.51×10^{-1}	2.35×10^{-2}	1.11×10^{-1}	5.55×10^{-2}
	30W (TB)	1.15×10^{-1}	5.74×10^{-2}	2.22×10^{-2}	1.11×10^{-2}	8.06×10^{-2}	1.55×10^{-2}	9.22×10^{-2}	4.61×10^{-2}
	30V (SB)	1.99×10^{-1}	9.93×10^{-2}	2.99×10^{-2}	1.49×10^{-2}	1.37×10^{-1}	2.02×10^{-2}	9.22×10^{-2}	4.61×10^{-2}
	35W (TB)	1.04×10^{-1}	5.21×10^{-2}	1.92×10^{-2}	9.61×10^{-3}	7.31×10^{-2}	1.33×10^{-2}	7.64×10^{-2}	3.82×10^{-2}
	35V (SB)	1.70×10^{-1}	8.51×10^{-2}	2.61×10^{-2}	1.31×10^{-2}	1.17×10^{-1}	1.77×10^{-2}	7.64×10^{-2}	3.82×10^{-2}
	45W (TB)	9.12×10^{-2}	4.56×10^{-2}	1.69×10^{-2}	8.47×10^{-3}	6.39×10^{-2}	1.17×10^{-2}	5.71×10^{-2}	2.85×10^{-2}
	55W (TB)	6.89×10^{-2}	3.44×10^{-2}	1.39×10^{-2}	6.93×10^{-3}	4.84×10^{-2}	9.66×10^{-3}	5.46×10^{-2}	2.73×10^{-2}
NR	25X	1.10×10^{-1}	7.78×10^{-2}	2.19×10^{-2}	1.55×10^{-2}	8.11×10^{-2}	1.63×10^{-2}	9.26×10^{-2}	6.58×10^{-2}
	25XL	8.91×10^{-2}	6.33×10^{-2}	1.79×10^{-2}	1.27×10^{-2}	6.55×10^{-2}	1.33×10^{-2}	9.26×10^{-2}	6.58×10^{-2}
	30	9.66×10^{-2}	6.86×10^{-2}	1.84×10^{-2}	1.31×10^{-2}	7.05×10^{-2}	1.35×10^{-2}	8.28×10^{-2}	5.88×10^{-2}
	30L	7.43×10^{-2}	5.27×10^{-2}	1.52×10^{-2}	1.08×10^{-2}	5.47×10^{-2}	1.13×10^{-2}	8.28×10^{-2}	5.88×10^{-2}
	35	8.82×10^{-2}	6.26×10^{-2}	1.64×10^{-2}	1.16×10^{-2}	6.42×10^{-2}	1.20×10^{-2}	6.92×10^{-2}	4.91×10^{-2}
	35L	6.67×10^{-2}	4.74×10^{-2}	1.35×10^{-2}	9.61×10^{-3}	4.90×10^{-2}	1.00×10^{-2}	6.92×10^{-2}	4.91×10^{-2}
	45	6.84×10^{-2}	4.86×10^{-2}	1.30×10^{-2}	9.23×10^{-3}	5.00×10^{-2}	9.58×10^{-3}	5.19×10^{-2}	3.68×10^{-2}
	45L	5.11×10^{-2}	3.62×10^{-2}	1.08×10^{-2}	7.66×10^{-3}	3.79×10^{-2}	8.07×10^{-3}	5.19×10^{-2}	3.68×10^{-2}
	55	5.75×10^{-2}	4.08×10^{-2}	1.11×10^{-2}	7.90×10^{-3}	4.21×10^{-2}	8.21×10^{-3}	4.44×10^{-2}	3.15×10^{-2}
	55L	4.53×10^{-2}	3.22×10^{-2}	9.16×10^{-3}	6.51×10^{-3}	3.34×10^{-2}	6.79×10^{-3}	4.44×10^{-2}	3.15×10^{-2}
	65	4.97×10^{-2}	3.53×10^{-2}	9.74×10^{-3}	6.91×10^{-3}	3.64×10^{-2}	7.18×10^{-3}	3.75×10^{-2}	2.66×10^{-2}
	65L	3.56×10^{-2}	2.53×10^{-2}	7.51×10^{-3}	5.33×10^{-3}	2.65×10^{-2}	5.61×10^{-3}	3.75×10^{-2}	2.66×10^{-2}
	75	4.21×10^{-2}	2.99×10^{-2}	8.31×10^{-3}	5.90×10^{-3}	3.08×10^{-2}	6.13×10^{-3}	3.16×10^{-2}	2.24×10^{-2}
	75L	3.14×10^{-2}	2.23×10^{-2}	6.74×10^{-3}	4.78×10^{-3}	2.33×10^{-2}	5.04×10^{-3}	3.16×10^{-2}	2.24×10^{-2}
	85	3.70×10^{-2}	2.62×10^{-2}	7.31×10^{-3}	5.19×10^{-3}	2.71×10^{-2}	5.40×10^{-3}	2.80×10^{-2}	1.99×10^{-2}
	85L	2.80×10^{-2}	1.99×10^{-2}	6.07×10^{-3}	4.31×10^{-3}	2.08×10^{-2}	4.55×10^{-3}	2.80×10^{-2}	1.99×10^{-2}
	100	3.05×10^{-2}	2.17×10^{-2}	6.20×10^{-3}	4.41×10^{-3}	2.26×10^{-2}	4.63×10^{-3}	2.38×10^{-2}	1.69×10^{-2}
	100L	2.74×10^{-2}	1.95×10^{-2}	5.46×10^{-3}	3.87×10^{-3}	2.00×10^{-2}	4.00×10^{-3}	2.38×10^{-2}	1.69×10^{-2}

K_{AR1} : Equivalent factor in the M_A radial direction when one LM block is used

K_{AL1} : Equivalent factor in the M_A reverse radial direction when one LM block is used

K_{AR2} : Equivalent factor in the M_A radial direction when two LM blocks are used in close contact with each other

K_{AL2} : Equivalent factor in the M_A reverse radial direction when two LM blocks are used in close contact with each other

K_{B1} : M_B Equivalent factor when one LM block is used

K_{B2} : M_B Equivalent factor when two LM blocks are used in close contact with each other

K_{CR} : Equivalent factor in the M_C radial direction

K_{CL} : Equivalent factor in the M_C reverse radial direction

Table5 Equivalent Factors (Models NRS and HRW)

Model No.		Equivalent factor							
		K_{AR1}	K_{AL1}	K_{AR2}	K_{AL2}	K_{B1}	K_{B2}	K_{CR}	K_{CL}
NRS	25X	1.05×10^{-1}		2.11×10^{-2}		1.05×10^{-1}	2.11×10^{-2}	9.41×10^{-2}	
	25XL	8.60×10^{-2}		1.73×10^{-2}		8.60×10^{-2}	1.73×10^{-2}	9.41×10^{-2}	
	30	9.30×10^{-2}		1.77×10^{-2}		9.30×10^{-2}	1.77×10^{-2}	8.44×10^{-2}	
	30L	7.17×10^{-2}		1.47×10^{-2}		7.17×10^{-2}	1.47×10^{-2}	8.44×10^{-2}	
	35	8.47×10^{-2}		1.57×10^{-2}		8.47×10^{-2}	1.57×10^{-2}	7.08×10^{-2}	
	35L	6.44×10^{-2}		1.31×10^{-2}		6.44×10^{-2}	1.31×10^{-2}	7.08×10^{-2}	
	45	6.58×10^{-2}		1.25×10^{-2}		6.58×10^{-2}	1.25×10^{-2}	5.26×10^{-2}	
	45L	4.92×10^{-2}		1.04×10^{-2}		4.92×10^{-2}	1.04×10^{-2}	5.26×10^{-2}	
	55	5.54×10^{-2}		1.07×10^{-2}		5.54×10^{-2}	1.07×10^{-2}	4.52×10^{-2}	
	55L	4.38×10^{-2}		8.85×10^{-3}		4.38×10^{-2}	8.85×10^{-3}	4.52×10^{-2}	
	65	4.79×10^{-2}		9.38×10^{-3}		4.79×10^{-2}	9.38×10^{-3}	3.81×10^{-2}	
	65L	3.43×10^{-2}		7.25×10^{-3}		3.43×10^{-2}	7.25×10^{-3}	3.81×10^{-2}	
	75	4.05×10^{-2}		8.01×10^{-3}		4.05×10^{-2}	8.01×10^{-3}	3.20×10^{-2}	
	75L	3.03×10^{-2}		6.50×10^{-3}		3.03×10^{-2}	6.50×10^{-3}	3.20×10^{-2}	
	85	3.56×10^{-2}		7.05×10^{-3}		3.56×10^{-2}	7.05×10^{-3}	2.83×10^{-2}	
	85L	2.70×10^{-2}		5.87×10^{-3}		2.70×10^{-2}	5.87×10^{-3}	2.83×10^{-2}	
	100	2.93×10^{-2}		5.97×10^{-3}		2.93×10^{-2}	5.97×10^{-3}	2.41×10^{-2}	
	100L	2.65×10^{-2}		5.27×10^{-3}		2.65×10^{-2}	5.27×10^{-3}	2.41×10^{-2}	
HRW	12	2.72×10^{-1}		5.16×10^{-2}		5.47×10^{-1}	1.04×10^{-1}	1.40×10^{-1}	
	14	2.28×10^{-1}		4.16×10^{-2}		4.54×10^{-1}	8.28×10^{-2}	1.01×10^{-1}	
	17	1.95×10^{-1}		3.33×10^{-2}		1.95×10^{-1}	3.33×10^{-2}	6.32×10^{-2}	
	21	1.64×10^{-1}		2.89×10^{-2}		1.64×10^{-1}	2.89×10^{-2}	5.92×10^{-2}	
	27	1.30×10^{-1}		2.33×10^{-2}		1.30×10^{-1}	2.33×10^{-2}	5.12×10^{-2}	
	35	8.66×10^{-2}		1.59×10^{-2}		8.66×10^{-2}	1.59×10^{-2}	3.06×10^{-2}	
	50	6.50×10^{-2}		1.21×10^{-2}		6.50×10^{-2}	1.21×10^{-2}	2.35×10^{-2}	
	60	5.77×10^{-2}		8.24×10^{-3}		5.77×10^{-2}	8.24×10^{-3}	1.77×10^{-2}	

K_{AR1} : Equivalent factor in the M_A radial direction when one LM block is used

K_{AL1} : Equivalent factor in the M_A reverse radial direction when one LM block is used

K_{AR2} : Equivalent factor in the M_A radial direction when two LM blocks are used in close contact with each other

K_{AL2} : Equivalent factor in the M_A reverse radial direction when two LM blocks are used in close contact with each other

K_{B1} : M_B Equivalent factor when one LM block is used

K_{B2} : M_B Equivalent factor when two LM blocks are used in close contact with each other

K_{CR} : Equivalent factor in the M_C radial direction

K_{CL} : Equivalent factor in the M_C reverse radial direction

Table6 Equivalent Factors (Model RSR)

Model No.		Equivalent factor							
		K_{AR1}	K_{AL1}	K_{AR2}	K_{AL2}	K_{B1}	K_{B2}	K_{CR}	K_{CL}
RSR	3M	9.20×10^{-1}		1.27×10^{-1}		9.20×10^{-1}	1.27×10^{-1}	6.06×10^{-1}	
	3N	6.06×10^{-1}		1.01×10^{-1}		6.06×10^{-1}	1.01×10^{-1}	6.06×10^{-1}	
	3W	7.03×10^{-1}		1.06×10^{-1}		7.03×10^{-1}	1.06×10^{-1}	3.17×10^{-1}	
	3WN	4.76×10^{-1}		8.27×10^{-2}		4.76×10^{-1}	8.27×10^{-2}	3.17×10^{-1}	
	5M	6.67×10^{-1}		9.06×10^{-2}		6.67×10^{-1}	9.06×10^{-2}	3.85×10^{-1}	
	5N	5.21×10^{-1}		8.00×10^{-2}		5.21×10^{-1}	8.00×10^{-2}	3.85×10^{-1}	
	5W	4.85×10^{-1}		7.28×10^{-2}		4.85×10^{-1}	7.28×10^{-2}	1.96×10^{-1}	
	5WN	3.44×10^{-1}		5.93×10^{-2}		3.44×10^{-1}	5.93×10^{-2}	1.96×10^{-1}	
	7M	4.66×10^{-1}		6.57×10^{-2}		4.66×10^{-1}	6.57×10^{-2}	2.74×10^{-1}	
	7Z	4.66×10^{-1}		6.60×10^{-2}		4.66×10^{-1}	6.60×10^{-2}	2.74×10^{-1}	
	7N	2.88×10^{-1}		5.01×10^{-2}		2.88×10^{-1}	5.01×10^{-2}	2.74×10^{-1}	
	7W	3.07×10^{-1}		5.30×10^{-2}		3.07×10^{-1}	5.30×10^{-2}	1.40×10^{-1}	
	7WZ	3.30×10^{-1}		5.12×10^{-2}		3.30×10^{-1}	5.12×10^{-2}	1.40×10^{-1}	
	7WN	2.18×10^{-1}		4.13×10^{-2}		2.18×10^{-1}	4.13×10^{-2}	1.40×10^{-1}	
	9K	3.06×10^{-1}		5.19×10^{-2}		3.06×10^{-1}	5.19×10^{-2}	2.15×10^{-1}	
	9Z	3.06×10^{-1}		5.23×10^{-2}		3.06×10^{-1}	5.23×10^{-2}	2.15×10^{-1}	
	9N	2.15×10^{-1}		4.08×10^{-2}		2.15×10^{-1}	4.08×10^{-2}	2.15×10^{-1}	
	9WV	2.44×10^{-1}		4.22×10^{-2}		2.44×10^{-1}	4.22×10^{-2}	1.09×10^{-1}	
	9WZ	2.44×10^{-1}		4.22×10^{-2}		2.44×10^{-1}	4.22×10^{-2}	1.09×10^{-1}	
	9WN	1.73×10^{-1}		3.32×10^{-2}		1.73×10^{-1}	4.22×10^{-2}	1.09×10^{-1}	
	12V	3.52×10^{-1}	2.46×10^{-1}	5.37×10^{-2}	3.76×10^{-2}	2.81×10^{-1}	4.21×10^{-2}	2.09×10^{-1}	1.46×10^{-1}
	12Z	3.52×10^{-1}	2.46×10^{-1}	5.37×10^{-2}	3.76×10^{-2}	2.81×10^{-1}	4.21×10^{-2}	2.09×10^{-1}	1.46×10^{-1}
	12N	2.30×10^{-1}	1.61×10^{-1}	4.08×10^{-2}	2.85×10^{-2}	1.85×10^{-1}	3.25×10^{-2}	2.09×10^{-1}	1.46×10^{-1}
	12WV	2.47×10^{-1}	1.73×10^{-1}	4.38×10^{-2}	3.07×10^{-2}	1.99×10^{-1}	3.49×10^{-2}	1.02×10^{-1}	7.15×10^{-2}
	12WZ	2.47×10^{-1}	1.73×10^{-1}	4.38×10^{-2}	3.07×10^{-2}	1.99×10^{-1}	3.49×10^{-2}	1.02×10^{-1}	7.15×10^{-2}
	12WN	1.71×10^{-1}	1.20×10^{-1}	3.36×10^{-2}	2.35×10^{-2}	1.38×10^{-1}	2.70×10^{-2}	1.02×10^{-1}	7.15×10^{-2}
	14WV	2.10×10^{-1}	1.47×10^{-1}	3.89×10^{-2}	2.73×10^{-2}	1.69×10^{-1}	3.10×10^{-2}	8.22×10^{-2}	5.75×10^{-2}
	15V	2.77×10^{-1}	1.94×10^{-1}	4.38×10^{-2}	3.07×10^{-2}	2.21×10^{-1}	3.45×10^{-2}	1.69×10^{-1}	1.18×10^{-1}
	15Z	2.77×10^{-1}	1.94×10^{-1}	4.38×10^{-2}	3.07×10^{-2}	2.21×10^{-1}	3.45×10^{-2}	1.69×10^{-1}	1.18×10^{-1}
	15N	1.70×10^{-1}	1.19×10^{-1}	3.24×10^{-2}	2.27×10^{-2}	1.37×10^{-1}	2.59×10^{-2}	1.69×10^{-1}	1.18×10^{-1}
	15WV	1.95×10^{-1}	1.36×10^{-1}	3.52×10^{-2}	2.46×10^{-2}	1.56×10^{-1}	2.80×10^{-2}	5.83×10^{-2}	4.08×10^{-2}
	15WZ	1.95×10^{-1}	1.36×10^{-1}	3.52×10^{-2}	2.46×10^{-2}	1.56×10^{-1}	2.80×10^{-2}	5.83×10^{-2}	4.08×10^{-2}
	15WN	1.34×10^{-1}	9.41×10^{-2}	2.68×10^{-2}	1.88×10^{-2}	1.09×10^{-1}	2.16×10^{-2}	5.82×10^{-2}	4.08×10^{-2}
	20V	1.68×10^{-1}	1.18×10^{-1}	2.92×10^{-2}	2.04×10^{-2}	1.35×10^{-1}	2.32×10^{-2}	1.30×10^{-1}	9.13×10^{-2}
	20N	1.20×10^{-1}	8.39×10^{-2}	2.30×10^{-2}	1.61×10^{-2}	9.68×10^{-2}	1.84×10^{-2}	1.30×10^{-1}	9.13×10^{-2}

K_{AR1} : Equivalent factor in the M_A radial direction when one LM block is used
K_{AL1} : Equivalent factor in the M_A reverse radial direction when one LM block is used
K_{AR2} : Equivalent factor in the M_A radial direction when two LM blocks are used in close contact with each other
K_{AL2} : Equivalent factor in the M_A reverse radial direction when two LM blocks are used in close contact with each other
K_{B1} : M_B Equivalent factor when one LM block is used
K_{B2} : M_B Equivalent factor when two LM blocks are used in close contact with each other
K_{CR} : Equivalent factor in the M_C radial direction
K_{CL} : Equivalent factor in the M_C reverse radial direction

Table7 Equivalent Factors (Models RSH, HR and GSR)

Model No.		Equivalent factor							
		K_{AR1}	K_{AL1}	K_{AR2}	K_{AL2}	K_{B1}	K_{B2}	K_{CR}	K_{CL}
RSH	7Z	4.66×10^{-1}		6.60×10^{-2}		4.66×10^{-1}	6.60×10^{-2}	2.74×10^{-1}	
	7WZ	3.30×10^{-1}		5.12×10^{-2}		3.30×10^{-1}	5.12×10^{-2}	1.40×10^{-1}	
	9Z	3.06×10^{-1}		5.23×10^{-2}		3.06×10^{-1}	5.23×10^{-2}	2.15×10^{-1}	
	9WZ	2.44×10^{-1}		4.22×10^{-2}		2.44×10^{-1}	4.22×10^{-2}	1.09×10^{-1}	
	12Z	3.52×10^{-1}	2.46×10^{-1}	5.37×10^{-2}	3.76×10^{-2}	2.81×10^{-1}	4.21×10^{-2}	2.09×10^{-1}	1.46×10^{-1}
	12WZ	2.47×10^{-1}	1.73×10^{-1}	4.38×10^{-2}	3.07×10^{-2}	1.99×10^{-1}	3.49×10^{-2}	1.02×10^{-1}	7.15×10^{-2}
	15Z	2.77×10^{-1}	1.94×10^{-1}	4.38×10^{-2}	3.07×10^{-2}	2.21×10^{-1}	3.45×10^{-2}	1.69×10^{-1}	1.18×10^{-1}
	15WZ	1.95×10^{-1}	1.36×10^{-1}	3.52×10^{-2}	2.46×10^{-2}	1.56×10^{-1}	2.80×10^{-2}	5.83×10^{-2}	4.08×10^{-2}
HR	918	2.65×10^{-1}	2.65×10^{-1}	—	—	2.65×10^{-1}	—	—	—
	1123	2.08×10^{-1}	2.08×10^{-1}	—	—	2.08×10^{-1}	—	—	—
	1530	1.56×10^{-1}	1.56×10^{-1}	—	—	1.56×10^{-1}	—	—	—
	2042	1.11×10^{-1}	1.11×10^{-1}	—	—	1.11×10^{-1}	—	—	—
	2042T	8.64×10^{-2}	8.64×10^{-2}	—	—	8.64×10^{-2}	—	—	—
	2555	7.79×10^{-2}	7.79×10^{-2}	—	—	7.79×10^{-2}	—	—	—
	2555T	6.13×10^{-2}	6.13×10^{-2}	—	—	6.13×10^{-2}	—	—	—
	3065	6.92×10^{-2}	6.92×10^{-2}	—	—	6.92×10^{-2}	—	—	—
	3065T	5.45×10^{-2}	5.45×10^{-2}	—	—	5.45×10^{-2}	—	—	—
	3575	6.23×10^{-2}	6.23×10^{-2}	—	—	6.23×10^{-2}	—	—	—
	3575T	4.90×10^{-2}	4.90×10^{-2}	—	—	4.90×10^{-2}	—	—	—
	4085	5.19×10^{-2}	5.19×10^{-2}	—	—	5.19×10^{-2}	—	—	—
	4085T	4.09×10^{-2}	4.09×10^{-2}	—	—	4.09×10^{-2}	—	—	—
	50105	4.15×10^{-2}	4.15×10^{-2}	—	—	4.15×10^{-2}	—	—	—
	50105T	3.27×10^{-2}	3.27×10^{-2}	—	—	3.27×10^{-2}	—	—	—
	60125	2.88×10^{-2}	2.88×10^{-2}	—	—	2.88×10^{-2}	—	—	—
GSR	15T	1.61×10^{-1}	1.44×10^{-1}	2.88×10^{-2}	2.59×10^{-2}	1.68×10^{-1}	3.01×10^{-2}	—	—
	15V	2.21×10^{-1}	1.99×10^{-1}	3.54×10^{-2}	3.18×10^{-2}	2.30×10^{-1}	3.68×10^{-2}	—	—
	20T	1.28×10^{-1}	1.16×10^{-1}	2.34×10^{-2}	2.10×10^{-2}	1.34×10^{-1}	2.44×10^{-2}	—	—
	20V	1.77×10^{-1}	1.59×10^{-1}	2.87×10^{-2}	2.58×10^{-2}	1.84×10^{-1}	2.99×10^{-2}	—	—
	25T	1.07×10^{-1}	9.63×10^{-2}	1.97×10^{-2}	1.77×10^{-2}	1.12×10^{-1}	2.06×10^{-2}	—	—
	25V	1.47×10^{-1}	1.33×10^{-1}	2.42×10^{-2}	2.18×10^{-2}	1.53×10^{-1}	2.52×10^{-2}	—	—
	30T	9.17×10^{-2}	8.26×10^{-2}	1.68×10^{-2}	1.51×10^{-2}	9.59×10^{-2}	1.76×10^{-2}	—	—
	35T	8.03×10^{-2}	7.22×10^{-2}	1.48×10^{-2}	1.33×10^{-2}	8.39×10^{-2}	1.55×10^{-2}	—	—

K_{AR1} : Equivalent factor in the M_A radial direction when one LM block is used

K_{AL1} : Equivalent factor in the M_A reverse radial direction when one LM block is used

K_{AR2} : Equivalent factor in the M_A radial direction when two LM blocks are used in close contact with each other

K_{AL2} : Equivalent factor in the M_A reverse radial direction when two LM blocks are used in close contact with each other

K_{B1} : M_B Equivalent factor when one LM block is used

K_{B2} : M_B Equivalent factor when two LM blocks are used in close contact with each other

K_{CR} : Equivalent factor in the M_C radial direction

K_{CL} : Equivalent factor in the M_C reverse radial direction

Table8 Equivalent Factors (Model CSR, MX,JR, NSR and SRG)

Model No.		Equivalent factor							
		K_{AR1}	K_{AL1}	K_{AR2}	K_{AL2}	K_{B1}	K_{B2}	K_{CR}	K_{CL}
CSR	15	1.68×10^{-1}		2.95×10^{-2}		1.68×10^{-1}	2.95×10^{-2}	1.60×10^{-1}	
	20S	1.25×10^{-1}		2.28×10^{-2}		1.25×10^{-1}	2.28×10^{-2}	1.18×10^{-1}	
	20	9.83×10^{-2}		1.91×10^{-2}		9.83×10^{-2}	1.91×10^{-2}	1.18×10^{-1}	
	25S	1.12×10^{-1}		2.01×10^{-2}		1.12×10^{-1}	2.01×10^{-2}	1.00×10^{-1}	
	25	8.66×10^{-2}		1.68×10^{-2}		8.66×10^{-2}	1.68×10^{-2}	1.00×10^{-1}	
	30S	8.93×10^{-2}		1.73×10^{-2}		8.93×10^{-2}	1.73×10^{-2}	8.31×10^{-2}	
	30	7.02×10^{-2}		1.43×10^{-2}		7.02×10^{-2}	1.43×10^{-2}	8.31×10^{-2}	
	35	6.15×10^{-2}		1.28×10^{-2}		6.15×10^{-2}	1.28×10^{-2}	6.74×10^{-2}	
	45	5.20×10^{-2}		1.00×10^{-2}		5.20×10^{-2}	1.00×10^{-2}	5.22×10^{-2}	
MX	5	4.27×10^{-1}		7.01×10^{-2}		4.27×10^{-1}	7.01×10^{-2}	3.85×10^{-2}	
	7W	2.18×10^{-1}		4.13×10^{-1}		2.18×10^{-1}	4.13×10^{-1}	1.40×10^{-1}	
JR	25	1.12×10^{-1}		2.01×10^{-2}		1.12×10^{-1}	2.01×10^{-2}	1.00×10^{-1}	
	35	7.81×10^{-2}		1.55×10^{-2}		7.81×10^{-2}	1.55×10^{-2}	6.74×10^{-2}	
	45	6.71×10^{-2}		1.21×10^{-2}		6.71×10^{-2}	1.21×10^{-2}	5.22×10^{-2}	
	55	5.59×10^{-2}		1.03×10^{-2}		5.59×10^{-2}	1.03×10^{-2}	4.27×10^{-2}	
NSR	20TBC	2.29×10^{-1}		2.68×10^{-2}		2.29×10^{-1}	2.68×10^{-2}	—	—
	25TBC	2.01×10^{-1}		2.27×10^{-2}		2.01×10^{-1}	2.27×10^{-2}	—	—
	30TBC	1.85×10^{-1}		1.93×10^{-2}		1.85×10^{-1}	1.93×10^{-2}	—	—
	40TBC	1.39×10^{-1}		1.60×10^{-2}		1.39×10^{-1}	1.60×10^{-2}	—	—
	50TBC	1.24×10^{-1}		1.42×10^{-2}		1.24×10^{-1}	1.42×10^{-2}	—	—
	70TBC	9.99×10^{-2}		1.15×10^{-2}		9.99×10^{-2}	1.15×10^{-2}	—	—
SRG	15	1.23×10^{-1}		2.07×10^{-2}		1.23×10^{-1}	2.07×10^{-2}	1.04×10^{-1}	
	20	9.60×10^{-2}		1.71×10^{-2}		9.60×10^{-2}	1.71×10^{-2}	8.00×10^{-2}	
	20L	7.21×10^{-2}		1.42×10^{-2}		7.21×10^{-2}	1.42×10^{-2}	8.00×10^{-2}	
	25	8.96×10^{-2}		1.55×10^{-2}		8.96×10^{-2}	1.55×10^{-2}	7.23×10^{-2}	
	25L	6.99×10^{-2}		1.31×10^{-2}		6.99×10^{-2}	1.31×10^{-2}	7.23×10^{-2}	
	30	8.06×10^{-2}		1.33×10^{-2}		8.06×10^{-2}	1.33×10^{-2}	5.61×10^{-2}	
	30L	6.12×10^{-2}		1.11×10^{-2}		6.12×10^{-2}	1.11×10^{-2}	5.61×10^{-2}	
	35	7.14×10^{-2}		1.18×10^{-2}		7.14×10^{-2}	1.18×10^{-2}	4.98×10^{-2}	
	35L	5.26×10^{-2}		9.67×10^{-3}		5.26×10^{-2}	9.67×10^{-3}	4.98×10^{-2}	
	45	5.49×10^{-2}		9.58×10^{-3}		5.49×10^{-2}	9.58×10^{-3}	3.85×10^{-2}	
	45L	4.18×10^{-2}		7.93×10^{-3}		4.18×10^{-2}	7.93×10^{-3}	3.85×10^{-2}	
	55	4.56×10^{-2}		8.04×10^{-3}		4.56×10^{-2}	8.04×10^{-3}	3.25×10^{-2}	
	55L	3.37×10^{-2}		6.42×10^{-3}		3.37×10^{-2}	6.42×10^{-3}	3.25×10^{-2}	
	65L	2.63×10^{-2}		4.97×10^{-3}		2.63×10^{-2}	4.97×10^{-3}	2.70×10^{-2}	

K_{AR1} : Equivalent factor in the M_A radial direction when one LM block is used
K_{AL1} : Equivalent factor in the M_A reverse radial direction when one LM block is used
K_{AR2} : Equivalent factor in the M_A radial direction when two LM blocks are used in close contact with each other
K_{AL2} : Equivalent factor in the M_A reverse radial direction when two LM blocks are used in close contact with each other
K_{B1} : M_B Equivalent factor when one LM block is used
K_{B2} : M_B Equivalent factor when two LM blocks are used in close contact with each other
K_{CR} : Equivalent factor in the M_C radial direction
K_{CL} : Equivalent factor in the M_C reverse radial direction

Table9 Equivalent Factors (Models SRN and SRW)

Model No.		Equivalent factor							
		K_{AR1}	K_{AL1}	K_{AR2}	K_{AL2}	K_{B1}	K_{B2}	K_{CR}	K_{CL}
SRN	35	7.14×10^{-2}		1.18×10^{-2}		7.14×10^{-2}	1.18×10^{-2}	4.98×10^{-2}	
	35L	5.26×10^{-2}		9.67×10^{-3}		5.26×10^{-2}	9.67×10^{-3}	4.98×10^{-2}	
	45	5.49×10^{-2}		9.58×10^{-3}		5.49×10^{-2}	9.58×10^{-3}	3.85×10^{-2}	
	45L	4.18×10^{-2}		7.93×10^{-3}		4.18×10^{-2}	7.93×10^{-3}	3.85×10^{-2}	
	55	4.56×10^{-2}		8.04×10^{-3}		4.56×10^{-2}	8.04×10^{-3}	3.25×10^{-2}	
	55L	3.37×10^{-2}		6.42×10^{-3}		3.37×10^{-2}	6.42×10^{-3}	3.25×10^{-2}	
	65L	2.63×10^{-2}		4.97×10^{-3}		2.63×10^{-2}	4.97×10^{-3}	2.70×10^{-2}	
SRW	70	4.18×10^{-2}		7.93×10^{-3}		4.18×10^{-2}	7.93×10^{-3}	2.52×10^{-2}	
	85	3.37×10^{-2}		6.42×10^{-3}		3.37×10^{-2}	6.42×10^{-3}	2.09×10^{-2}	
	100	2.63×10^{-2}		4.97×10^{-3}		2.63×10^{-2}	4.97×10^{-3}	1.77×10^{-2}	

K_{AR1} : Equivalent factor in the M_A radial direction when one LM block is used

K_{AL1} : Equivalent factor in the M_A reverse radial direction when one LM block is used

K_{AR2} : Equivalent factor in the M_A radial direction when two LM blocks are used in close contact with each other

K_{AL2} : Equivalent factor in the M_A reverse radial direction when two LM blocks are used in close contact with each other

K_{B1} : M_B Equivalent factor when one LM block is used

K_{B2} : M_B Equivalent factor when two LM blocks are used in close contact with each other

K_{CR} : Equivalent factor in the M_C radial direction

K_{CL} : Equivalent factor in the M_C reverse radial direction

[Example of calculation]

When one LM block is used

Model No.: SSR20XV1

Gravitational acceleration $g=9.8\ (m/s^2)$
Mass $m=10$ (kg)
$\ell_1=200$ (mm)
$\ell_2=100$ (mm)

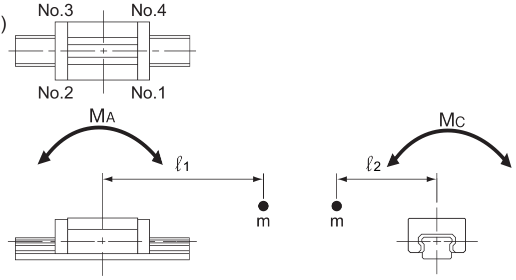


Fig.6 When One LM Block is Used

No.1 $P_1=mg+K_{AR1}\cdot mg\cdot\ell_1+K_{CR}\cdot mg\cdot\ell_2=98+0.275\times98\times200+0.129\times98\times100=6752$ (N)
No.2 $P_2=mg-K_{AL1}\cdot mg\cdot\ell_1+K_{CR}\cdot mg\cdot\ell_2=98-0.137\times98\times200+0.129\times98\times100=-1323$ (N)
No.3 $P_3=mg-K_{AL1}\cdot mg\cdot\ell_1-K_{CL}\cdot mg\cdot\ell_2=98-0.137\times98\times200-0.0644\times98\times100=-3218$ (N)
No.4 $P_4=mg+K_{AR1}\cdot mg\cdot\ell_1-K_{CL}\cdot mg\cdot\ell_2=98+0.275\times98\times200-0.0644\times98\times100=4857$ (N)

When two LM blocks are used in close contact with each other

Model No.: SNS30R2

Gravitational acceleration $g=9.8\ (m/s^2)$
Mass $m=5$ (kg)
$\ell_1=200$ (mm)
$\ell_2=150$ (mm)

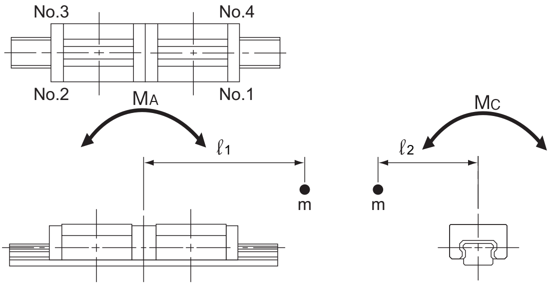


Fig.7 When Two LM Blocks are Used in Close Contact with Each Other

No.1 $P_1=\frac{mg}{2}+K_{AR2}\cdot mg\cdot\ell_1+K_{CR}\cdot\frac{mg\cdot\ell_2}{2}=\frac{49}{2}+0.018\times49\times200+0.0842\times\frac{49\times150}{2}=510.3$ (N)

No.2 $P_2=\frac{mg}{2}-K_{AL2}\cdot mg\cdot\ell_1+K_{CR}\cdot\frac{mg\cdot\ell_2}{2}=\frac{49}{2}-0.0151\times49\times200+0.0842\times\frac{49\times150}{2}=186$ (N)

No.3 $P_3=\frac{mg}{2}-K_{AL2}\cdot mg\cdot\ell_1-K_{CL}\cdot\frac{mg\cdot\ell_2}{2}=\frac{49}{2}-0.0151\times49\times200-0.0707\times\frac{49\times150}{2}=-383.3$ (N)

No.4 $P_4=\frac{mg}{2}+K_{AR2}\cdot mg\cdot\ell_1-K_{CL}\cdot\frac{mg\cdot\ell_2}{2}=\frac{49}{2}+0.018\times49\times200-0.0707\times\frac{49\times150}{2}=-58.9$ (N)

Note1) Since an LM Guide used in vertical installation receives only a moment load, there is no need to apply a load force (mg).
Note2) In some models, load ratings differ depending on the direction of the applied load. With such a model, calculate an equivalent load in the direction of the smallest load rating.

[Double-axis Use]

● Setting Conditions

Set the conditions needed to calculate the LM system's applied load and service life in hours.
The conditions consist of the following items.

(1) Mass: m (kg)
(2) Direction of the working load
(3) Position of the working point (e.g., center of gravity): ℓ_2, ℓ_3, h_1(mm)
(4) Thrust position: ℓ_4, h_2(mm)
(5) LM system arrangement: ℓ_0, ℓ_1(mm)
(No. of units and axes)
(6) Velocity diagram
Speed: V (mm/s)
Time constant: t_n (s)
Acceleration: α_n(mm/s^2)

$$(\alpha_n = \frac{V}{t_n})$$

(7) Duty cycle
Number of reciprocations per minute: N_1(min^{-1})
(8) Stroke length: ℓ_s(mm)
(9) Average speed: V_m(m/s)
(10) Required service life in hours: L_h(h)

Gravitational acceleration g=9.8 (m/s^2)

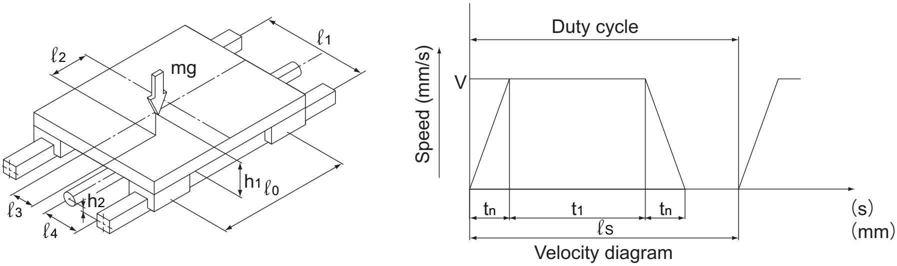


Fig.8 Condition

● Applied Load Equation

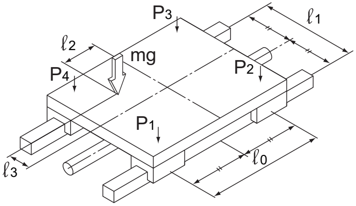
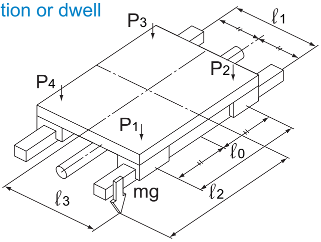
The load applied to the LM Guide varies with the external force, such as the position of the gravity center of an object, thrust position, inertia generated from acceleration/deceleration during start or stop, and cutting force.
In selecting an LM Guide, it is necessary to obtain the value of the applied load while taking into account these conditions.

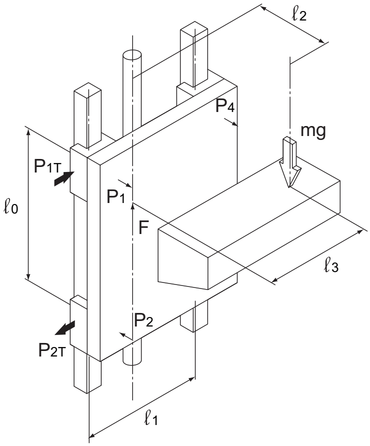
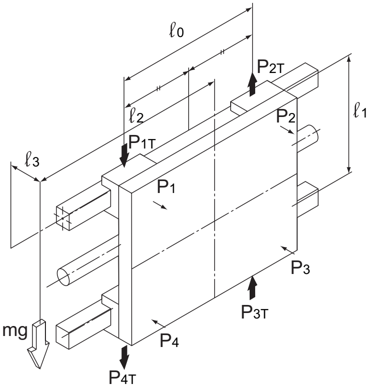
Calculate the load applied to the LM Guide in each of the examples 1 to 10 shown below.

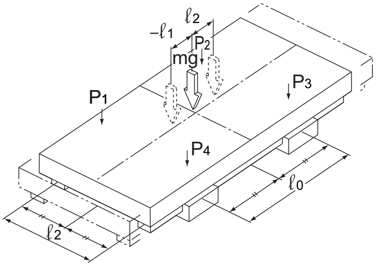
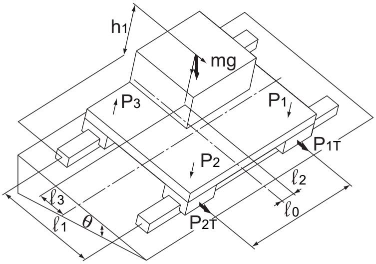
m	: Mass	(kg)
ℓ_n	: Distance	(mm)
F_n	: External force	(N)
P_n	: Applied load (radial/reverse radial direction)	(N)
P_{nT}	: Applied load (lateral directions)	(N)
g	: Gravitational acceleration ($g = 9.8 m/s^2$)	(m/s^2)
V	: Speed	(m/s)
t_n	: Time constant	(s)
α_n	: Acceleration	(m/s^2)

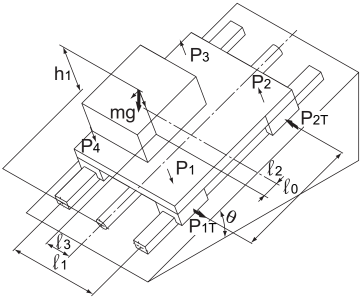
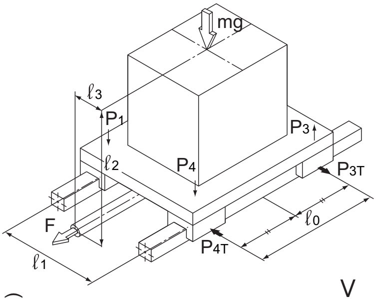
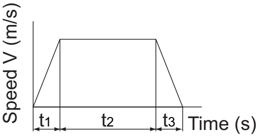
$$\left(\alpha_n = \frac{V}{t_n}\right)$$

[Example]

	Condition	Applied Load Equation
1	Horizontal mount (with the block traveling) Uniform motion or dwell 	$P_1 = \frac{mg}{4} + \frac{mg \cdot \ell_2}{2 \cdot \ell_0} - \frac{mg \cdot \ell_3}{2 \cdot \ell_1}$ $P_2 = \frac{mg}{4} - \frac{mg \cdot \ell_2}{2 \cdot \ell_0} - \frac{mg \cdot \ell_3}{2 \cdot \ell}$ $P_3 = \frac{mg}{4} - \frac{mg \cdot \ell_2}{2 \cdot \ell_0} + \frac{mg \cdot \ell_3}{2 \cdot \ell_1}$ $P_4 = \frac{mg}{4} + \frac{mg \cdot \ell_2}{2 \cdot \ell_0} + \frac{mg \cdot \ell_3}{2 \cdot \ell_1}$
2	Horizontal mount, overhung (with the block traveling) Uniform motion or dwell 	$P_1 = \frac{mg}{4} + \frac{mg \cdot \ell_2}{2 \cdot \ell_0} + \frac{mg \cdot \ell_3}{2 \cdot \ell_1}$ $P_2 = \frac{mg}{4} - \frac{mg \cdot \ell_2}{2 \cdot \ell_0} + \frac{mg \cdot \ell_3}{2 \cdot \ell_1}$ $P_3 = \frac{mg}{4} - \frac{mg \cdot \ell_2}{2 \cdot \ell_0} - \frac{mg \cdot \ell_3}{2 \cdot \ell_1}$ $P_4 = \frac{mg}{4} + \frac{mg \cdot \ell_2}{2 \cdot \ell_0} - \frac{mg \cdot \ell_3}{2 \cdot \ell_1}$

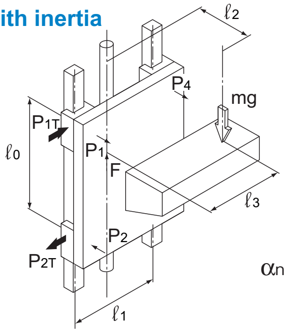
	Condition	Applied Load Equation
3	**Uniform motion or dwell**  E.g.: Vertical axis of industrial robot, automatic coating machine, lifter	$P_1 \text{ to } P_4 = \frac{mg \cdot \ell_2}{2 \cdot \ell_0}$ $P_{1T} \text{ to } P_{4T} = \frac{mg \cdot \ell_3}{2 \cdot \ell_0}$
4	**Wall mount** **Uniform motion or dwell**  E.g.: Travel axis of cross-rail loader	$P_1 \text{ to } P_4 = \frac{mg \cdot \ell_3}{2 \cdot \ell_1}$ $P_{1T} = P_{4T} = \frac{mg}{4} + \frac{mg \cdot \ell_2}{2 \cdot \ell_0}$ $P_{2T} = P_{3T} = \frac{mg}{4} - \frac{mg \cdot \ell_2}{2 \cdot \ell_0}$

	Condition	Applied Load Equation
5	**With the LM rails movable Horizontal mount**  E.g.: XY table sliding fork	$P_1 \text{ to } P_4 \text{ (max)} = \frac{mg}{4} + \frac{mg \cdot \ell_1}{2 \cdot \ell_0}$ $P_1 \text{ to } P_4 \text{ (min)} = \frac{mg}{4} - \frac{mg \cdot \ell_1}{2 \cdot \ell_0}$
6	**Laterally tilt mount**  E.g.: NC lathe Carriage	$P_1 = + \frac{mg \cdot \cos\theta}{4} + \frac{mg \cdot \cos\theta \cdot \ell_2}{2 \cdot \ell_0} - \frac{mg \cdot \cos\theta \cdot \ell_3}{2 \cdot \ell_1} + \frac{mg \cdot \sin\theta \cdot h_1}{2 \cdot \ell_1}$ $P_{1T} = \frac{mg \cdot \sin\theta}{4} + \frac{mg \cdot \sin\theta \cdot \ell_2}{2 \cdot \ell_0}$ $P_2 = + \frac{mg \cdot \cos\theta}{4} - \frac{mg \cdot \cos\theta \cdot \ell_2}{2 \cdot \ell_0} - \frac{mg \cdot \cos\theta \cdot \ell_3}{2 \cdot \ell_1} + \frac{mg \cdot \sin\theta \cdot h_1}{2 \cdot \ell_1}$ $P_{2T} = \frac{mg \cdot \sin\theta}{4} - \frac{mg \cdot \sin\theta \cdot \ell_2}{2 \cdot \ell_0}$ $P_3 = + \frac{mg \cdot \cos\theta}{4} - \frac{mg \cdot \cos\theta \cdot \ell_2}{2 \cdot \ell_0} + \frac{mg \cdot \cos\theta \cdot \ell_3}{2 \cdot \ell_1} - \frac{mg \cdot \sin\theta \cdot h_1}{2 \cdot \ell_1}$ $P_{3T} = \frac{mg \cdot \sin\theta}{4} - \frac{mg \cdot \sin\theta \cdot \ell_2}{2 \cdot \ell_0}$ $P_4 = + \frac{mg \cdot \cos\theta}{4} + \frac{mg \cdot \cos\theta \cdot \ell_2}{2 \cdot \ell_0} + \frac{mg \cdot \cos\theta \cdot \ell_3}{2 \cdot \ell_1} - \frac{mg \cdot \sin\theta \cdot h_1}{2 \cdot \ell_1}$ $P_{4T} = \frac{mg \cdot \sin\theta}{4} + \frac{mg \cdot \sin\theta \cdot \ell_2}{2 \cdot \ell_0}$

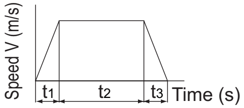
	Condition	Applied Load Equation
7	**Longitudinally tilt mount**  E.g.: NC lathe Tool rest	$P_1 = +\frac{mg\cdot\cos\theta}{4} + \frac{mg\cdot\cos\theta\cdot\ell_2}{2\cdot\ell_0} - \frac{mg\cdot\cos\theta\cdot\ell_3}{2\cdot\ell_1} + \frac{mg\cdot\sin\theta\cdot h_1}{2\cdot\ell_0}$ $P_{1T} = +\frac{mg\cdot\sin\theta\cdot\ell_3}{2\cdot\ell_0}$ $P_2 = +\frac{mg\cdot\cos\theta}{4} - \frac{mg\cdot\cos\theta\cdot\ell_2}{2\cdot\ell_0} - \frac{mg\cdot\cos\theta\cdot\ell_3}{2\cdot\ell_1} - \frac{mg\cdot\sin\theta\cdot h_1}{2\cdot\ell_0}$ $P_{2T} = -\frac{mg\cdot\sin\theta\cdot\ell_3}{2\cdot\ell_0}$ $P_3 = +\frac{mg\cdot\cos\theta}{4} - \frac{mg\cdot\cos\theta\cdot\ell_2}{2\cdot\ell_0} + \frac{mg\cdot\cos\theta\cdot\ell_3}{2\cdot\ell_1} - \frac{mg\cdot\sin\theta\cdot h_1}{2\cdot\ell_0}$ $P_{3T} = -\frac{mg\cdot\sin\theta\cdot\ell_3}{2\cdot\ell_0}$ $P_4 = +\frac{mg\cdot\cos\theta}{4} + \frac{mg\cdot\cos\theta\cdot\ell_2}{2\cdot\ell_0} + \frac{mg\cdot\cos\theta\cdot\ell_3}{2\cdot\ell_1} + \frac{mg\cdot\sin\theta\cdot h_1}{2\cdot\ell_0}$ $P_{4T} = +\frac{mg\cdot\sin\theta\cdot\ell_3}{2\cdot\ell_0}$
8	**Horizontal mount with inertia**  $\alpha_n = \frac{V}{t_n}$  Velocity diagram E.g.: Conveyance truck	During acceleration $P_1 = P_4 = \frac{mg}{4} - \frac{m\cdot\alpha_1\cdot\ell_2}{2\cdot\ell_0}$ $P_2 = P_3 = \frac{mg}{4} + \frac{m\cdot\alpha_1\cdot\ell_2}{2\cdot\ell_0}$ P_{1T} to $P_{4T} = \frac{m\cdot\alpha_1\cdot\ell_3}{2\cdot\ell_0}$ During uniform motion P_1 to $P_4 = \frac{mg}{4}$ During deceleration $P_1 = P_4 = \frac{mg}{4} + \frac{m\cdot\alpha_3\cdot\ell_2}{2\cdot\ell_0}$ $P_2 = P_3 = \frac{mg}{4} - \frac{m\cdot\alpha_3\cdot\ell_2}{2\cdot\ell_0}$ P_{1T} to $P_{4T} = \frac{m\cdot\alpha_3\cdot\ell_3}{2\cdot\ell_0}$

<table>
<tr><th></th><th>Condition</th><th>Applied Load Equation</th></tr>
<tr><td>9</td><td>

Vertical mount with inertia



$$\alpha_n = \frac{V}{t_n}$$



Velocity diagram

E.g.: Conveyance lift

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During acceleration

$$P_1 \text{ to } P_4 = \frac{m\cdot(g+\alpha_1)\cdot\ell_2}{2\cdot\ell_0}$$

$$P_{1T} \text{ to } P_{4T} = \frac{m\cdot(g+\alpha_1)\cdot\ell_3}{2\cdot\ell_0}$$

During uniform motion

$$P_1 \text{ to } P_4 = \frac{mg\cdot\ell_2}{2\cdot\ell_0}$$

$$P_{1T} \text{ to } P_{4T} = \frac{mg\cdot\ell_3}{2\cdot\ell_0}$$

During deceleration

$$P_1 \text{ to } P_4 = \frac{m\cdot(g-\alpha_3)\cdot\ell_2}{2\cdot\ell_0}$$

$$P_{1T} \text{ to } P_{4T} = \frac{m\cdot(g-\alpha_3)\cdot\ell_3}{2\cdot\ell_0}$$

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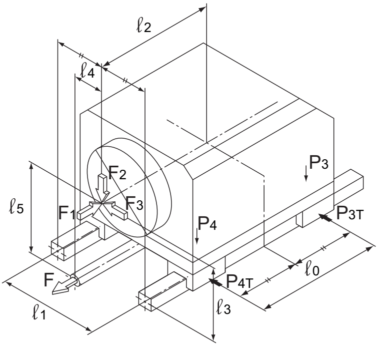
<tr><td>10</td><td>

Horizontal mount with external force



E.g.: Drill unit,
Milling machine,
Lathe,
Machining center
and other cutting machine

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Under force F_1

$$P_1 \text{ to } P_4 = \frac{F_1\cdot\ell_5}{2\cdot\ell_0}$$

$$P_{1T} \text{ to } P_{4T} = \frac{F_1\cdot\ell_4}{2\cdot\ell_0}$$

Under force F_2

$$P_1 = P_4 = \frac{F_2}{4} + \frac{F_2\cdot\ell_2}{2\cdot\ell_0}$$

$$P_2 = P_3 = \frac{F_2}{4} - \frac{F_2\cdot\ell_2}{2\cdot\ell_0}$$

Under force F_3

$$P_1 \text{ to } P_4 = \frac{F_3\cdot\ell_3}{2\cdot\ell_1}$$

$$P_{1T} = P_{4T} = \frac{F_3}{4} + \frac{F_3\cdot\ell_2}{2\cdot\ell_0}$$

$$P_{2T} = P_{3T} = \frac{F_3}{4} - \frac{F_3\cdot\ell_2}{2\cdot\ell_0}$$

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</table>

Calculating the Equivalent Load

The LM Guide can bear loads and moments in all directions, including a radial load (P_R), reverse radial load (P_L) and lateral loads (P_T), simultaneously.
Applied loads include the following.

P_R: Radial load
P_L: Reverse-radial load
P_T: Lateral load

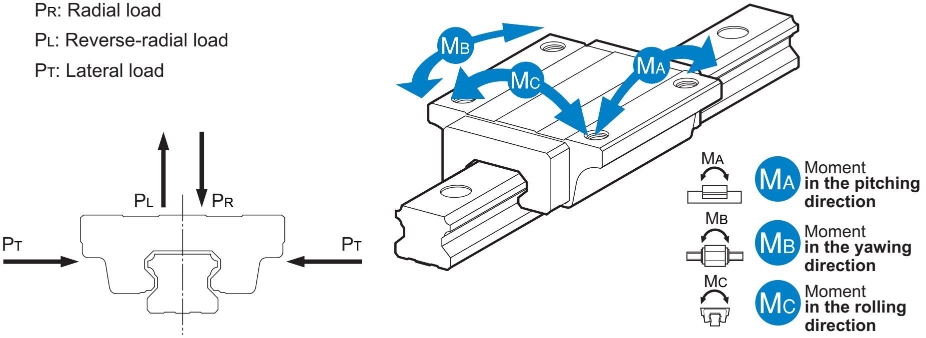


Fig.9 Directions of the Loads Applied on the LM Guide

[Equivalent Load P_E]

When two or more loads (e.g., radial load and lateral load) are simultaneously applied to the LM Guide, the service life and the static safety factor are calculated using equivalent load values obtained by converting all the loads into radial, lateral and other loads.

[Equivalent Load Equation]

The equivalent load equation for the LM Guide differs by model. For details, see the section corresponding to the subject model.

Example of equation for LM Guide model HSR

The equivalent load when a radial load (P_R) and a lateral load (P_T) are applied simultaneously is obtained using the following equation.

P_E(equivalent load)$=P_R+P_T$

P_R: Radial load
P_T: Lateral load

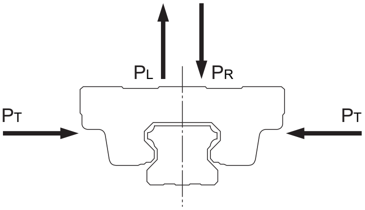


Fig.10 Equivalent of Load of the LM Guide

Calculating the Static Safety Factor

To calculate a load applied to the LM Guide, the average load required for calculating the service life and the maximum load needed for calculating the static safety factor must be obtained first. In a system subject to frequent starts and stops, placed under cutting forces or under a large moment caused by an overhang load, an excessively large load may apply to the LM Guide. When selecting a model number, make sure that the desired model is capable of receiving the required maximum load (whether stationary or in motion). Table10 shows standard values for the static safety factor.

Table10 Reference Value of Static Safety Factors (f_S)

Machine using the LM Guide	Load conditions	Lower limit of f_S
General industrial machinery	Without vibration or impact	1 to 1.3
	With vibration or impact	2 to 3
Machine tool	Without vibration or impact	1 to 1.5
	With vibration or impact	2.5 to 7

When the radial load is large	$\frac{f_H \cdot f_T \cdot f_C \cdot C_0}{P_R} \geqq f_S$
When the reverse radial load is large	$\frac{f_H \cdot f_T \cdot f_C \cdot C_{0L}}{P_L} \geqq f_S$
When the lateral loads are large	$\frac{f_H \cdot f_T \cdot f_C \cdot C_{0T}}{P_T} \geqq f_S$

f_S : Static safety factor

C_0 : Basic static load rating (radial direction) (N)

C_{0L} : Basic static load rating (reverse-radial direction) (N)

C_{0T} : Basic static load rating (lateral direction) (N)

P_R : Calculated load (radial direction) (N)

P_L : Calculated load (reverse-radial direction) (N)

P_T : Calculated load (lateral direction) (N)

f_H : Hardness factor (see Fig.11 on A-101)

f_T : Temperature factor (see Fig.12 on A-101)

f_C : Contact factor (see Table11 on A-101)

Calculating the Average Load

In cases where the load applied to each LM block fluctuates under different conditions, such as an industrial robot holding a work with its arm as it advances and receding with its arm empty, and a machine tool handling various workpieces, it is necessary to calculate the service life of the LM Block while taking into account such fluctuating loading conditions.

The average load (P_m) is the load under which the service life of the LM Guide is equivalent to that under varying loads applied to the LM blocks.

$$P_m = \sqrt[3]{\frac{1}{L} \cdot \sum_{n=1}^{n} (P_n{}^3 \cdot L_n)}$$

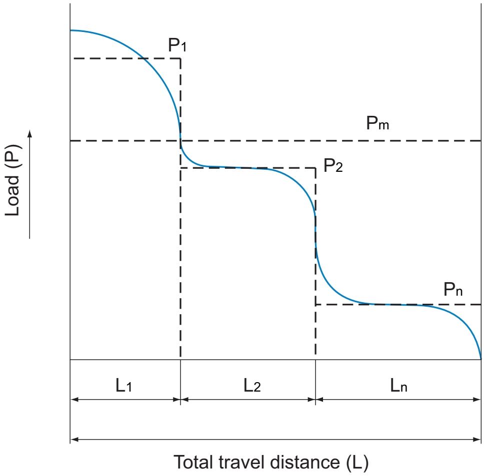
P_m : Average load (N)
P_n : Varying load (N)
L : Total travel distance (mm)
L_n : Distance traveled under load P_n (mm)

Note) The above equation or the equation (1) below applies when the rolling elements are balls.

(1) When the load fluctuates stepwise

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

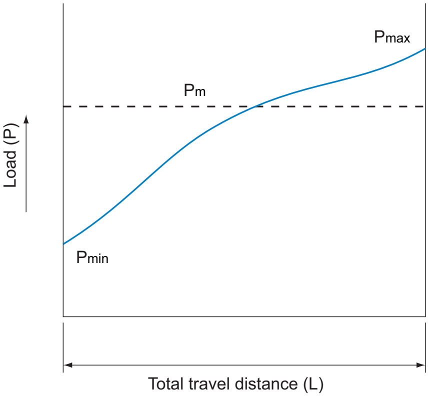
P_m : Average load (N)
P_n : Varying load (N)
L : Total travel distance (mm)
L_n : Distance traveled under P_n (mm)



(2) When the load fluctuates monotonically

$$P_m \fallingdotseq \frac{1}{3}\left(P_{min} + 2 \cdot P_{max}\right) \quad \cdots\cdots\cdots\cdots (2)$$

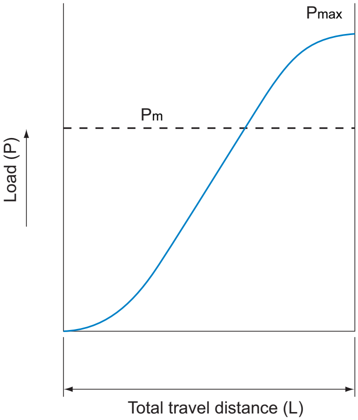
P_{min} : Minimum load (N)
P_{max} : Maximum load (N)

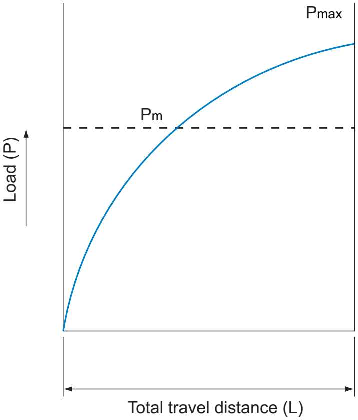


(3) When the load fluctuates sinusoidally

(a) $P_m \fallingdotseq 0.65 P_{max}$ ············(3)

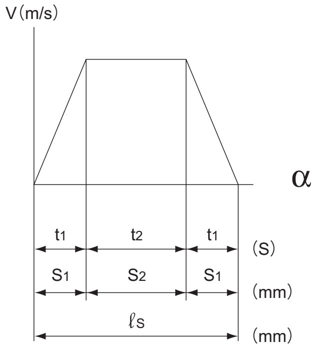
(b) $P_m \fallingdotseq 0.75 P_{max}$ ············(4)



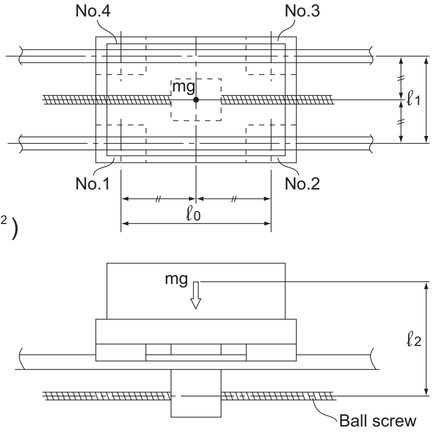


Example of Calculating the Average Load (1) - with Horizontal Mount and Acceleration/Deceleration Considered

[Conditions]



$$\alpha_1 = \frac{V}{t_1}\ (\mathrm{m/s^2})$$



[Load Applied to the LM Block]

●During uniform motion

$$P_1 = +\frac{mg}{4}$$

$$P_2 = +\frac{mg}{4}$$

$$P_3 = +\frac{mg}{4}$$

$$P_4 = +\frac{mg}{4}$$

●During acceleration

$$Pa_1 = P_1 + \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$$

$$Pa_2 = P_2 - \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$$

$$Pa_3 = P_3 - \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$$

$$Pa_4 = P_4 + \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$$

●During deceleration

$$Pd_1 = P_1 - \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$$

$$Pd_2 = P_2 + \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$$

$$Pd_3 = P_3 + \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$$

$$Pd_4 = P_4 - \frac{m \cdot \alpha_1 \cdot \ell_2}{2 \cdot \ell_0}$$

[Average load]

$$P_{m1} = \sqrt[3]{\frac{1}{\ell s}\left(Pa_1{}^3 \cdot s_1 + P_1{}^3 \cdot s_2 + Pd_1{}^3 \cdot s_3\right)}$$

$$P_{m2} = \sqrt[3]{\frac{1}{\ell s}\left(Pa_2{}^3 \cdot s_1 + P_2{}^3 \cdot s_2 + Pd_2{}^3 \cdot s_3\right)}$$

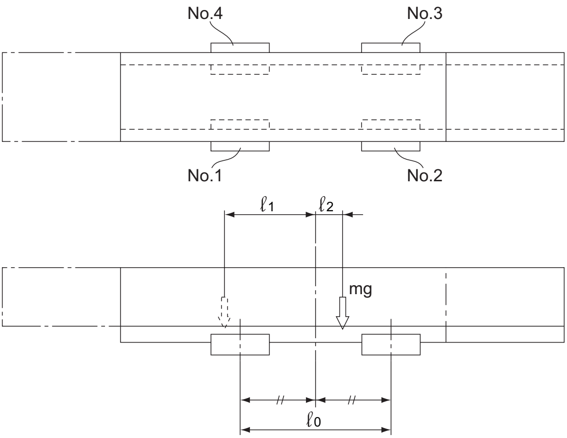
$$P_{m3} = \sqrt[3]{\frac{1}{\ell s}\left(Pa_3{}^3 \cdot s_1 + P_3{}^3 \cdot s_2 + Pd_3{}^3 \cdot s_3\right)}$$

$$P_{m4} = \sqrt[3]{\frac{1}{\ell s}\left(Pa_4{}^3 \cdot s_1 + P_4{}^3 \cdot s_2 + Pd_4{}^3 \cdot s_3\right)}$$

Note) Pa_n and Pd_n represent loads applied to each LM block. The suffix "n" indicates the block number in the diagram above.

Example of Calculating the Average Load (2) - When the Rails are Movable

[Conditions]



[Load Applied to the LM Block]

●At the left of the arm

$$P_{\ell 1} = +\frac{mg}{4} + \frac{mg \cdot \ell_1}{2 \cdot \ell_0}$$

$$P_{\ell 2} = +\frac{mg}{4} - \frac{mg \cdot \ell_1}{2 \cdot \ell_0}$$

$$P_{\ell 3} = +\frac{mg}{4} - \frac{mg \cdot \ell_1}{2 \cdot \ell_0}$$

$$P_{\ell 4} = +\frac{mg}{4} + \frac{mg \cdot \ell_1}{2 \cdot \ell_0}$$

●At the right of the arm

$$P_{r1} = +\frac{mg}{4} - \frac{mg \cdot \ell_2}{2 \cdot \ell_0}$$

$$P_{r2} = +\frac{mg}{4} + \frac{mg \cdot \ell_2}{2 \cdot \ell_0}$$

$$P_{r3} = +\frac{mg}{4} + \frac{mg \cdot \ell_2}{2 \cdot \ell_0}$$

$$P_{r4} = +\frac{mg}{4} - \frac{mg \cdot \ell_2}{2 \cdot \ell_0}$$

[Average load]

$$P_{m1} = \frac{1}{3}(2 \cdot |P_{\ell 1}| + |P_{r1}|)$$

$$P_{m2} = \frac{1}{3}(2 \cdot |P_{\ell 2}| + |P_{r2}|)$$

$$P_{m3} = \frac{1}{3}(2 \cdot |P_{\ell 3}| + |P_{r3}|)$$

$$P_{m4} = \frac{1}{3}(2 \cdot |P_{\ell 4}| + |P_{r4}|)$$

Note) $P_{\ell n}$ and P_{rn} represent loads applied to each LM block. The suffix "n" indicates the block number in the diagram above.

Calculating the Nominal Life

The service life of an LM Guide is subject to variations even under the same operational conditions. Therefore, it is necessary to use the nominal life defined below as a reference value for obtaining the service life of the LM Guide. The nominal life means the total travel distance that 90% of a group of units of the same LM Guide model can achieve without flaking (scale-like pieces on the metal surface) after individually running under the same conditions.

Nominal Life Equation for an LM Guide Using Balls

$$L = \left(\frac{f_H \cdot f_T \cdot f_C}{f_W} \cdot \frac{C}{P_C} \right)^3 \times 50$$

L : Nominal life (km)
C : Basic dynamic load rating (N)
P_C : Calculated load (N)
f_H : Hardness factor (see Fig.11 on A-101)
f_T : Temperature factor (see Fig.12 on A-101)
f_C : Contact factor (see Table11 on A-101)
f_W : Load factor (see Table12 on A-102)

Rated Life Equation for an LM Guide Using Rollers

$$L = \left(\frac{f_H \cdot f_T \cdot f_C}{f_W} \cdot \frac{C}{P_C} \right)^{\frac{10}{3}} \times 100$$

L : Nominal life (km)
C : Basic dynamic load rating (N)
P_C : Calculated load (N)
f_H : Hardness factor (see Fig.11 on A-101)
f_T : Temperature factor (see Fig.12 on A-101)
f_C : Contact factor (see Table11 on A-101)
f_W : Load factor (see Table12 on A-102)

Once the nominal life (L) has been obtained, the service life time can be obtained using the following equation if the stroke length and the number reciprocations are constant.

$$L_h = \frac{L \times 10^6}{2 \times \ell_s \times n_1 \times 60}$$

L_h : Service life time (h)
ℓ_s : Stroke length (mm)
n_1 : Number of reciprocations per minute (min^{-1})

[f_H: Hardness Factor]

To ensure the achievement of the optimum load capacity of the LM Guide, the raceway hardness must be between 58 and 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).
Since the LM Guide has sufficient hardness, the f_H value for the LM Guide is normally 1.0 unless otherwise specified.

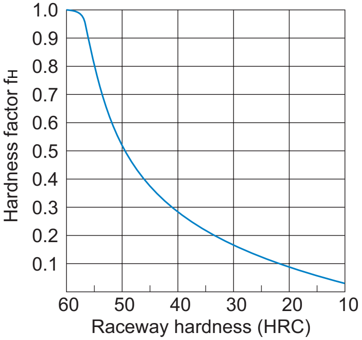


Fig.11 Hardness Factor (f_H)

[f_T:Temperature Factor]

If the temperature of the environment surrounding the operating LM Guide 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.12.
In addition, the selected LM Guide must also be of a high temperature type.

Note) The LM Guide is designed to normally be used at environment temperature of 80℃ or less.

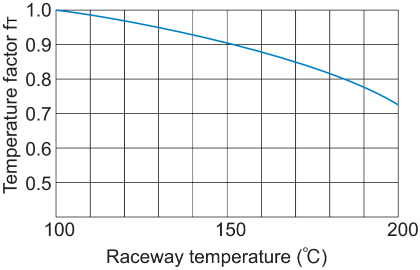


Fig.12 Temperature Factor (f_T)

[f_C: Contact Factor]

When multiple LM blocks are used in close contact with each other, it is difficult to achieve uniform load distribution due to moment loads and mounting-surface accuracy. When using multiple blocks in close contact with each other, multiply the basic load rating (C or C_0) by the corresponding contact factor indicated in Table11.

Note) If uneven load distribution is expected in a large machine, take into account the respective contact factor indicated in Table11.

Table11 Contact Factor (f_C)

Number of blocks used in close contact	Contact factor f_C
2	0.81
3	0.72
4	0.66
5	0.61
6 or greater	0.6
Normal use	1

[f_W: Load Factor]

In general, reciprocating machines tend to involve vibrations or impact during operation. It is extremely difficult to accurately determine vibrations generated during high-speed operation and impact during frequent start and stop. 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 Table12, which contains empirically obtained data.

Table12 Load Factor (f_W)

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

Example of Calculating the Nominal Life (1) - with Horizontal Mount and High-speed Acceleration

[Conditions]

Model No. : HSR35LA2SS+2500LP-Ⅱ
(basic dynamic load rating: C =50.2 kN)
(basic static load rating: C_0=81.4 kN)
Mass : m_1 =800 kg
m_2 =500 kg
Speed : V =0.5 m/s
Time : t_1 =0.05 s
t_2 =2.8 s
t_3 =0.15 s
Acceleration : α_1 =10 m/s²
α_3 =3.333 m/s²
Stroke : ℓ_s =1450 mm

Distance : ℓ_0=600 mm
ℓ_1=400 mm
ℓ_2=120 mm
ℓ_3=50 mm
ℓ_4=200 mm
ℓ_5=350 mm

Gravitational acceleration g=9.8 (m/s²)

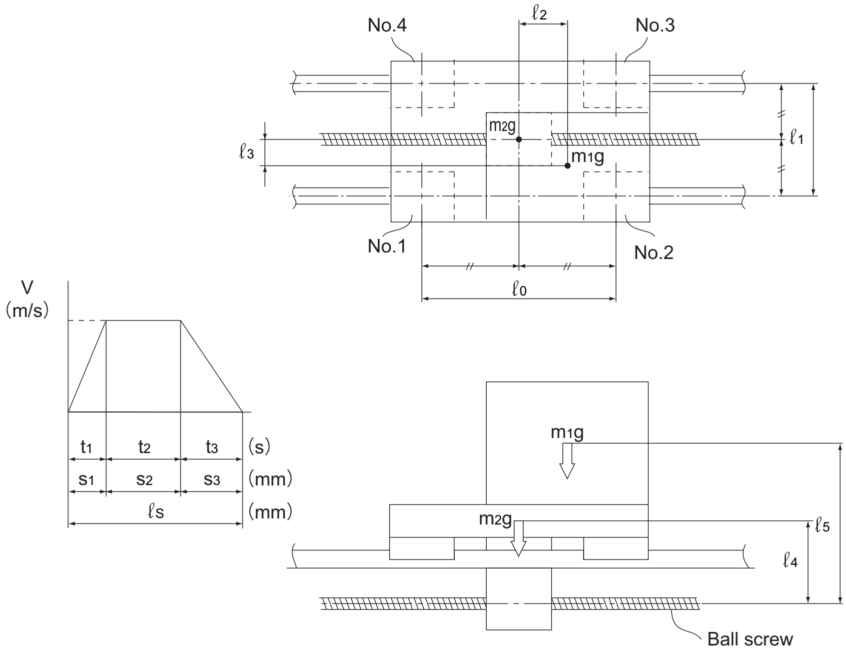


Fig.13 Condition

[Load Applied to the LM Block]

Calculate the load applied to each LM block.

● During uniform motion

■Applied load in the radial direction P_n

$$P_1 = +\frac{m_1g}{4} - \frac{m_1g\cdot \ell_2}{2\cdot \ell_0} + \frac{m_1g\cdot \ell_3}{2\cdot \ell_1} + \frac{m_2g}{4} = +2891\text{N}$$

$$P_2 = +\frac{m_1g}{4} + \frac{m_1g\cdot \ell_2}{2\cdot \ell_0} + \frac{m_1g\cdot \ell_3}{2\cdot \ell_1} + \frac{m_2g}{4} = +4459\text{N}$$

$$P_3 = +\frac{m_1g}{4} + \frac{m_1g\cdot \ell_2}{2\cdot \ell_0} - \frac{m_1g\cdot \ell_3}{2\cdot \ell_1} + \frac{m_2g}{4} = +3479\text{N}$$

$$P_4 = +\frac{m_1g}{4} - \frac{m_1g\cdot \ell_2}{2\cdot \ell_0} - \frac{m_1g\cdot \ell_3}{2\cdot \ell_1} + \frac{m_2g}{4} = +1911\text{N}$$

● During leftward acceleration

■Applied load in the radial direction $P\ell a_n$

$$P\ell a_1 = P_1 - \frac{m_1\cdot \alpha_1\cdot \ell_5}{2\cdot \ell_0} - \frac{m_2\cdot \alpha_1\cdot \ell_4}{2\cdot \ell_0} = -\ 275.6\text{ N}$$

$$P\ell a_2 = P_2 + \frac{m_1\cdot \alpha_1\cdot \ell_5}{2\cdot \ell_0} + \frac{m_2\cdot \alpha_1\cdot \ell_4}{2\cdot \ell_0} = +\ 7625.6\text{ N}$$

$$P\ell a_3 = P_3 + \frac{m_1\cdot \alpha_1\cdot \ell_5}{2\cdot \ell_0} + \frac{m_2\cdot \alpha_1\cdot \ell_4}{2\cdot \ell_0} = +\ 6645.6\text{ N}$$

$$P\ell a_4 = P_4 - \frac{m_1\cdot \alpha_1\cdot \ell_5}{2\cdot \ell_0} - \frac{m_2\cdot \alpha_1\cdot \ell_4}{2\cdot \ell_0} = -\ 1255.6\text{ N}$$

■Applied load in the lateral direction $Pt\ell a_n$

$$Pt\ell a_1 = -\frac{m_1\cdot \alpha_1\cdot \ell_3}{2\cdot \ell_0} = -\ 333.3\text{N}$$

$$Pt\ell a_2 = +\frac{m_1\cdot \alpha_1\cdot \ell_3}{2\cdot \ell_0} = +\ 333.3\text{N}$$

$$Pt\ell a_3 = +\frac{m_1\cdot \alpha_1\cdot \ell_3}{2\cdot \ell_0} = +\ 333.3\text{N}$$

$$Pt\ell a_4 = -\frac{m_1\cdot \alpha_1\cdot \ell_3}{2\cdot \ell_0} = -\ 333.3\text{N}$$

● During leftward deceleration

■Applied load in the radial direction $P\ell d_n$

$$P\ell d_1 = P_1 + \frac{m_1\cdot \alpha_3\cdot \ell_5}{2\cdot \ell_0} + \frac{m_2\cdot \alpha_3\cdot \ell_4}{2\cdot \ell_0} = +\ 3946.6\text{N}$$

$$P\ell d_2 = P_2 - \frac{m_1\cdot \alpha_3\cdot \ell_5}{2\cdot \ell_0} - \frac{m_2\cdot \alpha_3\cdot \ell_4}{2\cdot \ell_0} = +\ 3403.4\text{N}$$

$$P\ell d_3 = P_3 - \frac{m_1\cdot \alpha_3\cdot \ell_5}{2\cdot \ell_0} - \frac{m_2\cdot \alpha_3\cdot \ell_4}{2\cdot \ell_0} = +\ 2423.4\text{N}$$

$$P\ell d_4 = P_4 + \frac{m_1\cdot \alpha_3\cdot \ell_5}{2\cdot \ell_0} + \frac{m_2\cdot \alpha_3\cdot \ell_4}{2\cdot \ell_0} = +\ 2966.6\text{N}$$

■Applied load in the lateral direction $Pt\ell d_n$

$$Pt\ell d_1 = +\frac{m_1\cdot\alpha_3\cdot\ell_3}{2\cdot\ell_0} = +111.1\text{N}$$

$$Pt\ell d_2 = -\frac{m_1\cdot\alpha_3\cdot\ell_3}{2\cdot\ell_0} = -111.1\text{N}$$

$$Pt\ell d_3 = -\frac{m_1\cdot\alpha_3\cdot\ell_3}{2\cdot\ell_0} = -111.1\text{N}$$

$$Pt\ell d_4 = +\frac{m_1\cdot\alpha_3\cdot\ell_3}{2\cdot\ell_0} = +111.1\text{N}$$

● During rightward acceleration

■Applied load in the radial direction Pra_n

$$Pra_1 = P_1 + \frac{m_1\cdot\alpha_1\cdot\ell_5}{2\cdot\ell_0} + \frac{m_2\cdot\alpha_1\cdot\ell_4}{2\cdot\ell_0} = +6057.6\text{N}$$

$$Pra_2 = P_2 - \frac{m_1\cdot\alpha_1\cdot\ell_5}{2\cdot\ell_0} - \frac{m_2\cdot\alpha_1\cdot\ell_4}{2\cdot\ell_0} = +1292.4\text{N}$$

$$Pra_3 = P_3 - \frac{m_1\cdot\alpha_1\cdot\ell_5}{2\cdot\ell_0} - \frac{m_2\cdot\alpha_1\cdot\ell_4}{2\cdot\ell_0} = +\ 312.4\text{N}$$

$$Pra_4 = P_4 + \frac{m_1\cdot\alpha_1\cdot\ell_5}{2\cdot\ell_0} + \frac{m_2\cdot\alpha_1\cdot\ell_4}{2\cdot\ell_0} = +5077.6\text{N}$$

■Applied load in the lateral direction $Ptra_n$

$$Ptra_1 = +\frac{m_1\cdot\alpha_1\cdot\ell_3}{2\cdot\ell_0} = +333.3\text{N}$$

$$Ptra_2 = -\frac{m_1\cdot\alpha_1\cdot\ell_3}{2\cdot\ell_0} = -333.3\text{N}$$

$$Ptra_3 = -\frac{m_1\cdot\alpha_1\cdot\ell_3}{2\cdot\ell_0} = -333.3\text{N}$$

$$Ptra_4 = +\frac{m_1\cdot\alpha_1\cdot\ell_3}{2\cdot\ell_0} = +333.3\text{N}$$

● During rightward deceleration

■Applied load in the radial direction Prd_n

$$Prd_1 = P_1 - \frac{m_1\cdot\alpha_3\cdot\ell_5}{2\cdot\ell_0} - \frac{m_2\cdot\alpha_3\cdot\ell_4}{2\cdot\ell_0} = +1835.4\text{N}$$

$$Prd_2 = P_2 + \frac{m_1\cdot\alpha_3\cdot\ell_5}{2\cdot\ell_0} + \frac{m_2\cdot\alpha_3\cdot\ell_4}{2\cdot\ell_0} = +5514.6\text{N}$$

$$Prd_3 = P_3 + \frac{m_1\cdot\alpha_3\cdot\ell_5}{2\cdot\ell_0} + \frac{m_2\cdot\alpha_3\cdot\ell_4}{2\cdot\ell_0} = +4534.6\text{N}$$

$$Prd_4 = P_4 - \frac{m_1\cdot\alpha_3\cdot\ell_5}{2\cdot\ell_0} - \frac{m_2\cdot\alpha_3\cdot\ell_4}{2\cdot\ell_0} = +\ 855.4\text{N}$$

■Applied load in the lateral direction $Ptrd_n$

$$Ptrd_1 = -\frac{m_1 \cdot \alpha_3 \cdot \ell_3}{2 \cdot \ell_0} = -111.1\,\mathrm{N}$$

$$Ptrd_2 = +\frac{m_1 \cdot \alpha_3 \cdot \ell_3}{2 \cdot \ell_0} = +111.1\,\mathrm{N}$$

$$Ptrd_3 = +\frac{m_1 \cdot \alpha_3 \cdot \ell_3}{2 \cdot \ell_0} = +111.1\,\mathrm{N}$$

$$Ptrd_4 = +\frac{m_1 \cdot \alpha_3 \cdot \ell_3}{2 \cdot \ell_0} = -111.1\,\mathrm{N}$$

[Combined Radial And Thrust Load]

● During uniform motion:

$P_{E1} = P_1 = 2891$ N
$P_{E2} = P_2 = 4459$ N
$P_{E3} = P_3 = 3479$ N
$P_{E4} = P_4 = 1911$ N

● During leftward acceleration

$P_E\ell a_1 = |P\ell a_1| + |Pt\ell a_1| = 608.9$ N
$P_E\ell a_2 = |P\ell a_2| + |Pt\ell a_2| = 7958.9$ N
$P_E\ell a_3 = |P\ell a_3| + |Pt\ell a_3| = 6978.9$ N
$P_E\ell a_4 = |P\ell a_4| + |Pt\ell a_4| = 1588.9$ N

● During leftward deceleration

$P_E\ell d_1 = |P\ell d_1| + |Pt\ell d_1| = 4057.7$ N
$P_E\ell d_2 = |P\ell d_2| + |Pt\ell d_2| = 3514.5$ N
$P_E\ell d_3 = |P\ell d_3| + |Pt\ell d_3| = 2534.5$ N
$P_E\ell d_4 = |P\ell d_4| + |Pt\ell d_4| = 3077.7$ N

● During rightward acceleration

$P_Era_1 = |Pra_1| + |Ptra_1| = 6390.9$ N
$P_Era_2 = |Pra_2| + |Ptra_2| = 1625.7$ N
$P_Era_3 = |Pra_3| + |Ptra_3| = 645.7$ N
$P_Era_4 = |Pra_4| + |Ptra_4| = 5410.9$ N

● During rightward deceleration

$P_Erd_1 = |Prd_1| + |Ptrd_1| = 1946.5$ N
$P_Erd_2 = |Prd_2| + |Ptrd_2| = 5625.7$ N
$P_Erd_3 = |Prd_3| + |Ptrd_3| = 4645.7$ N
$P_Erd_4 = |Prd_4| + |Ptrd_4| = 966.5$ N

[Static Safety Factor]

As indicated above, the maximum load is applied to the LM Guide during the leftward acceleration of the second LM block. Therefore, the static safety factor (f_s) is obtained in the following equation.

$$f_S = \frac{C_0}{P_E\ell a_2} = \frac{81.4\times10^3}{7958.9} = 10.2$$

[Average Load P_{mn}]

Obtain the average load applied to each LM block.

$$P_{m1} = \sqrt[3]{\frac{1}{2\cdot \ell_S}\left(P_{E\ell a_1}{}^3\cdot S_1 + P_{E1}{}^3\cdot S_2 + P_{E\ell d_1}{}^3\cdot S_3 + P_{Era_1}{}^3\cdot S_1 + P_{E1}{}^3\cdot S_2 + P_{Erd_1}{}^3\cdot S_3\right)}$$

$$= \sqrt[3]{\frac{1}{2\times 1450}(608.9^3\times 12.5+2891^3\times 1400+4057.7^3\times 37.5+6390.9^3\times 12.5+2891^3\times 1400+1946.5^3\times 37.5)}$$

$$= 2940.1\text{N}$$

$$P_{m2} = \sqrt[3]{\frac{1}{2\cdot \ell_S}\left(P_{E\ell a_2}{}^3\cdot S_1 + P_{E2}{}^3\cdot S_2 + P_{E\ell d_2}{}^3\cdot S_3 + P_{Era_2}{}^3\cdot S_1 + P_{E2}{}^3\cdot S_2 + P_{Erd_2}{}^3\cdot S_3\right)}$$

$$= \sqrt[3]{\frac{1}{2\times 1450}(7958.9^3\times 12.5+4459^3\times 1400+3514.5^3\times 37.5+1625.7^3\times 12.5+4459^3\times 1400+5625.7^3\times 37.5)}$$

$$= 4492.2\text{N}$$

$$P_{m3} = \sqrt[3]{\frac{1}{2\cdot \ell_S}\left(P_{E\ell a_3}{}^3\cdot S_1 + P_{E3}{}^3\cdot S_2 + P_{E\ell d_3}{}^3\cdot S_3 + P_{Era_3}{}^3\cdot S_1 + P_{E3}{}^3\cdot S_2 + P_{Erd_3}{}^3\cdot S_3\right)}$$

$$= \sqrt[3]{\frac{1}{2\times 1450}(6978.9^3\times 12.5+3479^3\times 1400+2534.5^3\times 37.5+645.7^3\times 12.5+3479^3\times 1400+4645.7^3\times 37.5)}$$

$$= 3520.4\text{N}$$

$$P_{m4} = \sqrt[3]{\frac{1}{2\cdot \ell_S}\left(P_{E\ell a_4}{}^3\cdot S_1 + P_{E4}{}^3\cdot S_2 + P_{E\ell d_4}{}^3\cdot S_3 + P_{Era_4}{}^3\cdot S_1 + P_{E4}{}^3\cdot S_2 + P_{Erd_4}{}^3\cdot S_3\right)}$$

$$= \sqrt[3]{\frac{1}{2\times 1450}(1588.9^3\times 12.5+1911^3\times 1400+3077.7^3\times 37.5+5410.9^3\times 12.5+1911^3\times 1400+966.5^3\times 37.5)}$$

$$= 1985.5\text{N}$$

[Nominal Life L_n]

The nominal life of the four LM blocks is obtained from the corresponding nominal life equations shown below.

$$L_1 = \left(\frac{C}{f_W\cdot P_{m1}}\right)^3\times 50 = 73700\text{ km}$$

$$L_2 = \left(\frac{C}{f_W\cdot P_{m2}}\right)^3\times 50 = 20600\text{ km}$$

$$L_3 = \left(\frac{C}{f_W\cdot P_{m3}}\right)^3\times 50 = 43000\text{ km}$$

$$L_4 = \left(\frac{C}{f_W\cdot P_{m4}}\right)^3\times 50 = 239000\text{ km}$$

(where $f_W = 1.5$)

Therefore, the service life of the LM Guide used in a machine or equipment under the conditions stated above is equivalent to the nominal life of the second LM block, which is 20,600 km.

Example of Calculating the Nominal Life (2) - with Vertical Mount

[Conditions]
Model No. : HSR25CA2SS+1500L-Ⅱ
(basic dynamic load rating: C =19.9 kN)
(basic static load rating: C_0=34.4 kN)
Mass : m_0 =100 kg
m_1 =200 kg
m_2 =100 kg
Stroke : ℓ_S =1000 mm
Distance : ℓ_0=300 mm
ℓ_1=80 mm
ℓ_2=50 mm
ℓ_3=280 mm
ℓ_4=150 mm
ℓ_5=250 mm

The mass (m_0) is loaded only during ascent; it is removed during descent.

Gravitational acceleration g=9.8 (m/s^2)

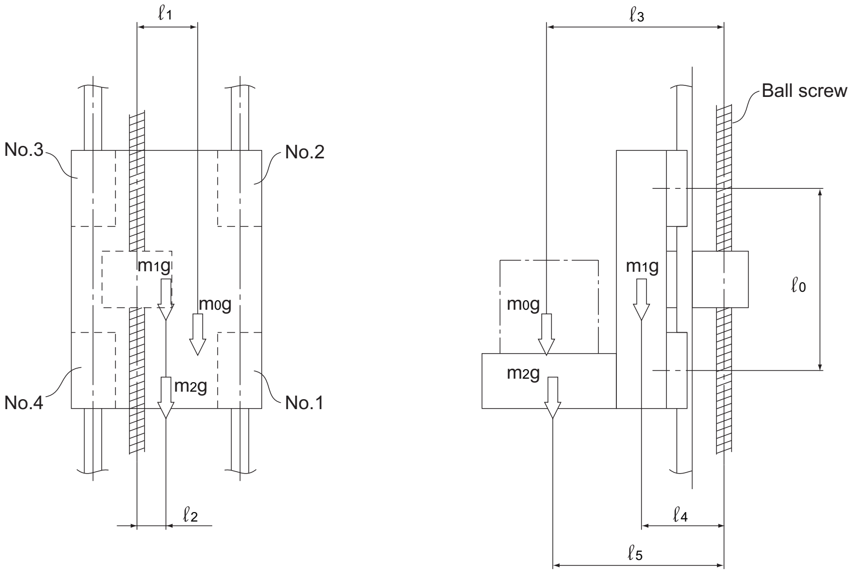


Fig.14 Condition

[Load Applied to the LM Block]

● During Ascent

■Load applied to each LM block in the radial direction Pu_n during ascent

$$Pu_1 = +\frac{m_1g\cdot\ell_4}{2\cdot\ell_0} + \frac{m_2g\cdot\ell_5}{2\cdot\ell_0} + \frac{m_0g\cdot\ell_3}{2\cdot\ell_0} = +1355.6\ \text{N}$$

$$Pu_2 = -\frac{m_1g\cdot\ell_4}{2\cdot\ell_0} - \frac{m_2g\cdot\ell_5}{2\cdot\ell_0} - \frac{m_0g\cdot\ell_3}{2\cdot\ell_0} = -1355.6\ \text{N}$$

$$Pu_3 = -\frac{m_1g\cdot\ell_4}{2\cdot\ell_0} - \frac{m_2g\cdot\ell_5}{2\cdot\ell_0} - \frac{m_0g\cdot\ell_3}{2\cdot\ell_0} = -1355.6\ \text{N}$$

$$Pu_4 = +\frac{m_1g\cdot\ell_4}{2\cdot\ell_0} + \frac{m_2g\cdot\ell_5}{2\cdot\ell_0} + \frac{m_0g\cdot\ell_3}{2\cdot\ell_0} = +1355.6\ \text{N}$$

■Load applied to each LM block in the lateral direction Ptu_n during ascent

$$Ptu_1 = +\frac{m_1g\cdot\ell_2}{2\cdot\ell_0} + \frac{m_2g\cdot\ell_2}{2\cdot\ell_0} + \frac{m_0g\cdot\ell_1}{2\cdot\ell_0} = +375.7\ \text{N}$$

$$Ptu_2 = -\frac{m_1g\cdot\ell_2}{2\cdot\ell_0} - \frac{m_2g\cdot\ell_2}{2\cdot\ell_0} - \frac{m_0g\cdot\ell_1}{2\cdot\ell_0} = -375.7\ \text{N}$$

$$Ptu_3 = -\frac{m_1g\cdot\ell_2}{2\cdot\ell_0} - \frac{m_2g\cdot\ell_2}{2\cdot\ell_0} - \frac{m_0g\cdot\ell_1}{2\cdot\ell_0} = -375.7\ \text{N}$$

$$Ptu_4 = +\frac{m_1g\cdot\ell_2}{2\cdot\ell_0} + \frac{m_2g\cdot\ell_2}{2\cdot\ell_0} + \frac{m_0g\cdot\ell_1}{2\cdot\ell_0} = +375.7\ \text{N}$$

● During Descent

■Load applied to each LM block in the radial direction Pd_n during descent

$$Pd_1 = +\frac{m_1g\cdot\ell_4}{2\cdot\ell_0} + \frac{m_2g\cdot\ell_5}{2\cdot\ell_0} = +898.3\ \text{N}$$

$$Pd_2 = -\frac{m_1g\cdot\ell_4}{2\cdot\ell_0} - \frac{m_2g\cdot\ell_5}{2\cdot\ell_0} = -898.3\ \text{N}$$

$$Pd_3 = -\frac{m_1g\cdot\ell_4}{2\cdot\ell_0} - \frac{m_2g\cdot\ell_5}{2\cdot\ell_0} = -898.3\ \text{N}$$

$$Pd_4 = +\frac{m_1g\cdot\ell_4}{2\cdot\ell_0} + \frac{m_2g\cdot\ell_5}{2\cdot\ell_0} = +898.3\ \text{N}$$

■Load applied to each LM block in the lateral direction Ptd_n during descent

$$Ptd_1 = +\frac{m_1g\cdot\ell_2}{2\cdot\ell_0} + \frac{m_2g\cdot\ell_2}{2\cdot\ell_0} = +245\ \text{N}$$

$$Ptd_2 = -\frac{m_1g\cdot\ell_2}{2\cdot\ell_0} - \frac{m_2g\cdot\ell_2}{2\cdot\ell_0} = -245\ \text{N}$$

$$Ptd_3 = -\frac{m_1g\cdot\ell_2}{2\cdot\ell_0} - \frac{m_2g\cdot\ell_2}{2\cdot\ell_0} = -245\ \text{N}$$

$$Ptd_4 = +\frac{m_1g\cdot\ell_2}{2\cdot\ell_0} + \frac{m_2g\cdot\ell_2}{2\cdot\ell_0} = +245\ \text{N}$$

[Combined Radial And Thrust Load]

- **During Ascent**

$P_{Eu1} = |P_{u1}| + |Pt_{u1}| = 1731.3$ N

$P_{Eu2} = |P_{u2}| + |Pt_{u2}| = 1731.3$ N

$P_{Eu3} = |P_{u3}| + |Pt_{u3}| = 1731.3$ N

$P_{Eu4} = |P_{u4}| + |Pt_{u4}| = 1731.3$ N

- **During Descent**

$P_{Ed1} = |Pd_1| + |Ptd_1| = 1143.3$ N

$P_{Ed2} = |Pd_2| + |Ptd_2| = 1143.3$ N

$P_{Ed3} = |Pd_3| + |Ptd_3| = 1143.3$ N

$P_{Ed4} = |Pd_4| + |Ptd_4| = 1143.3$ N

[Static Safety Factor]

The static safety factor (f_S) of the LM Guide used in a machine or equipment under the conditions stated above is obtained as follows.

$$f_S = \frac{C_0}{P_{EU2}} = \frac{34.4\times10^3}{1731.3} = 19.9$$

[Average Load P_{mn}]

Obtain the average load applied to each LM block.

$$P_{m1} = \sqrt[3]{\frac{1}{2\cdot\ell_S}(P_{EU1}{}^3\cdot\ell_S + P_{Ed1}{}^3\cdot\ell_S)} = 1495.1\ \text{N}$$

$$P_{m2} = \sqrt[3]{\frac{1}{2\cdot\ell_S}(P_{EU2}{}^3\cdot\ell_S + P_{Ed2}{}^3\cdot\ell_S)} = 1495.1\ \text{N}$$

$$P_{m3} = \sqrt[3]{\frac{1}{2\cdot\ell_S}(P_{EU3}{}^3\cdot\ell_S + P_{Ed3}{}^3\cdot\ell_S)} = 1495.1\ \text{N}$$

$$P_{m4} = \sqrt[3]{\frac{1}{2\cdot\ell_S}(P_{EU4}{}^3\cdot\ell_S + P_{Ed4}{}^3\cdot\ell_S)} = 1495.1\ \text{N}$$

[Nominal Life L_n]

The nominal life of the four LM blocks is obtained from the corresponding nominal life equations shown below.

$$L_1 = \left(\frac{C}{f_W\cdot P_{m1}}\right)^3 \times 50 = 68200\ \text{km}$$

$$L_2 = \left(\frac{C}{f_W\cdot P_{m2}}\right)^3 \times 50 = 68200\ \text{km}$$

$$L_3 = \left(\frac{C}{f_W\cdot P_{m3}}\right)^3 \times 50 = 68200\ \text{km}$$

$$L_4 = \left(\frac{C}{f_W\cdot P_{m4}}\right)^3 \times 50 = 68200\ \text{km}$$

(where $f_W = 1.2$)

Therefore, the service life of the LM Guide used in a machine or equipment under the conditions stated above is 68,200 km.

Predicting the Rigidity

Selecting a Radial Clearance (Preload)

Since the radial clearance of an LM Guide greatly affects the running accuracy, load carrying capacity and rigidity of the LM Guide, it is important to select an appropriate clearance according to the application. In general, selecting a negative clearance (i.e., a preload* is applied) while taking into account possible vibrations and impact generated from reciprocating motion favorably affects the service life and the accuracy.

For specific radial clearances, contact THK. We will help you select the optimal clearance according to the conditions.

The clearances of all LM Guide models (except model HR, GSR and GSR-R, which are separate types) are adjusted as specified before shipment, and therefore they do not need further preload adjustment.

Preload is an internal load applied to the rolling elements (balls, rollers, etc.) of an LM block in advance in order to increase its rigidity.

Table13 Types of Radial Clearance

	Normal Clearance	Clearance C1 (Light Preload)	Clearance C0 (Medium Preload)
Condition	● The loading direction is fixed, impact and vibrations are minimal and 2 rails are installed in parallel. ● Very high precision is not required, and the sliding resistance must be as low as possible.	● An overhang load or moment load is applied. ● LM Guide is used in a single-rail configuration. ● Light load and high accuracy are required.	● High rigidity is required and vibrations and impact are applied. ● Heavy-cutting machine tool
Examples of applications	• Beam-welding machine • Book-binding machin • Automatic packaging machine • XY axes of general industrial machinery • Automatic sash-manufacturing machine • Welding machine • Flame cutting machine • Tool changer • Various kinds of material feeder	• Grinding machine table feed axis • Automatic coating machine • Industrial robot • various kinds of material high speed feeder • NC drilling machine • Vertical axis of general industrial machinery • Printed circuit board drilling machine • Electric discharge machine • Measuring instrument • Precision XY table	• Machining center • NC lathe • Grinding stone feed axis of grinding machine • Milling machine • Vertical/horizontal boring machine • Tool rest guide • Vertical axis of machine tool

Service Life with a Preload Considered

When using an LM Guide under a medium preload (clearance C0), it is necessary to calculate the service life while taking into account the magnitude of the preload.
To identify the appropriate preload for any selected LM Guide model, contact THK.

Rigidity

When the LM Guide receives a load, its rolling element, LM blocks and LM rails are elastically deformed within a permissible load range. The ratio between the displacement and the load is called rigidity value. (Rigidity values are obtained using the equation shown below.) The LM Guide's rigidity increases according to the magnitude of the preload. Fig.15 shows rigidity difference between normal, C1 and C0 clearances.
The effect of a preload for a 4-way equal load type is translated into the calculated load approx. 2.8 times greater than the magnitude of the preload.

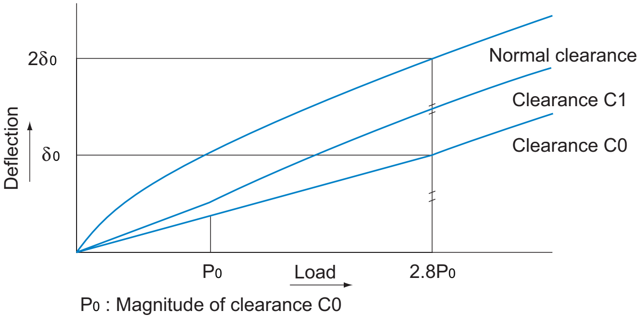
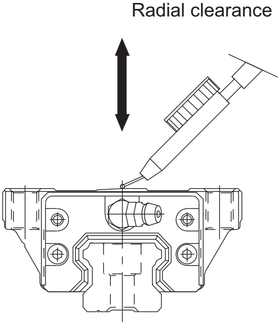


Fig.15 Rigidity Data

$$K=\frac{P}{\delta}$$

K	: Rigidity value	(N/µm)
δ	: Deflection	(µm)
P	: Calculated load	(N)

Radial Clearance Standard for Each Model



[Radial clearances of models SHS and SCR]

Unit: µm

Indication symbol	Normal	Light preload	Medium preload
Model No.	No Symbol	C1	C0
15	−5 to 0	−12 to −5	—
20	−6 to 0	−12 to −6	−18 to −12
25	−8 to 0	−14 to −8	−20 to −14
30	−9 to 0	−17 to −9	−27 to −17
35	−11 to 0	−19 to −11	−29 to −19
45	−12 to 0	−22 to −12	−32 to −22
55	−15 to 0	−28 to −16	−38 to −28
65	−18 to 0	−34 to −22	−45 to −34

[Radial clearance for model SSR]

Unit: µm

Indication symbol	Normal	Light preload
Model No.	No Symbol	C1
15	−4 to +2	−10 to −4
20	−5 to +2	−12 to −5
25	−6 to +3	−15 to −6
30	−7 to +4	−18 to −7
35	−8 to +4	−20 to −8

[Radial clearance for models SNR/SNS and NR/NRS]

Unit: µm

Indication symbol	Normal	Light preload	Medium preload
Model No.	No Symbol	C1	C0
25	−3 to +2	−6 to −3	−9 to −6
30	−4 to +2	−8 to −4	−12 to −8
35	−4 to +2	−8 to −4	−12 to −8
45	−5 to +3	−10 to −5	−15 to −10
55	−6 to +3	−11 to −6	−16 to −11
65	−8 to +3	−14 to −8	−20 to −14
75	−10 to +4	−17 to −10	−24 to −17
85	−13 to +4	−20 to −13	−27 to −20
100	−14 to +4	−24 to −14	−34 to −24

[Radial clearance for model SHW]

Unit: µm

Indication symbol	Normal	Light preload	Medium preload
Model No.	No Symbol	C1	C0
12	−1.5 to 0	−4 to −1	—
14	−2 to 0	−5 to −1	—
17	−3 to 0	−7 to −3	—
21	−4 to +2	−8 to −4	—
27	−5 to +2	−11 to −5	—
35	−8 to +4	−18 to −8	−28 to −18
50	−10 to +5	−24 to −10	−38 to −24

[Radial clearance for model SRS]

Unit: µm

Indication symbol	Normal	Light preload
Model No.	No Symbol	C1
7	−2 to +2	−3 to 0
9	−2 to +2	−4 to 0
12	−3 to +3	−6 to 0
15	−5 to +5	−10 to 0
20	−5 to +5	−10 to 0
25	−7 to +7	−14 to 0

[Radial clearance for models HSR, CSR and HSR-M1]

Unit: μm

Indication symbol	Normal	Light preload	Medium preload
Model No.	No Symbol	C1	C0
8	−1 to +1	−4 to −1	—
10	−2 to +2	−5 to −1	—
12	−3 to +3	−6 to −2	—
15	−4 to +2	−12 to −4	—
20	−5 to +2	−14 to −5	−23 to −14
25	−6 to +3	−16 to −6	−26 to −16
30	−7 to +4	−19 to −7	−31 to −19
35	−8 to +4	−22 to −8	−35 to −22
45	−10 to +5	−25 to −10	−40 to −25
55	−12 to +5	−29 to −12	−46 to −29
65	−14 to +7	−32 to −14	−50 to −32
85	−16 to +8	−36 to −16	−56 to −36
100	−19 to +9	−42 to −19	−65 to −42
120	−21 to +10	−47 to −21	−73 to −47
150	−23 to +11	−51 to −23	−79 to −51

[Model HSR Grade Ct Radial Clearance]

Unit: μm

Indication symbol	Normal
Model No.	No Symbol
15	−8 to +2
20	−14 to +2
25	−16 to +2
30	−18 to +4
35	−20 to +4

[Radial clearances of models SR and SR-M1]

Unit: μm

Indication symbol	Normal	Light preload	Medium preload
Model No.	No Symbol	C1	C0
15	−4 to +2	−10 to −4	—
20	−5 to +2	−12 to −5	−17 to −12
25	−6 to +3	−15 to −6	−21 to −15
30	−7 to +4	−18 to −7	−26 to −18
35	−8 to +4	−20 to −8	−31 to −20
45	−10 to +5	−24 to −10	−36 to −24
55	−12 to +5	−28 to −12	−45 to −28
70	−14 to +7	−32 to −14	−50 to −32
85	−20 to +9	−46 to −20	−70 to −46
100	−22 to +10	−52 to −22	−78 to −52
120	−25 to +12	−57 to −25	−87 to −57
150	−29 to +14	−69 to −29	−104 to −69

[Radial clearance for model HRW]

Unit: μm

Indication symbol	Normal	Light preload	Medium preload
Model No.	No Symbol	C1	C0
12	−1.5 to +1.5	−4 to −1	—
14	−2 to +2	−5 to −1	—
17	−3 to +2	−7 to −3	—
21	−4 to +2	−8 to −4	—
27	−5 to +2	−11 to −5	—
35	−8 to +4	−18 to −8	−28 to −18
50	−10 to +5	−24 to −10	−38 to −24
60	−12 to +5	−27 to −12	−42 to −27

[Radial clearance for models RSR, RSR-W, RSR-Z, RSR-WZ, RSH, RSH-Z and RSR-M1]

Unit: μm

Indication symbol	Normal	Light preload
Model No.	No Symbol	C1
3	0 to +1	−0.5 to 0
5	0 to +1.5	−1 to 0
7	−2 to +2	−3 to 0
9	−2 to +2	−4 to 0
12	−3 to +3	−6 to 0
15	−5 to +5	−10 to 0
20	−7 to +7	−14 to 0

[Radial clearance for model MX]

Unit: µm

Indication symbol	Normal	Light preload
Model No.	No Symbol	C1
5	0 to +1.5	−1 to 0
7	−2 to +2	−3 to 0

[Radial clearance for model JR]

Unit: µm

Indication symbol	Normal
Model No.	No Symbol
25	0 to +30
35	0 to +30
45	0 to +50
55	0 to +50

[Radial clearances for models HCR and HMG]

Unit: µm

Indication symbol	Normal	Light preload
Model No.	No Symbol	C1
12	−3 to +3	−6 to −2
15	−4 to +2	−12 to −4
25	−6 to +3	−16 to −6
35	−8 to +4	−22 to −8
45	−10 to +5	−25 to −10
65	−14 to +7	−32 to −14

[Radial clearance for model NSR-TBC]

Unit: µm

Indication symbol	Normal	Light preload	Medium preload
Model No.	No Symbol	C1	C0
20	−5 to +5	−15 to −5	−25 to −15
25	−5 to +5	−15 to −5	−25 to −15
30	−5 to +5	−15 to −5	−25 to −15
40	−8 to +8	−22 to −8	−36 to −22
50	−8 to +8	−22 to −8	−36 to −22
70	−10 to +10	−26 to −10	−42 to −26

[Radial clearance for model HSR-M2]

Unit: µm

Indication symbol	Normal	Light preload
Model No.	No Symbol	C1
15	−4 to +2	−12 to −4
20	−5 to +2	−14 to −5
25	−6 to +3	−16 to −6

[Radial clearances for models SRG and SRN]

Unit: µm

Indication symbol	Normal	Light preload	Medium preload
Model No.	No Symbol	C1	C0
15	−0.5 to 0	−1 to −0.5	−2 to −1
20	−0.8 to 0	−2 to −0.8	−3 to −2
25	−2 to −1	−3 to −2	−4 to −3
30	−2 to −1	−3 to −2	−4 to −3
35	−2 to −1	−3 to −2	−5 to −3
45	−2 to −1	−3 to −2	−5 to −3
55	−2 to −1	−4 to −2	−6 to −4
65	−3 to −1	−5 to −3	−8 to −5

[Radial clearance for model SRW]

Unit: µm

Indication symbol	Normal	Light preload	Medium preload
Model No.	No Symbol	C1	C0
70	−2 to −1	−3 to −2	−5 to −3
85	−2 to −1	−4 to −2	−6 to −4
100	−3 to −1	−5 to −3	−8 to −5

Determining the Accuracy

Accuracy Standards

Accuracy of the LM Guide is specified in terms of running parallelism, dimensional tolerance for height and width, and height and width difference between a pair when 2 or more LM blocks are used on one rail or when 2 or more rails are mounted on the same plane.
For details, see “Accuracy Standard for Each Model” on A-118 to A-128.

[Running of Parallelism]

It refers to the tolerance for parallelism between the LM block and the LM rail reference surface when the LM block travels the whole length of the LM rail with the LM rail secured on the reference reference surface using bolts.

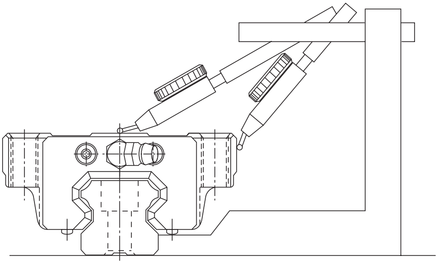


Fig.16 Running of Parallelism

[Difference in Height M]

Indicates a difference between the minimum and maximum values of height (M) of each of the LM blocks used on the same plane in combination.

[Difference in Width W_2]

Indicates a difference between the minimum and maximum values of the width (W_2) between each of the LM blocks, mounted on one LM rail in combination, and the LM rail.

Note1) When 2 or more rails are used on the same plane in parallel, only the width (W_2) tolerance and the difference on the master rail apply. The master LM rail is imprinted with "KB" (except for normal grade products) following the serial number.

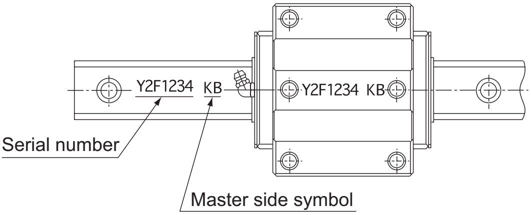


Fig.17 Master LM Rail

Note2) Accuracy measurements each represent the average value of the central point or the central area of the LM block.
Note3) The LM rail is smoothly curved so that the required accuracy is easily achieved by pressing the rail to the reference surface of the machine.
If it is mounted on a less rigid base such as an aluminum base, the curve of the rail will affect the accuracy of the machine. Therefore, it is necessary to define straightness of the rail in advance.

Guidelines for Accuracy Grades by Machine Type

Table14 shows guidelines for selecting an accuracy grade of the LM Guide according to the machine type.

Table14 Guideline for Accuracy Grades by Machine Type

Type of machine		Accuracy grades						
		Ct7	Ct5	Normal	H	P	SP	UP
Machine tool	Machining center					●	●	
	Lathe					●	●	
	Milling machine					●	●	
	Boring machine					●	●	
	Jig borer						●	●
	Grinding machine						●	●
	Electric discharge machine					●	●	●
	Punching press				●	●		
	Laser beam machine				●	●	●	
	Woodworking machine	●	●	●	●	●		
	NC drilling machine				●	●		
	Tapping center				●	●		
	Palette changer			●				
	ATC	●	●	●				
	Wire cutting machine					●	●	
	Dressing machine						●	●
Industrial robot	Cartesian coordinate			●	●	●		
	Cylindrical coordinate			●	●			
Semiconductor manufacturing equipment	Wire bonding machine					●	●	
	Prober						●	●
	Electronic component inserter				●	●		
	Printed circuit board drilling machine				●	●	●	
Other equipment	Injection molding machine			●	●			
	3D measuring instrument						●	●
	Office equipment	●	●	●	●			
	Conveyance system	●	●	●	●			
	XY table				●	●	●	
	Coating machine	●	●	●	●			
	Welding machine	●	●	●	●			
	Medical equipment			●	●			
	Digitizer				●	●	●	
	Inspection equipment					●	●	●

Ct7 : Grade Ct7
Ct5 : Grade Ct5
Normal : Normal grade
H : High accuracy grade
P : Precision Grade
SP : Super precision grade
UP : Ultra precision grade

Accuracy Standard for Each Model

- Accuracies of models XSHS, SSR, SNR/SNS, SHW, HSR, SR, NR/NRS, HRW, NSR-TBC, HSR-M1, SR-M1 HSR-M2, SRG and SRN are categorized into Ct7 grade (Ct7), Ct5 grade (Ct5), Normal grade (no symbol), High accuracy grade (H), Precision grade (P), Super precision grade (SP) and Ultra precision grade (UP) by model numbers, as indicated in Table16 on A-119.

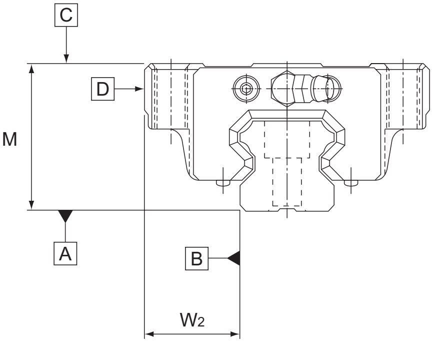


Fig.18

Table15 LM Rail Length and Running Parallelism by Accuracy Standard

Unit: µm

LM rail length (mm)		Running Parallelism Values						
Above	Or less	Grade Ct7	Grade Ct5	Normal grade	High-accuracy grade	Precision grade	Super precision grade	Ultra precision grade
—	50	6	6	5	3	2	1.5	1
50	80	6	6	5	3	2	1.5	1
80	125	6	6	5	3	2	1.5	1
125	200	7	6	5	3.5	2	1.5	1
200	250	9.5	6.5	6	4	2.5	1.5	1
250	315	11	7.5	7	4.5	3	1.5	1
315	400	13	8.5	8	5	3.5	2	1.5
400	500	16	11	9	6	4.5	2.5	1.5
500	630	18	13	11	7	5	3	2
630	800	20	15	12	8.5	6	3.5	2
800	1000	23	16	13	9	6.5	4	2.5
1000	1250	26	18	15	11	7.5	4.5	3
1250	1600	28	20	16	12	8	5	4
1600	2000	31	23	18	13	8.5	5.5	4.5
2000	2500	34	25	20	14	9.5	6	5
2500	3150	36	27	21	16	11	6.5	5.5
3150	4000	40	29	23	17	12	7.5	6
4000	5000	41	30	24	18	13	8.5	6.5

Note) Ct7 and Ct5 class are only applicable for model HSR.

Table16 Accuracy Standards for Models SHS, SSR, SNR/SNS, SHW, HSR, SR, NR/NRS, HRW, NSR-TBC, HSR-M1, SR-M1, HSR-M2, SRG, and SRN.

Unit: mm

Model No.	Accuracy standards	Grade Ct7	Grade Ct5	Normal grade	High-accuracy grade	Precision grade	Super precision grade	Ultra precision grade
	Item	Ct7	Ct5	No Symbol	H	P	SP	UP
8 10 12 14	Dimensional tolerance in height M	—	—	±0.07	±0.03	±0.015	±0.007	—
	Difference in height M	—	—	0.015	0.007	0.005	0.003	—
	Dimensional tolerance in width W_2	—	—	±0.04	±0.02	±0.01	±0.007	—
	Difference in width W_2	—	—	0.02	0.01	0.006	0.004	—
	Running parallelism of surface C against surface A	ΔC (as shown in A-118 Table15)						
	Running parallelism of surface D against surface B	ΔD (as shown in A-118 Table15)						
15 17 20 21	Dimensional tolerance in height M	±0.12	±0.12	±0.07	±0.03	0 −0.03	0 −0.015	0 −0.008
	Difference in height M	0.025	0.025	0.02	0.01	0.006	0.004	0.003
	Dimensional tolerance in width W_2	±0.12	±0.12	±0.06	±0.03	0 −0.02	0 −0.015	0 −0.008
	Difference in width W_2	0.025	0.025	0.02	0.01	0.006	0.004	0.003
	Running parallelism of surface C against surface A	ΔC (as shown in A-118 Table15)						
	Running parallelism of surface D against surface B	ΔD (as shown in A-118 Table15)						
25 27 30 35	Dimensional tolerance in height M	±0.12	±0.12	±0.08	±0.04	0 −0.04	0 −0.02	0 −0.01
	Difference in height M	0.025	0.025	0.02	0.015	0.007	0.005	0.003
	Dimensional tolerance in width W_2	±0.12	±0.12	±0.07	±0.03	0 −0.03	0 −0.015	0 −0.01
	Difference in width W_2	0.035	0.035	0.025	0.015	0.007	0.005	0.003
	Running parallelism of surface C against surface A	ΔC (as shown in A-118 Table15)						
	Running parallelism of surface D against surface B	ΔD (as shown in A-118 Table15)						
40 45 50 55 60	Dimensional tolerance in height M	—	—	±0.08	±0.04	0 −0.05	0 −0.03	0 −0.015
	Difference in height M	—	—	0.025	0.015	0.007	0.005	0.003
	Dimensional tolerance in width W_2	—	—	±0.07	±0.04	0 −0.04	0 −0.025	0 −0.015
	Difference in width W_2	—	—	0.03	0.015	0.007	0.005	0.003
	Running parallelism of surface C against surface A	ΔC (as shown in A-118 Table15)						
	Running parallelism of surface D against surface B	ΔD (as shown in A-118 Table15)						
65 70 75 85 100 120 150	Dimensional tolerance in height M	—	—	±0.08	±0.04	0 −0.05	0 −0.04	0 −0.03
	Difference in height M	—	—	0.03	0.02	0.01	0.007	0.005
	Dimensional tolerance in width W_2	—	—	±0.08	±0.04	0 −0.05	0 −0.04	0 −0.03
	Difference in width W_2	—	—	0.03	0.02	0.01	0.007	0.005
	Running parallelism of surface C against surface A	ΔC (as shown in A-118 Fig.18)						
	Running parallelism of surface D against surface B	ΔD (as shown in A-118 Fig.18)						

Note) XFor models SRG and SRN, only precision or higher grades apply. (Ct7 grade, Ct5 grade, normal grade and high accuracy grade are not available.)

Note) Ct7 and Ct5 class are only applicable for model HSR.

- Accuracies of model HMG are defined by model number as indicated in Table17.

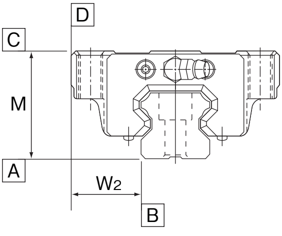


Fig.19

Table17 Model HMG Accuracy Standard

Unit: mm

Model No.	Accuracy Standards	Normal grade
	Item	No symbol
15	Dimensional tolerance in height M	±0.1
	Difference in height M	0.02
	Dimensional tolerance in width W_2	±0.1
	Difference in width W_2	0.02
	Running parallelism of surface C against surface A	ΔC (as shown in Table18)
	Running parallelism of surface D against surface B	ΔD (as shown in Table18)
25 35	Dimensional tolerance in height M	±0.1
	Difference in height M	0.02
	Dimensional tolerance in width W_2	±0.1
	Difference in width W_2	0.03
	Running parallelism of surface C against surface A	ΔC (as shown in Table18)
	Running parallelism of surface D against surface B	ΔD (as shown in Table18)
45 65	Dimensional tolerance in height M	±0.1
	Difference in height M	0.03
	Dimensional tolerance in width W_2	±0.1
	Difference in width W_2	0.03
	Running parallelism of surface C against surface A	ΔC (as shown in Table18)
	Running parallelism of surface D against surface B	ΔD (as shown in Table18)

Table18 LM Rail Length and Running Parallelism by Accuracy Standard

Unit: μm

LM rail length (mm)		Running Parallelism Values
Above	Or less	Normal grade
—	125	30
125	200	37
200	250	40
250	315	44
315	400	49
400	500	53
500	630	58
630	800	64
800	1000	70
1000	1250	77
1250	1600	84
1600	2000	92

- Accuracies of model HCR are categorized into normal and high accuracy grades by model number as indicated in Table19.

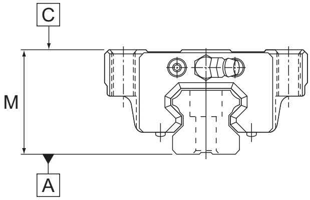


Fig.20

Table19 Accuracy Standard for Model HCR

Unit: mm

Model No.	Accuracy standards	Normal grade	High-accuracy grade
	Item	No Symbol	H
12 15 25 35	Dimensional tolerance in height M	±0.2	±0.2
	Difference in height M	0.05	0.03
	Running parallelism of surface C against surface A	ΔC (as shown in Table20)	
45 65	Dimensional tolerance in height M	±0.2	±0.2
	Difference in height M	0.06	0.04
	Running parallelism of surface C against surface A	ΔC (as shown in Table20)	

Table20 LM Rail Length and Running Parallelism by Accuracy Standard

Unit: μm

LM rail length (mm)		Running Parallelism Values	
Above	Or less	Normal grade	High-accuracy grade
—	125	30	15
125	200	37	18
200	250	40	20
250	315	44	22
315	400	49	24
400	500	53	26
500	630	58	29
630	800	64	32
800	1000	70	35
1000	1250	77	38
1250	1600	84	42
1600	2000	92	46

- Accuracies of model JR are defined by model number as indicated in Table21.

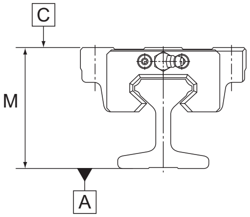


Fig.21

Table21 Accuracy Standard for Model JR

Unit: mm

Model No.	Accuracy standards	Normal grade
	Item	No Symbol
25 35	Difference in height M	0.05
	Running parallelism of surface C against surface A	ΔC (as shown in Table22)
45 55	Difference in height M	0.06
	Running parallelism of surface C against surface A	ΔC (as shown in Table22)

Table22 LM Rail Length and Running Parallelism by Accuracy Standard

Unit: μm

LM rail length (mm)		Running Parallelism Values
Above	Or less	Normal grade
—	50	5
50	80	5
80	125	5
125	200	6
200	250	8
250	315	9
315	400	11
400	500	13
500	630	15
630	800	17
800	1000	19
1000	1250	21
1250	1600	23
1600	2000	26
2000	2500	28
2500	3150	30
3150	4000	33
4000	5000	34

- Accuracies of models SCR and CSR are categorized into precision, super precision and ultra precision grades by model number as indicated in Table23.

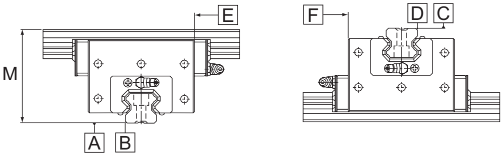


Fig.22

Table23 Accuracy Standard for Models SCR and CSR

Unit: mm

Model No.	Accuracy standards	Precision grade	Super precision grade	Ultra precision grade
	Item	P	SP	UP
15 20	Difference in height M	0.01	0.007	0.005
	Perpendicularity of surface D against surface B	0.005	0.004	0.003
	Running parallelism of surface E against surface B	ΔC (as shown in Table24)		
	Running parallelism of surface F against surface D	ΔD (as shown in Table24)		
25	Difference in height M	0.01	0.007	0.005
	Perpendicularity of surface D against surface B	0.008	0.006	0.004
	Running parallelism of surface E against surface B	ΔC (as shown in Table24)		
	Running parallelism of surface F against surface D	ΔD (as shown in Table24)		
30 35	Difference in height M	0.01	0.007	0.005
	Perpendicularity of surface D against surface B	0.01	0.007	0.005
	Running parallelism of surface E against surface B	ΔC (as shown in Table24)		
	Running parallelism of surface F against surface D	ΔD (as shown in Table24)		
45	Difference in height M	0.012	0.008	0.006
	Perpendicularity of surface D against surface B	0.012	0.008	0.006
	Running parallelism of surface E against surface B	ΔC (as shown in Table24)		
	Running parallelism of surface F against surface D	ΔD (as shown in Table24)		
65	Difference in height M	0.018	0.012	0.009
	Perpendicularity of surface D against surface B	0.018	0.012	0.009
	Running parallelism of surface E against surface B	ΔC (as shown in Table24)		
	Running parallelism of surface F against surface D	ΔD (as shown in Table24)		

Table24 LM Rail Length and Running Parallelism by Accuracy Standard

Unit: µm

LM rail length (mm)		Running Parallelism Values		
Above	Or less	Precision grade	Super precision grade	Ultra precision grade
—	50	2	1.5	1
50	80	2	1.5	1
80	125	2	1.5	1
125	200	2	1.5	1
200	250	2.5	1.5	1
250	315	3	1.5	1
315	400	3.5	2	1.5
400	500	4.5	2.5	1.5
500	630	5	3	2
630	800	6	3.5	2
800	1000	6.5	4	2.5
1000	1250	7.5	4.5	3
1250	1600	8	5	4
1600	2000	8.5	5.5	4.5
2000	2500	9.5	6	5
2500	3150	11	6.5	5.5
3150	4000	12	7.5	6
4000	5000	13	8.5	6.5

- Accuracies of model HR are categorized into normal, high accuracy, precision, super precision and ultra precision grades as indicated in Table25.

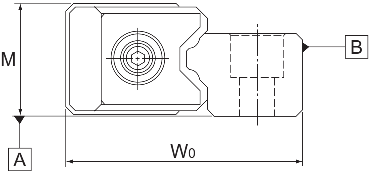


Fig.23

Table25 Accuracy Standard for Model HR

Unit: mm

Accuracy standards	Normal grade	High-accuracy grade	Precision grade	Super precision grade	Ultra precision grade
Item	No Symbol	H	P	SP	UP
Dimensional tolerance in height M	±0.1	±0.05	±0.025	±0.015	±0.01
Difference in height M Note 1)	0.03	0.02	0.01	0.005	0.003
Dimensional tolerance for total width W_0	±0.1		±0.05		
Difference in total width W_0 Note 2)	0.03	0.015	0.01	0.005	0.003
Parallelism of the raceway against surfaces A and B	ΔC (as shown in Table26)				

Note1) Difference in height M applies to a set of LM Guides used on the same plane.
Note2) Difference in total width W_0 applies to LM blocks used in combination on one LM rail.
Note3) Dimensional tolerance and difference in total width W_0 for precision and higher grades apply only to the master-rail side among a set of LM Guides. The master rail is imprinted with "KB" following a serial number.

Table26 LM Rail Length and Running Parallelism by Accuracy Standard

Unit: μm

LM rail length (mm)		Running Parallelism Values				
Above	Or less	Normal grade	High-accuracy grade	Precision grade	Super precision grade	Ultra precision grade
—	50	5	3	2	1.5	1
50	80	5	3	2	1.5	1
80	125	5	3	2	1.5	1
125	200	5	3.5	2	1.5	1
200	250	6	4	2.5	1.5	1
250	315	7	4.5	3	1.5	1
315	400	8	5	3.5	2	1.5
400	500	9	6	4.5	2.5	1.5
500	630	11	7	5	3	2
630	800	12	8.5	6	3.5	2
800	1000	13	9	6.5	4	2.5
1000	1250	15	11	7.5	4.5	3
1250	1600	16	12	8	5	4
1600	2000	18	13	8.5	5.5	4.5
2000	2500	20	14	9.5	6	5
2500	3150	21	16	11	6.5	5.5
3150	4000	23	17	12	7.5	6
4000	5000	24	18	13	8.5	6.5

- Accuracies of model GSR are categorized into normal, high accuracy and precision grades by model number as indicated in Table27.

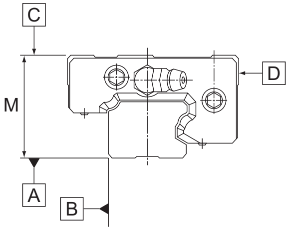


Fig.24

Table27 Accuracy Standard for Model GSR

Unit: mm

Model No.	Accuracy standards	Normal grade	High-accuracy grade	Precision grade
	Item	No Symbol	H	P
15 20	Dimensional tolerance in height M	±0.02		
	Running parallelism of surface C against surface A	ΔC (as shown in Table28)		
	Running parallelism of surface D against surface B	ΔD (as shown in Table28)		
25 30 35	Dimensional tolerance in height M	±0.03		
	Running parallelism of surface C against surface A	ΔC (as shown in Table28)		
	Running parallelism of surface D against surface B	ΔD (as shown in Table28)		

Table28 LM Rail Length and Running Parallelism by Accuracy Standard

Unit: μm

LM rail length (mm)		Running Parallelism Values		
Above	Or less	Normal grade	High-accuracy grade	Precision grade
—	50	5	3	2
50	80	5	3	2
80	125	5	3	2
125	200	5	3.5	2
200	250	6	4	2.5
250	315	7	4.5	3
315	400	8	5	3.5
400	500	9	6	4.5
500	630	11	7	5
630	800	12	8.5	6
800	1000	13	9	6.5
1000	1250	15	11	7.5
1250	1600	16	12	8
1600	2000	18	13	8.5
2000	2500	20	14	9.5
2500	3150	21	16	11
3150	4000	23	17	12
4000	5000	24	18	13

- Accuracies of model GSR-R are categorized into normal and high accuracy grades by model number as indicated in Table29.

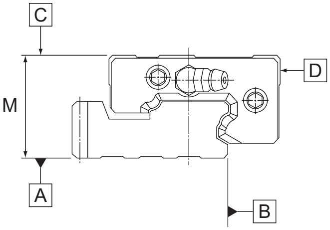


Fig.25

Table29 Accuracy Standard for GSR-R

Unit: mm

Model No.	Accuracy standards	Normal grade	High-accuracy grade
	Item	No Symbol	H
25 30 35	Dimensional tolerance in height M	±0.03	
	Running parallelism of surface C against surface A	ΔC (as shown in Table30)	
	Running parallelism of surface D against surface B	ΔD (as shown in Table30)	

Table30 LM Rail Length and Running Parallelism by Accuracy Standard

Unit: µm

LM rail length (mm)		Running Parallelism Values	
Above	Or less	Normal grade	High-accuracy grade
—	50	5	3
50	80	5	3
80	125	5	3
125	200	5	3.5
200	250	6	4
250	315	7	4.5
315	400	8	5
400	500	9	6
500	630	11	7
630	800	12	8.5
800	1000	13	9
1000	1250	15	11
1250	1600	16	12
1600	2000	18	13
2000	2500	20	14
2500	3150	21	16
3150	4000	23	17
4000	5000	24	18

- Accuracies of models SRS, RSR, RSR-M1, RSR-W, RSR-Z, RSR-WZ, RSH and RSH-Z are categorized into normal, high accuracy and precision grades by model number as indicated in Table31.

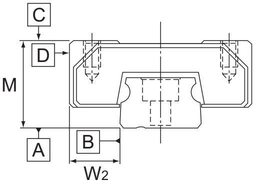


Fig.26

Table31 Accuracy Standards for Models SRS, RSR, RSR-M1, RSR-W, RSR-Z, RSR-WZ, RSH and RSH-Z

Unit: mm

Model No.	Accuracy standards	Normal grade	High-accuracy grade	Precision grade
	Item	No Symbol	H	P
3 5	Dimensional tolerance in height M	±0.03	—	±0.015
	Difference in height M	0.015	—	0.005
	Dimensional tolerance in width W_2	±0.03	—	±0.015
	Difference in width W_2	0.015	—	0.005
	Running parallelism of surface C against surface A	ΔC (as shown in Table32)		
	Running parallelism of surface D against surface B	ΔD (as shown in Table32)		
7 9 12 14 15 20 25	Dimensional tolerance in height M	±0.04	±0.02	±0.01
	Difference in height M	0.03	0.015	0.007
	Dimensional tolerance in width W_2	±0.04	±0.025	±0.015
	Difference in width W_2	0.03	0.02	0.01
	Running parallelism of surface C against surface A	ΔC (as shown in Table33)		
	Running parallelism of surface D against surface B	ΔD (as shown in Table33)		

Table32 LM Rail Length and Running Parallelism for Models RSR3 and 5 by Accuracy Standard

Unit: µm

LM rail length (mm)		Running Parallelism Values	
Above	Or less	Normal grade	Precision grade
—	25	2.5	1.5
25	50	3.5	2
50	100	5.5	3
100	150	7	4
150	200	8.4	5

Table33 LM Rail Length and Running Parallelism for Models SRS, RSR7 to 25, and RSH by Accuracy Standard

Unit: µm

LM rail length (mm)		Running Parallelism Values		
Above	Or less	Normal grade	High-accuracy grade	Precision grade
—	40	8	4	1
40	70	10	4	1
70	100	11	4	2
100	130	12	5	2
130	160	13	6	2
160	190	14	7	2
190	220	15	7	3
220	250	16	8	3
250	280	17	8	3
280	310	17	9	3
310	340	18	9	3
340	370	18	10	3
370	400	19	10	3
400	430	20	11	4
430	460	20	12	4
460	490	21	12	4
490	520	21	12	4
520	550	22	12	4
550	580	22	13	4
580	610	22	13	4
610	640	22	13	4
640	670	23	13	4
670	700	23	13	5
700	730	23	14	5
730	760	23	14	5
760	790	23	14	5
790	820	23	14	5
820	850	24	14	5
850	880	24	15	5
880	910	24	15	5
910	940	24	15	5
940	970	24	15	5
970	1000	25	16	5
1000	1030	25	16	5
1030	1060	25	16	6
1060	1090	25	16	6
1090	1120	25	16	6
1120	1150	25	16	6
1150	1180	26	17	6
1180	1210	26	17	6
1210	1240	26	17	6
1240	1270	26	17	6
1270	1300	26	17	6
1300	1330	26	17	6
1330	1360	27	18	6
1360	1390	27	18	6
1390	1420	27	18	6
1420	1450	27	18	7
1450	1480	27	18	7
1480	1510	27	18	7
1510	1540	28	19	7
1540	1570	28	19	7
1570	1600	28	19	7

- Accuracies of model MX are categorized into normal and precision grades by model number as indicated in Table34.

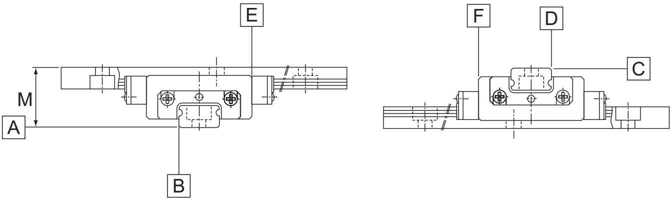


Fig.27

Table34 Accuracy Standard for Model MX

Unit: mm

Model No.	Accuracy standards	Normal grade	Precision grade
	Item	No Symbol	P
5	Difference in height M	0.015	0.005
	Perpendicularity of surface D against surface B	0.003	0.002
	Running parallelism of surface E against surface B	ΔC (as shown in Table35)	
	Running parallelism of surface F against surface D	ΔD (as shown in Table35)	
7	Difference in height M	0.03	0.007
	Perpendicularity of surface D against surface B	0.01	0.005
	Running parallelism of surface E against surface B	ΔC (as shown in Table36)	
	Running parallelism of surface F against surface D	ΔD (as shown in Table36)	

Table35 LM Rail Length and Running Parallelism for Model MX5 by Accuracy Standard

Unit: μm

LM rail length (mm)		Running Parallelism Values	
Above	Or less	Normal grade	Precision grade
—	25	2.5	1.5
25	50	3.5	2
50	100	5.5	3
100	150	7	4
150	200	8.4	5

Table36 LM Rail Length and Running Parallelism for Model MX7 by Accuracy Standard

Unit: μm

LM rail length (mm)		Running Parallelism Values	
Above	Or less	Normal grade	Precision grade
—	40	8	1
40	70	10	1
70	100	11	2
100	130	12	2
130	160	13	2
160	190	14	2
190	220	15	3
220	250	16	3
250	280	17	3
280	310	17	3
310	340	18	3
340	370	18	3
370	400	19	3
400	430	20	4
430	460	20	4
460	500	21	4

- Accuracies of model SRW are categorized into precision, super precision and ultra precision grades by model number as indicated in Table37.

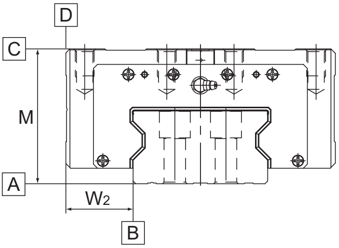


Fig.28

Table37 Accuracy Standard for Model SRW

Unit: mm

Model No.	Accuracy standards	Precision grade	Super precision grade	Ultra precision grade
	Item	P	SP	UP
70 85	Dimensional tolerance in height M	0 −0.05	0 −0.03	0 −0.015
	Difference in height M	0.007	0.005	0.003
	Dimensional tolerance in width W_2	0 −0.04	0 −0.025	0 −0.015
	Difference in width W_2	0.007	0.005	0.003
	Running parallelism of surface C against surface A	ΔC (as shown in Table38)		
	Running parallelism of surface D against surface B	ΔD (as shown in Table38)		
100	Dimensional tolerance in height M	0 −0.05	0 −0.04	0 −0.03
	Difference in height M	0.01	0.007	0.005
	Dimensional tolerance in width W_2	0 −0.05	0 −0.04	0 −0.03
	Difference in width W_2	0.01	0.007	0.005
	Running parallelism of surface C against surface A	ΔC (as shown in Table38)		
	Running parallelism of surface D against surface B	ΔD (as shown in Table38)		

Table38 LM Rail Length and Running Parallelism by Accuracy Standard

Unit: µm

LM rail length (mm)		Running Parallelism Values		
Above	Or less	Precision grade	Super precision grade	Ultra precision grade
—	50	2	1.5	1
50	80	2	1.5	1
80	125	2	1.5	1
125	200	2	1.5	1
200	250	2.5	1.5	1
250	315	3	1.5	1
315	400	3.5	2	1.5
400	500	4.5	2.5	1.5
500	630	5	3	2
630	800	6	3.5	2
800	1000	6.5	4	2.5
1000	1250	7.5	4.5	3
1250	1600	8	5	4
1600	2000	8.5	5.5	4.5
2000	2500	9.5	6	5
2500	3000	11	6.5	5.5

LM Guide

Feature of Each Model

Structure and Features of the Caged Ball LM Guide

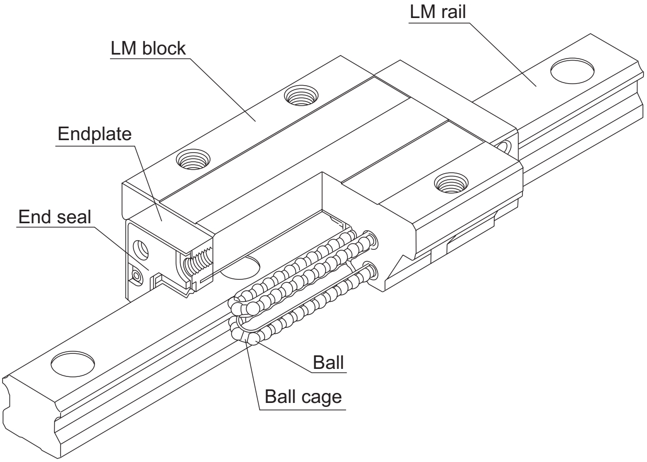


Fig.1 Structural Drawing of the Caged Ball LM Guide Model SHS

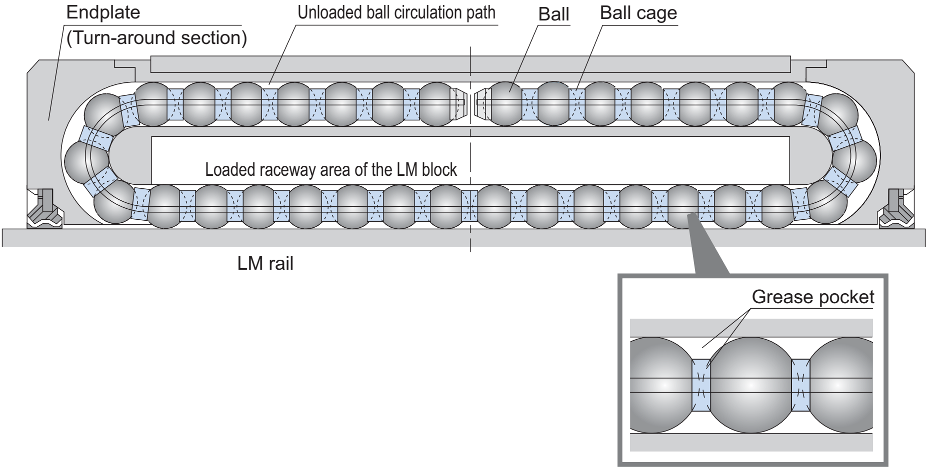


Fig.2 Circulation Structure inside the LM Block of the Caged Ball LM Guide

With the Caged Ball LM Guide, the use of a ball cage allows lines of evenly spaced balls to circulate, thus to eliminate friction between the balls.

In addition, grease held in a space between the ball circulation path and the ball cage (grease pocket) is applied on the contact surface between each ball and the ball cage as the ball rotates, forming an oil film on the ball surface. As a result, an oil film is not easily broken.

Advantages of the Ball Cage Technology

(1) The absence of friction between balls, together with increased grease retention, achieves long service life and long-term maintenance-free (lubrication-free) operation.
(2) The absence of ball-to-ball collision achieves low noise and acceptable running sound.
(3) The absence of friction between balls achieves low heat generation and high speed operation.
(4) The circulation of lines of evenly spaced balls ensures smooth ball rotation.
(5) The absence of friction between balls allows high grease retention and low dust generation.

[Long Service Life and Long-term Maintenance-free Operation]

- **Nominal Life Equation for the LM Guide**

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

L	: Nominal life	(km)
C	: Basic dynamic load rating	(N)
P	: Applied load	(N)

As indicated in the equation, the greater the basic dynamic load rating, the longer the nominal life of the LM Guide.

[Example of Calculation]

Comparison of Nominal Life Between the Caged Ball LM Guide model SHS25LR and the Conventional Full-ball Type Model HSR25LR

Calculation Assuming P = 13.6 kN
Basic dynamic rated load (C) of SHS25LR = 36.8 kN
Basic dynamic rated load (C) of HSR25LR = 27.2 kN

Model SHS25LR $$L = \left(\frac{C}{P}\right)^3 \times 50 = \left(\frac{36.8}{13.6}\right)^3 \times 50 = 990 \text{ km}$$

Model HSR25LR $$L = \left(\frac{C}{P}\right)^3 \times 50 = \left(\frac{27.2}{13.6}\right)^3 \times 50 = 400 \text{ km}$$

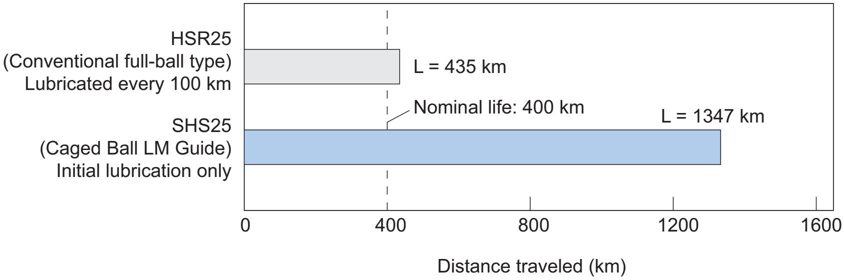
The nominal life of the Caged Ball LM Guide model SHS25LR is 2.4 times* longer than the conventional full-ball type model HSR25LR.

* When selecting a model number, it is necessary to perform a service life calculation according to the conditions.

● Data on Long Service Life and Long-term Maintenance-free Operation

Use of a ball cage eliminates friction between balls and increases grease retention, thus to achieve long service life and long-term maintenance-free operation.

[Condition]
Model No. : SHS25/HSR25
Speed : 60m/min
Stroke : 350mm
Acceleration: 9.8m/s^2
Orientation : horizontal
Load : Caged Ball LM Guide model SHS: 11.1kN
Conventional full-ball type model HSR: 9.8kN

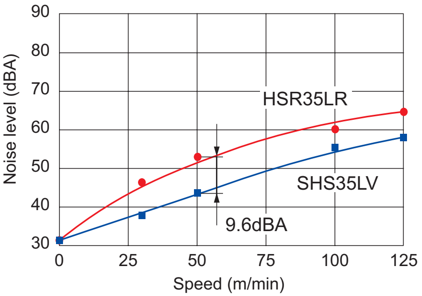


[Low Noise, Acceptable Running Sound]

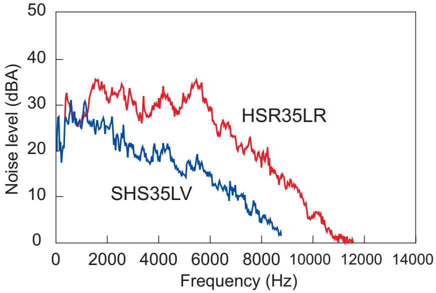
● Noise Level Data

Since the ball circulation path inside the LM block is made of resin, metallic noise between balls and the LM block is eliminated. In addition, use of a ball cage eliminates metallic noise of ball-to-ball collision, allowing a low noise level to be maintained even at high speed.

Model SHS35LV: Caged Ball LM Guide
Model HSR35LR: conventional full-ball type



Comparison of Noise Levels between Model SHS35LV and Model HSR35LR



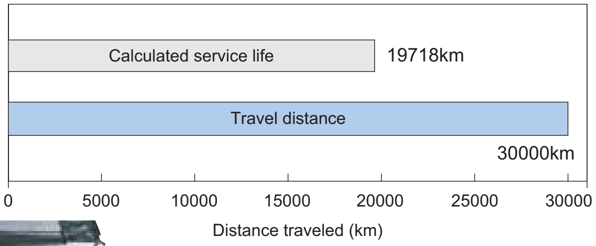
Comparison of Noise Levels between Model SHS35LV and Model HSR35LR (at speed of 50 m/min)

[High Speed]

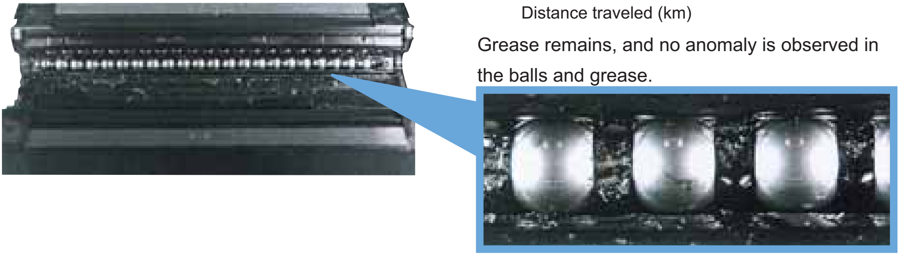
● High-speed Durability Test Data

Since use of a ball cage eliminates friction between balls, only a low level of heat is generated and superbly high speed is achieved.

[Condition]
Model No. : Caged Ball LM Guide Model SHS65LVSS
Speed : 200m/min
Stroke : 2500mm
Lubrication : initial lubrication only
Applied load: 34.5kN
Acceleration: 1.5G



Grease remains, and no anomaly is observed in the balls and grease.



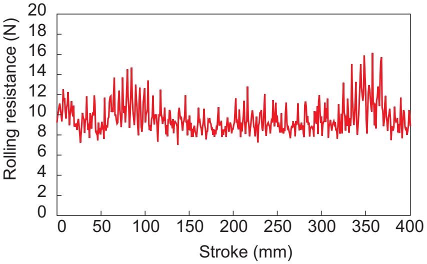
Detail view of the ball cage

[Smooth Motion]

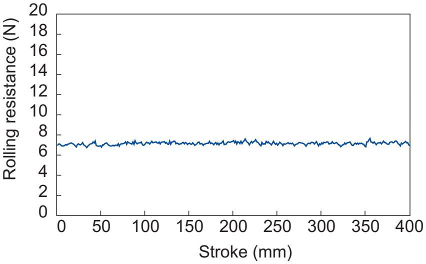
● Rolling Resistance Data

Use of a ball cage allows the balls to be uniformly aligned and prevents a line of balls from meandering as they enter the LM block. This enables smooth and stable motion to be achieved, minimizes fluctuations in rolling resistance, and ensures high accuracy, in any mounting orientation.

Model SHS25LV: Caged Ball LM Guide
Model HSR25LR: conventional full-ball type



Rolling Resistance Fluctuation Data with HSR25LR
(Feeding speed: 10mm/sec)



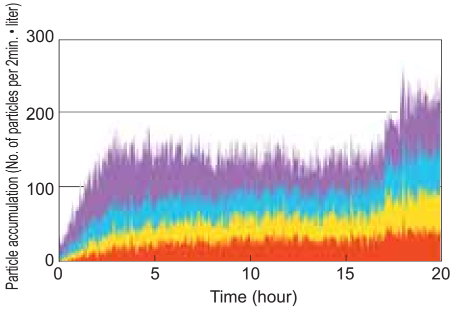
Rolling Resistance Fluctuation Data with SHS25LV
(Feeding speed: 10mm/sec)

[Low dust generation]

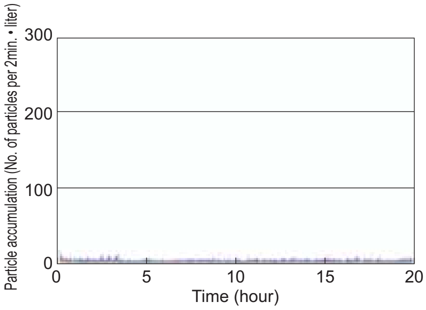
● Low Dust Generation Data

In addition to friction between balls, metallic contact has also been eliminated by using resin for the through holes. Furthermore, the Caged Ball LM Guide has a high level of grease retention and minimizes fly loss of grease, thus to achieve superbly low dust generation.

Particle diameter (μm)
🟪 0.3-0.5
🟦 0.5-1.0
🟨 1.0-2.0
🟥 2.0-5.0
⬛ 5.0-



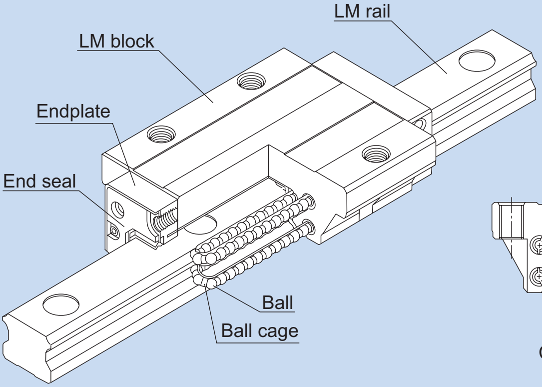
Conventional Full-ball Type

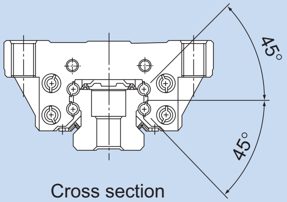


Caged Ball LM Guide Model SSR20

SHS

Caged Ball LM Guide
Global Standard Size Model SHS





Cross section

* For the ball cage, see A-130.

Structure and Features

Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and ball cages and endplates incorporated in the LM block allow the balls to circulate.
Each row of balls is placed at a contact angle of 45° so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse radial and lateral directions), enabling the LM Guide to be used in all orientations. In addition, the LM block can receive a well-balanced preload, increasing the rigidity in the four directions while maintaining a constant, low friction coefficient. With the low sectional height and the high rigidity design of the LM block, this model achieves highly accurate and stable straight motion.

[4-way Equal Load]

Each row of balls is placed at a contact angle of 45° so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse radial and lateral directions), enabling the LM Guide to be used in all orientations and in extensive applications.

[Self-adjustment Capability]

The self-adjustment capability through front-to-front configuration of THK's unique circular-arc grooves (DF set) enables a mounting error to be absorbed even under a preload, thus to achieve highly accurate, smooth straight motion.

[Global Standard Size]

SHS is designed to have dimensions almost the same as that of Full Ball LM Guide model HSR, which THK as a pioneer of the linear motion system has developed and is practically a global standard size.

[Low Center of Gravity, High Rigidity]

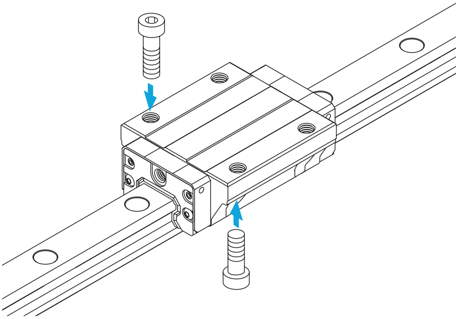
As a result of downsizing the LM rail section, the center of gravity is lowered and the rigidity is increased.

Types and Features

Model SHS-C

Specification Table⇒B-6

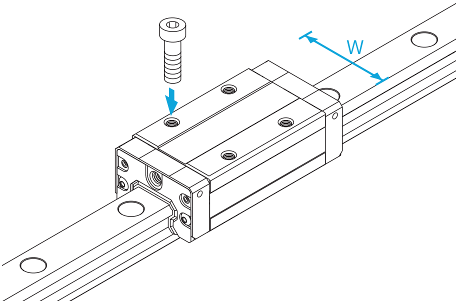
The flange of the LM block has tapped holes.
Can be mounted from the top or the bottom.
Used in places where the table cannot have through holes for mounting bolts.



Model SHS-V

Specification Table⇒B-8

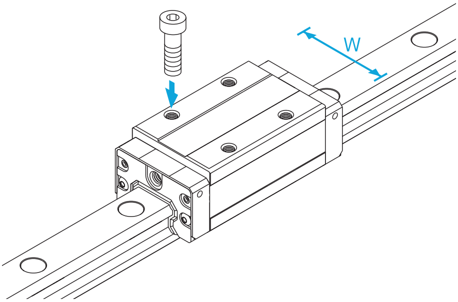
With this type, the LM block has a smaller width (W) and tapped holes.
Used in places where the space for table width is limited.



Model SHS-R

Specification Table⇒B-10

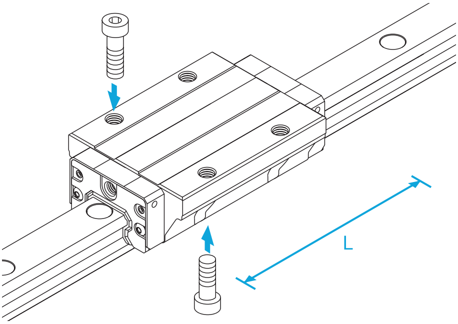
The LM block has a smaller width (W) and the mounting holes are tapped.
It succeeds the height dimension of full-ball type LM Guide HSR-R.



Model SHS-LC

Specification Table⇒B-6

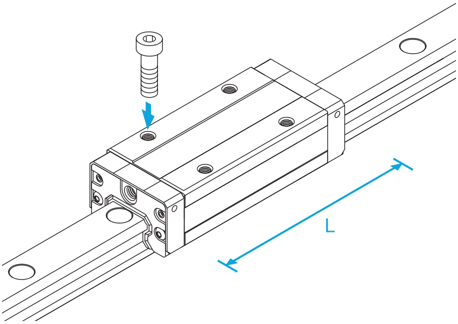
The LM block has the same cross-sectional shape as model SHS-C, but has a longer overall LM block length (L) and a greater rated load.



Model SHS-LV

Specification Table⇒B-8

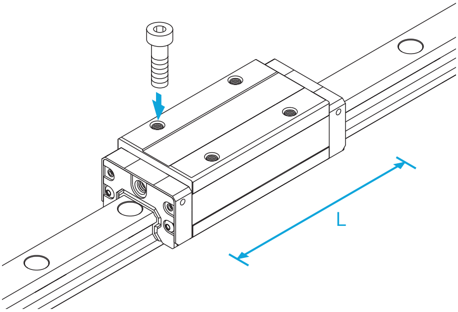
The LM block has the same cross-sectional shape as model SHS-V, but has a longer overall LM block length (L) and a greater rated load.



Model SHS-LR

Specification Table⇒B-10

The LM block has the same cross-sectional shape as model SHS-R, but has a longer overall LM block length (L) and a greater rated load.



Rated Loads in All Directions

Model SHS is capable of receiving loads in four directions: radial, reverse radial and lateral directions.

The basic load ratings are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for SHS.

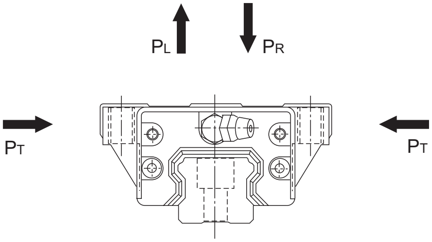


Fig.1

Equivalent Load

When the LM block of model SHS receives loads in all directions simultaneously, the equivalent load is obtained from the equation below.

$$\mathbf{P_E = P_R \; (P_L) + P_T}$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-113.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-327.

Error Allowance in the Parallelism between Two Rails

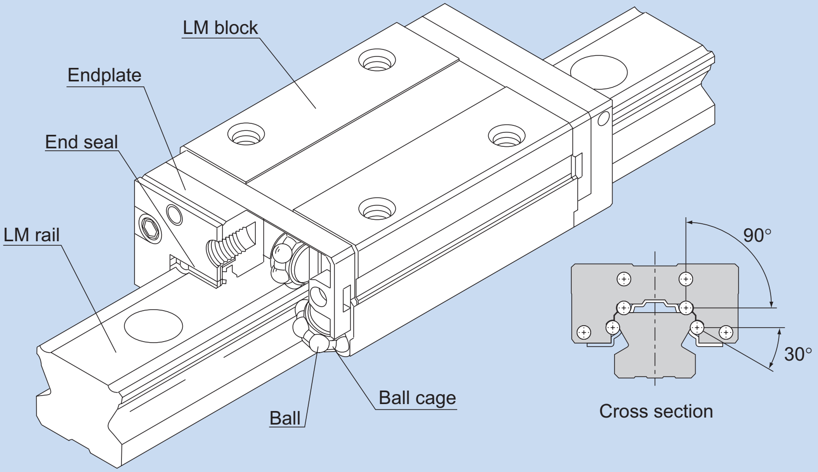
For details,see A-333.

Error Allowance in Vertical Level between Two Rails

For details,see A-336.

SSR

Caged Ball LM Guide
Radial Type Model SSR



* For the ball cage, see A-130.

Structure and Features

Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and ball cages and endplates incorporated in the LM block allow the balls to circulate.
Use of the ball cage eliminates friction between balls and increases grease retention, thus to achieve low noise, high speed and long-term maintenance-free operation.

[Compact, Radial Type]

The compact design with a low sectional height and the ball contact structure at 90° make SSR an optimal model for horizontal guides.

[Superb Planar Running Accuracy]

Use of a ball contact structure at 90° in the radial direction reduces displacement in the radial direction under a radial load and achieves highly accurate, smooth straight motion.

[Self-adjustment Capability]

The self-adjustment capability through front-to-front configuration of THK's unique circular-arc grooves (DF set) enables a mounting error to be absorbed even under a preload, thus to achieve highly accurate, smooth straight motion.

[Stainless Steel Type also Available as Standard]

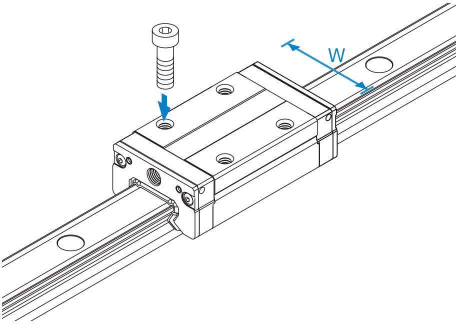
A stainless steel type with its LM block, LM rail and balls all made of stainless steel, which is superbly corrosion resistant, is also available as standard.

Types and Features

Model SSR-XW

Specification Table⇒B-16

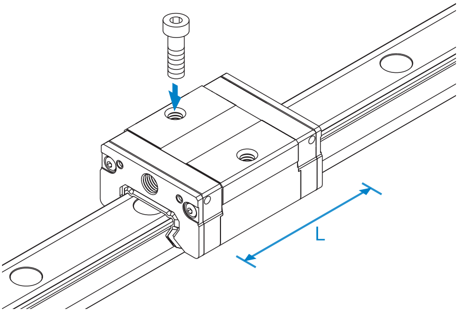
With this type, the LM block has a smaller width (W) and tapped holes.



Model SSR-XV

Specification Table⇒B-18

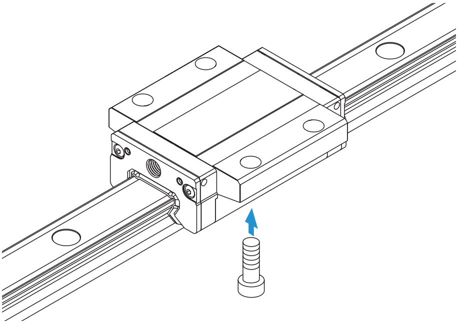
This type has the same cross-sectional shape as SSR-XW but has a shorter overall LM block length (L).



Model SSR-XTB

Specification Table⇒B-20

Since the LM block can be mounted from the bottom, this type is optimal for applications where through holes for mounting bolts cannot be drilled on the table.



Rated Loads in All Directions

Model SSR is capable of receiving loads in four directions: radial, reverse radial and lateral directions.
Its basic dynamic load rating is represented by the symbol in the radial direction indicated in Fig.1, and the actual value is provided in the specification table for SSR. The values in the reverse radial and lateral directions are obtained from Table1 below.

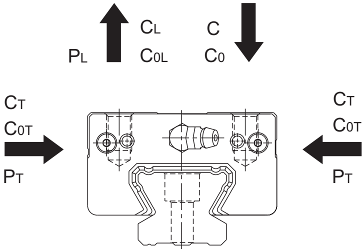


Fig.1

Table1 Rated Load of Model SSR in All Directions

Direction	Basic dynamic load rating	Basic static load rating
Radial direction	C	C_0
Reverse radial direction	$C_L=0.50C$	$C_{0L}=0.50C_0$
Lateral directions	$C_T=0.53C$	$C_{0T}=0.43C_0$

Equivalent Load

When the LM block of model SSR receives a reverse radial direction and a lateral direction simultaneously, the equivalent load is obtained in the equation below.

$$P_E = X \cdot P_L + Y \cdot P_T$$

P_E : Equivalent load (N)
: Reverse radial direction
: Lateral direction
P_L : Reverse radial load (N)
P_T : Lateral load (N)
X, Y : Equivalent factor (see Table2)

Table2 Equivalent Factor of Model SSR

P_E	X	Y
Equivalent load in reverse radial direction	1	1.155
Equivalent load in lateral direction	0.866	1

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-113.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-330.

Error Allowance in the Parallelism between Two Rails

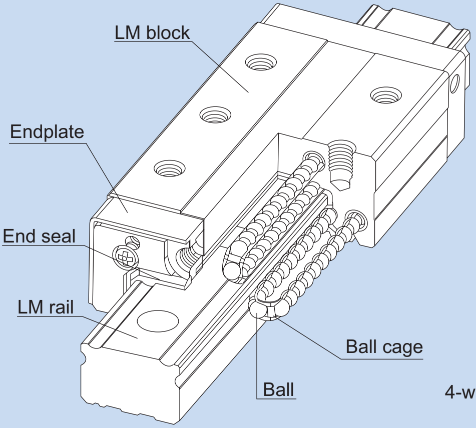
For details,see A-333.

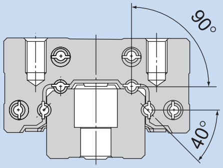
Error Allowance in Vertical Level between Two Rails

For details,see A-336.

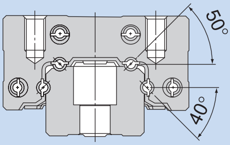
SNR/SNS

Caged Ball LM Guide
Ultra-heavy Load Type Models SNR/SNS





Radial type model SNR
Cross section



4-way equal load type model SNS
Cross section

* For the ball cage, see A-130.

Structure and Features ▶▶▶ A-149
Types and Features ▶▶▶ A-150
Rated Loads in All Directions ▶▶▶ A-153
Equivalent Load ▶▶▶ A-153
Service Life ▶▶▶ A-100
Radial Clearance Standard ▶▶▶ A-113
Accuracy Standards ▶▶▶ A-119
Shoulder Height of the Mounting Base and the Corner Radius ▶▶▶ A-327
Error Allowance in the Parallelism between Two Rails ▶▶▶ A-333/A-334
Error Allowance in Vertical Level between Two Rails ▶▶▶ A-336/A-337
Dimensional Drawing, Dimensional Table, Example of Model Number Coding ▶▶▶ B-26
Standard Length and Maximum Length of the LM Rail ▶▶▶ B-42

Structure and Features

Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and ball cages and endplates incorporated in the LM block allow the balls to circulate. Use of the ball cage eliminates friction between balls and increases grease retention, thus to achieve low noise, high speed and long-term maintenance-free operation.

[High Rigidity]

Models SNR/SNS are the most rigid types among the Caged Ball LM Guide series.
Both the radial type SNR and the 4-way equal load type SNS are available for each size variation. Depending on the intended use, you can select either type.

[Ultra-heavy Load]

Since the curvature of the raceway is approximated to the ball diameter, the ball contact area under a load is increased and the LM Guide is capable of receiving an ultra-heavy load.

[Increased Damping Effect]

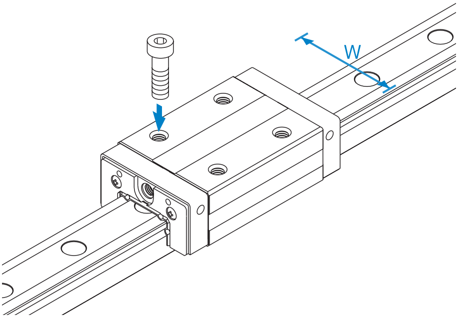
In rapid traverse where the LM block travels at high speed, no differential slip occurs and smooth motion is maintained, thus achieving highly accurate positioning. In heavy cutting where the LM block travels at low speed, favorable differential slip according to the cutting load occurs to increase frictional resistance, thus increasing the damping capacity.

Types and Features

Models SNR-R/SNS-R

Specification Table⇒B-26/B-28

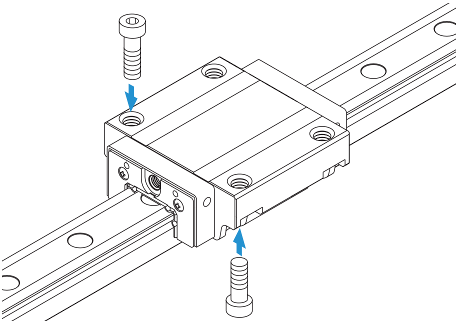
With this type, the LM block has a smaller width (W) and tapped holes.
Used in places where the space for table width is limited.



Models SNR-C/SNS-C

Specification Table⇒B-30/B-32

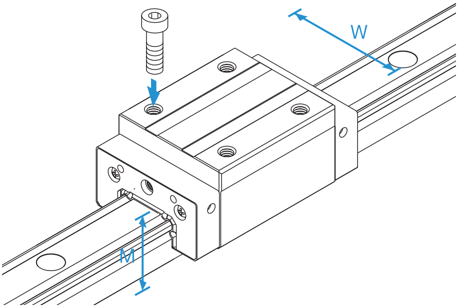
The flange of the LM block has tapped holes.
Can be mounted from the top or the bottom.
Used in places where the table cannot have through holes for mounting bolts.



Models SNR-RH/SNS-RH (Build to Order)

Specification Table⇒B-34/B-36

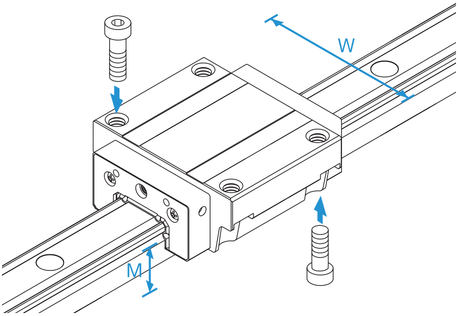
The dimensions are almost the same as that of LM Guide models SHS and HSR, and the LM block has tapped holes.



Models SNR-CH/SNS-CH (Build to Order)

Specification Table⇒B-38/B-40

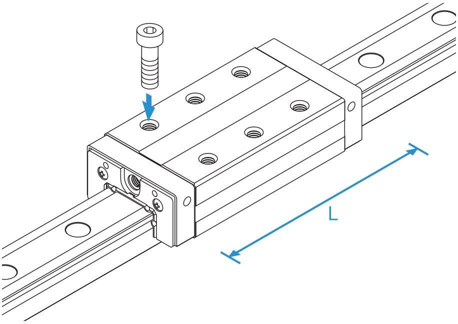
The dimensions are almost the same as that of LM Guide models SHS and HSR, and the flange of the LM block has tapped holes.



Models SNR-LR/SNS-LR

Specification Table⇒B-26/B-28

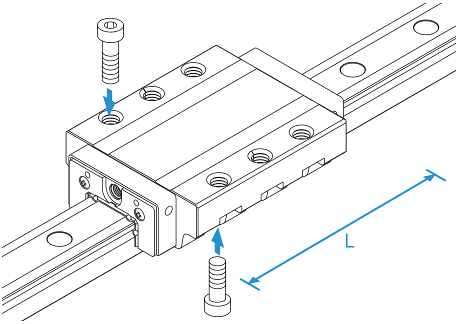
The LM block has the same cross-sectional shape as models SNR-R/SNS-R, but has a longer overall LM block length (L) and a greater rated load.



Models SNR-LC/SNS-LC

Specification Table⇒B-30/B-32

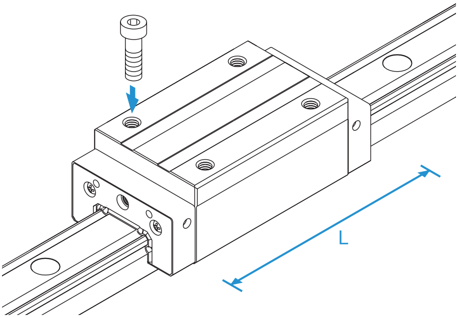
The LM block has the same cross-sectional shape as models SNR-C/SNS-C, but has a longer overall LM block length (L) and a greater rated load.



Models SNR-LRH/SNS-LRH (Build to Order)

Specification Table⇒B-34/B-36

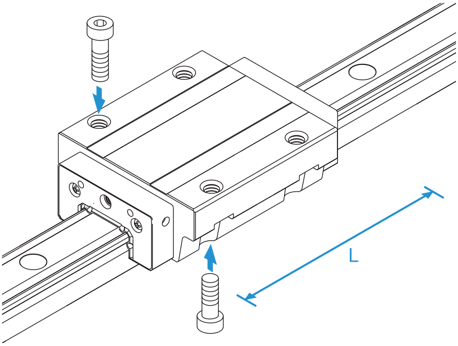
The LM block has the same cross-sectional shape as models SNR-RH/SNS-RH, but has a longer overall LM block length (L) and a greater rated load.



Models SNR-LCH/SNS-LCH (Build to Order)

Specification Table⇒B-38/B-40

The LM block has the same cross-sectional shape as models SNR-CH/SNS-CH, but has a longer overall LM block length (L) and a greater rated load.



Rated Loads in All Directions

Model SNR/SNS is capable of receiving loads in four directions: radial, reverse radial and lateral directions. Their basic dynamic load ratings are represented by the symbols in the radial direction indicated in Fig.1, and the actual values are provided in the specification tables for SNR/SNS. The values in the reverse radial and lateral directions are obtained from Table1 and Table2 below.

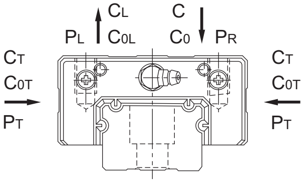


Fig.1

Table1 Basic Load Ratings of Model SNR in All Directions

Direction	SNR	
	Basic dynamic load rating	Basic static load rating
Radial direction	C	C_0
Reverse radial direction	$C_L=0.64C$	$C_{0L}=0.64C_0$
Lateral directions	$C_T=0.47C$	$C_{0T}=0.38C_0$

Table2 Basic Load Ratings of Model SNS in All Directions

Direction	SNS	
	Basic dynamic load rating	Basic static load rating
Radial direction	C	C_0
Reverse radial direction	$C_L=0.84C$	$C_{0L}=0.84C_0$
Lateral directions	$C_T=0.84C$	$C_{0T}=0.84C_0$

Equivalent Load

When the LM block of model SNR receives a reverse radial load and a lateral load simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_L + Y \cdot P_T$$

P_E : Equivalent load (N)
: Reverse radial direction
: Lateral direction
P_L : Reverse radial load (N)
P_T : Lateral load (N)
X, Y : Equivalent factor (see Table3)

Table3 Equivalent Factor of Model SNR

P_E	X	Y
Equivalent load in reverse radial direction	1	1.678
Equivalent load in lateral direction	0.596	1

When the LM block of model SNS receives a radial load and a lateral load, or a reverse radial load and a lateral load, simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_R\ (P_L) + Y \cdot P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)
X, Y : Equivalent factor
(see Table4 and Table5)

Table4 Equivalent Factor of Model SNS
(When radial and lateral loads are applied)

P_E	X	Y
Equivalent load in the radial direction	1	0.935
Equivalent load in lateral direction	1.07	1

Table5 Equivalent Factor of Model SNS
(When reverse radial load and lateral load are applied)

P_E	X	Y
Equivalent load in reverse radial direction	1	1.02
Equivalent load in lateral direction	0.986	1

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-113.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-327.

Error Allowance in the Parallelism between Two Rails

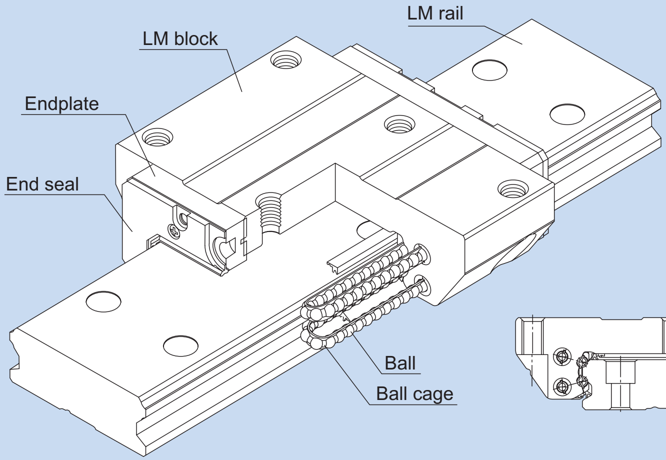
For details, A-333 and A-334.

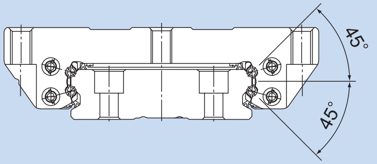
Error Allowance in Vertical Level between Two Rails

For details, A-336 and A-337.

SHW

Caged Ball LM Guide
Wide Rail Model SHW





* For the ball cage, see A-130.

Structure and Features

A wide and highly rigid LM Guide that uses ball cages to achieve low noise, long-term maintenance-free operation and high speed.

[Wide, Low Center of Gravity]
Model SHW, which has a wide LM rail and a low center of gravity, is optimal for locations requiring space saving and large M_C moment rigidity.

[4-way Equal Load]
Each row of balls is placed at a contact angle of 45° so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse radial and lateral directions), enabling the LM Guide to be used in all orientations and in extensive applications.

[Self-adjustment Capability]
The self-adjustment capability through front-to-front configuration of THK's unique circular-arc grooves (DF set) enables a mounting error to be absorbed even under a preload, thus to achieve highly accurate, smooth straight motion.

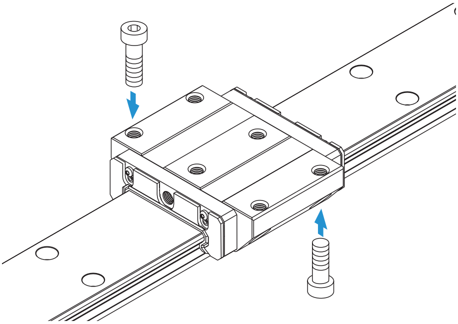
[Low Dust Generation]
Use of ball cages eliminates friction between balls and retains lubricant, thus achieving low dust generation.

Types and Features

Model SHW-CA

Specification Table⇒B-44

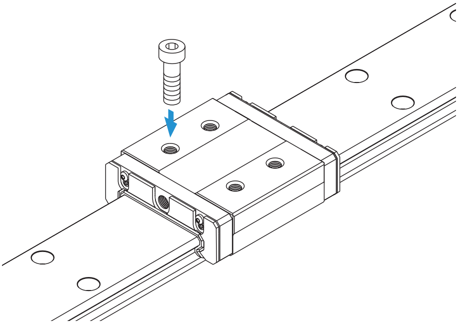
The flange of the LM block has tapped holes.
Can be mounted from the top or the bottom.



Model SHW-CR

Specification Table⇒B-46

The LM block has tapped holes.



Rated Loads in All Directions

Model SHW is capable of receiving loads in four directions: radial, reverse radial and lateral directions.

The basic load ratings are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for SHW.

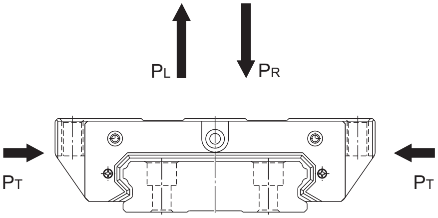


Fig.1

Equivalent Load

When the LM block of model SHW receives loads in all directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R \ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-113.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-330.

Error Allowance in the Parallelism between Two Rails

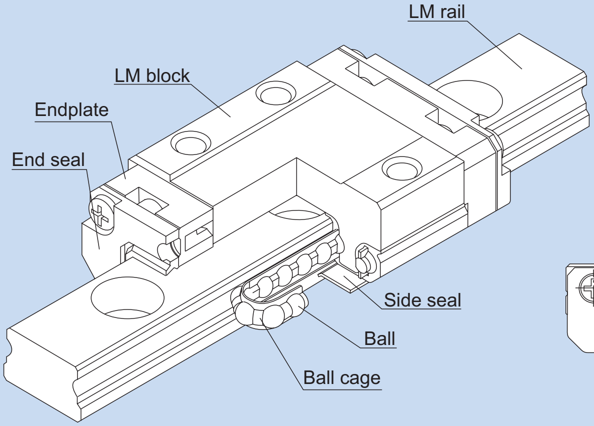
For details,see A-334.

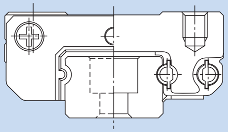
Error Allowance in Vertical Level between Two Rails

For details,see A-337.

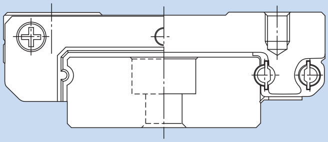
SRS

Caged Ball LM Guide
Miniature Type Model SRS





Compact type
Model SRS-M



Wide type
Model SRS-WM

* For the ball cage, see A-130.

Structure and Features

Caged Ball LM Guide model SRS has a structure where two raceways are incorporated into the compact body, enabling the model to receive loads in all directions, and to be used in locations where a moment is applied with a single rail. In addition, use of ball cages eliminates friction between balls, thus achieving high speed, low noise, acceptable running sound, long service life, and long-term maintenance-free operation.

[Low Dust Generation]
Use of ball cages eliminates friction between balls and retains lubricant, thus achieving low dust generation. In addition, the LM block and LM rail use stainless steel, which is highly resistant to corrosion.

[4-way Equal Load Type]
Since the right and left rows of balls under a load contact the raceway at 45°, this LM Guide is capable of receiving loads in the radial, reverse radial and lateral directions at equal values and being used in any orientations. With this well-balanced structure, this model can be used in extensive applications.

[Compact]
Since SRS has a compact structure where the rail cross section is designed to be low and that contains only two rows of balls, it can be installed in space-saving locations.

[Lightweight]
Since part of the LM block (e.g., around the ball relief hole) is made of resin and formed through insert molding, SRS is a lightweight, low inertia type of LM Guide.

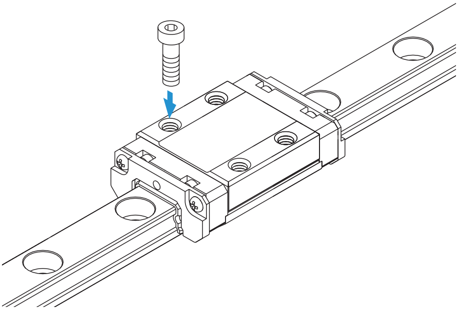
Types and Features

Model SRS-M

Specification Table⇒B-50

A standard type of SRS.

Note) In addition to model SRS-M, a full-ball type without ball cage is also available.If desiring this type, indicate type "SRS-G" when placing an order.However, since SRS-G does not have a ball cage, its dynamic load rating is smaller than SRS-M. See the table of basic load ratings for SRS-G on B-51 for details.

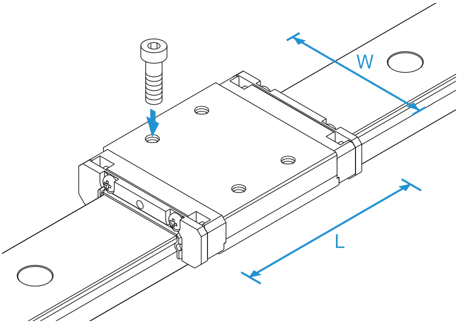


Model SRS-WM

Specification Table⇒B-52

Has a longer overall LM block length (L), a greater width and a larger rated load and permissible moment than SRS-M.

Note) In addition to model SRS-WM, a full-ball type without ball cage is also available.If desiring this type, indicate type "SRS-G" when placing an order.However, since SRS-G does not have a ball cage, its dynamic load rating is smaller than SRS-WM. See the table of basic load ratings for SRS-G on B-53 for details.



Rated Loads in All Directions

Model SRS is capable of receiving loads in four directions: radial, reverse radial and lateral directions.
Their basic dynamic load ratings are represented by the symbols in the radial direction indicated in Fig.1, and the actual values are provided in the specification table for SRS. The values in the reverse radial and lateral directions are obtained from Table1 below.

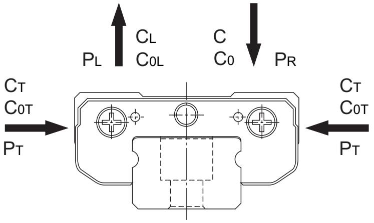


Fig.1

Table1 Rated Loads of Model SRS in All Directions

Direction	Basic dynamic load rating	Basic static load rating
Radial direction	C	C_0
Reverse radial direction	$C_L=C$	$C_{0L}=C_0$
Lateral directions (7M/7WM/ 9M/9WM/20M)	$C_T=1.19C$	$C_{0T}=1.19C_0$
Lateral directions (12M/12WM/ 15M/15WM/25M)	$C_T=C$	$C_{0T}=C_0$

Equivalent Load

When the LM block of model SRS receives a reverse radial load and a lateral load simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_R \, (P_L) + Y \cdot P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)
X, Y : Equivalent factor (see Table2)

Table2 Equivalent Factor of Model SRS

Equivalent Load P_E	Model No.	X	Y
Radial and reverse radial direction	7M/7WM/9M/ 9WM/20M	1	0.839
	12M/12WM/15M/ 15WM/25M	1	1
Lateral directions	7M/7WM/9M/ 9WM/20M	1.192	1
	12M/12WM/15M/ 15WM/25M	1	1

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-113.

Accuracy Standards

For details,see A-126.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-332.

Error Allowance in the Parallelism between Two Rails

For details,see A-334.

Error Allowance in Vertical Level between Two Rails

For details,see A-337.

Flatness of the LM Rail and the LM Block Mounting Surface

The values in Table3 apply when the clearance is a normal clearance. If the clearance is C1 clearance and two rails are used in combination, we recommend using 50% or less of the value in the table.

Note) Since SRS has Gothic-arch grooves, any accuracy error in the mounting surface may negatively affect the operation. Therefore, we recommend using SRS on a highly accurate mounting surface.

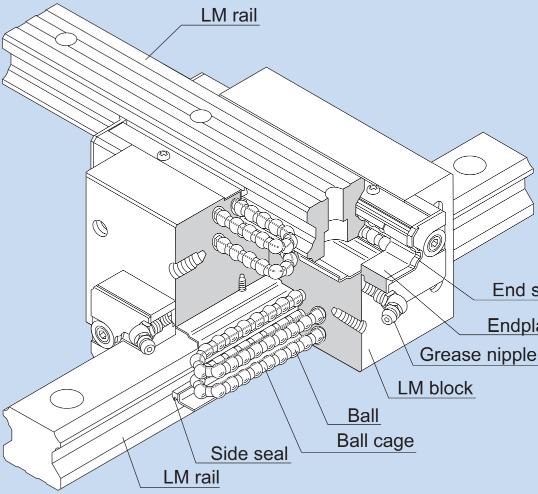
Table3 Flatness of the LM Rail and the LM Block Mounting Surface

Unit: mm

Model No.	Flatness error
SRS 7M	0.025/200
SRS 7WM	0.025/200
SRS 9M	0.035/200
SRS 9WM	0.035/200
SRS 12M	0.050/200
SRS 12WM	0.050/200
SRS 15M	0.060/200
SRS 15WM	0.060/200
SRS 20M	0.070/200
SRS 25M	0.070/200

SCR

Caged Ball LM Guide
Cross LM Guide Model SCR



* For the ball cage, see A-130.

Structure and Features

Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and ball cages and endplates incorporated in the LM block allow the balls to circulate.
This model is an integral type of Caged Ball LM Guide that squares an internal structure similar to model SHS, which has a proven track record and is highly reliable, with another and uses two LM rails in combination. Since an orthogonal LM system can be achieved with model SCR alone, a conventionally required saddle is no longer necessary, the structure for X-Y motion can be simplified and the whole system can be downsized.

[4-way Equal Load]

Each row of balls is placed at a contact angle of 45° so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse radial and lateral directions), enabling the LM Guide to be used in all orientations and in extensive applications.

[High Rigidity]

Since balls are arranged in four rows in a well-balanced manner, this model is stiff against a moment, and smooth straight motion is ensured even a preload is applied to increase the rigidity.
Since the rigidity of the LM block is higher than that of a combination of two LM blocks of the conventional type secured together back-to-back with bolts, this model is optimal for building an X-Y table that requires a high rigidity.

[Compact]

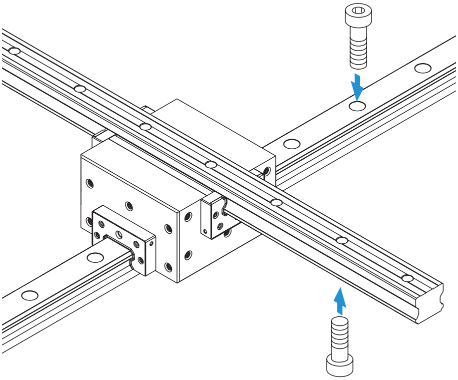
This model is an integral type of Caged Ball LM Guide that squares an internal structure similar to model SHS, which has a proven track record and is highly reliable, with another and uses two LM rails in combination. Since an orthogonal LM Guide can be achieved with model SCR alone, a conventionally required saddle is no longer necessary, the structure for X-Y motion can be simplified and the whole system can be downsized.

Types and Features

Model SCR

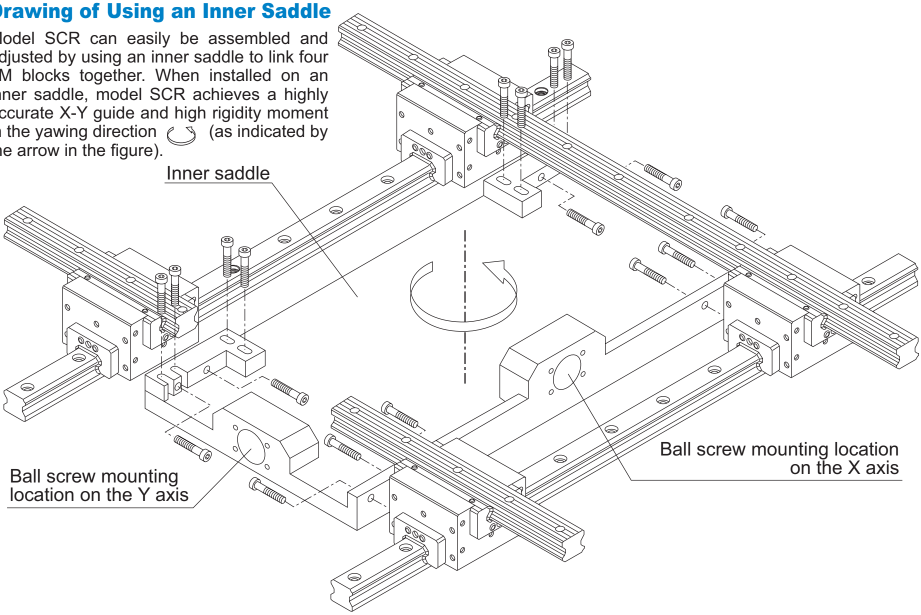
Specification Table⇒B-56

This model is a standard type.



Drawing of Using an Inner Saddle

Model SCR can easily be assembled and adjusted by using an inner saddle to link four LM blocks together. When installed on an inner saddle, model SCR achieves a highly accurate X-Y guide and high rigidity moment in the yawing direction ↻ (as indicated by the arrow in the figure).



Rated Loads in All Directions

Model SCR is capable of receiving loads in four directions: radial, reverse radial and lateral directions.
The basic load ratings are defined with a LM rail and a LM block, and uniform in the four directions (radial, reverse radial and lateral directions). Their actual values are provided in the specification table for SCR.

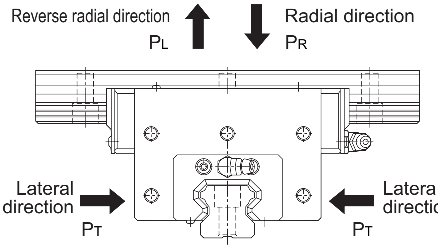


Fig.1

Equivalent Load

When the LM block of model SCR receives loads in all directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R \ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-113.

Accuracy Standards

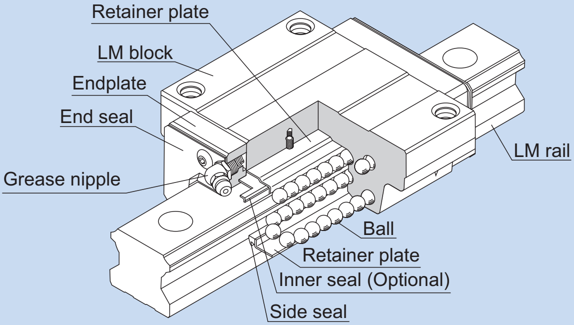
For details,see A-122.

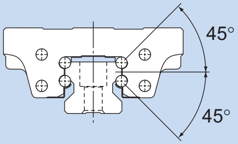
Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-327.

HSR

LM Guide
Global Standard Size Model HSR





Cross section

Structure and Features

Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate.

Since retainer plates hold the balls, they do not fall off even if the LM rail is pulled out (except models HSR 8, 10 and 12).

Each row of balls is placed at a contact angle of 45° so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse radial and lateral directions), enabling the LM Guide to be used in all orientations. In addition, the LM block can receive a well-balanced preload, increasing the rigidity in the four directions while maintaining a constant, low friction coefficient. With the low sectional height and the high rigidity design of the LM block, this model achieves highly accurate and stable straight motion.

[4-way Equal Load Type]

Each row of balls is placed at a contact angle of 45° so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse radial and lateral directions), enabling the LM Guide to be used in all orientations and in extensive applications.

[High Rigidity Type]

Since balls are arranged in four rows in a well-balanced manner, a large preload can be applied and the rigidity in four directions can easily be increased.

[Self-adjustment Capability]

The self-adjustment capability through front-to-front configuration of THK's unique circular-arc grooves (DF set) enables a mounting error to be absorbed even under a preload, thus to achieve highly accurate, smooth straight motion.

[High Durability]

Even under a preload or excessive biased load, differential slip of balls does not occur. As a result, smooth motion, high wear resistance, and long-term maintenance of accuracy are achieved.

[Stainless Steel Type also Available]

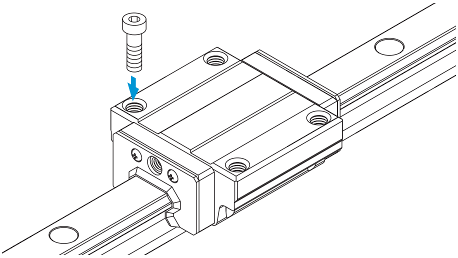
A special type which LM block, LM rail and balls are made of stainless steel is also available.

Types

Model HSR-A

Specification Table⇒B-62

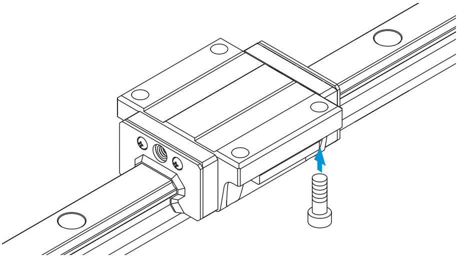
The flange of its LM block has tapped holes.



Model HSR-B

Specification Table⇒B-64

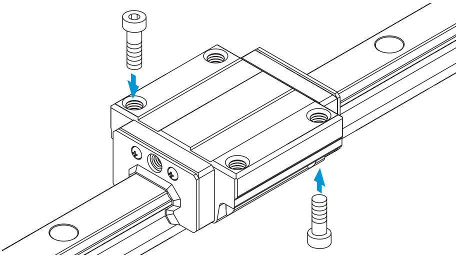
The flange of the LM block has through holes. Used in places where the table cannot have through holes for mounting bolts.



Model HSR-R Grade Ct

Specification Table⇒B-66

The flange of its LM block has tapped holes.
Can be mounted from the top or the bottom.

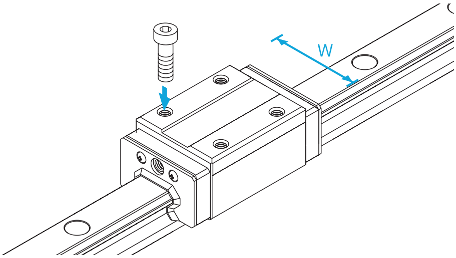


Model HSR-R

Specification Table⇒B-70

Having a smaller LM block width (W) and tapped holes, this model is optimal for compact design.

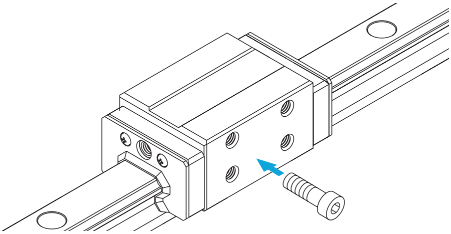
Low-priced LM rails and LM blocks are individually stocked. We also have Ct grade model HSR-R available with a short delivery time.



Model HSR-YR

Specification Table⇒B-74

When using two units of LM Guide facing each other, the previous model required much time in machining the table and had difficulty achieving the desired accuracy and adjusting the clearance. Since model HSR-YR has tapped holes on the side of the LM block, a simpler structure is gained and reduced man-hour and increase in accuracy can be achieved.



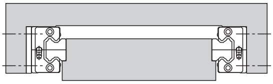


Fig.1 Conventional Structure

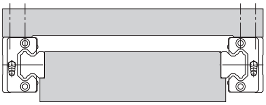
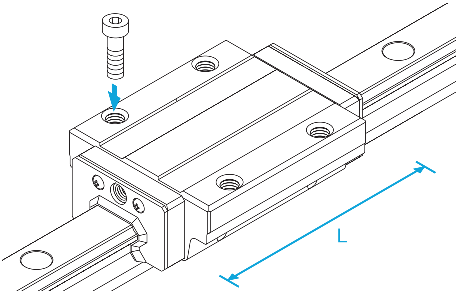


Fig.2 Mounting Structure for Model HSR-YR

Model HSR-LA

Specification Table⇒B-62

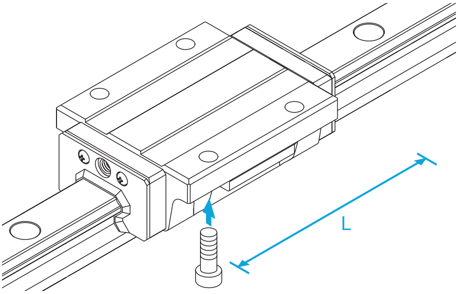
The LM block has the same cross-sectional shape as model HSR-A, but has a longer overall LM block length (L) and a greater rated load.



Model HSR-LB

Specification Table⇒B-64

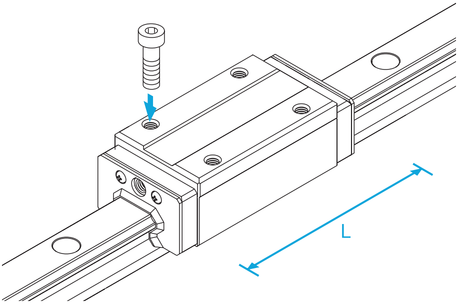
The LM block has the same cross-sectional shape as model HSR-B, but has a longer overall LM block length (L) and a greater rated load.



Model HSR-LR

Specification Table⇒B-70

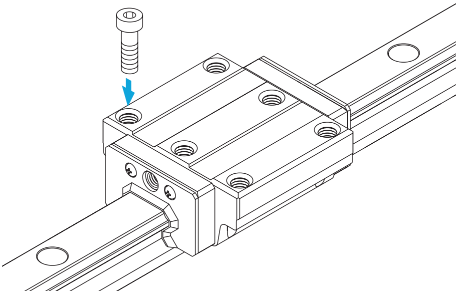
The LM block has the same cross-sectional shape as model HSR-R, but has a longer overall LM block length (L) and a greater rated load.



Model HSR-CA

Specification Table⇒B-76

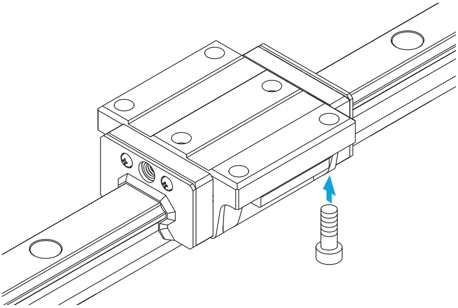
Has six tapped holes on the LM block.



Model HSR-CB

Specification Table⇒B-78

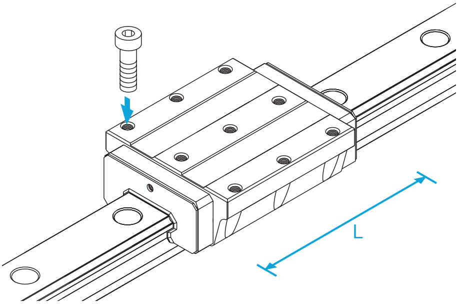
The LM block has six through holes. Used in places where the table cannot have through holes for mounting bolts.



Model HSR-HA

Specification Table⇒B-76

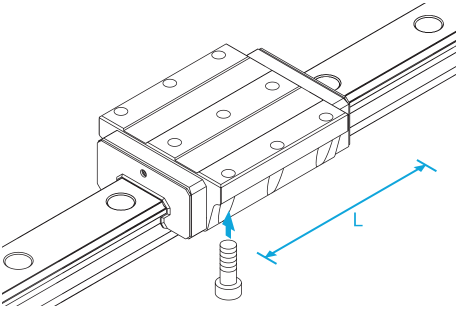
The LM block has the same cross-sectional shape as model HSR-CA, but has a longer overall LM block length (L) and a greater rated load.



Model HSR-HB

Specification Table⇒B-78

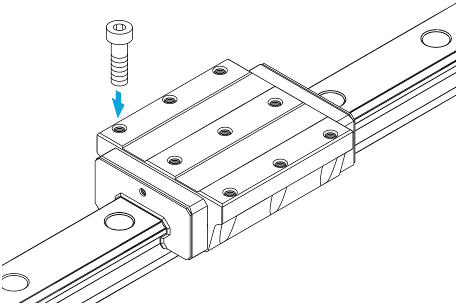
The LM block has the same cross sectional shape as model HSR-CB, but has a longer overall LM block length (L) and a greater rated load.



Models HSR 100/120/150 HA/HB/HR

Specification Table⇒B-80

Large types of model HSR that can be used in large-scale machine tools and building structures.



Rated Loads in All Directions

The basic load ratings are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for HSR.

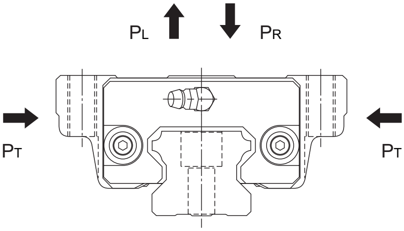


Fig.3 Model HSR

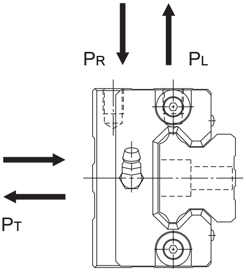


Fig.4 Model HSR-YR

Equivalent Load

When the LM block of model HSR receives loads in the reverse radial and lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R \ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-114.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-328.

Error Allowance in the Parallelism between Two Rails

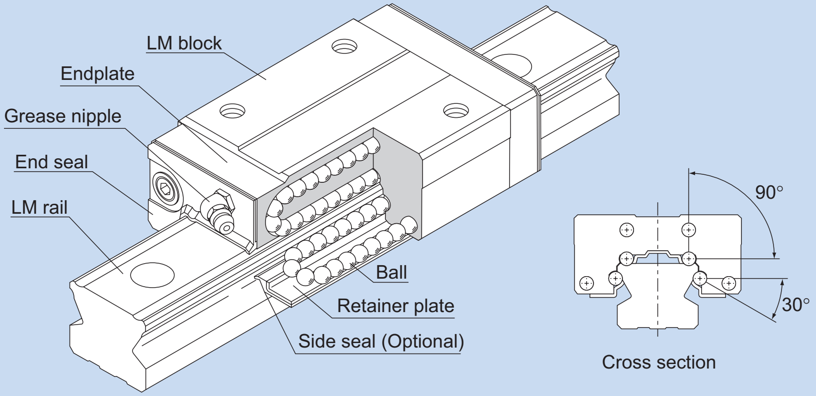
For details,see A-333.

Error Allowance in Vertical Level between Two Rails

For details,see A-336.

SR

LM Guide
Radial Type Model SR



Structure and Features

Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate. Since a retainer plate holds the balls, they will not fall off even if the LM block is removed from the LM rail. With the low sectional height and the high rigidity design of the LM block, this model achieves highly accurate and stable straight motion.

[Compact, Heavy Load]

Since it is a compact designed model that has a low sectional height and a ball contact structure rigid in the radial direction, this model is optimal for horizontal guide units.

[Mounting accuracy can easily be achieved]

Since this model is a self-adjusting type capable of easily absorbing an accuracy error in parallelism and level between two rails, highly accurate and smooth motion can be achieved.

[Low Noise]

The endplate installed at each end of the LM block is designed to ensure the smooth and low-noise circulation of the balls at the turning areas.

[High Durability]

Even under a preload or excessive biased load, differential slip of balls is minimal. As a result, high wear resistance and long-term maintenance of accuracy are achieved.

[Stainless Steel Type also Available]

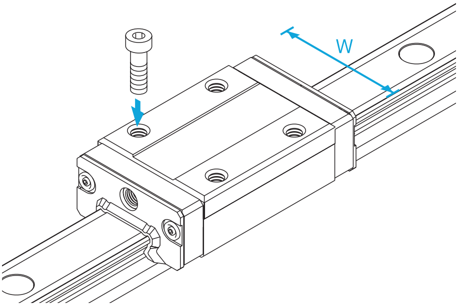
A special type which LM block, LM rail and balls are made of stainless steel is also available.

Types and Features

Model SR-W

Specification Table⇒B-86

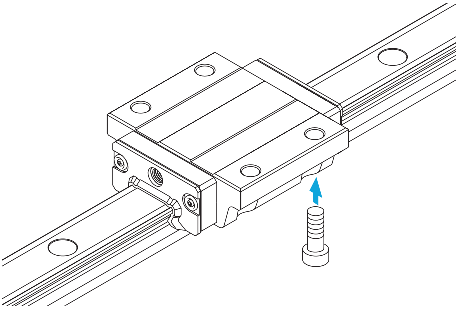
With this type, the LM block has a smaller width (W) and tapped holes.



Model SR-TB

Specification Table⇒B-88

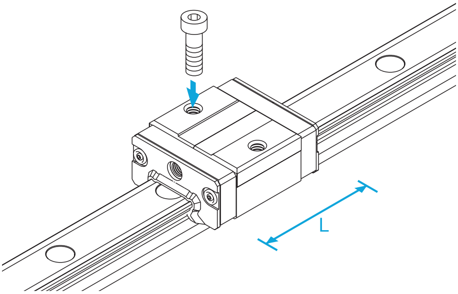
The LM block has the same height as model SR-W and can be mounted from the bottom.



Model SR-V

Specification Table⇒B-86

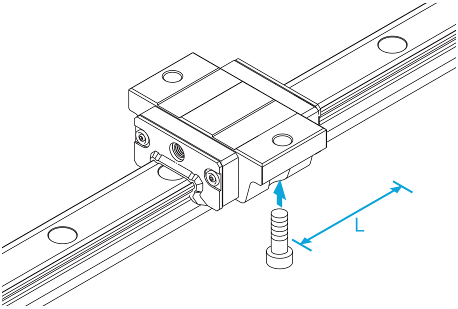
A space-saving type whose LM block has the same cross-sectional shape as model SR-W, but has a smaller overall LM block length (L).



Model SR-SB

Specification Table⇒B-88

A space-saving type whose LM block has the same cross-sectional shape as model SR-TB, but has a smaller overall LM block length (L).



Characteristics of Model SR

When compared to models having a contact angle of 45°, model SR shows excellent characteristics as indicated below. Using these characteristics, you can design and manufacture highly accurate and highly rigid machines or equipment.

Difference in Rated Load and Service Life

Since SR has a contact angle of 90°, its rated load and service life are different from those with a contact angle of 45°. When comparing model SR with a model that has a contact angle of 45° and when the same radial load is applied to the two models with the same ball diameter as shown in the figure below, the load applied to SR is 70% of the other model. As a result, the service life of SR is more than twice that of the other model.

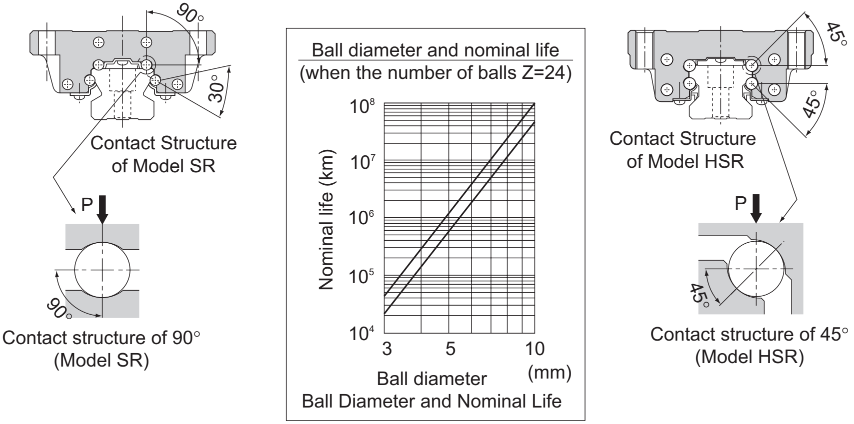


Fig.1

Difference in Accuracy

If a machining error (grinding error) occurs in the LM rail or LM block, it will affect the running accuracy. Assuming that there is a machining error of Δ on the raceway, it results in an error in the radial direction, and the error with the contact angle of 45° (model HSR) is 1.4 times greater than that of the contact angle of 90° (model SR). As for the machining error resulting in horizontal direction error, the error with the contact angle of 45° is 1.22 times greater than the contact angle of 30° .

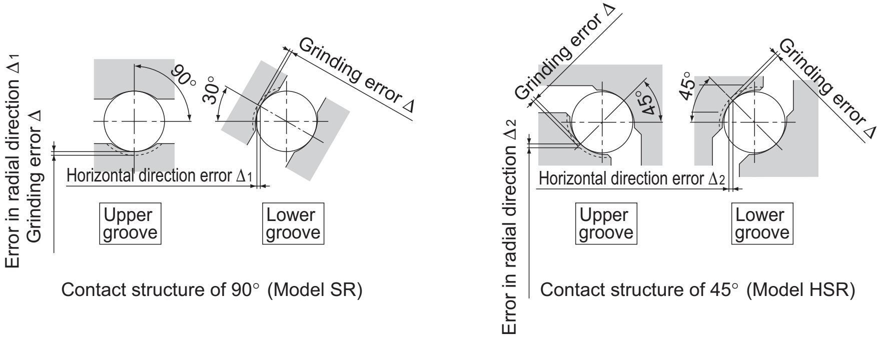


Fig.2 Machining Error and Accuracy

Difference in Rigidity

The 90° contact angle adopted by model SR has a difference with the 45° contact angle also in rigidity.
When the same radial load "P" is applied, the displacement in the radial direction with model SR is only 56% of that with the contact angle of 45°. Accordingly, where high rigidity in the radial direction is required, model SR is more advantageous. The figure below shows the difference in radial load and displacement.

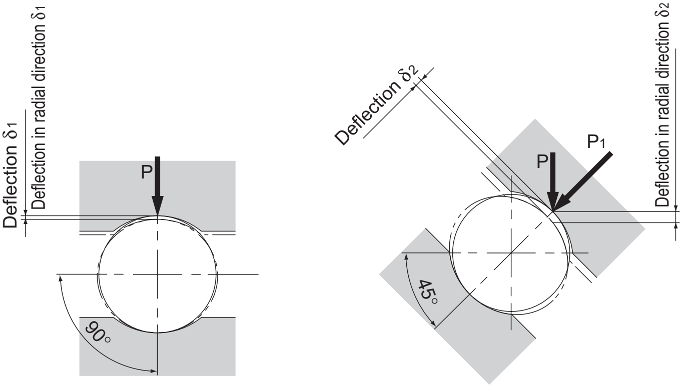


Fig.3 Deflection under a Radial Load

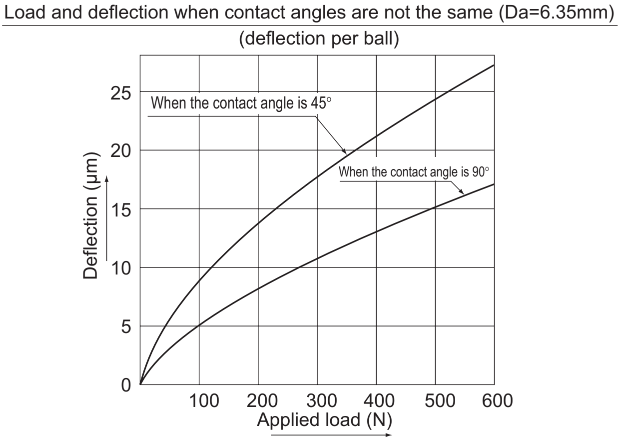


Fig.4 Radial Load and Deflection

Conclusion

As suggested above, model SR, which has a contact angle of 90° in the radial direction, is optimal for locations where the radial load is large, high rigidity is required or high running accuracy in the vertical and horizontal directions is required.
However, if the reverse radial load, the lateral load or the moment is large, we recommend model HSR, which has a contact angle of 45° (4-way equal load).

Rated Loads in All Directions

Model SR is capable of receiving loads in four directions: radial, reverse radial and lateral directions.

The basic load ratings indicate the values in the radial directions in Fig.5, and their actual values are provided in the specification table for SR. The values in the reverse radial and lateral directions are obtained from Table1 below.

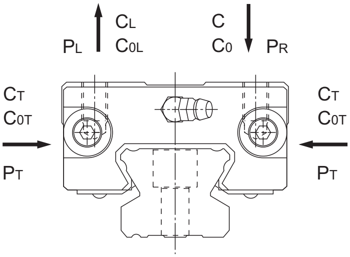


Fig.5

Table1 Rated Loads in All Directions with Model SR

Model No.	Direction	Basic dynamic load rating	Basic static load rating
SR 15 to 70	Radial direction	C	C_0
	Reverse radial direction	$C_L=0.62C$	$C_{0L}=0.50C_0$
	Lateral directions	$C_T=0.56C$	$C_{0T}=0.43C_0$
SR 85 to 150	Radial direction	C	C_0
	Reverse radial direction	$C_L=0.78C$	$C_{0L}=0.71C_0$
	Lateral directions	$C_T=0.48C$	$C_{0T}=0.35C_0$

Equivalent Load

When the LM block of model SR receives loads in the reverse radial and lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_L + Y \cdot P_T$$

P_E : Equivalent load (N)
: Reverse radial direction
: Lateral direction
P_L : Reverse radial load (N)
P_T : Lateral load (N)
X, Y : Equivalent factor (see Table2)

Table2 Equivalent Factor of Model SR

Model No.	P_E	X	Y
SR 15 to 70	Equivalent load in reverse radial direction	1	1.155
	Equivalent load in lateral direction	0.866	1
SR 85 to 150	Equivalent load in reverse radial direction	1	2
	Equivalent load in lateral direction	0.5	1

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-114.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-326.

Error Allowance in the Parallelism between Two Rails

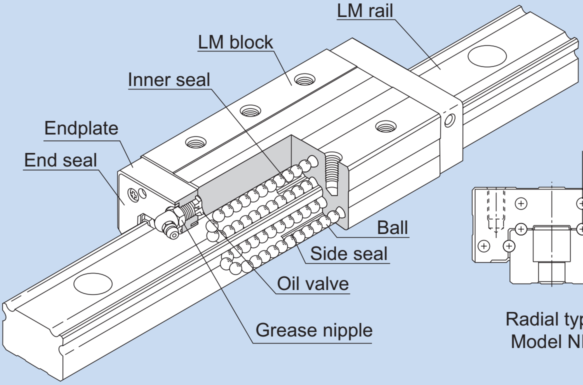
For details,see A-333.

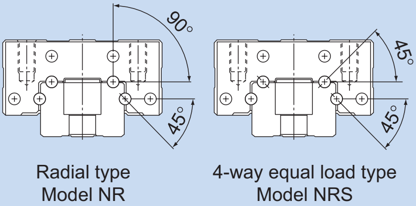
Error Allowance in Vertical Level between Two Rails

For details,see A-336.

NR/NRS

LM Guide
Ultra-heavy Load Type Models NR/NRS





Radial type
Model NR

4-way equal load type
Model NRS

Cross section

Structure and Features

Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate. The raceways are cut into deep grooves that have a radius closer to that of the balls than in the conventional design, using special equipment and an extremely precise cutting technique. This design allows high rigidity, high vibration/impact resistance and high damping capacity, all of which are required for machine tools, thus making these models capable of bearing ultra-heavy loads.

[Improved Damping Capacity]

While the machine tool (equipped with NR or NRS) is not cutting a workpiece during operation, the LM Guide travels normally and smoothly. While the machine tool is cutting the workpiece, the cutting force is applied to the LM Guide to increase and the contact area between the balls and the raceway, allowing an appropriate mixture of rolling and sliding motions to be achieved. Accordingly, the friction resistance is increased and the damping capacity is improved.

Since the absolute slip during the rolling and sliding motion is insignificant, it causes little wear and does not affect the service life.

[Highly Rational LM Guide]

The excessively large differential slip occurring in a Gothic-arch groove does not happen with these models. They smoothly travel and achieve high positioning accuracy during fast feeding. During the cutting operation, appropriate slip occurs according to the cutting load, the rolling resistance is increased and the damping capacity is increased. Thus, models NR and NRS are highly rational LM Guides.

[High Rigidity]

To increase the rigidity of the LM block and the LM rail, which may deteriorate the overall rigidity of the LM Guide in the reverse radial and lateral directions, THK made full use of FEM to achieve optimal design within the limited dimensional range.

For both the radial type model NR and the 4-way equal load type model NRS, THK offers two types with the same dimensions and different characteristics. It allows you to select the desired type according to the application.

[Ultra-heavy Load]

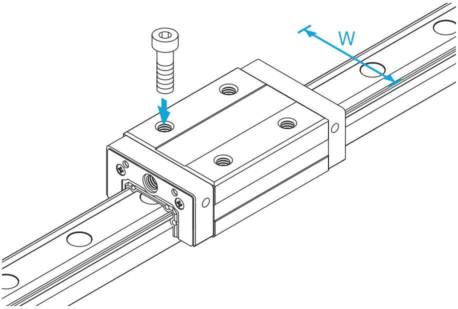
Since the curvature of the raceway is approximated to the ball diameter, the ball contact area under a load is increased and the LM Guide is capable of receiving an ultra-heavy load.

Types and Features

Models NR-R/NRS-R

Specification Table⇒B-94/B-96

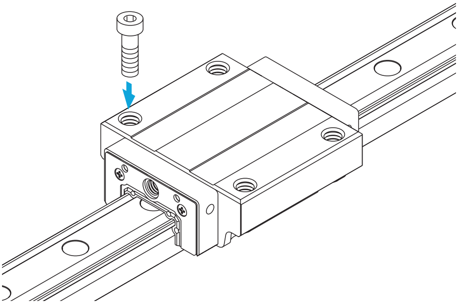
With this type, the LM block has a smaller width (W) and tapped holes. Used in places where the space for table width is limited.



Models NR-A/NRS-A

Specification Table⇒B-98/B-100

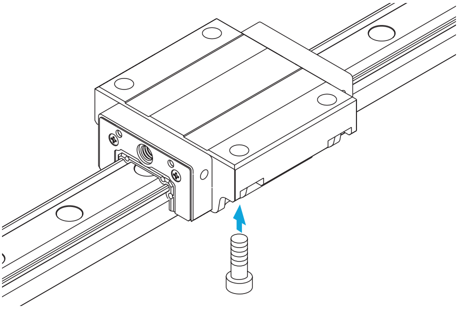
The flange of its LM block has tapped holes.



Models NR-B/NRS-B

Specification Table⇒B-102/B-104

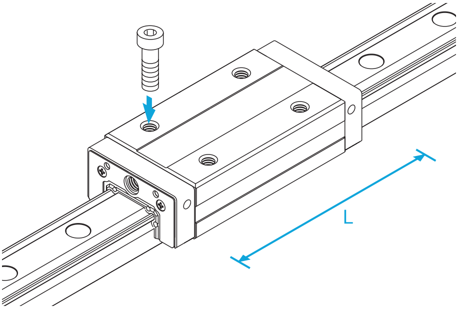
The flange of the LM block has through holes. Used in places where the table cannot have through holes for mounting bolts.



Models NR-LR/NRS-LR

Specification Table⇒B-94/B-96

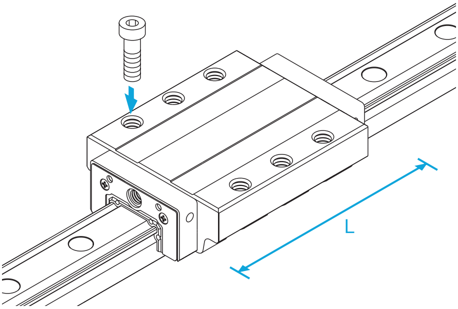
The LM block has the same cross-sectional shape as models NR-R/NRS-R, but has a longer overall LM block length (L) and a greater rated load.



Models NR-LA/NRS-LA

Specification Table⇒B-98/B-100

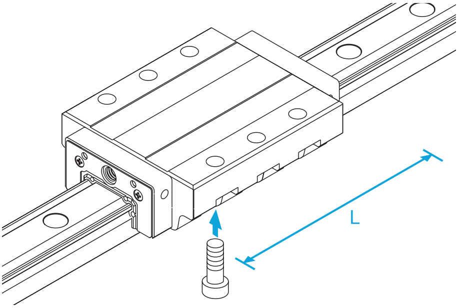
The LM block has the same cross-sectional shape as models NR-A/NRS-A, but has a longer overall LM block length (L) and a greater rated load.



Models NR-LB/NRS-LB

Specification Table⇒B-102/B-104

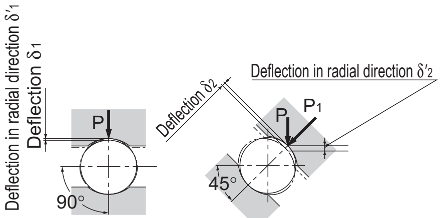
The LM block has the same cross-sectional shape as models NR-B/NRS-B, but has a longer overall LM block length (L) and a greater rated load.



Characteristics of Models NR and NRS

[Increased Rigidity in Major Load Directions]

The structure with a contact angle of 90° used in model NR differs from that with a 45° contact angle also in rigidity. Under the same radial load P, the displacement in the radial direction with model NR having a contact angle of 90° is 44% less than the 45°.



Contact structure of 90°
(Model NR)

Contact structure of 45°

Fig.1 Deflection under a Radial Load

Fig.2 shows the difference in radial load and displacement. Accordingly, where high rigidity in the radial direction is required, model NR is more advantageous.

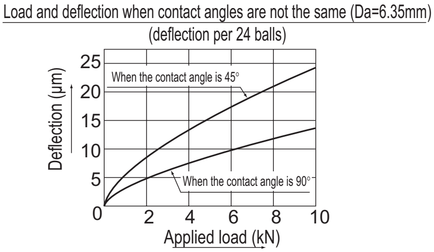


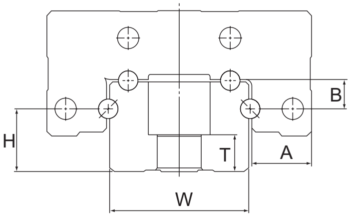
Fig.2 Radial Load and Deflection (normal clearance, no preload)

[Increased Rigidity in the Lateral and Reverse-radial Directions]

Since with LM Guide model NR, the distance "H" between the rail bottom and the lower-groove balls (balls receiving lateral loads) is short, the ratio between the rail width "W" and the distance "H" is small, and the distance "T" between the LM rail mounting bolt seat and the LM rail bottom is short. Accordingly, the deformation of the LM rail under a lateral load is minimal, and the rigidity in the lateral directions is increased.

Since the dimension "B" of the LM block is short and the thickness "A" is large, the lateral extension of the LM block under a reverse radial or lateral load is minimized. This structure allows the rigidity in the reverse radial direction to be increased.

In comparison to the old model with the same model number, the ball diameter of NR is smaller and the number of effective balls is approximately 1.3 times greater, thus increasing the static rigidity.



Radial type structure

Fig.3 Cross Section of Model NR

[Comparison of Contact Surface and Internal Stress between Different Contact Structures]

As shown in Fig.4, the contact area and the internal stress of a ball greatly vary depending on the shape of contact surface.

With the conventional roller guide, the effective length is shorter than the apparent value due to the retention of the rollers. Additionally, the change of stress distribution in the contact section caused by a mounting error significantly affects the differential slip.

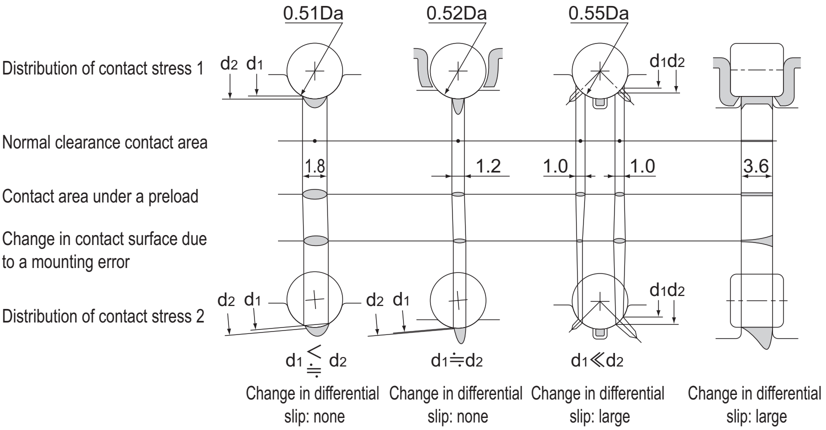


Fig.4 Comparison of Contact Surface (ϕ 6.350 ball, ϕ 6 x 6ℓ roller)

Rated Loads in All Directions

Models NR/NRS are capable of receiving loads in all four directions: radial, reverse radial and lateral directions.

The basic load ratings of model NR are indicated by the values in the radial directions in Fig.5, and their actual values are provided in the specification table for NR/NRS. The values in the reverse radial and lateral directions are obtained from table 1 below.

The basic load ratings of model NRS are equal in all the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for NR/NRS.

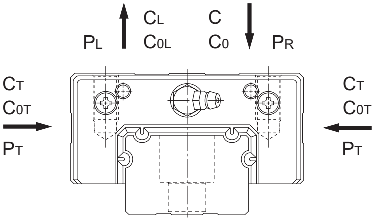


Fig.5

Table1 Rated Loads in All Directions with Model NR

Direction	Basic dynamic load rating	Basic static load rating
Radial direction	C	C_0
Reverse radial direction	$C_L=0.78C$	$C_{0L}=0.71C_0$
Lateral directions	$C_T=0.48C$	$C_{0T}=0.45C_0$

Equivalent Load

When the LM block of model NR receives loads in the reverse radial and lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_L + Y \cdot P_T$$

P_E : Equivalent load (N)

: Reverse radial direction

: Lateral direction

P_L : Reverse radial load (N)

P_T : Lateral load (N)

X, Y : Equivalent factor (see Table2)

Table2 Equivalent Factor of Model NR

P_E	X	Y
Equivalent load in reverse radial direction	1	2
Equivalent load in lateral direction	0.5	1

When the LM block of model NRS receives loads in the reverse radial and lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R\ (P_L) + P_T$$

P_E : Equivalent load (N)

: Radial direction

: Reverse radial direction

: Lateral direction

P_R : Radial load (N)

P_L : Reverse radial load (N)

P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-113.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-327.

Error Allowance in the Parallelism between Two Rails

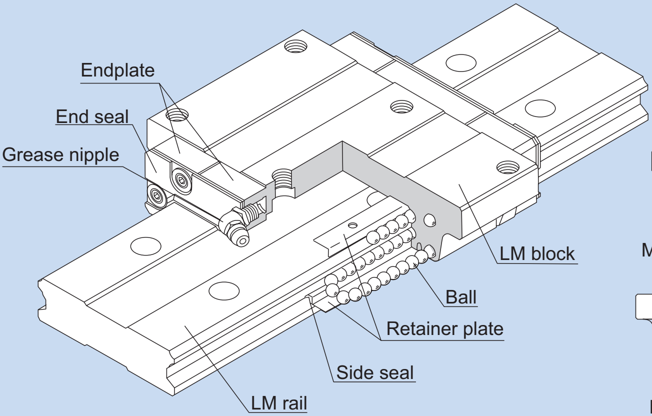
For details, A-333 and A-334.

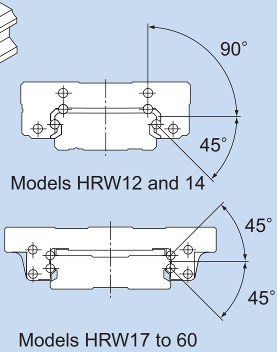
Error Allowance in Vertical Level between Two Rails

For details, A-336 and A-337.

HRW

LM Guide
Wide Rail Model HRW





Cross section

Structure and Features

Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate.
Since retainer plates hold the balls, they do not fall off even if the LM rail is pulled out. (except models HRW 12 and 14LR).
Each row of balls is placed at a contact angle of 45° so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse radial and lateral directions), enabling the LM Guide to be used in all orientations. In addition, the LM block can receive a well-balanced preload, increasing the rigidity in four directions while maintaining a constant, low friction coefficient. In a low center of gravity structure with a large rail width and a low overall height, this model can be used in places where space saving is required or high rigidity against a moment is required even in a single axis configuration.

[Compact, Heavy Load]

Since the number of effective balls is large, this model is highly rigid in all directions. It can adequately receive a moment even in a single rail configuration.
Additionally, since the second moment of inertia of the rail is large, the rigidity in the lateral directions is also high. Accordingly, it does not need reinforcement such as a side support.

[Self-adjustment Capability]

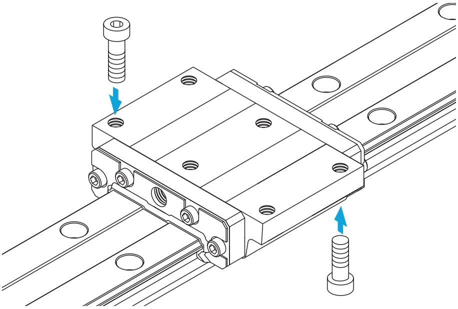
The self-adjustment capability through front-to-front configuration of THK's unique circular-arc grooves (DF set) enables a mounting error to be absorbed even under a preload, thus to achieve highly accurate, smooth straight motion.

Types and Features

Model HRW-CA

Specification Table⇒B-108

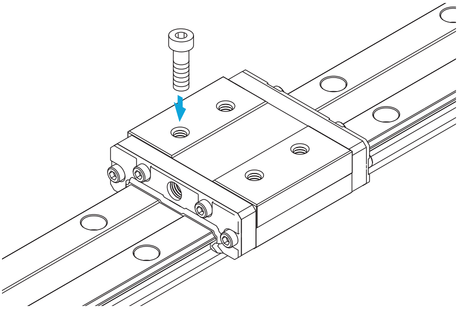
The flange of this LM block has tapped holes.
Can be mounted from the top or the bottom.



Model HRW-CR

Specification Table⇒B-110

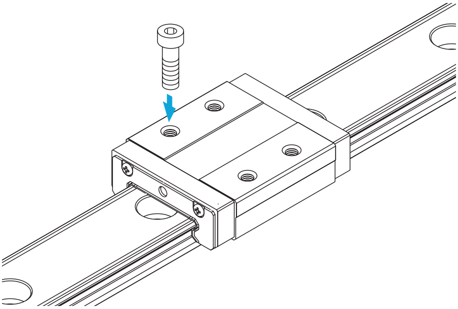
The LM block has tapped holes.



Miniature Type Model HRW-LR

Specification Table⇒B-110

The LM block has tapped holes.



Rated Loads in All Directions

Model HRW is capable of receiving loads in four directions: radial, reverse radial and lateral directions.

The basic load ratings of model HRW 17 to 60 are equal in all the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for HRW.

The basic load ratings of models HRW 12 and 14 indicate the values in the radial directions in Fig.1, and their actual values are provided in the specification table for HRW. The values in the reverse radial and lateral directions are obtained from Table1 below.

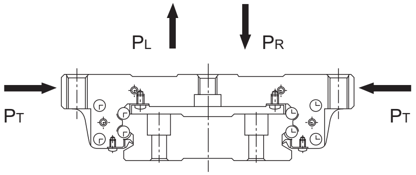


Fig.1

Table1 Rated Loads in All Directions with Models HRW 12 and 14

Direction	Basic dynamic load rating	Basic static load rating
Radial direction	C	C_0
Reverse radial direction	$C_L=0.78C$	$C_{0L}=0.71C_0$
Lateral directions	$C_T=0.48C$	$C_{0T}=0.35C_0$

Equivalent Load

When the LM block of models HRW 17 to 60 receives loads in the reverse radial and lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R\ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

When the LM block of models HRW 12 and 14 receives loads in the reverse radial and lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_L + Y \cdot P_T$$

P_E : Equivalent load (N)
: Reverse radial direction
: Lateral direction
P_L : Reverse radial load (N)
P_T : Lateral load (N)
X, Y : Equivalent factor (see Table2)

Table2 Equivalent Factor of Models HRW12 and 14

P_E	X	Y
Equivalent load in reverse radial direction	1	2
Equivalent load in lateral direction	0.5	1

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-114.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-330.

Error Allowance in the Parallelism between Two Rails

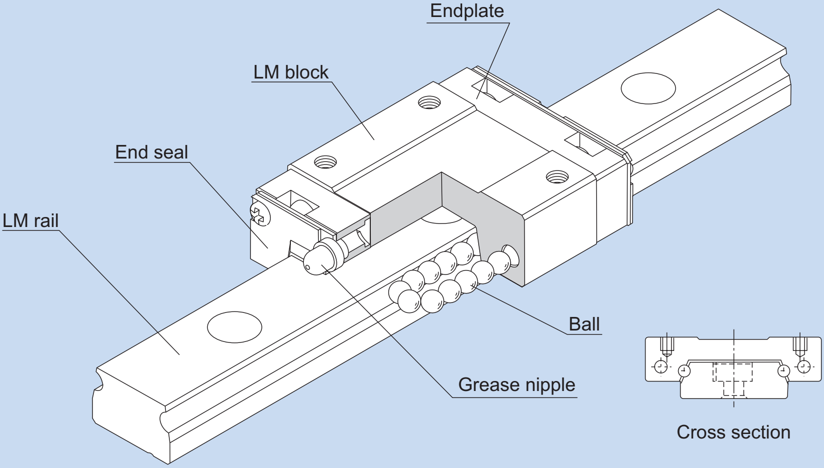
For details,see A-334.

Error Allowance in Vertical Level between Two Rails

For details,see A-337.

RSR/RSR-W

LM Guide
Miniature Type Models RSR/RSR-W



Structure and Features

With models RSR and RSR-W, balls roll in two rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate.
Balls circulate in a compact structure and perform infinite straight motion with no limit in stroke.
The LM block is designed to have a shape with high rigidity in a limited space, and in combination with large-diameter balls, demonstrates high rigidity in all directions.

[Ultra Compact]
The absence of cage displacement, a problem that cross-roller guides and types of ball slides with finite stroke tend to cause, make these models highly reliable LM systems.

[Capable of Receiving Loads in All Directions]
These models are capable of receiving loads in all directions, and a single-rail guide can adequately operate under a small moment load. Model RSR-W, in particular, has a greater number of effective balls and a broader LM rail to increase its rigidity against a moment. Thus, it achieves a more compact structure and more durable straight motion than a pair of linear bushes in parallel use.

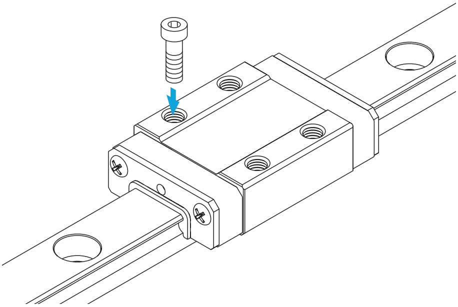
[Stainless Steel Type also Available]
A special type where LM block, LM rail and balls are made of stainless steel is also available.

Types and Features

Models RSR/RSR-K/RSR-V

Specification Table⇒B-116

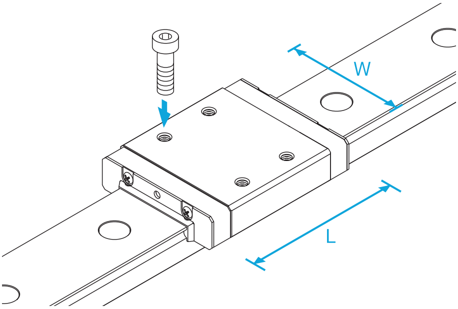
This model is a standard type.



Models RSR-W/WV

Specification Table⇒B-118

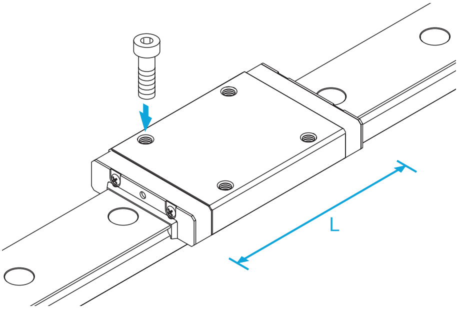
These models have greater overall LM block lengths (L), broader widths (W) and greater rated loads and permissible moments than standard types.



Model RSR-N

Specification Table⇒B-114

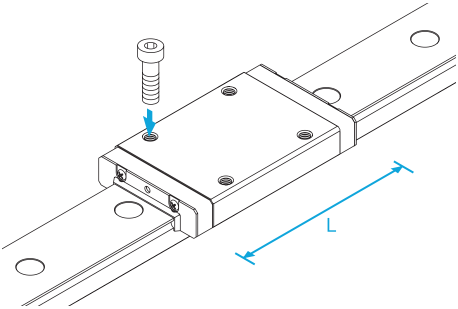
It has a longer overall LM block length (L) and a greater rated load than standard types.



Model RSR-WN

Specification Table⇒B-118

It has a longer overall LM block length (L), a greater rated load than standard types. Achieves the greatest load capacity among the miniature type LM Guide models.



Comparison of Model RSR-W with Other Model Numbers

[Locations where a Pair of Linear Bushes are Used]

- Unlike the linear bushes, model RSR-W can be used in a single-rail configuration and allows space saving.
- Since model RSR-W has more load-bearing balls per row and wider LM block and LM rail, thus to achieve high rigidity against an overhung load.
- Accuracy can be achieved simply by mounting the LM rail using bolts. Therefore, the assembly time can be shortened.

Example of comparing model RSR12W with model LM 10 in use

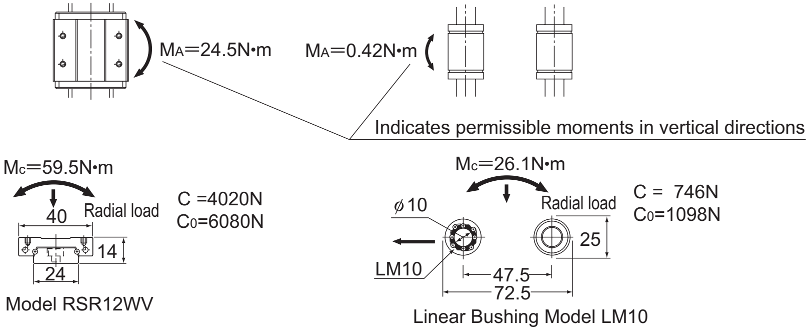


Fig.1

[Locations where a Cross-roller Table is Used]

- Does not show cage displacement even with vertical mount, and capable of performing infinite straight motion.
- Eliminates the need for difficult clearance adjustment and achieves long-term, smooth motion over a long period of time.
- Since the LM block width is large, the model can be used as a miniature table without any modification.

Example of comparing model RSR9WV with model VRM1035 in use

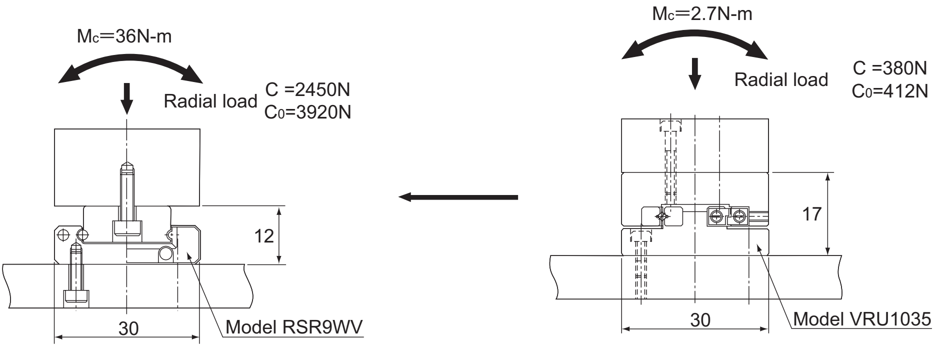


Fig.2

Rated Loads in All Directions

Model RSR is capable of receiving loads in four directions: radial, reverse radial and lateral directions.

The basic load ratings of models RSR3 to 9 are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for RSR.

The basic load ratings of models RSR12 to 20 indicate the values in the radial direction in Fig.3, and their actual values are provided in the specification table for RSR. The values in the reverse radial and lateral directions are obtained from Table1 below.

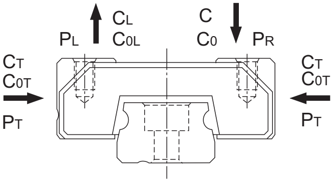


Fig.3

Table1 Basic Load Ratings of Models RSR12 to 20 in All Directions

Direction	Basic dynamic load rating	Basic static load rating
Radial direction	C	C_0
Reverse radial direction	$C_L=0.78C$	$C_{0L}=0.70C_0$
Lateral directions	$C_T=0.78C$	$C_{0T}=0.71C_0$

Equivalent Load

When the LM block of models RSR3 to 9 receives loads in all four directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R\ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

When the LM block of model RSR12 to 20 receives loads in the radial and lateral directions, or the reverse radial and lateral directions, simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X\cdot P_R\ (P_L) + Y\cdot P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)
X, Y : Equivalent factor
(see Table2 and Table3)

Table2 Equivalent Factor of Models RSR12 to 20
(When radial and lateral loads are applied)

P_E	X	Y
Equivalent load in the radial direction	1	0.83
Equivalent load in lateral direction	1.2	1

Table3 Equivalent Factor of Models RSR12 to 20
(When reverse radial and lateral loads are applied)

P_E	X	Y
Equivalent load in reverse radial direction	1	0.99
Equivalent load in lateral direction	1.01	1

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-114.

Accuracy Standards

For details,see A-126.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-332.

Error Allowance in the Parallelism between Two Rails

For details,see A-334.

Error Allowance in Vertical Level between Two Rails

For details,see A-337.

Accuracy of the Mounting Surface

Model RSR uses Gothic arch grooves in the ball raceways. When two rails of RSR are used in parallel, any error in accuracy of the mounting surface may increase rolling resistance and negatively affect the smooth motion of the guide. For specific accuracy of the mounting surface, see Permissible Error of the Mounting Surface on A-333.

When using this model in locations where it is difficult to obtain satisfactory accuracy of the mounting surface, we recommend using types RSR···A (semi standard) whose ball raceways have circular-arc grooves. (avoid using these types in a single-rail configuration).

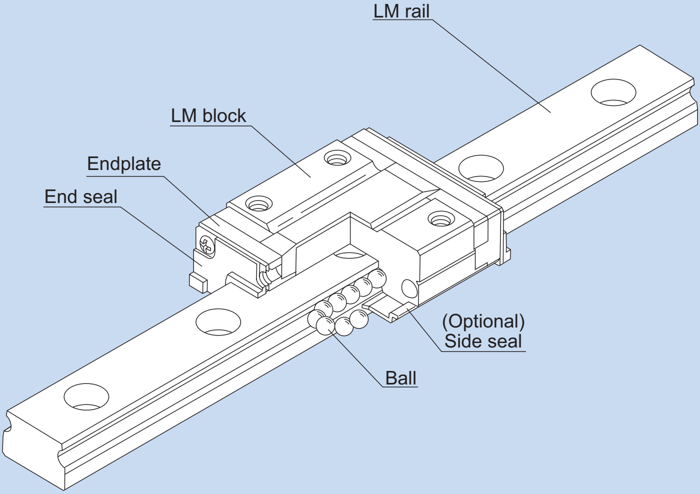
For specific accuracy of the mounting surface for types RSR···A, Permissible Error of the Mounting Surface is on A-333.

Flatness of the Mounting Surface

For details,see A-335.

RSR-Z

LM Guide
Miniature Type (Low Cost Type) Model RSR-Z



Structure and Features

Balls roll in two rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate.
Balls of model RSR-Z circulate in a compact structure and perform infinite straight motion with no limit in stroke.
Also, it has the same dimensions as models RSR/RSR-W, but achieves a lighter weight and a lower price.

[Lightweight]

Since part of the LM block body uses a resin material, the block mass is reduced by up to 28% from the conventional type model RSR-V. This makes RSR-Z a low-inertia type.

[Smooth Motion]

The unique structure of the endplate allows the balls to circulate smoothly and infinitely.

[Highly Corrosion Resistant]

Since the LM block, LM rail and balls use stainless steel, which is highly corrosion resistant, this model is optimal for clean room applications.

[Low Noise]

Since the unloaded ball path is made of resin, there is no metal to metal contact and low noise is achieved.

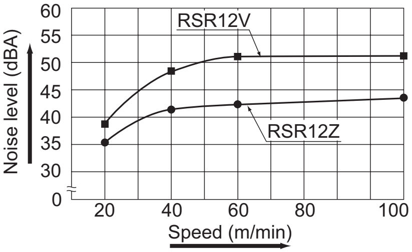
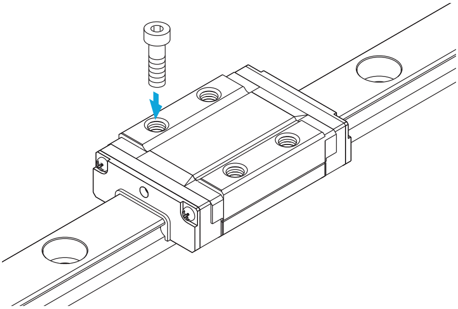


Fig.1 Noise Levels of Models RSR12Z and RSR12V

Model RSR-Z

Specification Table⇒B-122

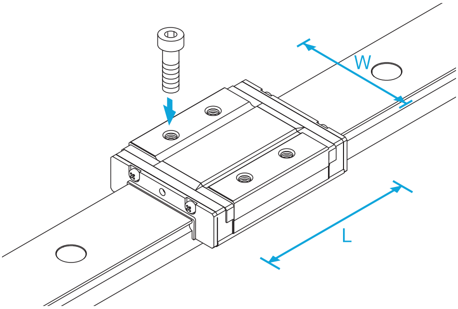
This model is a standard type.



Models RSR-WZ

Specification Table⇒B-124

It has a longer overall LM block length (L), a broader width (W) and greater rated load and permissible moment than RSR-Z.



Rated Loads in All Directions

Model RSR-Z is capable of receiving loads in four directions: radial, reverse radial and lateral directions.

The basic load ratings of models RSR7Z/WZ and 9Z/WZ are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for RSR-Z.

The basic load ratings of models RSR12Z/WZ and 15Z/WZ indicate the values in the radial direction in Fig.2, and their actual values are provided in the specification table for RSR-Z. The values in the reverse radial and lateral directions are obtained from Table1.

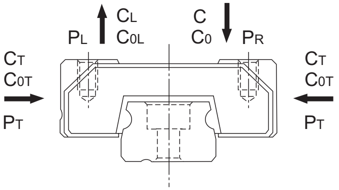


Fig.2

Table1 Basic Load Ratings of Models RSR12Z/WZ and 15Z/WZ in All Directions

Direction	Basic dynamic load rating	Basic static load rating
Radialdirection	C	C_0
Reverse radial direction	C_L=0.78C	C_{0L}=0.70C_0
Lateraldirections	C_T=0.78C	C_{0T}=0.71C_0

Equivalent Load

When the LM block of models RSR7Z/WZ and 9Z/WZ receives loads in all four directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R\ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

When the LM block of model RSR12Z/WZ and 15Z/WZ receives loads in the radial and lateral directions, or the reverse radial and lateral directions, simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_R\ (P_L) + Y \cdot P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)
X, Y : Equivalent factor
(see Table2 and Table3)

Table2 Equivalent Factor of Models RSR12Z/WZ and 15Z/WZ (when radial and lateral loads are applied)

P_E	X	Y
Equivalent load in the radial direction	1	0.83
Equivalent load in lateral direction	1.2	1

Table3 Equivalent Factor of Models RSR12Z/WZ and 15Z/WZ (when reverse radial and lateral loads are applied)

P_E	X	Y
Equivalent load in reverse radial direction	1	0.99
Equivalent load in lateral direction	1.01	1

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-114.

Accuracy Standards

For details,see A-126.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-332.

Error Allowance in the Parallelism between Two Rails

For details,see A-334.

Error Allowance in Vertical Level between Two Rails

For details,see A-337.

Accuracy of the Mounting Surface

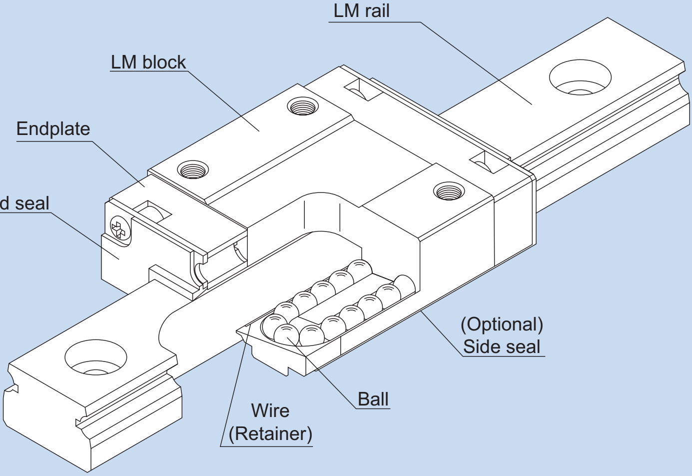
Model RSR-Z uses Gothic arch grooves in the ball raceways. When two rails are used in parallel, any error in accuracy of the mounting surface may increase rolling resistance and negatively affect the smooth motion of the guide. For specific accuracy of the mounting surface, see Permissible Error of the Mounting Surface on A-333.

Flatness of the Mounting Surface

For details,see A-335.

RSH

LM Guide
Miniature Type (with a Ball Retainer) Model RSH



Structure and Features

Balls roll in two rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate. Since a retainer holds the balls, they will not fall off even if the LM block is removed from the LM rail.
With the Miniature Type LM Guide Equipped with a Ball Retainer model RSH, balls circulate in a compact structure and perform infinite straight motion with no limit in stroke. The LM block is designed to have a shape with high rigidity in a limited space, and in combination with large-diameter balls, demonstrates high rigidity in all directions.

[Miniature Size]

This model is a highly reliable, ultra compact LM Guide that responds to weight saving and space saving.

[Capable of Receiving Loads in All Directions]

This model is capable of receiving loads in all directions, and has a high load capacity because of large-diameter balls incorporated in two rows of raceways.

[Highly Corrosion Resistant]

Since the LM block, LM rail and balls use stainless steel, which is highly corrosion resistant, this model is optimal for clean room applications.

[Equipped with a Ball Retainer]

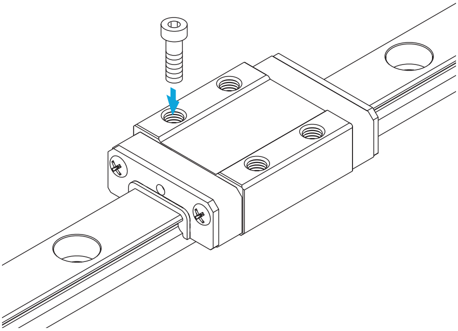
The LM block contains a retainer capable of preventing balls from falling off. Since the balls will not fall even if the LM block is removed from the LM rail, you can use this LM Guide at ease.

Types and Features

Model RSH

Specification Table⇒B-128

This model is a standard type.



Rated Loads in All Directions

Model RSH is capable of receiving loads in four directions: radial, reverse radial and lateral directions.
The basic load ratings of models RSH7 and 9 are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for RSH.
The basic load ratings of model RSH12 indicate the values in the radial direction in Fig.1, and their actual values are provided in the specification table for RSH. The values in the reverse radial and lateral directions are obtained from Table1 below.

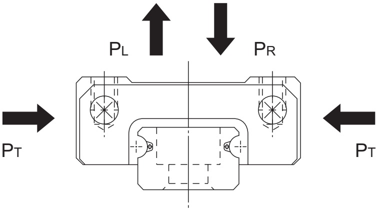


Fig.1

Table1 Basic Load Ratings of Model RSH12 in All Directions

Direction	Basic dynamic load rating	Basic static load rating
Radial direction	C	C_0
Reverse radial direction	$C_L=0.78C$	$C_{0L}=0.70C_0$
Lateral directions	$C_T=0.78C$	$C_{0T}=0.71C_0$

Equivalent Load

When the LM block of models RSH7 and 9 receives loads in all four directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R\ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

When the LM block of model RSH12 receives loads in the radial and lateral directions, or the reverse radial and lateral directions, simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_R\ (P_L) + Y \cdot P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)
X, Y : Equivalent factor
(see Table2 andTable3)

Table2 Equivalent Factor of Model RSH12
(when radial and lateral loads are applied)

P_E	X	Y
Equivalent load in the radial direction	1	0.83
Equivalent load in lateral direction	1.2	1

Table3 Equivalent Factor of Model RSH12
(when reverse radial and lateral loads are applied)

P_E	X	Y
Equivalent load in reverse radial direction	1	0.99
Equivalent load in lateral direction	1.01	1

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-114.

Accuracy Standards

For details,see A-126.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-332.

Error Allowance in the Parallelism between Two Rails

For details,see A-334.

Error Allowance in Vertical Level between Two Rails

For details,see A-337.

Accuracy of the Mounting Surface

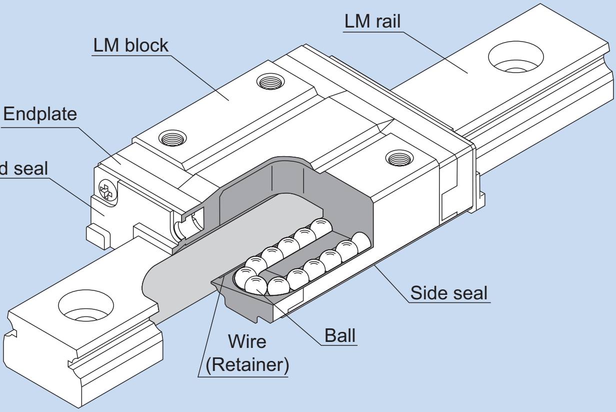
Model RSH uses Gothic arch grooves in the ball raceways. When two rails are used in parallel, any error in accuracy of the mounting surface may increase rolling resistance and negatively affect the smooth motion of the guide. For specific accuracy of the mounting surface, see Permissible Error of the Mounting Surface on A-333.

Flatness of the Mounting Surface

For details,see A-335.

RSH-Z

LM Guide
Miniature Type (with a Ball Retainer) Model RSH-Z



Structure and Features

Balls roll in two rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate. Since a retainer holds the balls, they will not fall off even if the LM block is removed from the LM rail.

With model RSH-Z, balls circulate in a compact structure and perform infinite straight motion with no limit in stroke.

Also, it has the same dimensions as the conventional model, but achieves a lower price.

[Equipped with a Ball Retainer]

Model RSH-Z has a retainer capable of preventing balls from falling off. Since the balls will not fall even if the LM block is removed from the LM rail, you can use this LM Guide at ease.

[Lightweight]

Since part of the LM block body uses a resin material, the block mass is reduced by up to 30% from the conventional type. This makes RSH-Z a low-inertia type.

[Highly Corrosion Resistant]

Since the LM block, LM rail and balls use stainless steel, which is highly corrosion resistant, this model is optimal for clean room applications.

[Low Noise]

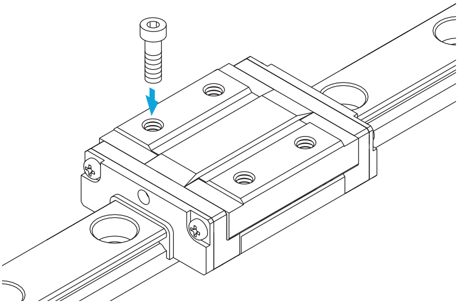
Since the unloaded ball path is made of resin, there is no metal to metal contact and low noise is achieved.

Types and Features

Model RSH-Z

Specification Table⇒B-132

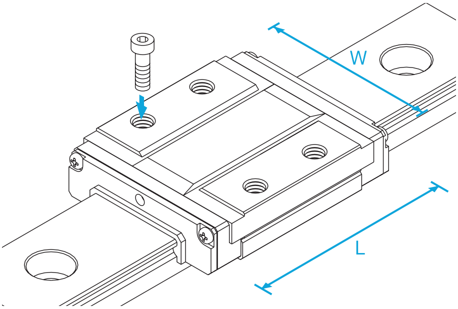
This model is a standard type.



Model RSH-WZ

Specification Table⇒B-134

This model has a greater overall LM block length (L), broader width (W) and greater rated load and permissible moment than model RSH-Z.



Rated Loads in All Directions

Model RSH-Z is capable of receiving loads in four directions: radial, reverse radial and lateral directions.

The basic load ratings of models RSH7Z/WZ and 9Z/WZ are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for RSH-Z.

The basic load ratings of models RSH12Z/WZ and 15Z/WZ indicate the values in the radial direction in Fig.1, and their actual values are provided in the specification table for RSH-Z. The values in the reverse radial and lateral directions are obtained from Table1 below.

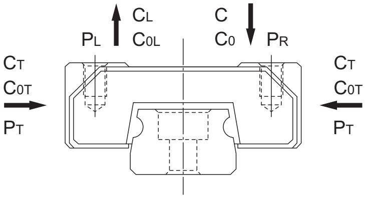


Fig.1

Table1 Basic Load Ratings of Models RSH12Z/WZ and 15Z/WZ in All Directions

Direction	Basic dynamic load rating	Basic static load rating
Radial direction	C	C_0
Reverse radial direction	$C_L=0.78C$	$C_{0L}=0.70C_0$
Lateral directions	$C_T=0.78C$	$C_{0T}=0.71C_0$

Equivalent Load

When the LM block of models RSH7Z/WZ and 9Z/WZ receives loads in all four directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R \ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

When the LM block of models RSH12Z/WZ and 15Z/WZ receives loads in the radial and lateral directions, or the reverse radial and lateral directions, simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_R \ (P_L) + Y \cdot P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)
X, Y : Equivalent factor
(see Table2 andTable3)

Table2 Equivalent Factor of Models RSH12Z/WZ and 15Z/WZ (when radial and lateral loads are applied)

P_E	X	Y
Equivalent load in the radial direction	1	0.83
Equivalent load in lateral direction	1.2	1

Table3 Equivalent Factor of Models RSH12Z/WZ and 15Z/WZ (when reverse radial and lateral loads are applied)

P_E	X	Y
Equivalent load in reverse radial direction	1	0.99
Equivalent load in lateral direction	1.01	1

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-114.

Accuracy Standards

For details,see A-126.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-332.

Error Allowance in the Parallelism between Two Rails

For details,see A-334.

Error Allowance in Vertical Level between Two Rails

For details,see A-337.

Accuracy of the Mounting Surface

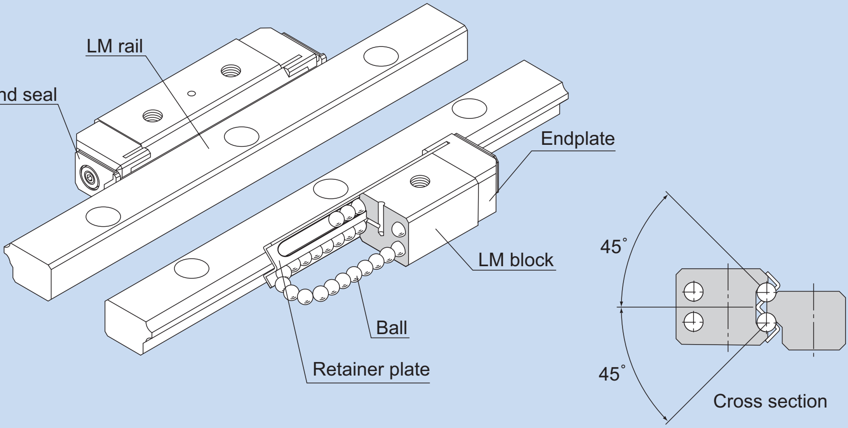
Models RSH-Z and WZ uses Gothic arch grooves in the ball raceways. When two rails are used in parallel, any error in accuracy of the mounting surface may increase rolling resistance and negatively affect the smooth motion of the guide. For specific accuracy of the mounting surface, see Permissible Error of the Mounting Surface on A-333.

Flatness of the Mounting Surface

For details,see A-335.

HR

LM Guide
Separate Type (4-way Equal Load) Model HR



Structure and Features

Balls roll in two rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate. Since retainer plates hold the balls, they do not fall off.
Because of the angular contact structure where two rows of balls rolling on the LM rail each contact the raceway at 45°, the same load can be applied in four directions (radial, reverse radial and lateral directions) if a set of LM rails and LM block is mounted on the same plane (i.e., when two LM rails are combined with an LM block on the same plane). Furthermore, since the sectional height is low, a compact and stable linear guide mechanism is achieved.
This structure makes clearance adjustment relatively easy, and is highly capable of absorbing a mounting error.

[Easy Installation]

Model HR is easier to adjust a clearance and achieve more accuracy than cross-roller guides.

[Self-adjustment Capability]

Even if the parallelism or the level between the two rails is poorly established, the self-adjustment capability through front-to-front configuration of THK's unique circular-arc grooves (DF set) enables a mounting error to be absorbed and smooth straight motion to be achieved even under a preload.

[4-way Equal Load Type]

When the two rails are mounted in parallel, each row of balls is placed at a contact angle of 45° so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse radial and lateral directions), enabling the LM Guide to be used in various orientations and in applications.

[Sectional Dimensions Approximate to Cross-roller Guides]

Since model HR is an infinite motion type whose retainer plate does not move, it is not associated with cage displacement that occurs with cross-roller guides. In addition, the sectional shape of model HR is approximate to that of cross-roller guides, therefore, its components are interchangeable with that of cross-roller guides.

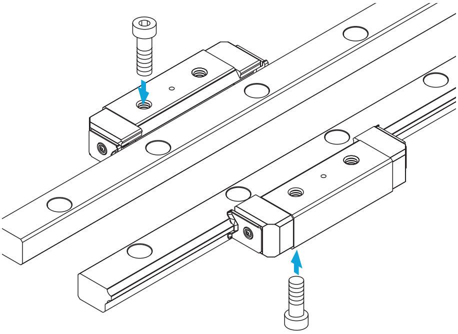
[Stainless Steel Type also Available]

A special type whose LM block, LM rail and balls are made of stainless steel is also available.

Model HR - Heavy-load Type

Specification Table⇒B-138

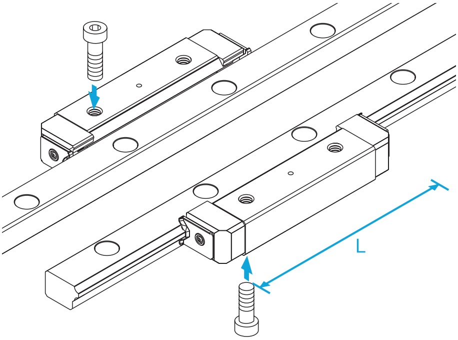
The LM blocks can be mounted from the top and the bottom.



Model HR-T-Ultra-heavy Load Type

Specification Table⇒B-140

Has the same cross-sectional shape as model HR, but has a greater overall LM block length (L) and a higher load rating.



Rated Loads in All Directions

When installed, one set of model HR is capable of receiving loads in all four directions: radial, reverse radial and lateral directions.
The basic load ratings of an installed set of model HR are equal in all four directions (radial, reverse radial and lateral directions). The basic load ratings in the specification table for model HR indicate the values in the radial direction per LM block as shown in Fig.1.

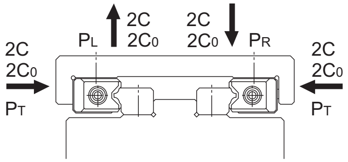


Fig.1

Equivalent Load

When the LM block of model HR receives loads in the reverse radial and lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R\ (P_L) + \frac{1}{2} P_T$$

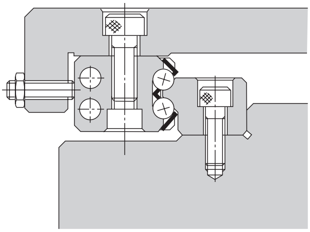
P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

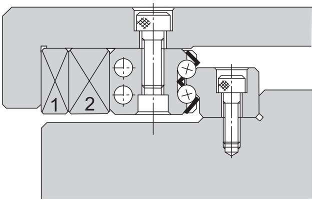
For details,see A-100.

Example of Clearance Adjustment

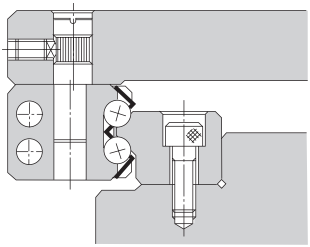
Design the clearance adjustment bolt so that it presses the center of the side face of the LM block.



a. Using an adjustment screw
Normally, an adjustment screw is used to press the LM block.



b. Using tapered gibs
When high accuracy and high rigidity are required, use tapered gibs 1) and 2).



c. Using an eccentric pin
A type using an eccentric pin to adjust the clearance is also available.

Accuracy Standards

For details,see A-123.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-331.

Error Allowance in the Parallelism between Two Rails

For details,see A-334.

Error Allowance in Vertical Level between Two Rails

For details,see A-337.

Comparison of Model Numbers with Cross-roller Guides

Each type of LM Guide model HR has sectional dimensions approximate to that of the corresponding cross roller guide model.

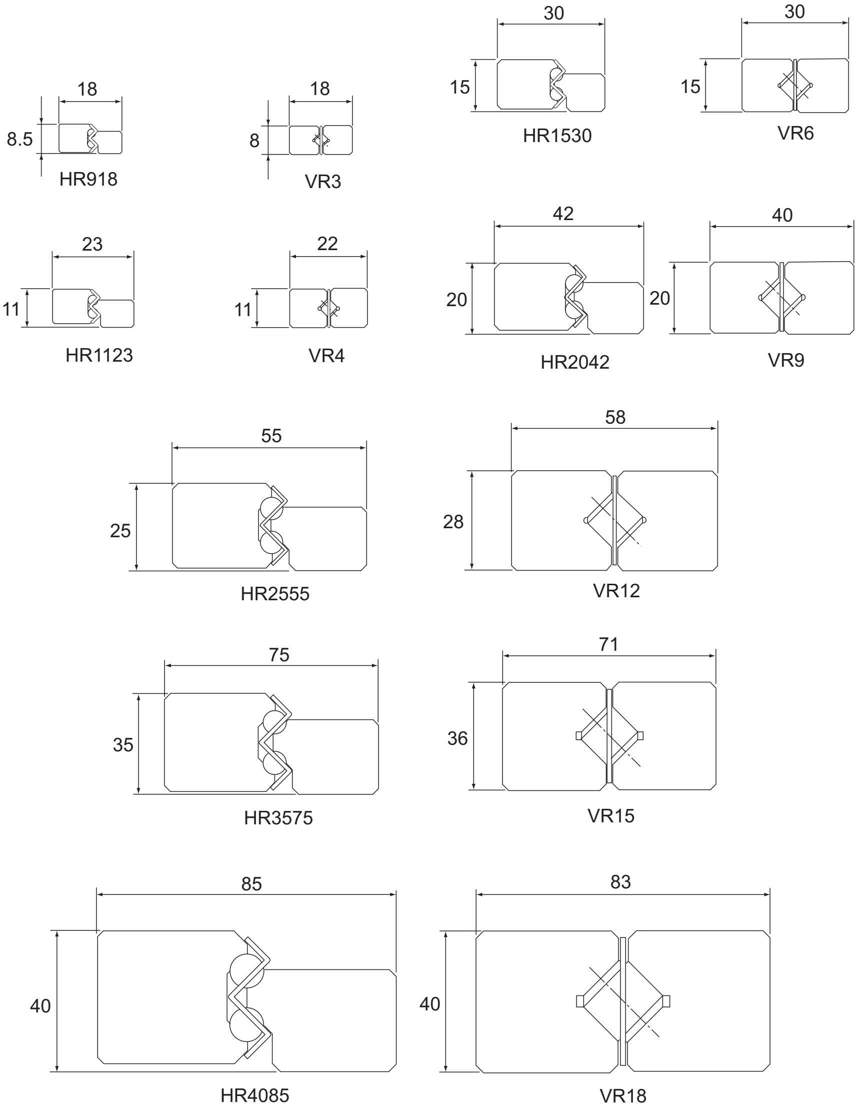
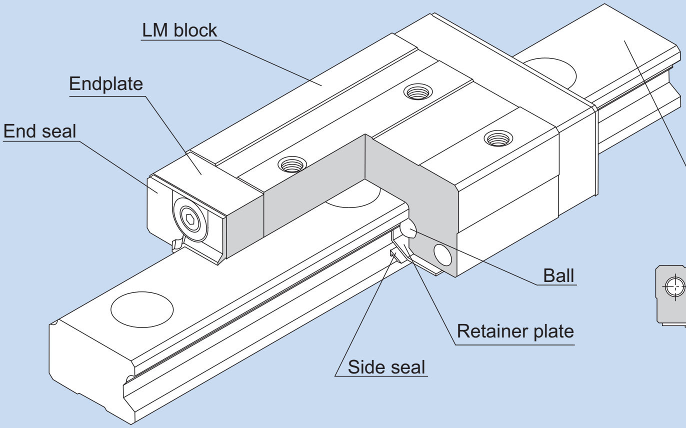
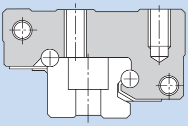


Fig.2

GSR

LM Guide
Separate Type (Radial) Model GSR




Cross section

Structure and Features

Balls roll in two rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate. Since retainer plates hold the balls, they do not fall off.
As the top face of the LM block is inclined, a clearance is eliminated and an appropriate preload is applied simply by securing the LM block with mounting bolts.
Model GSR has a special contact structure using circular-arc grooves. This increases self-adjusting capability and makes GSR an optimal model for places associated with difficulty establishing high accuracy and for general industrial machinery.

[Interchangeability]

Both the LM block and LM rail are interchangeable and can be stored separately. Therefore, it is possible to store a long-size LM rail and cut it to a desired length before using it.

[Compact]

Since model GSR has a low center of gravity structure with a low overall height, the machine can be downsized.

[Capable of Receiving a Load in any Direction]

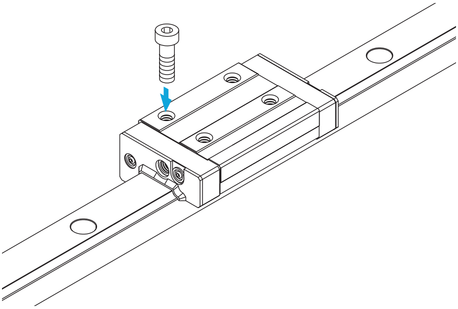
The ball contact angle is designed so that this model can receive a load in any direction. As a result, it can be used in places where a reverse radial load, lateral load or a moment in any direction is applied.

Types and Features

Model GSR-T

Specification Table⇒B-146

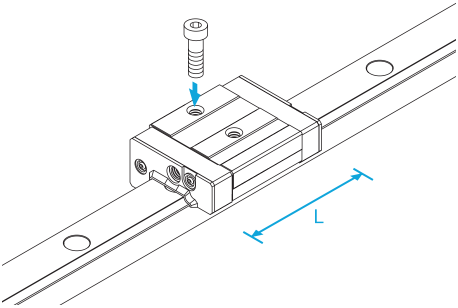
This model is a standard type.



Model GSR-V

Specification Table⇒B-146

A space-saving type that has the same cross-sectional shape as GSR-T, but has a shorter overall LM block length (L).



Rated Loads in All Directions

Model GSR is capable of receiving loads in four directions: radial, reverse radial and lateral directions.

The basic load ratings indicate the values in the radial direction in Fig.1, and their actual values are provided in the specification table for GSR. The values in the radial direction, tensile lateral direction and compressive lateral direction are obtained from Table1.

Note) Not available for a single-axis configuration.

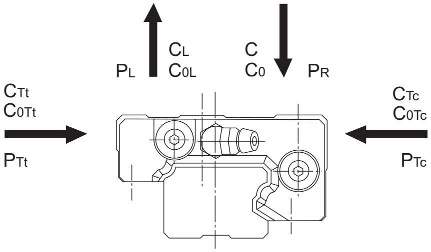


Fig.1

Table1 Basic Load Ratings of Model GSR in All Directions

Direction	Basic dynamic load rating	Basic static load rating
Radial direction	C	C_0
Reverse radial direction	$C_L=0.93C$	$C_{0L}=0.90C_0$
Tensile lateral direction	$C_{Tt}=0.84C$	$C_{0Tt}=0.78C_0$
Compressive lateral direction	$C_{Tc}=0.93C$	$C_{0Tc}=0.90C_0$

Equivalent Load

When the LM block of model GSR receives loads in the radial, tensile lateral, reverse radial and compressive lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_R + Y \cdot P_{Tt}$$
$$P_E = P_L + P_{Tc}$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Tensile lateral direction
: Compressive lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_{Tt} : Tensile lateral load (N)
P_{Tc} : Compressive lateral direction load (N)
X, Y : Equivalent factor (see Table2)

Table2 Equivalent Factor of Model GSR
(when radial and tensile lateral loads are applied)

P_E	X	Y
Equivalent load in the radial direction	1	1.28
Equivalent load in tensile lateral direction	0.781	1

Service Life

For details,see A-100.

Example of Clearance Adjustment

By providing a shoulder maybe on the side face of each LM block and pressing either LM block with a bolt, a preload is applied and the rigidity is increased.

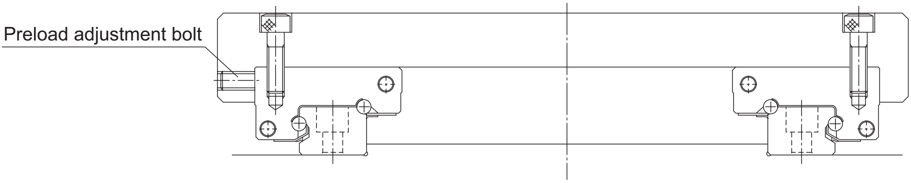


Fig.2 Example of Adjusting a Preload with a Push Bolt

Accuracy Standards

For details,see A-124.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-331.

Error Allowance in the Parallelism between Two Rails

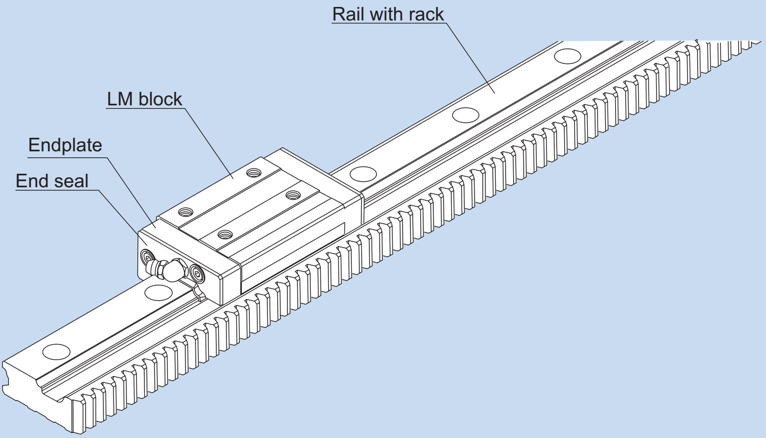
For details,see A-334.

Error Allowance in Vertical Level between Two Rails

For details,see A-337.

GSR-R

LM Guide
Separate Type (Radial) Model GSR-R



Structure and Features

Balls roll in two rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate. Since retainer plates hold the balls, they do not fall off.

As the top face of the LM block is inclined, a clearance is eliminated and an appropriate preload is applied simply by securing the LM block with mounting bolts.

Model GSR-R is based on model GSR, but has rack teeth on the LM rail. This facilitates the design and assembly of drive mechanisms.

[Reduced Machining and Assembly Costs]

The single-piece structure integrating the LM rail (linear guide) and rack (drive) reduces labor and time for machining the rack mounting surface and assembling and adjusting the guide system, thus to achieve significant cost reduction.

[Easy Designing]

The travel distance per turn of the pinion is specified by the integer value. This makes it easy to calculate the travel distance per pulse when the LM Guide is used in combination with a stepping motor or servomotor.

[Space Saving]

Since the rail has a rack, the machine size can be reduced.

[Long Stroke]

The end faces of the LM rail are machined for jointed use. To obtain a long stroke, simply joint LM rails of the standard length.

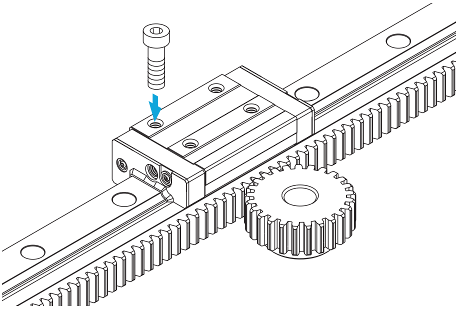
[High Durability]

The rack tooth has a width equal to the LM rail height, the rack uses high-grade steel with proven performance and the tooth surface are heat-treated, thereby to ensure high durability.

Model GSR-R (Rail with Rack)

Specification Table⇒B-150

Since the thrust load on the pinion shaft can be kept low due to rack-pinion meshing, it is easy to design systems with pinion shaft bearings and tables that are not so rigid.



Rated Loads in All Directions

Model GSR-R is capable of receiving loads in four directions: radial, reverse radial and lateral directions.

The basic load ratings indicate the values in the radial direction in Fig.1, and their actual values are provided in the specification table for GSR-R. The values in the radial direction, tensile lateral direction and compressive lateral direction are obtained from Table1.

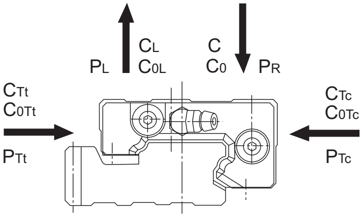


Fig.1

Table1 Basic Load Ratings of Model GSR-R in All Directions

Direction	Basic dynamic load rating	Basic static load rating
Radial direction	C	C_0
Reverse radial direction	$C_L=0.93C$	$C_{0L}=0.90C_0$
Tensile lateral direction	$C_{Tt}=0.84C$	$C_{0Tt}=0.78C_0$
Compressive lateral direction	$C_{Tc}=0.93C$	$C_{0Tc}=0.90C_0$

Equivalent Load

When the LM block of model GSR-R receives loads in the radial, tensile lateral, reverse radial and compressive lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_R + Y \cdot P_{Tt}$$
$$P_E = P_L + P_{Tc}$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Tensile lateral direction
: Compressive lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_{Tt} : Tensile lateral load (N)
P_{Tc} : Compressive lateral direction load (N)
X, Y : Equivalent factor (see Table2)

Table2 Equivalent Factor of Model GSR-R
(when radial and tensile lateral loads are applied)

P_E	X	Y
Equivalent load in the radial direction	1	1.28
Equivalent load in tensile lateral direction	0.781	1

Service Life

For details,see A-100.

Accuracy Standards

For details,see A-125.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-331.

Error Allowance in the Parallelism between Two Rails

For details,see A-334.

Error Allowance in Vertical Level between Two Rails

For details,see A-337.

Rack and Pinion

[Joining Two or More Rails]

The end faces of the rail with rack are machined so that a clearance is left after assembly in order to facilitate the assembly.
Use of a special jig as shown in Fig.2 will make the connection easier.
(THK also offers the rack-aligning jig.)

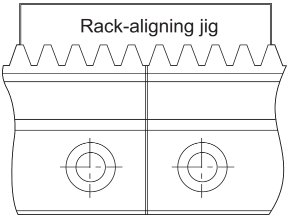


Fig.2 Rack Connection Method

[Reworking the Pinion Hole]

Only the teeth of the reworkable pinion-hole-diameter type (type C) are heat-treated. The hole and keyway can therefore be reworked by the user to the desired diameter and shape.
When reworking the pinion hole, be sure to take the following into account.
The material of the reworkable hole diameter type (type C): S45C

(1) When chucking the teeth of a reworkable hole diameter type, use a jaw scroll chuck or something like it to maintain the tooth profile.

(2) The pinion is produced using the center of the hole as a reference point. The center of the hole should therefore be used as a reference point when the pinion is aligned.
When checking the pinion runout, refer to the boss sides.

(3) Keep the reworked hole diameter within roughly 60 to 70% of the boss diameter.

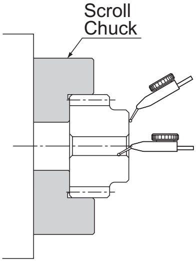


Fig.3

[Lubricating the Rack and Pinion]

To ensure smooth sliding on tooth surfaces and prevent wear, the teeth should be provided with a lubricant.

Note) Use a lubricant of the same type as that contained in the LM Guide.

[Checking Strength]

The strength of the assembled rack and pinion must be checked in advance.

(1) Calculate the maximum thrust acting on the pinion.

(2) Divide the permissible power transmission capacity of the pinion to be used (Table3) by an overload factor (Table4).

(3) By comparing the thrust acting on the pinion obtained in step 1 with the pinion power transmission capacity obtained in step 2, make sure the applied thrust does not exceed the permissible power transmission capacity.

[Example of calculation]

Model GSR-R is used in a horizontal conveyance system receiving a medium impact (assuming external load to be zero).

● Conditions

Subject model No. (pinion)	GP6-20A
Mass (table + work)	m=100kg
Speed	v=1 m/s
Acceleration/deceleration time	T_1 =0.1 s

● Consideration

(1) Calculating the maximum thrust

Calculated the thrust during acceleration/deceleration.

$$\mathbf{Fmax} = \mathbf{m} \cdot \frac{\mathbf{v}}{\mathbf{T_1}} = \mathbf{1.00kN}$$

(2) Permissible power transmission capacity of the pinion

$$\mathbf{Pmax} = \frac{\text{Permissible power transmission capacity (see Table 3)}}{\text{Overload factor (see Table 4)}} = \frac{2.33}{1.25}$$

$$= \mathbf{1.86kN}$$

(3) Comparison between the maximum thrust and the permissible power transmission capacity of the pinion

Fmax<Pmax

Therefore, it is judged that the subject model number can be used.

Table3 Permissible Power transmission Capacity

Unit: kN

Model No.	Permissible Power transmission Capacity	Supported model
GP 6-20A	2.33	GSR 25-R
GP 6-20C	2.05	
GP 6-25A	2.73	
GP 6-25C	2.23	
GP 8-20A	3.58	GSR 30-R
GP 8-20C	3.15	
GP 8-25A	4.19	
GP 8-25C	3.42	
GP10-20A	5.19	GSR 35-R
GP10-20C	4.57	
GP10-25A	6.06	
GP10-25C	4.96	

Table4 Overload Factor

Impact from the prime mover	Impact from the driven machine		
	Uniform load	Medium impact	Large impact
Uniform load (electric motor, turbine, hydraulic motor, etc.)	1.0	1.25	1.75

(Excerpt from JGMA401-01)

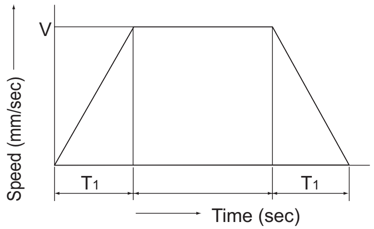
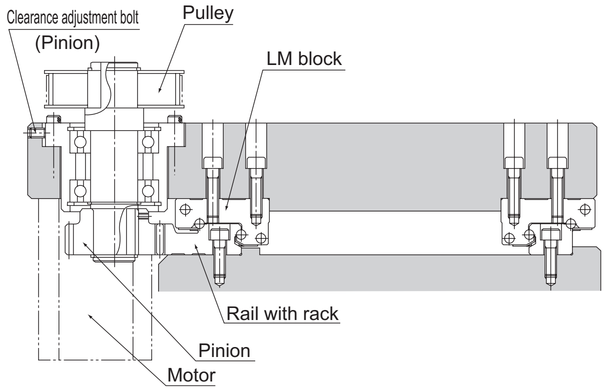
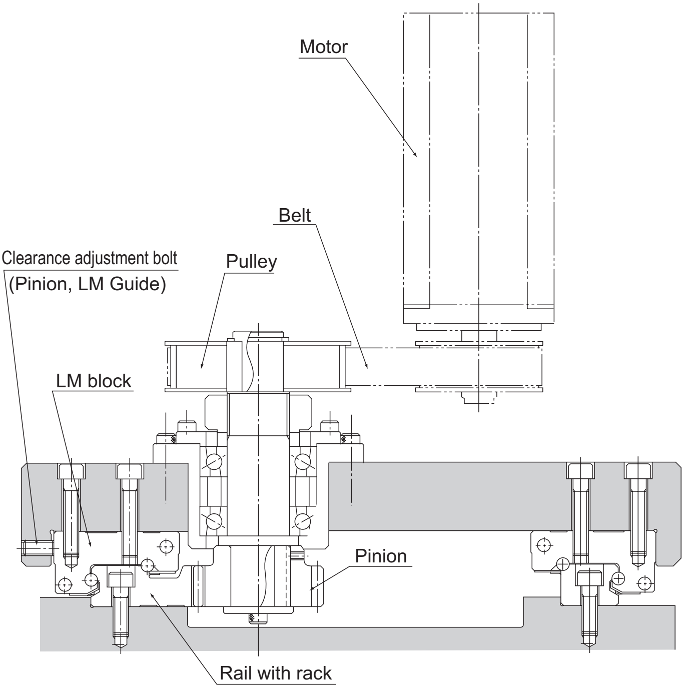


Fig.4

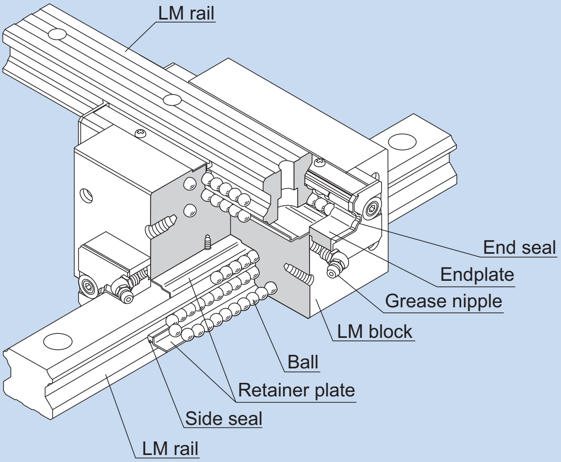
[Example of Assembling Model GSR-R with the Table]





CSR

LM Guide
Cross LM Guide Model CSR



Structure and Features

Balls roll in four rows of raceways precision-ground on a LM rail and a LM block, and endplates incorporated in the LM block allow the balls to circulate. Since retainer plates hold the balls, they do not fall off even if the LM rail is pulled out.
This model is an integral type of LM Guide that squares an internal structure similar to model HSR, which has a proven track record and is highly reliable, with another and uses two LM rails in combination. It is machined with high precision so that the perpendicularity of the hexahedron of the LM block is within 2 μm per 100 mm in error. The two rails are also machined with high precision in relative straightness. As a result, extremely high accuracy in orthogonality is achieved. Since an orthogonal LM system can be achieved with model CSR alone, a conventionally required saddle is no longer necessary, the structure for X-Y motion can be simplified and the whole system can be downsized.

[4-way Equal Load Type]

Each row of balls is placed at a contact angle of 45° so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse radial and lateral directions), enabling the LM Guide to be used in all orientations.

[High Rigidity]

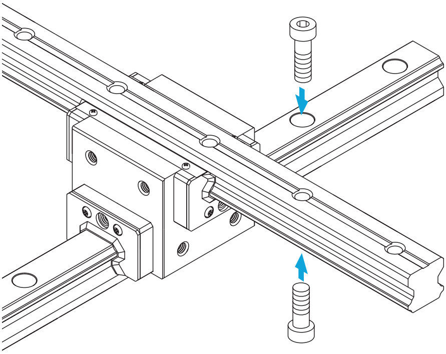
Since balls are arranged in four rows in a well-balanced manner, this model is stiff against a moment, and smooth straight motion is ensured even a preload is applied to increase the rigidity.
The rigidity of the LM blocks is 50% higher than that of a combination of two HSR LM blocks secured together back-to-back with bolts. Thus, CSR is an optimal LM Guide for building an X-Y table that requires high rigidity.

Types and Features

Model CSR-S

Specification Table⇒B-154

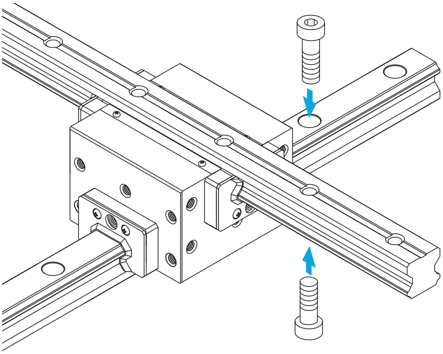
This model is a standard type.



Model CSR

Specification Table⇒B-154

It has a longer overall LM block length (L) and a greater rated load.



Rated Loads in All Directions

Model CSR is capable of receiving loads in four directions: radial, reverse radial and lateral directions.

The basic load ratings are defined with an LM rail and two LM blocks, and uniform in the four directions (radial, reverse radial and lateral directions). Their actual values are provided in the specification table for CSR.

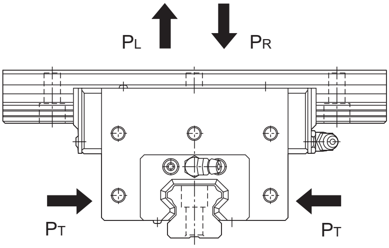


Fig.1

Equivalent Load

When the LM block of model CSR receives loads in the reverse radial and lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R \ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-114.

Accuracy Standards

For details,see A-122.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-326.

Error Allowance in the Parallelism between Two Rails

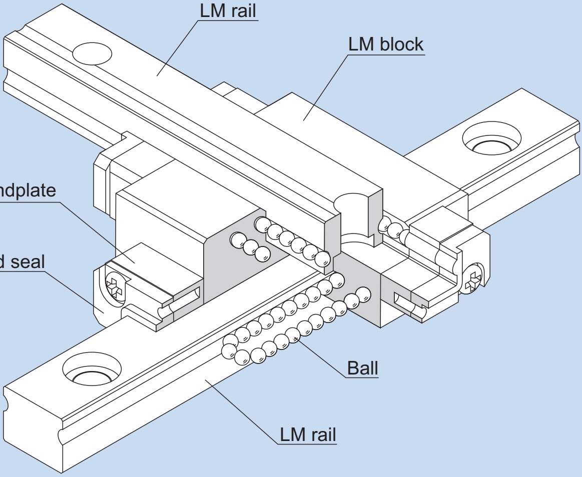
For details,see A-333.

Error Allowance in Vertical Level between Two Rails

For details,see A-336.

MX

LM Guide
Miniature Cross Guide Model MX



Structure and Features

Balls roll in two rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate. This model is an integral type of LM Guide that squares a unit of miniature LM Guide model RSR with another and uses two LM rails in combination. Since an orthogonal LM system with an extremely low height can be achieved with model MX alone, a conventionally required saddle is no longer necessary and the whole system can be downsized.

[4-way Equal Load Type]

Each row of balls is placed at a contact angle of 45° so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse radial and lateral directions), enabling the LM Guide to be used in all orientations.

[Tapped-hole LM Rail Type]

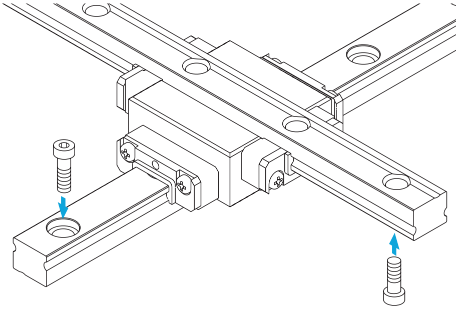
There are two types of the LM rail: one designed to be mounted from the top with bolts, and a semi-standard type whose bottom face has tapped holes, allowing the rail to be mounted from the bottom.

Types and Features

Model MX

Specification Table⇒B-160

MX is divided into two types: RSR5M cross type and RSR7WM cross type.



Rated Loads in All Directions

Model MX is capable of receiving loads in four directions: radial, reverse radial and lateral directions.
The basic load ratings are defined with an LM rail and an LM block, and uniform in the four directions (radial, reverse radial and lateral directions). Their actual values are provided in the specification table for MX.

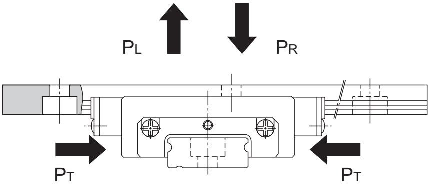


Fig.1

Equivalent Load

When the LM block of model MX receives loads in the radial, reverse radial and lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R \; (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-115.

Accuracy Standards

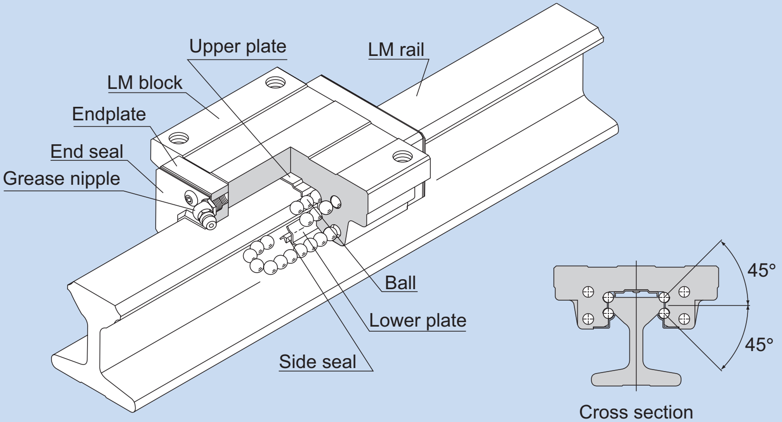
For details,see A-127.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-327.

JR

LM Guide
Structural Member Rail Model JR



Cross section

Structure and Features

Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate. Since retainer plates hold the balls, they do not fall off even if the LM rail is pulled out.

Model JR uses the same LM block as model HSR, which has a proven track record and is highly reliable. The LM rail has a sectional shape with high flexural rigidity, and therefore can be used as a structural member.

Unlike the conventional LM Guide type, whose LM rail was secured onto the base with bolts when installed, model JR's LM rail is integrated with the mounting base, and the top of the LM rail has the same structure as LM Guide model HSR. The lower part of the LM rail has a hardness of HRC25 or less, making it easy to cut the rail and enabling the rail to be welded.

When welding the rail, we recommend using welding rods compliant with JIS D 5816. (suggested manufacturer and model number: Kobelco LB-52).

[4-way Equal Load Type]

Each row of balls is placed at a contact angle of 45° so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse radial and lateral directions), enabling the LM Guide to be used in all orientations.

[Can be Mounted Even Under Rough Conditions]

Since the central part of the LM rail is slightly thinner than the ends, even if the parallelism between two rails is poor the LM rail is capable of absorbing the error by bending inward or outward.

[Sectional Shape with High Flexural Rigidity]

Since the LM rail has a sectional shape with high flexural rigidity, it can also be used as a structural member. In addition, even when the LM rail is partially fastened or supported in cantilever, the distortion is minimal.

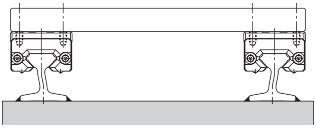


Fig.1

Second Moment of Inertia of the LM Rail

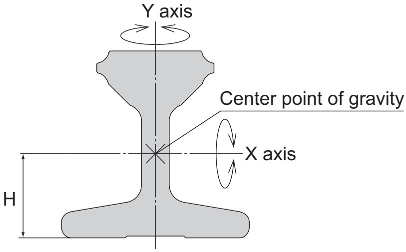


Fig.2

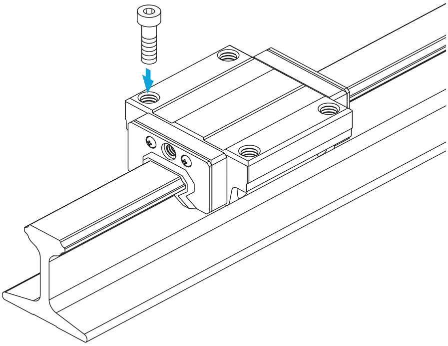
	Geometrical moment of inertia I [$\times 10^5$ mm^4]		Modulus of section Z [$\times 10^4$ mm^3]		Height of gravitational center H [mm]
	About X axis	About Y axis	About X axis	About Y axis	
JR 25	1.90	0.51	0.69	0.21	19.5
JR 35	4.26	1.32	1.43	0.49	24.3
JR 45	12.1	3.66	3.31	1.04	33.1
JR 55	27.6	6.54	5.89	1.40	43.3

Types and Features

Model JR-A

Specification Table⇒B-164

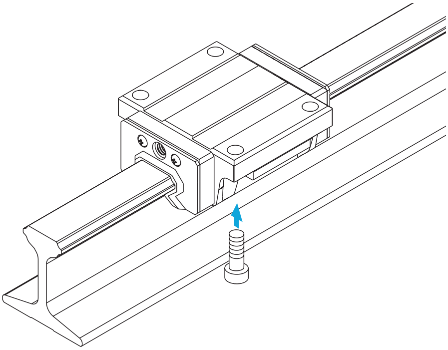
The flange of its LM block has tapped holes.



Model JR-B

Specification Table⇒B-164

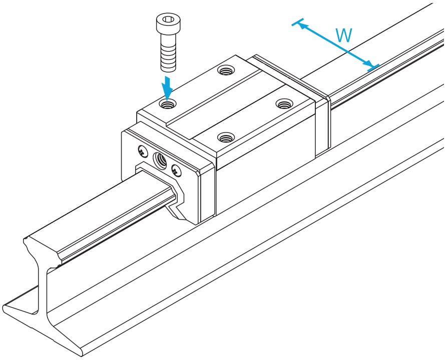
The flange of the LM block has through holes. Used in places where the table cannot have through holes for mounting bolts.



Model JR-R

Specification Table⇒B-164

With this type, the LM block has a smaller width (W) and tapped holes. Used in places where the table width is limited.



Rated Loads in All Directions

Model JR is capable of receiving loads in four directions: radial, reverse radial and lateral directions.
The basic load ratings are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for JR.

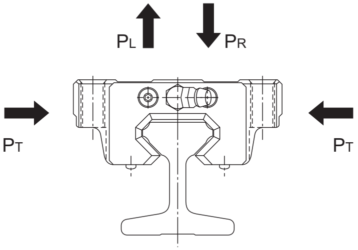


Fig.3

Equivalent Load

When the LM block of model JR receives loads in the radial, reverse radial and lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R\ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-115.

Accuracy Standards

For details,see A-121.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-326.

Error Allowance in the Parallelism between Two Rails

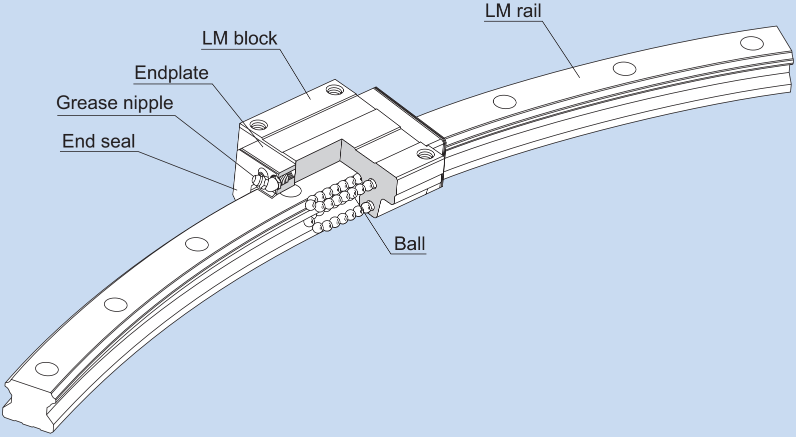
For details,see A-333.

Error Allowance in Vertical Level between Two Rails

For details,see A-336.

HCR

LM Guide
R Guide Model HCR



Structure and Features

Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate.
With a structure that is basically the same as four-way equal load type LM Guide model HSR, which has a proven track record, this R Guide is a new concept product that allows highly accurate circular motion.

[Freedom of Design]

Multiple LM blocks can individually move on the same rail. By arranging LM blocks on the load points, efficient structural design is achieved.

[Shortened Assembly Time]

This model allows clearance-free, highly accurate circular motion as opposed to sliding guides or cam followers. You can easily assemble this model simply by mounting the LM rail and LM blocks with bolts.

[Allows Circular Motion of 5m or Longer]

It allows circular motion of 5 m or longer, which is impossible with swivel bearings.
In addition, use of this model makes it easy to assemble, disassemble and reassemble equipment that circularly moves.

[Capable of Receiving Loads in All Directions]

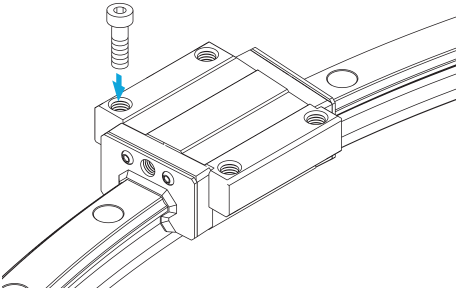
This model is capable of receiving loads in all directions since it has a structure that is basically the same as model HSR.

Types and Features

Model HCR

Specification Table⇒B-168

The flange of its LM block has tapped holes.



Rated Loads in All Directions

Model HCR is capable of receiving loads in four directions: radial, reverse radial and lateral directions.
The basic load ratings are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for HCR.

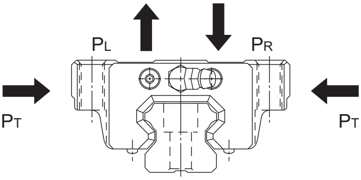


Fig.1

Equivalent Load

When the LM block of model HCR receives loads in all four directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R \ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-115.

Accuracy Standards

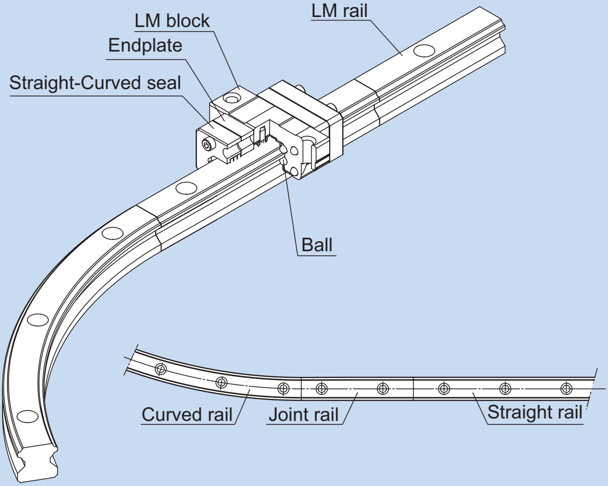
For details,see A-121.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-328.

HMG

LM Guide
Straight-Curved Guide Model HMG



Structure and Features

The Straight-Curved Guide HMG is a new straight-curved guide that allows the same type of LM blocks to continuously move on straight and curved rails by combining the technologies of the LM Guide HSR and the R Guide HCR. It achieves drastic cost reduction through improvement of work efficiency at the assembly and conveyance lines and the inspection equipment and simplification of the structure by eliminating a lift and a table.

[Freedom of Design]

It allows free combinations of straight and curved shapes.

Since LM blocks can smoothly transit between the straight and curved sections, various combinations of straight and curved rails can be joined into various shapes such as O, U, L and S shapes. In addition, HMG allows a large table to be mounted and a heavy object to be carried through combinations of multiple blocks on a single rail or 2 or more LM rails. Thus, it provides great freedom of design.

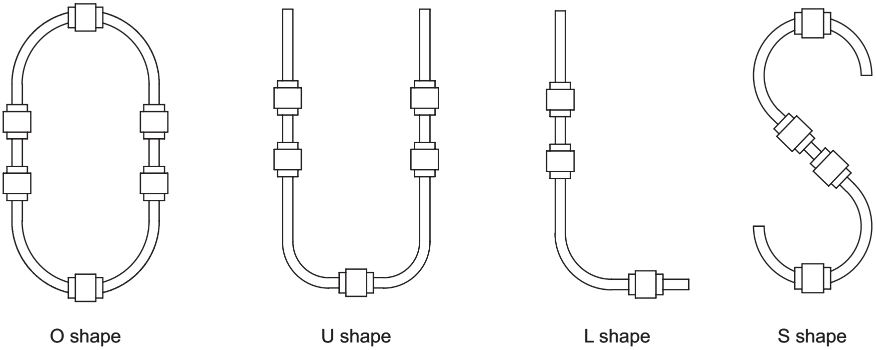


Fig.1 Examples of Joining Rails into Different Shapes

[Shortened Transportation Time]

Unlike the shuttle method, using HMG units in a circulating system allows workpieces to be placed while other workpieces are being inspected or mounted, thus to significantly improve process time. Increasing the number of tables can further shorten process time.

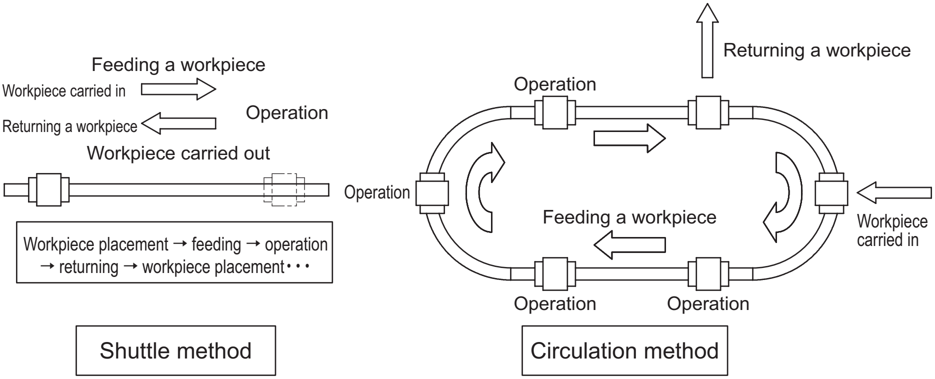


Fig.2 Improved process time

[Cost Reduction through a Simplified Mechanism]

Combination of straight and curved rails eliminates a lift and a turntable conventionally used for changing directions in the conveyance and production lines. Therefore, use of HMG simplifies the mechanism and eliminates a large number of parts, allowing the cost to be reduced. Additionally, man-hours in designing can also be reduced.

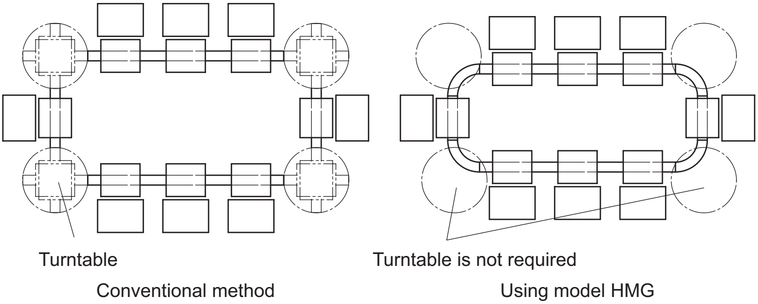


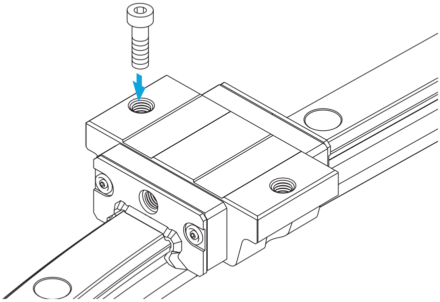
Fig.3

Types and Features

Model HMG

Specification Table⇒B-172

The flange of the LM block has tapped holes. Can be mounted from the top or the bottom.



Rated Loads in All Directions

Model HMG is capable of receiving loads in all four directions: radial, reverse radial and lateral directions.
The basic load ratings are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for HMG.

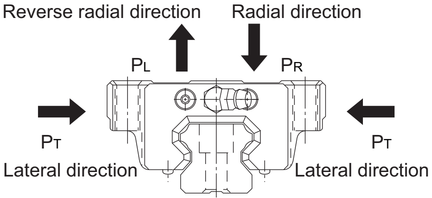


Fig.4

Equivalent Load

When the LM block of model HMG receives loads in all directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R\ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-115.

Accuracy Standards

For details,see A-121.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-328.

Examples of Table Mechanisms

The Straight-Curved Guide HMG requires a rotating mechanism or a slide mechanism for the table to rotate the curved sections when 2 or more rails are used or when 2 or more LM blocks are connected on a single rail. Refer to Fig.5 for examples of such mechanisms.

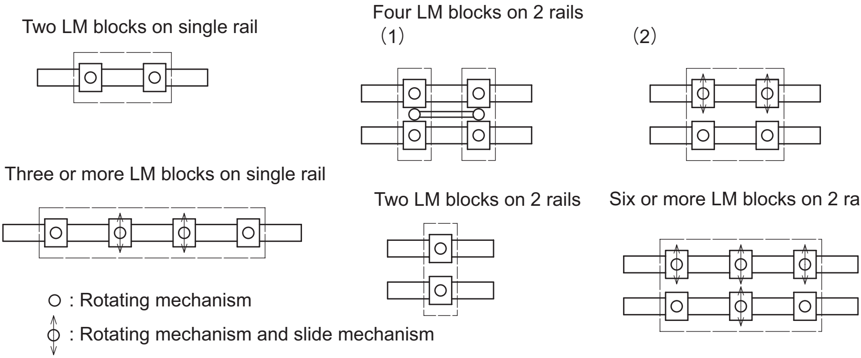


Fig.5 Examples of Table Mechanisms

Fig.6 shows examples of designing a table when units are used on multiple axes. HMG requires a rotating mechanism and a slide mechanism since the table is decentered when an LM block transits from a straight section to a curved section. The amount of decentering differs according to the radius of the curved section and the LM block span. Therefore, it is necessary to design the system in accordance with the corresponding specifications.

Fig.7 shows detail drawings of the slide and rotating mechanisms. In the figure, LM Guides are used in the slide mechanism and Cross-Roller Rings in the rotating mechanism to achieve smooth sliding and rotating motions.

For driving the Straight-Curved Guide, belt drives and chain drives are available.

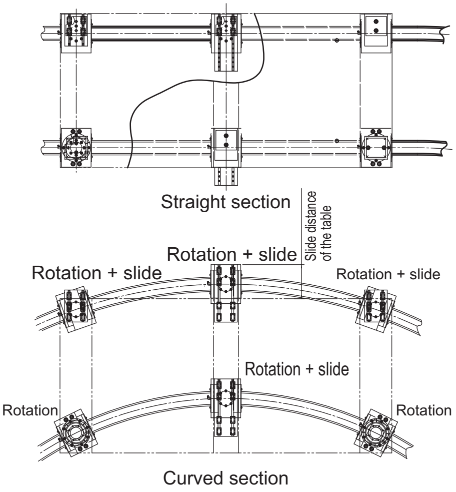


Fig.6

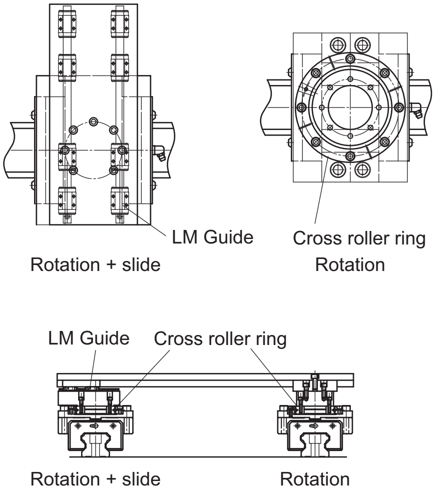
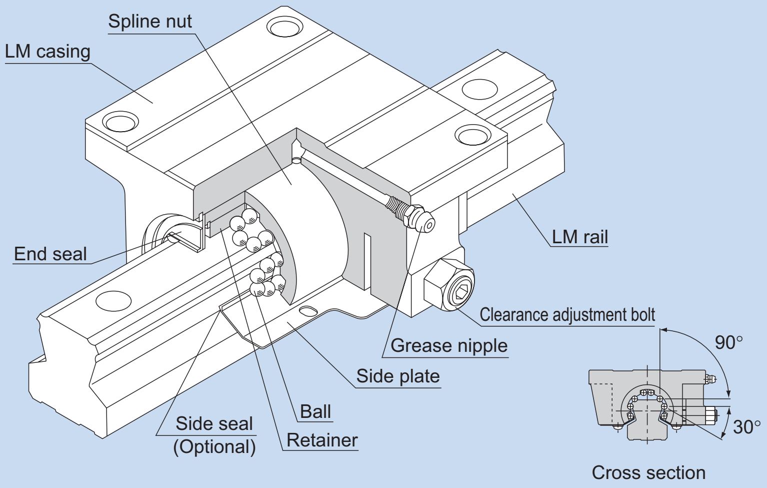


Fig.7

NSR-TBC

LM Guide
Self-aligning Type Model NSR-TBC



Structure and Features

Model NSR-TBC is the only LM Guide whose casing consists of two pieces instead of a single-piece LM block. The rigid, cast iron casing contains a cylindrical spline nut that is partially cut at an angle of 120°. This enables the model to self-aligning on the fitting surface with the casing, thus to permit rough installation.

[Capable of Receiving Loads in All Directions]
NSR-TBC has four rows of balls. The balls are arranged in two rows on each shoulder of the LM rail, and can receive loads in all four directions: upward, downward and lateral directions. Due to the self-aligning structure, however, a rotational moment (M_C) cannot be applied in a single-rail configuration.

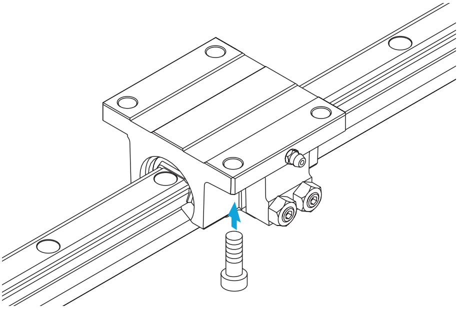
[Easy Installation and Accuracy Establishment]
Model NSR-TBC is highly capable of performing self-adjustment and self-alignment. As a result, even if two rails are not mounted with accuracy, the LM casing absorbs the error and it does not affect the traveling performance. Accordingly, the machine performance will not be deteriorated.

Types and Features

Model NSR-TBC

Specification Table⇒B-178

The flange of the LM casing has through holes, allowing the LM Guide to be mounted from the bottom.



Rated Loads in All Directions

Model NSR-TBC is capable of receiving loads in four directions: radial, reverse radial and lateral directions.
The basic load ratings indicate the values in the radial direction in Fig.1, and their actual values are provided in the specification table for NSR-TBC. The values in the reverse radial and lateral directions are obtained from Table1 below.

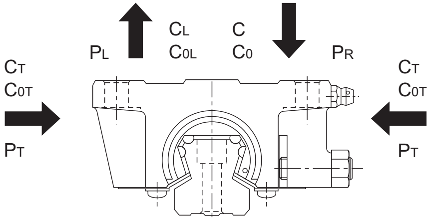


Fig.1

Table1 Basic Load Ratings of Model NSR-TBC in All Directions

Direction	Basic dynamic load rating	Basic static load rating
Radial direction	C	C_0
Reverse radial direction	$C_L=0.62C$	$C_{0L}=0.50C_0$
Lateral directions	$C_T=0.56C$	$C_{0T}=0.43C_0$

Equivalent Load

When the LM casing of model NSR-TBC receives loads in the reverse radial and lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_L + Y \cdot P_T$$

P_E : Equivalent load (N)
: Reverse radial direction
: Lateral direction
P_L : Reverse radial load (N)
P_T : Lateral load (N)
X, Y : Equivalent factor (see Table2)

Table2 Equivalent Factor of Model NSR-TBC

P_E	X	Y
Equivalent load in reverse radial direction	1	1.155
Equivalent load in lateral direction	0.866	1

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-115.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-326.

Error Allowance in the Parallelism between Two Rails

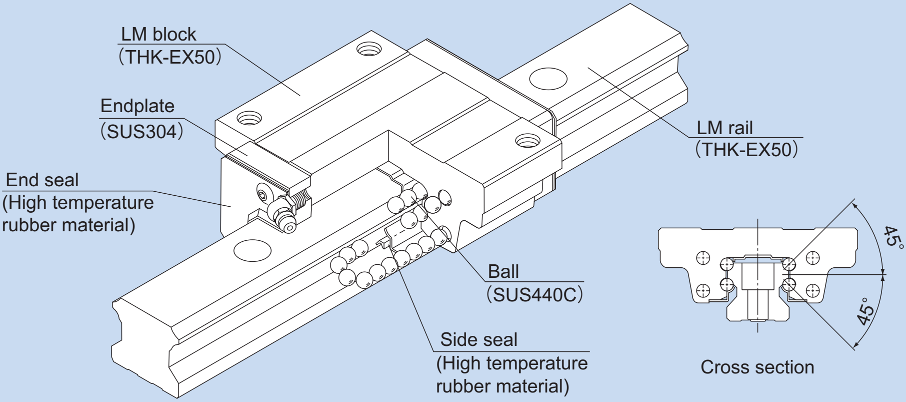
For details,see A-334.

Error Allowance in Vertical Level between Two Rails

For details,see A-337.

HSR-M1

LM Guide
High Temperature Type Model HSR-M1



Structure and Features

Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate.

Each row of balls is placed at a contact angle of 45° so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse radial and lateral directions), enabling the LM Guide to be used in all orientations.

The high temperature type LM Guide is capable of being used at service temperature up to 150 ℃ thanks to THK's unique technologies in material, heat treatment and lubrication.

[Maximum Service Temperature: 150℃]

Use of stainless steel in the endplates and high temperature rubber in the end seals achieves the maximum service temperature of 150℃.

[Dimensional Stability]

Since it is dimensionally stabilized, it demonstrates superb dimensional stability after being heated or cooled (note that it shows linear expansion at high temperature).

[Highly Corrosion Resistant]

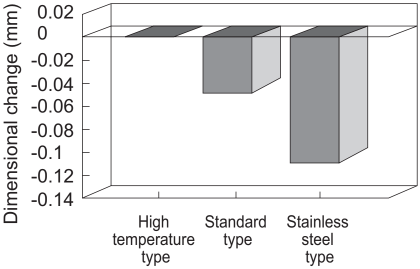
Since the LM block, LM rail and balls use stainless steel, which is highly corrosion resistant, this model is optimal for clean room applications.

[High Temperature Grease]

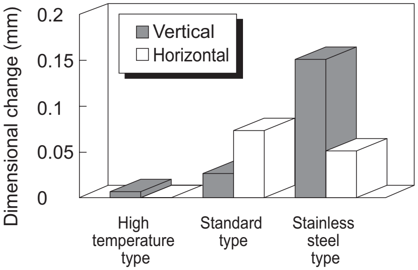
This model uses high temperature grease that shows little grease-based fluctuation in rolling resistance even if temperature changes from low to high levels.

● Dimensional Stability Data

Since this model has been treated for dimensional stability, its dimensional change after being cooled or heated is only minimal.



Overall LM Rail Length

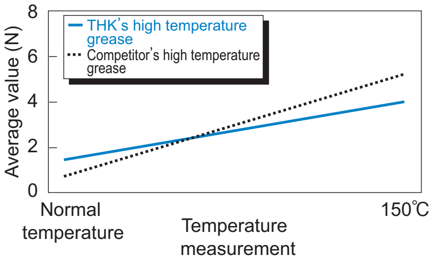


Curvature of the LM Rail

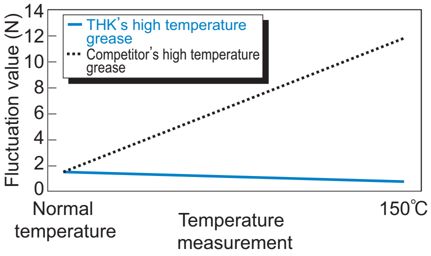
Note1) The above data on overall length and curvature indicate dimensional change when the LM rail is cooled to normal temperature after being heated at 150℃ for 100 hours.
Note2) The samples consist of high temperature, standard and stainless steel types of model HSR25 + 580L.

● Rolling Resistance Data in Relation to Grease

Use a high temperature grease with which the rolling resistance of the LM system little fluctuates even temperature changes from a normal to high range.



Average Value



Fluctuation Value

For the measurements above, model HSR25M1R1C1 is used.

● Thermal Characteristics of LM Rail and LM Block Materials

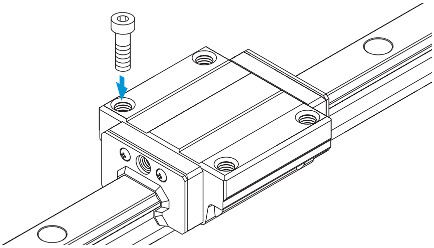
Specific heat capacity: 0.481 J/(g・K)
Thermal conductivity: 20.67 W/(m・K)
Average coefficient of linear expansion: 11.8×10⁻⁶/℃

Types and Features

Model HSR-M1A

Specification Table⇒B-182

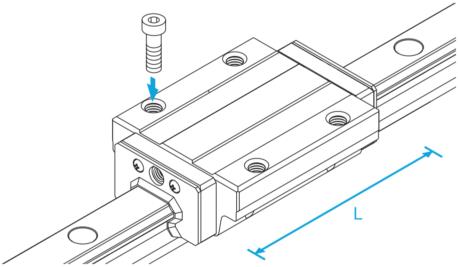
The flange of its LM block has tapped holes.



Model HSR-M1LA

Specification Table⇒B-182

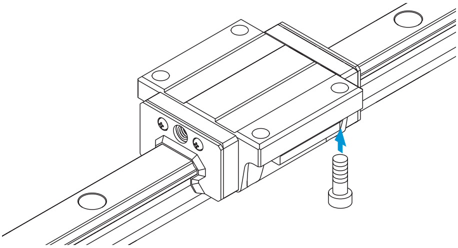
The LM block has the same cross-sectional shape as model HSR-M1A, but has a longer overall LM block length (L) and a greater rated load.



Model HSR-M1B

Specification Table⇒B-184

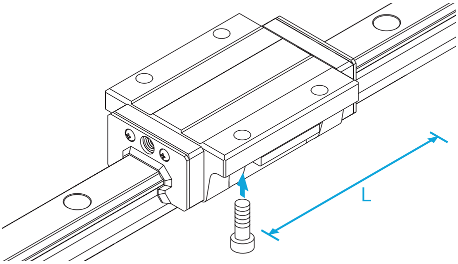
The flange of the LM block has through holes. Used in places where the table cannot have through holes for mounting bolts.



Model HSR-M1LB

Specification Table⇒B-184

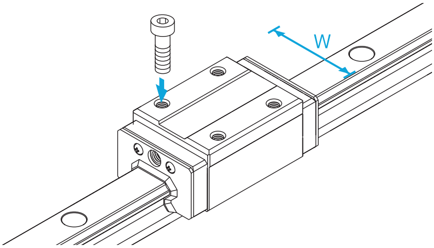
The LM block has the same sectional shape as model HSR-M1B, but has a longer overall LM block length (L) and a greater rated load.



Model HSR-M1R

Specification Table⇒B-186

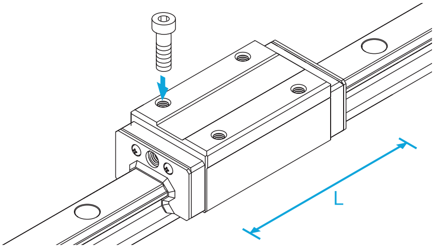
With this type, the LM block has a smaller width (W) and tapped holes. Used in places where the space for table width is limited.



Model HSR-M1LR

Specification Table⇒B-186

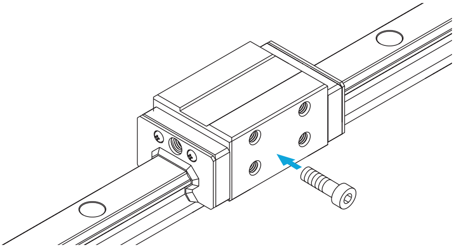
The LM block has the same sectional shape as model HSR-M1R, but has a longer overall LM block length (L) and a greater rated load.



Model HSR-M1YR

Specification Table⇒B-188

When using two units of LM Guide facing each other, the previous model required much time in machining the table and had difficulty achieving the desired accuracy and adjusting the clearance. Since model HSR-M1YR has tapped holes on the side of the LM block, a simpler structure is gained and significant man-hour cutting and accuracy increase can be achieved.



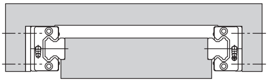


Fig.1 Conventional Structure

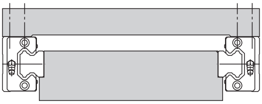


Fig.2 Mounting Structure for Model HSR-M1YR

Rated Loads in All Directions

Model HSR-M1 is capable of receiving loads in four directions: radial, reverse radial and lateral directions.

The basic load ratings are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for HSR-M1.

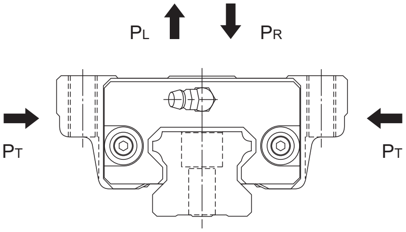


Fig.3 Model HSR-M1

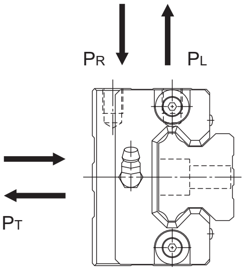


Fig.4 Model HSR-M1YR

Equivalent Load

When the LM block of model HSR-M1 receives loads in all directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R \ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-114.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-328.

Error Allowance in the Parallelism between Two Rails

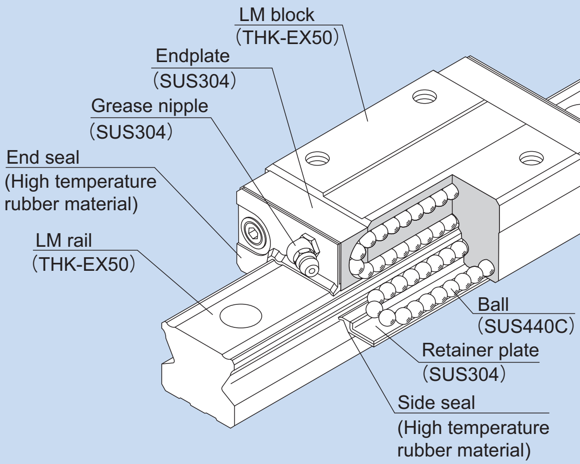
For details,see A-333.

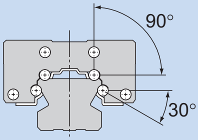
Error Allowance in Vertical Level between Two Rails

For details,see A-336.

SR-M1

LM Guide
High Temperature Type Model SR-M1





Cross section

Structure and Features

Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate.
Since it is a compactly designed model that has a low sectional height and a ball contact structure rigid in the radial direction, this model is optimal for horizontal guide units.
High temperature type LM Guide model SR-M1 is capable of being used at service temperature up to 150℃ thanks to THK's unique technologies in material, heat treatment and lubrication.

[Maximum Service Temperature: 150℃]
Use of stainless steel in the endplates and high temperature rubber in the end seals achieves the maximum service temperature of 150℃.

[Dimensional Stability]
Since it is dimensionally stabilized, it demonstrates superb dimensional stability after being heated or cooled (note that it shows linear expansion at high temperature).

[Highly Corrosion Resistant]
Since the LM block, LM rail and balls use stainless steel, which is highly corrosion resistant, this model is optimal for clean room applications.

[High Temperature Grease]
This model uses high temperature grease that shows little grease-based fluctuation in rolling resistance even if temperature changes from low to high levels.

Thermal Characteristics of LM Rail and LM Block Materials

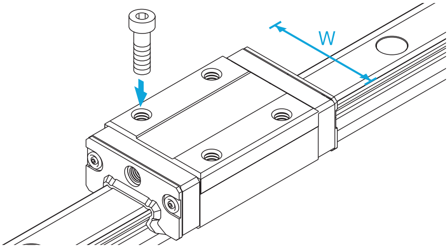
- Specific heat capacity: 0.481 J/(g•K)
- Thermal conductivity: 20.67 W/(m•K)
- Average coefficient of linear expansion: 11.8×10^{-6}/℃

Types and Features

Model SR-M1W

Specification Table⇒B-192

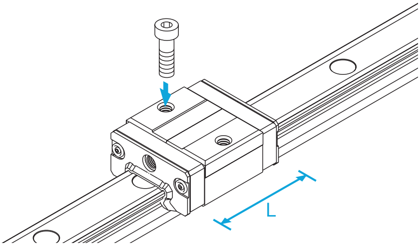
With this type, the LM block has a smaller width (W) and tapped holes.



Model SR-M1V

Specification Table⇒B-192

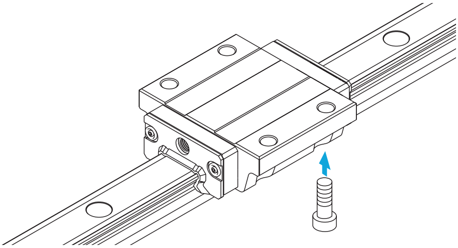
A space-saving type whose LM block has the same cross-sectional shape as model SR-M1W, but has a smaller overall LM block length (L).



Model SR-M1TB

Specification Table⇒B-194

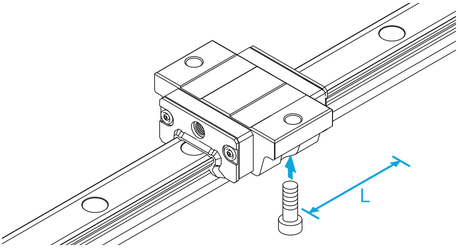
The LM block has the same height as model SR-M1W and can be mounted from the bottom.



Model SR- M1SB

Specification Table⇒B-194

A space-saving type whose LM block has the same sectional shape as model SR-M1TB, but has a smaller overall LM block length (L).



Rated Loads in All Directions

Model SR-M1 is capable of receiving loads in four directions: radial, reverse radial and lateral directions.
The basic load ratings indicate the values in the radial directions in Fig.1, and their actual values are provided in the specification table for SR-M1. The values in the reverse radial and lateral directions are obtained from Table1 below.

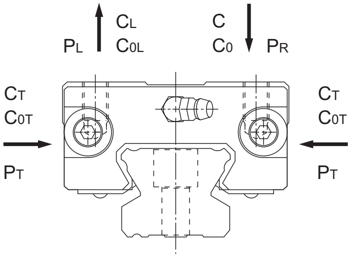


Fig.1

Table1 Rated Loads in All Directions with Model SR-M1

Model No.	Direction	Basic dynamic load rating	Basic static load rating
SR-M1 15 to 35	Radial direction	C	C_0
	Reverse radial direction	$C_L=0.62C$	$C_{0L}=0.50C_0$
	Lateral directions	$C_T=0.56C$	$C_{0T}=0.43C_0$

Equivalent Load

When the LM block of model SR-M1 receives loads in the reverse radial and lateral directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_L + Y \cdot P_T$$

P_E : Equivalent load (N)
: Reverse radial direction
: Lateral direction
P_L : Reverse radial load (N)
P_T : Lateral load (N)
X, Y : Equivalent factor (see Table2)

Table2 Equivalent Factor of Model SR-M1

Model No.	P_E	X	Y
SR-M1 15 to 35	Equivalent load in reverse radial direction	1	1.155
	Equivalent load in lateral direction	0.866	1

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-114.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-326.

Error Allowance in the Parallelism between Two Rails

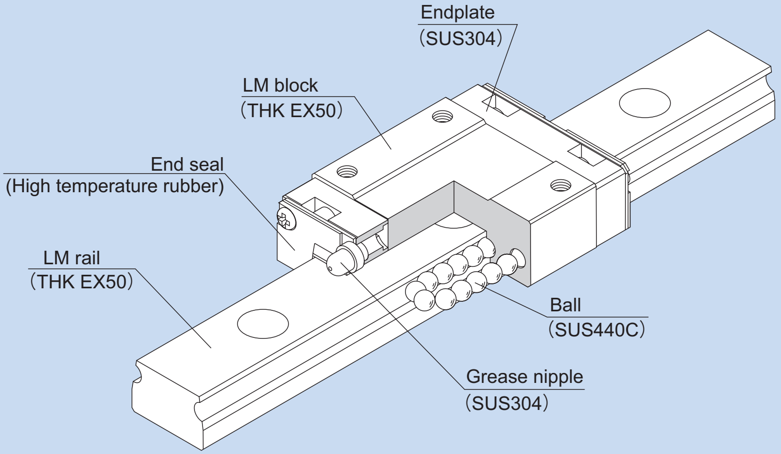
For details,see A-333.

Error Allowance in Vertical Level between Two Rails

For details,see A-336.

RSR-M1

LM Guide
High Temperature Type Model RSR-M1



Structure and Features

Balls roll in two rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate.
High temperature type miniature LM Guide model RSR-M1 is capable of being used at service temperature up to 150℃ thanks to THK's unique technologies in material, heat treatment and lubrication.

[Maximum Service Temperature: 150℃]
Use of stainless steel in the endplates and high temperature rubber in the end seals achieves the maximum service temperature of 150℃.

[Dimensional Stability]
Since it is dimensionally stabilized, it demonstrates superb dimensional stability after being heated or cooled (note that it shows linear expansion at high temperature).

[Highly Corrosion Resistant]
Since the LM block, LM rail and balls use stainless steel, which is highly corrosion resistant, this model is optimal for clean room applications.

[High Temperature Grease]
This model uses high temperature grease that shows little grease-based fluctuation in rolling resistance even if temperature changes from low to high levels.

Thermal Characteristics of LM Rail and LM Block Materials

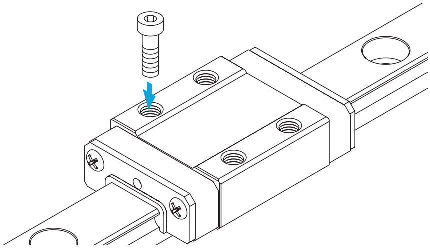
- Specific heat capacity: 0.481 J/(g•K)
- Thermal conductivity: 20.67 W/(m•K)
- Average coefficient of linear expansion: 11.8×10^{-6}/℃

Types and Features

Models RSR-M1, RSR-M1K, M1V

Specification Table⇒B-198

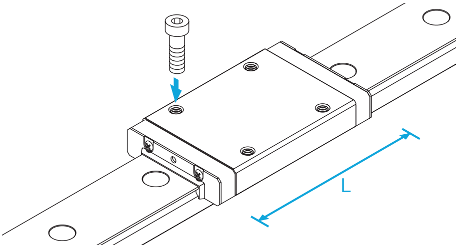
This model is a standard type.



Model RSR-M1N

Specification Table⇒B-198

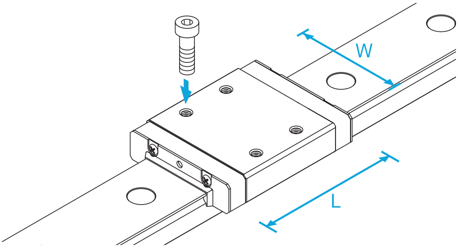
It has a longer overall LM block length (L) and a greater rated load than standard types.



Models RSR-M1W, M1WV

Specification Table⇒B-200

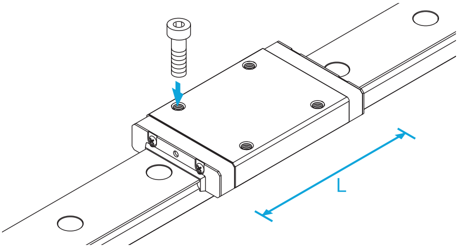
These models have greater overall LM block lengths (L), broader widths (W) and greater rated loads and permissible moments than standard types.



Model RSR-M1WN

Specification Table⇒B-200

It has a longer overall LM block length (L), a greater rated load than standard types. Achieves the greatest load capacity among the high temperature type miniature LM Guide models.



Rated Loads in All Directions

Model RSR-M1 is capable of receiving loads in four directions: radial, reverse radial and lateral directions.

The basic load ratings of models RSR9M1/M1W are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for RSR-M1.

The basic load ratings of models RSR12M1 to 20M1 indicate the values in the radial direction in Fig.1, and their actual values are provided in the specification table for RSR-M1. The values in the reverse radial and lateral directions are obtained from Table1 below.

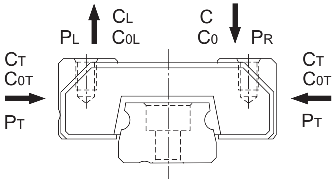


Fig.1

Table1 Basic Load Ratings of Models RSR12M1 to 20M1 in All Directions

Direction	Basic dynamic load rating	Basic static load rating
Radial direction	C	C_0
Reverse radial direction	$C_L=0.78C$	$C_{0L}=0.70C_0$
Lateral directions	$C_T=0.78C$	$C_{0T}=0.71C_0$

Equivalent Load

When the LM block of models RSR9M1/M1W receives loads in all four directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R \ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

When the LM block of models RSR12M1 to 20M1 receives loads in the radial and lateral directions, or the reverse radial and lateral directions, simultaneously, the equivalent load is obtained from the equation below.

$$P_E = X \cdot P_R \ (P_L) + Y \cdot P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)
X, Y : Equivalent factor
(see Table2 and Table3)

Table2 Equivalent Factor of Models RSR12M1 to 20M1(when radial and lateral loads are applied)

P_E	X	Y
Equivalent load in the radial direction	1	0.83
Equivalent load in lateral direction	1.2	1

Table3 Equivalent Factor of Models RSR12M1 to 20M1 (when reverse radial and lateral loads are applied)

P_E	X	Y
Equivalent load in reverse radial direction	1	0.99
Equivalent load in lateral direction	1.01	1

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-114.

Accuracy Standards

For details,see A-126.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-332.

Error Allowance in the Parallelism between Two Rails

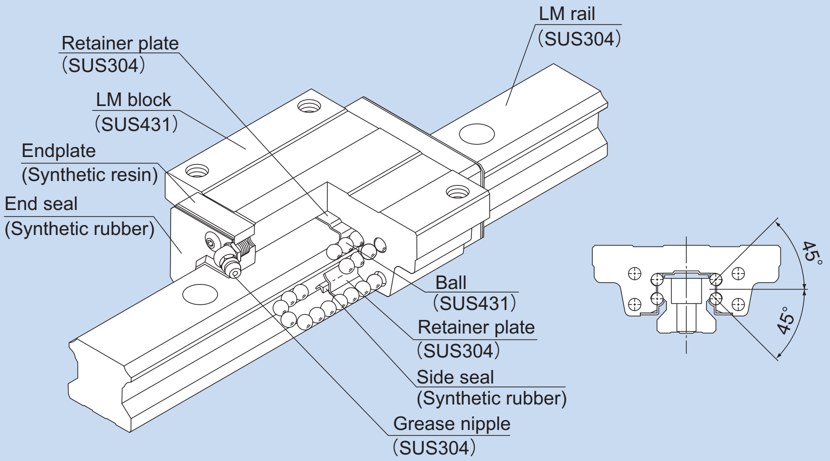
For details,see A-334.

Error Allowance in Vertical Level between Two Rails

For details,see A-337.

HSR-M2

LM Guide
High Corrosion Resistance Type Model HSR-M2



Structure and Features

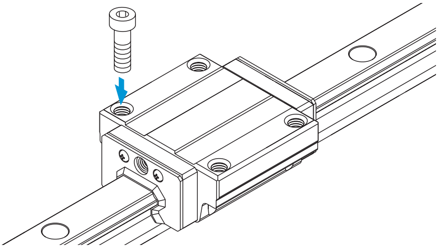
Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and endplates incorporated in the LM block allow the balls to circulate.
Each row of balls is placed at a contact angle of 45° so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse radial and lateral directions), enabling the LM Guide to be used in all orientations.
The LM rail, LM block and balls are made of highly corrosion resistant stainless steel and the other metal parts are made of stainless steel, allowing superb corrosion resistance to be achieved. As a result, the need for surface treatment is eliminated.

Types and Features

Model HSR-M2A

Specification Table⇒B-204

The flange of its LM block has tapped holes.



Rated Loads in All Directions

Model HSR-M2 is capable of receiving loads in four directions: radial, reverse radial and lateral directions.
The basic load ratings are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for HSR-M2.

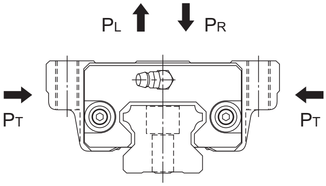


Fig.1 Model HSR-M2

Equivalent Load

When the LM block of model HSR-M2 receives loads in all directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R\ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction

P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-115.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-328.

Error Allowance in the Parallelism between Two Rails

For details,see A-333.

Error Allowance in Vertical Level between Two Rails

For details,see A-336.

Structure and Features of the Caged Roller LM Guide

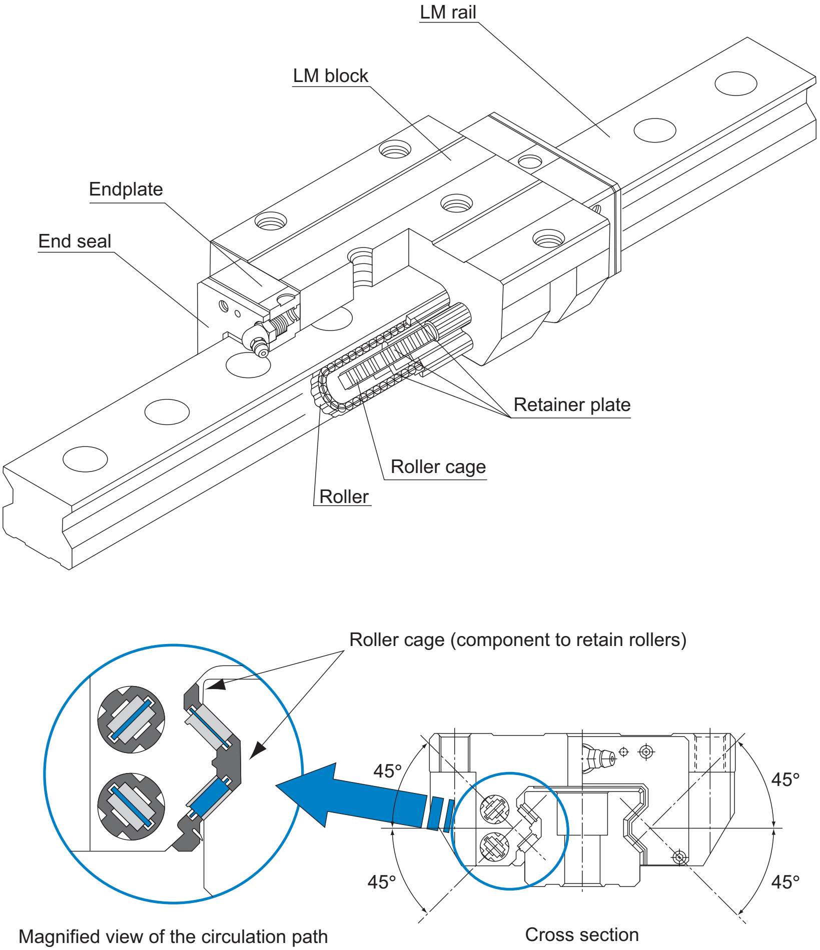


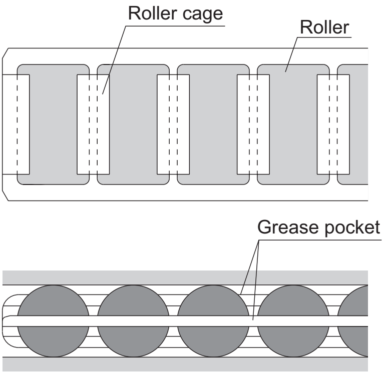
Fig.1 Structural Drawing of the Caged Roller LM Guide Model SRG

Caged Roller LM Guide is a roller guide that achieves low-friction, smooth motion and long-term maintenance-free operation by using a roller cage. In addition, to ensure ultra-high rigidity, rollers with low elastic deformation are used as the rolling elements and the roller diameter and the roller length are optimized.

Furthermore, the lines of rollers are placed at a contact angle of 45° so that the same rated load is applied in the four (radial, reverse and lateral) directions.

Advantages of the Caged Roller Technology

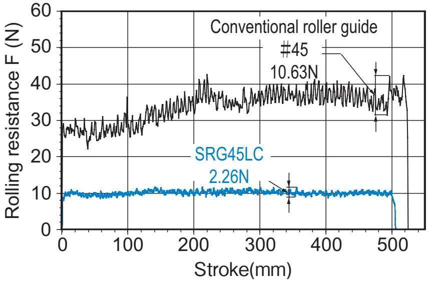
(1) Evenly spaced and aligned rollers circulate, preventing the rollers from skewing, minimizing rolling resistance fluctuations and achieving smooth and stable motion.
(2) The absence of friction between rollers allows grease to be retained in grease pockets and achieves long-term maintenance-free operation.
(3) The absence of friction between rollers achieves low heat generation and superbly high speed.
(4) The absence of roller-to-roller collision ensures low noise and acceptable running sound.



[Smooth Motion]

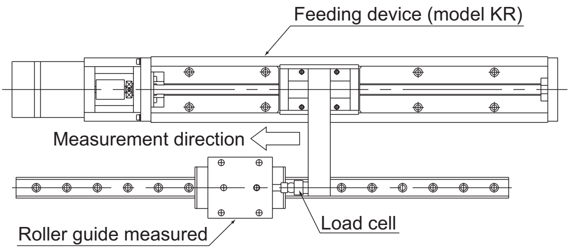
● Rolling Resistance Data

Evenly spaced and aligned rollers circulate, minimizing rolling resistance fluctuations and achieving smooth and stable motion.



Result of Measuring Rolling Resistance Fluctuations

[Conditions]
Feeding speed: 10mm/s
Applied load: no load (one block)



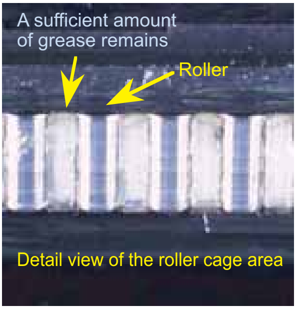
Rolling Resistance Measuring Machine

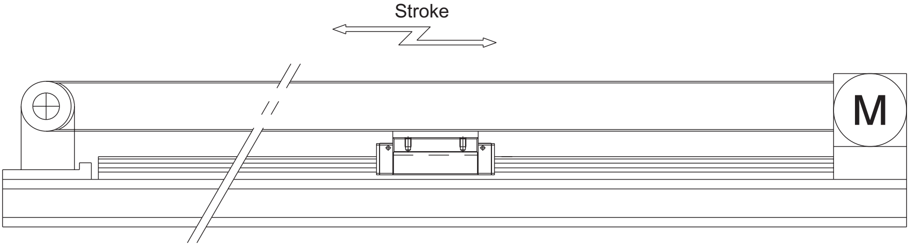
[Long-term Maintenance-free Operation]

● High-speed Durability Test Data

Use of a roller cage eliminates friction between rollers, minimizes heat generation and increases grease retention, thus to achieve long-term maintenance-free operation.

[Conditions]
Model No.: SRG45LC
Magnitude of preload: clearance C0
Speed: 180m/min
Acceleration: 1.5G
Stroke: 2300mm
Lubrication : Initial lubrication only
(THKAFB-LF Grease)





Test result: No anomaly observed after running 15,000 km

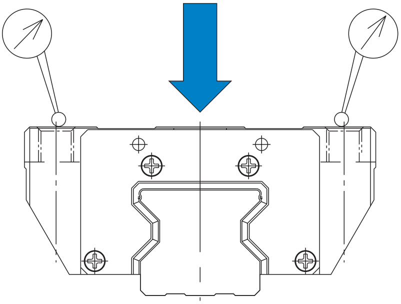
Result of High-speed Durability Test

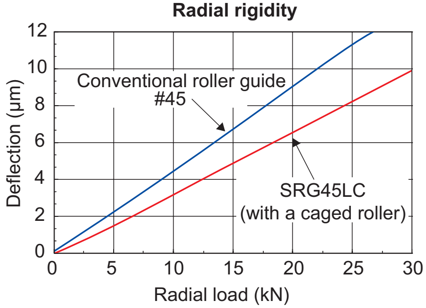
[Ultra-high Rigidity]

● High Rigidity Evaluation Data

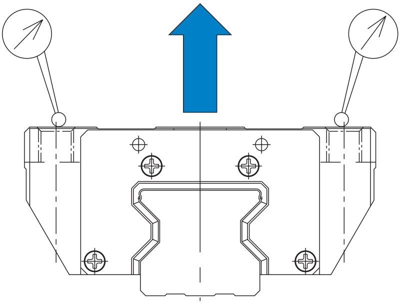
[Preload] SRG : radial clearance C0
Conventional type : radial clearance equivalent to C0

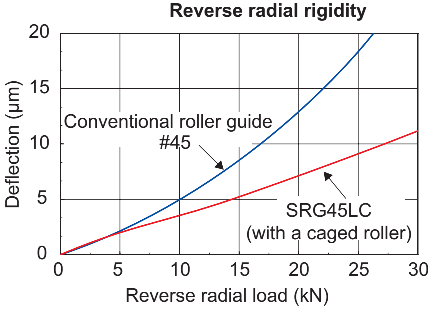
Radial rigidity



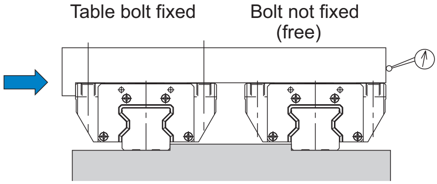


Reverse radial rigidity

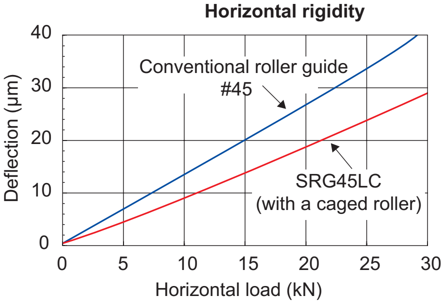




Horizontal rigidity

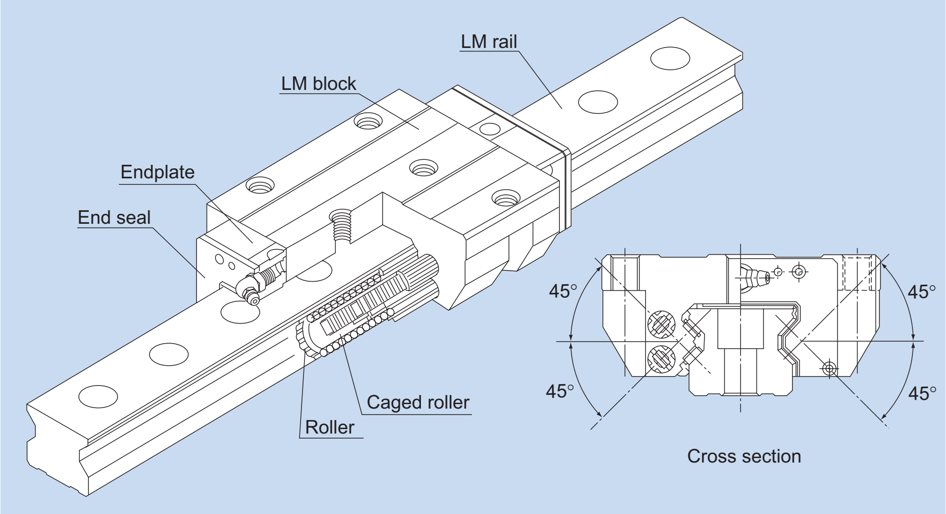


Rigidity is measured with the two axes placed in parallel and one of the axes not fixed with a bolt in order not to apply a moment.



SRG

Caged Roller LM Guide
Ultra-high Rigidity Type Model SRG



* For the caged roller, see A-296.

Structure and Features

SRN is an ultra-high rigidity Roller Guide that uses roller cages to allow low-friction, smooth motion and achieve long-term maintenance-free operation.

[Ultra-high Rigidity]

A higher rigidity is achieved by using highly rigid rollers as the rolling elements and having the overall roller length more than 1.5 times greater than the roller diameter.

[4-way Equal Load]

Since each row of rollers is arranged at a contact angle of 45° so that the LM block receives an equal load rating in all four directions (radial, reverse radial and lateral directions), high rigidity is ensured in all directions.

[Smooth Motion through Skewing Prevention]

The roller cage allows rollers to form an evenly spaced line while circulating, thus preventing the rollers from skewing as the block enters an loaded area. As a result, fluctuation of the rolling resistance is minimized, and stable, smooth motion is achieved.

[Long-term Maintenance-free Operation]

Use of roller cages eliminates friction between rollers and increases grease retention, enabling long-term maintenance-free operation to be achieved.

[Global Standard Size]

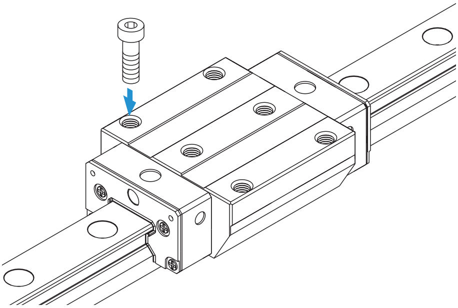
SRG is designed to have dimensions almost the same as that of Full Ball LM Guide model HSR, which THK as a pioneer of the linear motion system has developed and is practically a global standard size.

Types and Features

Models SRG-15A, 20A

Specification Table⇒B-208

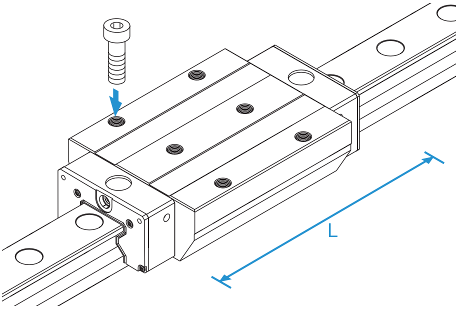
The flange of the LM block has tapped holes.
Can be mounted from the top or the bottom.



Model SRG-20L

Specification Table⇒B-208

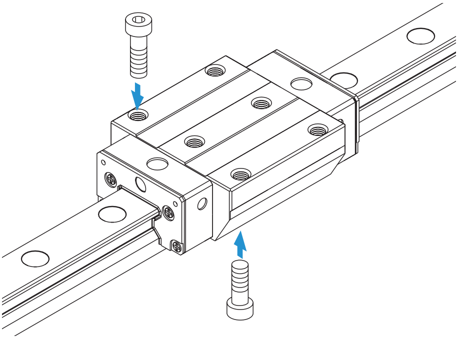
The LM block has the same cross-sectional shape as model SRG-A, but has a longer overall LM block length (L) and a greater rated load.



Model SRG-C

Specification Table⇒B-208

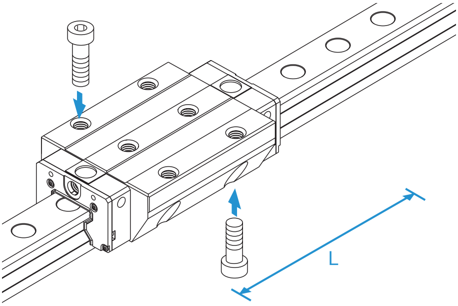
The flange of the LM block has tapped holes.
Can be mounted from the top or the bottom.
Used in places where the table cannot have through holes for mounting bolts.



Model SRG-LC

Specification Table⇒B-208

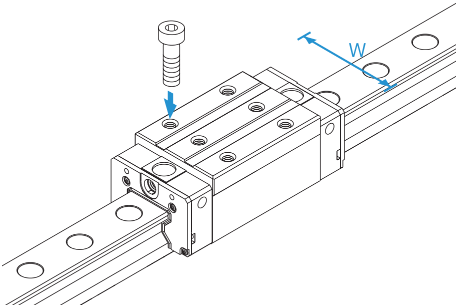
The LM block has the same cross-sectional shape as model SRG-C, but has a longer overall LM block length (L) and a greater rated load.



Model SRG-R

Specification Table⇒B-210

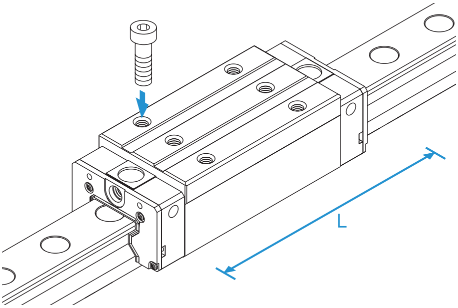
With this type, the LM block has a smaller width (W) and tapped holes.
Used in places where the space for table width is limited.



Model SRG-R

Specification Table⇒B-210

The LM block has the same cross-sectional shape as model SRG-R, but has a longer overall LM block length (L) and a greater rated load.



Rated Loads in All Directions

Model SRG is capable of receiving loads in four directions: radial, reverse radial and lateral directions.
The basic load ratings are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for SRG.

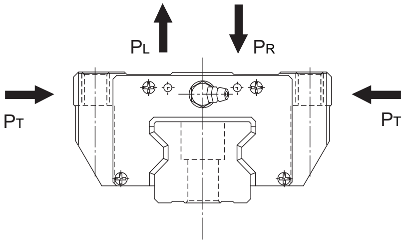


Fig.1

Equivalent Load

When the LM block of model SRG receives loads in all directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R\ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-115.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-329.

Error Allowance of the Mounting Surface

Caged Roller LM Guide model SRG is highly rigid since it uses rollers as its rolling elements, and the roller cage prevents the rollers from skewing. However, the mounting surface needs to be finished with high accuracy. If the error on the mounting surface is large, it will affect the rolling resistance and the service life. The following shows the maximum permissible value (limit value) according to the radial clearance.

Table1 Error Allowance in Parallelism (P) between Two Rails Unit: mm

Radial clearance	Normal	C1	C0
Model No.			
SRG 15	0.005	0.003	0.003
SRG 20	0.008	0.006	0.004
SRG 25	0.009	0.007	0.005
SRG 30	0.011	0.008	0.006
SRG 35	0.014	0.010	0.007
SRG 45	0.017	0.013	0.009
SRG 55	0.021	0.014	0.011
SRG 65	0.027	0.018	0.014

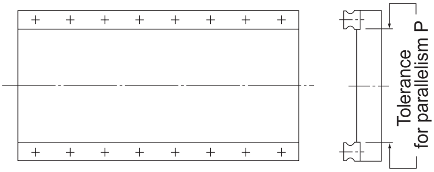


Fig.2

Table2 Error Allowance in Level (X) between the Rails Unit: mm

Radial clearance	Normal	C1	C0
Permissible error on the mounting surface X	0.00030 a	0.00021 a	0.00011 a

$X = X_1 + X_2$

X_1 : Level difference on the rail mounting surface

X_2 : Level difference on the block mounting surface

Example of calculation

Rail span when a = 500mm

Error allowance of the mounting surface X = 0.0003 × 500 = 0.15

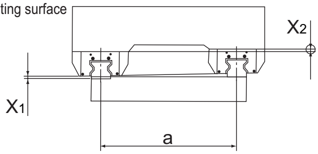


Fig.3

Table3 Error Allowance in Level (Y) in the Axial Direction Unit: mm

Permissible error on the mounting surface	0.000036 b

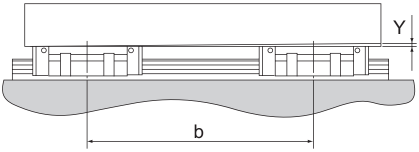
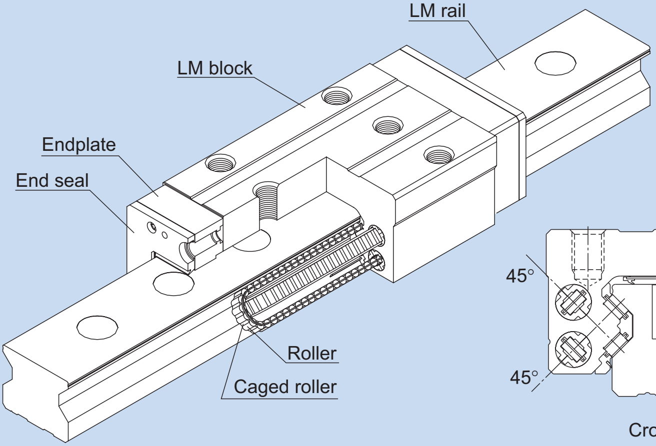
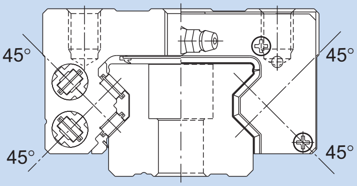


Fig.4

SRN

Caged Roller LM Guide
Ultra-high Rigidity Type (Low Center of Gravity) Model SRN





Cross section

* For the caged roller, see A-296.

Structure and Features

SRN is an ultra-high rigidity Roller Guide that uses roller cages to allow low-friction, smooth motion and achieve long-term maintenance-free operation.

[Ultra-high Rigidity]
A higher rigidity is achieved by using highly rigid rollers as the rolling elements and having the overall roller length more than 1.5 times greater than the roller diameter.

[4-way Equal Load]
Since each row of rollers is arranged at a contact angle of 45° so that the LM block receives an equal load rating in all four directions (radial, reverse radial and lateral directions), high rigidity is ensured in all directions.

[Smooth Motion through Skewing Prevention]
The roller cage allows rollers to form an evenly spaced line while circulating, thus preventing the rollers from skewing as the block enters an loaded area. As a result, fluctuation of the rolling resistance is minimized, and stable, smooth motion is achieved.

[Long-term Maintenance-free Operation]
Use of roller cages eliminates friction between rollers and increases grease retention, enabling long-term maintenance-free operation to be achieved.

[Global Standard Size]
SRG is designed to have dimensions almost the same as that of Full Ball LM Guide model HSR, which THK as a pioneer of the linear motion system has developed and is practically a global standard size.

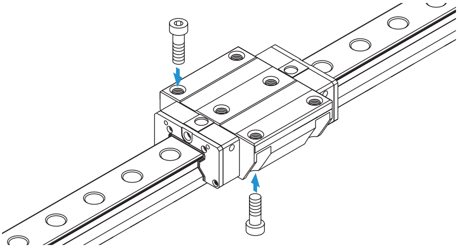
[Thin, Low Center of Gravity]
Since the overall height is lower than Caged Roller LM Guide model SRG, this model is optimal for compact design.

Types and Features

Model SRN-C

Specification Table⇒B-214

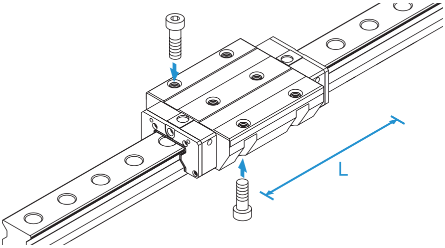
The flange of the LM block has tapped holes.
Can be mounted from the top or the bottom.
Used in places where the table cannot have through holes for mounting bolts.



Model SRN-LC

Specification Table⇒B-214

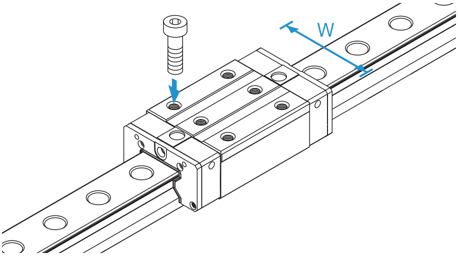
The LM block has the same cross-sectional shape as model SRN-C, but has a longer overall LM block length (L) and a greater rated load.



Model SRN-R

Specification Table⇒B-216

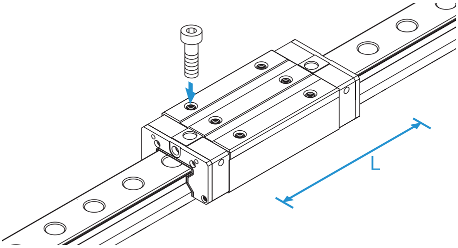
With this type, the LM block has a smaller width (W) and tapped holes.
Used in places where the space for table width is limited.



Model SRN-LR

Specification Table⇒B-216

The LM block has the same cross-sectional shape as model SRN-R, but has a longer overall LM block length (L) and a greater rated load.



Rated Loads in All Directions

Model SRN is capable of receiving loads in four directions: radial, reverse radial and lateral directions.
The basic load ratings are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table for SRN.

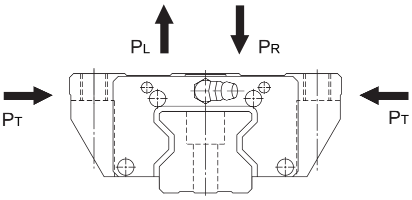


Fig.1

Equivalent Load

When the LM block of model SRN receives loads in all directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R \ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance Standard

For details,see A-115.

Accuracy Standards

For details,see A-119.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-329.

Error Allowance of the Mounting Surface

Caged Roller LM Guide model SRN is highly rigid since it uses rollers as its rolling elements, and the roller cage prevents the rollers from skewing. However, the mounting surface needs to be finished with high accuracy. If the error on the mounting surface is large, it will affect the rolling resistance and the service life. The following shows the maximum permissible value (limit value) according to the radial clearance.

Table1 Error Allowance in Parallelism (P) between Two Rails

Unit: mm

Radial clearance Model No.	Normal	C1	C0
SRN 35	0.014	0.010	0.007
SRN 45	0.017	0.013	0.009
SRN 55	0.021	0.014	0.011
SRN 65	0.027	0.018	0.014

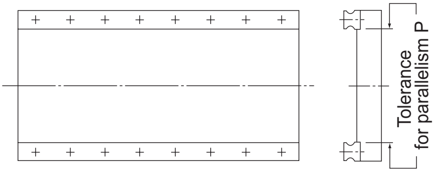


Fig.2

Table2 Error Allowance in Level (X) between the Rails

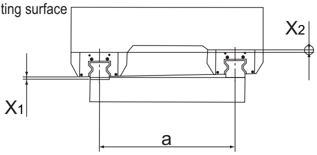
Unit: mm

Radial clearance	Normal	C1	C0
Permissible error on the mounting surface X	0.00030 a	0.00021 a	0.00011 a

$X = X_1 + X_2$

X_1 : Level difference on the rail mounting surface

X_2 : Level difference on the block mounting surface



Example of calculation

Rail span when $a = 500\text{mm}$

Error allowance of the mounting surface $X = 0.0003 \times 500$

$= 0.15$

Fig.3

Table3 Error Allowance in Level (Y) in the Axial Direction

Unit: mm

Permissible error on the mounting surface	0.000036 b

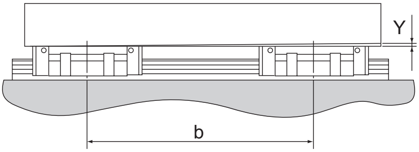
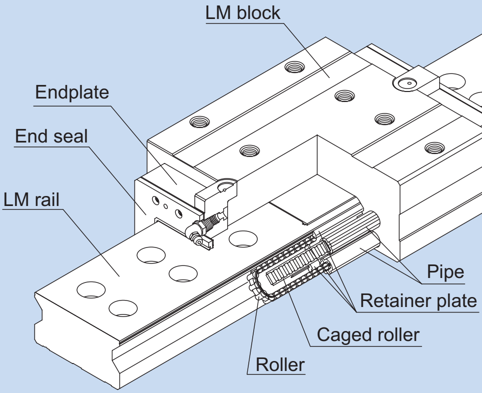
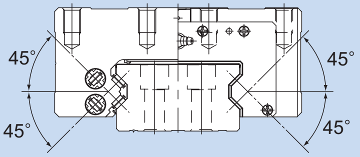


Fig.4

SRW

Caged Roller LM Guide
Ultra-high Rigidity Type (Wide) Model SRW





Cross section

* For the caged roller, see A-296.

Structure and Features

Based on Caged Roller LM Guide model SRG, this model has a wider rail and two rows of LM rail mounting holes to achieve high mounting strength and mounting stability. SRW is an ultra-high rigidity Roller Guide that uses roller cages to allow low-friction, smooth motion and achieve long-term maintenance-free operation.

[Ultra-high Rigidity]

Since it has a wide rail and can be secured on the table using two rows of mounting bolts, the mounting strength is significantly increased. In addition, since the crosswise raceway distance (L) is large, model SRW is structurally strong against a moment load (Mc moment) in the rolling direction.
Furthermore, model SRW uses rollers that show little elastic deformation as its rolling elements, and the overall length of each roller is 1.5 times greater than the diameter, thus to increase the rigidity.

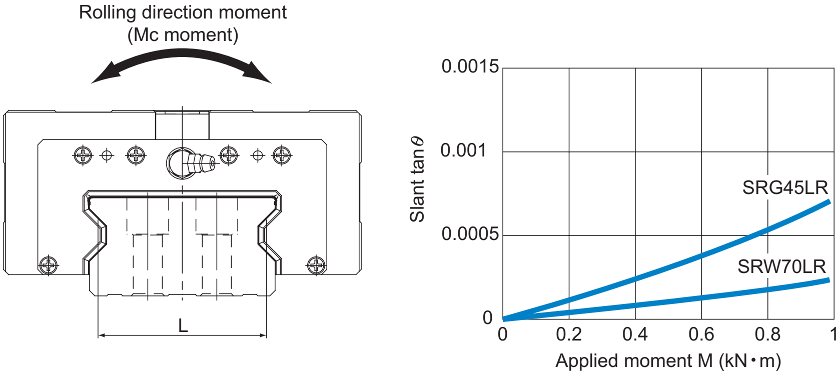


Fig.1 Result of Comparison between Models SRW and SRG in Moment Rigidity in the Rolling Direction (Mc Moment)

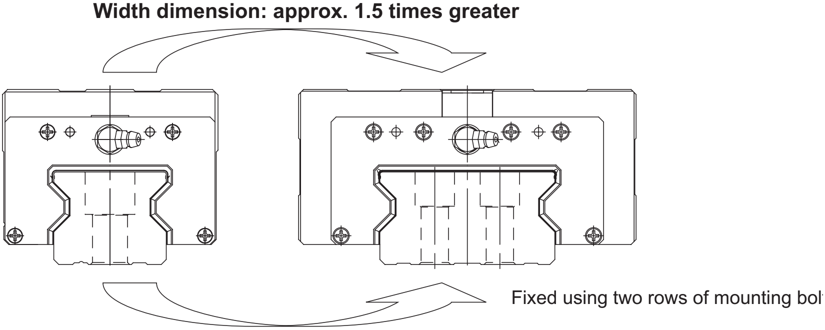


Fig.2 Comparison between Models SRW and SRG in Cross Section

[Smoothness Achieved through Skewing Prevention]

The roller cage allows rollers to form an evenly spaced line while circulating, thus preventing the rollers from skewing as the block enters an loaded area. As a result, fluctuation of the rolling resistance is minimized, and stable, smooth motion is achieved.

[Long-term Maintenance-free Operation]

Use of the roller cage eliminates friction between rollers and enables the lubricant to be retained in grease pockets formed between adjacent rollers. As the rollers circulate, the grease pocket serves to provide the required amount of lubricant to the contact curvature of the spacer and the roller, thus to achieve long-term maintenance-free operation.

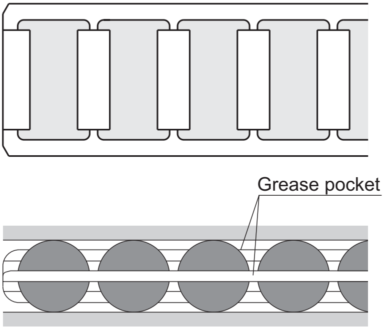


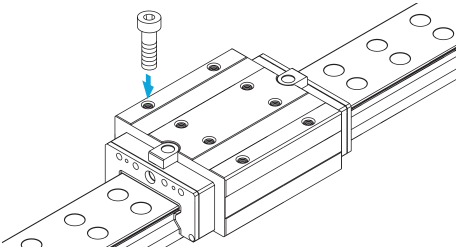
Fig.3

Types and Features

Model SRW-LR

Specification Table⇒B-220

The LM block has tapped holes.



Rated Loads in All Directions

Model SRW is capable of receiving loads in four directions: radial, reverse radial and lateral directions.

The basic load ratings are uniform in the four directions (radial, reverse radial and lateral directions), and their actual values are provided in the specification table.

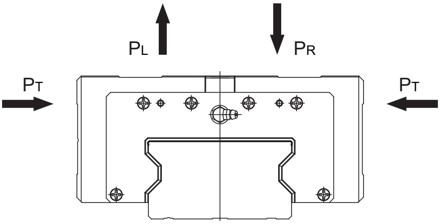


Fig.4

Equivalent Load

When the LM block of model SRW receives loads in all directions simultaneously, the equivalent load is obtained from the equation below.

$$P_E = P_R \ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Service Life

For details,see A-100.

Radial Clearance

For details,see A-115.

Accuracy Standards

For details,see A-128.

Shoulder Height of the Mounting Base and the Corner Radius

For details,see A-329.

Permissible Error of the Mounting Surface

Caged Roller LM Guide model SRW is highly rigid since it uses rollers as its rolling elements, and the roller cage prevents the rollers from skewing. However, the mounting surface needs to be finished with high accuracy. If the error on the mounting surface is large, it will affect the rolling resistance and the service life. The following shows the maximum permissible value (limit value) according to the radial clearance.

Table1 Error in Parallelism (P) between Two Rails

Unit: mm

Radial clearance	Normal	C1	C0
Model No.			
SRW 70	0.013	0.009	0.007
SRW 85	0.016	0.011	0.008
SRW 100	0.020	0.014	0.011

Table2 Error in Level (X) between Two Rails

Unit: mm

Radial clearance	Normal	C1	C0
Accuracy of the mounting surface X	0.00020a	0.00014a	0.000072a

$X=X_1+X_2$

X_1: Level difference on the rail mounting surface

X_2: Level difference on the block mounting surface

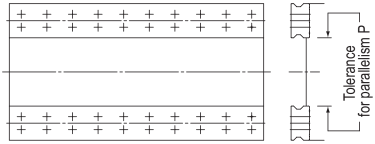


Fig.5

Table3 Error in Level (Y) in the Axial Direction

Unit: mm

Accuracy of the mounting surface	0.000036 b

Example of calculation

When the rail span :

a=500mm

Accuracy of the mounting surface

$X=0.0002\times500$

$=0.1$

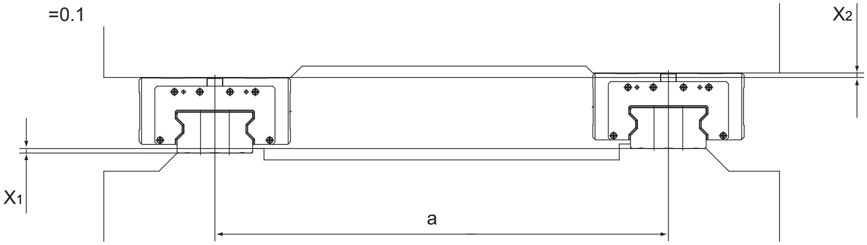


Fig.6

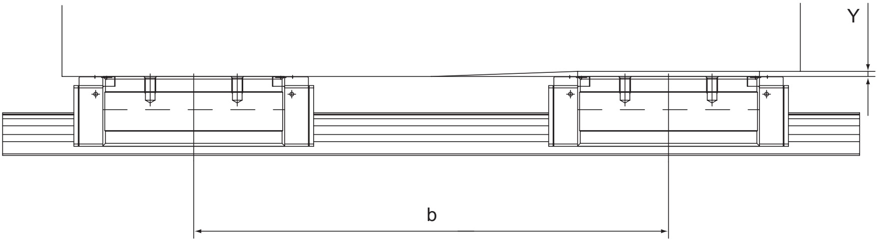


Fig.7

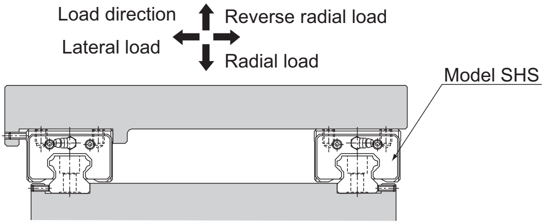
Designing the Guide System

THK offers various types of LM Guides in order to meet diversified conditions. Supporting ordinary horizontal mount, vertical mount, inverted mount, slant mount, wall mount and single-axis mount, the wide array of LM Guide types makes it easy to achieve a linear guide system with a long service life and high rigidity while minimizing the required space for installation.

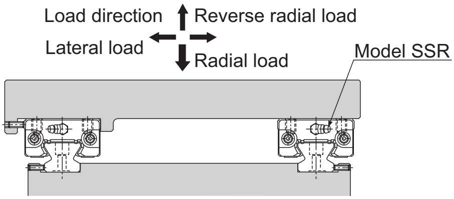
Examples of Arrangements of the Guide System

The following are representative guide systems and arrangements when installing the LM Guide.
(For indication of the reference surface, see A-338.)

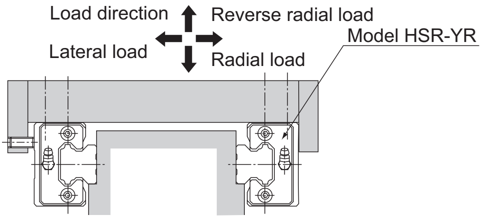
Double-rail configuration when high rigidity is required in all directions



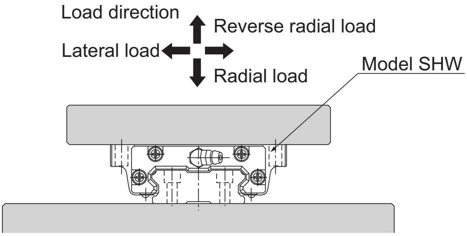
Double-rail configuration when high rigidity is required in the radial direction



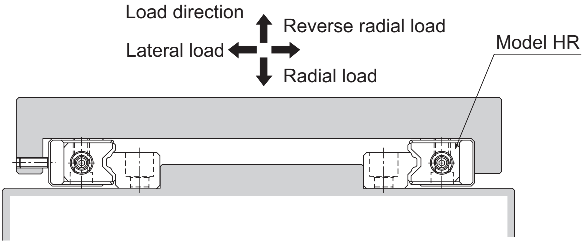
When high rigidity is required in all directions and the installation space is limited in height



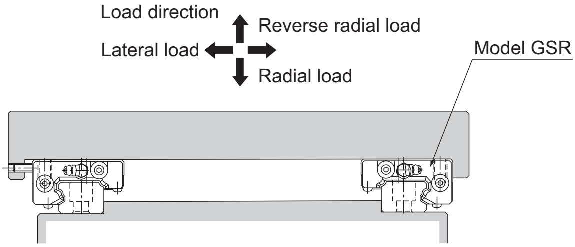
Single-rail configuration



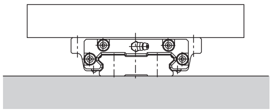
When the minimum possible height of the equipment is allowed (Adjustable preload type)



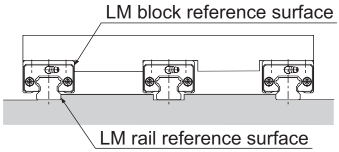
When a medium load is applied and the mounting surface is rough (Preload, self-adjusting type)



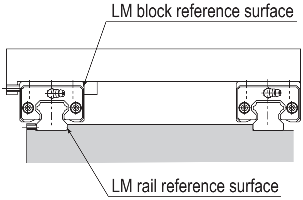
Single-rail configuration

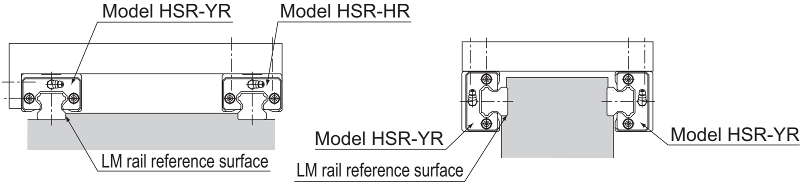


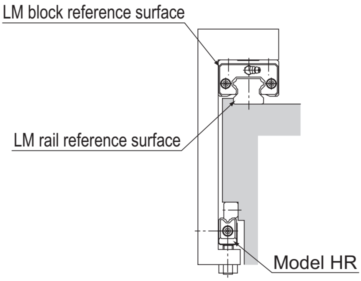
Triple-rail configuration

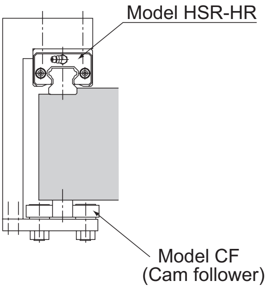


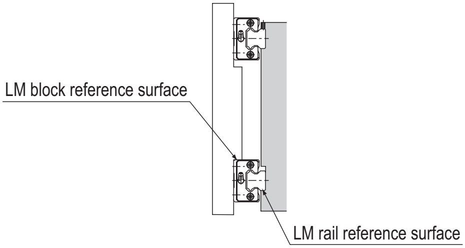
Double-rail configuration

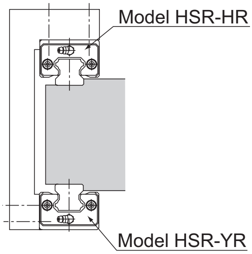




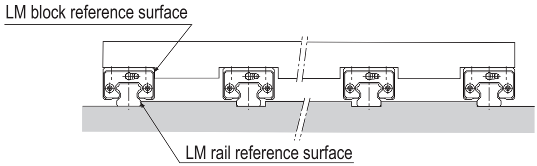


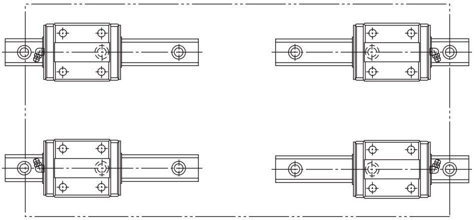


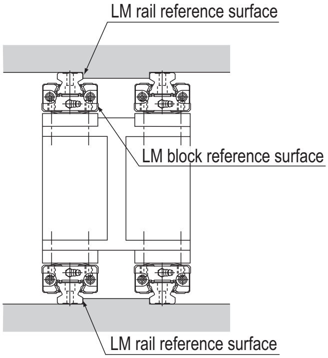


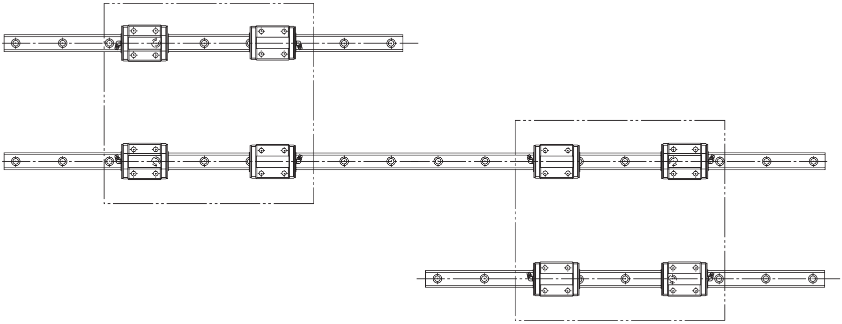


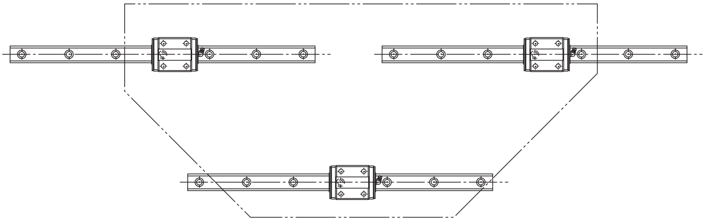
4-rail configuration











Method for Securing an LM Guide to Meet the Conditions

LM Guides are categorized into groups of types by mounting space and structure: a group of types to be mounted with bolts from the top, and another of types to be mounted from the bottom. LM rails are also divided into types secured with bolts and those secured with clamps (model JR). This wide array of types allows you to make a choice according to the application.

There are several ways of mounting the LM Guide as shown in Table1. When the machine is subject to vibrations that may cause the LM rail(s) or LM blocks to loosen, we recommend the securing method indicated by Fig.1 on A-323. (If 2 or more rails are used in parallel, only the LM block on the master rail should be secured in the crosswise direction.) If this method is not applicable for a structural reason, hammer in knock pins to secure the LM block(s) as shown in Table2 on A-323 When using knock pins, machine the top/bottom surfaces of the LM rail by 2 to 3 mm using a carbide end mill before drilling the holes since the surfaces are hardened.

Table1 Major Securing Methods on the Master-rail Side

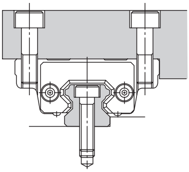
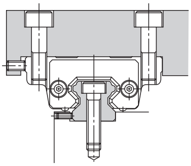
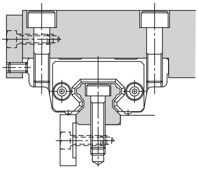
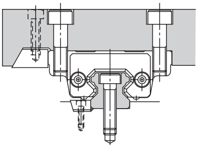
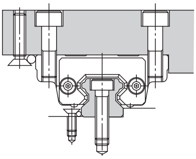
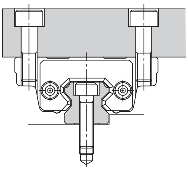
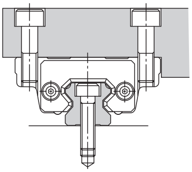
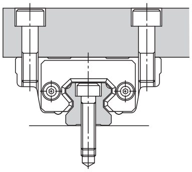
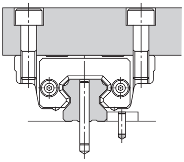
(a) Secured only with side reference surfaces	**(b) Secured with set screws**
	
(c) Secured with a presser plate	**(d) Secured with tapered gibs**
	
(e) Secured with pins	
	

Table2 Major Securing Methods on the Subsidiary-rail Side

(a) Secured only with the side reference surface of the rail	(b) Secured only with the side reference surface of the block
	
(c) Secured without a side reference surface	**(d) Secured with dowel pins**
	

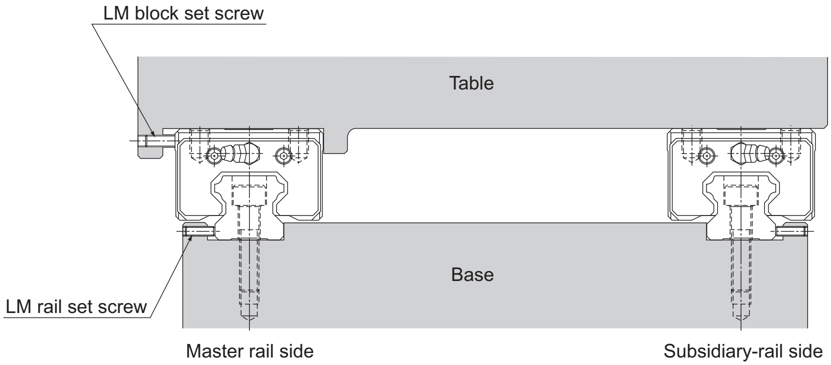
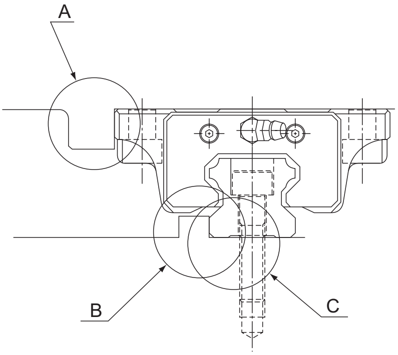


Fig.1 When the Machine Receives Vibrations or Impact

Designing a Mounting Surface

Designing a Mounting Surface

If particularly high accuracy is required for the machine to which an LM Guide is to be mounted, it is necessary to mount the LM rail with high accuracy. To achieve the desired accuracy, be sure to design the mounting surface while taking the following points into account.



[Corner Shape]

If the corner on the surface on which the LM rail or LM block is to be mounted is machined to be shaped R, which is greater than the chamfer dimension of the LM rail or LM block, then the rail or the block may not closely contact its reference surface. Therefore, when designing a mounting surface, it is important to carefully read the description on the “corner shape” of the subject model . (Fig.2)

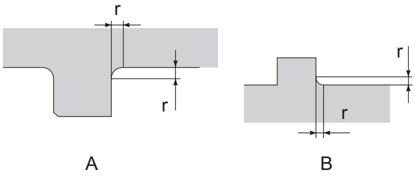


Fig.2

[Perpendicularity with the Reference Surface]

If the perpendicularity between the base mounting surface for the LM rail or the LM block and the reference surface is not accurate, the rail or the block may not closely contact the reference surface. Therefore, it is important to take into account an error of the perpendicularity between the mounting surface and the reference surface . (Fig.3)

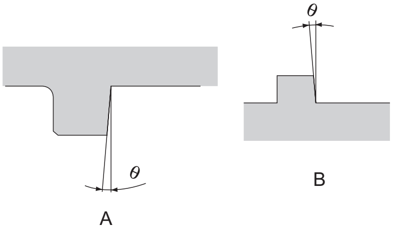


Fig.3

[Dimensions of the Reference Surface]

When designing the reference surface, be sure to take into account the height and the thickness of the datum area. If the datum area is too high, it may interfere with the LM block. If it is too low, the LM rail or the LM block may not closely contact the reference-surface depending on the chamfer of the rail or the block. Additionally, if the datum area is too thin, the desired accuracy may not be obtained due to poor rigidity of the datum area when a lateral load is applied or when performing positioning using a lateral mounting bolt . (Fig.4)

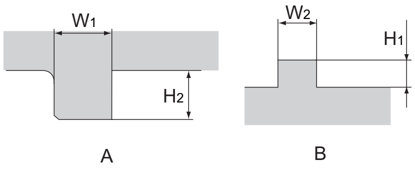


Fig.4

[Dimensional Tolerance between the Reference Surface and the Mounting Hole]

If the dimensional tolerance between the reference surface of the LM rail or the LM block and the mounting hole is too large, the rail or the block may not closely contact the reference surface when mounted on the base.
Normally, the tolerance should be within ±0.1 mm depending on the model. (Fig.5)

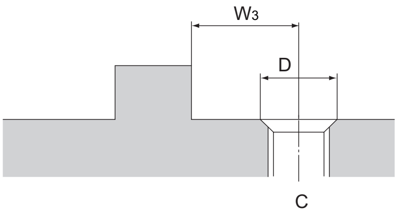


Fig.5

[Chamfer of the Tapped Mounting Hole]

To mount the LM rail, the mounting surface needs to be tapped and the tapped hole has to be chamfered. If the chamfer of the tapped hole is too large or too small, it may affect the accuracy . (Fig.6)

Guidelines for the chamfer dimension:
Chamfer diameter D = nominal diameter of the bolt + pitch

Example: Chamfer diameter D with M6 (pitch):
$D = 6 + 1 = 7$

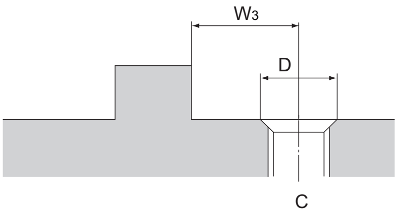
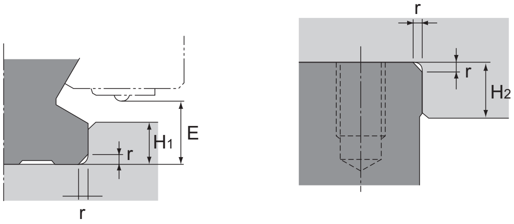


Fig.6

Shoulder Height of the Mounting Base and the Corner Radius

Normally, the mounting base for the LM rail and the LM block has a reference-surface on the side face of the shoulder of the base in order to allow easy installation and highly accurate positioning.
The height of the datum shoulder varies with model numbers. See A-326 to A-332 for details.
The corner of the mounting shoulder must be machined to have a recess, or machined to be smaller than the corner radius "r," to prevent interference with the chamfer of the LM rail or the LM block.
The corner radius varies with model numbers. See A-326 to A-332 for details.



Shoulder for the LM Rail

Shoulder for the LM Block (LM casing)

Fig.7

[Model SR, SR-M1]

Unit: mm

Model No.	Corner radius r(max)	Shoulder height for the LM rail H_1	Maximum shoulder height for the LM block H_2	E
15	0.5	3.8	4	4.5
20	0.5	5	5	6
25	1	5.5	5	7
30	1	8	6	9.5
35	1	9	6	11.5
45	1	10	8	12.5
55	1.5	11	8	13.5
70	1.5	12	10	15
85	1.2	8	12	18.5
100	1.2	10	15	19
120	1.2	12	20	15
150	1.2	12	20	22

[Model JR]

Unit: mm

Model No.	Corner radius r(max)	Shoulder height for the LM block H_2
25	1	5
35	1	6
45	1	8
55	1.5	10

[Model CSR]

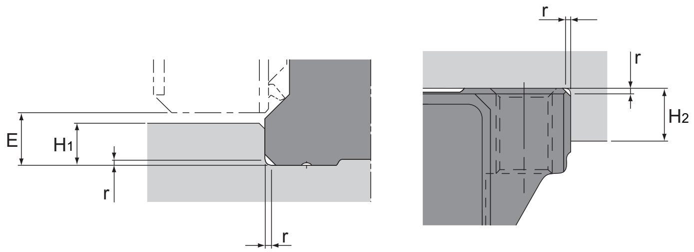
Unit: mm

Model No.	Corner radius r(max)	Shoulder height for the LM rail H_1	E
15	0.5	3	3.5
20	0.5	3.5	4
25	1	5	5.5
30	1	5	7
35	1	6	7.5
45	1	8	10

[Model NSR-TBC]

Unit: mm

Model No.	Corner radius r(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2	E
20	1	5	5	5.5
25	1	6	6	6.5
30	1	7	6	9
40	1	7	8	10.5
50	1	7	8	8
70	1	7	10	9.5



Shoulder for the LM Rail

Shoulder for the LM Block

Fig.8

[Model SHS]

Unit: mm

Model No.	Corner radius r(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2	E
15	0.5	2.5	4	3
20	0.5	3.5	5	4.6
25	1	5	5	5.8
30	1	5	5	7
35	1	6	6	7.5
45	1	7.5	8	8.9
55	1.5	10	10	12.7
65	1.5	15	10	19

[Model SCR]

Unit: mm

Model No.	Corner radius r(max)	Shoulder height for the LM rail H_1	E
15	0.5	2.5	3
20	0.5	3.5	4.6
25	1	5	5.8
30	1	5	7
35	1	6	7.5
45	1	7.5	8.9
65	1.5	15	19

[Models SNR/SNS, SNR/SNS-H and NR/NRS]

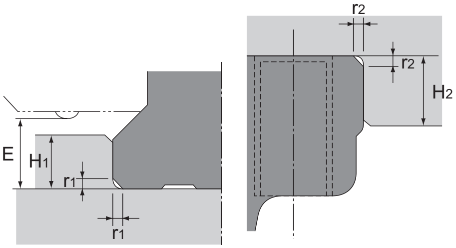
Unit: mm

Model No.	Corner radius r(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2	E
25X	1.5	5	5	5.5
30	1	5	5	7
35	1	6	6	9
45	1	8	8	11.5
55	1.5	10	10	14
65	1.5	10	10	15
75	1.5	12	12	15
85	1.5	14	14	17
100	2	16	16	20

[Model MX]

Unit: mm

Model No.	Corner radius for the LM rail r(max)	Shoulder height for the LM rail H_1	E
5	0.1	1.2	1.5
7W	0.1	1.7	2



Shoulder for the LM Rail Shoulder for the LM Block

Fig.9

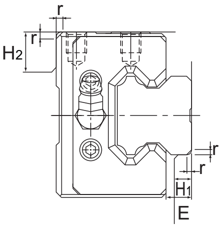


Fig.10

[Model HSR, HSR-M1 and HSR-M2]

Unit: mm

Model No.	Corner radius for the LM rail r_1(max)	Corner radius for the LM block r_2(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2	E
8	0.3	0.5	1.6	6	2.1
10	0.3	0.5	1.7	5	2.2
12	0.8	0.5	2.6	4	3.1
15	0.5	0.5	3	4	4.7
20	0.5	0.5	3.5	5	4
25	1	1	5	5	5.5
30	1	1	5	5	7
35	1	1	6	6	7.5
45	1	1	8	8	10
55	1.5	1.5	10	10	13
65	1.5	1.5	10	10	14
85	1.5	1.5	12	14	16
100	2	2	16	16	20.5
120	2.5	2.5	17	18	20
150	2.5	2.5	20	20	22.5

[Model HSR-YR]

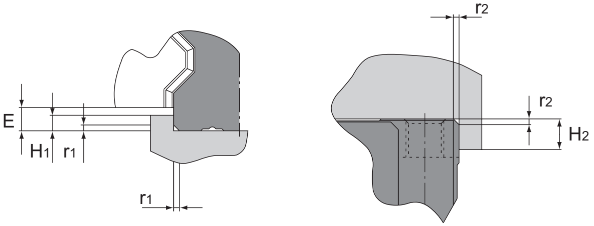
Unit: mm

Model No.	Corner radius r(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2	E
15	0.5	3	4	3.5
20	0.5	3.5	5	4
25	1	5	5	5.5
30	1	5	5	7
35	1	6	6	7.5
45	1	8	8	10
55	1.5	10	10	13
65	1.5	10	10	14

[Models HCR and HMG]

Unit: mm

Model No.	Corner radius for the LM rail r_1(max)	Corner radius for the LM block r_2(max)	Shoulder height for the LM rail H_1	Maximum shoulder height for the LM block H_2	E
12	0.8	0.5	2.6	6	3.1
15	0.5	0.5	3	4	3.5
25	1	1	5	5	5.5
35	1	1	6	6	7.5
45	1	1	8	8	10
65	1.5	1.5	10	10	14



Shoulder for the LM Rail

Shoulder for the LM Block

Fig.11

[Model SRG]

Unit: mm

Model No.	Corner radius for the LM rail r_1(max)	Corner radius for the LM block r_2(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2	E
15	0.5	0.5	2.5	4	3.0
20	0.5	0.5	3.5	5	4.6
25	1	1	4	5	4.5
30	1	1	4.5	5	5
35	1	1	5	6	6
45	1.5	1.5	6	8	8
55	1.5	1.5	8	10	10
65	1.5	2	9	10	11.5

[Model SRN]

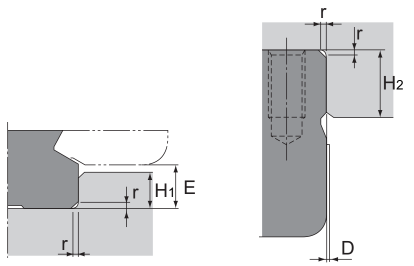
Unit: mm

Model No.	Corner radius for the LM rail r_1(max)	Corner radius for the LM block r_2(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2	E
35	1	1	5	6	6
45	1.5	1.5	6	8	7
55	1.5	1.5	8	10	10
65	1.5	2	8	10	10

[Model SRW]

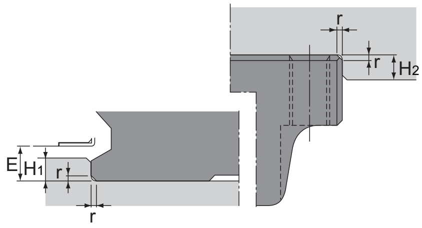
Unit: mm

Model No.	Corner radius for the LM rail r_1(max)	Corner radius for the LM block r_2(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2	E
70	1.5	1.5	6	8	8
85	1.5	1.5	8	10	10
100	1.5	2	9	10	11.5



Shoulder for the LM Rail Shoulder for the LM Block

Fig.12



Shoulder for the LM Rail Shoulder for the LM Block

Fig.13

[Model SSR]

Unit: mm

Model No.	Corner radius r(max)	Shoulder height for the LM rail H_1	Maximum shoulder height for the LM block H_2	E	D
15 X	0.5	3.8	5.5	4.5	0.3
20 X	0.5	5	7.5	6	0.3
25 X	1	5.5	8	6.8	0.4
30 X	1	8	11.5	9.5	0.4
35 X	1	9	16	11.5	0.4

Note) When closely contacting the LM block with the datum shoulder, the resin layer may stick out from the overall width of the LM block by the dimension D. To avoid this, machine the datum shoulder to have a recess or limit the datum shoulder's height below the dimension H_2.

[Models SHW and HRW]

Unit: mm

Model No.	Corner radius r(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2	E
12	0.5	1.5	4	2
14	0.5	1.5	5	2
17	0.4	2	4	2.5
21	0.4	2.5	5	3
27	0.4	2.5	5	3
35	0.8	3.5	5	4
50	0.8	3	6	3.4
60	1	5	8	6.5

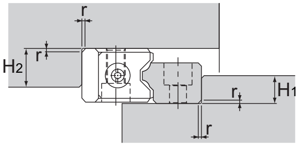


Fig.14

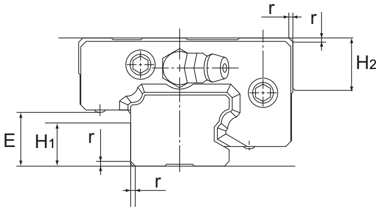


Fig.15

[Model HR]

Unit: mm

Model No.	Corner radius r(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2
918	0.3	5	6
1123	0.5	6	7
1530	0.5	8	10
2042	0.5	11	15
2555	1	13	18
3065	1	16	20
3575	1	18	26
4085	1.5	21	30
50105	1.5	26	32
60125	1.5	31	40

[Model GSR]

Unit: mm

Model No.	Corner radius r(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2	E
15	0.6	7	7	8
20	0.8	9	8	10.4
25	0.8	11	11	13.2
30	1.2	11	13	15
35	1.2	13	14	17.5

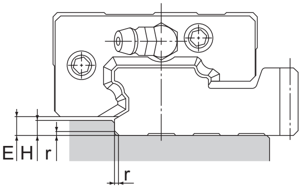
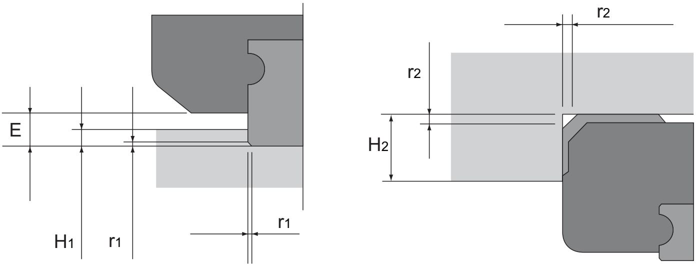


Fig.16

[Model GSR-R]

Unit: mm

Model No.	Corner radius r(max)	Shoulder height for the LM rail H	E
25	0.8	4	4.5
30	1.2	4	4.5
35	1.2	4.5	5.5



Shoulder for the LM Rail

Shoulder for the LM Block

Fig.17

[Model SRS]

Unit: mm

Model No.	Corner radius for the LM rail r_1(max)	Corner radius for the LM block r_2(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2	E
7 M	0.1	0.2	0.9	3.3	1.3
7 WM	0.1	0.1	1.4	3.8	1.8
9 M	0.1	0.3	0.5	4.9	0.9
9 WM	0.1	0.5	2.5	4.9	2.9
12 M	0.3	0.2	1.5	5.7	2
12 WM	0.3	0.3	2.5	5.7	3
15 M	0.3	0.4	2.2	6.5	2.7
15 WM	0.3	0.3	2.2	6.5	2.7
20 M	0.3	0.5	3	8.7	3.4
25 M	0.5	0.5	4.5	10.5	5

[Models RSR-Z and RSH-Z]

Unit: mm

Model No.	Corner radius for the LM rail r_1(max)	Corner radius for the LM block r_2(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2	E
7 Z	0.1	0.5	1.2	3	1.5
9 Z	0.3	0.5	1.9	3	2.2
12 Z	0.3	0.3	2.1	4	2.4
15 Z	0.3	0.3	2.5	5	3.4
7 WZ	0.1	0.1	1.7	3	2
9 WZ	0.1	0.1	2.5	3	2.9
12 WZ	0.3	0.3	3	4	3.4
15 WZ	0.3	0.3	3	5	3.4

[Model RSR, RSR-M1 and RSH]

Unit: mm

Model No.	Corner radius for the LM rail r_1(max)	Corner radius for the LM block r_2(max)	Shoulder height for the LM rail H_1	Shoulder height for the LM block H_2	E
3	0.1	0.3	0.8	1.2	1
5	0.1	0.3	1.2	2	1.5
7	0.1	0.5	1.2	3	1.5
9	0.3	0.5	1.9	3	2.2
12	0.3	0.3	1.4	4	3
15	0.3	0.3	2.3	5	4
20	0.5	0.5	5.5	5	7.5
3 W	0.1	0.3	0.7	2	1
5 W	0.1	0.3	1.2	2	1.5
7 W	0.1	0.1	1.7	3	2
9 W	0.1	0.1	3.9	3	4.2
12 W	0.3	0.3	3.7	4	4
14 W	0.3	0.3	3.2	5	3.5
15 W	0.3	0.3	3.7	5	4

Permissible Error of the Mounting Surface

The LM Guide allows smooth straight motion through its self-aligning capability even when there is a slight distortion or error on the mounting surface.

[Error Allowance in the Parallelism between Two Rails]

The following tables show error allowances in parallelism between two rails that will not affect the service life in normal operation.

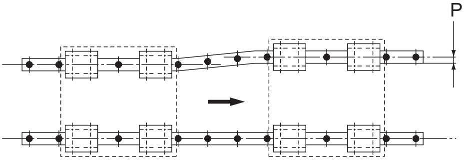


Fig.18 Error Allowance in Parallelism (P) between Two Rails

[Models SHS, HSR, CSR, HSR-M1, and HSR-M2]

Unit: μm

Model No.	Clearance C0	Clearance C1	Normal clearance
8	—	10	13
10	—	12	16
12	—	15	20
15	—	18	25
20	18	20	25
25	20	22	30
30	27	30	40
35	30	35	50
45	35	40	60
55	45	50	70
65	55	60	80
85	70	75	90
100	85	90	100
120	100	110	120
150	115	130	140

[Model JR]

Unit: μm

Model No.	—
25	100
35	200
45	300
55	400

[Model SSR, SR, SR-M1]

Unit: μm

Model No.	Clearance C0	Clearance C1	Normal clearance
15	—	25	35
20	25	30	40
25	30	35	50
30	35	40	60
35	45	50	70
45	55	60	80
55	65	70	100
70	65	80	110
85	80	90	120
100	90	100	130
120	100	110	140
150	110	120	150

[Models SNR, SNR-H and NR]

Unit: μm

Model No.	Clearance C0	Clearance C1	Normal clearance
25	14	15	21
30	19	21	28
35	21	25	35
45	25	28	42
55	32	35	49
65	39	42	56
75	44	47	60
85	49	53	63
100	60	63	70

[Models SNS, SNS-H and NRS]

Unit: µm

Model No.	Clearance C0	Clearance C1	Normal clearance
25	10	11	15
30	14	15	20
35	15	18	25
45	18	20	30
55	23	25	35
65	28	30	40
75	31	34	43
85	35	38	45
100	43	45	50

[Models SHW and HRW]

Unit: µm

Model No.	Clearance C0	Clearance C1	Normal clearance
12	—	10	13
14	—	12	16
17	—	15	20
21	—	18	25
27	—	20	25
35	20	22	30
50	27	30	40
60	30	35	50

[Models SRS, RSR, RSR-W, RSR-Z, RSH, RSH-Z and RSR-M1]

Unit: µm

Model No.	Gothic-arch groove		Circular-arc groove
	Clearance C1	Normal clearance	Normal clearance
3	—	2	—
5	—	2	—
7	—	3	—
9	3	4	11
12	5	9	15
14	6	10	—
15	6	10	18
20	8	13	25
25	10	15	30

[Model HR]

Unit: µm

Model No.	Clearance C0	Clearance C1	Normal clearance
918	—	7	10
1123	—	8	14
1530	—	12	18
2042	14	15	20
2555	20	24	35
3065	22	26	38
3575	24	28	42
4085	30	35	50
50105	38	42	55
60125	50	55	65

[Models GSR and GSR-R]

Unit: µm

Model No.	—
15	30
20	40
25	50
30	60
35	70

[Model NSR-TBC]

Unit: µm

Model No.	Clearance C1	Normal clearance
20	40	50
25	50	70
30	60	80
40	70	90
50	80	110
70	90	130

[Flatness of the Mounting Surface]

The following tables show errors in flatness of the mounting surface with models SRS, RSR, RSR-W and RSH that will not affect their service lives in normal operation. Note that if the flatness of the mounting surface is poorly established for models other than those above, it may affect the service life.

[Model SRS]

Unit: mm

Model No.	Flatness error
7 M	0.025/200
7 WM	0.025/200
9 M	0.035/200
9 WM	0.035/200
12 M	0.050/200
12 WM	0.050/200
15 M	0.060/200
15 WM	0.060/200
20 M	0.070/200
25 M	0.070/200

[Models RSR, RSR-W, RSR-Z, RSH and RSH-Z]

Unit: mm

Model No.	Flatness error
3	0.012/200
5	0.015/200
7	0.025/200
9	0.035/200
12	0.050/200
15	0.060/200
20	0.110/200
7 A	0.100/200
9 A	0.160/200
12 A	0.200/200
15 A	0.250/200
20 A	0.300/200

Note1) With the mounting surface, multiple accuracies are combined in many cases. Therefore, we recommend using 70% or less of the values above.
Note2) The above figures apply to normal clearances. When using two or more rails with clearance C1, we recommend using 50% or less of the values above.

[Error Allowance in Vertical Level between Two Rails]

The values in the tables on A-336 and A-337 represent error allowances in vertical level between two rails per axis-to-axis distance of 500 mm and are proportionate to axis-to-axis distances (200 mm for model RSR).

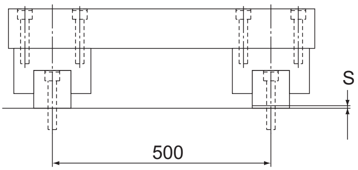


Fig.19 Error Allowance in Vertical Level (S) between Two Rails

[Models SHS, HSR, CSR, HSR-M1, and HSR-M2]

Unit: μm

Model No.	Clearance C0	Clearance C1	Normal clearance
8	—	11	40
10	—	16	50
12	—	20	65
15	—	85	130
20	50	85	130
25	70	85	130
30	90	110	170
35	120	150	210
45	140	170	250
55	170	210	300
65	200	250	350
85	240	290	400
100	280	330	450
120	320	370	500
150	360	410	550

[Model SSR, SR, SR-M1]

Unit: μm

Model No.	Clearance C0	Clearance C1	Normal clearance
15	—	100	180
20	80	100	180
25	100	120	200
30	120	150	240
35	170	210	300
45	200	240	360
55	250	300	420
70	300	350	480
85	350	420	540
100	400	480	600
120	450	540	720
150	500	600	780

[Models SNR, SNR-H and NR]

Unit: μm

Model No.	Clearance C0	Clearance C1	Normal clearance
25	35	43	65
30	45	55	85
35	60	75	105
45	70	85	125
55	85	105	150
65	100	125	175
75	110	135	188
85	120	145	200
100	140	165	225

[Model JR]

Unit: μm

Model No.	—
25	400
35	500
45	800
55	1000

[Models SNS, SNS-H and NRS]

Unit: µm

Model No.	Clearance C0	Clearance C1	Normal clearance
25	49	60	91
30	63	77	119
35	84	105	147
45	98	119	175
55	119	147	210
65	140	175	245
75	154	189	263
85	168	203	280
100	196	231	315

[Models SRS, RSR, RSR-W, RSR-Z, RSH, RSH-Z and RSR-M1]

Unit: µm

Model No.	Gothic-arch groove		Circular-arc groove
	Clearance C1	Normal clearance	Normal clearance
3	—	15	—
5	—	20	—
7	—	25	—
9	6	35	160
12	12	50	200
14	20	60	—
15	20	60	250
20	30	70	300
25	40	80	350

[Models SHW and HRW]

Unit: µm

Model No.	Clearance C0	Clearance C1	Normal clearance
12	—	11	40
14	—	16	50
17	—	20	65
21	—	85	130
27	—	85	130
35	70	85	130
50	90	110	170
60	120	150	210

[Model HR]

Unit: µm

Model No.	Clearance C0	Clearance C1	Normal clearance
918	—	15	45
1123	—	20	50
1530	—	60	90
2042	50	60	90
2555	85	100	150
3065	95	110	165
3575	100	120	175
4085	120	150	210
50105	140	175	245
60125	170	200	280

[Models GSR and GSR-R]

Unit: µm

Model No.	—
15	240
20	300
25	360
30	420
35	480

[Model NSR-TBC]

Unit: µm

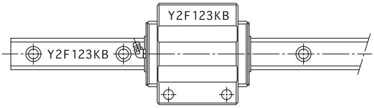
Model No.	Clearance C1	Normal clearance
20	210	300
25	240	360
30	270	420
40	360	540
50	420	600
70	480	660

Marking on the Master LM Guide and Combined Use

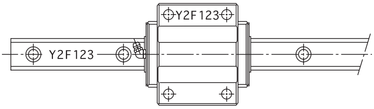
[Marking on the Master LM Guide]

All LM rails mounted on the same plane are marked with the same serial number. Of those LM rails, the one marked with "KB" after the serial number is the master LM rail. The LM block on the master LM rail has its reference surface finished to a designated accuracy, allowing it to serve as the positioning reference for the table. (See Fig.20.)

LM Guides of normal grade are not marked with "KB." Therefore, any one of the LM rails having the same serial number can be used as the master LM rail.



Master LM Guide



Subsidiary LM Guide

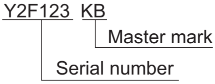
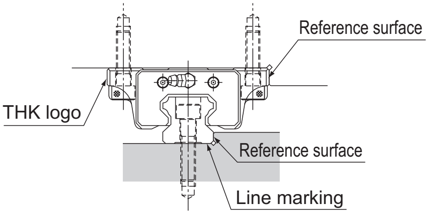


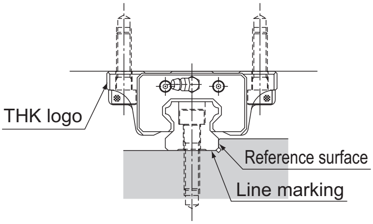
Fig.20 Master LM Guide and Subsidiary LM Guide

[Markings on the Reference Surface]

In the LM Guide, the reference surface of the LM block is opposite the surface marked with the THK logo, and that of the LM rail is on the surface marked with a line (see Fig.21). If it is necessary to reverse the reference surface of the LM rail and block, or if the grease nipple must be oriented in the opposite direction, specify it.



Master LM Guide



Subsidiary LM Guide

Fig.21 Markings on the Reference Surface

[Serial Number Marking and Combined Use of an LM Rail and LM Blocks]

An LM rail and LM block(s) used in combination must have the same serial number. When removing an LM block from the LM rail and reinstalling the LM block, make sure that they have the same serial number and the numbers are oriented in the same direction. (Fig.22)

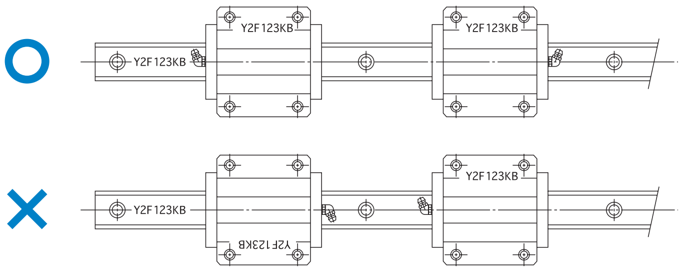


Fig.22 Serial Number Marking and Combined Use of an LM Rail and LM Blocks

[Use of Jointed Rails]

When a long LM rail is ordered, two or more rails will be jointed together to the desired length. When jointing rails, make sure that the joint match marks shown in Fig.23 are correctly positioned.

When two LM Guides with connected rails are to be arranged in parallel to each other, the two LM Guides will be manufactured so that the two LM Guides are axisymmetrically aligned.

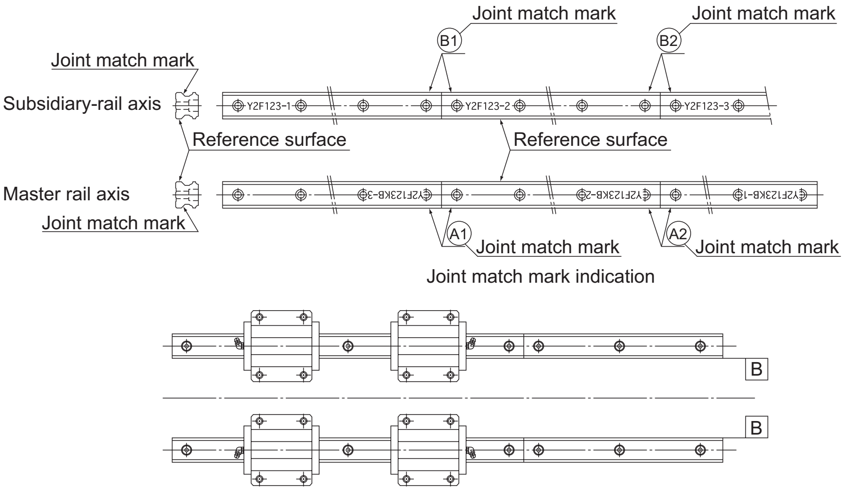


Fig.23 Use of Jointed Rails

Mounting the LM Guide

Mounting Procedure

[Example of Mounting the LM Guide When an Impact Load is Applied to the Machine and therefore Rigidity and High Accuracy are Required]

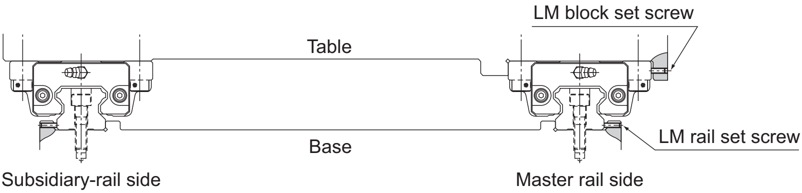


Fig.1 When an Impact Load is Applied to the Machine

● Mounting the LM Rail(s)

(1) Be sure to remove burr, dent and dust from the mounting surface of the machine to which the LM Guide is to be mounted before installing the LM Guide. (Fig.2)

Note) Since the LM Guide is coated with anti-rust oil, remove it from the reference surface by wiping the surface with washing oil before using the guide. Once the anti-rust oil has been removed, the reference surface is prone to getting rusted. We recommend applying low-viscosity spindle oil.

(2) Gently place the LM rail onto the base, and temporarily secure the bolts to the extent that the LM rail lightly contacts the mounting surface (align the line-marked side of the LM rail with the side reference-surface of the base). (Fig.3)

Note) The bolts for securing the LM Guide must be clean. When placing the bolts into the mounting holes of the LM rail, check if the bolt holes are displaced.(Fig.4) Forcibly tightening the bolt into a displaced hole may deteriorate the accuracy.

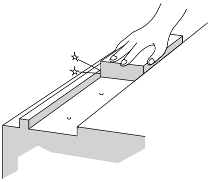


Fig.2 Checking the Mounting Surface

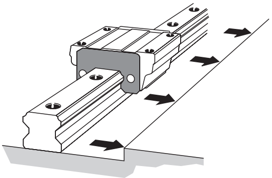


Fig.3 Aligning the LM Rail with the Reference-Surface

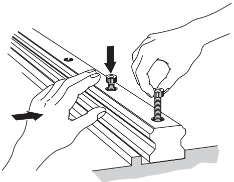


Fig.4 Checking with the Bolt for an Allowance

(3) Secure the set screws for the LM rail in order with a tightening force just enough to have the rail closely contact the side mounting surface. (Fig.5)

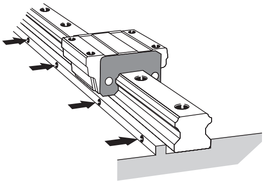


Fig.5 Tightening the Set screws

(4) Tighten the mounting bolts at the designated torque using a torque wrench. (See Fig.6, and Table1 and Table2 on A-350.)

Note) To achieve stable accuracy when tightening the LM rail mounting bolts, tighten them in order from the center to the rail ends.

(5) Mount the other rail in the same manner to complete the installation of the LM rails.

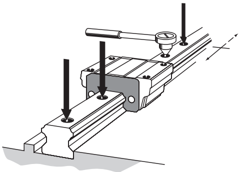


Fig.6 Fully Fastening the Mounting Bolts

(6) Hammer in caps into the bolt holes on the top face of each LM rail until the top of the cap is on the same level as the top face of the rail.

● Mounting the LM Blocks

(1) Gently place the table on the LM blocks and temporarily fasten the mounting bolts.

(2) Press the master side LM blocks to the side reference surface of the table using set screws and position the table. (See Fig.1 on A-340.)

(3) Fully fasten the mounting bolts on the master side and the subsidiary side to complete the installation.

Note) To evenly secure the table, tighten the mounting bolts in diagonal order as shown in Fig.7.

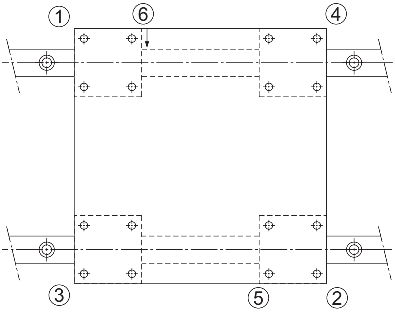


Fig.7 Sequence of Tightening the LM Blocks

This method saves time in establishing straightness of the LM rail and eliminates the need to machine securing dowel pins, thus to drastically shorten the installation man-hours.

[Example of Mounting the LM Guide When the Master LM Rail is not Provided with Set screws]

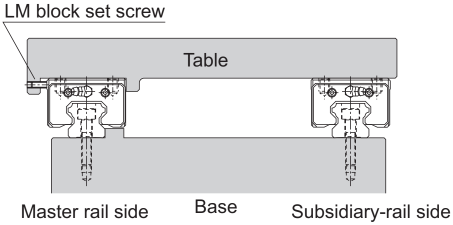


Fig.8 When the Master LM Rail is not Provided with Set screws

● Mounting the Master LM Rail

After temporarily fastening the mounting bolts, firmly press the LM rail to the side reference surface at the position of each mounting bolt using a small vice and fully fasten the bolt. Perform this in order from either rail end to the other. (Fig.9)

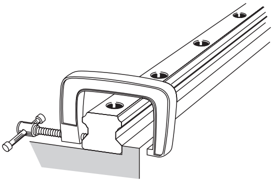


Fig.9

● Mounting the Subsidiary LM Rail

To mount the subsidiary LM rail in parallel with the master LM rail, which has been correctly installed, we recommend adopting the methods below.

■Using a Straight-edge

Place straight-edges between the two rails, and arrange the straight-edges in parallel with the side reference surface of the master LM rail using a dial gauge. Then, secure the mounting bolts in order while achieving straightness of the subsidiary rail with the straight edge as the reference by using the dial gauge. (Fig.10)

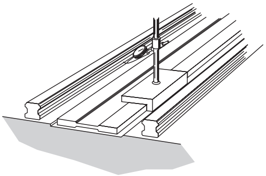


Fig.10

■Using Parallelism of the Table

Secure the two LM blocks on the master LM rail with the table (or a temporary table for measurement), and temporarily fasten the LM rail and the LM block on the subsidiary LM rail with the table. Place a dial gauge to the side face of the LM block on the subsidiary rail from the dial stand fixed on the table top, then fasten the bolts in order while achieving parallelism of the subsidiary LM rail by moving the table from the rail end. (Fig.11)

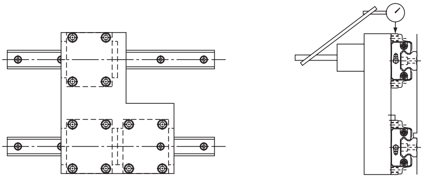


Fig.11

■Having the Subsidiary LM Rail Follow the Master LM Rail

Place the table on the blocks of the correctly mounted master LM rail and the temporarily fastened subsidiary LM rail, and fully fasten the two LM blocks on the master rail and one of the two LM blocks on the subsidiary rail with bolts. Fully tighten the mounting bolts on the subsidiary LM rail in order while temporarily fastening the remaining LM block on the subsidiary LM rail. (Fig.12)

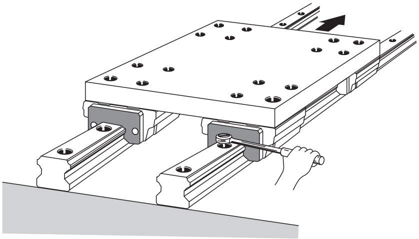


Fig.12

■Using a Jig

Use a jig like the one shown in Fig.13 to achieve parallelism of the reference surface on the subsidiary side against the side reference surface of the master side from one end of the rail by the mounting pitch, and at the same time, fully fasten the mounting bolts in order. (Fig.13)

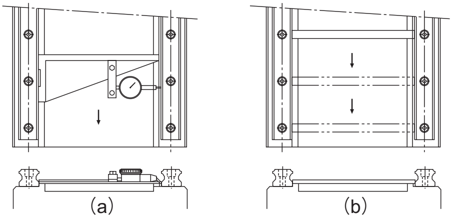


Fig.13

[Example of Mounting the LM Guide When the Master LM Rail Does not Have a Reference Surface]

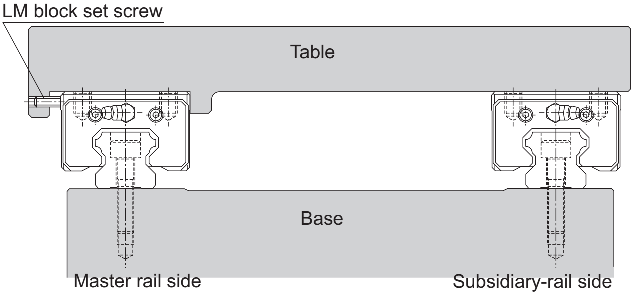


Fig.14

● Mounting the Master LM Rail

■Using a Temporary Reference Surface

You can temporarily set a reference surface near the LM rail mounting position on the base to achieve straightness of the LM rail from the rail end. In this method, two LM blocks must be joined together and attached to a measurement plate, as shown in Fig.15.

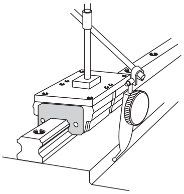


Fig.15

■Using a Straight-edge

After temporarily fastening the mounting bolts, use a dial gauge to check the straightness of the side reference surface of the LM rail from the rail end, and at the same time, fully fasten the mounting bolts.(Fig.16)

To mount the subsidiary LM rail, follow the procedure described on A-342.

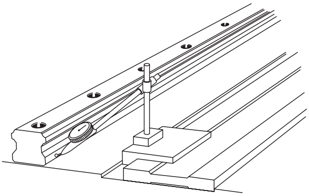


Fig.16

[Procedure for Assembling Model HR]

The following procedure is recommended for assembling model HR.

(1) Remove burr or knots from the LM rail mounting surface of the base using an oil-stone. (Fig.17)

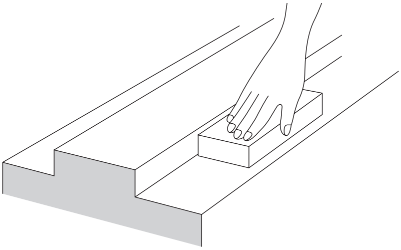


Fig.17

(2) Use a small vice to press the two LM rails to the base so that they closely contact the reference surface, then tighten the mounting bolts to the recommended torque (see A-350). (Fig.18)
   a. Check if any of the bolts has a sinking.
   b. Use a torque wrench to tighten the bolts in order from the center to both ends.

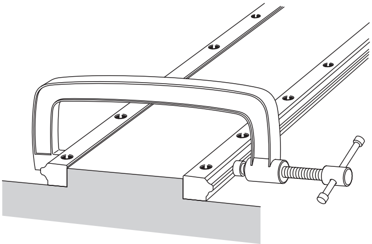


Fig.18

(3) Mount the LM blocks on the table, then install them onto the LM rails. Be sure the mounting bolts for the LM blocks are temporarily fastened.

(4) Tighten the clearance adjustment bolt alternately to adjust the clearance.
If a relatively large preload is applied in order to achieve high rigidity, control the tightening torque or the rolling resistance.
   a. It is preferable to use three clearance adjustment bolts for each LM block as shown in Fig.19.
   b. To obtain a favorable result of the clearance adjustment, set the tightening torque of the two outside screws at approx. 90% of that of the enter screw.

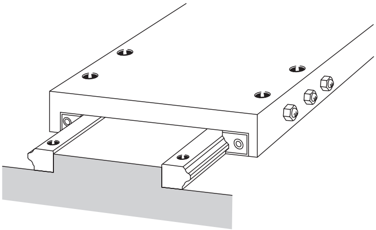


Fig.19

(5) Secure each LM block by gradually tightening the two LM block mounting bolts, which have temporarily been fastened, while sliding the table. (Fig.20)

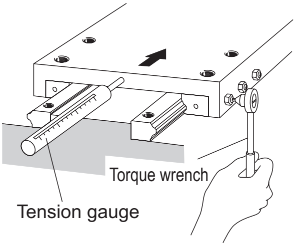
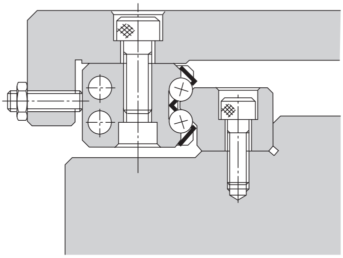


Fig.20

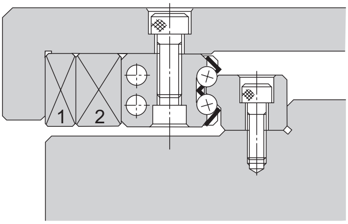
● Example of Clearance Adjustment

Design the clearance adjustment bolt so that it presses the center of the side face of the LM block.

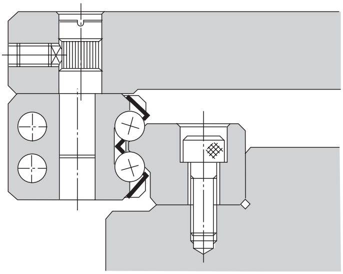
a. Using an adjustment screw
   Normally, an adjustment screw is used to press the LM block.



b. Using tapered gibs
   When high accuracy and high rigidity are required, use tapered gibs 1) and 2).



c. Using an eccentric pin
   A type using an eccentric pin to adjust the clearance is also available.



[Procedure for Assembling Model GSR]

The procedure for assembling model GSR is as follows:

(1) Align the table with the reference-surface of each LM block and fully fasten the mounting bolts to secure the blocks.
Both ends of the table must have a datum surface. (Fig.21)

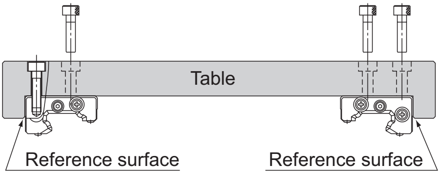


Fig.21

(2) Place LM rail A onto the base and align the rail with a straight-edge.
Fully fasten the mounting bolts using a torque wrench. (Fig.22)

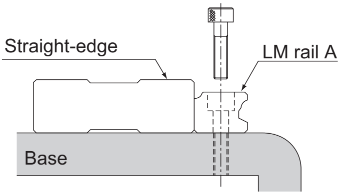


Fig.22

(3) Temporarily secure LM rail B onto the base, then mount the blocks on the rail by sliding the blocks.
Temporarily fasten LM rail B while pressing it toward the LM blocks. (Fig.23)

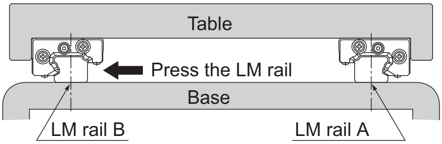


Fig.23

(4) Slide the table a few strokes to fit the LM blocks to LM rail B, then fully fasten LM rail B using a torque wrench. (Fig.24)

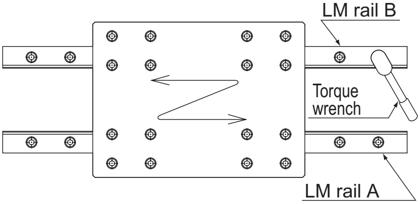


Fig.24

If there are more GSR units to be assembled, we recommend producing a jig like the one shown in Fig.25 first. You can easily mount LM rails while achieving parallelism of the LM rails using the jig.

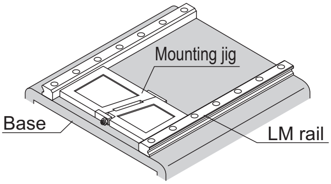


Fig.25

[Procedure for Assembling Model JR]

● Mounting the LM Rails

When two LM rails are to be used in parallel as shown in Fig.26, first secure one LM rail on the base, and place a dial gauge on the LM block. Then, place the pointer of the dial gauge on the side face and top face of the other LM rail to simultaneously adjust the parallelism and the level, thus to complete mounting the LM rails.

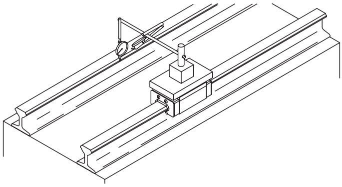


Fig.26

● Jointing LM Rails

When two or more LM rails are to be jointed, a special metal fitting as shown in Fig.27 is available. For such applications, specify this fitting when ordering the LM Guide.

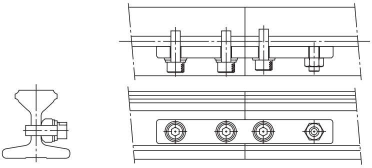


Fig.27

● Welding the LM Rail

When welding the LM rail, it is best to weld the LM rail while clamping it at the welding point with a small vice or the like as shown in Fig.28. For effective welding, we recommend the following welding conditions. (During welding the LM rail, take care to prevent spatter from contacting the LM rail raceway.)

[Welding conditions]
Preheating temperature:200℃
Postheating temperature:350℃

Note) If the temperature exceeds 750℃, the LM rail may be hardened again.

[For shielded metal arc welding]
Welding rod: LB-52 (Kobelco)

[For carbon dioxide arc welding]
Wire: YGW12
Electric current: 200A

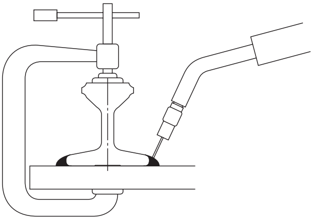


Fig.28

[Procedure for Assembling Model HCR]

To install the LM rails of R Guide model HCR, we recommend having any form of datum point (such as a pin) on the reference side (inside) of the LM rail, and pressing the LM rail to the datum point then stopping the LM rail with a presser plate from the counter-reference surface.

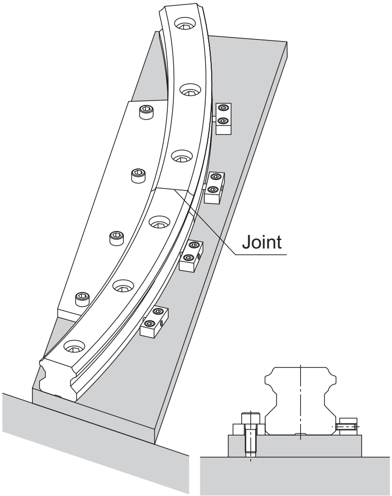


Fig.29 Method for Securing the LM Rails at the Joint

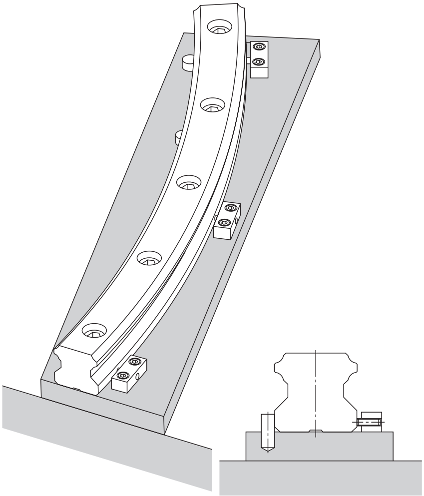
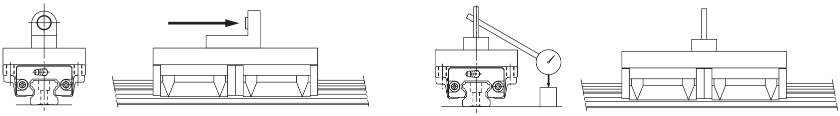


Fig.30 Method for Securing the LM Rail Using a Pin as a Datum Point

Methods for Measuring Accuracy after Installation

[When Measuring Running Accuracy for Single Rail Application]

When measuring running accuracy of the LM block, stable accuracy can be obtained by securing two LM blocks on an inspection plate, as shown in Fig.31. When using a dial gauge, we recommend placing the straight-edge as close as possible to the LM block in order to perform accurate measurement.



1) Measurement method using an auto-collimator

2) Measurement method using a dial gauge

Fig.31 Methods for Measuring Accuracy after Installation

Recommended Tightening Torque for LM Rails

With high-precision LM rails for the LM Guide, their raceways are ground and accuracy is inspected with the rails tightened with bolts. When mounting a high-precision LM rail on a machine, we recommend using the corresponding tightening torque indicated in Table1 or Table2

Table1 Tightening Torques when Pan Head Screws are Used

Unit: N-cm

Screw model No.	Tightening torque	
	Not hardened	Hardened
M 2	17.6	21.6
M 2.3	29.4	35.3
M 2.6	44.1	52.9

Table2 Tightening Torques when Hexagonal-Socket-Head Type Bolts are Used

Unit: N-cm

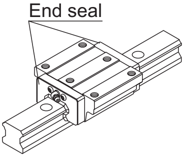
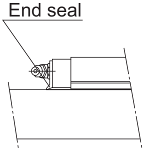
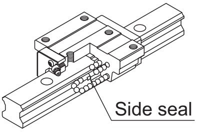
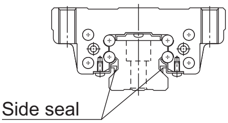
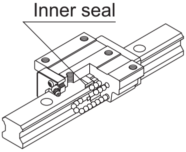
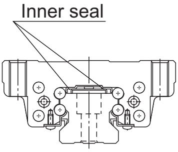
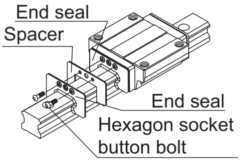
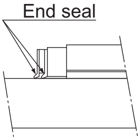
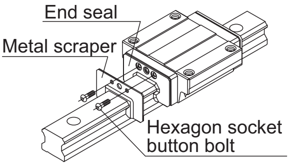
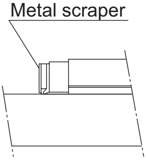
Screw model No.	Tightening torque		
	Iron	Casting	Aluminum
M 2	58.8	39.2	29.4
M 2.3	78.4	53.9	39.2
M 2.6	118	78.4	58.8
M 3	196	127	98
M 4	412	274	206
M 5	882	588	441
M 6	1370	921	686
M 8	3040	2010	1470
M 10	6760	4510	3330
M 12	11800	7840	5880
M 14	15700	10500	7840
M 16	19600	13100	9800
M 20	38200	25500	19100
M 22	51900	34800	26000
M 24	65700	44100	32800
M 30	130000	87200	65200

LM Guide

Options

Seal and Metal Scraper

- ●For the supported models, see the table of options by model number on A-370.
- ●For the LM block dimension (dimension L) with seal attached, see B-224 to B-230.
- ●For the seal resistance, see A-372 to A-374.

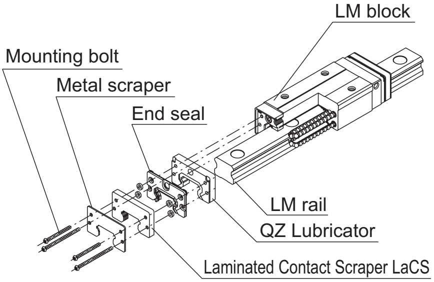
Item name	Schematic diagram / mounting location	Purpose/location of use
End Seal	 	Used in locations exposed to dust
Side Seal	 	Used in locations where dust may enter the LM block from the side or bottom surface, such as vertical, horizontal and inverted mounts
Inner Seal	 	Used in locations severely exposed to dust or cutting chips
Double Seals	 	Used in locations exposed to much dust or many cutting chips
Metal Scraper (Non-contact)	 	Used in locations where welding spatter may adhere to the LM rail

Symbol	Contamination protection accessory
UU	End seal
SS	With end seal + side seal + inner seal
DD	With double seals + side seal + inner seal
ZZ	With end seal + side seal + inner seal + metal scraper
KK	With double seals + side seal + inner seal + metal scraper

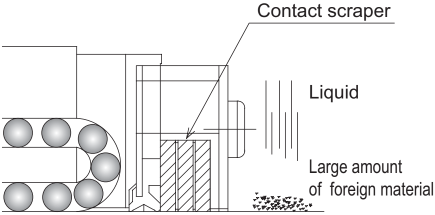
Laminated Contact Scraper LaCS

- **For the supported models, see the table of options by model number on A-370.**
- **For the LM block dimension (dimension L) with LaCS attached, see B-224 to B-230.**
- **For the resistance of LaCS, see A-375.**

For locations with adverse environment, Laminated Contact Scraper LaCS is available.
LaCS removes minute foreign material adhering to the LM rail in multiple stages and prevents it from entering the LM block with laminated contact structure (3-layer scraper).



Appearance Drawing



Structural Drawing

[Features]

- Since the 3 layers of scrapers fully contact the LM rail, LaCS is highly capable of removing minute foreign material.
- Since it uses oil-impregnated, foam synthetic rubber with a self-lubricating function, low friction resistance is achieved.

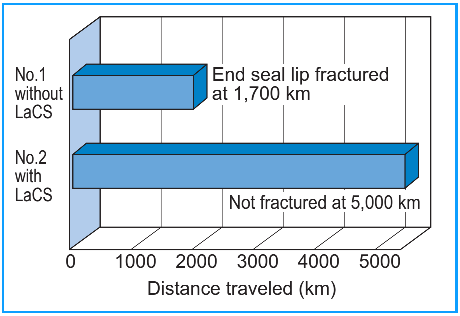
Symbol	Contamination protection accessory
SSHH	With end seal + side seal + inner seal + LaCS
DDHH	With double seals + side seal + inner seal + LaCS
ZZHH	With end seal + side seal + inner seal + metal scraper + LaCS
KKHH	With double seals + side seal + inner seal + metal scraper + LaCS

Test under an Environment with a Water-soluble Coolant

[Test conditions] Test environment: water-soluble coolant

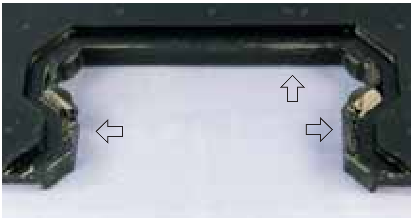
Item		Description
Tested model	No.1	SHS45R1SS+3000L (end seal only)
	No.2	SHS45R1SSHH+3000L (end seal and LaCS)
Maximum speed		200m/min
Environmental conditions		Coolant sprayed: 5 time per day

[Test result]



Magnified view of the end seal lip

No. 1: without LaCS - lip fractured at 1,700 km



⇦ Areas marked with arrow are fractured

No. 2: with LaCS - no anomaly observed after traveling 5,000 km

Lip has not been fractured

Test under an Environment with Minute Foreign Matter

[Test conditions] Test environment: minute foreign material

Item		Description
Tested model	No.1	SNR45R1DD+600L (double seals only)
	No.2	SNR45R1HH+600L (LaCS only)
Max speed/ acceleration		60m/min, 1G
External load		9.6kN
Foreign material conditions		Type: FCD450#115 (particle diameter: 125 μm or less)
		Sprayed amount: 1g/1hour (total sprayed amount: 120 g)

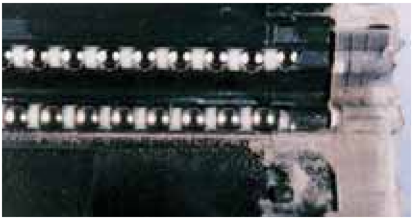
[Test result] Amount of foreign material entering the raceway

Seal configuration		Amount of foreign material entering the raceway g
Double-seal configuration (2 end seals superposed with each other)	Tested model 1	0.3
	Tested model 2	0.3
	Tested model 3	0.3
LaCS	Tested model 1	0
	Tested model 2	0
	Tested model 3	0

No. 1 Traveled 100 km (double-seal configuration)

Large amount of foreign matter has entered the raceway

No. 2 Traveled 100 km (LaCS only)



No foreign matter entering the raceway observed

Light-Resistance Contact Seal LiCS

- **For the supported models, see the table of options by model number on A-370.**
- **For the LM block dimension (dimension L) with LiCS attached, see B-233.**
- **For the resistance of LiCS, see A-376.**

LiCS is a light sliding resistance contact seal. It is effective in removing dust on the raceway and retaining a lubricant such as grease. It achieves extremely low drag and smooth, stable motion.

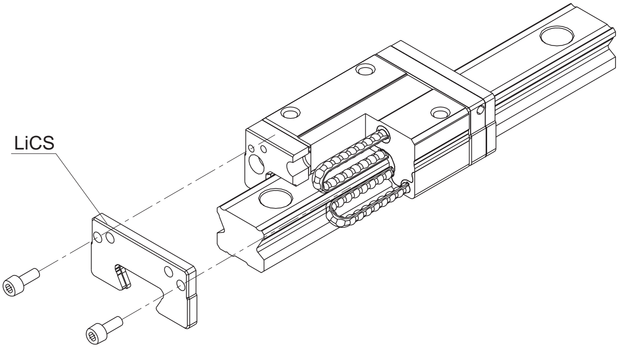


Fig.1 Structural Drawing of SSR + LiCS

[Features]

Light-Resistance Contact Seal LiCS is a seal that uses a light-resistance material in its sealing element and contacts the LM rail raceway to achieve low drag resistance. It is optimal for applications where low drag resistance is required, such as semiconductor-related devices, inspection devices and OA equipment all of which are used in favorable environments.

- Since the sealing element contacts the LM rail raceway, it is effective in removing dust on the raceway.
- Use of oil-impregnated, expanded synthetic rubber, which has excellent self-lubricating property, achieves low drag resistance.

Model number coding

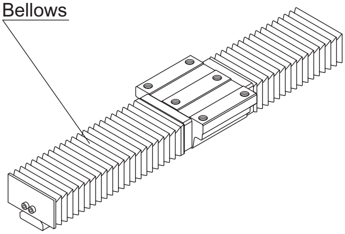
SSR20 XW 2 GG C1 +600L P -Ⅱ

SSR20: LM Guide model number
XW: Type of LM block
2: No. of LM blocks used on the same rail
GG: With LiCS seal on both ends
C1: Radial clearance symbol
Normal (No symbol)
Light preload (C1)
Medium preload (C0)
+600L: LM rail length (in mm)
P: Accuracy symbol
Normal grade (No Symbol) / High accuracy grade (H)
Precision grade (P) / Super precision grade (SP)
Ultra precision grade (UP)
-Ⅱ: Symbol for number of axes

Symbol	Contamination protection accessory
GG	LiCS
PP	With LiCS + side seal + inner seal

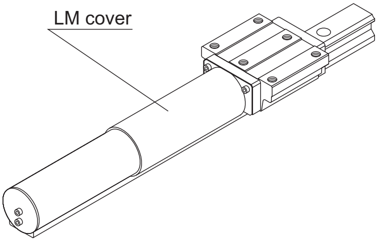
Dedicated Bellows

- For the supported models, see the table of options by model number on A-370.
- For the dedicated bellows dimensions, see B-235 to B-247.

Item name	Schematic diagram / mounting location	Purpose/location of use
Dedicated Bellows		Used in locations exposed to dust or cutting chips

Dedicated LM Cover

- For the supported models, see the table of options by model number on A-370.
- For the dimensions of the dedicated LM cover, see B-248 to B-249.

Item name	Schematic diagram / mounting location	Purpose/location of use
Dedicated LM Cover		Used in locations exposed to dust or cutting chips Used in locations where high temperature foreign material such as flying spatter

Cap C

If any of the LM rail mounting holes of an LM Guide is filled with cutting chips or foreign material, they may enter the LM block structure. Entrance of such foreign material can be prevented by covering each LM rail mounting hole with the dedicated cap.

Since the dedicated cap C for LM rail mounting holes uses a special synthetic resin with high oil resistance and high wear resistance, it is highly durable. Different sizes of the dedicated cap C are in stock as standard for hexagonal-socket-head type bolts of M3 to M22.

To attach the dedicated cap to the mounting hole, place a flat metal piece like one shown in Fig.1 on the cap and gradually hammer in the cap until it is on the same level as the top face of the LM rail. When attaching the dedicated cap C for LM rail mounting holes, do not remove any of the LM blocks from the LM rail.

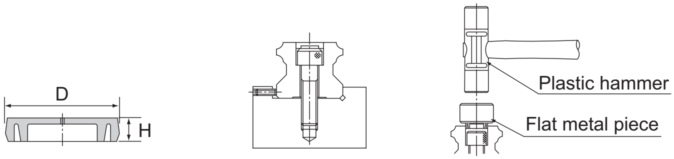


Fig.1 Cap C

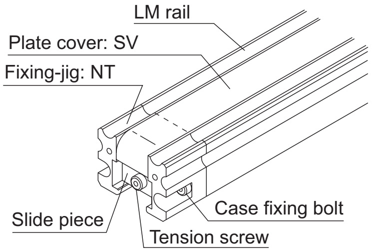
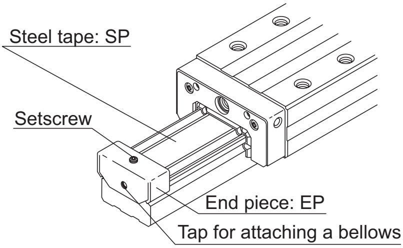
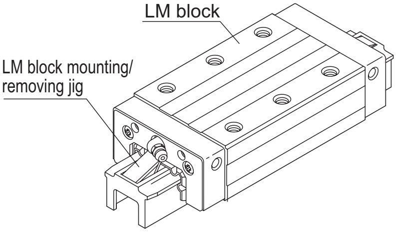
Table1 List of Model Numbers Supported for the Dedicated Cap C for LM Rail Mounting Holes

Model No.	Bolt used	Main dimen-sions (mm)		Supported model number														
		D	H	SSR	SCR	SR	SNR SNS	NR NRS	SHS HSR CSR HCR	HMG	SHW HRW	SRG SRN	GSR	HR	SRS RSR RSH	SRS-W RSR-W RSH-W	NSR-TBC	SRW
C3	M3	6.3	1.2	—	—	15	—	—	12	—	—	—	—	1123 1530	12 15	9	—	—
C4	M4	7.8	1.0	15Y	—	—	—	—	15	15	12,14, 17,21, 27	15	15	—	14	—	—	—
C5	M5	9.8	2.4	20	—	20	25	25X	20	—	—	20	20	2042	20	—	20	—
C6	M6	11.4	2.7	25Y 30	25	25Y 30	30	30	25	25	35	25	25	—	25	—	25 30	—
C8	M8	14.4	3.7	35	30 35	35	35	35	30 35	35	50	30 35	30	2555 3065	—	—	40	—
C10	M10	18.0	3.7	—	—	45	—	—	—	—	60	—	35	3575	—	—	50	70
C12	M12	20.5	4.7	—	45	55	45	45	45	45	—	45	—	4085	—	—	70	85
C14	M14	23.5	5.7	—	—	—	55	55	55	—	—	55	—	—	—	—	—	100
C16	M16	26.5	5.7	—	65	70 85	65	65	65	65	—	65	—	50105	—	—	—	—
C22	M22	35.5	5.7	—	—	—	—	85	85	—	—	—	—	—	—	—	—	—

Note) The dedicated cap for the LM rail mounting hole can be made of other materials (e.g., metal). Contact THK for details.

Plate Cover SV
Steel Tape SP

●For the supported models, see the table of options by model number on A-370.

Item name	Schematic diagram / mounting location	Purpose/location of use
Plate Cover SV		For the LM Guide, steel tapes are available as an essential means of contamination protection for machine tools. By covering the LM rail mounting holes with an ultra-thin stainless steel (SUS304) plate, the plate cover SV drastically increases sealability, thus to prevent the penetration of a coolant or cutting chips from the top face of the LM rail, which was previously impossible. For the mounting method, see A-359. Note) When mounting the plate cover, the LM rail needs to be machined. Indicate that the plate cover is required when ordering the LM Guide.
Steel Tape SP	 	For the LM Guide, steel tapes are available as an essential means of contamination protection for machine tools. By covering the LM rail mounting holes with an ultra-thin stainless steel (SUS304) plate, the plate cover SV drastically increases sealability, thus to prevent the penetration of a coolant or cutting chips from the top face of the LM rail, which was previously impossible. (When mounting the steel tape, end piece EP can be used as a means to secure the cover.) For the mounting method, see A-360. Note) When mounting the steel tape, the LM rail needs to be machined. Indicate that the steel tape is required when ordering the LM Guide.

[Mounting Procedure for Plate Cover SV]

(1) Attach slide pieces to the plate cover.
Place the slide pieces on the plate cover with their chamfered sides facing outward, hold the plate cover with the slide pieces and the securing plates, and then secure them with countersunk screws.

(2) Use an LM block mounting/removing jig to remove the LM block from the LM rail, and then mount the fixing-jigs onto the LM rail.
Identify the positions of the mounting holes on the fixing jigs, then secure the jigs with hexagonal-socket-head type bolts.

(3) Temporarily secure either slide piece.
Insert either slide piece into one of the fixing-jigs, then attach the slide piece to the LM rail's end face using the tension adjustment bolt and gently secure the bolt until the bolt head is inside the fixing-jig.

(4) Temporarily secure the other slide piece.
Temporarily secure the other slide piece in the same manner as above.

(5) Apply tension to the plate cover.
Apply tension to the plate cover by evenly securing the tension adjustment bolts on both ends of the LM rail. Make sure there is only a small difference between the H and H' dimensions in Fig.5. If the difference is too large, there may be no interference left on either end.

(6) Mount the LM block on the LM rail.
Identity the reference surface of the LM rail and the LM block, then insert the LM rail into the LM block using the LM block mounting /removing jig.

Note1) When removing or the mounting the LM block, use much care not to let the balls fall off.

Note2) The plate cover is an ultra-thin stainless steel (SUS304) plate. When handing it, use much care not to bend it.

Note3) The plate cover is available for models SNR/SNS35 to 65 and models NR/NRS35 to 100.

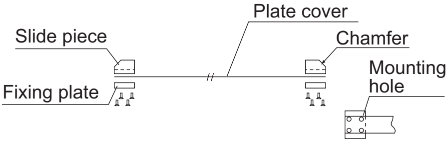


Fig.1

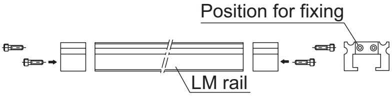


Fig.2

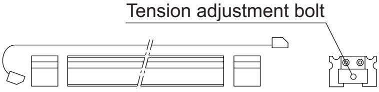


Fig.3

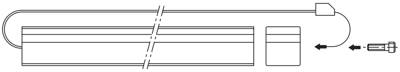


Fig.4

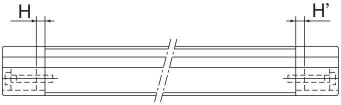


Fig.5

[Mounting Procedure for Steel Tape SP]

(1) Use an LM block mounting/removing jig to remove the LM block from the LM rail.

(2) Thoroughly degrease and clean the top face of the LM rail, to which the steel tape is to be adhered. For degreasing, use an adequately volatile detergent (e.g., industrial alcohol).

(3) Carefully adhere the steel tape from the end with care not to let it bend or sag, while gradually peeling the release paper from the steel tape.

(4) Have the steel tape settle on the rail by rubbing the tape. The adhesive strength increases with time. The adhering tape can be peeled off by pulling its end upward.

(5) Mount the LM block onto the LM rail using the LM block mounting/removing jig.

(6) Attach the end pieces on both ends of the LM rail and further secure the steel tape. When securing the end pieces, fasten only the setscrew on the top face of each end piece.
(The tap on the end face of the end piece is used for mounting a bellows.)

Note1) The setscrew on the side face is used to lightly secure the bent steel tape. Be sure to stop fastening the screw as soon as it hits the end face, and do not force the screw further.

Note2) Since the steel tape is a thin steel plate, mishandling it may cause an accident such as cutting your finger. When handling it, take an effective safety measure such as wearing rubber gloves.

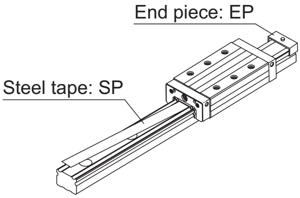


Fig.6

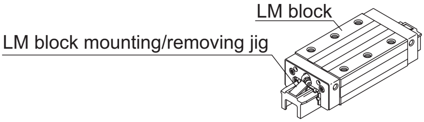


Fig.7

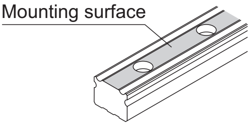


Fig.8

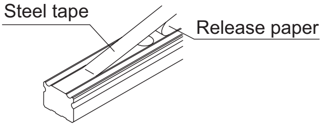


Fig.9

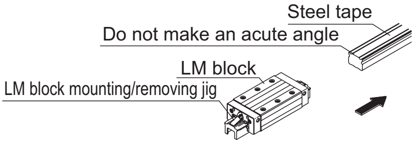


Fig.10

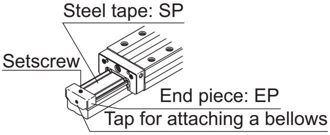
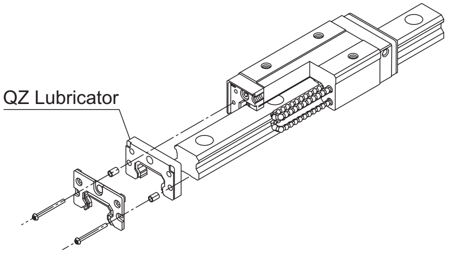


Fig.11

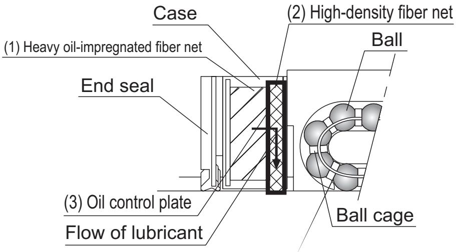
QZ Lubricator

●For the supported models, see the table of options by model number on A-370.
●For the LM block dimension with QZ attached, see B-251 to B-253.

QZ Lubricator feeds the right amount of lubricant to the raceway on the LM rail. This allows an oil film to continuously be formed between the rolling element and the raceway, and drastically extends the lubrication and maintenance intervals.
The structure of QZ Lubricator consists of three major components: (1) a heavy oil-impregnated fiber net (function to store lubricant), (2) a high-density fiber net (function to apply lubricant to the raceway) and (3) an oil-control plate (function to adjust oil flow). The lubricant contained in QZ Lubricator is fed by the capillary phenomenon, which is used also in felt pens and many other products, as the fundamental principle.



Appearance Drawing



Structural Drawing

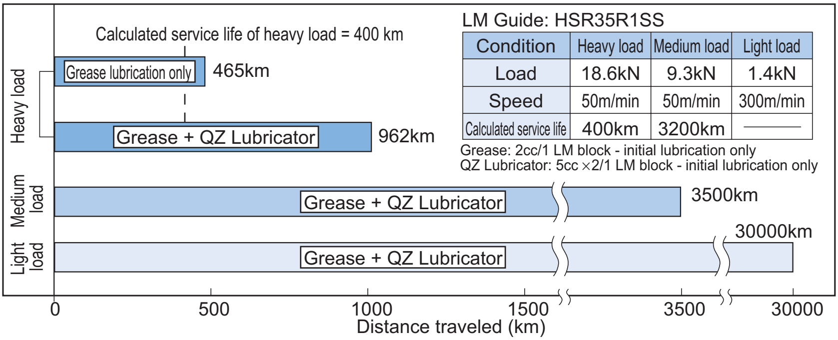
[Features]

- Since it supplements an oil loss, the lubrication maintenance interval can be significantly extended.
- Eco-friendly lubrication system that does not contaminate the surrounding area since it feeds the right amount of lubricant to the ball raceway.

Symbol	Contamination protection accessory
QZUU	With end seal + QZ
QZSS	With end seal + side seal + inner seal + QZ
QZDD	With double seals + side seal + inner seal + QZ
QZZZ	With end seal + side seal + inner seal + metal scraper + QZ
QZKK	With double seals + side seal + inner seal + metal scraper + QZ
QZGG	With LiCS + QZ
QZPP	With LiCS + side seal + inner seal + QZ
QZSSHH	With end seal + side seal + inner seal + LaCS + QZ
QZDDHH	With double seals + side seal + inner seal + LaCS + QZ
QZZZHH	With end seal + side seal + inner seal + metal scraper + LaCS + QZ
QZKKHH	With double seals + side seal + inner seal + metal scraper + LaCS + QZ

- **Significantly Extended Maintenance Interval**

Attaching QZ Lubricator helps extend the maintenance interval throughout the whole load range from the light load area to the heavy load area.



LM Guide: HSR35R1SS

Condition	Heavy load	Medium load	Light load
Load	18.6kN	9.3kN	1.4kN
Speed	50m/min	50m/min	300m/min
Calculated service life	400km	3200km	———

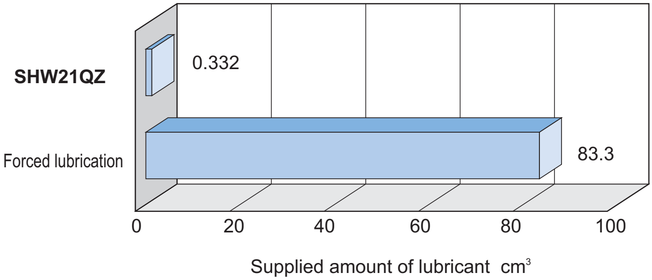
Grease: 2cc/1 LM block - initial lubrication only
QZ Lubricator: 5cc ×2/1 LM block - initial lubrication only

LM Guide Running Test without Replenishment of Lubricant

- **Effective Use of Lubricant**

Since the lubricator feeds the right amount of lubricant to the ball raceway, lubricant can be used efficiently.
[Test conditions] speed: 300 m/min

Comparison of lubricant consumption after traveling 5,000 km



Amount of oil contained in QZ Lubricator
$0.166cm^3$/ 2 units
(attached to both ends of the LM block)
$=0.332cm^3$

Compared

Forced lubrication
$0.03cm^3/6min \times 16667min$
$=83.3cm^3$

Lubricant consumption is 1/250 less than forced lubrication.

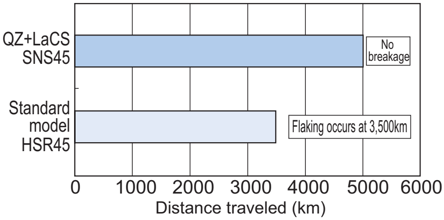
● Effective in Helping Lubrication under Severe Environments

A 5,000 km durability test was conducted under severe environments (containing coolant and contaminated environment).

[Test conditions]

Model No.	SNS45	HSR45
Load	8kN	6kN
Speed	60m/min	
Coolant	Immersed 48 hrs, dried 96 hrs	
Foreign material	Foundry dust (125 μm or less)	
Lubrication	AFA Grease + QZ	Super Multi 68 Oiling cycle: 0.1cc/shot Periodically lubricated every 16 min

[Test result]



* When using the LM system under severe environment, use QZ Lubricator and Laminated Contact Scraper LaCS (see "Laminated Contact Scraper LaCS" on A-353) in combination.

Lubrication Adapter

An oil lubricant-only lubrication adapter is available for models NR/NRS.
Even if the LM Guide is installed in an orientation where oil lubrication is difficult, such as wall mount and inversed mount, the adapter is capable of feeding a constant quantity of lubricant to the four raceways.

[Features]

The dedicated lubrication adapter for models NR-NRS is built in with a constant quantity distributor. Therefore, the adapter can accurately feed a constant quantity of lubricant to each raceway regardless of the mounting orientation.
The adapter is economical since it is capable of constantly feeding the optimum amount of lubricant and helping eliminate the supply of surplus lubricant.
To provide pipe arrangement, simply connect an intermittent lubrication pump widely used for ordinary machine tools to the greasing holes (M8) on the front and the side of the lubrication adapter.

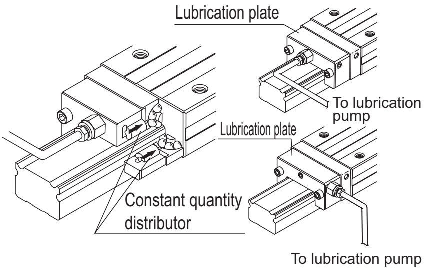


Fig.1 Structural Drawing

[Specifications]

Viscosity range of lubricant used	32 to 64 mm²/s recommended
Discharge	0.03×4, 0.06×4cc/1shot
Diameter of pipe connected	ϕ4, ϕ6
Material	Aluminum alloy

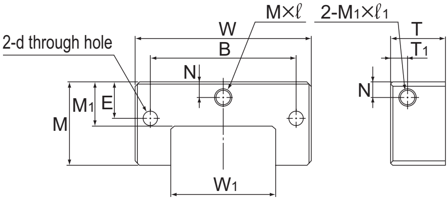


Fig.2

Table1 Dimension Table for Lubrication Adapter

Unit: mm

Model No.	Main dimensions												Quantity per shot (cc/shot)
	Width W	Height M	T	W_1	M_1	B	E	N	T_1	d	$M\times\ell$	$M_1\times\ell_1$	
A30N	56	29	25	29	14.5	46	14	5	5.3	3.5	M8×8	M8×8	0.03×4
A35N	66	33	25	35	17	54	16.5	6	5.3	4.5	M8×8	M8×8	
A45N	81	38	25	48	20	67	16.5	7	7.8	6.6	M8×8	M8×8	
A55N	94	45.5	25	56	22	76	20.5	7	7.8	6.6	M8×8	M8×8	0.06×4
A65N	119	55.5	25	67	26.3	92	25.5	11.5	7.8	9	M8×8	M8×8	
A85N	147	68.5	25	92	34	114	32	15.5	7.8	9	M8×8	M8×8	

Removing/mounting Jig

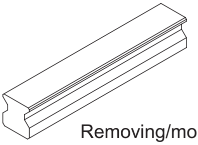
When assembling the guide, do not remove the LM block from the LM rail whenever possible. If it is inevitable to remove the LM block due to the plate cover type or the assembly procedure, be sure to use the removing/mounting jig.

Mounting the LM block without using the removing/mounting jig may cause rolling elements to fall from the LM block due to contamination by foreign material, damage to internal components or slight inclination. Mounting the LM block with some of the rolling elements missing may also cause damage to the LM block at an early stage.

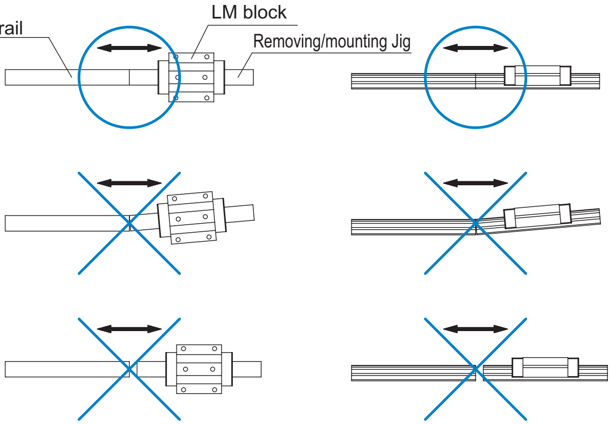
When using the removing/mounting jig, do not incline the jig and match the ends of both LM rails.

If any of the rolling elements falls from the LM block, contact THK instead of using the product.

Note that the removing/mounting jig is not included in the LM Guide package as standard. When desiring to use it, contact THK.



Removing/mounting Jig
(Material: ABS resin)



End Piece EP

For those models whose balls may fall if the LM rail is pulled out of the LM block, an end piece is attached to the product to prevent the LM block from being removed from the LM rail.

For models that can use the end piece, see the table below.

If removing the end piece when using the LM Guide, be sure that the LM block will not overshoot.

The end piece can also be used as a fixing jig for a steel tape, and is available also for the LM rail of models SSR, SR and HSR.

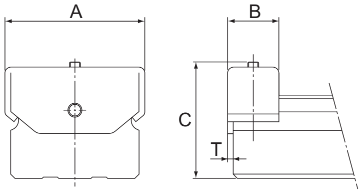


Fig.1 End Piece EP for Models NR/NRS

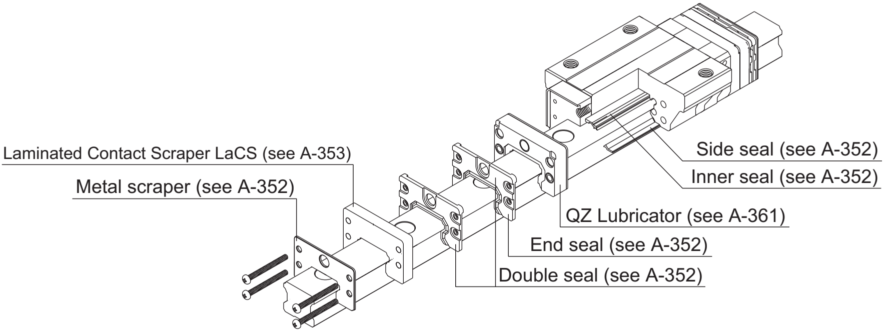
Table1 Dimension Table for End Piece EP for Models NR/NRS

Unit: mm

Model No.	A	B	C	T
NR/NRS 25X	26	14	25	1.5
NR/NRS 30	31	14	31	1.5
NR/NRS 35	38	16	32.5	2
NR/NRS 45	49	18	41	2
NR/NRS 55	57	20	46.5	2
NR/NRS 65	69.4	22	59	3.2
NR/NRS 75	81.7	28	56	3.2
NR/NRS 85	91.4	22	68	3.2
NR/NRS 100	106.4	25	73	3.2

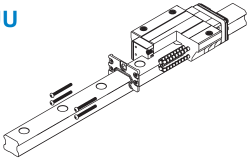
List of Parts Symbols

●For supported model numbers, see the correspondence table of options by model number on A-370.

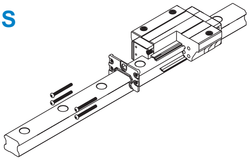


Symbol	Lubrication and Dust Prevention Accessories
UU	End seal
SS	With end seal + side seal + inner seal
DD	With double seals + side seal + inner seal
ZZ	With end seal + side seal + inner seal + metal scraper
KK	With double seals + side seal + inner seal + metal scraper
GG	LiCS
PP	With LiCS + side seal + inner seal
SSHH	With end seal + side seal + inner seal + LaCS
DDHH	With double seals + side seal + inner seal + LaCS
ZZHH	With end seal + side seal + inner seal + metal scraper + LaCS
KKHH	With double seals + side seal + inner seal + metal scraper + LaCS
QZUU	With end seal + QZ
QZSS	With end seal + side seal + inner seal + QZ
QZDD	With double seals + side seal + inner seal + QZ
QZZZ	With end seal + side seal + inner seal + metal scraper + QZ
QZKK	With double seals + side seal + inner seal + metal scraper + QZ
QZGG	With LiCS + QZ
QZPP	With LiCS + side seal + inner seal + QZ
QZSSHH	With end seal + side seal + inner seal + LaCS + QZ
QZDDHH	With double seals + side seal + inner seal + LaCS + QZ
QZZZHH	With end seal + side seal + inner seal + metal scraper + LaCS + QZ
QZKKHH	With double seals + side seal + inner seal + metal scraper + LaCS + QZ

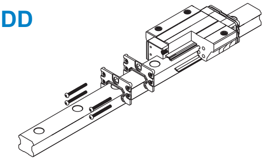
UU



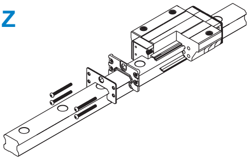
SS



DD



ZZ



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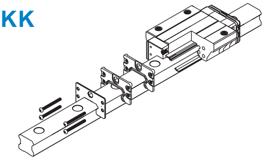

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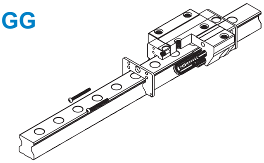

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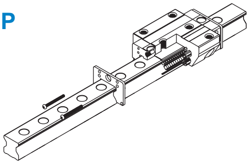

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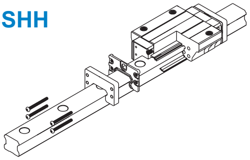

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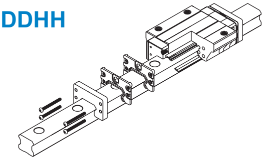

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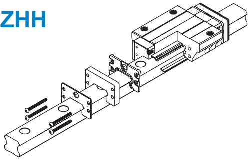

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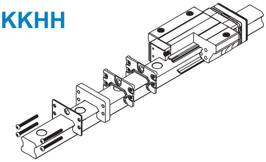

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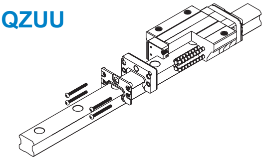

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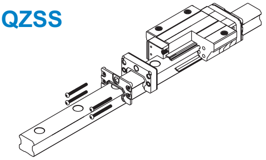

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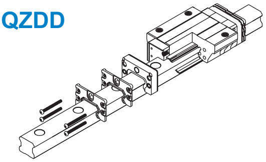

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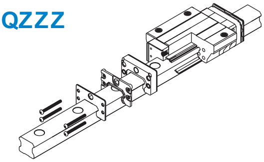

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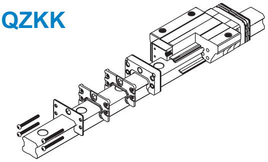

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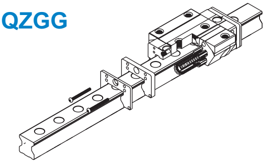

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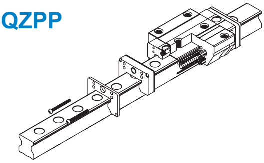

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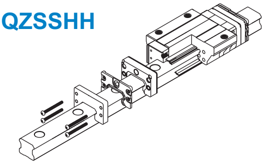

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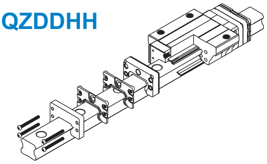

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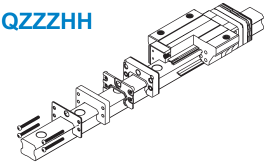

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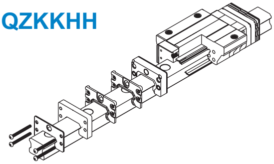

Table of Supported Options by Models

For the overall length with an option attached, see B-224 to B-255.

Type			Model No.		Caged Ball									
					*1 SHS	*2 SSR	*3 SNR SNS	*4 SHW	*5 SRS	SCR	*6 HSR	*7 SR	*8 NR NRS	*9 HRW
			Symbol	Reference page	A-136	A-142	A-148	A-156	A-160	A-166	A-170	A-178	A-186	A-194
Contamination Protection	[2]	End seal	UU	A-352 to A-353	○	○★	○	○★	○	○	○★	○★	○★	○★
		[1]	SS		◇★	○	◇★	◇	○★	○★	△	○	○	○
			DD		◇	○	◇	◇	—	○	△	△	○	△
			ZZ		◇	○	◇	◇	—	○	△	△	○	△
			KK		◇	○	◇	◇	—	○	△	△	○	△
		LaCS+[1]	HH		○	○	○	△	△	○	△	—	△	—
	Low-resistance end seal		LL	—	—	—	—	—	—	—	△	△	—	—
		+ Side seal	RR	—	—	—	—	—	—	—	○	○	—	—
	LiCS		GG	A-355	—	○	—	—	—	—	—	—	—	—
			PP		—	○	—	—	—	—	—	—	—	—
	Plate Cover SV		Z	A-358	—	—	△	—	—	—	—	—	○	—
	Steel Tape SP		Z		○	△	△	—	—	—	△	△	△	—
	Dedicated cap C *15		—	A-357	○	○	○	○	△	○	○	○	○	○
	Dedicated bellows		—	A-356	B-235	B-236	B-237	B-238	—	—	B-239	B-241	B-243	B-244
	Dedicated cover		—		—	—	—	—	—	—	B-248	B-249	—	—
	Tapped-hole LM rail type		K	—	○	○	—	—	—	B-59	B-83	B-91	—	—
Lubrication	QZ Lubricator	QZ+[2]	QZ	A-361	○	○	○	○	○	○	△	—	△	—
	End plate with/without side nipple		—	—	◎	◎	◎	△	△	○	—	—	○	—
Corrosion Prevention	AP-HC, AP-C, AP-CF		F	A-20	○	○	○	○	—	○	○	○	○	○
	Stainless Steel LM Guide		M	A-19	—	△	—	△	○	—	△	△	—	△

*1. Model SHS: steel tape SP – applicable to models SHS15 to 65.
*2. Model SSR: steel tape SP – not applicable to model SSR15; stainless steel type – not applicable to model SSR35.
*3. Models SNR/SNS: plate cover SV – applicable to models SNR/SNS35 to 65;
steel tape SP – applicable to models SNR/SNS25 to 65.
*4. Model SHW: inner seal and LaCS are not applicable to models SHW12, 14 and 17.
Models SHW12 and 14 cannot have a grease nipple; instead, a greasing hole is available.
stainless steel type – not applicable to some models (contact THK for details).
*5. Model SRS: LaCS – applicable to models SRS20 and 25.
Models SRS9M, 9WM, 12M and 12WM cannot have a grease nipple; instead, a greasing hole is available.
*6. Model HSR: SS – applicable to models HSR15 to 150; DD, ZZ and KK -- applicable to models HSR15 to 65;
LaCS -- applicable to models HSR15 to 35;
LL -- applicable to models HSR15 to 65;
steel tape SP: applicable to models HSR15 to 100; for models HSR8 to 12, only UU is applicable;
stainless steel type – not applicable to some models (contact THK for details).
for model Model HSR-R Grade Ct, only SS is applicable.
*7. Model SR: DD, ZZ and KK – applicable to models SR15 to 70; LL -- applicable to models SR15 to 25;
steel tape SP: applicable to models SR20 to 70;
for models SR85 to 150, only UU and SS are applicable;
stainless steel type – not applicable to some models (contact THK for details).

◎: Option ○: Applicable △: Not applicable for some models
★: THK recommendation (standard stock product) ◇: With inner seal attached

	Full-ball																	Caged roller		
	*10 RSR RSR-W	RSR-Z RSR-WZ	RSH	RSH-Z RSH-WZ	*11 HR	GSR	GSR-R	CSR	MX	JR	*12 HCR	HMG	NSR-TBC	HSR-M1	SR-M1	RSR-M1	HSR-M2	*13 SRG	*14 SRN	SRW
	A-200	A-208	A-214	A-218	A-224	A-230	A-236	A-244	A-248	A-252	A-258	A-262	A-268	A-272	A-280	A-286	A-292	A-300	A-306	A-312
	○★	○	○★	○	○★	○★	○	○	○★	○	○	○	○	○	○	○	○	○	○	○
	—	△★	—	△★	—	○	○	○	—	○	○	—	○	○	○	—	○	○★	○★	○
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	—	—	—	—	—	—	—	—	—	—	—	—	B-245	—	—	—	—	B-246	—	B-247
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	B-157	—	—	—	—	—	—	—	—	—	—	—	—
	△	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	○	○	○
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	○	○	○
	○	—	○	—	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	○	○	○	○	△	—	—	—	○	—	—	—	—	—	—	—	—	—	—	—

*8. Models NR/NRS: LaCS and QZ – applicable to models NR/NRS25 to 65;
steel tape SP -- applicable to models NR/NRS25 to 100
*9. Model HRW: for models HRW12 and 14, only UU and SS is applicable; model HRW17 and 21 cannot have a side seal;
stainless steel type – not applicable to models HRW50 and 60
*10. Model RSR: QZ – applicable to models RSR9 to 15.
*11. Model HR: stainless steel type – applicable to models HR918 to 2555.
For locations where adequate dust prevention cannot be provided with the end seal alone, consider using also a bellows and a cover.
*12. Model HCR: DD, ZZ and KK – may not applicable depending on R; for model HCR12, only UU is applicable.
*13. Model SRG: LaCS – applicable to all model numbers except model SRG15;
plate cover SV – applicable to models SRG35 to 65; GG and PP – applicable to only model SRG15.
*14. Model SRN: LaCS – applicable to all model numbers except model SRN15;
plate cover SV – applicable to models SRN35 to 65.
*15. Dedicated cap C – may not be attached depending on the size of the model.

Seal Resistance Value

Unit: N

Model No.		Seal symbol	Seal resistance value
SHS	15	SS	4.5
	20		7.0
	25		10.5
	30		17.0
	35		20.5
	45		30.0
	55		31.5
	65		43.0
SSR	15X	UU	2.0
	20X		2.6
	25X		3.5
	30X		4.9
	35X		6.3
SNR/SNS	25	SS	8
	30		14
	35		14
	45		16
	55		20
	65		25
	85		30
SHW	12CA/CR	UU	1.0
	12HR		1.0
	14		1.2
	17		1.4
	21		4.9
	27		4.9
	35		9.8
	50		14.7
	12CA/CR	SS	1.4
	12HR		1.8
	14		1.8
	17		2.2
	21		6.9
	27		8.9
	35		15.8
	50		22.7

Unit: N

Model No.		Seal symbol	Seal resistance value
SRS	7M	SS	0.08
	7WM		0.12
	9M		0.2
	9WM		1.0
	12M		0.6
	12WM		1.3
	15M		1.0
	15WM		1.6
	20M		1.3
	25M		1.6
SCR	15	SS	2.5MAX
	20		3MAX
	25		5MAX
	30		10MAX
	35		12MAX
	45		20MAX
	65		30MAX
HSR	8	UU	0.5
	10		0.8
	12		1.2
	15		2.0
	20		2.5
	25		3.9
	30		7.8
	35		11.8
	45		19.6
	55		19.6
	65		34.3
	85		34.3
SR	15	UU	2.5
	20		3.4
	25		4.4
	30		8.8
	35		11.8
	45		12.7
	55		15.7
	70		19.6

Unit: N

Model No.		Seal symbol	Seal resistance value
NR/NRS	25X	UU	15
	30		17
	35		23
	45		24
	55		29
	65		42
	75		42
	85		42
	100		51
HRW	12	UU	0.2
	14		0.3
	17		2.9
	21		4.9
	27		4.9
	35		9.8
	50		14.7
	60		19.6
RSR	5	UU	0.06
	7		0.08
	9		0.1
	12		0.4
	15		0.8
	20		1.0
	3W		0.2
	5W		0.3
	7W		0.4
	9W		0.8
	12W		1.1
	14W		1.2
	15W		1.3
	7Z		0.08
	9Z		0.1
	12Z		0.4
	15Z		0.8
	7WZ		0.4
	9WZ		0.8
	12WZ		1.1
	15WZ		1.3

Unit: N

Model No.		Seal symbol	Seal resistance value
RSH	7	UU	0.08
	9		0.1
	12		0.4
	7Z		0.08
	9Z		0.1
	12Z		0.4
	15Z		0.8
	7WZ		0.4
	9WZ		0.8
	12WZ		1.1
	15WZ		1.3
HR	918	UU	0.5
	1123		0.7
	1530		1.0
	2042		2.0
	2555		2.9
	3065		3.4
	3575		3.9
	4085		4.4
	50105		5.9
	60125		9.8
GSR	15	UU	2.5
	20		3.1
	25		4.4
	30		6.3
	35		7.6
	25-R		4.4
	30-R		6.3
	35-R		7.6
CSR	15	UU	2.0
	20		2.5
	25		3.9
	30		7.8
	35		11.8
	45		19.6
MX	5	UU	0.06
	7W		0.4

Unit: N

Model No.		Seal symbol	Seal resistance value
JR	25	UU	3.9
	35		11.8
	45		19.6
	55		19.6
HCR	12	UU	1.2
	15		2.0
	25		3.9
	35		11.8
	45		19.6
	65		34.3
HMG	15	UU	3
	25		6
	35		8
	45		12
	65		40
NSR	20TBC	UU	4.9
	25TBC		4.9
	30TBC		6.9
	40TBC		9.8
	50TBC		14.7
	70TBC		24.5
HSR	15M1	UU	2.0
	20M1		2.5
	25M1		3.9
	30M1		7.8
	35M1		11.8
SR	15M1	UU	2.5
	20M1		3.4
	25M1		4.4
	30M1		8.8
	35M1		11.8

Unit: N

Model No.		Seal symbol	Seal resistance value
RSR	9M1	UU	0.1
	12M1		0.4
	15M1		0.8
	20M1		1.0
	9M1W		0.8
	12M1W		1.1
	15M1W		1.3
HSR	15M2	UU	2.0
	20M2		2.5
	25M2		3.9
SRG	15	SS	13
	20		18
	25		19
	30		24
	35		30
	45		30
	55		35
	65		40
SRN	35	SS	30
	45		30
	55		35
	65		40
SRW	70	SS	32
	85		37
	100		43

Resistance of LaCS

Unit: N

Model No.		Resistance of LaCS
SHS	15	5.2
	20	6.5
	25	11.7
	30	18.2
	35	20.8
	45	26.0
	55	32.5
	65	39.0
SSR	15	5.9
	20	6.9
	25	8.1
	30	12.8
	35	15.1
SNR/SNS NR/NRS	25	8.1
	30	13.4
	35	15.5
	45	23.3
	55	28.6
	65	39.6
	85	52.7
SHW	21	3.9
	27	6.5
	35	13.0
	50	19.5
SRS	20	5.2
	25	7.8

Unit: N

Model No.		Resistance of LaCS
SCR	15	5.2
	20	6.5
	25	11.7
	30	18.2
	35	20.8
	45	26.0
	65	39.0
HSR	15	3.8
	20	5.6
	25	7.5
	30	14.9
	35	22.4
SRG	20	6.1
	25	6.9
	30	8.2
	35	9.1
	45	14.3
	55	18.2
	65	26.0
SRN	35	9.1
	45	14.3
	55	18.2
	65	22.1
SRW	70	32.8
	85	39.7
	100	58.3

Note1) Each resistance value in the table only consists of that of LaCS, and does not include sliding resistances of seals and other accessories.
Note2) For the maximum service speed of LaCS, contact THK.

Maximum Seal Resistance of LiCS

Unit: N

Model No.		Resistance of LiCS
SSR	15X	1
	20X	1.1
	25X	1.6
	30X	1.6
	35X	2
SRG	15	0.7

Note) The value indicates the sliding resistance of two LiCS units per LM block and does not include the sliding resistances of the LM block and the side seals.

Greasing Hole

[Grease Nipple and Greasing Hole for Models SHW and SRS]

Models SHW and SRS do not have a grease nipple as standard. Installation of a grease nipple and the drilling of a greasing hole is performed at THK. When ordering SHW and SRS, indicate that the desired model requires a grease nipple or greasing hole. (For greasing hole dimensions and supported grease nipple types and dimensions, see Table1.)

When using SHW and SRS under harsh conditions, use QZ Lubricator* (optional) or Laminated Contact Scraper LaCS* (optional).

Note1) Grease nipple is not available for models SHW12, SHW14, SRS9M, SRS9WM, SRS12M and SRS12WM. They can have a greasing hole.
Note2) Using a greasing hole other than for greasing may cause damage.
Note3) For QZ Lubricator*, see A-361. For Laminated Contact Scraper LaCS*, see A-353.
Note4) When desiring a grease nipple for a model attached with QZ Lubricator, contact THK.

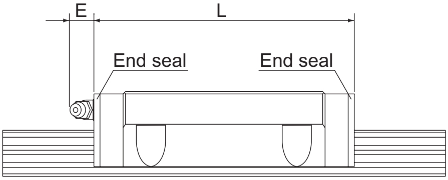


Fig.1 Dimensions of the Grease Nipple for Model SHW

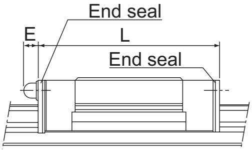


Fig.2 Dimensions of the Grease Nipple for Model SRS

Note) For the L dimension, see the corresponding specification table.

Table1 Table of Grease Nipple and Greasing Hole Dimensions

Unit: mm

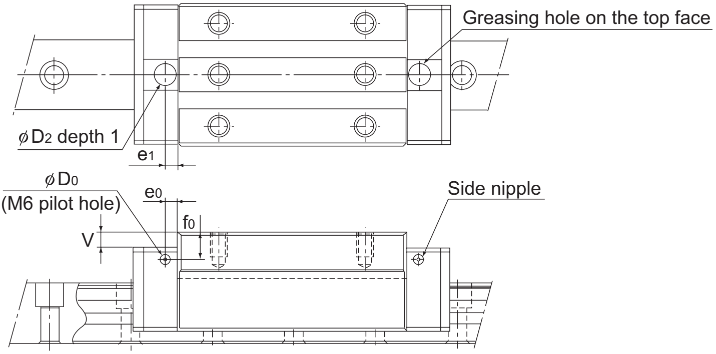
Model No.		E	Grease nipple or greasing hole
SHW	12	—	ϕ2.2 drilled hole
	14	—	ϕ2.2 drilled hole
	17	5	PB107
	21	5.5	PB1021B
	27	12	B-M6F
	35	12	B-M6F
	50	16	B-PT1/8
SRS	9M	—	ϕ1.5 drilled hole
	9WM	—	ϕ1.6 drilled hole
	12M	—	ϕ2.0 drilled hole
	12WM	—	ϕ2.0 drilled hole
	15M	4.0 (5.0)	PB107
	15WM	4.0 (5.0)	PB107
	20M	3.5 (5.0)	PB107
	25M	4.0 (5.5)	PB1021B

Note) Figures in the parentheses indicate dimensions without a seal.

[Greasing Hole for Model SRG]

Model SRG allows lubrication from both the side and top faces of the LM block. The greasing hole of standard types is not drilled through in order to prevent foreign material from entering the LM block. When using the greasing hole, contact THK.

When using the greasing hole on the top face of models SRG-R and SRG-LR, a greasing adapter is separately required. Contact THK for details.



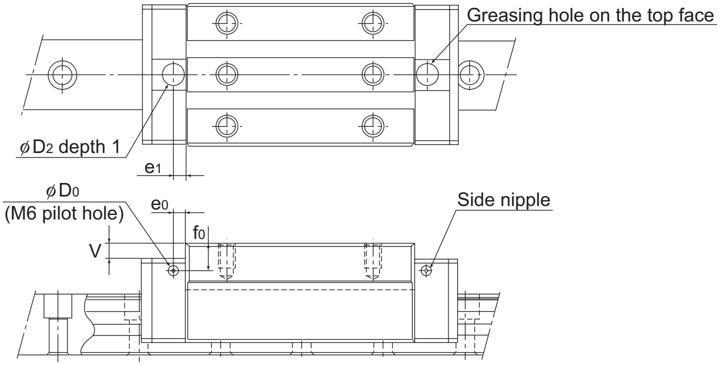
Unit: mm

Model No.		Pilot hole for side nipple			Applicable nipple	Greasing hole on the top face			
		e_0	f_0	D_0		D_2	(O-ring)	V	e_1
SRG	15A 15V	4	4	2.9	PB107	9.2	(P6)	0.5	5.5
	20A 20LA	4	5	2.9	PB107	9.2	(P6)	0.5	6.5
	20V 20LV	4	5	2.9	PB107	9.2	(P6)	0.5	6.5
	25C 25LC	6	6.3	5.2	M6F	10.2	(P7)	0.5	6
	25R 25LR	6	10.3	5.2	M6F	10.2	(P7)	4.5	6
	30C 30LC	6	5.8	5.2	M6F	10.2	(P7)	0.4	6
	30R 30LR	6	8.8	5.2	M6F	10.2	(P7)	3.4	6
	35C 35LC	6	6	5.2	M6F	10.2	(P7)	0.4	6
	35R 35LR	6	13	5.2	M6F	10.2	(P7)	7.4	6
	45C 45LC	7	7	5.2	M6F	10.2	(P7)	0.4	7
	45R 45LR	7	17	5.2	M6F	10.2	(P7)	10.4	7
	55C 55LC	9	8.5	5.2	M6F	10.2	(P7)	0.4	11
	55R 55LR	9	18.5	5.2	M6F	10.2	(P7)	10.4	11
	65LC	9	13.5	5.2	M6F	10.2	(P7)	0.4	10
	65LV	9	13.5	5.2	M6F	10.2	(P7)	0.4	10

Note) The greasing interval is longer than that of full-roller types because of the roller cage effect. However, the actual greasing interval may vary depending on the service environment, such as a high load and high speed. Contact THK for details.

[Greasing Hole for Model SRN]

Model SRN allows lubrication from both the side and top faces of the LM block. The greasing hole of standard types is not drilled through in order to prevent foreign material from entering the LM block. When using the greasing hole, contact THK.



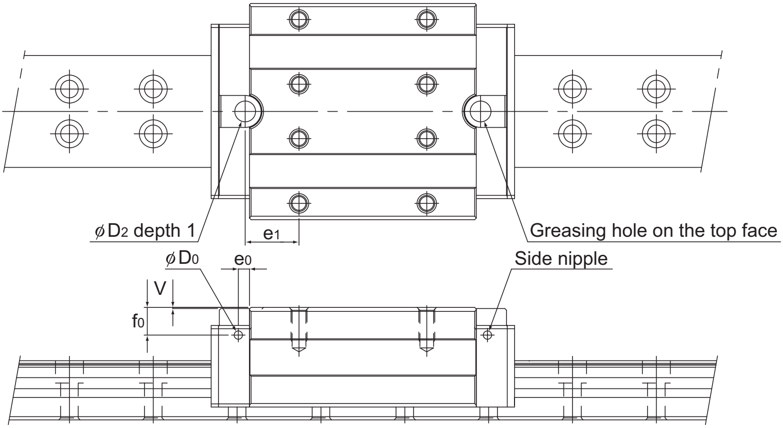
Unit: mm

Model No.		Pilot hole for side nipple			Applicable nipple	Greasing hole on the top face			
		e_0	f_0	D_0		D_2	(O-ring)	V	e_1
SRN	35C 35LC	8	6.5	5.2	M6F	10.2	(P7)	0.4	6
	35R 35LR	8	6.5	5.2	M6F	10.2	(P7)	0.4	6
	45C 45LC	8.5	7	5.2	M6F	10.2	(P7)	0.4	7
	45R 45LR	8.5	7	5.2	M6F	10.2	(P7)	0.4	7
	55C 55LC	10	8	5.2	M6F	10.2	(P7)	0.4	11
	55R 55LR	10	8	5.2	M6F	10.2	(P7)	0.4	11
	65LC	9	11	5.2	M6F	10.2	(P7)	0.4	10
	65LR	9	11	5.2	M6F	10.2	(P7)	0.4	10

Note) The greasing interval is longer than that of full-roller types because of the roller cage effect. However, the actual greasing interval may vary depending on the service environment, such as a high load and high speed. Contact THK for details.

[Greasing Hole for Model SRW]

Model SRW allows lubrication from both the side and top faces of the LM block. The greasing hole of standard types is not drilled through in order to prevent foreign material from entering the LM block. When using the greasing hole, contact THK.



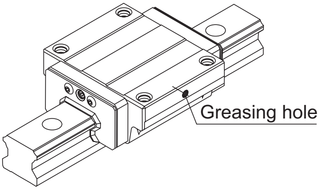
Unit: mm

Model No.		Pilot hole for side nipple			Applicable nipple	Greasing hole on the top face		
		e_0	f_0	D_0		D_2 (O-ring)	V	e_1
SRW	70	7	17	5.2	M6F	13 (P10)	0.4	33.7
	85	9	17.7	5.2	M6F	13 (P10)	0.4	42.75
	100	9	22.4	5.2	M6F	13 (P10)	0.4	55

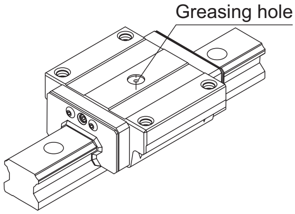
Note) The greasing interval is longer than that of full-roller types because of the roller cage effect. However, the actual greasing interval may vary depending on the service environment, such as a high load and high speed. Contact THK for details.

[Semi-standard Greasing Hole for Model HSR]

For model HSR, a semi-standard greasing hole is available. Specify the appropriate model number according to the application.



Type with a Greasing Hole Drilled on the Side Surface



Type with a Greasing Hole Drilled on the Top Face

[Lubrication for Model HR]

The LM block has a greasing hole in the center of its top face. To provide lubrication through this hole, the table must be machined to also have a greasing hole as shown in Fig.3 and attach a grease nipple or the like. When using oil lubrication, it is necessary to identify the lubrication route. Contact THK for details.

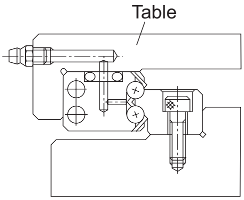


Fig.3 Example of Machining a Greasing Hole

Precautions on Using the LM Guide

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.
(2) Tilting an LM block or LM rail may cause them to fall by their own weight.
(3) Dropping or hitting the LM Guide may damage it. Giving an impact to the product could also cause damage to its function even if the product looks intact.

[Lubrication]

(1) Thoroughly remove anti-rust oil and feed lubricant before using the product.
(2) Do not mix lubricants of different physical properties.
(3) In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, normal lubricants may not be used. Contact THK for details.
(4) When planning to use a special lubricant, contact THK before using it.
(5) When adopting oil lubrication, the lubricant may not be distributed throughout the LM system depending on the mounting orientation of the system. Contact THK for details.
(6) Lubrication interval varies according to the conditions. Contact THK for details.

[Precautions on Use]

(1) Entrance of foreign material may cause damage to the ball (roller) circulating path or functional loss. Prevent foreign material, such as dust or cutting chips, from entering the system.
(2) When planning to use the LM system in an environment where the coolant penetrates the LM block, it may cause trouble to product functions depending on the type of the coolant. Contact THK for details.
(3) Contact THK if you desire to use the product at a temperature of 80℃ or higher.
(4) If foreign material such as dust or cutting chips adheres to the product, replenish the lubricant after cleaning the product with pure white kerosene. For available types of detergent, contact THK.
(5) When using the LM Guide with inverted mount, breakage of the endplate due to an accident or the like may cause balls (rollers) to fall and the LM block to come off from the LM rail and fall. In these cases, take preventive measures such as adding a safety mechanism for preventing such falls.
(6) When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, contact THK in advance.
(7) When removing the LM block from the LM rail and then replacing the block, an LM block mounting/removing jig that facilitates such installation is available. Contact THK for details.

[Storage]

When storing the LM Guide, enclose it in a package designated by THK and store it in a horizontal orientation while avoiding high temperature, low temperature and high humidity.

Precautions on Using Options for the LM Guide

QZ Lubricator

[Handling]

Dropping or hitting the product may damage it. Use much care when handling it.
Do not block the vent hole with grease or the like.

[Service Environment]

Be sure the service temperature of this product is between -10 to +50℃, and do not clean the product by immersing it in an organic solvent or white kerosene, or leave it unpacked. When using it out of the service temperature range, contact THK in advance.

[Use in a Special Environment]

When desiring to use the product in a special environment, contact THK.

[Precaution on Selection]

Secure a stroke longer than the overall LM block with QZ Lubricator attached.

[Corrosion Prevention]

QZ is a lubricating device designed to feed a minimum amount of oil to the raceway, and does not provide an anti-rust effect to the whole LM Guide. When using it in an environment subject to a coolant or the like, we strongly recommend applying grease to the mounting base of the LM Guide and to the rail ends as an anti-rust measure.

Laminated Contact Scraper LaCS, Side Scraper

[Service Environment]

Be sure the service temperature of this product is between -20 to +80℃, and do not clean the product by immersing it in an organic solvent or white kerosene, or leave it unpacked.

[Impregnating Oil]

The lubricant impregnated into the scraper is used to increase its sliding capability. For lubrication of the LM Guide, attach QZ Lubricator, or the grease nipple on the side face of the end plate of the LM block, before providing a lubricant.

[Function]

It is specifically designed to provide dust prevention capability to remove foreign material and liquid. To seal oil, an end seal is required.

[Design]

When using the product, be sure to attach the rail cap C or the plate cover.

Light Sliding Resistance Contact Seal LiCS

[Service Environment]

Be sure the service temperature of this product is between -20 to +80℃, and do not clean the product by immersing it in an organic solvent or white kerosene, or leave it unpacked.
It contacts only with the LM rail raceway. Do not use it in harsh environments.

[Impregnating Oil]

The lubricant impregnated into LiCS is used to increase its sliding capability. For lubrication of the LM Guide, attach the grease nipple on the end plate of the LM block before providing a lubricant.

LM Guide Actuator

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

Dimensional Drawing, Dimensional Table

* Please see the separate "B Product Specifications".

LM Guide Actuator

Model KR

LM Guide + Ball Screw = Integral-structure Actuator

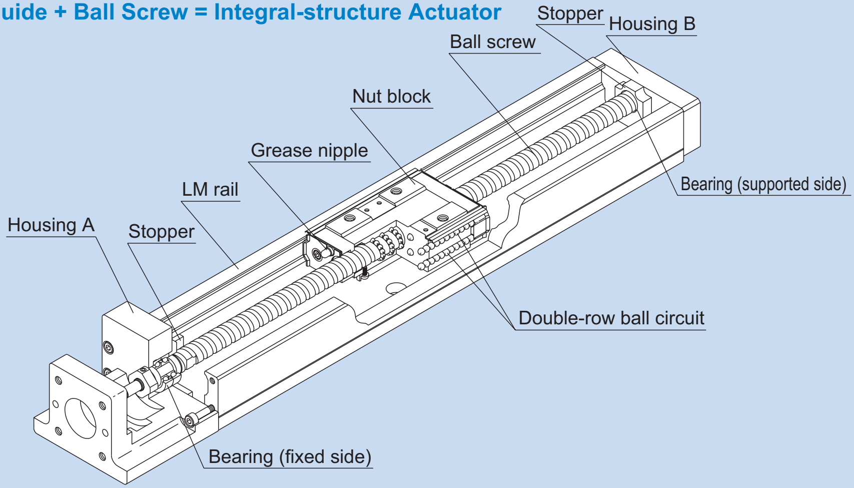


Fig.1 Structure of LM Guide Actuator Model KR

Structure and Features

Because of its integral-structure nut block consisting of a highly rigid LM rail with a U-shaped cross section, LM Guide units on both side faces and a Ball Screw unit in the center, LM Guide Actuator model KR achieves a highly rigid and highly accurate actuator in a minimal space.

In addition, since the housings A and B also serve as support units and the nut block as a table, the this model allows significant reduction of man-hours and time required for design and assembly since it incorporates a support unit and a table, thus to contribute to total cost cutting.

[4-way Equal Load]

Each train of balls is arranged at a contact angle of 45° so that the rated load on the nut block is uniform in the four directions (radial, reverse radial and lateral directions). As a result, model KR can be used in any mounting orientation.

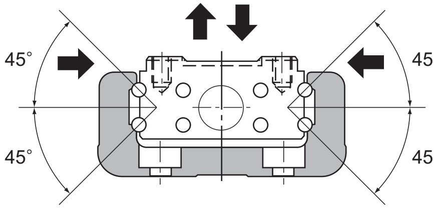


Fig.2 Load Capacity and Contact Angle of Model KR

[High Rigidity]

Unlike the conventional LM Guide, model KR uses an outer rail structure to achieve higher rigidity against an overhung load.

The LM rail has a wide U-shaped cross section to reduce the weight and minimize deflection.

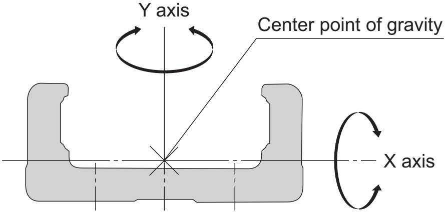


Fig.3 Cross Section of the LM Rail

Table1 Cross-sectional Characteristics of the LM Rail

Unit: mm^4

Model No.	I_X	I_Y	Mass (kg/100mm)
KR15	9.08×10^2	1.42×10^4	0.104
KR20	6.1×10^3	6.2×10^4	0.26
KR26	1.7×10^4	1.5×10^5	0.39
KR30H	2.7×10^4	2.8×10^5	0.5
KR33	6.2×10^4	3.8×10^5	0.66
KR45H	8.4×10^4	8.9×10^5	0.9
KR46	2.4×10^5	1.5×10^6	1.26
KR55	2.2×10^5	2.3×10^6	1.5
KR65	4.6×10^5	5.9×10^6	2.31

I_X=geometrical moment of inertia around X axis
I_Y=geometrical moment of inertia around Y axis

[High Accuracy]

Since the linear guide section consists of 4 rows of circular-arc grooves that enable balls to smoothly move even under a preload, a highly rigid guide with no clearance is achieved. Additionally, variation in frictional resistance caused by load fluctuation is minimized, allowing the system to follow highly accurate feed.

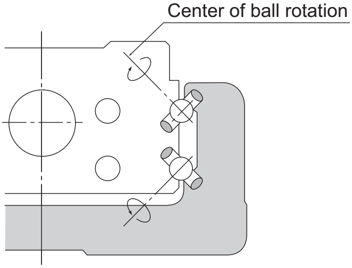


Fig.4 Contact Structure of Model KR

[Space Saving]

Use of a nut block integrating LM Guide units on both ends and a Ball Screw unit in the center makes model KR a highly rigid and highly accurate actuator in a minimal space.

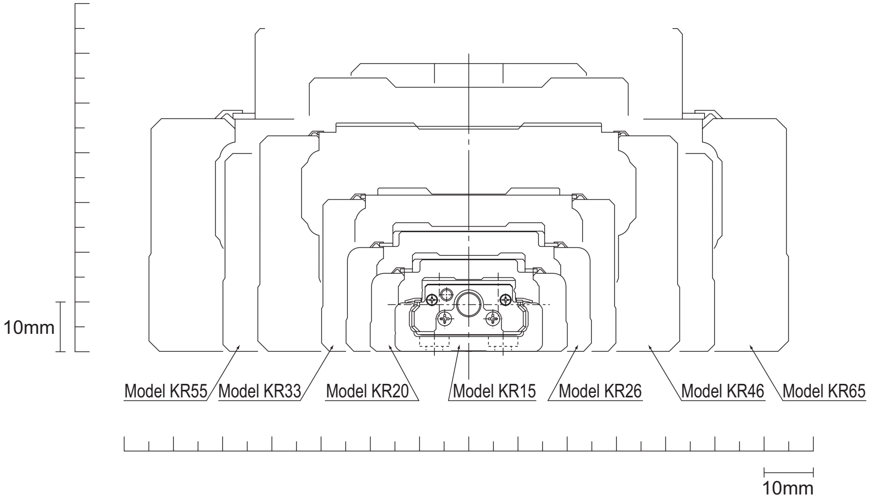


Fig.5 Cross Sectional Drawing

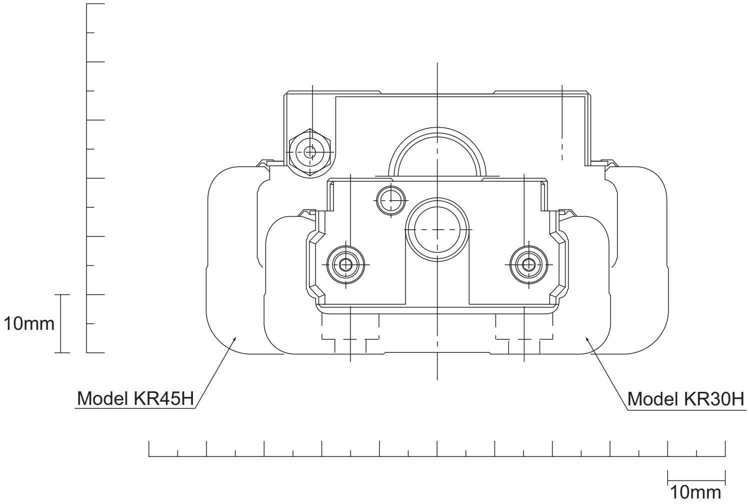


Fig.6 Cross Sectional Drawing

[Seal]

Model KR is equipped with end seals and side seals for dust prevention as standard.

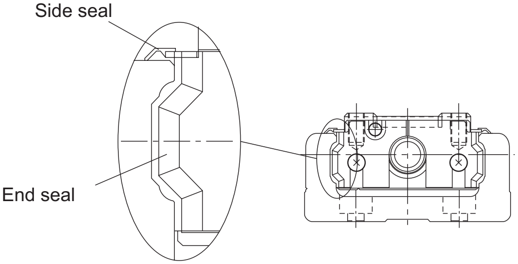


Table2 shows the rolling resistance and seal resistance per nut block (guide section).

Table2 Maximum Resistance Value Unit: N

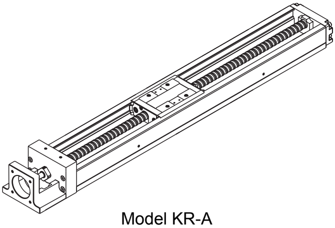
Model No.	Rolling resistance value	Seal resistance value	Total
KR15	0.2	0.7	0.9
KR20	0.5	0.7	1.2
KR26	0.6	0.8	1.4
KR30H	1.5	2.0	3.5
KR33	1.5	1.9	3.4
KR45H	2.5	2.6	5.1
KR46	2.5	2.5	5
KR55	5.0	3.8	8.8
KR65	6.0	4.1	10.1

Note) The rolling resistance represents the value when a lubricant is not used.

Types and Features

Model KR-A (with a Single Long Nut Block)

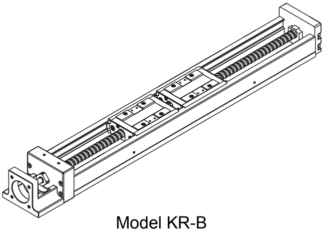
Representative model of KR.



Model KR-A

Model KR-B (with Two Long Nut Blocks)

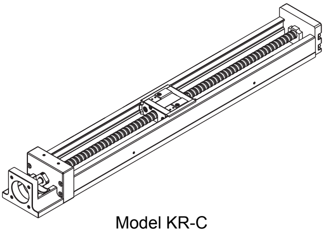
Equipped with two units of the nut block of model KR-A, this model achieves higher rigidity, higher load capacity and higher accuracy.



Model KR-B

Model KR-C (with a Single Short Nut Block)

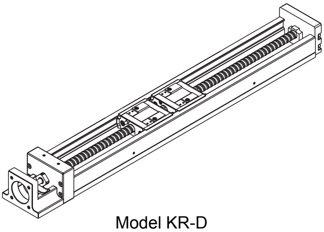
This model has a shorter overall length of the nut block and a longer stroke than model KR-A. (Supported models: model KR30H, 33, 45H, 46)



Model KR-C

Model KR-D (with Two Short Nut Blocks)

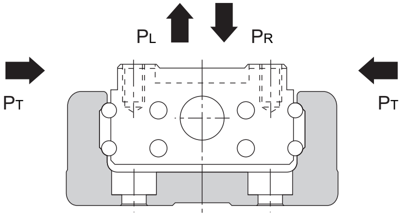
Equipped with two units of the nut block of model KR-C, this design allows a span between blocks that suits the equipment, thus to achieve high rigidity.
(Supported models: model KR30H, 33, 45H, 46)



Model KR-D

Load Ratings in All Directions and Static Permissible Moment

[Load Rating]



- **LM Guide Unit**

Model KR is capable of receiving loads in four directions: radial, reverse radial and lateral directions. Its basic load ratings are equal in all four directions (radial, reverse radial and lateral directions), and their values are indicated in Table3 on A-392 and A-393.

- **Ball Screw Unit**

Since the nut block is incorporated with a Ball Screw, model KR is capable of receiving an axial load. The basic load rating value is indicated in Table3 on A-392 and A-393.

- **Bearing Unit (Fixed Side)**

Since housing A contains an angular bearing, model KR is capable of receiving an axial load. The basic load rating value is indicated in Table3 on A-392 and A-393.

[Equivalent Load (LM Guide Unit)]

The equivalent load when the LM Guide unit of model KR simultaneously receives loads in all directions is obtained from the following equation.

$$P_E = P_R\ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral direction
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

Table3 Load Rating of Model KR

Model No.			KR15		KR20		KR26	
			KR1501	KR1502	KR2001	KR2006	KR2602	KR2606
LM guide unit	Basic dynamic load rating C (N)	Long nut block types A, B	1930		3590		7240	
		Short nut block types C, D	—		—		—	
	Basic static load rating C_0 (N)	Long nut block types A, B	3450		6300		12150	
		Short nut block types C, D	—		—		—	
	Radial clearance (mm)	Normal grade, high accuracy grade	−0.001 to +0.002		−0.003 to +0.002		−0.004 to +0.002	
		Precision grade	−0.005 to −0.002		−0.007 to −0.003		−0.01 to −0.004	
Ball screw unit	Basic dynamic load rating Ca (N)	Normal grade, high accuracy grade	340	230	660	860	2350	1950
		Precision grade	340	230	660	1060	2350	2390
	Basic static load rating C_0a (N)	Normal grade, high accuracy grade	660	410	1170	1450	4020	3510
		Precision grade	660	410	1170	1600	4020	3900
	Screw shaft diameter (mm)		5		6		8	
	Lead (mm)		1	2	1	6	2	6
	Thread minor diameter (mm)		4.5		5.3	5.0	6.6	6.7
	Ball center-to-center diameter (mm)		5.15		6.15	6.3	8.3	8.4
Bearing unit (Fixed side)	Axial direction	Basic dynamic load rating Ca (N)	590		1000		1380	
		Static permissible load P_0a (N)	290		1240		1760	

Note1) The load ratings in the LM Guide unit each indicate the load rating per LM block.

Note2) The Ball Screw of precision grade (grade P) for models KR30H, KR33, KR45H10 and KR4610 is incorporated with spacer balls in the proportion of one to one.

Note3) The Ball Screw of precision grade (grade P) for models KR45H20, KR4620, KR55 and KR65 is incorporated with spacer balls in the proportion of two to one.

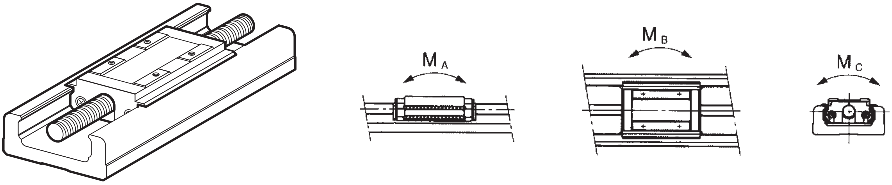
Symbols in the parentheses indicate units.

KR30H		KR33		KR45H		KR46		KR55	KR65
KR30H06	KR30H10	KR3306	KR3310	KR45H10	KR45H20	KR4610	KR4620		
11600		11600		23300		27400		38100	50900
4900		4900		11900		14000		—	—
20200		20200		39200		45500		61900	80900
10000		10000		19600		22700		—	—
−0.004 to +0.002		−0.004 to +0.002		−0.006 to +0.003		−0.006 to +0.003		−0.007 to +0.004	−0.008 to +0.004
−0.012 to −0.004		−0.012 to −0.004		−0.016 to −0.006		−0.016 to −0.006		−0.019 to −0.007	−0.022 to −0.008
2840	1760	2840	1760	3140	3040	3140	3040	3620	5680
2250	1370	2250	1370	2940	3430	2940	3430	3980	5950
4900	2840	4900	2840	6760	7150	6760	7150	9290	14500
2740	1570	2740	1570	3720	5290	3720	5290	6850	10700
10		10		15		15		20	25
6	10	6	10	10	20	10	20	20	25
7.8		7.8		12.5		12.5		17.5	22
10.5		10.5		15.75		15.75		20.75	26
1790		1790		6660		6660		7600	13700
2590		2590		3240		3240		3990	5830

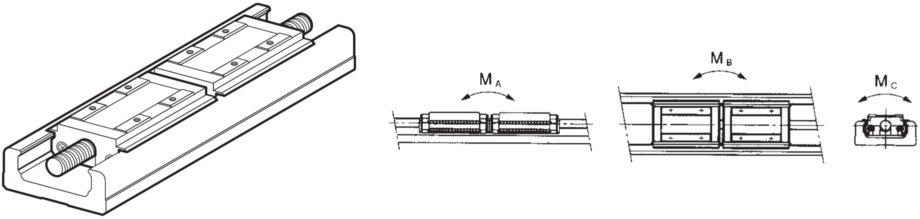
[Static Permissible Moment (LM Guide Unit)]

The LM Guide unit of model KR is capable of receiving moments in four directions only with a single nut block.

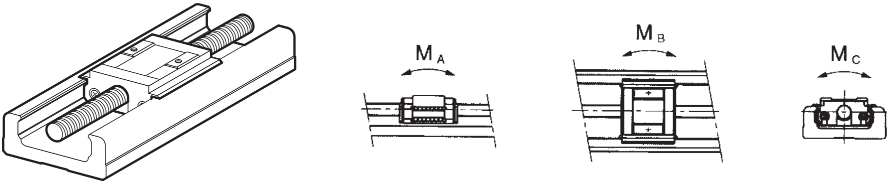
Table4 on A-395 shows static permissible moments in the M_A, M_B and M_C directions.



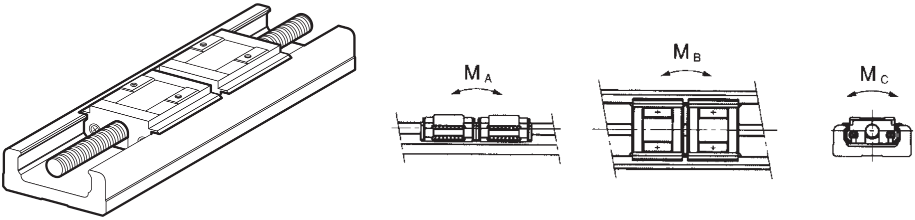
With a single long nut block (type A)



With double long nut blocks (type B)



With a single short nut block (type C)



With double short nut blocks (type D)

Table4 Static Permissible Moments of Model KR

Unit: N-m

Model No.	Static permissible moment		
	M_A	M_B	M_C
KR15-A	12.1	12.1	38
KR15-B	70.3	70.3	76
KR20-A	31	31	83
KR20-B	176	176	165
KR26-A	84	84	208
KR26-B	480	480	416
KR30H-A	166	166	428
KR30H-B	908	908	857
KR30H-C	44	44	214
KR30H-D	319	319	427
KR33-A	166	166	428
KR33-B	908	908	857
KR33-C	44	44	214
KR33-D	319	319	427
KR45H-A	486	486	925
KR45H-B	2732	2732	1850
KR45H-C	130	130	463
KR45H-D	994	994	925
KR46-A	547	547	1400
KR46-B	2940	2940	2800
KR46-C	149	149	700
KR46-D	1010	1010	1400
KR55-A	870	870	2280
KR55-B	4890	4890	4570
KR65-A	1300	1300	3920
KR65-B	7230	7230	7840

Note1) Symbols A, B, C or D in the end of each model number indicates the nut block size and the number of nut blocks used.
A: With a single long nut block
B: With double long nut blocks
C: With a single short nut block
D: With double short nut blocks
Note2) The values for models KR - B/D indicate the values when double nut blocks are used in close contact with each other.

Maximum Travel Speed and the Maximum Length

The maximum travel speed of model KR is limited by the dangerous speed of the ball screw shaft and the DN value regardless of the maximum rotation speed of the motor. These factors must be taken into account especially when model KR operates at high speed.

The maximum lengths are indicated in terms of LM rail length.

Table5 Maximum Travel Speed and the Maximum Length

Model No.	Ball Screw lead (mm)	LM rail length (mm)	Maximum travel speed (mm/s)						Maximum length(mm)	
			Precision grade	High-accuracy grade	Normal grade	Precision grade	High-accuracy grade	Normal grade	Precision grade	High-accuracy grade, normal grade
			Long block			Short block				
KR15	01	—	160	160	—	—	—	—	250	250
	02	—	330	330		—	—	—		
KR20	01	—	190	190		—	—	—	250	250
	06	—	1100	790		—	—	—		
KR26	02	—	280	280		—	—	—	350	350
	06	—	830	590		—	—	—		
KR30H	06	150	660	470		660	470		600	700
		200	660	470		660	470			
		300	660	470		660	470			
		400	660	470		660	470			
		500	590	360		530	470			
		600	395	395		360	360			
	10	150	1100	790		1100	790			
		200	1100	790		1100	790			
		300	1100	790		1100	790			
		400	1100	790		1100	790			
		500	980	790		880	790			
		600	650	650		600	600			
KR33	06	150	660	470		660	470		600	700
		200	660	470		660	470			
		300	660	470		660	470			
		400	660	470		660	470			
		500	590	360		530	470			
		600	395	395		360	360			
	10	150	1100	790		1100	790			
		200	1100	790		1100	790			
		300	1100	790		1100	790			
		400	1100	790		1100	790			
		500	980	790		880	790			
		600	650	650		600	600			
KR45H	10	340	740	520		740	520		800	1200
		440	740	520		740	520			
		540	740	520		740	520			
		640	740	520		740	520			
		740	730	520		640	520			
		840	—	520		—	520			
		940	—	430		—	380			
	20	340	1480	1050		1480	1050			
		440	1480	1050		1480	1050			
		540	1480	1050		1480	1050			
		640	1480	1050		1480	1050			
		740	1430	1050		1280	1050			
		840	—	1050		—	1050			
		940	—	840		—	770			

Model No.	Ball Screw lead (mm)	LM rail length (mm)	Maximum travel speed (mm/s)						Maximum length(mm)	
			Precision grade	High-accuracy grade	Normal grade	Precision grade	High-accuracy grade	Normal grade	Precision grade	High-accuracy grade, normal grade
			Long block			Short block				
KR46	10	340	740	520		740	520		800	1200
		440	740	520		740	520			
		540	740	520		740	520			
		640	740	520		740	520			
		740	730	520		650	520			
		840	—	520		—	520			
		940	—	430		—	390			
	20	340	1480	1050		1480	1050			
		440	1480	1050		1480	1050			
		540	1480	1050		1480	1050			
		640	1480	1050		1480	1050			
		740	1440	1050		1300	1050			
		840	—	1050		—	1050			
		940	—	840		—	780			
KR55	20	980	1120	800		—	—	—	1180	2000
		1080	900	800		—	—	—		
		1180	740	740		—	—	—		
		1280	—	620		—	—	—		
		1380	—	530		—	—	—		
KR65	25	980	1120	800		—	—	—	1380	2000
		1180	1120	800		—	—	—		
		1380	840	800		—	—	—		
		1680	—	550		—	—	—		

* Any rail length greater than the standard rail length is limited by the dangerous speed. If desiring such a rail length, contact THK.

Lubrication

Table6 shows standard greases used in model KR and grease nipple types.

Table6

Model No.	Standard grease	Grease nipple
KR15	THK AFF Grease	—
KR20	THK AFA Grease	PB107
KR26	THK AFA Grease	PB107
KR30H	THK AFB-LF Grease	PB107
KR33	THK AFB-LF Grease	PB107
KR45H	THK AFB-LF Grease	A-M6F
KR46	THK AFB-LF Grease	A-M6F
KR55	THK AFB-LF Grease	A-M6F
KR65	THK AFB-LF Grease	A-M6F

Service Life

Model KR consists of an LM Guide, a Ball Screw and a support bearing. The nominal life of each component can be obtained using the basic dynamic load rating indicated in Table3 on A-392 and A-393 (Rated Load of Model KR).

[LM Guide Unit]

● Nominal Life

$$L = \left(\frac{f_C \cdot C}{f_W \cdot P_C}\right)^3 \times 50$$

L : Nominal life (km)
(The total travel distance that 90% of a group of identical LM Guide units independently operating under the same conditions can achieve without showing flaking)
C : Basic dynamic load rating (N)
P_C : Calculated applied load (N)
f_W : Load factor (see Table8 on A-401)
f_C : Contact factor (see Table7 on A-401)

- If a moment is applied to model KR-A/C or model KR-B/D using two nut blocks in close contact with each other, calculate the equivalent load by multiplying the applied moment by the equivalent factor indicated in Table9 on A-401.

$$P_m = K \cdot M$$

P_m : Equivalent load (per nut block) (N)
K : Equivalent moment factor(see Table9 on A-401)
M : Applied moment (N-mm)
(If planning to use three or more nut blocks, or use nut blocks with a wide span, contact THK.)

- If moment Mc is applied to model KR-B/D

$$P_m = \frac{K_C \cdot M_C}{2}$$

- If a radial load (P) and a moment are simultaneously applied to model KR

$$P_E = P_m + P$$

P_E : Total equivalent radial load (N)
Perform a nominal life calculation using the above data.

● Service Life Time

When the nominal life (L) has been obtained, if the stroke length and the number of reciprocations are constant, the service life time is obtained using the equation below.

$$L_h = \frac{L \times 10^6}{2 \cdot \ell_s \cdot n_1 \times 60}$$

L_h : Service life time (h)
ℓ_s : Stroke length (mm)
n_1 : Number of reciprocations per minute(min^{-1})

[Ball Screw Unit/Bearing Unit(Fixed Side)]

● Nominal Life

$$L = \left(\frac{Ca}{f_W \cdot Fa}\right)^3 \times 10^6$$

L : Nominal life (rev)
(The total number of revolutions that 90% of a group of identical Ball Screw units independently operating under the same conditions can achieve without showing flaking)
Ca : Basic dynamic load rating (N)
Fa : Applied axial load (N)
f_W : Load factor (see Table8 on A-401)

When the nominal life has been obtained from the equation above, if the stroke length and the number of reciprocations per minute are constant, the service life time is obtained using the following equation.

● Service Life Time

$$L_h = \frac{L \cdot \ell}{2 \cdot \ell_s \cdot n_1 \times 60}$$

L_h : Service life time (h)
ℓ_s : Stroke length (mm)
n_1 : Number of reciprocations per minute(min^{-1})
ℓ : Ball Screw lead (mm)

■f_C: Contact Factor

If two nut blocks are used in close contact with each other with model KR-B/D, multiply the basic load rating by the corresponding contact factor indicated in Table7.

Table7 Contact Factor (f_C)

Block type	Contact factor f_C
A, C type	1
B, D type	0.81

■f_W: Load Factor

Table8 shows load factors.

Table8 Load Factor (f_W)

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

■K: Moment Equivalent Factor (LM Guide Unit)

When model KR travels under a moment, the distribution of load applied to the LM Guide is locally large (see A-75). In such cases, calculate the load by multiplying the moment value by the corresponding moment equivalent factor indicated in Table9.

Symbols K_A, K_B and K_C indicate the moment equivalent loads in the M_A, M_B and M_C directions, respectively.

Table9 Equivalent moment factor(K)

Model No.	K_A	K_B	K_C
KR15-A	3.2×10^{-1}	3.2×10^{-1}	9.09×10^{-2}
KR15-B	5.96×10^{-2}	5.96×10^{-2}	9.09×10^{-2}
KR20-A	2.4×10^{-1}	2.4×10^{-1}	7.69×10^{-2}
KR20-B	4.26×10^{-2}	4.26×10^{-2}	7.69×10^{-2}
KR26-A	1.73×10^{-1}	1.73×10^{-1}	5.88×10^{-2}
KR26-B	3.06×10^{-2}	3.06×10^{-2}	5.88×10^{-2}
KR30H-A	1.51×10^{-1}	1.51×10^{-1}	4.78×10^{-2}
KR30H-B	2.76×10^{-2}	2.76×10^{-2}	4.78×10^{-2}
KR30H-C	2.77×10^{-1}	2.77×10^{-1}	4.78×10^{-2}
KR30H-D	3.99×10^{-2}	3.99×10^{-2}	4.78×10^{-2}
KR33-A	1.51×10^{-1}	1.51×10^{-1}	4.93×10^{-2}
KR33-B	2.57×10^{-2}	2.57×10^{-2}	4.93×10^{-2}
KR33-C	2.77×10^{-1}	2.77×10^{-1}	4.93×10^{-2}
KR33-D	3.55×10^{-2}	3.55×10^{-2}	4.93×10^{-2}
KR45H-A	9.83×10^{-2}	9.83×10^{-2}	3.45×10^{-2}
KR45H-B	1.87×10^{-2}	1.87×10^{-2}	3.45×10^{-2}
KR45H-C	1.83×10^{-1}	1.83×10^{-1}	3.45×10^{-2}
KR45H-D	2.81×10^{-2}	2.81×10^{-2}	3.45×10^{-2}
KR46-A	1.01×10^{-1}	1.01×10^{-1}	3.38×10^{-2}
KR46-B	1.78×10^{-2}	1.78×10^{-2}	3.38×10^{-2}
KR46-C	1.85×10^{-1}	1.85×10^{-1}	3.38×10^{-2}
KR46-D	2.5×10^{-2}	2.5×10^{-2}	3.38×10^{-2}
KR55-A	8.63×10^{-2}	8.63×10^{-2}	2.83×10^{-2}
KR55-B	1.53×10^{-2}	1.53×10^{-2}	2.83×10^{-2}
KR65-A	7.55×10^{-2}	7.55×10^{-2}	2.14×10^{-2}
KR65-B	1.35×10^{-2}	1.35×10^{-2}	2.14×10^{-2}

Note) The values for models KR-B/D indicate the values when double nut blocks are used in close contact with each other.

Static Safety Factor

[Calculating the Static Safety Factor]

● LM Guide Unit

To calculate a load applied to the LM Guide of model KR, the average load required for calculating the service life and the maximum load needed for calculating the static safety factor must be obtained first. In particular, if the system starts and stops frequently, or if a large moment caused by an overhung load is applied to the system, it may receive an unexpectedly large load.

When selecting a model number, make sure that the desired model is capable of receiving the required maximum load (whether stationary or in motion).

$$f_s = \frac{C_0}{P_{max}}$$

f_s : Static safety factor

C_0 : Basic static load rating (N)

P_{max} : Maximum applied load (N)

* The basic static load rating is a static load with a constant direction and magnitude whereby the sum of the permanent deformation of the rolling element and that of the raceway on the contact area under the maximum stress is 0.0001 times the rolling element diameter.

● Ball Screw Unit/Bearing Unit(Fixed Side)

If an unexpected external force is applied in the axial direction as a result of an inertia caused by an impact or start and stop while model KR is stationary or operating, it is necessary to take into account the static safety factor.

$$f_s = \frac{C_{0a}}{F_{max}}$$

f_s : Static safety factor

C_{0a} : Basic static load rating (N)

F_{max} : Maximum applied load (N)

[Standard Values for the Static Safety Factor (f_s)]

Machine using the LM system	Load conditions	Lower limit of f_s
General industrial machinery	Without vibration or impact	1 to 1.3
	With vibration or impact	2 to 3

* The standard value of the static safety factor may vary according to the conditions such as environment, lubrication status, mounting section accuracy or rigidity.

Example of Calculating the Nominal Life

[Condition (Horizontal Installation)]

Assumed model number : KR 5520A
LM Guide unit (C=38100N, C_0=61900N)
Ball Screw unit (C_a=3620N, C_{0a}=9290N)
Bearing unit(Fixed Side) (C_a=7600N, P_{0a}=3990N)
Mass : m = 30kg
Speed : v = 500mm/s
Acceleration : α =2.4m/s^2
Stroke : ℓ_s = 1200mm
Gravitational acceleration : g = 9.807m/s^2
Velocity diagram : see Fig.7

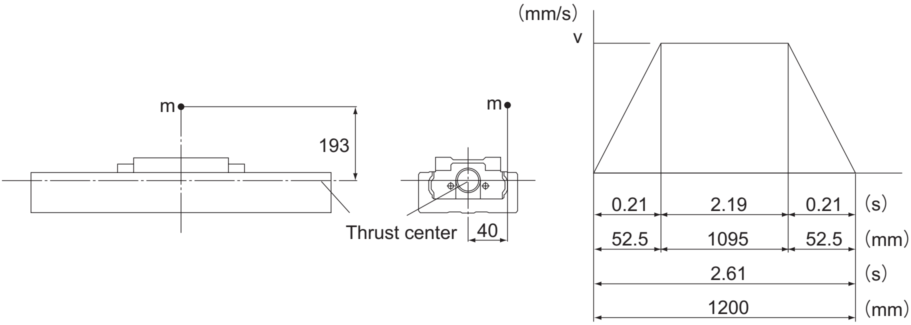


Fig.7

[Consideration]

● Studying the LM Guide Unit

■Load Applied to the Nut Block

* Assuming that a single nut block is used, convert applied moments M_A and M_B into applied load by multiplying them by the moment equivalent factor (K_A=K_B=8.63 × 10^{-2}).

* Assuming that a single shaft is used, convert applied moment M_C into applied load by multiplying it by the moment equivalent factor (K_C=2.83 × 10^{-2}).

- During uniform motion:
  $P_1 = mg + K_C \cdot mg \times 40 = 627$ N
- During acceleration:
  $P_{1a} = P_1 + K_A \cdot m\alpha \times 193 = 1826$ N
  $P_{1aT} = - K_B \cdot m\alpha \times 40 = - 249$ N
- During deceleration:
  $P_{1d} = P_1 - K_A \cdot m\alpha \times 193 = -572$ N
  $P_{1dT} = K_B \cdot m\alpha \times 40 = 249$ N

* Since the groove under a load is different from the assumed groove, give "0" (zero) to P_{1aT} and P_{1d}.

■Combined Radial And Thrust Load

- During uniform motion:
  $P_{1E} = P_1 = 627$ N
- During acceleration:
  $P_{1aE} = P_{1a} + P_{1aT} = 1826$ N
- During deceleration:
  $P_{1dE} = P_{1d} + P_{1dT} = 249$ N

■Static Safety Factor

$$f_s = \frac{C_0}{P_{max}} = \frac{C_0}{P_{1aE}} = 33.9$$

■Nominal Life

- Average load

$$P_m = \sqrt[3]{\frac{1}{\ell_S}(P_{1E}{}^3 \times 1095 + P_{1aE}{}^3 \times 52.5 + P_{1dE}{}^3 \times 52.5)} = 790 \text{ N}$$

- Nominal life

$$L = \left(\frac{C}{f_W \cdot P_m}\right)^3 \times 50 = 3.25 \times 10^6 \text{ km}$$

f_W : Load factor (1.2)

● Studying the Ball Screw Unit

■Axial load

- During forward uniform motion:

$Fa_1 = \mu \cdot mg + f = 11\ N$

μ : Friction coefficient(0.005)

f : Rolling resistance of one KR block + seal resistance(10.0 N)

- During forward acceleration:

$Fa_2 = Fa_1 + m\alpha = 83\ N$

- During forward deceleration:

$Fa_3 = Fa_1 - m\alpha = -61\ N$

- During uniform backward motion

$Fa_4 = -Fa_1 = -11\ N$

- During backward acceleration:

$Fa_5 = Fa_4 - m\alpha = -83\ N$

- During backward deceleration:

$Fa_6 = Fa_4 + m\alpha = 61\ N$

* Since the groove under a load is different from the assumed groove, give "0" (zero) to Fa_3, Fa_4 and Fa_5.

■Static Safety Factor

$$f_s = \frac{C_{0a}}{Fa_{max}} = \frac{C_{0a}}{Fa_2} = 111.9$$

■Buckling Load

$$P_1 = \frac{n \cdot \pi^2 \cdot E \cdot I}{\ell_a^{\,2}} \times 0.5 = 11000\ N$$

P_1 : Buckling load (N)

ℓ_a : Distance between two mounting surfaces (1300 mm)

E : Young's modulus (2.06×10^5 N/mm^2)

n : Factor for mounting method (fixed-fixed: 4.0, see A-694)

0.5 : Safety factor

I : Minimum geometrical moment of inertia of the shaft (mm^4)

$$I = \frac{\pi}{64} \cdot d_1^{\,4}$$

d_1 : Screw-shaft thread minor diameter (17.5 mm)

■Permissible tensile Compressive Load

$$P_2 = \delta \cdot \frac{\pi}{4} \cdot d_1^{\,2} = 35300\ \text{N}$$

P_2 : Permissible tensile compressive load (N)
δ : Permissible tensile compressive stress ($147\ \text{N/mm}^2$)
d_1 : Screw-shaft thread minor diameter (17.5mm)

■Dangerous Speed

$$N_1 = \frac{60 \cdot \lambda^2}{2\pi \cdot \ell_b^{\,2}} \cdot \sqrt{\frac{E \times 10^3 \cdot I}{\gamma \cdot A}} \times 0.8 = 1560\ \text{min}^{-1}$$

N_1 : Dangerous speed (min^{-1})
ℓ_b : Distance between two mounting surfaces (1300mm)
γ : Density ($7.85 \times 10^{-6}\ \text{kg/mm}^3$)
λ : Factor according to the mounting method (fixed-supported 3.927, see A-696)
0.8 : Safety factor

■DN Value

DN=31125(≦50000)
D : Ball center-to-center diameter (20.75mm)
N : Maximum working rotation speed ($1500\ \text{min}^{-1}$)

■Nominal Life

● Average axial load

$$F_{am} = \sqrt[3]{\frac{1}{2 \cdot \ell_s}(F_{a1}^{\,3} \times 1095 + F_{a2}^{\,3} \times 52.5 + F_{a6}^{\,3} \times 52.5)} = 26.2\ \text{N}$$

● Nominal life

$$L = \left(\frac{C_a}{f_w \cdot F_{am}}\right)^3 \cdot \ell = 3.05 \times 10^7\ \text{km}$$

f_w : Load factor (1.2)
ℓ : Ball Screw lead (20mm)

● Bearing Unit (Fixed Side)

■Axial Load (Same as the Ball Screw Unit)

F_{a1} = 11 N
F_{a2} = 83 N
F_{a3} = 0 N
F_{a4} = 0 N
F_{a5} = 0 N
F_{a6} = 61 N

■Static Safety Factor

$$f_s = \frac{P_{0a}}{F_{a\max}} = \frac{P_{0a}}{F_{a2}} = 48.0$$

■Nominal Life

- Average axial load

$$F_{am} = \sqrt[3]{\frac{1}{2 \cdot \ell_s}\left(F_{a1}^3 \times 1095 + F_{a2}^3 \times 52.5 + F_{a6}^3 \times 52.5\right)} = 26.2\ \mathrm{N}$$

- Nominal life

$$L = \left(\frac{C_a}{f_w \cdot F_{am}}\right)^3 \times 10^6 = 1.41 \times 10^{13}\ \mathrm{rev}$$

f_w : Load factor (1.2)

* Convert the above nominal life into the service life in travel distance of the Ball Screw.

$L_s = L \cdot \ell \times 10^{-6} = 2.82 \times 10^8$ km

[Result]

The table below shows the result of the examination.

KR5520A	LM guide unit	Ball screw unit	Bearing unit (Fixed side)
Static safety factor	33.9	111.9	48.0
Buckling load(N)	—	11000	—
Permissible tensile compressive load(N)	—	35300	—
Dangerous speed(min^{-1})	—	1560	—
DN Value	—	31125	—
Nominal life(km)	3.25×10^6	3.05×10^7	2.82×10^8
Maximum axial load(N)	—	76	—
Maximum working rotation speed(min^{-1})	—	1500	—

Note1) From the static safety coefficient and other values above, it is judged that the assumed model can be used.
Note2) Of the rated lives of the three components, the shortest value (of LM Guide unit) is considered the nominal life of the assumed model KR 5520A.

[Condition (Vertical Installation)]

Assumed model number : KR 5520A
  LM Guide Unit (C = 38100 N, C_0 = 61900N)
  Ball Screw Unit (C_a=3620 N, C_{0a}=9290 N)
  Bearing Unit(Fixed Side) (C_a=7600 N, P_{0a}=3990 N)
Mass : m = 30 kg
Speed : v = 500mm/s
Acceleration : α =2.4 m/s^2
Stroke : ℓ_s = 1200 mm
Gravitational acceleration : g = 9.807 m/s^2
Velocity diagram see Fig.8

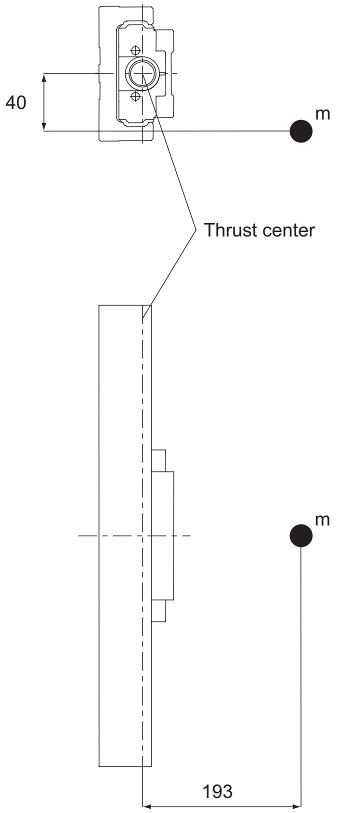


Fig.8

[Consideration]

● Studying the LM Guide Unit

■Load Applied to the Block

* Assuming that a single block is used, convert applied moments M_A and M_B into applied load by multiplying them by the moment equivalent factor ($K_A=K_B=8.63\text{x}10^{-2}$).

- During uniform motion:

$P_1 = K_A \cdot mg \times 193 = 4900$ N

$P_{1T} = K_B \cdot mg \times 40 = 1016$ N

- During acceleration:

$P_{1a} = P_1 + K_A \cdot m\alpha \times 193 = 6100$ N

$P_{1aT} = P_{1T} + K_B \cdot m\alpha \times 40 = 1264$ N

- During deceleration:

$P_{1d} = P_1 - K_A \cdot m\alpha \times 193 = 3701$ N

$P_{1dT} = P_{1d} - K_B \cdot m\alpha \times 40 = 767$ N

■Combined Radial And Thrust Load

- During uniform motion:

$P_{1E} = P_1 + P_{1T} = 5916$ N

- During acceleration:

$P_{1aE} = P_{1a} + P_{1aT} = 7364$ N

- During deceleration:

$P_{1dE} = P_{1d} + P_{1dT} = 4468$ N

■Static Safety Factor

$$f_s = \frac{C_0}{P_{max}} = \frac{C_0}{P_{1aE}} = 8.4$$

■Nominal Life

- Average load

$$P_m = \sqrt[3]{\frac{1}{\ell_S}(P_{1E}{}^3 \times 1095 + P_{1aE}{}^3 \times 52.5 + P_{1dE}{}^3 \times 52.5)} = 5947 \text{ N}$$

- Nominal life

$$L = \left(\frac{C}{f_W \cdot P_m}\right)^3 \times 50 = 7.61 \times 10^3 \text{ km}$$

f_W : Load factor (1.2)

● Studying the Ball Screw Unit

■Axial Load

- During upward uniform motion:

$Fa_1 = mg + \mu \cdot mg + f = 306\ N$

μ : Friction coefficient (0.005)   f : Sliding resistance per block (10.0 N)

- During upward acceleration:

$Fa_2 = Fa_1 + m\alpha = 378\ N$

- During upward deceleration:

$Fa_3 = Fa_1 - m\alpha = 234\ N$

- During downward uniform motion:

$Fa_4 = mg - \mu \cdot mg - f = 283\ N$

- During downward acceleration:

$Fa_5 = Fa_4 - m\alpha = 211\ N$

- During downward deceleration:

$Fa_6 = Fa_4 + m\alpha = 355\ N$

■Static Safety Factor

$$f_s = \frac{C_0a}{F_{max}} = \frac{C_0a}{Fa_2} = 24.5$$

■Buckling Load

Same as Horizontal Installation

■Permissible Tensile Compressive Load

Same as Horizontal Installation

■Dangerous Speed

Same as Horizontal Installation

■DN Value

Same as Horizontal Installation

■Nominal Life

- Average axial load

$$F_m = \sqrt[3]{\frac{1}{2 \cdot \ell_s}(Fa_1{}^3 \times 1095 + Fa_2{}^3 \times 525 + Fa_3{}^3 \times 525 + Fa_4{}^3 \times 1095 + Fa_5{}^3 \times 525 + Fa_6{}^3 \times 525)} = 296\ N$$

- Nominal life

$$L = \left(\frac{Ca}{f_w \cdot F_m}\right)^3 \times \ell = 2.12 \times 10^4\ km$$

f_w : Load factor (1.2) ℓ : Lead (20mm)

● Bearing Unit (Fixed Side)

■Axial Load (Same as the Ball Screw Unit)

$Fa_1 = 306$ N
$Fa_2 = 378$ N
$Fa_3 = 234$ N
$Fa_4 = 283$ N
$Fa_5 = 211$ N
$Fa_6 = 355$ N

■Static Safety Factor

$$f_s = \frac{P_{0a}}{F_{max}} = \frac{P_{0a}}{Fa_2} = 10.5$$

■Nominal Life

● Average axial load

$$F_m = \sqrt[3]{\frac{1}{2\cdot\ell_s}\left(Fa_1^{\,3}\times1095 + Fa_2^{\,3}\times525 + Fa_3^{\,3}\times525 + Fa_4^{\,3}\times1095 + Fa_5^{\,3}\times525 + Fa_6^{\,3}\times525\right)} = 296\text{ N}$$

● Nominal life

$$L = \left(\frac{Ca}{f_w\cdot F_m}\right)^3\times10^6 = 9.80\times10^9\text{ rev}$$

f_W : Load factor (1.2)

* Convert the above nominal life into the service life in travel distance of the Ball Screw.

$L_S = L\cdot\ell\times10^{-6} = 1.96\times10^5$ km

[Result]

The table below shows the result of the examination.

KR5520A	LM guide unit	Ball screw unit	Bearing unit (Fixed side)
Static safety factor	8.4	24.5	10.5
Buckling load(N)	—	11000	—
Permissible tensile compressive load(N)	—	35300	—
Dangerous speed(min^{-1})	—	1560	—
DN Value	—	31125	—
Nominal life(km)	7.61×10^3	2.12×10^4	1.96×10^5
Maximum axial load(N)	—	76	—
Maximum working rotation speed(min^{-1})	—	1500	—

Note1) From the static safety coefficient and other values above, it is judged that the assumed model can be used.
Note2) Of the rated lives of the three components, the shortest value (of LM Guide unit) is considered the nominal life of the assumed model KR 5520A.

Accuracy Standards

The accuracy of model KR is defined in positioning repeatability, positioning accuracy, backlash and running parallelism.

[Positioning Repeatability]

After repeating positioning to a given point in the same direction seven times, measure the halting point and obtain the value of half the maximum difference. Perform this measurement in the center and both ends of the travel distance, use the maximum value as the measurement value and express the value of half the maximum difference with symbol "±" as positioning repeatability.

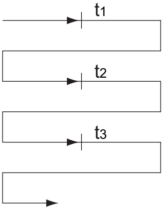


Fig.9 Positioning Repeatability

[Positioning Accuracy]

Using the maximum stroke as the reference length, express the maximum error between the actual distance traveled from the reference point and the command value in an absolute value as positioning accuracy.

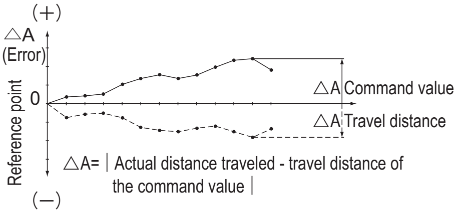


Fig.10 Positioning Accuracy

[Running of Parallelism]

Place a straightedge on the surface table where model KR is mounted, measure almost throughout the travel distance of the nut block using a test indicator. Use the maximum difference among the readings within the travel distance as the running parallelism measurement.

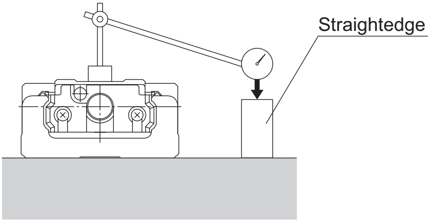


Fig.11 Running of Parallelism

[Backlash]

Feed and slightly move the nut block and read the measurement on the test indicator as the reference value. Subsequently, apply a load to the nut block from the same direction (table feed direction), and then release the nut block from the load. Use the difference between the reference value and the return as the backlash measurement.

Perform this measurement in the center and near both ends, and use the maximum value as the measurement value.

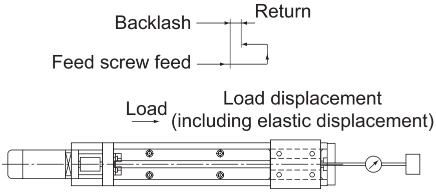


Fig.12 Backlash

The accuracies of model KR are classified into normal grade (no symbol), high accuracy grade (H) and precision grade (P). Tables below show standards for all the accuracies.

Table10 Normal Grade (No Symbol)

Unit: mm

Model No.	Rail length	Positioning Repeatability	Positioning Accuracy	Running of parallelism	Backlash	Starting torque (N・cm)
KR20	100	±0.01	No standard defined	No standard defined	0.02	0.5
	150					
	200					
KR26	150	±0.01	No standard defined	No standard defined	0.02	1.5
	200					
	250					
	300					
KR30H	150	±0.01	No standard defined	No standard defined	0.02	7
	200					
	300					
	400					
	500					
	600					
KR33	150	±0.01	No standard defined	No standard defined	0.02	7
	200					
	300					
	400					
	500					
	600					
KR45H	340	±0.01	No standard defined	No standard defined	0.02	10
	440					
	540					
	640					
	740					
	840					
	940					
KR46	340	±0.01	No standard defined	No standard defined	0.02	10
	440					
	540					
	640					
	740					
	940					
KR55	980	±0.01	No standard defined	No standard defined	0.05	12
	1080					
	1180					
	1280					
	1380					
KR65	980	±0.01	No standard defined	No standard defined	0.05	12
	1180					
	1380					
	1680	±0.012				15

Note1) The evaluation method complies with THK standards.
Note2) Measurement is performed using an inspection-use motor. For motor wrap types, measurement with motor wrap completion is not performed.
Note3) The starting torque represents the value when THK AFB-LF Grease is used.
However, that of models KR20 and KR26 represents the value when THK AFA Grease is used, and that of KR15 represents the value when THK AFF Grease is used.
Note4) If highly viscous grease such as vacuum grease and clean room grease is used, the actual starting torque may exceed the corresponding value in the table. Use much care in selecting a motor.
Note5) For accuracy with a rail length longer than the standard rail length, contact THK.

Table11 High Accuracy Grade (H)

Unit: mm

Model No.	Rail length	Positioning Repeatability	Positioning Accuracy	Running of parallelism	Backlash	Starting torque (N•cm)
KR15	75	±0.004	0.04	0.02	0.01	0.4
	100					
	125					
	150					
	175					
	200					
KR20	100	±0.005	0.06	0.025	0.01	0.5
	150					
	200					
KR26	150	±0.005	0.06	0.025	0.01	1.5
	200					
	250					
	300					
KR30H	150	±0.005	0.06	0.025	0.02	7
	200					
	300					
	400					
	500		0.1	0.035		
	600					
KR33	150	±0.005	0.06	0.025	0.02	7
	200					
	300					
	400					
	500		0.1	0.035		
	600					
KR45H	340	±0.005	0.1	0.035	0.02	10
	440					
	540					
	640					
	740		0.12	0.04		
	840		0.15	0.05		
	940					
KR46	340	±0.005	0.1	0.035	0.02	10
	440					
	540					
	640					
	740		0.12	0.04		
	940		0.15	0.05		
KR55	980	±0.005	0.18	0.05	0.05	12
	1080					
	1180		0.25			
	1280					
	1380					
KR65	980	±0.008	0.18	0.05	0.05	12
	1180		0.2			
	1380					
	1680		0.28	0.055		15

Table12 Precision Grade (P)

Unit: mm

Model No.	Rail length	Positioning Repeatability	Positioning Accuracy	Running of parallelism	Backlash	Starting torque (N･cm)
KR15	75	±0.003	0.02	0.01	0.002	0.8
	100					
	125					
	150					
	175					
	200					
KR20	100	±0.003	0.02	0.01	0.003	1.2
	150					
	200					
KR26	150	±0.003	0.02	0.01	0.003	4
	200					
	250					
	300					
KR30H	150	±0.003	0.02	0.01	0.003	15
	200					
	300					
	400					
	500		0.025	0.015		
	600					
KR33	150	±0.003	0.02	0.01	0.003	15
	200					
	300					
	400					
	500		0.025	0.015		
	600					
KR45H	340	±0.003	0.025	0.015	0.003	15
	440					
	540					
	640					17
	740		0.03	0.02		
KR46	340	±0.003	0.025	0.015	0.003	15
	440					
	540					
	640					17
	740		0.03	0.02		
KR55	980	±0.005	0.035	0.025	0.003	17
	1080					
	1180		0.04	0.03		20
KR65	980	±0.005	0.035	0.025	0.005	20
	1180					
	1380		0.04	0.03		22

Note1) The evaluation method complies with THK standards.
Note2) Measurement is performed using an inspection-use motor. For motor wrap types, measurement with motor wrap completion is not performed.
Note3) The starting torque represents the value when THK AFB-LF Grease is used.
However, that of models KR20 and KR26 represents the value when THK AFA Grease is used, and that of KR15 represents the value when THK AFF Grease is used.
Note4) If highly viscous grease such as vacuum grease and clean room grease is used, the actual starting torque may exceed the corresponding value in the table. Use much care in selecting a motor.
Note5) For accuracy with a rail length longer than the standard rail length, contact THK.

Caged Ball LM Guide Actuator

Model SKR

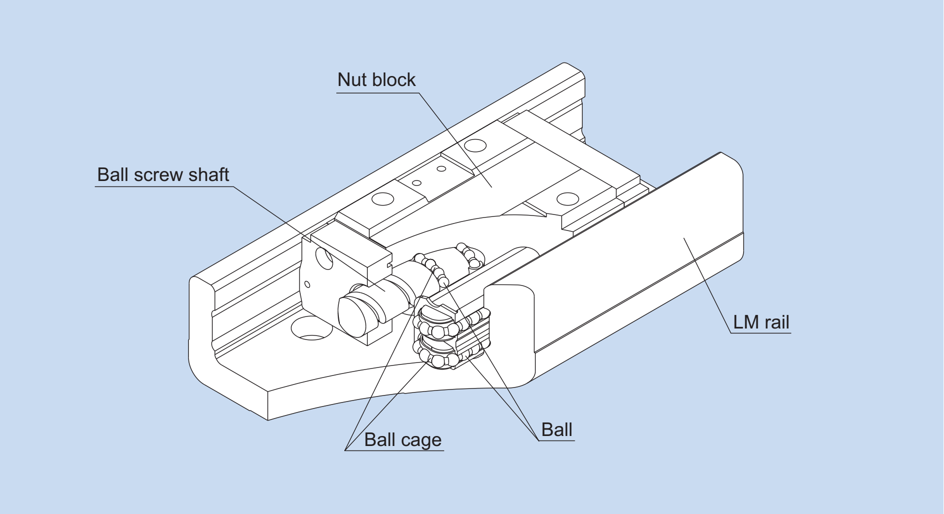


Fig.1 Structure of Caged Ball LM Guide Model SKR

Structure and Features

Caged Ball LM Guide Actuator model SKR is a compact actuator that has a nut block consisting of LM blocks and a ball screw nut integrated inside a U-shaped LM rail.
In addition, this model achieves high speed operation, lower noise and longer-term maintenance-free operation by using ball cages in the LM Guide units and the Ball Screw unit.

[4-way Equal Load]

Each train of balls is arranged at a contact angle of 45° so that the rated load on the nut block is uniform in the four directions (radial, reverse radial and lateral directions). As a result, model SKR can be used in any mounting orientation.

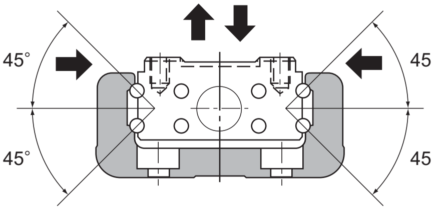


Fig.2 Load Capacity and Contact Angle of Model SKR

[High Rigidity]

Use of an LM rail with a U-shaped cross section increases the rigidity against a moment and torsion.

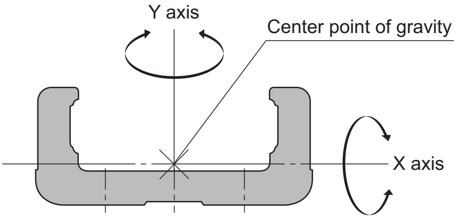


Fig.3 Cross Section of the LM Rail

[High Accuracy]

Since the linear guide section consists of 4 rows of circular-arc grooves that enable balls to smoothly move even under a preload, a highly rigid guide with no clearance is achieved. Additionally, variation in frictional resistance caused by load fluctuation is minimized, allowing the system to follow highly accurate feed.

Table1 Cross-sectional Characteristics of the LM Rail

Unit: mm⁴

Model No.	I_X	I_Y	Mass (kg/100mm)
SKR33	5.35×10^4	3.52×10^5	0.61
SKR46	2.05×10^5	1.45×10^6	1.26

I_X=geometrical moment of inertia around X axis
I_Y=geometrical moment of inertia around Y axis

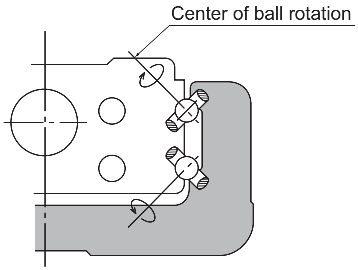


Fig.4 Contact Structure of SKR

[Space Saving]

Due to an integral structure where LM Guide units are placed on both side faces of the nut block and a Ball Screw unit is placed in the center of the nut block, a highly rigid and highly accurate actuator with a minimal space is achieved.

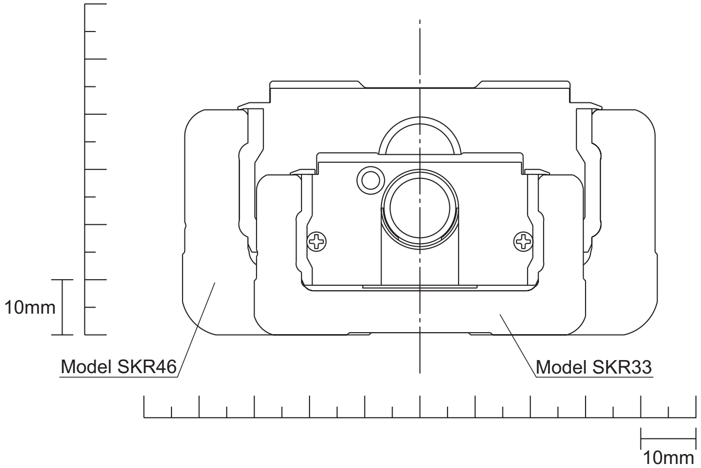


Fig.5 Cross Sectional Drawing

[High Speed]

Model SKR supports a latest high-rotation servomotor (6,000 min^{-1}) using a ball cage and is capable of operating at higher speed than the conventional model KR.

In addition, a new type with a 20 -mm lead is added to lineups of the new model SKR33 in order to achieve fast feed (formerly, only 6 mm and 10 mm ball screw leads were available for the conventional model KR33).

Table2 Maximum Travel Speed

Model No.	Ball Screw lead (mm)	LM rail length (mm)	Maximum travel speed (mm/s)		Maximum length(mm)
			Long block	Short block	
SKR33	6	150	600		700
		200	600		
		300	600		
		400	600		
		500	600		
		600	552	503	
		700	393	364	
	10	150	1000		
		200	1000		
		300	1000		
		400	1000		
		500	1000		
		600	920	839	
		700	656	607	
	20	150	2000	—	
		200	2000	—	
		300	2000	—	
		400	2000	—	
		500	2000	—	
		600	1780	—	
		700	1276	—	
SKR46	10	340	1000		940
		440	1000		
		540	1000		
		640	1026	914	
		740	736	667	
		940	431	400	
	20	340	2000		
		440	2000		
		540	2000		
		640	1988	1774	
		740	1433	1300	
		940	845	784	

The maximum travel speed of model SKR is limited by the dangerous speed of the ball screw shaft despite the maximum rotation speed of the motor (6,000 min^{-1}). Take much care when using the product at high speed.

When considering the use of this model at speed higher than the maximum speed indicated above, contact THK.

Caged Ball/Roller Technology

[High Lubricity]

Model SKR uses ball cages to eliminate friction between balls and significantly improve torque characteristics. As a result, the torque fluctuation is reduced and superb lubricity is achieved.

Item	Description
Shaft diameter/lead	ϕ13/10mm
Shaft rotation speed	60min^{-1}

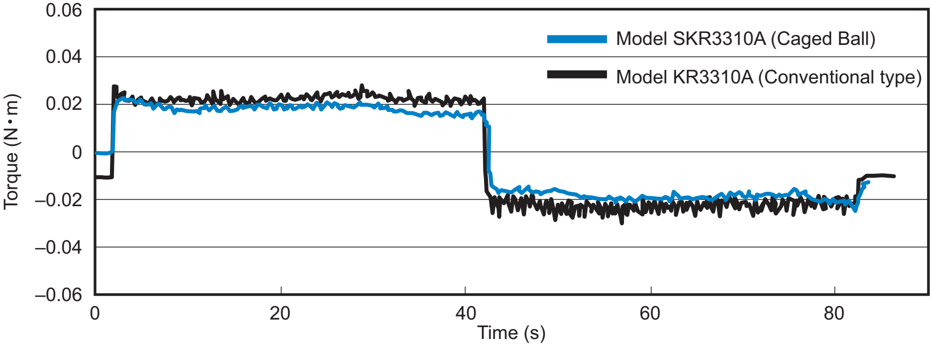


Fig.6 Comparison of Torque Fluctuation between Model SKR and Model KR

[Low Noise, Acceptable Running Sound]

Model SKR uses ball cages in the LM Guide unit and the Ball Screw unit. As a result, low noise and acceptable running sound are achieved.

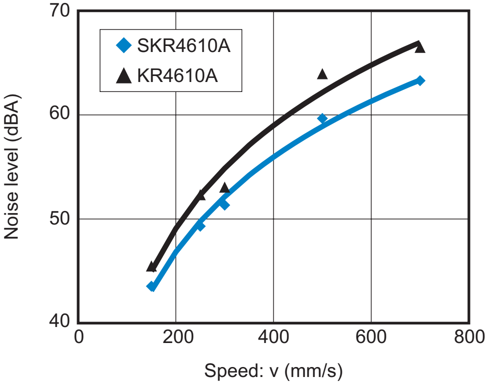


Fig.7 Comparison of Noise between Model SKR4610A and Model KR4610A

[Long-term Maintenance-free Operation]

With model SKR, the ball cage effect helps increase grease retention and achieve long-term maintenance-free operation.

[Long Service Life – 3 Times Longer (with Model *KR3310. Calculated from the Following Equation)]

With model SKR, both the LM Guide unit and the Ball Screw unit have larger basic dynamic load ratings, and therefore a longer service life is achieved.

The rated service life is calculated from the following equation.

LM guide unit

$L=(C/P)^3 \times 50$

L : Nominal life (km)
C : Basic dynamic load rating (N)
P : Applied load (N)

Ball screw unit

$L=(Ca/Fa)^3 \times 10^6$

L : Nominal life (rev)
Ca : Basic dynamic load rating (N)
Fa : Applied axial load (N)

As indicated in the equation above, the greater the basic dynamic load rating, the longer the service life of both the LM Guide unit and the Ball Screw unit.

Table3 Comparison of Basic Dynamic Load Rating between Model SKR and Model KR Unit: N

Basic dynamic load rating		SKR3310	KR3310	SKR4620	KR4620
LM guide unit	Long type block	17000	11600	39500	27400
	Short type block	11300	4900	28400	14000
Ball screw unit		2700	1760	4240	3040

[Seal]

Model SKR is equipped with end seals and side seals for contamination protection as standard.

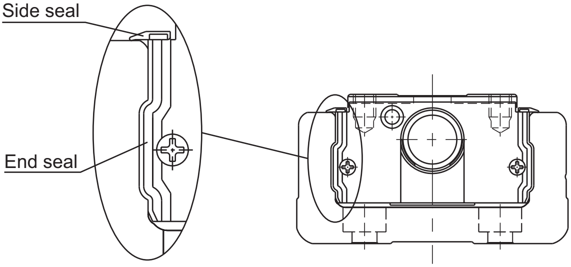


Table4 shows the rolling resistance and seal resistance per nut block (guide section).

Table4 Maximum Resistance Value Unit: N

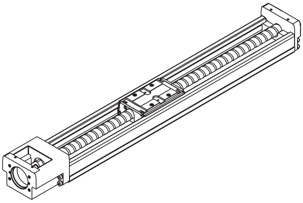
Model No.	Rolling resistance value	Seal resistance value	Total
SKR33	3.0	1.4	4.4
SKR46	2.5	1.8	4.3

Note) The rolling resistance represents the value when a lubricant is not used.

Types and Features

Model SKR-A

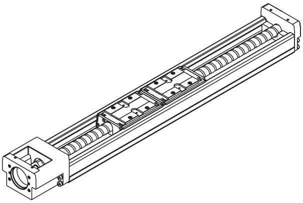
Representative model of SKR.



Model SKR-A

Model SKR-B

Equipped with two units of the nut block of model SKR-A, this model achieves higher rigidity, higher load capacity and higher accuracy.

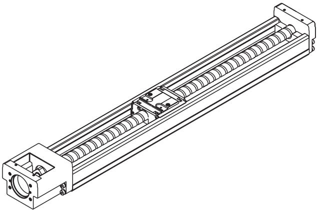


Model SKR-B

Model SKR-C

This model has a shorter overall length of the block and a longer stroke than model SKR-A.

* With model SKR3320, a short-block type is not available.

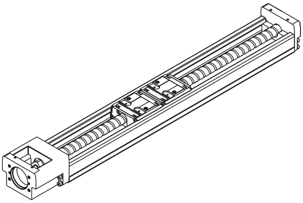


Model SKR-C

Model SKR-D

Equipped with two units of the nut block of model SKR-C, this design allows a span between blocks that suits the equipment, thus to achieve high rigidity.

* With model SKR3320, a short-block type is not available.

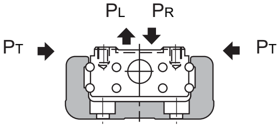


Model SKR-D

Load Ratings in All Directions and Permissible Moment

[Load Rating]

Caged Ball LM Guide Actuator Model SKR consists of an LM Guide, a Ball Screw and a support bearing.



● LM Guide Unit

Model SKR is capable of receiving loads in four directions: radial, reverse radial and lateral directions. Its basic load ratings are equal in all four directions (radial, reverse radial and lateral directions), and their values are indicated in Table5.

● Ball Screw Unit

Since the nut block is incorporated with a ball screw nut, model SKR is capable of receiving an axial load. The basic load rating value is indicated in Table5.

● Bearing Unit (Fixed Side)

Since housing A contains an angular bearing, model SKR is capable of receiving an axial load. The basic load rating value is indicated in Table5.

[Equivalent Load (LM Guide Unit)]

The equivalent load when the LM Guide unit of model SKR simultaneously receives loads in all directions is obtained from the following equation.

$$P_E = P_R\ (P_L) + P_T$$

P_E : Equivalent load (N)
: Radial direction
: Reverse radial direction
: Lateral directions
P_R : Radial load (N)
P_L : Reverse radial load (N)
P_T : Lateral load (N)

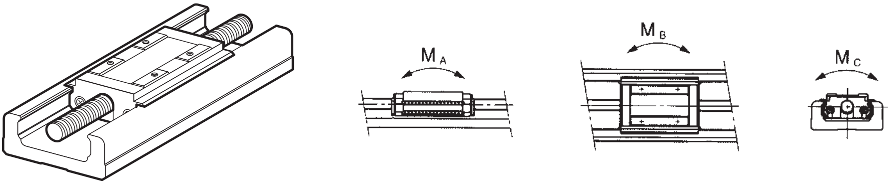
Table5 Load Rating of Model SKR Symbols in the parentheses indicate units.

Model No.			SKR33			SKR46	
			SKR3306	SKR3310	SKR3320	SKR4610	SKR4620
LM guide unit	Basic dynamic load rating C (N)	Long nut block types A, B	17000			39500	
		Short nut block types C, D	11300			28400	
	Basic static load rating C_0 (N)	Long nut block types A, B	20400			45900	
		Short nut block types C, D	11500			28700	
	Radial clearance (mm)	Normal grade, high accuracy grade	0 to −0.004			0 to −0.006	
		Precision grade	−0.004 to −0.012			−0.006 to −0.016	
Ball screw unit	Basic dynamic load rating Ca (N)		4400	2700	2620	4350	4240
	Basic static load rating C_0a (N)		6290	3780	3770	6990	7040
	Screw shaft out diameter (mm)		13			15	
	Lead (mm)		6	10	20	10	20
	Thread minor diameter (mm)		10.8			12.5	
	Ball center-to-center diameter (mm)		13.5			15.75	
Bearing unit (Fixed side)	Axial direction	Basic dynamic load rating Ca (N)	6250			6700	
		Static permissible load P_0a (N)	2700			3330	

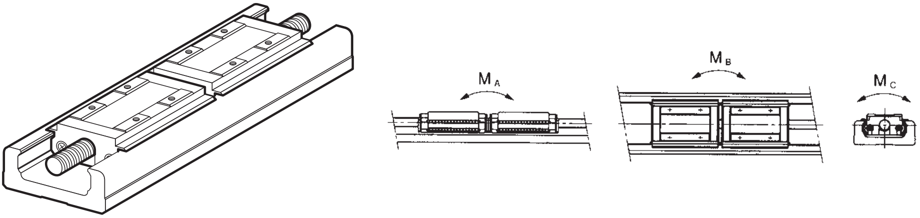
Note1) The load ratings in the LM Guide unit each indicate the load rating per LM block.
Note2) With model SKR3320, a short-block type is not available.

[Permissible Moment (LM Guide Unit)]

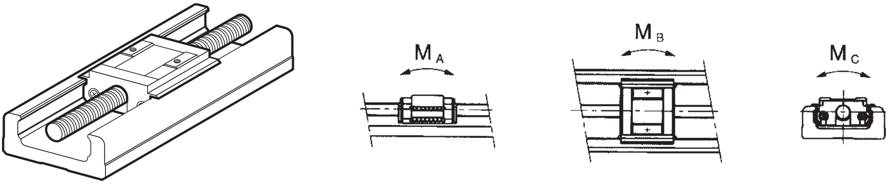
The LM Guide unit of model SKR is capable of receiving moments in four directions only with a single nut block. Table6 on A-425 shows static permissible moments in the M_A, M_B and M_C directions.



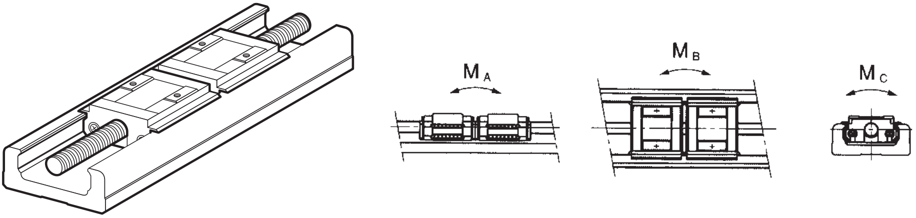
With a single long nut block (type A)



With double long nut blocks (type B)



With a single short nut block (type C)



With double short nut blocks (type D)

Table6 Static Permissible Moments of Model SKR

Unit: N-m

Model No.	Static permissible moment		
	M_A	M_B	M_C
SKR33-A	173	173	424
SKR33-B	990	990	848
SKR33-C	58	58	240
SKR33-D	390	390	480
SKR46-A	579	579	1390
SKR46-B	3240	3240	2780
SKR46-C	236	236	870
SKR46-D	1460	1460	1740

Note1) Symbols A, B, C or D in the end of each model number indicates the nut block size and the number of nut blocks used.
A: With a single long nut block
B: With double long nut blocks
C: With a single short nut block
D: With double short nut blocks
Note2) The values for models SKR-B/D indicate the values when double nut blocks are used in close contact with each other.

Lubrication

Standard greases used in model SKR are indicated below. For model SKR, a grease nipple can be attached per your request.

Table7

Model No.	Standard grease	THK grease nipples that can be attached
SKR33	THK AFB-LF Grease	PB107
SKR46	THK AFB-LF Grease	A-M6F

Service Life

Caged Ball LM Guide Actuator Model SKR consists of an LM Guide, a Ball Screw and a support bearing. The service life of each component can be obtained using the basic dynamic load rating indicated in Table5 on A-423 (Rated Load of Model KR).

[LM Guide Unit]

● Nominal Life

The nominal life (L) means the total travel distance that 90% of a group of units of the same LM Guide model can achieve without flaking (scale-like pieces on the metal surface) after individually running under the same conditions.

The nominal life of the LM Guide is obtained using the following equation.

$$L = \left(\frac{f_C \cdot C}{f_W \cdot P_C}\right)^3 \times 50$$

L : Nominal life (km)
C : Basic dynamic load rating (N)
P_C : Calculated applied load (N)
f_W : Load factor (see Table8 on A-427)
f_C : Contact factor (see Table9 on A-427)

- If a moment is applied to model SKR-A/C or model SKR-B/D using two nut blocks in close contact with each other, calculate the equivalent load by multiplying the applied moment by the equivalent factor indicated in Table10 on A-427.

$$P_m = K \cdot M$$

P_m : Equivalent load (per nut block) (N)
K : Equivalent moment factor
M : Applied moment (N-mm)

(If planning to use three or more nut blocks, or use nut blocks with a wide span, contact THK.)

If moment Mc is applied to model SKR-B/D

$$P_m = \frac{K_C \cdot M_C}{2}$$

- If a radial load (P) and a moment are simultaneously applied to model SKR

$$P_E = P_m + P$$

P_E : Overall equivalent radial load (N)

Perform a nominal life calculation using the above data.

● Service Life Time

When the nominal life (L) has been obtained, if the stroke length and the number of reciprocations are constant, the service life time is obtained using the equation below.

$$L_h = \frac{L \times 10^6}{2 \cdot \ell_s \cdot n_1 \times 60}$$

L_h : Service life time (h)
ℓ_s : Stroke length (mm)
n_1 : Number of reciprocations per minute (min^{-1})

[Ball Screw Unit/Bearing Unit(Fixed Side)]

● Nominal Life

The nominal life (L) means the total travel distance that 90% of a group of units of the same Ball Screw (bearing) can achieve without flaking after individually running under the same conditions.

The nominal life of the Ball Screw unit/bearing unit (fixed side) is obtained using the following equation.

$$L = \left(\frac{C_a}{f_W \cdot F_a} \right)^3 \times 10^6$$

L : Nominal life (rev)
C_a : Basic dynamic load rating (N)
F_a : Axial load (N)
f_W : Load factor (see Table8)

Table8 Load Factor (f_W)

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

● Service Life Time

When the nominal life (L) has been obtained, if the stroke length and the number of reciprocations are constant, the service life time is obtained using the equation below.

$$L_h = \frac{L \cdot \ell}{2 \cdot \ell_s \cdot n_1 \times 60}$$

L_h : Service life time (h)
ℓ_s : Stroke length (mm)
n_1 : Number of reciprocations per minute (min^{-1})
ℓ : Ball Screw lead (mm)

■f_C: Contact Factor

If two nut blocks are used in close contact with each other with model SKR-B/D, multiply the basic load rating by the corresponding contact factor indicated in Table9.

Table9 Contact Factor (f_C)

Block type	Contact factor f_C
A, C type	1.0
B, D type	0.81

■f_W: Load Factor

Table8 shows load factors.

■K: Moment Equivalent Factor (LM Guide Unit)

When model SKR travels under a moment, the distribution of load applied to the LM Guide is locally large. In such cases, calculate the load by multiplying the moment value by the corresponding moment equivalent factor indicated in Table10.

Symbols K_A, K_B and K_C indicate the moment equivalent loads in the M_A, M_B and M_C directions, respectively.

Table10 Equivalent moment factor(K)

Model No.	K_A	K_B	K_C
SKR33-A	1.42×10^{-1}	1.42×10^{-1}	5.05×10^{-2}
SKR33-B	2.47×10^{-2}	2.47×10^{-2}	5.05×10^{-2}
SKR33-C	2.39×10^{-1}	2.39×10^{-1}	5.05×10^{-2}
SKR33-D	3.54×10^{-2}	3.54×10^{-2}	5.05×10^{-2}
SKR46-A	9.51×10^{-2}	9.51×10^{-2}	3.46×10^{-2}
SKR46-B	1.70×10^{-2}	1.70×10^{-2}	3.46×10^{-2}
SKR46-C	1.46×10^{-1}	1.46×10^{-1}	3.46×10^{-2}
SKR46-D	2.36×10^{-2}	2.36×10^{-2}	3.46×10^{-2}

K_A: Moment equivalent factor in the M_A direction.
K_B: Moment equivalent factor in the M_B direction.
K_C: Moment equivalent factor in the M_C direction.
Note) The values for models SKR-B/D indicate the values when double nut blocks are used in close contact with each other.

Accuracy Standards

The accuracy of model SKR is defined in positioning repeatability, positioning accuracy, backlash and running parallelism.

[Positioning Repeatability]

After repeating positioning to a given point in the same direction seven times, measure the halting point and obtain the value of half the maximum difference. Perform this measurement in the center and both ends of the travel distance, use the maximum value as the measurement value and express the value of half the maximum difference with symbol "±" as positioning repeatability.

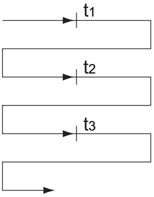


Fig.8 Positioning Repeatability

[Positioning Accuracy]

Using the maximum stroke as the reference length, express the maximum error between the actual distance traveled from the reference point and the command value in an absolute value as positioning accuracy.

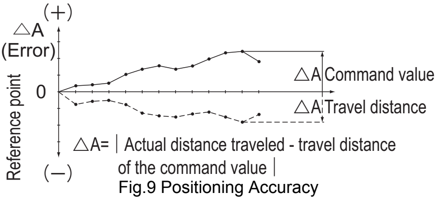


Fig.9 Positioning Accuracy

[Running of Parallelism]

Place a straightedge on the surface table where model SKR is mounted, measure almost throughout the travel distance of the nut block using a test indicator. Use the maximum difference among the readings within the travel distance as the running parallelism measurement.

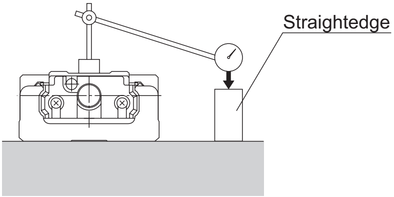


Fig.10 Running of Parallelism

[Backlash]

Feed and slightly move the nut block and read the measurement on the test indicator as the reference value. Subsequently, apply a load to the nut block from the same direction (table feed direction), and then release the nut block from the load. Use the difference between the reference value and the return as the backlash measurement.

Perform this measurement in the center and near both ends, and use the maximum value as the measurement value.

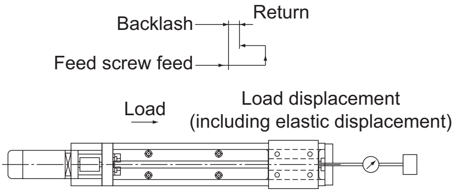


Fig.11 Backlash

The accuracies of model SKR are classified into normal grade (no symbol), high accuracy grade (H) and precision grade (P). Tables below show standards for all the accuracies.

Table11 Normal Grade (No Symbol)

Unit: mm

Model No.	Rail length	Positioning Repeatability	Positioning Accuracy	Running of parallelism	Backlash	Starting torque (N•cm)
SKR33	150	±0.010	No standard defined	No standard defined	0.020	7
	200					
	300					
	400					
	500					
	600					
	700					
SKR46	340	±0.010	No standard defined	No standard defined	0.020	10
	440					
	540					
	640					
	740					
	940					

Table12 High Accuracy Grade (H)

Unit: mm

Model No.	Rail length	Positioning Repeatability	Positioning Accuracy	Running of parallelism	Backlash	Starting torque (N•cm)
SKR33	150	±0.005	0.060	0.025	0.020	7
	200					
	300					
	400					
	500		0.100	0.035		
	600					
	700		0.120	0.040		
SKR46	340	±0.005	0.100	0.035	0.020	10
	440					
	540					
	640					
	740		0.120	0.040		
	940		0.150	0.050		

Table13 Precision Grade (P)

Unit: mm

Model No.	Rail length	Positioning Repeatability	Positioning Accuracy	Running of parallelism	Backlash	Starting torque (N•cm)
SKR33	150	±0.003	0.020	0.010	0.003	15
	200					
	300					
	400					
	500		0.025	0.015		
	600					
	700		0.030	0.020		
SKR46	340	±0.003	0.025	0.015	0.003	15
	440					
	540					
	640					17
	740		0.030	0.020		

Note1) The evaluation method complies with THK standards.
Note2) The starting torque represents the value when THK AFB-LF Grease is used.
Note3) If highly viscous grease such as vacuum grease and clean room grease is used, the actual starting torque may exceed the corresponding value in the table. Use much care in selecting a motor.
Note4) For accuracy with a rail length longer than the standard rail length, contact THK.

Options

Various types of options are available for models KR and SKR. Select an appropriate model according to your application.

Name		Reference page	Overview
Cover	Cover	A-431	Serve as contamination protection accessories or the likes
	Bellows	B-302	
Sensor	Proximity sensor	B-309	Supporting manufacturer: Yamatake, SUNX
	Photo sensor	B-310	Supporting manufacturer: Omron
	Sensor rail	B-311	For mounting a sensor
Motor bracket	Housing	A-434	For standard type model KR without a motor If the customer manufactures a motor braket For motor wrap type
	Table of Motors Used in Model KR and Corresponding Motor Brackets	B-312	Supporting manufacturer: Yaskawa Electric, Mitsubishi Electric, Matsushita Electric,.Sanyo Electric, Omron, Fanuc and Oriental Motor
	Motor bracket dimensional table for model KR	B-314	—
	Table of Motors Used in Model SKR and Corresponding Motor Brackets	B-336	Supporting manufacturer: Yaskawa Electric, Mitsubishi Electric, Matsushita Electric,.Sanyo Electric, Omron, Fanuc and Oriental Motor
	Motor bracket dimensional table for model SKR	B-337	—

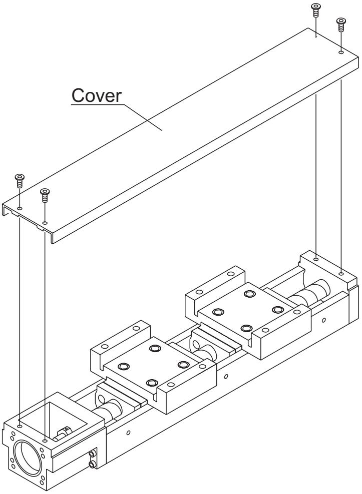
Table1 Table of Applicable Options

Model No.	Cover	Bellows	Proximity sensor	Photo sensor	Housing A for a Separate Motor	Turnaround Housing A	Intermediate Flange
KR15	○	○	○	—	—	—	○
KR20	○	○	○	○	—	—	○
KR26	○	○	○	○	—	—	○
KR30H	○	○	○	○	—	—	○
KR33	○	○	○	○	○	○	○
KR45H	○	○	○	○	—	—	○
KR46	○	○	○	○	○	○	○
KR55	○	○	○	○	—	○	○
KR65	○	○	○	○	—	○	○
SKR33	○	—	○	○	—	—	○
SKR46	○	—	○	○	—	—	○

Cover

For models KR and SKR, covers are available as an option.

[Example of Installation]



Model SKR33(with a Cover)

Bellows

●For dimensions of the bellows, see B-302 to B-307.

For model KR, a bellows is available for contamination protection in addition to a cover.

dammy

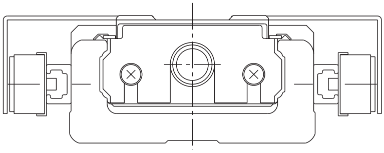
Sensor

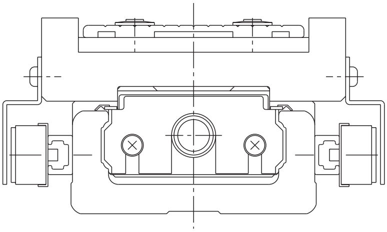
●For detailed dimensions, see B-308 to B-311.

Optional proximity sensors and photo sensors are available for models KR and SKR. Models equipped with a sensor are also provided with a dedicated sensor rail/sensor dog (detecting plate).

Some models with a short rail are attached with a sensor and sensor rail on both sides. See the table below.

[Example of Installation]





Model No.	Rail length
KR15A	75L
	100L
KR15B	125L
KR20A	75L
	100L
	125L
KR20B	125L
	150L
KR26A	100L
	125L
	150L
KR26B	175L
	200L

Motor Bracket

●For detailed dimensions, see B-312 to B-345.

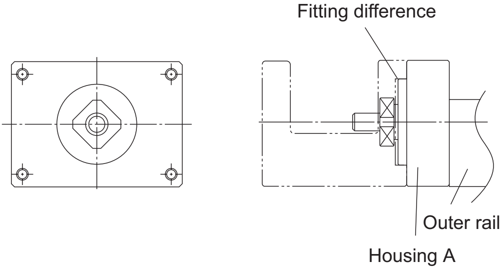
[Housing]

● Housing A

THK also offers Housing A for a separate motor and Turnaround Housing A as options in order to support a motor bracket or a turnaround section that the customer individually manufactures.

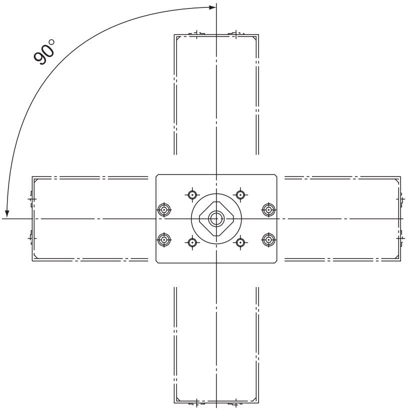
● Housing A for a Separate Motor

By using the fitting difference, the user can easily mount a separately manufactured motor bracket.



● Turnaround Housing A

Since the mounting holes are drilled in constant pitches, the user can select how to mount the motor bracket.



Motor Wrap Type (for Reference)

Motor wrap types are available that allow the motor to be turned around in order to minimize the dimension in the longitudinal direction. Contact THK for details. (Pulley ratio: 1:1)

XY Bracket (for Reference)

Brackets for installing models KR33 and 46 only are available as standard. The brackets use aluminum to reduce the weights and keep the inertia as low as possible.

Precautions on Using Models KR/SKR

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.
(2) Dropping or hitting the product may damage it. Giving an impact to the product could also cause damage to its function even if the product looks intact.

[Lubrication]

(1) Thoroughly remove anti-rust oil and feed lubricant before using the product.
(2) Do not mix lubricants of different physical properties.
(3) In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, normal lubricants may not be used. Contact THK for details.
(4) When planning to use a special lubricant, contact THK before using it.
(5) When adopting oil lubrication, contact THK in advance.
(6) To maximize the performance, lubrication is required. Using the product without lubrication may increase wear of the rolling elements or shorten the service life. In normal use, the lubricant must be replenished every 100 km as a guide. However, the greasing interval varies according to the conditions. We recommend determining the greasing interval based on the result of the initial inspection. For clean room applications, low dust generative AFF Grease is available. Contact THK for details.

[Precautions on Use]

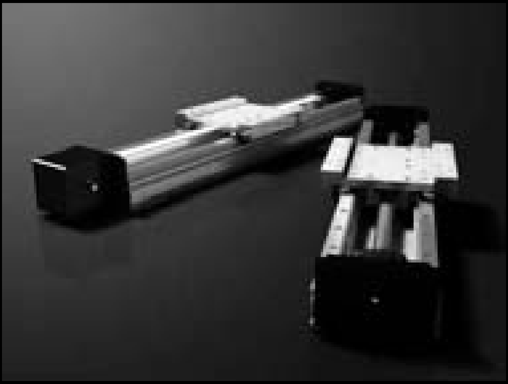
(1) Entrance of foreign material may cause damage to the ball circulating component or functional loss. Prevent foreign material, such as dust or cutting chips, from entering the system.
(2) When planning to use the product in an environment where the coolant penetrates the nut block, contact THK in advance.
(3) The service temperature range of this product is 0 to 40℃ (no freezing or condensation). If you consider using this product outside the service temperature range, contact THK.
(4) Exceeding the dangerous speed may lead the components to be damaged or cause an accident. Be sure to use the product within the specification range designated by THK.
(5) When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, contact THK in advance.

[Safety precautions]

(1) If the product is operating or in the ready state, never touch a moving part. In addition, do not enter the operating area of the actuator.
(2) If two or more people are involved in the operation, confirm the procedures such as a sequence, signs and anomalies in advance, and appoint another person for monitoring the operation.

[Storage]

When storing the product, enclose it in a package designated by THK and store it in a horizontal orientation while avoiding high temperature, low temperature and high humidity.



LM Actuator

THK General Catalog

A Technical Descriptions of the Products

Model GL

B Product Specifications (Separate)

Dimensional Drawing, Dimensional Table

* Please see the separate "B Product Specifications".

Feature of the LM Actuator Model GL

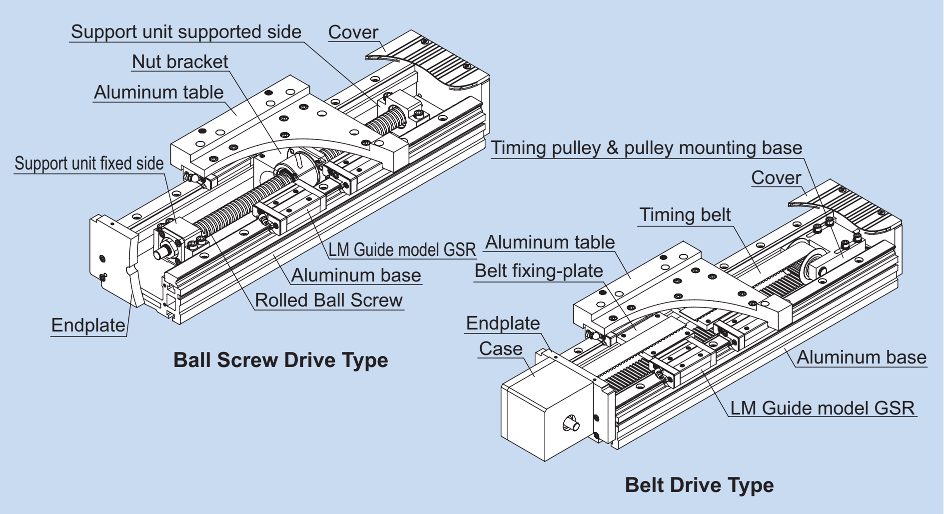


Fig.1 Structures of the Ball Screw Drive Type of Model GL and the Belt Drive Type of Model GL

Structure and Features

Model GL is a single-axis actuator that allows a ball screw drive or a belt drive to be integrated with an aluminum base on which the LM Guide model GSR is mounted. For the ball screw drive type of model GL, several ball screw leads are available to select from. The belt drive type of model GL supports a long stroke.

Model GL is used mainly in conveyance-related applications.

[Drive Methods are Selectable]

With model GL, two drive types are available to select from: a ball screw drive type and a belt drive type

- Ball screw specifications
  Different ball screw leads are selectable for each model number.

Table1 Ball Screw Leads by Model Numbers

	Ball Screw lead (mm)
GL 15	5, 16, 30
GL 20	5, 20, 40

- Belt drive type
  Since it uses a highly rigid belt (wire woven), this type excels in high speed operation, and is not subject to restriction by dangerous speed as opposed to ball screw type. Therefore , it supports a longer stroke (up to 2720 mm for model GL20) than ball screw type. In addition, this type uses a timing pulley with different pitch circle diameter according to the model number.

Table2 Pitch Circle Diameter of the Timing Pulley

	Pitch circle diameter (P.C.D) (mm)
GL 15	35.01
GL 20	38.20

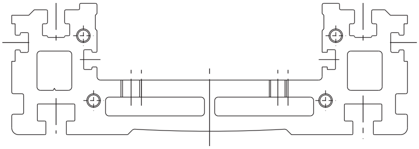
Note) When using AC servomotor drive, we recommend also using a reducer. For details, contact THK.

[Lightweight, High Rigidity]

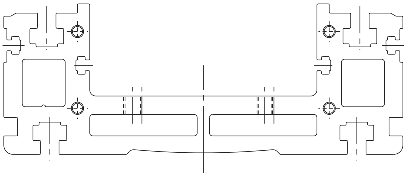
The base using an extruded aluminum material has a hollow sectional shape, thus achieving lightweight and high rigidity.

Table3 Geometrical Moment of Inertia and Mass of the Aluminum Base

	Geometrical moment of inertia		Mass (kg/1000mm)
	I_X (mm^4)	I_Y (mm^4)	
GL15	2.0×10^5	2.7×10^6	5.1
GL20	4.62×10^5	4.62×10^6	6.8



GL15



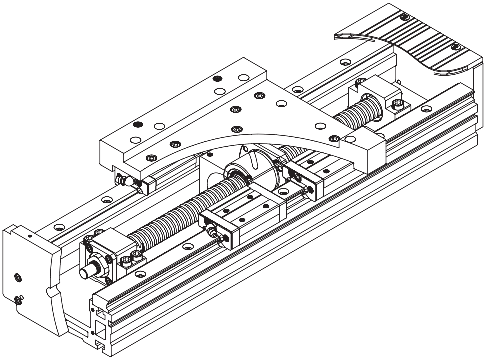
GL20

Fig.2 Cross Section of the Aluminum Base

Types of the LM Actuator Model GL

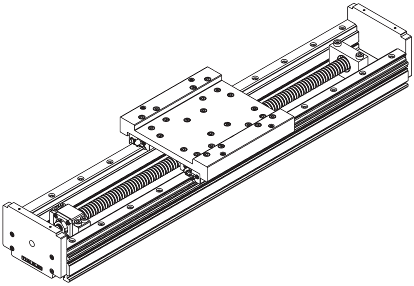
Types and Features

[Ball Screw Drive Type]



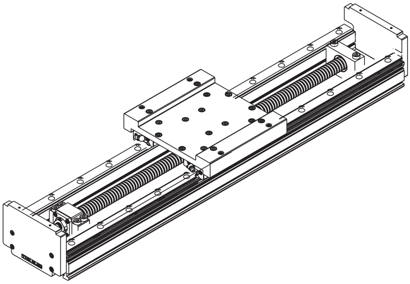
Long Table

This type has 4 units of LM Guide model GSR --- T (long type) attached with a dedicated table.

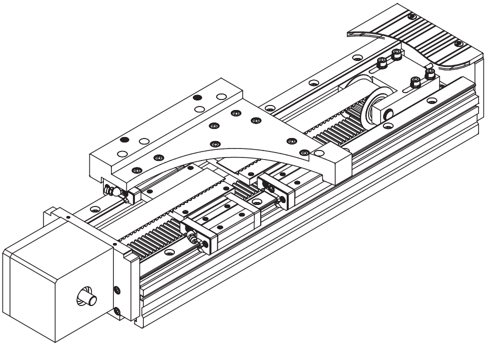


Short Table

This type has 4 units of LM Guide model GSR --- V (short type) attached with a dedicated table.

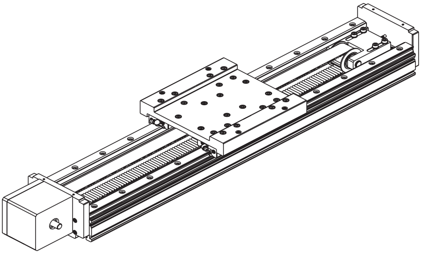


[Belt Drive Type]



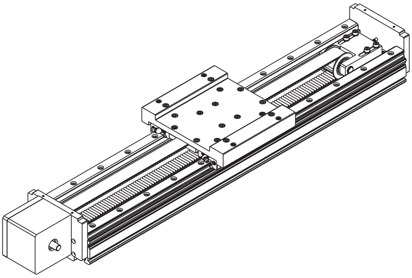
Long Table

This type has 4 units of LM Guide model GSR --- T (long type) attached with a dedicated table.



Short Table

This type has 4 units of LM Guide model GSR --- V (short type) attached with a dedicated table.



Load Rating

The following table shows the load ratings of the LM Guide, the Ball Screw and the support bearing used in model GL, which will help select a specific GL model.

[LM Guide Unit]

Model GL uses LM Guide model GSR for its guide unit.

Table1 shows the load ratings of the LM Guide model GSR used in model GL.

Table1 Load Rating of an LM Guide

	Model No.	Basic dynamic load rating C (kN)	Basic static load rating C0 (kN)
GL 15	GSR 15V	4.31	5.59
	GSR 15T	5.69	8.43
GL 20	GSR 20V	7.01	8.82
	GSR 20T	9.22	13.2

[Ball Screw Unit]

The ball screw drive type of model GL uses a THK Ball Screw for its ball screw unit.

Table2 shows the load ratings of the ball screw used in the ball screw drive type of model GL.

Table2 Load Ratings of the Ball Screw Unit

	Model No.	Basic dynamic load rating Ca (kN)	Basic static load rating C0a (kN)
GL 15	BTK1605-2.6ZZ	5.4	13.3
	BLK1616-3.6ZZ	10.5	25.9
	WTF1530-2ZZ	5.6	12.4
GL 20	BTK2005-2.6ZZ	6	16.5
	BLK2020-3.6ZZ	7.7	22.3
	WTF2040-2ZZ	5.4	13.6

[Support Bearing Unit]

The ball screw drive type of model GL uses a THK Ball Screw for its ball screw unit.

Table3 shows the load ratings of the ball screw used in the ball screw drive type of model GL.

Table3 Load Ratings of and the Static Permissible Load of the Support Bearing Unit

	Model No.	Basic dynamic load rating Ca (N)	Static permissible load P_0a (N)
GL 15	GK 10	6080	2100
GL 20	GK 12	6660	2200

Maximum Travel Speed

The maximum travel speed of the ball screw drive type of model GL is limited by the DN value of and the dangerous speed of the ball screw regardless of the maximum rotation speed of the motor.

Table4 Maximum Travel Speed Unit: mm/sec

Base length (mm)	GL 15			GL 20		
	Lead (mm)			Lead (mm)		
	5	16	30	5	20	40
340	248	1120	2220	—	—	—
460	248	1120	2220	203	740	2247
580	248	1120	2220	203	740	2247
700	248	1120	2220	203	740	2247
820	248	1120	2120	203	707	2247
1060	203	667	1145	203	382	2127
1240	141	464	795	180	265	1480
1420	104	341	585	133	195	1087
1600	—	—	—	102	150	833
1780	—	—	—	81	118	660

Accuracy Standards

The accuracy of model GL is defined in terms of positioning repeatability.

[Positioning Repeatability]

After repeating positioning to a given point in the same direction seven times, measure the halting point and obtain the value of half the maximum difference. Perform this measurement in the center and both ends of the travel distance, use the maximum value as the measurement value and express the value of half the maximum difference with symbol "±" as positioning repeatability.

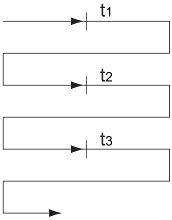


Fig.1 Positioning Repeatability

Table5 Accuracy of Each Model Unit: mm

Drive method	Model No.	
	GL 15	GL 20
Ball screw	±0.02	±0.02
Belt	±0.08	±0.08

Various types of options are available for model GL. Select an appropriate model according to your application.

Name	Reference page	Overview
Cover	A-444	Serve as contamination protection accessories or the likes
Bellows	A-445	
Endplate	A-445	For ball screw drive type
Sensor	A-445	Proximity sensor, photo sensor
Plate nut for mounting the base	A-445	Used for securing the base mounting bolt

Cover

For model GL, a cover is available for contamination protection from entering the top face.

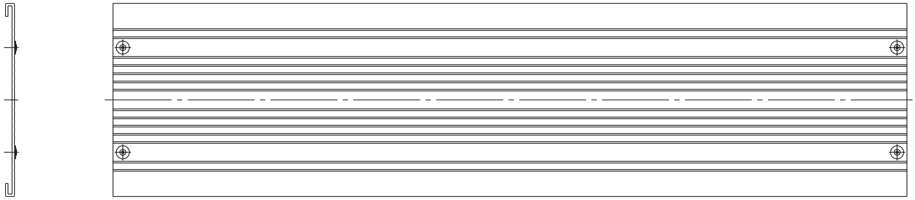
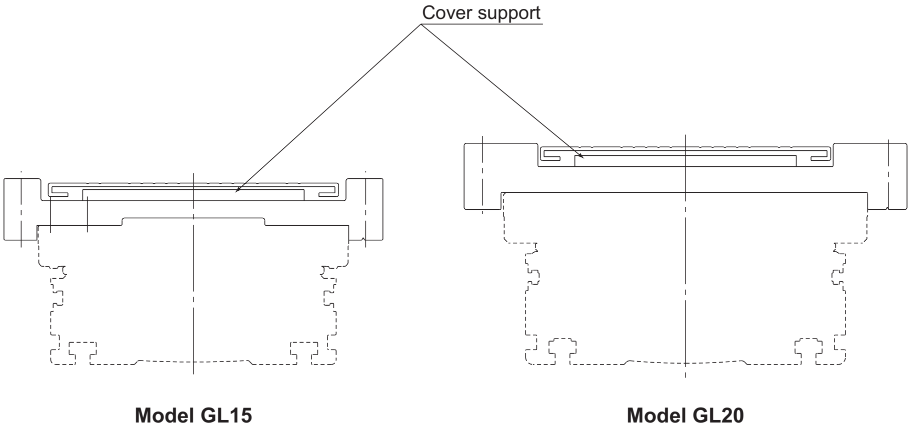


Fig.1 Outline Drawing of the Cover

* Greater the base length, the greater the defection of the cover. To prevent the cover from deflecting, attach a cover support on the table (see figure below). The cover is attached as standard for models with a base length of 1060 mm or longer.



Cross section of the cover support

Bellows

●For dimensions of the bellows, see B-358 to B-361.

For model GL, a bellows is available for contamination protection in addition to a cover.

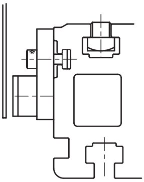
Endplate

●For detailed dimensions, see B-362.

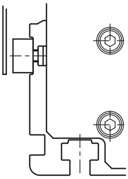
With the ball screw drive type of model GL, the end plate on the motor mounting side is machined according to the motor used. Indicate the motor to be used when placing an order to THK.

Sensor

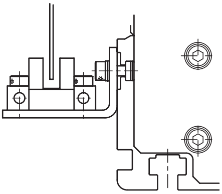
Various types of sensors can be mounted for model GL. Contact THK for details.



GXL-N12F



TL-W3MC1



EE-SX671

Proximity sensor	GXL-N12F (SUNX) TL-W3MC1 (Omron)
Photo micro sensor	EE-SX671 (Omron)

Plate Nut for Mounting the Base

●For detailed dimensions, see B-362.

For model GL, a plate nut for mounting the base is available. It is attached as standard when mode GL is delivered.

[Handling]

(1) Disassembling parts may cause foreign material to enter the system or deteriorate the accuracy. Do not disassemble the product.
(2) Dropping or hitting the LM Actuator model GL may damage it. Giving an impact to the Slide Rail could also cause damage to its function even if the product looks intact.

[Lubrication]

(1) Thoroughly remove anti-rust oil and feed lubricant before using the product.
(2) Do not mix lubricants of different physical properties.
(3) In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, normal lubricants may not be used. Contact THK for details. For clean room applications, low dust-generative grease is available. Contact THK for details.
(4) When planning to use a special lubricant, contact THK before using it.
(5) To maximize the performance of the LM Actuator model GL, lubrication is required. Using the product without lubrication may increase wear of the rolling elements or shorten the service life.
(6) In normal use, the lubricant must be replenished every 100 km as a guide. However, the greasing interval varies according to the conditions. We recommend determining the greasing interval based on the result of the initial inspection.

[Precautions on Use]

(1) Entrance of foreign material may cause damage to the ball circulating component or functional loss. Prevent foreign material, such as dust or cutting chips, from entering the system.
(2) When planning to use the LM system in an environment where the coolant penetrates the LM Actuator model GL, it may cause trouble to product functions depending on the type of the coolant. Contact THK for details.
(3) The service temperature range of this product is 0 to 40℃ (no freezing or condensation). If you consider using this product outside the service temperature range, contact THK.
(4) When using the LM system in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, contact THK in advance.
(5) Exceeding the permissible rotational speed may lead the components to be damaged or cause an accident. Be sure to use the product within the specification range designated by THK.

[Safety precautions]

(1) If the product is operating or in the ready state, never touch a moving part. In addition, do not enter the operating area of the actuator.
(2) If two or more people are involved in the operation, confirm the procedures such as a sequence, signs and anomalies in advance, and appoint another person for monitoring the operation.

[Storage]

When storing the LM Actuator model GL, enclose it in a package designated by THK and store it in a horizontal orientation while avoiding high temperature, low temperature and high humidity.

Ball Spline

THK General Catalog

Ball Spline

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

Dimensional Drawing, Dimensional Table

High Torque Type Ball Spline

Medium Torque Type Ball Spline

Rotary Ball Spline With Geared type

Rotary Ball Spline With Support Bearing type

* Please see the separate "B Product Specifications".

Features of the Ball Spline

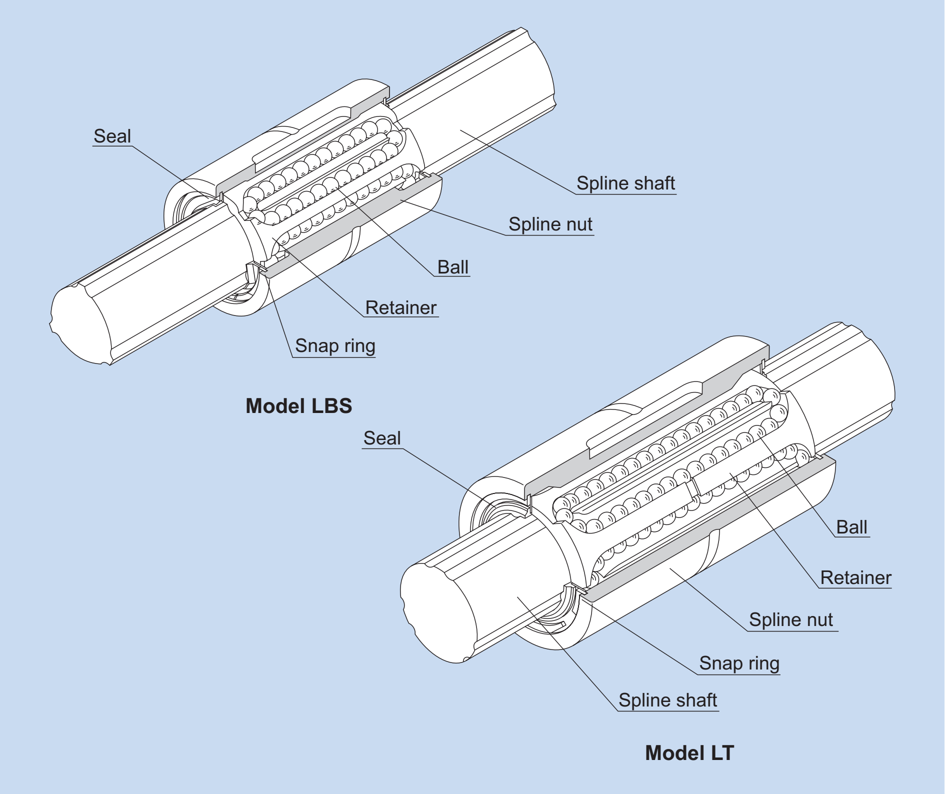
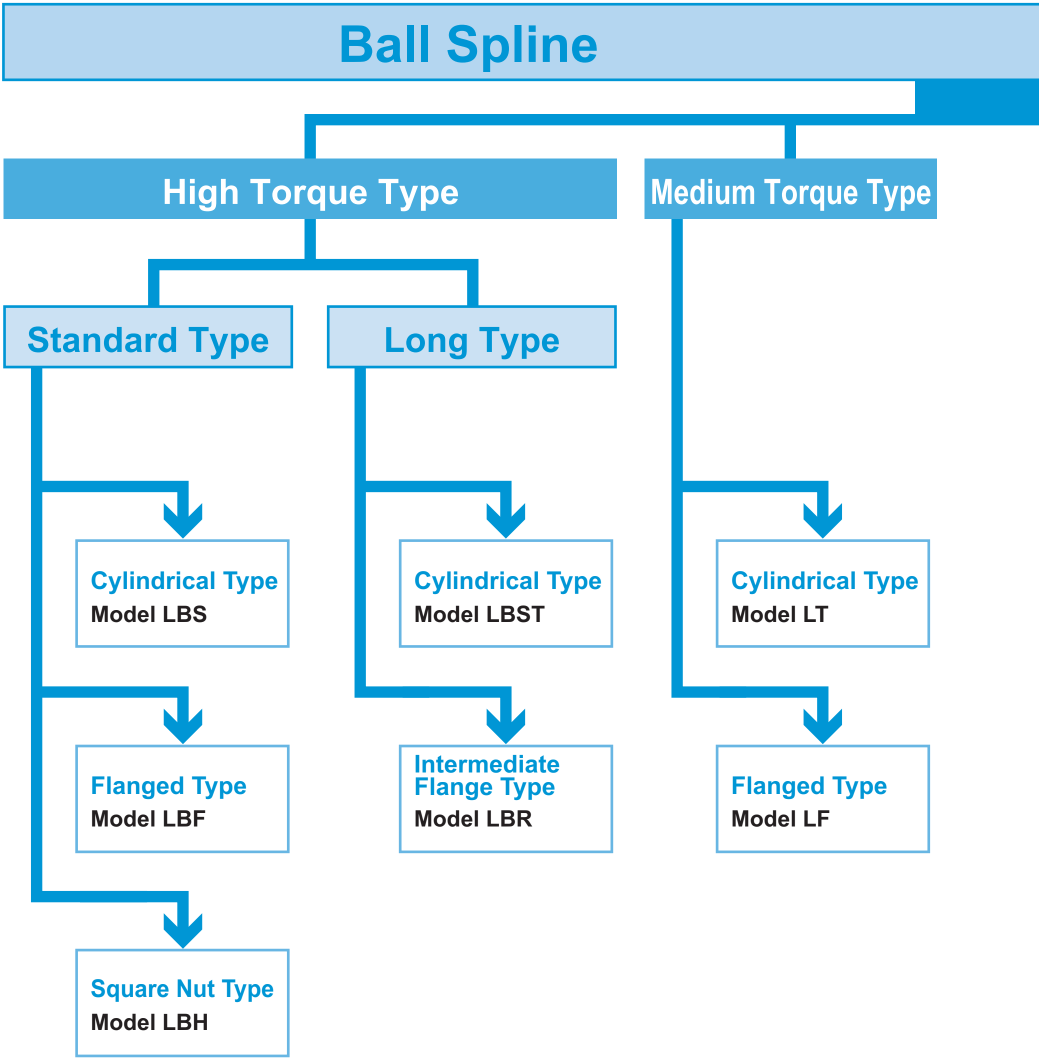


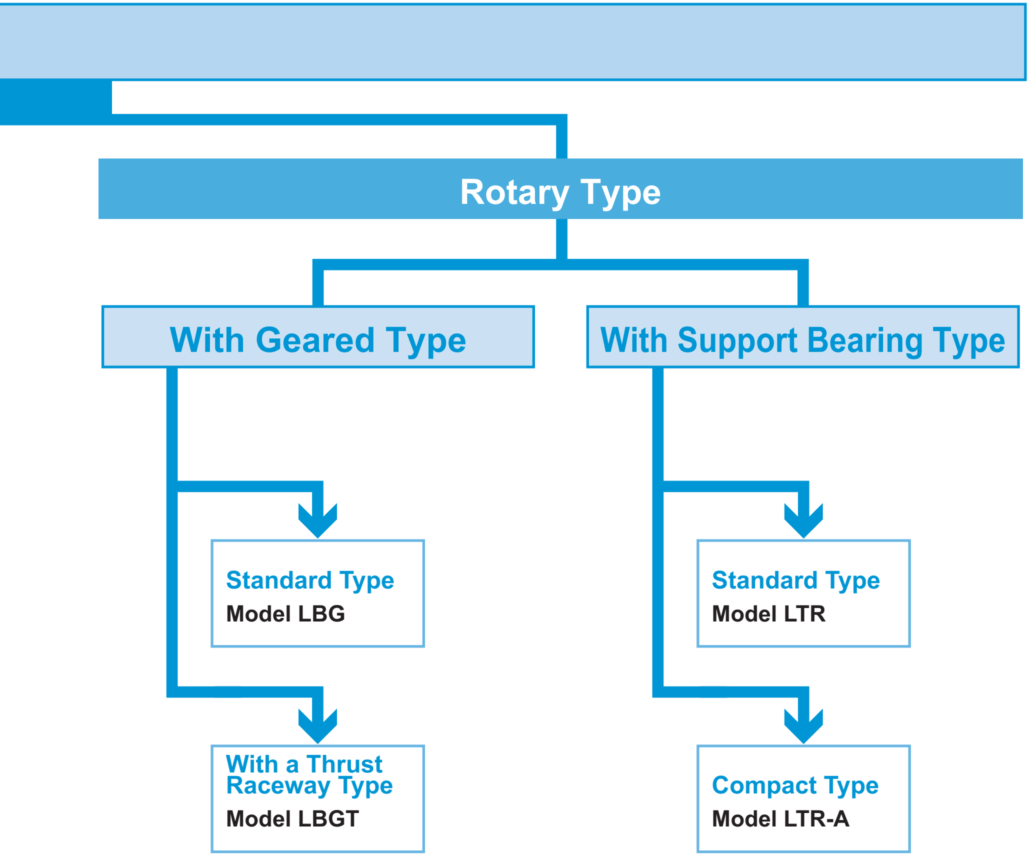
Fig.1 Structure of Ball Spline Models LBS and LT

Structure and Features

The Ball Spline is an innovative linear motion system in which balls accommodated in the spline nut transmit torque while linearly moving on precision-ground raceways on the spline shaft.
Unlike the conventional structure, a single spline nut can provide a preload with THK's Ball Spline. As a result, the Ball Spline demonstrates high performance in environments subject to vibrations and impact loads, locations where a high level of positioning accuracy is required or areas where high-speed kinetic performance is required.
In addition, even when used as an alternative to a linear bushing, the Ball Spline achieves a rated load more than 10 times greater than the linear bushing with the same shaft diameter, allowing it to compactly be designed and used in locations where an overhung load or a moment load is applied. Thus, the Ball Spline provides a high degree of safety and long service life.

Classification of Ball Splines

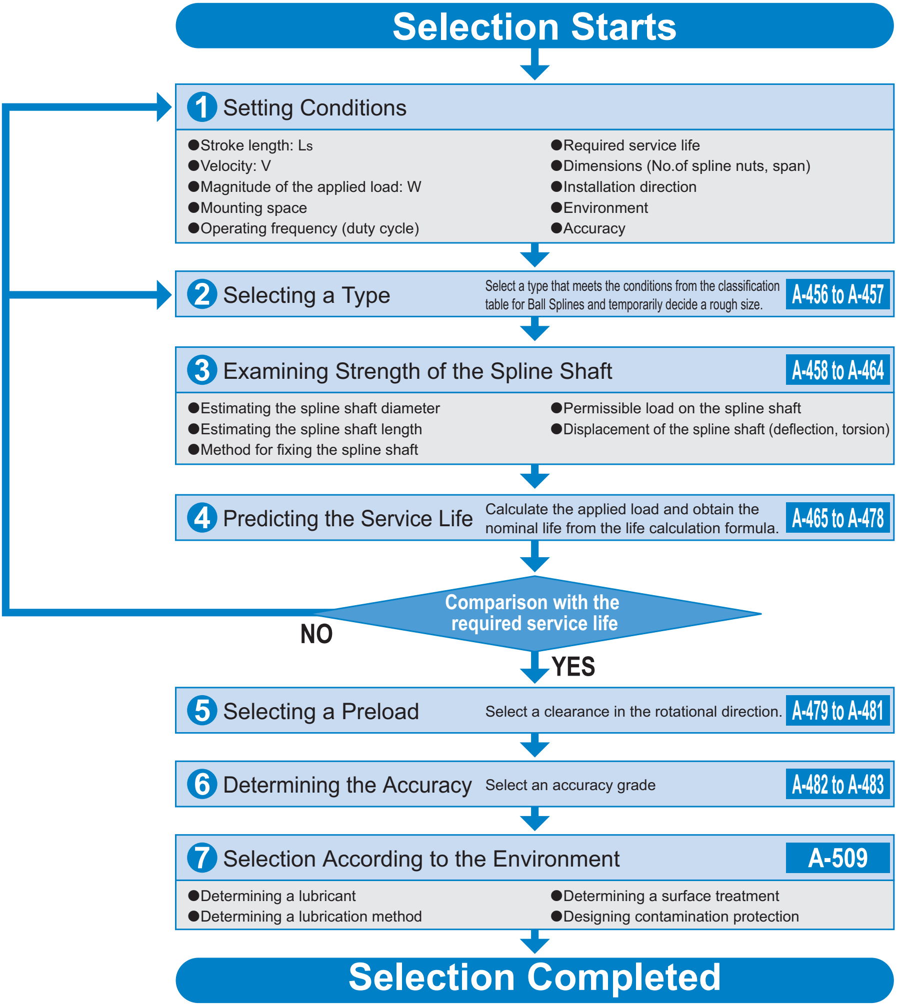



Rotary Type
With Geared Type
With Support Bearing Type
Standard Type
Model LBG
With a Thrust Raceway Type
Model LBGT
Standard Type
Model LTR
Compact Type
Model LTR-A

Flowchart for Selecting a Ball Spline

Steps for Selecting a Ball Spline

The following is a flowchart as a measuring stick for selecting a Ball Spline.



Selection Starts

① Setting Conditions

- ●Stroke length: Ls
- ●Velocity: V
- ●Magnitude of the applied load: W
- ●Mounting space
- ●Operating frequency (duty cycle)
- ●Required service life
- ●Dimensions (No.of spline nuts, span)
- ●Installation direction
- ●Environment
- ●Accuracy

② Selecting a Type Select a type that meets the conditions from the classification table for Ball Splines and temporarily decide a rough size. **A-456 to A-457**

③ Examining Strength of the Spline Shaft **A-458 to A-464**

- ●Estimating the spline shaft diameter
- ●Estimating the spline shaft length
- ●Method for fixing the spline shaft
- ●Permissible load on the spline shaft
- ●Displacement of the spline shaft (deflection, torsion)

④ Predicting the Service Life Calculate the applied load and obtain the nominal life from the life calculation formula. **A-465 to A-478**

Comparison with the required service life

NO

YES

⑤ Selecting a Preload Select a clearance in the rotational direction. **A-479 to A-481**

⑥ Determining the Accuracy Select an accuracy grade **A-482 to A-483**

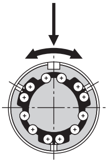
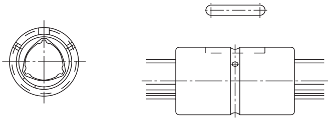
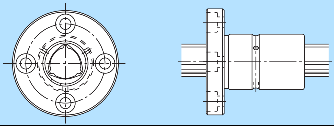
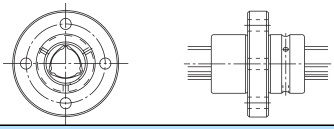
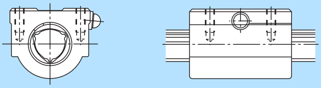
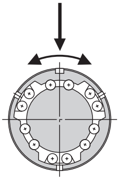
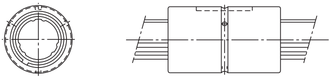
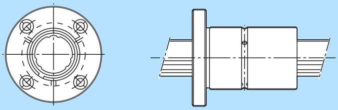
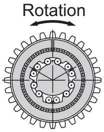
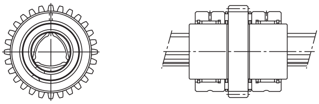
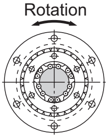
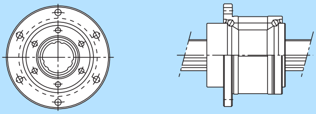
⑦ Selection According to the Environment **A-509**

- ●Determining a lubricant
- ●Determining a lubrication method
- ●Determining a surface treatment
- ●Designing contamination protection

Selection Completed

Selecting a Type

There are three types of the Ball Spline: high torque type, medium torque type and rotary type. You can choose a type according to the intended use. In addition, wide arrays of spline nut shapes are available for each type, enabling the user to choose a desired shape according to the mounting or service requirements.

Classification		Type	Shape	Shaft diameter
High torque type		Type LBS Type LBST		Nominal shaft diameter 6 to 150mm
		Type LBF		Nominal shaft diameter 15 to 100mm
		Type LBR		Nominal shaft diameter 15 to 100mm
		Type LBH		Nominal shaft diameter 15 to 50mm
Medium torque type		Type LT		Nominal shaft diameter 4 to 100mm
		Type LF		Nominal shaft diameter 6 to 50mm
Rotary type		Type LBG Type LBGT		Nominal shaft diameter 20 to 85mm
		Type LTR-A Type LTR		Nominal shaft diameter 8 to 60mm

*For specification tables for each model, please see the separate "B Product Specifications".

Specification Table	Structure and features	Major application
B-368	● The spline shaft has three crests equidistantly formed at angles of 120°. On both sides of each crest, two rows (six rows in total) of balls are arranged to hold the crest from both sides. The angular-contact design of the ball contact areas allows an appropriate preload to be evenly applied. ● Since the balls circulate inside the spline nut, the outer dimensions of the spline nut are compactly designed. ● Even under a large preload, smooth straight motion is achieved. ● Since the contact angle is large (45°) and the displacement is minimal, high rigidity is achieved. ● No angular backlash occurs. ● Capable of transmitting a large torque.	● Column and arm of industrial robot ● Automatic loader ● Transfer machine ● Automatic conveyance system ● Tire molding machine ● Spindle of spot-welding machine ● Guide shaft of high-speed automatic coating machine ● Riveting machine ● Wire winder ● Work head of electric discharge machine ● Spindle drive shaft of grinding machine ● Speed gears ● Precision indexing machine
B-374		
B-376		
B-378		
B-386	● The spline shaft has two to three crests. On both sides of each crest, two rows (four to six rows in total) of balls are arranged to hold the crest from both sides. This design allows an appropriate preload to be evenly applied. ● The contact angle of 20° and an appropriate preload level eliminate angular backlash, providing high-torque moment rigidity.	● Die-set shaft and similar applications requiring straight motion under a heavy load ● Loading system and similar applications requiring rotation to a given angle at a fixed position ● Automatic gas-welding machine spindle and similar applications requiring a whirl-stop on one shaft ● Column and arm of industrial robot ● Spot-welding machine ● Riveting machine ● Book-binding machine ● Automatic filler ● XY recorders ● Automatic spinner ● Optical measuring instrument
B-388		
B-396	● A unit type that has the same contact structure as model LBS. The flange circumference on the spline nut is machined to have gear teeth, and radial and thrust needle bearings are compactly combined on the circumference of the spline nut.	● Speed gears for high torque transmission
B-404	● A lightweight and compact type based on model LT, but has a spline nut circumference machined to have angular-contact type ball raceways to accommodate support bearings.	● Z axis of scalar robot ● Wire winder

Studying the Spline Shaft Strength

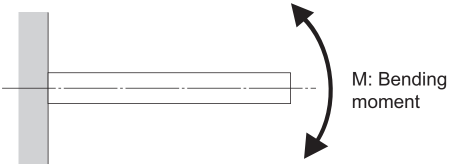
The spline shaft of the Ball Spline is a compound shaft capable of receiving a radial load and torque. When the load and torque are large, the spline shaft strength must be taken into account.

[Spline Shaft Receiving a Bending Load]

When a bending load is applied to the spline shaft of a Ball Spline, obtain the spline shaft diameter using the equation (1) below.

$$M = \sigma \cdot Z \quad \text{and} \quad Z = \frac{M}{\sigma} \quad \cdots\cdots\cdots\cdots(1)$$

M : Maximum bending moment acting on the spline shaft (N-mm)
σ : Permissible bending stress of the spline shaft (98N/mm^2)
Z : Modulus section factor of the spline shaft (mm^3) (see Table3 on A-463 and Table4 on A-464)

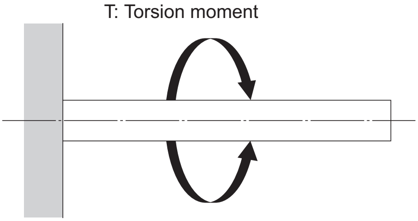


[Spline Shaft Receiving a Torsion Load]

When a torsion load is applied on the spline shaft of a Ball Spline, obtain the spline shaft diameter using the equation (2) below.

$$T = \tau_a \cdot Z_P \quad \text{and} \quad Z_P = \frac{T}{\tau_a} \quad \cdots\cdots\cdots\cdots(2)$$

T : Maximum torsion moment (N-mm)
τ_a : Permissible torsion stress of the spline shaft (49N/mm^2)
Z_p : Polar modulus of section of the spline nut (mm^3) (see Table3 on A-463 and Table4 on A-464)



[When the Spline Shaft Simultaneously Receives a Bending Load and a Torsion Load]

When the spline shaft of a Ball Spline receives a bending load and a torsion load simultaneously, calculate two separate spline shaft diameters: one for the equivalent bending moment (M_e) and the other for the equivalent torsion moment (T_e). Then, use the greater value as the spline shaft diameter.

Equivalent bending moment

$$M_e = \frac{M+\sqrt{M^2+T^2}}{2} = \frac{M}{2}\left\{1+\sqrt{1+\left(\frac{T}{M}\right)^2}\right\} \cdots\cdots\cdots\cdots(3)$$

$M_e = \sigma \cdot Z$

Equivalent torsion moment

$$T_e = \sqrt{M^2+T^2} = M \cdot \sqrt{1+\left(\frac{T}{M}\right)^2} \cdots\cdots\cdots\cdots(4)$$

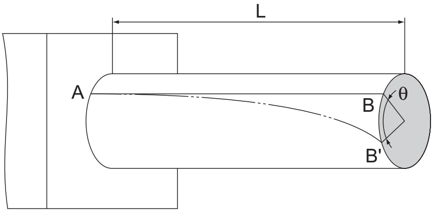
$T_e = \tau_a \cdot Z_p$

[Rigidity of the Spline Shaft]

The rigidity of the spline shaft is expressed as a torsion angle per meter of shaft length. Its value should be limited within 1°/4.

$$\theta = 57.3 \times \frac{T \cdot L}{G \cdot I_P} \cdots\cdots\cdots\cdots(5)$$

$$\text{Rigidity of the shaft} = \frac{\text{Torsion angle}}{\text{Unit length}} = \frac{\theta \cdot \ell}{L} < \frac{1°}{4}$$



θ : Torsion angle (°)
L : Spline shaft length (mm)
G : Transverse elastic modulus (7.9×10^4N/mm^2)
ℓ : Unit length (1000mm)
I_p : Polar moment of inertia (mm^4) (see Table3 on A-463 and Table4 on A-464)

[Deflection and Deflection Angle of the Spline Shaft]

The deflection and deflection angle of the Ball Spline shaft need to be calculated using equations that meet the relevant conditions. Table1 and Table2 represent these conditions and the corresponding equations.

Table3 and Table4 (A-463 and A-464) show the modulus section (Z) and the geometrical moments of inertia (I) of the spline shaft. Using Z and I values in the tables, the strength and displacement (deflection) of a typical Ball Spline model can be obtained.

Table1 Deflection and Deflection Angle Equations

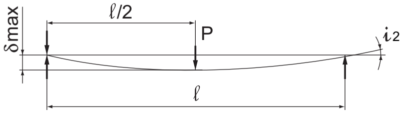
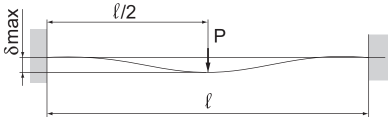
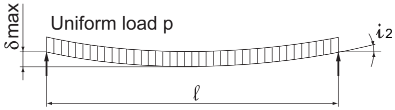
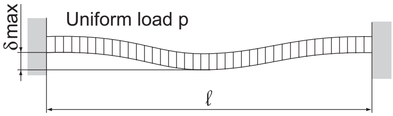
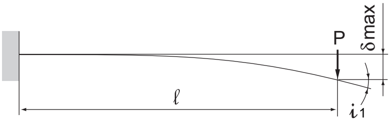
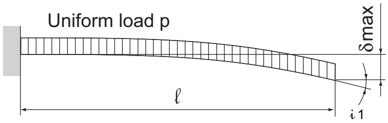
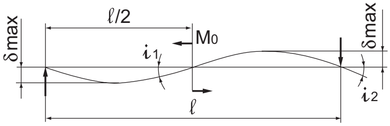
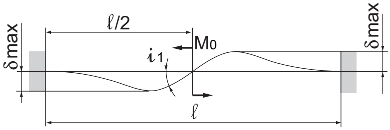
Support method	Condition	Deflection equation	Deflection angle equation
Both ends free		$\delta_{max} = \dfrac{P\ell^3}{48EI}$	$i_1 = 0$ $i_2 = \dfrac{P\ell^2}{16EI}$
Both ends fas-tened		$\delta_{max} = \dfrac{P\ell^3}{192EI}$	$i_1 = 0$ $i_2 = 0$
Both ends free		$\delta_{max} = \dfrac{5p\ell^4}{384EI}$	$i_2 = \dfrac{p\ell^3}{24EI}$
Both ends fas-tened		$\delta_{max} = \dfrac{p\ell^4}{384EI}$	$i_2 = 0$

Table2 Deflection and Deflection Angle Equations

Support method	Condition	Deflection equation	Deflection angle equation
One end fas-tened		$\delta_{max} = \frac{P\ell^3}{3EI}$	$i_1 = \frac{P\ell^2}{2EI}$ $i_2 = 0$
One end fas-tened		$\delta_{max} = \frac{P\ell^4}{8EI}$	$i_1 = \frac{P\ell^3}{6EI}$ $i_2 = 0$
Both ends free		$\delta_{max} = \frac{\sqrt{3}M_0\ell^2}{216EI}$	$i_1 = \frac{M_0\ell}{12EI}$ $i_2 = \frac{M_0\ell}{24EI}$
Both ends fas-tened		$\delta_{max} = \frac{M_0\ell^2}{216EI}$	$i_1 = \frac{M_0\ell}{16EI}$ $i_2 = 0$

δ_{max}: Maximum deflection(mm)
M_0: Moment(N-mm)
ℓ: Span (mm)
I: Geometrical moment of inertia(mm^4)
i_1: Deflection angle at loading point
i_2: Deflection angle at supporting point
P: Concentrated load(N)
p: Uniform load(N/mm)
E: Modulus of longitudinal elasticity 2.06×10^5 (N/mm^2)

[Dangerous Speed of the Spline Shaft]

When a Ball Spline shaft is used to transmit power while rotating, as the rotational speed of the shaft increases, the rotation cycle nears the natural frequency of the spline shaft. It may cause resonance and eventually result in inability to move. Therefore, the maximum shaft speed must be limited to a level that does not cause resonance. If the shaft's rotation cycle exceeds or nears the resonance point during operation, it is necessary to reconsider the spline shaft diameter. The critical speed of the spline shaft is obtained using the equation (6) below, in which the value is multiplied by a safety factor of 0.8.

● Critical Speed

$$N_c = \frac{60\lambda^2}{2\pi \cdot \ell_b^2} \cdot \sqrt{\frac{E \times 10^3 \cdot I}{\gamma \cdot A}} \times 0.8 \quad \cdots(6)$$

N_c : Dangerous speed (min^{-1})

ℓ_b : Distance between two mounting surfaces (mm)

E : Young's modulus (2.06×10^5 N/mm^2)

I : Minimum geometrical moment of inertia of the shaft (mm^4)

$$I = \frac{\pi}{64} d^4 \qquad \text{d:Minor diameter} \quad \text{(mm)}$$

(see Table7 and Table8 on A-468)

γ : Density (specific gravity) (7.85×10^{-6}kg/mm^3)

$$A = \frac{\pi}{4} d^2 \qquad \text{d: Minor diameter} \quad \text{(mm)}$$

(see Table7 and Table8 on A-468)

A : Spline shaft cross-sectional area (mm^2)

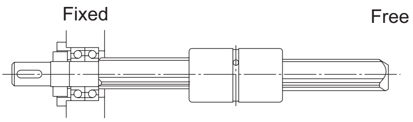
λ : Factor according to the mounting method

(1)Fixed - free λ=1.875

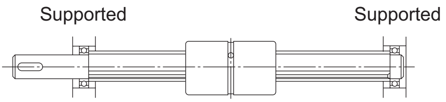
(2)Supported - supported λ=3.142

(3)Fixed - supported λ=3.927

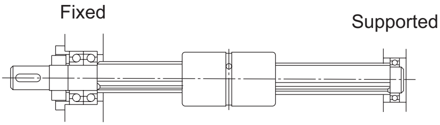
(4)Fixed - fixed λ=4.73



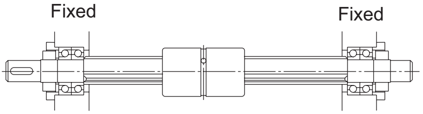
Fixed - free



Supported - supported



Fixed - supported



Fixed - fixed

[Cross-sectional Characteristics of the Spline Shaft]

● Cross-sectional Characteristics of the Spline Shaft for Ball Spline Models LBS, LBST, LBF, LBR, LBH, LBG and LBGT

Table3 Cross-sectional Characteristics of the Spline Shaft for Models LBS, LBST, LBF, LBR, LBH, LBG and LBGT

Nominal shaft diameter		I: Geometrical moment of inertia mm^4	Z: Modulus section mm^3	I_P: Polar momentof inertia mm^4	Z_P: Section modulus mm^3
6	Solid shaft	50.6	17.8	1.03×10^{2}	36.2
8	Solid shaft	1.64×10^{2}	42.9	3.35×10^{2}	87.8
10	Solid shaft	3.32×10^{2}	73.0	6.80×10^{2}	1.50×10^{2}
15	Solid shaft	1.27×10^{3}	2.00×10^{2}	2.55×10^{3}	4.03×10^{2}
20	Solid shaft	3.82×10^{3}	4.58×10^{2}	7.72×10^{3}	9.26×10^{2}
	Hollow shaft	3.79×10^{3}	4.56×10^{2}	7.59×10^{3}	9.11×10^{2}
25	Solid shaft	9.62×10^{3}	9.14×10^{2}	1.94×10^{4}	1.85×10^{3}
	Hollow shaft	9.50×10^{3}	9.05×10^{2}	1.90×10^{4}	1.81×10^{3}
30	Solid shaft	1.87×10^{4}	1.50×10^{3}	3.77×10^{4}	3.04×10^{3}
	Hollow shaft	1.78×10^{4}	1.44×10^{3}	3.57×10^{4}	2.88×10^{3}
40	Solid shaft	6.17×10^{4}	3.69×10^{3}	1.25×10^{5}	7.46×10^{3}
	Hollow shaft	5.71×10^{4}	3.42×10^{3}	1.14×10^{5}	6.84×10^{3}
50	Solid shaft	1.49×10^{5}	7.15×10^{3}	3.01×10^{5}	1.45×10^{4}
	Hollow shaft	1.34×10^{5}	6.46×10^{3}	2.69×10^{5}	1.29×10^{4}
60	Solid shaft	3.17×10^{5}	1.26×10^{4}	6.33×10^{5}	2.53×10^{4}
	Hollow shaft	2.77×10^{5}	1.11×10^{4}	5.54×10^{5}	2.21×10^{4}
70	Solid shaft	5.77×10^{5}	1.97×10^{4}	1.16×10^{6}	3.99×10^{4}
	Hollow shaft	5.07×10^{5}	1.74×10^{4}	1.01×10^{6}	3.49×10^{4}
85	Solid shaft	1.33×10^{6}	3.69×10^{4}	2.62×10^{6}	7.32×10^{4}
	Hollow shaft	1.11×10^{6}	3.10×10^{4}	2.22×10^{6}	6.20×10^{4}
100	Solid shaft	2.69×10^{6}	6.25×10^{4}	5.33×10^{6}	1.25×10^{5}
	Hollow shaft	2.18×10^{6}	5.10×10^{4}	4.37×10^{6}	1.02×10^{5}
120	Solid shaft	5.95×10^{6}	1.13×10^{5}	1.18×10^{7}	2.26×10^{5}
	Hollow shaft	5.28×10^{6}	1.01×10^{5}	1.06×10^{7}	2.02×10^{5}
150	Solid shaft	1.61×10^{7}	2.40×10^{5}	3.20×10^{7}	4.76×10^{5}
	Hollow shaft	1.40×10^{7}	2.08×10^{5}	2.79×10^{7}	4.16×10^{5}

Note) For the hole-shape of the hollow spline shaft, see B-381 and B-400.

Cross-sectional Characteristics of the Spline Shaft for Ball Spline Models LT, LF, LTR and LTR-A

Table4 Cross-sectional Characteristics of the Spline Shaft for Models LT, LF, LTR and LTR-A

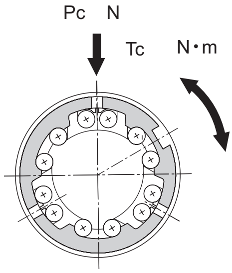
Nominal shaft diameter			I: Geometrical moment of inertia mm^4	Z: Modulus section mm^3	I$_P$: Polar moment of inertia mm^4	Z$_P$: Section modulus mm^3
4	Solid shaft		11.39	5.84	22.78	11.68
5	Solid shaft		27.88	11.43	55.76	22.85
6	Solid shaft		57.80	19.7	1.19×10^2	40.50
	Hollow shaft	Type K	55.87	18.9	1.16×10^2	39.20
8	Solid shaft		1.86×10^2	47.4	3.81×10^2	96.60
	Hollow shaft	Type K	1.81×10^2	46.0	3.74×10^2	94.60
10	Solid shaft		4.54×10^2	92.6	9.32×10^2	1.89×10^2
	Hollow shaft	Type K	4.41×10^2	89.5	9.09×10^2	1.84×10^2
13	Solid shaft		1.32×10^3	2.09×10^2	2.70×10^3	4.19×10^2
	Hollow shaft	Type K	1.29×10^3	2.00×10^2	2.63×10^3	4.09×10^2
16	Solid shaft		3.09×10^3	3.90×10^2	6.18×10^3	7.80×10^2
	Hollow shaft	Type K	2.97×10^3	3.75×10^2	5.95×10^3	7.51×10^2
		Type N	2.37×10^3	2.99×10^2	4.74×10^3	5.99×10^2
20	Solid shaft		7.61×10^3	7.67×10^2	1.52×10^4	1.53×10^3
	Hollow shaft	Type K	7.12×10^3	7.18×10^2	1.42×10^4	1.43×10^3
		Type N	5.72×10^3	5.77×10^2	1.14×10^4	1.15×10^3
25	Solid shaft		1.86×10^4	1.50×10^3	3.71×10^4	2.99×10^3
	Hollow shaft	Type K	1.75×10^4	1.41×10^3	3.51×10^4	2.83×10^3
		Type N	1.34×10^4	1.08×10^3	2.68×10^4	2.16×10^3
30	Solid shaft		3.86×10^4	2.59×10^3	7.71×10^4	5.18×10^3
	Hollow shaft	Type K	3.53×10^4	2.37×10^3	7.07×10^4	4.74×10^3
		Type N	2.90×10^4	1.95×10^3	5.80×10^4	3.89×10^3
32	Solid shaft		5.01×10^4	3.15×10^3	9.90×10^4	6.27×10^3
	Hollow shaft	Type K	4.50×10^4	2.83×10^3	8.87×10^4	5.61×10^3
		Type N	3.64×10^4	2.29×10^3	7.15×10^4	4.53×10^3
40	Solid shaft		1.22×10^5	6.14×10^3	2.40×10^5	1.21×10^4
	Hollow shaft	Type K	1.10×10^5	5.55×10^3	2.17×10^5	1.10×10^4
		Type N	8.70×10^4	4.39×10^3	1.71×10^5	8.64×10^3
50	Solid shaft		2.97×10^5	1.20×10^4	5.94×10^5	2.40×10^4
	Hollow shaft	Type K	2.78×10^5	1.12×10^4	5.56×10^5	2.24×10^4
		Type N	2.14×10^5	8.63×10^3	4.29×10^5	1.73×10^4
60	Solid shaft		6.16×10^5	2.07×10^4	1.23×10^6	4.14×10^4
	Hollow shaft	Type K	5.56×10^5	1.90×10^4	1.13×10^6	3.79×10^4
80	Solid shaft		1.95×10^6	4.91×10^4	3.90×10^6	9.82×10^4
	Hollow shaft	Type K	1.58×10^6	3.97×10^4	3.15×10^6	7.95×10^4
100	Solid shaft		4.78×10^6	9.62×10^4	9.56×10^6	1.92×10^5
	Hollow shaft	Type K	3.76×10^6	7.57×10^4	7.52×10^6	1.51×10^5

Note) For the hole-shape of the hollow spline shaft.
For type K: see B-391 and B-408.
For type N: see B-391 and B-408.

Predicting the Service Life

[Nominal Life]

The service life of a Ball Spline varies from unit to unit even if they are manufactured through the same process and used in the same operating conditions. Therefore, the nominal life defined below is normally used as a guidepost for obtaining the service life of a Ball Spline.
Nominal life is the total travel distance that 90% of a group of identical ball splines independently operating under the same conditions can achieve without showing flaking (scale-like pieces on a metal surface).



[Calculating the Nominal Life]

The nominal life of a Ball Spline varies with types of loads applied during operation: torque load, radial load and moment load. The corresponding nominal life values are obtained using the equations (7) to (10) below. (The basic load ratings in these loading directions are indicated in the specification table for the corresponding model number.)

- **When a Torque Load is Applied**

$$L = \left(\frac{f_T \cdot f_C}{f_W} \cdot \frac{C_T}{T_C}\right)^3 \times 50 \quad \cdots\cdots\cdots(7)$$

- **When a Radial Load is Applied**

$$L = \left(\frac{f_T \cdot f_C}{f_W} \cdot \frac{C}{P_C}\right)^3 \times 50 \quad \cdots\cdots\cdots(8)$$

L : Nominal life (km)
C_T : Basic dynamic torque rating (N-m)
T_C : Calculated torque applied (N-m)
C : Basic dynamic load rating (N)
P_C : Calculated radial load (N)
f_T : Temperature factor (see Fig.1 on A-467)
f_C : Contact factor (see Table5 on A-467)
f_W : Load factor (see Table6 on A-467)

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

When a torque load and a radial load are simultaneously applied, calculate the nominal life by obtaining the equivalent radial load using the equation (9) below.

$$P_E = P_C + \frac{4 \cdot T_C \times 10^3}{i \cdot dp \cdot \cos\alpha} \quad \cdots\cdots\cdots(9)$$

P_E : Equivalent radial load (N)
$\cos\alpha$: Contact angle i=Number of rows of balls under a load

Type LBS α=45°	i=2(LBS10 or smaller)
	i=3(LBS15 or greater)
Type LT α=70°	i=2(LT13 or smaller)
	i=3(LT16 or greater)

dp : Ball center-to-center diameter (mm)
(see Table7 and Table8 on A-468)

● When a Moment Load is Applied to a Single Nut or Two Nuts in Close Contact with Each Other

Obtain the equivalent radial load using the equation (10) below.

$$P_u = K \cdot M \quad \cdots\cdots\cdots(10)$$

P_u : Equivalent radial load (N)
(with a moment applied)
K : Equivalent Factors (see Table9 on A-471, Table10 on A-472)
M : Applied moment (N-mm)

However, M should be within the range of the static permissible moment.

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

Calculated the nominal life from the sum of the radial load and the equivalent radial load.

● Calculating the Service Life Time

When the nominal life (L) has been obtained in the equation above, if the stroke length and the number of reciprocations per minute are constant, the service life time is obtained using the equation (11) below.

$$L_h = \frac{L \times 10^3}{2 \times \ell_S \times n_1 \times 60} \quad \cdots\cdots\cdots(11)$$

L_h : Service life time (h)
ℓ_S : Stroke length (m)
n_1 : Number of reciprocations per minute (opm)

■f_T:Temperature Factor

If the temperature of the environment surrounding the operating Ball Spline 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.1.
In addition, the Ball Spline must be of a high temperature type.

Note) If the environment temperature exceeds 80 ℃, high-tem-perature types of seal and retainer are required. ContactTHK for details.

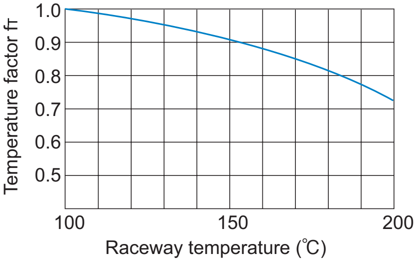


Fig.1 Temperature Factor (f_T)

■f_C: Contact Factor

When multiple spline nuts 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 Table5.

Note) If uneven load distribution is expected in a large machine, take into account the respective contact factor indicated in Table5.

Table5 Contact Factor (f_C)

Number of spline 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 involve vibrations or impact during operation. It is extremely difficult to accurately determine vibrations generated during high-speed operation and impact during frequent start and stop. When loads applied on a Ball Spline cannot be measured, or when speed and impact have a significant influence, divide the basic load rating (C or C_0), by the corresponding load factor in the table of empirically obtained data on Table6.

Table6 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

Table7 Sectional Shape of the Spline Shaft for Models LBS, LBST, LBF, LBR, LBH, LBG and LBGT

Unit: mm

Nominal shaft diameter	15	20	25	30	40	50	60	70	85	100	120	150
Minor diameter ϕd	11.7	15.3	19.5	22.5	31	39	46.5	54.5	67	81	101	130
Outer diameter ϕD_0	14.5	19.7	24.5	29.6	39.8	49.5	60	70	84	99	117	147
Ball center-to-center diameter ϕ dp	15	20	25	30	40	50	60	70	85	100	120	150

* The minor diameter ϕd must be a value at which no groove is left after machining.

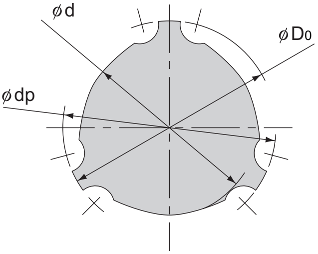
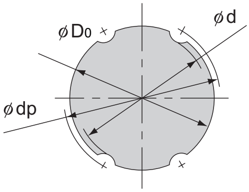


Table8 Sectional Shape of the Spline Shaft for Models LT, LF, LTR and LTR-A

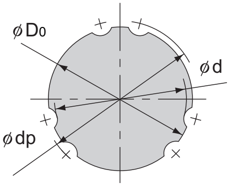
Unit: mm

Nominal shaft diameter	4	5	6	8	10	13	16	20	25	30	32	40	50	60	80	100
Minor diameter ϕd	3.5	4.5	5	7	8.5	11.5	14.5	18.5	23	28	30	37.5	46.5	56.5	75.5	95
Outer diameter ϕD_0	4	5	6	8	10	13	16	20	25	30	32	40	50	60	80	100
Ball center-to-center diameter ϕ dp	4.6	5.7	7	9.3	11.5	14.8	17.8	22.1	27.6	33.2	35.2	44.2	55.2	66.3	87.9	109.5
Outer diameter tolerance	$^{0}_{-0.012}$			$^{0}_{-0.015}$		$^{0}_{-0.018}$		$^{0}_{-0.021}$				$^{0}_{-0.025}$		$^{0}_{-0.03}$		$^{0}_{-0.035}$

* The minor diameter ϕd must be a value at which no groove is left after machining.



Nominal shaft diameter: 13 mm or less



Nominal shaft diameter: 16 mm or more

[Calculating the Average Load]

When the load applied on the spline shaft fluctuates according to varying conditions, such as an industrial robot arm traveling forward while holding a workpiece and traveling backward with empty weight, and a machine tool handling various workpieces, this varying load condition must be taken into account in service life calculation.

The average load (P_m) is a constant load under which the service life of an operating Ball Spline with its spline nut receiving a fluctuation load in varying conditions is equivalent to the service life under this varying load condition.

The following is the basic equation.

$$P_m = \sqrt[3]{\frac{1}{L}\cdot\sum_{n=1}^{n}(P_n^3\cdot L_n)}$$

P_m : Average Load (N)
P_n : Varying load (N)
L : Total travel distance (mm)
L_n : Distance traveled under P_n (mm)

● When the Load Fluctuates Stepwise

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

P_m : Average Load (N)
P_n : Varying load (N)
L : Total travel distance (m)
L_n : Distance traveled under load P_n (m)

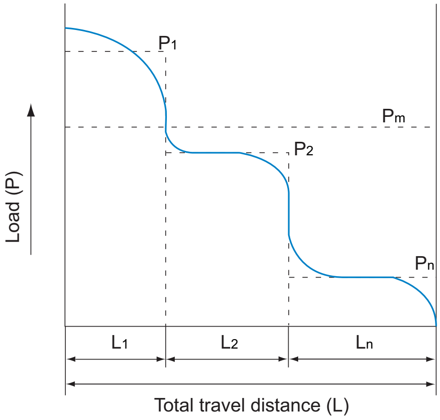


Fig.2

- **When the Load Fluctuates Monotonically**

$$P_m \fallingdotseq \frac{1}{3}(P_{min} + 2 \cdot P_{max}) \cdots\cdots\cdots\cdots (2)$$

P_{min} : Minimum load (N)
P_{max} : Maximum load (N)

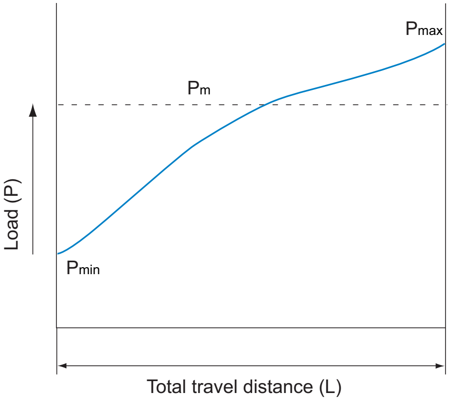


Fig.3

- **When the Load Fluctuates Sinusoidally**

(a) $P_m \fallingdotseq 0.65P_{max} \cdots\cdots\cdots\cdots (3)$ (b) $P_m \fallingdotseq 0.75P_{max} \cdots\cdots\cdots\cdots (4)$

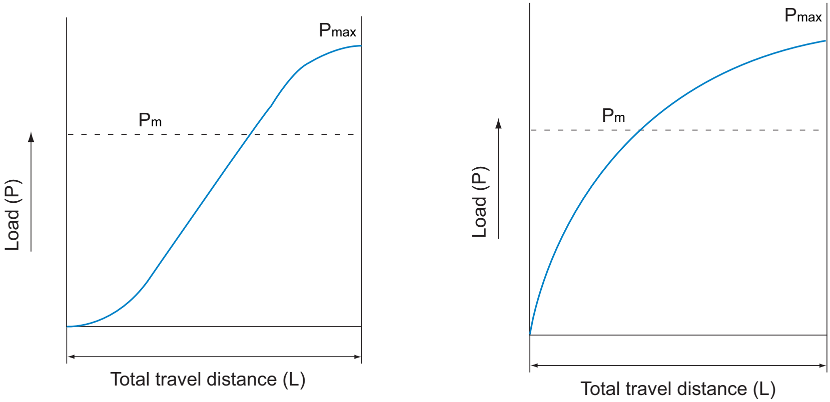
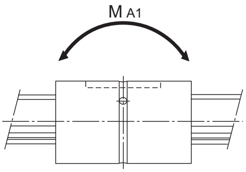


Fig.4

[Equivalent Factor]

Table9 below and Table10 on A-472 show equivalent radial load factors calculated under a moment load.

● Table of Equivalent Factors for Ball Spline Model LBS



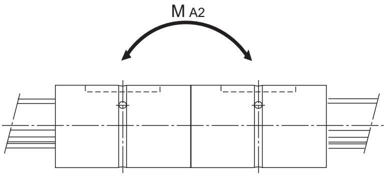


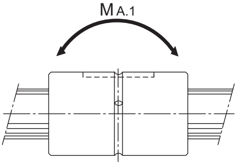
Table9

Model No.	Equivalent factor: K	
	Single spline nut	Two spline nuts in close contact with each other
LBS 6	0.61	0.074
LBS 8	0.46	0.060
LBS 10	0.54	0.049
LBS 15	0.22	0.022
LBS 20	0.24	0.03
LBST 20	0.17	0.027
LBS 25	0.19	0.026
LBST 25	0.14	0.023
LBS 30	0.16	0.022
LBST 30	0.12	0.02
LBS 40	0.12	0.017
LBST 40	0.1	0.016
LBS 50	0.11	0.015
LBST 50	0.09	0.014
LBS 60	0.08	0.013
LBS 70	0.1	0.013
LBST 70	0.08	0.012
LBS 85	0.08	0.011
LBST 85	0.07	0.01
LBS 100	0.08	0.009
LBST 100	0.06	0.009
LBST 120	0.05	0.008
LBST 150	0.045	0.006

Note1) Values of equivalent factor K for model LBF are the same as that for model LBS.

Note2) Values of equivalent factor K for models LBR, LBG, LBGT and LBH are the same as that for model LBST.
However the values of model LBF60 are the same as that for model LBST60.
The values of model LBH15 are the same as that for model LBS15.

● Table of Equivalent Factors for Ball Spline Model LT



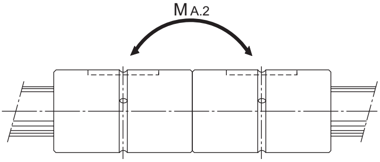


Table10

Model No.	Equivalent factor: K	
	Single spline nut	Two spline nuts in close contact with each other
LT 4	0.65	0.096
LT 5	0.55	0.076
LT 6	0.47	0.06
LT 8	0.47	0.058
LT 10	0.31	0.045
LT 13	0.3	0.042
LT 16	0.19	0.032
LT 20	0.16	0.026
LT 25	0.13	0.023
LT 30	0.12	0.02
LT 40	0.088	0.016
LT 50	0.071	0.013
LT 60	0.07	0.011
LT 80	0.062	0.009
LT100	0.057	0.008

Note) Values of equivalent factor K for model LF are the same as that for model LT.

[Example of Calculating the Service Life]

● Example of Calculation - 1

An industrial robot arm (horizontal)

[Conditions]

Mass applied to the arm end m=50kg

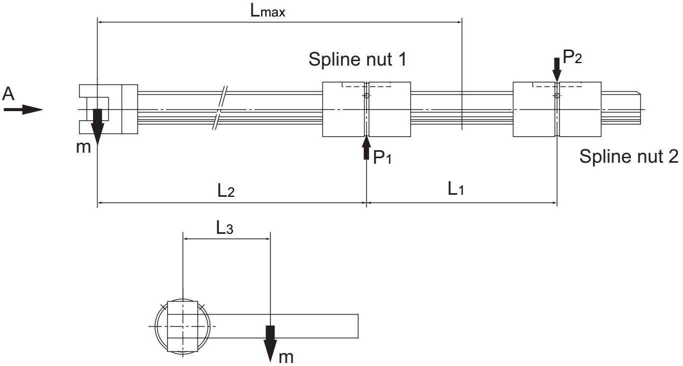
Stroke ℓ_S=200mm

Spline nut mounting span (estimate) L_1=150mm

Arm length at maximum stroke L_{max}=400mm

L_2=325mm

L_3=50mm



A arrow view

(The Ball Spline type is LBS in this example.)

Fig.5

■Shaft Strength Calculation

Calculate the bending moment (M) and the torsion moment (T) applied on the shaft.

$M=m\times 9.8\times L_{max}=196000\text{N-mm}$

$T=m\times 9.8\times L_3=24500\text{N-mm}$

Since the bending and torsion moments are applied simultaneously, obtain the corresponding bending moment (M_e) and torsion moment (T_e), and then determine the shaft diameter based on the greater value. From equations (3) and (4) on A-459,

$$M_e=\frac{M+\sqrt{M^2+T^2}}{2}\fallingdotseq 196762.7\text{N}\cdot\text{mm}$$

$$T_e=\sqrt{M^2+T^2}\fallingdotseq 197525.3\text{N}\cdot\text{mm}$$

$$M_e<T_e$$

$\therefore T_e=\tau_a\times Z_P$ Hence,

$$Z_P=\frac{T_e}{\tau_a}\fallingdotseq 4031\text{mm}^3$$

Thus, judging from Table3 on A-463, the nominal shaft diameter that meets Z_p is at least 40 mm.

■Average Load P_m

Obtain an applied load value when the arm is extended to the maximum length (P_{max}), and another when the arm is contracted (P_{min}). Based on the values obtained, calculate the average load on the spline shaft nut.

$$P_{1max} = \frac{m \times 9.8(L_1+L_2)}{L_1} \fallingdotseq 1551.7N$$

$$P_{2max} = \frac{m \times 9.8 \times L_2}{L_1} \fallingdotseq 1061.7N$$

When the arm is contracted

$$P_{1min} = \frac{m \times 9.8 \times [(L_2-\ell_S) + L_1]}{L_1} \fallingdotseq 898.3N$$

$$P_{2min} = \frac{m \times 9.8 \times (L_2 - \ell_S)}{L_1} \fallingdotseq 408.3N$$

As this load is monotonically varying as shown in the Fig.3 on A-470, calculate the average load using the equation (2) on A-470.

The average load (P_{1m}) on spline nut 1

$$P_{1m} \fallingdotseq \frac{1}{3}(P_{1min} + 2P_{1max}) = 1333.9N$$

The average load (P_{2m}) on spline nut 2

$$P_{2m} \fallingdotseq \frac{1}{3}(P_{2min} + 2P_{2max}) = 843.9N$$

Obtain the torque applied on one spline nut.

$$T = \frac{m \times 9.8 \times L_3}{2} = 12250N \cdot mm$$

Since the radial load and the torque are simultaneously applied, calculate the equivalent radial load using equation (9) on A-466.

$$P_{1E} = P_{1m} + \frac{4 \times T}{3 \times dp \times \cos\alpha} = 1911.4N$$

$$P_{2E} = P_{2m} + \frac{4 \times T}{3 \times dp \times \cos\alpha} = 1421.4N$$

■Nominal Life L_n

Based on the nominal life equation (8) on A-465, each nominal life is obtained as follows.

$$\text{Nominal life of the spline nut } L_1 = \left(\frac{f_T \times f_C}{f_W} \times \frac{C}{P_{1E}}\right)^3 \times 50 = 68867.4km$$

$$\text{Nominal life of the spline nut } L_2 = \left(\frac{f_T \times f_C}{f_W} \times \frac{C}{P_{2E}}\right)^3 \times 50 = 167463.2km$$

f_T: Temperature factor = 1 (from Fig.1 on A-467)
f_C: Contact factor = 1 (from Table5 on A-467)
f_W: Load factor = 1.5 (from Table6 on A-467)
C: Basic dynamic load rating = 31.9 kN (model LBS40)

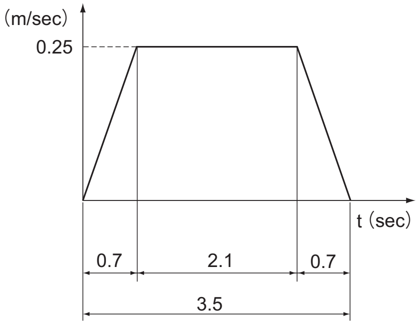
Given the nominal life obtained for each spline nut above, the nominal life of the Ball Spline unit is equal to that of spline nut 1, which is 68867.4km.

● Example of Calculation - 2

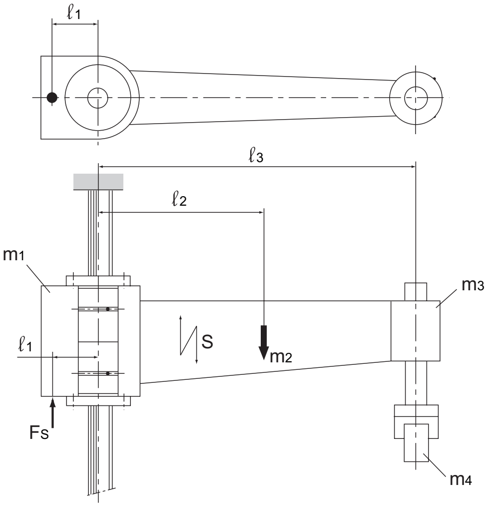
[Conditions]

Thrust position: F_S
Stroke velocity: V_{max} = 0.25m/sec
Acceleration: a=0.36m/sec^2 (from the respective velocity diagram)
Stroke: S=700mm
Housing mass: m_1=30kg
Arm mass : m_2=20kg
Head mass: m_3=15kg
Work mass: m_4=12kg

Distance from the thrust position to each mass
ℓ_1=200mm ℓ_2=500mm
ℓ_3=1276mm
Cycle (1 cycle: 30 sec)
1. Descent (3.5sec) 2.Dwell (1sec): with a work
3. Ascend (3.5sec) 4.Dwell (7sec)
5. Descent (3.5sec) 6.Dwell (1sec): without a work
7. Ascend (3.5sec) 8.Dwell (7sec)



Velocity diagram



(The Ball Spline type is LBF in this example.)

Fig.6

■Shaft Strength Calculation

Calculate the shaft strength while assuming the shaft diameter to be 60 mm. (with double spline nut in contact with each other)

■Calculating the Moment (M_n) Applying on the Spline Nut during Acceleration, Uniform Motion and Deceleration with Different Masses (m_n)

Applied moment during deceleration: M_1

$$\mathbf{M_1 = m_n \times 9.8 \left(1 \pm \frac{a}{g}\right) \times \ell_n} \quad \cdots\cdots\cdots\text{(a)}$$

Applied moment during uniform motion: M_2

$$\mathbf{M_2 = m_n \times 9.8 \times \ell_n} \quad \cdots\cdots\cdots\text{(b)}$$

Applied moment during deceleration: M_3

$$\mathbf{M_3 = m_n \times 9.8 \left(1 \pm \frac{a}{g}\right) \times \ell_n} \quad \cdots\cdots\cdots\text{(c)}$$

m_n: Mass (kg)
a : Acceleration (m/sec^2)
g : Gravitational acceleration(m/sec^2)
ℓ_n : Offset from each loading point to the trust center(mm)
Assume:

$$A = \left(1 + \frac{a}{g}\right), \quad B = \left(1 - \frac{a}{g}\right)$$

- During descent

From equation (c), during acceleration

M_{m1} $=m_1\times9.8\times B\times\ell_1+m_2\times9.8\times B\times(\ell_1+\ell_2)+m_3\times9.8\times B\times(\ell_1+\ell_3)$

=398105.01N-mm

From equation (b), during uniform motion

M_{m2} $=m_1\times9.8\times\ell_1+m_2\times9.8\times(\ell_1+\ell_2)+m_3\times9.8\times(\ell_1+\ell_3)$

=412972N-mm

From equation (a), during deceleration

M_{m3} $=m_1\times9.8\times A\times\ell_1+m_2\times9.8\times A\times(\ell_1+\ell_2)+m_3\times9.8\times A\times(\ell_1+\ell_3)$

=427838.99N-mm

- During ascent

From equation (a), during acceleration

M_{m1}' $=m_1\times9.8\times A\times\ell_1+m_2\times9.8\times A\times(\ell_1+\ell_2)+m_3\times9.8\times A\times(\ell_1+\ell_3)$

=427838.99N-mm

From equation (b), during uniform motion

M_{m2}' $=m_1\times9.8\times\ell_1+m_2\times9.8\times(\ell_1+\ell_2)+m_3\times(\ell_1+\ell_3)$

=412972N-mm

From equation (c), during deceleration

M_{m3}' $=m_1\times9.8\times B\times\ell_1+m_2\times9.8\times B\times(\ell_1+\ell_2)+m_3\times9.8\times B\times(\ell_1+\ell_3)$

=398105.01N-mm

- During descent (with a work loaded)

From equation (c), during acceleration

M_{m1}'' $=M_{m1}+m_4\times9.8\times B\times(\ell_1+\ell_3)$

=565433.83N-mm

From equation (b), during uniform motion

M_{m2}'' $=M_{m2}+m_4\times9.8\times(\ell_1+\ell_3)$

=586549.6N-mm

From equation (a), during deceleration

M_{m3}'' $=M_{m3}+m_4\times9.8\times A\times(\ell_1+\ell_3)$

=607665.37N-mm

- During ascent (with a work loaded)

From equation (a), during acceleration

M_{m1}''' $=M_{m1}'+m_4\times9.8\times A\times(\ell_1+\ell_3)$

=607665.37N・mm

From equation (b), during uniform motion

M_{m2}''' $=M_{m2}'+m_4\times9.8\times(\ell_1+\ell_3)$

=586549.6N-mm

From equation (c), during deceleration

M_{m3}''' $=M_{m3}'+m_4\times9.8\times B\times(\ell_1+\ell_3)$

=565433.83N-mm

$\therefore M_1=M_{m1}=M_{m3}'$=398105.01N-mm

$M_2=M_{m2}=M_{m2}'$=412972N-mm

$M_3=M_{m3}=M_{m1}'$=427838.99N-mm

$M_1'=M_{m1}''=M_{m3}'''$=565433.83N-mm

$M_2'=M_{m2}''=M_{m2}'''$=586549.6N-mm

$M_3'=M_{m3}''=M_{m1}'''$=607665.37N-mm

■Calculating the Equivalent Radial Load Considered to be Applied to the Spline Nut with Different Moments

Relational expression between moment M_n and P_n

$$\mathbf{P_n = M_n \times K} \qquad \cdots\cdots\cdots(d)$$

P_n	: Equivalent radial load	(N)
M_n	: Applied moment	(N-mm)
K	: Equivalent factor (from Table9 to A-471) (If two spline nuts of LBF60 contact with each other, K = 0.013)	

Calculate the equivalent radial load with different applied moments using equation (d).

$P_{m1} = P_{m3}' = M_1 \times 0.013 \fallingdotseq 5175.4\text{N}$

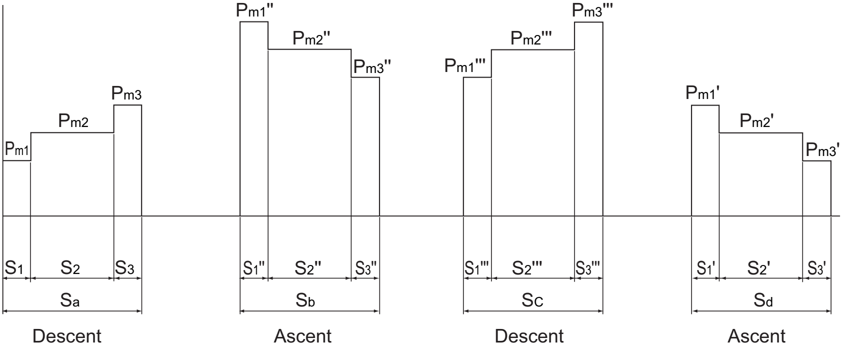
$P_{m2} = P_{m2}' = M_2 \times 0.013 \fallingdotseq 5368.6\text{N}$

$P_{m3} = P_{m1}' = M_3 \times 0.013 \fallingdotseq 5561.9\text{N}$

$P_{m1}'' = P_{m3}''' = M_1' \times 0.013 \fallingdotseq 7350.7\text{N}$

$P_{m2}'' = P_{m2}''' = M_2' \times 0.013 \fallingdotseq 7625.2\text{N}$

$P_{m3}'' = P_{m1}''' = M_3' \times 0.013 \fallingdotseq 7899.7\text{N}$



$$\begin{cases} P_1 = P_{m1} = P_{m3}' \fallingdotseq 5175.4\text{N} \\ P_2 = P_{m2} = P_{m2}' \fallingdotseq 5368.6\text{N} \\ P_3 = P_{m3} = P_{m1}' \fallingdotseq 5561.9\text{N} \end{cases} \quad \begin{cases} P_4 = P_{m1}'' = P_{m3}''' \fallingdotseq 7350.7\text{N} \\ P_5 = P_{m2}'' = P_{m2}''' \fallingdotseq 7625.2\text{N} \\ P_6 = P_{m3}'' = P_{m1}''' \fallingdotseq 7899.7\text{N} \end{cases} \quad \begin{cases} S = S_a = S_b = S_c = S_d = 700\text{mm} \\ S_1 = S_1 = S_1' = S_1'' = S_1''' = 87.5\text{mm} \\ S_2 = S_2 = S_2' = S_2'' = S_2''' = 525\text{mm} \\ S_3 = S_3 = S_3' = S_3'' = S_3''' = 87.5\text{mm} \end{cases}$$

■Calculating the Average Load P_m

Using equation (1) on A-469,

$$P_m = \sqrt[3]{\frac{1}{4 \times S} \left[2\{(P_1^3 \times S_1) + (P_2^3 \times S_2) + (P_3^3 \times S_3)\} + 2\{(P_4^3 \times S_3) + (P_5^3 \times S_2) + (P_6^3 \times S_1)\} \right]}$$

$$\fallingdotseq 6689.5\text{N}$$

■Calculating the Rated Life L from the Average Load

Using equation (8) on A-465,

$$L = \left(\frac{f_T \cdot f_C}{f_W} \cdot \frac{C}{P_m} \right)^3 \times 50$$

$$= 7630\text{km}$$

f_T	: Temperature factor = 1	(from Fig.1 on A-467)
f_C	: Contact factor=0.81	(from Table5 on A-467)
f_W	: Load factor=1.5	(from Table6 on A-467)
C	: Basic dynamic load rating = 66.2 kN	(model LBF60)

Given the result above, the nominal life of model LBF60 with double spline nuts used in close contact with each other is 7,630 km.

Selecting a Preload

A preload on the Ball Spline significantly affects its accuracy, load resistance and rigidity. Therefore, it is necessary to select the most appropriate clearance according to the intended use.
Specific clearance values are standardized for each model, allowing you to select a clearance that meets the conditions.

Clearance in the Rotation Direction

With the Ball Spline, the sum of clearances in the circumferential direction is standardized as the clearance in the rotational direction. For models LBS and LT, which are especially suitable for transmission of rotational torque, clearances in the rotational directions are defined.

Clearance in the rotational direction (BCD)

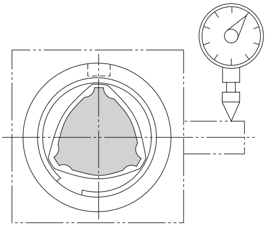
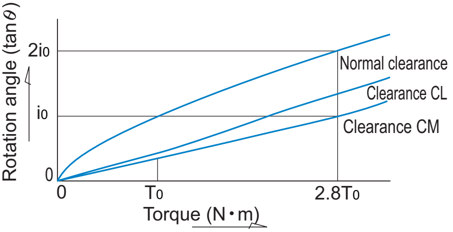


Fig.7 Measurement of Clearance in the Rotational Direction

Preload and Rigidity

Preload is defined as the load preliminarily applied to the ball in order to eliminate angular backlash (clearance in the rotational direction) and increase rigidity. When given a preload, the Ball Spline is capable of increasing its rigidity by eliminating the angular backlash according to the magnitude of the preload. Fig.8 shows the displacement in the rotational direction when a rotational torque is applied.
Thus, the effect of a preload can be obtained up to 2.8 times that of the applied preload. When given the same rotational torque, the displacement when a preload is applied is 0.5 or less of that without a preload. The rigidity with a preload is at least twice greater than that without a preload.



To: Applied preload

Fig.8

Conditions and Guidelines for Selecting of a Preload

Table11 provides guidelines for selecting a clearance in the rotational direction with given conditions of the Ball Spline.

The rotational clearance of the Ball Spline significantly affects the accuracy and rigidity of the spline nut. Therefore, it is essential to select a correct clearance according to the intended use. Generally, the Ball Spline is provided with a preload. When it is used in repeated circular motion or reciprocating straight motion, the Ball Spline is subject to a large vibration impact, and therefore, its service life and accuracy are significantly increased with a preload.

Table11 Guidelines for Selecting a Clearance in the Rotational Direction for the Ball Spline

Clearance in the rotation direction	Condition	Examples of applications
Normal grade (No symbol)	● Smooth motion with a small force is desired. ● A torque is always applied in the same direction.	• Measuring instruments • Automatic drafting machine • Geometrical measuring equipment • Dynamometer • Wire winder • Automatic welding machine • Main shaft of horning machine • Automatic packing machine
Light preload (CL)	● An overhang load or moment load is present. ● High positioning accuracy is required. ● Alternating load is applied.	• Industrial robot arm • Automatic loaders • Guide shaft of automatic coating machine • Main shaft of electric discharge machine • Guide shaft for press die setting • Main shaft of drilling machine
Medium preload (CM)	● High rigidity is required and vibrations and impact are applied. ● Receives a moment load with a single spline nut.	• Steering shaft of construction vehicle • Shaft of spot-welding machine • Indexing shaft of automatic lathe tool rest

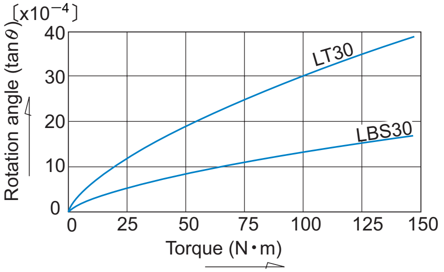


Fig.9 Comparison between LBS and LT for Zero Clearance

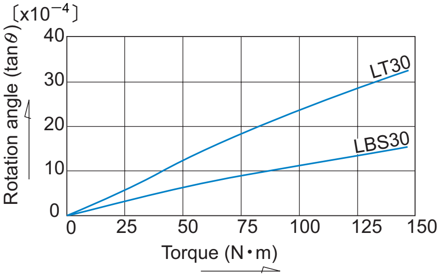


Fig.10 Comparison between LBS and LT for Clearance CL

Table12 Clearance in the Rotational Direction for Models LBS, LBF, LBST, LBR and LBH Unit: μm

Symbol	Normal	Light preload	Medium preload
Nominal shaft diameter	No Symbol	CL	CM
6 8	−2 to +1	−6 to −2	—
10 15	−3 to +2	−9 to −3	−15 to −9
20 25 30	−4 to +2	−12 to −4	−20 to −12
40 50 60	−6 to +3	−18 to −6	−30 to −18
70 85	−8 to +4	−24 to −8	−40 to −24
100 120	−10 to +5	−30 to −10	−50 to −30
150	−15 to +7	−40 to −15	−70 to −40

Table13 Clearance in the Rotational Direction for Models LT and LF Unit: μm

Symbol	Normal	Light preload	Medium preload
Nominal shaft diameter	No Symbol	CL	CM
4 5 6 8 10 13	−2 to +1	−6 to −2	—
16 20	−2 to +1	−6 to −2	−9 to −5
25 30	−3 to +2	−10 to −4	−14 to −8
40 50	−4 to +2	−16 to −8	−22 to −14
60 80	−5 to +2	−22 to −12	−30 to −20
100	−6 to +3	−26 to −14	−36 to −24

Table14 Clearance in the Rotational Direction for Models LBG and LBGT Unit: μm

Symbol	Normal	Light preload	Medium preload
Nominal shaft diameter	No Symbol	CL	CM
20 25 30	−4 to +2	−12 to −4	−20 to −12
40 50 60	−6 to +3	−18 to −6	−30 to −18
70 85	−8 to +4	−24 to −8	−40 to −24

Table15 Clearance in the Rotational Direction for Model LTR Unit: μm

Symbol	Normal	Light preload	Medium preload
Nominal shaft diameter	No Symbol	CL	CM
8 10	−2 to +1	−6 to −2	—
16 20	−2 to +1	−6 to −2	−9 to −5
25 32	−3 to +2	−10 to −4	−14 to −8
40 50	−4 to +2	−16 to −8	−22 to −14
60	−5 to +2	−22 to −12	−30 to −20

Determining the Accuracy

Accuracy Grades

The accuracy of the Ball Spline is classified into three grades: normal grade (no symbol), high accuracy grade (H) and precision grade (P), according to the runout of spline nut circumference in relation to the support of the spline shaft. Fig.11 shows measurement items.

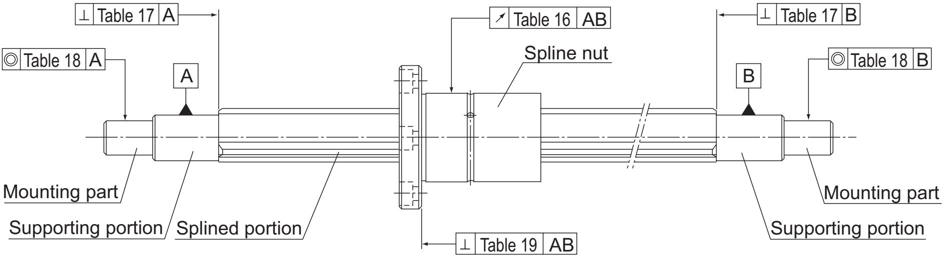


Fig.11 Accuracy Measurement Items of the Ball Spline

Accuracy Standards

Table16 to Table19 show measurement items of the Ball Spline.

Table16 Runout of the Spline Nut Circumference in Relation to the Support of the Spline Shaft Unit: µm

Accuracy		Runout(max)																							
Nominal shaft diameter Overall spline shaft length (mm)		4 to 8 Note			10			13 to 20			25 to 32			40, 50			60 to 80			85 to 120			150		
Above	Or less	Normal	Upper	Precision	Normal	Upper	Precision	Normal	Upper	Precision	Normal	Upper	Precision	Normal	Upper	Precision	Normal	Upper	Precision	Normal	Upper	Precision	Normal	Upper	Precision
—	200	72	46	26	59	36	20	56	34	18	53	32	18	53	32	16	51	30	16	51	30	16	—	—	—
200	315	133	(89)	—	83	54	32	71	45	25	58	39	21	58	36	19	55	34	17	53	32	17	—	—	—
315	400	—	—	—	103	68	—	83	53	31	70	44	25	63	39	21	58	36	19	55	34	17	—	—	—
400	500	—	—	—	123	—	—	95	62	38	78	50	29	68	43	24	61	38	21	57	35	19	46	36	19
500	630	—	—	—	—	—	—	112	—	—	88	57	34	74	47	27	65	41	23	60	37	20	49	39	21
630	800	—	—	—	—	—	—	—	—	—	103	68	42	84	54	32	71	45	26	64	40	22	53	43	24
800	1000	—	—	—	—	—	—	—	—	—	124	83	—	97	63	38	79	51	30	69	43	24	58	48	27
1000	1250	—	—	—	—	—	—	—	—	—	—	—	—	114	76	47	90	59	35	76	48	28	63	55	32
1250	1600	—	—	—	—	—	—	—	—	—	—	—	—	139	93	—	106	70	43	86	55	33	80	65	40
1600	2000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	128	86	54	99	65	40	100	80	50
2000	2500	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	156	—	—	117	78	49	125	100	68
2500	3000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	143	96	61	150	129	84

Note) Dimensions in parentheses do not apply to nominal shaft diameter of 4.
Note) Applicable to models LBS, LBST, LBF, LBR, LT and LF.

Table17 Perpendicularity of the Spline Shaft End Face in Relation to the Support of the Spline Shaft Unit: μm

Accuracy	Perpendicularity (max)		
Nominal shaft diameter	Normal grade (No symbol)	High accuracy grade (H)	Precision Grade (P)
4 5 6 8 10	22	9	6
13 15 16 20	27	11	8
25 30 32	33	13	9
40 50	39	16	11
60 70 80	46	19	13
85 100 120	54	22	15
150	63	25	18

Table18 Concentricity of the Part-mounting in Relation to the Support of the Spline Shaft Unit: μm

Accuracy	Concentricity (max)		
Nominal shaft diameter	Normal grade (No symbol)	High accuracy grade (H)	Precision Grade (P)
4 5 6 8	33	14	8
10	41	17	10
13 15 16 20	46	19	12
25 30 32	53	22	13
40 50	62	25	15
60 70 80	73	29	17
85 100 120	86	34	20
150	100	40	23

Table19 Straightness of the Flange-mounting Surface of the Spline Nut in Relation to the Support of the Spline Shaft
Unit: μm

Accuracy	Perpendicularity (max)		
Nominal shaft diameter	Normal grade (No symbol)	High accuracy grade (H)	Precision Grade (P)
6 8	27	11	8
10 13	33	13	9
15 16 20 25 30	39	16	11
40 50	46	19	13
60 70 80 85	54	22	15
100	63	25	18

Note) This table does not apply to models LBG, LBGT, LTR and LTR-A.

High Torque Type Ball Spline

Models LBS, LBF, LBH, LBST and LBR

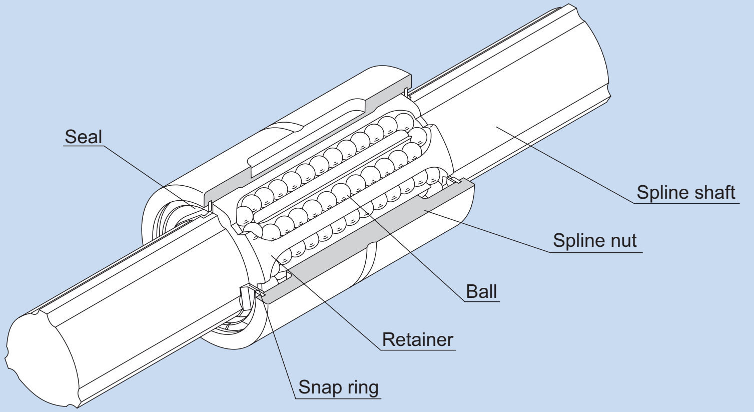


Fig.1 Structure of High Torque Type Ball Spline Model LBS

Structure and Features

With the high torque type Ball Spline, the spline shaft has three crests positioned equidistantly at 120°, and along both sides of each crest, two rows of balls (six rows in total) are arranged so as to hold the crest, as shown in Fig.1.

The raceways are precision ground into R-shaped grooves whose diameters are approximate to the ball diameter. When a torque is generated from the spline shaft or the spline nut, the three rows of balls on the load-bearing side evenly receive the torque, and the center of rotation is automatically determined. When the rotation reverses, the remaining three rows of balls on the unloaded side receive the torque.

The rows of balls are held in a retainer incorporated in the spline nut so that they smoothly roll and circulate. With this design, balls will not fall even if the spline shaft is removed from the nut.

[No Angular Backlash]

With the high torque type Ball Spline, a single spline nut provides a preload to eliminate angular backlash and increase the rigidity.

Unlike conventional ball splines with circular-arc groove or Gothic-arch groove, the high torque type Ball Spline eliminates the need for twisting two spline nuts to provide a preload, thus allowing compact design to be achieved easily.

[High Rigidity and Accurate Positioning]

Since this model has a large contact angle and provides a preload from a single spline nut, the initial displacement is minimal and high rigidity and high positioning accuracy are achieved.

[High-speed Motion, High-speed Rotation]

Adoption of a structure with high grease retention and a rigid retainer enables the ball spline to operate over a long period with grease lubrication even in high-speed straight motion. Since the distance in the radius direction is almost uniform between the loaded balls and the unloaded balls, the balls are little affected by the centrifugal force and smooth straight motion is achieved even during high-speed rotation.

[Compact Design]

Unlike conventional ball splines, unloaded balls do not circulate on the outer surface of the spline nut with this model. As a result, the outer diameter of the spline nut is reduced and a space-saving and compact design is achieved.

[Ball Retaining Type]

Use of a retainer prevents the balls from falling even if the spline shaft is pulled out of the spline nut.

[Can be Used as a Linear Bushing for Heavy Loads]

Since the raceways are machined into R grooves whose diameter is almost equal to the ball diameter, the contact area of the ball is large and the load capacity is large also in the radial direction.

[Double, Parallel Shafts can be Replaced with a Single Shaft]

Since a single shaft is capable of receiving a load in the torque direction and the radial direction, double shafts in parallel configuration can be replaced with a single-shaft configuration. This allows easy installation and achieves space-saving design.

Applications

The high torque type Ball Spline is a reliable straight motion system used in a wide array of applications such as the columns and arms of industrial robot, automatic loader, transfer machine, automatic conveyance system, tire forming machine, spindle of spot welding machine, guide shaft of high-speed automatic coating machine, riveting machine, wire winder, work head of electric discharge machine, spindle drive shaft of grinding machine, speed gears and precision indexing shaft.

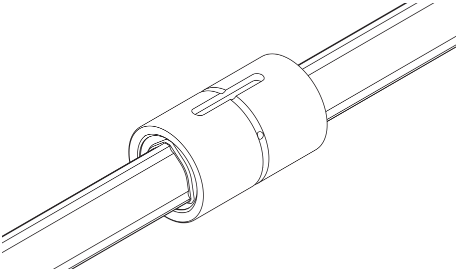
Types and Features

[Types of Spline Nuts]

Cylindrical Type Ball Spline Model LBS (Medium Load Type)

Specification Table⇒B-368

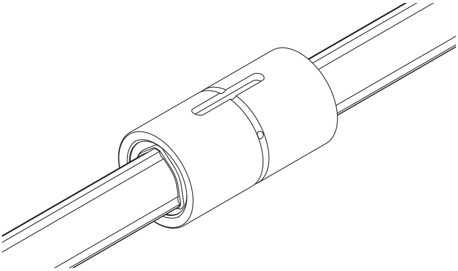
The most compact type with a straight cylindrical spline nut. When transmitting a torque, a key is driven into the body. The outer surface of the spline nut is provided with anti-carbonation treatment.



Cylindrical Type Ball Spline Model LBST (Heavy Load Type)

Specification Table⇒B-372

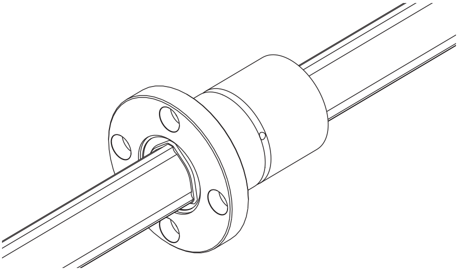
A heavy load type that has the same spline nut diameter as model LBS, but has a longer spline nut length. It is optimal for locations where the space is small, a large torque is applied, and an overhang load or moment load is applied.



Flanged Type Ball Spline Model LBF

Specification Table⇒B-374

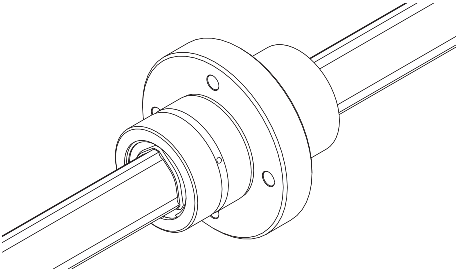
The spline nut can be attached to the housing via the flange, making assembly simple. It is optimal for locations where the housing may be deformed if a keyway is machined on its surface, and where the housing width is small.
Since it allows a dowel pin to be driven into the flange, angular backlash occurring in the fitting can completely be eliminated.



Flanged Type Ball Spline Model LBR

Specification Table⇒B-376

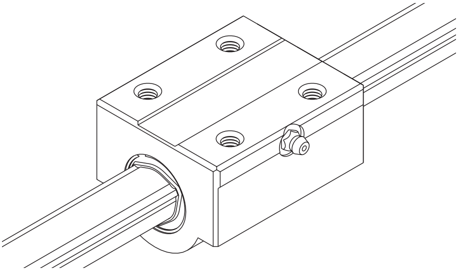
Based on the heavy load type model LBST, this model has a flange in the central area, making itself optimal for locations under a moment load such as arms of industrial robots.



Rectangular Type Ball Spline Model LBH

Specification Table⇒B-378

Its rigid rectangular spline nut does not require a housing and can be directly mounted on the machine body. Thus, a compact, highly rigid linear guide system is achieved.



Precision Solid Spline Shaft (Standard Type)

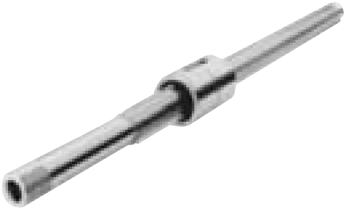
The spline shaft is cold-drawn and its raceway is precision ground. It is used in combination with a spline nut.

Special Spline Shaft

THK manufactures a spline shaft with thicker ends or thicker middle area through special processing at your request.

Hollow Spline Shaft (Type K)

A drawn, hollow spline shaft is available for requirements such as piping, wiring, air-vent and weight reduction.



Service Life

For details,see A-465.

Clearance in the Rotation Direction

For details,see A-481.

Accuracy Standards

For details,see A-482.

Housing Inner-diameter Tolerance

When fitting the Ball Spline with the housing, tight fitting is normally recommended. If the accuracy of the Ball Spline does not need to be very high, clearance fitting is also acceptable.

Table1 Housing Inner-diameter Tolerance

Housing Inner-diameter Tolerance	General conditions	H7
	When clearance needs to be small	J6

Spline Shaft

Spline shafts are divided in shape into precision solid spline shaft, special spline shaft and hollow spline shaft (type K), as described on A-488.
For details, see B-381 to B-383.

Accessories

Ball Spline models LBS and LBST are provided with a standard key.
For detailed dimensions, see B-384.

Medium Torque Type Ball Spline

Models LT and LF

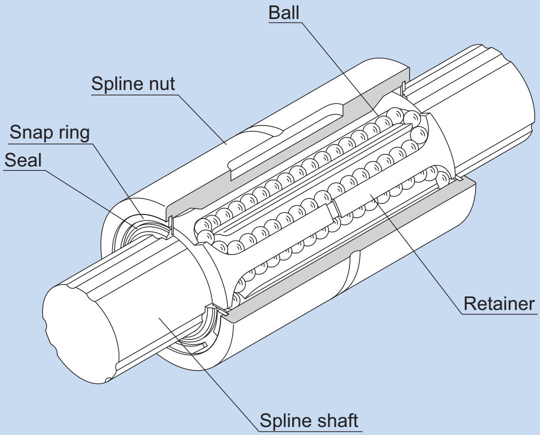


Fig.1 Structure of Medium Torque Type Ball Spline Model LT

Structure and Features

With the medium torque type Ball Spline, the spline shaft has two to three crests on the circumference, and along both sides of each crest, two rows of balls (four or six rows in total) are arranged to hold the crest so that a reasonable preload is applied.
The rows of balls are held in a special resin retainer incorporated in the spline nut so that they smoothly roll and circulate. With this design, balls will not fall even if the nut is removed from the spline shaft.

[Large Load Capacity]

The raceways are formed into circular-arc grooves approximate to the ball curvature and ensure angular contact. Thus, this model has a large load capacity in the radial and torque directions.

[No Angular Backlash]

Two rows of balls facing one another hold a crest, formed on the circumference of the spline nut, at a contact angle of 20° to provide a preload in an angular-contact structure. This eliminates an angular backlash in the rotational direction and increases the rigidity.

[High Rigidity]

Since the contact angle is large and an appropriate preload is given, high rigidity against torque and moment is achieved.

[Ball Retaining Type]

Use of a retainer prevents the balls from falling even if the spline shaft is pulled out of the spline nut. (except for models LT4 and 5)

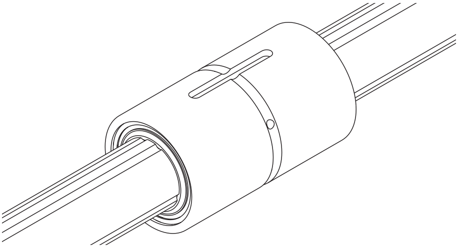
Types and Features

[Types of Spline Nuts]

Cylindrical Type Ball Spline Model LT

Specification Table⇒B-386

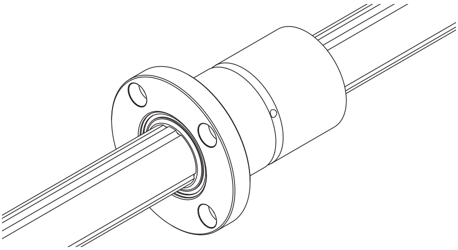
The most compact type with a straight cylindrical spline nut. When transmitting a torque, a key is driven into the body.



Flanged Type Ball Spline Model LF

Specification Table⇒B-388

The spline nut can be attached to the housing via the flange, making assembly simple.
It is optimal for locations where the housing may be deformed if a keyway is machined on its surface, and where the housing width is small.
Since it allows a dowel pin to be driven into the flange, angular backlash occurring in the fitting can completely be eliminated.



dammy

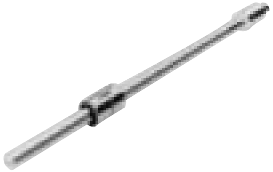
[Types of Spline Shafts]

Precision Solid Spline Shaft (Standard Type)

The raceway of the spline shaft is precision ground. It is used in combination with a spline nut.

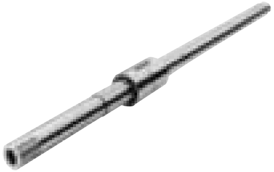
Special Spline Shaft

THK manufactures a spline shaft with thicker ends or thicker middle area through special processing at your request.



Hollow Spline Shaft (Type K)

A drawn, hollow spline shaft is available for requirements such as piping, wiring, air-vent and weight reduction.



Thick

Hollow Spline Shaft (Type N)

A drawn, hollow spline shaft is available for requirements such as piping, wiring, air-vent and weight reduction.

Thin

Service Life

For details,see A-465.

Clearance in the Rotation Direction

For details,see A-481.

Accuracy Standards

For details,see A-482.

Housing Inner-diameter Tolerance

When fitting the Ball Spline with the housing, tight fitting is normally recommended. If the accuracy of the Ball Spline does not need to be very high, clearance fitting is also acceptable.

Table1 Housing Inner-diameter Tolerance

Housing Inner-diameter Tolerance	General conditions	H7
	When clearance needs to be small	J6

Spline Shaft

Spline shafts are divided in shape into precision solid spline shaft, special spline shaft and hollow spline shaft (types K and N), as described on A-493.
For details, see B-391 to B-392.

Accessories

Ball Spline model LT is provided with a standard key.
For detailed dimensions, see B-393.

Rotary Ball Spline

With Geared type

Models LBG and LBGT

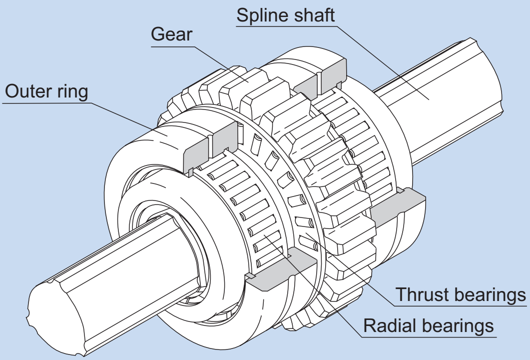


Fig.1 Structure of Rotary Ball Spline Model LBG

Structure and Features

With the Rotary Ball Spline, the spline shaft has three crests, and along both sides of each crest, two rows of balls (six rows in total) are arranged to hold the crest so that a reasonable preload is applied. These models are unit types based on model LBR, but have gear teeth on the flange circumference and radial and thrust bearings on the spline nut, all compactly integrated.

The rows of balls are held in a special resin retainer so that they smoothly roll and circulate. With this design, balls will not fall even if the spline shaft is removed.

[No Angular Backlash]

The spline shaft has three crests positioned equidistantly at 120° and along both sides of each crest, two rows of balls (six rows in total) are arranged so as to hold the crest at a contact angle of 45° and provide a preload. As a result, backlash in the rotational direction is eliminated and the rigidity is increased.

[Compact Design]

The spline nut is compactly integrated with radial and thrust bearings, allowing compact design to be achieved.

[High Rigidity]

Since the contact angle is large and an appropriate preload is given, high rigidity against torque and moment is achieved.

Use of needle bearings in the support unit achieves a rigid nut support strong against a radial load.

[Optimal for Torque Transmission with Spline Nut Drive]

Since the support bearings allow a rigid nut support, these models are optimal for torque transmission with spline nut drive.

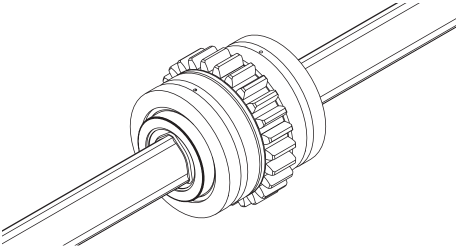
Types and Features

[Types of Spline Nuts]

Ball Spline with Gears Model LBG

Specification Table⇒B-396

These models are unit types based on model LBR, but have gear teeth on the flange circumference and radial and thrust bearings on the spline nut, all compactly integrated. It is optimal for a torque transmission mechanism with spline nut drive.

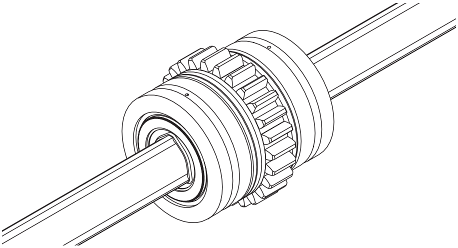


Without a thrust raceway

Ball Spline with Gears Model LBGT

Specification Table⇒B-398

These models are unit types based on model LBR, but have gear teeth on the flange circumference and radial and thrust bearings on the spline nut, all compactly integrated. It is optimal for a torque transmission mechanism with spline nut drive.



With a thrust raceway

[Types of Spline Shafts]

For details,see A-488.

Service Life

For details,see A-465.

Clearance in the Rotation Direction

For details,see A-481.

Accuracy Standards

For details,see A-482.

Housing Inner-diameter Tolerance

Table1 shows housing inner-diameter tolerance for models LBG and LBGT.

Table1 Housing Inner-diameter Tolerance

Housing Inner-diameter Tolerance	General conditions	H7
	When clearance needs to be small	J6

Spline Shaft

Spline shafts are divided in shape into precision solid spline shaft, special spline shaft and hollow spline shaft (type K), as described on A-488.
For details, see B-400 to B-401.

Rotary Ball Spline
With Support Bearing Type

Models LTR and LTR-A

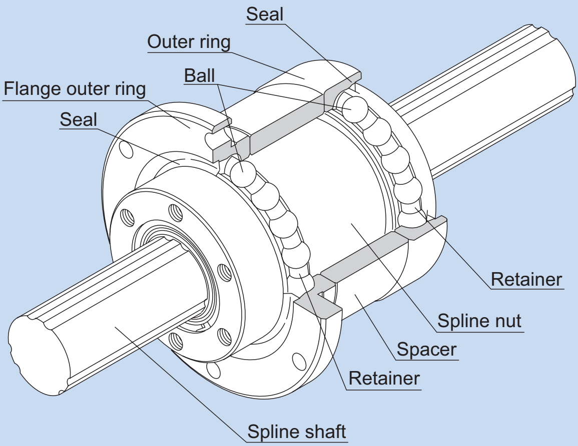


Fig.1 Structure of Rotary Ball Spline Model LTR

Structure and Features

With the Rotary Ball Spline model LTR, the spline shaft has three crests on the circumference, and along both sides of each crest, two rows of balls (six rows in total) are arranged to hold the crest so that a reasonable preload is applied.
Angular-contact ball raceways are machined on the outer surface of the spline nut to constitute support bearings, allowing the whole body to be compactly and lightly designed.
The rows of balls are held in a special resin retainer so that they smoothly roll and circulate. With this design, balls will not fall even if the spline shaft is removed.
In addition, a dedicated seal for preventing foreign material from entering the support bearings is available.

[No Angular Backlash]

Two rows of balls facing one another hold a crest, formed on the circumference of the spline nut, at a contact angle of 20° to provide a preload in an angular-contact structure. This eliminates an angular backlash in the rotational direction and increases the rigidity.

[Compact Design]

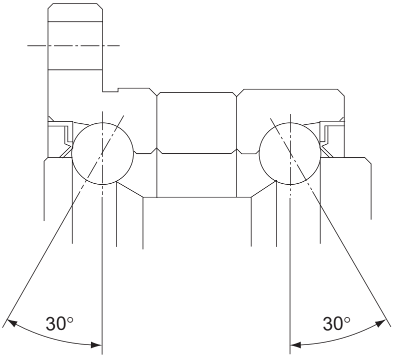
The spline nut is integrated with the support bearings, allowing highly accurate, compact design to be achieved.

[Easy Installation]

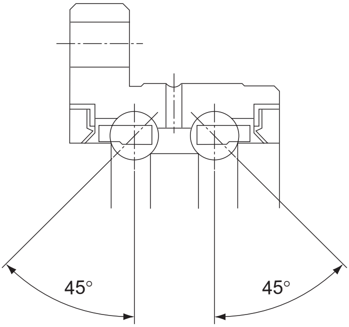
This ball spline can easily be installed by simply securing it to the housing using bolts.

[High Rigidity]

Since the contact angle is large and an appropriate preload is given, high rigidity against torque and moment is achieved.
The support bearing has a contact angle of 30° to secure high rigidity against a moment load, thus to achieve a rigid shaft support.
Model LTR-A, a compact type of LTR, has a contact angle of 45° .



Model LTR



Model LTR-A

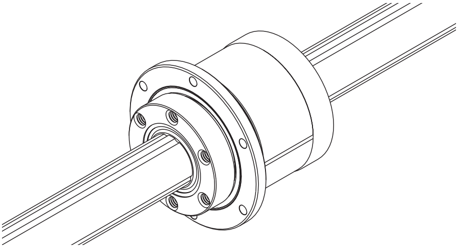
Types and Features

[Types of Spline Nuts]

Ball Spline Model LTR

Specification Table⇒B-406

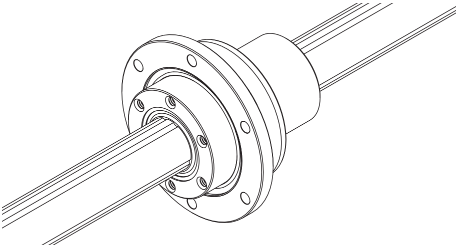
A compact unit type whose support bearings are directly integrated with the outer surface of the spline nut.



Ball Spline Model LTR-A

Specification Table⇒B-404

A compact type even smaller than LTR.



[Types of Spline Shafts]

For details,see A-493.

Service Life

For details,see A-465.

Clearance in the Rotation Direction

For details,see A-481.

Accuracy Standards

For details,see A-482.

Housing Inner-diameter Tolerance

For the housing inner-diameter tolerance for model LTR, class H7 is recommended.

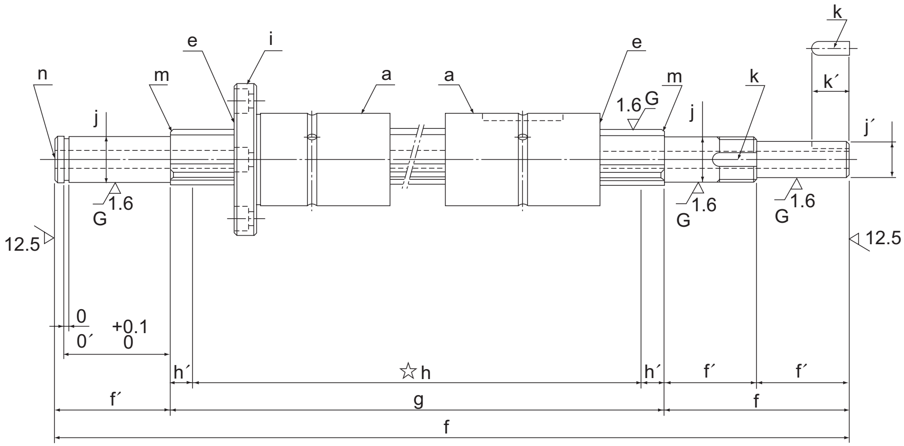
Spline Shaft

Spline shafts are divided in shape into precision solid spline shaft, special spline shaft and hollow spline shaft (types K and N), as described on A-493.
For details, see B-408 to B-409.

Checking List for Spline Shaft End Shape

If desiring a ball spline type with its end specially machined, check the following items when placing an order.

The diagram below shows a basic configuration of the Ball Spline.



[Check Items]

- a. Type of the spline nut to be fit
- b. Number of spline nuts
- c. Clearance in the rotation direction
- d. Accuracy
- e. With/without a seal (for a single seal, check its orientation)
- f. Overall length (including all dimensions? Total value correct?)
- g. Effective spline length
- h. Hardened area (mark the location with symbol ☆ and indicate the purpose of hardening)
- i. Orientation of the flange (for flanged type)
- j. Spline shaft end shape (thicker than the minimum spline diameter?) (black, mill scale)
- k. Positional relationship between the spline nut and the spline shaft end shape (keyway of the spline nut, flange mounting hole)
- l. Indication of chamfering for each part
- m. Shape of chamfer on the spline shaft end (see B-382)
- n. Intended purpose of the though hole in the spline shaft if any
- o. o'. Snap ring groove
- p. Maximum length
- q. Precedented or not

Housing Inner-diameter Tolerance

When fitting the spline nut with the housing, tight fitting is normally recommended. If the accuracy of the Ball Spline does not need to be very high, clearance fitting is also acceptable.

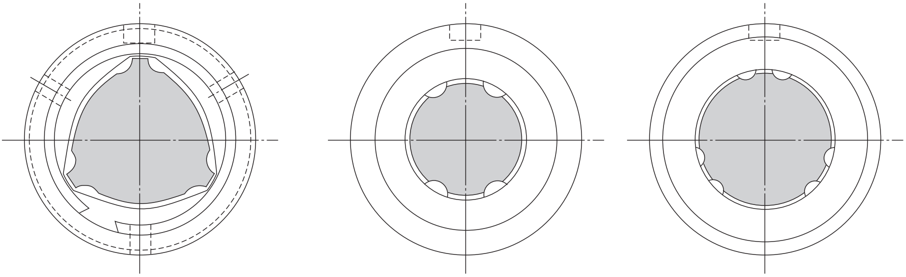
Table1 Housing Inner-diameter Tolerance

Housing Inner-diameter Tolerance	General conditions	H7
	When clearance needs to be small	J6

Note) For the housing inner-diameter tolerance of Rotary Ball Spline model LTR, H7 is recommended.

Positions of the Spline-nut Keyway and Mounting Holes

The keyways formed on the outer surface of straight nuts for Ball Spline models are positioned where balls under a load are placed as shown in Fig.1.
The flange-mounting holes of the flange types are positioned as shown in Fig.2.
When placing an order, indicate their positions in relation to the keyway or the like to be formed on the spline shaft.



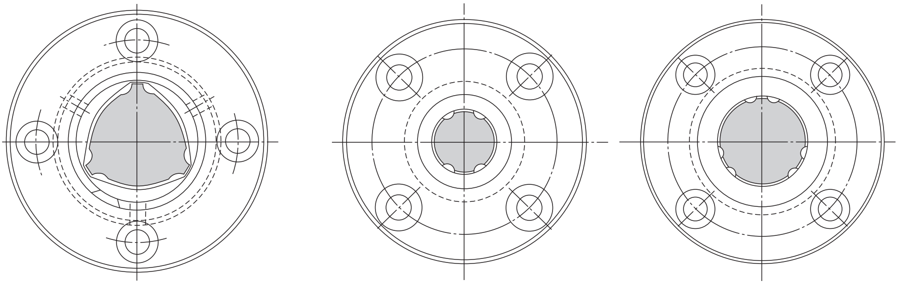
Model LT13 or smaller

Model LT16 or greater

Model LBS

Model LT

Fig.1 Positions of Keyways



Model LF13 or smaller

Model LF16 or greater

Model LBF

Model LF

Fig.2 Positions of Flange Mounting Holes

Assembling the Ball Spline

Mounting the Spline

Fig.1 and Fig.2 shows examples of mounting the spline nut. Although the Ball Spline does not require a large strength for securing it in the spline shaft direction, do not support the spline only with driving fitting.

Straight nut type

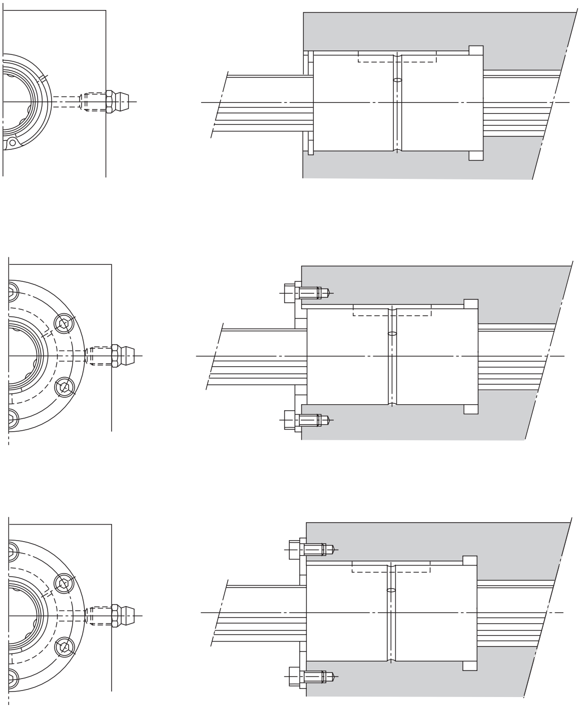
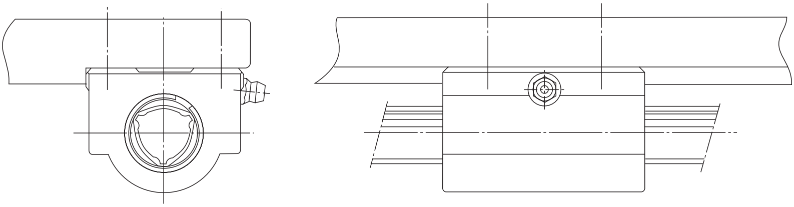
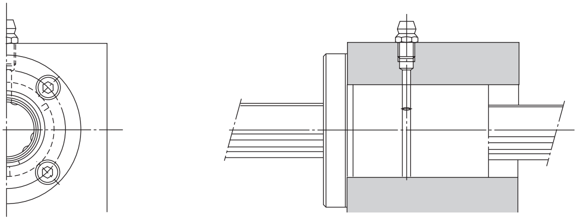


Fig.1 Examples of Fitting the Spline Nut

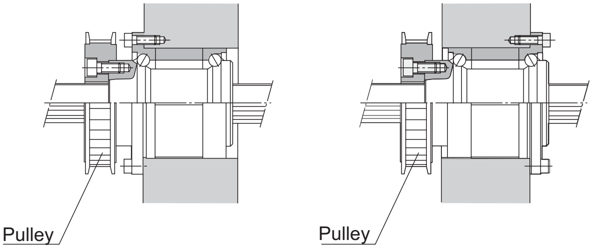
Model LBH



Flanged type



Model LTR



Model LBG

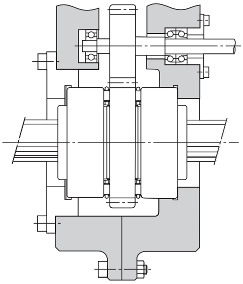


Fig.2 Examples of Fitting the Spline Nut

Installing the Spline Nut

When installing the spline nut into the housing, do not hit the side plate or the seal, but gently insert it using a jig (Fig.3).

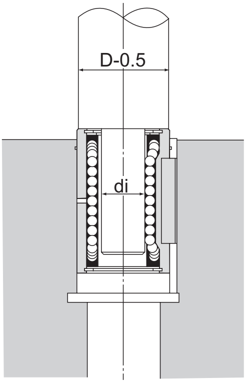


Fig.3

Table1 Dimensions of the Jig for Model LBS

Unit: mm

Nominal shaft diameter	15	20	25	30	40	50	60	70	85	100	120	150
di	12.5	16.1	20.3	24.4	32.4	40.1	47.8	55.9	69.3	83.8	103.8	131.8

Table2 Dimensions of the Jig for Model LT

Unit: mm

Nominal shaft diameter	6	8	10	13	16	20	25	30	40	50	60	80	100
di	5.0	7	8.5	11.5	14.5	18.5	23	28	37.5	46.5	56	75.5	94.5

Installation of the Spline Shaft

When installing the spline shaft into the spline nut, identify the matching marks (Fig.4) on the spline shaft and the spline nut, and then insert the shaft straightforward while checking their relative positions.

Note that forcibly inserting the shaft may cause balls to fall off.

If the spline nut is attached with a seal or given a preload, apply a lubricant to the outer surface of the spline shaft.

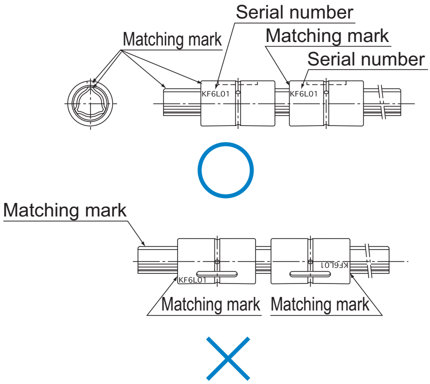


Fig.4

Lubrication

To prevent foreign material from entering the spline nut and the lubricant from leaking, special synthetic resin seals with high wear resistance are available for the Ball Spline.

Spline nuts with seals (seal for both ends type UU, and seal for one end) contain high-quality lithium-soap group grease No. 2. However, if using them at high speed or with a long stroke, replenish grease of the same type through the greasing hole on the spline nut after running in.

Afterward, replenish grease of the same type as necessary according to the service conditions.

The greasing interval differs depending on the conditions. Normally, replenish the lubricant (or replace the product) roughly every 100 km of travel distance (six months to one year) as a rule of thumb.

For a Ball Spline model type without a seal, apply grease to the interior of the spline nut or to the raceways of the spline shaft.

Material and Surface Treatment

Depending on the service environment, the Ball Spline requires anticorrosive treatment or a different material. For details of anticorrosive treatment and material change, contact THK.

Contamination Protection

Entrance of dust or other foreign material into the spline nut will cause abnormal wear or shorten the service life. Therefore, it is necessary to prevent detrimental foreign material from entering the Ball Spline. When entrance of dust or other foreign material is predicted, it is important to select an effective sealing device or dust-control device that meets the environment conditions.

For the Ball Spline, a special synthetic rubber seal that is highly resistant to wear is available as a contamination protection accessory. If desiring a higher contamination protection effect, a felt seal is also available for some types. For details about the felt seal, contact THK.

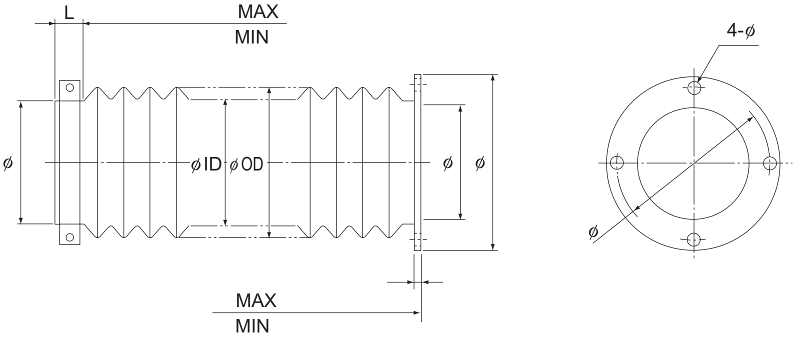
In addition, THK produces round bellows. Contact us for details.

Table1 Contamination protection accessory symbol

Symbol	Contamination protection accessory
No Symbol	Without seal
UU	Rubber seal attached on both ends of spline nut
U	Rubber seal attached on either end of spline nut
DD	Felt seal attached on both ends of spline nut
D	Felt seal attached on either end of spline nut
ZZ	Rubber seal attached on both ends of support bearings
Z	Rubber seal attached on either end of support bearings

Specifications of the Bellows

Bellows are available as a contamination protection accessory. Use this specification sheet.



(Band type) (Flange type)

Specifications of the Bellows

Supported Ball Screw models:

Dimensions of the Bellows

Stroke:( ) mm MAX:( ) mm MIN:( ) mm

Permissible outer diameter:(ϕOD) Desired inner diameter:(ϕID)

How It Is Used

Installation direction:(horizontal, vertical, slant) Speed: ( )mm/sec. min.

Motion:(reciprocation, vibration)

Conditions

Resistance to oil and water: (necessary, unnecessary) Oil name ( )

Chemical resistance: Name ( ) × ( ) %

Location: (indoor, outdoor)

Remarks:

Number of Units To Be Manufactured:

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.
(2) Tilting a spline nut or spline shaft may cause them to fall by their own weight.
(3) Dropping or hitting the Ball Spline may damage it. Giving an impact to the product could also cause damage to its function even if the product looks intact.

[Lubrication]

(1) Thoroughly remove anti-rust oil and feed lubricant before using the product.
(2) Do not mix lubricants of different physical properties.
(3) In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, normal lubricants may not be used. Contact THK for details.
(4) When planning to use a special lubricant, contact THK before using it.
(5) When adopting oil lubrication, the lubricant may not be distributed throughout the product depending on the mounting orientation of the system. Contact THK for details.
(6) Lubrication interval varies according to the conditions. Contact THK for details.

[Precautions on Use]

(1) Entrance of foreign material may cause damage to the ball circulating component or functional loss. Prevent foreign material, such as dust or cutting chips, from entering the system.
(2) Contact THK if you desire to use the product at a temperature of 80℃ or higher.
(3) When planning to use the product in an environment where the coolant penetrates the spline nut, it may cause trouble to product functions depending on the type of the coolant. Contact THK for details.
(4) If foreign material adheres to the product, replenish the lubricant after cleaning the product.
(5) When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, contact THK in advance.
(6) Do not remove the spline nut from the spline shaft unnecessarily. If you inevitably reassemble the product, check the relative positions of the spline nut and the spline shaft by identifying the matching marks on them. Be sure not to twist the spline nut and the spline shaft when inserting the shaft into the nut. Forcibly inserting it may cause balls to fall. For a type equipped with seals, apply a lubricant to the circumference of the shaft.
(7) When installing the spline shaft into the housing, do not hit the seal section or the stop ring section. Doing so may cause malfunction.
(8) Giving a shock to the product may cause a functional loss. Do not drop the product or hit it with a tool.
(9) Take care not to let the spline nut run on the incomplete spline section. Doing so may cause malfunction.

[Storage]

When storing the Ball Spline, enclose it in a package designated by THK and store it in a horizontal orientation while avoiding high temperature, low temperature and high humidity. If the product is stored in an inappropriate position, the spline shaft could bend.

[Other]

If you have any trouble or question when handling the product, contact THK.

Spline Nut

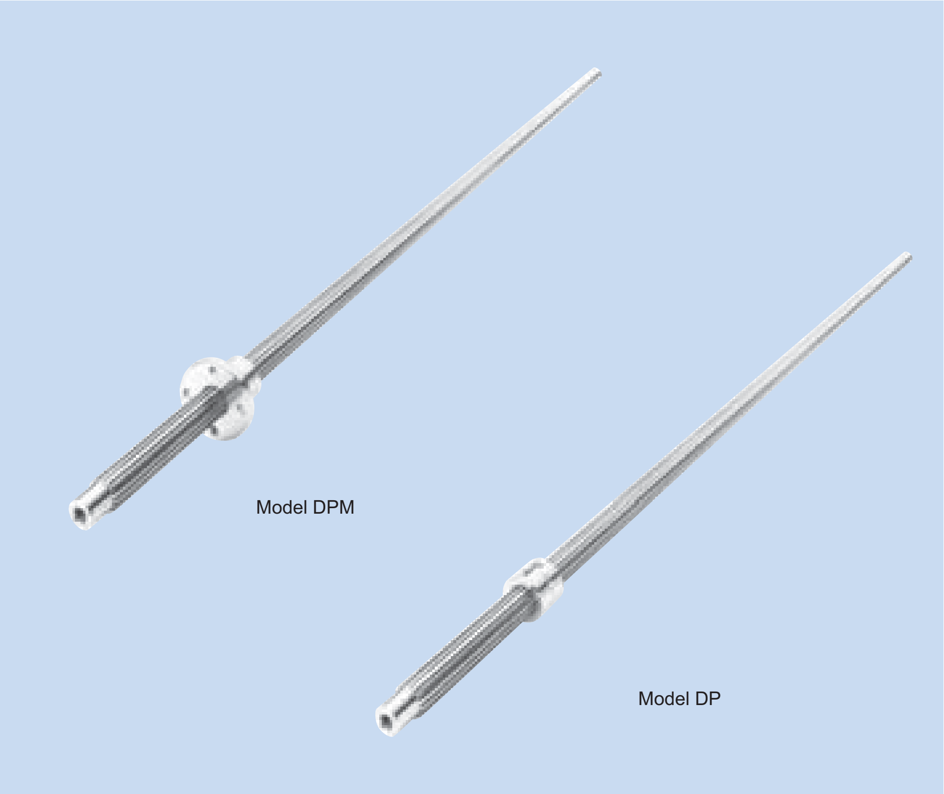
THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Spline Nut



Structure and Features

Spline Nut models DPM and DP are low price bearings that are made of a special alloy (see A-515) formed by die casting and use highly accurate spline shafts as the core. Unlike conventional machined spline nuts, the sliding surface of these models maintains a chill layer formed in the rolling process, thus achieving high wear resistance.

The surface of the spline shafts to be used in combination with the nuts is hardened through rolling and is mirror-finished. Accordingly, smooth sliding motion is achieved.

The specially designed teeth of the spline have large contact areas, as well as concentricity, which enable the shaft to automatically establish the center as a torque is applied. Therefore, the teeth demonstrate stable performance in transmitting a torque.

Features of the Special Rolled Shafts

Dedicated rolled shafts with standardized lengths are available for the Spline Nut.

[Increased Wear Resistance]
The shaft teeth are formed by cold gear rolling, and the surface of the tooth surface is hardened to over 250 HV and mirror-finished. As a result, the shafts are highly wear resistant and achieve significantly smooth motion when used in combination with nuts.

[Improved Mechanical Properties]
Inside the teeth of the rolled shaft, a fiber flow occurs along the contour of the tooth surface of the shaft, making the structure around the teeth roots dense. As a result, the fatigue strength is increased.

[Additional Machining of the Shaft End Support]
Since each shaft is rolled, additional machining of the support bearing of the shaft end can easily be performed by lathing or milling.

High Strength Zinc Alloy

The high strength zinc alloy used in the spline nuts is a material that is highly resistant to seizure and wear and has a high load carrying capacity. Its composition, mechanical properties, physical properties and wear resistance are given below.

[Composition]

Table1 Composition of the High Strength Zinc Alloy

Unit: %

Item	Description
Aℓ	3 to 4
Cu	3 to 4
Mg	0.03 to 0.06
Be	0.02 to 0.06
Ti	0.04 to 0.12
Zn	Remaining portion

[Mechanical Properties]

Item	Description
Tensile strength	275 to 314 N/mm²
Tensile yield strength (0.2%)	216 to 245 N/mm²
Compressive strength	539 to 686 N/mm²
Compressive yield strength (0.2%)	294 to 343 N/mm²
Fatigue strength	132 N/mm² × 10^7 (Schenk bending test)
Charpy impact	0.098 to 0.49 N-m/mm²
Elongation	1 to 5 %
Hardness	120 to 145 HV

[Physical Properties]

Item	Description
Specific gravity	6.8
Specific heat	460 J/ (kg・K)
Melting point	390 ℃
Thermal expansion coefficient	24×10^{-6}

[Wear Resistance]

[Test conditions: Amsler wear-tester]

Item	Description
Test piece rotational speed	185 min^{-1}
Load	392 N
Lubricant	Dynamo oil

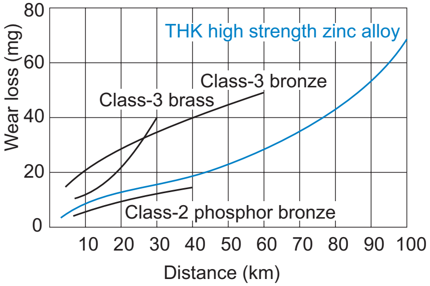


Fig.1 Wear Resistance of the High Strength Zinc Alloy

Clearance in the Rotation Direction

Clearance in the rotational direction: $\alpha \leqq 20'$ MAX

Selecting a Spline Nut

[Dynamic Permissible Torque T and Dynamic Permissible Thrust F]

The dynamic permissible torque (T) and the dynamic permissible thrust (F) are the torque and the thrust at which the contact surface pressure on the tooth surface of the bearing is 9.8 N/mm^2. These values are used as a measuring stick for the strength of the spline nut.

[pV Value]

With a sliding bearing, a pV value, which is the product of the contact surface pressure (p) and the sliding speed (V), is used as a measuring stick to judge whether the assumed model can be used. Use the corresponding pV value indicated in Fig.1 as a guide for selecting a spline nut. The pV value also varies according to the lubrication conditions.

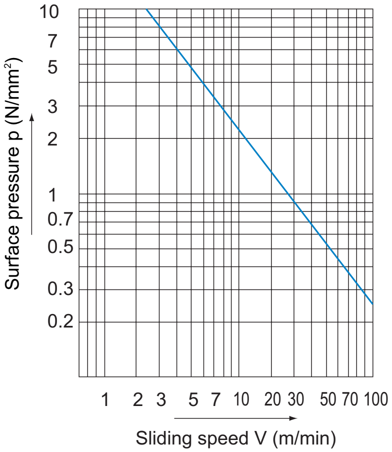


Fig.1 pV Value

● f$_S$: Safety Factor

To calculate a load applied to the spline nut, it is necessary to accurately obtain the effect of the inertia that changes with the weight and dynamic speed of an object. In general, with reciprocating or rotating machines, it is not easy to accurately obtain all the factors such as the effect of the start and stop, which are always repeated. Therefore, if the actual load cannot be obtained, it is necessary to select a bearing while taking into account the empirically obtained safety factors (f$_S$) shown in Table1.

Table1 Safety Factor (f$_S$)

Type of load	Lower limit of f$_S$
For a static load less frequently used	1 to 2
For an ordinary single-directional load	2 to 3
For a load accompanied by vibrations/impact	4 or greater

● f_T:Temperature Factor

If the temperature of the spline nut exceeds the normal temperature range, the seizure resistance of the nut and the strength of the material will decrease. Therefore, it is necessary to multiply the dynamic permissible torque (T) and the dynamic permissible thrust (F) by the corresponding temperature factor indicated in Fig.2.

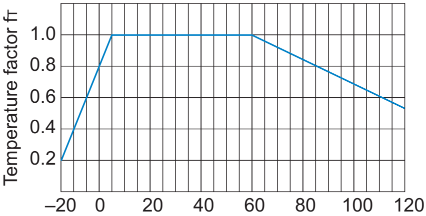


Fig.2 Temperature factor

Accordingly, when selecting a spline nut, the following equations need to be met in terms of its strength.

Dynamic permissible torque (T)

$$f_S \leqq \frac{f_T \cdot T}{P_T}$$

Static permissible thrust (F)

$$f_S \leqq \frac{f_T \cdot F}{P_F}$$

f_S : Static safety factor (see Table1 on A-517)
f_T : Temperature factor (see Fig.2)
T : Dynamic permissible torque (N-m)
P_T : Applied torque (N-m)
F : Dynamic permissible thrust (N)
P_F : Axial load (N)

● Hardness of the Surface and Wear Resistance

The hardness of the shaft significantly affects the wear resistance of the spline nut. If the hardness is equal to or less than 250 HV, the abrasion loss increases as indicated in Fig.3. The roughness of the surface should preferably be 0.80a or less.

A specially rolled shaft achieves surface hardness of 250 HV or greater, through hardening as a result of rolling, and a surface roughness of 0.20a or less. Thus, the dedicated rolled shaft is highly wear resistant.

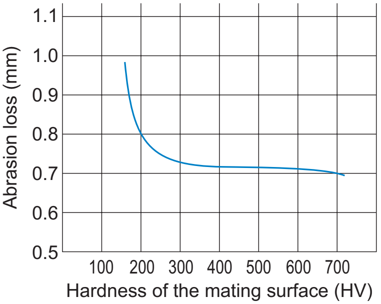


Fig.3 Hardness of the Surface and Wear Resistance

[Calculating the Contact Surface Pressure p]

$$p = \frac{P_T}{T} \times 9.8$$

p : Contact surface pressure on the tooth under a load torque (P_T) (N/mm^2)
T : Dynamic permissible torque (N-m)
P_T : Applied torque (N-m)

[Calculating the Sliding Speed]

With splines, the sliding speed of the tooth surface is equal to the feeding speed.

V : Sliding speed of the tooth (m/min)

[Example of calculation]

Use Spline Nut DPM and reciprocate it at a speed in the axial direction of 5 m/min while transmitting a load torque of 78 N-m. Since the applied torque is not consistent in direction, it is important to select a spline nut that can be used in locations accompanied by vibrations and impact.
First, select a nut that has a dynamic permissible torque (T) at which it can be used.

$$T \geqq \frac{f_S \cdot P_T}{f_T} = \frac{4 \times 78}{1} = 312 \mathrm{N \cdot m}$$

Safety factor (f_S) =4
Temperature factor (f_T) = 1
Applied torque (P_T) =78 N-m

Select Spline Nut model DPM3560 (dynamic permissible torque T = 443 N-m), which satisfies the dynamic permissible torque (T) above.
Obtain the pV value.
Obtain the contact surface pressure (p).

$$p = \frac{P_T}{T} \times 9.8 = \frac{78}{443} \times 9.8 \fallingdotseq 1.73 \mathrm{N/mm^2}$$

Obtain the sliding speed (V).

$$V = 5 \mathrm{m/min}$$

From the diagram of pV values (see Fig.1 on A-517), it is judged that there will be no abnormal wear if the sliding speed (V) is 13.5 m/min or below against the "p" value of 1.73 N/mm². Therefore, it is appropriate to select model DPM3560.

Fit

For the fitting between the spline nut circumference and the housing, we recommend loose fitting or tight fitting.

Housing inner-diameter tolerance: H8 or J8

Installation

[About Chamfer of the Housing's Mouth]

To increase the strength of the root of the flange of the spline nut, the corner is machined to have an R shape. Therefore, it is necessary to chamfer the inner edge of the housing's mouth.

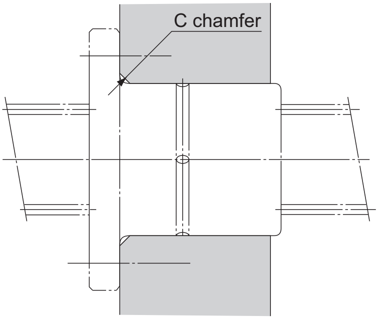


Fig.1

Table1 Chamfer of the Housing's Mouth

Unit: mm

Model No.	Chamfer of the mouth C (Min.)
DPM	
12	2
15	
17	
20	
25	2.5
30	
35	3
40	
45	
50	

Lubrication

Select a lubrication method according to the conditions of the spline nut.

[Oil Lubrication]

For the lubrication of the spline nut, oil lubrication is recommended. Specifically, oil-bath lubrication or drop lubrication is particularly effective. Oil-bath lubrication is the most appropriate method since it meets harsh conditions such as high speed, heavy load or external heat transmission, and it cools the spline nut. Drop lubrication suits low to medium speed and a light to medium load. Select a lubricant according to the conditions as indicated in Table2.

Table2 Selection of a Lubricant

Condition	Types of Lubricants
Low speed, high load, high temperature	High-viscosity sliding surface oil or turbine oil
Low speed, light load, low temperature	Low-viscosity sliding surface oil or turbine oil

[Grease Lubrication]

In low-speed feed, which occurs less frequently, the user can lubricate the slide system by manually applying grease to the shaft on a regular basis or using the greasing hole on the spline nut. We recommend using lithium-soap group grease No. 2.

Linear Bushing

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Linear Bushing

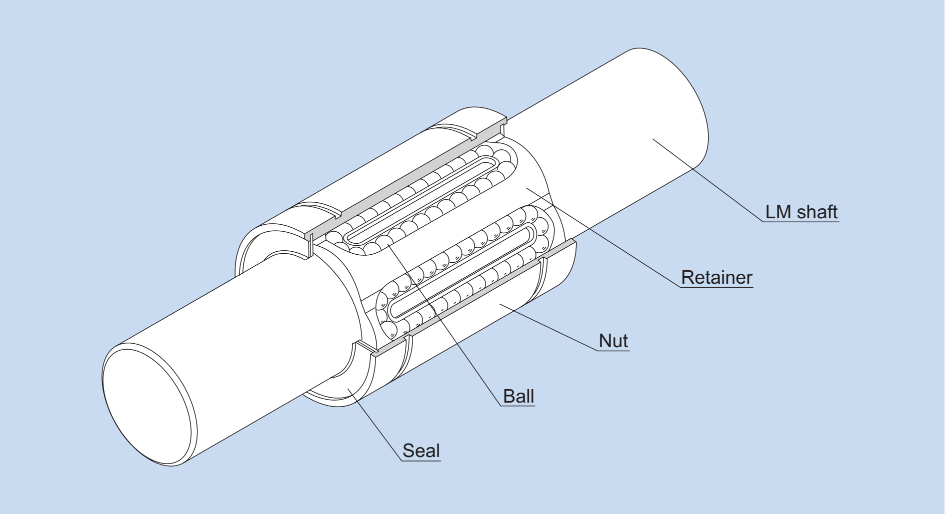


Fig.1 Structure of Linear Bushing Model LM···UU

Structure and Features

Linear Bushing model LM is a linear motion system used in combination with a cylindrical LM shaft to perform infinite straight motion. The balls in the loaded area of the nut are in point contact with the LM shaft. This allows straight motion with minimal friction resistance and achieves highly accurate and smooth motion despite the small permissible load.

The nut uses high-carbon chromium bearing steel and its outer and inner surfaces are ground after being heat-treated.

The Linear Bushing is used in a broad array of applications, such as slide units of precision equipment including OA equipment and peripherals, measuring instruments, automatic recorders and digital 3D measuring instruments, industrial machines including multi-spindle drilling machine, punching press, tool grinder, automatic gas cutting apparatus, printing machine, card selector and food packing machine.

[Interchangeability]

Since the dimensional tolerances of the Linear Bush's components are standardized, they are interchangeable. The LM shaft is machined through cylindrical grinding, which can easily be performed, and it allows highly accurate fitting clearance to be achieved.

[Highly Accurate Retainer Plate]

Since the retainer, which guides three to eight rows of balls, is integrally molded, it is capable of accurately guiding the balls in the traveling direction and achieving stable running accuracy.
Small-diameter types use integrally molded retainers made of synthetic resin. It reduces noise generated during operation and allows for superb lubrication.

[Wide Array of Types]

A wide array of types are available, such as standard type, clearance-adjustable type, open type, long type and flanged linear bushing, allowing the user to select a type that meets the intended use.

Dedicated Shafts for Model LM

The LM shaft of the Linear Bushing needs to be manufactured with much consideration for hardness, surface roughness and dimensional accuracy of the shaft since balls roll directly on it.
THK manufactures dedicated LM shafts for the Linear Bushing.

Standard LM Shafts

THK manufactures high quality, dedicated LM shafts for Linear Bushing model LM series.

Specially Machined Types

THK also supports special machining processes such as tapping, milling, threading, through hole and joggling, as shown in the Fig.2, at your request.

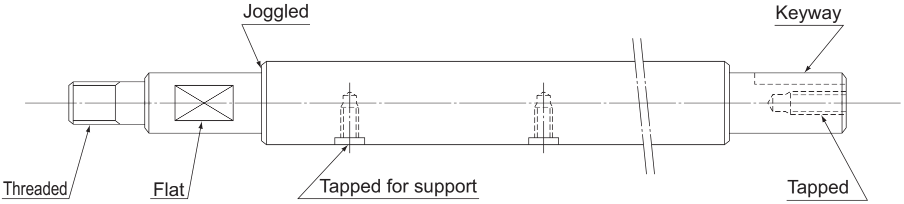


Fig.2

Table of Rows of Balls and Masses for Clearance-adjustable Types and Open Types of the Linear Bushing

Shaft diameter	Clearance-adjustable type			Open type		
	Model No.	Rows of balls	Mass g	Model No.	Rows of balls	Mass g
6	LM 6-AJ	4	7.8	—	—	—
8	LM 8S-AJ	4	10	—	—	—
	LM 8-AJ	4	14.7	—	—	—
10	LM 10-AJ	4	29	—	—	—
12	LM 12-AJ	4	31	LM 12-OP	3	25
13	LM 13-AJ	4	42	LM 13-OP	3	34
16	LM 16-AJ	5(4)	68	LM 16-OP	4(3)	52
20	LM 20-AJ	5	85	LM 20-OP	4	69
25	LM 25-AJ	6(5)	216	LM 25-OP	5(4)	188
30	LM 30-AJ	6	245	LM 30-OP	5	210
35	LM 35-AJ	6	384	LM 35-OP	5	350
38	LM 38-AJ	6	475	LM 38-OP	5	400
40	LM 40-AJ	6	579	LM 40-OP	5	500
50	LM 50-AJ	6	1560	LM 50-OP	5	1340
60	LM 60-AJ	6	1820	LM 60-OP	5	1650
80	LM 80-AJ	6	4320	LM 80-OP	5	3750
100	LM 100-AJ	6	8540	LM 100-OP	5	7200
120	LM 120-AJ	8	14900	LM 120-OP	6	11600

Note) The numbers of ball rows in the table apply to types using a resin retainer. Those of types using a metal retainer are indicated in parentheses.

Linear Bushing Types

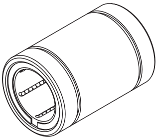
Types and Features

Standard Type

With the Linear Bushing nut having the most accurate cylindrical shape, this type is widely used.

There are two series of the Linear Bushing in dimensional group.

- Model LM
  Metric units series used most widely in Japan
- Model LM-MG
  Stainless steel version of type LM
- Model LME
  Metric units series commonly used in Europe



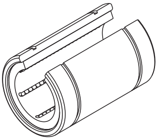
Standard Type

Open Type

The nut is partially cut open by one row of balls (50° to 80°). This enables the Linear Bushing to be used even in locations where the LM shaft is supported by a column or fulcrum. In addition, a clearance can easily be adjusted.

Models LM-OP/LME-OP

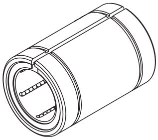
Model LM-MG-OP



Open Type

Clearance-adjustable Type

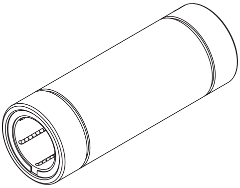
This type has the same dimensions as the standard type, but the nut has a slit in the direction of the LM shaft. This allows the linear bushing to be installed in a housing whose inner diameter is adjustable, and enables the clearance between the LM shaft and the housing to easily be adjusted.
Models LM-AJ/LME-AJ
Model LM-MG-AJ



Clearance-adjustable Type

Long Type

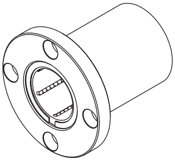
Containing two units of the standard retainer plate, this type is optimal for locations where a moment load is present and reduces man-hours in installation.
Model LM-L············Standard type



Long Type

Flanged Type (Round)

The nut of the standard type Linear Bushing is integrated with a flange. This enables the Linear Bushing to be directly mounted onto the housing with bolts, thus achieving easy installation.
Model LMF···············Standard type
Model LMF-M············Made of stainless steel

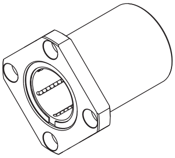


Flanged Type (Round)

Flanged Type (Square)

Like model LMF, this type also has a flange, but the flange is cut to a square shape. Since the height is lower than the circular flange type, compact design is allowed.

Model LMK··············Standard type
Model LMK-M···········Made of stainless steel

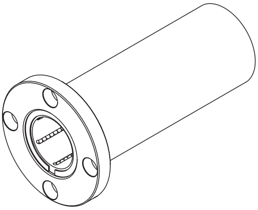


Flanged Type (Square)

Flanged Type (Round) - Long

The nut of the long type Linear Bushing is integrated with a flange. This enables the Linear Bushing to be directly mounted onto the housing with bolts, thus achieving easy installation. Containing two units of the standard retainer plate, this type is optimal for locations where a moment load is present.

Model LMF-L···········Standard type
Model LMF-ML·········Made of stainless steel

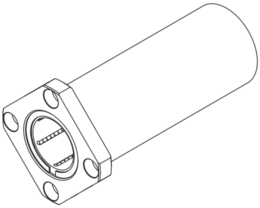


Flanged Type (Round) - Long

Flanged Type (Square) - Long

Like model LMF-L, this type also has a flange, but the flange is cut to a square shape. Since the height is lower than the circular flange type, compact design is allowed.

Model LMK-L···········Standard type
Model LMK-ML·········Made of stainless steel

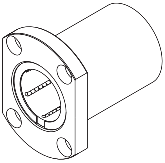


Flanged Type (Square) - Long

Flanged Type (Cut Flange)

The nut is integrated with a cut flange. Since the height is lower than model LMK, compact design is allowed. Since the rows of balls in the Linear Bushing are arranged so that two rows receive the load from the flat side, a long service life can be achieved.

Model LMH··············Standard type

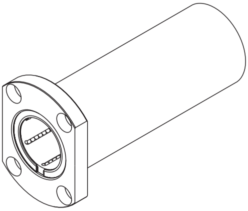


Flanged Type (Cut Flange)

Flanged Type (Cut Flange) - Long

The flange is a cut flange and lower than model LMK-L, allowing compact design. Containing two units of the standard retainer plate, this type is optimal for locations where a moment load is present. Since the rows of balls in the Linear Bushing are arranged so that two rows receive the load from the flat side, a long service life can be achieved.

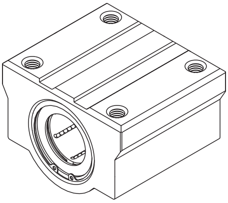
Model LMH-L···········Standard type



Flanged Type (Cut Flange) - Long

Linear Bushing Model SC

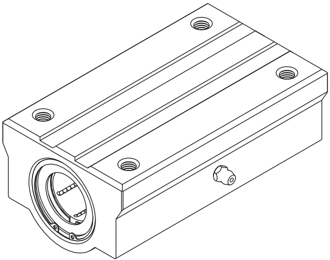
It is a case unit where the standard type of Linear Bushing is incorporated into a small, lightweight aluminum casing. This model can easily be mounted simply by securing it to the table with bolts.



Linear Bushing Model SC

Linear Bushing (Long) Model SL

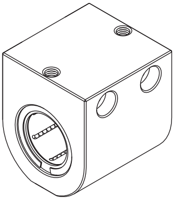
A long version of model SC, this model contains two units of the standard type Linear Bushing in an aluminum casing.



Linear Bushing (Long) Model SL

Linear Bushing Model SH

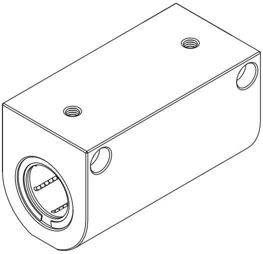
It is a case unit where the standard type of Linear Bushing is incorporated into a smaller and lighter aluminum casing than model SC. This model allows even more compact design than model SC. It also has flexibility in mounting orientation. Additionally, it is structured so that two rows of balls receive the load from the top of the casing, allowing a long service life to be achieved.



Linear Bushing Model SH

Linear Bushing (Long) Model SH-L

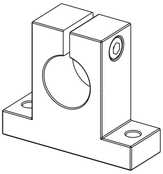
A long version of model SH, this model is a case unit that contains two units of the standard type Linear Bushing in an aluminum casing.



Linear Bushing (Long) Model SH-L

LM Shaft End Support Model SK

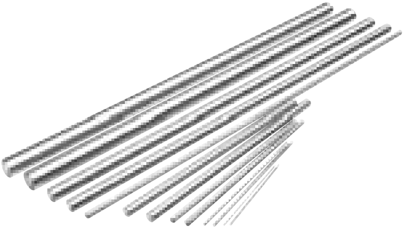
An aluminum-made light fulcrum for securing an LM shaft. The LM shaft mounting section has a slit, enabling the linear bushing to firmly secure an LM shaft using bolts.



LM Shaft End Support Model SK

Standard LM Shafts

THK manufactures high quality, dedicated LM shafts for Linear Bushing model LM series.



Standard LM Shafts

Build-to-order LM Shafts

THK also manufactures hollow LM shafts and specially machined shafts at your request.

Build-to-order LM Shafts

Classification Table

Linear Bushing

Flange Type

Circular Flange

Standard Type

- **Model LMF**
  - SUJ2
  - Resin
- **Model LMF-M**
  - SUS
  - Resin

Long Type

- **Model LMF-L**
  - SUJ2
  - Resin
- **Model LMF-ML**
  - SUS
  - Resin

Square Flange

Standard Type

- **Model LMK**
  - SUJ2
  - Resin
- **Model LMK-M**
  - SUS
  - Resin

Long Type

- **Model LMK-L**
  - SUJ2
  - Resin
- **Model LMK-ML**
  - SUS
  - Resin

Cut Flange

Standard Type

- **Model LMH**
  - SUJ2
  - Resin

Long Type

- **Model LMH-L**
  - SUJ2
  - Resin

LM Shaft

Standard LM Shafts

- **Model SF**

Build-to-order LM Shafts

LM Shaft End Support

- **Model SK**
  - SUJ2
  - Resin

Flange-less Type

Standard Type

Model LM
SUJ2
Resin

Model LME
SUJ2
Resin

Model LM-GA
SUJ2
Metal

Model LM-MG
SUS
Resin

Open Type

Model LM-OP
SUJ2
Resin

Model LME-OP
SUJ2
Resin

Model LM-MG-OP
SUS
Resin

Long Type

Model LM-L
SUJ2
Resin

Clearance-adjustable Type

Model LM-AJ
SUJ2
Resin

Model LME-AJ
SUJ2
Resin

Model LM-MG-AJ
SUS
Resin

Encased Type

Standard Type

Model SC
SUJ2
Resin

Model SH
SUJ2
Resin

Long Type

Model SL
SUJ2
Resin

Model SH-L
SUJ2
Resin

Type of Material

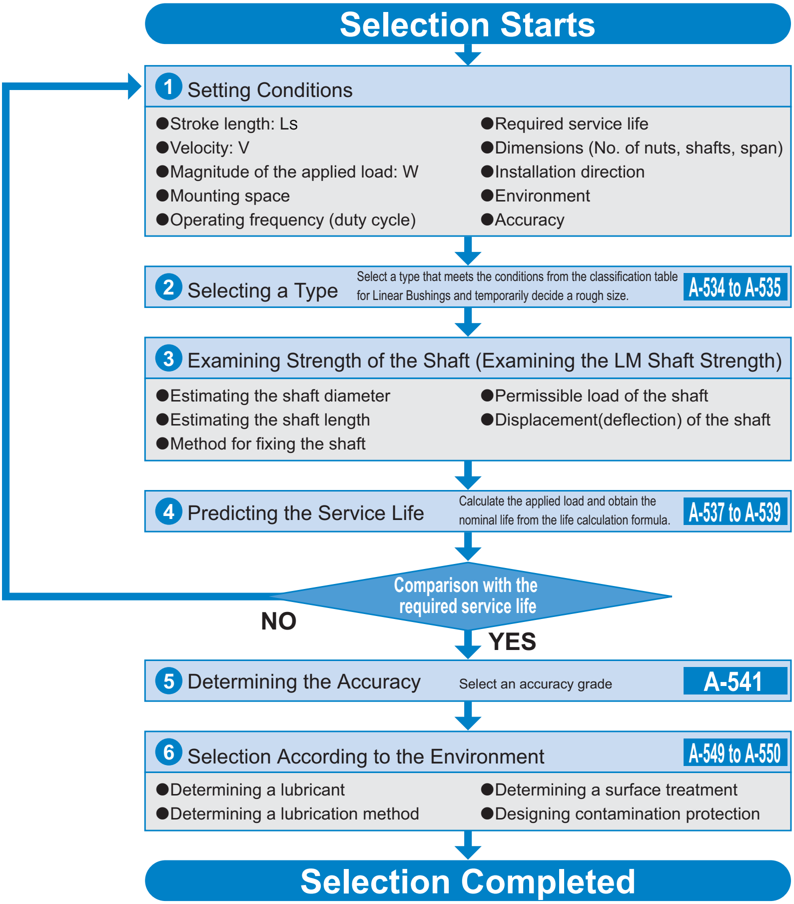
Model No.
Nut Material
Retainer Material

- SUJ2 (High-carbon Chromium Bearing Steel)
- SUS (Stainless Steel)

Flowchart for Selecting a Linear Bushing

Steps for Selecting a Linear Bushing

The following flowchart should be used as a guide for selecting a Linear Bushing.



Selection Starts

1 Setting Conditions

- Stroke length: Ls
- Velocity: V
- Magnitude of the applied load: W
- Mounting space
- Operating frequency (duty cycle)
- Required service life
- Dimensions (No. of nuts, shafts, span)
- Installation direction
- Environment
- Accuracy

2 Selecting a Type

Select a type that meets the conditions from the classification table for Linear Bushings and temporarily decide a rough size.

A-534 to A-535

3 Examining Strength of the Shaft (Examining the LM Shaft Strength)

- Estimating the shaft diameter
- Estimating the shaft length
- Method for fixing the shaft
- Permissible load of the shaft
- Displacement(deflection) of the shaft

4 Predicting the Service Life

Calculate the applied load and obtain the nominal life from the life calculation formula.

A-537 to A-539

Comparison with the required service life

NO

YES

5 Determining the Accuracy

Select an accuracy grade

A-541

6 Selection According to the Environment

A-549 to A-550

- Determining a lubricant
- Determining a lubrication method
- Determining a surface treatment
- Designing contamination protection

Selection Completed

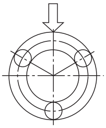
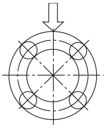
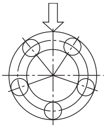
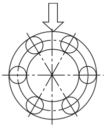
Rated Load and Nominal Life

[Load Rating]

The rated load of the Linear Bushing varies according to the position of balls in relation to the load direction. The basic load ratings indicated in the specification tables each indicate the value when one row of balls receiving a load are directly under the load.

If the Linear Bushing is mounted so that two rows of balls evenly receive the load in the load direction, the rated load changes as shown in table 1.

Table1

Rows of balls	Ball position	Load Rating
3 rows		1×C
4 rows		1.41×C
5 rows		1.46×C
6 rows		1.28×C

For specific values for "C" above, see the respective specification table.

[Calculating the Nominal Life]

The nominal life of the Linear Bushing is obtained using the following equation.

$$L = \left(\frac{f_H \cdot f_T \cdot f_C}{f_W} \cdot \frac{C}{P_C}\right)^3 \times 50$$

L : Nominal life (km)
C : Basic dynamic load rating (N)
P_C : Calculated load (N)
f_T : Temperature factor (see Fig.2 on A-539)
f_C : Contact factor (see Table2 on A-539)
f_W : Load factor (see Table3 on A-539)
f_H : Hardness factor (see Fig.1)

● When a Moment Load is Applied to a Single Nut or Two Nuts in Close Contact with Each Other

When a moment load is applied to a single nut or two nuts in close contact with each other, calculate the equivalent radial load at the time the moment is applied.

$$P_u = K \cdot M$$

P_u : Equivalent radial load (N)
(with a moment applied)
K : Equivalent factors
(see Table4 to Table6 on A-540)
M : Applied moment (N-mm)

However, "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, calculate the service life based on the sum of the radial load and the equivalent radial load.

■f_H: Hardness Factor

To maximize the load capacity of the Linear Bushing, 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 the Linear Bushing has sufficient hardness.

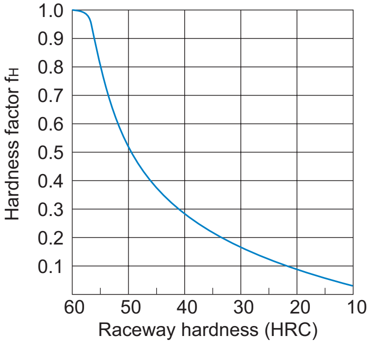


Fig.1 Hardness Factor (f_H)

■f_T:Temperature Factor

If the temperature of the environment surrounding the operating Linear Bushing 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.2.
Also note that the Linear Bushing itself must be of high temperature type.

Note) If the environment temperature exceeds 80 ℃ , use a Linear Bushing type equipped with metal retainer plates.

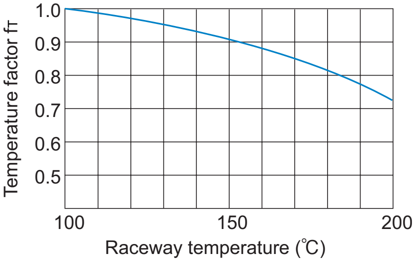


Fig.2 Temperature Factor (f_T)

■f_C: Contact Factor

When multiple nuts 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 Table2.

Note) If uneven load distribution is expected in a large machine, take into account the respective contact factor indicated in Table2.

Table2 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 involve vibrations or impact during operation. It is difficult to accurately determine vibrations generated during high-speed operation and impact during frequent start and stop motion. Therefore, when loads applied on a Linear Bushing cannot be measured, or when speed and impact have a significant influence, divide the basic load rating (C or C_0), by the corresponding load factor in Table3.

Table3 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

[Calculating the Service Life Time]

When the nominal life (L) has been obtained, if the stroke length and the number of reciprocations per minute are constant, the service life time is obtained using the following equation.

$$L_h = \frac{L \times 10^3}{2 \times \ell_s \times n_1 \times 60}$$

L_h : Service life time (h)
ℓ_s : Stroke length (m)
n_1 : Number of reciprocations per minute (min^{-1})

Table of Equivalent Factors

Table4 Equivalent Factors of Model LM

Model No.	Equivalent factor: K	
	Single nut	Double blocks
LM 3	1.566	0.26
LM 4	1.566	0.21
LM 5	1.253	0.178
LM 6	0.553	0.162
LM 8S	0.708	0.166
LM 8	0.442	0.128
LM 10	0.389	0.101
LM 12	0.389	0.097
LM 13	0.343	0.093
LM 16	0.279	0.084
LM 20	0.257	0.071
LM 25	0.163	0.054
LM 30	0.153	0.049
LM 35	0.143	0.045
LM 38	0.127	0.042
LM 40	0.117	0.04
LM 50	0.096	0.032
LM 60	0.093	0.028
LM 80	0.077	0.022
LM 100	0.065	0.017
LM 120	0.051	0.015

Note) Equivalent factors for models LMF, LMK, LMH and SC are the same as that for model LM.

Table5 Equivalent Factors of Model LM-L

Model No.	Equivalent factor: K
	Single nut
LM 3L	0.654
LM 4L	0.578
LM 5L	0.446
LM 6L	0.402
LM 8L	0.302
LM 10L	0.236
LM 12L	0.226
LM 13L	0.214
LM 16L	0.192
LM 20L	0.164
LM 25L	0.12
LM 30L	0.106
LM 35L	0.1
LM 40L	0.086
LM 50L	0.068
LM 60L	0.062

Note) Equivalent factors for models LMF-L, LMK-L and LMH-L are the same as that for model LM-L.

Table6 Equivalent Factors of Model LME

Model No.	Equivalent factor: K	
	Single nut	Double blocks
LME 5	0.669	0.123
LME 8	0.514	0.116
LME 12	0.389	0.09
LME 16	0.343	0.081
LME 20	0.291	0.063
LME 25	0.209	0.052
LME 30	0.167	0.045
LME 40	0.127	0.039
LME 50	0.105	0.031
LME 60	0.093	0.024
LME 80	0.077	0.018

Accuracy Standards

The accuracy of the Linear Bushing in inscribed bore diameter, outer diameter, width and eccentricity is described in the corresponding specification table. The accuracy of mode LM in inscribed bore diameter and eccentricity is classified into high accuracy grade (no symbol) and precision grade (P). (Accuracy symbol is expressed at the end of the model number.)

The accuracy of clearance-adjustable types (-AJ) and open types (-OP) in inscribed bore diameter and outer diameter indicates the value before division.

Assembling the Linear Bushing

[Inner Diameter of the Housing]

Table1 shows recommended housing inner-diameter tolerance for the Linear Bushing. When fitting the Linear Bushing with the housing, loose fit is normally recommended. If the clearance needs to be smaller, provide transition fit.

Table1 Housing Inner-diameter Tolerance

Type		Housing	
Model No.	Accuracy	Loose fit	Transition fit
LM	High accuracy grade (no symbol)	H7	J7
	Precision Grade (P)	H6	J6
LME	—	H7	K6, J6
LMF	High accuracy grade (no symbol)	H7	J7
LMK			
LMH			
LM-L			
LMF-L			
LMK-L			
LMH-L			

[Clearance between the Nut and the LM Shaft]

When using the Linear Bushing in combination with an LM shaft, use normal clearance in ordinary use and small gap if the clearance is to be minimized.

Note1) If the clearance after installation is to be negative, it is preferable not to exceed the radial clearance tolerance indicated in the specification table.

Note2) The shaft tolerance for Linear Bushing models SC, SL SH and SH-L falls under high accuracy grade (no symbol).

Table2 Shaft Outer-diameter Tolerance

Type		LM Shaft	
Model No.	Accuracy	Normal clearance	Small gap
LM	High accuracy grade (no symbol)	f6, g6	h6
	Precision Grade (P)	f5, g5	h5
LME	—	h7	k6
LMF	High accuracy grade (no symbol)	f6, g6	h6
LMK			
LMH			
LM-L			
LMF-L			
LMK-L			
LMH-L			

[Mounting the Nut]

Although the Linear Bushing does not require a large amount of strength for securing it in the axial direction, do not rely only on a press fit to support the nut. For the housing inner-diameter tolerance, see Table1 on A-542.

● Installing the Standard Type

Fig.1 and Fig.2 show examples of installing the standard type Linear Bushing.
When securing the Linear Bushing, use snap rings or stopper plates.

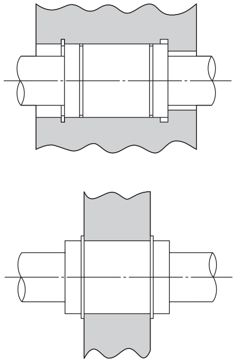


Fig.1 Snap Ring

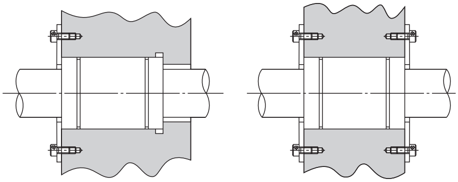


Fig.2 Stopper Plate

■Snap Ring for Installation

To secure Linear Bushing model LM, snap rings indicated in Table3 are available.

Note1) For models indicated with parentheses, use C-shape concentric snap rings.
Note2) The Table3 commonly applies to models LM, LM-GA, LM-MG and LM-L.

Table3 Types of Snap Rings

Model No.	Snap ring			
	For outer surface		For inner surface	
	Needle snap ring	C-shape snap ring	Needle snap ring	C-shape snap ring
LM 3	—	—	AR 7	—
LM 4	—	—	8	—
LM 5	WR 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 38	—	56・58	57	—
LM 40	—	60	60	60
LM 50	—	80	80	80
LM 60	—	90	90	90
LM 80A	—	120	120	120
LM 100A	—	(150)	150	—
LM 120A	—	(180)	180	—

■Set Screws Not Allowed

Securing the nut by pressing the outer surface with one set screw as shown in Fig.3 will cause the nut to be deformed.

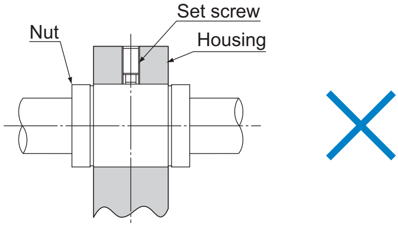
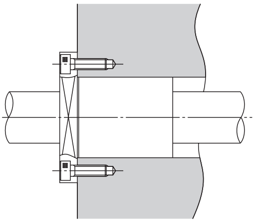


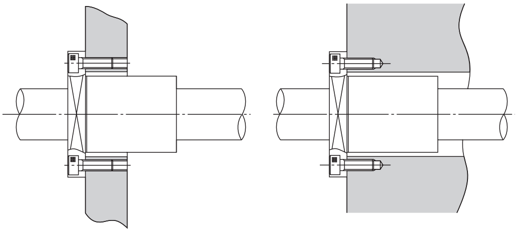
Fig.3

● Installing a Flanged Type

With models LMF, LMK and LMH, the nut is integrated with a flange. Therefore, the Linear Bushing can be mounted only via the flange.



Nut mounted via socket and spigot joint



Mounted via a flange only

● Installing a Clearance-adjustable Type

To adjust the clearance of a clearance-adjustable type (-AJ), use a housing that allows adjustment of the nut outer diameter so as to facilitate the adjustment of the clearance between the Linear Bushing and the LM shaft. Positioning the slit of the Linear Bushing at an angle of 90° with the housing's slit will provide uniform deformation in the circumferential direction. (See Fig.4.)

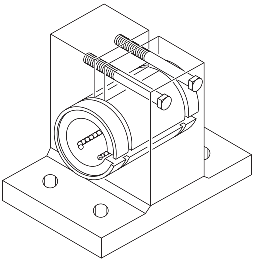


Fig.4

● Mounting an Open Type

For an open type (-OP), also use a housing that allows adjustment of the nut outer diameter as shown in Fig.5.

Open types are normally used with a light preload. Be sure not to give an excessive preload.

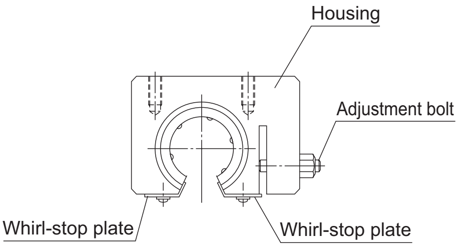
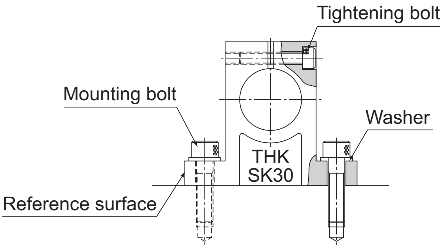


Fig.5

[Mounting the Shaft End Support]

Shaft end support model SK can easily be secured to the table using mounting bolts. Model SK enables the LM shaft to firmly be secured using tightening bolts.



[Installing an LM Case Unit]

● Attaching Model SC (SL)

Since models SC and SL can be attached from the top or bottom by simply tightening it using bolts, the installation time can be shortened. (See Fig.6.)

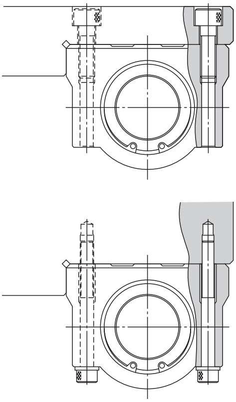


Fig.6

● Attaching Model SH (SH-L)

Since models SH and SH-L can be attached from the top or bottom by simply tightening it using bolts, the installation time can be shortened.(See Fig.7.)

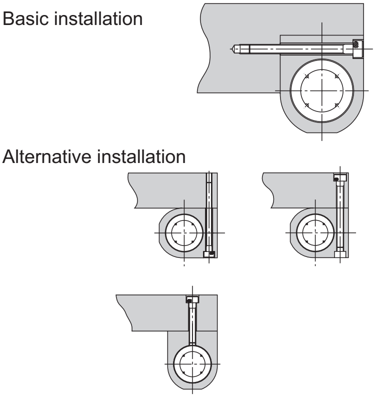
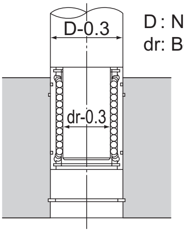


Fig.7

[Incorporating the Nut]

When incorporating the standard Linear Bushing into a housing, use a jig and drive in the nut, or use a flatter plate and gently hit the nut, instead of directly hitting the side plate or the seal. (See Fig.8.)



D : Nut outer diameter
dr: Bore diameter

Fig.8

[Inserting the LM Shaft]

When inserting the LM shaft into the Linear Bushing, align the center of the shaft with that of the nut and gently insert the shaft straightforward into the nut. If the shaft is slanted while it is inserted, balls may fall off or the retainer may be deformed. (See Fig.9.)

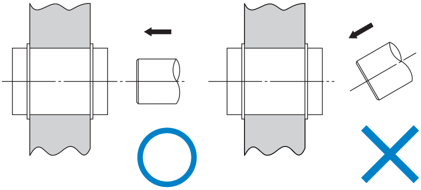


Fig.9

[When Under a Moment Load]

When using the Linear Bushing, make sure the load is evenly distributed on the whole ball raceway. In particular, if a moment load is applied, use two or more Linear Bushing units on the same LM shaft and secure an adequately large distance between the units.

If using the Linear Bushing under a moment load, also calculate the equivalent radial load and identify the correct model number. (See A-538.)

[Rotational Use Not Allowed]

The Linear Bushing is not suitable for rotational use for a structural reason. (See Fig.10.)

Forcibly rotating it may cause an unexpected accident.

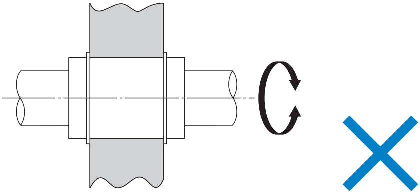


Fig.10

[Precautions on Installing an Open Three-ball-row Type Linear Bushing]

When installing an open three-ball-row type Linear Bushing, mount it while taking into account the load distribution as indicated in Fig.11.

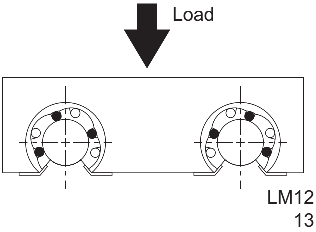


Fig.11

[Attaching Felt Seal Model FLM]

The felt seal can be press-fit into a housing finished to H7, but cannot be used as a stopper for preventing the Linear Bushing from coming off. Be sure to use the felt seal by attaching it as indicated in the Fig.12.
Also make sure to impregnate the felt with sufficient lubricant before attaching it.

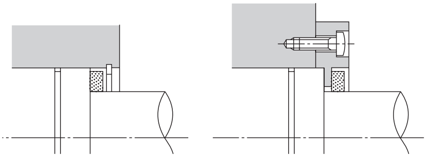


Fig.12

Lubrication

The Linear Bushing requires grease or oil as a lubricant for its operation.

[Grease Lubrication]

When installing a type attached with seals on both sides (⋯UU) to the LM shaft, apply grease to rows of balls in the Linear Bushing.
When installing standard types (without seal), perform the same as above or apply grease to the LM shaft.
Afterward, replenish grease of the same type as necessary according to the service conditions.
We recommend using high-quality lithium-soap group grease No. 2.

[Oil Lubrication]

Turbine oil, machine oil and spindle oil are commonly used as a lubricant.
When oiling the Linear Bushing, drop oil on the LM shaft, or infuse it from the greasing hole on the housing as shown in Fig.1.

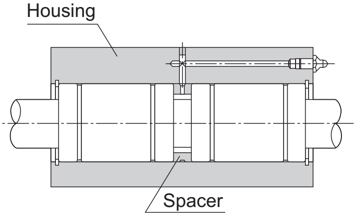


Fig.1

Material and Surface Treatment

For the Linear Bushing and the LM shaft, highly corrosion-resistant stainless steel types are available for some models.
Although the LM shaft can be surface treated, some types may not be suitable for the treatment. Contact THK for details.

Contamination Protection

Entrance of dust or other foreign material into the Linear Bushing will cause abnormal wear or shorten the service life. When nut contamination is expected, it is important to select an effective sealing device or dust-control device that meets the environment conditions.

For the Linear Bushing, a special synthetic rubber seal that is highly resistant to wear and a felt seal (highly dust preventive with low seal resistance) are available as contamination protection accessories.

In addition, THK produces round bellows. Contact us for details.

Felt Seal Model FLM

●For detailed dimensions, see B-461.

Linear Bushing model LM series include types equipped with a special synthetic rubber seal (LM···UU, U). If desiring to have an additional contamination protection measure, or desiring to lower the seal resistance, use the felt seal model FLM.

Precautions on Use

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.

(2) Dropping or hitting the Linear Bushing may damage it. Giving an impact force to the bushing could also cause damage even if the product looks intact.

[Lubrication]

(1) Thoroughly remove anti-rust oil and feed lubricant before using the product.

(2) Do not mix lubricants of different physical properties.

(3) In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, normal lubricants may not be used. Contact THK for details.

(4) When planning to use a special lubricant, contact THK before using it.

[Precautions on Use]

(1) Entrance of foreign material may cause damage to the ball circulating component or functional loss. Prevent foreign material, such as dust or cutting chips, from entering the system.

(2) Do not use the product at temperature of 80 ℃ or higher. Contact THK if you desire to use the product at a temperature of 80℃ or higher.

(3) Please be careful when using the product in an environment with excessive coolant. The coolant may cause premature failure if it penetrates the bushing nut. Contact THK for further details.

(4) If foreign material adheres to the product, replenish the lubricant after cleaning the product.

(5) When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, contact THK in advance.

[Storage]

When storing the Linear Bushing, enclose it in a package designated by THK and store it while avoiding high temperature, low temperature and high humidity.

LM Stroke

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

LM Stroke

Models ST, ST-B and STI

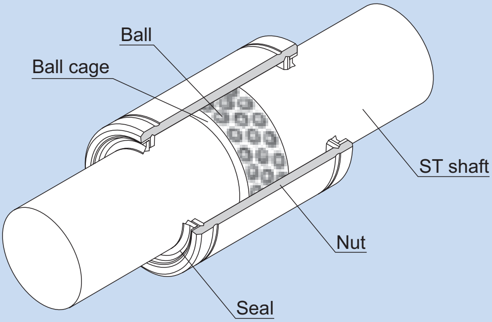


Fig.1 Structure of LM Stroke Model ST

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. 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 setting, ink roll unit of printing machine, workpiece chuck unit of punching press, press feeder, work head of electric discharge machine, wound roll corrector, spinning and weaving machine, distortion measuring equipment, spindle of optical measuring instrument, 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 the LM stroke to perform rolling motion at 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.

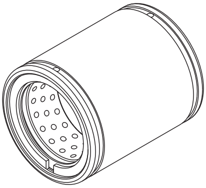
[High Accuracy at a Low Price]
A highly accurate slide unit can be produced at a low price.

Types and Features

Light Load Type Model ST

Specification Table⇒B-464

Model ST is a light load type that allows for a long stroke.
Shaft diameter:ϕ6 to ϕ100
In addition, a type attached with seal is available. Model ST-UU

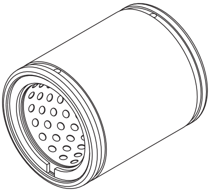


Model ST

Medium Load Type Model ST-B

Specification Table⇒B-464

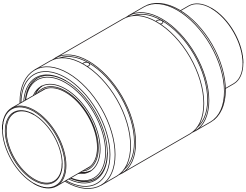
It has the same dimensions as model ST, but has a shorter stroke and achieves a rated load twice that of ST.
Shaft diameter:ϕ8 to ϕ100
In addition, a type attached with seal is available. Model ST-UUB



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.

[Nominal Life]

The nominal life of model ST is obtained using the following equation.

$$L = \left(\frac{f_H \cdot f_T \cdot f_C}{f_W} \cdot \frac{C}{P_C}\right)^3$$

L : Nominal life (rotating 10^6 times)
(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 (kN)
P_C : Calculated radial load (kN)
f_H : Hardness factor (see Fig.2 on A-557)
f_T : Temperature factor (see Fig.3 on A-557)
f_C : Contact factor (see Table1 on A-558)
f_W : Load factor (see Table2 on A-558)

[Calculating the Service Life Time]

When the nominal life (L) 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 equation.

- **For Rotating Motion or Complex Motion**

$$L_h = \frac{10^6 \times L}{60\sqrt{(dm \cdot n)^2 + (10 \times \alpha \cdot \ell_S \cdot n_1)^2}/dm}$$

- **For Reciprocating Motion**

$$L_h = \frac{10^6 \times L}{60 \times 10 \times \alpha \cdot \ell_S \cdot n_1 / (\pi \cdot dm)}$$

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)
($dm \fallingdotseq 1.15 \times dr$)
dr : Ball inscribed bore diameter (mm)
α : Factor for cage material
($\alpha = 0.7$)

[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.

$n_1 \leqq 5000$

$\ell_s \cdot n_1 \leqq 50000$

● 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.

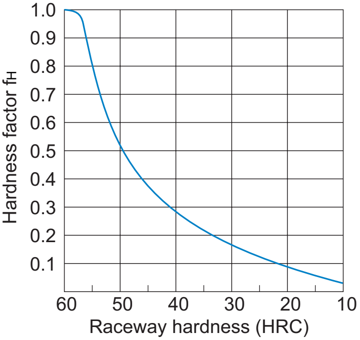


Fig.2 Hardness Factor (f_H)

● 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.

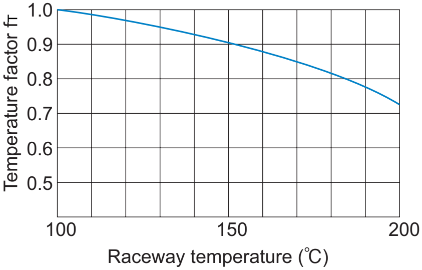


Fig.3 Temperature Factor (f_T)

● 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 involve vibrations or impact during operation. It is extremely difficult to accurately determine vibrations generated during high-speed operation and impact during frequent start and stop. Therefore, when speed and vibrations have a significant influence, divide the basic dynamic load rating (C or C_0), by the corresponding load factor in Table2 of empirically obtained data.

Table2 Load Factor (f_w)

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

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.

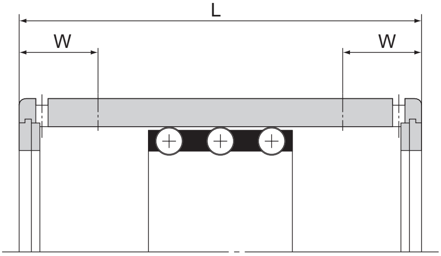


Fig.4 Measurement Range of the Nut

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

W : Length out of the measurement range (mm)

L : Nut length (mm)

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 0 and 10 μm.

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 0.40a or less. If higher wear resistance is required, finish the surface to 0.20a 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.

Miniature Stroke

Model MST

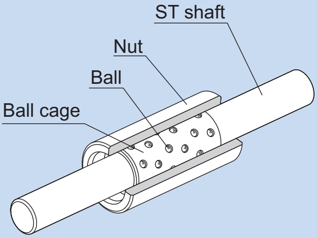


Fig.1 Structure of Miniature Stroke Model MST

Structure and Features

Model MST consists of an ST shaft, ball cage and nut. These components can freely be combined according to the application. The sectional shape is small, the clearance is minimal and the motion is extremely light and smooth. Accordingly, model MST can be used in a variety of small, precision measuring equipment such as optic measuring instrument's spindle, pen plotter, OA equipment, computer terminals, automatic scale, digital length measuring machine and solenoid valve.

[Highly Accurate Bearing]

Precision steel balls (sphericity in mutual difference: 0.0003 mm) compliant with JIS B 1501 are incorporated in a copper alloy ball cage to ensure high accuracy. The ball cage serves to prevent the balls from falling off with a unique ball-retaining design.

[Highly Durable Bearing]

The nut of the ST shaft uses a selected material, and is heat-treated and ground. In addition, the raceways are finished with ultra fine finish. The rows of balls are densely arranged in the ball cage, and the balls are placed so that the ball raceways do not overlap with each other. It enables this model to be used over a long period without wear and to demonstrate high durability.

[Compact Bearing]
Use of a combination of balls with a 1 mm diameter and a thin nut allows a small sectional shape and space-saving design.

[Bearing with Extremely Low Frictional Resistance]
Since the balls are in point-contact with the raceways, rolling loss is minimal and rolling motion with low-friction is achieved.

Fit

The inner surface of the housing must be finished to H6 to H7, and secured with an adhesive after the nut is inserted.
When press fitting is required, mounting the nut to the hole will reduce the inner diameter. Therefore, be sure to check the inner diameter after press fitting the nut and adjust the shaft diameter so that a correct preload is achieved. Also make sure that the preload must not exceed -2μm.

Travel Distance of the Ball Cage

The ball cage can travel up to 1/2 of the stroke length (ℓs) of the nut or the ST shaft in the same direction.

Die-setting Ball Cage

Models KS and BS

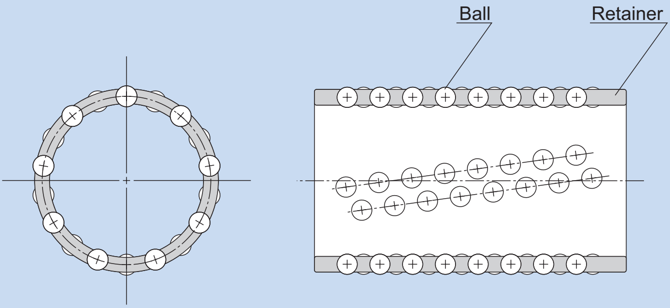


Fig.1 Structure of Die-setting Ball Cage Model KS

Structure and Features

With models KS and BS, a large number of precision steel balls (sphericity in mutual difference: 0.0005 mm) compliant with JIS B 1501 are incorporated in a lightweight, highly rigid ball cage. The balls are arranged along the circumference of the ball cage in spirals so that the ball raceways do not overlap with each other. It enables these models to be used over a long period without wear and to demonstrate high durability.

In addition, the ball pockets, which hold the balls, are finished with precision and continuously caulked with a unique process, enabling them to prevent the balls from falling. It allows the system to travel smoothly even if the ball cage is longer than the housing.

These ball cages are used in precision press die set, spinning and weaving machine, precision measuring instrument, automatic recorder, medical equipment and various machine tools.

Rated Load and Service Life

The rated loads of models KS and BS are indicated in the respective specification tables. Their service lives are obtained using the service life equation for LM Stroke model ST on A-556.

Fit

When using the Die-setting Ball Cage in the guide unit of the guide post of a precision press die set, normally select a negative clearance in order to increase the accuracy and the ball cage rigidity. Table1 shows typical fitting between the hole and the shaft. Select a combination of a hole and a shaft so that the clearance does not exceed the tolerance value of the radial clearance indicated in the specification table.

Table1 Fitting between Holes and Shaft

Tolerance in hole dimensions: D	K5
Dimensional tolerance of the shaft: d	h5

Installation of the Ball Cage

Fig.2 shows examples of mounting the Die-setting Ball Cage.

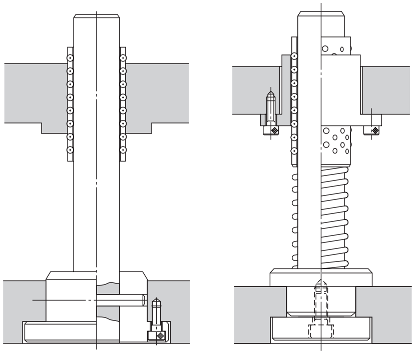


Fig.2 Example of Installation

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.
(2) Dropping or hitting the LM Stroke may damage it. Giving an impact force to the product could also cause damage even if the product looks intact.

[Lubrication]

(1) LM Stroke model ST can use either oil or grease as a lubricant. Select either lubricant according to the DN value. When using grease, we recommend high-quality lithium-soap group grease No. 2.
(2) Thoroughly remove anti-rust oil and feed lubricant before using the product.
(3) Do not mix lubricants of different physical properties.
(4) In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, normal lubricants may not be used. Contact THK for details.
(5) When planning to use a special lubricant, contact THK before using it.

[Precautions on Use]

(1) Entrance of foreign material into LM Stroke model ST may cause abnormal wear or shorten the service life. When entrance of foreign material is predicted, it is important to select an effective sealing device or dust-control device that meets the environment conditions. For LM Stroke model ST, a special synthetic rubber seal (ST···UU) that is highly resistant to wear and a felt seal with high contamination protection effect and low seal resistance (ST···DD) are available for some types as contamination protection accessories.
(2) If foreign material adheres to the product, replenish the lubricant after cleaning the product.
(3) Contact THK if you desire to use the product at a temperature of 80℃ or higher.
(4) Please be careful when using the product in an environment with excessive coolant. The coolant may cause premature failure if it penetrates the bushing nut. Contact THK for further details.
(5) When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, contact THK in advance.

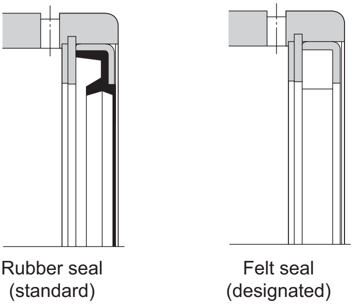


Fig.1 Types of the Seal for the LM Stroke

[Storage]

When storing the LM Stroke, enclose it in a package designated by THK and store it while avoiding high temperature, low temperature and high humidity.

Precision Linear Pack

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Precision Linear Pack

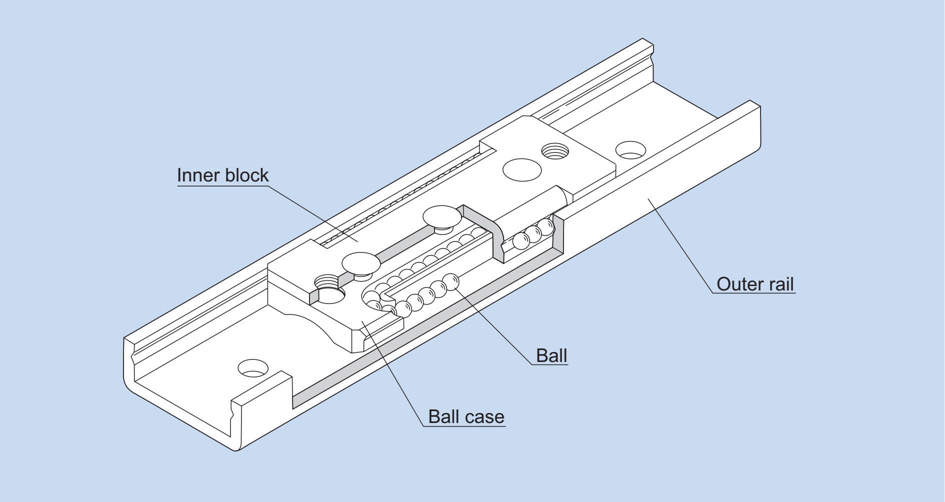


Fig.1 Structure of Precision Linear Pack Model ER

Structure and Features

Model ER is a slide unit using a stainless steel plate that is precision formed, heat-treated and then ground. It has a structure where balls roll between the V-shaped grooves machined on the outer rail and the inner block to allow the system to slide. It is an ultra-thin, lightweight unit in which the balls circulate in a ball case incorporated in the inner block to perform infinite straight motion.
This model is used in extensive applications such as magnetic disc devices, electronic equipment, semiconductor manufacturing equipment, medical equipment, measuring equipment, plotting machines and photocopiers.

[Reduced Design and Assembly Costs]

It provides a highly accurate linear guide system with lower design cost and fewer assembly man-hours than the conventional miniature ball bearings used in precision machines and other equipment.

[Maintains Long-term Stability]

It is a ball-circulating type slide unit with an extremely small friction coefficient. This slide unit maintains stable performance over a long period of time.

[Lightweight, Compact Design and High-speed Response]

The outer rail and the inner block are composed of very thin stainless steel plates.
Since the linear pack is light, it has a small inertial moment and demonstrates superb high-speed response.

Rated Load and Nominal Life

[Rated Loads in All Directions]

The basic load rating in the specification table indicates the rated load in the radial direction as shown in Fig.2. The rated loads in the reverse radial and lateral directions are obtained from Table1 below.

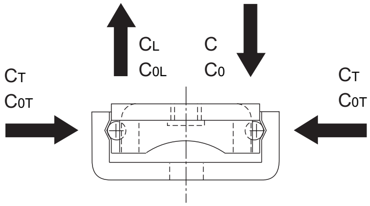


Fig.2 Rated Loads in All Directions

Table1 Rated Loads in All Directions

	Basic dynamic load rating	Basic static load rating
Radial direction	C (indicated in the specification table)	C_0 (indicated in the specification table)
Reverse radial direction	$C_L=C$	$C_{0L}=C_0$
Lateral directions	$C_T=1.47C$	$C_{0T}=1.73C_0$

[Static Safety Factor f_S]

Model ER may receive an unexpected external force while it is stationary or operative due to the generation of an inertia caused by vibrations and impact or start and stop. It is necessary to consider a static safety factor against such a working load.

$$f_S = \frac{f_C \cdot C_0}{P_C}$$

f_S : Static safety factor (see Table2)
f_C : Contact factor (see Table3 on A-568)
C_0 : Basic static load rating (N)
P_C : Calculated load (N)

● Reference Value of Static Safety Factor

The static safety factors indicated in Table2 are the lower limits of reference values in the respective conditions.

Table2 Reference Value of Static Safety Factors (f_S)

Machine using the LM system	Condition	Lower limit of f_S
General industrial machinery	Without vibration or impact	1 to 1.3
	With vibration or impact	2 to 7

[Nominal Life]

The nominal life of model ER is obtained using the following equation.

$$L = \left(\frac{f_C}{f_W} \cdot \frac{C}{P_C}\right)^3 \times 50$$

L : Nominal life (km)
(The total number of revolutions that 90% of a group of identical ER units independently operating under the same conditions can achieve without showing flaking)
C : Basic dynamic load rating (N)
P_C : Calculated load (N)
f_C : Contact factor (see Table3)
f_W : Load factor (see Table4 on A-569)

[Calculating the Service Life Time]

When the nominal life (L) has been obtained, if the stroke length and the number of reciprocations per minute are constant, the service life time is obtained using the following equation.

$$L_h = \frac{L \times 10^6}{2 \times \ell_S \times n_1 \times 60}$$

L_h : Service life time (h)
ℓ_S : Stroke length (mm)
n_1 : Number of reciprocations per minute (min^{-1})

● f_C: Contact Factor

When multiple inner blocks are used in close contact with each other, their linear motion is affected by a moment load 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 Table3.

Table3 Contact Factor (f_C)

Number of inner blocks in close contact with each other	Contact factor f_C
2	0.81
3	0.72
Normal use 1	1

● f_W: Load Factor

In general, reciprocating machines tend to involve vibrations or impact during operation. It is extremely difficult to accurately determine vibrations generated during high-speed operation and impact during frequent start and stop. Therefore, when the actual load applied on model ER cannot be obtained, or when speed and vibrations have a significant influence, divide the basic dynamic load rating (C) by the corresponding load factor in Table4 of empirically obtained data.

Table4 Load Factor (f_W)

Vibrations/ impact	Speed(V)	f_W
Faint	Very low $V \leqq 0.25$m/s	1 to 1.2
Weak	Slow $0.25 < V \leqq 1$m/s	1.2 to 1.5

Accuracy Standards

The running straightness of model ER is indicated in Table5. (See Fig.3.)

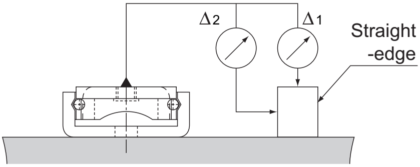


Fig.3 Method for Measuring Running Straightness

Table5 Running Straightness Unit: mm

Stroke length		Running straightness of inner block in vertical directions Δ1	Running straightness of inner block in horizontal directions Δ2
Above	Or less		
—	20	0.002	0.004
20	40	0.003	0.006
40	60	0.004	0.008
60	80	0.005	0.010
80	100	0.006	0.012
100	120	0.008	0.016

Radial Clearance

The radial clearance of model ER means the value for the motion of the central part of the inner block when the inner block is slightly moved with a vertically constant force in the middle of the outer rail in the longitudinal direction. The negative values in table 6 indicate that the respective models are provided with a preload when assembled and have no clearance between their inner blocks and the outer rails.

Table6 Radial Clearance Unit: µm

Model No.	Radial clearance	
	Normal	C1
ER 513	±2	−2 to 0
ER 616	±2	−3 to 0
ER 920	±2	−4 to 0
ER 1025	±3	−6 to 0

Note) When desiring normal clearance, add no symbol; when desiring C1 clearance, indicate "C1" in the model number.
(see "Model number coding" on B-476)

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.
(2) Dropping or hitting the Precision Linear Pack may damage it. Giving an impact to the product could also cause damage to its function even if the product looks intact.
(3) Removing the inner block of the Precision Linear Pack from the outer rail or letting it overshoot will cause balls to fall off.

[Lubrication]

(1) Thoroughly remove anti-rust oil with a cleaning detergent and apply lubricant before using the product. As the most suitable grease, we recommend THK AFC Grease, which maintains lubricity over a long period of time. For lubrication in a clean room, low dust generation THK AFE-CA Grease and THK AFF Grease are recommended.
(2) Do not mix lubricants of different physical properties.
(3) In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, normal lubricants may not be used. Contact THK for details.
(4) When planning to use a special lubricant, contact THK before using it.

[Installation]

The mounting surface of Precision Linear Pack model ER must be finished to the maximum accuracy.
For securing the outer rail of models ER513 and ER613, also purchase and use No. 0 screws for precision equipment (see Table1). (If using ordinary screws, the inner block may hit the screw head.)

Table1 Outer Rail Fixing Screws for Models ER513 and ER616

Model No.	Type	Nominal name of screw × pitch
ER 513	No. 0 pan-head screw (class 1)	M2×0.4
ER 616		M2.6×0.45

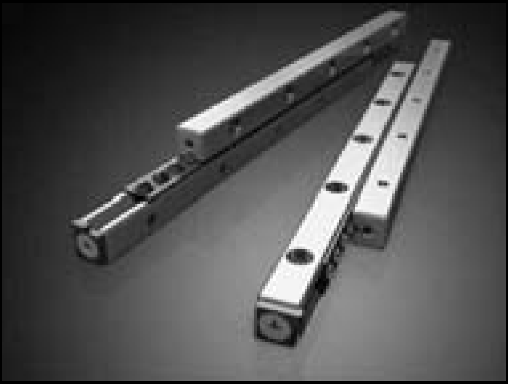
Japan Camera Industry Association Standard JCIS 10-70
Cross-recessed screw for precision equipment (No. 0 screw)

[Precautions on Use]

(1) Entrance of foreign material may cause damage to the ball circulating component or functional loss. Prevent foreign material, such as dust or cutting chips, from entering the system.
(2) If foreign material such as dust of cutting chips adheres to the product, replenish the lubricant after cleaning the product with pure white kerosene.
(3) Contact THK if you desire to use the product at a temperature of 80℃ or higher.
(4) When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, contact THK in advance.

[Storage]

When storing the Precision Linear Pack, enclose it in a package designated by THK and store it while avoiding high temperature, low temperature and high humidity.



Cross Roller Guide/Ball Guide

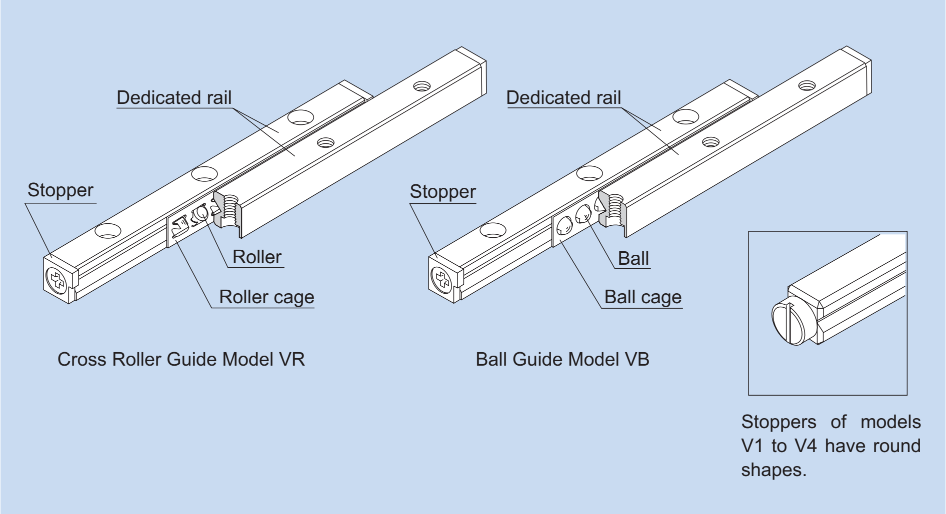
THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Cross Roller Guide/Ball Guide



Cross Roller Guide Model VR

Ball Guide Model VB

Stoppers of models V1 to V4 have round shapes.

Fig.1 Structure of Cross Roller Guide Model VR and Ball Guide Model VB

Structure and Features

In model VR, precision rollers are orthogonally aligned one after another in a roller cage that is combined with a dedicated rail having a raceway cut into a V-shape groove. When two units of the Cross Roller Guide are mounted in parallel, the guide system is capable of receiving loads in the four directions. In addition, since the Cross Roller Guide can be given a preload, a clearance-free, highly rigid and smooth slide mechanism is achieved.
Model VB is a low-friction, high-accuracy, finite LM system consisting of precision steel balls, arranged in short pitches in a ball cage model B, and a dedicated rail model V.
The Cross Roller Guide and the Ball Guide are used in the slide unit of various devices such as OA equipment and its peripherals, measuring instruments, precision equipment including a printed circuit board drilling machine, optic measuring machines, optic stages, handling mechanisms and X-Ray machines.

[Long Service Life, High Rigidity]

With a unique roller retaining mechanism, the effective contact length of the rollers is 1.7 times greater than the conventional type. Furthermore, the roller pitch interval is short and a sufficient number of rollers are installed, thus increasing the rigidity by two and the service life by six times greater than the conventional type. As a result, a safety-oriented design against vibrations and impact, which commonly occur in ordinary straight motion mechanisms, can be achieved.

[Smooth Motion]

With model VR, the rollers are individually held in a cage and roller pockets formed on the cage are in surface contact with the rollers to increase grease retention. Thus, smooth motion with little wear and friction is achieved.

[Highly Corrosion Resistant]

Model VR series and model VB series both include types made of stainless steel, which is highly corrosion resistant.

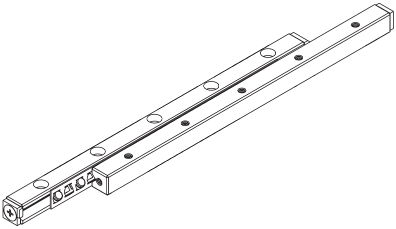
Types of the Cross Roller Guide/Ball Guide

Types and Features

Cross Roller Guide Model VR

Specification Table⇒B-480

A compact, highly rigid LM system whose roller cage holding precision rollers orthogonally aligned one after another travels by half the stroke on a V-shaped groove formed on a rail.

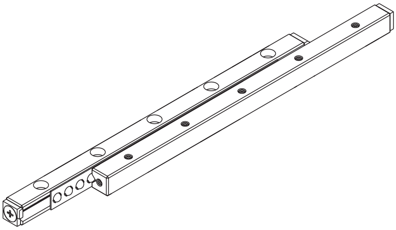


Model VR

Ball Guide Model VB

Specification Table⇒B-498

A low-friction, highly accurate LM system whose ball cage holding precision balls in short pitches travels by half the stroke on a V-shaped groove formed on a rail.



Model VB

Rated Load and Nominal Life

[Rated Loads in All Directions]

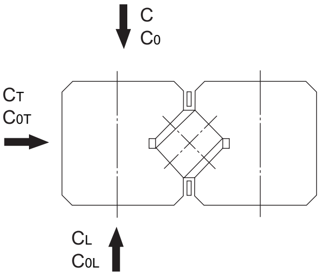
The basic load ratings (C_z and C_{0z}) in the specification table indicate the values per rolling element in the directions shown in Fig.1. When obtaining the nominal life, calculate the basic load ratings (C and C_0) of the actually used rolling elements from the equation below.

- **For Model VR**

$$C = C_L = \left(\frac{Z}{2}\right)^{\frac{3}{4}} \times C_z,\quad C_T = 2C$$

$$C_0 = C_{0L} = \frac{Z}{2} \times C_{0z},\quad C_{0T} = 2C_0$$

(For $\frac{Z}{2}$, truncate the decimals.)

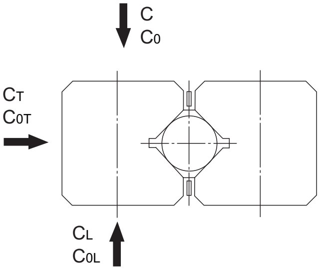


Model VR

- **For Model VB**

$$C = C_L = Z^{\frac{2}{3}} \times C_z,\quad C_T = 2C$$

$$C_0 = C_{0L} = Z \times C_{0z},\quad C_{0T} = 2C_0$$



Model VB

Fig.1

C : Basic dynamic load rating (kN)
C_0 : Basic static load rating (kN)
C_z : Basic dynamic load rating in the specification table (kN)
C_{0z} : Basic static load rating in the specification table (kN)
Z : Number of rolling elements used (number of rolling elements within the effective load range)

[Static Safety Factor f_S]

Models VR and VB may receive an unexpected external force while it is stationary or operative due to the generation of an inertia caused by vibrations and impact or start and stop. It is necessary to consider a static safety factor against such a working load.

$$f_S = \frac{C_0}{P_C}$$

f_S : Static safety factor (see Table1)
C_0 : Basic static load rating (kN)
P_C : Calculated load (kN)

Table1 Reference Values of Static Safety Factor (f_S)

Machine using the LM system	Basic dynamic load rating	Lower limit of f_S
General industrial machinery	Without vibration or impact	1 to 1.3
	With vibration or impact	2 to 3

[Nominal Life]

When the basic dynamic load ratings have been obtained, the rated lives of model VR and model VB are obtained using the following equations.

- **For Model VR**

$$L = \left(\frac{f_T}{f_W} \cdot \frac{C}{P_C}\right)^{\frac{10}{3}} \times 100$$

- **For Model VB**

$$L = \left(\frac{f_T}{f_W} \cdot \frac{C}{P_C}\right)^{3} \times 50$$

L : Nominal life (km)
(The total number of revolutions that 90% of a group of identical VR (VB) units independently operating under the same conditions can achieve without showing flaking)
C : Basic dynamic load rating (kN)
P_C : Calculated load (kN)
f_T : Temperature factor (see Fig.2 on A-577)
f_W : Load factor (see Table2 on A-577)

[Calculating the Service Life Time]

When the nominal life (L) has been obtained, if the stroke length and the number of reciprocations per minute are constant, the service life time is obtained using the following equation.

$$L_h = \frac{L \times 10^6}{2 \times \ell_S \times n_1 \times 60}$$

L_h : Service life time (h)
ℓ_S : Stroke length (mm)
n_1 : Number of reciprocations per minute (min^{-1})

● f_T: Temperature Factor

If the temperature of the environment surrounding the operating model VR or VB 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.2.

Note) If the environment temperature exceeds 100 ℃ , contact THK.

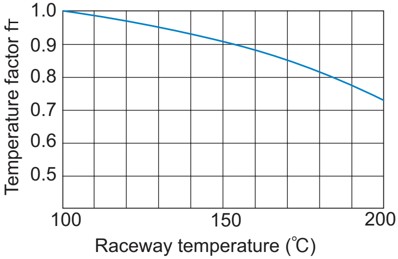


Fig.2 Temperature Factor (f_T)

● f_W: Load Factor

In general, reciprocating machines tend to involve vibrations or impact during operation. It is extremely difficult to accurately determine vibrations generated during high-speed operation and impact during frequent start and stop. Therefore, when the actual load applied on model VR or VB cannot be obtained, or when speed and vibrations have a significant influence, divide the basic load rating (C or C_0), by the corresponding load factor in Table2 of empirically obtained data.

Table2 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

Accuracy Standards

The accuracy of the dedicated rail for the Cross Roller Guide is classified into high accuracy grade (H) and precision grade (P) as shown in Table3.

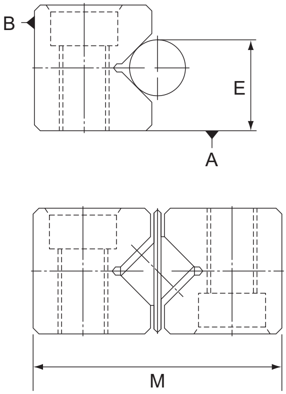


Fig.3

Table3 Accuracy Standards for Dedicated Rail Model V

Unit: mm

Accuracy grades	High-accuracy grade	Precision grade
Symbol	H	P
Item		
Parallelism of the raceway against surfaces A and B	As per Fig.4	
Dimensional tolerance in height E	±0.02	±0.01
Difference in height E (note)	0.01	0.005
Dimensional tolerance in width M	$^{0}_{-0.2}$	$^{0}_{-0.1}$

Note) The difference in height E applies to four rails used on the same plane.

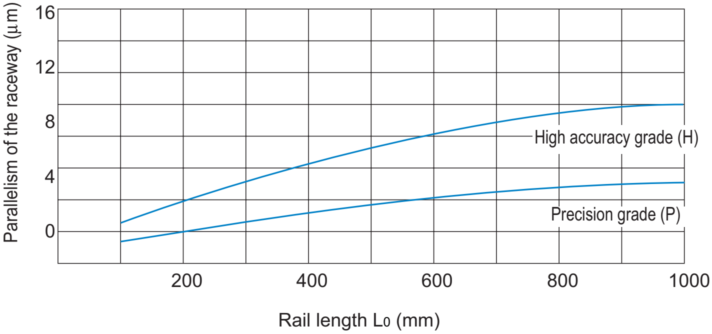


Fig.4 Rail Length and Parallelism of the Raceway

Installation Procedure

When using clearance adjustment bolts:

(1) Closely contact rails 2 and 3 onto the base, and rail 1 onto the table, and then firmly tighten the rail mounting bolts.

(2) Temporarily fasten rail 4 to the table.

Note) The rail mounting bolts must be designed so that they can be fully fastened while maintaining the rail installed.

(3) Place the base and the tables as shown in Fig.1, and then insert the roller cage from the end. If the cage does not enter because there is no clearance, slide rail 4 toward the adjustment bolt first, and then insert the cage again.

(4) Place a dial gauge as shown in Fig.1. Then, lightly screw all adjustment bolts evenly until the clearance is almost eliminated while gently pressing the table sideways.

(5) Attach the stopper to the rail end.

(6) Slide the table and adjust the cage position so as to achieve the required stroke.

(7) Position the roller cage in the center of the rail as shown in Fig.2-1. Then, evenly tighten the adjustment bolts (b, c and d) that are within the area where the roller is present until the dial gauge indicates the required displacement. Fully fasten the mounting bolts where adjustment was performed.

Note) The displacement indicated on the gauge represents the preload per roller cage.

(8) Slide the table as shown in Fig.2-2, and adjust the remaining adjustment bolts (a and e) in the same manner.

Note) When installing two or more units, first measure the tightening torque of the adjustment bolts for the first unit or the sliding resistance of the fist unit. Then, install the second (and later) unit so that its/their tightening torque(s) or sliding resistance(s) equal(s) that of the first unit. In this way, almost uniform preloads can be provided.

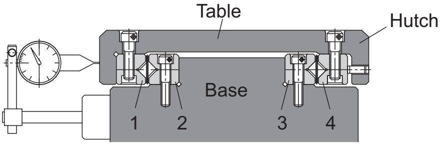


Fig.1 Installation of the Cross Roller Guide

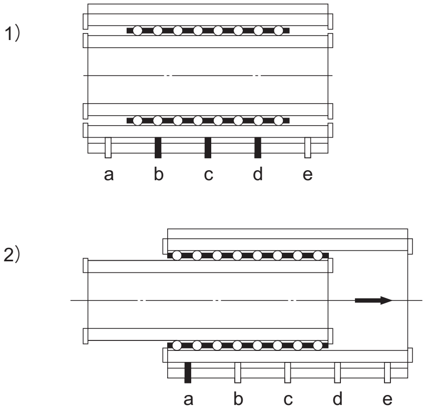
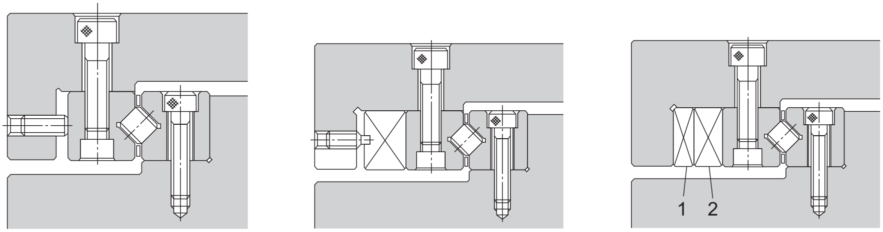


Fig.2 Sequence of Tightening the Adjustment Bolts

Example of Clearance Adjustment

Design the adjustment bolt so that it presses the rail on the same level as the roller.



Normally, press the rail with the adjustment bolt.

When a certain level of accuracy and rigidity is required, use a presser plate.

When high accuracy and high rigidity are required, use tapered gibs 1 and 2.

Fig.3 Example of Clearance Adjustment

Preload

An excessive preload may cause indentation, shorten the service life or cause trouble. The permissible preload per roller cage is indicated in the specification table. Tighten the adjustment bolts while monitoring the displacement of the roller contact area.

Accuracy of the Mounting Surface

To achieve a high level of running accuracy, it is also necessary to establish a certain level of accuracy in parallelism and straightness. Preferably, the parallelism and the flatness of the rail-mounting surface should be finished by grinding or similar machining to at least the same degree as the parallelism of the rail (see A-578). Also, mount the rail so that it closely contacts the mounting surface.

Dedicated Mounting Bolt

To mount the rail where normal clearance is to be adjusted, use the screw hole drilled on the rail as shown in Fig.1. The holes of the bolt (d_1 and D_1) must be machined so that they are greater by the adjustment allowance.

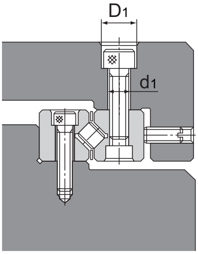


Fig.1

If it is inevitable to adopt a mounting method like the one shown in Fig.2 for a structural reason, use the dedicated mounting bolt (S) indicated in Fig.3.

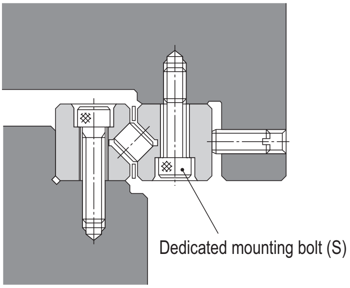


Fig.2

Table1 Dedicated Mounting Bolt

Unit: mm

Model No.	S	d	D	H	L	B	Supported rail
S 3	M3	2.3	5	3	12	2.5	V3
S 4	M4	3.1	5.8	4	15	3	V4
S 6	M5	3.9	8	5	20	4	V6
S 9	M6	4.6	8.5	6	30	5	V9
S 12	M8	6.25	11.3	8	40	6	V12
S 15	M10	7.9	13.9	10	45	8	V15
S 18	M12	9.6	15.8	12	50	10	V18

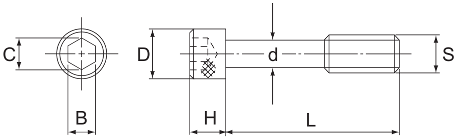


Fig.3 Dedicated Mounting Bolt

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.
(2) Dropping or hitting the Cross Roller Guide/Ball Guide may damage it. Giving an impact to it could also cause damage to its function even if the product looks intact.

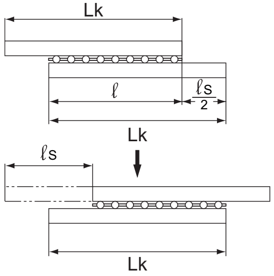
[Lubrication]

(1) Thoroughly remove anti-rust oil and feed lubricant before using the product.
(2) Do not mix lubricants of different physical properties.
(3) In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, normal lubricants may not be used. Contact THK for details.
(4) When planning to use a special lubricant, contact THK before using it.

[Rail Length]

The roller cage and the ball cage move half the travel distance of the table in the same direction. To prevent the cage from overhanging from the raceway base when the cage length is "ℓ" and the stroke length is "ℓ_s", the rail length (Lk) must be at least the following.

$$Lk \geqq \ell + \frac{\ell_s}{2}$$



[Offset of the Cage]

The cage, which retains rollers (or balls), demonstrates extremely accurate motion. However, it may be offset as affected by driving vibrations, inertia or impact.
If using the Cross Roller Guide or Ball Guide in the following conditions, contact THK.

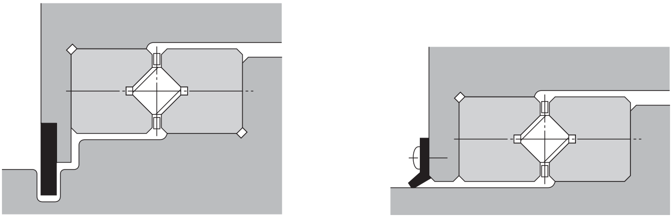
- Vertical use
- Pneumatic cylinder drive
- Cam drive
- High speed crank drive
- Under a large moment load
- Butting the guide's external stopper with the table

[Stopper]

Stoppers are attached to the rail ends in order to prevent the cage from falling off. Note, however, that frequently colliding the cage with the stopper may cause wear of the stopper and loosening of the stopper fastening screws, and may cause the cage to fall off.

[Contamination Protection]

As a means to prevent foreign material from entering the Cross Roller Guide or the Ball Guide, contamination protection accessories for the side faces as shown in Fig.1 are available. For contamination protection in the front and rear directions, consider using a bellows or a telescopic cover.



Labyrinth cover

Wiper seal

Fig.1 Contamination Protection Methods

[Precautions on Use]

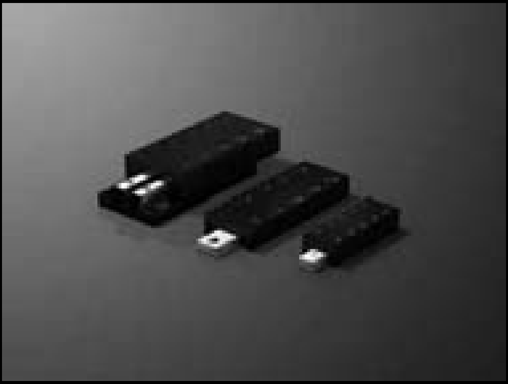
(1) If foreign material adheres to the product, replenish the lubricant after cleaning the product.

(2) Contact THK if you desire to use the product at a temperature of 100℃ or higher.

(3) When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, contact THK in advance.

[Storage]

When storing the Cross Roller Guide/Ball Guide, enclose it in a package designated by THK and store it while avoiding high temperature, low temperature and high humidity.



Cross Roller Table

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Cross Roller Table

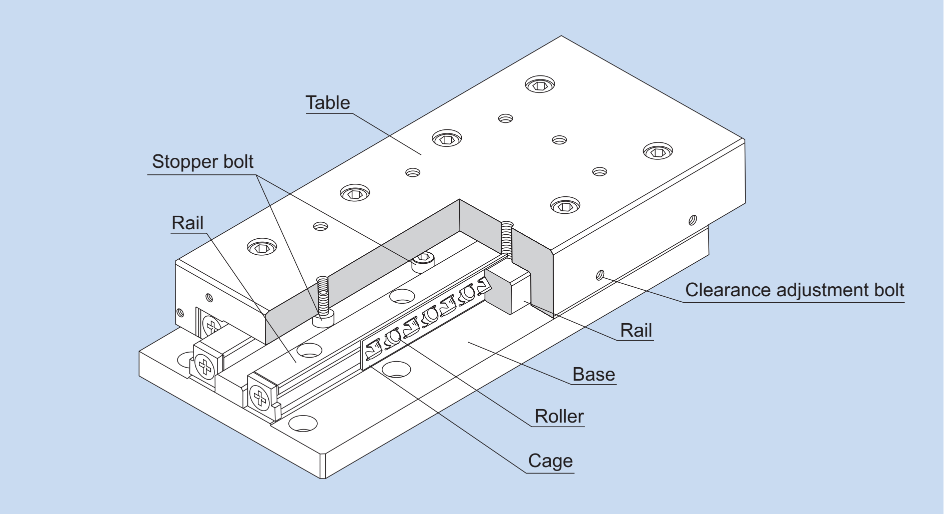


Fig.1 Structure of the Cross Roller Table

Structure and Features

The Cross Roller Table is a compact, highly rigid finite linear guide unit that has the Cross Roller Guide(s) between the precision-machined table and base.
There are two types of the Cross Roller Table: model VRU, and a miniature type model VRT. The Cross Roller Table is used in extensive applications such as OA equipment and peripherals, measuring instruments and printed circuit board drilling machines.

[Easy Installation]

Since the Cross Roller Guide(s) is installed between the precision-machined table and base, a highly accurate linear guide mechanism is achieved simply by mounting the product with bolts.

[Large Permissible Load]

Since rollers with large rated loads are installed in short pitches, the cross roller guide is capable of bearing a heavy load, achieving a highly rigid linear guide mechanism and gaining a long service life.

[Diversified Usage]

Since the rollers are orthogonally arranged one after another, the guide system is capable of evenly receiving loads in the four directions applied on the table. (See Fig.2.)

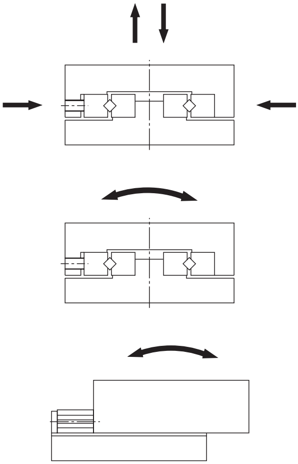
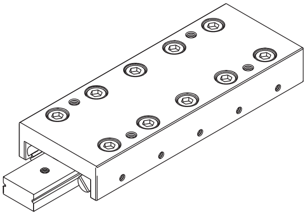


Fig.2 Load Directions

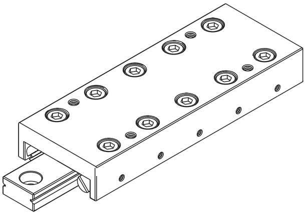
[Highly Corrosion Resistant]

The base and the table of models VRT-M and VRT-AM use stainless steel. Their rails, rollers, roller cages and screws are also made of stainless steel. As a result, these guide systems have significantly high corrosion resistance.

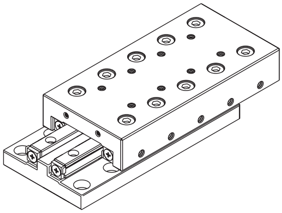
The base and the table of model VRU-M are made of aluminum.



Model VRT



Model VRT-A



Model VRU

Rated Load and Nominal Life

[Rated Loads in All Directions]

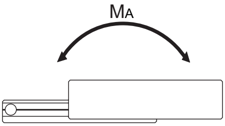
The rated loads of models VRT, VRT-A and VRU are equal in four directions (radial, reverse radial and lateral directions), and their values are expressed as C and C_0 in the corresponding specification tables.

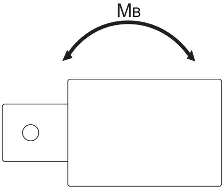
[Static Safety Factor f_S]

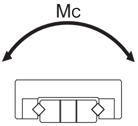
The Cross Roller Table may receive an unexpected external force while it is stationary or operative due to the generation of an inertia caused by vibrations and impact or start and stop. It is necessary to consider a static safety factor against such a working load.

$$f_S = \frac{C_0}{P_C} \quad \text{or} \quad f_S = \frac{M_0}{M}$$

f_S : Static safety factor
C_0 : Basic static load rating (kN)
M_0 : Static permissible moment
(M_A, M_B and M_C)
P_C : Calculated load (kN)
M : Calculated moment (kN)







● Reference value of static safety factor

The static safety factors indicated in Table1 are the lower limits of reference values in the respective conditions.

Table1 Reference Values of Static Safety Factor (f_S)

Machine using the LM system	Basic dynamic load rating	Lower limit of f_S
General industrial machinery	Without vibration or impact	1 to 1.3
	With vibration or impact	2 to 3

[Nominal Life]

The nominal life of the Cross Roller Table is obtained using the following equation.

$$L = \left(\frac{f_T}{f_W} \cdot \frac{C}{P_C} \right)^{\frac{10}{3}} \times 100$$

L : Nominal life (km)
(The total number of revolutions that 90% of a group of identical VRT, VRT-A or VRU units independently operating under the same conditions can achieve without showing flaking)
C : Basic dynamic load rating (kN)
P_C : Calculated radial load (kN)
f_T : Temperature factor (see Fig.1 on A-590)
f_W : Load factor (see Table2 on A-590)

[Calculating the Service Life Time]

When the nominal life (L) has been obtained, if the stroke length and the number of reciprocations per minute are constant, the service life time is obtained using the following equation.

$$L_h = \frac{L \times 10^6}{2 \times \ell_S \times n_1 \times 60}$$

L_h : Service life time (h)
ℓ_S : Stroke length (mm)
n_1 : Number of reciprocations per minute (min^{-1})

- **f_T: Temperature Factor**

If the temperature of the environment surrounding the operating model VRT, VRT-A or VRU 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.1.

Note) If the environment temperature exceeds 100 ℃ , contact THK.

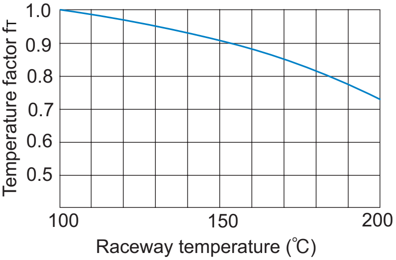


Fig.1 Temperature Factor (f_T)

- **f_W: Load Factor**

In general, reciprocating machines tend to involve vibrations or impact during operation. It is extremely difficult to accurately determine vibrations generated during high-speed operation and impact during frequent start and stop. Therefore, when the actual load applied on model VRT, VRT-A or VRU cannot be obtained, or when speed and vibrations have a significant influence, divide the basic load rating (C or C_0), by the corresponding load factor in Table2 of empirically obtained data.

Table2 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

Accuracy Standards

The dimensional tolerances of Cross Roller Table models VRT, VRT-A and VRU in height (M) and width (W), and the running accuracy of the base against the mounting surfaces C and D are indicated in the corresponding specification tables.

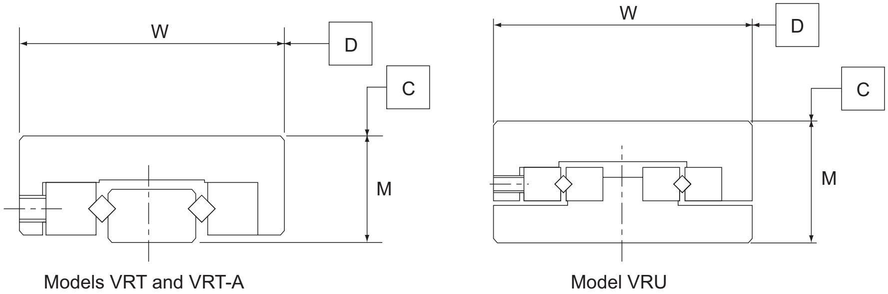


Fig.2 Accuracy Standards

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.

(2) Dropping or hitting the Cross Roller Table may damage it. Giving an impact to it could also cause damage to its function even if the product looks intact.

[Lubrication]

(1) For lubrication of the Cross Roller Table, use lithium-soap group grease or oil when it is necessary as with ordinary bearings.

(2) Thoroughly remove anti-rust oil and feed lubricant before using the product.

(3) Do not mix lubricants of different physical properties.

(4) In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, normal lubricants may not be used. Contact THK for details.

(5) When planning to use a special lubricant, contact THK before using it.

[Additional Machining of the Table and the Base]

When additionally machining the table and the base of the Cross Roller Table according to the conditions such as drilling mounting holes, adhere to the following precautions.

(1) Do not let cutting chips enter the Cross Roller Guide unit.

(2) Machine the mounting holes as blind holes, not though holes.
THK can perform additional machining such as mounting holes as requested.

The clearance of the Cross Roller Table is adjusted to the appropriate preload. Do not touch the clearance adjustment screw.

[Offset of the Cage]

The cage, which retains rollers (or balls), demonstrates extremely accurate motion. However, it may be offset as affected by driving vibrations, inertia or impact.

If using the Cross Roller Guide or Ball Guide in the following conditions, contact THK.

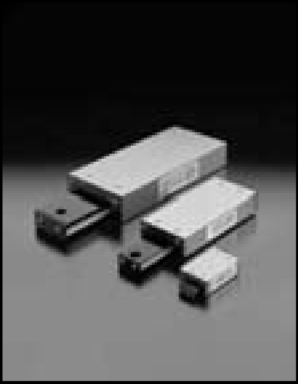
- Vertical use
- Pneumatic cylinder drive
- Cam drive
- High speed crank drive
- Under a large moment load
- Butting the guide's external stopper with the table

[Precautions on Use]

(1) Entrance of foreign material may cause damage to the ball circulating component or functional loss. Prevent foreign material, such as dust or cutting chips, from entering the system.
(2) If foreign material adheres to the product, replenish the lubricant after cleaning the product.
(3) Contact THK if you desire to use the product at a temperature of 100℃ or higher.
(4) When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, contact THK in advance.

[Storage]

When storing the Cross Roller Table, enclose it in a package designated by THK and store it while avoiding high temperature, low temperature and high humidity.



Linear Ball Slide

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Linear Ball Slide

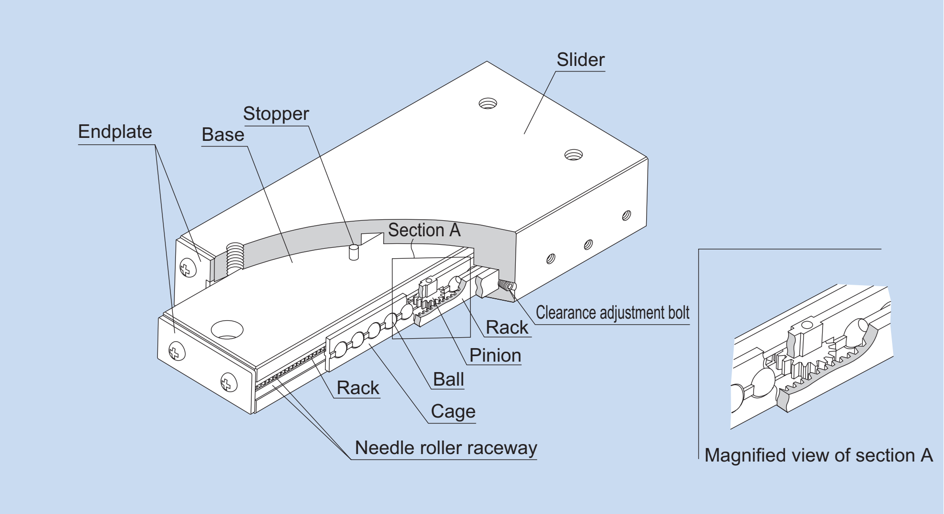


Fig.1 Structure of Linear Ball Slide Model LSP

Structure and Features

The Linear Ball Slide is a highly corrosion resistant slide unit that has an extremely low friction coefficient because stainless steel balls roll on four stainless steel needle roller raceways that are hardened and ground.

In addition, model LSP has a pinion gear in the center and a rack on the base to prevent the cage from slipping.

A ball slide equipped with a cylinder model LSC has a cylinder for drive in the base to downsize the system and reduce the space and the weight.

Its components are all made of stainless steel, which is highly corrosion resistant. Furthermore, since its inertia is small, the slide system is highly responsive to high speed. By simply securing the Linear Ball Slide on the mounting surface, the user can easily achieve a linear guide mechanism. Thus, this slide system is optimal for locations requiring high accuracy, such as optic measuring machines, automatic recorders, small electronic-parts assembling machines, OA equipment and its peripherals.

[A Unit Type That Allows Easy Installation]

The clearance and motion of the slider is adjusted to the best state. Therefore, a highly accurate slide mechanism can be gained by simply mounting the unit on the flat-finished mounting surface.

[Lightweight and Compact]

A light aluminum alloy is used in the base and the slider to reduce the weight.

[Smooth Motion]

The balls and the raceway (needle roller raceway) are in point contact, which causes the smallest rolling loss, and the balls are evenly retained in the ball cage. This allows the slide system to perform rolling motion at a minimal coefficient of friction (μ = 0.0006 to 0.0012).

[Highly Corrosion Resistant]

The base and the slider are made of an aluminum alloy and their surfaces are treated with alumite (anodization processing), which is highly resistant to corrosion and wear.

The balls, needle roller raceways and screws are made of stainless steel, making the system highly corrosion resistant.

Types of the Linear Ball Slide

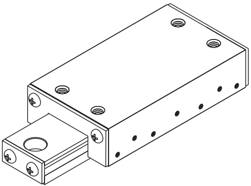
Types and Features

Linear Ball Slide with a Rack Model LSP

Specification Table⇒B-514

With model LSP, the cage has a rack and pinion mechanism, thus to prevent the cage from slipping.
Also, since the cage does not slip even in vertical mount, this model is used in an even broader range of applications.

Note) Do not use the stopper as a mechanical stopper.



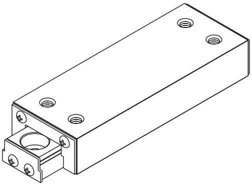
Model LSP

Linear Ball Slide Model LS

Specification Table⇒B-516

Model LS is a unit-type linear system for finite motion that has a structure where balls are arranged between the base and the slider via a needle roller raceway.
It is incorporated with a stopper mechanism, thus to prevent damage deformation caused by collision between the cage and the endplate.

Note) Do not use the stopper as a mechanical stopper.



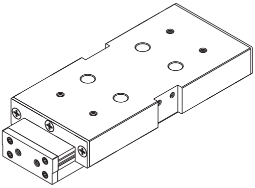
Model LS

Linear Ball Slide with a Cylinder Model LSC

Specification Table⇒B-518

Model LSC contains an air cylinder for drive inside the base. Feeding air from the two ports on the side face of the base allows the slide to perform reciprocating motion. Since the cylinder is of double-acting type, horizontal traveling speed can be adjusted using the speed controller. The cylinder and the piston are made of a corrosion resistant aluminum alloy, and their surfaces are specially treated to increase wear resistance and durability. Additionally, the cage has a rack and pinion mechanism, thus enabling the cage to operate without slipping.
Air-feeding ports for piping are provided on one side face, ensuring a certain degree of operability and easy assembly even if the installation site has a limited space and is complex.
The table on the right shows the specifications of the air cylinder incorporated in model LSC.

Note) Do not use the stopper as a mechanical stopper.



Model LSC

<Cylinder specifications>

Type of action	Double-acting
Fluid used	air (no lubrication)
Working pressure	100 kPa to 700 kPa (1 kgf/cm^2 to 7 kgf/cm^2)
Stroke velocity	50 to 300mm/s

[Speed Controller]

Fig.2 shows the shape of the speed controller.

Note) The speed controller is optional.
(control method: meter out)

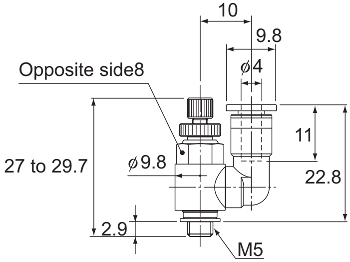


Fig.2 Shape of the Speed Controller (common to all model numbers)

[Dedicated Unit Base Model B]

With Linear Ball Slide model LSC, a limit switch for detecting the stroke end can be mounted using a dedicated unit base (Fig.3). When fine positioning is required, a dedicated stopper can be mounted on the unit base to adjust the position. (excluding model LSC1015)

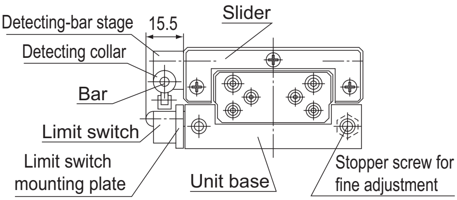
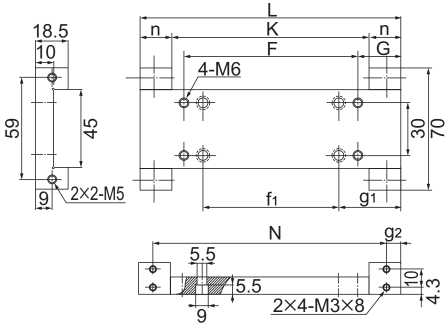
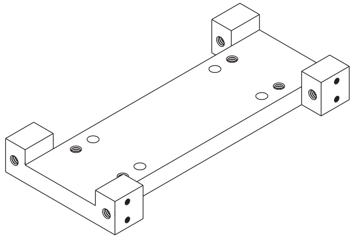


Fig.3 Unit Base and Limit Switch Installation





Unit: mm

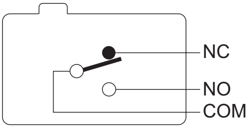
Unit base Model B	Unit base dimensions									Mass
	Length L	F	G	f_1	g_1	K	n	N	g_2	kg
LSC1515	80	40	21	23	29.5	56	12	68	6	0.12
LSC1530	110	60	25	40	35	74	18	94	8	0.16
LSC1550	150	100	25	78	36	114	18	134	8	0.21

[Limit Switch]

The specifications of the limit switch are as follows.

<Limit switch specifications>

Type	D2VW-5L2A-1 (Omron)
Contact type	contact (1C contact)



<Rated Specifications>

Type	Rated voltage (V)		Non-inductive load (A)				Inductive load (A)	
			Resistance load		Ramp load		Inductive load	
			Normally closed	Normally open	Normally closed	Normally open	Normally closed	Normally open
D2VW-5	AC	125	5		0.5		4	
		250	5		0.5		4	
	DC	30	5		3		4	
		125	0.4		0.1		0.4	

Note1) The above figures indicate the constant current.
Note2) Inductive load refers to power factor of 0.7 or greater (alternate current) and time constant of 7 ms or less (direct current).
Note3) Ramp load implies a rush current 10 times greater.
Note4) The above rated values apply when a test is conducted with the following conditions in accordance with JIS C 4505.
(1) Ambient temperature: 20℃± 2℃
(2) Ambient humidity: 65% ± 5% RH
(3) Operating frequency: 30 times/min

Note) For applications under a minute load (5 to 24 VDC), a minute-load type is available. Contact THK for details.

Rated Load and Nominal Life

[Rated Loads in All Directions]

The rated loads of models LS, LSP and LSC are identical in the vertical and horizontal directions.

[Static Safety Factor f_S]

Linear Ball Slide models LS, LSP or LSC may receive an unexpected external force while it is stationary or operative due to the generation of an inertia caused by vibrations and impact or start and stop. It is necessary to consider a static safety factor against such a working load.

$$f_S = \frac{C_0}{P_C} \quad \text{or} \quad f_S = \frac{M_0}{M}$$

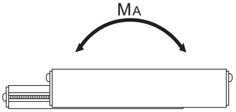
f_S : Static safety factor

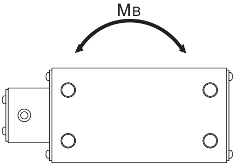
C_0 : Basic static load rating (N)

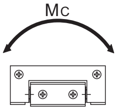
M_0 : Static permissible moment (M_A, M_B and M_C) (N-m)

P_C : Calculated load (N)

M : Calculated moment (N-m)







● Reference Value of Static Safety Factor

The static safety factors indicated in Table1 are the lower limits of reference values in the respective conditions.

Table1 Reference Value of Static Safety Factors (f_S)

Machine using the LM system	Load conditions	Lower limit of f_S
General industrial machinery	Without vibration or impact	1 to 1.3
	With vibration or impact	2 to 7

[Nominal Life]

The service life of the Linear Ball Slide is obtained using the following equation.

$$L = \left(\frac{1}{f_W} \cdot \frac{C}{P_C}\right)^3 \times 50$$

L : Nominal life (km)
(The total number of revolutions that 90% of a group of identical Linear Ball Slide units independently operating under the same conditions can achieve without showing flaking)
C : Basic dynamic load rating (N)
P_C : Calculated load (N)
f_W : Load factor (see Table2)

[Calculating the Service Life Time]

When the nominal life (L) has been obtained, if the stroke length and the number of reciprocations per minute are constant, the service life time is obtained using the following equation.

$$L_h = \frac{L \times 10^6}{2 \times \ell_S \times n_1 \times 60}$$

L_h : Service life time (h)
ℓ_S : Stroke length (mm)
n_1 : Number of reciprocations per minute (min^{-1})

● f_W: Load Factor

In general, reciprocating machines tend to involve vibrations or impact during operation. It is extremely difficult to accurately determine vibrations generated during high-speed operation and impact during frequent start and stop. Therefore, when the actual load applied on model VR or VB cannot be obtained, or when speed and vibrations have a significant influence, divide the basic load rating (C or C_0), by the corresponding load factor in Table2 of empirically obtained data.

Table2 Load Factor (f_W)

Vibrations/ impact	Speed(V)	f_W
Faint	Very low $V \leqq 0.25$m/s	1 to 1.2
Weak	Slow $0.25 < V \leqq 1$m/s	1.2 to 1.5

Accuracy Standards

The accuracies of Linear Ball Slide models LS, LSP and LSC are defined as follows.

Running parallelism of the top face of the slide
: 0.010mm MAX/10mm
Positioning repeatability of the top face of the slide
: 0.0015mm MAX

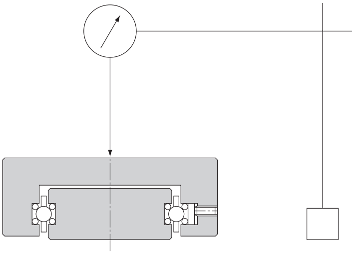


Fig.1 Accuracy Standards

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.
(2) Dropping or hitting the Linear Ball Slide may damage it. Giving an impact to the product could also cause damage to its function even if the product looks intact.

[Lubrication]

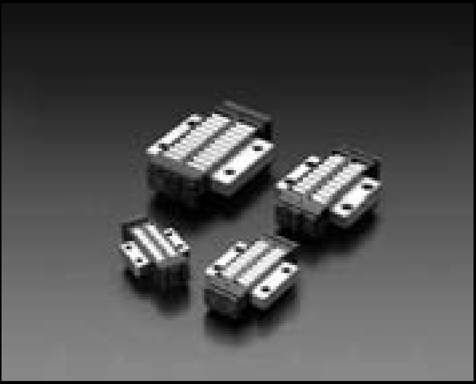
(1) Apply lubricant before using the product.
(2) Do not mix lubricants of different physical properties.
(3) In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, normal lubricants may not be used. Contact THK for details.
(4) When planning to use a special lubricant, contact THK before using it.

[Precautions on Use]

(1) Entrance of foreign material may cause damage to the ball circulating component or functional loss. Prevent foreign material, such as dust or cutting chips, from entering the system.
(2) If foreign material such as dust of cutting chips adheres to the product, replenish the lubricant after cleaning the product with pure white kerosene.
(3) Contact THK if you desire to use the product at a temperature of 80℃ or higher.
(4) When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, contact THK in advance.
(5) The Linear Ball Slide is incorporated with a stopper mechanism that prevents the slider from coming off. If impact is given, the stopper may be damaged. Do not use this stopper as a mechanical stopper.

[Storage]

When storing the Linear Ball Slide, enclose it in a package designated by THK and store it while avoiding high temperature, low temperature and high humidity.



LM Roller

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the LM Roller

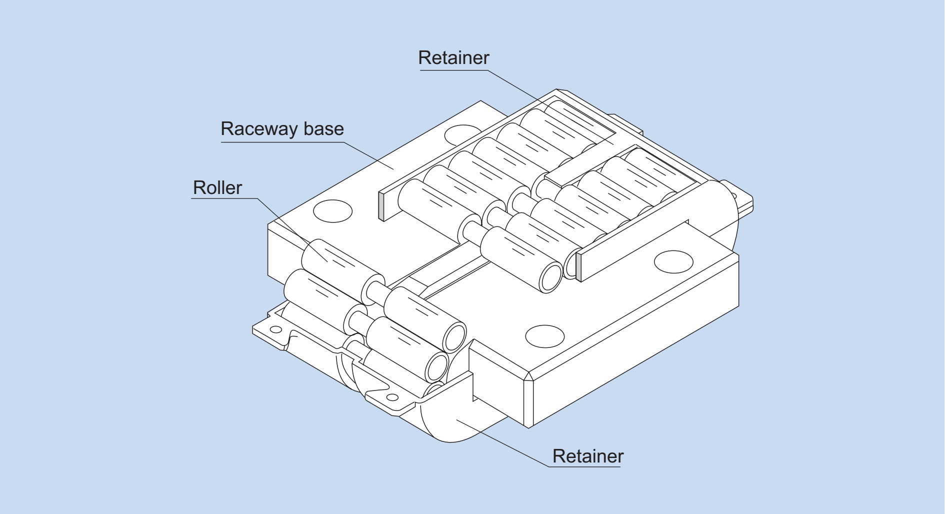


Fig.1 Structure of LM Roller Model LR

Structure and Features

In the LM Roller, dual rollers assembled on the circumference of the precision-ground, rigid raceway base travel in infinite circulation while being held by a retainer. A center guide integrated with the raceway base is formed in the central part of the loaded area of the raceway base to constantly correct skewing of the rollers. This unique structure ensures smooth rolling motion. The LM Roller is used in applications such as the XYZ guide of NC machine tools, precision press ram guides, press dies changers and heavy-load conveyance systems.

[Supports an Ultra Heavy Load and Ensures Smooth Motion]

The LM Roller is compact and capable of carrying a heavy load, and one unit of model LR50130 (length: 130 mm; width: 82 mm; height: 42 mm) is capable of receiving a 255 kN load. Moreover, because of rolling motion, this model has a low friction coefficient (μ = 0.005 to 0.01) and is free from stick-slip, thus achieving highly accurate straight motion.

[High Combined Accuracy]

In general, when supporting a single plane with LM rollers, multiple units of LM rollers are combined on the same plane, and therefore, the height difference between the rollers significantly affects the machine accuracy and service life. With THK LM Roller, the user can select a combination of models with a height difference of up to 2 μm.

[Rational Skewing-preventing Structure]

With an LM system using rollers, once the rollers skew, it increases friction resistance or decreases running accuracy.

To prevent skewing, the LM Roller has roller guides on the center of the retainer full circle, and in the center of the loaded area on the raceway base. This structure enables the LM Roller to automatically correct skewing caused by a mounting accuracy error and the rollers to travel in an orderly manner. It also allows the LM Roller to be installed with slant mount or wall mount while demonstrating high performance.

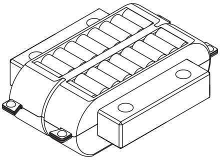
Types of the LM Roller

Types and Features

Model LR

Specification Table⇒B-524

This model is designed to be fit into a groove machined on the mounting surface. By screwing bolts into four holes on the raceway base, it is secured on the mounting surface. (Fixture models SM and SE are also available.)

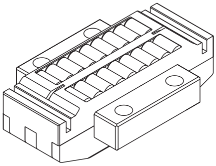


Model LR

Model LR-Z

Specification Table⇒B-524

A lighter type that uses a resin retainer and is designed to be mounted in the same manner as model LR. Since it has a groove for installing a seal, a special rubber seal with a high contamination protection effect can easily be attached. In addition, this model is capable of high-speed traveling at 1 m/s.

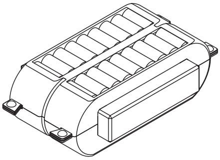


Model LR-Z

Model LRA

Specification Table⇒B-525

Just like model LR, this model is also designed to be fit into a groove. It is a compact type that can be mounted using fixture model SM or SE and bolts.

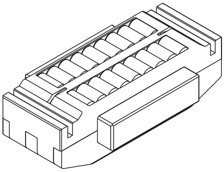


Model LRA

Model LRA-Z

Specification Table⇒B-525

A lighter type that uses a resin retainer and is designed to be mounted in the same manner as model LRA. Since it has a groove for installing a seal, a special rubber seal with a high contamination protection effect can easily be attached. In addition, this model is capable of high-speed traveling at 1 m/s.

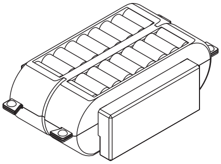


Model LRA-Z

Model LRB

Specification Table⇒B-526

Since this model does not require a groove on the mounting surface, man-hours for machining can be reduced. It can be mounted using fixture model SMB or SE and bolts.

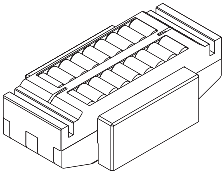


Model LRB

Model LRB-Z

Specification Table⇒B-526

A lighter type that uses a resin retainer and is designed to be mounted in the same manner as model LRB. Since it has a groove for installing a seal, a special rubber seal with a high contamination protection effect can easily be attached. In addition, this model is capable of high-speed traveling at 1 m/s.

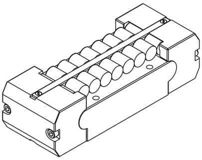


Model LRB-Z

Model LRU

Specification Table⇒B-527

Since this model does not require a groove on the mounting surface, man-hours for machining can be reduced. By screwing bolts into four holes on the raceway base, it is secured on the mounting surface.



Model LRU

Nominal Life

[Static Safety Factor f_S]

The LM Roller may receive an unexpected external force while it is stationary or operative due to the generation of an inertia caused by vibrations and impact or start and stop. It is necessary to consider a static safety factor against such a working load.

$$f_S = \frac{f_C \cdot C_0}{P_C}$$

f_S : Static safety factor
f_C : Contact factor (see Table2 on A-610)
C_0 : Basic static load rating (kN)
P_C : Calculated load (kN)

● Reference Value of Static Safety Factor

The static safety factors indicated in Table1 are the lower limits of reference values in the respective conditions.

Table1 Reference Value of Static Safety Factors (f_S)

Machine using the LM system	Basic dynamic load rating	Lower limit of f_S
General industrial machinery	Without vibration or impact	1 to 1.3
	With vibration or impact	2 to 3
Machine tool	Without vibration or impact	1 to 1.5
	With vibration or impact	2.5 to 7

[Nominal Life]

The nominal life of the LM Roller is obtained using the basic dynamic load rating (C) indicated in the corresponding specification table, and the following equation.

$$L = \left(\frac{f_H \cdot f_C \cdot f_T}{f_W} \cdot \frac{C}{P_C} \right)^{\frac{10}{3}} \times 100$$

L : Nominal life (km)
(The total number of revolutions that 90% of a group of identical LM Roller units independently operating under the same conditions can achieve without showing flaking)
C : Basic dynamic load rating (kN)
P_C : Calculated radial load (kN)
f_H : Hardness factor (see Fig.1)
f_T : Temperature factor (see Fig.2 on A-610)
f_C : Contact factor (see Table2 on A-610)
f_W : Load factor (see Table3 on A-610)

[Calculating the Service Life Time]

When the nominal life (L) has been obtained, if the stroke length and the number of reciprocations per minute are constant, the service life time is obtained using the following equation.

$$L_h = \frac{L \times 10^6}{2 \times \ell_S \times n_1 \times 60}$$

L_h : Service life time (h)
ℓ_S : Stroke length (mm)
n_1 : Number of reciprocations per minute (min^{-1})

● f_H: Hardness Factor

To maximize the load capacity of the LM system, 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).

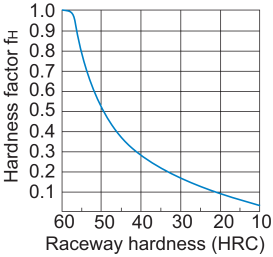


Fig.1 Hardness Factor (f_H)

● f_T: Temperature Factor

If the temperature of the environment surrounding the operating LM Roller 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.2.

Note) The normal service temperature of the LM Roller is 80 ℃ at a maximum. If the ambient temperature exceeds 80℃, contact THK.

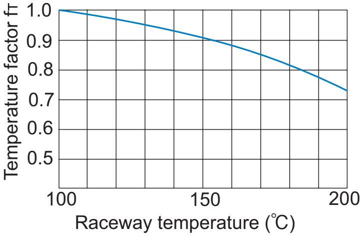


Fig.2 Temperature Factor (f_T)

● f_C: Contact Factor

When multiple LM Roller units are used in near 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 Table2.

Note) If uneven load distribution is expected in a large machine, take into account the respective contact factor indicated in Table2.

Table2 Contact Factor (f_C)

Number of LM Roller units 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 involve vibrations or impact during operation. It is extremely difficult to accurately determine vibrations generated during high-speed operation and impact during frequent start and stop. Therefore, when the actual load applied to the LM Roller cannot be obtained, or when speed and impact have a significant influence, divide the basic load rating (C or C_0) by the corresponding load factor in Table3 of empirically obtained data.

Table3 Load Factor (f_W)

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

Accuracy Standards

When multiple LM Roller units are arranged on the same plane, the mounting heights of the LM Roller units must be identical in order to achieve uniform load distribution. The dimensional tolerance of the LM Roller in height (A) is defined as indicated in Table4. When ordering LM Roller units to be used on the same plane, specify their tolerances with the same classification symbol.

Each classification symbol is marked on the package box and on the side face of the LM Roller's raceway base as indicated in Fig.4. (except for normal grade)

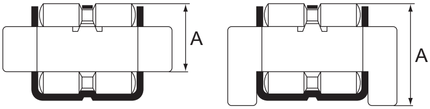


Fig.3 Mounting Height (A) of the LM Roller

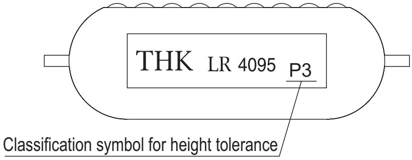


Fig.4

Table4 Classification of Dimensional Tolerances in Height (A)

Unit: μm

Accuracy Grades	Dimensional tolerance for A	Classification symbol
Normal grade	0 to −10	No Symbol
High grade	0 to −5	H5
	−5 to −10	H10
Precision grade	0 to −3	P3
	−3 to −6	P6
	−6 to −9	P9
	−9 to −12	P12
Ultra-precision grade	0 to −2	SP2
	−2 to −4	SP4
	−4 to −6	SP6
	−6 to −8	SP8
	−8 to −10	SP10

Raceway

To maximize the performance of the LM Roller, it is necessary to take into account the hardness, surface roughness and accuracy of the raceway, on which the rollers directly roll, when manufacturing the product. In particular, the hardness significantly affects the service life. Therefore, it is important to take much care in selecting a material and heat treatment method.

[Hardness]

We recommend surface hardness of 58 HRC (≒ 653 HV) or higher. The depth of the hardened layer is determined by the size of the LM Roller; we recommend approximately 2 mm for general use. If the hardness of the raceway is lower or the raceway cannot be hardened, multiply the load rating by the corresponding hardness factor (see Fig.1 on A-609).

[Material]

The following materials are generally used as suitable for surface hardening through induction-hardening and flame quenching.

- 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)

If the machine body is a mold, depending on the conditions, a hardened steel plate may not be used and instead, the surface of mold itself may be hardened.

[Surface Roughness]

To achieve smooth motion, the surface should preferably be finished to 0.40a or less. If slight wear is allowed in the initial stage, the surface may be finished to approximately 0.80a.

[Accuracy]

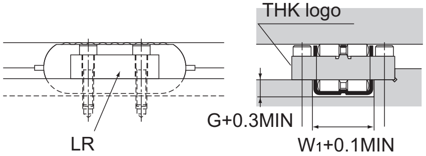
When high accuracy is required, securing a hardened steel plate to the machine body may cause undulation on the raceway. To avoid this, secure the LM Roller with bolts before grinding the hardened steel plate as with when mounting the product, or tightening it to the machine body before grinding and finishing the raceway, to produce a good result.

Installing the LM Roller

Fig.1 shows examples of installing the LM Roller. To minimize the gradient of the LM Roller in the traveling direction, provide a reference surface on the mounting surface and press the LM Roller toward it. The mounting reference surface of the LM Roller is opposite of the THK logo marked on the raceway base.

(a) Installing models LR, LRU and LR-Z

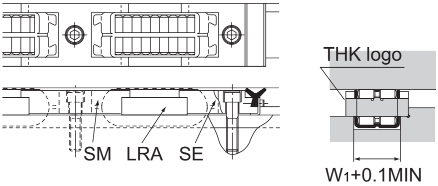
Use the four mounting bolt holes on the raceway base to mount the LM Roller.



For G and W_1, see the specification table.

(b) Installing models LRA and LRA-Z

The LM Roller can easily be secured using fixture model SM or SE. SE is provided with a wiper to increase contamination protection effect.



For W_1, see the specification table.

(c) Installing models LRB and LRB-Z

The LM Roller can easily be secured using fixture model SMB or SEB. SEB is provided with a wiper to increase contamination protection effect.

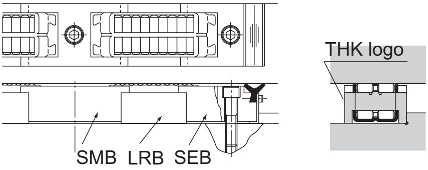


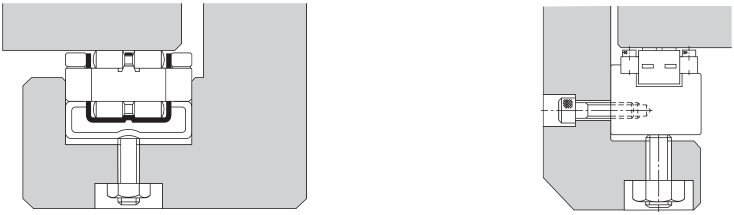
Fig.1 Installing the LM Roller

Guidance for Adjusting the Clearance

To secure stable accuracy during operation, the LM Roller is provided with a light preload. Provision of a preload is especially effective also in increasing the service life for applications where a vibration impact load or overhang load is applied.

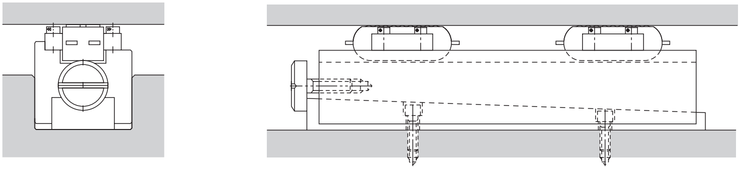
Fig.2 shows clearance adjusting methods that are commonly practiced.

Normally, it is preferable to provide a preload that is approximately 3% of the basic dynamic load rating (C). Providing a preload to the LM Roller will stabilize the accuracy.



(a) Using a dedicated stopper

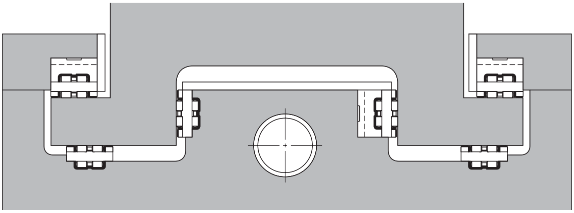
(b) Using a set screw

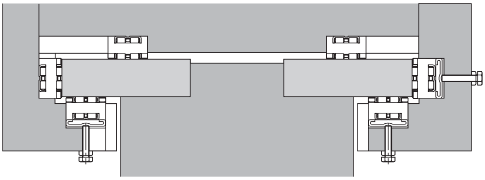


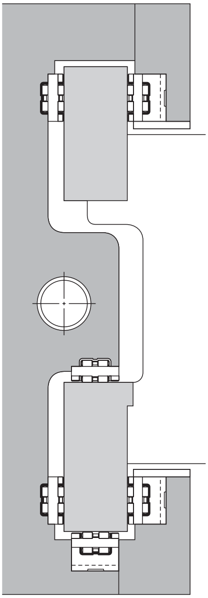
(c) Adjusting a tapered gib

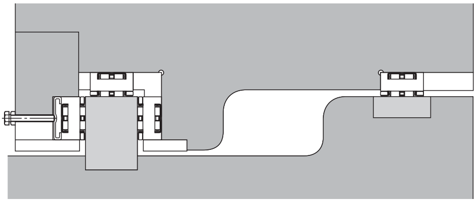
Fig.2 Methods for Adjusting the Clearance of the LM Roller

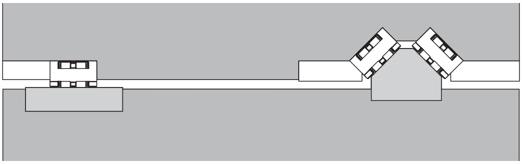
Examples of Arranging LM Roller Units





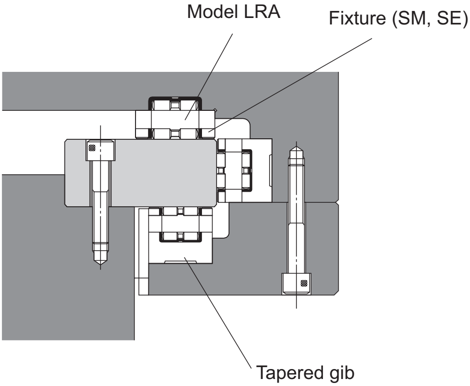




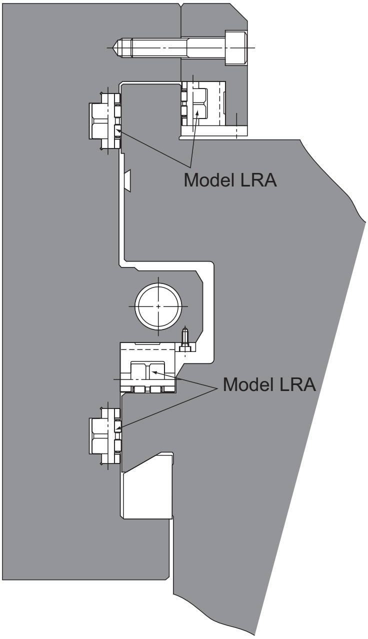


Examples of Installing the LM Roller

Assembling the slide section



Using the cross rail of a vertical lathe



Spring Pad Model PA

●For detailed dimensions, see B-528.

Item name	Schematic diagram / mounting location	Purpose/location of use
Spring Pad Model PA		By attaching this spring pad to the back of the LM Roller as shown in Fig.2 (a) on A-614 . Turning the adjustment bolt, adjustment of a clearance and a preload can easily be done.

[Guidance for Using the Spring Pad]

Spring pad model PA is a low price item that enables easy adjustment and achieves self-aligning. A preload can easily be adjusted by installing the spring pad to the machine and externally tightening the adjustment bolt using a torque wrench. As a result, the need for troublesome shim adjustment and machining for matching is eliminated.

● Example of Using the Spring Pad

(1) When using the spring pad in the opposite position to provide a preload

To prevent the table from lifting or guiding it horizontally, using the spring pad on one side as shown in Fig.1 will easily provide a preload and eliminate vibrations and play of the machine.

(2) When applying both sliding and rolling on the same plane

When desiring to increase friction resistance because the table inertia is large, or desiring to increase rigidity under a heavy load, the spring pad can be used in combination with the sliding surface. To do so, install the LM Roller and the spring pad to several locations on the table as shown in Fig.2, and then tighten the adjustment bolt by the load to be allocated to the LM Roller.

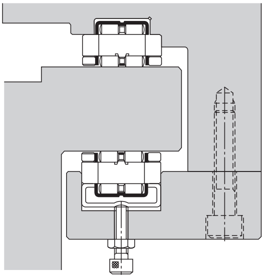


Fig.1

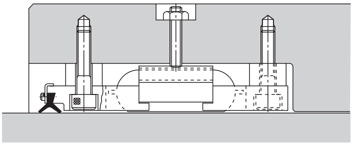


Fig.2

● Guidance for Installing the Spring Pad

Fig.3 shows examples of installing the spring pad model PA to the bottom of the LM Roller and adjusting the clearance and providing a preload.

The dimensions in this example are indicated in the specification table for the spring pad model PA.

The following is the procedure for the installation.

(1) Secure the fixture and the spacer. Adjust them so that the LM Roller can move vertically.

(2) Turn the adjustment bolt until the LM Roller hits the raceway.

(3) Turn the adjustment bolt using a torque wrench and tighten it until the desired torque is reached. A preload is provided via the spring pad model PA.

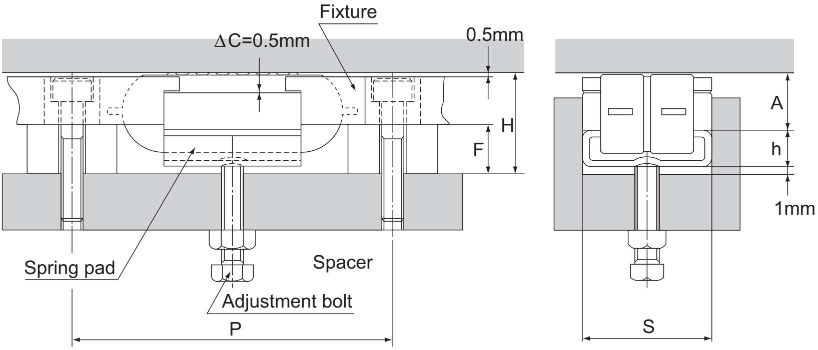
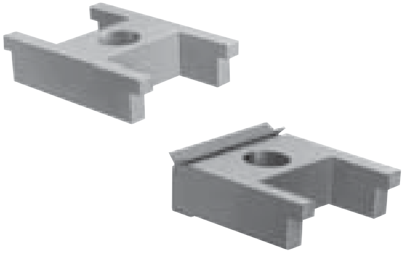


Fig.3

Fixture Models SM/SMB and SE/SEB

●For detailed dimensions, see B-529.

Item name	Schematic diagram / mounting location	Purpose/location of use
Fixture Models SM/SMB and SE/SEB		Use of fixture model SM or SE eliminates the need to machine thin tapped holes for mounting the LM Roller, and allows the roller to firmly be secured. Models SE and SEB each have a special rubber wiper with double lips to achieve a high contamination protection effect.

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.

(2) Dropping or hitting the LM Roller may damage it. Giving an impact to the product could also cause damage to its function even if the product looks intact.

[Contamination Protection and Lubrication]

With the LM Roller, once foreign material enters the raceway due to poor contamination protection, it cannot be removed easily and tends to severely damage the raceway or the LM rollers. Therefore, use much care in contamination protection.

Fixture for the LM Roller models SE and SEB each have a special rubber wiper with double lips to achieve a high contamination protection effect. Feeding grease between the double lips when attaching the fixture, as shown in Fig.1, will further increase the effect.

For locations subject to cutting chips or welding spatter, it is necessary to use a contamination protection cover such as a bellows and a telescopic cover, or a wiper reinforced with a metal plate as indicated in Fig.2.

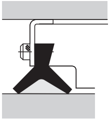


Fig.1 Wiper of Fixture Models SE and SEB

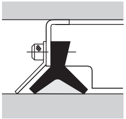


Fig.2 Reinforced Wiper

For contamination protection of the side faces, items as shown in Fig.3 are available.

The required quantity of lubricant is much smaller than sliding guides, making the lubrication control easy.

As for the lubricant, the same type of grease or lubricant as that of ordinary bearings will be adequately effective. To achieve a high level of grease retention, it is preferable to use lithium-soap group grease No. 1 or 2, or slightly viscous sliding surface oil or turbine oil.

To replenish the lubricant to the LM Roller, drop the lubricant from the greasing hole provided on the back of the retainer as necessary, or directly drop it to the raceway. If the LM Roller is not used frequently, it is also possible to apply grease to the rollers of the product.

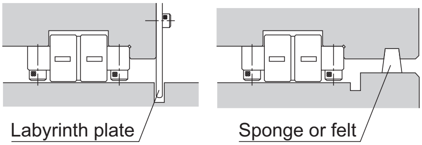


Fig.3

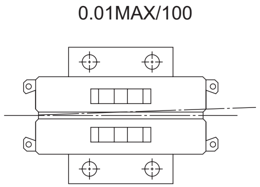
[Mounting Reference Surface]

To help correctly mount the LM Roller in the traveling direction, it has a mounting reference surface on the side face of the raceway base. The reference surface is on the opposite side of the THK logo.

[Mounting Precision]

To maximize the performance of the LM Roller, it is necessary to distribute the load as evenly as possible when mounting the product. For the parallelism between the roller and the raceway indicated in Fig.4, we recommend 0.015 mm or less against 100 mm. For the allowable tilt of the roller in the longitudinal direction, 0.01 mm or less against 100 mm is recommended.

(a) Parallelism between the LM Roller and the raceway (b) Allowable tilt of the roller in the longitudinal direction



(c) Parallelism between the LM Roller and the raceway in the horizontal direction

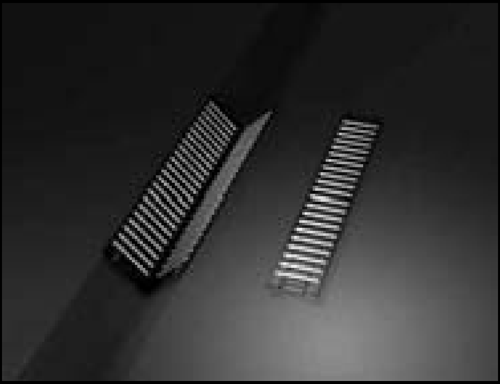
Fig.4 LM Roller and Mounting Precision

[Precautions on Use]

(1) If foreign material adheres to the product, replenish the lubricant after cleaning the product.
(2) Do not use the resin retainer for LM Roller model LR (A, B)-Z and seals (including SE and SEB) in an environment at temperature of 80℃ or higher.
(3) When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, contact THK in advance.

[Storage]

When storing the LM Roller, enclose it in a package designated by THK and store it while avoiding high temperature, low temperature and high humidity.



Flat Roller

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Flat Roller

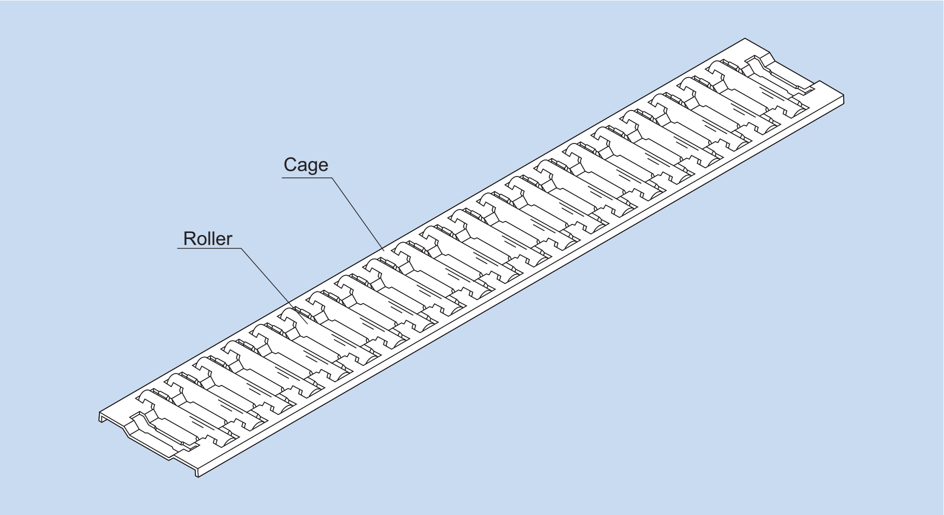


Fig.1 Structure of LM Flat Roller Model FT

Structure and Features

With the Flat Roller, precision rollers compliant with JIS B 1506 are installed in pockets of a cage made of a thin steel plate pressed into M shape (in cross section) to increase its rigidity. Thanks to its structural design, the rollers do not fall off because they are held in cage pockets. Since the cage, which is incorporated with rollers having a diameter of 5 mm or larger, is of roller-lifter type, smooth motion is achieved without damaging the raceway even if the hardness of the raceway is low. The Flat Roller is sandwiched between the two raceways. As the table moves, the Flat Roller travels by half the distance of the table in the same direction. For example, if the table moves 500 mm, the Flat Roller travels 250 mm in the same direction.

The Flat Roller is optimal for large machine tools such as planer, horizontal milling machines and cylindrical grinding machines, and for locations requiring high accuracy such as surface grinding machines, cylindrical grinder and optic measuring machines.

[Large Load Capacity]

Sine rollers are installed in short pitches, the Flat Roller has a large load capacity, and depending on the conditions, it can be used on the raceway of a mold that is little hardened. In addition, the deflection rigidity of the table is almost the same as that of a sliding surface.

[Combined Accuracy of 90° V Surface and Flat Surface Supported as Standard]

The Flat Roller is designed so that it can be mounted on the 90° V-flat sliding surface, which is the most common configuration among narrow guide types of tables and saddles of machinery. It allows the product to be used without major design change.

[Lowest Friction among Roller Type LM Systems]

Since the rollers are evenly held in a light, rigid cage, friction between rollers is eliminated and skewing of the rollers is minimized. As a result, a small friction coefficient (μ = 0.001 to 0.0025) is achieved, and stick-slip, which is problematic with sliding surfaces, does not occur.

[Instant Connection of the Cage]

When installing the Flat Roller in a large machine, it can easily be connected on the bed. This allows the Flat Roller to be installed even with the longest type.

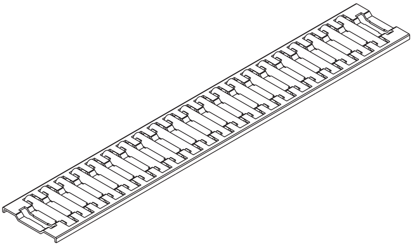
Types of the Flat Roller

Types and Features

Model FT/FT-V

Specification Table⇒B-532

These models have a single row of rollers and are mainly used on the flat surface.

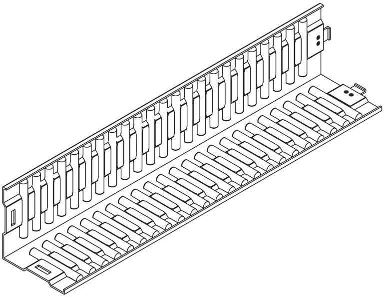


Models FT/FT-V

Model FTW/FTW-V

Specification Table⇒B-533

These models have two or more rows of rollers, and their cages are shaped to bend at 90°. Each model uses rollers with a diameter 0.7071 times greater than that of the rollers on the flat surface so that model FT or FT-V can be mounted on the 90° V surface at the same height if model FT or FT-V is used on the flat surface.



Models FTW/FTW-V

Rated Load and Nominal Life

[Static Safety Factor f_S]

The Flat Roller may receive an unexpected external force while it is stationary or operative due to the generation of an inertia caused by vibrations and impact or start and stop. It is necessary to consider a static safety factor against such a working load.

$$f_S = \frac{f_C \cdot C_0}{P_C}$$

f_S : Static safety factor
f_C : Contact factor
(see [Load Rating] and [Nominal Life] on A-626)
C_0 : Basic static load rating (kN)
P_C : Calculated radial load (kN)

● Reference Value of Static Safety Factor

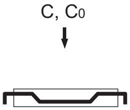
The static safety factors indicated in Table1 are the lower limits of reference values in the respective conditions.

Table1 Reference Value of Static Safety Factors (f_S)

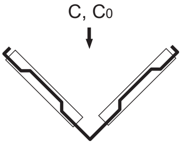
Machine using the LM system	Basic dynamic load rating	Lower limit of f_S
General industrial machinery	Without vibration or impact	1 to 1.3
	With vibration or impact	2 to 3
Machine tool	Without vibration or impact	1 to 1.5
	With vibration or impact	2.5 to 7

[Load Rating]

The rated loads shown in the specification tables represent the rated loads with a unit length (ℓ) in the directions indicated in the figure below.



Model FT or FT-V



Model FTW or FTW-V

If the length of the Flat Roller in the effective load range differs from the unit length (ℓ), approximate rated loads (C_ℓ and $C_{0\ell}$) can be obtained using the following equation.

$$C_\ell = \left(\frac{\ell_0}{\ell}\right)^{\frac{3}{4}} \times C$$

$$C_{0\ell} = \frac{\ell_0}{\ell} \cdot C_0$$

C_ℓ : Basic dynamic load rating in the effective load range (kN)

ℓ_0 : Length in effective load range (mm)

ℓ : Unit length (see the specification table) (mm)

$C_{0\ell}$: Basic static load rating in the effective load range (kN)

C : Basic dynamic load rating (kN)

C_0 : Basic static load rating (kN)

Note) Note that if the hardness of the raceway is lower than 58 HRC, the rated loads will be decreased. (See Fig.2 on A-627.)

[Nominal Life]

When the basic dynamic load rating (C_ℓ) of the Flat Roller in the effective load range has been obtained from the equation above, the nominal life is obtained using the following equation.

$$L = \left(\frac{f_H \cdot f_C \cdot f_T}{f_W} \cdot \frac{C_\ell}{P_C}\right)^{\frac{10}{3}} \times 100$$

L : Nominal life (km)
(The total number of revolutions that 90% of a group of identical Flat Roller units independently operating under the same conditions can achieve without showing flaking)

C_ℓ : Basic dynamic load rating (kN)

P_C : Calculated radial load (kN)

f_H : Hardness factor (see Fig.2 on A-627)

f_T : Temperature factor (see Fig.1 on A-627)

f_W : Load factor (see Table2 on A-627)

f_C : Contact factor$^{\text{Note)}}$

Note) Contact factor is determined according to the contact state of the two planes between which the rollers travel. If the contact ratio between the two planes is 50%, set the contact factor as f_C = 0.5 for safety's sake.

[Calculating the Service Life Time]

When the nominal life (L) has been obtained, if the stroke length and the number of reciprocations per minute are constant, the service life time is obtained using the following equation.

$$L_h = \frac{L \times 10^6}{2 \times \ell_S \times n_1 \times 60}$$

L_h : Service life time (h)
ℓ_S : Stroke length (mm)
n_1 : Number of reciprocations per minute (min^{-1})

● f_T: Temperature Factor

If the temperature of the environment surrounding the operating Flat Roller 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.1.

Note) If the environment temperature exceeds 100 ℃ , contact THK.

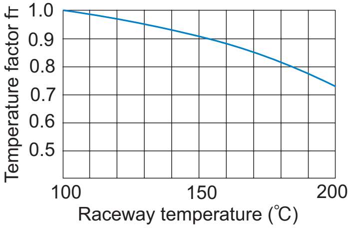


Fig.1 Temperature Factor (f_T)

● f_H: Hardness Factor

To maximize the load capacity of the LM system, 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).

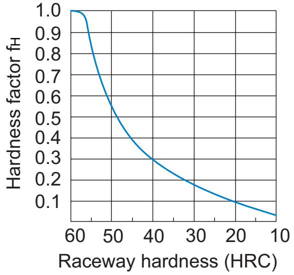


Fig.2 Hardness Factor (f_H)

● f_W: Load Factor

In general, reciprocating machines tend to involve vibrations or impact during operation. It is extremely difficult to accurately determine vibrations generated during high-speed operation and impact during frequent start and stop. Therefore, when the actual load applied cannot be obtained, or when speed and impact have a significant influence, divide the basic load rating (C or C_0), by the corresponding load factor in Table2 of empirically obtained data.

Table2 Load Factor (f_W)

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

Accuracy Standards

The accuracy of the Flat Roller is classified into normal grade, high accuracy grade and precision grade according to the difference in diameter between the rollers incorporated in a single cage. When it is necessary to specify the dimensional tolerance in the roller diameter for reasons related to the required accuracy or combination, select the desired accuracy from Table3 and specify the corresponding accuracy symbol.

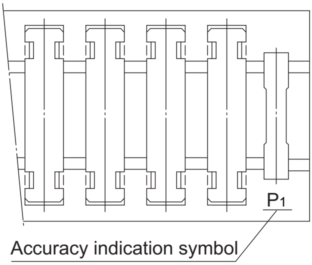


Fig.3

Table3 Classification of Roller Diameters for Selection

Unit: μm

Accuracy grades	Diameter difference	Dimensional tolerance in diameter	Accuracy indication symbol
Normal grade	3	0 to −3	No Symbol
High grade	2	0 to −2	H2
		−2 to −4	H4
		−4 to −6	H6
Precision grade	1	0 to −1	P1

Note) The accuracy indication symbol is marked on the end of the cage as shown in Fig.3.

Raceway

To maximize the performance of the Flat Roller, it is necessary to take into account the hardness, surface roughness and accuracy of the raceway, on which the rollers directly roll, when manufacturing the product. In particular, the hardness significantly affects the service life. Therefore, it is important to take much care in selecting a material and heat treatment method.

[Hardness]

We recommend surface hardness of 58 HRC (≒ 653 HV) or higher. The depth of the hardened layer is determined by the size of the Flat Roller; we recommend approximately 2 mm for general use. If the hardness of the raceway is lower or the raceway cannot be hardened, multiply the load rating by the corresponding hardness factor indicated in Fig.2 on A-627.

[Material]

The following materials are generally used as suitable for surface hardening through induction-hardening and flame quenching.

- 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)

If the machine body is a mold, depending on the conditions, a hardened steel plate may not be used and instead, the surface of mold itself may be hardened.

[Surface Roughness]

To achieve smooth motion, the surface should preferably be finished to 0.40a or less. If slight wear is allowed in the initial stage, the surface may be finished to approximately 0.80a.

[Accuracy]

When high accuracy is required, securing a hardened steel plate to the machine body may cause undulation on the raceway. To avoid this, secure the Flat Roller with bolts before grinding the hardened steel plate as with when mounting the product, or tightening it to the machine body before grinding and finishing the raceway, to produce a good result.

Installing the Flat Roller

[Combination of 90° V Surface and Flat Surface]

The Flat Roller can be mounted directly onto the guide surface on the 90° V surface and flat surface. Table1 shows examples of their combinations.

Note) The roller diameter (Da) for model numbers containing symbol V at the end represents the value $\frac{1}{\sqrt{2}}$ times that of types for the same model number with no symbol.
The diameter of the roller to be combined with 90°V surface will be $\frac{1}{\sqrt{2}}$ times that of the roller on the flat surface.
For example, when using model FT4035 (roller diameter: ϕ 4) on the flat surface, use model FTW4030V (roller diameter: ϕ 2.828) on the V surface. Performance of the Flat Roller is significantly affected by the contact state of the upper and lower raceways. You can check the fit before installing the Flat Roller by designing the raceways as indicated in Fig. 1.

Table1 Example of Combinations

90°V surface		Flat surface	
Model No.	Roller diameter Da	Model No.	Roller diameter Da
FTW 4030V	2.828	FT 4030	4
FTW 4030V	2.828	FT 4035	4
FTW 5035V	3.535	FT 5038	5
FTW 5035V	3.535	FT 5043	5
FTW 5045	5	FT 10060V	7.071
FTW 5050	5	FT 10060V	7.071
FTW 10070V	7.071	FT 10080	10

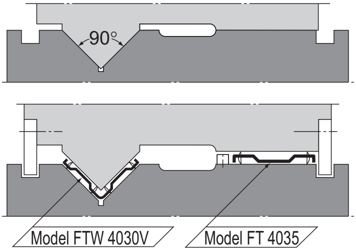


Fig.1 Example of Combinations

[Other Example of Installation]

In locations where a lifting load or an overhang load is applied, the Flat Roller can be installed as shown in Fig.2.

For details on clearance adjustment from the side face, see Example of Clearance Adjustment for the Cross Roller Guide on A-580.

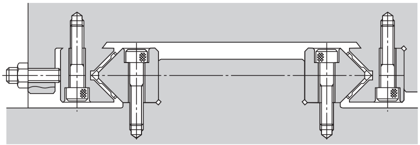


Fig.2 Location where a Lifting Load is Applied

[Determining the Flat Roller Length]

The Flat Roller travels 1/2 of the travel distance of the table in the same direction. Therefore, it is necessary to calculate the stroke length and the Flat Roller length as indicated below.

To keep the Flat Roller under the table, obtain Flat Roller length ℓ_S as follows.

$\ell_S \leqq L_B - L_T$

The Flat Roller length:

$$\ell = L_T + \frac{\ell_S}{2} = 0.5(L_B + L_T)$$

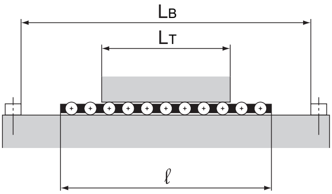


Fig.3

[Connecting Flat Roller Units]

When it is necessary to joint two or more Flat Roller units, use a joint plate as shown in Fig.4 to join them on the base. When placing an order, indicate the overall length for actual use. Note, however, that model FT2010 units cannot be joined together.

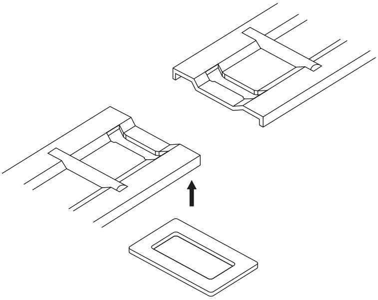
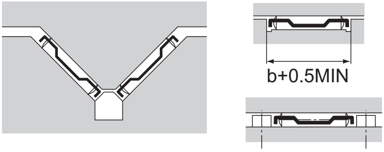


Fig.4 Connection of Model FT Units

[Guiding the Flat Roller]

To guide model FT or FT-V, follow the instruction as shown in Fig.5.



For "b", see the specification table.

Fig.5 Guiding the Flat Roller

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.

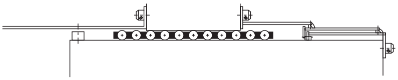
(2) Dropping or hitting the Flat Roller may damage it. Giving an impact to the product could also cause damage to its function even if the product looks intact.

[Contamination Protection and Lubrication]

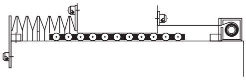
With the Flat Roller, once foreign material enters the raceway due to poor contamination protection, it cannot be removed easily and tends to severely damage the raceway or the Flat rollers. Therefore, use much care in contamination protection. Normally, for contamination protection of the Flat Roller, a bellows or a telescopic cover that covers the whole sliding surface, as shown in Fig.1, is effective.

The required quantity of lubricant is much smaller than sliding metals, making the lubrication control easy.

Since the Flat Roller has high lubricant retention, it is suitable for grease lubrication. It is preferable to use lithium-soap group grease No. 1 or 2, or slightly viscous sliding surface oil or turbine oil.



(a) Copper cover or telescopic cover



(b) Bellows or roller blind

Fig.1 Contamination Protection Methods

[Attaching the Stopper]

Although the Flat Roller performs extremely accurate motion, it may cause a traveling error due to uneven load distribution or non-uniform stop. Therefore, we recommend attaching a stopper on the end of the base or the table.

[Chamfering the End Face of the Table]

If the Flat Roller is longer than the overall table length, finely chamfer the end face of the table so that the rollers are easily fed to the table.

[Mounting Precision]

To maximize the performance of the Flat Roller, it is necessary to distribute the load as evenly as possible when mounting the product. For the allowable tilt as shown in Fig.2, we recommend 0.1 mm or less against 1,000 mm.

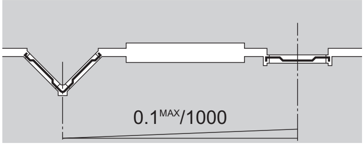


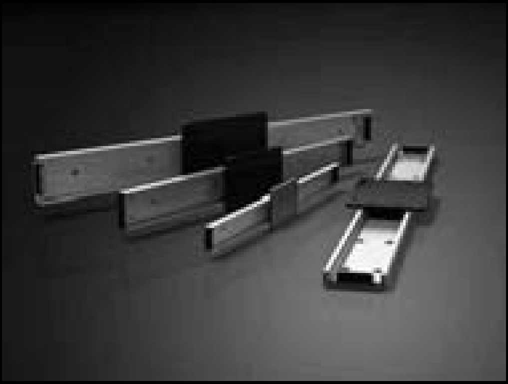
Fig.2 Mounting Precision

[Precautions on Use]

(1) If foreign material adheres to the product, replenish the lubricant after cleaning the product.
(2) Contact THK if you desire to use the product at a temperature of 100℃ or higher.
(3) When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, contact THK in advance.
(4) The Flat Roller cannot be used as a roller conveyor.
(5) A moment, vertical mount, uneven contact and machine vibrations may cause the cage to slip. If slippage of the cage is inevitable, we recommend using an LM Guide system designed for infinite motion.

[Storage]

When storing the Flat Roller, enclose it in a package designated by THK and store it while avoiding high temperature, low temperature and high humidity.



Slide Pack

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Slide Pack

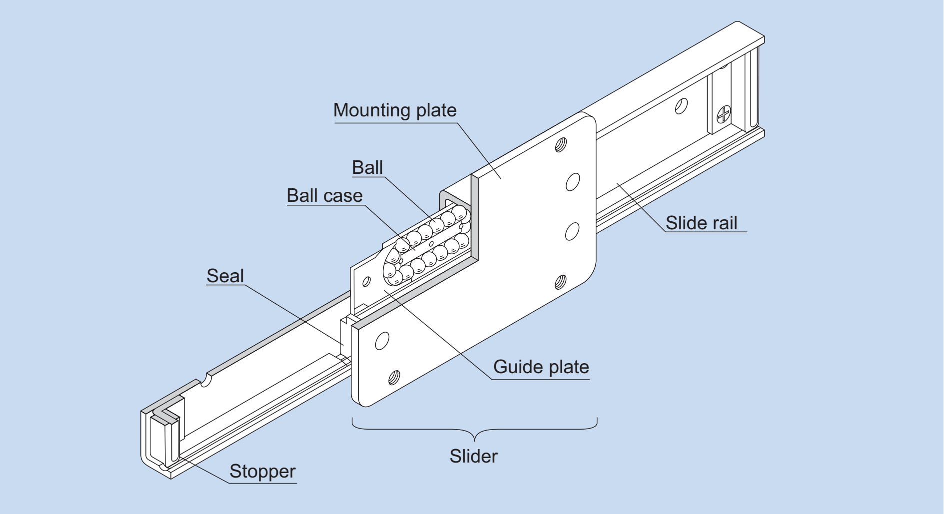


Fig.1 Structure of Slide Pack Model FBW-RUU

Structure and Features

Slide Pack model FBW is an LM system in which a precision press molded slider that contains balls performs infinite straight motion. Used in combination with a slide rail, the Slide Pack achieves lightweight and compact design and smooth straight motion at a low price.

The ball case and the slide rail are nitrided to ensure high wear resistance. (The slide rail of model FBW 2560R is made of stainless steel.)

The Slide Pack is optimal for slide units of photocopiers, tool cabinets, electronic equipment cabinets, moving seats, automatic vending machines, machine tool slide covers, cash registers, heavy doors and curtain walls.

[Low Cost, Interchangeable]

Since it is press molded with precision, this LM system achieves stable quality and interchangeability at low cost.

[Infinite Stroke Length]

Unlike the conventional finite stroke type, the slider is capable of performing infinite motion. When connected with a slide rail, it can be used in long-stroke applications.

[Easy Installation and Handling]

Because of the structure that prevents balls from falling off even if the slider is removed from the slide rail, this model is easy to handle and can be used in a complex construction where it is impossible to install an LM system unless it is disassembled.

[A Type Equipped with a Contamination Protection Seal Also Standardized]

A type equipped with a contamination protection seal is standardized for locations where cutting chips or dust may enter the system.

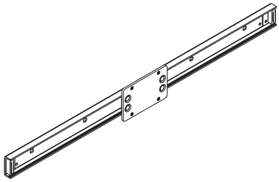
Types of the Slide Pack

Type

Model FBW 2560R

Specification Table⇒B-536

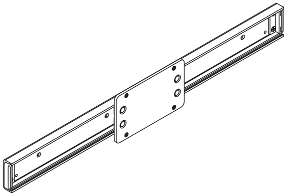
This model is a compact type.



Model FBW 3590R

Specification Table⇒B-536

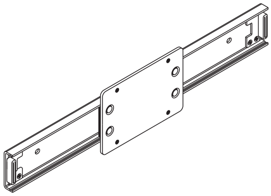
This model is a standard type.



Model FBW 50110R

Specification Table⇒B-537

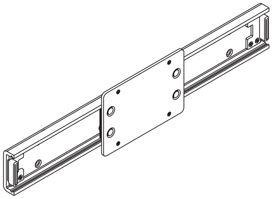
This model is a heavy load type.



Model FBW 50110H

Specification Table⇒B-537

This model is a high rigidity type.



Clearance

Model FBW is manufactured to the following accuracies.

Vertical clearance: 0.03 mm or less

Horizontal clearance: 0.1 mm or less

These specifications are values when the slide rail is attached to a rigid base.

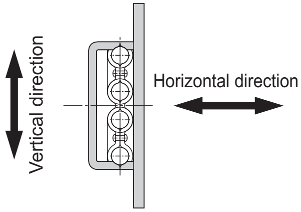


Fig.2

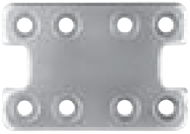
Contamination Protection

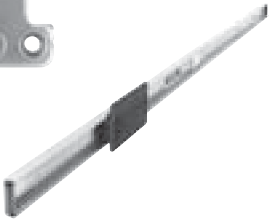
For Slide Pack model FBW-R (H), a special synthetic rubber seal with high contamination protection characteristics, capable of preventing foreign material from entering the slider and the lubricant from leaking, is available. The seal increases the contamination protection effect by contacting both the slide rail raceway where balls roll and the slide rail itself.

Metal Dustproof Cover

For Slide Pack model FBW, steel covers that cover the whole slide rail to prevent foreign material from entering the slide are available.
For detailed dimensions, see B-538.

Jointed Slide Rails





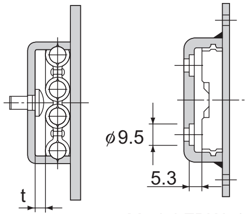
If the required specifications exceed the standard stroke, two or more slide rails can be connected. When placing an order, indicate the overall length.

Installation

[Mounting Screws of the Slide Rail]

Since the space for securing the mounting screws of the slide rail is small as shown in Fig.1, we recommend using button-head bolt or binding-head bolt (JIS B 1111 annex).

Note) The slide rail of model FBW 50110H is countersunk. We recommend mounting the slide rail using hexagonal-socket-head type bolts (M5).



Model FBW50110H

Fig.1

Unit: mm

Model No.	t
FBW 2560R	3.2
FBW 3590R	3.4
FBW 50110R	3.4
FBW 50110H	—

[Attaching the Stopper]

If the slider may overshoot and come off of the slide rail, attach the dedicated stopper to the slide rail end as shown in Fig.2.

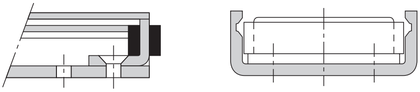


Fig.2

[Installing the Slider]

With model FBW-R (H), balls will not fall off even if the slider is removed from the slide rail. However, they could fall if the slider is twisted when reattaching it to the slide rail. Whenever possible, do not remove the slider from the slide rail when installing the Slide Pack.

[Groove Dimensions]

Fig.3 shows the dimensions of grooves for applications where model FBW-R (H) is installed in a groove.

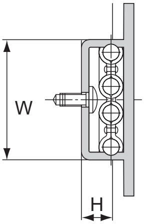


Fig.3

Unit: mm

Model No.	W	H
FBW 2560R	$24.8^{+0.15}_{+0.1}$	7.4
FBW 3590R	$37^{+0.15}_{+0.1}$	10
FBW 50110R	$50^{+0.15}_{+0.1}$	10
FBW 50110H	$54.4^{+0.15}_{+0.1}$	13

Lubrication

Apply high-quality lithium soap group grease to the raceway of the slide rail before using the product.

Precautions on Use

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.
(2) Tilting the slider or slide rail may cause them to fall by their own weight.
(3) Dropping or hitting the Slide Pack may damage it. Giving an impact to the Slide Pack could also cause damage to its function even if the product looks intact.

[Lubrication]

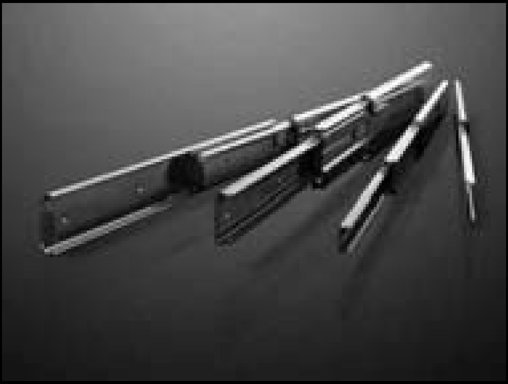
(1) Apply high-quality lithium soap group grease to the raceway of the slide rail before using the product.
(2) Do not mix lubricants of different physical properties.

[Precautions on Use]

(1) The static permissible load of the Slide Pack varies according to the direction.
(2) Entrance of foreign material may cause damage to the ball circulating component or functional loss. Prevent foreign material, such as dust or cutting chips, from entering the system.
(3) If foreign material such as dust or cutting chips adheres to the product, replenish the lubricant after cleaning the product with pure white kerosene.
(4) Avoid using the product at other than normal temperature, or using it in harsh conditions such as intensive reciprocations that generate frictional heat and environments with water or dust.
(5) When using the Slide Pack with inverted mount, breakage of the slider due to an accident or the like may cause balls to fall and the slider to come off from the slide rail and fall. In these cases, take preventive measures such as adding a safety mechanism for preventing such falls.
(6) When you remove the slider from the slide rail and then reassemble them, inserting the slide rail into the slider while twisting them may cause balls to fall or damage the slider. Be sure to gently insert the rail straight into the slider while checking the position of the slider balls and that of the rail raceway.

[Storage]

When storing the Slide Pack, enclose it in a package designated by THK and store it while avoiding high temperature, low temperature and high humidity.



Slide Rail

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

Dimensional Drawing, Dimensional Table

* Please see the separate "B Product Specifications".

Features of the Slide Rail

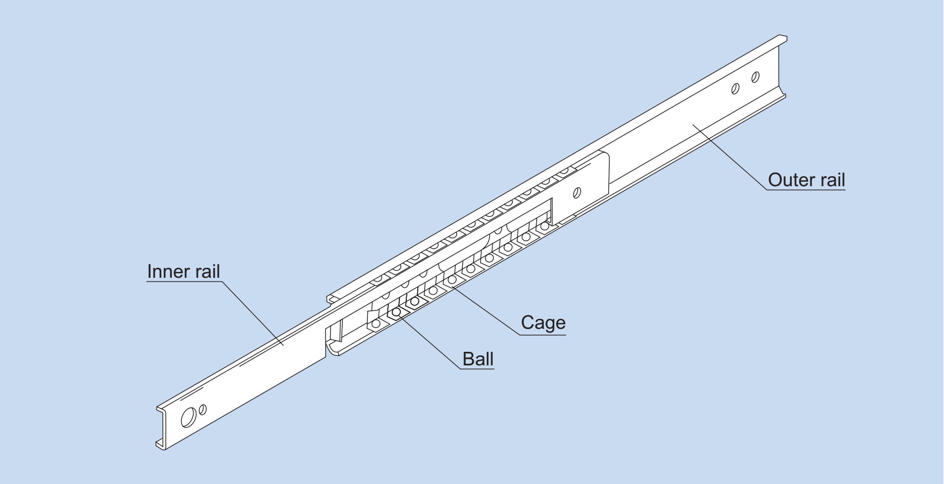


Fig.1 Structure of Slide Rail Model FBL

Structure and Features

Slide Rail model FBL is a thin, compact, lightweight and ultra-low price slide unit for finite motion. It has two rows of balls placed between an inner rail (made of a steel sheet roll-formed with precision) and an outer rail. The balls are evenly spaced by a cage press-molded with precision, thus eliminating friction between balls and achieving a smooth slide mechanism.
Since model FBL achieves smooth straight motion with easy installation, it can be used in a wide range of applications such as photocopiers, measuring instruments, telecommunication equipment, medical equipment, automatic vending machines and various types of office equipment.

[Unit Type That Allows Easy Installation]

Since the clearance and the motion of the slide unit are optimally adjusted, simply mounting the unit onto the base or the table using screws will achieve a slide mechanism with virtually no running noise.

[Thin and Compact]

Since the sectional shape is thin designed, this slide pack only requires a small side space for installation. In addition, a desired number of slide pack units can be installed in parallel according to the load conditions.

[Maintenance-free Operation]

Since the slide rail is treated with zinc plating, it is highly corrosion resistant. In addition, the slide unit contains lithium soap-based grease, which is highly stable against oxidation.

Types of the Slide Rail

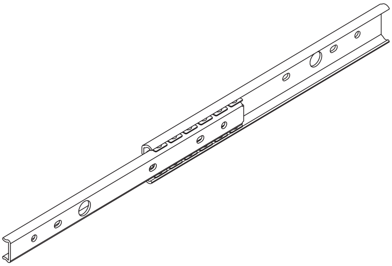
Types and Features

[Single Slides for Light Load]

Model FBL 27S

Specification Table⇒B-542

The most compact slide rail from THK.

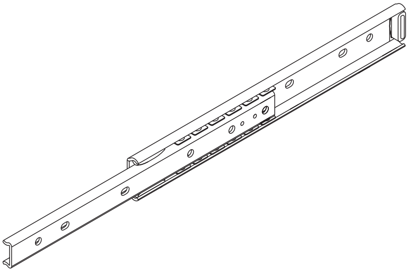


Model FBL 27S

Model FBL 27S-P14

Specification Table⇒B-543

An inner rail pulling type of model FBL 27S. Releasing the automatic free disconnection spring attached on the inner rail allows the slide rail to be pulled out. When stored, the spring is automatically released unidirectionally under a certain pressure.

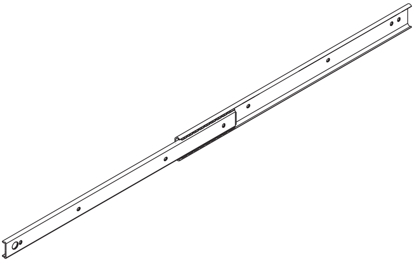


Model FBL 27S-P14

Model FBL 35S

Specification Table⇒B-544

A single slide type of Slide Rail with the most fundamental shape.

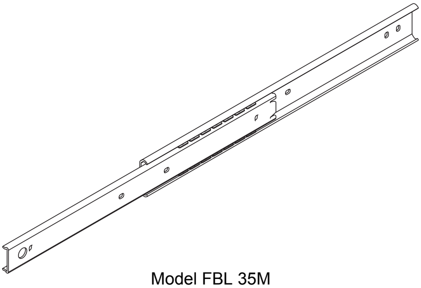


Model FBL 35S

Model FBL 35M

Specification Table⇒B-545

An inner rail pulling type of model FBL 35S. It stops by frictional resistance when the slide rail is fully opened, and is pulled out when being pulled further with force.
(brake-stop type)

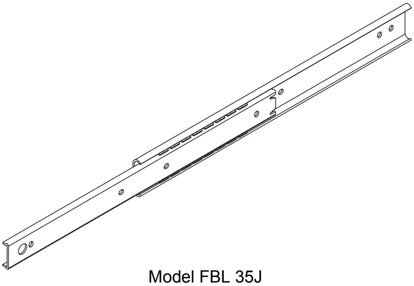


Model FBL 35M

Model FBL 35J

Specification Table⇒B-546

Based on model FBL 35M, this model has a lead ball that serves as a guide when the inner rail is inserted.

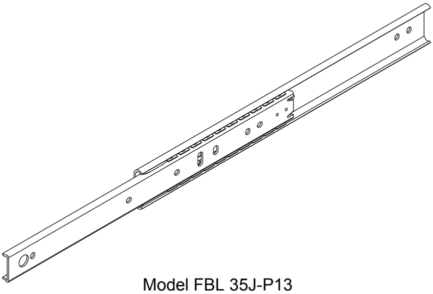


Model FBL 35J

Model FBL 35J-P13

Specification Table⇒B-547

An inner rail pulling type of model FBL 35S. Releasing the disconnection spring attached on the inner rail allows the slide rail to be pulled out. When folded, the locked state with the disconnect spring is manually released.

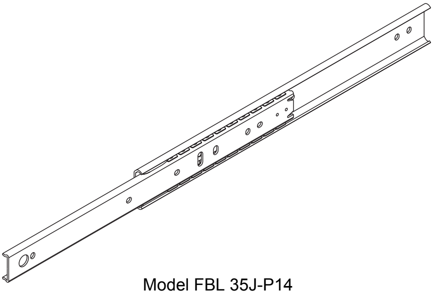


Model FBL 35J-P13

Model FBL 35J-P14

Specification Table⇒B-548

An inner rail pulling type of model FBL 35S. Releasing the automatic free disconnection spring attached on the inner rail allows the slide rail to be pulled out. When stored, the spring is automatically released unidirectionally under a certain pressure.

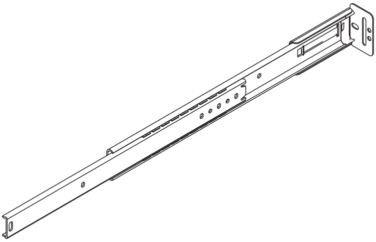


Model FBL 35J-P14

Model FBL 35B

Specification Table⇒B-549

A brake-stop type of model FBL 35M. It can be mounted on the bottom face of a moving object when used.



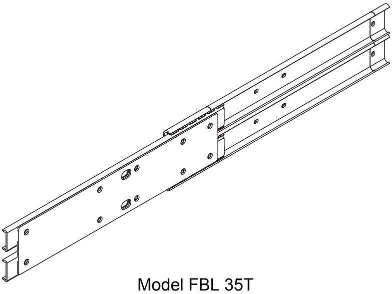
Model FBL 35B

[Single Slides for Medium Load]

Model FBL 35T

Specification Table⇒B-550

A single slide combining two units of model FBL 35S. When folded, the locked state with the disconnect spring is manually released.



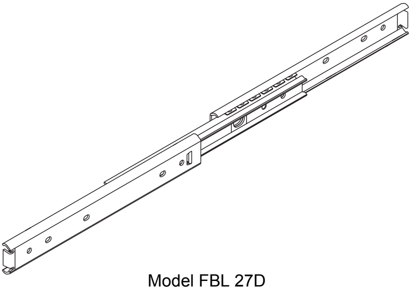
Model FBL 35T

[Double Slides for Light Load]

Model FBL 27D

Specification Table⇒B-551

A double-slide type that combines two units of model FBL 27S back-to-back. It is widely used in various types of OA equipment.

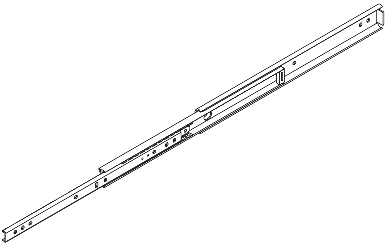


Model FBL 27D

Model FBL 35E-P14

Specification Table⇒B-552

A three-rail, double-slide type that allows a long stroke in a small space. Releasing the automatic free disconnection spring attached on the inner rail allows the inner rail to be pulled out. When folded, the locked state is automatically released under a certain pressure in the folding direction.



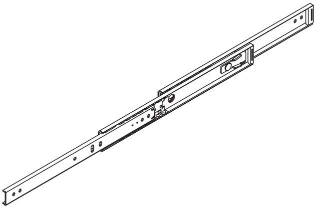
Model FBL 35E-P14

[Double Slides for Medium Load]

Model FBL 35G-P13

Specification Table⇒B-553

A double-slide type that combines two units of model FBL 35S front-to-front. Releasing the automatic free disconnection spring attached on the inner rail allows the inner rail to be pulled out. When folded, the locked state with the disconnect spring is manually released. It is also equipped with a pull-lock mechanism that functions when the slide rail is fully opened.

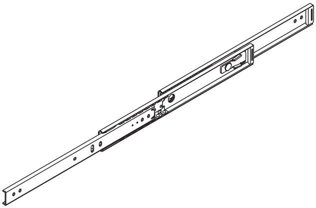


Model FBL 35G-P13

Model FBL 35G-P14

Specification Table⇒B-554

A double-slide type that combines two units of model FBL 35S front-to-front. Releasing the automatic free disconnection spring attached on the inner rail allows the inner rail to be pulled out. When folded, the lock state with the disconnect spring can automatically be released under a certain pressure in the folding direction. It is also equipped with a pull-lock mechanism that functions when the slide rail is fully opened.

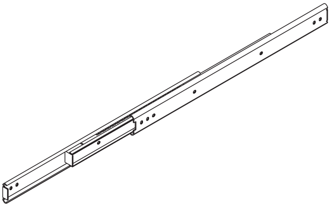


Model FBL 35G-P14

Model FBL 35D

Specification Table⇒B-555

A double-slide type that combines two units of model FBL 35S back-to-back. It is extensively used regardless of the industry.

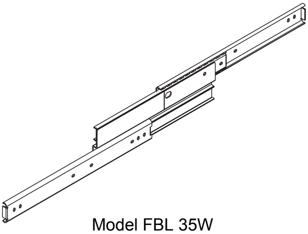


Model FBL 35D

Model FBL 35W

Specification Table⇒B-556

A double-slide type based on model FBL 35S that achieves a thickness of one single-slide unit.

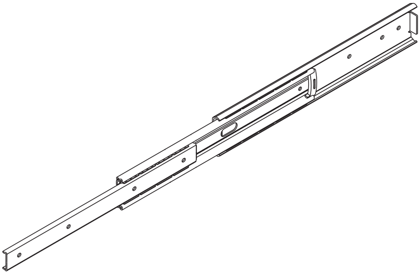


Model FBL 35W

Model FBL 51H

Specification Table⇒B-557

A three-rail, double-slide type that allows for a long stroke. With the smallest thickness, this model can be used in a space-saving location even under a large load.

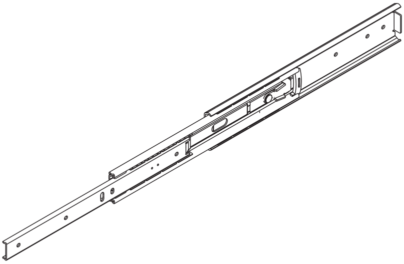


Model FBL 51H

Model FBL 51H-P13

Specification Table⇒B-558

A three-rail, double-slide type that allows a long stroke. With the smallest thickness, this model can be used in a space-saving location even under a large load. Releasing the automatic free disconnection spring attached on the inner rail allows the inner rail to be pulled out. When folded, the locked state with the disconnect spring is manually released. It is also equipped with a lock mechanism that functions when the slide rail is fully opened.

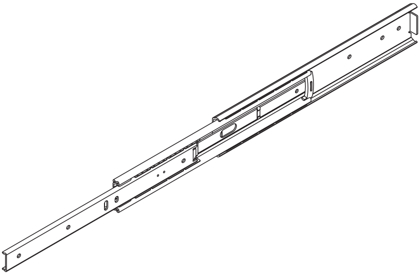


Model FBL 51H-P13

Model FBL 51H-P14

Specification Table⇒B-559

A three-rail, double-slide type that allows a long stroke. With the smallest thickness, this model can be used in a space-saving location even under a large load. Releasing the automatic free disconnection spring attached on the inner rail allows the inner rail to be pulled out. When folded, the locked state is automatically released under a certain pressure in the folding direction.



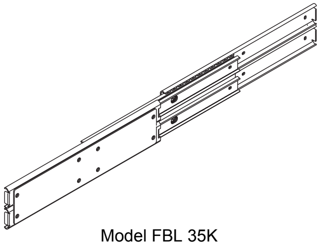
Model FBL 51H-P14

[Double Slides for Heavy Load]

Model FBL 35K

Specification Table⇒B-560

A double-slide type combining 4 units of model FBL 35S. It achieves the largest permissible load among all types and is optimal for opening/ closing heavy objects.

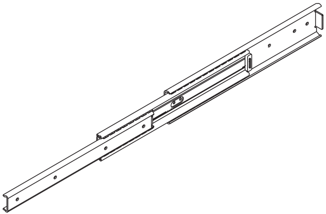


Model FBL 35K

Model FBL 56H

Specification Table⇒B-561

A double-slide type with the largest permissible load among the three rails. It is used extensively in various types of OA furniture.

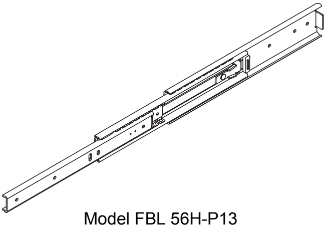


Model FBL 56H

Model FBL 56H-P13

Specification Table⇒B-562

A double-slide type with the largest permissible load among the three rails. Releasing the automatic free disconnection spring attached on the inner rail allows the inner rail to be pulled out. When folded, the locked state with the disconnect spring is manually released. It is also equipped with a lock mechanism that functions when the slide rail is fully opened.

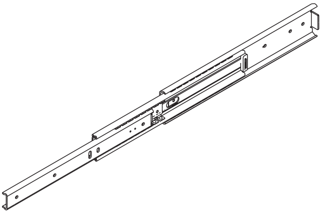


Model FBL 56H-P13

Model FBL 561H-P14

Specification Table⇒B-563

A double-slide type with the largest permissible load among the three rails. Releasing the automatic free disconnection spring attached on the inner rail allows the inner rail to be pulled out. When folded, the locked state is automatically released under a certain pressure in the folding direction.



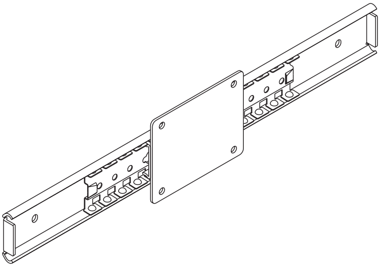
Model FBL 56H-P14

[Linear Type Slides]

Light Load Type Model FBL 35F

Specification Table⇒B-564

Using a flange type that can easily be mounted, this slide-type model is capable of performing straight, finite motion.

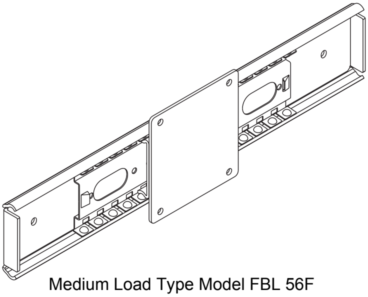


Light Load Type Model FBL 35F

Medium Load Type Model FBL 56F

Specification Table⇒B-565

Using a flange type that can easily be mounted, this slide-type model is capable of performing straight, finite motion. It is optimal for locations under a large working load.

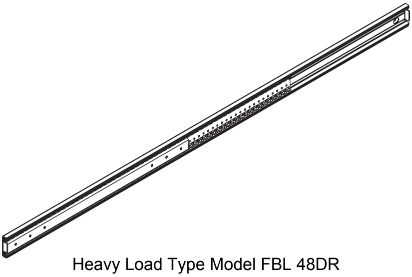


Medium Load Type Model FBL 56F

Heavy Load Type Model FBL 48DR

Specification Table⇒B-566

A heavy-load, low-friction slide rail developed for sliding heavy doors.



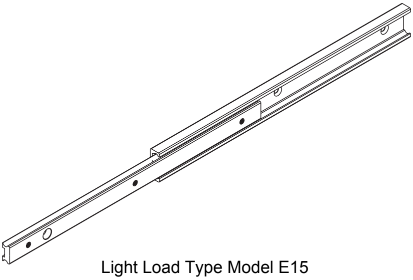
Heavy Load Type Model FBL 48DR

[**Aluminum Alloy Slide Rail**]

Light Load Type Model E15

Specification Table⇒B-567

The lightest and most compact single slide in the aluminum alloy series. It is especially suitable for locations with magnetism, locations requiring antirust measures and locations where much importance is given to appearance.

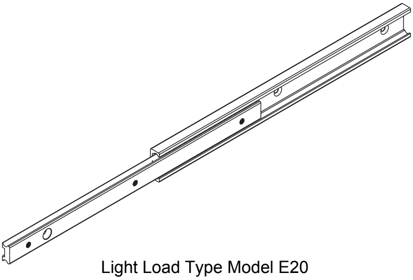


Light Load Type Model E15

Light Load Type Model E20

Specification Table⇒B-568

A single-slide with the most fundamental shape in the aluminum alloy series. It is especially suitable for locations with magnetism, locations requiring antirust measures and locations where much importance is given to appearance.

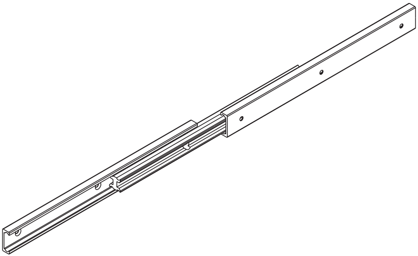


Light Load Type Model E20

Light Load Type Model D20

Specification Table⇒B-569

The lightest and most compact double slides in the aluminum alloy series. It is especially suitable for locations with magnetism, locations requiring antirust measures and locations where much importance is given to appearance.



Light Load Type Model D20

Classification Table for Slide Rails

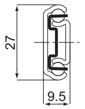
Slide Rail

Single Slide

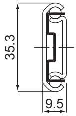
For Light Load

Model FBL27S

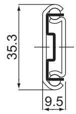
Model FBL27S-P14



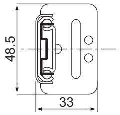
Model FBL35S



Model FBL35M



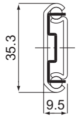
Model FBL35B



Model FBL35J

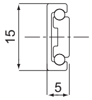
Model FBL35J-P13

Model FBL35J-P14



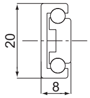
Model E15

(Made of Aluminum)



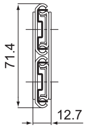
Model E20

(Made of Aluminum)



For Medium Load

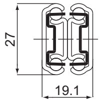
Model FBL35T



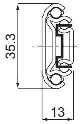
Double Slide

For Light Load

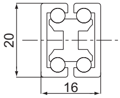
Model FBL27D



Model FBL35E-P14



Model D20 (Made of Aluminum)

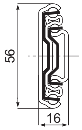


For Heavy Load

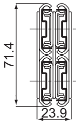
Model FBL56H

Model FBL56H-P13

Model FBL56H-P14



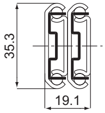
Model FBL35K



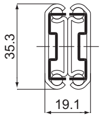
For Medium Load

Model FBL35G-P13

Model FBL35G-P14



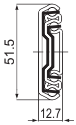
Model FBL35D



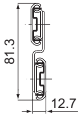
Model FBL51H

Model FBL51H-P13

Model FBL51H-P14



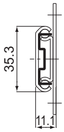
Model FBL35W



Linear Type Slide

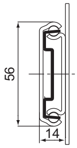
For Light Load

Model FBL35F



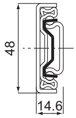
For Medium Load

Model FBL56F



For Heavy Load

Model FBL48DR



Mounting the Slide Rail

[Mounting Screws of the Slide Rail]

The slide rail is designed to be mounted using M4 screws. Since the mounting space is small as shown in Fig.1, we recommend using button-head bolt or binding-head bolt (JIS B 1111 annex).

Note) For models FBL27S/27S-P14/27D, use M4 binding-head bolt, or M3 button-head bolt or binding-head bolt.
Note) For model FBL48DR, use M5×8 mounting screw.
Note) For model E15, use M2.6 countersunk screw.
Note) For models E20 and D20, use M3 countersunk screw.
Note) For model FBL 35E, use M3 button-head bolts or binding-head bolts.

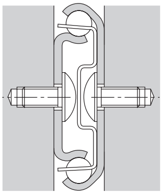


Fig.1

[Attaching the Slide Rail]

While keeping the maximum stroke, mount the outer rail at the section where the inner rail and the outer rail overlap, slide the inner rail backward, and then secure the rail using a screw through the access hole.

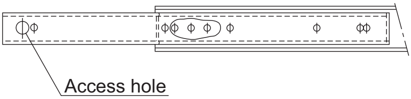


Fig.2

[Permissible Load and Mounting Orientation]

For use other than with the mounting orientation shown in Fig.3, contact THK.

The permissible load of the Slide Rail indicates the load in the direction Pa that two rails can receive in the middle of the inner rail length at the maximum stroke.

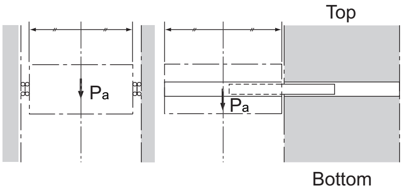


Fig.3

[Surface Treatment]

The surface of the Slide Rail is treated with electro-galvanizing (gloss chromate treatment) as standard. Colored chromate treatment and chrome plating are also available. Contact THK for details.

[Handling]

(1) Tilting a slide rail may cause it to fall by its own weight.

(2) Dropping or hitting the Slide Rail may damage it. Giving an impact force to the slide rail could also cause damage even if the product looks intact.

[Precautions on Use]

(1) When mounting the Slide Rail, use care to always keep both rails in parallel.

(2) Entrance of foreign material may cause damage to the Slide Rail or functional loss.

(3) Avoid using the product at other than normal temperature, or using it in harsh conditions such as intensive reciprocations that generate frictional heat and environments with water or dust.

(4) The durability of the Slide Rail varies depending on factors such as the drawing dimension, travel distance, mounting conditions and environment in addition to operating frequency. Take these factors into account when making a selection.

[Storage]

When storing the Slide Rail, avoid high temperature, low temperature and high humidity.

Ball Screw

THK General Catalog

Ball Screw

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Ball Screw

Driving Torque One Third of the Sliding Screw

With the Ball Screw, balls roll between the screw shaft and the nut to achieve high efficiency. Its required driving torque is only one third of the conventional sliding screw. (See Fig.1 and Fig.2.) As a result, it is capable of not only converting rotational motion to straight motion, but also converting straight motion to rotational motion.

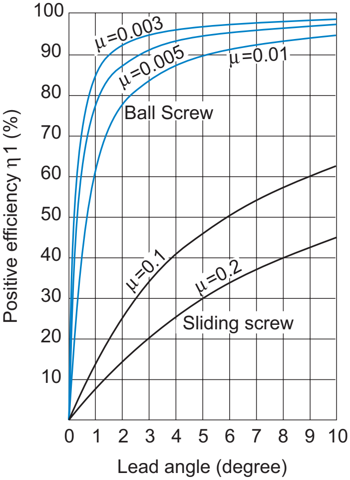


Fig.1 Positive Efficiency (Rotational to Linear)

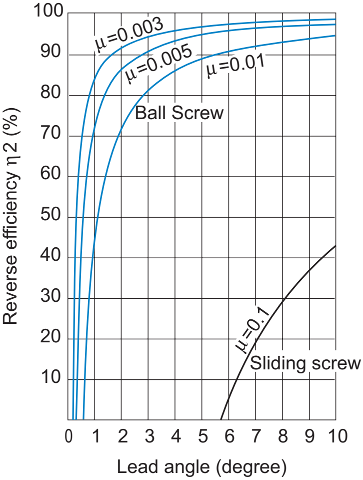


Fig.2 Reverse Efficiency (Linear to Rotational)

[Calculating the Lead Angle]

$$\tan\beta = \frac{Ph}{\pi \cdot d_P} \quad \cdots\cdots\cdots(1)$$

β	: Lead angle	(°)
d_P	: Ball center-to-center diameter	(mm)
Ph	: Feed screw lead	(mm)

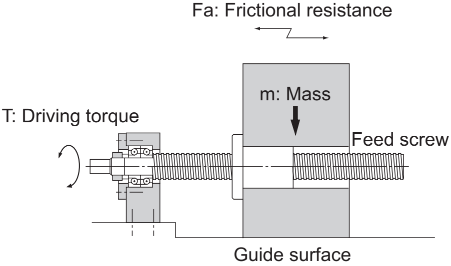
[Relationship between Thrust and Torque]

The torque or the thrust generated when thrust or torque is applied is obtained from equations (2) to (4).

● Driving Torque Required to Gain Thrust

$$T = \frac{Fa \cdot Ph}{2\pi \cdot \eta_1} \quad \cdots\cdots\cdots (2)$$

T : Driving torque (N-mm)
Fa : Frictional resistance on the guide surface (N)
$Fa = \mu \times mg$
μ : Frictional coefficient of the guide surface
g : Gravitational acceleration (9.8 m/s²)
m : Mass of the transferred object (kg)
Ph : Feed screw lead (mm)
η1 : Positive efficiency of feed screw (see Fig.1 on A-664)



● Thrust Generated When Torque is Applied

$$Fa = \frac{2\pi \cdot \eta_1 \cdot T}{Ph} \quad \cdots\cdots\cdots (3)$$

Fa : Thrust generated (N)
T : Driving torque (N-mm)
Ph : Feed screw lead (mm)
η1 : Positive efficiency of feed screw (see Fig.1 on A-664)

● Torque Generated When Thrust is Applied

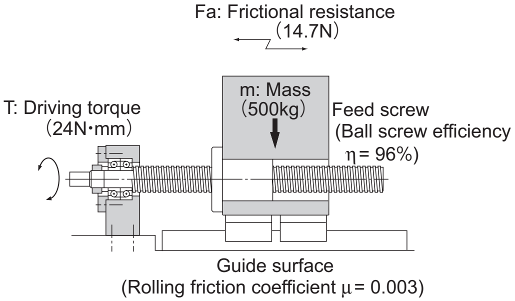
$$T = \frac{Ph \cdot \eta_2 \cdot Fa}{2\pi} \quad \cdots\cdots\cdots (4)$$

T : Torque generated (N-m)
Fa : Thrust generated (N)
Ph : Feed screw lead (mm)
η2 : Reverse efficiency of feed screw (see Fig.2 on A-664)

[Examples of Calculating Driving Torque]

When moving an object with a mass of 500 kg using a screw with an effective diameter of 33 mm and a lead length of 10 mm (lead angle: 5°30'), the required torque is obtained as follows.

Rolling guide ($\mu = 0.003$)
Ball Screw (from $\mu = 0.003$, $\eta = 0.96$)



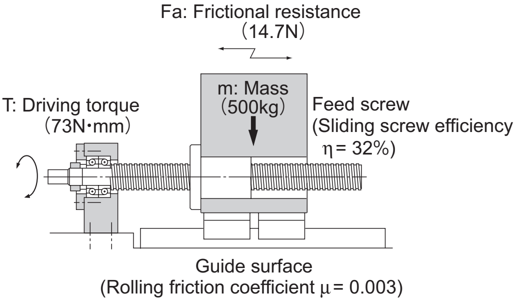
Frictional resistance on the guide surface

$$Fa = 0.003 \times 500 \times 9.8 = 14.7N$$

Driving torque

$$T = \frac{14.7 \times 10}{2\pi \times 0.96} = 24 \text{ N} \cdot \text{mm}$$

Rolling guide ($\mu = 0.003$)
Ball Screw (from $\mu = 0.2$, $\eta = 0.32$)



Frictional resistance on the guide surface

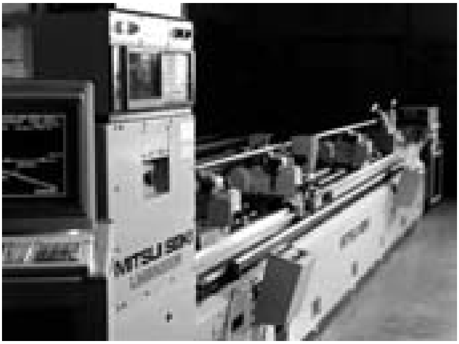
$$Fa = 0.003 \times 500 \times 9.8 = 14.7N$$

Driving torque

$$T = \frac{14.7 \times 10}{2\pi \times 0.32} = 73 \text{ N} \cdot \text{mm}$$

Ensuring High Accuracy

The Ball Screw is ground with the highest-level facilities and equipment at a strictly temperaturecontrolled factory, Its accuracy is assured under a thorough quality control system that covers assembly to inspection.



Automatic lead-measuring machine using laser

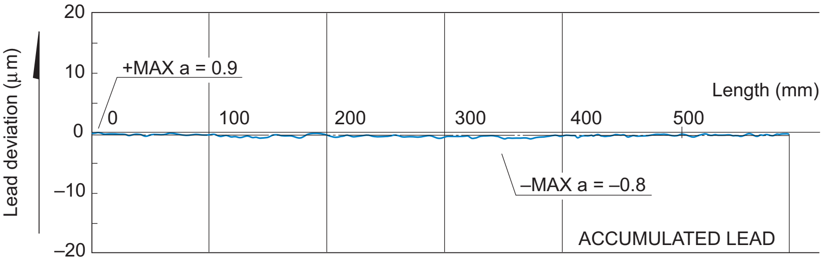


Fig.3 Lead Accuracy Measurement

[Conditions]
Model No.: BIF3205-10RRG0+903LC2

Table1 Lead Accuracy Measurement Unit: mm

Item	Standard value	Actual measurement
Directional target point	0	—
Representative travel distance error	±0.011	−0.0012
Fluctuation	0.008	0.0017

Capable of Micro Feeding

The Ball Screw requires a minimal starting torque due to its rolling motion, and does not cause a slip, which is inevitable with a sliding motion. Therefore, it is capable of an accurate micro feeding.
Fig.4 shows a travel distance of the Ball Screw in one-pulse, 0.1-μm feeding. (LM Guide is used for the guide surface.)

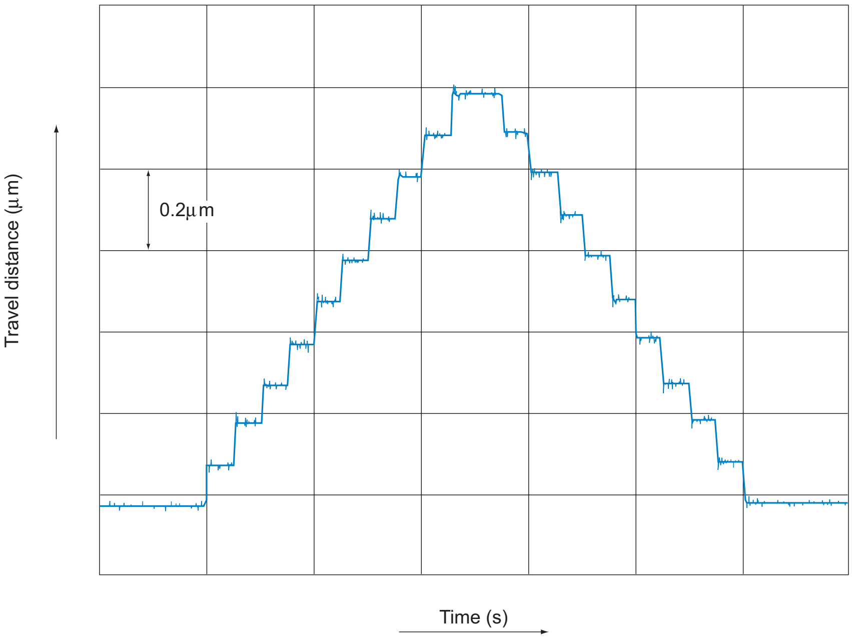


Fig.4 Data on Travel in 0.1-μm Feeding

High Rigidity without Backlash

Since the Ball Screw is capable of receiving a preload, the axial clearance can be reduced to below zero and the high rigidity is achieved because of the preload. In Fig.5, when an axial load is applied in the positive (+) direction, the table is displaced in the same (+) direction. When an axial load is provided in the reverse (-) direction, the table is displaced in the same (-) direction. Fig.6 shows the relationship between the axial load and the axial displacement. As indicated in Fig.6, as the direction of the axial load changes, the axial clearance occurs as a displacement. Additionally, when the Ball Screw is provided with a preload, it gains a higher rigidity and a smaller axial displacement than a zero clearance in the axial direction.

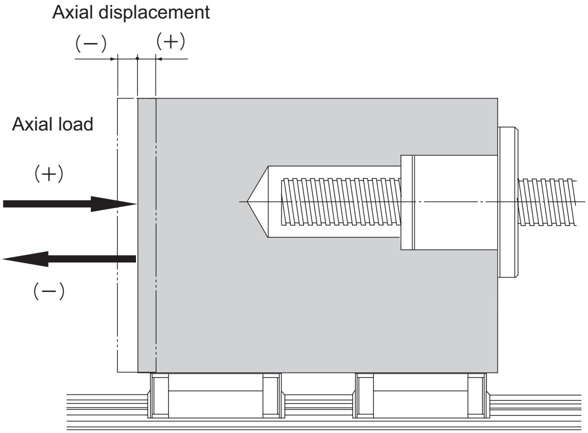


Fig.5

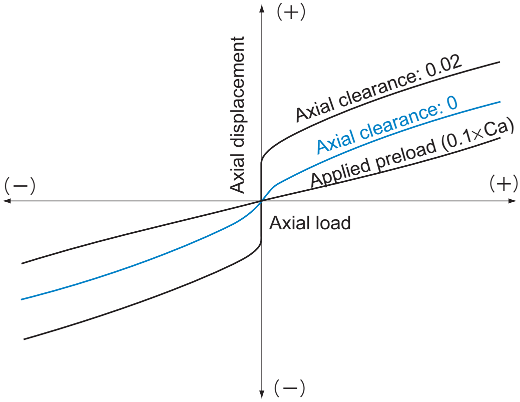


Fig.6 Axial Displacement in Relation to Axial Load

Capable of Fast Feed

Since the Ball Screw is highly efficient and generates little heat, it is capable of a fast feed.

[Example of High Speed]

Fig.7 shows a speed diagram for a large lead rolled Ball Screw operating at 2 m/s.

[Conditions]

Item	Description
Sample	Large Lead Rolled Ball Screw WTF3060 (Shaft diameter: 30mm; lead: 60mm)
Maximum speed	2m/s (Ball Screw rotational speed: 2,000 min^{-1})
Guide surface	LM Guide model SR25W

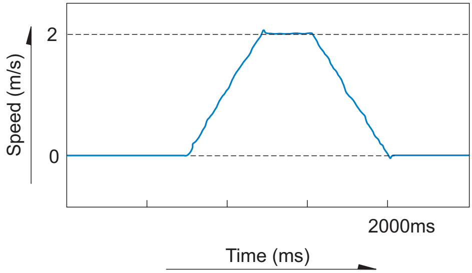


Fig.7 Velocity diagram

[Example of Heat Generation]

Fig.8 shows data on heat generation from the screw shaft when a Ball Screw is used in an operating pattern indicated in Fig.9

[Conditions]

Item	Description
Sample	Double-nut precision Ball Screw BNFN4010-5 (Shaft diameter: 40 mm; lead: 10 mm; applied preload: 2,700 N)
Maximum speed	0.217m/s (13m/min) (Ball Screw rotational speed: 1300 min^{-1})
Low speed	0.0042m/s (0.25m/min) (Ball Screw rotational speed: 25 min^{-1})
Guide surface	LM Guide model HSR35CA
Lubricant	Lithium-based grease (No. 2)

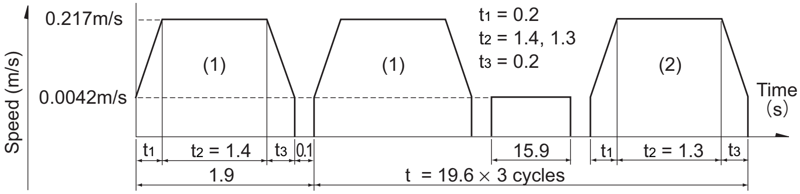


Fig.8 Operating Pattern

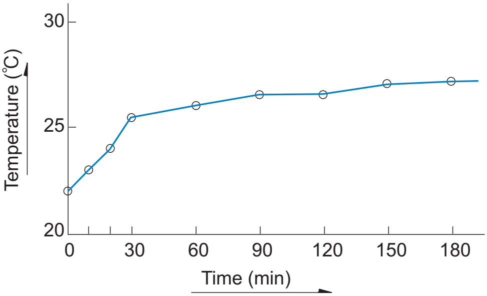
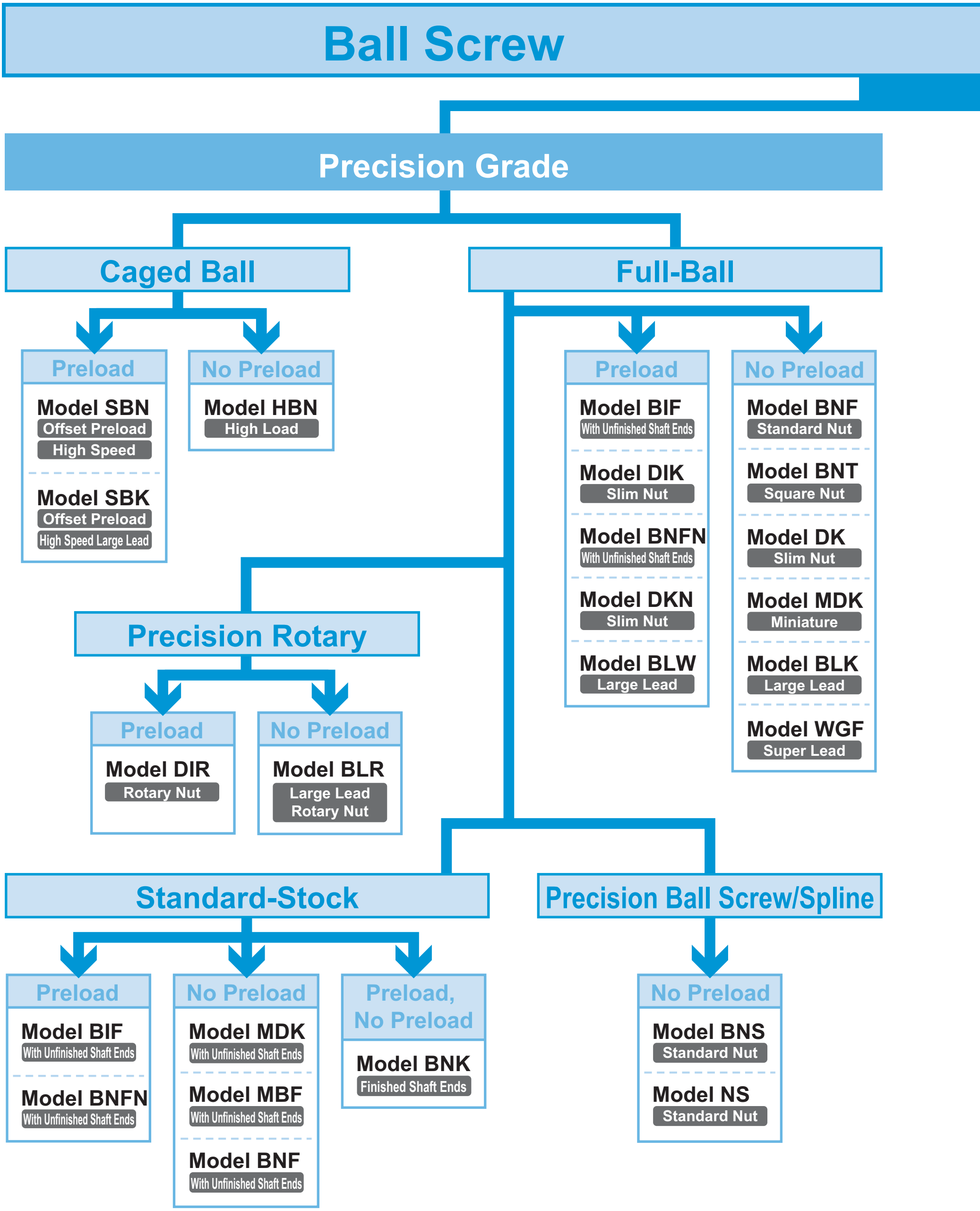


Fig.9 Ball Screw Heat Generation Data

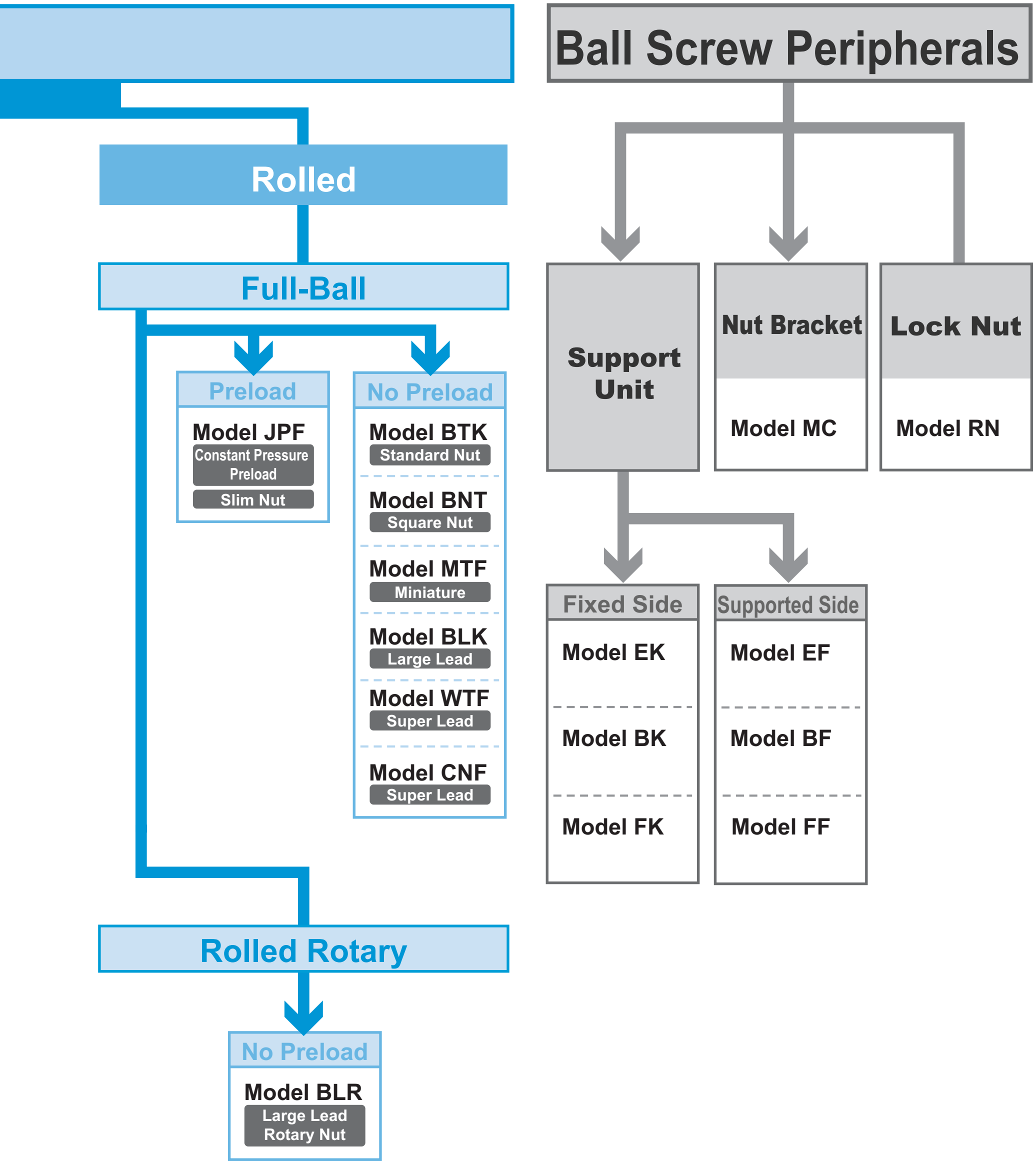
Types of Ball Screws



Ball Screw

Precision Grade

- **Caged Ball**
  - Preload
    - **Model SBN** Offset Preload, High Speed
    - **Model SBK** Offset Preload, High Speed Large Lead
  - No Preload
    - **Model HBN** High Load
- **Full-Ball**
  - Preload
    - **Model BIF** With Unfinished Shaft Ends
    - **Model DIK** Slim Nut
    - **Model BNFN** With Unfinished Shaft Ends
    - **Model DKN** Slim Nut
    - **Model BLW** Large Lead
  - No Preload
    - **Model BNF** Standard Nut
    - **Model BNT** Square Nut
    - **Model DK** Slim Nut
    - **Model MDK** Miniature
    - **Model BLK** Large Lead
    - **Model WGF** Super Lead
  - **Precision Rotary**
    - Preload
      - **Model DIR** Rotary Nut
    - No Preload
      - **Model BLR** Large Lead Rotary Nut
  - **Standard-Stock**
    - Preload
      - **Model BIF** With Unfinished Shaft Ends
      - **Model BNFN** With Unfinished Shaft Ends
    - No Preload
      - **Model MDK** With Unfinished Shaft Ends
      - **Model MBF** With Unfinished Shaft Ends
      - **Model BNF** With Unfinished Shaft Ends
    - Preload, No Preload
      - **Model BNK** Finished Shaft Ends
  - **Precision Ball Screw/Spline**
    - No Preload
      - **Model BNS** Standard Nut
      - **Model NS** Standard Nut



- Rolled
  - Full-Ball
    - Preload
      - Model JPF (Constant Pressure Preload; Slim Nut)
    - No Preload
      - Model BTK (Standard Nut)
      - Model BNT (Square Nut)
      - Model MTF (Miniature)
      - Model BLK (Large Lead)
      - Model WTF (Super Lead)
      - Model CNF (Super Lead)
  - Rolled Rotary
    - No Preload
      - Model BLR (Large Lead Rotary Nut)

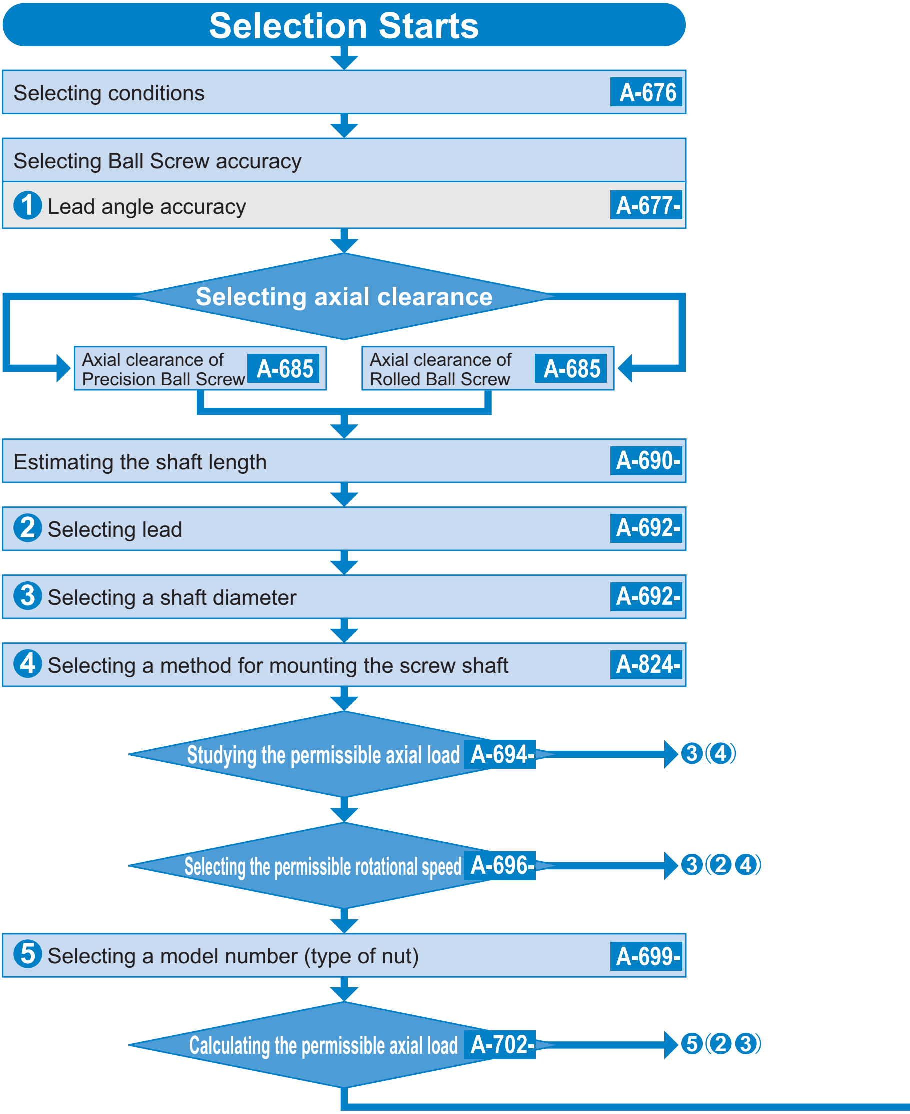
Ball Screw Peripherals

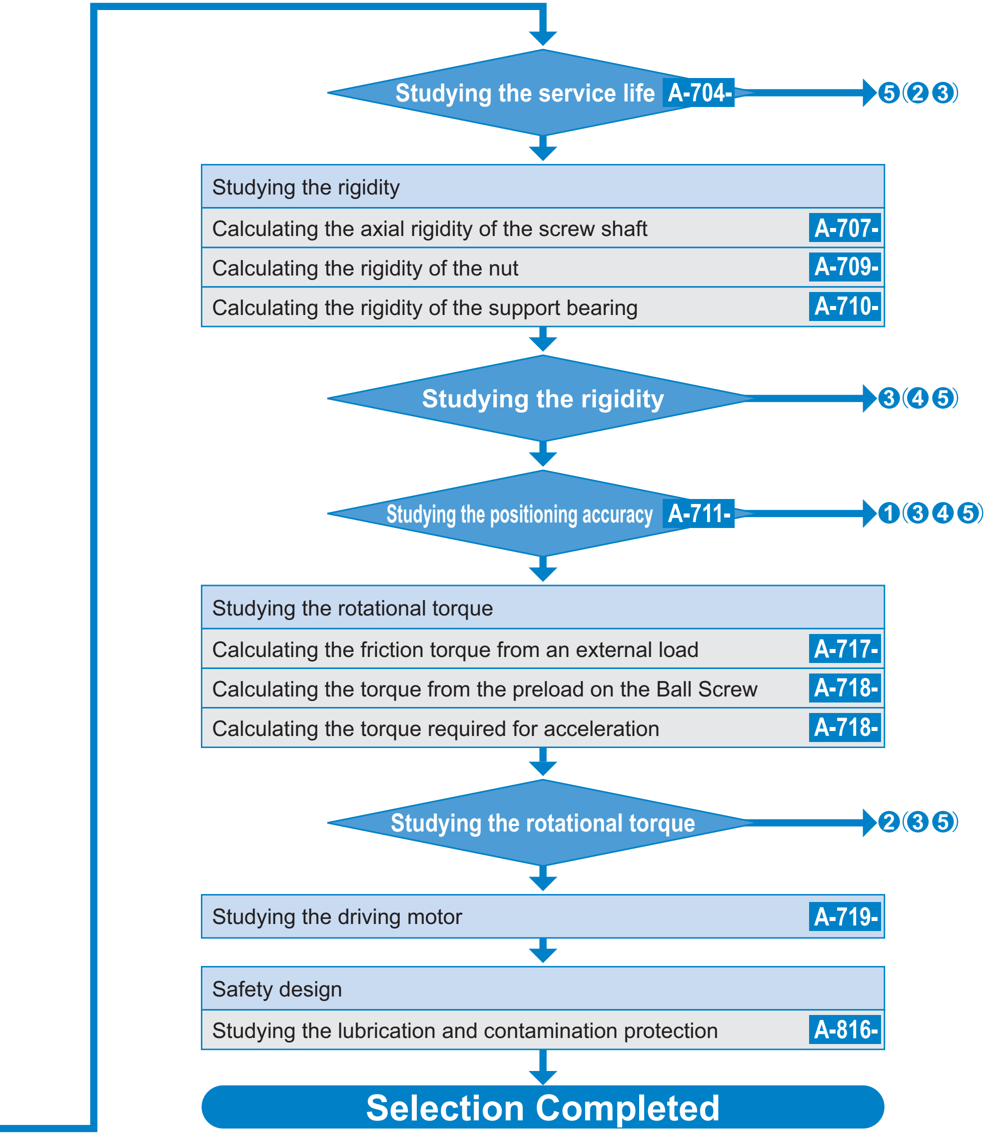
- Support Unit
  - Fixed Side
    - Model EK
    - Model BK
    - Model FK
  - Supported Side
    - Model EF
    - Model BF
    - Model FF
- Nut Bracket
  - Model MC
- Lock Nut
  - Model RN

Flowchart for Selecting a Ball Screw

[Ball Screw Selection Procedure]

When selecting a Ball Screw, it is necessary to make a selection while considering various parameters. The following is a flowchart for selecting a Ball Screw.





Studying the service life A-704- → ❺(❷❸)

Studying the rigidity

- Calculating the axial rigidity of the screw shaft A-707-
- Calculating the rigidity of the nut A-709-
- Calculating the rigidity of the support bearing A-710-

Studying the rigidity → ❸(❹❺)

Studying the positioning accuracy A-711- → ❶(❸❹❺)

Studying the rotational torque

- Calculating the friction torque from an external load A-717-
- Calculating the torque from the preload on the Ball Screw A-718-
- Calculating the torque required for acceleration A-718-

Studying the rotational torque → ❷(❸❺)

Studying the driving motor A-719-

Safety design

- Studying the lubrication and contamination protection A-816-

Selection Completed

[Conditions of the Ball Screw]

The following conditions are required when selecting a Ball Screw.

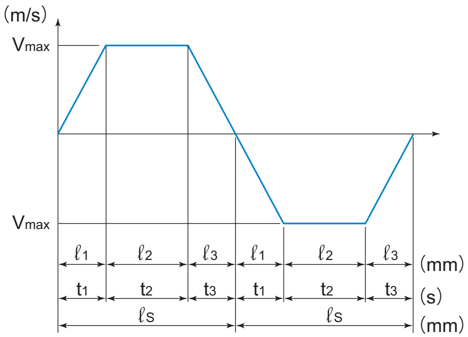
Transfer orientation	(horizontal, vertical, etc.)
Transferred mass	m (kg)
Table guide method	(sliding, rolling)
Frictional coefficient of the guide surface	μ (-)
Guide surface resistance	f (N)
External load in the axial direction	F (N)
Desired service life time	L_h (h)

Stroke length	ℓ_S (mm)
Operating speed	V_{max} (m/s)
Acceleration time	t_1 (s)
Even speed time	t_2 (s)
Deceleration time	t_3 (s)

Acceleration

$$\alpha = \frac{V_{max}}{t_1} \quad (\mathrm{m/s^2})$$

Acceleration distance	$\ell_1 = V_{max} \times t_1 \times 1000/2$ (mm)
Even speed distance	$\ell_2 = V_{max} \times t_2 \times 1000$ (mm)
Deceleration distance	$\ell_3 = V_{max} \times t_3 \times 1000/2$ (mm)
Number of reciprocations per minute	n ($\mathrm{min^{-1}}$)



Velocity diagram

Positioning accuracy	(mm)
Positioning accuracy repeatability	(mm)
Backlash	(mm)
Minimum feed amount	s (mm/pulse)

Driving motor (AC servomotor, stepping motor, etc.)

The rated rotational speed of the motor	N_{MO} ($\mathrm{min^{-1}}$)
Inertial moment of the motor	J_M ($\mathrm{kg \cdot m^2}$)
Motor resolution	(pulse/rev)
Reduction ratio	A (-)

Accuracy of the Ball Screw

Lead Angle Accuracy

The accuracy of the Ball Screw in the lead angle is controlled in accordance with the JIS standards (JIS B 1192 - 1997).

Accuracy grades C0 to C5 are defined in the linearity and the directional property, and C7 to C10 in the travel distance error in relation to 300 mm.

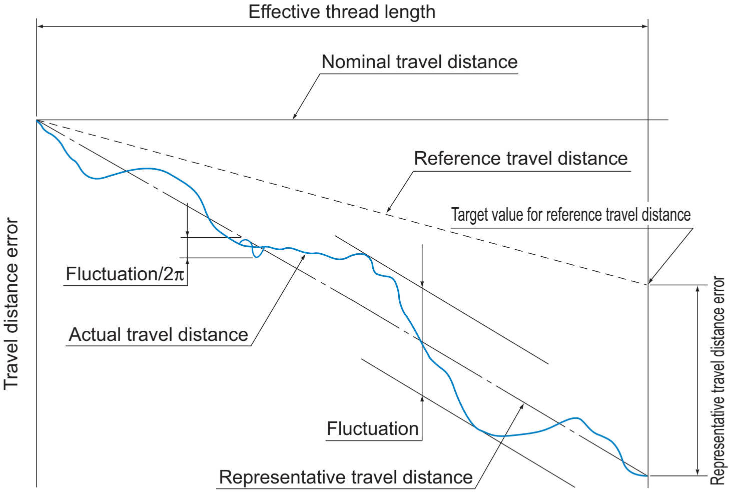


Fig.1 Terms on Lead Angle Accuracy

[Actual Travel Distance]
An error in the travel distance measured with an actual Ball Screw.

[Reference Travel Distance]
Generally, it is the same as nominal travel distance, but can be an intentionally corrected value of the nominal travel distance according to the intended use.

[Target Value for Reference Travel Distance]
You may provide some tension in order to prevent the screw shaft from runout, or set the reference travel distance in "negative" or "positive" value in advance given the possible expansion/ contraction from external load or temperature. In such cases, indicate a target value for the reference travel distance.

[Representative Travel Distance]
It is a straight line representing the tendency in the actual travel distance, and obtained with the least squares method from the curve that indicates the actual travel distance.

[Representative Travel Distance Error (in ±)]
Difference between the representative travel distance and the reference travel distance.

[Fluctuation]
The maximum width of the actual travel distance between two straight lines drawn in parallel with the representative travel distance.

[Fluctuation/300]
Indicates a fluctuation against a given thread length of 300 mm.

[Fluctuation/2π]
A fluctuation in one revolution of the screw shaft.

Table1 Lead Angle Accuracy (Permissible Value) Unit: µm

		Precision Ball Screw												
												Rolled Ball Screw		
Accuracy grades		C0		C1		C2		C3		C5		C7	C8	C10
Effective thread length		Representative travel distance error	Fluctuation	Representative travel distance error	Fluctuation	Representative travel distance error	Fluctuation	Representative travel distance error	Fluctuation	Representative travel distance error	Fluctuation	Travel distance error	Travel distance error	Travel distance error
Above	Or less													
—	100	3	3	3.5	5	5	7	8	8	18	18	±50/ 300mm	±100/ 300mm	±210/ 300mm
100	200	3.5	3	4.5	5	7	7	10	8	20	18			
200	315	4	3.5	6	5	8	7	12	8	23	18			
315	400	5	3.5	7	5	9	7	13	10	25	20			
400	500	6	4	8	5	10	7	15	10	27	20			
500	630	6	4	9	6	11	8	16	12	30	23			
630	800	7	5	10	7	13	9	18	13	35	25			
800	1000	8	6	11	8	15	10	21	15	40	27			
1000	1250	9	6	13	9	18	11	24	16	46	30			
1250	1600	11	7	15	10	21	13	29	18	54	35			
1600	2000	—	—	18	11	25	15	35	21	65	40			
2000	2500	—	—	22	13	30	18	41	24	77	46			
2500	3150	—	—	26	15	36	21	50	29	93	54			
3150	4000	—	—	30	18	44	25	60	35	115	65			
4000	5000	—	—	—	—	52	30	72	41	140	77			
5000	6300	—	—	—	—	65	36	90	50	170	93			
6300	8000	—	—	—	—	—	—	110	60	210	115			
8000	10000	—	—	—	—	—	—	—	—	260	140			

Note) Unit of effective thread length: mm

Table2 Fluctuation in Thread Length of 300 mm and in One Revolution (permissible value) Unit: µm

Accuracy grades	C0	C1	C2	C3	C5	C7	C8	C10
Fluctuation/300	3.5	5	7	8	18	—	—	—
Fluctuation/2π	3	4	5	6	8	—	—	—

Table3 Types and Grades

Type	Series symbol	Grade	Remarks
For positioning	Cp	1, 3, 5	ISO compliant
For conveyance	Ct	1, 3, 5, 7, 10	

Note) Accuracy grades apply also to the Cp series and Ct series. Contact THK for details.

Example: When the lead of a Ball Screw manufactured is measured with a target value for the reference travel distance of −9 µm/500 mm, the following data are obtained.

Table4 Measurement Data on Travel Distance Error

Unit: mm

Command position (A)	0	50	100	150
Travel distance (B)	0	49.998	100.001	149.996
Travel distance error (A–B)	0	−0.002	+0.001	−0.004

Command position (A)	200	250	300	350
Travel distance (B)	199.995	249.993	299.989	349.885
Travel distance error (A–B)	−0.005	−0.007	−0.011	−0.015

Command position (A)	400	450	500
Travel distance (B)	399.983	449.981	499.984
Travel distance error (A–B)	−0.017	−0.019	−0.016

The measurement data are expressed in a graph as shown in Fig.2.
The positioning error (A-B) is indicated as the actual travel distance while the straight line representing the tendency of the (A-B) graph refers to the representative travel distance.
The difference between the reference travel distance and the representative travel distance appears as the representative travel distance error.

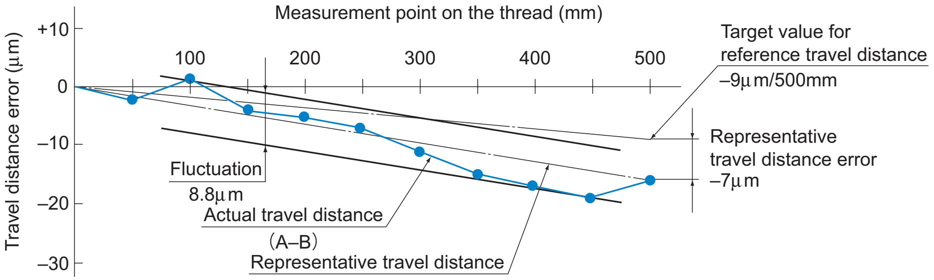
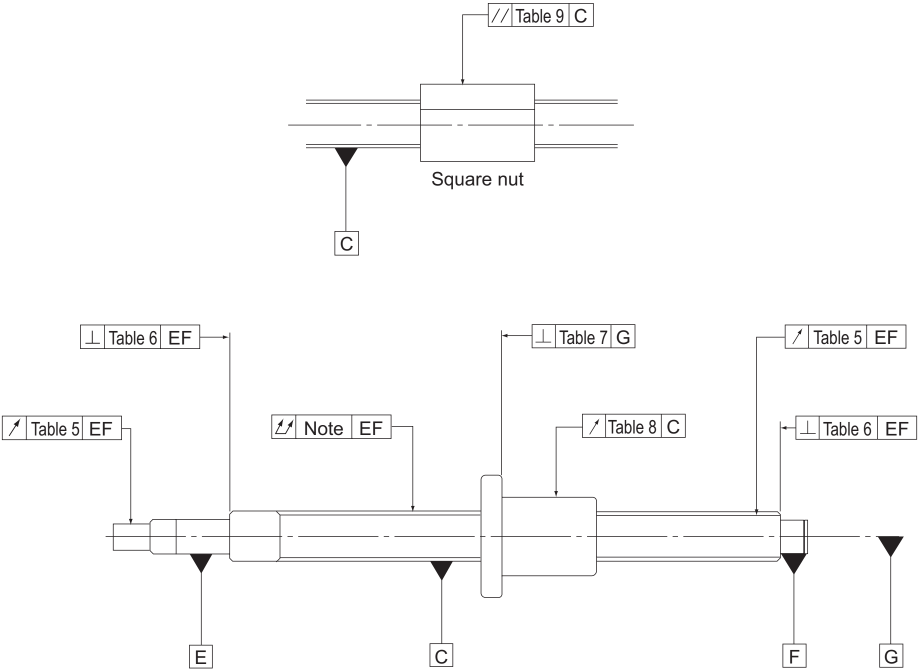


Fig.2 Measurement Data on Travel Distance Error

[Measurements]
Representative travel distance error: -7µm
Fluctuation: 8.8µm

Accuracy of the Mounting Surface

The accuracy of the Ball Screw mounting surface complies with the JIS standard (JIS B 1192-1997).



Note) For the overall radial runout of the screw shaft axis, refer to JIS B 1192-1997.

Fig.3 Accuracy of the Mounting Surface of the Ball Screw

[Accuracy Standards for the Mounting Surface]

Table5 to Table9 show accuracy standards for the mounting surfaces of the precision Ball Screw.

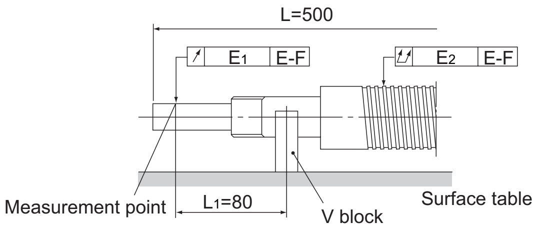
Table5 Radial Runout of the Circumference of the Thread Root in Relation to the Supporting Portion Axis of the Screw Shaft

Unit: µm

Screw shaft outer diameter (mm)		Runout (maximum)					
Above	Or less	C0	C1	C2	C3	C5	C7
—	8	3	5	7	8	10	14
8	12	4	5	7	8	11	14
12	20	4	6	8	9	12	14
20	32	5	7	9	10	13	20
32	50	6	8	10	12	15	20
50	80	7	9	11	13	17	20
80	100	—	10	12	15	20	30

Note) The measurements on these items include the effect of the runout of the screw shaft diameter. Therefore, it is necessary to obtain the correction value from the overall runout of the screw shaft axis, using the ratio of the distance between the fulcrum and measurement point to the overall screw shaft length, and add the obtained value to the table above.

Example: model No. DIK2005-6RRGO+500LC5



$$\mathbf{E_1 = e + \Delta e}$$

e : Standard value in Table5 (0.012)
Δe : Correction value

$$\mathbf{\Delta e = \frac{L_1}{L} \times E_2}$$

$$= \frac{80}{500} \times 0.06$$

$$= 0.01$$

E_2 : Overall radial runout of the screw shaft axis (0.06)

$$E_1 = 0.012 + 0.01$$

$$= 0.022$$

Table6 Perpendicularity of the Supporting Portion End of the Screw Shaft to the Supporting Portion Axis

Unit: µm

Screw shaft outer diameter (mm)		Perpendicularity (maximum)					
Above	Or less	C0	C1	C2	C3	C5	C7
—	8	2	3	3	4	5	7
8	12	2	3	3	4	5	7
12	20	2	3	3	4	5	7
20	32	2	3	3	4	5	7
32	50	2	3	3	4	5	8
50	80	3	4	4	5	7	10
80	100	—	4	5	6	8	11

Table7 Perpendicularity of the Flange Mounting Surface of the Screw Shaft to the Screw Shaft Axis

Unit: µm

Nut diameter (mm)		Perpendicularity (maximum)					
Above	Or less	C0	C1	C2	C3	C5	C7
—	20	5	6	7	8	10	14
20	32	5	6	7	8	10	14
32	50	6	7	8	8	11	18
50	80	7	8	9	10	13	18
80	125	7	9	10	12	15	20
125	160	8	10	11	13	17	20
160	200	—	11	12	14	18	25

Table8 Radial Runout of the Nut Circumference in Relation to the Screw Shaft Axis

Unit: µm

Nut diameter (mm)		Runout (maximum)					
Above	Or less	C0	C1	C2	C3	C5	C7
—	20	5	6	7	9	12	20
20	32	6	7	8	10	12	20
32	50	7	8	10	12	15	30
50	80	8	10	12	15	19	30
80	125	9	12	16	20	27	40
125	160	10	13	17	22	30	40
160	200	—	16	20	25	34	50

Table9 Parallelism of the Nut Circumference (Flat Mounting Surface) to the Screw Shaft Axis

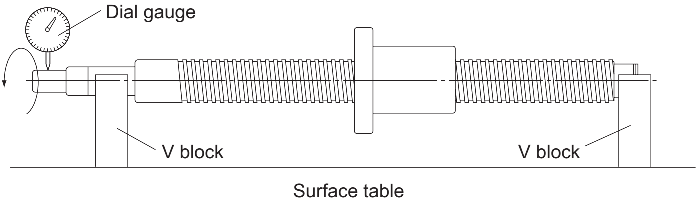
Unit: µm

Mounting reference length (mm)		Parallelism (maximum)					
Above	Or less	C0	C1	C2	C3	C5	C7
—	50	5	6	7	8	10	17
50	100	7	8	9	10	13	17
100	200	—	10	11	13	17	30

[Method for Measuring Accuracy of the Mounting Surface]

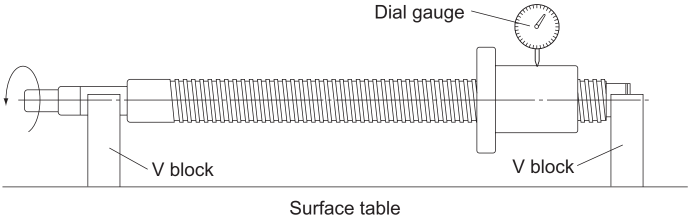
● Radial Runout of the Circumference of the Part Mounting Section in Relation to the Supporting Portion Axis of the Screw Shaft (see Table5 on A-681)

Support the supporting portion of the screw shaft with V blocks. Place a probe on the circumference of the part mounting section, and read the largest difference on the dial gauge as a measurement when turning the screw shaft by one revolution.



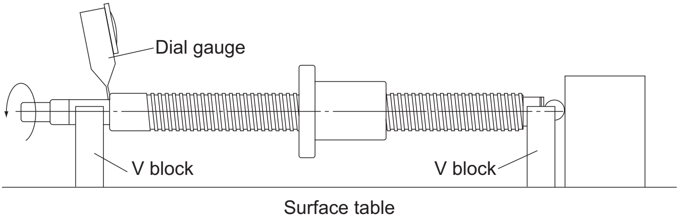
● Radial Runout of the Circumference of the Thread Root in Relation to the Supporting Portion Axis of the Screw Shaft (see Table5 on A-681)

Support the supporting portion of the screw shaft with V blocks. Place a probe on the circumference of the nut, and read the largest difference on the dial gauge as a measurement when turning the screw shaft by one revolution without turning the nut.



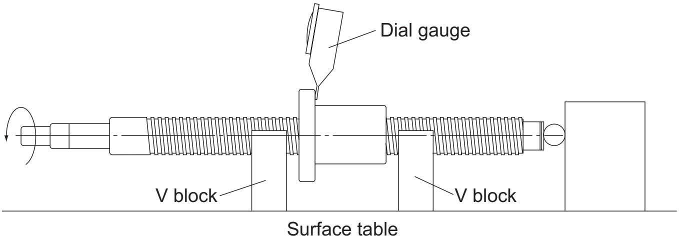
● Perpendicularity of the Supporting Portion End of the Screw Shaft to the Supporting Portion Axis (see Table6 on A-682)

Support the supporting portion of the screw shaft with V blocks. Place a probe on the screw shaft's supporting portion end, and read the largest difference on the dial gauge as a measurement when turning the screw shaft by one revolution.



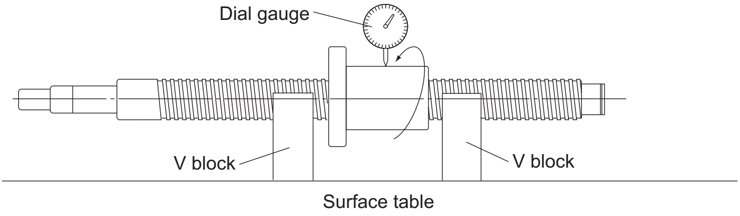
● Perpendicularity of the Flange Mounting Surface of the Screw Shaft to the Screw Shaft Axis (see Table7 on A-682)

Support the thread of the screw shaft with V blocks near the nut. Place a probe on the flange end, and read the largest difference on the dial gauge as a measurement when simultaneously turning the screw shaft and the nut by one revolution.



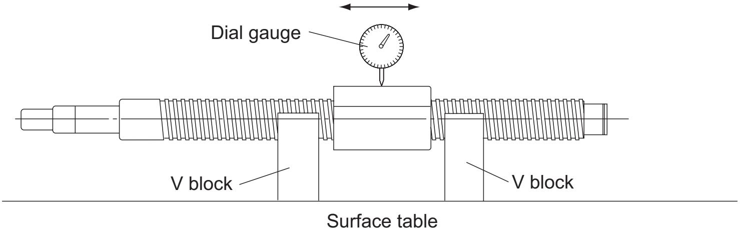
- **Radial Runout of the Nut Circumference in Relation to the Screw Shaft Axis (see Table8 on A-682)**

Support the thread of the screw shaft with V blocks near the nut. Place a probe on the circumference of the nut, and read the largest difference on the dial gauge as a measurement when turning the nut by one revolution without turning the screw shaft.



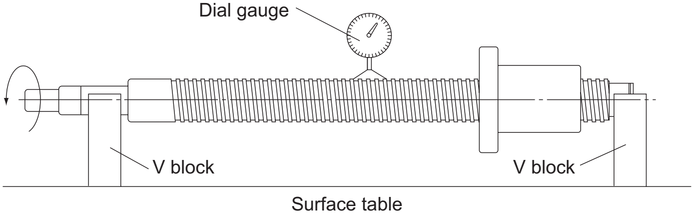
- **Parallelism of the Nut Circumference (Flat Mounting Surface) to the Screw Shaft Axis (see Table9 on A-682)**

Support the thread of the screw shaft with V blocks near the nut. Place a probe on the circumference of the nut (flat mounting surface), and read the largest difference on the dial gauge as a measurement when moving the dial gauge in parallel with the screw shaft.



- **Overall Radial Runout of the Screw Shaft Axis**

Support the supporting portion of the screw shaft with V blocks. Place a probe on the circumference of the screw shaft, and read the largest difference on the dial gauge at several points in the axial directions as a measurement when turning the screw shaft by one revolution.



Note) For the overall radial runout of the screw shaft axis, refer to JIS B 1192-1997.

Axial Clearance

[Axial Clearance of the Precision Ball Screw]

Table10 shows the axial clearance of the precision Screw Ball. If the manufacturing length exceeds the value in Table11, the resultant clearance may partially be negative (preload applied).

Table10 Axial Clearance of the Precision Ball Screw

Unit: mm

Clearance symbol	G0	GT	G1	G2	G3
Axial clearance	0 or less	0 to 0.005	0 to 0.01	0 to 0.02	0 to 0.05

Table11 Maximum Length of the Precision Ball Screw in Axial Clearance

Unit: mm

Screw shaft outer diameter	Overall thread length						
	Clearance GT		Clearance G1		Clearance G2		
	C0 to C3	C5	C0 to C3	C5	C0 to C3	C5	C7
4 to 6	80	100	80	100	80	100	120
8 to 10	250	200	250	250	250	300	300
12 to 16	500	400	500	500	700	600	500
18 to 25	800	700	800	700	1000	1000	1000
28 to 32	900	800	1100	900	1400	1200	1200
36 to 45	1000	800	1300	1000	2000	1500	1500
50 to 70	1200	1000	1600	1300	2500	2000	2000
80 to 100	—	—	1800	1500	4000	3000	3000

* When manufacturing the Ball Screw of precision-grade accuracy C7 with clearance GT or G1, the resultant clearance is partially negative.

[Axial Clearance of the Rolled Ball Screw]

Table12 shows axial clearance of the rolled Ball Screw.

Table12 Axial Clearance of the Rolled Ball Screw

Unit: mm

Screw shaft outer diameter	Axial clearance (maximum)
6 to 12	0.05
14 to 28	0.1
30 to 32	0.14
36 to 45	0.17
50	0.2

Preload

A preload is provided in order to eliminate the axial clearance and minimize the displacement under an axial load.
When performing a highly accurate positioning, a preload is generally provided.

[Rigidity of the Ball Screw under a Preload]

When a preload is provided to the Ball Screw, the rigidity of the nut is increased.
Fig.4 shows elastic displacement curves of the Ball Screw under a preload and without a preload.

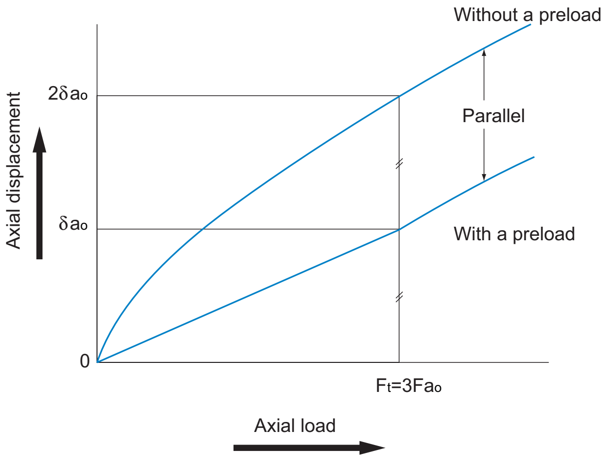
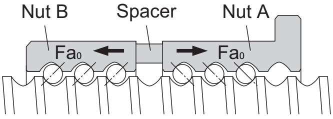


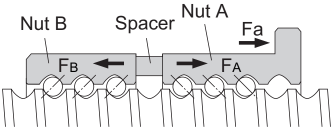
Fig.4 Elastic Displacement Curve of the Ball Screw

dammy

Fig.5 shows a double-nut type of the Ball Screw.



External load: 0



External load: Fa

Fig.5

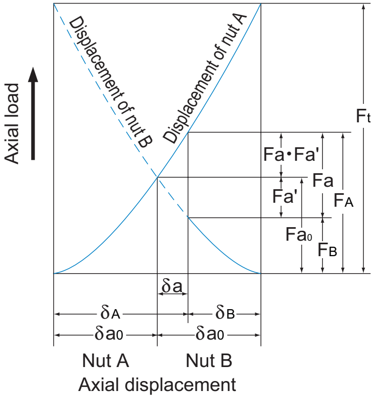


Fig.6

Nuts A and B are provided with preload Fa_0 from the spacer. Because of the preload, nuts A and B are elastically displaced by δa_0 each. If an axial load (Fa) is applied from outside in this state, the displacement of nuts A and B is calculated as follows.

$$\delta_A = \delta a_0 + \delta a \qquad \delta_B = \delta a_0 - \delta a$$

In other words, the loads on nut A and B are expressed as follows:

$$F_A = Fa_0 + (Fa - Fa') \quad F_B = Fa_0 - Fa'$$

Therefore, under a preload, the load that nut A receives equals to Fa - Fa'. This means that since load Fa', which is applied when nut A receives no preload, is deducted from Fa, the displacement of nut A is smaller.

This effect extends to the point where the displacement (δa_0) caused by the preload applied on nut B reaches zero.

To what extent is the elastic displacement reduced? The relationship between the axial load on the Ball Screw under no preload and the elastic displacement can be expressed by $\delta a \propto Fa^{2/3}$. From Fig.6, the following equations are established.

$$\delta a_0 = KFa_0^{2/3} \qquad (K: \text{constant})$$

$$2\delta a_0 = KF_t^{2/3}$$

$$\left(\frac{F_t}{Fa_0}\right)^{\frac{2}{3}} = 2 \quad F_t = 2^{3/2} \times Fa_0 = 2.8Fa_0 \fallingdotseq 3Fa_0$$

Thus, the Ball Screw under a preload is displaced by δa_0 when an axial load (F_t) approximately three times greater than the preload is provided from outside. As a result, the displacement of the Ball Screw under a preload is half the displacement ($2\delta a_0$) of the Ball Screw without a preload.

As stated above, since the preloading is effective up to approximately three times the applied preload, the optimum preload is one third of the maximum axial load.

Note, however, that an excessive preload adversely affects the service life and heat generation. As a guideline, the maximum preload should be set at 10% of the basic dynamic load rating (Ca) at a maximum.

[Preload Torque]

The preload torque of the Ball Screw in lead is controlled in accordance with the JIS standard (JIS B 1192-1997).

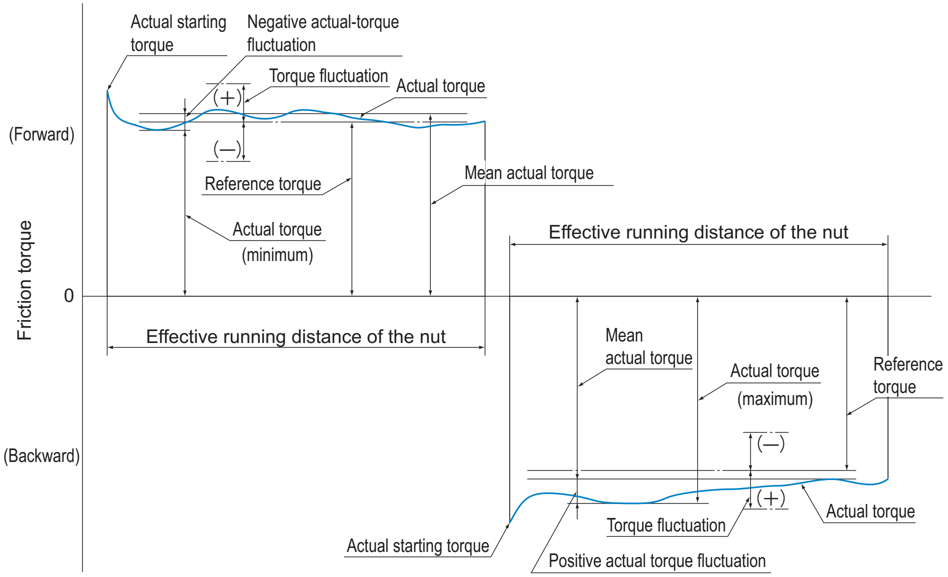


Fig.7 Terms on Preload Torque

● Dynamic Preload Torque

A torque required to continuously rotate the screw shaft of a Ball Screw under a given preload without an external load applied.

● Actual Torque

A dynamic preload torque measured with an actual Ball Screw.

● Torque Fluctuation

Variation in a dynamic preload torque set at a target value. It can be positive or negative in relation to the reference torque.

● Coefficient of Torque Fluctuation

Ratio of torque fluctuation to the reference torque.

● Reference Torque

A dynamic preload torque set as a target.

● Calculating the Reference Torque

The reference torque of a Ball Screw provided with a preload is obtained in the following equation (5).

$$T_p = 0.05\,(\tan\beta)^{-0.5}\,\frac{Fa_0 \cdot Ph}{2\pi} \quad \cdots\cdots\cdots (5)$$

T_p	: Reference torque	(N-mm)
β	: Lead angle	
Fa_0	: Applied preload	(N)
Ph	: Lead	(mm)

Example: When a preload of 3,000 N is provided to the Ball Screw model BNFN4010-5G0 + 1500LC3 with a thread length of 1,300 mm (shaft diameter: 40 mm; ball center-to-center diameter: 41.75 mm; lead: 10 mm), the preload torque of the Ball Screw is calculated in the steps below.

■Calculating the Reference Torque

β : Lead angle

$$\tan\beta = \frac{\text{lead}}{\pi \times \text{ball center-to-center diameter}} = \frac{10}{\pi \times 41.75} = 0.0762$$

Fa_0 : Applied preload=3000N
Ph : Lead = 10mm

$$T_p = 0.05\,(\tan\beta)^{-0.5}\,\frac{Fa_0 \cdot Ph}{2\pi} = 0.05\,(0.0762)^{-0.5}\,\frac{3000 \times 10}{2\pi} = 865\text{N} \cdot \text{mm}$$

■Calculating the Torque Fluctuation

$$\frac{\text{thread length}}{\text{screw shaft outer diameter}} = \frac{1300}{40} = 32.5 \leqq 40$$

Thus, with the reference torque in Table13 being between 600 and 1,000 N-mm, effective thread length 4,000 mm or less and accuracy grade C3, the coefficient of torque fluctuation is obtained as ±30%.

As a result, the torque fluctuation is calculated as follows.

$865 \times (1 \pm 0.3) = 606\ \text{N} \cdot \text{mm to } 1125\ \text{N} \cdot \text{mm}$

■Result

Reference torque : 865 N-mn
Torque fluctuation : 606 N-mm to 1125 N-mm

Table13 Tolerance Range in Torque Fluctuation

Reference torque N・mm		Effective thread length									
		4000mm or less								Above 4,000 mm and 10,000 mm or less	
		$\frac{\text{thread length}}{\text{screw shaft outer diameter}} \leqq 40$				$40 < \frac{\text{thread length}}{\text{screw shaft outer diameter}} < 60$				—	
		Accuracy grades				Accuracy grades				Accuracy grades	
Above	Or less	C0	C1	C2, C3	C5	C0	C1	C2, C3	C5	C2, C3	C5
200	400	±35%	±40%	±45%	±55%	±45%	±45%	±55%	±65%	—	—
400	600	±25%	±30%	±35%	±45%	±38%	±38%	±45%	±50%	—	—
600	1000	±20%	±25%	±30%	±35%	±30%	±30%	±35%	±40%	±40%	±45%
1000	2500	±15%	±20%	±25%	±30%	±25%	±25%	±30%	±35%	±35%	±40%
2500	6300	±10%	±15%	±20%	±25%	±20%	±20%	±25%	±30%	±30%	±35%
6300	10000	—	—	±15%	±20%	—	—	±20%	±25%	±25%	±30%

Selecting a Screw Shaft

Maximum Length of the Screw Shaft

The maximum length of the precision Ball Screw and the rolled Ball Screw are shown in Table14 and Table15 (A-691) respectively.
If the shaft dimensions exceed the manufacturing limit in Table14 or Table15, contact THK.

Table14 Maximum Length of the Precision Ball Screw by Accuracy Grade Unit: mm

Screw shaft outer diameter	Overall screw shaft length					
	C0	C1	C2	C3	C5	C7
4	90	110	120	120	120	120
6	150	170	210	210	210	210
8	230	270	340	340	340	340
10	350	400	500	500	500	500
12	440	500	630	680	680	680
13	440	500	630	680	680	680
14	530	620	770	870	890	890
15	570	670	830	950	980	1100
16	620	730	900	1050	1100	1400
18	720	840	1050	1220	1350	1600
20	820	950	1200	1400	1600	1800
25	1100	1400	1600	1800	2000	2400
28	1300	1600	1900	2100	2350	2700
30	1450	1700	2050	2300	2570	2950
32	1600	1800	2200	2500	2800	3200
36	2000	2100	2550	2950	3250	3650
40		2400	2900	3400	3700	4300
45		2750	3350	3950	4350	5050
50		3100	3800	4500	5000	5800
55		3450	4150	5300	6050	6500
63		4000	5200	5800	6700	7700
70			6300	6450	7650	9000
80				7900	9000	10000
100				10000	10000	

Table15 Maximum Length of the Rolled Ball Screw by Accuracy Grade

Unit: mm

Screw shaft outer diameter	Overall screw shaft length		
	C7	C8	C10
6 to 8	320	320	—
10 to 12	500	1000	—
14 to 15	1500	1500	1500
16 to 18	1500	1800	1800
20	2000	2200	2200
25	2000	3000	3000
28	3000	3000	3000
30	3000	3000	4000
32 to 36	3000	4000	4000
40	3000	5000	5000
45	3000	5500	5500
50	3000	6000	6000

Standard Combinations of Shaft Diameter and Lead for the Precision Ball Screw

Table16 shows the standard combinations of shaft diameter and lead for the precision Ball Screw. If a Ball Screw not covered by the table is required,contact THK.

Table16 Standard Combinations of Screw Shaft and Lead (Precision Ball Screw) Unit: mm

Screw shaft outer diameter	Lead																					
	1	2	4	5	6	8	10	12	15	16	20	24	25	30	32	36	40	50	60	80	90	100
4	●																					
5	●																					
6	●																					
8	●	●					●	○														
10		●	●				●		○													
12		●		●		●																
13											○											
14		●	●	●		●																
15							●				●			○			○					
16			○	●	○		○			●												
18							●															
20			○	●	○	○	●	○			●						○		○			
25			○	●	○	○	●	○		○	●		○					○				
28				○	●	○	○															
30																			○		○	
32			○	●	●	○	●	○			○				○							
36					○	○	●	○		○	○	○				○						
40				○	○	○	●	●		○	○			○			○			○		
45					○	○	○	○		○	○											
50				○		○	●	○		○	○			○		○		○				○
55							○	○		○	○			○		○						
63							○	○		○	○											
70							○	○			○											
80							○	○			○											
100											○											

●: off-the-shelf products [standard-stock products equipped with the standardized screw shafts (with unfinished shaft ends/finished shaft ends)]
○: Semi-standard stock

Standard Combinations of Shaft Diameter and Lead for the Rolled Ball Screw

Table17 shows the standard combinations of shaft diameter and lead for the rolled Ball Screw.

Table17 Standard Combinations of Screw Shaft and Lead (Rolled Ball Screw)

Unit: mm

Screw shaft outer diameter	Lead																			
	1	2	4	5	6	8	10	12	16	20	24	25	30	32	36	40	50	60	80	100
6	●																			
8		●																		
10		●			○															
12		●				○														
14			●	●																
15							●			●			●							
16				●					●											
18						●														
20				●			●			●						●				
25				●			●					●					●			
28					●															
30																		●		
32							●							●						
36							●			●	●				●					
40							●									●			●	
45								●												
50									●								●			●

●: Standard stock
○: Semi-standard stock

Permissible Axial Load

[Buckling Load on the Screw Shaft]

With the Ball Screw, it is necessary to select a screw shaft so that it will not buckle when the maximum compressive load is applied in the axial direction.

Fig.8 on A-695 shows the relationship between the screw shaft diameter and a buckling load.

If determining a buckling load by calculation, it can be obtained from the equation (6) below. Note that in this equation, a safety factor of 0.5 is multiplied to the result.

$$P_1 = \frac{\eta_1 \cdot \pi^2 \cdot E \cdot I}{\ell_a{}^2} 0.5 = \eta_2 \frac{d_1{}^4}{\ell_a{}^2} 10^4 \quad \cdots\cdots\cdots(6)$$

P_1 : Buckling load (N)

ℓ_a : Distance between two mounting surfaces (mm)

E : Young's modulus (2.06×10^5 N/mm^2)

I : Minimum geometrical moment of inertia of the shaft (mm^4)

$I = \frac{\pi}{64} d_1{}^4$ d_1: screw-shaft thread minor diameter (mm)

η_1, η_2=Factor according to the mounting method

Fixed - free	$\eta_1=0.25$	$\eta_2=1.3$
Fixed - supported	$\eta_1=2$	$\eta_2=10$
Fixed - fixed	$\eta_1=4$	$\eta_2=20$

[Permissible Tensile Compressive Load on the Screw Shaft]

If an axial load is applied to the Ball Screw, it is necessary to take into account not only the buckling load but also the permissible tensile compressive load in relation to the yielding stress on the screw shaft.

The permissible tensile compressive load is obtained from the equation (7).

$$P_2 = \sigma \frac{\pi}{4} d_1{}^2 = 116 d_1{}^2 \quad \cdots\cdots\cdots(7)$$

P_2 : Permissible tensile compressive load (N)

σ : Permissible tensile compressive stress (147 MPa)

d_1 : Screw-shaft thread minor diameter (mm)

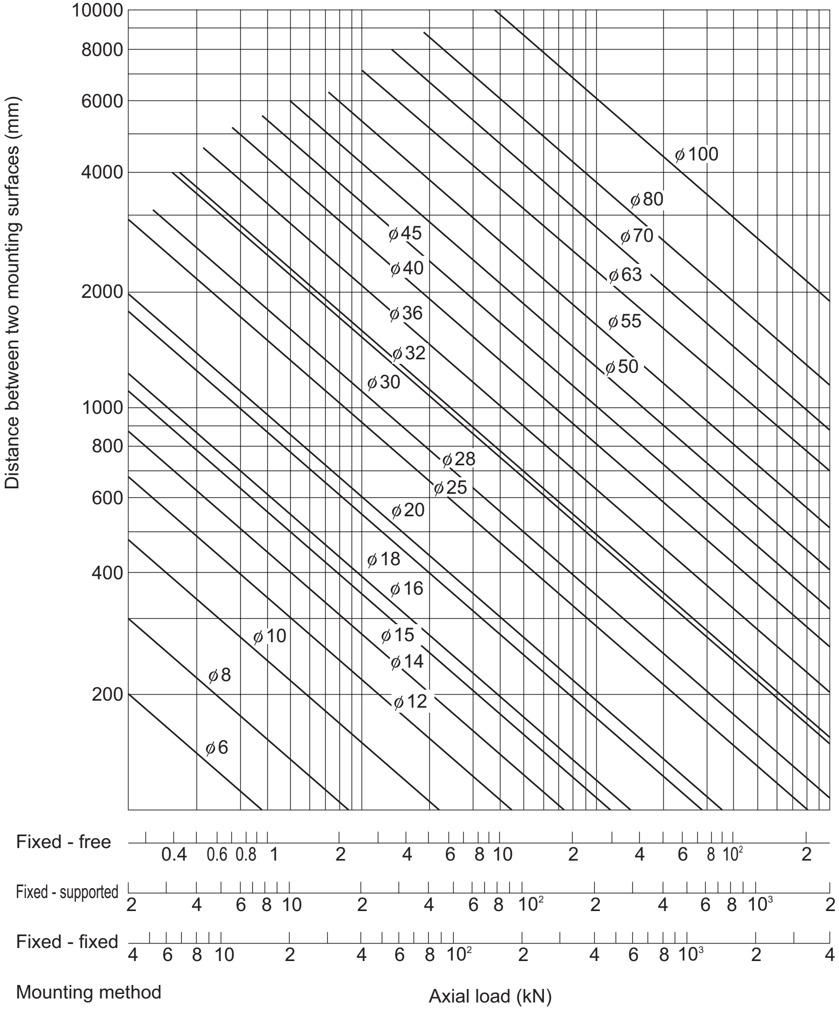


Fig.8 Permissible Tensile Compressive Load Diagram

Permissible Rotational Speed

[Dangerous Speed of the Screw Shaft]

When the rotational speed reaches a high magnitude, the Ball Screw may resonate and eventually become unable to operate due to the screw shaft's natural frequency. Therefore, it is necessary to select a model so that it is used below the resonance point (dangerous speed).

Fig.9 on A-698 shows the relationship between the screw shaft diameter and a dangerous speed.

If determining a dangerous speed by calculation, it can be obtained from the equation (8) below. Note that in this equation, a safety factor of 0.8 is multiplied to the result.

$$N_1 = \frac{60 \cdot \lambda_1^2}{2\pi \cdot \ell_b^2} \times \sqrt{\frac{E \times 10^3 \cdot I}{\gamma \cdot A}} \times 0.8 = \lambda_2 \cdot \frac{d_1}{\ell_b^2} \cdot 10^7 \quad \cdots\cdots\cdots(8)$$

N_1 : Permissible rotational speed determined by dangerous speed (min^{-1})

ℓ_b : Distance between two mounting surfaces (mm)

E : Young's modulus (2.06×10^5 N/mm^2)

I : Minimum geometrical moment of inertia of the shaft (mm^4)

$$I = \frac{\pi}{64} d_1^4$$

d_1: screw-shaft thread minor diameter (mm)

γ : Density (specific gravity) (7.85×10^{-6} kg/mm^3)

A : Screw shaft cross-sectional area (mm^2)

$$A = \frac{\pi}{4} d_1^2$$

λ_1, λ_2 : Factor according to the mounting method

Fixed - free	$\lambda_1=1.875$	$\lambda_2=3.4$
Supported - supported	$\lambda_1=3.142$	$\lambda_2=9.7$
Fixed - supported	$\lambda_1=3.927$	$\lambda_2=15.1$
Fixed - fixed	$\lambda_1=4.73$	$\lambda_2=21.9$

[DN Value]

The permissible rotational speed of the Ball Screw must be obtained from the dangerous speed of the screw shaft and the DN value.

The permissible rotational speed determined by the DN value is obtained using the equations (9) to (13) below.

● Ball Screw with Ball Cage

■Models SBN and HBN

$$N_2 = \frac{130000}{D} \quad \cdots\cdots\cdots(9)$$

N_2 : Permissible rotational speed determined by the DN value (min^{-1}(rpm))
D : Ball center-to-center diameter
(indicated in the specification tables of the respective model number)

■Model SBK

$$N_2 = \frac{160000}{D} \quad \cdots\cdots\cdots(10)$$

● Precision Ball Screw

$$N_2 = \frac{70000}{D} \quad \cdots\cdots\cdots(11)$$

● Rolled Ball Screw

(excluding large lead type)

$$N_2 = \frac{50000}{D} \quad \cdots\cdots\cdots(12)$$

● Large-Lead Rolled Ball Screw

$$N_2 = \frac{70000}{D} \quad \cdots\cdots\cdots(13)$$

Of the permissible rotational speed determined by dangerous speed (N_1) and the permissible rotational speed determined by DN value (N_2), the lower rotational speed is regarded as the permissible rotational speed.

If the working rotational speed exceeds N_2, a high-speed type Ball Screw is available. Contact THK for details.

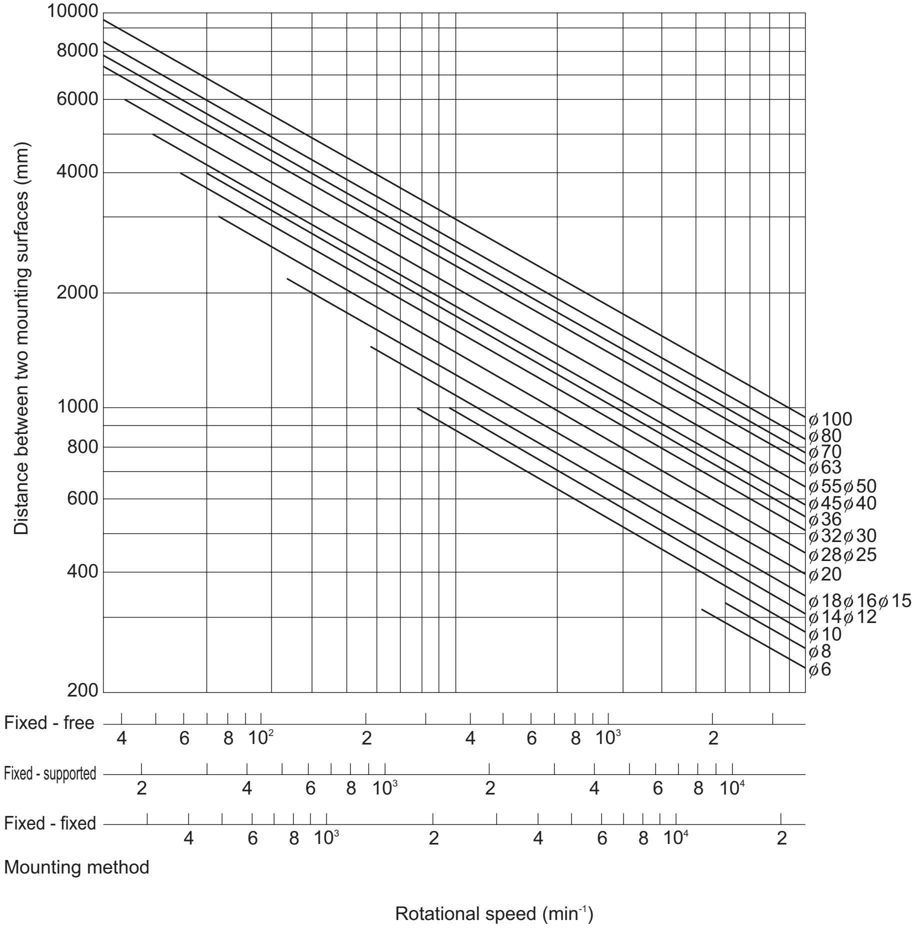


Fig.9 Permissible Rotational Speed Diagram

Selecting a Nut

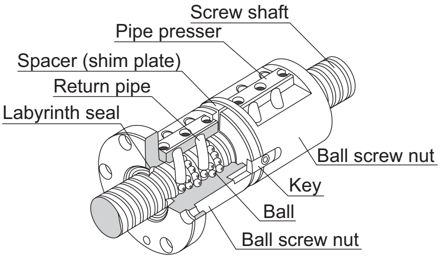
Types of Nuts

The nuts of the Ball Screws are categorized by the ball circulation method into the return-pipe type, the deflector type and end the cap type. These three nut types are described as follows.
In addition to the circulation methods, the Ball Screws are categorized also by the preloading method.

[Types by Ball Circulation Method]

● Return-pipe Type (Models SBN, BNF, BNT, BNFN, BIF and BTK) Return-piece Type (Model HBN)

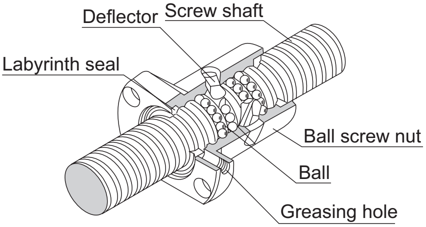
These are most common types of nuts that use a return pipe for ball circulation. The return pipe allows balls to be picked up, pass through the pipe, and return to their original positions to complete infinite motion.



Example of Structure of Return-Pipe Nut

● Deflector Type (Models DK, DKN, DIK, JPF and DIR)

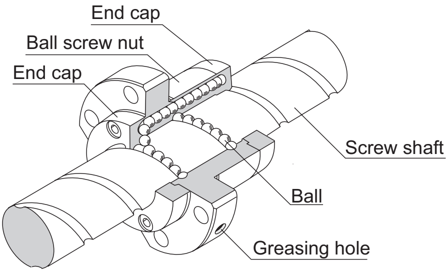
These are the most compact type of nut. The balls change their traveling direction with a deflector, pass over the circumference of the screw shaft, and return to their original positions to complete an infinite motion.



Example of Structure of Simple Nut

● End-cap Type: Large lead Nut (Models SBK, BLK, WGF, BLW, WTF, CNF and BLR)

These nuts are most suitable for the fast feed. The balls are picked up with an end cap, pass through the through hole of the nut, and return to their original positions to complete an infinite motion.



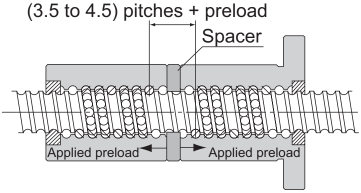
Example of Structure of Large lead Nut

[Types by Preloading Method]

● Fixed-point Preloading

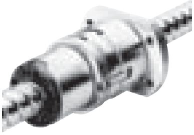
■Double-nut Preload (Models BNFN, DKN and BLW)

A spacer is inserted between two nuts to provide a preload.



Model BNFN

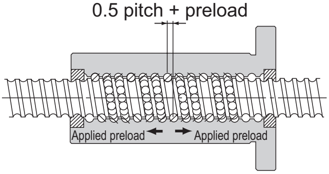
Model DKN

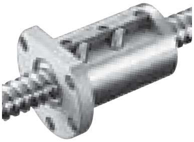


Model BLW

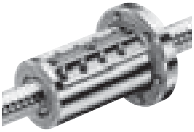
■Offset Preload (Models SBN, BIF, DIK, SBK and DIR)

More compact than the double-nut method, the offset preloading provides a preload by changing the groove pitch of the nut without using a spacer.



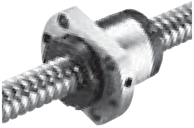


Model SBN

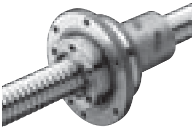


Model BIF

Model DIK



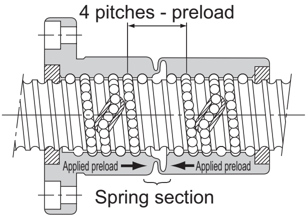
Model SBK



Model DIR

● Constant Pressure Preloading (Model JPF)

With this method, a spring structure is installed almost in the middle of the nut, and it provides a preload by changing the groove pitch in the middle of the nut.



Model JPF

Selecting a Model Number

Calculating the Axial Load

[In Horizontal Mount]

With ordinary conveyance systems, the axial load (Fa_n) applied when horizontally reciprocating the work is obtained in the equation below.

$$Fa_1 = \mu \cdot mg + f + m\alpha \quad \cdots\cdots\cdots\cdots (14)$$

$$Fa_2 = \mu \cdot mg + f \quad \cdots\cdots\cdots\cdots (15)$$

$$Fa_3 = \mu \cdot mg + f - m\alpha \quad \cdots\cdots\cdots\cdots (16)$$

$$Fa_4 = -\mu \cdot mg - f - m\alpha \quad \cdots\cdots\cdots\cdots (17)$$

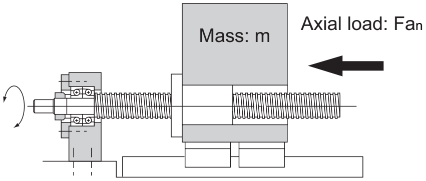
$$Fa_5 = -\mu \cdot mg - f \quad \cdots\cdots\cdots\cdots (18)$$

$$Fa_6 = -\mu \cdot mg - f + m\alpha \quad \cdots\cdots\cdots\cdots (19)$$

V_{max} : Maximum speed (m/s)
t_1 : Acceleration time (m/s)

$\alpha = \frac{V_{max}}{t_1}$: Acceleration (m/s^2)

Fa_1 : Axial load during forward acceleration (N)
Fa_2 : Axial load during forward uniform motion (N)
Fa_3 : Axial load during forward deceleration (N)
Fa_4 : Axial load during backward acceleration (N)
Fa_5 : Axial load during uniform backward motion (N)



Fa_6 : Axial load during backward deceleration (N)
m : Transferred mass (kg)
μ : Frictional coefficient of the guide surface (–)
f : Guide surface resistance (without load) (N)

[In Vertical Mount]

With ordinary conveyance systems, the axial load (Fa_n) applied when vertically reciprocating the work is obtained in the equation below.

$$Fa_1 = mg + f + m\alpha \quad \cdots\cdots\cdots\cdots (20)$$

$$Fa_2 = mg + f \quad \cdots\cdots\cdots\cdots (21)$$

$$Fa_3 = mg + f - m\alpha \quad \cdots\cdots\cdots\cdots (22)$$

$$Fa_4 = mg - f - m\alpha \quad \cdots\cdots\cdots\cdots (23)$$

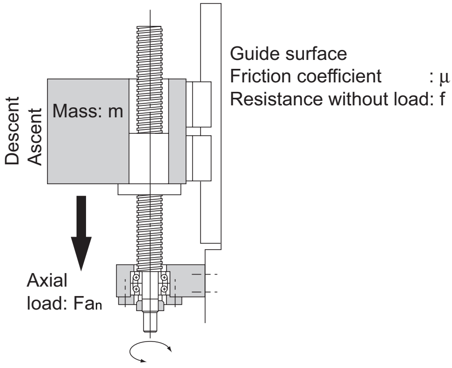
$$Fa_5 = mg - f \quad \cdots\cdots\cdots\cdots (24)$$

$$Fa_6 = mg - f + m\alpha \quad \cdots\cdots\cdots\cdots (25)$$

V_{max} : Maximum speed (m/s)
t_1 : Acceleration time (m/s)

$\alpha = \frac{V_{max}}{t_1}$: Acceleration (m/s^2)

Fa_1 : Axial load during upward acceleration (N)
Fa_2 : Axial load during uniform upward motion (N)
Fa_3 : Axial load during upward deceleration (N)
Fa_4 : Axial load during downward acceleration (N)
Fa_5 : Axial load during uniform downward motion (N)



Fa_6 : Axial load during downward deceleration (N)
m : Transferred mass (kg)
f : Guide surface resistance (without load) (N)

Static Safety Factor

The basic static load rating (C_0a) generally equals to the permissible axial load of a Ball Screw. Depending on the conditions, it is necessary to take into account the following static safety factor against the calculated load. When the Ball Screw is stationary or in motion, unexpected external force may be applied through an inertia caused by the impact or the start and stop.

$$Fa_{max} = \frac{C_0a}{f_S} \quad \cdots\cdots\cdots(26)$$

Fa_{max}	: Permissible Axial Load	(kN)
C_0a	: Basic static load rating*	(kN)
f_S	: Static safety factor	(see Table18)

Table18 Static Safety Factor (f_S)

Machine using the LM system	Load conditions	Lower limit of f_S
General industrial machinery	Without vibration or impact	1 to 1.3
	With vibration or impact	2 to 3
Machine tool	Without vibration or impact	1 to 1.5
	With vibration or impact	2.5 to 7

The basic static load rating (C_0a) is a static load with a constant direction and magnitude whereby the sum of the permanent deformation of the rolling element and that of the raceway on the contact area under the maximum stress is 0.0001 times the rolling element diameter. With the Ball Screw, it is defined as the axial load. (Specific values of each Ball Screw model are indicated in the specification tables for the corresponding model number.)

Studying the Service Life

[Service Life of the Ball Screw]

The Ball Screw in motion under an external load receives the continuous stress on its raceways and balls. When the stress reaches the limit, the raceways break from the fatigue and their surfaces partially disintegrate in scale-like pieces. This phenomenon is called flaking. The service life of the Ball Screw is the total number of revolutions until the first flaking occurs on any of the raceways or the balls as a result of the rolling fatigue of the material.

The service life of the Ball Screw varies from unit to unit even if they are manufactured in the same process and used in the same operating conditions. For this reason, when determining the service life of a Ball Screw unit, the nominal life as defined below is used as a guideline.

The nominal life is the total number of revolutions that 90% of identical Ball Screw units in a group achieve without developing flaking (scale-like pieces of a metal surface) after they independently operate in the same conditions.

[Calculating the Rated Life]

The service life of the Ball Screw is calculated from the equation (27) below using the basic dynamic load rating (Ca) and the applied axial load.

● Nominal Life (Total Number of Revolutions)

$$L = \left(\frac{C_a}{f_W \cdot F_a}\right)^3 \times 10^6 \quad \cdots\cdots\cdots(27)$$

L : Nominal life (total number of revolutions) (rev)
Ca : Basic dynamic load rating* (N)
Fa : Applied axial load (N)
f_W : Load factor (see Table19)

Table19 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

* The basic dynamic load rating (Ca) is used in calculating the service life when a Ball Screw operates under a load. The basic dynamic load rating is a load with interlocked direction and magnitude under which the nominal life (L) equals to 10^6rev. when a group of the same Ball Screw units independently operate. (Specific basic dynamic load ratings (Ca) are indicated in the specification tables of the corresponding model numbers.)

● Service Life Time

If the revolutions per minute is determined, the service life time can be calculated from the equation (28) below using the nominal life (L).

$$L_h = \frac{L}{60 \times N} = \frac{L \times Ph}{2 \times 60 \times n \times \ell_s} \quad \cdots\cdots\cdots(28)$$

L_h	: Service life time	(h)
N	: Revolutions per minute	(min^{-1})
n	: Number of reciprocations per minute	(min^{-1})
Ph	: Ball Screw lead	(mm)
ℓ_s	: Stroke length	(mm)

● Service Life in Travel Distance

The service life in travel distance can be calculated from the equation (29) below using the nominal life (L) and the Ball Screw lead.

$$L_s = \frac{L \times Ph}{10^6} \quad \cdots\cdots\cdots(29)$$

L_s	: Service Life in Travel Distance	(km)
Ph	: Ball Screw lead	(mm)

● Applied Load and Service Life with a Preload Taken into Account

If the Ball Screw is used under a preload (medium preload), it is necessary to consider the applied preload in calculating the service life since the ball screw nut already receives an internal load. For details on applied preload for a specific model number, contact THK.

● Average Axial Load

If an axial load acting on the Ball Screw is present, it is necessary to calculate the service life by determining the average axial load.

The average axial load (F_m) is a constant load that equals to the service life in fluctuating the load conditions.

If the load changes in steps, the average axial load can be obtained from the equation below.

$$F_m = \sqrt[3]{\frac{1}{\ell}\left(Fa_1^{\,3}\ell_1 + Fa_2^{\,3}\ell_2 + \cdot\cdot\cdot\cdot + Fa_n^{\,3}\ell_n\right)} \quad \cdots\cdots\cdots(30)$$

F_m	: Average Axial Load	(N)
Fa_n	: Varying load	(N)
ℓ_n	: Distance traveled under load (F_n)	
ℓ	: Total travel distance	

To determine the average axial load using a rotational speed and time, instead of a distance, calculate the average axial load by determining the distance in the equation below.

$\ell = \ell_1 + \ell_2 + \cdots \ell_n$

$\ell_1 = N_1 \cdot t_1$

$\ell_2 = N_2 \cdot t_2$

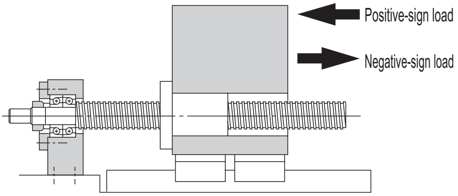
$\ell_n = N_n \cdot t_n$

N: Rotational speed

t: Time

■When the Applied Load Sign Changes

When all signs for fluctuating loads are the same, the equation (30) applies without problem. However, if the sign for the fluctuating load changes according to the operation, it is necessary to calculate both the average axial load of the positive-sign load and that of the negative-sign load while taking in to account the load direction (when calculating the average axial load of the positive-sign load, assume the negative-sign load to be zero). Of the two average axial loads, the greater value is regarded as the average axial load for calculating the service life.



Example: Calculate the average axial load with the following load conditions.

Operation No.	Varying load Fa_n(N)	Travel distance ℓ_n(mm)
No.1	10	10
No.2	50	50
No.3	−40	10
No.4	−10	70

The subscripts of the fluctuating load symbol and the travel distance symbol indicate operation numbers.

- Average axial load of positive-sign load

To calculate the average axial load of the positive-sign load, assume Fa_3 and Fa_4 to be zero.

$$F_{m1} = \sqrt[3]{\frac{Fa_1^3 \times \ell_1 + Fa_2^3 \times \ell_2}{\ell_1 + \ell_2 + \ell_3 + \ell_4}} = 35.5\text{N}$$

- Average axial load of negative-sign load

To calculate the average axial load of the negative-sign load, assume Fa_1 and Fa_2 to be zero.

$$F_{m2} = \sqrt[3]{\frac{|Fa_3|^3 \times \ell_3 + |Fa_4|^3 \times \ell_4}{\ell_1 + \ell_2 + \ell_3 + \ell_4}} = 17.2\text{N}$$

Accordingly, the average axial load of the positive-sign load (F_{m1}) is adopted as the average axial load (F_m) for calculating the service life.

Studying the Rigidity

To increase the positioning accuracy of feed screws in NC machine tools or the precision machines, or to reduce the displacement caused by the cutting force, it is necessary to design the rigidity of the components in a well-balanced manner.

Axial Rigidity of the Feed Screw System

When the axial rigidity of a feed screw system is K, the elastic displacement in the axial direction can be obtained using the equation (31) below.

$$\delta = \frac{Fa}{K} \quad \cdots\cdots\cdots(31)$$

δ : Elastic displacement of a feed screw system in the axial direction (μm)
Fa : Applied axial load (N)

The axial rigidity (K) of the feed screw system is obtained using the equation (32) below.

$$\frac{1}{K} = \frac{1}{K_S} + \frac{1}{K_N} + \frac{1}{K_B} + \frac{1}{K_H} \quad \cdots\cdots\cdots(32)$$

K : Axial Rigidity of the Feed Screw System (N/μm)
K_S : Axial rigidity of the screw shaft (N/μm)
K_N : Axial rigidity of the nut (N/μm)
K_B : Axial rigidity of the support bearing(N/μm)
K_H : Rigidity of the nut bracket and the support bearing bracket (N/μm)

[Axial rigidity of the screw shaft]
The axial rigidity of a screw shaft varies depending on the method for mounting the shaft.

- **For Fixed-Supported (or -Free) Configuration**

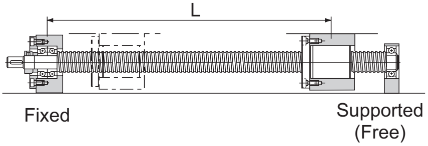
$$K_S = \frac{A \cdot E}{1000 \cdot L} \quad \cdots\cdots\cdots(33)$$

A : Screw shaft cross-sectional area (mm^2)

$$A = \frac{\pi}{4} d_1^2$$

d_1 : Screw-shaft thread minor diameter (mm)
E : Young's modulus (2.06×10^5 N/mm^2)
L : Distance between two mounting surfaces (mm)

Fig.10 onA-708 shows an axial rigidity diagram for the screw shaft.



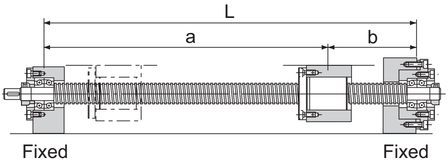
For Fixed-Fixed Configuration

$$K_s = \frac{A \cdot E \cdot L}{1000 \cdot a \cdot b} \quad \cdots\cdots\cdots(34)$$

K_s becomes the lowest and the elastic displacement in the axial direction is the greatest at the position of $a = b = \frac{L}{2}$.

$$K_s = \frac{4A \cdot E}{1000L}$$

Fig.11 on A-709 shows an axial rigidity diagram of the screw shaft in this configuration.



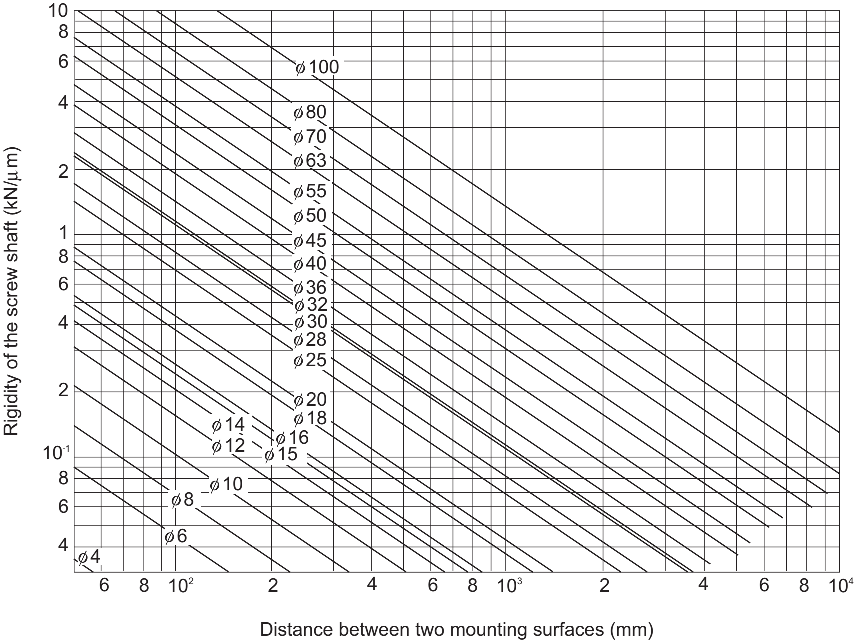


Fig.10 Axial Rigidity of the Screw Shaft (Fixed-Free, Fixed-Supported)

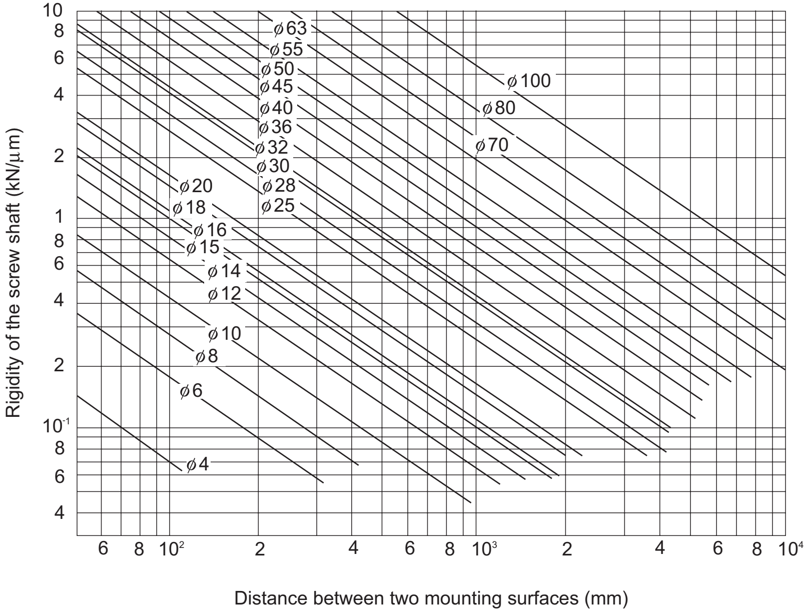


Fig.11 Axial Rigidity of the Screw Shaft (Fixed-Fixed)

[Axial rigidity of the nut]

The axial rigidity of the nut varies widely with preloads.

● No Preload Type

The logical rigidity in the axial direction when an axial load accounting for 30% of the basic dynamic load rating (Ca) is applied is indicated in the specification tables of the corresponding model number. This value does not include the rigidity of the components related to the nut-mounting bracket. In general, set the rigidity at roughly 80% of the value in the table.

The rigidity when the applied axial load is not 30% of the basic dynamic load rating (Ca) is calculated using the equation (35) below.

$$K_N = K\left(\frac{Fa}{0.3Ca}\right)^{\frac{1}{3}} \times 0.8 \quad \cdots\cdots\cdots (35)$$

K_N : Axial rigidity of the nut (N/µm)
K : Rigidity value in the specification tables (N/µm)
Fa : Applied axial load (N)
Ca : Basic dynamic load rating (N)

● Preload Type

The logical rigidity in the axial direction when an axial load accounting for 10% of the basic dynamic load rating (Ca) is applied is indicated in the dimensional table of the corresponding model number. This value does not include the rigidity of the components related to the nut-mounting bracket. In general, generally set the rigidity at roughly 80% of the value in the table.

The rigidity when the applied preload is not 10% of the basic dynamic load rating (Ca) is calculated using the equation (36) below.

$$K_N = K\left(\frac{Fa_0}{0.1Ca}\right)^{\frac{1}{3}} \times 0.8 \quad \cdots\cdots\cdots(36)$$

K_N : Axial rigidity of the nut (N/μm)
K : Rigidity value in the specification tables (N/μm)
Fa_0 : Applied preload (N)
Ca : Basic dynamic load rating (N)

[Axial rigidity of the support bearing]

The rigidity of the Ball Screw support bearing varies depending on the support bearing used.

The calculation of the rigidity with a representative angular ball bearing is shown in the equation (37) below.

$$K_B \fallingdotseq \frac{3Fa_0}{\delta a_0} \quad \cdots\cdots\cdots(37)$$

K_B : Axial rigidity of the support bearing (N/μm)
Fa_0 : Applied preload of the support bearing (N)
δa_0 : Axial displacements (μm)

$$\delta a_0 = \frac{0.45}{\sin\alpha}\left(\frac{Q^2}{Da}\right)^{\frac{1}{3}}$$

$$Q = \frac{Fa_0}{Z\sin\alpha}$$

Q : Axial load (N)
Da : Ball diameter of the support bearing (mm)
α : Initial contact angle of the support bearing (°)
Z : Number of balls

For details of a specific support bearing, contact its manufacturer.

[Axial Rigidity of the Nut Bracket and the Support Bearing Bracket]

Take this factor into consideration when designing your machine. Set the rigidity as high as possible.

Studying the Positioning Accuracy

Causes of Error in the Positioning Accuracy

The causes of error in the positioning accuracy include the lead angle accuracy, the axial clearance and the axial rigidity of the feed screw system. Other important factors include the thermal displacement from heat and the orientation change of the guide system during traveling.

Studying the Lead Angle Accuracy

It is necessary to select the correct accuracy grade of the Ball Screw that satisfies the required positioning accuracy from the Ball Screw accuracies (Table1 on A-678). Table20 on A-712 shows examples of selecting the accuracy grades by the application.

Studying the Axial Clearance

The axial clearance is not a factor of positioning accuracy in single-directional feed. However, it will cause a backlash when the feed direction is inversed or the axial load is inversed. Select an axial clearance that meets the required backlash from Table10 and Table12 on A-685.

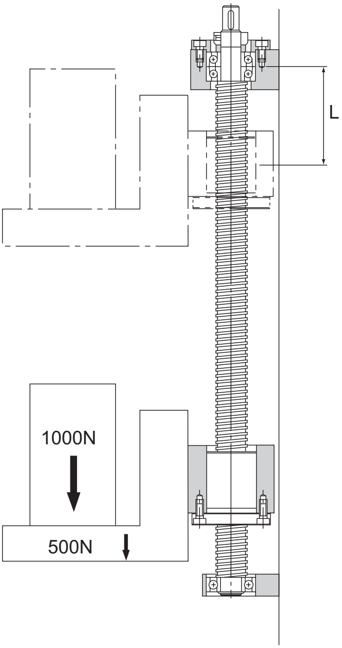
Table20 Examples of Selecting Accuracy Grades by Application

Applications		Shaft	Accuracy grades							
			C0	C1	C2	C3	C5	C7	C8	C10
NC machine tools	Lathe	X		●	●	●	●			
		Z				●	●			
	Machining center	XY			●	●	●			
		Z			●	●	●			
	Drilling machine	XY				●	●			
		Z					●	●		
	Jig borer	XY	●	●						
		Z	●	●						
	Surface grinder	X				●	●			
		Y		●	●	●	●			
		Z		●	●	●	●			
	Cylindrical grinder	X	●	●	●					
		Z		●	●	●				
	Electric discharge machine	XY	●	●	●					
		Z		●	●	●	●			
	Electric discharge machine Wire cutting machine	XY	●	●	●					
		Z	●	●	●	●				
		UV		●	●	●				
	Punching press	XY				●	●	●		
	Laser beam machine	X				●	●	●		
		Z				●	●	●		
	Woodworking machine						●	●	●	●
General-purpose machine; dedicated machine						●	●	●	●	●
Industrial robot	Cartesian coordinate	Assembly				●	●	●	●	
		Other					●	●	●	●
	Vertical articulated type	Assembly					●	●	●	
		Other						●	●	
	Cylindrical coordinate					●	●	●		
Semiconductor manufacturing machine	Photolithography machine		●	●						
	Chemical treatment machine				●	●	●	●	●	●
	Wire bonding machine			●	●					
	Prober		●	●	●	●				
	Printed circuit board drilling machine			●	●	●	●	●		
	Electronic component inserter				●	●	●	●		
3D measuring instrument			●	●	●					
Image processing machine			●	●	●					
Injection molding machine								●	●	●
Office equipment							●	●	●	●

Studying the Axial Clearance of the Feed Screw System

Of the axial rigidities of the feed screw system, the axial rigidity of the screw shaft fluctuates according to the stroke position. When the axial rigidity is large, such change in the axial rigidity of the screw shaft will affect the positioning accuracy. Therefore, it is necessary to take into account the rigidity of the feed screw system (A-707 to A-710).

Example: Positioning error due to the axial rigidity of the feed screw system during a vertical transfer



[Conditions]
Transferred weight: 1,000 N; table weight: 500 N
Ball Screw used: model BNF2512–2.5 (screw-shaft thread minor diameter d_1 = 21.9 mm)
Stroke length: 600 mm (L=100 mm to 700 mm)
Screw shaft mounting type: fixed-supported

[Consideration]

The difference in axial rigidity between L = 100 mm and L = 700 mm applied only to the axial rigidity of the screw shaft.
Therefore, positioning error due to the axial rigidity of the feed screw system equals to the difference in the axial displacement of the screw shaft between L = 100 mm and L = 700 mm.

[Axial Rigidity of the Screw Shaft (see A-707 and A-708)]

$$K_S = \frac{A \cdot E}{1000L} = \frac{376.5 \times 2.06 \times 10^5}{1000 \times L} = \frac{77.6 \times 10^3}{L}$$

$$A = \frac{\pi}{4} d_1^2 = \frac{\pi}{4} \times 21.9^2 = 376.5\text{mm}^2$$

$$E = 2.06 \times 10^5 \text{ N/mm}^2$$

(1) When L = 100 mm

$$K_{S1} = \frac{77.6 \times 10^3}{100} = 776 \text{ N}/\mu\text{m}$$

(2) When L = 700mm

$$K_{S2} = \frac{77.6 \times 10^3}{700} = 111 \text{ N}/\mu\text{m}$$

[Axial Displacement due to Axial Rigidity of the Screw Shaft]

(1) When L = 100 mm

$$\delta_1 = \frac{Fa}{K_{S1}} = \frac{1000+500}{776} = 1.9\mu\text{m}$$

(2) When L = 700mm

$$\delta_2 = \frac{Fa}{K_{S2}} = \frac{1000+500}{111} = 13.5\mu\text{m}$$

[Positioning Error due to Axial Rigidity of the Feed Screw System]

Positioning accuracy=$\delta_1 - \delta_2$=1.9−13.5

=−11.6μm

Therefore, the positioning error due to the axial rigidity of the feed screw system is 11.6 μm.

Studying the Thermal Displacement through Heat Generation

If the temperature of the screw shaft increases during operation, the screw shaft is elongated due to heat thereby to lowering the positioning accuracy. The expansion and contraction of the screw shaft is calculated using the equation (38) below.

$$\Delta\ell = \rho \times \Delta t \times \ell \quad \cdots\cdots\cdots(38)$$

$\Delta\ell$	: Axial expansion/contraction of the screw shaft	(mm)
ρ	: Thermal expansion coefficient	(12×10^{-6}/℃)
Δt	: Temperature change in the screw shaft	(℃)
ℓ	: Effective thread length	(mm)

Thus, if the temperature of the screw shaft increases by 1℃, the screw shaft is elongated by 12 μm per meter. Therefore, as the Ball Screw travels faster, the more heat is generated. So, as the temperature increases, the positioning accuracy lowers. Accordingly, if high accuracy is required, it is necessary to take measures to cope with the temperature increase.

[Measures to Cope with the Temperature Rise]

● Minimize the Heat Generation

- Minimize the preloads on the Ball Screw and the support bearing.
- Increase the Ball Screw lead and reduce the rotational speed.
- Select a correct lubricant. (See Accessories for Lubrication on A-954.)
- Cool the circumference of the screw shaft with a lubricant or air.

● Avoid Effect of Temperature Rise through Heat Generation

- Set a negative target value for the reference travel distance of the Ball Screw.
  Generally, set a negative target value for the reference travel distance assuming a temperature increase of 2℃ to 5℃ by heat.
  (–0.02mm to –0.06 mm/m)
- Preload the shaft screw with tension. (See Fig.3 of the structure on A-825.)

Studying the Orientation Change during Traveling

The lead angle accuracy of the Ball Screw equals the positioning accuracy of the shaft center of the Ball Screw. Normally, the point where the highest positioning accuracy is required changes according to the ball screw center and the vertical or horizontal direction. Therefore, the orientation change during traveling affects the positioning accuracy.

The largest factor of orientation change affecting the positioning accuracy is pitching if the change occurs in the ball screw center and the vertical direction, and yawing if the change occurs in the horizontal direction.

Accordingly, it is necessary to study the orientation change (accuracy in pitching, yawing, etc.) during the traveling on the basis of the distance from the ball screw center to the location where positioning accuracy is required.

Positioning error due to pitching and yawing is obtained using the equation (39) below.

$$A = \ell \times \sin\theta \quad \cdots\cdots\cdots(39)$$

A: Positioning accuracy due to pitching (or yawing)	(mm)
ℓ : Vertical (or horizontal) distance from the ball screw center	(mm) (see Fig.12)
θ : Pitching (or yawing)	(°)

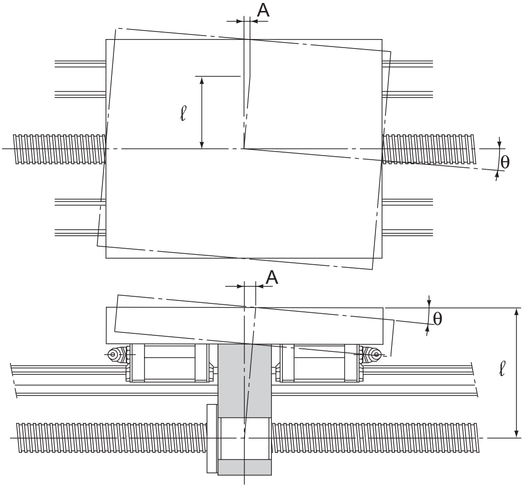


Fig.12

Studying the Rotational Torque

The rotational torque required to convert rotational motion of the Ball Screw into straight motion is obtained using the equation (40) below.

[During Uniform Motion]

$$T_t = T_1 + T_2 + T_4 \quad \cdots\cdots\cdots(40)$$

T_t : Rotational torque required during uniform motion (N-mm)
T_1 : Frictional torque due to an external load (N-mm)
T_2 : Preload torque of the Ball Screw (N-mm)
T_4 : Other torque (N-mm)
(frictional torque of the support bearing and oil seal)

[During Acceleration]

$$T_K = T_t + T_3 \quad \cdots\cdots\cdots(41)$$

T_K : Rotational torque required during acceleration (N-mm)
T_3 : Torque required for acceleration (N-mm)

[During Deceleration]

$$T_g = T_t - T_3 \quad \cdots\cdots\cdots(42)$$

T_g : Rotational torque required for deceleration (N-mm)

Frictional Torque Due to an External Load

Of the turning forces required for the Ball Screw, the rotational torque needed for an external load (guide surface resistance or external force) is obtained using the equation (43) below

$$T_1 = \frac{Fa \cdot Ph}{2\pi \cdot \eta} \cdot A \quad \cdots\cdots\cdots(43)$$

T_1 : Frictional torque due to an external load (N-mm)
Fa : Applied axial load (N)
Ph : Ball Screw lead (mm)
η : Ball Screw efficiency (0.9 to 0.95)
A : Reduction ratio

Torque Due to a Preload on the Ball Screw

For a preload on the Ball Screw, see "Preload Torque" on A-688.

$$T_2 = T_d \cdot A \quad \cdots\cdots\cdots(44)$$

T_2 : Preload torque of the Ball Screw (N-mm)
T_d : Preload torque of the Ball Screw (N-mm)
A : Reduction ratio

Torque Required for Acceleration

$$T_3 = J \times \omega' \times 10^3 \quad \cdots\cdots\cdots(45)$$

T_3 : Torque required for acceleration (N-mm)
J : Inertial moment $(kg \cdot m^2)$
ω' : Angular acceleration (rad/s^2)

$$J = m\left(\frac{Ph}{2\pi}\right)^2 \cdot A^2 \cdot 10^{-6} + J_S \cdot A^2 + J_A \cdot A^2 + J_B$$

m : Transferred mass (kg)
Ph : Ball Screw lead (mm)
J_S : Inertial moment of the screw shaft $(kg \cdot m^2)$
(indicated in the specification tables of the respective model number)
A : Reduction ratio
J_A : Inertial moment of gears, etc. attached to the screw shaft side $(kg \cdot m^2)$
J_B : Inertial moment of gears, etc. attached to the motor side d $(kg \cdot m^2)$

$$\omega' = \frac{2\pi \cdot Nm}{60t}$$

Nm : Motor revolutions per minute (min^{-1})
t : Acceleration time (s)

[Ref.] Inertial moment of a round object

$$J = \frac{m \cdot D^2}{8 \cdot 10^6}$$

J : Inertial moment $(kg \cdot m^2)$
m : Mass of a round object (kg)
D : Screw shaft outer diameter (mm)

Studying the Driving Motor

When selecting a driving motor required to rotate the Ball Screw, normally take into account the rotational speed, rotational torque and minimum feed amount.

When Using a Servomotor

[Rotational Speed]

The rotational speed required for the motor is obtained using the equation (46) based on the feed speed, Ball Screw lead and reduction ratio.

$$N_M = \frac{V \times 1000 \times 60}{Ph} \times \frac{1}{A} \quad \cdots\cdots\cdots(46)$$

N_M : Required rotational speed of the motor (min^{-1})
V : Feeding speed (m/s)
Ph : Ball Screw lead (mm)
A : Reduction ratio

The rated rotational speed of the motor must be equal to or above the calculated value (N_M) above.

$N_M \leqq N_R$

N_R : The rated rotational speed of the motor (min^{-1})

[Required Resolution]

Resolutions required for the encoder and the driver are obtained using the equation (47) based on the minimum feed amount, Ball Screw lead and reduction ratio.

$$B = \frac{Ph \cdot A}{S} \quad \cdots\cdots\cdots(47)$$

B : Resolution required for the encoder and the driver (p/rev)
Ph : Ball Screw lead (mm)
A : Reduction ratio
S : Minimum feed amount (mm)

[Motor Torque]

The torque required for the motor differs between uniform motion, acceleration and deceleration. To calculate the rotational torque, see "Studying the Rotational Torque" on A-717.

a. Maximum torque

The maximum torque required for the motor must be equal to or below the maximum peak torque of the motor.

$T_{max} \leqq Tp_{max}$

T_{max} : Maximum torque acting on the motor

Tp_{max} : Maximum peak torque of the motor

b. Effective torque value

The effective value of the torque required for the motor must be calculated. The effective value of the torque is obtained using the equation (48) below.

$$T_{rms} = \sqrt{\frac{T_1^2 \times t_1 + T_2^2 \times t_2 + T_3^2 \times t_3}{t}} \quad \cdots\cdots\cdots (48)$$

T_{rms}	: Effective torque value	(N-mm)
T_n	: Fluctuating torque	(N-mm)
t_n	: Time during which the torque T_n is applied	(s)
t	: Cycle time ($t=t_1+t_2+t_3$)	(s)

The calculated effective value of the torque must be equal to or below the rated torque of the motor.

$T_{rms} \leqq T_R$

T_R : Rated torque of the motor (N-mm)

[Inertial Moment]

The inertial moment required for the motor is obtained using the equation (49) below.

$$J_M = \frac{J}{C} \quad \cdots\cdots\cdots (49)$$

J_M : Inertial moment required for the motor (kg•m^2)

C : Factor determined by the motor and the driver

(It is normally between 3 to 10. However, it varies depending on the motor and the driver. Check the specific value in the catalog by the motor manufacturer.)

The inertial moment of the motor must be equal to or above the calculated J_M value.

When Using a Stepping Motor (Pulse Motor)

[Minimal Feed Amount(per Step)]

The step angle required for the motor and the driver is obtained using the equation (50) below based on the minimum feed amount, the Ball Screw lead and the reduction ratio.

$$E = \frac{360S}{Ph \cdot A} \quad \cdots\cdots\cdots (50)$$

E	: Step angle required for the motor and the driver (°)	
S	: Minimum feed amount (per step)	(mm)
Ph	: Ball Screw lead	(mm)
A	: Reduction ratio	

[Pulse Speed and Motor Torque]

a. Pulse speed

The pulse speed is obtained using the equation (51) below based on the feed speed and the minimum feed amount.

$$f = \frac{V \times 1000}{S} \quad \cdots\cdots\cdots (51)$$

f	: Pulse speed	(Hz)
V	: Feeding speed	(m/s)
S	: Minimum feed amount	(mm)

b. Torque required for the motor

The torque required for the motor differs between the uniform motion, the acceleration and the deceleration. To calculate the rotational torque, see "Studying the Rotational Torque" on A-717.

Thus, the pulse speed required for the motor and the required torque can be calculated in the manner described above.

Although the torque varies depending on the motors, normally the calculated torque should be doubled to ensure safety. Check if the torque can be used in the motor's speed-torque curve.

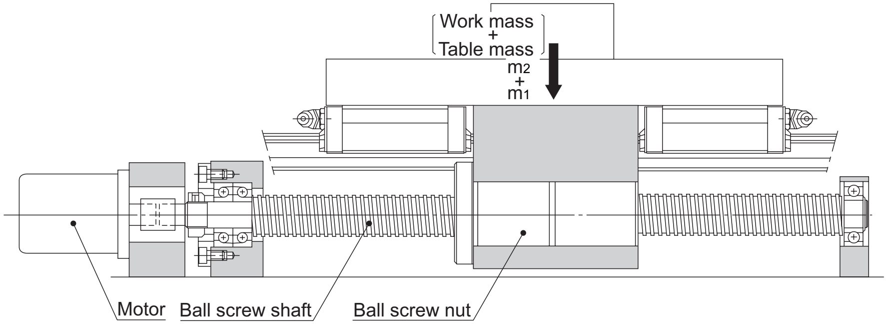
Examples of Selecting a Ball Screw

High-speed Transfer Equipment (Horizontal Use)

[Selection Conditions]

Table Mass	m_1 =60kg
Work Mass	m_2 =20kg
Stroke length	ℓ_S=1000mm
Maximum speed	V_{max}=1m/s
Acceleration time	t_1 = 0.15s
Deceleration time	t_3 = 0.15s
Number of reciprocations per minute	n =8min^{-1}
Backlash	0.15mm
Positioning accuracy	±0.3 mm/1000 mm (Perform positioning from the negative direction)

Positioning Repeatability	±0.1 mm
Minimum feed amount	s = 0.02mm/pulse
Desired service life time	30000h
Driving motor	AC servo motor Rated rotational speed: 3,000 min^{-1}
Inertial moment of the motor	J_m =1×10^{-3} kg•m^2
Reduction gear	None (direct coupling) A=1
Frictional coefficient of the guide surface	μ =0.003 (rolling)
Guide surface resistance	f=15 N (without load)



[Selection Items]

Screw shaft diameter
Lead
Nut model No.
Accuracy
Axial clearance
Screw shaft support method
Driving motor

[Selecting Lead Angle Accuracy and Axial Clearance]

● Selecting Lead Angle Accuracy

To achieve positioning accuracy of ±0.3 mm/1,000 mm:

$$\frac{\pm 0.3}{1000}=\frac{\pm 0.09}{300}$$

The lead angle accuracy must be ±0.09 mm/300 mm or higher.

Therefore, select the following as the accuracy grade of the Ball Screw (see Table1 on A-678).

C7 (travel distance error: ±0.05mm/300mm)

Accuracy grade C7 is available for both the Rolled and the Precision Ball Screws. Assume that a Rolled Ball Screw is selected here because it is less costly.

● Selecting Axial Clearance

To satisfy the backlash of 0.15 mm, it is necessary to select a Ball Screw with an axial clearance of 0.15 mm or less.

Therefore, a Rolled Ball Screw model with a screw shaft diameter of 32 mm or less that meets the axial clearance of 0.15 mm or less (see Table12 on A-685) meets the requirements.

Thus, a Rolled Ball Screw model with a screw shaft diameter of 32 mm or less and an accuracy grade of C7 is selected.

[Selecting a Screw Shaft]

● Assuming the Screw Shaft Length

Assume the overall nut length to be 100 mm and the screw shaft end length to be 100 mm.

Therefore, the overall length is determined as follows based on the stroke length of 1,000 mm.

1000 + 200 = 1200 mm

Thus, the screw shaft length is assumed to be 1,200 mm.

● Selecting a Lead

With the driving motor's rated rotational speed being 3,000 min^{-1} and the maximum speed 1 m/s, the Ball Screw lead is obtained as follows:

$$\frac{1\times1000\times60}{3000}=20\ \text{mm}$$

Therefore, it is necessary to select a type with a lead of 20 mm or longer.

In addition, the Ball Screw and the motor can be mounted in direct coupling without using a reduction gear. The minimum resolution per revolution of an AC servomotor is obtained based on the resolution of the encoder (1,000 p/rev; 1,500 p/rev) provided as a standard accessory for the AC servomotor, as indicated below.

1000 p/rev(without multiplication)
1500 p/rev(without multiplication)
2000 p/rev(doubled)
3000 p/rev(doubled)
4000 p/rev(quadrupled)
6000 p/rev(quadrupled)

To meet the minimum feed amount of 0.02 mm/pulse, which is the selection requirement, the following should apply.

Lead 20mm —— 1000 p/rev
30mm —— 1500 p/rev
40mm —— 2000 p/rev
60mm —— 3000 p/rev
80mm —— 4000 p/rev

● Selecting a Screw Shaft Diameter

Those Ball Screw models that meet the requirements defined in Section [Selecting Lead Angle Accuracy and Axial Clearance] on A-723: a rolled Ball Screw with a screw shaft diameter of 32 mm or less; and the requirement defined in Section [Selecting a Screw Shaft] on A-723: a lead of 20, 30, 40, 60 or 80 mm (see Table17 on A-693) are as follows.

Shaft diameter	Lead
15mm ——	20mm
15mm ——	30mm
20mm ——	20mm
20mm ——	40mm
30mm ——	60mm

Since the screw shaft length has to be 1,200 mm as indicated in Section [Selecting a Screw Shaft] on A-723, the shaft diameter of 15 mm is insufficient. Therefore, the Ball Screw should have a screw shaft diameter of 20 mm or greater.

Accordingly, there are three combinations of screw shaft diameters and leads that meet the requirements: screw shaft diameter of 20 mm/lead of 20 mm; 20 mm/40 mm; and 30 mm/60 mm.

● Selecting a Screw Shaft Support Method

Since the assumed type has a long stroke length of 1,000 mm and operates at high speed of 1 m/s, select either the fixed-supported or fixed-fixed configuration for the screw shaft support.

However, the fixed-fixed configuration requires a complicated structure, needs high accuracy in the installation.

Accordingly, the fixed-supported configuration is selected as the screw shaft support method.

● Studying the Permissible Axial Load

■Calculating the Maximum Axial Load

Guide surface resistance	f=15 N (without load)
Table Mass	m_1 =60 kg
Work Mass	m_2 =20 kg
Frictional coefficient of the guide surface	$\mu = 0.003$
Maximum speed	V_{max}=1 m/s
Gravitational acceleration	$g = 9.807$ m/s^2
Acceleration time	$t_1 = 0.15$s

Accordingly, the required values are obtained as follows.

Acceleration:

$$\alpha = \frac{V_{max}}{t_1} = 6.67 \text{ m/s}^2$$

During forward acceleration:

$$Fa_1 = \mu \cdot (m_1 + m_2)\, g + f + (m_1 + m_2) \cdot \alpha = 550 \text{ N}$$

During forward uniform motion:

$$Fa_2 = \mu \cdot (m_1 + m_2)\, g + f = 17 \text{ N}$$

During forward deceleration:

$$Fa_3 = \mu \cdot (m_1 + m_2)\, g + f - (m_1 + m_2) \cdot \alpha = -516 \text{ N}$$

During backward acceleration:

$$Fa_4 = -\mu \cdot (m_1 + m_2)\, g - f - (m_1 + m_2) \cdot \alpha = -550 \text{ N}$$

During uniform backward motion:

$$Fa_5 = -\mu \cdot (m_1 + m_2)\, g - f = -17 \text{ N}$$

During backward deceleration:

$$Fa_6 = -\mu \cdot (m_1 + m_2)\, g - f + (m_1 + m_2) \cdot \alpha = 516 \text{ N}$$

Thus, the maximum axial load applied on the Ball Screw is as follows:

$$Fa_{max} = Fa_1 = 550 \text{ N}$$

Therefore, if there is no problem with a shaft diameter of 20 mm and a lead of 20 mm (smallest thread minor diameter of 17.5 mm), then the screw shaft diameter of 30 mm should meet the requirements. Thus, the following calculations for the buckling load and the permissible compressive and tensile load of the screw shaft are performed while assuming a screw shaft diameter of 20 mm and a lead of 20 mm.

■Buckling Load on the Screw Shaft

Factor according to the mounting method η_2=20 (see A-694)

Since the mounting method for the section between the nut and the bearing, where buckling is to be considered, is "fixed-fixed: "

Distance between two mounting surfaces ℓ_a=1100 mm (estimate)
Screw-shaft thread minor diameter d_1=17.5 mm

$$P_1 = \eta_2 \cdot \frac{d_1^{\ 4}}{\ell_a^{\ 2}} \times 10^4 = 20 \times \frac{17.5^4}{1100^2} \times 10^4 = 15500 \text{ N}$$

■Permissible Compressive and Tensile Load of the Screw Shaft

$P_2 = 116 \times d_1^{\ 2} = 116 \times 17.5^2 = 35500$ N

Thus, the buckling load and the permissible compressive and the tensile load of the screw shaft are at least equal to the maximum axial load. Therefore, a Ball Screw that meets these requirements can be used without a problem.

● Studying the Permissible Rotational Speed

■Maximum Rotational Speed

● Screw shaft diameter: 20 mm; lead: 20 mm

Maximum speed V_{max}=1 m/s
Lead Ph= 20 mm

$$N_{max} = \frac{V_{max} \times 60 \times 10^3}{Ph} = 3000 \text{ min}^{-1}$$

● Screw shaft diameter: 20 mm; lead: 40mm

Maximum speed V_{max}=1 m/s
Lead Ph= 40 mm

$$N_{max} = \frac{V_{max} \times 60 \times 10^3}{Ph} = 1500 \text{ min}^{-1}$$

● Screw shaft diameter: 30mm; lead: 60mm

Maximum speed V_{max}=1 m/s
Lead Ph= 60 mm

$$N_{max} = \frac{V_{max} \times 60 \times 10^3}{Ph} = 1000 \text{ min}^{-1}$$

■Permissible Rotational Speed Determined by the Dangerous Speed of the Screw Shaft

Factor according to the mounting method λ_2=15.1 (see A-696)

Since the mounting method for the section between the nut and the bearing, where dangerous speed is to be considered, is "fixed-supported: "

Distance between two mounting surfaces ℓ_b=1100 mm (estimate)

- Screw shaft diameter: 20 mm; lead: 20 mm and 40 mm

Screw-shaft thread minor diameter d_1=17.5mm

$$N_1 = \lambda_2 \times \frac{d_1}{\ell_b^{\,2}} 10^7 = 15.1 \times \frac{17.5}{1100^2} \times 10^7 = 2180\ \mathrm{min}^{-1}$$

- Screw shaft diameter: 30mm; lead: 60mm

Screw-shaft thread minor diameter d_1=26.4mm

$$N_1 = \lambda_2 \times \frac{d_1}{\ell_b^{\,2}} 10^7 = 15.1 \times \frac{26.4}{1100^2} \times 10^7 = 3294\ \mathrm{min}^{-1}$$

■Permissible Rotational Speed Determined by the DN Value

- Screw shaft diameter: 20 mm; lead: 20 mm and 40mm (large lead Ball Screw)

Ball center-to-center diameter D=20.75 mm

$$N_2 = \frac{70000}{D} = \frac{70000}{20.75} = 3370\ \mathrm{min}^{-1}$$

- Screw shaft diameter: 30 mm; lead: 60 mm (large lead Ball Screw)

Ball center-to-center diameter D=31.25 mm

$$N_2 = \frac{70000}{D} = \frac{70000}{31.25} = 2240\ \mathrm{min}^{-1}$$

Thus, with a Ball Screw having a screw shaft diameter of 20 mm and a lead of 20 mm, the maximum rotational speed exceeds the dangerous speed.

In contrast, a combination of a screw shaft diameter of 20 mm and a lead of 40 mm, and another of a screw shaft diameter of 30 mm and a lead of 60 mm, meet the dangerous speed and the DN value.

Accordingly, a Ball Screw with a screw shaft diameter of 20 mm and a lead of 40 mm, or with a screw shaft diameter of 30 mm and a lead of 60 mm, is selected.

[Selecting a Nut]

● Selecting a Nut Model Number

Rolled Ball Screw models with a screw shaft diameter of 20 mm and a lead of 40 mm, or with a screw shaft diameter of 30 mm and a lead of 60 mm, are large lead Rolled Ball Screw model WTF variations.

WTF2040-2
(Ca=5.4 kN, C_0a=13.6 kN)
WTF2040-3
(Ca=6.6 kN, C_0a=17.2 kN)
WTF3060-2
(Ca=11.8 kN, C_0a=30.6 kN)
WTF3060-3
(Ca=14.5 kN, C_0a=38.9 kN)

● Studying the Permissible Axial Load

Study the permissible axial load of model WTF2040-2 (C_0a = 13.6 kN).
Assuming that this model is used in high-speed transfer equipment and an impact load is applied during deceleration, set the static safety factor (f_S) at 2.5 (see Table18 on A-703).

$$\frac{C_0a}{f_S} = \frac{13.6}{2.5} = 5.44\ \text{kN} = 5440\ \text{N}$$

The obtained permissible axial load is greater than the maximum axial load of 550 N, and therefore, there will be no problem with this model.

■Calculating the Travel Distance

Maximum speed V_{max}=1 m/s
Acceleration time t_1 = 0.15s
Deceleration time t_3 = 0.15s

- Travel distance during acceleration

$$\ell_{1,4} = \frac{V_{max} \cdot t_1}{2} \times 10^3 = \frac{1 \times 0.15}{2} \times 10^3 = 75\ \text{mm}$$

- Travel distance during uniform motion

$$\ell_{2,5} = \ell_S - \frac{V_{max} \cdot t_1 + V_{max} \cdot t_3}{2} \times 10^3 = 1000 - \frac{1 \times 0.15 + 1 \times 0.15}{2} \times 10^3 = 850\ \text{mm}$$

- Travel distance during deceleration

$$\ell_{3,6} = \frac{V_{max} \cdot t_3}{2} \times 10^3 = \frac{1 \times 0.15}{2} \times 10^3 = 75\ \text{mm}$$

Based on the conditions above, the relationship between the applied axial load and the travel distance is shown in the table below.

Motion	Applied axial load Fa_N(N)	Travel distance ℓ_N(mm)
No.1: During forward acceleration	550	75
No.2: During forward uniform motion	17	850
No.3: During forward deceleration	−516	75
No.4: During backward acceleration	−550	75
No.5: During uniform backward motion	−17	850
No.6: During backward deceleration	516	75

* The subscript (N) indicates a motion number.

Since the load direction (as expressed in positive or negative sign) is reversed with Fa_3, Fa_4 and Fa_5, calculate the average axial load in the two directions.

■Average Axial Load

- Average axial load in the positive direction

Since the load direction varies, calculate the average axial load while assuming $Fa_{3,4,5}$ = 0N.

$$F_{m1} = \sqrt[3]{\frac{Fa_1^{\,3}\times \ell_1 + Fa_2^{\,3}\times \ell_2 + Fa_6^{\,3}\times \ell_6}{\ell_1+\ell_2+\ell_3+\ell_4+\ell_5+\ell_6}} = 225\ \text{N}$$

- Average axial load in the negative direction

Since the load direction varies, calculate the average axial load while assuming $Fa_{1,2,6}$ = 0N.

$$F_{m2} = \sqrt[3]{\frac{|Fa_3|^3\times \ell_3 + |Fa_4|^3\times \ell_4 + |Fa_5|^3\times \ell_5}{\ell_1+\ell_2+\ell_3+\ell_4+\ell_5+\ell_6}} = 225\ \text{N}$$

Since $F_{m1} = F_{m2}$, assume the average axial load to be $F_m = F_{m1} = F_{m2} = 225$ N.

■Nominal Life

Load factor	f_W= 1.5 (see Table19 on A-704)
Average load	F_m= 225 N
Nominal life	L (rev)

$$L = \left(\frac{Ca}{f_W \cdot F_m}\right)^3 \times 10^6$$

Assumed model number	Dynamic load rating Ca(N)	Nominal life L(rev)
WTF 2040-2	5400	4.1×10^{9}
WTF 2040-3	6600	7.47×10^{9}
WTF 3060-2	11800	4.27×10^{10}
WTF 3060-3	14500	7.93×10^{10}

■Average Revolutions per Minute

Number of reciprocations per minute	$n = 8\text{min}^{-1}$
Stroke	$\ell_s = 1000$ mm

- Lead: Ph = 40 mm

$$N_m = \frac{2 \times n \times \ell_s}{Ph} = \frac{2 \times 8 \times 1000}{40} = 400\ \text{min}^{-1}$$

- Lead: Ph = 60 mm

$$N_m = \frac{2 \times n \times \ell_s}{Ph} = \frac{2 \times 8 \times 1000}{60} = 267\ \text{min}^{-1}$$

■Calculating the Service Life Time on the Basis of the Nominal Life

- WTF2040-2

Nominal life	$L = 4.1 \times 10^9$ rev
Average revolutions per minute	$Nm = 400\ \text{min}^{-1}$

$$L_h = \frac{L}{60 \times N_m} = \frac{4.1 \times 10^9}{60 \times 400} = 171000\ \text{h}$$

- WTF2040-3

Nominal life	$L = 7.47 \times 10^9$ rev
Average revolutions per minute	$Nm = 400\ \text{min}^{-1}$

$$L_h = \frac{L}{60 \times N_m} = \frac{7.47 \times 10^9}{60 \times 400} = 311000\ \text{h}$$

- WTF3060-2

Nominal life	$L = 4.27 \times 10^{10}$ rev
Average revolutions per minute	$Nm = 267\ \text{min}^{-1}$

$$L_h = \frac{L}{60 \times N_m} = \frac{4.27 \times 10^{10}}{60 \times 267} = 2670000\ \text{h}$$

- WTF3060-3

Nominal life	$L = 7.93 \times 10^{10}$ rev
Average revolutions per minute	$Nm = 267\ \text{min}^{-1}$

$$L_h = \frac{L}{60 \times N_m} = \frac{7.93 \times 10^{10}}{60 \times 267} = 4950000\ \text{h}$$

■Calculating the Service Life in Travel Distance on the Basis of the Nominal Life

● WTF2040-2

Nominal life	$L=4.1\times10^{9}$ rev
Lead	$Ph= 40$ mm

$L_S = L \times Ph \times 10^{-6} = 164000$ km

● WTF2040-3

Nominal life	$L=7.47\times10^{9}$ rev
Lead	$Ph= 40$ mm

$L_S = L \times Ph \times 10^{-6} = 298800$ km

● WTF3060-2

Nominal life	$L=4.27\times10^{10}$ rev
Lead	$Ph= 60$ mm

$L_S = L \times Ph \times 10^{-6} = 2562000$ km

● WTF3060-3

Nominal life	$L=7.93\times10^{10}$ rev
Lead	$Ph= 60$ mm

$L_S = L \times Ph \times 10^{-6} = 4758000$ km

With all the conditions stated above, the following models satisfying the desired service life time of 30,000 hours are selected.

WTF 2040-2
WTF 2040-3
WTF 3060-2
WTF 3060-3

[Studying the Rigidity]

Since the conditions for selection do not include rigidity and this element is not particularly necessary, it is not described here.

[Studying the Positioning Accuracy]

● Studying the Lead Angle Accuracy

Accuracy grade C7 was selected in Section [Selecting Lead Angle Accuracy and Axial Clearance] on A-723.

C7 (travel distance error: ±0.05mm/300mm)

● Studying the Axial Clearance

Since positioning is performed in a given direction only, axial clearance is not included in the positioning accuracy. As a result, there is no need to study the axial clearance.

WTF2040: axial clearance: 0.1 mm
WTF3060: axial clearance: 0.14 mm

● Studying the Axial Rigidity

Since the load direction does not change, it is unnecessary to study the positioning accuracy on the basis of the axial rigidity.

● Studying the Thermal Displacement through Heat Generation

Assume the temperature rise during operation to be 5℃.

The positioning accuracy based on the temperature rise is obtained as follows:

$$\begin{aligned}\Delta\ell &= \rho \times \Delta t \times \ell \\ &= 12 \times 10^{-6} \times 5 \times 1000 \\ &= 0.06 \text{ mm}\end{aligned}$$

● Studying the Orientation Change during Traveling

Since the ball screw center is 150 mm away from the point where the highest accuracy is required, it is necessary to study the orientation change during traveling.

Assume that pitching can be done within ±10 seconds because of the structure. The positioning error due to the pitching is obtained as follows:

$$\begin{aligned}\Delta a &= \ell \times \sin\theta \\ &= 150 \times \sin(\pm 10'') \\ &= \pm\, 0.007 \text{ mm}\end{aligned}$$

Thus, the positioning accuracy (Δp) is obtained as follows:

$$\Delta p = \frac{\pm 0.05 \times 1000}{300} \pm 0.007 + 0.06 = 0.234 \text{ mm}$$

Since models WTF2040-2, WTF2040-3, WTF3060-2 and WTF3060-3 meet the selection requirements throughout the studying process in Section [Selecting Lead Angle Accuracy and Axial Clearance] on A-723 to Section [Studying the Positioning Accuracy] on A-732, the most compact model WTF2040-2 is selected.

[Studying the Rotational Torque]

● Friction Torque Due to an External Load

The friction toruque is obtained as follows:

$$T_1 = \frac{Fa \cdot Ph}{2\pi \cdot \eta} \cdot A = \frac{17 \times 40}{2 \times \pi \times 0.9} \times 1 = 120 \text{ N} \cdot \text{mm}$$

● Torque Due to a Preload on the Ball Screw

The Ball Screw is not provided with a preload.

● Torque Required for Acceleration

Inertial Moment

Since the inertial moment per unit length of the screw shaft is 1.23 x 10^{-3} kg•cm^2/mm (see the specification table), the inertial moment of the screw shaft with an overall length of 1200 mm is obtained as follows.

$J_s = 1.23 \times 10^{-3} \times 1200 = 1.48 \text{ kg} \cdot \text{cm}^2$
$= 1.48 \times 10^{-4} \text{ kg} \cdot \text{m}^2$

$$J = (m_1 + m_2)\left(\frac{Ph}{2 \times \pi}\right)^2 \cdot A^2 \times 10^{-6} + J_s \cdot A^2 = (60 + 20)\left(\frac{40}{2 \times \pi}\right)^2 \times 1^2 \times 10^{-6} + 1.48 \times 10^{-4} \times 1^2$$

$$= 3.39 \times 10^{-3} \text{ kg} \cdot \text{m}^2$$

Angular acceleration:

$$\omega' = \frac{2\pi \cdot Nm}{60 \cdot t_1} = \frac{2\pi \times 1500}{60 \times 0.15} = 1050 \text{ rad/s}^2$$

Based on the above, the torque required for acceleration is obtained as follows.

$T_2 = (J + J_m) \times \omega' = (3.39 \times 10^{-3} + 1 \times 10^{-3}) \times 1050 = 4.61 \text{N} \cdot \text{m}$
$= 4.61 \times 10^3 \text{ N} \cdot \text{mm}$

Therefore, the required torque is specified as follows.

During acceleration

$T_k = T_1 + T_2 = 120 + 4.61 \times 10^3 = 4730 \text{ N} \cdot \text{mm}$

During uniform motion

$T_t = T_1 = 120 \text{ N} \cdot \text{mm}$

During deceleration

$T_g = T_1 - T_2 = 120 - 4.61 \times 10^3 = -4490 \text{ N} \cdot \text{mm}$

[Studying the Driving Motor]

● Rotational Speed

Since the Ball Screw lead is selected based on the rated rotational speed of the motor, it is unnecessary to study the rotational speed of the motor.

Maximum working rotational speed: 1500 min^{-1}
Rated rotational speed of the motor: 3000 min^{-1}

● Minimum Feed Amount

As with the rotational speed, the Ball Screw lead is selected based on the encoder normally used for an AC servomotor. Therefore, it is unnecessary to study this factor.

Encoder resolution : 1000 p/rev.
Doubled : 2000 p/rev

● Motor Torque

The torque during acceleration calculated in Section [Studying the Rotational Torque] on A-733 is the required maximum torque.

$T_{max} = 4730\ \text{N} \cdot \text{mm}$

Therefore, the instantaneous maximum torque of the AC servomotor needs to be at least 4,730 N-mm.

● Effective Torque Value

The selection requirements and the torque calculated in Section [Studying the Rotational Torque] on A-733 can be expressed as follows.

During acceleration:
$T_k = 4730\ \text{N} \cdot \text{mm}$
$t_1 = 0.15\ \text{s}$
During uniform motion:
$T_t = 120\ \text{N} \cdot \text{mm}$
$t_2 = 0.85\ \text{s}$
During deceleration:
$T_g = 4490\ \text{N} \cdot \text{mm}$
$t_3 = 0.15\ \text{s}$
When stationary:
$T_S = 0$
$t_4 = 2.6\ \text{s}$

The effective torque is obtained as follows, and the rated torque of the motor must be 1305 N•mm or greater.

$$T_{rms} = \sqrt{\frac{T_k^2 \cdot t_1 + T_t^2 \cdot t_2 + T_g^2 \cdot t_3 + T_s^2 \cdot t_4}{t_1 + t_2 + t_3 + t_4}} = \sqrt{\frac{4730^2 \times 0.15 + 120^2 \times 0.85 + 4490^2 \times 0.15 + 0}{0.15 + 0.85 + 0.15 + 2.6}}$$

$$= 1305\ \text{N} \cdot \text{mm}$$

● Inertial Moment

The inertial moment applied to the motor equals to the inertial moment calculated in Section [Studying the Rotational Torque] on A-733.

$J = 3.39 \times 10^{-3}\ \mathrm{kg \cdot m^2}$

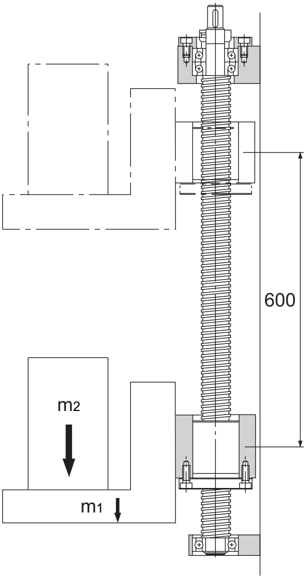
Normally, the motor needs to have an inertial moment at least one tenth of the inertial moment applied to the motor, although the specific value varies depending on the motor manufacturer. Therefore, the inertial moment of the AC servomotor must be $3.39 \times 10^{-4}\mathrm{kg\text{-}m^2}$ or greater.

The selection has been completed.

Vertical Conveyance System

[Selection Conditions]

Table Mass	m_1 =40kg
Work Mass	m_2 =10kg
Stroke length	ℓ_s= 600mm
Maximum speed	V_{max}=0.3m/s
Acceleration time	t_1 = 0.2s
Deceleration time	t_3 = 0.2s
Number of reciprocations per minute	n =5min^{-1}
Backlash	0.1mm
Positioning accuracy	±0.7mm/600mm
Positioning Repeatability	±0.05mm
Minimum feed amount	s = 0.01mm/pulse
Service life time	20000h
Driving motor	AC servo motor Rated rotational speed: 3,000 min^{-1}
Inertial moment of the motor	J_m =5×10^{-5} kg•m^2
Reduction gear	None (direct coupling)
Frictional coefficient of the guide surface	μ =0.003 (rolling)
Guide surface resistance	f=20 N (without load)



[Selection Items]

Screw shaft diameter
Lead
Nut model No.
Accuracy
Axial clearance
Screw shaft support method
Driving motor

[Selecting Lead Angle Accuracy and Axial Clearance]

● Selecting the Lead Angle Accuracy

To achieve positioning accuracy of ±0.7mm/600mm:

$$\frac{\pm 0.7}{600} = \frac{\pm 0.35}{300}$$

The lead angle accuracy must be ±0.35mm/300 mm or higher.

Therefore, the accuracy grade of the Ball Screw (see Table1 on A-678) needs to be C10 (travel distance error: ±0.21 mm/300 mm).

Accuracy grade C10 is available for low priced, Rolled Ball Screws. Assume that a Rolled Ball Screw is selected.

● Selecting the Axial Clearance

The required backlashes is 0.1 mm or less. However, since an axial load is constantly applied in a single direction with vertical mount, the axial load does not serve as a backlash no matter how large it is.

Therefore, a low price, rolled Ball Screw is selected since there will not be a problem in axial clearance.

[Selecting a Screw Shaft]

● Assuming the Screw Shaft Length

Assume the overall nut length to be 100 mm and the screw shaft end length to be 100 mm.

Therefore, the overall length is determined as follows based on the stroke length of 600mm.

$$600 + 200 = 800 \text{ mm}$$

Thus, the screw shaft length is assumed to be 800 mm.

● Selecting the Lead

With the driving motor's rated rotational speed being 3,000 min^{-1} and the maximum speed 0.3 m/s, the Ball Screw lead is obtained as follows:

$$\frac{0.3 \times 60 \times 1000}{3000} = 6 \text{ mm}$$

Therefore, it is necessary to select a type with a lead of 6mm or longer.

In addition, the Ball Screw and the motor can be mounted in direct coupling without using a reduction gear. The minimum resolution per revolution of an AC servomotor is obtained based on the resolution of the encoder (1,000 p/rev; 1,500 p/rev) provided as a standard accessory for the AC servomotor, as indicated below.

1000 p/rev(without multiplication)
1500 p/rev(without multiplication)
2000 p/rev(doubled)
3000 p/rev(doubled)
4000 p/rev(quadrupled)
6000 p/rev(quadrupled)

To meet the minimum feed amount of 0.010mm/pulse, which is the selection requirement, the following should apply.

Lead 6mm ── 3000 p/rev
8mm ── 4000 p/rev
10mm ── 1000 p/rev
20mm ── 2000 p/rev
40mm ── 2000 p/rev

However, with the lead being 6 mm or 8 mm, the feed distance is 0.002 mm/pulse, and the starting pulse of the controller that issues commands to the motor driver needs to be at least 150 kpps, and the cost of the controller may be higher.

In addition, if the lead of the Ball Screw is greater, the torque required for the motor is also greater, and thus the cost will be higher.

Therefore, select 10 mm for the Ball Screw lead.

● Selecting the Screw Shaft Diameter

Those Ball Screw models that meet the lead being 10 mm as described in Section [Selecting Lead Angle Accuracy and Axial Clearance] on A-737 and Section [Selecting a Screw Shaft] on A-737 (see Table17 on A-693) are as follows.

Shaft diameter Lead
15mm ── 10mm
20mm ── 10mm
25mm ── 10mm

Accordingly, the combination of a screw shaft diameter of 15 mm and a lead 10 mm is selected.

● Selecting the Screw Shaft Support Method

Since the assumed Ball Screw has a stroke length of 600 mm and operates at a maximum speed of 0.3 m/s (Ball Screw rotational speed: 1,800 min^{-1}), select the fixed-supported configuration for the screw shaft support.

● Studying the Permissible Axial Load

■Calculating the Maximum Axial Load

Guide surface resistance	$f=20$ N (without load)
Table Mass	$m_1=40$ kg
Work Mass	$m_2=10$ kg
Maximum speed	$V_{max}=0.3$ m/s
Acceleration time	$t_1=0.2$s

Accordingly, the required values are obtained as follows.

Acceleration

$$\alpha = \frac{V_{max}}{t_1} = 1.5\ \text{m/s}^2$$

During upward acceleration:

$$Fa_1 = (m_1 + m_2)\cdot g + f + (m_1 + m_2)\cdot \alpha = 585\ \text{N}$$

During upward uniform motion:

$$Fa_2 = (m_1 + m_2)\cdot g + f = 510\ \text{N}$$

During upward deceleration:

$$Fa_3 = (m_1 + m_2)\cdot g + f - (m_1 + m_2)\cdot \alpha = 435\ \text{N}$$

During downward acceleration:

$$Fa_4 = (m_1 + m_2)\cdot g - f - (m_1 + m_2)\cdot \alpha = 395\ \text{N}$$

During downward uniform motion:

$$Fa_5 = (m_1 + m_2)\cdot g - f = 470\ \text{N}$$

During downward deceleration:

$$Fa_6 = (m_1 + m_2)\cdot g - f + (m_1 + m_2)\cdot \alpha = 545\ \text{N}$$

Thus, the maximum axial load applied on the Ball Screw is as follows:

$$Fa_{max} = Fa_1 = 585\ \text{N}$$

■Buckling Load of the Screw Shaft

Factor according to the mounting method $\eta_2=20$ (see A-694)

Since the mounting method for the section between the nut and the bearing, where buckling is to be considered, is "fixed-fixed: "

Distance between two mounting surfaces	$\ell_a=700$ mm (estimate)
Screw-shaft thread minor diameter	$d_1=12.5$ mm

$$P_1 = \eta_2 \cdot \frac{d_1^{\,4}}{\ell_a^{\,2}} \times 10^4 = 20 \times \frac{12.5^4}{700^2} \times 10^4 = 9960\ \text{N}$$

■Permissible Compressive and Tensile Load of the Screw Shaft

$$P_2 = 116d_1^{\,2} = 116 \times 12.5^2 = 18100\ \text{N}$$

Thus, the buckling load and the permissible compressive and tensile load of the screw shaft are at least equal to the maximum axial load. Therefore, a Ball Screw that meets these requirements can be used without a problem.

● Studying the Permissible Rotational Speed

■Maximum Rotational Speed

● Screw shaft diameter: 15mm; lead: 10mm

Maximum speed	V_{max}=0.3 m/s
Lead	Ph= 10 mm

$$N_{max} = \frac{V_{max} \times 60 \times 10^3}{Ph} = 1800 \text{ min}^{-1}$$

■Permissible Rotational Speed Determined by the Dangerous Speed of the Screw Shaft

Factor according to the mounting method λ_2=15.1 (see A-696)

Since the mounting method for the section between the nut and the bearing, where dangerous speed is to be considered, is "fixed-supported: "

Distance between two mounting surfaces ℓ_b=700 mm (estimate)

● Screw shaft diameter: 15mm; lead: 10mm

Screw-shaft thread minor diameter d_1=12.5 mm

$$N_1 = \lambda_2 \times \frac{d_1}{\ell_b{}^2} 10^7 = 15.1 \times \frac{12.5}{700^2} \times 10^7 = 3852 \text{ min}^{-1}$$

■Permissible Rotational Speed Determined by the DN Value

● Screw shaft diameter: 15mm; lead: 10mm (large lead Ball Screw)

Ball center-to-center diameter D=15.75 mm

$$N_2 = \frac{70000}{D} = \frac{70000}{15.75} = 4444 \text{ min}^{-1}$$

Thus, the dangerous speed and the DN value of the screw shaft are met.

[Selecting a Nut]

● Selecting a Nut Model Number

The Rolled Ball Screw with a screw shaft diameter of 15 mm and a lead of 10 mm is the following large-lead Rolled Ball Screw model.

BLK1510-5.6
(C_a=9.8 kN, C_{0a}=25.2 kN)

● Studying the Permissible Axial Load

Assuming that an impact load is applied during an acceleration and a deceleration, set the static safety factor (f_S) at 2 (see Table18 on A-703).

$$Fa_{max} = \frac{C_{0}a}{f_S} = \frac{25.2}{2} = 12.6\ \text{kN} = 12600\ \text{N}$$

The obtained permissible axial load is greater than the maximum axial load of 585 N, and therefore, there will be no problem with this model.

● Studying the Service Life

■Calculating the Travel Distance

Maximum speed	V_{max}=0.3 m/s
Acceleration time	t_1 = 0.2s
Deceleration time	t_3 = 0.2s

- Travel distance during acceleration

$$\ell_{1,4} = \frac{V_{max} \cdot t_1}{2} \times 10^3 = \frac{1.3 \times 0.2}{2} \times 10^3 = 30\ \text{mm}$$

- Travel distance during uniform motion

$$\ell_{2,5} = \ell_S - \frac{V_{max} \cdot t_1 + V_{max} \cdot t_3}{2} \times 10^3 = 600 - \frac{0.3 \times 0.2 + 0.3 \times 0.2}{2} \times 10^3 = 540\ \text{mm}$$

- Travel distance during deceleration

$$\ell_{3,6} = \frac{V_{max} \cdot t_3}{2} \times 10^3 = \frac{0.3 \times 0.2}{2} \times 10^3 = 30\ \text{mm}$$

Based on the conditions above, the relationship between the applied axial load and the travel distance is shown in the table below.

Motion	Applied axial load Fa_N(N)	Travel distance ℓ_N(mm)
No1: During upward acceleration	585	30
No2: During upward uniform motion	510	540
No3: During upward deceleration	435	30
No4: During downward acceleration	395	30
No5: During downward uniform motion	470	540
No6: During downward deceleration	545	30

* The subscript (N) indicates a motion number.

■Average Axial Load

$$F_m = \sqrt[3]{\frac{1}{2\times \ell_s}(Fa_1^3 \cdot \ell_1 + Fa_2^3 \cdot \ell_2 + Fa_3^3 \cdot \ell_3 + Fa_4^3 \cdot \ell_4 + Fa_5^3 \cdot \ell_5 + Fa_6^3 \cdot \ell_6)} = 225\ N$$

■Nominal Life

Dynamic load rating	Ca= 9800 N
Load factor	f_w= 1.5 (see Table19 on A-704)
Average load	F_m= 492 N
Nominal life	L (rev)

$$L = \left(\frac{Ca}{f_w \cdot F_m}\right)^3 \times 10^6 = \left(\frac{9800}{1.5\times 492}\right)^3 \times 10^6 = 2.34 \times 10^9\ \text{rev}$$

■Average Revolutions per Minute

Number of reciprocations per minute	n = 5 min^{-1}
Stroke	ℓ_s=600 mm
Lead	Ph= 10 mm

$$N_m = \frac{2\times n\times \ell_s}{Ph} = \frac{2\times 5\times 600}{10} = 600\ \text{min}^{-1}$$

■Calculating the Service Life Time on the Basis of the Nominal Life

Nominal life	L=2.34×10^9 rev
Average revolutions per minute	N_m = 600 min^{-1}

$$L_h = \frac{L}{60 \cdot N_m} = \frac{2.34\times 10^9}{60\times 600} = 65000\ h$$

■Calculating the Service Life in Travel Distance on the Basis of the Nominal Life

Nominal life	L=2.34×10^9 rev
Lead	Ph= 10 mm

$L_s = L \times Ph \times 10^{-6} = 23400$ km

With all the conditions stated above, model BLK1510-5.6 satisfies the desired service life time of 20,000 hours.

[Studying the Rigidity]

Since the conditions for selection do not include rigidity and this element is not particularly necessary, it is not described here.

[Studying the Positioning Accuracy]

● Studying the Lead Angle Accuracy

Accuracy grade C10 was selected in Section [Selecting Lead Angle Accuracy and Axial Clearance] on A-737.

C10 (travel distance error: ±0.21mm/300mm)

● Studying the Axial Clearance

Since the axial load is constantly present in a given direction only because of vertical mount, there is no need to study the axial clearance.

● Studying the Axial Rigidity

Since the lead angle accuracy is achieved beyond the required positioning accuracy, there is no need to study the positioning accuracy determined by axial rigidity.

● Studying the Thermal Displacement through Heat Generation

Since the lead angle accuracy is achieved beyond the required positioning accuracy, there is no need to study the positioning accuracy determined by the heat generation.

● Studying the Orientation Change during Traveling

Since the lead angle accuracy is achieved at a much higher degree than the required positioning accuracy, there is no need to study the positioning accuracy.

[Studying the Rotational Torque]

● Frictional Torque Due to an External Load

During upward uniform motion:

$$T_1 = \frac{Fa_2 \cdot Ph}{2 \times \pi \times \eta} = \frac{510 \times 10}{2 \times \pi \times 0.9} = 900\ \mathrm{N \cdot mm}$$

During downward uniform motion:

$$T_2 = \frac{Fa_5 \cdot Ph}{2 \times \pi \times \eta} = \frac{470 \times 10}{2 \times \pi \times 0.9} = 830\ \mathrm{N \cdot mm}$$

● Torque Due to a Preload on the Ball Screw

The Ball Screw is not provided with a preload.

● Torque Required for Acceleration

Inertial Moment:

Since the inertial moment per unit length of the screw shaft is 3.9 x 10^{-4} kg•cm^2/mm (see the specification table), the inertial moment of the screw shaft with an overall length of 800mm is obtained as follows.

$J_S = 3.9 \times 10^{-4} \times 800 = 0.31\ \mathrm{kg \cdot cm^2}$

$\quad = 0.31 \times 10^{-4}\ \mathrm{kg \cdot m^2}$

$$J = (m_1 + m_2)\left(\frac{Ph}{2\times\pi}\right)^2 \cdot A^2 \times 10^{-6} + J_S \cdot A^2 = (40+10)\left(\frac{10}{2\times\pi}\right)^2 \times 1^2 \times 10^{-6} + 0.31 \times 10^{-4} \times 1^2$$

$$= 1.58 \times 10^{-4}\ \mathrm{kg \cdot m^2}$$

Angular acceleration:

$$\omega' = \frac{2\pi \cdot Nm}{60 \cdot t} = \frac{2\pi \times 1800}{60 \times 0.2} = 942\ \mathrm{rad/s^2}$$

Based on the above, the torque required for acceleration is obtained as follows.

$T_3 = (J + J_m) \cdot \omega' = (1.58 \times 10^{-4} + 5 \times 10^{-5}) \times 942 = 0.2\ \mathrm{N \cdot m} = 200\ \mathrm{N \cdot mm}$

Therefore, the required torque is specified as follows.

During upward acceleration:

$T_{k1} = T_1 + T_3 = 900 + 200 = 1100\ \mathrm{N \cdot mm}$

During upward uniform motion:

$T_{t1} = T_1 = 900\ \mathrm{N \cdot mm}$

During upward deceleration:

$T_{g1} = T_1 - T_3 = 900 - 200 = 700\ \mathrm{N \cdot mm}$

During downward acceleration:

$T_{k2} = 630\ \mathrm{N \cdot mm}$

During downward uniform motion:

$T_{t2} = 830\ \mathrm{N \cdot mm}$

During downward deceleration:

$T_{g2} = 1030\ \mathrm{N\text{-}mm}$

[Studying the Driving Motor]

● Rotational Speed

Since the Ball Screw lead is selected based on the rated rotational speed of the motor, it is unnecessary to study the rotational speed of the motor.

Maximum working rotational speed: 1800 min^{-1}
Rated rotational speed of the motor: 3000 min^{-1}

● Minimum Feed Amount

As with the rotational speed, the Ball Screw lead is selected based on the encoder normally used for an AC servomotor. Therefore, it is unnecessary to study this factor.

Encoder resolution: 1000 p/rev.

● Motor Torque

The torque during acceleration calculated in Section [Studying the Rotational Torque] on A-743 is the required maximum torque.

$T_{max} = T_{k1} = 1100\ N{\cdot}mm$

Therefore, the maximum peak torque of the AC servomotor needs to be at least 1100 N-mm.

● Effective Torque Value

The selection requirements and the torque calculated in Section [Studying the Rotational Torque] on A-743 can be expressed as follows.

During upward acceleration:
$T_{k1} = 1100\ N{\cdot}mm$
$t_1 = 0.2\ s$
During upward uniform motion:
$T_{t1} = 900\ N{\cdot}mm$
$t_2 = 1.8\ s$
During upward deceleration:
$T_{g1} = 700\ N{\cdot}mm$
$t_3 = 0.2\ s$
During downward acceleration:
$T_{k2} = 630\ N{\cdot}mm$
$t_1 = 0.2\ s$
During downward uniform motion:
$T_{t2} = 830\ N{\cdot}mm$
$t_2 = 1.8\ s$
During downward deceleration:
$T_{g2} = 1030\ N\text{-}mm$
$t_3 = 0.2\ s$
When stationary(m_2=0):
$T_S = 658\ N{\cdot}mm$
$t_4 = 7.6\ s$

The effective torque is obtained as follows, and the rated torque of the motor must be 743 N•mm or greater.

$$T_{rms} = \sqrt{\frac{T_{k1}{}^2 \cdot t_1 + T_{t1}{}^2 \cdot t_2 + T_{g1}{}^2 \cdot t_3 + T_{k2}{}^2 \cdot t_1 + T_{t2}{}^2 \cdot t_2 + T_{g2}{}^2 \cdot t_3 + T_s{}^2 \cdot t_4}{t_1 + t_2 + t_3 + t_1 + t_2 + t_3 + t_4}}$$

$$= \sqrt{\frac{1100^2 \times 0.2 + 900^2 \times 1.8 + 700^2 \times 0.2 + 630^2 \times 0.2 + 830^2 \times 1.8 + 1030^2 \times 0.2 + 658^2 \times 7.6}{0.2 + 1.8 + 0.2 + 0.2 + 1.8 + 0.2 + 7.6}}$$

$$= 743 \text{ N} \cdot \text{mm}$$

● Inertial Moment

The inertial moment applied to the motor equals to the inertial moment calculated in Section [Studying the Rotational Torque] on A-743.

$J = 1.58 \times 10^{-4}$ kg・m^2

Normally, the motor needs to have an inertial moment at least one tenth of the inertial moment applied to the motor, although the specific value varies depending on the motor manufacturer.
Therefore, the inertial moment of the AC servomotor must be 1.58×10^{-5}kg-m^2 or greater.

The selection has been completed.

Ball Screw

Accuracy of Each Model

Precision, Caged Ball Screw

Models SBN, SBK and HBN

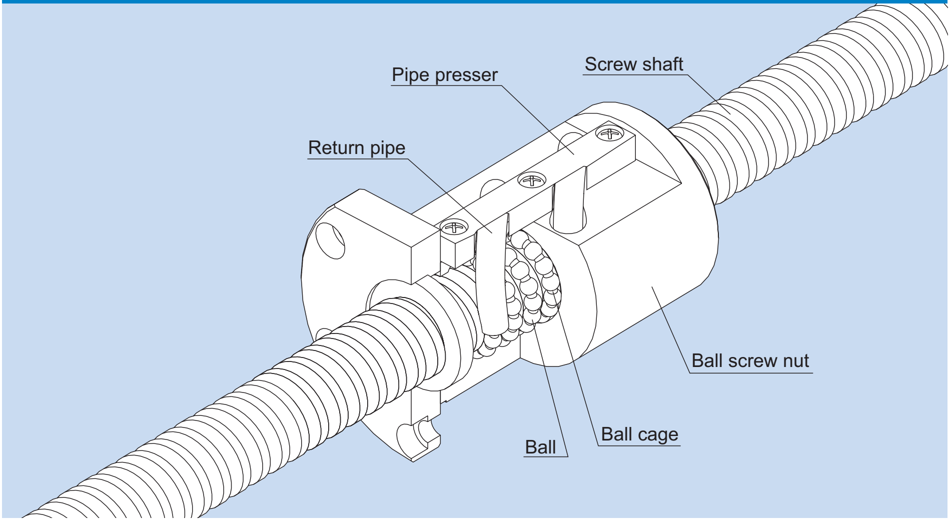


Fig.1 Structure of High-Speed Ball Screw with Ball Cage Model SBN

Structure and Features

The use of a ball cage in the Ball Screw with the Ball Cage eliminates collision and friction between balls and increases the grease retention. This makes it possible to achieve a low noise, a low torque fluctuation and a long-term maintenance-free operation.
In addition, this Ball Screw is superbly capable of responding to the high speed because of an ideal ball recirculation structure, a strengthened circulation path and an adoption of the ball cage.

Ball Cage Effect

[Low Noise, Acceptable Running Sound]

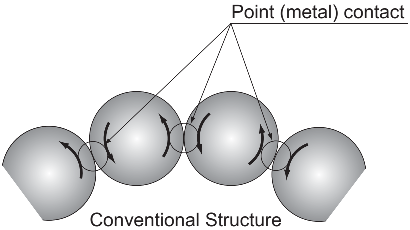
The use of the ball cage eliminates the collision noise between the balls. Additionally, as balls are picked up in the tangential direction, the collision noise from the ball circulation has also been eliminated.

[Long-term Maintenance-free Operation]

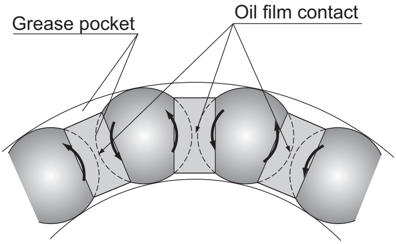
The friction between the balls has been eliminated, and the grease retention has been improved through the provision of grease pockets. As a result, the long-term maintenance-free operation (i.e., lubrication is unnecessary over a long period) is achieved.

[Smooth Motion]

The use of a ball cage eliminates the friction between the balls and minimizes the torque fluctuation, thus allowing the smooth motion to be achieved.



Conventional Structure



Structure of the Ball Screw with Ball Cage

[Low Noise]

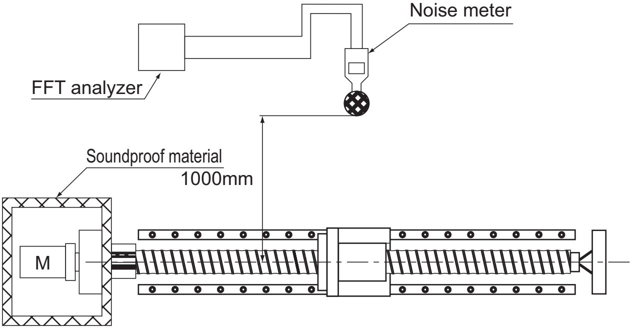
● Noise Level Data

Since the balls in the Ball Screw with the Ball Cage do not collide with each other, they do not produce a metallic sound and a low noise level is achieved.

■Noise Measurement

[Conditions]

Item	Description
Sample	High load ball screw with ball cage HBN3210-5 Conventional type: model BNF3210-5
Stroke	600mm
Lubrication	Grease lubrication (lithium-based grease containing extreme pressure agent)



Noise measurement instrument

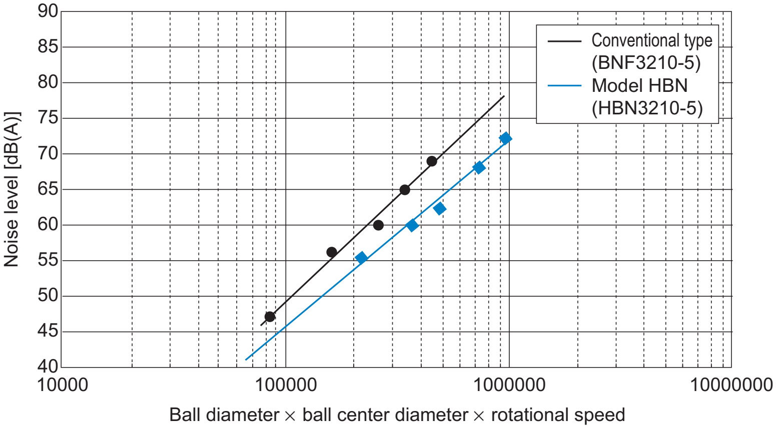


Fig.2 Ball Screw Noise Level

[Long-term Maintenance-free Operation]

● High speed, Load-bearing Capacity

Thanks to the ball circulating method supporting high speed and the caged ball technology, the Ball Screw with Ball Cage excels in high speed and load-bearing capacity.

■High Speed Durability Test

[Test conditions]

Item	Description
Sample	High Speed Ball Screw with Ball Cage SBN3210-7
Speed	3900(min^{-1})(DN value*: 130,000)
Stroke	400mm
Lubricant	THK AFG Grease
Quantity	12cm^3(lubricated every 1000km)
Applied load	1.73kN
Acceleration	1G

* DN value: Ball center-to-center diameter x revolutions per minute

[Test result]

Shows no deviation after running 10,000 km.

■Load Bearing Test

[Test conditions]

Item	Description
Sample	High Speed Ball Screw with Ball Cage SBN3210-7
Speed	1500(min^{-1})(DN value*: 50,000)
Stroke	300mm
Lubricant	THK AFG Grease
Quantity	12cm^3
Applied load	17.3kN(0.5Ca)
Acceleration	0.5G

[Test result]

Shows no deviation after running a distance 2.5 times the calculated service life.

[Smooth Motion]

● Low Torque Fluctuation

The caged ball technology allows smoother motion than the conventional type to be achieved, thus to reduce torque fluctuation.

[Conditions]

Item	Description
Shaft diameter/ lead	32/10mm
Shaft rotational speed	60min^{-1}

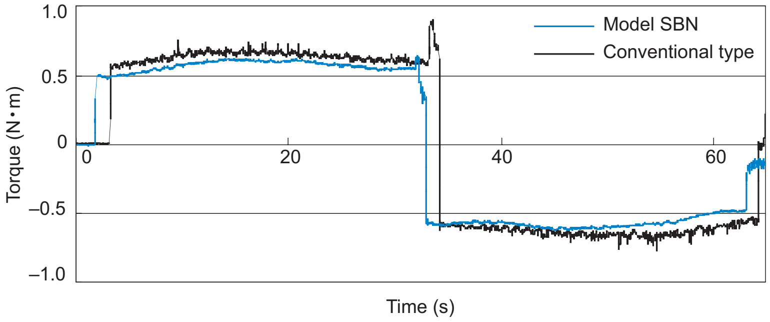


Fig.3 Torque Fluctuation Data

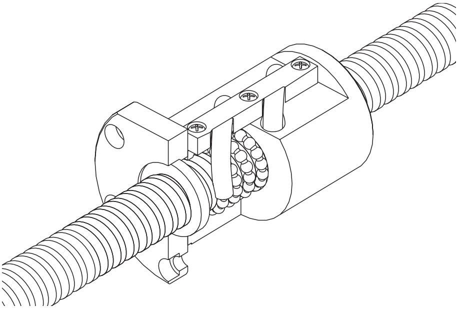
Types and Features

[Preload Type]

Model SBN

Specification Table⇒B-576

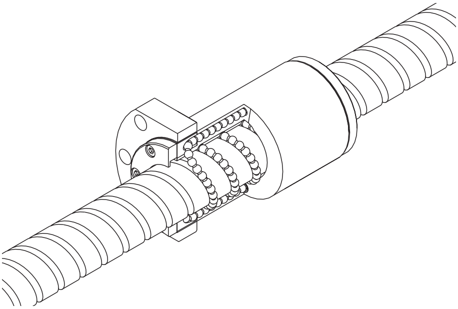
Model SBN has a circulation structure where balls are picked up in the tangential direction and is provided with a strengthened circulation path, thus to achieve a DN value of 130,000.



Model SBK

Specification Table⇒B-578

As a result of adopting the offset preloading method, which shifts two rows of grooves of the ball screw nut, a compact structure is achieved.

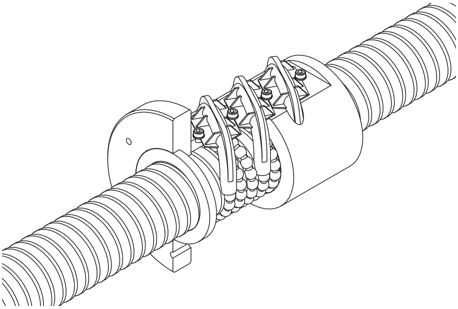


[No Preload Type]

Model HBN

Specification Table⇒B-580

With the optimal design for high loads, this Ball Screw model achieves a rated load more than twice the conventional type.



Service Life

For details,see A-704.

Axial Clearance

For details,see A-685.

Accuracy Standards

For details,see A-678.

Standard-Stock Precision Ball Screw

Unfinished Shaft Ends
Models BIF, BNFN, MDK, MBF and BNF

Structure and Features

This type of Ball Screw is mass manufactured by cutting the standardized screw shafts of Precision Ball Screws to regular lengths. Additional machining of the shaft ends can easily be performed.
To meet various intended purposes, THK offers several Ball Screw models with different types of nuts: the double-nut type (model BNFN), the single-nut type (model BNF), the offset preload-nut type (model BIF) and the miniature Ball Screw (models MDK and MBF).

[Contamination Protection]

Nuts of the following model numbers are attached with a labyrinth seal.

- All variations of models BNFN, BNF and BIF
- Model MDK0802/1002/1202/1402/1404/1405

When dust or other foreign materials may enter the Ball Screw, it is necessary to use a contamination protection device (e.g., bellows) to completely protect the screw shaft.

[Lubrication]

The ball screw nuts are supplied with lithium soap-group grease with shipments.
(Models MDK and MBF are applied only with an anti-rust oil.)

[Additional Machining of the Shaft End]

Since only the effective thread of the screw shaft is surface treated with induction-hardening (all variations of models BNFN, BNF and BIF; model MDK 1405) or carburizing (all variations of model MBF; model MDK0401 to 1404), the shaft ends can additionally be machined easily either by grinding or milling.
In addition, since both ends of the screw shaft have a center hole, they can be cylindrically ground.

Surface hardness of the effect thread	: HRC58 to 64
Hardness of the screw shaft ends	
All variation of models BNFN, BNF and BIF; model MDK 1405	: HRC22 to 27
All variations of model MBF; model MDK0401 to 1404	: HRC35 or below

THK has standardized the shapes of the screw shaft ends in order to allow speedy estimation and manufacturing of the Ball Screws.
The shapes of shaft ends are divided into those allowing the standard support units to be used (symbols H, K and J) and those compliant with JIS B 1192-1997 (symbols A, B and C). See A-810 for details.

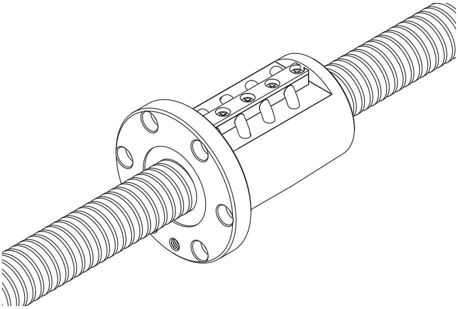
Types and Features

[Preload Type]

Model BIF

Specification Table⇒B-594

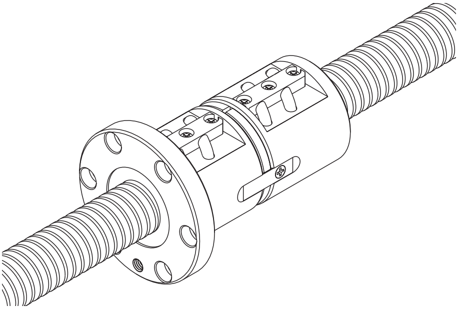
The right and left screws are provided with a phase in the middle of the ball screw nut, and an axial clearance is set at a below-zero value (under a preload). This compact model is capable of a smooth motion.



Model BNFN

Specification Table⇒B-594

The most common type with a preload provided via a spacer between the two combined ball screw nuts to eliminate backlash. It can be mounted using the bolt holes drilled on the flange.



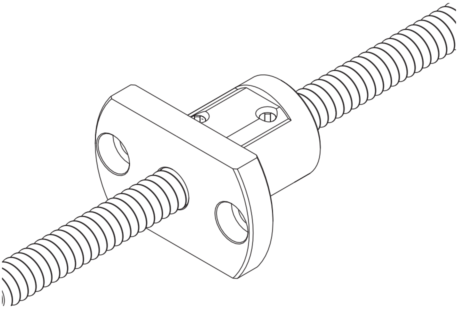
dammy

[No Preload Type]

Models MDK and MBF

Specification Table⇒B-584

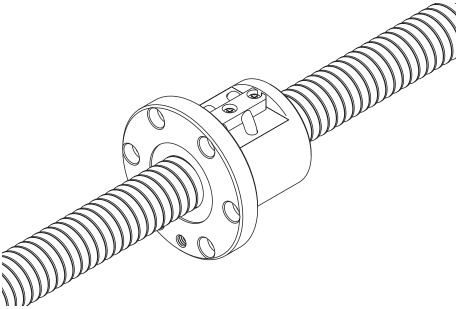
A miniature type with a screw shaft diameter of ϕ4 to ϕ14 mm and a lead of 1 to 5mm.



Model BNF

Specification Table⇒B-594

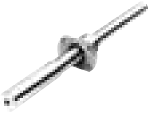
The simplest type with a single ball screw nut. It is designed to be mounted using the bolt holes drilled on the flange.



Service Life

For details,see A-704.

Nut Types and Axial Clearance

Screw shaft outer diameter (mm)	ϕ 4 to 14			
	Model MDK		Model MBF	
Nut type	 No preload type		 No preload type	
Accuracy grades	C3, C5	C7	C3, C5	C7
Axial clearance (mm)	0.005 or less (GT)	0.02 or less (G2)	0.005 or less (GT)	0.02 or less (G2)
Preload	—		—	

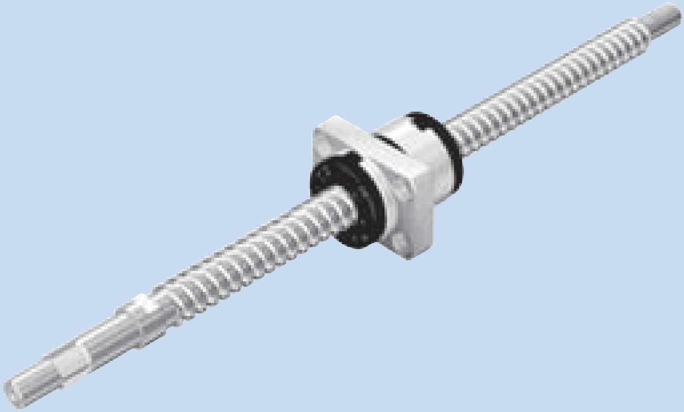
Note) The symbols in the parentheses indicate axial clearance symbols.

Screw shaft out diameter (mm)	ϕ16 to 50					
	Model BIF		Model BNFN		Model BNF	
Nut type	 Preload Type		 Preload Type		 No preload type	
Accuracy grades	C5	C7	C5	C7	C5	C7
Axial clearance (mm)	0 or less (G0)	0 or less (G0)	0 or less (G0)	0 or less (G0)	0.01 or less (G1)	0.02 or less (G2)
Preload	0.05Ca	0.05Ca	0.05Ca	0.05Ca	—	—

Note1) The symbols in the parentheses indicate axial clearance symbols.
Note2) Symbol "Ca" for preload indicates the basic dynamic load rating.

Standard-Stock Precision Ball Screw

Finished Shaft Ends
Model BNK



Features

To meet the space-saving requirement, this type of Ball Screw has a standardized screw shaft and a ball screw nut. The ends of the screw shaft are standardized to fit the corresponding support unit. The shaft support method with models BNK0401, 0501 and 0601 is "fixed-free," while other models use the "fixed-supported" method with the shaft directly coupled with the motor.
Screw shafts and nuts are compactly designed. When a support unit and a nut bracket are combined with a Ball Screw, the assembly can be mounted on your machine as it is. Thus, a high-accuracy feed mechanism can easily be achieved.

[Contamination Protection and Lubrication]

Each ball screw nut contains a right amount of grease. In addition, the ball nuts of model BNK0802 or higher contain a labyrinth seal (with models BNK1510, BNK1520, BNK1616, BNK2020 and BNK2520, the end cap also serves as a labyrinth seal).
When foreign materials may enter the screw nut, it is necessary to use a dust-prevention device (e.g., bellows) to completely protect the screw shaft.

Types and Features

Model BNK

Specification Table⇒B-608

For this model, screw shafts with a diameter ϕ4 to ϕ25 mm and a lead 1 to 20 mm are available as the standard.

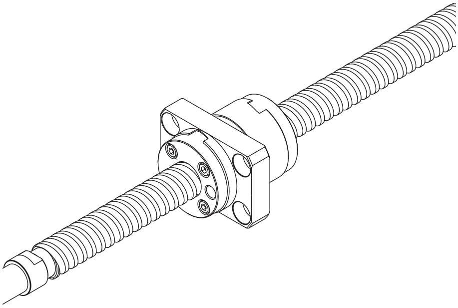


Table of Ball Screw Types with Finished Shaft Ends and the Corresponding Support Units and Nut Brackets

Model No.		BNK								
		0401	0501	0601	0801	0802	0810	1002	1004	1010
Accuracy grades		C3, C5, C7	C3, C5, C7	C3, C5, C7	C3, C5, C7	C3, C5, C7	C5, C7	C3, C5, C7	C3, C5, C7	C5, C7
Axial clearance[Note]		G0 GT G2	G0 GT G2	G0 GT G2	G0 GT G2	G0 GT G2	— GT G2	G0 GT G2	G0 GT G2	G0 GT G2
Stroke (mm)	20	●	●							
	30									
	40	●	●	●	●	●				
	50							●	●	
	60									
	70	●	●	●	●	●				
	100			●	●	●	●	●	●	●
	120									
	150				●	●	●	●	●	●
	170									
	200						●	●	●	●
	250						●		●	●
	300						●			●
	350									
	400									
	450									
	500									
	550									
	600									
	700									
	800									
	900									
	1000									
	1100									
	1200									
	1400									
	1600									
Support unit: square on fixed side		EK4	EK4	EK5	EK6	EK6	EK6	EK8	EK10	EK10
Support unit: round on fixed side		FK4	FK4	FK5	FK6	FK6	FK6	FK8	FK10	FK10
Support unit: square on supported side		—	—	—	EF6	EF6	EF6	EF8	EF10	EF10
Support unit: round on supported side		—	—	—	FF6	FF6	FF6	FF8	FF10	FF10
Nut bracket		—	—	—	—	—	—	—	MC1004	MC1004

Note) Axial clearance: G0: 0 or less
GT: 0.005 mm or less
G2: 0.02 mm or less

For details of the support unit and the nut bracket, see A-802 onward and A-812 onward, respectively.

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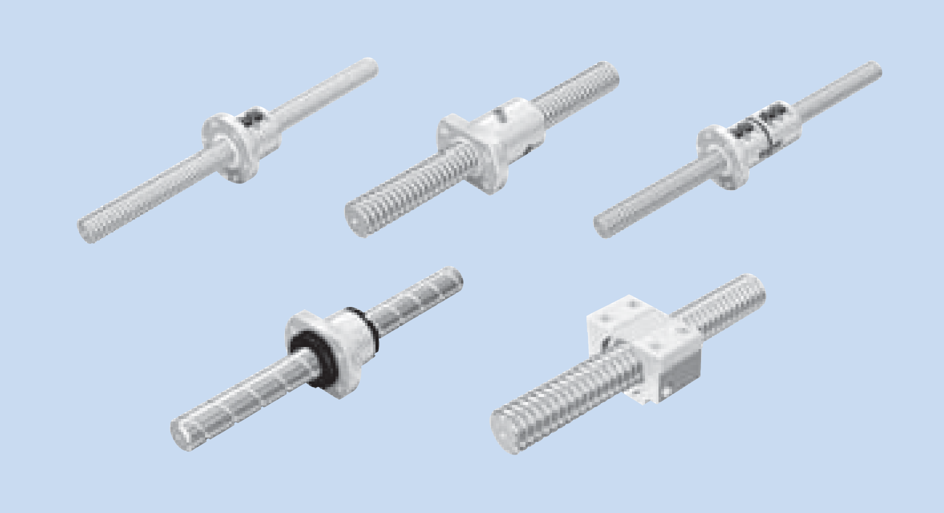
	BNK											
	1202	1205	1208	1402	1404	1408	1510	1520	1616	2010	2020	2520
	C3, C5, C7	C3, C5, C7	C7	C3, C5, C7	C3, C5, C7	C5, C7	C5, C7	C5, C7	C5, C7	C5, C7	C5, C7	C5, C7
	G0 GT G2	G0 GT G2	— — G2	G0 GT G2	G0 GT G2	G0 GT G2	G0 GT G2	G0 GT G2	G0 GT G2	G0 GT G2	G0 GT G2	G0 GT G2
	●	●	●	●								
	●	●	●	●	●							
	●	●	●	●	●	●	●	●	●			
	●	●	●	●	●	●	●	●	●			
	●	●	●			●	●	●	●			
				●	●	●	●	●	●	●	●	
						●	●	●	●			
					●	●	●	●	●	●	●	
						●	●	●	●			
						●	●	●	●	●	●	●
						●	●	●	●			
						●	●	●	●	●	●	●
						●	●	●	●	●	●	
							●	●	●	●	●	●
										●	●	
										●	●	●
										●	●	
												●
												●
												●
	EK10	EK10	EK10	EK12	EK12	EK12	EK12	EK12	EK12	EK15	EK15	EK20
	FK10	FK10	FK10	FK12	FK12	FK12	FK12	FK12	FK12	FK15	FK15	FK20
	EF10	EF10	EF10	EF12	EF12	EF12	EF12	EF12	EF12	EF15	EF15	EF20
	FF10	FF10	FF10	FF12	FF12	FF12	FF12	FF12	FF12	FF15	FF15	FF20
	—	MC1205	MC1205	—	—	MC1408	MC1408	MC1408	MC1408	MC2010	MC2020	—

Precision Ball Screw

Models BIF, DIK, BNFN, DKN, BLW, BNF, DK, MDK, BLK/WGF and BNT



For THK Precision Ball Screws, a wide array of precision-ground screw shafts and ball screw nuts are available as standard to meet diversified applications.

Structure and Features

[Combinations of Various shaft Diameters and Leads]

You can select the combination of a shaft diameter and a lead that meet the intended use from the various nut types and the screw shaft leads. Those nut types include the return-pipe nuts, which represent the most extensive variations among the series, the compact simple nuts and the large-lead end-cap nuts.

[Standard-stock Types (with Unfinished Shaft Ends/Finished Shaft Ends) are Available]

The unfinished shaft end types, which are mass manufactured by cutting the standardized screw shafts to the standard lengths, and those with finished shaft ends, for which the screw shaft ends are machined to match the corresponding the support units, are available as the standard.

[Accuracy Standards Compliant with JIS (ISO)]

The accuracy of the Ball Screw is controlled in accordance with the JIS standards (JIS B1192-1997).

	Precision Ball Screw						Rolled Ball Screw	
Accuracy grades	C0	C1	C2	C3	C5	C7	C8	C10

Type	Series symbol	Grade	Remarks
For positioning	C	0, 1, 3, 5	JIS series
	Cp	1, 3, 5	ISO compliant
For conveyance	Ct	1, 3, 5, 7, 10	

[Options that Meet the Environment are Available]

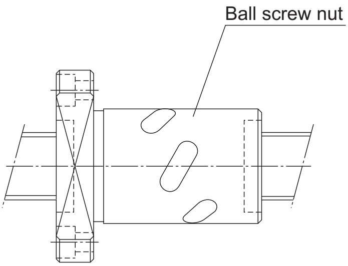
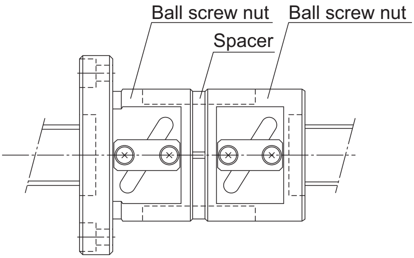
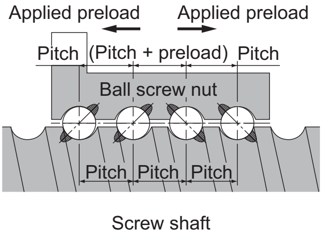
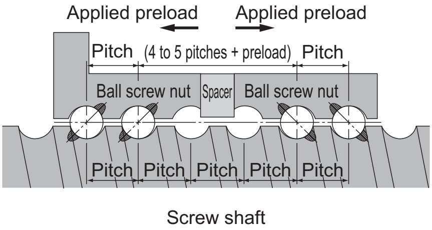
Options are available consisting of a lubricator (QZ), which enables the maintenance interval to be significantly extended, and a wiper ring (W), which improves the ability to remove foreign materials in adverse environments.

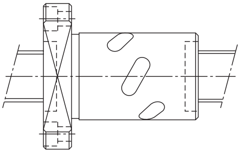
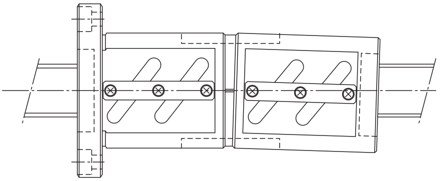
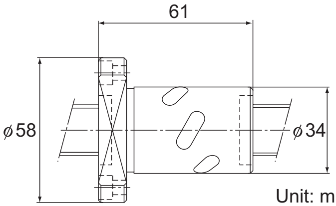
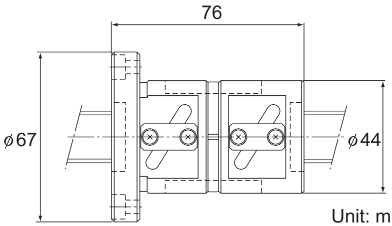
[Structure and Features of Offset Preload Type Simple-Nut Ball Screw Model DIK]

The Simple-Nut Ball Screw model DIK is an offset preload type in which a phase is provided in the middle of a single ball screw nut, and an axial clearance is set at a below-zero value (under a preload).

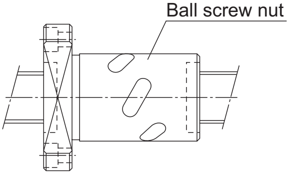
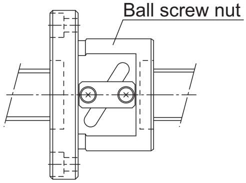
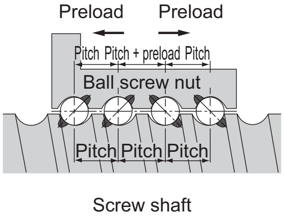
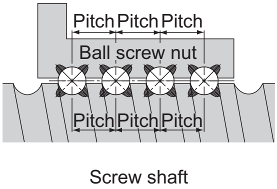
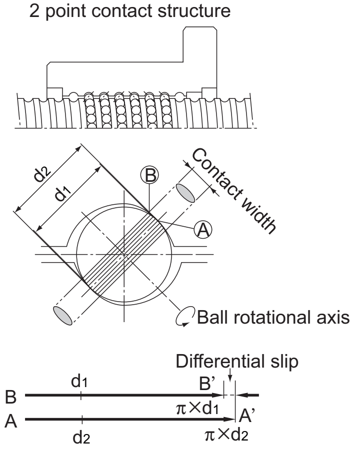
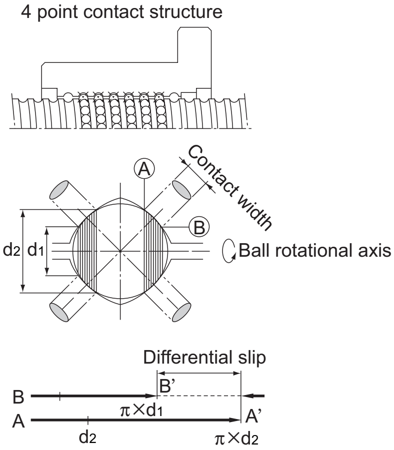
Model DIK has a more compact structure and allows smoother motion than the conventional double-nut type (spacer inserted between two nuts).

[Comparison between the Simple Nut and the Double-Nuts]

<table>
<tr><th>Simple-Nut Ball Screw Model DIK</th><th>Conventional Double-Nut Type Ball Screw Model BNFN</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">Preloading Structure</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

<table>
<tr><th>Simple-Nut Ball Screw Model DIK</th><th>Conventional Double-Nut Type Ball Screw Model BNFN</th></tr>
<tr><td colspan="2">Rotational Performance</td></tr>
<tr><td>The preload adjustment with Simple Nut Ball Screw model DIK is performed according to the ball diameter. This eliminates the inconsistency in the contact angle, which is the most important factor of the Ball Screw performance. It also ensures the high rigidity, the smooth motion and the high wobbling accuracy.
</td><td>The use of a spacer in the double-nuts tends to cause inconsistency in the contact angle due to inaccurate flatness of the spacer surface and an inaccurate perpendicularity of the nut. This results in a non-uniform ball contact, an inferior rotational performance and a low wobbling accuracy.
</td></tr>
<tr><td colspan="2">Dimensions</td></tr>
<tr><td>Since Simple-Nut Ball Screw model DIK is based on a preloading mechanism that does not require a spacer, the overall nut length can be kept short. As a result, the whole nut can be lightly and compactly designed.

Unit: mm
Model DIK 2005-6</td><td>
Unit: mm
Model BNFN 2005-2.5</td></tr>
</table>

[Comparison between the Offset Preload Type of Simple-Nut Ball Screw and the Oversize Preload Nut Ball Screw]

<table>
<tr><th>Simple-Nut Ball Screw Model DIK</th><th>Conventional Oversize Preload Nut Ball Screw Model BNF</th></tr>
<tr><td> </td><td> </td></tr>
<tr><td colspan="2">Preloading Structure</td></tr>
<tr><td> </td><td> </td></tr>
<tr><td colspan="2">Accuracy Life</td></tr>
<tr><td>Simple-Nut Ball Screw model DIK has a similar preloading structure to that of the double-nut type although the former only has one ball screw shaft. As a result, no differential slip or spin occurs, thus to minimize the increase in the rotational torque and the generation of heat. Accordingly, a high level of accuracy can be maintained over a long period.
 </td><td>With the oversize preload nut Ball Screw, a preload is provided through the balls each in contact with the raceway at four points. This causes differential slip and spin to increase the rotational torque, resulting in an accelerated wear and a heat generation. Therefore, the accuracy deteriorates in a short period.
 </td></tr>
</table>

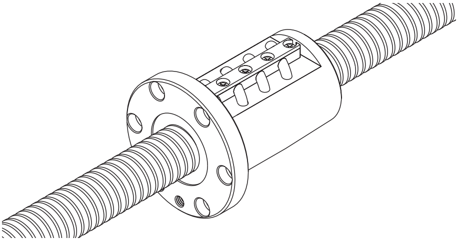
Types and Features

[Preload Type]

Model BIF

Specification Table⇒B-652

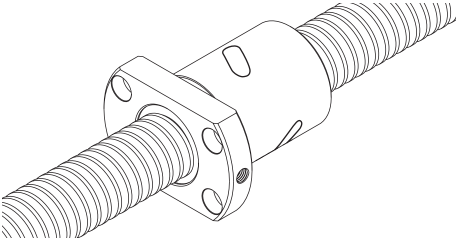
The right and the left screws are provided with a phase in the middle of the ball screw nut, and an axial clearance is set at a below-zero value (under a preload). This compact model is capable of a smooth motion.



Model DIK

Specification Table⇒B-652

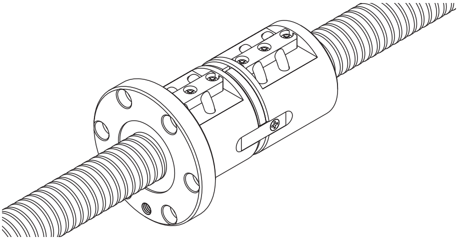
The right and the left screws are provided with a phase in the middle of the ball screw nut, and an axial clearance is set at a below-zero value (under a preload). This compact model is capable of a smooth motion.



Model BNFN

Specification Table⇒B-652

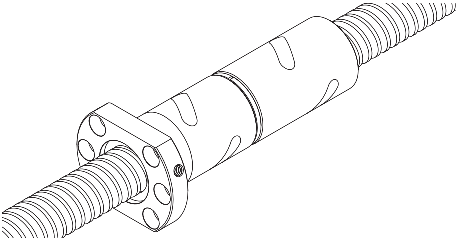
The most common type with a preload provided via a spacer between the two combined ball screw nuts to eliminate the backlash. It can be mounted using the bolt holes drilled on the flange.



Model DKN

Specification Table⇒B-672

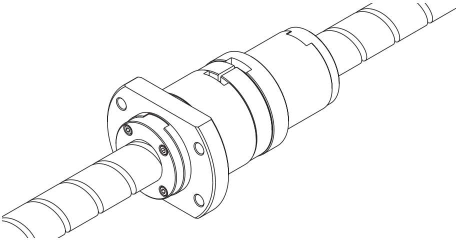
A preload is provided via a spacer between the two combined ball screw nuts to achieve a below-zero axial clearance (under a preload).



Model BLW

Specification Table⇒B-652

Since a preload is provided through a spacer between two large lead nuts, high-speed feed without by backlash is ensured.

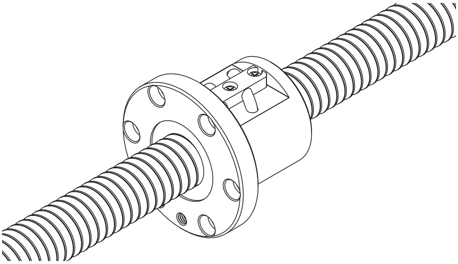


[No Preload Type]

Model BNF

Specification Table⇒B-686

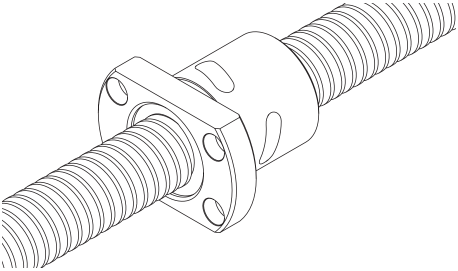
The simplest type with a single ball screw nut. It is designed to be mounted using the bolt holes drilled on the flange.



Model DK

Specification Table⇒B-686

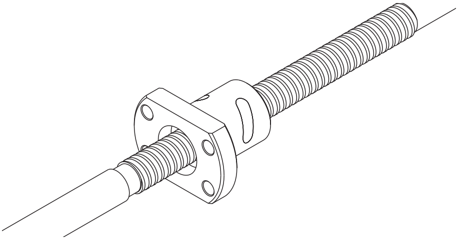
The most compact type, with a ball screw nut diameter 70 to 80% of that of the return-pipe nut.



Model MDK

Specification Table⇒B-686

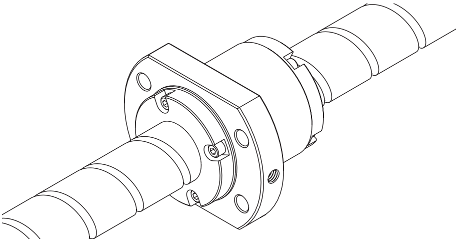
This model is a miniature nut with a screw shaft diameter of ϕ4 to 14 mm and a lead of 1 to 5 mm.



Models BLK/WGF

Specification Table⇒B-686

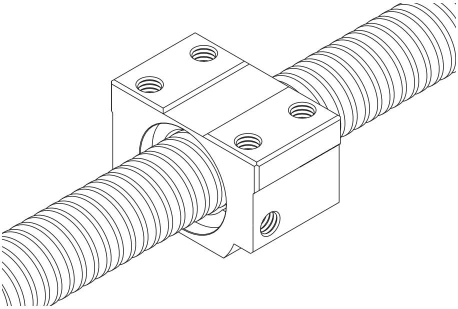
With model BLK, the shaft diameter is equal to the lead dimension. Model WGF has a lead dimension 1.5 to 3 times longer than the shaft diameter.



Square Ball Screw Nut Model BNT

Specification Table⇒B-716

Since mounting screw holes are machined on the square ball screw nut, this model can compactly be mounted on the machine without a housing.



Service Life

For details,see A-704.

Axial Clearance

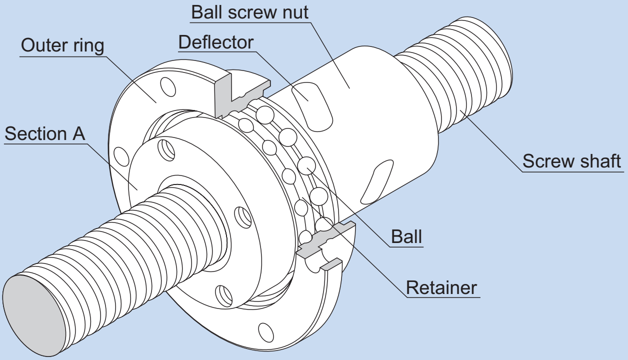
For details,see A-685.

Accuracy Standards

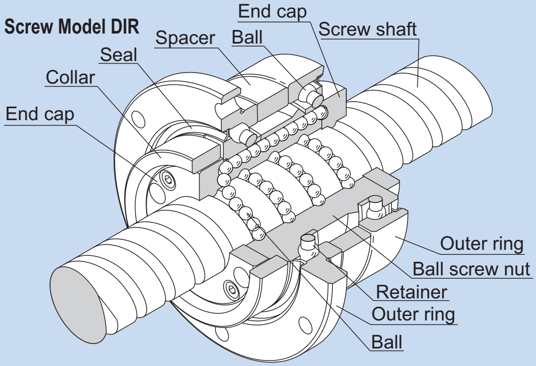
For details,see A-678.

Precision Rotary Ball Screw

Models DIR and BLR



Structure of Standard-Lead Rotary Nut Ball Screw Model DIR



Structure of Large Lead Rotary Nut Ball Screw Model BLR

Structure and Features

[Model DIR]

Standard-Lead Rotary-Nut Ball Screw model DIR is a rotary-nut Ball Screw that has a structure where a simple-nut Ball Screw is integrated with a support bearing.

Its ball screw nut serves as a ball recirculation structure using deflectors. Balls travel along the groove of the deflector mounted in the ball screw nut to the adjacent raceway, and then circulate back to the loaded area to complete an infinite rolling motion.

Being an offset preload nut, the single ball screw nut provides different phases to the right and left thread in the middle of the nut, thus to set the axial clearance below zero (a preload is provided). This allows more compact, smoother motion to be achieved than the conventional double-nut type (a spacer is inserted between two nuts).

The support bearing comprises of two rows of DB type angular bearings with a contact angle of 45° to provide a preload. The collar, previously used to mount a pulley, is integrated with the ball screw nut. (See the A section.)

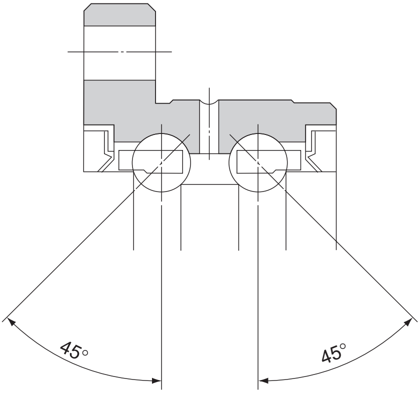


Fig.1 Structure of the Support Bearing

● Compact

Because of the internal circulation mechanism using a deflector, the outer diameter is only 70 to 80%, and the overall length is 60 to 80%, of that of the return-pipe nut, thus to reduce the weight and decrease the inertia during acceleration.

Since the nut and the support bearing are integrated, a highly accurate, and a compact design is achieved.

In addition, small inertia due to the lightweight ball screw nut ensures high responsiveness.

● Capable of Fine Positioning

Being a Standard-Lead Ball Screw, it is capable of fine positioning despite that the ball screw nut rotates.

● Accuracy can Easily be Established

As the support bearing is integrated with the outer ring, the bearing can be assembled with the nut housing on the end face of the outer ring flange. This makes it easy to center the ball screw nut and establish accuracy.

● Well Balanced

Since the deflector is evenly placed along the circumference, a superb balance is ensured while the ball screw nut is rotating.

- **Stability in the Low-speed Range**

Traditionally, motors tend to have an uneven torque and a speed in the low-speed range due to the external causes. With model DIR, the motor can be connected independently with the screw shaft and the ball screw nut, thus to allow micro feeding within the motor's stable rotation range.

[Model BLR]

The Rotary Ball Screw is a rotary-nut ball screw unit that has an integrated structure consisting of a ball screw nut and a support bearing. The support bearing is an angular bearing that has a contact angle of 60°, contains an increased number of balls and achieves large axial rigidity.

Model BLR is divided into two types: Precision Ball Screw and Rolled Screw Ball.

- **Smooth Motion**

It achieves smoother motion than rack-and-pinion based straight motion. Also, since the screw shaft does not rotate because of the ball screw nut drive, this model does not show skipping, produces low noise and generates little heat.

- **Low Noise even in High-speed Rotation**

Model BLR produces very low noise when the balls are picked up along the end cap. In addition, the balls circulate by passing through the ball screw nut, allowing this model to be used at high speed.

- **High Rigidity**

The support bearing of this model is larger than that of the screw shaft rotational type. Thus, its axial rigidity is significantly increased.

- **Compact**

Since the nut and the support bearing are integrated, a highly accurate, and a compact design is achieved.

- **Easy Installation**

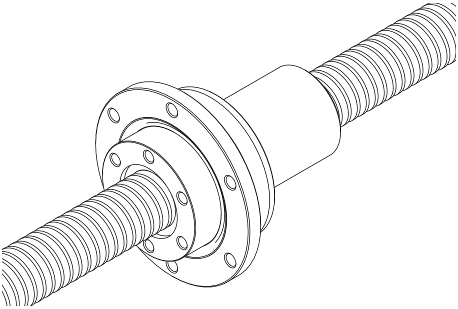
By simply mounting this model to the housing with bolts, a ball screw nut rotating mechanism can be obtained. (For the housing's inner-diameter tolerance, H7 is recommended.)

Type

[Preload Type]

Model DIR

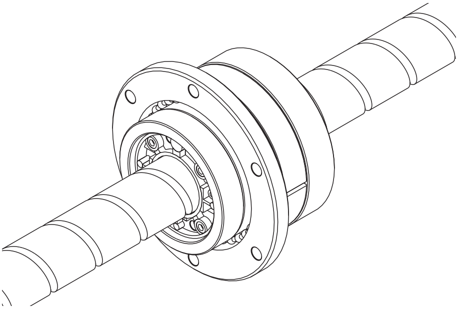
Specification Table⇒B-720



[No Preload Type]

Model BLR

Specification Table⇒B-722



Service Life

For details,see A-704.

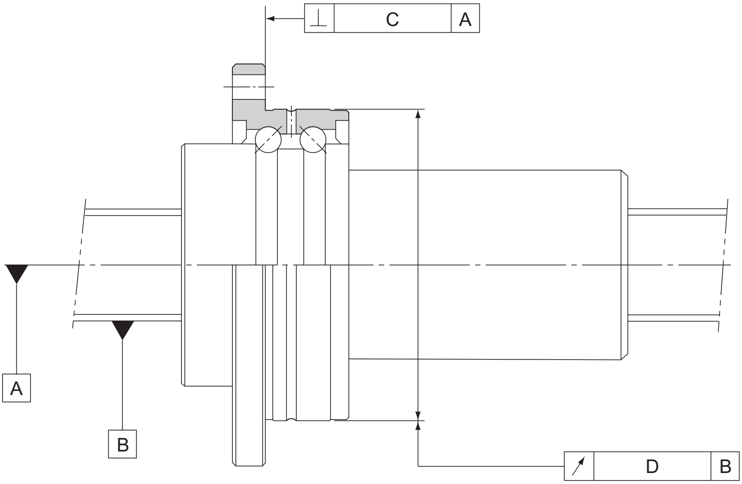
Axial Clearance

For details,see A-685.

Accuracy Standards

[Model DIR]

The accuracy of model DIR is compliant with a the JIS standard (JIS B 1192-1997) except for the radial runout of the circumference of the ball screw nut from the screw axis (D) and the perpendicularity of the flange-mounting surface against the screw axis (C).

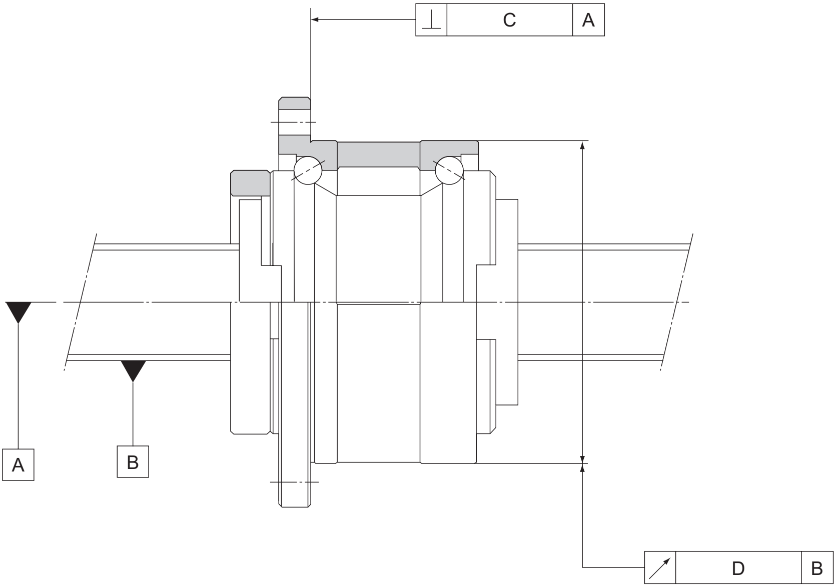


Unit: mm

Accuracy grades	C3		C5		C7	
Model No.	C	D	C	D	C	D
DIR 16□□	0.013	0.017	0.016	0.020	0.023	0.035
DIR 20□□	0.013	0.017	0.016	0.020	0.023	0.035
DIR 25□□	0.015	0.020	0.018	0.024	0.023	0.035
DIR 32□□	0.015	0.020	0.018	0.024	0.023	0.035
DIR 36□□	0.016	0.021	0.019	0.025	0.024	0.036
DIR 40□□	0.018	0.026	0.021	0.033	0.026	0.036

[Model BLR]

The accuracy of model BLR is compliant with a the JIS standard (JIS B 1192-1997) except for the radial runout of the circumference of the ball screw nut from the screw axis (D) and the perpendicularity of the flange-mounting surface against the screw axis (C).

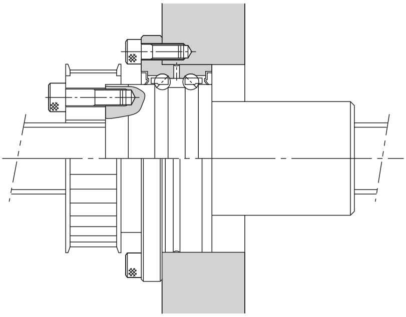


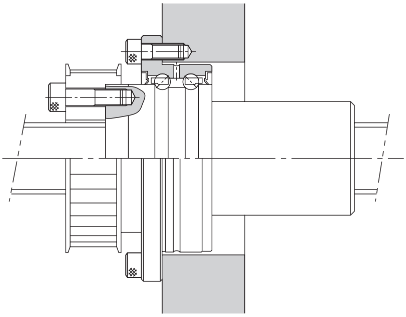
Unit: mm

Lead angle accuracy	C3		C5		C7	
Accuracy grades	C3		C5		C7	
Model No.	C	D	C	D	C	D
BLR 1616	0.013	0.017	0.016	0.020	0.023	0.035
BLR 2020	0.013	0.017	0.016	0.020	0.023	0.035
BLR 2525	0.015	0.020	0.018	0.024	0.023	0.035
BLR 3232	0.015	0.020	0.018	0.024	0.023	0.035
BLR 3636	0.016	0.021	0.019	0.025	0.024	0.036
BLR 4040	0.018	0.026	0.021	0.033	0.026	0.046
BLR 5050	0.018	0.026	0.021	0.033	0.026	0.046

Example of Assembly

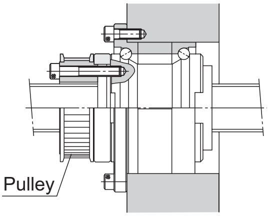
[Example of Mounting Ball Screw Nut Model DIR]



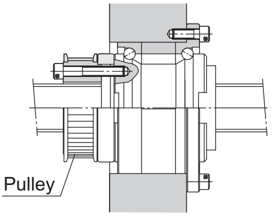


Installation to the housing can be performed on the end face of the outer ring flange.

[Example of Mounting Ball Screw Nut Model BLR]



Standard installation method



Inverted flange

Note) If the flange is to be inverted, indicate “K” in the model number. (applicable only to model BLR)

Example: BLR 2020-3.6 K UU

Symbol for inverted flange (No symbol for standard flange orientation)

[Example of Mounting Model BLR on the Table]

(1) Screw shaft free, ball screw nut fixed
(Suitable for a long table)

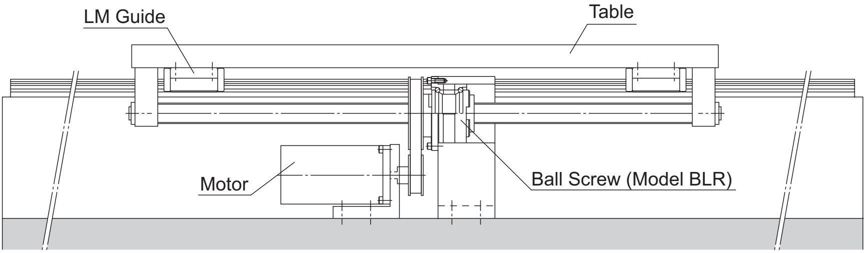


Fig.2 Example of Installation on the Table (Ball Screw Nut Fixed)

(2) Ball screw nut free, screw shaft fixed
(Suitable for a short table and a long stroke)

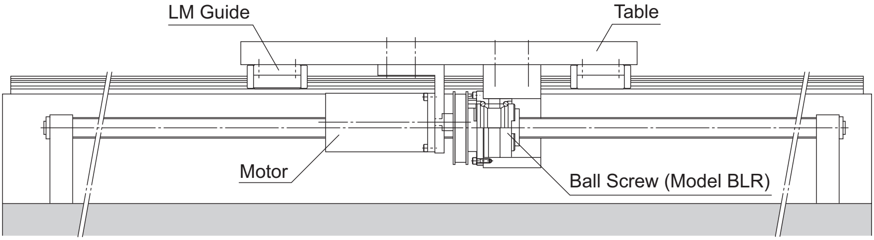
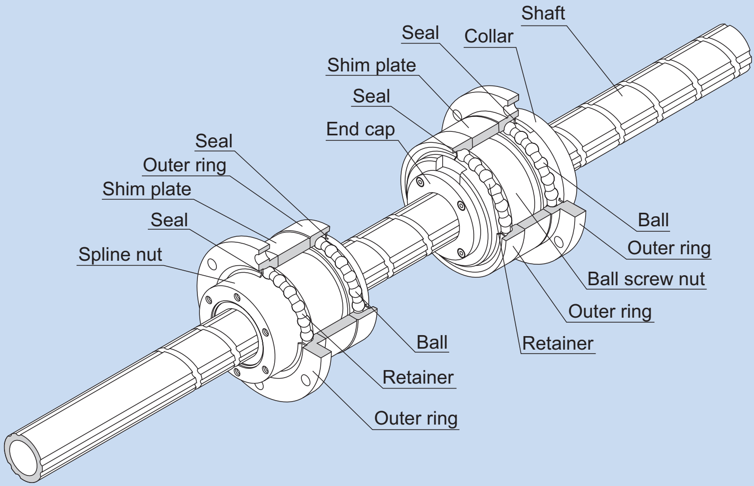


Fig.3 Example of Installation on the Table (Screw Shaft Fixed)

Precision Ball Screw/Spline

Models BNS-A, BNS, NS-A and NS



Structure and Features

The Ball Screw/Spline contains the Ball Screw grooves and the Ball Spline groove crossing one another. The nuts of the Ball Screw and the Ball Spline have dedicated support bearings directly embedded on the circumference of the nuts.
The Ball Screw/Spline is capable of performing three (rotational, linear and spiral) modes of motion with a single shaft by rotating or stopping the spline nut.
It is optimal for machines using a combination of rotary and straight motions, such as scholar robot's Z-axis, assembly robot, automatic loader, and machining center's ATC equipment.

[Zero Axial Clearance]

The Ball Spline has an angular-contact structure that causes no backlash in the rotational direction, enabling highly accurate positioning.

[Lightweight and Compact]

Since the nut and the support bearing are integrated, highly accurate, compact design is achieved. In addition, small inertia because of the lightweight ball screw nut ensures high responsiveness.

[Easy Installation]

The Ball Spline nut is designed so that balls do not fall off even if the spline nut is removed from the shaft, making installation easy. The Ball Screw/Spline can easily be mounted simply by securing it to the housing with bolts. (For the housing's inner-diameter tolerance, H7 is recommended.)

[Smooth Motion with Low Noise]

As the Ball Screw is based on an end cap mechanism, smooth motion with low noise is achieved.

[Highly Rigid Support Bearing]

The support bearing on the Ball Screw has a contact angle of 60° in the axial direction while that on the Ball Spline has a contact angle of 30° in the moment direction, thus to provide a highly rigid shaft support.
In addition, a dedicated rubber seal is attached as standard to prevent entry of foreign materials.

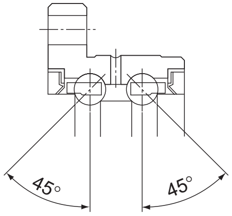


Fig.1 Structure of Support Bearing Model BNS-A

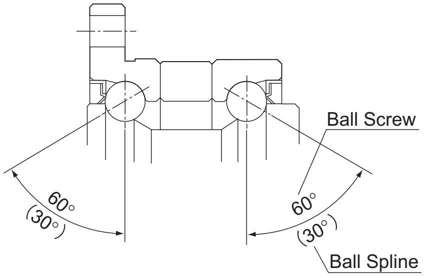
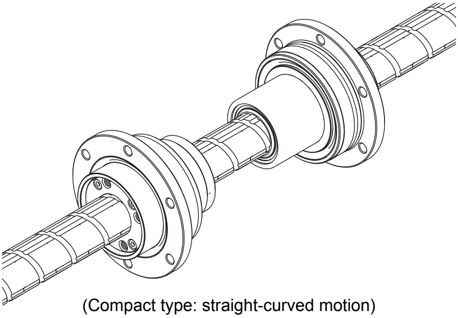


Fig.2 Structure of Support Bearing Model BNS

Type

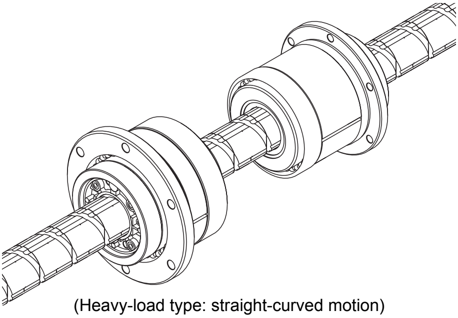
[No Preload Type]

Model BNS-A Specification Table⇒B-726



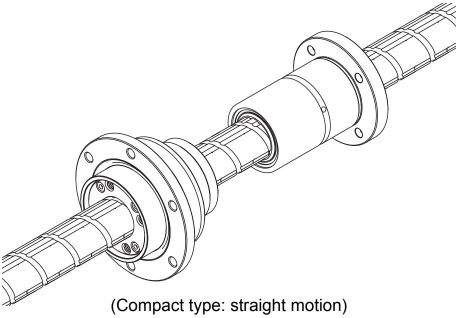
(Compact type: straight-curved motion)

Model BNS Specification Table⇒B-728



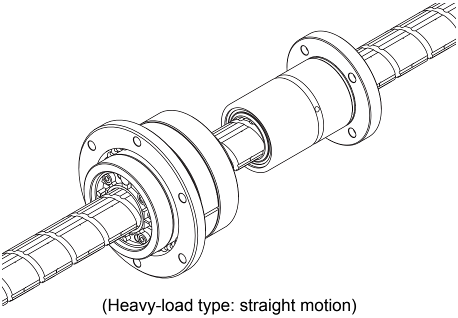
(Heavy-load type: straight-curved motion)

Model NS-A Specification Table⇒B-730



(Compact type: straight motion)

Model NS Specification Table⇒B-732



(Heavy-load type: straight motion)

Service Life

For details,see A-704.

Axial Clearance

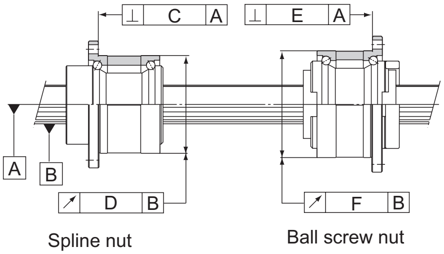
For details,see A-685.

Accuracy Standards

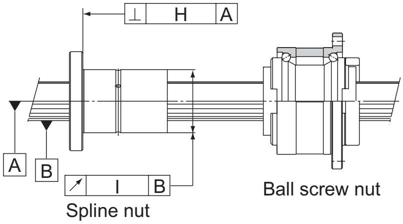
The Ball Screw/Spline is manufactured with the following specifications.

[Ball Screw]
Axial clearance: 0 or less
Lead angle accuracy: C5
(For detailed specifications, see A-678.)

[Ball Spline]
Clearance in the rotational direction: 0 or less (CL: light preload)
(For detailed specifications, see A-481.)
Accuracy grade: class H
(For detailed specifications, see A-482.)



Model BNS



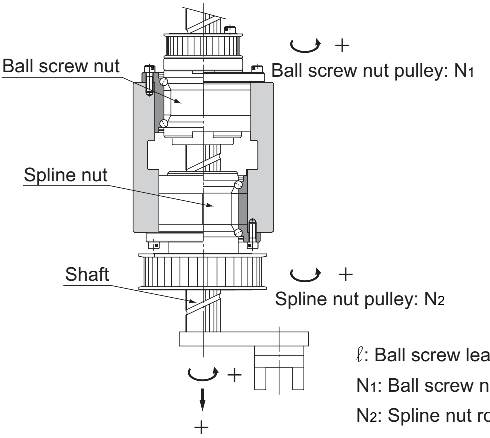
Model NS

Unit: mm

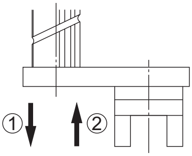
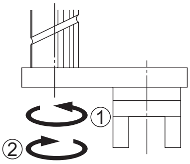
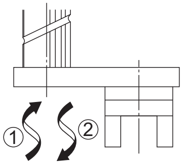
Model No.	C	D	E	F	H	I
BNS 0812 NS 0812	0.014	0.017	0.014	0.016	0.010	0.013
BNS 1015 NS 1015	0.014	0.017	0.014	0.016	0.010	0.013
BNS 1616 NS 1616	0.018	0.021	0.016	0.020	0.013	0.016
BNS 2020 NS 2020	0.018	0.021	0.016	0.020	0.013	0.016
BNS 2525 NS 2525	0.021	0.021	0.018	0.024	0.016	0.016
BNS 3232 NS 3232	0.021	0.021	0.018	0.024	0.016	0.016
BNS 4040 NS 4040	0.025	0.025	0.021	0.033	0.019	0.019
BNS 5050 NS 5050	0.025	0.025	0.021	0.033	0.019	0.019

Action Patterns

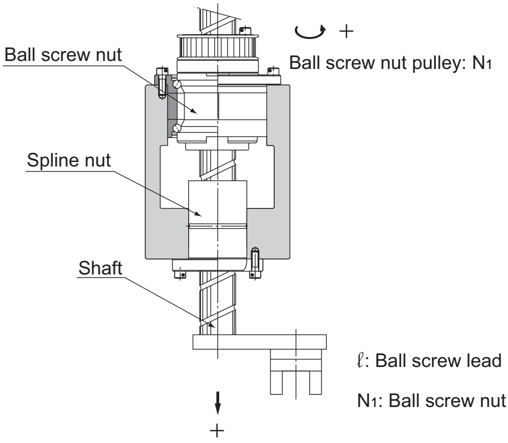
[Model BNS Basic Actions]



ℓ: Ball screw lead (mm)
N_1: Ball screw nut rotational speed (min^{-1})
N_2: Spline nut rotational speed (min^{-1})

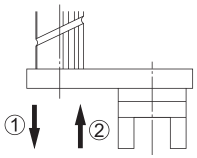
Motion		Action direction	Input		Shaft motion	
			Ball screw pulley	Ball spline pulley	Vertical direction (speed)	Rotational direction (rotation speed)
1. Vertical 	(1)	Vertical direction→down Rotational direction→0	N_1 (Forward)	0	$V=N_1\cdot\ell$ $(N_1\neq0)$	0
	(2)	Vertical direction→up Rotational direction→0	$-N_1$ (Reverse)	0	$V=-N_1\cdot\ell$ $(N_1\neq0)$	0
2. Rotation 	(1)	Vertical direction→0 Rotational direction→forward	N_1	N_2 (Forward)	0	N_2(Forward) $(N_1=N_2\neq0)$
	(2)	Vertical direction→0 Rotational direction→reverse	$-N_1$	$-N_2$ (Reverse)	0	$-N_2$(Reverse) $(-N_1=-N_2\neq0)$
3. Spiral 	(1)	Vertical direction→up Rotational direction→forward	0	N_2 $(N_2\neq0)$	$V=N_2\cdot\ell$	N_2 (Forward)
	(2)	Vertical direction→down Rotational direction→reverse	0	$-N_2$ $(-N_2\neq0)$	$V=-N_2\cdot\ell$	$-N_2$ (Reverse)

[Model NS Basic Actions]

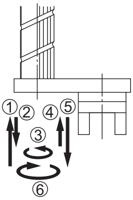
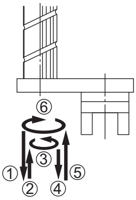
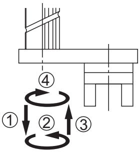
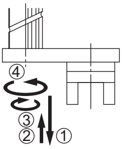


ℓ: Ball screw lead (mm)

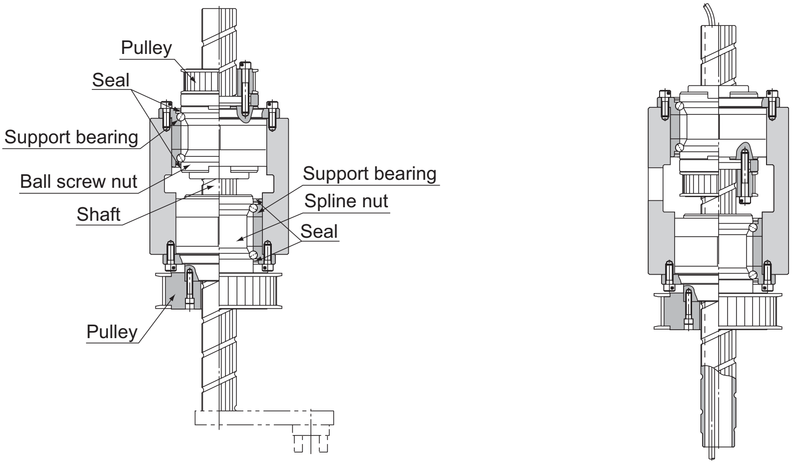
N_1: Ball screw nut rotational speed (min^{-1})

Motion		Action direction	Input	Shaft motion
			Ball screw pulley	Vertical direction (speed)
1. Vertical 	(1)	Vertical direction →down	N_1 (Forward)	$V=N_1\cdot\ell$ ($N_1\neq0$)
	(2)	Vertical direction →up	$-N_1$ (Reverse)	$V=-N_1\cdot\ell$ ($N_1\neq0$)

[Model BNS Extended Actions]

Motion		Action direction	Input		Shaft motion	
			Ball screw pulley	Ball spline pulley	Vertical direction (speed)	Rotational direction (rotational speed)
1. Up→down→forward →up→down→reverse 	(1)	Vertical direction→up	$-N_1$ (Reverse)	0	$V=-N_1 \cdot \ell$ $(N_1 \neq 0)$	0
	(2)	Vertical direction→down	N_1 (Forward)	0	$V=N_1 \cdot \ell$ $(N_1 \neq 0)$	0
	(3)	Rotational direction→forward	N_1	N_2 (Forward)	0	N_2(Forward) $(N_1=N_2 \neq 0)$
	(4)	Vertical direction→up	$-N_1$	0	$V=-N_1 \cdot \ell$ $(N_1 \neq 0)$	0
	(5)	Vertical direction→down	N_1	0	$V=N_1 \cdot \ell$ $(N_1 \neq 0)$	0
	(6)	Rotational direction→reverse	$-N_1$	$-N_2$ (Reverse)	0	$-N_2$(Reverse) $(-N_1=N_2 \neq 0)$
2. Down→up→forward →down→up→reverse 	(1)	Vertical direction→down	N_1	0	$V=N_1 \cdot \ell$ $(N_1 \neq 0)$	0
	(2)	Vertical direction→up	$-N_1$	0	$V=-N_1 \cdot \ell$ $(N_1 \neq 0)$	0
	(3)	Rotational direction→forward	N_1	N_2	0	N_2 $(N_1=N_2 \neq 0)$
	(4)	Vertical direction→down	N_1	0	$V=N_1 \cdot \ell$ $(N_1 \neq 0)$	0
	(5)	Vertical direction→up	$-N_1$	0	$V=-N_1 \cdot \ell$ $(N_1 \neq 0)$	0
	(6)	Rotational direction→reverse	$-N_1$	$-N_2$	0	$-N_2$ $(-N_1=N_2 \neq 0)$
3. Down→forward →up→reverse 	(1)	Vertical direction→down	N_1	0	$V=N_1 \cdot \ell$ $(N_1 \neq 0)$	0
	(2)	Rotational direction→forward	N_1	N_2	0	N_2 $(N_1=N_2 \neq 0)$
	(3)	Vertical direction→up	$-N_1$	0	$V=-N_1 \cdot \ell$ $(N_1 \neq 0)$	0
	(4)	Rotational direction→reverse	$-N_1$	$-N_2$	0	$-N_2$ $(-N_1=N_2 \neq 0)$
4. Down→up →reverse→forward 	(1)	Vertical direction→down	N_1	0	$V=N_1 \cdot \ell$ $(N_1 \neq 0)$	0
	(2)	Vertical direction→up	$-N_1$	0	$V=-N_1 \cdot \ell$ $(N_1 \neq 0)$	0
	(3)	Rotational direction→reverse	$-N_1$	$-N_2$	0	$-N_2$ $(-N_1=N_2 \neq 0)$
	(4)	Rotational direction→forward	N_1	N_2	0	N_2 $(N_1=N_2 \neq 0)$

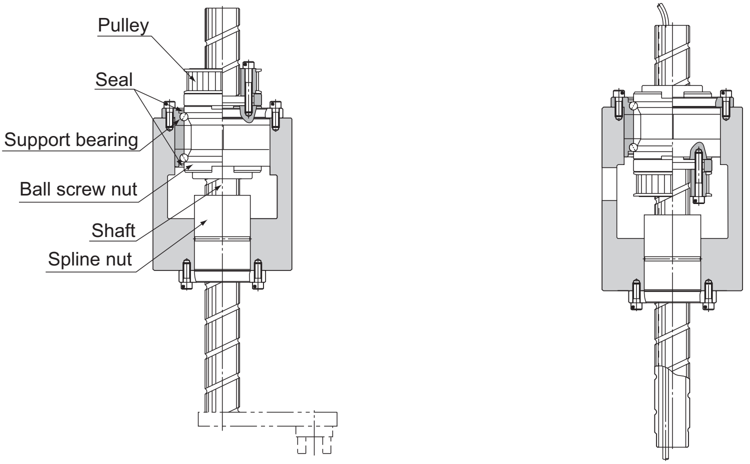
Example of Assembly



●Example of installing the ball screw nut input pulley and the spline nut input pulley, both outside the housing. The housing length is minimized.

●Example of installing the ball screw nut pulley inside the housing.

Fig.3 Example of Assembling Model BNS



●Example of installing the ball screw nut pulley outside the housing. The housing length is minimized.

●Example of installing the ball screw nut pulley inside the housing.

Fig.4 Example of Assembling Model NS

Example of Using the Spring Pad

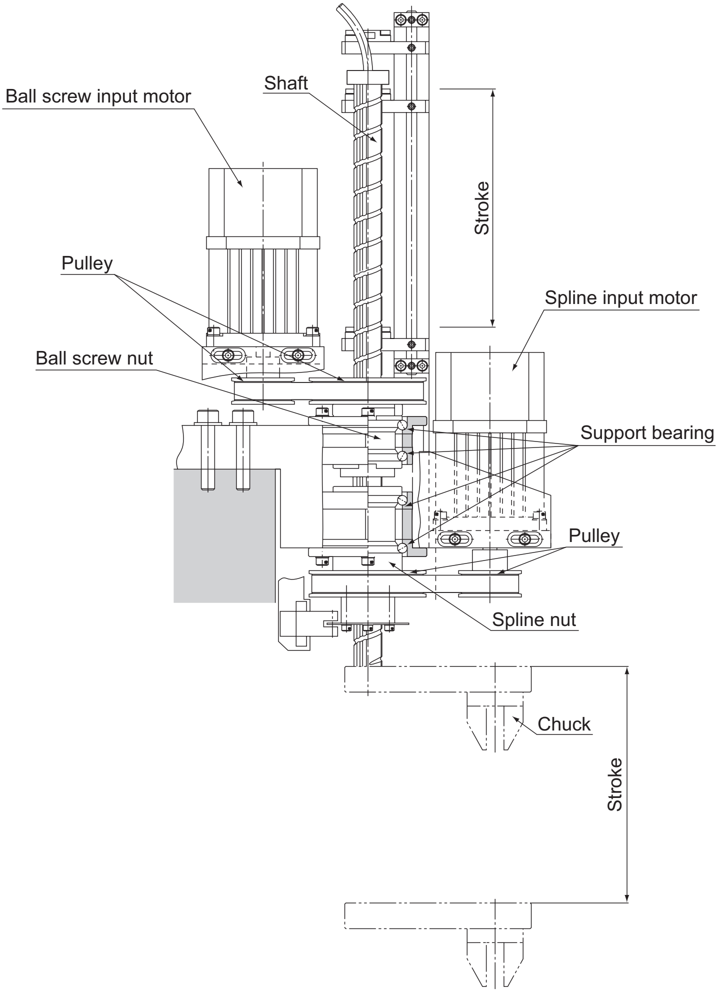


Fig.5 Example of Using Model BNS

Precautions on Use

[Lubrication]

When lubricating the Ball Screw/Spline, attach the greasing plate to the housing in advance.

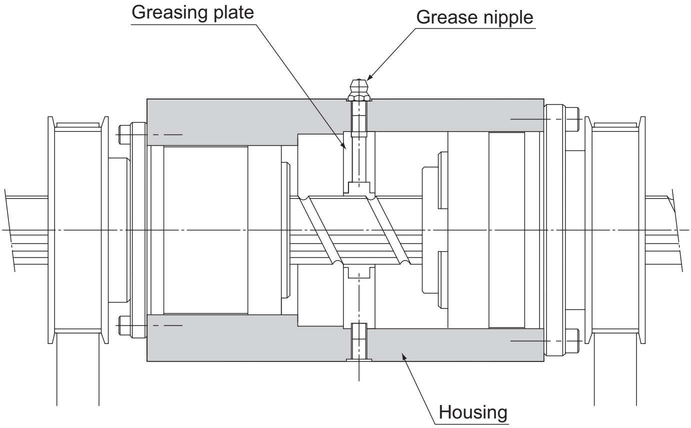
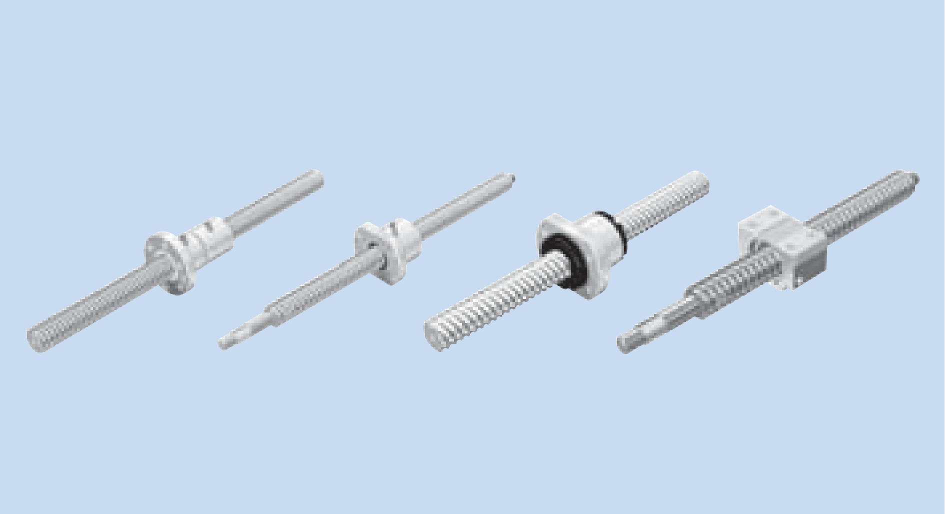


Fig.6 Lubrication Methods

Rolled Ball Screw

Models JPF, BTK, MTF, BLK/WTF, CNF and BNT



Structure and Features

THK Rolled Ball Screws are low priced feed screws that use a screw shaft rolled with high accuracy and specially surface-ground, instead of a thread-ground shaft used in the Precision Ball Screws.
The ball raceways of the ball screw nut are all thread-ground, thus to achieve a smaller axial clearance and smoother motion than the conventional rolled ball screw.
In addition, a wide array of types are offered as standard in order to allow optimal products to be selected according to the application.

[Achieves Lead Angle Accuracy of Class C7]

Screw shafts with travel distance error of classes C7 and C8 are also manufactured as the standard in addition to class C10 to meet a broad range of applications.

Travel distance C7: ±0.05/300 (mm)
C8: ±0.10/300 (mm)
C10: ±0.21/300 (mm)

(For maximum length of screw shaft by accuracy grade, see A-691.)

[Achieves Roughness of the Ball Raceways of the Screw Shaft at 0.20 a or Less]

The surface of the screw shaft's ball raceways is specially ground after the shaft is rolled to ensure surface roughness of 0.20 a or less, which is equal to that of the ground thread of the Precision Ball Screw.

[The Ball Raceways of the Ball Screw Nut are All Finished by Grinding]

THK finishes the ball raceways of Rolled Ball Screw nuts by grinding, just as the Precision Ball Screws, to secure the durability and the smooth motion.

[Low Price]

The screw shaft is induction-hardened or carburized after being rolled, and its surface is then specially ground. This allows the rolled Ball Screw to be priced lower than the Precision Ball Screw with a ground thread.

[High Dust-prevention Effect]

The ball screw nut is incorporated with a compact labyrinth seal or a brush seal. This achieves a low friction, a high dust-prevention effect and a longer service life of the Ball Screw.

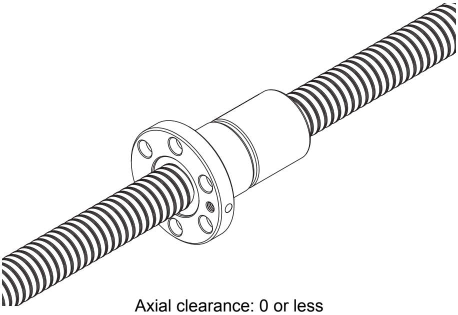
Types and Features

[Preload Type]

Model JPF

Specification Table⇒B-736

This model achieves a zero-backlash through a constant preloading method by shifting the phase with the central part of a simple nut as the spring structure.
The constant preload method allows the ball screw to absorb a pitch error and achieve a smooth motion.



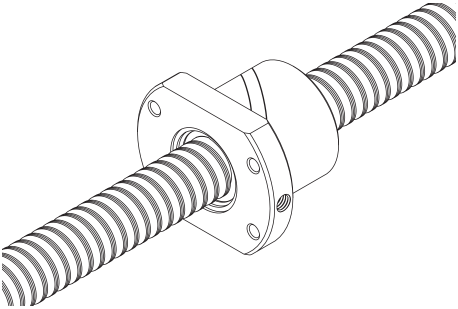
Axial clearance: 0 or less

[No Preload Type]

Model BTK

Specification Table⇒B-738

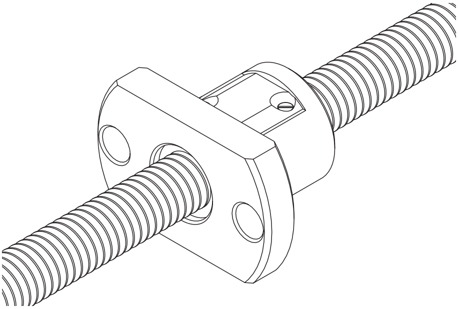
A compact type with a round nut incorporated with a return pipe. The flange circumference is cut flat at the top and bottom, allowing the shaft center to be positioned lower.



Model MTF

Specification Table⇒B-738

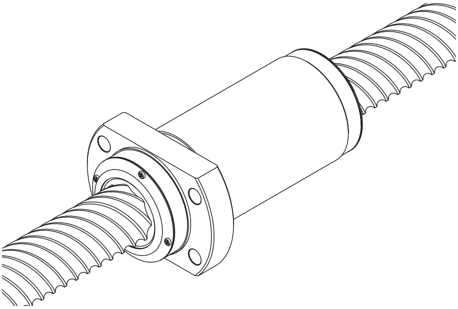
A miniature type with a screw shaft diameter of ϕ6 to ϕ12 mm and a lead of 1 to 2 mm.



Models BLK/WTF

Specification Table⇒B-738

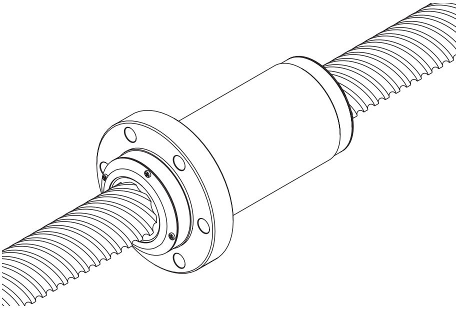
Using an end-cap method, these models achieve stable motion in a high-speed rotation.



Model CNF

Specification Table⇒B-738

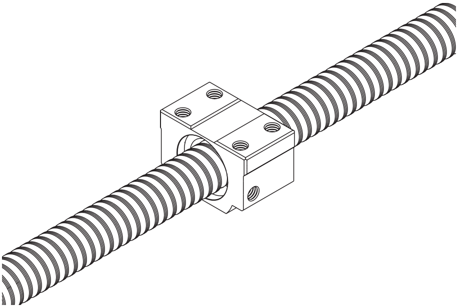
With a combination of 4 rows of large-lead loaded grooves and a long nut, a long service life is achieved.



Square Ball Screw Nut Model BNT

Specification Table⇒B-744

Since the mounting screw holes are machined on the square ball screw nut, this model can compactly be mounted on the machine without a housing.



Service Life

For details,see A-704.

Axial Clearance

For details,see A-685.

Accuracy Standards

For details,see A-678.

Rolled Rotary Ball Screw

Model BLR

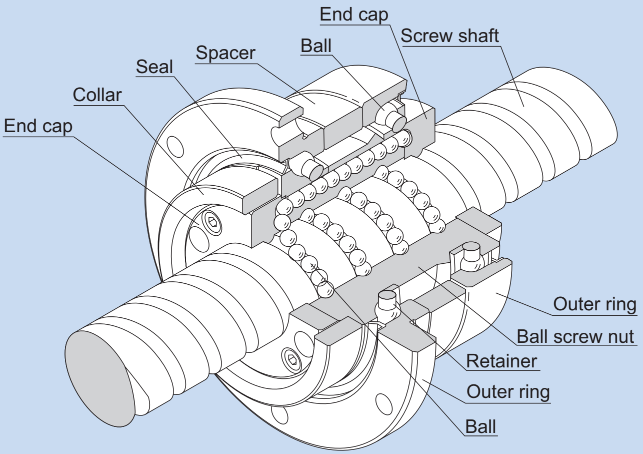


Fig.1 Structure of Large Lead Rotary Nut Ball Screw Model BLR

Structure and Features

The Rotary Ball Screw is a rotary-nut ball screw unit that has an integrated structure consisting of a ball screw nut and a support bearing. The support bearing is an angular bearing that has a contact angle of 60°, contains an increased number of balls and achieves a large axial rigidity.
Model BLR is divided into two types: the Precision Ball Screw and the Rolled Screw Ball.

[Smooth Motion]

It achieves smoother motion than the rack-and-pinion based straight motion. Also, since the screw shaft does not rotate because of the ball screw nut drive, this model does not show skipping, produces low noise and generates little heat.

[Low Noise even in High-speed Rotation]

Model BLR produces very low noise when the balls are picked up along the end cap. In addition, the balls circulate by passing through the ball screw nut, allowing this model to be used at high speed.

[High Rigidity]

The support bearing of this model is larger than that of the screw shaft rotational type. Thus, its axial rigidity is significantly increased.

[Compact]

Since the nut and the support bearing are integrated, a highly accurate, and a compact design is achieved.

[Easy Installation]

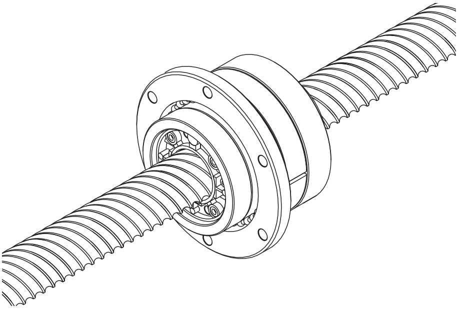
By simply mounting this model to the housing using bolts, a ball screw nut rotating mechanism can be obtained. (For the housing's inner-diameter tolerance, H7 is recommended.)

Type

[No Preload Type]

Model BLR

Specification Table⇒B-748



Service Life

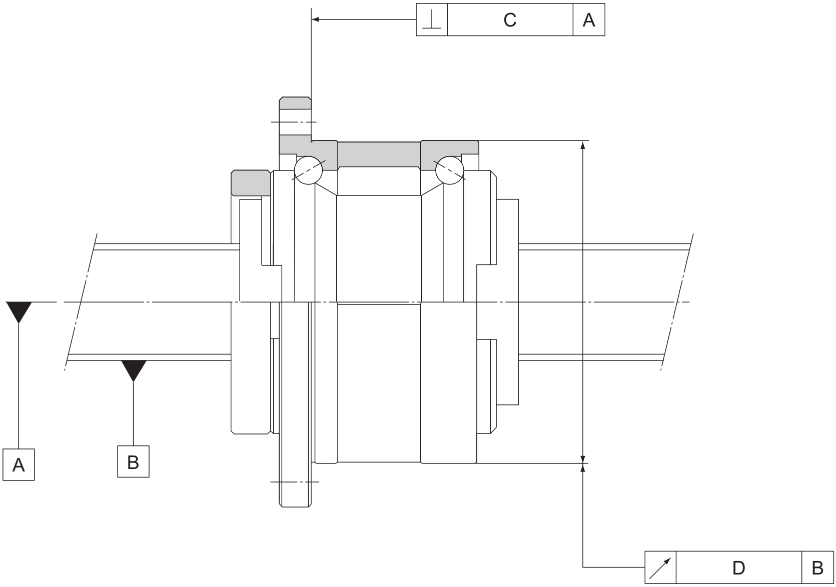
For details,see A-704.

Axial Clearance

For details,see A-685.

Accuracy Standards

The accuracy of model BLR is compliant with the JIS standard (JIS B 1192-1997) except for the radial runout of the circumference of the ball screw nut from the screw axis (D) and the perpendicularity of the flange-mounting surface against the screw axis (C).

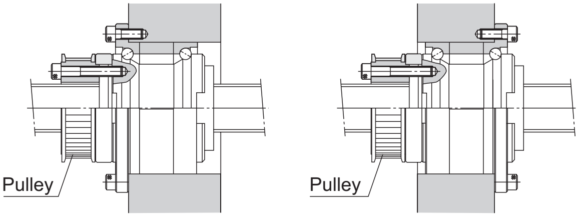


Unit: mm

Lead angle accuracy	C7, C8, C10	
Accuracy grades	C10	
Model No.	C	D
BLR 1616	0.035	0.065
BLR 2020	0.035	0.065
BLR 2525	0.035	0.065
BLR 3232	0.035	0.065
BLR 3636	0.036	0.066
BLR 4040	0.046	0.086
BLR 5050	0.046	0.086

Example of Assembly

[Example of Mounting Ball Screw Nut Model BLR]



Standard installation method Inverted flange

Note) If the flange is to be inverted, indicate “K” in the model number. (applicable only to model BLR)

Example: BLR 2020-3.6 K UU
Symbol for invert
(No symbol for standard flange orientation)

[Example of Mounting Model BLR on the Table]

(1) Screw shaft free, ball screw nut fixed
(Suitable for a long table)

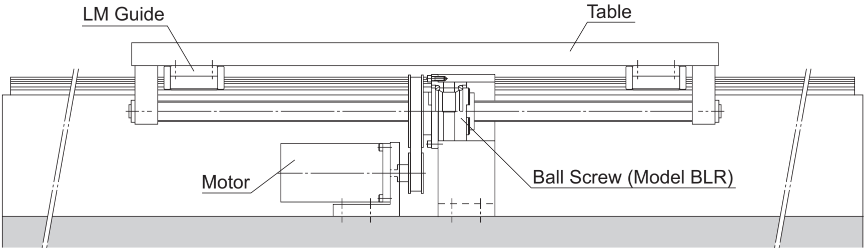


Fig.2 Example of Installation on the Table (Ball Screw Nut Fixed)

(2) Ball screw nut free, screw shaft fixed
(Suitable for a short table and a long stroke)

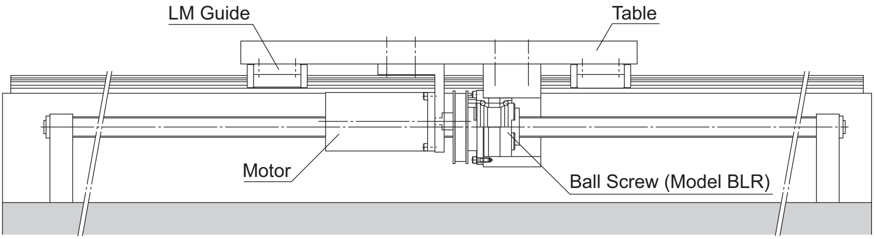


Fig.3 Example of Installation on the Table (Screw Shaft Fixed)

Ball Screw

Ball Screw Peripherals

Support Unit

Models EK, BK, FK, EF, BF and FF

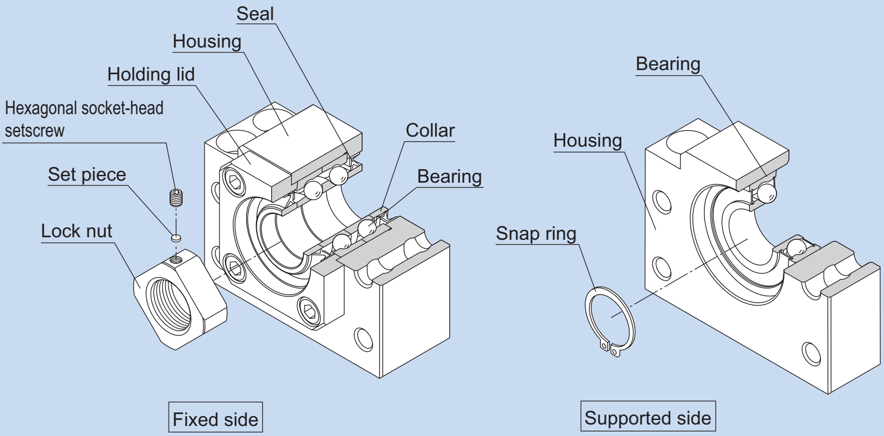


Fig.1 Structure of the Support Unit

Structure and Features

The Support Unit comes in six types: models EK, FK, EF, and FF, which are standardized for the standard Ball Screw assembly provided with the finished shaft ends, and models BK and BF, which are standardized for ball screws in general.
The Support Unit on the fixed side contains a JIS Class 5-compliant angular bearing provided with an adjusted preload. The miniature type Support Unit models EK/FK 4, 5, 6 and 8, in particular, incorporate a miniature bearing with a contact angle of 45° developed exclusively for miniature Ball Screws. This provides stable rotational performance with a high rigidity and an accuracy.
The Support Unit on the supported side uses a deep-groove ball bearing.
The internal bearings of the Support Unit models EK, FK and BK contain an appropriate amount of lithium soap-group grease that is sealed with a special seal. Thus, these models are capable of operating over a long period.

[Uses the Optimal Bearing]

To ensure the rigidity balance with the Ball Screw, the Support Unit uses an angular bearing (contact angle: 30°; DF configuration) with a high rigidity and a low torque. Miniature Support Unit models EK/FK 4, 5, 6 and 8 are incorporated with a miniature angular bearing with a contact angle of 45° developed exclusively for miniature Ball Screws. This bearing has a greater contact angle of 45° and an increased number of balls with a smaller diameter. The high rigidity and accuracy of the miniature angular bearing provides the stable rotational performance.

[Support Unit Shapes]

The square and round shapes are available for the Support Unit to allow the selection according to the intended use.

[Compact and Easy Installation]

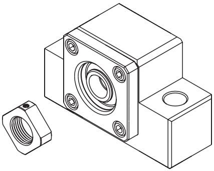
The Support Unit is compactly designed to accommodate the space in the installation site. As the bearing is provided with an appropriately adjusted preload, the Support Unit can be assembled with a Ball Screw unit with no further machining. Accordingly, the required man-hours in the assembly can be reduced and the assembly accuracy can be increased.

Type

[For the Fixed Side]

Square Type Model EK

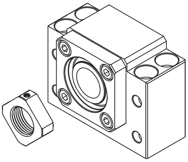
Specification Table⇒B-754



(Inner diameter: ϕ4 to ϕ20)

Square Type Model BK

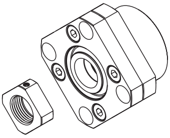
Specification Table⇒B-756



(Inner diameter: ϕ10 to ϕ40)

Round Type Model FK

Specification Table⇒B-758

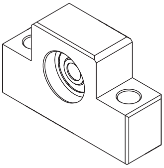


(Inner diameter: ϕ4 to ϕ30)

[For the Supported Side]

Square Type Model EF

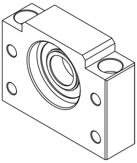
Specification Table⇒B-762



(Inner diameter: ϕ6 to ϕ20)

Square Type Model BF

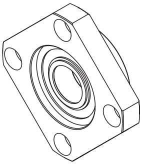
Specification Table⇒B-764



(Inner diameter: ϕ8 to ϕ40)

Round Type Model FF

Specification Table⇒B-766



(Inner diameter: ϕ6 to ϕ30)

Types of Support Units and Applicable Screw Shaft Outer Diameters

Inner diameter of the fixed side Support Unit (mm)	Applicable model No. of the fixed side Support Unit	Inner diameter of the supported side Support Unit (mm)	Applicable model No. of the supported side Support Unit	Applicable screw shaft outer diameter (mm)
4	EK 4 FK 4	—	—	ϕ4
5	EK 5 FK 5	—	—	ϕ6
6	EK 6 FK 6	6	EF 6 FF 6	ϕ8
8	EK 8 FK 8	6	EF 8 FF 6	ϕ10
10	EK 10 FK 10 BK 10	8	EF 10 FF 10 BF 10	ϕ12, ϕ14
12	EK 12 FK 12 BK 12	10	EF 12 FF 12 BF 12	ϕ14, ϕ15, ϕ16
15	EK 15 FK 15 BK 15	15	EF 15 FF 15 BF 15	ϕ20
17	BK 17	17	BF 17	ϕ20, ϕ25
20	EK 20 FK 20 BK 20	20	EF 20 FF 20 BF 20	ϕ25, ϕ28, ϕ32
25	FK 25 BK 25	25	FF 25 BF 25	ϕ36
30	FK 30 BK 30	30	FF 30 BF 30	ϕ40, ϕ45
35	BK 35	35	BF 35	ϕ45
40	BK 40	40	BF 40	ϕ50

Note) The Supports Units in this table apply only to those Ball Screw models with recommended shaft ends shapes H, J and K, indicated on A-810.

Model Numbers of Bearings and Characteristic Values

Angular ball bearing on the fixed side					Deep-groove ball bearing on the supported side			
Support Unit model No.	Bearing model No.	Axial direction			Support Unit model No.	Bearing model No.	Radial direction	
		Basic dynamic load rating Ca (kN)	Note) Permissible load (kN)	Rigidity (N/µm)			Basic dynamic load rating C(kN)	Basic static load rating C_0(kN)
EK 4 FK 4	AC4-12P5	0.93	1.1	27	—	—	—	—
EK 5 FK 5	AC5-14P5	1	1.24	29	—	—	—	—
EK 6 FK 6	AC6-16P5	1.38	1.76	35	EF 6 FF 6	606ZZ	2.19	0.87
EK 8 FK 8	79M8DF GMP5	2.93	2.15	49	EF 8	606ZZ	2.19	0.87
EK 10 FK 10 BK 10	7000HTDF GMP5	6.08	3.1	65	EF 10 FF 10 BF 10	608ZZ	3.35	1.4
EK 12 FK 12 BK 12	7001HTDF GMP5	6.66	3.25	88	EF 12 FF 12 BF 12	6000ZZ	4.55	1.96
EK 15 FK 15 BK 15	7002HTDF GMP5	7.6	4	100	EF 15 FF 15 BF 15	6002ZZ	5.6	2.84
BK 17	7203HTDF GMP5	13.7	5.85	125	BF 17	6203ZZ	9.6	4.6
EK 20 FK 20	7204HTDF GMP5	17.9	9.5	170	EF 20 FF 20	6204ZZ	12.8	6.65
BK 20	7004HTDF GMP5	12.7	7.55	140	BF 20	6004ZZ	9.4	5.05
FK 25 BK 25	7205HTDF GMP5	20.2	11.5	190	FF 25 BF 25	6205ZZ	14	7.85
FK 30 BK 30	7206HTDF GMP5	28	16.3	195	FF 30 BF 30	6206ZZ	19.5	11.3
BK 35	7207HTDF GMP5	37.2	21.9	255	BF35	6207ZZ	25.7	15.3
BK 40	7208HTDF GMP5	44.1	27.1	270	BF 40	6208ZZ	29.1	17.8

Note) "Permissible load" indicates the static permissible load.

Example of Installation

[Square Type Support Unit]

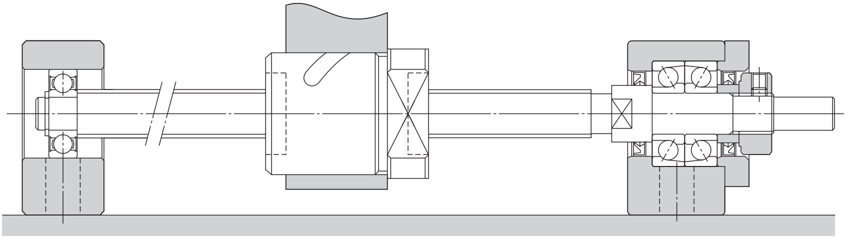


Fig.2 Example of Installing a Square Type Support Unit

[Round Type Support Unit]

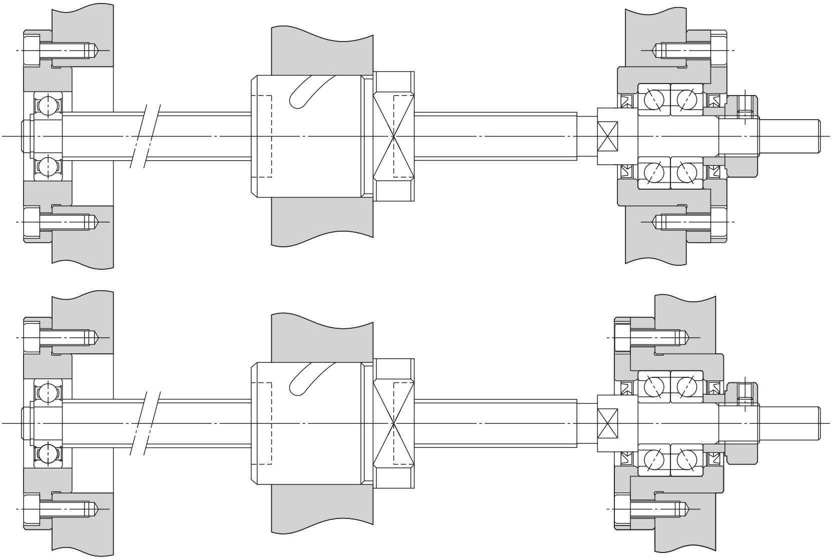


Fig.3 Example of Installing a Round Type Support Unit

Mounting Procedure

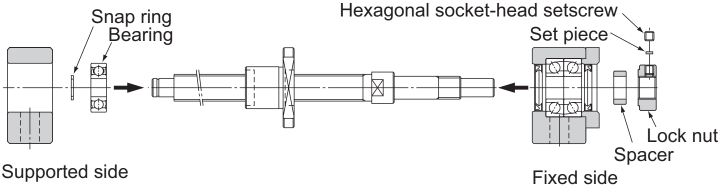
[Installing the Support Unit]

(1) Install the fixed side Support Unit with the screw shaft.

(2) After inserting the fixed side Support Unit, secure the lock nut using the fastening set piece and the hexagonal socket-head setscrews.

(3) Attach the supported side bearing to the screw shaft and secure the bearing using the snap ring, and then install the assembly to the housing on the supported side.

Note1) Do no disassemble the Support Unit.
Note2) When inserting the screw shaft to the Support Unit, take care not to let the oil seal lip turn outward.
Note3) When securing the set piece with a hexagonal socket-head setscrew, apply an adhesive to the hexagonal socket-head setscrew before tightening it in order to prevent the screw from loosening. If planning to use the product in a harsh environment, it is also necessary to take a measure to prevent other components/parts from loosening. Contact THK for details.



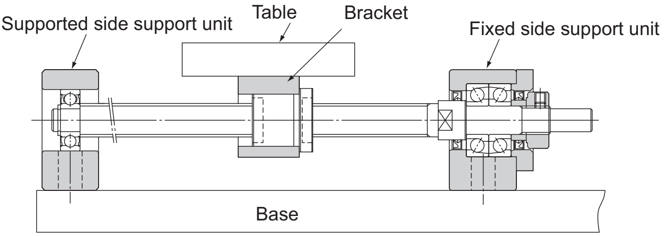
[Installation onto the Table and the Base]

(1) If using a bracket when mounting the ball screw nut to the table, insert the nut into the bracket and temporarily fasten it.

(2) Temporarily fasten the fixed side Support Unit to the base.
In doing so, press the table toward the fixed side Support Unit to align the axial center, and adjust the table so that it can travel freely.

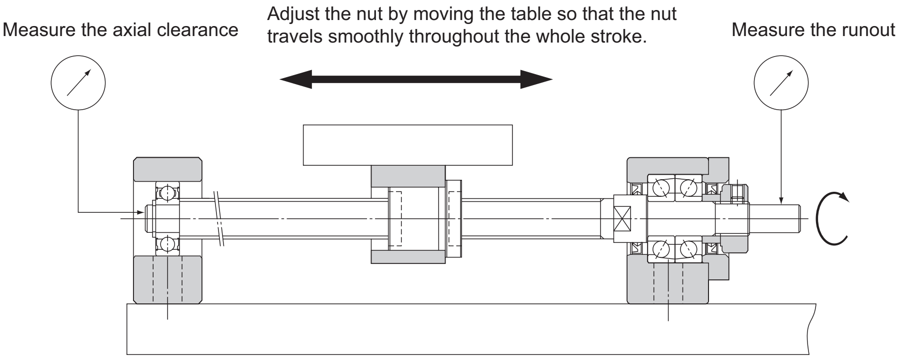
- If using the fixed side Support Unit as the reference point, secure a clearance between the ball screw nut and the table or inside the bracket when making adjustment.
- If using the table as the reference point, make the adjustment either by using the shim (for a square type Support Unit), or securing the clearance between the outer surface of the nut and the inner surface of the mounting section (for a round type Support Unit).

(3) Press the table toward the fixed-side Support Unit to align the axial center. Make the adjustment by reciprocating the table several times so that the nut travels smoothly throughout the whole stroke, and temporarily secure the Support Unit to the base.



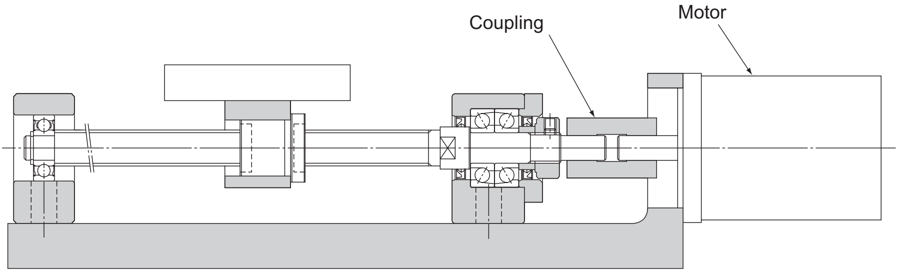
[Checking the Accuracy and Fully Fastening the Support Unit]

While checking the runout of the ball screw shaft end and the axial clearance using a dial gauge, fully fasten the ball screw nut, the nut bracket, the fixed side Support Unit and the supported-side Support Unit, in this order.



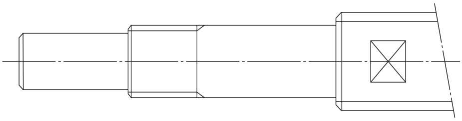
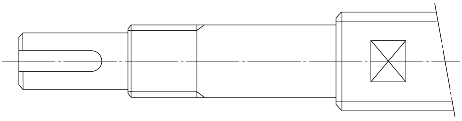
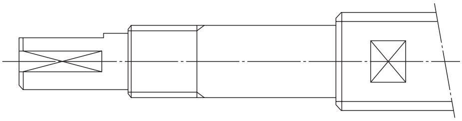
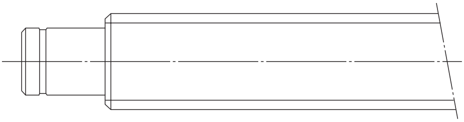
[Connection with the Motor]

(1) Mount the motor bracket to the base.
(2) Connect the motor and the ball screw using a coupling.
Note) Make sure the mounting accuracy is maintained.
(3) Thoroughly perform the break-in for the system.



Types of Recommended Shapes of the Shaft Ends

To ensure speedy estimates and manufacturing of Ball Screws, THK has standardized the shaft end shapes of the screw shafts. The recommended shapes of shaft ends consist of shapes H, K and J, which allow standard Support Units to be used.

Mounting method	Symbol for shaft end shape		Shape	Supported Support Unit
Fixed	H J	H1		FK EK
		J1		BK
		H2		FK EK
		J2		BK
		H3		FK EK
		J3		BK
Supported	K			FF EF BF

Nut bracket

Model MC

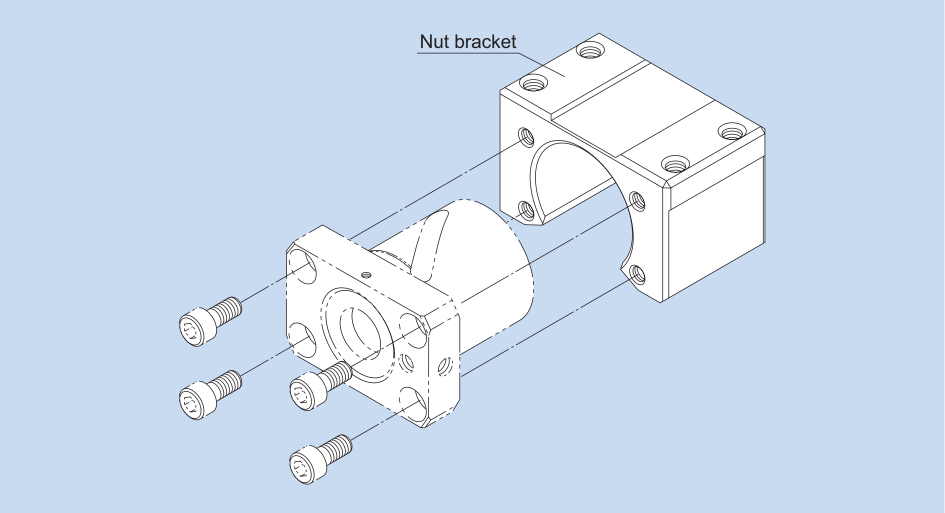


Fig.1 Structure of the Nut Bracket

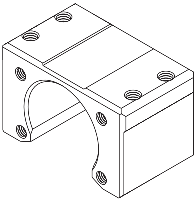
Structure and Features

The Nut Bracket is standardized for the standard Ball Screw assembly provided with finished shaft ends. It is designed to be secured directly on the table with bolts. Since the height is low, it can be mounted on the table only using bolts.

Type

Nut Bracket Model MC

Specification Table⇒B-774



Lock nut

Model RN

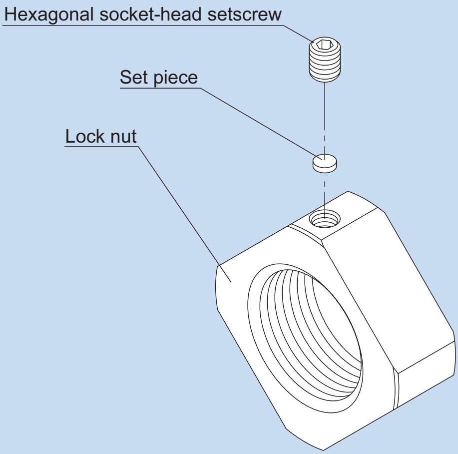


Fig.1 Structure of the Lock Nut

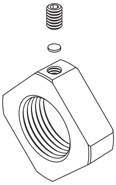
Structure and Features

The Lock Nut for the Ball Screws is capable of fastening the screw shaft and the bearing with a high accuracy.
The provided hexagonal socket-head setscrew and the set piece prevent the Lock Nut from loosening and ensure firm fastening. The Lock Nut comes in various types ranging from model M4 to model M40.

Type

Lock Nut Model RN

Specification Table⇒B-776



Ball Screw

Options

Lubrication

To maximize the performance of the Ball Screw, it is necessary to select a lubricant and a lubrication method according to the conditions.

For types of lubricants, characteristics of lubricants and lubrication methods, see the section on “Accessories for Lubrication” on A-954.

Also, QZ Lubricator is available as an optional accessory that significantly increases the maintenance interval.

Corrosion Prevention (Surface Treatment, etc.)

Depending on the service environment, the Ball Screw requires anticorrosive treatment or a different material. For details of an anticorrosive treatment and a material change, contact THK. (see A-18)

Contamination Protection

The dust and foreign materials that enter the Ball Screw may cause accelerated wear and breakage, as with roller bearings. Therefore, on parts where contamination by dust or foreign materials (e.g., cutting chips) is predicted, screw shafts must always be completely covered by contamination protection devices (e.g., bellows, screw cover, wiper ring).

If the Ball Screw is used in an atmosphere free from the foreign materials but with suspended dust, a labyrinth seal (for precision Ball Screws) with symbol RR and a brush seal (for rolled Ball Screws) with symbol ZZ can be used as contamination protection devices.

The labyrinth seal is designed to maintain a slight clearance between the seal and the screw shaft raceway so that torque does not develop and no heat is generated, though its effect in contamination protection is limited.

With Ball Screws except the large lead and super lead types, there is no difference in nut dimensions between those with and without a seal.

With the wiper ring, special resin with high wear resistance and low dust generation removes foreign materials while closely contacting the circumference of the ball screw shaft and the screw thread. It is capable of preventing foreign materials from entering the Ball Screw even in a severe environment.

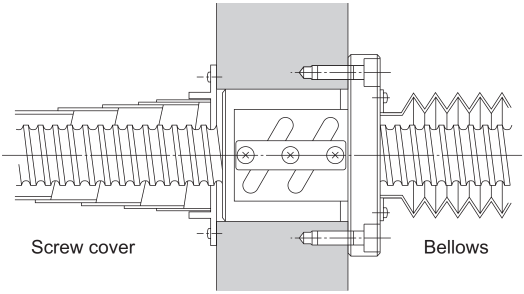
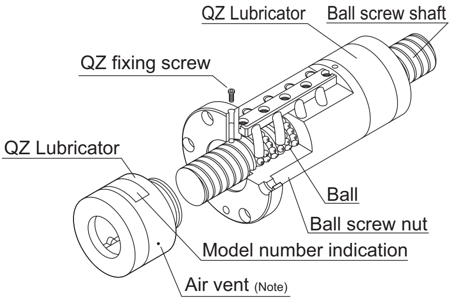


Fig.1 Contamination Protection Cover

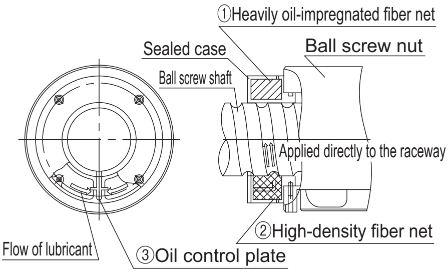
QZ Lubricator

●**For the supported models and the ball screw nut dimension with QZ attached, see B-778 to B-783.**

QZ Lubricator feeds a right amount of lubricant to the ball raceway of the ball screw shaft. This allows an oil film to be constantly formed between the balls and the raceway, improves lubrications and significantly extends the lubrication maintenance interval.
The structure of QZ Lubricator consists of three major components: (1) a heavily oil-impregnated fiber net (stores the lubricant), (2) a high-density fiber net (applies the lubricant to the raceway) and (3) an oil-control plate (adjusts the oil flow). The lubricant contained in the QZ Lubricator is fed by the capillary phenomenon, which is used also in felt pens and many other products.



Appearance Drawing



Structural Drawing

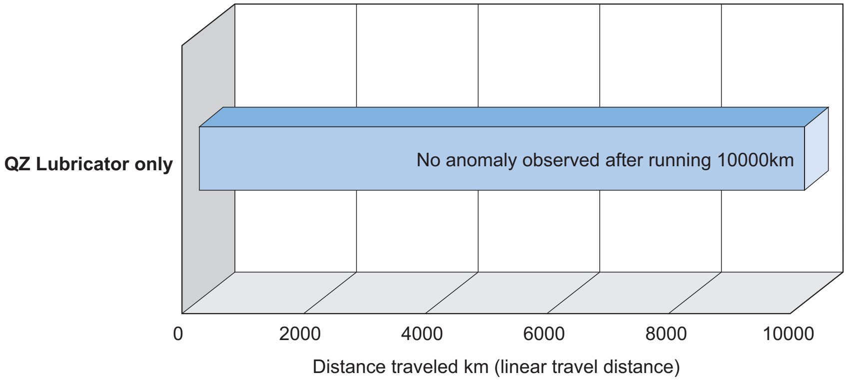
[Features]

- Since it supplements an oil loss, the lubrication maintenance interval can be significantly extended.
- Since the right amount of lubricant is applied to the ball raceway, an environmentally friendly lubrication system that does not contaminate the surroundings is achieved.

Note) QZ Lubricator has a vent hole. Do not block the hole with grease or the like.

● Significantly extended maintenance interval

Since QZ Lubricator continuously feeds a lubricant over a long period, the maintenance interval can be extended significantly.

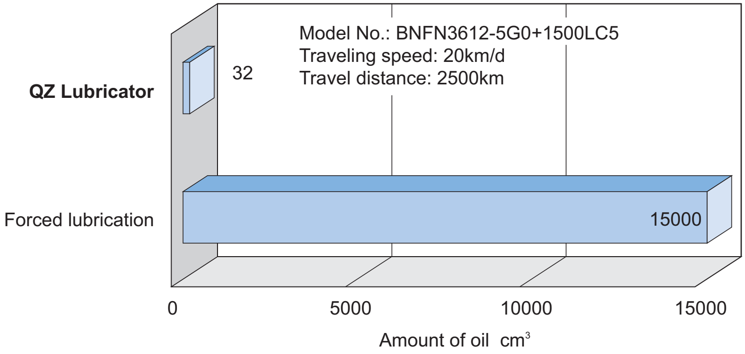


[Test conditions]

Item	Description
Ball Screw	BIF2510
Maximum rotational speed	2500min^{-1}
Maximum speed	25m/min
Stroke	500mm
Load	Internal preload only

● Environmentally friendly lubrication system

Since the QZ Lubricator feeds the right amount of lubricant directly to the raceway, the lubricant can effectively be used without waste.



QZ Lubricator + THK AFA Grease

32cm^3

(QZ Lubricator attached to both ends of the ball screw nut)

Compared

Forced lubrication

$0.25\text{cm}^3/3\text{min}\times24\text{h}\times125\text{d}$

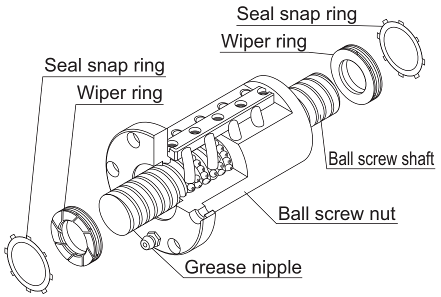
$=15000\text{cm}^3$

Reduced to approx. $\frac{1}{470}$

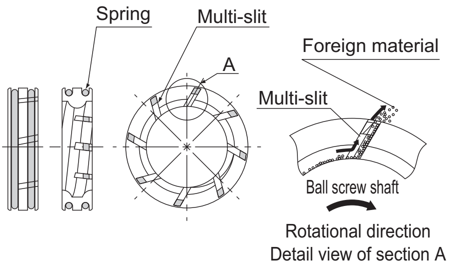
Wiper Ring W

●For the supported models and the ball screw nut dimension with Wiper ring W attached, see B-778 to B-783.

With the wiper ring W, special resin with a high wear resistance and a low dust generation which removes and prevents foreign materials from entering the ball screw nut while elastically contacting the circumference of the ball screw shaft and the screw thread.



Appearance Drawing



Structural Drawing

[Features]

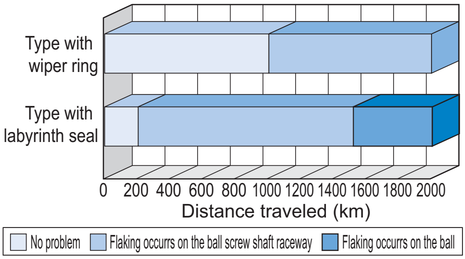
- A total of eight slits on the circumference remove foreign materials in succession, and prevent entrance of foreign material.
- Contacts the ball screw shaft to reduce the flowing out of grease.
- Contacts the ball screw shaft at a constant pressure level using a spring, thus to minimize the heat generation.
- Since the material is highly resistant to the wear and the chemicals, its performance will not easily be deteriorated even if it is used over a long period.

● Test in an environment exposed to contaminated environment

[Test conditions]

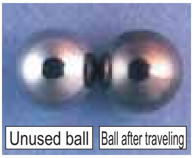
Item	Description
Model No.	BIF3210–5G0+1500LC5
Maximum rotational speed	1000min^{-1}
Maximum speed	10m/min
Maximum circumferential speed	1.8m/s
Time constant	60ms
Dowel	1s
Stroke	900mm
Load (through internal load)	1.31kN
Grease	THK AFG Grease 8cm^3 (Initial lubrication to the ball screw nut only)
Foundry dust	FCD400 average particle diameter: 250μm
Volume of foreign material per shaft	5g/h

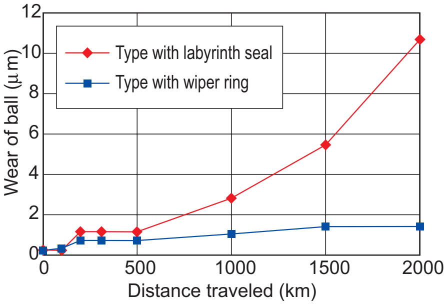
[Test result]



- Type with wiper ring
  Slight flaking occurred in the ball screw shaft at travel distant of 1,000 km.
- Type with labyrinth seal
  Flaking occurred throughout the circumference of the screw shaft raceway at travel distance of 200 km.
  Flaking occurred on the balls after traveling 1,500 km.

Change in the ball after traveling 2000 km

(1) Type with wiper ring	(2) Type with labyrinth seal
	
●Discolored, but no breakage	●Flaking occurs



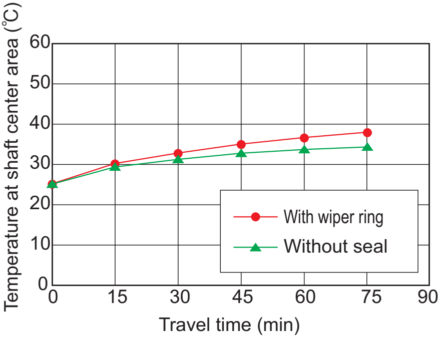
- Type with wiper ring
  Wear of balls at a travel distance of 2,000 km: 1.4 μm.
- Type with labyrinth seal
  Starts to be worn rapidly after 500 km, and the ball wear amount at the travel distance of 2,000 km: 11 μm

● Heat Generation Test

[Test conditions]

Item	Description
Model No.	BLK3232–3.6G0+1426LC5
Maximum rotational speed	1000min^{-1}
Maximum speed	32m/min
Maximum circumferential speed	1.7m/s
Time constant	100ms
Stroke	1000mm
Load (through internal load)	0.98kN
Grease	THK AFG Grease 5cm^3 (contained in the ball screw nut)

[Test result]

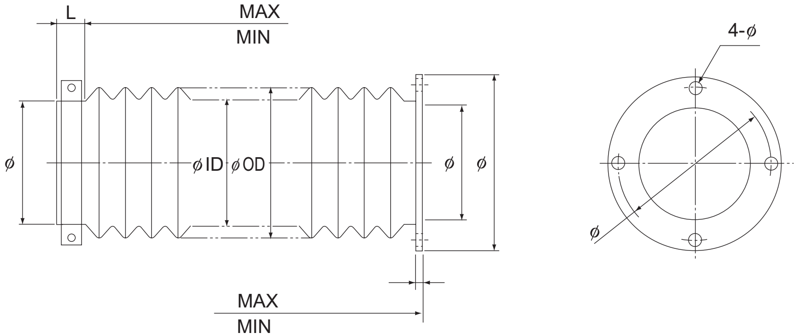


Unit: ℃

Item	With wiper ring	Without seal
Heat generation temperature	37.1	34.5
Temperature rise	12.2	8.9

Specifications of the Bellows

Bellows are available as a contamination protection accessory. Use this specification sheet.



(Band type) (Flange type)

Specifications of the Bellows

Supported Ball Screw models:

Dimensions of the Bellows

Stroke:( ) mm MAX:( ) mm MIN:( ) mm

Permissible outer diameter:(ϕOD) Desired inner diameter:(ϕID)

How It Is Used

Installation direction:(horizontal, vertical, slant) Speed: ( )mm/sec. mm/min.

Motion:(reciprocation, vibration)

Conditions

Resistance to oil and water: (necessary, unnecessary) Oil name ( )

Chemical resistance: Name ( ) × ( ) %

Location: (indoor, outdoor)

Remarks:

Number of Units To Be Manufactured:

Method for Mounting the Ball Screw Shaft

Fig.1 to Fig.4 show the representative mounting methods for the screw shaft.
The permissible axial load and the permissible rotational speed vary with mounting methods for the screw shaft. Therefore, it is necessary to select an appropriate mounting method according to the conditions.

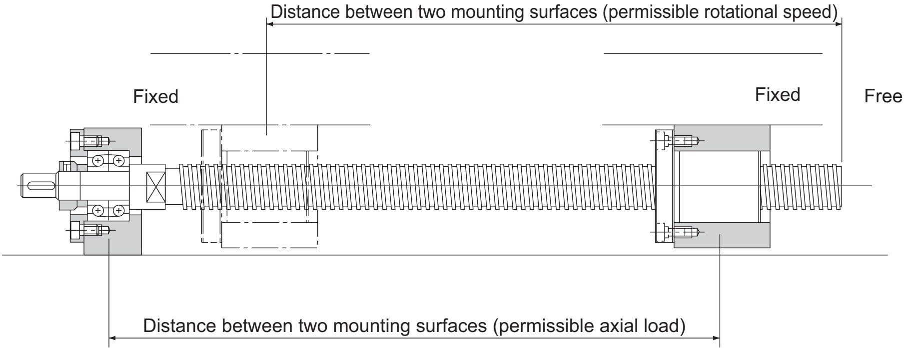


Fig.1 Screw Shaft Mounting Method: Fixed - Free

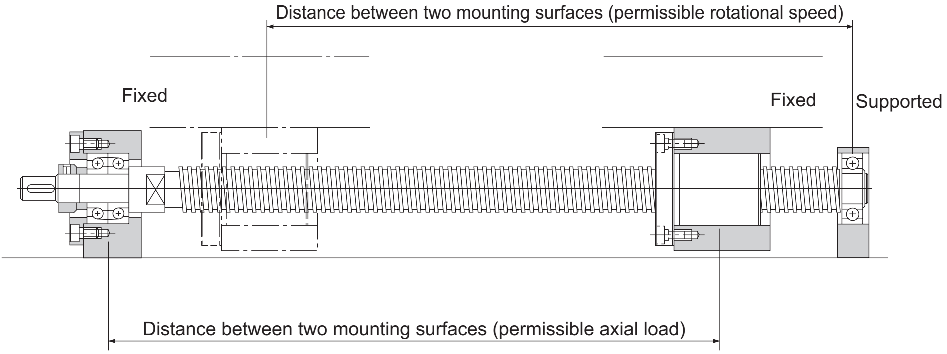


Fig.2 Screw Shaft Mounting Method: Fixed - Supported

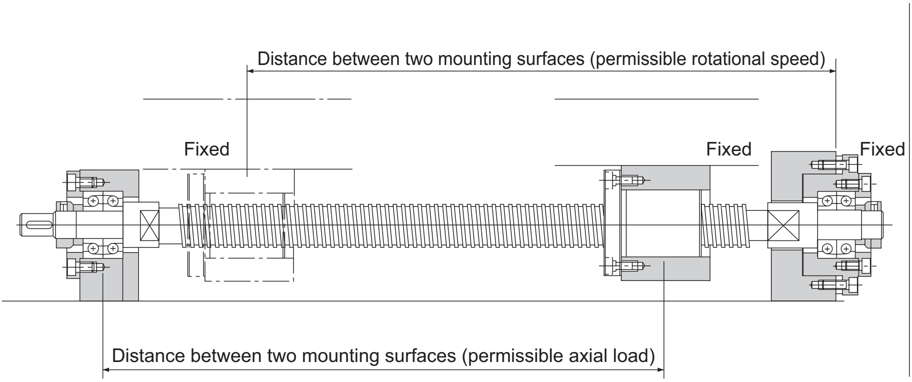


Fig.3 Screw Shaft Mounting Method: Fixed - Fixed

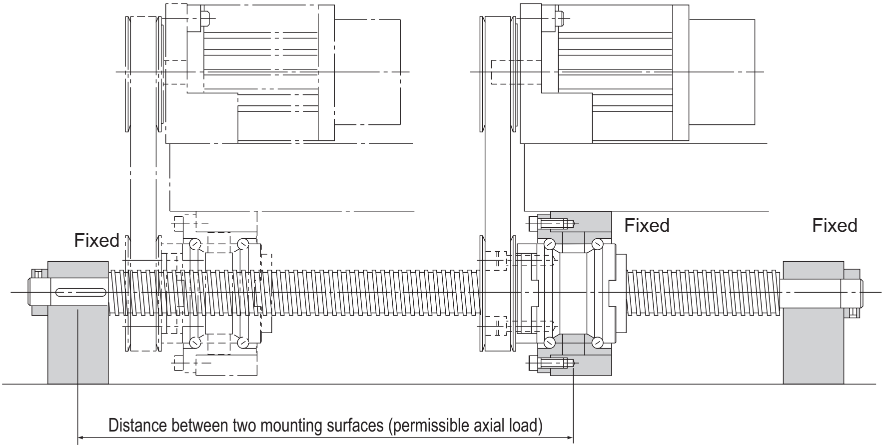


Fig.4 Screw Shaft Mounting Method for Rotary Nut Ball Screw: Fixed - Fixed

Maintenance Method

Amount of Lubricant

If the amount of the lubricant to the Ball Screw is insufficient, it may cause a lubrication breakdown, and if it is excessive, it may cause heat to be generated and the resistance to be increased. It is necessary to select an amount that meets the conditions.

[Grease]
The feed amount of grease is generally approximately one third of the spatial volume inside the nut.

[Oil]
Table 1 shows a guideline for the feed amount of oil.
Note, that the amount varies according to the stroke, the oil type and the conditions (e.g., suppressed heat generation).

Table1 Guideline for the Feed Amount of Oil

(Interval: 3 minutes)

Shaft diameter (mm)	Amount of lubricant (cc)
4 to 8	0.03
10 to 14	0.05
15 to 18	0.07
20 to 25	0.1
28 to 32	0.15
36 to 40	0.25
45 to 50	0.3
55 to 63	0.4
70 to 100	0.5

[Handling]

(1) Disassembling the components may cause dust to enter the system or degrade the mounting accuracy of parts. Do not disassemble the product.
(2) Tilting the screw shaft and the ball screw nut may cause them to fall by their own weight.
(3) Dropping or hitting the Ball Screw may damage the ball circulation section, which may cause the functional loss. Giving an impact to the product could also cause a damage to its function even if the product looks intact.

[Lubrication]

(1) Thoroughly remove anti-rust oil and feed lubricant before using the product.
(2) Do not mix the lubricants of different physical properties.
(3) In locations exposed to constant vibrations or in special environments such as clean rooms, a vacuum and a low/high temperature, normal lubricants may not be used. Contact THK for details.
(4) When planning to use a special lubricant, contact THK before using it.
(5) The lubrication interval varies according to the conditions. Contact THK for details.

[Precautions on Use]

(1) Do not remove the ball screw nut from the ball screw shaft. Doing so may cause the balls or the nut to fall off.
(2) Entrance of foreign materials to the ball screw nut may cause damages to the ball circulating path or functional loss. Prevent foreign materials, such as dust or cutting chips, from entering the system.
(3) If the foreign materials such as dust or cutting chips adheres to the product, replenish the lubricant after cleaning the product with pure white kerosene. For available types of detergent, contact THK.
(4) When planning to use the product in an environment where the coolant penetrates the spline nut, it may cause problems to product functions depending on the type of the coolant. Contact THK for details.
(5) Contact THK if you desire to use the product at a temperature of 80℃ or higher.
(6) If using the product with vertical mount, the ball screw nut may fall by its weight. Attach a mechanism to prevent it from falling.
(7) Exceeding the permissible rotational speed may lead the components to be damaged or cause an accident. Be sure to use the product within the specification range designated by THK.
(8) Forcefully driving in the ball screw shaft or the ball screw nut may cause an indentation on the raceway. Use care when mounting the components.
(9) If an offset or skewing occurs with the ball screw shaft support and the ball screw nut, it may substantially shorten the service life. Pay attention to components to be mounted and to the mounting accuracy.
(10) When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, a vacuum and a low/high temperature, contact THK in advance.
(11) Letting the ball screw nut overshoot will cause balls to fall off or the ball-circulating components to be damaged.

[Storage]

When storing the Ball Screw, enclose it in a package designated by THK and store it in a horizontal orientation while avoiding a high temperature, a low temperature and a high humidity.

Lead Screw Nut

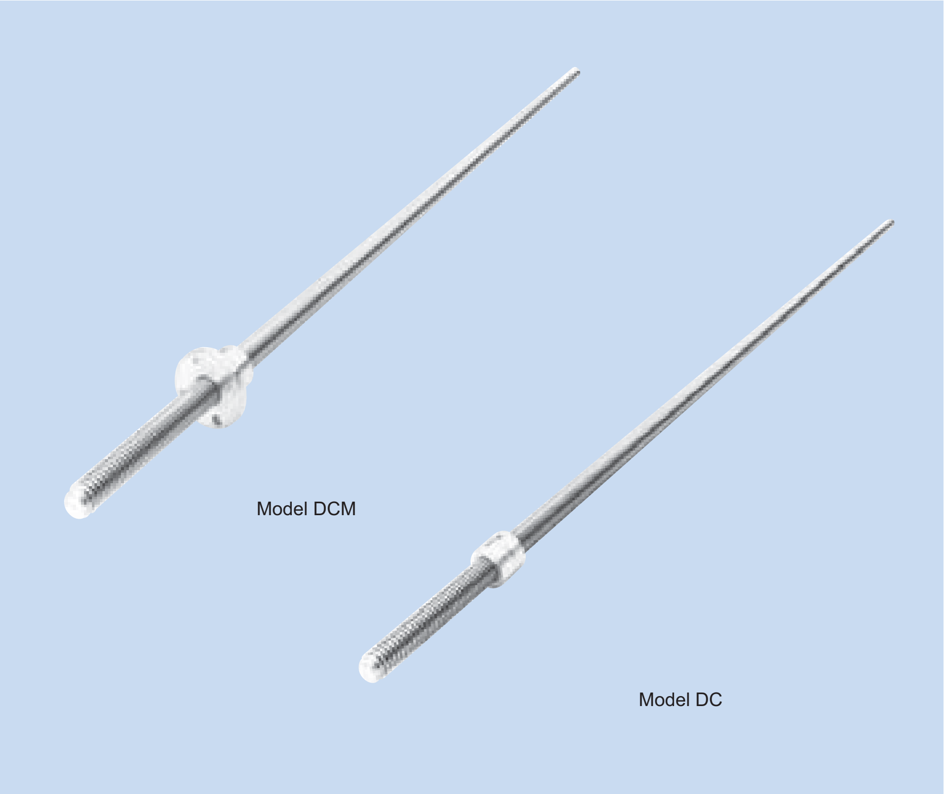
THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Lead Screw Nut



Structure and Features

The lead Screw Nut models DCM and DC are manufactured to meet the standards for the 30° trapezoidal threads. They use a special alloy (see A-831) for the nuts and have a precision male thread, formed through die casting, as the core. As a result, these bearings achieve less unevenness in accuracy and higher accuracy and wear resistance than the machined lead screw nuts.
For the screw shafts to be used with this product, the rolled shafts are available as the standard.
In addition, the cut screw shafts and the ground screw shafts are also available according to the application. Contact THK for details.

Features of the Special Rolled Shafts

The dedicated rolled shafts with the standardized lengths are available for the Lead Screw Nut.

[Increased Wear Resistance]

The shaft teeth are formed by cold gear rolling, and the surface of the tooth surface is hardened to over 250 HV and are mirror-finished. As a result, the shafts are highly wear resistant and achieve significantly smooth motion when used in combination with lead screw nuts.

[Improved Mechanical Properties]

Inside the teeth of the rolled shaft, a fiber flow occurs along the contour of the tooth surface of the shaft, making the structure around the teeth roots dense. As a result, the fatigue strength is increased.

[Additional Machining of the Shaft End Support]

Since each shaft is rolled, additional machining of the support bearing of the shaft end can easily be performed by lathing or milling.

High Strength Zinc Alloy

The high strength zinc alloy used in the lead screw nuts is a material that is highly resistant to seizure and the wear and has a high load carrying capacity. Its composition, the mechanical properties, the physical properties and the wear resistance are given below.

[Composition]

Table1 Composition of the High Strength Zinc Alloy

Unit: %

Item	Description
Aℓ	3 to 4
Cu	3 to 4
Mg	0.03 to 0.06
Be	0.02 to 0.06
Ti	0.04 to 0.12
Zn	Remaining portion

[Mechanical Properties]

Item	Description
Tensile strength	275 to 314 N/mm^2
Tensile yield strength (0.2%)	216 to 245 N/mm^2
Compressive strength	539 to 686 N/mm^2
Compressive yield strength (0.2%)	294 to 343 N/mm^2
Fatigue strength	132 N/mm^2 × 10^7 (Schenk bending test)
Charpy impact	0.098 to 0.49 N-m/mm^2
Elongation	1 to 5 %
Hardness	120 to 145 HV

[Physical Properties]

Item	Description
Specific gravity	6.8
Specific heat	460 J/ (kg・K)
Melting point	390 ℃
Thermal expansion coefficient	24 × 10^{-6}

[Wear Resistance]

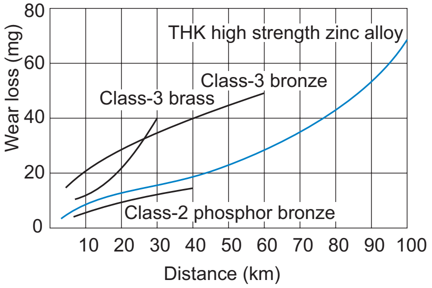


Fig.1 Wear Resistance of the High Strength Zinc Alloy

[Test conditions: Amsler wear-tester]

Item	Description
Test piece rotational speed	185 min^{-1}
Load	392 N
Lubricant	Dynamo oil

Selecting a Lead Screw Nut

[Dynamic Permissible Torque T and Dynamic Permissible Thrust F]

The dynamic permissible torque (T) and the dynamic permissible thrust (F) are the torque and the thrust at which the contact surface pressure on the tooth surface of the bearing is 9.8 N/mm². These values are used as a measuring stick for the strength of the lead screw nut.

[pV Value]

With a sliding bearing, a pV value, which is the product of the contact surface pressure (p) and the sliding speed (V), is used as a measuring stick to judge whether the assumed model can be used. Use the corresponding pV value indicated in Fig.1 as a guide for selecting a lead screw nut. The pV value varies also according to the lubrication conditions.

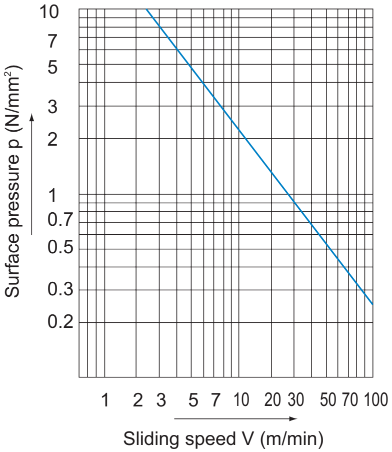


Fig.1 pV Value

● f_S: Safety Factor

To calculate a load applied to the lead screw nut, it is necessary to accurately obtain the effect of the inertia that changes with the weight and dynamic speed of an object. In general, with the reciprocating or the rotating machines, it is not easy to accurately obtain all the factors such as the effect of the start and stop, which are always repeated. Therefore, if the actual load cannot be obtained, it is necessary to select a bearing while taking into account the empirically obtained safety factors (f_S) shown in Table1.

Table1 Safety Factor (f_S)

Type of load	Lower limit of f_S
For a static load less frequently used	1 to 2
For an ordinary single-directional load	2 to 3
For a load accompanied by vibrations/impact	4 or greater

● f_T: Temperature Factor

If the temperature of the lead screw nut exceeds the normal temperature range, the seizure resistance of the nut and the strength of the material will decrease. Therefore, it is necessary to multiply the dynamic permissible torque (T) and the dynamic permissible thrust (F) by the corresponding temperature factor indicated in Fig.2.

Accordingly, when selecting a lead screw nut, the following equations need to be met in terms of its strength.

Dynamic permissible torque(T)

$$f_S \leqq \frac{f_T \cdot T}{P_T}$$

Static permissible thrust(F)

$$f_S \leqq \frac{f_T \cdot F}{P_F}$$

f_S : Safety factor (see A-833Table1)
f_T : Temperature factor (see Fig.2)
T : Dynamic permissible torque (N-m)
P_T : Applied torque (N-m)
F : Dynamic permissible thrust (N)
P_F : Axial load (N)

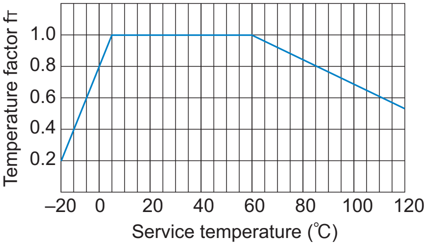


Fig.2 Temperature Factor

● Hardness of the Surface and the Wear Resistance

The hardness of the shaft significantly affects the wear resistance of the lead screw nut. If the hardness is equal to or less than 250 HV, the abrasion loss increases as indicated in Fig.3. The roughness of the surface should preferably be 0.80a or less.

A special rolled shaft achieves the surface hardness of 250 HV or greater, through hardening as a result of rolling, and surface roughness of 0.20a or less. Thererfore, the dedicated rolled shaft is highly wear resistant.

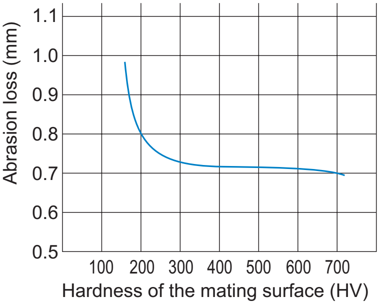


Fig.3 Hardness of the Surface and Wear Resistance

[Calculating the Contact Surface Pressure p]

The value of "p" is obtained as followed.

$$\mathbf{p = \frac{P_F}{F} \times 9.8}$$

p : Contact surface pressure on the tooth from an axial load (P_F N) (N/mm²)
F : Dynamic permissible thrust (N)
P_F : Axial load (N)

[Calculating the Sliding Speed V on the Teeth]

The value of "V" is obtained as followed.

$$\mathbf{V = \frac{\pi \cdot Do \cdot n}{\cos\alpha \times 10^3}}$$

V : Sliding speed (m/min)
Do : Effective diameter (mm)
(see specification table)
n : Rotation speed per minute (min^{-1})
α : Lead angle (degree)
(see specification table)
R : Lead (mm)

[Example of Calculation]

Assuming that Lead Screw Nut model DCM is used, select a lead screw nut that travels at feed speed S = 3 m/min while receiving an axial load P_F = 1,080 N, which is applied in one direction. First, tentatively select model DCM32 (dynamic permissible thrust F = 21,100 N). Obtain the contact surface pressure (p).

$$p = \frac{P_F}{F} \times 9.8 = \frac{1080}{21100} \times 9.8 \fallingdotseq 0.50\ \text{N/mm}^2$$

Obtain the sliding speed (V).
The rotation speed per minute (n) of the screw shaft needed to move it at feed speed S = 3 m/min is calculated as follows.

$$n = \frac{S}{\ell \times 10^{-3}} = \frac{3}{6 \times 10^{-3}} = 500\ \text{min}^{-1}$$

$$V = \frac{\pi \cdot Do \cdot 500}{\cos\alpha \times 10^3} = \frac{\pi \times 29 \times 500}{\cos 3°46' \times 10^3} \fallingdotseq 45.6\ \text{m/min}$$

From the diagram of pV values (see Fig.1 on A-833), it is judged that there will be no abnormal wear if the sliding speed (V) is 47 m/min or below against the "p" value of 0.50 N/mm². Second, obtain the safety factor (f_S) against the dynamic permissible thrust (F). Given the conditions: temperature factor f_T = 1 and applied load P_F= 1,080 N, the safety factor is calculated as follows.

$$f_S \leqq \frac{f_T \cdot F}{P_F} = \frac{1 \times 21100}{1080} = 19.5$$

Since the required strength will be met if "f_S" is at least 2 because of the type of load, it is appropriate to select model DCM32.

Efficiency and Thrust

The efficiency (η) at which the screw transfers a torque into thrust is obtained from the following equation.

$$\eta = \frac{1 - \mu\tan\alpha}{1 + \mu/\tan\alpha}$$

η : Efficiency
α : Lead angle
μ : Frictional resistance

Fig.4 shows the result of the above equation.

The thrust generated when a torque is applied is obtained from the following equation.

$$Fa = \frac{2 \cdot \pi \cdot \eta \cdot T}{R \times 10^{-3}}$$

Fa	: Thrust generated	(N)
T	: Torque (input)	(N-m)
R	: Lead	(mm)

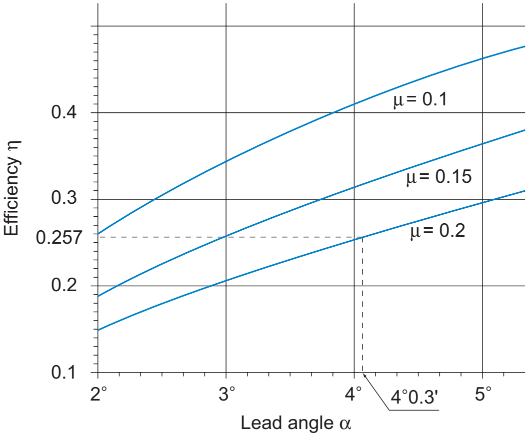


Fig.4 Efficiency

[Example of Calculation]

Assuming that Lead Screw Nut model DCM20 is used and the input torque T = 19.6 N-m, obtain the thrust to be generated.
Calculate the efficiency (η) when μ = 0.2.
The lead angle (α) of model DCM20: 4°03'
From the diagram in Fig.4, the efficiency (η) when the friction coefficient μ = 0.2 is obtained as η = 0.257.
Obtain the thrust generated.

$$Fa = \frac{2 \cdot \pi \cdot \eta \cdot T}{R \times 10^{-3}} = \frac{2 \times \pi \times 0.25 \times 19.6}{4 \times 10^{-3}} \fallingdotseq 7700\ N$$

Accuracy Standards

Table2 Accuracy of the Screw Shaft of Models DCM and DC

Unit: mm

Shaft symbol	Rolled shaft	Cut shaft	Ground shaft
Accuracy	T^{Note}	K^{Note}	G^{Note}
Single pitch error (max)	±0.020	±0.015	±0.005
Accumulated pitch error (max)	±0.15/300	±0.05/300	±0.015/300

Note) Symbols T, K and G indicate machining methods for the screw shaft. The cut shafts and ground shafts are build-to-order.

Fit

For the fitting between the lead screw nut circumference and the housing, we recommend a loose fitting or a tight fitting.
Housing inner-diameter tolerance: H8 or J8

Installation

[About Chamfer of the Housing's Mouth]

To increase the strength of the root of the flange of the lead screw nut, the corner is machined to have an R shape. Therefore, it is necessary to chamfer the inner edge of the housing's mouth.

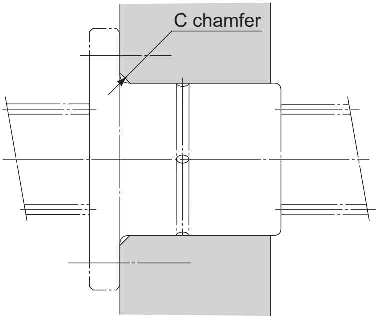


Fig.1

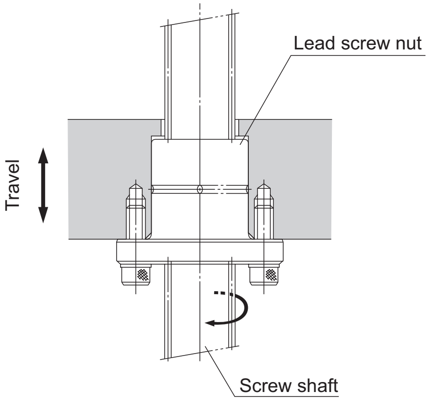
Table1 Chamfer of the Housing's Mouth

Unit: mm

Model No.	Chamfer of the mouth C (Min.)
DCM	
12	2
14	
16	
18	
20	
22	2.5
25	
28	
32	
36	3
40	
45	
50	

[Recommended Mounting Orientation]

When vertically conveying a heavy object using the screw shaft, it is safe to mount the screw as shown in Fig.2 where supports are provided on the mounting holes to prevent the moving object from falling even if the lead screw nut is broken due to an overload or an impact.



Shaft rotation
(Shaft side fixed)

Fig.2 Recommended Mounting Orientation

[Example of Installation]

Fig.3 shows examples of mounting the lead screw nuts. When mounting a lead screw nut, secure sufficient tightening strength in the axial direction. For the housing inner-diameter tolerance, see the section concerning fitting on A-838.

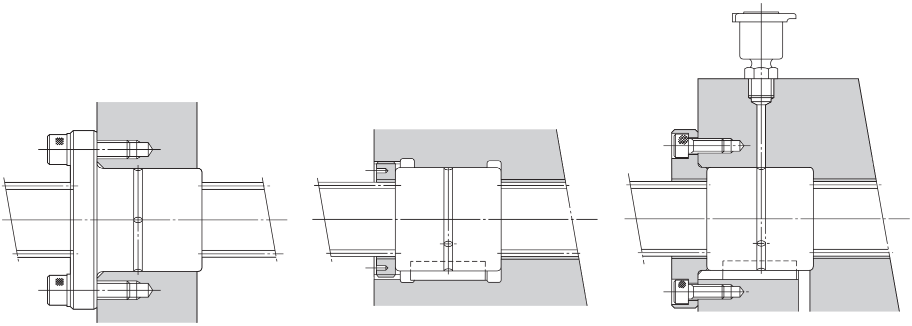


Fig.3 Examples of Installing the Lead Screw Nut

Lubrication

Select a lubrication method according to the conditions of the lead screw nut.

[Oil Lubrication]

For a lubrication of the lead screw nut, an oil lubrication is recommended. Specifically, an oil-bath lubrication or drop the lubrication is particularly effective. An oil-bath lubrication is the most appropriate method since it meets harsh conditions such as high speed, a heavy load or an external heat transmission and it cools the lead screw nut. The drop lubrication is appropriate for low to medium speed and a light to medium load. Select a lubricant according to the conditions as indicated in Table2.

Table2 Selection of a Lubricant

Condition	Types of Lubricants
Low speed, high load, high temperature	High-viscosity sliding surface oil or turbine oil
High speed, light load, low temperature	Low-viscosity sliding surface oil or turbine oil

[Grease Lubrication]

In the low-speed feed, which occurs less frequently, the user can lubricate the slide system by manually applying grease to the shaft on a regular basis or using the greasing hole on the lead screw nut. We recommend using lithium-soap group grease No. 2.

Change Nut

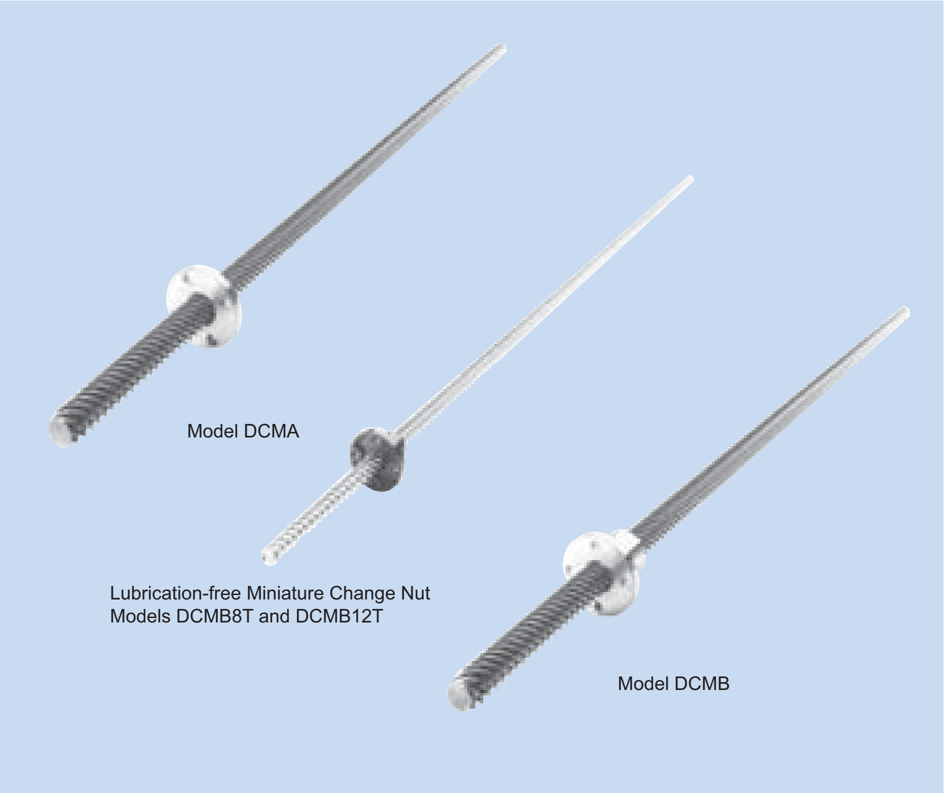
THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Change Nut



Structure and Features

The Change Nut models DCMA and DCMB have a lead angle of 45°, which is difficult to achieve through machining. Each model is capable of converting a straight motion to a rotary motion, or a vise versa, at 70% efficiency. Because of the large leads, they are optimal for providing a fast feed mechanism at a low-speed rotation. The multi-thread screw shafts to be combined with these change nuts are formed through cold gear rolling. The surface of the teeth is hardened to over 250 HV and mirror-finished. As a result, the shafts are highly wear resistant and achieve significantly smooth motion when used in combination with these change nuts. Models DCMA40, DCMB40 or higher are designed for use in combination with the cut screw shafts.
The Miniature Change Nuts are made of an oil-impregnated plastic, and have a wear resistance and excel in lubrication especially in an oil-less operation. In addition, since the high level of their performances can be maintained for a long period, they allow long-term maintenance-free operation.

Features of the Special Rolled Shafts

Dedicated rolled shafts with the standardized lengths are available for the Change Nut.

[Increased Wear Resistance]

The shaft teeth are formed by cold gear rolling, and the tooth surface is hardened to over 250 HV and mirror-finished. As a result, the shafts are highly wear resistant and achieve significantly smooth motion when used in combination with the nuts.

[Improved Mechanical Properties]

Inside the teeth of the rolled shaft, a fiber flow occurs along the contour of the tooth surface of the shaft, making the structure around the teeth roots dense. As a result, the fatigue strength is increased.

[Additional Machining of the Shaft End Support]

Since each shaft is rolled, additional machining of the support bearing of the shaft end can easily be performed by lathing or milling.

High Strength Zinc Alloy

The high strength zinc alloy used in the change nuts is a material that is highly resistant to seizure and the wear and has a high load carrying capacity. Its composition, the mechanical properties, the physical properties and the wear resistance are given below.

[Composition]

Table1 Composition of the High Strength Zinc Alloy

Unit: %

Item	Description
Aℓ	3 to 4
Cu	3 to 4
Mg	0.03 to 0.06
Be	0.02 to 0.06
Ti	0.04 to 0.12
Zn	Remaining portion

[Mechanical Properties]

Item	Description
Tensile strength	275 to 314 N/mm^2
Tensile yield strength (0.2%)	216 to 245 N/mm^2
Compressive strength	539 to 686 N/mm^2
Compressive yield strength (0.2%)	294 to 343 N/mm^2
Fatigue strength	132 N/mm^2 × 10^7 (Schenk bending test)
Charpy impact	0.098 to 0.49 N-m/mm^2
Elongation	1 to 5 %
Hardness	120 to 145 HV

[Physical Properties]

Item	Description
Specific gravity	6.8
Specific heat	460 J/(kg・K)
Melting point	390 ℃
Thermal expansion coefficient	24 × 10^{-6}

[Wear Resistance]

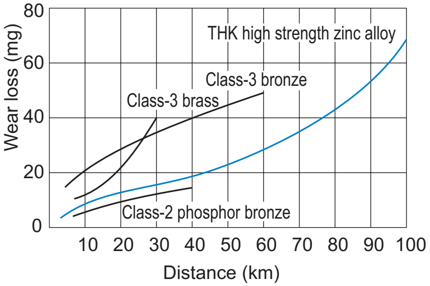


Fig.1 Wear Resistance of the High Strength Zinc Alloy

[Test conditions: Amsler wear-tester]

Item	Description
Test piece rotational speed	185 min^{-1}
Load	392 N
Lubricant	Dynamo oil

Selecting a Change Nut

[Dynamic Permissible Torque T and Dynamic Permissible Thrust F]

The dynamic permissible torque (T) and the dynamic permissible thrust (F) are the torque and the thrust at which the contact surface pressure on the tooth surface of the bearing is 9.8 N/mm². These values are used as a measuring stick for the strength of the chang nut.

[pV Value]

With a sliding bearing, a pV value, which is the product of the contact surface pressure (p) and the sliding speed (V), is used as a measuring stick to judge whether the assumed model can be used. Use the corresponding pV value indicated in Fig.1 as a guide for selecting a change nut. The pV value varies also according to the lubrication conditions.

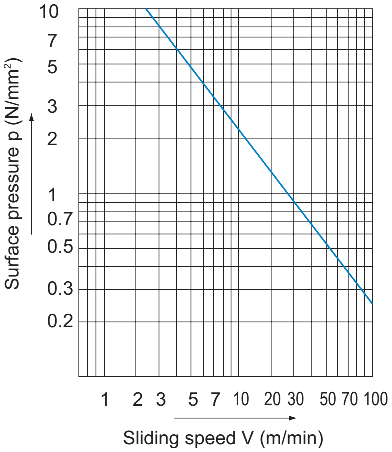


Fig.1 pV Value

● f_S: Safety Factor

To calculate a load applied to the change nut, it is necessary to accurately obtain the effect of the inertia that changes with the weight and the dynamic speed of an object. In general, with the reciprocating or the rotating machines, it is not easy to accurately obtain all the factors such as the effect of the start and stop, which are always repeated. Therefore, if the actual load cannot be obtained, it is necessary to select a bearing while taking into account the empirically obtained safety factors (f_S) shown in Table1.

Table1 Safety Factor (f_S)

Type of load	Lower limit of f_S
For a static load less frequently used	1 to 2
For an ordinary single-directional load	2 to 3
For a load accompanied by vibrations/impact	4 or greater

● f_T: Temperature Factor

If the temperature of the change nut exceeds the normal temperature range, the seizure resistance of the nut and the strength of the material will decrease. Therefore, it is necessary to multiply the dynamic permissible torque (T) and the dynamic permissible thrust (F) by the corresponding temperature factor indicated in Fig.2.

Note) In the case of a miniature Change Nut, be sure to use it at 60℃ or below.

Accordingly, when selecting a change nut, the following equations need to be met in terms of its strength.

Dynamic permissible torque(T)

$$f_S \leqq \frac{f_T \cdot T}{P_T}$$

Static permissible thrust(F)

$$f_S \leqq \frac{f_T \cdot F}{P_F}$$

f_S : Static safety factor (see Table1 on A-845)
f_T : Temperature factor (see Fig.2)
T : Dynamic permissible torque (N-m)
P_T : Applied torque (N-m)
F : Dynamic permissible thrust (N)
P_F : Axial load (N)

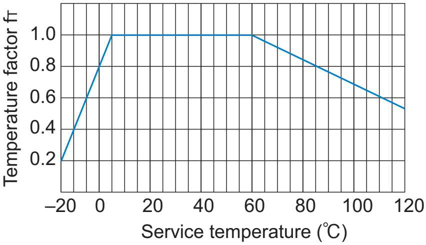


Fig.2 Temperature Factor

● Hardness of the Surface and Wear Resistance

The hardness of the shaft significantly affects the wear resistance of the change nut. If the hardness is equal to or less than 250 HV, the abrasion loss increases as indicated in Fig.3. The roughness of the surface should preferably be 0.80a or less.

A special rolled shaft achieves surface hardness of 250 HV or greater, through hardening as a result of rolling, and surface roughness of 0.20a or less. Thus, the dedicated rolled shaft is highly wear resistant.

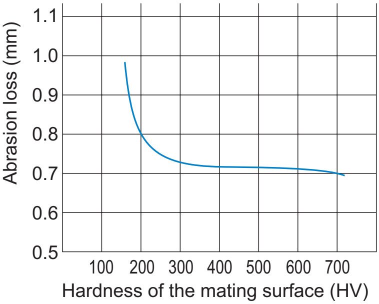


Fig.3 Hardness of the Surface and Wear Resistance

[Calculating the Contact Surface Pressure p]

The value of "p" is obtained as followed.

- **If an axial load is applied:**

$$p = \frac{P_F}{F} \times 9.8$$

p : Contact surface pressure on the tooth from an axial load (P_F N) (N/mm^2)
F : Dynamic permissible thrust (N)
P_F : Axial load (N)

- **If a torque is applied:**

$$p = \frac{P_T}{T} \times 9.8$$

p : Contact surface pressure on the tooth under a load torque (P_T N-m) (N/mm^2)
T : Dynamic permissible torque (N-m)
P_T : Applied torque (N-m)

[Calculating the Sliding Speed V on the Teeth]

The value of "V" is obtained as followed.

$$V = \frac{\sqrt{2} \cdot \pi \cdot Do \cdot n}{10^3}$$

V : Sliding speed (m/min)
Do : Effective diameter
(see specification table) (mm)
n : Rotation speed per minute (min^{-1})
R : Lead (mm)

[Example of Calculation]

Assuming that Change Nut model DCMB is used, select a screw nut that travels at feed speed S = 10 m/min while receiving an axial load P_F = 1,760 N accompanied by vibrations.
Obtain the pV value.
First, tentatively select model DCMB25T (dynamic permissible thrust F = 12,700 N).
Obtain the contact surface pressure (p).

$$p = \frac{P_F}{F} \times 9.8 = \frac{1760}{12700} \times 9.8 \fallingdotseq 1.36\ \text{N/mm}^2$$

Obtain the sliding speed (V). The revolutions per minute (n) of the screw shaft needed to move it at feed speed S = 10 m/min is calculated as follows.

$$n = \frac{S}{R \times 10^{-3}} = \frac{3}{73.3 \times 10^{-3}} \fallingdotseq 136\text{min}^{-1}$$

$$V = \frac{\sqrt{2} \cdot \pi \cdot Do \cdot n}{10^3} = \frac{\sqrt{2} \times \pi \times 23.1 \times 136}{10^3} \fallingdotseq 14.0\ \text{m/min}$$

From the diagram of pV values (see Fig.1 on A-845), it is judged that there will be no abnormal wear if the sliding speed (V) is 16m/min or below against the "p" value of1.36 N/mm².

Second, obtain the safety factor (f_S) against the dynamic permissible thrust (F).
Given the conditions:
Temperature factor f_T = 1, and
Applied load P_F= 1,760 N, the safety factor is calculated as follows.

$$f_S \leqq \frac{f_T \cdot F}{P_F} = \frac{1 \times 12700}{1760} = 7.2$$

Since the required strength will be met if "f_S" is at least 4 because of the type of load, it is appropriate to select model DCMB25T.

Efficiency, Thrust and Torque

The efficiency (η) of the change nut in relation to the friction coefficient (μ) is indicated in Table2.

Table2 Friction Coefficient and Efficiency

Frictional coefficient (μ)	0.1	0.15	0.2
Efficiency (η)	0.82	0.74	0.67

The thrust generated when a torque is applied is obtained from the following equation.

$$Fa = 2\cdot\pi\cdot\eta\cdot T/R\times10^{-3}$$

Fa : Thrust generated (N)
T : Torque (input) (N-m)
R : Lead (mm)

Also, the torque generated when a thrust is applied is obtained from the following equation.

$$T = \eta\cdot Fa\cdot R\times10^{-3}/2\pi$$

T : Torque generated (N-m)
Fa : Thrust (input) (N)
R : Lead (mm)

[Example of Calculation - 1]

Assuming that Change Nut model DCMB20T is used and the torque T is equal to 19.6 N-m, obtain the thrust to be generated.
If "μ" is 0.2, the efficiency "η" is 0.67 (see Table2), and the generated thrust (Fa) is calculated as follows.

$$Fa = 2\cdot\pi\cdot\eta\cdot T/R\times10^{-3} = \frac{2\times\pi\times0.67\times19.6}{60\times10^{-3}} \fallingdotseq 1370\ \text{N}$$

[Example of Calculation - 2]

Assuming that Change Nut model DCMB20T is used and the thrust Fa is equal to 980 N, obtain the torque to be generated.
If "μ" is 0.2, the efficiency "η" is 0.67 (see Table2), and the generated torque (T) is calculated as follows.

$$T = \frac{\eta\cdot Fa\cdot R\times10^{-3}}{2\pi} = \frac{0.67\times980\times60\times10^{-3}}{2\pi} = 6.27\ \text{N}\cdot\text{m}$$

Accuracy Standards

Table3 Accuracy of the Screw Shaft of Models DCMA and DCMB

Unit: mm

Shaft symbol	Rolled shaft
Accuracy	T^{Note}
Single pitch error (max)	±0.025
Accumulated pitch error (max)	±0.2/300

Note) Symbol T indicates the machining method for the screw shaft.

Fit

For the fitting between the change nut circumference and the housing, we recommend a loose fitting or a tight fitting.
Housing inner-diameter tolerance: H8 or J8

Installation

[About Chamfer of the Housing's Mouth]

To increase the strength of the root of the flange of the change nut, the corner is machined to have an R shape. Therefore, it is necessary to chamfer the inner edge of the housing's mouth.

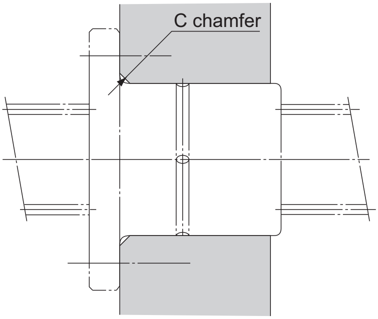


Fig.1

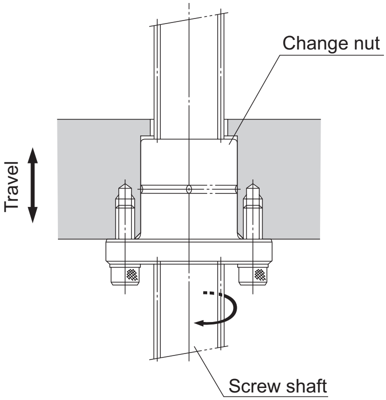
Table1 Chamfer of the Housing's Mouth

Unit: mm

Model No.	Chamfer of the mouth C (Min.)
DCMA DCMB	
8	1.2
12	1.5
15	2
17	
20	
25	2.5
30	
35	3
40	
45	
50	

[Recommended Mounting Orientation]

When vertically conveying a heavy object using the screw shaft, it is safe to mount the screw as shown in Fig.2 where supports are provided on the mounting holes to prevent the moving object from falling even if the change nut is broken due to an overload or an impact.



Shaft rotation

(Shaft side fixed)

Fig.2 Recommended Mounting Orientation

Lubrication

Select a lubrication method according to the conditions of the change nut.

[Oil Lubrication]

For the lubrication of the change nut, an oil lubrication is recommended. Specifically, an oil-bath lubrication or a drop lubrication is particularly effective. An oil-bath lubrication is the most appropriate method since it meets the harsh conditions such as a high speed, a heavy load or an external heat transmission and it cools the change nut. The drop lubrication is appropriate for the low to medium speed and a light to medium load. Select a lubricant according to the conditions as indicated in Table2.

Table2 Selection of a Lubricant

Conditions	Types of Lubricants
Low speed, high load, high temperature	High-viscosity sliding surface oil or turbine oil
High speed, light load, low temperature	Low-viscosity sliding surface oil or turbine oil

[Grease Lubrication]

In a low-speed feed, which occurs less frequently, the user can lubricate the slide system by manually applying the grease to the shaft on a regular basis or using the greasing hole on the change nut. We recommend using the lithium-soap group grease No. 2.

[Initial Lubrication of the Miniature Change Nut]

Since the Miniature Change Nut is made of oil-impregnated plastics, it can be used without the lubrication during an operation. For the initial lubrication, use some oil or grease. Note that lubricants containing large amount of extreme pressure agent are not suitable.

Cross-Roller Ring

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Cross-Roller Ring

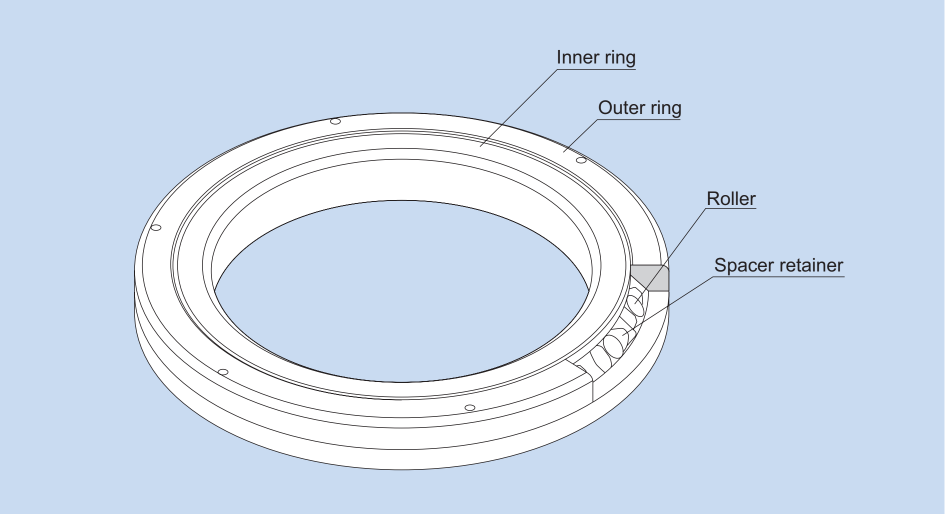


Fig.1 Structure of Cross Roller-Ring Model RB

Structure and Features

With the Cross-Roller Ring, cylindrical rollers are arranged with each roller perpendicular to the adjacent roller, in a 90° V groove, separated from each other by a spacer retainer. This design allows just one bearing to receive loads in all directions including radial, axial and moment loads.
Since the Cross-Roller Ring achieves high rigidity despite the minimum possible dimensions of the inner and outer rings, it is optimal for applications such as joints and swiveling units of industrial robots, swiveling tables of machining centers, rotary units of manipulators, precision rotary tables, medical equipment, measuring instruments and IC manufacturing machines.

[High Rotation Accuracy]

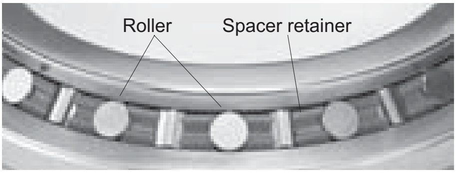
The spacer retainer fitting among cross-arrayed rollers prevents rollers from skewing and the rotational torque from increasing due to friction between rollers. Unlike conventional types using steel sheet retainers, the Cross-Roller Ring does not cause unilateral contact of roller or seize. Thus, even under a preload, the Cross-Roller Ring provides stable rotation.
Since the inner and outer rings are designed to be separable, the bearing clearance can be adjusted. In addition, a preload can be applied. These features enable accurate rotation.

[Easy Handling]

The inner and outer rings, which are separable, are secured to the Cross-Roller Ring body after being installed with rollers and spacer retainers in order to prevent the rings from separating from each other. Thus, it is easy to handle the rings when installing the Cross-Roller Ring.

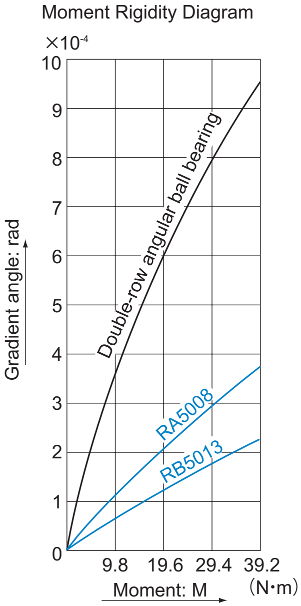
[Skewing Prevention]

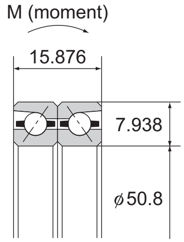
The spacer retainer keeps rollers in their proper position, thereby preventing them from skewing (tilted rollers). This eliminates friction between rollers, and therefore secures a stable rotational torque.



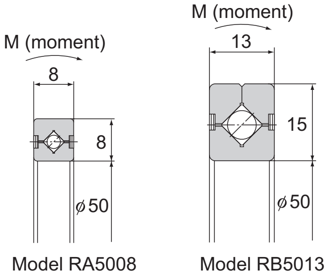
[Increased Rigidity (Three to Four Times Greater than the Conventional Type)]

Unlike the thin angular ball bearings installed in double rows, the cross array of rollers allows a single Cross-Roller Ring unit to receive loads in all directions, increasing the rigidity to three to four times greater than the conventional type.





Angular Ball Bearing



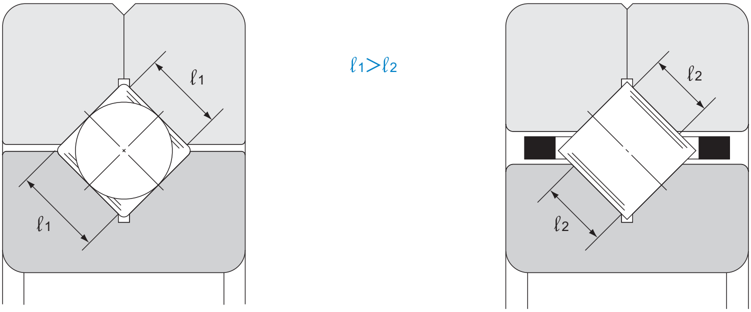
Model RA5008 Model RB5013

Cross Roller Ring

[Large Load Capacity]

(1) Compared with conventional steel sheet retainers, the spacer retainer allows a longer effective contact length of each roller, thus significantly increasing the load capacity.
The spacer retainer guides rollers by supporting them over the entire length of each roller, whereas the conventional type of retainer supports them only at a point at the center of each roller. Such one-point contact cannot sufficiently prevent skewing.

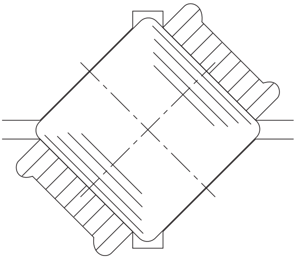
Roller contact length



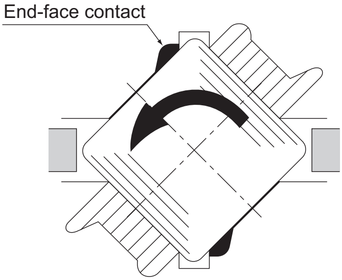
With a spacer retainer

With a steel sheet retainer (conventional type)

(2) In conventional types, the loaded areas are asymmetrical between the outer ring and the inner ring sides around the roller longitudinal axis. The greater the applied load is, the greater the moment becomes, leading end-face contact to occur. This causes frictional resistance, which hinders smooth rotation and quickens wear.



Loaded areas symmetrical
With a spacer retainer



Loaded areas asymmetrical
With a steel sheet retainer (conventional type)

Types of the Cross-Roller Ring

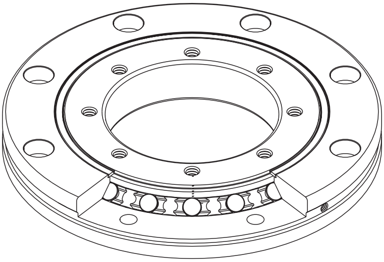
Types and Features

Model RU (Integrated Inner/Outer Ring Type)

Specification Table⇒B-796

Since holes are drilled for mounting, the need for a presser flange and a housing is eliminated.Also, owing to the integrated inner/outer ring type stryucture with washer, there is almost no effect from installation on performance, allowing stable rotational accuracy and torque to be obtained.

Can be used for both outer and inner ring rotation.



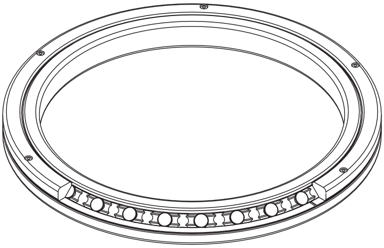
Model RU

Model RB (Separable Outer Ring Type for Inner Ring Rotation)

Specification Table⇒B-798

Cross-Roller Ring basic type, with a separable outer ring, and an inner ring integrated with the main body.It is used in locations where the rotational accuracy of the inner ring is required.

It is used, for example, in the swivel portions of index tables of machine tools.

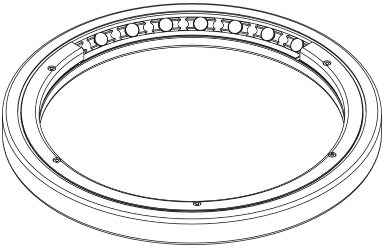


Model RB

Model RE (Two-piece Inner Ring Type for Outer Ring Rotation)

Specification Table⇒B-801

Main dimensions are the same as model RB. This model is used in locations where the rotational accuracy of the outer ring is required.

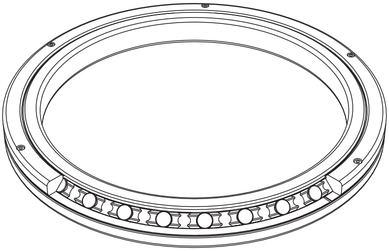


Model RE

USP-Grade Series of Models RB and RE

Specification Table⇒B-804

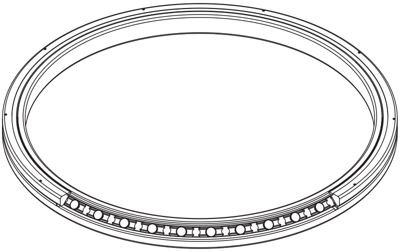
The rotation accuracy of the USP-Grade Series achieves the ultra precision grade that surpasses the world's highest accuracy standards such as JIS Class 2, ISO Class 2, DIN P2 and AFBMA ABCE9.



Model RA (Separable Outer Ring Type for Inner Ring Rotation)

Specification Table⇒B-805

A compact type similar to model RB with the thinnest possible inner and outer rings.
Optimal for locations requiring a light-weight and compact design such as the swivel portions of robots and manipulators.

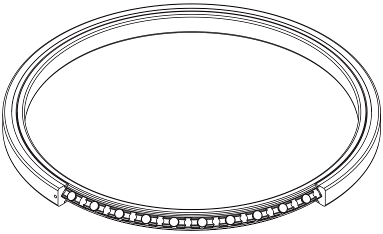


Model RA

Model RA-C (Singe-Split Type)

Specification Table⇒B-806

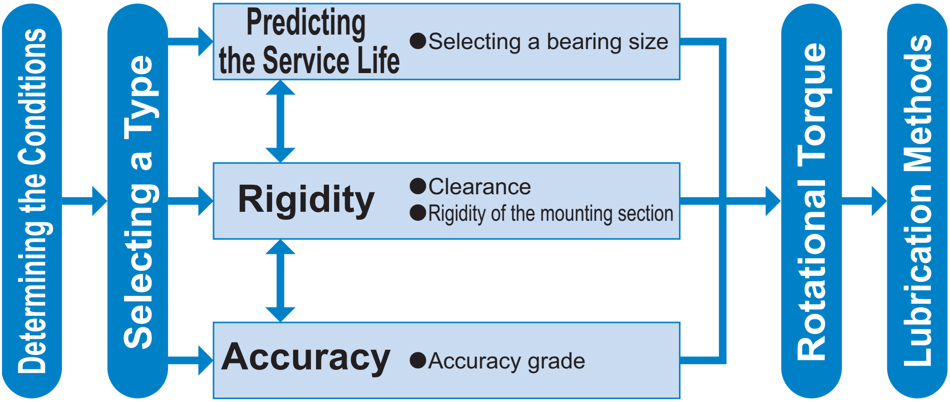
The main dimensions are the same as that of model RA.Owing to its Single-split Outer Ring structure with a highly rigid outer ring, this model can be used for outer ring rotation.



Model RA-C

Selecting a Cross-Roller Ring

The following diagram shows a typical procedure for selecting a Cross-Roller Ring.



Determining the Conditions

Selecting a Type

Predicting the Service Life
- Selecting a bearing size

Rigidity
- Clearance
- Rigidity of the mounting section

Accuracy
- Accuracy grade

Rotational Torque

Lubrication Methods

- Inner ring rotating······Model RB
- Outer ring rotating······Model RE
- Mounting space···Models RA-C and RA

Nominal Life

The service life of the Cross-Roller Ring is obtained from the following equation.

$$L = \left(\frac{f_T \cdot C}{f_W \cdot P_C}\right)^{\frac{10}{3}} \times 10^6$$

L : Nominal life
(The total number of revolutions that 90% of a group of identical Cross-Roller Ring units independently operating under the same conditions can achieve without showing flaking from rolling fatigue)
C : Basic dynamic load rating* (N)
P_C : Dynamic equivalent radial load (N)
f_T : Temperature factor (see Fig.1)
f_W : Load factor (see Table1)

* The basic dynamic load rating (C) of the Cross-Roller Ring shows the radial load with interlocked direction and magnitude, under which the nominal life (L) is 1 million revolutions when a group of identical Cross-Roller Ring units independently operate under the same conditions. The basic dynamic load rating (C) is indicated in the specification tables.

[Dynamic Equivalent Radial Load P_C]

The dynamic equivalent radial load of the Cross-Roller Ring is obtained from the following equation.

$$P_C = X \cdot \left(Fr + \frac{2M}{dp}\right) + Y \cdot Fa$$

P_C : Dynamic equivalent radial load (N)
Fr : Radial load (N)
Fa : Axial load (N)
M : Moment (N-mm)
X : Dynamic radial facto (see Table2)
Y : Dynamic axial factor (see Table2)
dp : Roller pitch circle diameter (mm)

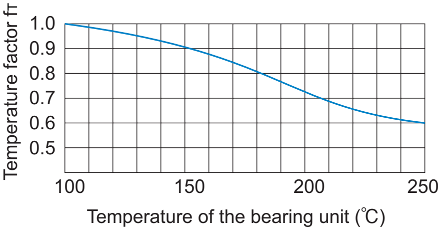


Fig.1 Temperature Factor (f_T)

Note) The normal service temperature is 80 ℃ or below. If the product is to be used at a higher temperature, contact THK.

Table1 Load Factor (f_W)

Service condition	f_W
Smooth motion without impact	1 to 1.2
Normal motion	1.2 to 1.5
Motion with severe impact	1.5 to 3

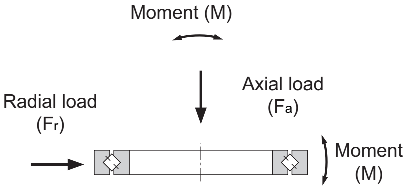


Fig.2

Table2 Dynamic Radial Factor and Dynamic Axial Factor

Classification	X	Y
$\frac{Fa}{Fr + 2M/dp} \leqq 1.5$	1	0.45
$\frac{Fa}{Fr + 2M/dp} > 1.5$	0.67	0.67

- ● If Fr = 0N and M = 0 N-mm, perform calculation while assuming that X = 0.67 and Y = 0.67.
- ● For service life calculation with a preload taken into account, contact THK.

[Example of Calculating the Nominal Life]

Assuming that model RB25025 is used under the following conditions, calculate its nominal life (L).

m_1 =100 kg
m_2 =200 kg
m_3 =300 kg
D_1 =300 mm
D_2 =150 mm
H =200 mm
C =69.3 kN
C_0 =150 kN
dp =277.5 mm
F =100 N
ω =2 rad/s(ω: angular velocity)

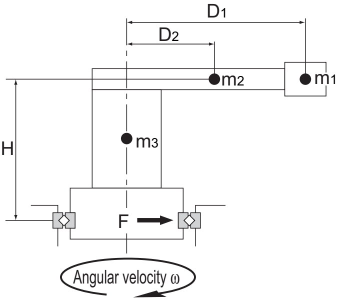


Fig.3

Radial load : Fr $=F+m_1\cdot D_1\times10^{-3}\cdot\omega^2+m_2\cdot D_2\times10^{-3}\cdot\omega^2$
$=100+100\cdot300\times10^{-3}\cdot2^2+200\cdot150\times10^{-3}\cdot2^2$
$=340$ N

Axial load : Fa $=(m_1+m_2+m_3)\times g$
$=(100+200+300)\times9.807$
$=5884.2$ N

Moment :M $=m_1\cdot g\times D_1+m_2\cdot g\times D_2+(m_1\cdot D_1\times10^{-3}\cdot\omega^2+m_2\cdot D_2\times10^{-3}\cdot\omega^2)\times H$
$=100\cdot9.807\times300+200\cdot9.807\times150+$
$(100\cdot300\times10^{-3}\cdot2^2+200\cdot150\times10^{-3}\cdot2^2)\times200$
$=636420$ N·mm

$$\frac{Fa}{Fr+2M/dp}=\frac{5884.2}{340+2\times636420/277.5}=1.19\leqq1.5$$

∴X =1 , Y =0.45

Therefore, the dynamic equivalent radial load (P_c) is obtained as follows.

$$P_C=X\left(Fr+\frac{2M}{dp}\right)+Y\cdot Fa=1\times\left(340+\frac{2\cdot636420}{277.5}\right)+0.45\times5884.2=7574.7\text{ N}$$

If f_W = 1.2, the nominal life is calculated as follows.Thus, the nominal life (L) is 8.7×10^8 revolutions.

$$L=\left(\frac{f_T\cdot C}{f_W\cdot P_C}\right)^{\frac{10}{3}}=\left(\frac{1\times69.3\times10^3}{1.2\times7574.7}\right)^{\frac{10}{3}}\times10^6=8.7\times10^8\quad\text{Rotation}$$

Static Safety Factor

The basic static load rating C_0 refers to the static load with constant direction and magnitude, under which the calculated contact stress in the center of the contact area between the roller and the raceway under the maximum load is 4000 MPa. (If the contact stress exceeds this level, it will affect the rotation.) This value is indicated as "C_0" in the specification tables. When a load is statically or dynamically applied, it is necessary to consider the static safety factor as shown below.

$$\frac{C_0}{P_0} = f_S$$

f_S : Static safety factor (see Table3)
C_0 : Basic static load rating (N)
P_0 : Static equivalent radial load (N)

Table3 Static Safety Factor (f_S)

Load conditions	Lower limit of f_S
Normal load	1 to 2
Impact load	2 to 3

[Static Equivalent Radial Load P_0]

The static equivalent radial load of the Cross-Roller Ring is obtained from the following equation.

$$P_0 = X_0 \cdot \left(Fr + \frac{2M}{dp}\right) + Y_0 \cdot Fa$$

P_0 : Static equivalent radial load (N)
Fr : Radial load (N)
Fa : Axial load (N)
M : Moment (N-mm)
X_0 : Static radial factor ($X_0=1$)
Y_0 : Static axial factor ($Y_0=0.44$)
dp : Roller pitch circle diameter (mm)

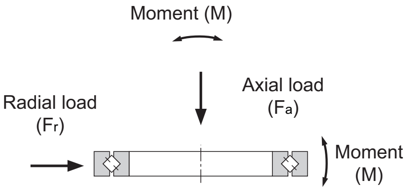


Fig.4

[Example of Calculating a Static Safety Factor]

Assuming that model RB25025 is used under the following conditions, calculate its static safety factor (f_s).

m_1 =100 kg
m_2 =200 kg
m_3 =300 kg
D_1 =300 mm
D_2 =150 mm
H =200 mm
C =69.3 kN
C_0 =150 kN
dp =277.5 mm
F =100 N
ω =2 rad/s(ω: angular velocity)

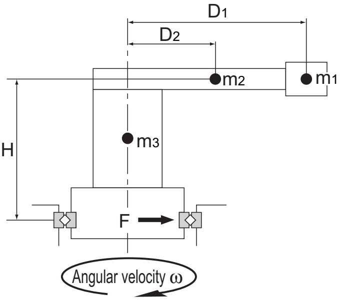


Fig.5

Radial load : Fr
$$\begin{aligned} Fr &= F+m_1\cdot D_1\times10^{-3}\cdot\omega^2+m_2\cdot D_2\times10^{-3}\cdot\omega^2 \\ &= 100+100\cdot300\times10^{-3}\cdot2^2+200\cdot150\times10^{-3}\cdot2^2 \\ &= 340\text{ N} \end{aligned}$$

Axial load : Fa
$$\begin{aligned} Fa &= (m_1+m_2+m_3)\times g \\ &= (100+200+300)\times9.807 \\ &= 5884.2\text{ N} \end{aligned}$$

Moment :M
$$\begin{aligned} M &= m_1\cdot g\times D_1+m_2\cdot g\times D_2+(m_1\cdot D_1\times10^{-3}\cdot\omega^2+m_2\cdot D_2\times10^{-3}\cdot\omega^2)\times H \\ &= 100\cdot9.807\times300+200\cdot9.807\times150+ \\ &\quad (100\cdot300\times10^{-3}\cdot2^2+200\cdot150\times10^{-3}\cdot2^2)\times200 \\ &= 636420\text{ N}\cdot\text{mm} \end{aligned}$$

Therefore, the static equivalent radial load (P_0) is obtained as follows.

$$P_0 = X\left(Fr+\frac{2M}{dp}\right)+Y\cdot Fa = 1\times\left(340+\frac{2\cdot636420}{277.5}\right)+0.44\times5884.2 = 7515.8\text{ N}$$

$$\therefore f_s = \frac{150\times10^3}{7515.8} = 20$$

Thus, the static safety factor (f_s) is 20.

Static Permissible Moment

The static permissible moment (M_0) of the Cross-Roller Ring is obtained from the following equation.

$$M_0 = C_0 \cdot \frac{dp}{2} \times 10^{-3}$$

M_0	: Static permissible moment	(kN-m)
C_0	: Basic static load rating	(kN)
dp	: Roller pitch circle diameter	(mm)

[Example of Calculating a Static Permissible Moment]

Model No. RB25025

C =69.3 kN

C_0 =150 kN

dp =277.5 mm

The static permissible moment is calculated as follows.

$$M_0 = C_0 \cdot \frac{dp}{2} \times 10^{-3} = 150 \cdot \frac{277.5}{2} \times 10^{-3} = 20.8 \text{ kN} \cdot \text{m}$$

Static Permissible Axial Load

The static permissible axial load (Fa_0) of the Cross-Roller Ring is obtained from the following equation.

$$Fa_0 = \frac{C_0}{Y_0}$$

Fa_0	: Static permissible axial load	(kN)
Y_0	: Static axial factor	(Y_0=0.44)

[Example of Calculating a Static Permissible Axial Load]

Model No. RB25025

C =69.3 kN

C_0 =150 kN

The static permissible axial load (Fa_0) is calculated as follows.

$$Fa_0 = \frac{C_0}{Y_0} = \frac{150}{0.44} = 340.9 \text{ kN}$$

Accuracy Standards

The Cross-Roller Ring is manufactured with the accuracy and the dimensional tolerance according to Table4 to Table13.

Table4 Rotational Accuracy of the Inner Ring of Model RU

Unit: µm

Model No.	Radial runout tolerance of the inner ring			Axial runout tolerance of the inner ring		
	Grade P5	Grade P4	Grade P2	Grade P5	Grade P4	Grade P2
RU42	4	3	2.5	4	3	2.5
RU66	5	4	2.5	5	4	2.5
RU85	5	4	2.5	5	4	2.5
RU124	5	4	2.5	5	4	2.5
RU148	6	5	2.5	6	5	2.5
RU178	6	5	2.5	6	5	2.5
RU228	8	6	5	8	6	5
RU297	10	8	5	10	8	5
RU445	15	12	7	15	12	7

Note) For model RU, grade P5 is standard rotational accuracy.(Not indicated in model number.)

Table5 Rotational Accuracy of the Outer Ring of Model RU

Unit: µm

Model No.	Radial runout tolerance of the outer ring			Axial runout tolerance of the outer ring		
	Grade P5	Grade P4	Grade P2	Grade P5	Grade P4	Grade P2
RU42	8	5	4	8	5	4
RU66	10	6	5	10	6	5
RU85	10	6	5	10	6	5
RU124	13	8	5	13	8	5
RU148	15	10	7	15	10	7
RU178	15	10	7	15	10	7
RU228	18	11	7	18	11	7
RU297	20	13	8	20	13	8
RU445	25	16	10	25	16	10

Note) For model RU, grade P5 is standard rotational accuracy.(Not indicated in model number.)

Table6 Rotational Accuracy of the Inner Ring of Model RB

Unit: µm

Nominal dimension of the bearing inner diameter (d) (mm)		Radial runout tolerance of the inner ring					Axial runout tolerance of the inner ring				
		Grade 0	Grade PE6	Grade PE5	Grade PE4	Grade PE2	Grade 0	Grade PE6	Grade PE5	Grade PE4	Grade PE2
Above	Or less		Grade P6	Grade P5	Grade P4	Grade P2		Grade P6	Grade P5	Grade P4	Grade P2
18	30	13	8	4	3	2.5	13	8	4	3	2.5
30	50	15	10	5	4	2.5	15	10	5	4	2.5
50	80	20	10	5	4	2.5	20	10	5	4	2.5
80	120	25	13	6	5	2.5	25	13	6	5	2.5
120	150	30	18	8	6	2.5	30	18	8	6	2.5
150	180	30	18	8	6	5	30	18	8	6	5
180	250	40	20	10	8	5	40	20	10	8	5
250	315	50	25	13	10	—	50	25	13	10	—
315	400	60	30	15	12	—	60	30	15	12	—
400	500	65	35	18	14	—	65	35	18	14	—
500	630	70	40	20	16	—	70	40	20	16	—
630	800	80	—	—	—	—	80	—	—	—	—
800	1000	90	—	—	—	—	90	—	—	—	—
1000	1250	100	—	—	—	—	100	—	—	—	—

Table7 Rotational Accuracy of the Outer Ring of Model RE

Unit: µm

Nominal dimension of the bearing outer diameter (D) (mm)		Radial runout tolerance of the outer ring					Axial runout tolerance of the outer ring				
		Grade 0	Grade PE6	Grade PE5	Grade PE4	Grade PE2	Grade 0	Grade PE6	Grade PE5	Grade PE4	Grade PE2
Above	Or less		Grade P6	Grade P5	Grade P4	Grade P2		Grade P6	Grade P5	Grade P4	Grade P2
30	50	20	10	7	5	2.5	20	10	7	5	2.5
50	80	25	13	8	5	4	25	13	8	5	4
80	120	35	18	10	6	5	35	18	10	6	5
120	150	40	20	11	7	5	40	20	11	7	5
150	180	45	23	13	8	5	45	23	13	8	5
180	250	50	25	15	10	7	50	25	15	10	7
250	315	60	30	18	11	7	60	30	18	11	7
315	400	70	35	20	13	8	70	35	20	13	8
400	500	80	40	23	15	—	80	40	23	15	—
500	630	100	50	25	16	—	100	50	25	16	—
630	800	120	60	30	20	—	120	60	30	20	—
800	1000	120	75	—	—	—	120	75	—	—	—
1000	1250	120	—	—	—	—	120	—	—	—	—
1250	1600	120	—	—	—	—	120	—	—	—	—

Table8 Rotational Accuracy of the Inner Ring of Model RA and RA-C

Unit: µm

Nominal dimension of the bearing inner diameter (d) (mm)		Tolerance in radial runout and axial runout
Above	Or less	
40	65	13
65	80	15
80	100	15
100	120	20
120	140	25
140	180	25
180	200	30

Note) If higher accuracy than the above values is required for the inner ring in rotational accuracy for models RA and RA-C, contact THK.

Table9 Rotational Accuracy of the Outer Ring of Model RA-C

Unit: µm

Nominal dimension of the bearing outer diameter (D) (mm)		Tolerance in radial runout and axial runout
Above	Or less	
65	80	13
80	100	15
100	120	15
120	140	20
140	180	25
180	200	25
200	250	30

Note) The rotational accuracy of the outer ring for model RA-C indicates the value before separation.

Table10 Dimensional Tolerance of the Bearing Inner Diameter

Unit: µm

Nominal dimension of the bearing inner diameter (d) (mm)		Tolerance of dm(note 2)							
		Grades 0, P6, P5, P4 and P2		Grade PE6		Grade PE5		Grade PE4 and PE2	
Above	Or less	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
18	30	0	−10	0	−8	0	−6	0	−5
30	50	0	−12	0	−10	0	−8	0	−6
50	80	0	−15	0	−12	0	−9	0	−7
80	120	0	−20	0	−15	0	−10	0	−8
120	150	0	−25	0	−18	0	−13	0	−10
150	180	0	−25	0	−18	0	−13	0	−10
180	250	0	−30	0	−22	0	−15	0	−12
250	315	0	−35	0	−25	0	−18	—	—
315	400	0	−40	0	−30	0	−23	—	—
400	500	0	−45	0	−35	—	—	—	—
500	630	0	−50	0	−40	—	—	—	—
630	800	0	−75	—	—	—	—	—	—
800	1000	0	−100	—	—	—	—	—	—
1000	1250	0	−125	—	—	—	—	—	—

Note1) Standard inner diameter accuracy of models RA, RA-C and RU is 0. For higher accuracy than 0, contact THK.
Note2) "dm" represents the arithmetic average of the maximum and minimum diameters obtained in measuring the bearing inner diameter at two points.
Note3) For accuracy grades in bearing inner diameter with no values indicated in the table, the highest value among low accuracy grades applies.

Table11 Dimensional Tolerance of the Bearing Outer Diameter

Unit: µm

Nominal dimension of the bearing outer diameter (D) (mm)		Tolerance of Dm(note 2)							
		Grades 0, P6, P5, P4 and P2		Grade PE6		Grade PE5		Grade PE4 and PE2	
Above	Or less	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
30	50	0	−11	0	−9	0	−7	0	−6
50	80	0	−13	0	−11	0	−9	0	−7
80	120	0	−15	0	−13	0	−10	0	−8
120	150	0	−18	0	−15	0	−11	0	−9
150	180	0	−25	0	−18	0	−13	0	−10
180	250	0	−30	0	−20	0	−15	0	−11
250	315	0	−35	0	−25	0	−18	0	−13
315	400	0	−40	0	−28	0	−20	0	−15
400	500	0	−45	0	−33	0	−23	—	—
500	630	0	−50	0	−38	0	−28	—	—
630	800	0	−75	0	−45	0	−35	—	—
800	1000	0	−100	—	—	—	—	—	—
1000	1250	0	−125	—	—	—	—	—	—
1250	1600	0	−160	—	—	—	—	—	—

Note1) Standard outer diameter accuracy of models RA, RA-C and RU is 0. For higher accuracy than 0, contact THK.
Note2) "Dm" represents the arithmetic average of the maximum and minimum diameters obtained in measuring the bearing outer diameter at two points.
Note3) For accuracy grades in bearing outer diameter with no values indicated in the table, the highest value among low accuracy grades applies.

Table12 Tolerance in the Width of the Inner and Outer Rings for Models RU

Unit: µm

Model No.	Tolerrance of B	
	Upper	Lower
RU42	0	−75
RU66	0	−75
RU85	0	−75
RU124	0	−75
RU148	0	−75
RU178	0	−100
RU228	0	−100
RU297	0	−100
RU445	0	−100

Table13 Tolerance in the Width of the Inner and Outer Rings (Common to All Grades) for Models RB and RE

Unit: µm

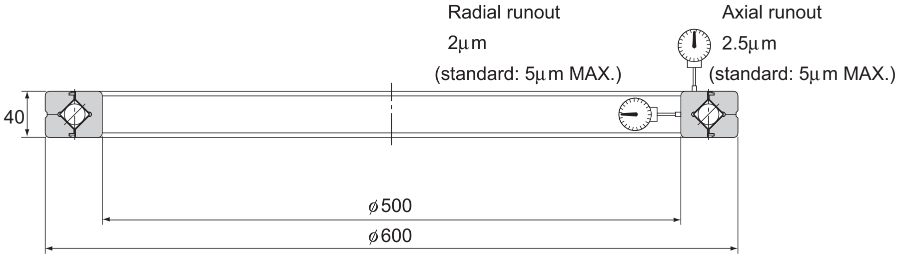
Nominal dimension of the bearing inner diameter (d) (mm)		Tolerrance of B		Tolerrance of B1	
		Applied to the inner ring of RB and the outer ring of RE		Applied to the outer ring of RB and the inner ring of RE	
Above	Or less	Upper	Lower	Upper	Lower
18	30	0	−75	0	−100
30	50	0	−75	0	−100
50	80	0	−75	0	−100
80	120	0	−75	0	−100
120	150	0	−100	0	−120
150	180	0	−100	0	−120
180	250	0	−100	0	−120
250	315	0	−120	0	−150
315	400	0	−150	0	−200
400	500	0	−150	0	−200
500	630	0	−150	0	−200
630	800	0	−150	0	−200
800	1000	0	−300	0	−400
1000	1250	0	−300	0	−400

Note) All B and B1 types of models RA and RA-C are manufactured with tolerance between -0.120 and 0.

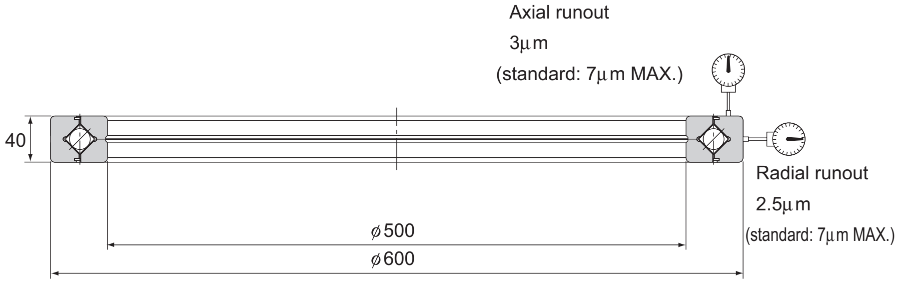
Accuracy Standard of the USP-Grade Series

[Examples of Rotational Accuracy of the USP-Grade Series Cross-Roller Rings]

The rotation accuracy of the USP-Grade Series achieves the ultra precision grade that surpasses the world's highest accuracy standards such as JIS Class 2, ISO Class 2, DIN P2 and AFBMA ABEC9.



Rotational Accuracy of the Inner Ring of Model RB50040CC0USP



Rotational Accuracy of the Outer Ring of Model RE50040CC0USP

[Accuracy Standards]

The USP-grade series of models RB and RE are manufactured with runout accuracies according to Table14.

Table14 Runout Accuracies of the USP-grade Series

Unit: µm

Nominal inner diameter (d) and outer diameter (D) (mm)		Runout accuracy of the inner ring of model RB		Runout accuracy of the outer ring of model RE	
Above	Or less	Radial runout tolerance	Axial runout tolerance	Radial runout tolerance	Axial runout tolerance
80	180	2.5	2.5	3	3
180	250	3	3	4	4
250	315	4	4	4	4
315	400	4	4	5	5
400	500	5	5	5	5
500	630	6	6	7	7
630	800	—	—	8	8

Radial Clearance

Table15 shows the radial clearance of model RU, Table16 that of the standard type of models RB and RE, Table17 that of the USP-grade series of models RB and RE, and Table18 that of the thin type of models RA and RA-C.

Table15 Radial clearance for model RU

Unit: µm

Model No.	CC0		C0	
	Starting torque (N•m)		Radial clearance (µm)	
	Min.	Max.	Min.	Max.
RU42	0.1	0.5	0	25
RU66	0.3	2.2	0	30
RU85	0.4	3	0	40
RU124	1	6	0	40
RU148	1	10	0	40
RU178	3	15	0	50
RU228	5	20	0	60
RU297	10	35	0	70
RU445	20	55	0	100

Note) Model RU clearance CC0 is controlled by starting torque.Starting torque for clearance CC0 does not include seal resistance value.

Table16 Radial Clearances of Models RB and RE

Unit: µm

Pitch circle diameter of the roller (dp) (mm)		CC0		C0		C1	
Above	Or less	Min.	Max.	Min.	Max.	Min.	Max.
18	30	–8	0	0	15	15	35
30	50	–8	0	0	25	25	50
50	80	–10	0	0	30	30	60
80	120	–10	0	0	40	40	70
120	140	–10	0	0	40	40	80
140	160	–10	0	0	40	40	90
160	180	–10	0	0	50	50	100
180	200	–10	0	0	50	50	110
200	225	–10	0	0	60	60	120
225	250	–10	0	0	60	60	130
250	280	–15	0	0	80	80	150
280	315	–15	0	30	100	100	170
315	355	–15	0	30	110	110	190
355	400	–15	0	30	120	120	210
400	450	–20	0	30	130	130	230
450	500	–20	0	30	130	130	250
500	560	–20	0	30	150	150	280
560	630	–20	0	40	170	170	310
630	710	–20	0	40	190	190	350
710	800	–30	0	40	210	210	390
800	900	–30	0	40	230	230	430
900	1000	–30	0	50	260	260	480
1000	1120	–30	0	60	290	290	530
1120	1250	–30	0	60	320	320	580
1250	1400	–30	0	70	350	350	630

Table17 Radial Clearances of USP-grade Series of Models RB and RE

Unit: µm

Pitch circle diameter of the roller (dp) (mm)		CC0		C0	
Above	Or less	Min.	Max.	Min.	Max.
120	160	–10	0	0	40
160	200	–10	0	0	50
200	250	–10	0	0	60
250	280	–15	0	0	80
280	315	–15	0	0	100
315	355	–15	0	0	110
355	400	–15	0	0	120
400	500	–20	0	0	130
500	560	–20	0	0	150
560	630	–20	0	0	170
630	710	–20	0	0	190

Table18 Radial Clearances of Models RA and RA-C

Unit: µm

Pitch circle diameter of the roller (dp) (mm)		CC0		C0	
Above	Or less	Min.	Max.	Min.	Max.
50	80	–8	0	0	15
80	120	–8	0	0	15
120	140	–8	0	0	15
140	160	–8	0	0	15
160	180	–10	0	0	20
180	200	–10	0	0	20
200	225	–10	0	0	20

Moment Rigidity

Fig.6 to Fig.9 show moment rigidity diagrams for the Cross-Roller Ring as a separate unit. Rigidity is affected by the deformation of the housing, presser flange and bolts. Therefore, the strength of these parts must be taken into account.

(Radial clearance: 0)

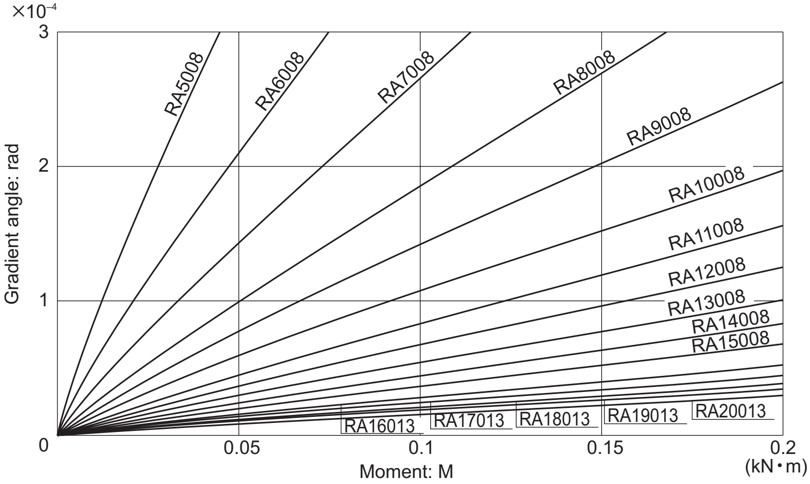


Fig.6

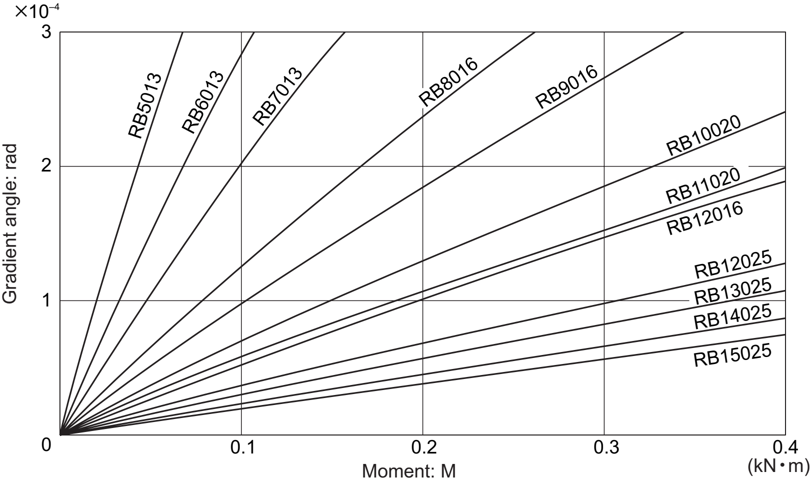


Fig.7

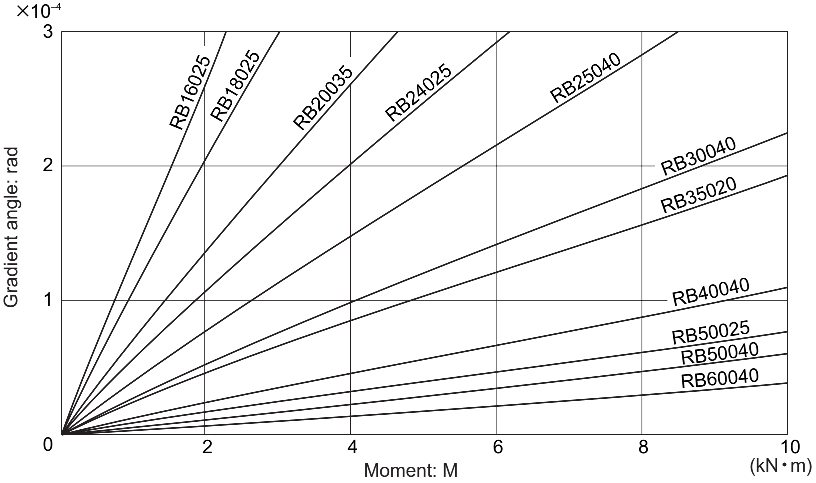

×10⁻⁴
3
2
1
0
Gradient angle: rad
RB16025
RB18025
RB20035
RB24025
RB25040
RB30040
RB35020
RB40040
RB50025
RB50040
RB60040
2
4
6
8
10
(kN・m)
Moment: M

Fig.8

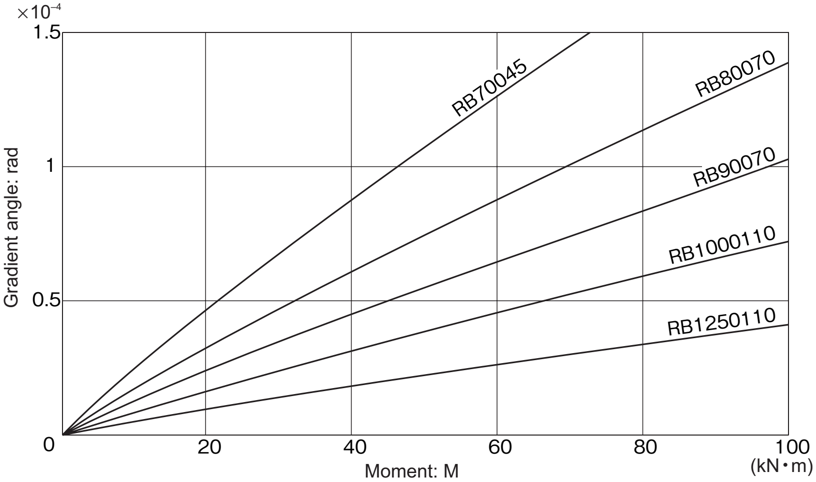

×10⁻⁴
1.5
1
0.5
0
Gradient angle: rad
RB70045
RB80070
RB90070
RB1000110
RB1250110
20
40
60
80
100
(kN・m)
Moment: M

Fig.9

Fit

[Fitting of Models RU]

Fitting for model RU is basically not required. However, for fitting requiring positioning accuracy, h7 and H7 are recommended.

[Fitting of Models RB, RE and RA]

For the fitting of models RB, RE and RA, we recommend using the combinations indicated in Table1.

Table1 Fitting of Models RB, RE and RA

Radial clearance	Service condition		Shaft	Housing
C0	Inner ring rotational load	Normal load	h5	H7
		Large impact and moment	h5	H7
	Outer ring rotational load	Normal load	g5	Js7
		Large impact and moment	g5	Js7
C1	Inner ring rotational load	Normal load	j5	H7
		Large impact and moment	k5	Js7
	Outer ring rotational load	Normal load	g6	Js7
		Large impact and moment	h5	K7

Note) For the fitting for clearance CC0, avoid interference because it will cause an excessive preload. As for the fitting when you have selected clearance CC0 for the joints or swiveling unit of a robot, the combination of g5 and H7 is recommended.

[Fitting of the USP-grade]

For the fitting of the USP-grade series of models RB and RE, we recommend using the combinations indicated in Table2.

Table2 Fitting of the USP-grade

Radial clearance	Condition	Shaft	Housing
CC0	Inner ring rotational load	h5	J7
	Outer ring rotational load	g5	Js7
C0	Inner ring rotational load	j5	J7
	Outer ring rotational load	g5	K7

[Fitting for Model RA-C]

For the fitting of model RA-C, we recommend using the combinations indicated in Table3.

Table3 Fitting for Model RA-C

Radial clearance	Condition	Shaft	Housing
CC0	Inner ring rotational load	h5	J7
	Outer ring rotational load	g5	Js7
C0	Inner ring rotational load	j5	J7
	Outer ring rotational load	g5	K7

Designing the Housing and the Presser Flange

Since the Cross-Roller Ring is a compact, thin device, special consideration must be given to the rigidity of the housing and the presser flange.

With types having a separable outer ring, insufficiency in the strength of the housing, pressure flange or the presser bolt will result in the inability to evenly hold the inner or outer ring, or the deformation of the bearing when a moment load is applied. Consequently, the contact area of the rollers will become uneven, causing the bearing's performance to significantly deteriorate.

Fig.2 shows examples of installing the Cross-Roller Ring.

[Housing]

When determining the thickness of the housing, make sure it is at least 60% of the sectional height of the bearing as a guide.

$$\text{Housing thickness } T=\frac{D-d}{2}\ \text{X}\ 0.6 \text{ or greater}$$

(D: outer diameter of the outer ring;
d: inner diameter of the inner ring)

If tapped holes for removing the inner or outer ring (Fig.1) are provided, the ring can be removed without causing damage to the bearing. When removing the outer ring, do not press the inner ring, or vise versa. For the dimensions of the presser on the side(s), see the shoulder dimensions indicated in the corresponding specification table.

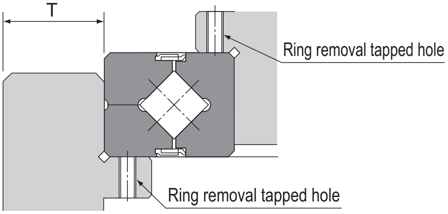
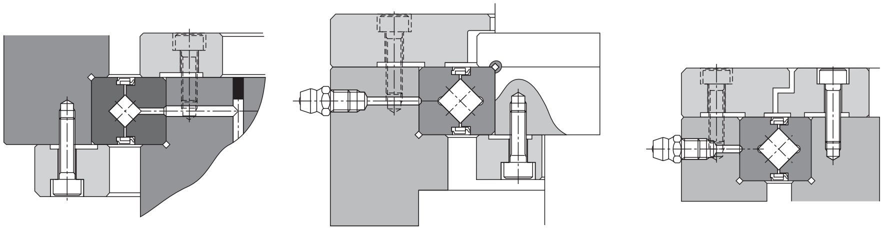


Fig.1



a. Outer ring rotating in the swiveling unit

A heavy body part is mounted after the inner and outer rings are secured.

b. Inner ring rotating in the swiveling unit
(with seals attached)

c. Inner and outer rings secured in the same direction in the swiveling unit
(with seals attached)

Fig.2 Example of Installation

[Presser Flange and Presser Bolt]

When determining the thickness of the presser flange (F) or the clearance of the flange section (S), refer to the dimensions indicated below as a guide.

As for the number of the presser bolts, the greater the number of the bolts, the more stable the system becomes. As a guide, however, it is normally appropriate to use the number of bolts indicated in Table4 and equidistantly arrange them.

F = B×0.5 to B×1.2

$H = B^{\ 0}_{-0.1}$

S = 0.5 mm

Even if the shaft and the housing are made of light alloy, it is recommendable to select a steel-based material for the presser flange.

When tightening the presser bolts, firmly secure them using a torque wrench or the like so that they will not loosen. Table5 shows tightening torques for the housing and presser flanges made of typical steel materials with medium hardness.

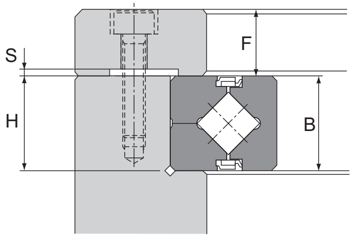


Table4 Number of Presser Bolts and Bolt Sizes

Unit: mm

Outer diameter of the outer ring (D)		No. of bolts	Bolt size (reference value)
Above	Or less		
—	100	8 or more	M3 to M5
100	200	12 or more	M4 to M8
200	500	16 or more	M5 to M12
500	—	24 or more	M12 or thicker

Table5 Bolt Tightening Torque Unit: N-m

Screw model No.	Tightening torque	Screw model No.	Tightening torque
M3	2	M10	70
M4	4	M12	120
M5	9	M16	200
M6	14	M20	390
M8	30	M22	530

Procedure for Assembly

When assembling the Cross-Roller Ring, follow the steps below.

[Inspecting the Parts before Assembling Them]

Thoroughly clean the housing and other parts to be assembled, and check if there is no burr or knots.

[Installing the Cross-Roller Ring into the Housing or onto the Shaft]

Since the Cross-Roller Ring is a thin bearing, it tends to tilt as it is installed. To prevent it, gradually drive the Cross-Roller Ring into the housing or onto the shaft by gently hitting it with a plastic hammer while keeping it horizontal. Be sure to keep hammering it with much care until you hear it fully contact the reference surface.

[Attaching the Presser Flange]

(1) Place the presser flange onto the Cross-Roller Ring. Rock the flange several times to match the bolt holes.

(2) Insert the presser bolts into the holes. Manually turn the bolts and make sure they do not show skewing caused by misalignment of the holes.

(3) Fasten the presser bolts in three to four steps from temporary to full fastening by repeatedly securing the bolts in the diagonal order, as shown in Fig.1. When tightening the separable inner or outer ring, slightly turning the integral outer or inner ring will correct the dislocation between the ring and the body.

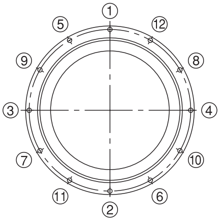


Fig.1 Tightening Sequence

[Handling]

(1) The separable inner or outer ring is fastened in place using special rivets, bolts or nuts when delivered. When installing it to the system, do not disassemble it. Also, erroneously installing the spacer retainer will significantly affect the rotational performance of the system. Do not disassemble the bearing.

(2) The matching mark of the inner or outer ring may be slightly misaligned when delivered. In that case, loosen the bolts that secure the inner or outer ring, and correct the alignment using a plastic hammer or the like, before installing it to the housing. (Let the securing rivets follow the housing.)

(3) When installing or removing the Cross-Roller Ring, do not apply force to the fixing rivets or the bolts.

(4) When mounting the presser flange, take into account the dimensional tolerances of the parts so that the flange firmly holds the inner and outer ring from the side.

(5) Dropping or hitting the Cross-Roller Ring may damage it. Giving an impact force to the bushing could also cause damage even if the product looks intact.

[Lubrication]

(1) Since each Cross-Roller Ring unit contains high-quality lithium soap group grease No. 2, you can start using the product without replenishing grease. However, the product requires regular lubrication since it has a smaller internal space than ordinary roller bearings and because the rollers need frequent lubrication due to their rolling contact structure.
To replenish grease, it is necessary to secure greasing holes that lead to the oil grooves formed on the inner and outer rings. As for the lubrication interval, normally replenish grease of the same group so that it is distributed throughout the interior of the bearing at least every six to twelve months.
When the bearing is filled up with grease, the initial rotational torque temporarily increases. However, surplus grease will run off of the seals and the torque will return to the normal level in a short period. The thin type does not have an oil groove. Secure an oil groove inside the housing for lubrication.

(2) Do not mix greases with different physical properties.

(3) In locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, normal lubricants may not be used. Contact THK for details.

(4) When planning to use a special lubricant, contact THK before using it.

[Precautions on Use]

(1) Entrance of foreign material may cause damage to the ball circulating path or functional loss. Prevent foreign material, such as dust or cutting chips, from entering the system.

(2) Contact THK if you desire to use the product at a temperature of 80℃ or higher.

(3) If planning to use the Cross-Roller Ring in an environment where a coolant penetrates into the product, contact THK.

(4) If foreign material adheres to the product, replenish the lubricant after cleaning the product.

(5) When using the product in locations exposed to constant vibrations or in special environments such as clean rooms, vacuum and low/high temperature, contact THK in advance.

Cam Follower

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Cam Follower

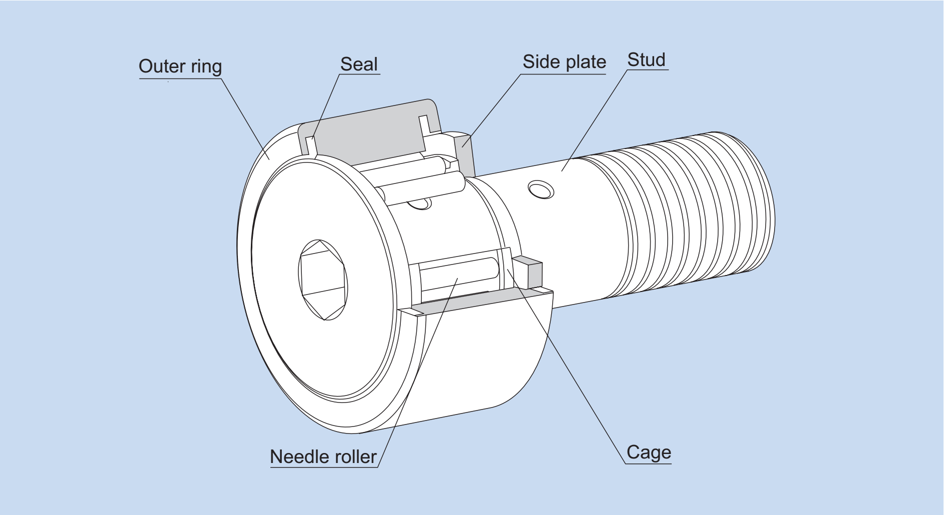


Fig.1 Structure of Cam Follower Model CF⋯UU-A

Structure and Features

The Cam Follower is a compact and highly rigid bearing with a shaft. It contains needle bearings and is used as a guide roller for cam mechanisms or straight motion.

Since its outer ring rotates while keeping direct contact with the mating surface, this product is thick-walled and designed to bear an impact load.

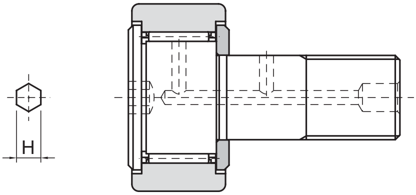
Inside the outer ring, needle rollers and a precision cage are incorporated. This prevents the product from skewing and achieves a superb rotation performance. And, as a result, the product is capable of easily withstanding high-speed rotation.

There are two types of the outer ring in shape: spherical and cylindrical. The spherical outer ring easily absorbs a distortion of the shaft center when the cam follower is installed and helps lighten a biased load.

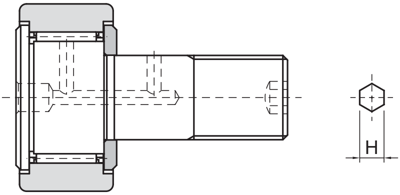
The Cam Follower is used in a wide range of applications such as cam mechanisms of automatic machines, dedicated machines as well as carrier systems, conveyors, bookbinding machines, tool changers of machining centers, pallet changers, automatic coating machines, and sliding forks of automatic warehouses.

Cam Follower with a Hexagon Socket

For Cam Follower model CF, Cam Follower Containing Thrust Balls model CFN and Eccentric Cam Follower model CFH, hexagon socket studs that allow easy eccentricity adjustment are available.
If desiring a hexagon socket on the stud head, add "A" to the end of the model number. If desiring a hexagon socket on the stud thread, add "B". ("B" applies to model CF12 or higher.)



Model CF-A



Model CF-B

The Same Dimension of the Hexagonal Width Across Flats (H Dimension) Applies to Both Type A and Type B.

Cam Follower Containing Thrust Balls

Even a slight mounting error in a high speed cam mechanism operating in a harsh environment could cause abnormal wear to the thrust unit of the cam follower. In such a case, using Cam Follower Containing Thrust Balls model CFN will bring about a significant effect in increasing the durability.
Models CFN5 to 12 are standard-stock items. If desiring a size other than the standard items, contact THK.
Model CFN is capable of receiving a thrust load caused by a slight mounting error. However, it is necessary to minimize a component of thrust force, or prevent it from occurring, when designing the cam mechanism and installing the Cam Follower.

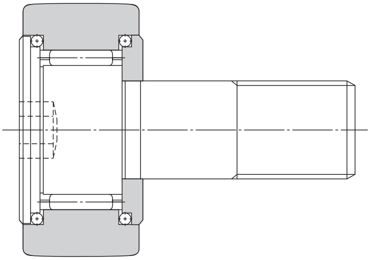


Fig.2

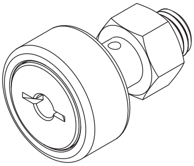
Types of the Cam Follower

Types and Features

Popular Type Cam Follower Model CF

Specification Table⇒B-808

It is a popular type of Cam Follower provided with a driver groove on the head of the stud. A highly corrosion resistant stainless steel type (symbol M) is also available.



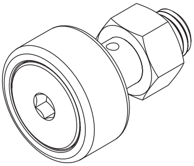
Model CF

Cam Follower with a Hexagon Socket Model CF-A

Specification Table⇒B-810

Since the stud head has a hexagon socket, this model can easily be installed using a hexagon wrench.

A type whose stud screw has a hexagon socket (CF-B) is also available. (applicable to stud diameter of 12 or greater)

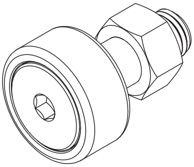


Model CF-A

Eccentric Cam Follower with a Hexagon Socket Model CFH-A

Specification Table⇒B-814

This model can be installed in the same mounting hole as that of model CF. Since the mounting shaft of the stud and the stud head are eccentric by 0.25 mm to 1.0 mm, the position of this model can easily be adjusted simply by turning the stud. Thus, it is a compact, highly accurate eccentric cam follower with an integral structure. As a result, the man-hours for machining and assembly can significantly be reduced because it is unnecessary to align the cam follower with the cam groove and machine the mounting-hole area with precision.

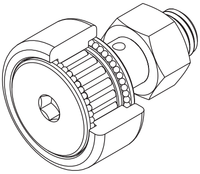


Model CFH-A

Cam Follower Containing Thrust Balls Model CFN

Specification Table⇒B-816

Based on the popular type Cam Follower, this model is incorporated with thrust load balls.

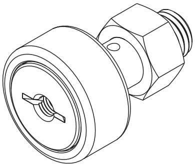


Model CFN

Cam Follower with a Tapped Hole for Greasing Model CFT

Specification Table⇒B-818

Basically the same as the popular type Cam Follower, this model is provided with tapped holes for piping on the stud head and the thread. It is optimal for locations where an integrated piping for greasing is required.

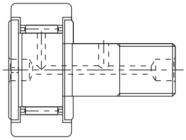
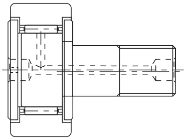
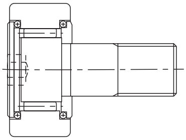


Model CFT

Types and Model Numbers of Cam Followers

The Cam Follower is divided into several types as indicated in Table1.

Table1 Types and Model Numbers of Cam Followers

Type		Popular Type	Eccentric Cam Follower	Containing Thrust Balls
Shape				
Cylindrical outer ring	Stud with a hexagon socket	CF-A (CF⋯UU-A)	CFH-A (CFH⋯UU-A)	——
	Stud with a driver groove	CF (CF⋯UU)	CFH (CFH⋯UU)	——
	With a tapped hole for greasing	CFT (CFT⋯UU)	CFHT (CFHT⋯UU)	——
	Made of stainless steel	CF-M (CF⋯MUU)	CFH-M (CFH⋯MUU)	——
Spherical outer ring	Stud with a hexagon socket	CF-R-A (CF⋯UUR-A)	CFH-R-A (CFH⋯UUR-A)	CFN-R-A
	Stud with a driver groove	CF-R (CF⋯UUR)	CFH-R (CFH⋯UUR)	——
	With a tapped hole for greasing	CFT-R (CFT⋯UUR)	CFHT-R (CFHT⋯UUR)	——
	Made of stainless steel	CF-MR (CF⋯MUUR)	CFH-MR (CFH⋯MUUR)	——

Note1) The symbols in the parentheses indicate model numbers of types with seals.
Note2) THK also manufactures low-speed full-roller types with long service lives. For these full-roller types, symbol "V" is indicated.
Note3) Symbol M indicates stainless steel type.

Example: CF 12 V UUR

Full-roller type

Classification Table

Cam Follower

- **Popular Type**
  - **Stud with a Hexagon Socket Type**
    - Model CF-A — Cylindrical Outer Ring
    - Model CF-B — Cylindrical Outer Ring
    - Model CF-R-A — Spherical Outer Ring
  - **Stud with a Driver Groove Type**
    - Model CF — Cylindrical Outer Ring
    - Model CF-R — Spherical Outer Ring
  - **With a Tapped Hole for Greasing Type**
    - Model CFT — Cylindrical Outer Ring
    - Model CFT-R — Spherical Outer Ring
- **Eccentricity Type**
  - **Stud with a Hexagon Socket Type**
    - Model CFH-A — Cylindrical Outer Ring
    - Model CFH-R-A — Spherical Outer Ring
  - **With a Tapped Hole for Greasing Type**
    - Model CFHT — Cylindrical Outer Ring
    - Model CFHT-R — Spherical Outer Ring
  - **Stud with a Driver Groove Type**
    - Model CFH — Cylindrical Outer Ring
    - Model CFH-R — Spherical Outer Ring
- **Containing Thrust Balls**
  - **Stud with a Hexagon Socket Type**
    - Model CFN-R-A — Spherical Outer Ring

Nominal Life

[Static Safety Factor]

The basic static load rating C_0 refers to the static load with constant direction and magnitude, under which the calculated contact stress in the center of the contact area between the roller and the raceway under the maximum load is 4000 MPa. (If the contact stress exceeds this level, it will affect the rotation.) This value is indicated as "C_0" in the dimensional tables. When a load is statically or dynamically applied, it is necessary to consider the static safety factor as shown below.

$$\frac{C_0}{P_0} = f_S$$

f_S : Static safety factor in relation to C_0 (see Table1)
C_0 : Basic static load rating (kN)
P_0 : Radial load (kN)

The permissible load (F_0) indicates the permissible value of the applied load determined by the strength of the stud section of the Cam Follower. Therefore, it is necessary to consider the static safety factor f_M against F_0 as well as f_S.

$$\frac{F_0}{P_0} = f_M$$

f_M : Static safety factor in relation to F_0 (see Table1)
F_0 : Permissible load (kN)
P_0 : Radial load (kN)

Table1 Static Safety Factor (f_S, f_M)

Load conditions	Lower limit of f_S and f_M
Normal load	1 to 2
Impact load	2 to 3

[Nominal Life]

The service life of the Cam Follower is obtained from the following equation.

$$L = \left(\frac{f_T \cdot C}{f_W \cdot P_C}\right)^{\frac{10}{3}} \times 10^6$$

L : Nominal life
(The total number of revolutions that 90% of a group of identical Cam Follower units independently operating under the same conditions can achieve without showing flaking from rolling fatigue)
C : Basic dynamic load rating* (kN)
P_C : Radial load (kN)
f_T : Temperature factor (see Fig.1 on A-886)
f_W : Load factor (see Table2 on A-886)

* The basic dynamic load rating (C) of the Cam Follower shows the load with interlocked direction and magnitude, under which the nominal life (L) is 1 million revolutions when a group of identical Cam Follower units independently operate. The basic dynamic load rating (C) is indicated in the corresponding specification table.

[Calculating the Service Life Time]

When the nominal life (L) has been obtained, the service life time (L_h) is obtained from the following equation.

- **For Linear Motion**

$$L_h = \frac{D \cdot \pi \cdot L}{2 \times \ell_s \cdot n_1 \times 60}$$

L_h : Service life time (h)
L : Nominal life
D : Bearing outer diameter (mm)
ℓ_s : Stroke length (mm)
n_1 : Number of reciprocations per minute (min^{-1})

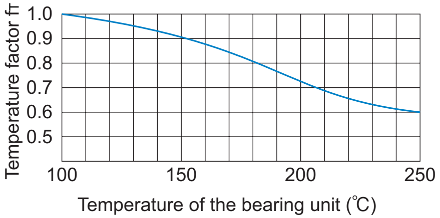


Fig.1 Temperature Factor (f_T)

Note) The normal service temperature is 80 ℃ or below. If the product is to be used at a higher temperature, contact THK.

- **For Rotary Motion**

$$L_h = \frac{D \cdot L}{D_1 \cdot n \times 60}$$

D_1 : Outer ring contact average diameter of the cam (mm)
n : Revolutions per minute of the cam (min^{-1})

Table2 Load Factor (f_W)

Condition	f_W
Smooth motion without impact	1 to 1.2
Normal motion	1.2 to 1.5
Motion with severe impact	1.5 to 3

Accuracy Standards

Cam Followers are manufactured with accuracies according to Table3.

(1) Dimensional tolerance of the cylindrical outer ring in outer diameter D: Table3
(2) Dimensional tolerance of the spherical outer ring in outer diameter D: $^{0}_{-0.05}$
(3) Dimensional tolerance of the Cam Follower in stud diameter d: h7
(4) Dimensional tolerance of the outer ring in width B: $^{0}_{-0.12}$

Table3 Accuracy of the Outer Ring (JIS Class 0)

Unit: μm

Nominal dimension of the bearing outer diameter (D) (mm)		Tolerance of the bearing in outer diameter (Dm) (note)		Tolerance of the outer ring in radial runout (max)
Above	Or less	Upper	Lower	
6	18	0	−8	15
18	30	0	−9	15
30	50	0	−11	20
50	80	0	−13	25
80	120	0	−15	35

Note) "Dm" represents the arithmetic average of the maximum and minimum diameters obtained in measuring the bearing outer diameter at two points.

Track Load Capacity

The track load capacity means the permissible load at which the outer ring of a bearing and the mating surface are capable of withstanding repeated use over a long period.
The track load capacity provided in the specification table indicates the value when using a steel material with tensile strength of 1.24 kN/mm^2 as the mating material. Therefore, it is possible to increase the track load capacity by increasing the hardness of the material. Fig.2 shows the hardness of the mating material and the track capacity factor in relation to tensile strength. To obtain the track load capacity of each mating material, multiply the track load capacity shown in the corresponding specification table by the respective track load factor.

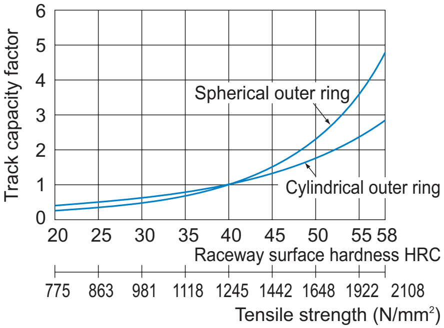


Fig.2 Track Capacity Factor

Note) For the mating material, we recommend using those materials with the raceway hardness of 20 HRC or higher and the tensile strength of 775 N/mm^2 or higher.

[Example of Calculating a Track Load Capacity]

Obtain the track load capacity when heat-treating the mating material, which a bearing whose outer ring has a track load capacity of 5.29 kN contacts, to hardness of 50 HRC.
The track capacity factor when the hardness is 50 HRC is 2.32, as indicated in Fig.2. Therefore, the desired track load capacity is calculated as follows.
The track load capacity=5.29kN×2.32=12.3kN

Radial Clearance

The radial clearances of Cam Followers meet clearance C2 (see Table4).
(Normal clearance applies to full-roller types.)

Table4 Radial Clearance Unit: µm

Model No.	Clearance C2 (with cage)		Normal clearance (full rollers)	
CF, CFN, CFH, CFT and CFHT	Min.	Max.	Min.	Max.
3 to 4	3	17	10	25
5 to 8	5	20	15	30
10 to 12–1	5	25	15	35
16 to 20–1	10	30	20	40
24 to 30–2	10	40	25	55

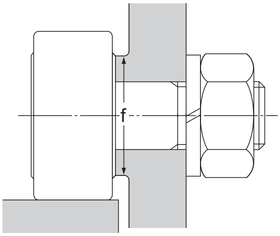
Fit

For the dimensional tolerance of the Cam Follower in stud-mounting hole, we recommend the following fitting.
The dimensional tolerance of the stud-mounting hole: H7

Installation

[Mounting Section]

Establish perpendicularity between the stud-mounting hole and the mounting surface, and chamfer the mouth of the hole to the smallest possible radius, preferably C0.5. Also, the diameter of the mounting surface should preferably be at least equal to the dimension "f" indicated in the specification table.
If the outer ring unilaterally or unevenly contacts the mating raceway, we recommend using model CF-R, whose outer ring circumference is spherically ground.



[Mating Raceway]

For the material of the mating raceway, see Track Load Capacity on A-887.

[About the Mounting Method]

Do not tap the bracket and directly tighten the product without using a nut as shown in Fig.1. Doing so may result in an insufficient tightening torque, or cause the bending stress to concentrate in the male thread and damage the stud if the thread is loosened.

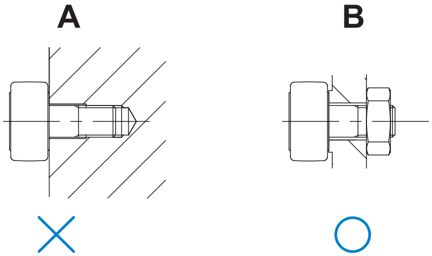


Fig.1

Installation

[Installing the Cam Follower]

If the Cam Follower is to be used under a heavy load, it is necessary to install the product so that the greasing hole on the stud is out of the loaded area. To help identify the position of the greasing hole, the THK logo is marked on the side face of the stud collar. (See Fig.1.)
The vertical hole in the middle of the stud is used as a whirl stop or a greasing hole.

Make sure that the outer ring is evenly in contact with the mating surface. When installing the Cam Follower, also make sure its axis is perpendicular to the traveling direction.

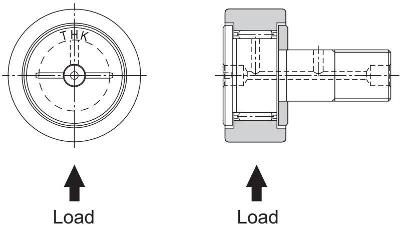


Fig.1 Positions of the THK Logo and the Greasing Holes

● Tightening Torque for the Stud

Since the stud of the Cam Follower receives bending stress and tensile stress caused by a bearing load, it is necessary to keep the tightening torque of the screw from exceeding the values indicated in Table1.

If the mounting screw may be loosened due to vibrations or impact, use a spring washer, thin nuts of JIS B 1811 Class 3 as double-nuts or a special nut capable of preventing itself from loosening.

Table1 Maximum Tightening Torque of the Screw

Model No	Maximum tightening torque N-m
CF, CFN, CFH, CFT	
3	0.392
4	0.98
5	1.96
6	2.94
8	7.84
10 10-1	16.7
12 12-1	29.4
16	70.6
18	98
20 20-1	137
24 24-1	245
30 30-1 30-2	480

Note) 1 N-m equals to 0.102 kgf-m.

[Installing the Eccentric Cam Follower]

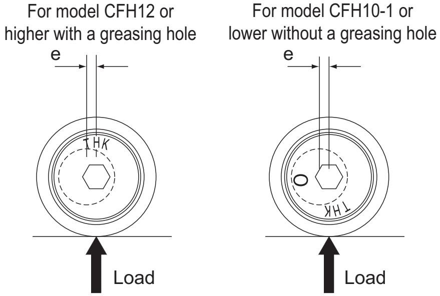
The eccentricity is adjusted in the following steps.

(1) Insert the stud into the mounting hole, and lightly tighten the nut until the nut starts turning. In doing so, position the THK logo in relation to the load direction as shown in Fig.2.

(2) Use the hexagon socket on the stud head to turn the stud and adjust the clearance between the stud and the mating contact surface.

(3) After adjusting the clearance, tighten the nut while keeping the stud from turning. Be sure the maximum tightening torque in Table1 on A-889 is not exceeded.

The surface of the Cam Follower stud is hardened. Take this into account when machining the stud.



For model CFH12 or higher with a greasing hole

The figure shows the position of the THK logo in relation to the eccentricity direction for model CFH12 or higher with a greasing hole.

For model CFH10-1 or lower without a greasing hole

For model CFH10-1 or lower without a greasing hole, the “O” mark indicates the eccentricity direction. There is no relationship between the THK logo and the eccentricity direction.

Fig.2

Contamination Protection and Lubrication

The Cam Follower models include seal types (model numbers: "⋯UU"), which are incorporated with special synthetic rubber seals that are highly resistant to wear in order to prevent foreign material from entering the interior of the cam follower and the lubricant from leaking.

Since each Cam Follower unit with seals contains high-quality lithium soap group grease No. 2, you can start using the product without replenishing grease. Exceptionally, model CFN contains AFC Grease.

If your Cam Follower does not have seals, fill grease from the greasing hole on the stud or the inner ring. However, some of the model numbers with stud diameters of 10 mm or less do not have a greasing hole and are provided with initial lubrication only, and therefore do not allow replenishment of grease.

The appropriate fill quantity is a half to one third of the space inside the bearing. The lubrication interval varies depending on the operating conditions. As a guide, however, replenish grease of the same group every six months to two years for types with a cage, or every one to 6 months for full-roller types.

Even with types equipped with seals ("⋯UU"), surplus grease may seep during the initial operation period or immediately after resumption of grease replenishment. If desiring to avoid contamination of the surrounding area of the machine by grease, first perform seasoning or the like in advance, and then wipe the seeping surplus grease.

When driving the dedicated grease nipple onto the Cam Follower, use a jig like the one shown in Fig.3 to provide pressure to the flange of the nipple.

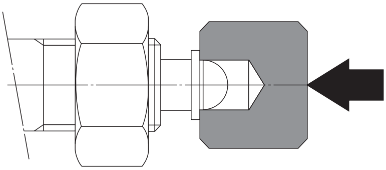


Fig.3

Accessories for the Cam Follower

Table1 shows accessories for standard types of Cam Followers. The dedicated grease nipple is attached at your request. If desiring the dedicated grease nipple, add symbol “N” to the end of the model number.

Example: CF 12 UUR -N

Dedicated grease nipple

Table1 Accessories

Model No.		Plug[note 1]	Plug[note 2]	Nut JIS Class 2	Grease[note 3]
CF CFH	Without seal	Included in package	Included in package	Included in package	Not contained
	With seal	Included in package	Included in package	Included in package	Filled with grease
CFN		Included in package	Included in package	Included in package	Filled with grease
CFT	Without seal	—	—	Included in package	Not contained
	With seal	—	—	Included in package	Filled with grease

Note1) The plug is used to prevent grease from leaking. However, it is not included in the packages of model CF5, and hexagon socket types of models CFN10 (R)-A and CF (CFH) 10-1 (R)-A or lower.

Note2) The plug is used to close an unused greasing hole. However, it is not attached to model CF (CFH) 10-1 or lower.

Note3) All models without a greasing hole are filled with grease when assembled regardless of whether a seal is attached or not.

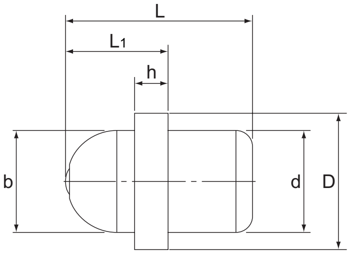


Table2 Specification Table for Grease Nipples

Supported models	Nipple dimensions						Nipple model No.
CF, CFN, CFH	d	b	D	h	L	L_1	
5	3.1	6	7.5	1.5	9	5.5	NP3.2×3.5
6 to 10	4	6	7.5	1.5	10	5.5	PB1021B
12 to 18	6	6	8	2	11	6	NP6×5
20 to 30	8	6	10	3	16	7	NP8×9

Note) The grease nipple is not attached to models CFN10 (R)-A and CF (CFH) 10-1 (R)-A or lower.

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.

(2) Dropping or hitting the Cam Follower may damage it. Giving an impact to it could also cause damage to its function even if the product looks intact.

[Lubrication]

(1) Some types of the Cam Follower do not contain grease depending on the size and on whether seals are attached. Carefully refer to Table1 on A-892, and if the desired model does not contain grease, apply grease to the product as necessary before using it. Lithium soap-based grease No. 2 is available as standard. (Use THK AFC Grease for model CFN.)

(2) Do not mix lubricants of different physical properties. In addition, replenish a lubricant also during operation as necessary.

(3) We recommend applying a lubricant to the mating surface where the Cam Follower travels.

[Precautions on Use]

(1) When securing the Cam Follower, use a torque wrench or the like to tighten the product at a torque equivalent to the corresponding value in Table1 on A-889.

(2) When using the product in locations exposed to vibrations or an impact load or in a special environment such as a clean room, vacuum and low/high temperature, contact THK in advance.

(3) Entrance of foreign material such as dust may cause damage or functional loss. Prevent foreign material, such as dust and cutting chips, from entering the product.

(4) Cam Followers are designed for use under a radial load. Do not use the product under a thrust load.

[Storage]

When storing the Cam Follower, enclose it in a package designated by THK and store it while avoiding high temperature, low temperature and high humidity.

Roller Follower

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Roller Follower

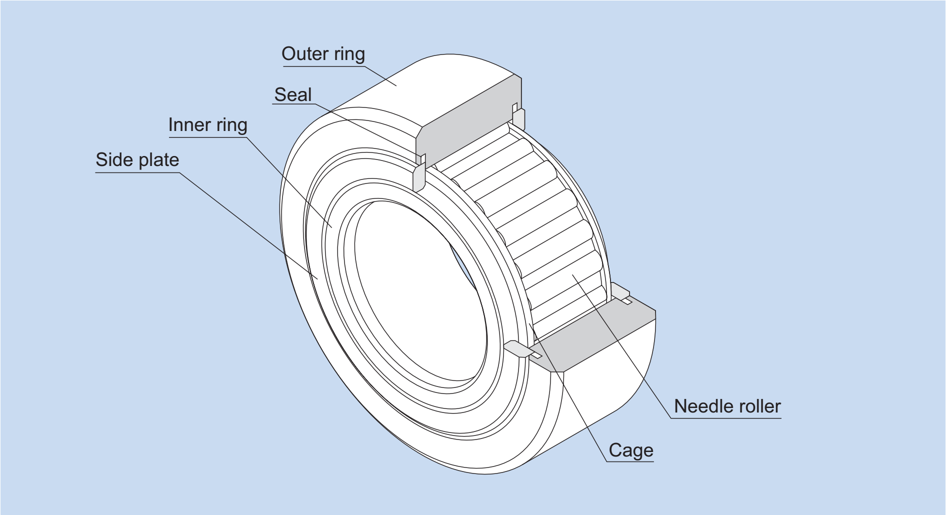


Fig.1 Structure of Roller Follower Model NAST-ZZUU

Structure and Features

The Roller Follower is a compact and highly rigid bearing system. It contains needle bearings and is used as a guide roller for cam discs and straight motion.

Since its outer ring rotates while keeping direct contact with the mating surface, this product is thick-walled and designed to bear an impact load.

Inside the outer ring, needle rollers and a precision cage are incorporated. This prevents the product from skewing and achieves a superb rotation performance. And, as a result, the product is capable of easily withstanding high-speed rotation.

Roller Followers are divided into two types: separable type whose inner ring can be separated, and non-separable type whose inner ring cannot be separated.

There are two types of the outer ring in shape: spherical and cylindrical. The spherical outer ring easily absorbs a distortion of the shaft center when the cam follower is installed and helps lighten a biased load.

The Roller Follower is used in a wide range of applications such as cam mechanisms of automatic machines, dedicated machines as well as carrier systems, conveyors, bookbinding machines, tool changers of machining centers, pallet changers, automatic coating machines, and sliding forks of automatic warehouses.

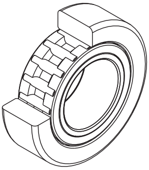
Types of the Roller Follower

Types and Features

Model NAST (Separable Type)

Specification Table⇒B-822

Model NAST is a separable type of bearing system that combines a thick-wall outer ring, an inner ring and needle rollers equipped with a precision cage.

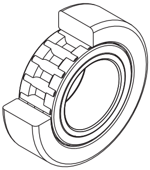


Model NAST

Model NAST-R (Separable Type)

Specification Table⇒B-822

This model is a spherical outer ring type of model NAST.
Since the circumference of the outer ring is spherically ground, it helps lighten a biased load (symbol R).

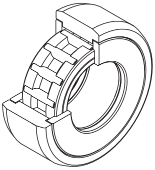


Model NAST-R

Model NAST-ZZ (Separable Type)

Specification Table⇒B-823

This separable type of bearing system has a labyrinth seal consisting of a pair of side plates formed on both sides of the inner ring of model NAST. (Model number of the type attached with seals is NAST-ZZUU.)

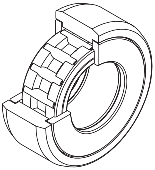


Model NAST-ZZ

Model NAST- ZZR (Separable Type)

Specification Table⇒B-823

This model is a spherical outer ring type of model NAST-ZZ.
It easily corrects a distortion of the shaft center when the roller follower is installed.
Since the circumference of the outer ring is spherically ground, it helps lighten a biased load (symbol R). (Model number of the type attached with seals is NAST-ZZUUR.)

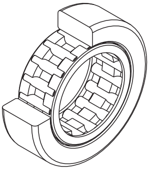


Model NAST-ZZR

Model RNAST (Separable Type)

Specification Table⇒B-824

This model is basically the same as model NAST, but does not have an inner ring.

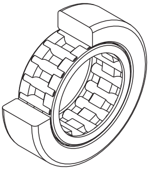


Model RNAST

Model RNAST-R (Separable Type)

Specification Table⇒B-824

This model is basically the same as model NAST-R, but does not have an inner ring.
Since the circumference of the outer ring is spherically ground, it helps lighten a biased load (symbol R).

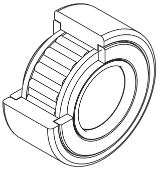


Model RNAST-R

Model NART-R(Non-separable Type)

Specification Table⇒B-825

This model is a non-separable type of bearing system whose inner ring is fixed to the side plates.
Since the circumference of the outer ring is spherically ground, it helps lighten a biased load (symbol R). (Model number of the type attached with seals is NART-UUR.)

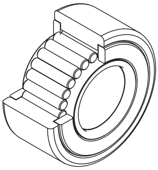


Model NART-R

Model NART-VR (Non-separable Type)

Specification Table⇒B-825

Based on model NART-R, this model is a full-roller bearing suitable for locations where a heavy load is applied in low speed operation.
Since the circumference of the outer ring is spherically ground, it helps lighten a biased load (symbol R). (Model number of the type attached with seals is NART-VUUR.)



Model NART-VR

- Stainless steel types are available for all the above models. (symbol M)

Types of the Roller Follower

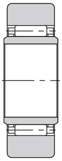
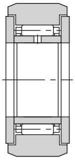
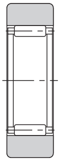
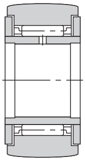
Roller Follower

- **Separable Type**
  - **Standard Type** Model NAST
  - **Standard Type** Model NAST-R
  - **Type with Side Plate** Model NAST-ZZ
  - **Type with Side Plate** Model NAST-ZZR
  - **Type without Inner Ring** Model RNAST
  - **Type without Inner Ring** Model RNAST-R
- **Non-separable Type**
  - **Standard Type** Model NART-R
  - **Full-roller Type** Model NART-VR

Types and Model Numbers of the Roller Follower

The Roller Follower is divided into several types as indicated in Table1.

Table1 Types of Roller Follower

Classification		Separable type			Non-separable type
		Standard type	Type with side plate	Type without inner ring	Standard type Full-roller type
Main model No.		NAST	NAST-ZZ	RNAST	NART
Shape					
Cylindrical outer ring	Without seal	NAST NAST-M	NAST-ZZ NAST-ZZM	RNAST RNAST-M	—
	With seal	—	NAST-ZZUU NAST-ZZMUU	—	—
Spherical outer ring	Without seal	NAST-R NAST-MR	NAST-ZZR NAST-ZZMR	RNAST-R RNAST-MR	NART-R NART-MR
	With seal	—	NAST-ZZUUR NAST-ZZMUUR	—	NART-UUR NART-MUUR
Full rollers	Without seal	—	—	—	NART-VR NART-VMR
	With seal	—	—	—	NART-VUUR NART-VMUUR

Symbol M indicates stainless steel type.

Nominal Life

[Static Safety Factor]

The basic static load rating C_0 refers to the static load with constant direction and magnitude, under which the calculated contact stress in the center of the contact area between the roller and the raceway under the maximum load is 4000 MPa. (If the contact stress exceeds this level, it will affect the rotation.) This value is indicated as "C_0" in the specification tables. When a load is statically or dynamically applied, it is necessary to consider the static safety factor as shown below.

$$\frac{C_0}{P_0} = f_S$$

f_S : Static safety factor (see Table2)
C_0 : Basic static load rating (kN)
P_0 : Radial load (kN)

Table2 Static Safety Factor (f_S)

Load conditions	Lower limit of f_S
Normal load	1 to 3
Impact load	3 to 5

[Nominal Life]

The service life of the Roller Follower is obtained from the following equation.

$$L = \left(\frac{f_T \cdot C}{f_W \cdot P_C} \right)^{\frac{10}{3}} \times 10^6$$

L : Nominal life
(The total number of revolutions that 90% of a group of identical Roller Follower units independently operating under the same conditions can achieve without showing flaking from rolling fatigue)
C : Basic dynamic load rating* (kN)
P_c : Radial load (kN)
f_T : Temperature factor (see Fig.1 on A-903)
f_W : Load factor (see Table3 on A-903)

* The basic dynamic load rating (C) of the Roller Follower shows the load with interlocked direction and magnitude, under which the nominal life (L) is 1 million revolutions when a group of identical Roller Follower units independently operate. The basic dynamic load rating (C) is indicated in the corresponding specification table.

[Calculating the Service Life Time]

When the nominal life (L) has been obtained, the service life time (L_h) is obtained from the following equation.

- **For Linear Motion**

$$L_h = \frac{D \cdot \pi \cdot L}{2 \times \ell_s \cdot n_1 \times 60}$$

L_h : Service life time (h)
L : Nominal life
D : Bearing outer diameter (mm)
ℓ_s : Stroke length (mm)
n_1 : Number of reciprocations per minute (min^{-1})

- **For Rotary Motion**

$$L_h = \frac{D \cdot L}{D_1 \cdot n \times 60}$$

D_1 : Outer ring contact average diameter of the cam (mm)
n : Rotation speed per minute of the cam (min^{-1})

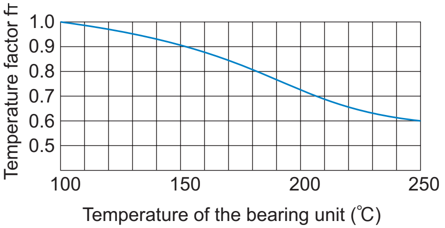


Fig.1 Temperature Factor (f_T)

Note) The normal service temperature is 80 ℃ or below. If the product is to be used at a higher temperature, contact THK.

Table3 Load Factor (f_W)

Service condition	f_W
Smooth motion without impact	1 to 1.2
Normal motion	1.2 to 1.5
Motion with severe impact	1.5 to 3

Accuracy Standards

Roller Followers are manufactured with accuracies in accordance with the following.

(1) Dimensional tolerance of the spherical outer ring in outer diameter D: $^{0}_{-0.05}$
(2) Dimensional tolerance of model RNAST in inscribed bore diameter dr: F6
(3) Dimensional tolerance of model NART in bearing width B_1: Table4
(4) Accuracy of the inner ring and accuracy of the outer ring in width: Table5
(5) Accuracy of the outer ring: Table6

Table4 Dimensional tolerance of model NART in bearing width B_1

Model No. NART	Dimensional tolerance (h12)	
	Upper limit	Lower limit
5 to 12	0	−0.18
15 to 35	0	−0.21
40 to 50	0	−0.25

Table5 Accuracy of the Inner Ring and Accuracy of the Outer Ring in Width (JIS Class 0)

Unit: μm

Nominal dimension of the bearing inner diameter (di) (mm)		Tolerance of the bearing in outer diameter (dm) (note)		Tolerance of the inner ring (or outer ring) in width		Tolerance of the inner ring in radial runout (max)
Above	Or less	Upper	Lower	Upper	Lower	
2.5	10	0	−8	0	−120	10
10	18	0	−8	0	−120	10
18	30	0	−10	0	−120	13
30	50	0	−12	0	−120	15

Note) "dm" represents the arithmetic average of the maximum and minimum diameters obtained in measuring the bearing inner diameter at two points.

Table6 Accuracy of the Outer Ring (JIS Class 0)

Unit: μm

Nominal dimension of the bearing outer diameter (D) (mm)		Tolerance of the bearing in outer diameter (Dm) (note)		Tolerance of the outer ring in radial runout (max)
Above	Or less	Upper	Lower	
6	18	0	−9	15
18	30	0	−9	15
30	50	0	−11	20
50	80	0	−13	25
80	120	0	−15	35

Note) "Dm" represents the arithmetic average of the maximum and minimum diameters obtained in measuring the bearing outer diameter at two points.

Track Load Capacity

The track load capacity means the permissible load at which the outer ring of a Roller Follower and the mating surface are capable of withstanding repeated use over a long period.

The track load capacity provided in the specification table, indicates the value when using a steel material with tensile strength of 1.2 kN/mm^2 as the mating material. Therefore, it is possible to increase the track load capacity by increasing the hardness of the material. Fig.2 shows the hardness of the mating material and the track capacity factor in relation to tensile strength. To obtain the track load capacity of each mating material, multiply the track load capacity shown in the corresponding specification table by the respective track load factor.

Note) For the mating material, we recommend using those materials with the raceway hardness of 20 HRC or higher and the tensile strength of 775 N/mm^2 or higher.

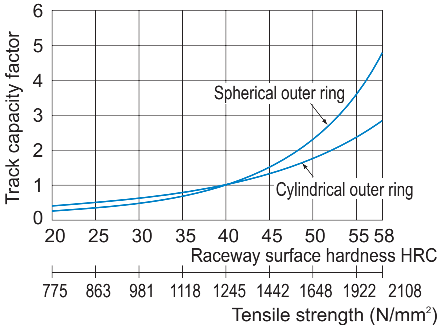


Fig.2 Track Capacity Factor

[Example of Calculating a Track Load Capacity]

Obtain the track load capacity when heat-treating the mating material, which a bearing whose outer ring has a track load capacity of 5.29 kN contacts, to hardness of 50 HRC.
The track capacity factor when the hardness is 50 HRC is 2.32, as indicated in Fig.2. Therefore, the desired track load capacity is calculated as follows.
The track load capacity=5.29kN×2.32=12.3kN

Radial Clearance

The radial clearances of Roller Followers meet the clearance indicatedin the table below. (Normal clearance applies to full-roller types.)

Model NAST, NAST-ZZ Unit: μm

Model No.	Clearance C2 (with cage)	
	Min.	Max.
6	5	20
8 to 12	5	25
15 to 25	10	30
30 to 40	10	40
45 to 50	15	50

Model RNAST Unit: μm

Model No.	Clearance C2 (with cage)	
	Min.	Max.
5 to 6	5	20
8 to 12	5	25
15 to 25	10	30
30 to 40	10	40
45 to 50	15	50

Model NART Unit: μm

Model No.	Clearance C2 (with cage)		Normal clearance (full rollers)	
	Min.	Max.	Min.	Max.
5 to 6	5	20	15	30
8 to 12	5	25	15	35
15 to 20	10	30	20	40
25 to 40	10	40	25	55
45 to 50	15	50	30	65

Fit

For the fitting of the Roller Follower with the shaft, we recommend the combinations indicated in Table1.

Table1 Fitting with the Shaft

No Inner Ring	Inner Ring
k5, k6	g6, h6

Mounting Section

- To protect the side plate of models NART and NAST-ZZ, the height of the mounting section must be equal to or greater than the “a” dimension indicated in the specification table
- The surface hardness of the shaft to be used with a Roller Follower without inner ring must be between 54 and 64 HRC. For the surface roughness, we recommend 0.2 μm Ra or below.
- For the mating raceway, see "Track Load Capacity" on A-904.
- If the outer ring unilaterally or unevenly contacts the mating raceway, we recommend using a type whose outer ring circumference is spherically ground.
- The side plate of model NART is press-fit onto the inner ring. If the plate is pressed under an external force, it may cause abnormal rotation. Do not use the product in the manner that the side plate is pressed.
- The structure of the Roller Follower is designed to receive a radial load. If it receives a thrust load, the side plates or the outer ring may be damaged. Therefore, it is necessary to design the system and install the product so that the generation of a component of the thrust is limited to a minimum.

Installation

Fig.1 shows examples of installing the Roller Follower.

- If the Roller Follower is to be used under a heavy load, it is necessary to install the product so that the greasing hole of the inner ring is out of the loaded area.

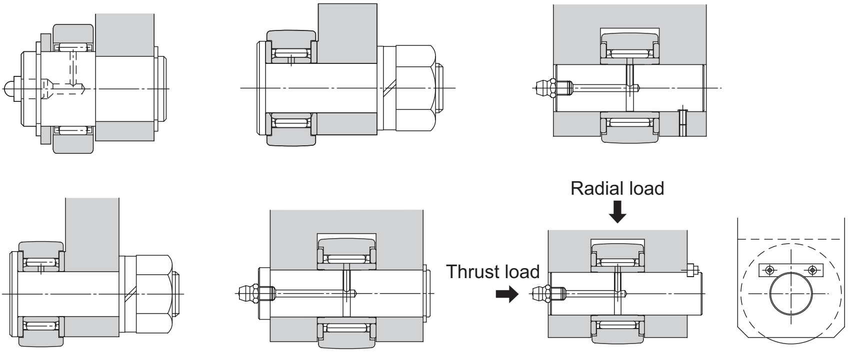


Fig.1 Examples of Installing the Roller Follower

Contamination Protection and Lubrication

The Roller Follower models include seal types (model numbers: "···UU"), which are incorporated with special synthetic rubber seals that are highly resistant to wear in order to prevent foreign material from entering the interior of the roller follower and the lubricant from leaking.

Some models are not filled with grease when assembled. When using a model not filled with grease, apply and fill grease to the interior first (lithium-based grease with consistency of No. 2).

Model No.		Grease
NAST(R)	No seal setting	Not filled with grease
RNAST(R)		
NAST-ZZ(R)	Without seal	Filled with grease
NART-(V)R	With seal	

The lubrication interval varies depending on the operating conditions. As a guide, however, replenish grease of the same group every six months to two years for types with a cage, or every one to six months for full-roller types.

Even with types equipped with seals ("···UU"), surplus grease may seep during the initial operation period or immediately after resumption of grease replenishment. If desiring to avoid contamination of the surrounding area of the machine by grease, first perform seasoning or the like in advance, and then wipe the seeping surplus grease.

[Handling]

(1) Disassembling components may cause dust to enter the system or degrade mounting accuracy of parts. Do not disassemble the product.

(2) Dropping or hitting the Roller Follower may damage it. Giving an impact to it could also cause damage to its function even if the product looks intact.

[Lubrication]

(1) Some types of the Roller Follower do not contain grease depending on the model number. Carefully refer to A-906, and if the desired model does not contain grease, apply grease to the product as necessary before using it. Lithium soap-based grease No. 2 is available as standard.

(2) Do not mix lubricants of different physical properties. In addition, replenish a lubricant also during operation as necessary.

(3) We recommend applying a lubricant to the mating surface where the Roller Follower travels.

[Precautions on Use]

(1) When using the product in locations exposed to vibrations or an impact load or in a special environment such as a clean room, vacuum and low/high temperature, contact THK in advance.

(2) Entrance of foreign material such as dust may cause damage or functional loss. Prevent foreign material, such as dust and cutting chips, from entering the product.

(3) Roller Followers are designed for use under a radial load. Do not use the product under a thrust load.

[Storage]

When storing the Roller Follower, enclose it in a package designated by THK and store it while avoiding high temperature, low temperature and high humidity.

Spherical Plain Bearing

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Spherical Plain Bearing

Structure and Features

Spherical Bearings models SB and SA1 are self-aligning plain bearings designed for heavy loads. The inner and outer rings of these models use high-carbon chromium bearing steel that is hardened and ground, are treated with phosphate coating, which is highly resistant to corrosion and wear, and seized with molybdenum disulfide (MoS_2).
The Spherical Plain Bearing is capable of receiving a large radial load and thrust loads in both directions. Furthermore, because of its high resistance to impact loads, the Spherical Plain Bearing is optimal for low speed, heavy load rocking components such as the cylinder clevises or hinges of construction and civil-engineering machinery and the suspensions of trucks.

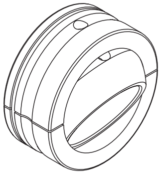
Types of the Spherical Plain Bearing

Types and Features

Model SB

Specification Table⇒B-828

The most popular type of Spherical Plain Bearing in Japan, model SB has wide spherical contact areas and is used as a bearing for heavy loads. The outer ring is split at two points, enabling the inner ring to be accommodated.

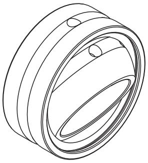


Model SB

Model SA1

Specification Table⇒B-830

This type of Spherical Plain Bearing is widely used in Europe. The outer ring is split at one point (outer rings with diameter of ϕ100 or thicker are split at two points), and the width and thickness are smaller than model SB. Thus, this model can be used in small spaces. Types attached with highly dust-preventive dust seals on both ends (model SA1···UU) are also available.



Model SA1

Selecting a Spherical Plain Bearing

When selecting a Spherical Plain Bearing, follow the instructions below while referring to the basic dynamic load rating (C) and the basic static load rating (C_0) indicated in the corresponding specification table, as a measuring stick.

[Spherical Plain Bearing Service Life G]

The basic dynamic load rating (C) is used to calculate the service life when the bearing oscillates under a load.

The basic dynamic load rating is calculated based on the contact surface pressure of the spherical sliding section.

The Spherical Plain Bearing service life G is expressed in the total number of rocking motions until it becomes impossible for the bearing to perform normal operation due to the increase in the radial clearance or in the temperature of the bearing as a result of wear on the spherical sliding section.

Since the bearing service life is affected by various factors such as the material of the bearing, magnitude and direction of the load, lubrication conditions and sliding speed, the calculated value can be used as an empirical, practical value.

$$G = b_1 \cdot b_2 \cdot b_3 \cdot b_4 \cdot b_5 \frac{3}{Da \cdot \beta} \cdot \frac{C}{P} \times 10^8$$

G : Bearing service life
(total number of rocking motions or total number of revolutions)
C : Basic dynamic load rating (N)
P : Equivalent radial load (N)
b_1 : Load direction factor (see Table1)
b_2 : Lubrication factor (see Table1)
b_3 : Temperature factor (see Table1)
b_4 : Dimension factor (see Fig.1)
b_5 : Material factor (see Fig.2)
Da : Spherical diameter (mm)
(see the specification table)
β : Oscillation half angle (degree)
(for rotary motion, β=90°)

Table1

Type		b_1		b_2		b_3		
		Load direction		Regular lubrication		Temperature ℃		
		Fixed	Alternating	Not provided	Provided	−30 +80	+80 +150	+150 +180
Spherical Plain Bearing	Without seal	1	5	0.08	1	1	1	0.7
	With seal	1	5	0.08	1	1	—	—

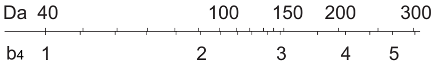


Fig.1 Dimension Factor

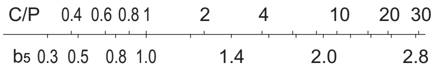


Fig.2 Material Factor

[Equivalent Radial Load]

The Spherical Plain Bearing is capable of receiving a radial load and a thrust load simultaneously. If the magnitude and direction of the load applied are constant, the equivalent radial load is obtained from the following equation.

$$P = Fr + YFa$$

P : Equivalent radial load (N)
Fr : Radial load (N)
Fa : Trust load (N)
Y : Thrust load factor (see Table2)

Table2 Thrust Load Factor

Fa/Fr≦	0.1	0.2	0.3	0.4	0.5
Thrust load factor (Y)	0.8	1	1.5	2.5	3

[Static Safety Factor f_S]

If the Spherical Plain Bearing is to be used under a stationary load or in slight rocking motion, select a model using the basic static load rating (C_0) as a guide. The basic static load rating refers to the stationary load that the bearing can receive without damaging the bearing and without causing permanent deformation that would prevent smooth motion.

In general, set the safety factor at three or greater taking into account the rigidity of the shaft and the housing.

$$f_S = \frac{C_0}{P} \geqq 3$$

f_S : Static safety factor
C_0 : Basic static load rating
P : Equivalent radial load

[pV Value]

The permissible sliding speed at which the Spherical Plain Bearing can be used varies depending on the load, lubrication conditions and cooling status. The recommended pV value for continuous motion under a load applied in a constant direction is calculated as follows.

$$pV \leqq 400\ \mathrm{N/mm^2 \cdot mm/sec}$$

If the Spherical Plain Bearing performs adiabatic operation or the load direction changes, the heat produced on the sliding surface easily radiates. Therefore, it is possible to set a higher pV value.
The contact surface pressure (p) of the Spherical Plain Bearing is obtained from the following equation.

$$p = \frac{P}{Da \cdot B}$$

p : Contact surface pressure (N/mm²)
P : Equivalent radial load (N)
Da : Spherical diameter (see the specification table) (mm)
B : Outer ring width (see the specification table) (mm)

The sliding speed is calculated as follows.

$$V = \frac{\pi \cdot Da \cdot \beta \cdot f}{90 \times 60}$$

V : Sliding speed (mm/sec)
β : Oscillation half angle (degree)
f : Number of rocking motions per minute ($\mathrm{min^{-1}}$)

The Spherical Plain Bearing can be used at sliding speed of up to 100 mm/sec in oscillating motion, or up to 300 mm/sec in rotary motion in favorable lubrication status.

[Example of Calculating a pV Value]

Assuming that model SB25 is used in a location where the shaft rotates 60 turns per minute at an angle of 40° (oscillation half angle : 20°) and the maximum varying load of 1,500 N is applied, determine whether the model number is appropriate and calculate the service life under these conditions. Assume that the bearing temperature is +80 ℃ or less and the product is regularly provided with sufficient lubrication. Calculate the pV value and examine if the bearing size is appropriate.
The contact surface pressure (p) is calculated as follows.

$$p = \frac{P}{Da \cdot B} = \frac{1500}{36 \times 18} = 2.31\ \mathrm{N/mm^2} \quad \left(\begin{array}{l}\text{B: outer ring width of model SB25} = 18 \\ \text{Da: spherical diameter of model SB25} = 36\end{array}\right)$$

The sliding speed (V) is obtained from the following equation.

$$V = \frac{\pi \cdot Da \cdot \beta \cdot f}{90 \times 60} = \frac{3.14 \times 36 \times \left(\frac{40}{2}\right) \times 60}{90 \times 60} = 25.12\ \mathrm{mm/sec}$$

The pV value is calculated as follows.
$pV = 58.0\ \mathrm{N/mm^2 \cdot mm/sec}$
Since both the pV value and the sliding speed (V) meet the requirements, model SB25 can be used.
Next, calculate the service life of the bearing (G) as follows.

$$G = b_1 \cdot b_2 \cdot b_3 \cdot b_4 \cdot b_5 \frac{3}{Da \cdot \beta} \cdot \frac{C}{P} \times 10^8$$

$$= 5 \times 1 \times 1 \times 1 \times 2.2 \times \frac{3}{36 \times 20} \times \frac{15300}{1500} \times 10^8 = 4.7 \times 10^7\ (\mathrm{min^{-1}})$$

Accuracy Standards

The dimensional tolerances of the Spherical Plain Bearing are defined as indicated in Table3.

Table3 Accuracy of the Spherical Plain Bearing

Unit: µm

Nominal dimension of the inner diameter (d) and outer diameter (D) (mm)		Tolerance in inner diameter (dm)		Tolerance in outer diameter (Dm)		Tolerance of the inner outer ring in width (B_1, B)	
Above	Or less	Upper	Lower	Upper	Lower	Upper	Lower
10	18	0	−8	—	—	0	−120
18	30	0	−10	0	−9	0	−120
30	50	0	−12	0	−11	0	−120
50	80	0	−15	0	−13	0	−150
80	120	0	−20	0	−15	0	−200
120	150	0	−25	0	−18	0	−250
150	180	0	−25	0	−25	0	−250
180	250	0	−30	0	−30	0	−300
250	315	—	—	0	−35	0	−350
315	400	—	—	0	−40	0	−400

Note1) "dm" and "Dm" represent the arithmetic averages of the maximum and minimum diameters obtained in measuring the inner and outer diameters at two points.
Note2) The dimensional tolerances of the inner and outer diameters are the values before they are surface treated.
Note3) The dimensional tolerance of the outer ring is the value before it is split.
Note4) Tolerances of the inner and outer diameters in width (B_1, B) are assumed to be equal, and obtained from the nominal dimension of the inner diameter of the inner ring.

Radial Clearance

Table4 shows radial clearances of the Spherical Plain Bearing.

Table4 Radial Clearances of the Spherical Plain Bearing

Unit: µm

Berring inner diameter (d) (mm)		Radial clearance	
Above	Or less	Min.	Max.
—	17	70	125
17	30	75	140
30	50	85	150
50	65	90	160
65	80	95	170
80	100	100	185
100	120	110	200
120	150	120	215
150	240	130	230

Note1) The radial clearance indicates the value before the outer ring is split.
Note2) The axial clearance is approximately twice the radial clearance.

Fit

The fitting between the Spherical Plain Bearing and the shaft or the housing is selected according to the conditions. Table1 shows recommended values.

Table1 Recommended Fitting Values

Service condition		Shaft	Housing
Inner ring rotational load	Normal load	k6	H7
	Indeterminate load	m6	H7
Outer ring rotational load	Normal load	g6	M7
	Indeterminate load	h6	N7

Note1) If the product is to be installed so that the inner ring rotates and the fitting with the shaft is to be clearance fitting, harden the surface of the shaft in advance.
Note2) "N7" is recommended for light alloy housings.

[Shaft Designing]

If the inner ring is to be fit onto the shaft in loose fitting and the product is to be used under a heavy load, the shaft may slip on the inner circumference of the inner ring. To prevent the slippage, the shaft hardness must be 58 HRC or higher and the surface roughness must be 0.80 a or below.

Permissible Tilt Angles

The permissible tilt angle of the Spherical Plain Bearing varies according to the shaft shape as indicated in Table2.

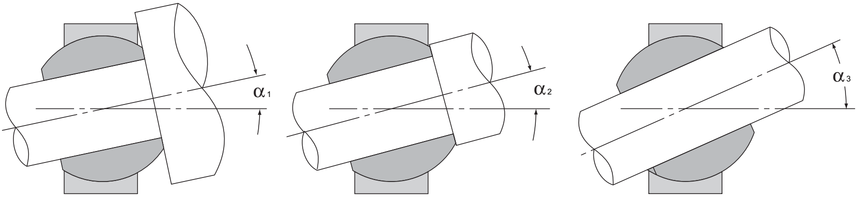


Table2 Permissible Tilt Angles

Unit: degree

Model No.	Permissible tilt angles		
	α_1	α_2	α_3
SB 12	5	7	18
SB 15	4	6	18
SB 20	3	4	14
SB 22	4	6	16
SB 25	4	5	16
SB 30	4	6	17
SB 35	4	5	14
SB 40	4	6	12
SB 45	4	5	13
SB 50	4	5	16
SB 55	4	6	16
SB 60	4	6	18
SB 65	4	5	16
SB 70	4	5	15
SB 75	4	5	18
SB 80	4	5	18
SB 85	4	6	16
SB 90	4	5	16
SB 95	4	5	17
SB 100	4	5	18
SB 110	4	5	16
SB 115	4	5	14
SB 120	4	6	15
SB 130	4	5	14
SB 150	4	5	12

Unit: degree

Model No.	Permissible tilt angles		
	α_1	α_2^{Note}	α_3
SA1 12	8	11 (6)	25
SA1 15	6	8 (5)	18
SA1 17	7	10 (7)	23
SA1 20	6	9 (6)	21
SA1 25	6	7 (4)	18
SA1 30	4	6 (4)	16
SA1 35	5	6 (4)	16
SA1 40	5	7 (4)	16
SA1 45	6	7 (4)	16
SA1 50	5	6 (4)	15
SA1 60	5	6 (3)	14
SA1 70	5	6 (4)	14
SA1 80	4	6 (4)	14
SA1 90	4	5 (3)	12
SA1 100	5	7 (5)	14
SA1 110	5	6 (4)	15
SA1 120	4	6 (4)	15
SA1 140	5	7 (5)	16
SA1 160	6	8 (6)	13
SA1 180	5	6 (5)	16
SA1 200	6	7 (6)	13
SA1 220	6	8 (6)	15
SA1 240	6	8 (6)	17

Note) The values in the parentheses apply to types attached with a seal.

Installation

(1) Do not use the product in the manner that the permissible tilting angle is exceeded since doing so may damage the product.

(2) The Spherical Plain Bearing is designed for use under a radial load. Do not use the product if the trust load component or the load component in the thrust direction exceeds 50% of the resultant force consisting of the radial load and the thrust load.

(3) When installing the Spherical Plain Bearing, pay attention to the mounting orientation so that the slit of the outer ring receives a minimum load.

[Temperature Range]

The permissible temperature range of the Spherical Plain Bearing is limited between -30℃ and 80℃ depending on the seal material and determined by the permissible temperature range of the grease used.

Lubrication

The spherical sliding surface of the Spherical Plain Bearing is seized with a solid lubricant film of molybdenum disulfide. This enables the Spherical Plain Bearing to be used over a relatively long period without further lubrication under a static load, in low-speed rocking motion or in intermittent rotary motion. However, it is generally necessary to replenish grease on a regular basis. If a heavy load is applied, consider using lithium soap group grease containing molybdenum disulfide. The inner and outer rings of the Spherical Plain Bearing have greasing holes as a means to facilitate the flow of the lubricant inside the bearing.

[Lubrication Interval]

Since the Spherical Plain Bearing is delivered without being applied with a lubricant, it is necessary to replenish an appropriate amount of grease after installing the Spherical Plain Bearing. We recommend filling grease also to the space surrounding the Spherical Plain Bearing. It is also recommendable to shorten the lubrication interval in the start-up period in order to lighten the initial wear and extend the service life.

The lubrication interval varies according to the magnitude of the load, frequency of the vibrations and other conditions. Provide lubrication while referring to the values in Table1 as a guide.

Table1 Lubrication Interval

Type of load	Required minimum lubrication interval
Unilateral load	G/ 40
Fluctuating load	G/ 180

G: Service life of the bearing (total number of rocking motions or total number of revolutions)

Contamination Protection

Spherical Bearing model SA1 is provided with a seal designed to prevent humidity or other deleterious material from entering the bearing. This seal is effective in increasing the service life of the bearing. The seal for Spherical Bearing model SA1 is made of oil-resistant synthetic rubber and has double lips as the sealing element. These lips closely contact the spherical inner ring. The seal can be used within the temperature range between -30℃ and 80℃, and is highly resistant to wear and capable of operating for a long period of time. If the product is used in an environment where sand or soil matter may enter the bearing, the service life of the seal is shortened. We recommend lubricating the product on a regular basis.

[Handling]

(1) When installing model SA1 or model SB, they must not be disassembled before installation.

(2) Dropping or hitting the Spherical Plain Bearing may damage it.
Giving an impact to it could also cause damage to its function even if the product looks intact.

[Lubrication]

(1) For details of the lubrication, see A-918.

(2) Do not mix lubricants of different physical properties.

[Precautions on Use]

(1) When using the product in locations exposed to vibrations or an impact load or in a special environment such as a clean room, vacuum and low/high temperature, contact THK in advance.

(2) Entrance of foreign material such as dust between the outer and inner rings may cause damage or functional loss. Prevent foreign material, such as dust and cutting chips, from entering the product.

[Storage]

When storing the Spherical Plain Bearing, avoid high temperature, low temperature and high humidity.

Link Ball®

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Link Ball

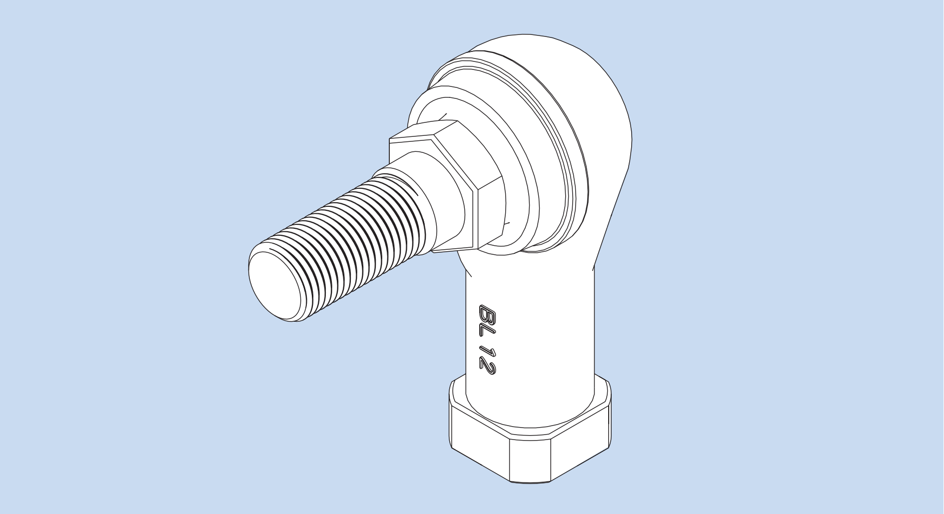


Fig.1 Structure of Link Ball Model BL

Structure and Features

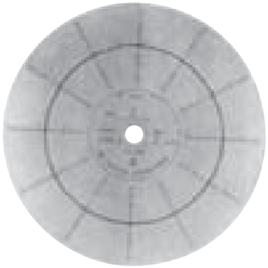
With the Link Ball, a highly accurate bearing steel ball used in the spherical area is first encased in the holder by die cast molding, and then is specially welded with the shank. This unique process enables the mirror surface of the steel ball to be transferred or duplicated on the spherical surface inside the holder to ensure full contact between the ball and the holder. As a result, smooth motion is achieved with a minimum clearance.

[Compact Design]

Model AL has an adequately firm and yet extremely compact shape because of a highly balanced design. Together with use of an A-1 alloy, a light-weight, compact design has been achieved. Thus, this model is optimal for use in an automobile height sensor or transmission control.

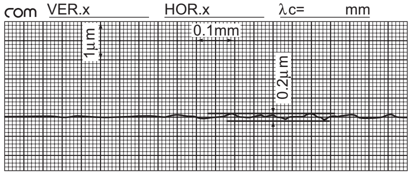
[Achieves Sphericity of 0.001 mm]

The spherical surface of the shank ball is transferred on the inner surface of the holder while maintaining the sphericity of the bearing steel ball. This allows smooth motion to be achieved with a minimum clearance and provides favorable operability and feel to the link motion.

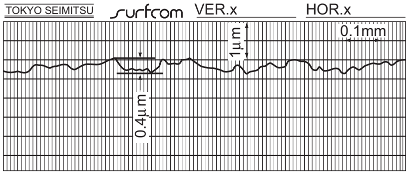


Sphericity: 0.001 mm

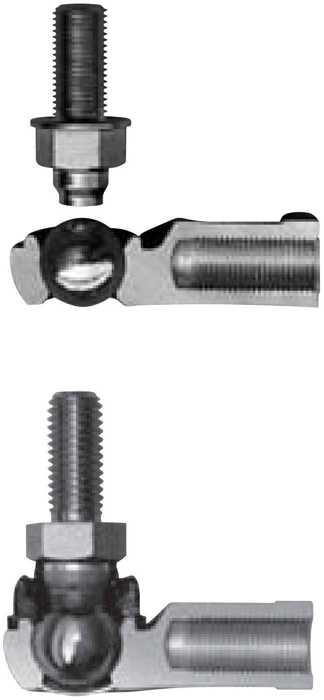
Sphericity of the spherical surface of the ball shank



Roughness of the spherical surface of the ball shank



Roughness of the spherical surface of the holder



Cut sample of the spherical area of model BL

[Two Types of Holder Material]

Model AL uses the newly developed high strength aluminum alloy “A-1 Alloy” (see A-925), which is light and highly resistant to wear. Models BL, RBL and RBI use the proven, high strength zinc alloy (see A-926).

[High Lubricity]

Since models AL and BL and those models attached with boots contain grease, they have high lubricity and increased wear resistance.

[Large Hexagonal Bolt Seat]

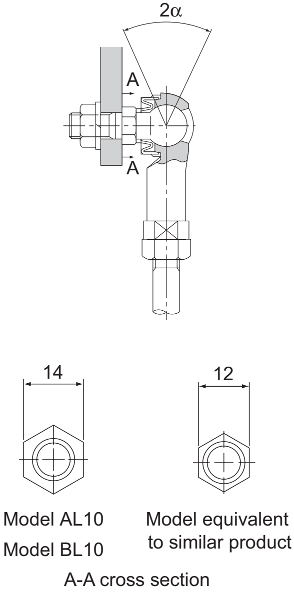
The hexagonal bolt seat of the shank has the same dimensions as the seating surface for small hexagon head bolts in accordance with automotive specifications. This prevents the seating surface from sinking and ensures a stable link motion mechanism.

[Lightweight, High Strength]

Use of the A-1 Alloy enables the Link Ball to achieve mechanical strength approximately twice that of the commonly used aluminum die cast material ADC 12, or almost equal to the high strength zinc alloy, while maintaining aluminum alloys' advantages: lightweight and corrosion resistance.

[Equipped with a Boot for Protection against Muddy Water]

Use of a boot with high trackability in the ball shank prevents muddy water from entering the spherical area even in a muddy atmosphere. Accordingly, those types equipped with boots are used also in outdoor applications and automobile parts under the chassis. For details, see the muddy water test data (A-930 and A-931).



Jaw Span for Wrenching

Alloy

[High Strength Aluminum Alloy “A-1 Alloy”]

“A-1 Alloy,” a newly developed high strength aluminum alloy, is an alloy with Aℓ-Zn-Si3 being the main components, is used in the holder of model AL.

● Features of the A-1 Alloy

- Achieves one of the highest strengths among the existing aluminum die cast alloys.
- Has yield strength approximately twice that of the commonly used aluminum die cast alloy (ADC 12).
- Has hardness equal to the high strength zinc alloy and achieves high wear resistance.
- Achieves specific gravity less than a half of the high strength zinc alloy to allow significant weight saving.
- Highly corrosion resistance and can be used as an automotive part related to wheel control.

● Mechanical Properties

Tensile strength : 343 to 392 N/mm^2
Tensile yield strength (0.2%) : 245 to 294 N/mm^2
Compressive strength : 490 to 637 N/mm^2
Compressive yield strength (0.2%) : 294 to 343 N/mm^2
Charpy impact : 0.098 to 0.196 N-m/mm^2
Elongation : 2 to 3 %
Hardness : 140 to 160 HV

● Physical Properties

Specific gravity : 3
Melting point : 570℃
Specific heat : 793 J/(kg・k)
Linear expansion rate : 22×10^{-6}

● Wear Resistance

The result of our test has proven that the wear resistance of the A-1 alloy is equivalent to the high strength zinc alloy.

Rotation-and-rocking durability test between model AL10D (A-1 alloy) and model BL10D (high strength zinc alloy)

<Test conditions>

Item	Description	
Environment temperature	Normal temperature	
Applied load	±1.9kN (perpendicular to the axis) (note)	
Loading frequency	0.6Hz	
Kinematic angle	Rotation ±20°	Rocking ±20°
No. of cycles	40 times/min.	40 times/min.
Total No. of cycles	1,000,000 cycles	

Note) For the load direction, see A-927.

<Test result: change in clearance (mm)> Unit: mm

Model No.	AL10D (A-1 alloy)	BL10D (high strength zinc alloy)
Perpendicular to the axis	0.036	0.033
Axial direction	0.052	0.045

[High Strength Zinc Alloy]

The high strength zinc alloy used in the holders of models BL, RBL, RBI and TBS has been developed as a bearing alloy by mixing Aℓ, Cu, Mg, Be and Ti as well as zinc as the base component. It is excellent in mechanical properties, seizure resistance and wear resistance.

● Composition

Table1 Composition of the High Strength Zinc Alloy

Unit: %

Item	Description
Aℓ	3 to 4
Cu	3 to 4
Mg	0.03 to 0.06
Be	0.02 to 0.06
Ti	0.04 to 0.12
Zn	Remaining portion

● Mechanical Properties

Tensile strength	: 275 to 314 N/mm^2
Tensile yield strength (0.2%)	: 216 to 245 N/mm^2
Compressive strength	: 539 to 686 N/mm^2
Compressive yield strength (0.2%)	: 294 to 343 N/mm^2
Fatigue strength	: 132 N/mm^2 × 10^7 (Schenk bending test)
Charpy impact	: 0.098 to 0.49 N-m/mm^2
Elongation	: 1 to 5%
Hardness	: 120 to 145 HV

● Physical Properties

Specific gravity	: 6.8
Melting point	: 390℃
Specific heat	: 460 J/(kg・k)
Linear expansion rate	: 24 × 10^{-6}

● Wear Resistance

The wear resistance of the high strength zinc alloy is superior to that of class-3 brass and class-3 bronze, almost equal to that of class-2 phosphor bronze.

Amsler wear-tester

Test piece rotation speed	: 185 min^{-1}
Load	: 392 N
Lubricant	: Dynamo oil

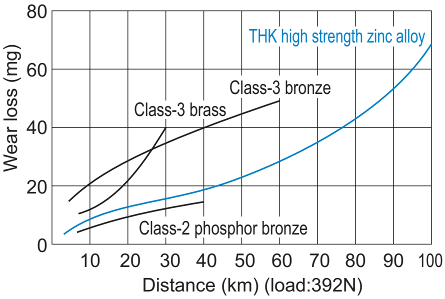


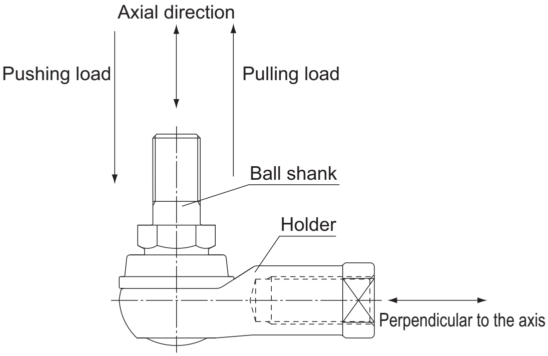
Fig.2 Wear Resistance of the High Strength Zinc Alloy

How Load Directions Are Called

Regardless of the shape, the direction of the load applied to the Link Ball is called "axial direction" if it is parallel to the axis of the ball shank, and "perpendicular-to-axis direction" if it is perpendicular to the axis.

Pushing Load and Pulling Load

Of the loads applied in the axial direction, the load in the direction of the ball shank being pressed toward the holder is called "pushing load" and the load in the direction of the ball shank being pulled from the holder is called "pulling load."



Performance Tests with the Link Ball

Tensile Strength Test with Model AL10D

[Test Method]

Place model AL10D on an Amsler universal testing machine as shown in Fig.3, then apply a load perpendicular to the axis to measure the tensile break load.

[Test Result]

All samples are broken in the shank, indicating that the holder has sufficient strength.

Sample No.	Breaking load (kN)	Broken point
1	18.82	A
2	18.72	A
3	18.6	A
4	18.78	A
5	18.45	A
6	18.95	A
7	18.65	A
8	18.91	A
9	18.55	A
10	18.5	A
$\overline{X}$	18.693	—
R	0.5	—

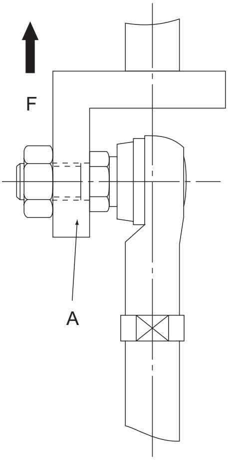


Fig.3

Durability Tests with Link Ball Model AL

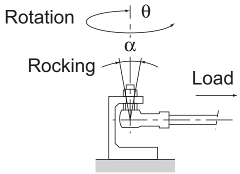
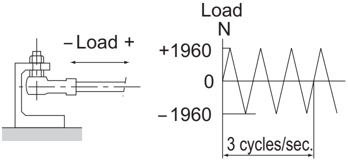
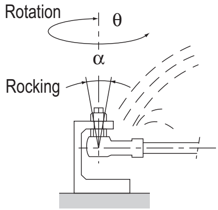
[Purpose of the Tests]

The tests were conducted to identify the durability of Link Ball model AL while assuming that it is used for automobile suspensions.

[Tested Product]

Link Ball model AL10D

[Test Items, Test Conditions and Test Results]

Test item	Test conditions					
	Applied load	Rotation or rocking angle	Frequency	Total number of revolutions or time	Service environment	Load conditions, etc.
Rotation-and-rocking durability	1960N Load direction: Perpendicular to the axis (one direction)	Rotation angle: θ=±5° Rocking angle: θ=±10°	Rotation: 25 times/min. Rocking: 75 times/min.	500,000 cycles (rocking)	Normal temperature	
Fatigue durability test	±1960N Load direction: Perpendicular to the axis (both directions)	—	180 times/min.	1 million cycles (rocking)	Normal temperature	
Muddy-water rotation-and-rocking durability (identify sealability of the boot)	—	Rotation angle: θ=±12° Rocking angle: θ=±12°	Rotation: 25 times/min. Rocking: 75 times/min.	500,000 cycles (rocking)	Normal temperature	Discharge muddy water to the boot ● Discharge rate: 1 ℓ/min. ● Contaminates 10% of JIS Class-8 Kanto loamy layer powder 
Boot weathering test	—	—	—	96 hours	−30℃	Left standing
				96 hours	70℃	Left standing
		Rotation angle: θ=±10°	60 times/min.	144 hours	40℃	● Ozone concentration: 80pphm
Salt-water spray resistance test	—	—	—	200 hours	35℃	● Salt-water concentration: 5% ● Spray solution temperature: 33 to 37℃ ● Spray pressure: 0.098MPa ● Following spray test, apply pushing load to measure strength

[Comprehensive Evaluation]

The results of the durability tests indicate that Link Ball model AL has sufficient strength, wear resistance, corrosion resistance and boot sealability.

This is attributable to the superb characteristics of the newly developed alloy A-1 and the effect of THK's unique manufacturing process. Thus,THK Link Ball model AL provides a high level of performance as a lightweight component.

dammy

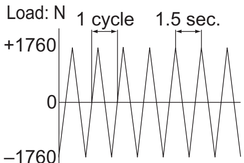
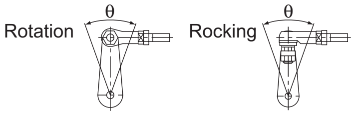
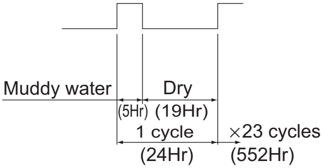
<table>
<tr><th colspan="3">Test Result</th><th>Evaluation</th></tr>
<tr><td rowspan="2">Sample No.</td><td colspan="2">Change in clearance (mm)</td><td rowspan="6">● Despite harsh test conditions where complex link motion was required under an axial load, no anomaly was observed in the samples after the test, and the abrasion loss was minimal and consistent among the samples. This indicates that the Link Ball has superb wear resistance and stable quality.</td></tr>
<tr><td>Perpendicular to the axis</td><td>Axial direction</td></tr>
<tr><td>(1)</td><td>0.038</td><td>0.02</td></tr>
<tr><td>(2)</td><td>0.04</td><td>0.03</td></tr>
<tr><td>(3)</td><td>0.042</td><td>0.04</td></tr>
<tr><td>(4)</td><td>0.038</td><td>0.03</td></tr>
<tr><td colspan="3">● Appearance
No anomaly was observed including fracture of the samples.
● Motion
The ball shank was capable of smoothly oscillating after the test, without any anomaly such as heavy and jerky motion.</td><td>● No anomaly in appearance or function was observed in the sample after the fatigue durability test involving 1 million cycles of rocking. This indicates that the product is sufficiently capable of continuously operating and has superb wear resistance.</td></tr>
<tr><td colspan="3">● Motion
The ball shank was capable of smoothly oscillating after the test, without any anomaly such as heavy and jerky motion.
● Muddy water penetration
No muddy water penetration was observed in visual inspection with the boot removed.
● Boot status
No breakage of the boot or abnormal wear of the lip was observed.</td><td>● No anomaly in motion was observed in the sample, and no muddy water penetration into the boot or no grease deterioration was found after the test. This verifies that the boot has reliable sealability.</td></tr>
<tr><td colspan="3">● Boot status
The boot showed no harmful ozone crack and maintained its pre-test status, including softness, after the test.</td><td>● No anomaly was observed in the sample after the test. The fact that no muddy water penetration into the boot or no grease deterioration was found in the sample after the above durability test verifies that the boot has reliable weatherability.</td></tr>
<tr><td colspan="3">● Appearance
No erosion was observed in the holder, and no other anomaly including breakage was found either.
● Appearance
The ball shank was capable of smoothly oscillating after the test.</td><td>● No erosion-based deterioration of the sample was observed in function and performance.
This demonstrates that the A-1 alloy has superb corrosion resistance.</td></tr>
</table>

Durability Tests with Link Ball Model BL

[Purpose of the Tests]

The tests were conducted to identify the performance difference between THK Link Ball model BL and an equivalent product of a competitor. As a result, model BL has been used in joints for transmission control units of automobiles, trucks and buses and for steering mechanisms of agricultural tractors.

[Tested Product, Test Items, Test Conditions and Test Results]

Test item	Tested model No.	Test conditions					
		Applied load	Rotation or rocking angle	Frequency	Total number of revolutions or time	Service environment	Load conditions, etc.
Rotation-and-rocking durability	Comparison of THK Link Ball model BL10D and competitor's product	±1760N (load direction: perpendicular to the axis)	Rotation angle: θ=±20° Rocking angle: α=±20°	40 times/min.	1,000,000 cycles	Normal temperature	The loading diagram is as follows.  The motion direction is as follows: 
Low-temperature rotation durability	THK Link Ball model BL10D only	±1225N (load direction: perpendicular to the axis)	Rotation angle: θ=±30°	60 times/min.		–30℃	Low-temperature retention time: 280 hours Motion in the rotational direction
High temperature rotation durability						100℃	High temperature retention time: 280 hours Motion in the rotational direction
Muddy-water rotation durability						Normal temperature	Motion: rotational direction and oscillation on a separate basis Muddy water discharge pattern Muddy water concentration: 5 Wt% of salt and dust each in 1 liter of water Discharge direction: against the boot lip Discharge pressure: 5 kg/cm^3 
Muddy-water rocking durability	Comparison of THK Link Ball model BL10D and competitor's product		Rocking angle: α=±20°				

[Comprehensive Evaluation]

As a result of comparing THK Link Ball model BL10D and a competitor's product in representative durability tests, it is demonstrated that model BL10D is superior in strength and wear resistance of the holder and sealability of the boot.

These features are achieved through THK's unique manufacturing process for the holder and the shank, the material used, the structure of upper and lower grease pockets on the spherical area and the development of a highly sealable boot.

Test Result					Evaluation
	Sample No.	Change in clearance (µm)		Conditions of the holder, etc.	
		Perpendicular to the axis	Axial direction		
THK model BL10D	(1)	26	42	The shank was capable of smoothly rotating after the 1-million cycle test, and capable of continuously operating.	● Even in complex link motion, THK model BL10D demonstrated higher durability and wear resistance of the holder than competitor's product.
	(2)	25	40		
Competitor's product	(1)	Broke in the holder neck after 8,600 cycles 154	60	Wear and damage were observed in the holder's spherical area in approx. 150,000-cycle operation.	● The abrasion loss of the competitor's product immediately before the breakage of the holder was 6 times greater than THK model BL10D (perpendicular to the axis).
	(2)	Broke in the holder neck after 151,300 cycles 62	20		
THK model BL10D	(1)	63	65	The boot did not show a crack or the like at low temperature	● This indicates that THK model BL10D is sufficiently capable of operating in outdoor applications in cold climates.
	(2)	56	59		
	(1)	79	84	The holder did not show abnormal wear and the boot did not show thermal deterioration at high temperature.	● This indicates that THK model BL10D is sufficiently capable of operating in hot areas of a truck engine.
	(2)	74	78		
	(1)	48	51	No muddy-water penetration that may cause wear was observed.	● This indicates that THK model BL10D is sufficiently capable of operating in environments subject to muddy water such as trucks, construction vehicles and agricultural machines since the sealing effect of the boot prevents penetration of muddy water.
	(2)	57	63		
	(1)	32	38		
	(2)	35	42		
Competitor's product	(1)	240	105	Muddy water penetrated the boot, the spherical area showed chipping and the boot had cuts.	● The competitor's product cannot be used in environments subject to muddy water since chipping or the like may occur in such environments. In addition, wear of the spherical area reached 0.24 mm, 7.4 times greater than THK model BL10D.
	(2)	246	107		

Types of the Link Ball

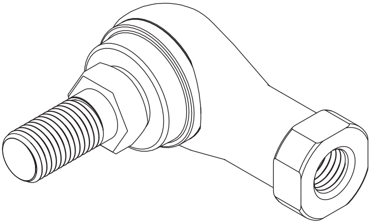
Types and Features

Model AL

Specification Table⇒B-834

The holder is connected in perpendicular to the shank, which comprises a male thread specially welded with a highly accurate steel ball. With a grease pocket formed on the top and bottom of the spherical area, this model achieves high lubricity and high wear resistance.

Use of the A-1 alloy in the holder significantly reduces the weight.



Model AL

"A-1 Alloy," a high strength aluminum alloy newly developed for the Link Ball, has yield strength approximately twice that of the commonly used aluminum die cast material ADC 12, and its strength and wear resistance are equivalent to the high strength zinc alloy.

With its specific gravity less than that of the high strength zinc alloy, model AL is optimal as an automotive part that requires lightweight, high strength, high corrosion resistance and high wear resistance.

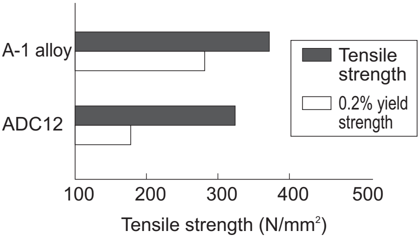


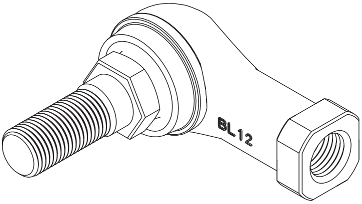
Fig.4 Tensile Strength and Yield Strength of THK A-1 Alloy and ADC 12

Model BL

Specification Table⇒B-836

A compact type of model RBL, this model's holder made of the high strength-zinc alloy is connected in perpendicular to the shank, which is incorporated with a ball.

With a grease pocket formed on the top and bottom of the spherical area, this model achieves high lubricity and high wear resistance.

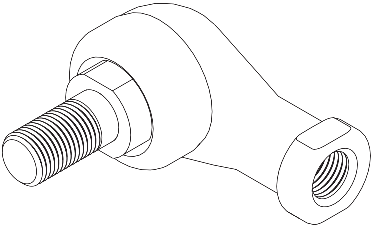


Model BL

Model RBL

Specification Table⇒B-838

The holder made of the high strength zinc alloy is connected in perpendicular to the shank, which is incorporated with a ball.
Since grease is contained in the boot, this model achieves high lubricity and high wear resistance.

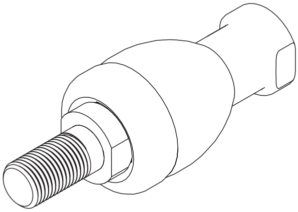


Model RBL

Model RBI

Specification Table⇒B-840

With this Link Ball model, the high strength zinc alloy is used in its holder and the mounting bolt and the holder are arranged on the same axis, allowing this model to receive both a compressive load and a pulling load.
Since grease is contained in the boot, this model achieves high lubricity and high wear resistance.

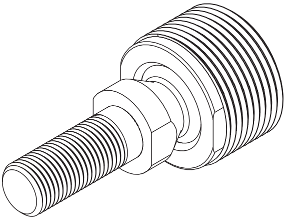


Model RBI

Model TBS

Specification Table⇒B-842

The rolled thread on the circumference of the outer ring allows this model to easily be mounted on the housing. Simply by tightening the screw, the user can achieve play-free, firm installation.
Since the coating area of sphere is large, the model is capable of receiving a large axial load.



Model TBS

Selecting a Link Ball

The selected bearing must meet both the permissible load obtained from equation (1) and the dynamic load capacity obtained from equation (2).

[Permissible Load P]

The yield-point strength indicated in the specification tables refers to the mechanical strength of the bearing. With models AL, BL and RBL, the yield point strength indicates the strength when a load is applied perpendicular to the ball shank axis. With model RBI, it indicates the strength when an axial load is applied to the holder in the shank axis direction.

Table1 Safety Factor (f_S)

Type of load	Lower limit of f_S
Constant load in a constant direction	2 to 3
Fluctuating load in a constant direction	3 to 5
Load in varying directions	5 to 8

According to the type of the load, select a bearing that satisfies the following equation from a mechanical strength's viewpoint.

$$P \leqq \frac{P_k}{f_S} \quad \cdots\cdots\cdots\cdots(1)$$

P : Permissible Load (N)
P_k : Yield-point strength (N)
f_S : Safety factor (see Table1)

[Dynamic Load Capacity C_d]

The dynamic load capacity (C_d) refers to the upper limit of load that the spherical area of the Link Ball can receive without showing seizure while the Link Ball is rotating or oscillating. The dynamic load capacity is obtained from the following approximation formula using the static load capacity (C_S) (note) indicated in the dimensional table.

$$C_d = \frac{C_S}{\sqrt[3]{n}} \quad \cdots\cdots\cdots\cdots(2)$$

C_d : Dynamic load capacity (N)
C_s : Static load capacity (N)
n : Rotation speed per minute (min^{-1})

Note) Static load capacity (C_s) refers to the value obtained by multiplying the projected area on the spherical section by the permissible surface pressure, and is used to obtain the dynamic load capacity.

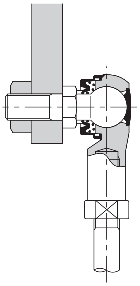
Permissible Tilt Angles

The permissible tilting angles of Link Ball models are indicated in the corresponding specification tables.

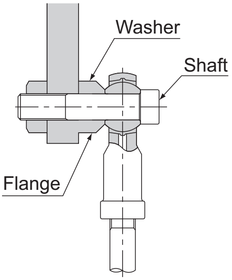
Note) If the permissible tilt angle is exceeded, it may cause serious damage to the holder or the boot. Be sure to use the Link Ball within its permissible tilt angle.

Example of Installation

[Comparison of THK Link Ball and the Conventional Rod End]



THK model BL

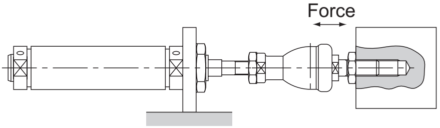


Conventional Rod End model PHS

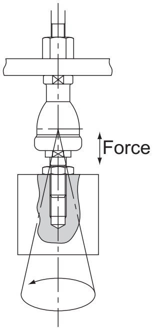
- Sine it has a shaft, model BL can easily be installed (especially useful for rod assembly).
- Because of the improved shape of the boot lip, the spherical area is protected from muddy water even in a muddy atmosphere.
- Since it contains grease, it can be used without further lubrication. (with the boot attached)
- Unlike the conventional type, which has a clearance between the shaft and the inner circumference of the inner ring and cannot be fixed completely, model BL has minimum distortion and high rigidity since the shank is integrated with the ball.

[Examples of Installing Model RBI]

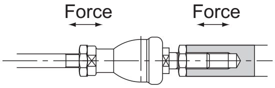
Joint for cylinder end metal fitting



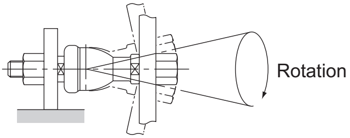
Suspending a light object



Connecting a rod in the axial direction



Rotation support



[Temperature Range]

The temperature range of the Link Ball series is basically between -20℃ and 80℃. If the service temperature exceeds this range, contact THK(see examples of testing the product at temperature other than the above temperature range on A-930 to A-933)

[Handling]

Dropping or hitting the Link Ball may damage it. Giving an impact to it could also cause functional damage to it even if the product looks intact.

[Lubrication]

(1) All Link Ball models except model TBS contain lithium soap-based grease in their boots and can be used without further greasing. For model TBS and those models without boot, apply grease to the spherical section as necessary.

(2) Do not mix lubricants of different physical properties.

[Precautions on Use]

(1) Do not use the product in the manner that the permissible tilting angle is exceeded since doing so may damage the product.

(2) When using the product in locations exposed to vibrations or an impact load or in a special environment such as a clean room, vacuum and low/high temperature, contact THK in advance.

(3) Entrance of foreign material such as dust between the holder and the inner ring may cause damage or functional loss. Prevent foreign material, such as dust and cutting chips, from entering the product.

(4) Models AL, BL and RBL are designed for use under a load in the direction perpendicular to the axis, while models RBI and TBS are designed for use under an axial load. Take this into account when selecting a model.

[Storage]

When storing the Link Ball, avoid high temperature, low temperature and high humidity.

Rod End

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

Features of the Rod End

Features

The Rod End is a self-aligning plain bearing that uses a spherical inner ring which has the same level of accuracy and hardness as bearing steel balls. With the combination of a spherical inner ring whose sliding surface is mirror-finished and a rationally designed holder, the Rod End ensures play-free, extremely smooth rotation and oscillation.

Special Bearing Alloy

[High Strength Zinc Alloy]

The high strength zinc alloy, developed as an alloy for bearings, is composed of Aℓ, Cu, Mg, Be and Ti as well as zinc as the base. It is excellent in mechanical properties, seizure resistance and wear resistance.

● Composition

Table1 Composition of the High Strength Zinc Alloy

Unit: %

Item	Description
Aℓ	3 to 4
Cu	3 to 4
Mg	0.03 to 0.06
Be	0.02 to 0.06
Ti	0.04 to 0.12
Zn	Remaining portion

● Mechanical Properties

Tensile strength	: 275 to 314 N/mm^2
Tensile yield strength (0.2%)	: 216 to 245 N/mm^2
Compressive strength	: 539 to 686 N/mm^2
Compressive yield strength (0.2%)	: 294 to 343 N/mm^2
Fatigue strength	: 132 N/mm^2 × 10^7 (Schenk bending test)
Charpy impact	: 0.098 to 0.49 N-m/mm^2
Elongation	: 1 to 5%
Hardness	: 120 to 145 HV

● Physical Properties

Specific gravity : 6.8
Melting point : 390℃
Specific heat : 460 J/ (kg・k)
Linear expansion rate : 24×10^{-6}

● Wear Resistance

The wear resistance of the high strength zinc alloy is superior to that of class-3 brass and class-3 bronze, almost equal to that of class-2 phosphor bronze.

Amsler wear-tester
Test piece rotation speed : 185 min^{-1}
Load : 392 N
Lubricant : Dynamo oil

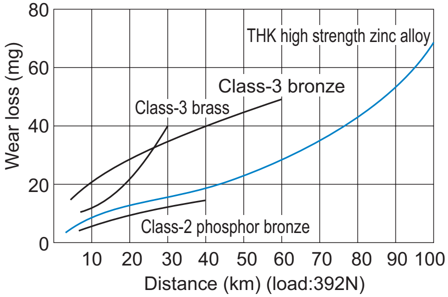


Fig.1 Wear Resistance of the High Strength Zinc Alloy

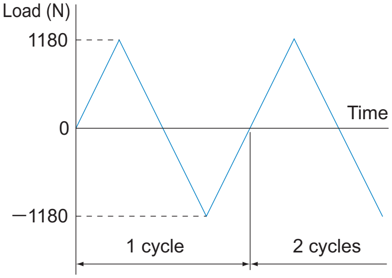
Performance Test with the Rod End

This test has been conducted to identify the difference in performance between THK Rod End model HS and an equivalent product by a competitor.

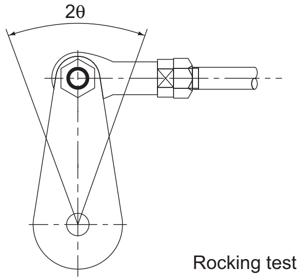
[Wear Test Conditions]

Item	Description
Subject Rod End	THK: Model HS8 Stainless steel model equivalent of the above
Type of test	Rocking test
Applied load	±1,180 N in the radial direction
Kinematic angle	Oscillation angle: 2θ=40°(±20°)
Lubrication	No lubrication
Number of cycles per minute	60opm
Total number of cycles	1 million cycles
Testing equipment	Bench testing machine (normal temperature)

The applied load diagram is shown below.



The kinematic angle is shown below.



[Result of the Wear Test]

Table2 Change in the Spherical Clearance Unit: mm

Abrasion loss after 1-million-cycle test			
Model No.	Number of times	Rocking test	
		Radial direction	Axial direction
HS 8	Initial stage (at start-up)	0.008	0.01
	1 million cycles	0.035	0.075
	Change	0.027	0.065
Stainless steel model equivalent of the above	Initial stage (at start-up)	0.005	0.005
	40,000 cycles	0.22	0.2
	Change after 40,000 cycles	0.215	0.065
	Note: The holder is elongated and fractured after 76,300 cycles.		

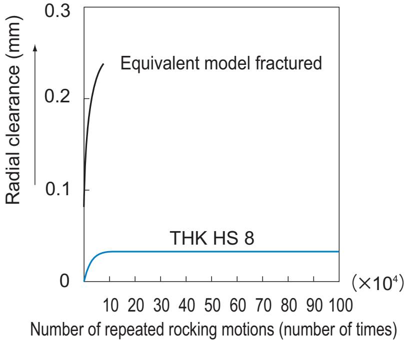


Fig.2 Wear Diagram

(1) Although model HS8 withstood the repeated durability test with an applied load of ±1,180 N and the total number of cycles being 1 million, the holder of the stainless steel equivalent model was elongated and fractured after only 76,300 cycles.

(2) The result shows that the increase in wear of model HS8 in the radial direction since the initial wear (approximately 100,000 cycles) was minimal.

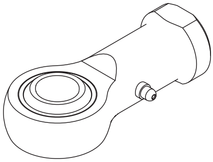
Types of the Rod End

Types and Features

Type Provided with a Female Threading - Model PHS

Specification Table⇒B-846

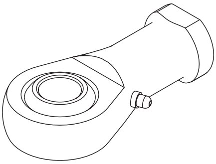
With model PHS, a special copper alloy with high conformability is inserted between the chromate treatment steel holder and the spherical inner ring in which only the circumference of the spherical area is hard chrome plated. This structure ensures high rigidity, high wear resistance and high corrosion resistance.
The grease nipple on the holder allows grease to be applied to the sliding surface as necessary.


Model PHS

Die Cast, Low Price Type - Model RBH

Specification Table⇒B-848

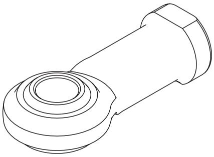
This model is a high-accuracy, low cost rod end in which the spherical inner ring serves as the core and the holder is formed by die casting.
The holder is made of a high strength zinc alloy (see A-942), which is superb in mechanical properties and bearing characteristics.


Model RBH

No Lubrication Type - Model NHS-T

Specification Table⇒B-850

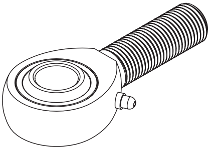
This no lubrication rod end uses self-lubricating synthetic resin formed between the steel holder and the spherical inner ring.
Since the clearance on the sliding surface is minimized, an accurate link motion is achieved.


Model NHS-T

Male thread Type - Model POS

Specification Table⇒B-852

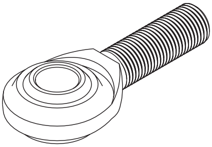
This model is a highly rigid rod end that is basically the same as the female threading type model PHS, but has a male thread on the holder end.


Model POS

No Lubrication, Male thread Type - Model NOS-T

Specification Table⇒B-854

This model is a no lubrication rod end that is basically the same as the female threading type model NHS-T, but has a male thread on the holder end.

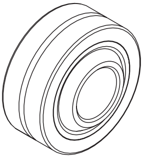


Model NOS-T

Standard Type - Model PB

Specification Table⇒B-856

With model PB, a special copper alloy with high conformability is inserted between the steel outer ring and the spherical inner ring in which only the spherical area is hard chrome plated. This structure makes this model a high rigid Spherical Plain Bearing with high corrosion resistance and high wear resistance.
The oil groove and the greasing hole on the outer ring allow grease to be applied to the sliding surface as necessary.

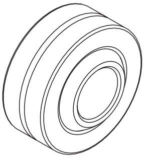


Model PB

Die Cast Type - Model PBA

Specification Table⇒B-857

This model is a high-accuracy, low cost Spherical Plain Bearing in which the spherical inner ring serves as the core and the outer ring is formed by die casting.
The outer ring is made of a high strength zinc alloy (see A-942), which is superb in bearing characteristics.

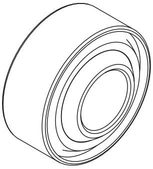


Model PBA

No Lubrication Type - Model NB-T

Specification Table⇒B-858

This no lubrication bearing uses self-lubricating synthetic resin formed between the steel outer ring and the spherical inner ring.



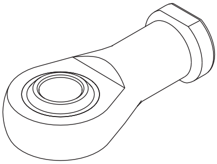
Model NB-T

[Build to Order]

No Lubrication, Corrosion-resistant Type - Model HS

Specification Table⇒B-860

This no lubrication Spherical Plain Bearing uses a special fluorine sheet adhering to the holder's spherical area. The holder is made of an aluminum alloy.
This product is built to order. Contact THK for details.



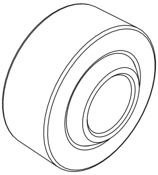
Model HS

[Build to Order]

No Lubrication Type - Model HB

Specification Table⇒B-862

This no lubrication Spherical Plain Bearing uses a special fluorine sheet adhering to the outer ring's spherical area.
This product is built to order. Contact THK for details.



Model HB

Selecting a Rod End

[Permissible Load P]

The static load capacity (C_s) indicated in the specification tables, is presented as a guide for the mechanical strength of the Rod End. Select a bearing while taking into account the safety factor (f_S) indicated in Table1 according to the type of the load.

Table1 Safety Factor (f_S)

Type of load	Lower limit of f_S
Constant load in a constant direction	2 to 3
Fluctuating load in a constant direction	3 to 5
Load in varying directions	5 to 8

According to the type of load, select a bearing that satisfies the following equation from a mechanical strength's viewpoint.

$$P \leqq \frac{C_S}{f_S} \qquad \cdots\cdots\cdots(1)$$

P	: Permissible Load	(N)
C_S	: Static load capacity	(N)
f_S	: Safety factor	(see Table1)

[Dynamic Load Capacity C_d]

The dynamic load capacity refers to the upper limit of load that the spherical area can receive without showing seizure while the Rod End is rotating or oscillating. The dynamic load capacity is obtained from the following approximation formula using the static load capacity (C_S) (note 1) indicated in the specification table.

$$C_d = \frac{C_S}{\sqrt[3]{n}} \qquad \cdots\cdots\cdots(2)$$

C_d	: Dynamic load capacity	(N)
C_S	: Static load capacity	(N)
n	: Rotation speed per minute	(min^{-1})

The selected bearing must meet both the permissible load obtained from equation (1) and the dynamic load capacity obtained from equation (2).

Note1) Static load capacity (C_s) refers to the value obtained by multiplying the projected area on the spherical section by the permissible surface pressure, and is used to obtain the dynamic load capacity.

Permissible Tilt Angles

The permissible tilt angles α_1, α_2 and α_3 of the Rod End are indicated in Table1.

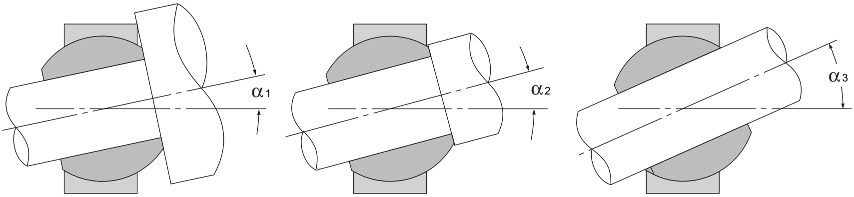


Table1 Permissible Tilt Angles

Model No.	Permissible tilt angles		
	α_1	α_2	α_3
NHS 3T, NOS 3T	8	10	42
NHS 4T, NOS 4T	9	11	35
PHS 5, RBH 5, NHS 5T, POS 5, NOS 5T, PB 5, PBA 5	8	13	30
PHS 6, RBH 6, NHS 6T, POS 6, NOS 6T, PB 6, PBA 6	8	13	30
PHS 8, RBH 8, NHS 8T, POS 8, NOS 8T, PB 8, PBA 8	8	14	25
PHS 10, RBH 10, NHS 10T, POS 10, NOS 10T, PB 10, PBA 10	8	14	25
PHS 12, RBH 12, NHS 12T, POS 12, NOS 12T, PB 12, PBA 12	8	13	25
PHS 14, RBH 14, NHS 14T, POS 14, NOS 14T, PB 14, PBA 14, NB 14T	10	16	24
PHS 16, RBH 16, NHS 16T, POS 16, NOS 16T, PB 16, PBA 16, NB 16T	9	15	24
PHS 18, RBH 18, NHS 18T, POS 18, NOS 18T, PB 18, PBA 18, NB 18T	9	15	24
PHS 20, RBH 20, NHS 20T, POS 20, NOS 20T, PB 20, PBA 20, NB 20T	9	15	24
PHS 22, RBH 22, NHS 22T, POS 22, NOS 22T, PB 22, PBA 22, NB 22T	10	15	23
PHS 25, POS 25, PB 25	9	15	23
PHS 30, POS 30, PB 30	10	17	23

Installation

Please note that the Rod End is not capable of receiving a thrust load indicated in Fig.1.

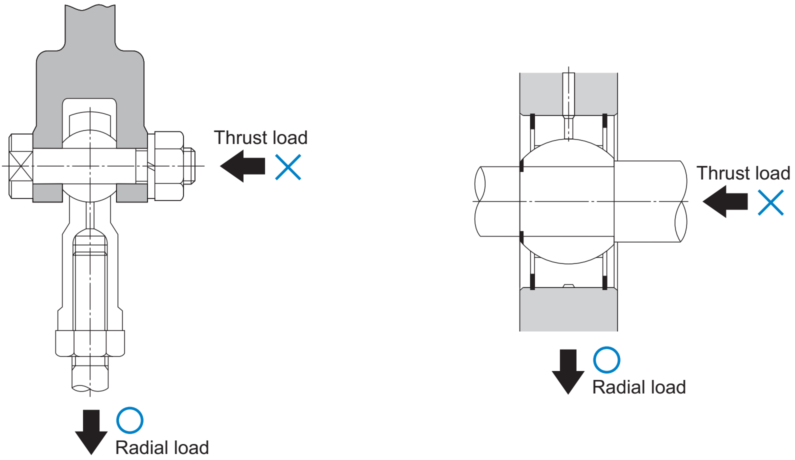


Fig.1 Examples of Installing the Rod End

[Service Temperature]

If any of models RBH, PBA, HS and HB, all of which use the high strength zinc alloy and an aluminum alloy in the holder and the outer ring, and of models NHS-T, NOS-T and NB-T, which use synthetic-resin bushes, is to be used at temperature of 80 ℃ or higher, or receives an impact at low temperature, contact THK.

[Handling]

Dropping or hitting the Rod End may damage it. Giving an impact to it could also cause damage to its function even if the product looks intact.

[Lubrication]

All Rod End models except lubrication-free types must be greased before being used (lithium soap-based grease No. 2 is recommended). When greasing the Rod End before using it, do not mix lubricants of different physical properties. In addition, replenish a lubricant also during operation as necessary.

[Precautions on Use]

(1) Do not use the product in the manner that the permissible tilting angle is exceeded since doing so may damage the product.
(2) When using the product in locations exposed to vibrations or an impact load or in a special environment such as a clean room, vacuum and low/high temperature, contact THK in advance.
(3) Entrance of foreign material such as dust between the holder and the inner ring may cause damage or functional loss. Prevent foreign material, such as dust and cutting chips, from entering the product.
(4) The Rod End is designed for use under a radial load. Do not use the product under a thrust load.

[Storage]

When storing the Rod End, avoid high temperature, low temperature and high humidity.

Accessories for Lubrication

THK General Catalog

A Technical Descriptions of the Products

B Product Specifications (Separate)

* Please see the separate "B Product Specifications".

When using an LM system, it is necessary to provide effective lubrication. Without lubrication, the rolling elements or the raceway may be worn faster and the service life may be shortened.
A lubricant has effects such as the following.
(1) Minimizes friction in moving elements to prevent seizure and reduce wear.
(2) Forms an oil film on the raceway to decrease stress acting on the surface and extend rolling fatigue life.
(3) Covers the metal surface to prevent rust formation.
To fully bring out an LM system's functions, it is necessary to provide lubrication according to the conditions.
Even with an LM system with seals, the internal lubricant gradually seeps out during operation. Therefore, the system needs to be lubricated at an appropriate interval according to the conditions.

Types of Lubricants

LM systems mainly use grease or sliding surface oil for their lubricants.
The requirements that lubricants need to satisfy generally consist of the following.
(1) High oil film strength
(2) Low friction
(3) High wear resistance
(4) High thermal stability
(5) Non-corrosive
(6) Highly anti-corrosive
(7) Minimal dust/water content
(8) Consistency of grease must not be altered to a significant extent even after it is repeatedly stirred.

For lubricants that meet these requirements, see A-955.

Grease Lubrication

Greasing intervals vary depending on the conditions and environments. For normal use, we recommend greasing the system approximately every 100 km of travel distance.
Normally, replenish grease of the same group from the grease nipple or greasing hole provided on the LM system. Mixing different types of grease may deteriorate the system's performance, such as increased consistency.

Lubricant	Type	Brand name
Grease	Lithium-based grease (JIS No. 2) Urea-based grease (JIS No. 2)	AFA Grease (THK) see A-959 AFB-LF Grease (THK) see A-960 AFC Grease (THK) see A-961 AFE-CA Grease (THK) see A-963 AFF Grease (THK) see A-965 AFG Grease (THK) see A-968 Albania Grease No.2 (Showa Shell Sekiyu) Daphne Exponex Grease No.2 (Idemitsu) or equivalent

* Recommended greases vary according to the conditions and environment. See A-958 to A-969 for details.

Oil Lubrication

LM systems that require oil lubrication are shipped with only anti-rust oil applied. When placing an order, specify the required lubricant oil. If the LM system is to be mounted other than in horizontal orientation, part of the raceway may be poorly lubricated. Therefore, be sure to inform us of the mounting orientation of the LM system. (For details on mounting orientations, see A-58.)

- The amount of oil to be supplied varies with stroke length. For a long stroke, increase the lubrication frequency or the amount of oil so that an oil film reaches the stroke end of the raceway.
- In environments where a liquid coolant is spattered, the lubricant will be mixed with the coolant, and this can result in the lubricant being emulsified or washed away, causing significantly degraded lubrication performance. In such settings, apply a lubricant with high viscosity (kinematic viscosity: approx. 68 cst) and high emulsification-resistant, and adjust the lubrication frequency or the amount of the feed lubricant.
  For machine tools and similar devices that are subject to heavy loads and require high rigidity and operate at high speed, it is advisable to apply oil lubrication.
- Make sure that lubrication oil normally discharges from the ends of your lubrication piping, i.e., the oiling ports that connect to your LM system.

Lubricant	Type	Brand name
Oil	Sliding surface oil or turbine oil ISOVG32 to 68	Super Multi 32 to 68 (Idemitsu) Vactra No.2S (ExxonMobile) DT Oil (ExxonMobile) Tonner Oil (Showa Shell Sekiyu) or equivalent

Lubrication under Special Environments

For use under special conditions, such as continual vibrations, clean room, vacuum, low temperature and high temperature, normal grease may not be used in some cases. For lubricants that meet such conditions, contact THK.

Table1 Lubricants Used under Special Environments

Service environment	Lubricant characteristics	Brand name
High-speed moving parts	Grease with low torque and low heat generation	AFG Grease(THK) see A-968 AFA Grease(THK) see A-959 NBU15(NOK Kluba) Multemp (Kyodo Yushi) or equivalent
Vacuum	Fluorine based vacuum grease or oil (vapor pressure varies by brand) Note 1	Fomblin Grease (Solvay Solexis) Fomblin Oil (Solvay Solexis) Barrierta IEL/V (NOK Kluba) Isoflex(NOK Kluba) Krytox (Dupont)
Clean room	Grease with very low dust generation	AFE-CA Grease(THK) see A-963 AFF Grease(THK) see A-965
Environments subject to microvibrations or microstrokes, which may cause fretting corrosion	Grease that easily forms an oil film and has high fretting resistance	AFC Grease(THK) see A-961
Environments subject to a spattering coolant such as machine tools	Highly anti-corrosive, refined mineral oil or synthetic oil that forms a strong oil film and is not easily emulsified or washed away by coolant Water-resistant grease Note 2	Super Multi 68 (Idemitsu) Vactra No.2S (ExxonMobile) or equivalent

Note1) When using a vacuum grease, be sure that some brands have starting resistances several times greater than ordinary lithium-based greases.

Note2) In an environment subject to a spattering water-soluble coolant, some brands of intermediate viscosity significantly decrease their lubricity or do not properly form an oil film. Check the compatibility between the lubricant and the coolant.

Note3) Do not mix greases with different physical properties.

Lubrication Methods

There are roughly three methods of lubricating LM systems: manual lubrication using a grease gun or manual pump; forced oiling with the aid of an automatic pump; and oil-bath lubrication.

Manual Lubrication

Generally, grease is replenished periodically, fed through a grease nipple provided on the LM system, using a grease gun. (Fig.1)
For systems that have many locations to be lubricated, establish a centralized piping system and periodically provide grease from a single point using a manual pump. (Fig.2)

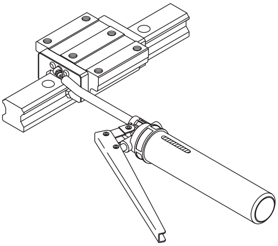


Fig.1 Lubrication Using a Grease Gun

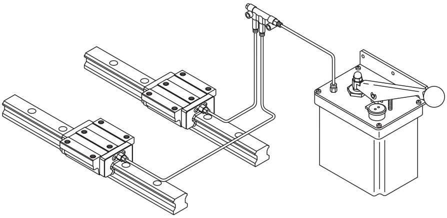


Fig.2 Lubrication through a Centralized Piping System

Note) When a centralized piping system is used, lubricant may not reach the pipe end due to the viscous resistance inside the pipe. Select the right type of grease while taking into account the consistency of the grease and the pipe diameter.

Forced Lubrication Method

In this method, a given amount of lubricant is forcibly fed at a given interval. Normally, the lubricant is not collected after use. (Fig.3)
Although a special lubrication system using a piping or the like needs to be designed, this method reduces the likelihood of forgetting to replenish lubricant.
This method is used mainly for oil lubrication. If using grease, it is necessary to examine the appropriate piping diameter and the required grease consistency.

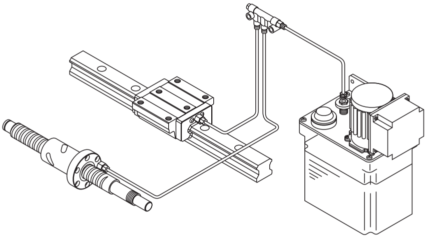


Fig.3 Forced Lubrication Method

Lubrication Accessory Series for LM Systems

THK provides a wide array of lubrication accessories such as grease, grease guns, grease nipples and plumbing fixtures available for various applications. (A-959 to A-970)

THK Original Grease

THK provides various types of THK original greaseneeded for the lubrication of LM systems. They are available for various conditions and environments.

[Table for Grease Selection]

Refer to the table below that allows you to select a type of grease according to the application of the LM system.

Also note that the color of the decorative package varies according to the type (both 70 g and 400 g).

Name of grease		AFA Grease	AFB-LF Grease	AFC Grease	AFE-CA Grease	AFF Grease	AFG Grease
Features		Long service life	All-purpose grease	High-speed/ micro-vibration grease	Grease for clean environment	Grease for clean environment	Grease for heat of Ball Screw
Base oil		high-grade synthetic oil	refined mineral oil	high-grade synthetic oil	high-grade synthetic oil	high-grade synthetic oil	high-grade synthetic oil
Consistency enhancer		Urea-based	Lithium-based	Urea-based	Urea-based	Lithium-based	Urea-based
Service Temperature Range (℃)		−45 to 160	−15 to 100	−54 to 177	−40 to 160 (200)	−40 to 120	−45 to 160
Applications	General industrial machinery	●	●	—	—	—	—
	Machine tool	—	●	●	—	—	●
	Semiconductor manufacturing equipment	—	●	●	●	●	—
	Special environments	—	—	●	●	●	●
Capacity	70g	●	●	●	●	●	●
	400g	●	●	●	●	●	●
Color of decorative package		Green	Orange	Mazarine	Lime green	Light blue	Blue
Reference page		A-959	A-960	A-961	A-963	A-965	A-968

Model number coding

●Type of packing···bellows cartridge

AFC + 70

Cartridge capacity (70 g / 400 g)

Type of grease (AFA Grease, AFB-LF Grease, AFC Grease, AFE Grease, AFF Grease, AFG Grease)

THK Original Grease

AFA Grease

●Base oil: high-grade synthetic oil
●Consistency enhancer: urea-based

AFA Grease is a high-grade, long-life grease developed with a urea-based consistency enhancer using a high-grade synthetic oil as the base oil.

[Features]

(1) Long service life

Unlike ordinary soap based grease for metal lubrication, AFA Grease excels in antioxidation stability and therefore can be used for a long period of time.

(2) Wide temperature range

The lubricating performance remains high over a wide range of temperatures from -45℃ to +160℃.

Even at low temperatures, AFA Grease requires only a low starting torque.

(3) High water resistance

AFA Grease is less vulnerable to moisture penetration than other types of grease because of its high water resistance.

(4) High mechanical stability

AFA Grease is not easily softened and demonstrates excellent mechanical stability even when used for a long period of time.

[Representative Physical Properties]

Test item		Representative value	Test method
Worked penetration (25℃, 60W)		285	JIS K 2220 7
Dropping point: ℃		261	JIS K 2220 8
Copper plate corrosion (B method, 100℃, 24h)		Accepted	JIS K 2220 9
Evaporation amount: mass% (99℃, 22h)		0.2	JIS K 2220 10
Oil separation rate: mass% (100℃, 30h)		0.5	JIS K 2220 11
Stability of oxidation: kPa (99℃, 100h)		80	JIS K 2220 12
Mixing stability (100,000 W)		329	JIS K 2220 15
Grease removal resistance during water rinse: mass% (38℃, 1h)		0.6	JIS K 2220 16
Low temperature torque: N-m (-20℃)	Start	0.17	JIS K 2220 18
	(revolutions)	0.07	
Anticorrosive test: (52℃, 48h)		Accepted	ASTM D1743-73
Service Temperature Limit (℃)		−45 to 160	—

[Rotation Torque Testing with Ball Screw Grease]

<Test method>

Apply 1 cc of grease to the LM Guide of KR4620A+640L and 2 cc to the Ball Screw (initial lubrication only), and then measure the torque at each motor rotation speed.

In torque measurement, output values on the driver torque monitor are used.

Comparative Table of Rotation Torque of Ball Screws by Grease

Unit: N-cm

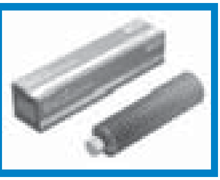
Grease	Central value of dynamic viscosity CST (mm²/S)(40℃)	Dynamic viscosity range CST (mm²/S)(40℃)	Rotational speed			
			100min⁻¹	1000min⁻¹	2000min⁻¹	4000min⁻¹
AFA Grease	25	22.5 to 27.5	11.27	11.27	12.25	14.6
Grease of manufacturer I	130	117 to 143	14.6	23.13	31.16	43.12
Grease of manufacturer K	15.3	13.8 to 16.8	12.64	12.05	13.03	14.41
Lubricant VG32	32	28.8 to 35.2	11.17	10.78	13.43	14.7

Note) The values of the competitors' greases are that of low-torque greases.

THK Original Grease

AFB-LF Grease

●Base oil: refined mineral oil
●Consistency enhancer: lithium-based



AFB-LF Grease is a general-purpose grease developed with a lithium-based consistency enhancer using refined mineral oil as the base oil. It excels in extreme pressure resistance and mechanical stability.

[Features]

(1) High extreme pressure resistance
Compared with lithium-based greases available on the market, AFB-LF Grease has higher wear resistance and outstanding resistance to extreme pressure.

(2) High mechanical stability
AFB-LF Grease is not easily softened and demonstrates excellent mechanical stability even when used for a long period of time.

(3) High water resistance
AFB-LF Grease is a highly water resistant grease that is less vulnerable to moisture penetration and little decreases resistance to extreme pressure.

[Representative Physical Properties]

Test item	Representative value	Test method
Worked penetration (25℃, 60W)	275	JIS K 2220 7
Dropping point: ℃	193	JIS K 2220 8
Copper plate corrosion (B method, 100℃, 24h)	Accepted	JIS K 2220 9
Evaporation amount: mass% (99℃, 22h)	0.36	JIS K 2220 10
Oil separation rate: mass% (100℃, 24h)	0.6	JIS K 2220 11
Stability of oxidation: kPa (99℃, 100h)	15	JIS K 2220 12
Mixing stability (100,000 W)	345	JIS K 2220 15
Timken load capacity: N	200	JIS K 2220 20
Grease removal resistance during water rinse: mass% (38℃, 1h)	1.8	JIS K 2220 16
Anticorrosive test: (52℃, 48h)	Accepted	ASTM D1743-73
Service Temperature Limit (℃)	−15 to 100	—

THK Original Grease

AFC Grease

- **Base oil: high-grade synthetic oil**
- **Consistency enhancer: urea-based**

AFC Grease has high fretting-corrosion resistance due to a special additive and a urea-based consistency enhancer using a high-grade synthetic oil as the base oil.

[Features]

(1) High fretting-corrosion resistance

AFC Grease is designed to be highly effective in preventing fretting corrosion.

(2) Long service life

Unlike ordinary soap based grease for metal lubrication, AFC Grease excels in antioxidation stability and therefore can be used for a long period of time. As a result, maintenance work is reduced.

(3) Wide temperature range

Since a high-grade synthetic oil is used as the base oil, the lubricating performance remains high over a wide range of temperatures from -54 ℃ to +177 ℃.

[Representative Physical Properties]

Test item		Representative value	Test method
Worked penetration (25℃, 60W)		288	JIS K 2220 7
Dropping point: ℃		269	JIS K 2220 8
Copper plate corrosion (B method, 100℃, 24h)		Accepted	JIS K 2220 9
Evaporation amount: mass% (177℃, 22h)		7.9	JIS K 2220 10
Oil separation rate: mass% (177℃, 30h)		2	JIS K 2220 11
Stability of oxidation: MPa (99℃, 100h)		0.065	JIS K 2220 12
No. of contaminants: pieces/cm^3 25 to 75 µm 75µm or more		370 0	JIS K 2220 13
Mixing stability (100,000 W)		341	JIS K 2220 15
Grease removal resistance during water rinse: mass% (38℃, 1h)		0.6	JIS K 2220 16
Low temperature torque: N-m (−54℃)	Start	0.63	JIS K 2220 18
	(revolutions)	0.068	
Anticorrosive test: (52℃, 48h)		Accepted	ASTM D1743-73
Vibration test (200h)		Accepted	—
Service Temperature Limit (℃)		−54 to 177	—

[Test Data on Fretting-corrosion Resistance]

● Test Data on AFC Grease (Comparison of Raceway Conditions)

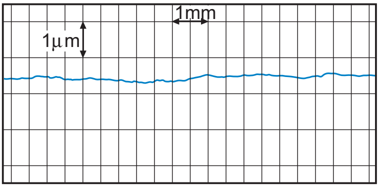
The test data in the figure shows the result of comparing AFC Grease with an ordinary bearing grease.

<Test conditions>

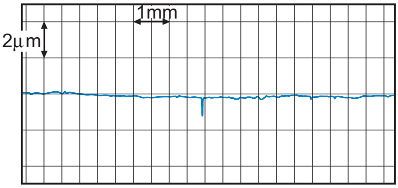
Item	Description
Stroke	3mm
Number of strokes per minute	200min^{-1}
Total number of strokes	2.88×10^{5} (24 hours)
Surface pressure	1118MPa
Grease quantity	12g/1LM block (replenished every 8 hours)

AFC Grease

Before travel

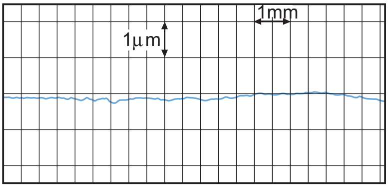


After travel (no fretting corrosion observed)

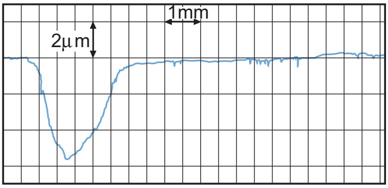


General-purpose bearing grease

Before travel



After travel (fretting corrosion observed)



THK Original Grease

AFE-CA Grease

- **Base oil: high-grade synthetic oil**
- **Consistency enhancer: urea-based**

AFE-CA Grease uses urea as a consistency enhancer and a high-grade synthetic oil as the base oil. It has low dust generative characteristics and is therefore a suitable grease for clean room environments.

[Features]

(1) Low dust generation
Compared with vacuum greases in conventional use, AFE-CA Grease generates less dust and therefore is ideal for use in clean rooms.

(2) Long service life
Unlike ordinary soap based grease for metal lubrication, AFE-CA Grease excels in antioxidation stability and therefore can be used for a long period of time. As a result, maintenance work is reduced.

[Representative Physical Properties]

Test item		Representative value	Test method
Worked penetration (25℃, 60W)		260	JIS K 2220 7
Dropping point: ℃		240<	JIS K 2220 8
Copper plate corrosion (100℃, 24h)		Accepted	JIS K 2220 9
Evaporation amount: mass% (99℃, 22h)		0.1	JIS K 2220 10
Oil separation rate: mass% (100℃, 24h)		0.8	JIS K 2220 11
Stability of oxidation: kPa (99℃, 100h)		20	JIS K 2220 12
No. of contaminants: pieces/cm^3	75μm or more	0	JIS K 2220 13
	125μm or more	0	
Mixing stability (100,000 W)		311	JIS K 2220 15
Low temperature torque: N-m (-20℃)	Start	0.130	JIS K 2220 18
	(revolutions)	0.078	
Apparent viscosity: Pa•s (-10℃, $10S^{-1}$)		230	JIS K 2220 19
Bearing rust prevention: (52℃, 48h)		#1	ASTM D1743-73
Service Temperature Limit (℃)		−40 to 180	—

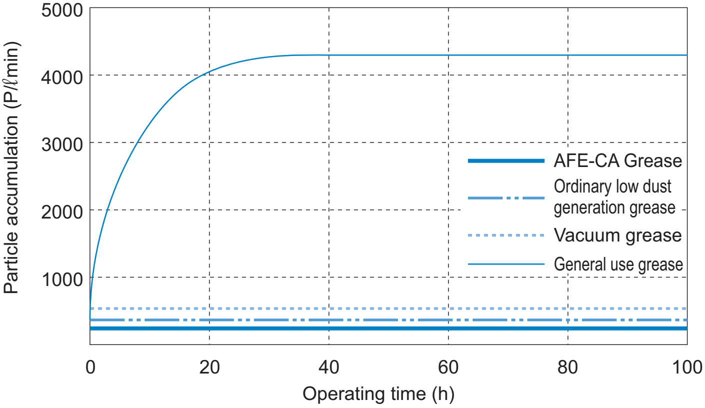
[Test Data on Low Dust Generative Characteristics]

● Test Data on AFE-CA Grease (Comparison of Particle Accumulation)

The test data in the figure shows the result of comparing particle accumulation between AFE-CA Grease with another grease.

<Test conditions>

Item	Description
Sample model No.	THK KR4610
Screw Ball rotational speed	1000min^{-1}
Stroke	210mm
Grease quantity	2 cc in both the Ball Screw and the LM Guide
Flow rate during measurement	1ℓ/min
Measuring instrument	Dust counter
Particle size	0.5µm



THK Original Grease

AFF Grease

●Base oil: high-grade synthetic oil
●Consistency enhancer: lithium-based

AFF Grease uses a high-grade synthetic oil, lithium-based consistency enhancer and a special additive. It achieves stable rolling resistance, low dust generation and high fretting resistance, at a level that conventional vacuum greases or low dust generation greases have not reached.

[Features]

(1) Stable rolling resistance
Since the viscous resistance is low, the rolling resistance fluctuation is also low. Thus, superb conformity is achieved at low speed.

(2) Low dust generation
AFF Grease generates little dust, making itself an ideal grease for use in clean rooms.

(3) Fretting resistance
Since AFF Grease is highly resistant to wear from microvibrations, it allows the greasing interval to be extended.

[Representative Physical Properties]

Test item		Representative value	Test method
Worked penetration (25℃, 60W)		315	JIS K 2220 7
Dropping point: ℃		216	JIS K 2220 8
Copper plate corrosion (100℃, 24h)		Accepted	JIS K 2220 9
Evaporation amount: mass% (99℃, 22h)		0.43	JIS K 2220 10
Oil separation rate: mass% (100℃, 24h)		0.57	JIS K 2220 11
Stability of oxidation: kPa (99℃, 100h)		39	JIS K 2220 12
No. of contaminants: pieces/cm^3			JIS K 2220 13
25µm or more		0	
75µm or more		0	
125µm or more		0	
Mixing stability (100,000 W)		329	JIS K 2220 15
Low temperature torque: N-m (-20℃)	Start	0.22	JIS K 2220 18
	(revolutions)	0.04	
Apparent viscosity: Pa•s (-10℃, $10S^{-1}$)		3400	JIS K 2220 19
Timken load capacity: N		88.2	JIS K 2220 20
4-ball testing (burn-in load): N		3089	ASTM D2596
Fretting resistance: mg		3.8	ASTM D4170 compliant
Bearing rust prevention: (52℃, 48h)		#1	ASTM D1743-73
Service Temperature Limit (℃)		−40 to 120	—

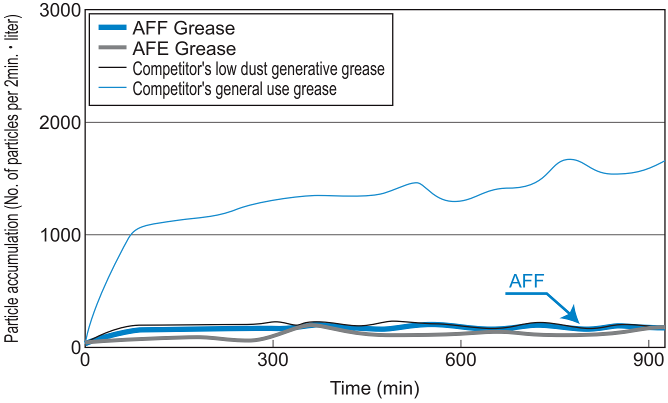
[Test Data on Low Dust Generative Characteristics]

● Test Data on AFF Grease (Comparison of Particle Accumulation)

The test data in the figure shows the result of comparing particle accumulation between AFF Grease with another grease.

<Test conditions>

Item	Description
Model No.	SR20W1+280LP
Grease quantity	1cm³/ LM block (initial lubrication only)
Amount of air supplied	500cm³/min
[Measurement instrument]	Particle counter
Diameter of particle measured	0.3μm or more
Feeding speed	30m/min
Stroke	200mm



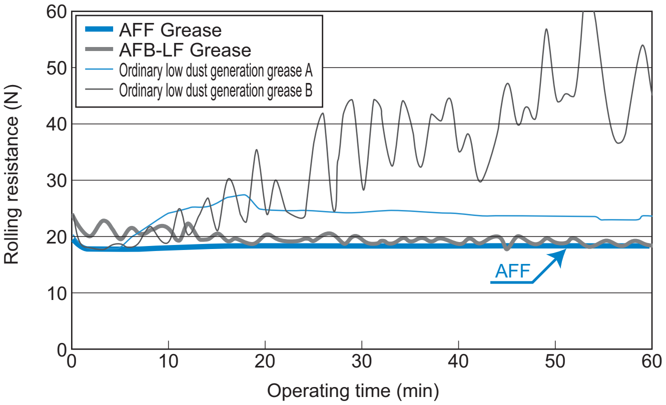
[Rolling Resistance Characteristics at Low Speed]

● Rolling Resistance at Low Speed

The data in the figure represent the test results of comparing rolling resistances at low speed between AFF Grease and other greases.

<Test conditions>

Item	Description
Model No.	HSR35RC0+440LP
Grease quantity	4cm³/ LM block (initial lubrication only)
Feeding speed	1mm/s
Stroke	3mm



THK Original Grease

AFG Grease

- Base oil: high-grade synthetic oil
- Consistency enhancer: urea-based

AFG Grease is a high-grade grease for Ball Screws that uses a high-grade synthetic oil as the base oil and a urea-based consistency enhancer. It excels in low heat generation and supports a wide temperature range from low to high temperature.

[Features]

(1) Low heat generation
Since the viscous resistance is low, the grease generates only a minimal level of heat even during high-speed operation.

(2) Low viscosity
Since the viscosity is low, a stable rotational torque is achieved.

(3) Wide temperature range
Maintains a high level of lubricity in a wide temperature range of -45℃ to +160℃.

(4) Long service life
AFG Grease is not easily softened and excels in antioxidation stability even after a long-term operation.

(5) Water resistance
AFG Grease is a highly water resistant grease that is less vulnerable to moisture penetration and little decreases resistance to extreme pressure.

[Representative Physical Properties]

Test item		Representative value	Test method
Worked penetration (25℃, 60W)		285	JIS K 2220 5.3
Dropping point: ℃		261	JIS K 2220 5.4
Copper plate corrosion (100℃, 24h)		Accepted	JIS K 2220 5.5
Evaporation amount: mass% (99℃, 22h)		0.2	JIS K 2220 5.6
Oil separation rate: mass% (100℃, 24h)		0.5	JIS K 2220 5.7
Stability of oxidation: MPa (99℃, 100h)		0.029	JIS K 2220 5.8
Mixing stability (100,000 W)		329	JIS K 2220 5.11
Grease removal resistance during water rinse: mass% (38℃, 1h)		0.6	JIS K 2220 5.12
Low temperature torque: N-m (-20℃)	Start	0.439	JIS K 2220 5.14
	(revolutions)	0.049	
Anticorrosive test: (52℃, 48h)		1,1,1	ASTM D1743
Service Temperature Range (℃)		−45 to 160	—

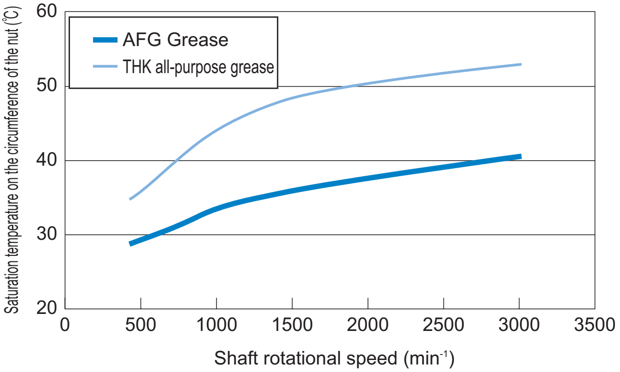
[Test Data on Low Heat Generation Characteristics]

● Test Data on AFG Grease (Comparison of Heat Generation)

The test data in the figure represent the results of comparing heat generation between AFG Grease and other greases.

<Test conditions>

Item	Description
Shaft diameter/lead	32/10mm
Feeding speed	67 to 500mm/s
Shaft rotation speed	400 to 3000 min^{-1}
Stroke	400mm
Grease quantity	12cm^3
Temperature measurement point	Nut circumference



Lubrication Equipment

Grease Gun Unit MG70

●For detailed dimensions, see B-864.

Grease Gun Unit MG70 is capable of lubricating small to large types of LM Guides by replacing dedicated nozzles (attached). For small LM Guides, MG70 is provided with dedicated attachments. The user can select from these attachments according to the model number and the installation space. MG70 has a slit window, allowing the user to check the remaining amount of grease.
It is equipped with a bellows cartridge that can hold 70 g of grease and is replaceable without smirching your hand. It supports a wide range of grease products, including AFA Grease, AFB-LF Grease, AFC Grease and AFE-CA Grease, to meet varied conditions. This enables you to make a selection according to the area requiring grease. (See A-959 to A-969.)
Since the grease to be used is sold separately, you must purchase it separately.

Accessories for Lubrication

Special Plumbing Fixtures

●For detailed dimensions, see B-865.

For centralized greasing and oil lubrication, special plumbing fixtures are available from THK. When ordering an LM system, specify the model number, mounting orientation and piping direction. We will ship the LM system attached with the corresponding fixture.

Accessories for Lubrication

Grease Nipple

●For detailed dimensions, see B-866.

THK provides various types of grease nipples needed for the lubrication of LM systems.

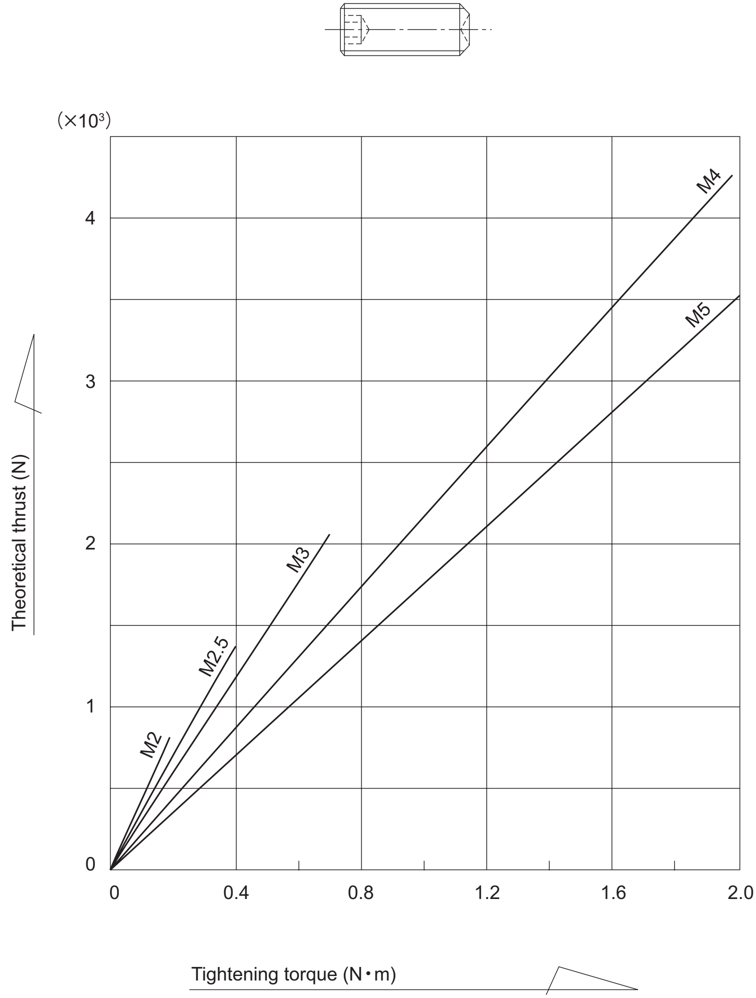
Appendix

THK General Catalog

Appendix Tables

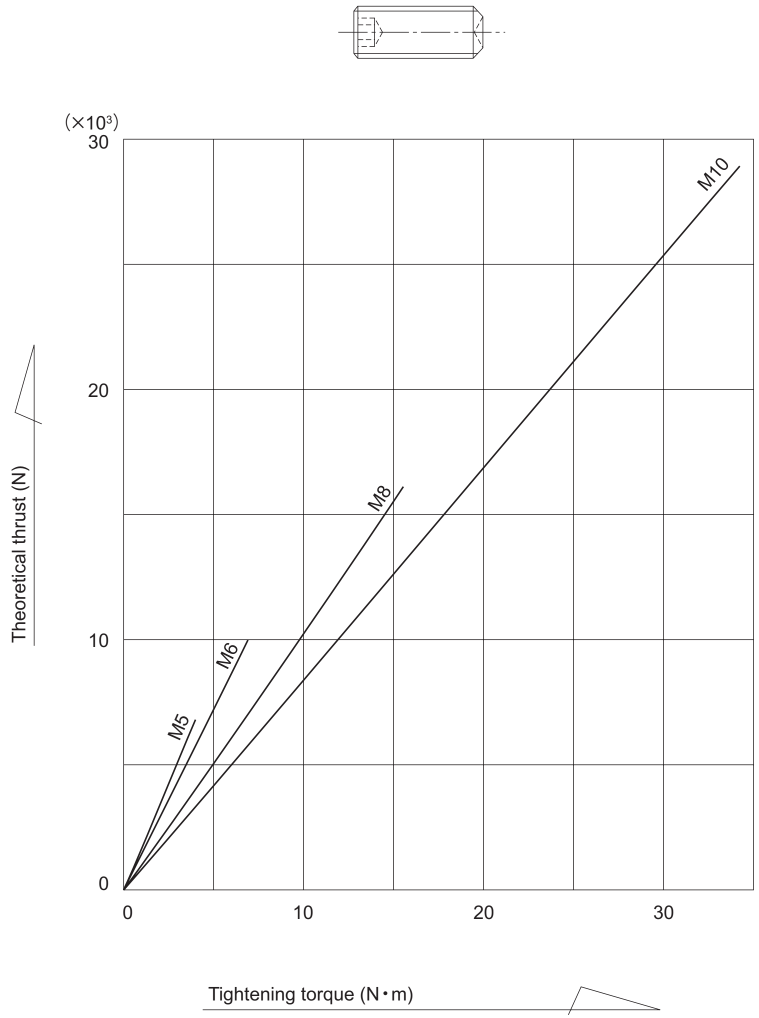
Tightening Torques and Theoretical Thrusts for Hexagonal Socket-head Setscrew

[M2 to M5, Cut-point]



Note) The theoretical thrust may vary depending on the lubrication and the conditions of the surfaces of the setscrew or the reference surface (μ = 0.13).

[M5 to M10, Cut-point]



Note) The theoretical thrust may vary depending on the lubrication and the conditions of the surfaces of the setscrew or the reference surface (μ = 0.13).

Dimensional Tolerances of the Shafts

Dimension classification (mm)		e	f		g		h						js		
Above	Or less	e6	f5	f6	g5	g6	h5	h6	h7	h8	h9	h10	js5	js6	js7
3	6	−20 −28	−10 −15	−10 −18	−4 −9	−4 −12	0 −5	0 −8	0 −12	0 −18	0 −30	0 −48	±2.5	±4	±6
6	10	−25 −34	−13 −19	−13 −22	−5 −11	−5 −14	0 −6	0 −9	0 −15	0 −22	0 −36	0 −58	±3	±4.5	±7.5
10	14	−32 −43	−16 −24	−16 −27	−6 −14	−6 −17	0 −8	0 −11	0 −18	0 −27	0 −43	0 −70	±4	±5.5	±9
14	18														
18	24	−40 −53	−20 −29	−20 −33	−7 −16	−7 −20	0 −9	0 −13	0 −21	0 −33	0 −52	0 −84	±4.5	±6.5	±10.5
24	30														
30	40	−50 −66	−25 −36	−25 −41	−9 −20	−9 −25	0 −11	0 −16	0 −25	0 −39	0 −62	0 −100	±5.5	±8	±12.5
40	50														
50	65	−60 −79	−30 −43	−30 −49	−10 −23	−10 −29	0 −13	0 −19	0 −30	0 −46	0 −74	0 −120	±6.5	±9.5	±15
65	80														
80	100	−72 −94	−36 −51	−36 −58	−12 −27	−12 −34	0 −15	0 −22	0 −35	0 −54	0 −87	0 −140	±7.5	±11	±17.5
100	120														
120	140	−85 −110	−43 −61	−43 −68	−14 −32	−14 −39	0 −18	0 −25	0 −40	0 −63	0 −100	0 −160	±9	±12.5	±20
140	160														
160	180														
180	200	−100 −129	−50 −70	−50 −79	−15 −35	−15 −44	0 −20	0 −29	0 −46	0 −72	0 −115	0 −185	±10	±14.5	±23
200	225														
225	250														
250	280	−110 −142	−56 −79	−56 −88	−17 −40	−17 −49	0 −23	0 −32	0 −52	0 −81	0 −130	0 −210	±11.5	±16	±26
280	315														
315	355	−125 −161	−62 −87	−62 −98	−18 −43	−18 −54	0 −25	0 −36	0 −57	0 −89	0 −140	0 −230	±12.5	±18	±28.5
355	400														
400	450	−135 −175	−68 −95	−68 −108	−20 −47	−20 −60	0 −27	0 −40	0 −63	0 −97	0 −155	0 −250	±13.5	±20	±31.5
450	500														
500	560	−145 −189	−76 −106	−76 −120	−22 −52	−22 −66	0 −30	0 −44	0 −70	0 −110	0 −175	0 −280	±15	±22	±35
560	630														
630	710	−160 −210	−80 −115	−80 −130	−24 −59	−24 −74	0 −35	0 −50	0 −80	0 −125	0 −200	0 −320	±17.5	±25	±40
710	800														
800	900	−170 −226	−86 −126	−86 −142	−26 −66	−26 −82	0 −40	0 −56	0 −90	0 −140	0 −230	0 −360	±20	±28	±45
900	1000														
1000	1120	−195 −261	−98 −144	−98 −164	−28 −74	−28 −94	0 −46	0 −66	0 −105	0 −165	0 −260	0 −420	±23	±33	±52.5
1120	1250														
1250	1400	−220 −298	−110 −164	−110 −188	−30 −84	−30 −108	0 −54	0 −78	0 −125	0 −195	0 −310	0 −500	±27	±39	±62.5
1400	1600														

dammy

Unit: µm=0.001mm

j		k			m		n		p		Dimension classification (mm)	
j5	j6	k5	k6	k7	m5	m6	n5	n6	p5	p6	Above	Or less
+3 −2	+6 −2	+6 +1	+9 +1	+13 +1	+9 +4	+12 +4	+13 +8	+16 +8	+17 +12	+20 +12	3	6
+4 −2	+7 −2	+7 +1	+10 +1	+16 +1	+12 +6	+15 +6	+16 +10	+19 +10	+21 +15	+24 +15	6	10
+5 −3	+8 −3	+9 +1	+12 +1	+19 +1	+15 +7	+18 +7	+20 +12	+23 +12	+26 +18	+29 +18	10	14
											14	18
+5 −4	+9 −4	+11 +2	+15 +2	+23 +2	+17 +8	+21 +8	+24 +15	+28 +15	+31 +22	+35 +22	18	24
											24	30
+6 −5	+11 −5	+13 +2	+18 +2	+27 +2	+20 +9	+25 +9	+28 +17	+33 +17	+37 +26	+42 +26	30	40
											40	50
+6 −7	+12 −7	+15 +2	+21 +2	+32 +2	+24 +11	+30 +11	+33 +20	+39 +20	+45 +32	+51 +32	50	65
											65	80
+6 −9	+13 −9	+18 +3	+25 +3	+38 +3	+28 +13	+35 +13	+38 +23	+45 +23	+52 +37	+59 +37	80	100
											100	120
+7 −11	+14 −11	+21 +3	+28 +3	+43 +3	+33 +15	+40 +15	+45 +27	+52 +27	+61 +43	+68 +43	120	140
											140	160
											160	180
+7 −13	+16 −13	+24 +4	+33 +4	+50 +4	+37 +17	+46 +17	+51 +31	+60 +31	+70 +50	+79 +50	180	200
											200	225
											225	250
+7 −16	+16 −16	+27 +4	+36 +4	+56 +4	+43 +20	+52 +20	+57 +34	+66 +34	+79 +56	+88 +56	250	280
											280	315
+7 −18	+18 −18	+29 +4	+40 +4	+61 +4	+46 +21	+57 +21	+62 +37	+73 +37	+87 +62	+98 +62	315	355
											355	400
+7 −20	+20 −20	+32 +5	+45 +5	+68 +5	+50 +23	+63 +23	+67 +40	+80 +40	+95 +68	+108 +68	400	450
											450	500
—	—	+30 0	+44 0	+70 0	+56 +26	+70 +26	+74 +44	+88 +44	+108 +78	+122 +78	500	560
											560	630
—	—	+35 0	+50 0	+80 0	+65 +30	+80 +30	+85 +50	+100 +50	+123 +88	+138 +88	630	710
											710	800
—	—	+40 0	+56 0	+90 0	+74 +34	+90 +34	+96 +56	+112 +56	+140 +100	+156 +100	800	900
											900	1000
—	—	+46 0	+66 0	+105 0	+86 +40	+106 +40	+112 +66	+132 +66	+166 +120	+186 +120	1000	1120
											1120	1250
—	—	+54 0	+78 0	+125 0	+102 +48	+126 +48	+132 +78	+156 +78	+194 +140	+218 +140	1250	1400
											1400	1600

Dimensional Tolerances of Housing Holes

Dimension classification (mm)		E		F			G		H					
Above	Or less	E6	E7	F6	F7	F8	G6	G7	H5	H6	H7	H8	H9	H10
3	6	+28 +20	+32 +20	+18 +10	+22 +10	+28 +10	+12 +4	+16 +4	+5 0	+8 0	+12 0	+18 0	+30 0	+48 0
6	10	+34 +25	+40 +25	+22 +13	+28 +13	+35 +13	+14 +5	+20 +5	+6 0	+9 0	+15 0	+22 0	+36 0	+58 0
10	14	+43 +32	+50 +32	+27 +16	+34 +16	+48 +16	+17 +6	+24 +6	+8 0	+11 0	+18 0	+27 0	+43 0	+70 0
14	18													
18	24	+53 +40	+61 +40	+33 +20	+41 +20	+53 +20	+20 +7	+28 +7	+9 0	+13 0	+21 0	+33 0	+52 0	+84 0
24	30													
30	40	+66 +50	+75 +50	+41 +25	+50 +25	+64 +25	+25 +9	+34 +9	+11 0	+16 0	+25 0	+39 0	+62 0	+100 0
40	50													
50	65	+79 +60	+90 +60	+49 +30	+60 +30	+76 +30	+29 +10	+40 +10	+13 0	+19 0	+30 0	+46 0	+74 0	+120 0
65	80													
80	100	+94 +72	+107 +72	+58 +36	+71 +36	+90 +36	+34 +12	+47 +12	+15 0	+22 0	+35 0	+54 0	+87 0	+140 0
100	120													
120	140	+110 +85	+125 +85	+68 +43	+83 +43	+106 +43	+39 +14	+54 +14	+18 0	+25 0	+40 0	+63 0	+100 0	+160 0
140	160													
160	180													
180	200	+129 +100	+146 +100	+79 +50	+96 +50	+122 +50	+44 +15	+61 +15	+20 0	+29 0	+46 0	+72 0	+115 0	+185 0
200	225													
225	250													
250	280	+142 +110	+162 +110	+88 +56	+108 +56	+137 +56	+49 +17	+69 +17	+23 0	+32 0	+52 0	+81 0	+130 0	+210 0
280	315													
315	355	+161 +125	+182 +125	+98 +62	+119 +62	+151 +62	+54 +18	+75 +18	+25 0	+36 0	+57 0	+89 0	+140 0	+230 0
355	400													
400	450	+175 +135	+198 +135	+108 +68	+131 +68	+165 +68	+60 +20	+83 +20	+27 0	+40 0	+63 0	+97 0	+155 0	+250 0
450	500													
500	560	+189 +145	+215 +145	+120 +76	+146 +76	+186 +76	+66 +22	+92 +22	+30 0	+44 0	+70 0	+110 0	+175 0	+280 0
560	630													
630	710	+210 +160	+240 +160	+130 +80	+160 +80	+205 +80	+74 +24	+104 +24	+35 0	+50 0	+80 0	+125 0	+200 0	+320 0
710	800													
800	900	+226 +170	+260 +170	+142 +86	+176 +86	+226 +86	+82 +26	+116 +26	+40 0	+56 0	+90 0	+140 0	+230 0	+360 0
900	1000													
1000	1120	+261 +195	+300 +195	+164 +98	+203 +98	+263 +98	+94 +28	+133 +28	+46 0	+66 0	+105 0	+165 0	+260 0	+420 0
1120	1250													
1250	1400	+298 +220	+345 +220	+188 +110	+235 +110	+305 +110	+108 +30	+155 +30	+54 0	+78 0	+125 0	+195 0	+310 0	+500 0
1400	1600													

Unit: μm=0.001mm

Js		J		K		M		N		P		Dimension classification (mm)	
Js6	Js7	J6	J7	K6	K7	M6	M7	N6	N7	P6	P7	Above	Or less
±4	±6	+5 −3	+6 −6	+2 −6	+3 −9	−1 −9	0 −12	−5 −13	−4 −16	−9 −17	−8 −20	3	6
±4.5	±7.5	+5 −4	+8 −7	+2 −7	+5 −10	−3 −12	0 −15	−7 −16	−4 −19	−12 −21	−9 −24	6	10
±5.5	±9	+6 −5	+10 −8	+2 −9	+6 −12	−4 −15	0 −18	−9 −20	−5 −23	−15 −26	−11 −29	10	14
												14	18
±6.5	±10.5	+8 −5	+12 −9	+2 −11	+6 −15	−4 −17	0 −21	−11 −24	−7 −28	−18 −31	−14 −35	18	24
												24	30
±8	±12.5	+10 −6	+14 −11	+3 −13	+7 −18	−4 −20	0 −25	−12 −28	−8 −33	−21 −37	−17 −42	30	40
												40	50
±9.5	±15	+13 −6	+18 −12	+4 −15	+9 −21	−5 −24	0 −30	−14 −33	−9 −39	−26 −45	−21 −51	50	65
												65	80
±11	±17.5	+16 −6	+22 −13	+4 −18	+10 −25	−6 −28	0 −35	−16 −38	−10 −45	−30 −52	−24 −59	80	100
												100	120
±12.5	±20	+18 −7	+26 −14	+4 −21	+12 −28	−8 −33	0 −40	−20 −45	−12 −52	−36 −61	−28 −68	120	140
												140	160
												160	180
±14.5	±23	+22 −7	+30 −16	+5 −24	+13 −33	−8 −37	0 −46	−22 −51	−14 −60	−41 −70	−33 −79	180	200
												200	225
												225	250
±16	±26	+25 −7	+36 −16	+5 −27	+16 −36	−9 −41	0 −52	−25 −57	−14 −66	−47 −79	−36 −88	250	280
												280	315
±18	±28.5	+29 −7	+39 −18	+7 −29	+17 −40	−10 −46	0 −57	−26 −62	−16 −73	−51 −87	−41 −98	315	355
												355	400
±20	±31.5	+33 −7	+43 −20	+8 −32	+18 −45	−10 −50	0 −63	−27 −67	−17 −80	−55 −95	−45 −108	400	450
												450	500
±22	±35	—	—	—	—	−26 −70	−26 −96	−44 −88	−44 −114	−78 −122	−78 −148	500	560
												560	630
±25	±40	—	—	—	—	−30 −80	−30 −110	−50 −100	−50 −130	−88 −138	−88 −168	630	710
												710	800
±28	±45	—	—	—	—	−34 −90	−34 −124	−56 −112	−56 −146	−100 −156	−100 −190	800	900
												900	1000
±33	±52.5	—	—	—	—	−40 −106	−40 −145	−66 −132	−66 −171	−120 −186	−120 −225	1000	1120
												1120	1250
±39	±62.5	—	—	—	—	−48 −126	−48 −173	−78 −156	−78 −203	−140 −218	−140 −265	1250	1400
												1400	1600

SI Unit Conversion Table

[Conversion to SI Units]

Amount	Name of unit	Symbol	Factor of conversion to SI	Name of SI unit	Symbol
Angle	Degree Minute Second	° ′ ″	$\pi/180$ $\pi/10800$ $\pi/648000$	Radian	rad
Length	Meter Angstrom X-ray unit Nautical mile	m Å n mile	1 10^{-10} $\approx 1.00208 \times 10^{-13}$ 1852	Meter	m
Area	Square meter Are Hectare	m^2 a ha	1 10^2 10^4	Square meter	m^2
Volume	Cubic meter Liter	m^3 ℓ (L)	1 10^{-3}	Cubic meter	m^3
Mass	Kilogram Ton Atomic-mass unit	kg t u	1 10^3 $\approx 1.66057 \times 10^{-27}$	Kilogram	kg
Time	Second Minute Hour Day	s min h d	1 60 3600 86400	Second	S
Speed	Meter per second Knot	m/s kn	1 1852/3600	Meter per second	m/s
Frequency	cycle	s^{-1}	1	Hertz	Hz
Rotational speed	Revolution per minute	rpm	1	Per minute	min^{-1}
Angular velocity	Radian per minute	rad/s	1	Radian per minute	rad/s
Acceleration	Meter per second per second G	m/s^2 G	1 9.80665	Meter per second per second	m/s^2
Force	Weight kilogram Weight ton Dyne	kgf tf dyn	9.80665 9806.65 10^{-5}	Newton	N
Moment of force	Weight kilogram meter	kgf-m	9.80665	Newton meter	N-m
Stress and pressure	Weight kilogram per square meter Weight kilogram per square centimeter Weight kilogram per square millimeter	kgf/m^2 kgf/cm^2 kgf/mm^2	9.80665 9.80665×10^4 9.80665×10^6	Pascal	Pa
Pressure	Water column meter Mercury column meter Torr Atmosphere Bar	mH_2O mmHg Torr atm bar	9806.65 101325/760 101325/760 101325 10^5	Pascal	Pa
Energy	Erg IT calorie Weight kilogram meter Kilowatt hour Metric Horsepower hour Electron volt	erg cal_{IT} kgf-m kW・h PS・h eV	10^{-7} 4.1868 9.80665 3.600×10^6 $\approx 2.64779 \times 10^6$ $\approx 1.60219 \times 10^{-19}$	Joule	J
Power	Watt Metric Horsepower Kilogram force-meter	W PS kgf-m/s	1 ≈ 735.5 9.80665	Watt	W

dammy

Amount	Name of unit	Symbol	Factor of conversion to SI	Name of SI unit	Symbol
Viscosity	Poise	P	10^{-1}	Pascal second	Pa-s
	Centipoise	cP	10^{-3}		
	Kilogram force-second per square meter	kgf-s/m^{2}	9.80665		
Kinematic viscosity	Stokes	St	10^{-1}	Square meter per second	m^{2}/s
	Centistokes	cSt	10^{-6}		
Temperature	Degree	℃	+273.15	Kelvin	K
Radioactivity	Curie	Ci	3.7×10^{10}	Becquerel	Bq
Dose	Roentgen	R	2.58×10^{-4}	Coulomb per kilogram	C/kg
Absorbed dose	Rad	rad	10^{-2}	Gray	Gy
Equivalent dose	Rem	rem	10^{-2}	Sievert	Sv
Magnetic flux	Maxwell	Mx	10^{-8}	Weber	Wb
Magnetic flux density	Gamma	γ	10^{-9}	Tesla	T
	Gauss	Gs	10^{-4}		
Magnetic-field intensity	Oersted	Oe	$10^{3}/4\pi$	Ampere per meter	A/m
Quantity of electricity	Coulomb	C	1	Coulomb	C
Voltage potentialdifference	bolt	V	1	bolt	V
Electrostatic capacity	Farad	F	1	Farad	F
(Electric) resistance	Ohm	Ω	1	Ohm	Ω
(Electric) conductance	Siemens	S	1	Siemens	S
Inductance	Henry	H	1	Henry	H
Current	Ampere	A	1	Ampere	A

[Comparative Table of SI, CGS System and Gravitational System Units]

Amount	Length	Mass	Time	Acceleration	Force	Stress	Pressure	Energy
Unit system	L	M	T					
SI CGS system Gravitational system	m cm m	kg g kgf-s^2/m	s s s	m/s^2 Gal m/s^2	N dyn kgf	Pa dyn/cm^2 kgf/m^2	Pa dyn/cm^2 kgf/m^2	J erg kgf-cm

Amount	Power	Temperature	Viscosity	Kinematic viscosity	Magnetic flux	Magnetic flux density	Magnetic-field intensity
Unit system							
SI CGS system Gravitational system	W erg/s kgf-m/s	K ℃ ℃	Pa-s P kgf-s/m^2	m^2/s St m^2/s	Wb Mx —	T Gs —	A/m Oe —

[Integer Multipliers of 10 of SI Units]

Number of digits multiplied to unit	Prefix		Number of digits multiplied to unit	Prefix	
	Name	Symbol		Name	Symbol
10^{18}	Exa	E	10^{-1}	Deci	d
10^{15}	Peta	P	10^{-2}	Centi	c
10^{12}	Tera	T	10^{-3}	Milli	m
10^{9}	Giga	G	10^{-6}	Micro	μ
10^{6}	Mega	M	10^{-9}	Nano	n
10^{3}	Kilo	k	10^{-12}	Pico	p
10^{2}	Hecto	h	10^{-15}	Femto	f
10	Deca	da	10^{-18}	Atto	a

[Hardness Conversion Table]

Rockwell	Vickers hardness	Brinell hardness HB		Rockwell hardness		Shore hardness
C-scale hardness HRC (load: 1471 N)	Hardness HV	Standard ball	Tungsten carbide ball	HRA A scale Load: 588.4N Brale indenter	HRB B scale Load: 980.7N Ball with diam of 1/16 in.	Hardness HS
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

Rockwell	Vickers hardness	Brinell hardness HB		Rockwell hardness		Shore hardness
C-scale hardness HRC (load: 1471 N)	Hardness HV	Standard ball	Tungsten carbide ball	HRA A scale Load: 588.4N Brale indenter	HRB B scale Load: 980.7N Ball with diam of 1/16 in.	Hardness HS
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	73.1	—	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

THK General Catalog

Index of Model Numbers

T H K CO., LTD.

Head Office 3-11-6 Nishi-Gotanda, Shinagawa-ku, Tokyo 141-8503 JAPAN
International Sales Department Phone:+81-3-5434-0351 Fax:+81-3-5434-0353

NORTH AMERICA

THK America, Inc.

HEADQUARTERS
200 East Commerce Drive, Schaumburg, IL. 60173, U.S.A.
Phone:+1-847-310-1111 Fax:+1-847-310-1271

CHICAGO OFFICE
200 East Commerce Drive, Schaumburg, IL. 60173, U.S.A.
Phone:+1-847-310-1111 Fax:+1-847-310-1182

NEW YORK OFFICE
400 Rella BLVD, Suite 208, Montebello, NY. 10901, U.S.A.
Phone:+1-845-369-4035 Fax:+1-845-369-4909

ATLANTA OFFICE
3000 Northwoods Parkway, Suite 200, Norcross, GA 30071-1525,U.S.A.
Phone:+1-770-840-7990 Fax:+1-770-840-7897

LOS ANGELES OFFICE
34 Executive Park, Suite 215 Irvine, CA. 92614, U.S.A.
Phone:+1-949-955-3145 Fax:+1-949-955-3149

SAN FRANCISCO OFFICE
4603-E Las Positas RD. Livermore, CA. 94551, U.S.A.
Phone:+1-925-455-8948 Fax:+1-925-455-8965

BOSTON OFFICE
480 Neponset St. #10B, Canton, MA. 02021, U.S.A.
Phone:+1-781-575-1151 Fax:+1-781-575-9295

DETROIT OFFICE
2600 South Telegraph Road, Suite 190 Bloomfield Hills, MI. 48302, U.S.A.
Phone:+1-248-858-9330 Fax:+1-248-858-9455

TORONTO OFFICE
3600B Laird Road, Unit #10 Mississauga, ONT Canada L5L 6A7
Phone:+1-905-820-7800 Fax:+1-905-820-7811

SOUTH AMERICA

THK Brasil LTDA
Av. Corifeu de Azevedo Marques,4.077 Butanta-Sao Paulo-Sao Paulo Brazil
05339-002
Phone:+55-11-3767-0100 Fax:+55-11-3767-0101

CHINA

THK (CHINA) CO., LTD.

HEADQUARTERS
No.41 Dalian Economic & Technical Development Zone,
Liaoning Province 116600, China
Phone:+86-411-8733-7111 Fax:+86-411-8733-7000

SHANGHAI OFFICE
1002 Kirin Plaza, 666 Gubei Road, Shanghai 200336, China
Phone:+86-21-6219-3000 Fax:+86-21-6219-9890

BEIJING OFFICE
2 Xin Yuan nan Road, Chaoyang District, Beijing 100004,
China KUNLUN HOTEL, Room No,417, China
Phone:+86-10-6590-3259 Fax:+86-10-6590-3557

CHENGDU OFFICE
Room No.2002 Western Tower No.19, Sec4,
Renmin nan Rd Chengdu 610041, China
Phone:+86-28-8525-2356 Fax:+86-28-8525-6357

GUANGZHOU OFFICE
Room No,A625 Landmark Canton Hotel, No 8,
Qiao Guang Rd, Guangzhou 510000, China
Phone:+86-20-8333-9770 Fax:+86-20-8333-9726

THK (SHANGHAI) CO., LTD.
1003-A Kirin Plaza, 666 Gubei Road, Shanghai 200336, China
Phone:+86-21-6725-5280 Fax:+86-21-6219-9890

TAIWAN

THK TAIWAN CO., LTD.

TAIPEI OFFICE
Suite A, 7Fl., No.152, Sec 4, Chengde Rd., Shrlin Chiu, Taipei, Taiwan 112, R.O.C.
Phone:+886-2-2888-3818 Fax:+886-2-2888-3819

TAICHUNG OFFICE
2, 35th Rd., Taichung Ind. Park, Taichung, Taiwan 40707, R.O.C.
Phone:+886-4-2359-1505 Fax:+886-4-2359-1506

SOUTHERN OFFICE
6F. 2, NO.77, Sec.2, Jhonghua E.Rd., East District, Tainan city, 701 Taiwan R.O.C.
Phone:+886-6-289-7668 Fax:+886-6-289-7669

KOREA

SEOUL REPRESENTATIVE OFFICE
Geumgang Tower Bldg 16F.,889-13, Daechi-dong, Gangnam-gu, Seoul 135-280,
Korea
Phone:+82-2-3468-4351 Fax:+82-2-3468-4353

SINGAPORE

SINGAPORE REPRESENTATIVE OFFICE

INDIA

BANGALORE REPRESENTATIVE OFFICE
1050, 11th main R.P.C Layout Bangalore 560040, India
Phone:+91-080-2330-1524 Fax:+91-080-2330-1524

EUROPE

THK GmbH

EUROPEAN HEADQUARTERS
Hubert-Wollenberg-Strasse 13-15, D-40878 Ratingen, Germany
Phone:+49-2102-7425-0 Fax:+49-2102-7425-217

DÜSSELDORF OFFICE
Hubert-Wollenberg-Strasse 13-15, D-40878 Ratingen, Germany
Phone:+49-2102-7425-0 Fax:+49-2102-7425-299

STUTTGART OFFICE
Heinrich-Lanz-Strasse 3, D-70825 Korntal-Münchingen, Germany
Phone:+49-7150-9199-0 Fax:+49-7150-9199-888

MÜNCHEN OFFICE
Max-Planck-Strasse 13, D-85716 Unterschleissheim, Germany
Phone:+49-8937-0616-0 Fax:+49-8937-0616-26

U.K. OFFICE
1 Harrison Close Knowlhill Milton Keynes MK5 8PA
Phone:+44-1908-30-3050 Fax:+44-1908-30-3070

ITALY MILANO OFFICE
Via Buonarroti, 182, 20052 Monza (MI), Italy
Phone:+39-039-284-2079 Fax:+39-039-284-2527

ITALY BOLOGNA OFFICE
Via Della Salute, 16/2, 40132 Bologna(BO), Italy
Phone:+39-051-641-2211 Fax:+39-051-641-2230

SWEDEN OFFICE
Veddestavägen 15B, S-17562 Järfälla, Sweden
Phone:+46-8-445-7630 Fax:+46-8-445-7639

AUSTRIA OFFICE
Edelmüllerstrasse 2, A-4061 Pasching, Austria
Phone:+43-7229-51400 Fax:+43-7229-51400-79

SPAIN OFFICE
C/Andorra 19A, Sant Boi de Llobregat, 08830 Barcelona, Spain
Phone:+34-93-652-5740 Fax:+34-93-652-5746

TURKEY OFFICE
Huseyin Colak Street Nail Ergin Business Center No:7 Ground
Floor Apartment No:2 Kozyatagi Kadikoy / Istanbul, Turkey
Phone:+90-216-463-0047 Fax:+90-216-463-0042

THK France S. A. S.
Les carres du Parc 10 rue des Rosieristes Immeuble A 69410 Champagne
Mont D'or, France
Phone:+33-4-3749-1400 Fax:+33-4-3749-1401

AFRICA

THK GmbH

SOUTH AFRICA REPRESENTATIVE OFFICE
P.O.Box 13033 Witfield Johannesburg 1467, South Africa
Phone:+27-11-821-3666 Fax:+27-11-821-3661

PRODUCTION FACILITY

THK Manufacturing of America, Inc.
P.O.Box 759, 471 North High Street, Hebron, OH. 43025, U.S.A.
Phone:+1-740-928-1415 Fax:+1-740-928-1418

THK Manufacturing of Europe S. A. S.
Parc d'Activités la Passerelle, 68190 Ensisheim, France
Phone:+33-3-8983-4400 Fax:+33-3-8983-4409

PGM Ballscrews Ireland Ltd.
Tallaght Business Park, Whitestown, Industrial Estate, Tallaght, Dublin24, Ireland
Phone:+353-1-462-8101 Fax:+353-1-462-9080

DALIAN THK CO., LTD.
No.29 Huo Ju Road, Qi Xian Ling, Gan Jing Zi District, Dalian City,
Liao Ning Sheng, China 116023
Phone:+86-411-8479-0999 Fax:+86-411-8479-0111

THK MANUFACTURING OF CHINA (WUXI) CO., LTD.
No.19, Changjiang South Road, Wuxi, Jiangsu, 214028, China
Phone:+86-510-8534-4333 Fax:+86-510-8534-4666

THK MANUFACTURING OF CHINA(LIAONING) CO., LTD.
No.41, Dalian Economic & Technical Development Zone.
Liaoning Province. China
Phone:+86-411-8733-7333 Fax:+86-411-8733-7222

SAMICK THK CO., LTD.
1005, Weolam-dong, Dalseo-gu, Daegu, Korea
Phone:+82-53-665-7000 Fax:+82-53-581-8272

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20061211 Printed in Japan

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