Technical Reference

Smooth Silent Ecological

Caged Technology

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Caged Technology

Introduction

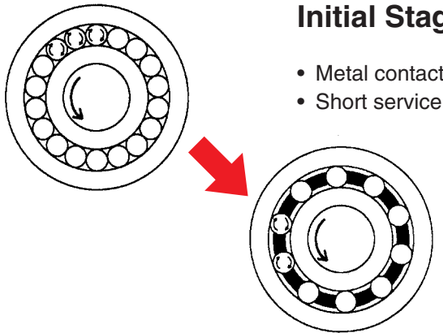
Since ball bearings in the initial stage of development were not provided with a cage, they produced high levels of noise, had a short service life and were unable to be used at high rotating speeds.

Later, ball bearings with cage were developed that exhibited low noise levels even at high rotating speeds.

In addition, these ball bearings with cage were able to demonstrate long service life despite the number of balls being fewer than packed ball types, and evolved significantly so that they were able to be used in a wide range of applications.

THK, the first manufacturer in the world to develop the LM Guide, has developed its LM Guide with Caged Ball Technology that is able to achieve a dramatic improvement in performance over conventional products. The LM Guide with Caged Ball Technology delivers a long service life and excellent high-speed performance in the same manner as roller bearings, while also eliminating maintenance for a long period of time.

Rotary Bearings



Initial Stage of Development (Full Ball Type)

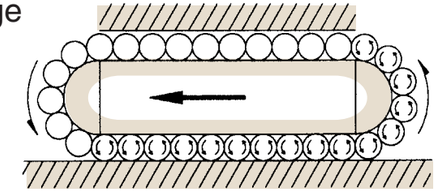
- Metal contact between balls caused a shortage of grease life.
- Short service life

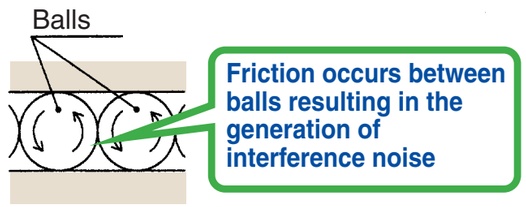
Current Bearings (with Cage)

- Grease is held by the cage for excellent lubrication.
- No metal contact between balls for extended service life.
- No metal contact between balls suppresses generation of heat.
- No metal contact between balls eliminates ball collision noise.
- Balls exhibit orderly movement for smooth operation.

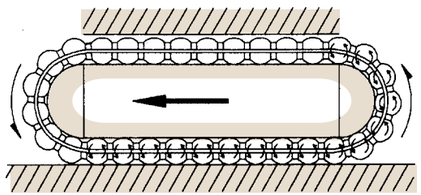
Case of the LM Guide

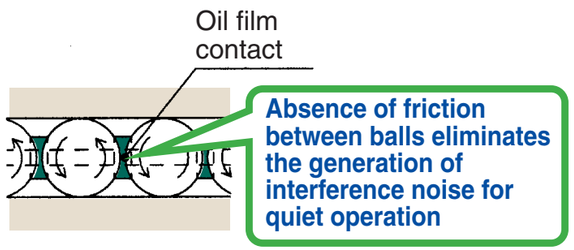
Without ball cage



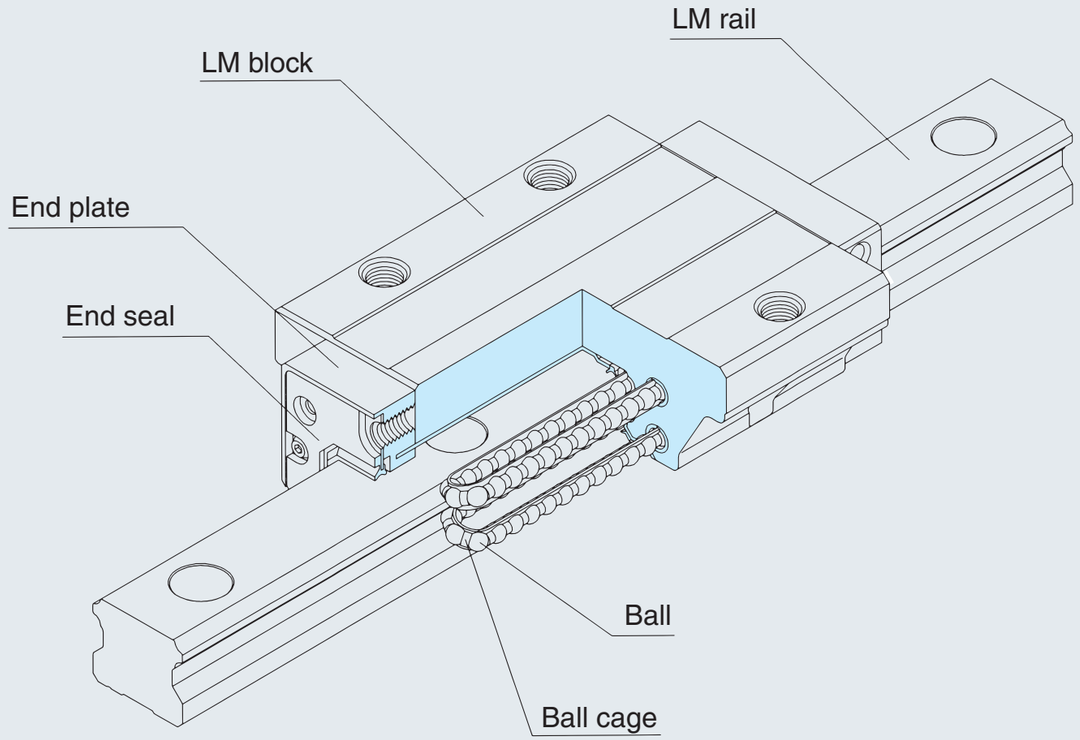


With ball cage





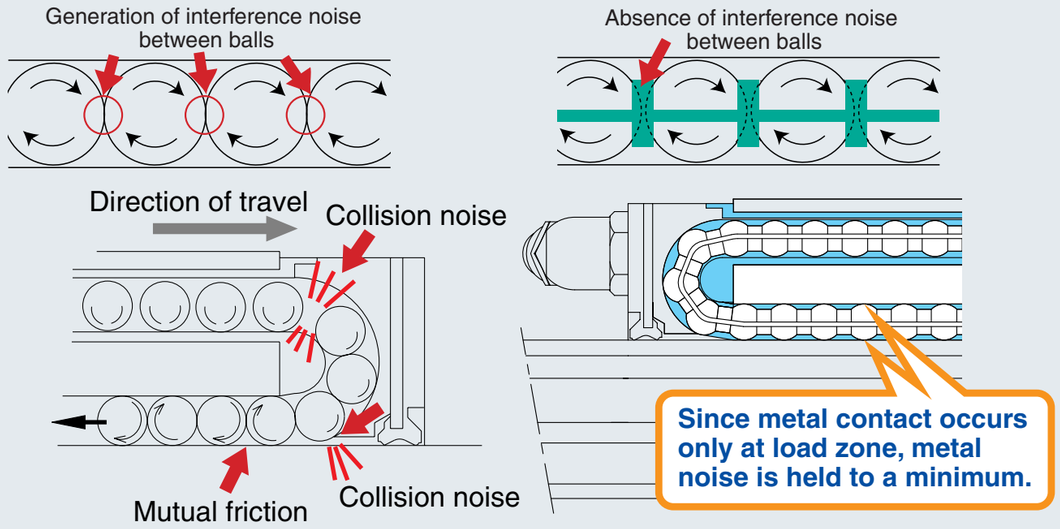
Structure of the LM Guide with Ball Cage



Advantage 1 of Caged Ball

Quiet Operation that Minimizes Metal Contact

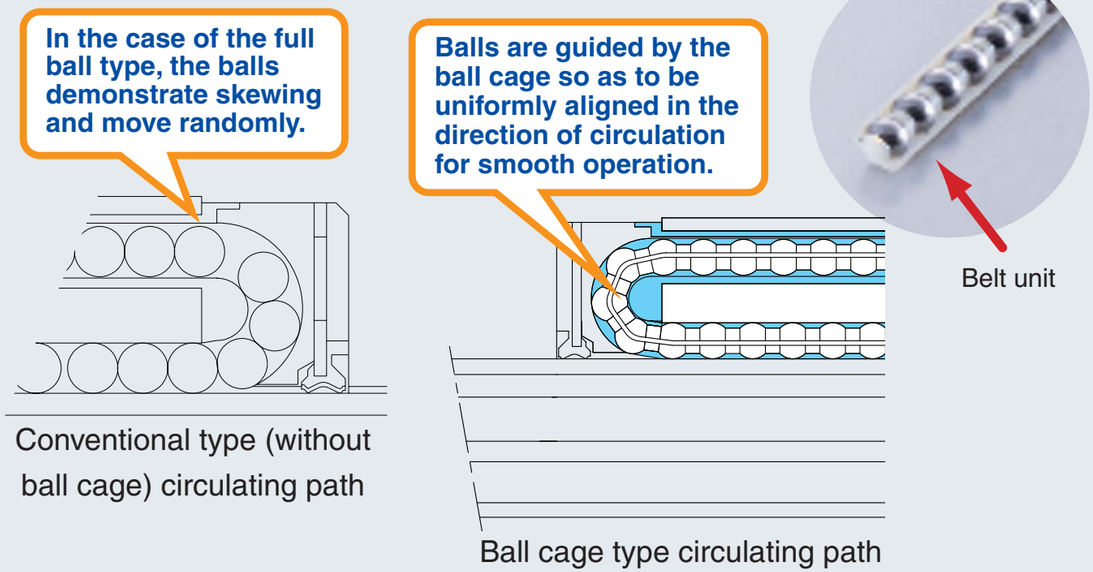
Interference noise between balls is eliminated by the ball cage resulting in quiet operation.



Advantage 2 of Caged Ball

Orderly Ball Movement

Since the balls are held by the ball cage in the form of a belt, they are aligned uniformly and move in a circulating manner. There is no skewing of the balls, while sudden variations in friction are also eliminated, allowing for stable movement.



Conventional type (without ball cage) circulating path

Ball cage type circulating path

Advantage 3 of Caged Ball

Original Cage Structure Exhibiting Excellent High-Speed Performance

The use of ball cages eliminates generation of heat caused by friction between balls resulting in excellent high-speed performance.

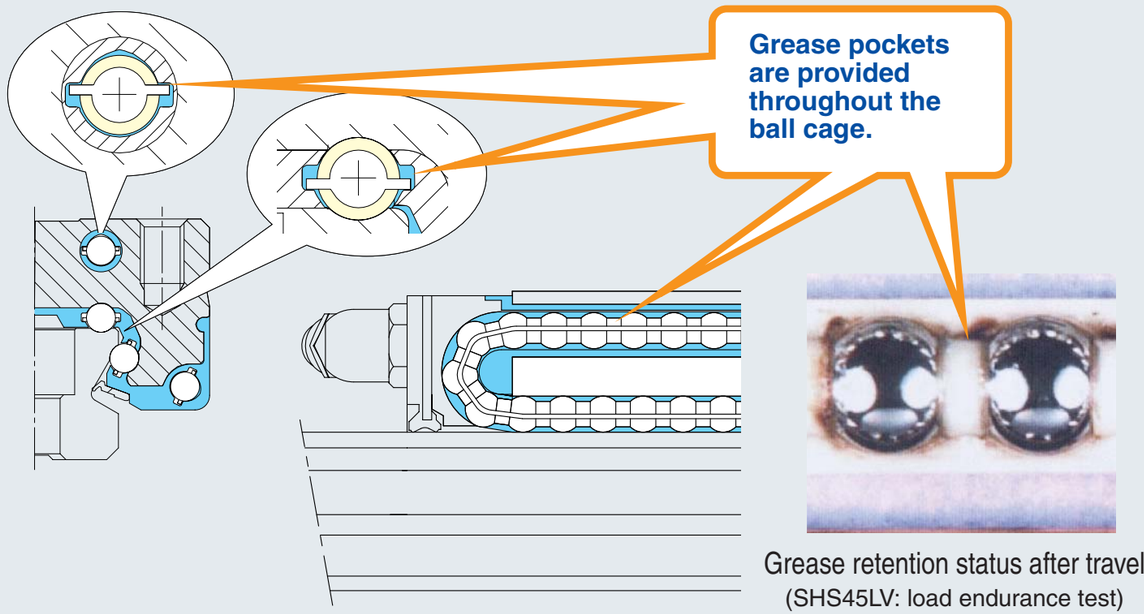
Contact state between balls and ball cage

State at turning sections

Advantage 4 of Caged Ball

Grease Holding Structure (Consecutive Grease Pockets) for Long-Term, Maintenance-Free Operation, Long Service Life

Grease pockets are provided consecutively over the entire ball circulating path to constantly lubricate the balls enabling long-term, maintenance-free operation, Long Service Life.



Grease retention status after travel
(SHS45LV: load endurance test)

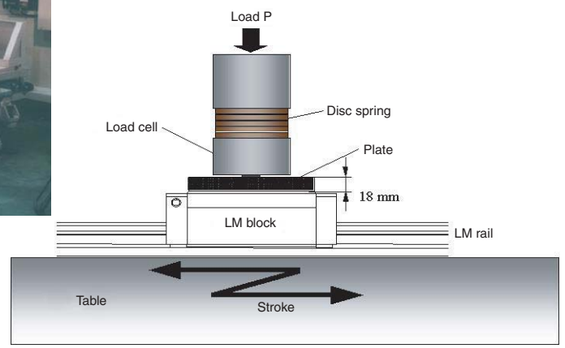
Data on LM Guide with Caged Ball

Improved Service Life

The Caged Ball not only allows the LM guide to be run for a long time period free of maintenance, but also significantly improves the service life of the system. As described below, a performed service life test has offered data about this improvement.

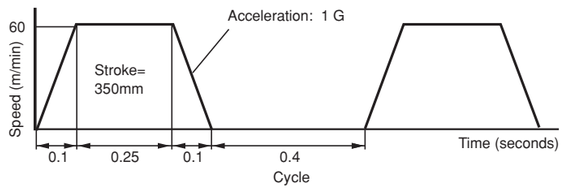
Service life test for LM Guide

1. Testing instrumentation

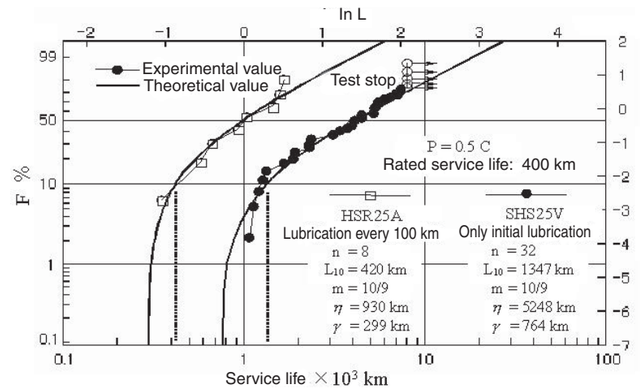


2. Testing parameters

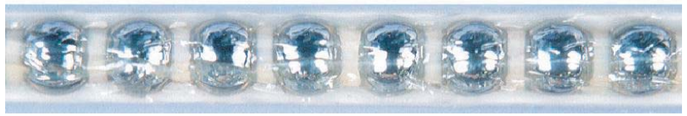
Model	:	SHS25V1SS+580LP
Number of pieces	:	32
Load	:	11.1 kN per LM block (0.35 C)
Surface pressure	:	2,664 MPa
Lubricant	:	Lithium soap base grease No. 2, Only initial lubrication



3. Test results



Status of Remaining Grease after the Durability Test



Ball cage before running

Ball cage after running 8,000 km
Nominal life: L_{10} = 400 km

5 mm

Remaining grease is observed in the ball cage.

The results of the performed test indicate that the dynamic durability values of the LM guide implemented by Caged Technology are higher than of the conventional LM guide.

Comparison in terms of dynamic durability values (C) and service life (L)

Calculation Example

LM guide with caged ball ·····Model SHS25L C=36.8 kN
LM guide without caged ball·····Model HSR25L C=27.2 kN
Under an applied load of P=13.6kN

LM guide with caged ball
Model SHS25L ····· $L=\left(\frac{C}{P}\right)^3\times 50=\left(\frac{36.8}{13.6}\right)^3\times 50=990\text{km}$

LM guide without caged bal
Model HSR25L ····· $L=\left(\frac{C}{P}\right)^3\times 50=\left(\frac{27.2}{13.6}\right)^3\times 50=400\text{km}$

● Comparison in terms of dynamic durability values ····· $\frac{36.8}{27.2}=1.3$

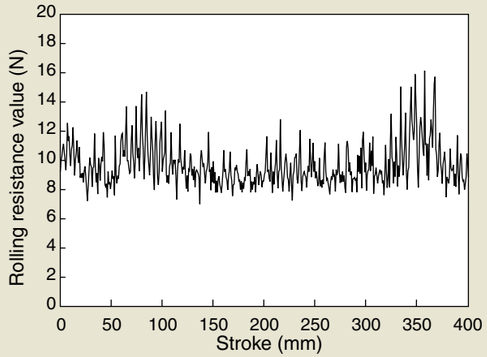
● Service life····· $\frac{990}{400}=2.4*$

*For details, see General catalog

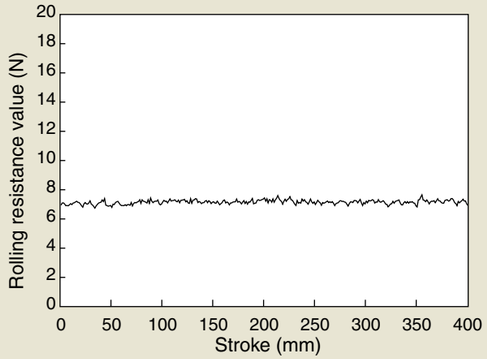
LM Guide with Caged Ball Technology

■Rolling Resistance Data

The use of a ball cage enables the balls to be uniformly aligned, eliminating snaking of the balls that occurs when they enter the block. As a result, smooth and stable movement can be obtained in all forms of installation, and fluctuations in rolling resistance are reduced for the realization of high accuracy.



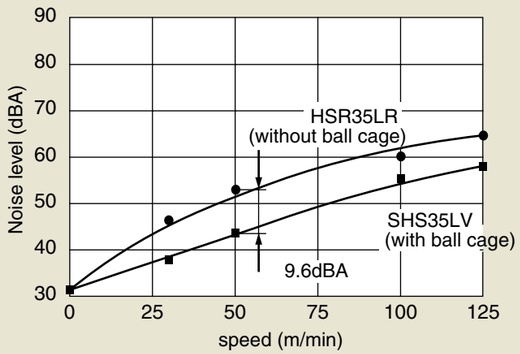
Results of Measuring Fluctuations in Rolling Resistance of HSR25LR (without ball cage)
(feeding speed: 10 mm/sec)



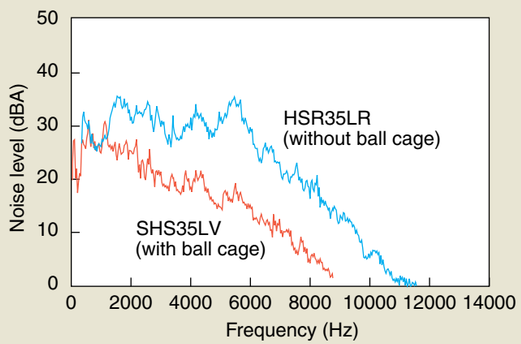
Results of Measuring Fluctuations in Rolling Resistance of SHS25LV (with ball cage)
(feeding speed: 10 mm/sec)

■Noise Level Data

The use of a ball cage eliminates interference between balls to realize low noise levels.



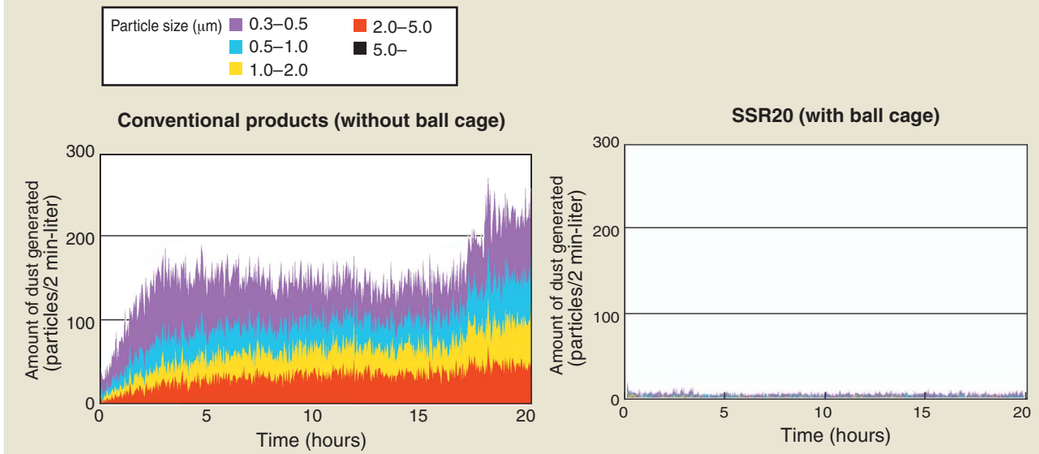
Comparison of Noise Levels
Between the SHS35LV and HSR35LR



Comparison of Noise Levels
Between the SHS35LV and HSR35LR
(speed: 50 m/min)

■Low Generation of Dust

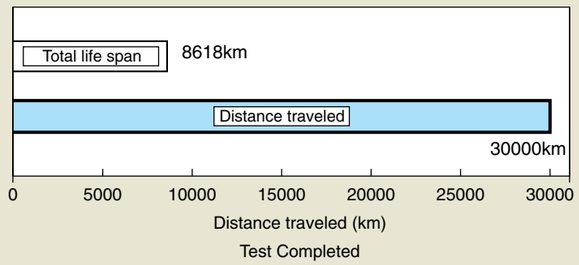
The use of a ball cage eliminates friction between balls resulting in a corresponding decrease in the generation of metal wear fragments for outstanding effects against prevention of the generation of dust.

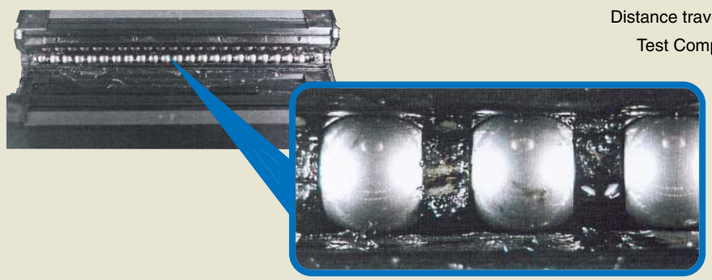


■High-Speed Durability Test Results

Since the use of a ball cage eliminates friction between balls, there is less generation of heat making it possible to demonstrate excellent high-speed operation.

Sample	: SHS65LVSS
Speed	: 200 m/min
Stroke	: 2500 mm
Lubrication	: Initial injection of grease only
Load	: 34.5 kN
Acceleration	: 1.5 G





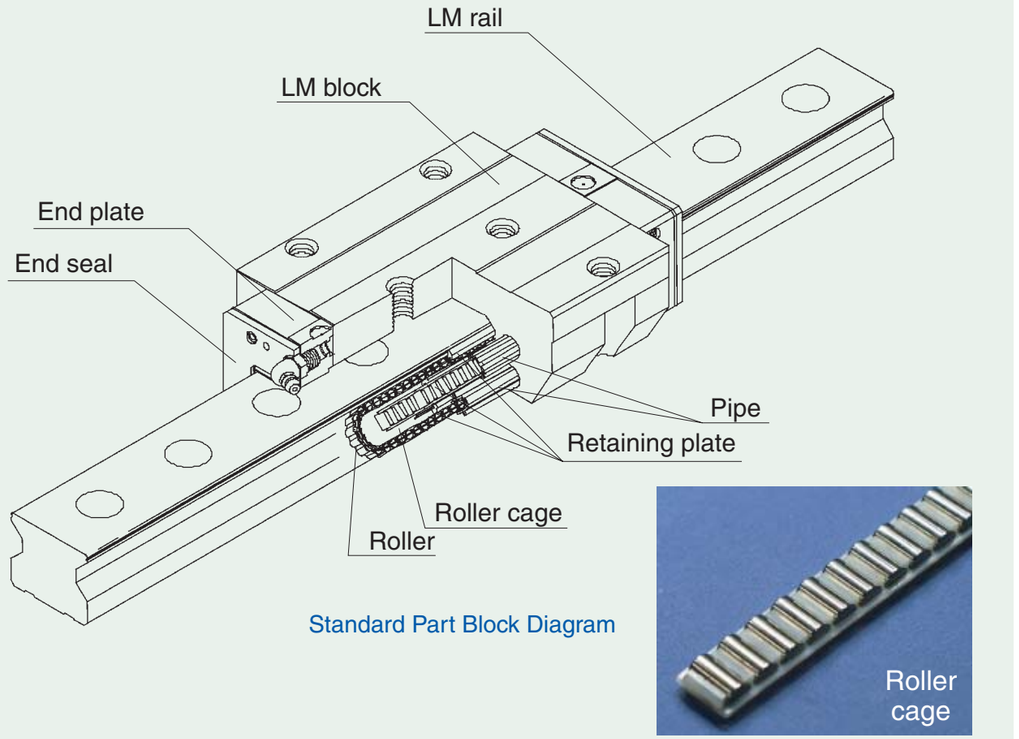
Detailed drawing of ball cage

Grease was still present and there were no abnormalities observed in the balls or grease.

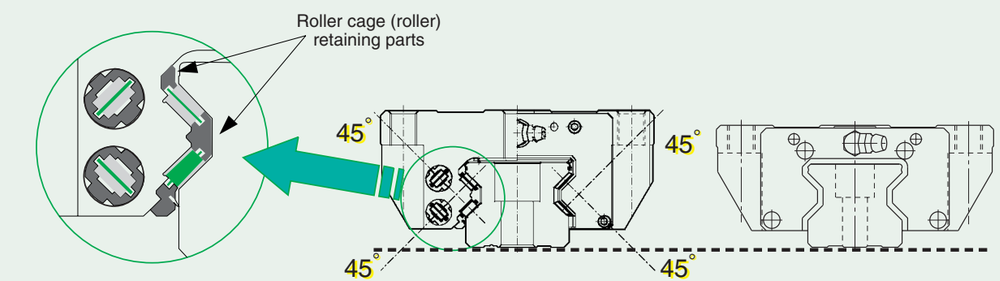
Caged Roller Technology

SRG/SRN

Structure of the SRG/SRN type



Standard Part Block Diagram



Enlarged view of circulating path

Type SRG

Type SRN

Cross-sectional view

Features of the SRG and SRN type

Prevents roller skewing

The use of a roller cage allows the rollers to circulate while uniformly aligned, preventing skewing when entering block load area, and reducing variation in rolling resistance to obtain stable and smooth movement.

Long-Term, Maintenance-Free Operation

The use of a roller cage eliminates friction between rollers, and retains lubricant in the grease pockets between adjacent rollers, ensuring the required amount of lubricating oil is supplied to the curved contact surfaces of the spacers and rollers of the circulating path to realize long-term maintenance-free operation.

Ultra-High Rigidity

Ultra-high rigidity is achieved by using rollers having a low degree of elastic deformation for the rolling elements and an optimized roller diameter and length. Also, each row of rollers is arranged at a 45° contact angle so that an equal load rating is applied in four directions (radial, reverse radial, and lateral directions).

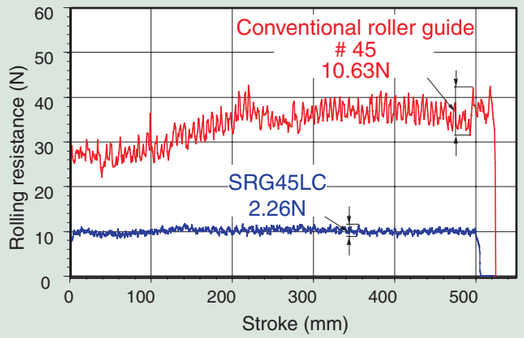
Global Standard Dimensions

The dimensional design complies with the Type HSR developed by THK as the pioneer of linear motion systems and has become the global standard.

LM Guide with Caged Roller Technology

■Rolling Resistance Value Data

The use of a roller cage eliminates friction between rollers while also enabling the rollers to circulate while uniformly aligned. As a result, there is reduced occurrence of skewing allowing the obtaining of stable movement.



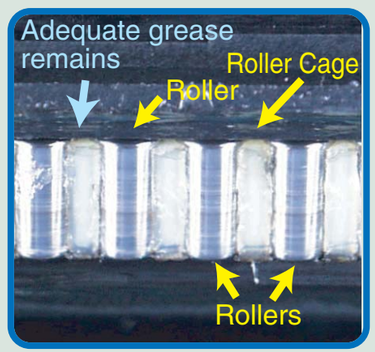
■Durability Data

The use of a roller cage enables grease to be retained in the spacer portions between adjacent rollers, realizing long-term, maintenance-free operation by inhibiting the escape of grease from the circulating path.

Sample) : SRG45LCC0

Conditions) : Pre-loading : C0 clearance
Speed : 180 m/min
Acceleration : 1.5 G
Stroke : 2300 mm
Lubricant : Initial injection of grease only

- Intermediate results:
  No abnormalities during 15,000 km of travel
  (**flaking or insufficient grease was not observed.**)



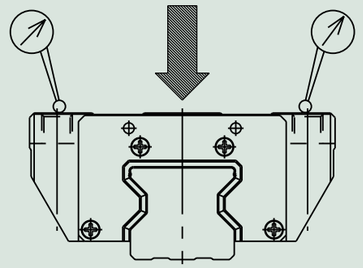
Detailed drawing of roller cage

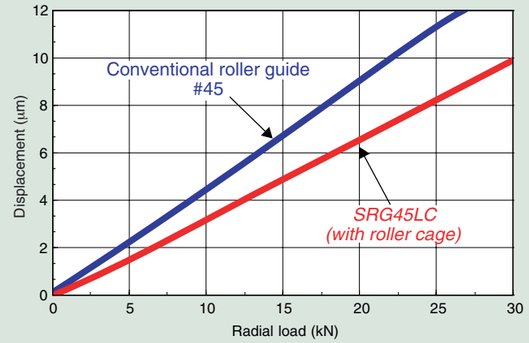
No discoloration of grease is observed.

■Rigidity values

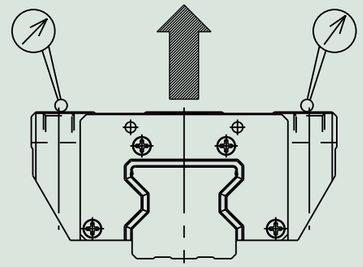
Radial clearance SRG : Clearance C0
Conventional roller guide : Equivalent to C0

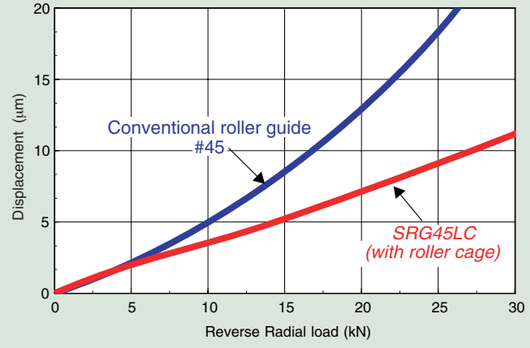
Radial rigidity



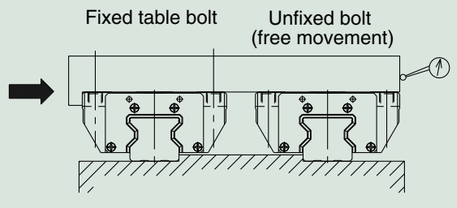


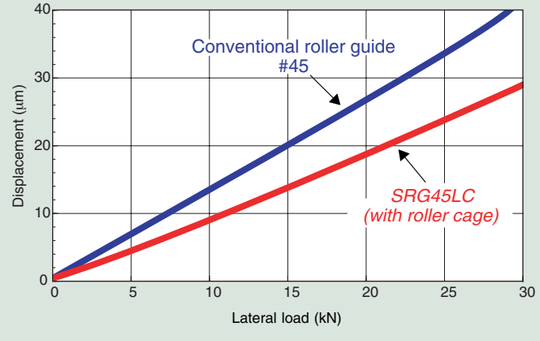
Reverse radial rigidity





Lateral rigidity

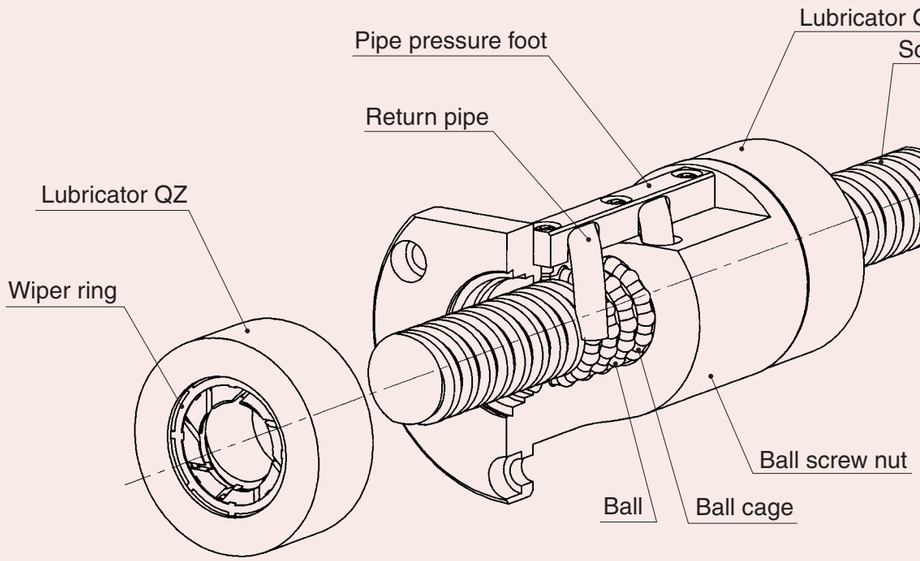


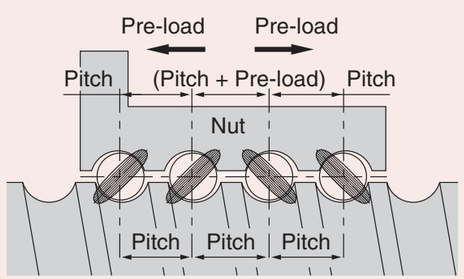


High-Speed Ball Screw with Ball Cage

SBN

Structure of the SBN type



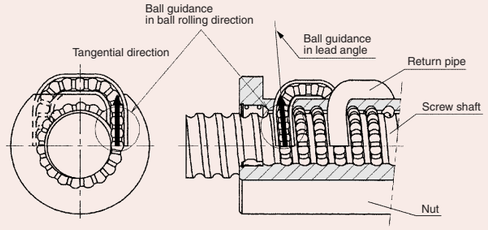


Features of the SBN type

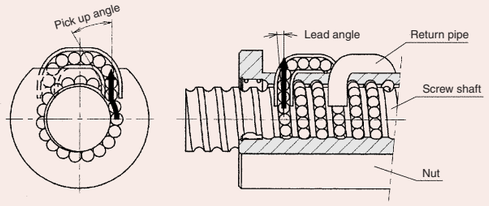
High-Speed Compatibility

The SBN type return pipe offers the ideal circulation method for creating a flexible ball track as a result of not having a lip so that balls are picked up in the tangential direction. In addition, the use of a design that provides the return pipe and ball cage with adequate strength **enables the SBN type to be used at a DN value of 130,000**.

SBN Type



Conventional Type



Low Noise Levels and Good Sound Quality

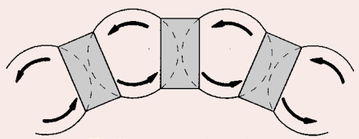
Ball cages arranged between the balls eliminate collision noise between the balls. In addition, the absence of a lip on the return pipe enables balls to be picked up in the tangential direction which also eliminates collision noise. The result is the **realization of low noise levels and good sound quality**.

Long-Term, Maintenance-Free Operation

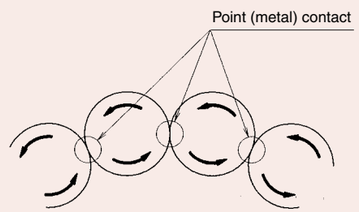
Long-term, maintenance free operation is realized as a result of the ball cage holding the grease. In addition, installation of the optional wiper ring and lubricator QZ* contributes to long-term, maintenance-free operation even in harsh environments (in the presence of coolant or foreign matter).
(*: Please contact THK regarding the wiper ring and ball screw lubricator QZ.)

Excellent Sliding Properties

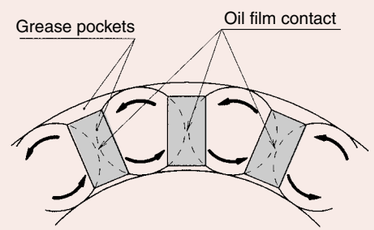
Ball cages arranged between balls eliminate mutual friction of the balls and significantly improve torque characteristics. Pre-load dynamic torque fluctuations are also reduced allowing the obtaining of **excellent sliding properties**.



Ball cage structure



Conventional structure



Locations of grease pockets

Improved Service Life

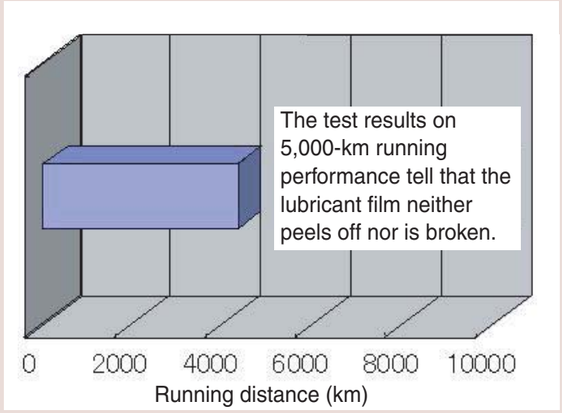
■Service life test

Service life test under a high speed (free of maintenance)

Testing instrumentation for a long-period high-speed test was used to test model SBN with lubrication system QZ. The operating cycles were run under a DN value of 130,000 and with only initial lubrication carried out.

Conditions

Test item	Value
Shaft diameter/lead	32 / 10 mm
Number of test pieces	1
Load	1,720 N (Only initial tension)
Speed	39 m/min
Shaft rotational speed	3,900 min^{-1} DN value: 130,000
Acceleration	9.8 m/s^2(1G)
Stroke	400 mm
Lubricant	THK AFG grease
Lubrication frequency	Only initial lubrication
Testing instrumentation	Testing instrumentation for the long-time high-speed test



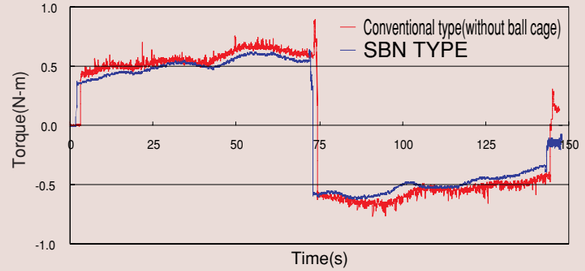
Ball Screw with Caged Ball Technology

■Torque Fluctuations and Sliding Properties

The ball cage reduces torque fluctuations enabling the obtaining of excellent constant speed characteristics even at low speed for a high degree of positioning accuracy.

Conditions

Item	Description
Shaft diameter/lead	32 / 10 mm
Speed	10 mm/s
Shaft rotational speed	60 min^{-1}
Stroke	700 mm
Lubricant	Mobil Vactra No. 2 oil

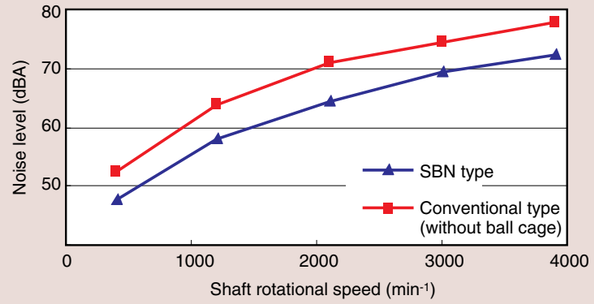


■Noise Level Data

The use of a ball cage reduces friction between balls to realize low noise levels.

Conditions

Item	Description
Shaft diameter/lead	32 / 10 mm
Lubricant	THK AFG grease
Measuring distance	1 m

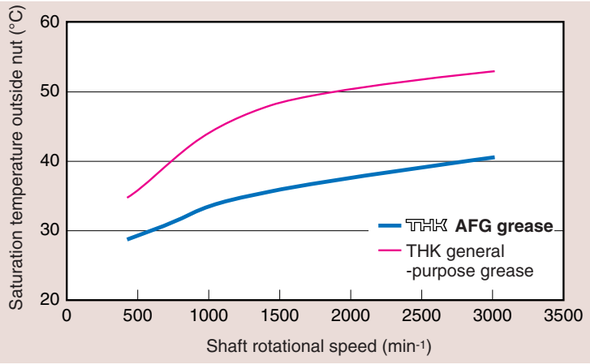


■Heat Generation Data

Although the use of ball cage eliminates friction between balls making it possible to demonstrate low levels of heat generation and outstanding high-speed operation, the use of THK AFG grease (low heat-generation grease) suppresses heat generation even more.

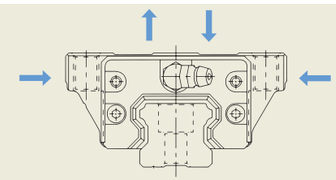
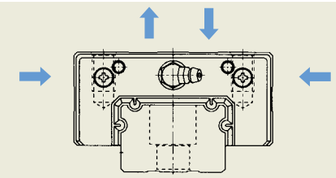
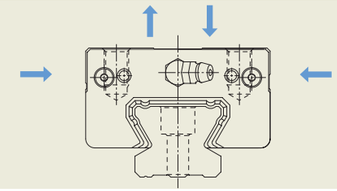
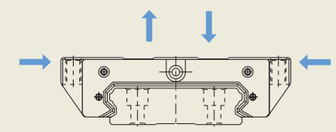
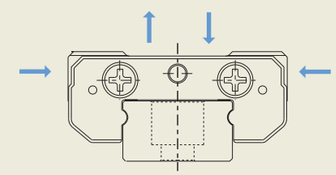
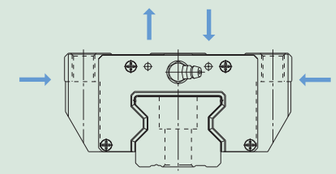
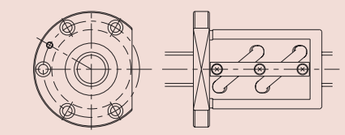
Conditions

Item	Description
Shaft diameter/lead	32 / 10 mm
Shaft rotational speed	400-3000 min^{-1}
Stroke	400 mm
Lubricant	THK AFG grease THK general-purpose grease



Caged Technology Products Provide Outstanding Features

S Series

		Rigidity Cross-Sectional Drawing	Applications
LM Guide with Caged Ball Technology	The World Standard **Type SHS**		Machining centers NC lathes Drilling machines Electrical discharge machines Transport systems
	Ultra-Heavy Duty Type **Type SNR/SNS**		Machining centers NC lathes Grinders Five-face processing machines
	Radial Type **Type SSR**		Grinders Semiconductor manufacturing equipment Printed circuit board drilling machines Three-dimensional measuring instruments Chip mounters Health care equipment
	Wide, Low Center of Gravity Type **Type SHW**		Printed circuit board drilling machines Semiconductor manufacturing equipment Electrical discharge machines Transport systems Optical stages
	Lightweight, Compact Type **Type SRS**		Semiconductor manufacturing equipment Optical stages Health care equipment IC bonders
LM Guide with Caged Roller Technology	Ultra-High Rigidity Type **Type SRG/SRN**		Five-face processing machines High-precision machining centers Heavy cutting machine tools High-precision lathes Jig borers
Ball Screw with Caged Ball Technology	High-Speed Ball Screw **Type SBN**		High-speed machining centers High-speed chip mounters High-speed printed circuit board drilling machines High-speed transport systems