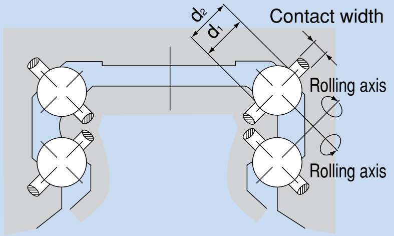
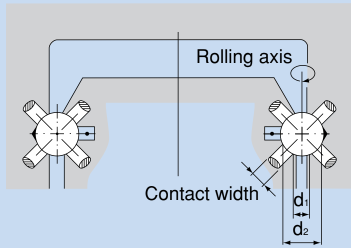
1.1. Ideal Four-Row, Circular-Arc Groove, Two-Point Contact Structure

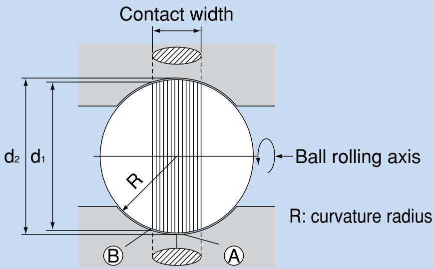
The LM Guide has a self-adjusting capability that competitors' products do not have.
This feature is achieved with an ideal four-row, circular-arc groove, two-point contact structure.

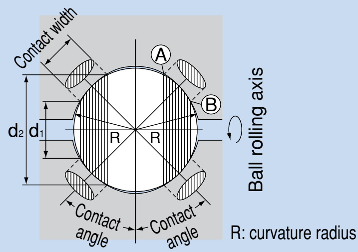
Comparison of Characteristics between the LM Guide and Similar Products

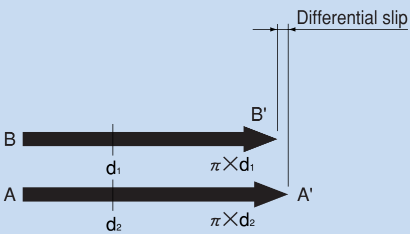
LM Guide: four-row, circular-arc groove, two-point contact structure	Other product: two-row, Gothic-arch groove four-point contact structure
LM Guide Model HSR	Two-row Gothic-arch groove product

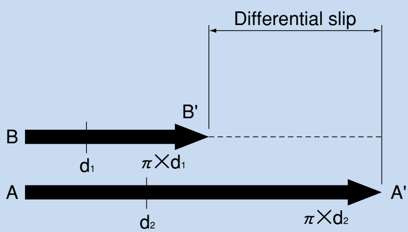












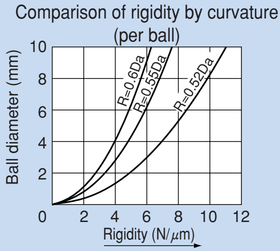
As indicated in the figure(s) above, when the ball rotates one revolution, the ball slips by the difference between the circumference of the inner contact diameter (πd_1) and that of the outer contact diameter (πd_2). This slip is called differential slip. If the difference is large, the ball rotates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

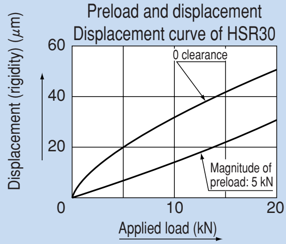
Four-Row, Circular-Arc Groove, Two-Point Contact Structure	Two-Row, Gothic-Arch Groove, Four-Point Contact Structure
Smooth motion	
Since the ball contacts the groove at two points in the load direction as shown in the figure on page A-5 even under a preload or a normal load, the difference between d_1 and d_2 is small and the differential slip is minimized to allow smooth rolling motion.	The difference between d_1 and d_2 in the contact area is large as shown in the figure on page A-5. 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, or ③ The mounting parallelism between the two axes is poor
Accuracy and rigidity of the mounting surface	
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.	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.
Rigidity	
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.	Since differential slip occurs due to the four-point contact, a sufficient preload cannot be applied and high rigidity cannot be obtained.
Rated load	
Since the curvature radius of the ball raceway is 51 to 52% of the ball diameter, a large rated load can be obtained.	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.

Difference in rigidity

As shown in the figure below, the rigidity widely varies according to the difference in curvature radius or difference in preload.

Curvature radius and rigidity





Difference in service life

Since the rated load 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%.

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 accuracy 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-row, 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

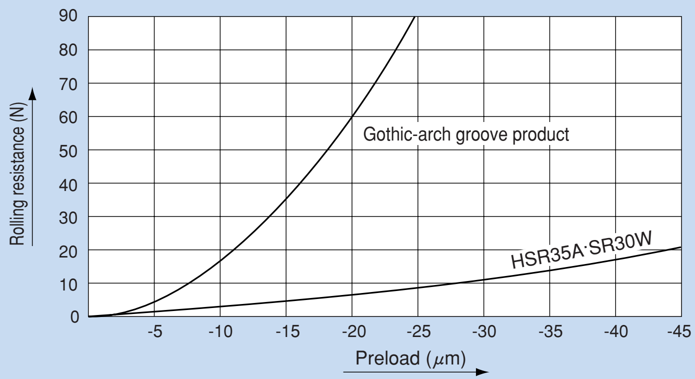
Type with dimensions similar to HSR30:	2 sets

Conditions

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

Data 1: Preload and rolling resistance

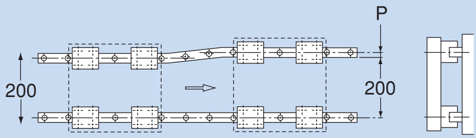
When a preload is applied, the rolling resistance of the Gothic-arch groove product steeply increases and differential slip occurs. Even under a preload, the rolling resistance of the LM Guide does not increase.

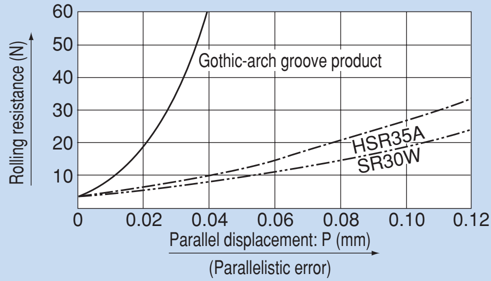


Data 2: Error in parallelism of two axes and rolling resistance

As shown in the figure below, 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.





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.