A-Ⅱ-8 Noise

- Appropriate design and highly accurate processing technology contribute to reducing noise of NSK linear guides.
- Fig. Ⅱ-8•1 is a noise-level data plot. The product of D_w (mm) ball diameter of linear guide and travel speed V (m/min) is shown on the abscissa. The noise level is shown on the ordinate.
- The plot indicates that the noise levels remain within a narrow straight belt irrespective of the linear guide type (LH25 through LH65 are plotted here).
- Noise level can be estimated; find the ball diameter from the linear guide model number, then incorporate a travel speed.

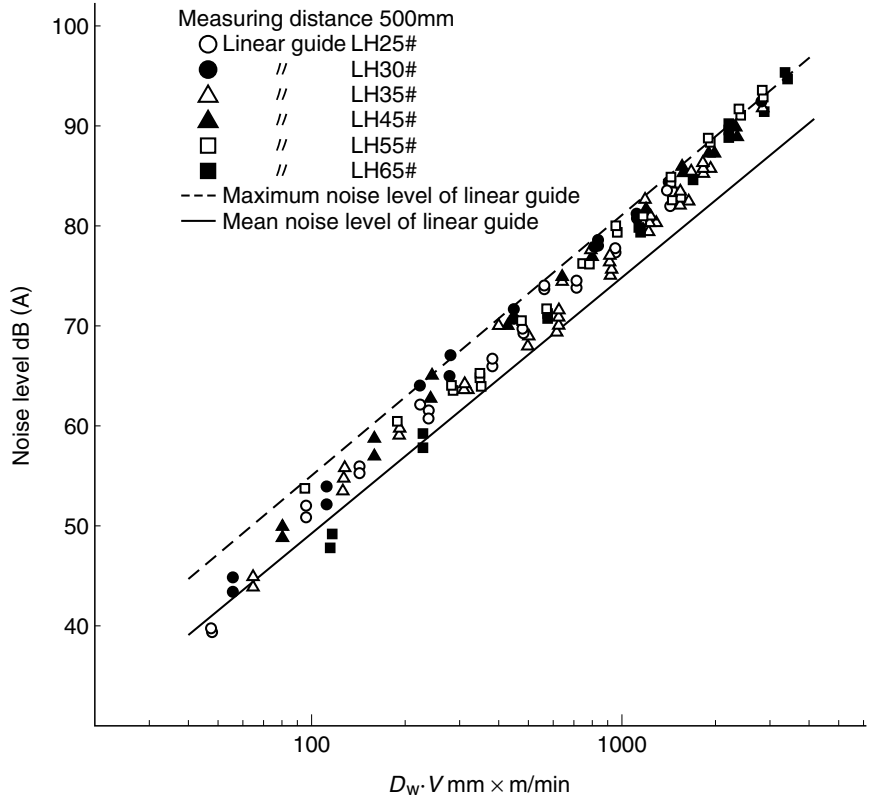


Fig. Ⅱ-8•1 Noise levels of linear guides

Example of estimate
LS30, and the travel speed is 100 m/min.
D_w = 4.762; V = 100 m/min
Therefore,
$D_w \cdot V$ = 4.762 x 100 = 476.2
Therefore, from Fig. Ⅱ-8•1, the noise level is 66 ~ 72dB (A).

A-Ⅱ-9 Arrangement and Mounting of Linear Guide

A-Ⅱ-9.1 Arrangement

- For NSK linear guide, the datum face of the rail and of the ball slide are marked with either an "datum face groove" or with an "arrow."
- In case that two or more linear guides are used together, one linear guide is designated as a reference side guide, and the rest is adjusting side guide(s). The reference side rail has its reference number, serial number, and "KL" mark on the opposite side of the datum face (Fig. Ⅱ-9•1).
- When the datum faces of the reference side rail and ball slides are pressed to their mounting datum faces respectively, the variation of distance (mounting width W_2 or W_3) between the datum faces of the rails and that of the ball slides must be a minimum and therefore, it is specified as the standard.
(Fig. Ⅱ-9•2 and Ⅱ-9•3)
- The ways to indicate the datum faces of LE and LU Series are shown in Table Ⅱ-9•1.

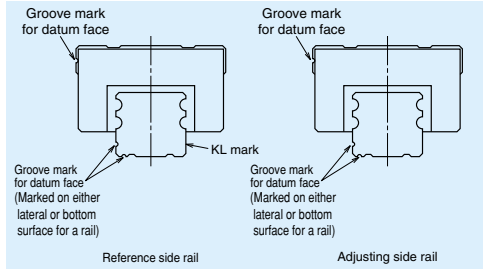


Fig. Ⅱ-9•1

Example of arrangement

- Arrangement of the linear guide must be determined taking into account the table position, its direction (horizontal, vertical, inclined, hanging from the ceiling), stroke, the size of bed and the table in the equipment as a whole. Table II-9.2 shows a common arrangement examples, and features/precautions for each case.

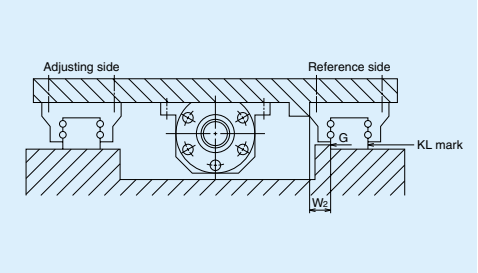


Fig. Ⅱ-9•2 Most common setting of the reference side rail

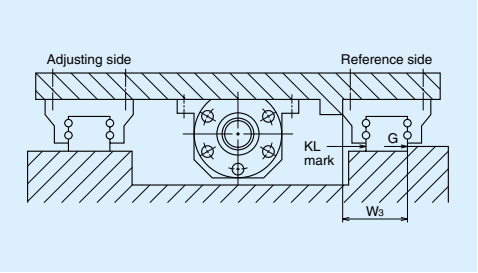


Fig. Ⅱ-9•3 Setting of the reference side rail in certain occasions

Table Ⅱ-9.1 Marks on the rail datum faces in LE, LU Series

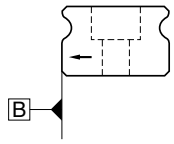
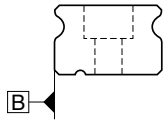
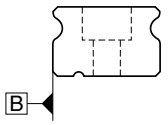
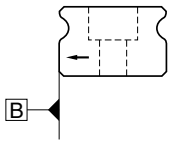
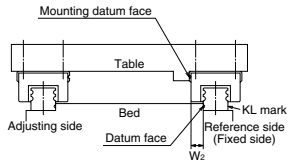
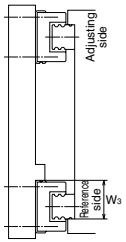
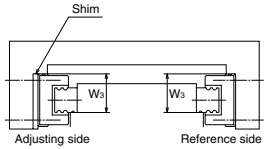
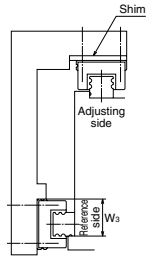
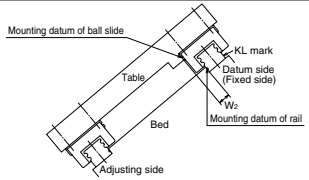
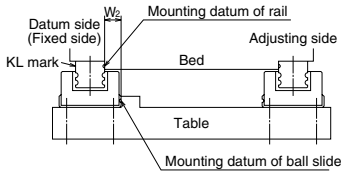
Material \ Model No.	LU05, 07, 09 LE05, 07, 09, 12	LU12, 15	LE15 LE09, 12 (with a ball retainer)
Special high carbon steel			
Stainless steel			

Table Ⅱ-9•2 Arrangement example

Arrangement	Features/Precautions
	• Easy in highly-accurate installation (recommended arrangement)
	• Easy in highly-accurate installation • Lubricant oil may not be supplied to ball slide. Precaution is required in the oil supply design.
	• Slightly difficult for highly-accurate installation • Life of linear guide is affected by mounting accuracy. • When oil lubricant is used, precaution is required in oil supply design.
	• Difficult for highly-accurate installation • For a linear guide mounted in sideways, precaution is required in oil supply design if oil lubricant is used.
	• Rather easy in highly-accurate installation • When oil lubricant is used, precaution is required in oil supply design.
	• Easy in highly-accurate installation if the linear guide is installed to the machine base first, then hang upside down along with the machine base. • Ball slide may detach from the rail and fall down if the linear guide is damaged and all the balls in the ball slide fall out. It is necessary to take preventive measures against the falling of the ball slide.

A-Ⅱ-9.2 Mounting Accuracy

(1) Accuracy of the mounting base of machine

• Mounting accuracy of linear guide usually copies the accuracy of the machine base.
• However, when two or more ball slides are assembled to each rail, the table stroke becomes shorter than the mounting surface. This, along with the fact that the mounting error is evenly spread, contributes to a higher table accuracy than the mounting face accuracy, reducing the error to about 1/3 in average (Fig. Ⅱ-9•4).

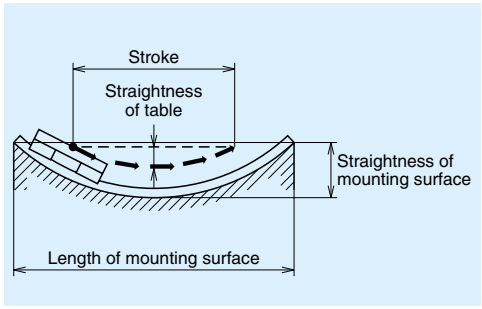
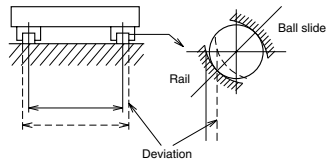
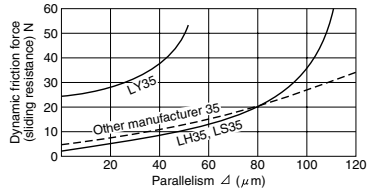
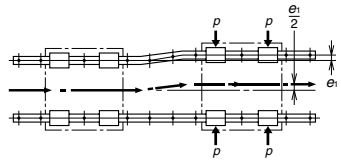


Fig. Ⅱ-9•4

(2) Installation error

• Mounting error affects mainly three factors: life, friction and accuracy (Table Ⅱ-9•3).

Table Ⅱ-9•3 Influence of mounting error

Factor	Influence	
Life		• Large mounting error generates a force which twists the ball slide and reduces its life. • It also distorts the contact point of the ball and the groove and changes contact angle, lowering rigidity.
Friction		• LH and LS Series are affected very little by mounting error thanks to their small friction. (self alignment) • However, because of off-set gothic arch grooves, their friction suddenly soars once the mounting error exceeds a certain level. • Mounting error severely affects friction of LY Series with heavy preload.
Accuracy		• When rigidity of four ball slides are equal, the theoretical straightness becomes 1/2 of the installation error e_1. • However, this value becomes slightly larger due to deformation of the rail and the machine base.

(3) Permissible values of mounting error

- Of the three major factors which are affected by the mounting error, NSK focuses on life. By the NSK standard, permissible values of mounting error are the values which allows 5000 km or longer life under the following conditions.
  - Load volume per ball slide is 8% of the basic dynamic load rating C.
  - Rigidity of the machine base is infinite.
- Fig. Ⅱ-9•5 and Ⅱ-9•6 are representing the mounting errors. Their permissible values of mounting error are shown in Table Ⅱ-9•4 to Ⅱ-9•7.

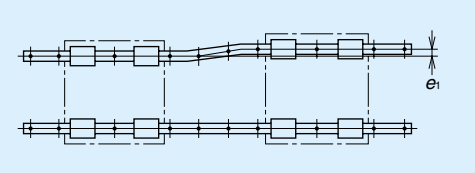


Fig. Ⅱ-9•5

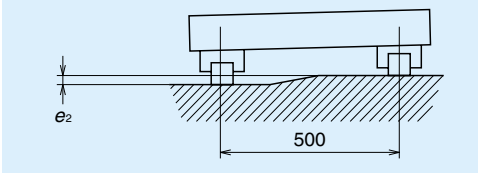


Fig. Ⅱ-9•6

Table Ⅱ-9•4 Permissible values of parallelism for LH and SH Series Unit: μm

Value	Preload	Model No.								
		H15	H20	H25	H30	H35	H45	H55	H65	H85
Permissible values of parallelism in two rails e_1	Z0, ZT	22	30	40	45	55	65	80	110	120
	Z1, ZZ	18	20	25	30	35	45	55	70	90
	Z3	13	15	20	25	30	40	45	60	70
Permissible values of parallelism (height) in two rails e_2	Z0, ZT	375μm/500mm								
	Z1, ZZ, Z3	330μm/500mm								

Table Ⅱ-9•5 Permissible values of parallelism for LS and SS Series Unit: μm

Value	Preload	Model No.				
		S15	S20	S25	S30	S35
Permissible values of parallelism in two rails e_1	Z0, ZT	20	22	30	35	40
	Z1, ZZ	15	17	20	25	30
	Z3	12	15	15	20	25
Permissible values of parallelism (height) in two rails e_2	Z0, ZT	375μm/500mm				
	Z1, ZZ, Z3	330μm/500mm				

Table Ⅱ-9•6 Permissible values of parallelism for LA Series Unit: μm

Value	Preload	Model No.					
		LA25	LA30	LA35	LA45	LA55	LA65
Permissible values of parallelism in two rails e_1	Z3	15	17	20	25	30	40
	Z4	13	15	17	20	25	30
Permissible values of parallelism (height) in two rails e_2		185μm/500mm					

Table Ⅱ-9•7 Permissible values of parallelism for LY Series Unit: μm

Value	Preload	Model No.							
		LY15	LY20	LY25	LY30	LY35	LY45	LY55	LY65
Permissible values of parallelism in two rails e_1	Z0	20	25	25	25	30	40	50	60
	Z1	20	25	20	25	30	35	45	50
	Z2	15	20	20	20	25	30	40	45
	Z3	15	20	15	20	20	25	35	40
	Z4	—	—	15	15	20	25	30	35
Permissible values of parallelism (height) in two rails e_2	185μm/500mm								

Table Ⅱ-9•8 Permissible values of parallelism for LU, LE and LW Series Unit: μm

		Preload	LU					LE					LW				
			05	07	09	12	15	05	07	09	12	15	17	21	27	35	50
規格	e_1	Z0, ZT	10	12	15	20	25	10	12	15	18	22	20	20	25	38	50
		Z1	7	10	13	15	21	5	7	10	13	17	9	9	13	23	34
	e_2	Z0, ZT	150μm/200mm					50μm/200mm					100μm/500mm				
		Z1	90μm/200mm					35μm/200mm					45μm/500mm				

(4) Running accuracy and the influence of even-off effect

- When installed in a machine base, the linear guide is affected by the flatness of the mounting face of the machine base. However, in the case of two-rails/four-ball slides specification, which is most widely used, the straightness as a table unit is generally less than the straightness as a single component. This is due to the even-off effect generated by the shorter stroke, compared to rail length, as well as by interaction between the rails, and ball slides.
- Fig. Ⅱ-9•9 shows an actually measured straightness of the table which uses NSK linear guide. In this case, the final straightness of the table is about 1/5 of the straightness of the mounting face.

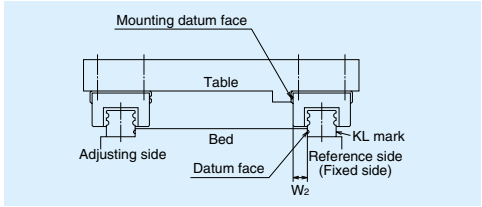


Fig. Ⅱ-9•7

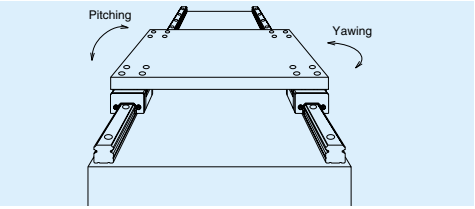
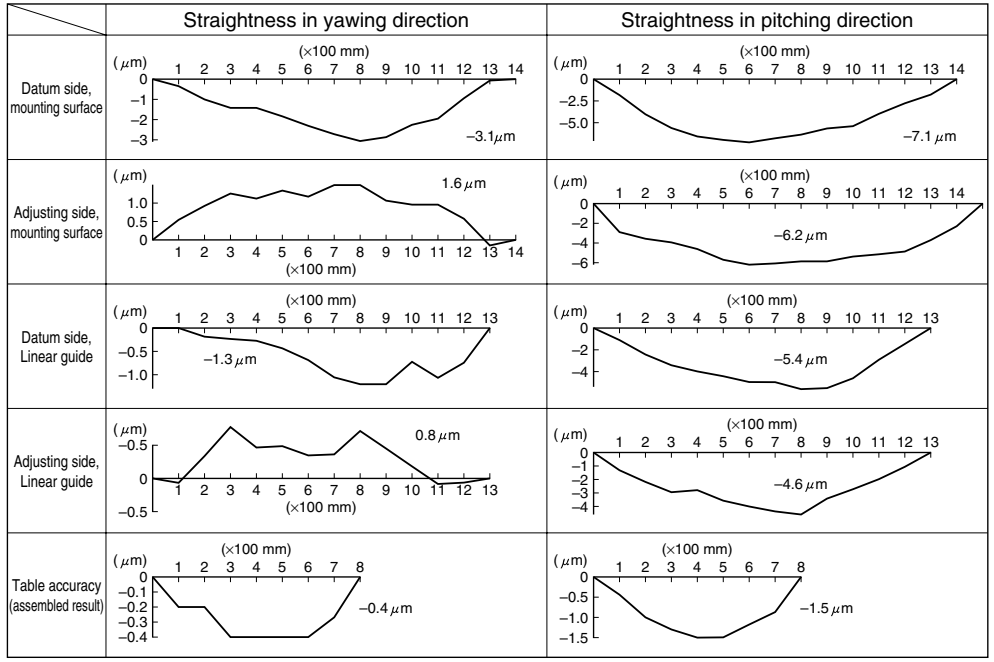


Fig. Ⅱ-9•8

Fig. Ⅱ-9•9 Straightness of the table equipped with linear guide



A-Ⅱ-9.3 Installation

(1) Shoulder height of the mounting face of the machine base and corner radius r

- Fig. Ⅱ-9•10, Ⅱ-9•11, Table Ⅱ-9•9 and Ⅱ-9•10 show shoulder height of the mounting face of the machine base and the size of corner r. These figures are relevant when the linear guide is pressed to the shoulder of the bed or table (the raised section from where the mounting face begins), and horizontally secured to it.
- The shoulder should be thick (wide) enough, so it is not deformed by the pressing force.

(2) Tightening torque of the bolt

- Table Ⅱ-9•8 shows tightening torque of the bolt when the rail is secured to the fixture of ball groove grinding machine.
- Apply same torque in this table when securing the rail to the machine base. Equal accuracy at the time of grinding can be obtained.

Table Ⅱ-9•8 Bolt tightening torque (Bolt material: High carbon chromium steel)

Unit: N · m

Bolt size	Tightening torque	Bolt size	Tightening torque
M2.3	0.38	M10	43
M2.5	0.58	M12	76
M3	1.06	M14	122
M4	2.5	M16	196
M5	5.1	M18	265
M6	8.6	M22	520
M8	22	—	—

(3) Installation procedures

- There are two installation ways depending on the accuracy requirement.
  a. Installation with high accuracy
  b. Accuracy is not high, but easy to install
- For both methods, wipe off the rust preventive oil applied to the linear guide. Remove burrs and small bumps on the bed and table mounting face with an oilstone (Fig. Ⅱ-9•12).
  Apply machine oil or similar oil with low viscosity to the mounting face to increase the rust preventive effect.
- Linear guide is a precision product. Handle with care.

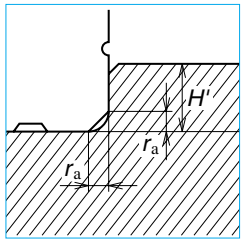


Fig. Ⅱ-9•10 Shoulder for the rail datum face

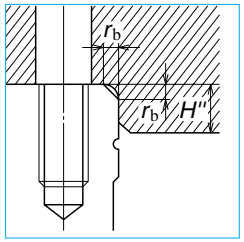


Fig. Ⅱ-9•11 Shoulder for the ball slide datum face

Table Ⅱ-9•9 Height of the shoulder and corner radius of the mounting face (LH, LS, LA and LY Series)

Unit: mm

Rail width	Corner radius (maximum)		Shoulder height for the rail	
	r_a	r_b	H'	H''
15	0.5	0.5	4.0	4
20	0.5	0.5	4.5	5
25	0.5	0.5	5.0	5
30	0.5	0.5	6.0	6
35	0.5	0.5	6.0	6
45	0.7	0.7	8.0	8
55	0.7	0.7	10.0	10
65	1.0	1.0	11.0	11
85	1.5	1.5	15.0	15

Table Ⅱ-9•10 Height of the shoulder and corner radius of the mounting face (LU, LE and LW Series)

Unit: mm

Rail width	Corner radius (maximum)		Shoulder height for the rail	
	r_a	r_b	H'	H''
LU05	0.2	0.2	0.7	2
LU07	0.2	0.3	1.2	3
LU09	0.3	0.3	1.9	3
LU12	0.3	0.3	2.5	4
LU15	0.3	0.5	3.5	5
LE05	0.2	0.2	1.1	2
LE07	0.2	0.3	1.7	3
LE09	0.3	0.3	3.5	3
LE12	0.3	0.3	3.5	4
LE15	0.3	0.5	3.5	5
LW17	0.3	0.3	2.2	4
LW21	0.3	0.3	2.5	5
LW27	0.5	0.5	3.5	5
LW35	0.5	0.8	3.5	5
LW50	0.8	0.8	4.0	6

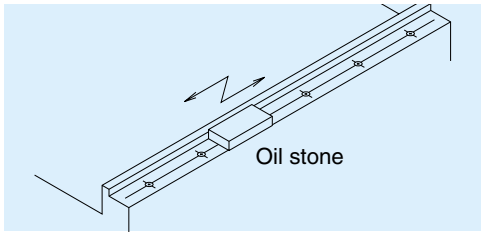


Fig. Ⅱ-9•12

Ⓐ Highly accurate installation

ⓐ Rail installation procedures

ⓐ-1) Machine base has a shoulder on the side where the reference side rail is installed.

① Confirm that the rail is reference side rail, and the datum face of the rail comes to face to face with the shoulder of the bed. Keep the ball slides on the rail, and carefully place the rail on the bed on its mounting face. Temporarily tighten the bolts.
At this time, press the rail from sideways to make the rail tightly contact to the shoulder of the bed. Apply tightening torque to the bolt in Table Ⅱ-9•7 when tightening a shoulder plate (Fig. Ⅱ-9•13).
Refer to "**(4) Various methods to press linear guide sideways.**"

② For final tightening of the bolts to secure the rail, tighten the bolt on either end of the rail, then proceed to other end.
If the datum face is on the left side as shown in Fig. Ⅱ-9•14, tighten the bolt at the farthest end first, then proceed to near end.
This way, a bolt rotating force presses the rail against the shoulder. (Therefore, the rail is pressed sufficiently tight against the shoulder by merely pressing the rail by hand. But if there is a possibility applying a lateral impact load, it is necessary to use a shoulder plate to prevent the rail from slipping.)

③ If the mounting face of the bed where the adjusting side rail is installed also has a shoulder, repeat the steps ① - ②.

④ If there is no shoulder on the mounting face of the bed for the adjusting side rail: Secure a measuring table to the ball slides of the reference side rail (Fig. Ⅱ-9•15). Use this to adjust the parallelism of the adjusting side rail. Check parallelism of the adjusting side rail with a dial gauge from one end of the rail, tightening the bolts one by one.
The measuring table is more stable if secured to two bearings, but one bearing is sufficient.
Parallelism between two rails can also be checked by the same method in Fig. Ⅱ-9•15 when there is a shoulder on the face where the adjusting side rail is installed.

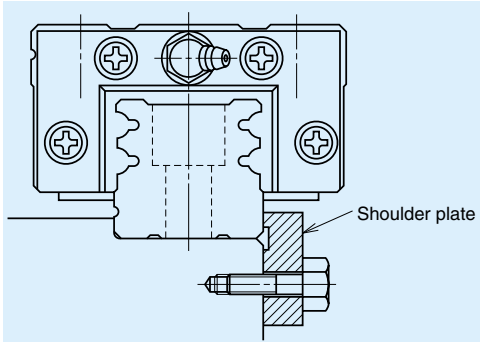


Fig. Ⅱ-9•13 Pressing the rail from sideways

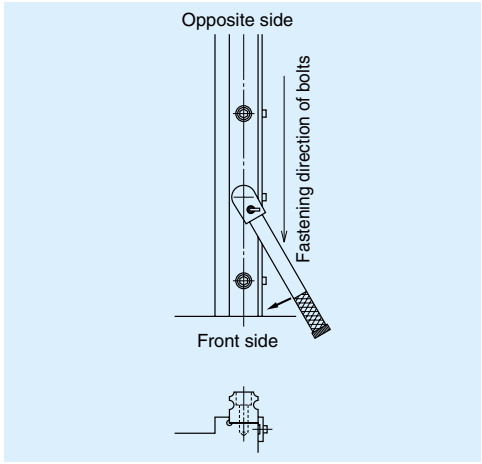


Fig. Ⅱ-9•14 Rail installation

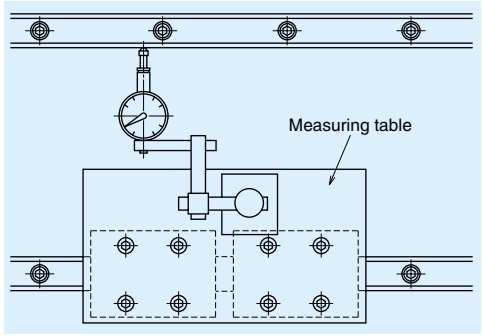


Fig. Ⅱ-9•15 Measuring parallelism

ⓐ-2) **When machine base does not have a shoulder on the side where the reference side rail is installed**

① Carefully place the reference side rail on the bed on its mounting face. Temporarily tighten the bolts. Do not tighten the bolts all the way, but stop tightening when the bolt enters halfway into the bolt hole. This makes the proceeding steps easier.

② Place the straight edge almost parallel to the reference side rail which is temporarily secured by bolts. (At the both ends of the rail and straight edge, the distance between them shall be almost same.)

③ Once the position of the straight edge is determined, use it as the reference. With a dial gauge, check parallelism with the rail, and adjust the rail if necessary. Then tighten the bolts.
Ensure that the straight edge does not move while the bolts are being tightened.
This procedure should be carried out starting from one end of the rail to the other end. (Fig. Ⅱ-9•16).

④ Finally tighten all bolts with specified torque.

⑤ There are two ways for installation of adjusting side rail:
1. Based on the straight edge which is used for reference side rail installation
2. Based on the reference side rail which is installed prior to the adjusting side rail.
In both way, use a dial gauge to measure parallelism.
Other procedures are the same as ①~④, and the ④ for case where there is a shoulder on the machine base.

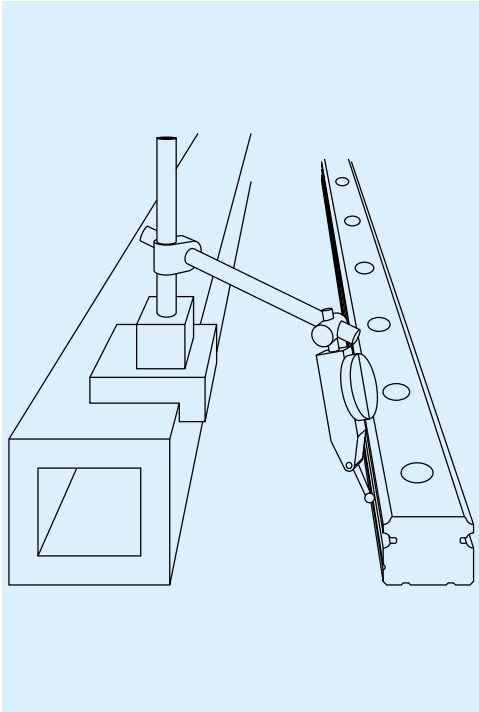


Fig. Ⅱ-9•16

ⓑ **Procedures of ball slide installation**

ⓑ-1) **When table has a shoulder**

① Arrange the ball slides so that locations match to their mounting section of the table. Carefully place the table on the ball slides. Temporarily tighten all bolts.

② While pressing the table from sideways, further tighten the bolts which secure the ball slides on the reference side, so the table shoulder and the ball slide's mounting datum face are sufficiently tightly pressed.
If a shoulder plate is provided, first tighten the bolts of the plate, then further tighten the bolts to the ball slides (Fig. Ⅱ-9•17).

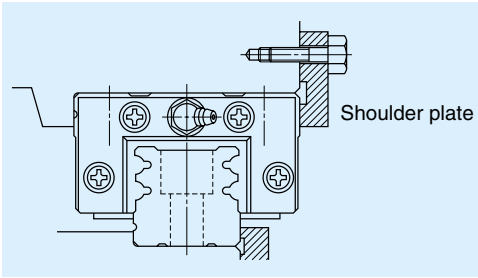


Fig. Ⅱ-9•17 Pressing ball slide from sideways

③ Then, further tighten the bolts for ball slides on the adjusting side rail.
Move the table by hand to confirm that there is no abnormality such as excessive friction force during stroking. (This confirms that the correct installation steps were taken.)

④ Finally, tighten all bolts with standard torque.

ⓑ-2) **When table does not have a shoulder**

① Arrange the ball slides so that locations match to their mounting section of the table. Carefully place the table on the ball slides. Temporarily tighten bolts to secure ball slides.

② Since the table does not have a shoulder, immediately tighten the bolts further to secure ball slides.

③ Move the table by hand to confirm that there is no abnormality. Finally, tighten all bolts with standard torque.

Ⓑ **Easy installation**

① Carefully place the reference side rail on the bed. Then tighten the bolts for installation with specified torque.

② Temporarily tighten the bolts on the adjusting side rail.

③ Tighten the ball slides on the reference side rail and one ball slide on the adjustment side rail with specified torque. Leave the rest of the ball slide on the adjusting side rail temporarily tightened (Fig. Ⅱ-9•18).

④ While moving the table with each pitch of the bolt for rail: With specified torque, tighten the rail mounting bolt which is located immediately adjacent to the ball slide on the adjusting side rail that had been finally tightened.
Take this procedure from one end to the other.

⑤ Return the table to the original position once. Then with standard torque, tighten the rest of the ball slides on the adjusting side. Then, by the same procedure as in ④, tighten the rest of the rail mounting bolts with standard torque. Move the table to check any abnormality such as large friction force.

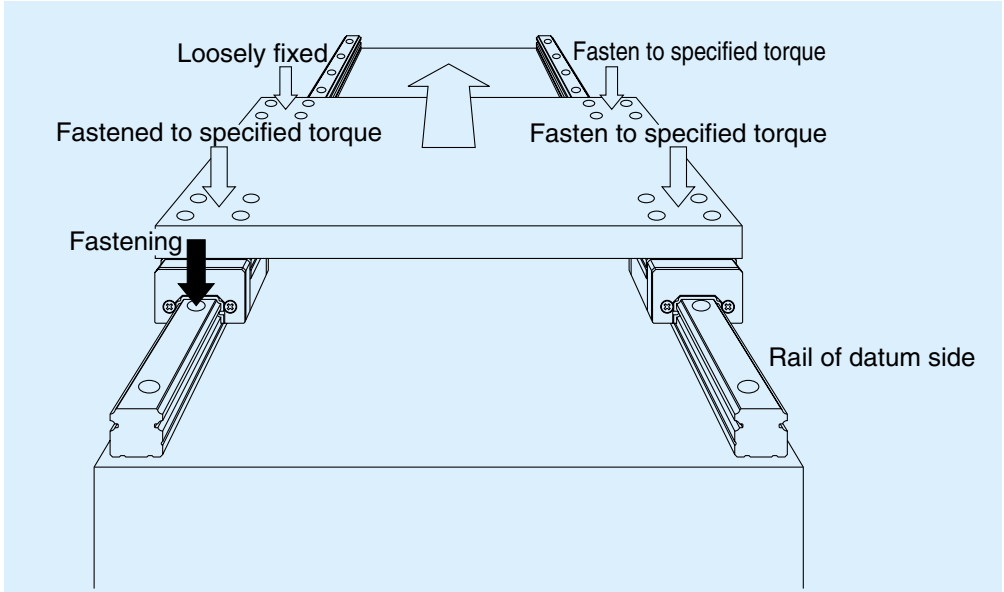


Fig. Ⅱ-9•18 Easy installation

(4) Various methods to press linear guide sideways

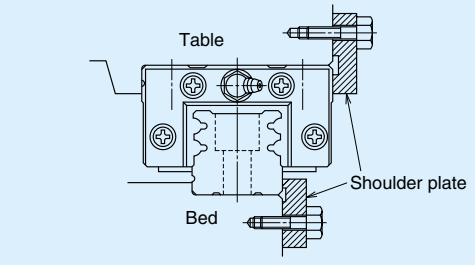


Fig. Ⅱ-9•19 **Recommended method**

- This method is most widely used, and generally recommended. The ball slide and the rail should protrude slightly from the sides of table and bed. The shoulder plate should have a recess, so the corners of the rail and ball slide do not touch the shoulder plate.

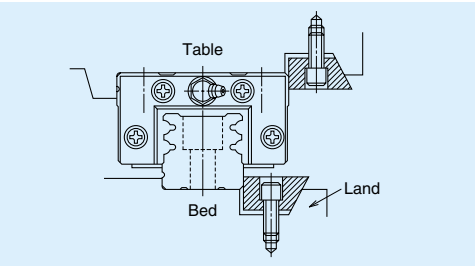


Fig. Ⅱ-9•20 **Installation that requires caution**

- A tapered block is squeezed in. But the slightest tightening of the bolt generates a large pressing force to the side. Too much tightening may cause the rail to deform, or the land (shown in the figure left) to warp to the right. This method requires caution.

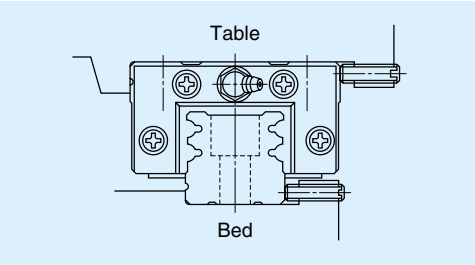


Fig. Ⅱ-9•21

- The bolt that presses rail must be thin due to limited space.

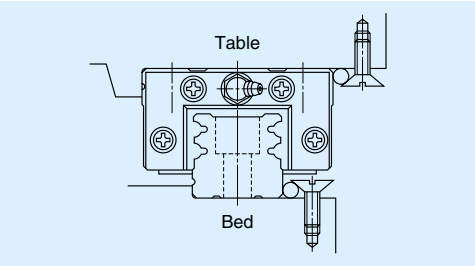


Fig. Ⅱ-9•22

- Press a needle-shape roller with a taper section of the head of a slotted pan head screw. Watch out for the position of the screw.

A-Ⅱ-9.4 Assemble Interchangeable Linear Guide

- Interchangeable ball slide is assembled on a provisinal rail (an inserting tool) when it is delivered (Fig. Ⅱ-9•23).
- NSK standard grease is packed into the ball slide, allowing immediate use.

Assembly procedures of interchangeable linear guide

Follow steps as described below.

① Wipe off the rust preventive oil from the rail and ball slide.

② Please match an groove mark for datum face of bearing with a rail to become an assembling state desired.

③ Align the provisional rail to the rail in the bottom and side faces. Press the provisional rail lightly against the rail, and move the ball slide over the rail (Fig. Ⅱ-9•23).

A-Ⅱ-9.5 Butting Rail Specification

- A rail which requires the length that exceeds manufactured maximum length comes in butting specification.
- The rail with butting specification are marked with alphabet (A, B, C ...) and an arrow on the opposite side of the mounting datum face. Use the alphabets and arrows for assembly order and direction of the rail (Fig. Ⅱ-9•25).
  The interchangeable rails for butting specification are only marked with the arrows.
- The pitch of the rail mounting hole on the butting section should be as F in Fig. Ⅱ-9•26. When two rails are used in parallel, the butted sections should not align. This is to avoid change in the running accuracy of the table at the butted sections.
- We recommend shifting the butting sections more than the length of a ball slide. If the higher running accuracy is required, consider installing the ball slides into the table so that they do not simultaneously pass the butting sections.

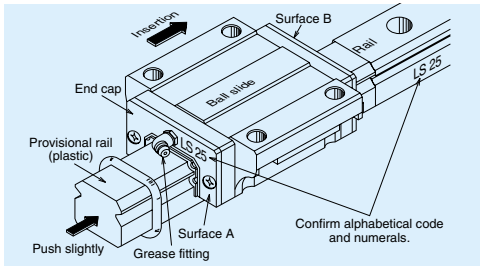


Fig. Ⅱ-9•23 **Inserting interchangeable ball slide into the rail**

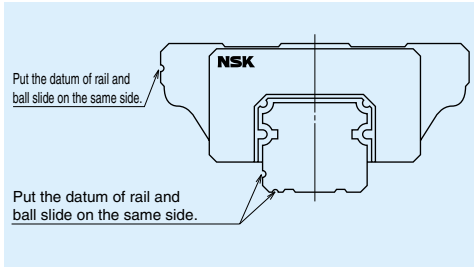


Fig. Ⅱ-9•24

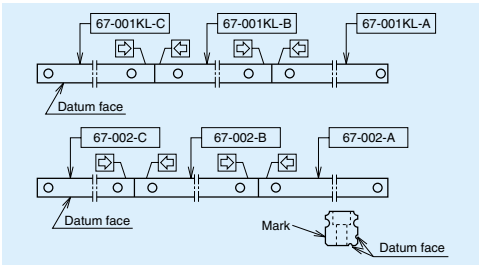


Fig. Ⅱ-9•25

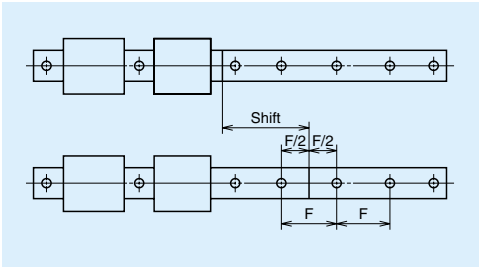


Fig. Ⅱ-9•26

A-Ⅱ-9.6 Handling Preloaded Assembly

- In case of the preloaded assembly (non interchangeable), do not remove ball slides from the rail as a general rule.
- If it is unavoidable to remove ball slide from the rail, make certain to use a provisional rail (a tool used to insert a ball slide to the rail) as shown in Fig. Ⅱ-9•27.
- Provisional rail for each model is in stock.
- Pay due attention to the assembly mark when returning the ball slide back to the rail. Follow the cautions described below.

Mark for assembling ball slide and rail

- Rails of preloaded assembly (not interchangeable) are marked with a reference number and a serial number on the opposite of the datum face.
- Ball slide to be combined are also marked with the same serial number (reference number is not marked).
- Furthermore, ball slides are marked with an arrow. Ball slides should be positioned with their arrows facing each other.
- In case that the ball slides had to be removed from the rail, confirm their serial numbers and the directions of arrows for re-assembly (Fig. Ⅱ-9•28).
- When two or more rails are used in a single set, serial numbers are in sequence if their reference numbers are the same. The linear guide with smallest serial number has the "KL" mark (Fig. Ⅱ-9•29).
- When two or more rails of different reference number are used in a single set, the rails and ball slides have the same serial number. In this case, when ball slide is removed from the rail, it is confusing which rail each ball slide was previously installed. When removing ball slides from the rail for an unavoidable reason (Fig. Ⅱ-9•30), sufficient precaution is required.

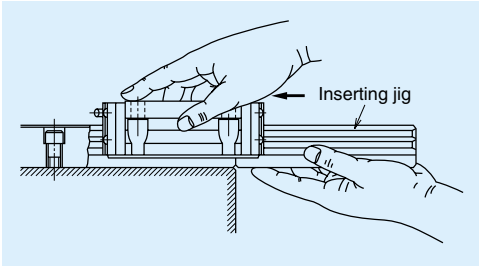


Fig. Ⅱ-9•27

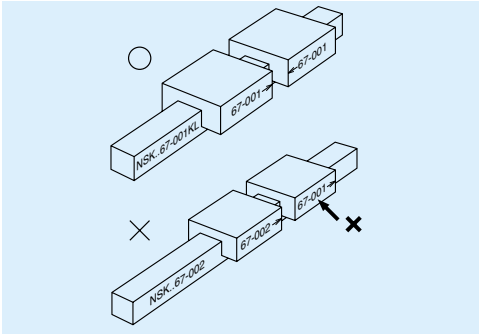


Fig. Ⅱ-9•28

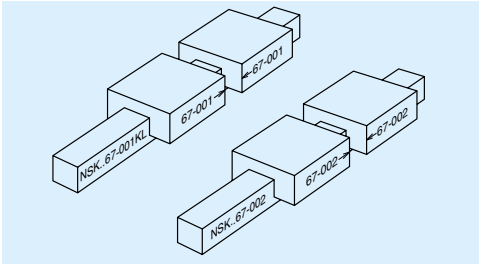


Fig. Ⅱ-9•29 When two rails have the same reference number

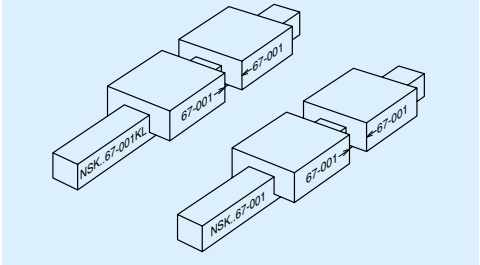


Fig. Ⅱ-9•30 When two rails have different reference number

A-Ⅱ-10 Drills to Select Linear Guide

A-Ⅱ-10.1 Single Axis Material Handling System

This section explains linear guide selection, life calculation, and deformation at load acting point for a single axis material handling system equipped with linear guide.

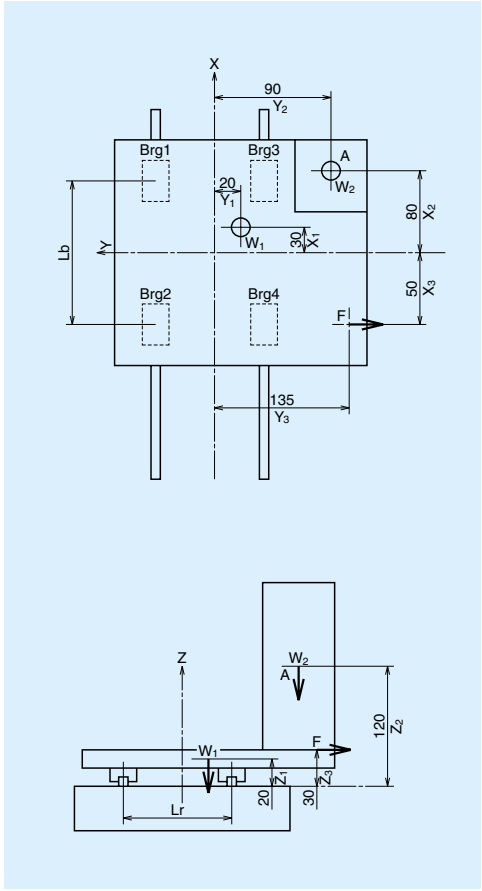


Fig. Ⅱ-10•1 Single axis material handling system

The work load is applied only to one way of stroke. Assume that the load is acting in full stroke as the condition of acting load is unknown.

Specification of Single axis material handling system

Table weight	W1 : 150 (N)
Weight of the work	W2 : 200 (N)
Acting load	F : 200 (N)
Ball slide span	L_b : 100 (mm)
Rail span	L_r : 90 (mm)

Load point coordinates from the table center (mm)

Load	X coordinate	Y coordinate	Z coordinate
W1	30	– 20	20
W2	80	– 90	120
F	– 50	– 135	30

Stroke: 1000 mm
(1 cycle: 2000 mm)

Environment	: 10-30 (°C)
Travel speed	: 12 (m/min)
Time to reach travel speed	: 0.25 (sec)
Operating hour	: 16 (hr/day)

(1) Selection of linear guide model

Select a type of linear guide from "**A-Ⅰ-2.1 Types and Characteristics of Linear Guide**." Since this material handling system has 2 rails and 4 ball slides, **LH, LS, and LU Series** are suitable.