

## General Explanation



# Selection Procedure

Selection of Linear Way and Linear Roller Way should be considered from the most important required matter to details in order.  
Typical procedure is shown below.

## Example of Linear Way and Linear Roller Way selection procedure



Life of linear motion rolling guides

Even in normal operational status, a linear motion rolling guide will reach the end of its life after a certain period of operations. As repeated load is constantly applied onto a raceway and rolling elements of the linear motion rolling guide, this leads to leprous damage (scale-like wear fragments) called fatigue flaking due to rolling contact fatigue of materials, it will be unusable at the end. Total traveling distance before occurrence of this fatigue flaking on a raceway or rolling elements is called the life of linear motion rolling guide.

As the life of linear motion rolling guide may vary depending on material fatigue phenomenon, rating life based on statistic calculation is used.

Rating life

Rating life of linear motion rolling guide refers to the total traveling distance 90% of a group of the same linear motion rolling guide can operate without linear motion rolling guide material damages due to rolling contact fatigue when they are operated individually under the same conditions.

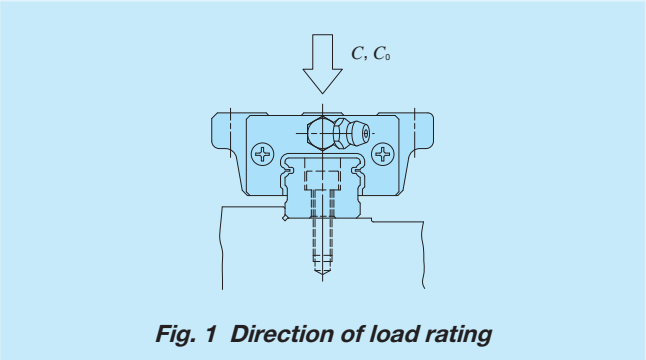


Fig. 1 Direction of load rating

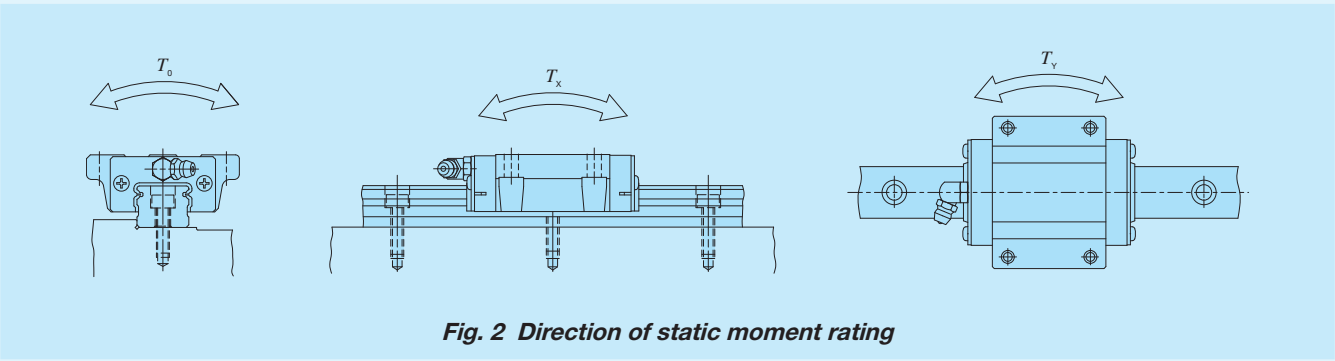


Fig. 2 Direction of static moment rating

Basic dynamic load rating C

Complying with ISO 14728-1

Basic dynamic load rating refers to load with certain direction and size that is logically endurable for rating life of  $50 \times 10^3$  m when a group of the same linear motion rolling guides is operated individually under the same conditions.

Basic static load rating C\_0

Complying with ISO 14728-2

Basic static load rating refers to static load generating a certain contact stress at the center of contact part of the rolling elements and a raceway under maximum load, which is the load at the allowable limit for normal rolling motion. Generally, it is used considering static safety factor.

Static moment rating T\_0, T\_x, T\_y

Static moment rating refers to static moment load generating a certain contact stress at the center of contact parts of rolling elements and a raceway under the maximum load when the moment load shown in Fig. 2 is loaded, which is the moment load at the allowable limit for normal rolling motion. Generally, it is used considering static safety factor.

Calculating formula of life

The rating life calculation formulas are shown below.

Linear Way

$$L=50\left(\frac{C}{P}\right)^3 \cdots \cdots \cdots (1)$$

Linear Roller Way

$$L=50\left(\frac{C}{P}\right)^{10/3} \cdots \cdots \cdots (2)$$

where, L: Rating life,  $10^3$  m  
C: Basic dynamic load rating, N  
P: Dynamic equivalent load, N

Life time can be calculated by applying a stroke length and a number of strokes per minute to the formula below.

$$L_h=\frac{10^6 L}{2Sn_1 \times 60} \cdots \cdots \cdots (3)$$

where,  $L_h$ : Rating life in hours, h  
S: Stroke length, mm  
 $n_1$ : Number of strokes per minute, cpm

Load factor

Load applied to a linear motion rolling guide can be larger than theoretical load due to machine vibration or shock. Generally, the applied load is obtained by multiplying it by the load factor indicated in Table 1.

Table 1 Load factor

| Operating conditions             | $f_w$     |
|----------------------------------|-----------|
| Smooth operation free from shock | 1 ~ 1.2   |
| Normal operation                 | 1.2 ~ 1.5 |
| Operation with shock load        | 1.5 ~ 3   |

Static safety factor

Generally, basic static load rating and static moment rating is considered as load at the allowable limit for normal rolling motion. However, static safety factor must be considered according to operating conditions and required performance of the linear motion rolling guide.

Static safety factor can be obtained by the following equation and typical values are indicated in Tables 2.1 and 2.2.

Equation (6) is a representative equation for a moment load. Moment load and static moment rating in each direction is applied for the calculation.

$$f_s=\frac{C_0}{P_0} \cdots \cdots \cdots (5)$$

$$f_s=\frac{T_0}{M_0} \cdots \cdots \cdots (6)$$

where,  $f_s$ : Static safety factor  
 $C_0$ : Basic static load rating, N  
 $P_0$ : Static equivalent load, N  
 $T_0$ : Static moment rating, N · m  
 $M_0$ : Moment load in each direction, N · m  
(maximum moment load)

Table 2.1 Static safety factor for Linear Way

| Operational conditions                  | $f_s$ |
|-----------------------------------------|-------|
| Operation with vibration and / or shock | 3 ~ 5 |
| High operating performance              | 2 ~ 4 |
| Normal operating conditions             | 1 ~ 3 |

Table 2.2 Static safety factor for Linear Roller Way

| Operational conditions                  | $f_s$   |
|-----------------------------------------|---------|
| Operation with vibration and / or shock | 4 ~ 6   |
| High operating performance              | 3 ~ 5   |
| Normal operating conditions             | 2.5 ~ 3 |

Dynamic equivalent load

When a load is applied in a direction other than that of the basic dynamic load rating or a complex load is applied, the dynamic equivalent load must be calculated to obtain the basic rating life.

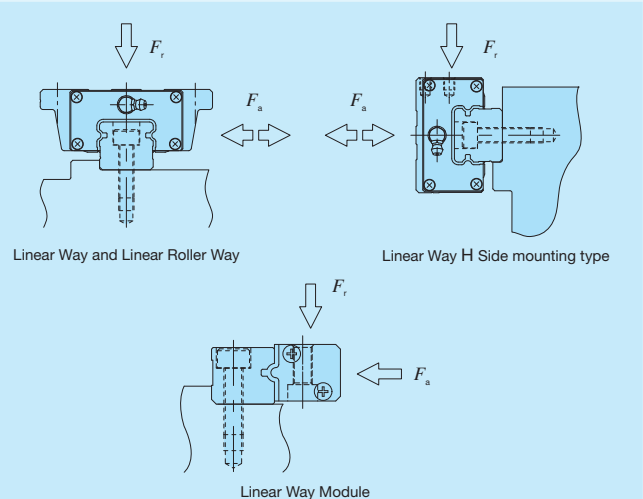
Obtain the downward and lateral conversion loads from the loads and moments in various directions.

$$F_{re}=k_r|F_r|+\frac{C_0}{T_0}|M_0|+\frac{C_0}{T_x}|M_x| \dots\dots\dots(7)$$

$$F_{ae}=k_a|F_a|+\frac{C_0}{T_y}|M_y| \dots\dots\dots(8)$$

where,  $F_{re}$  : Downward conversion load, N  
 $F_{ae}$  : Lateral conversion load, N  
 $F_r$  : Downward load, N  
 $F_a$  : Lateral load, N  
 $M_0$  : Moment load in the  $T_0$  direction, N · m  
 $M_x$  : Moment load in the  $T_x$  direction, N · m  
 $M_y$  : Moment load in the  $T_y$  direction, N · m  
 $k_r, k_a$  : Conversion factors for load direction  
(See Table 3)  
 $C_0$  : Basic static load rating, N  
 $T_0$  : Static moment rating in the  $T_0$  direction, N · m  
 $T_x$  : Static moment rating in the  $T_x$  direction, N · m  
 $T_y$  : Static moment rating in the  $T_y$  direction, N · m

Table 3 Conversion factor for load direction

|  |                          |                      |           |              |
|------------------------------------------------------------------------------------|--------------------------|----------------------|-----------|--------------|
| Series name and size                                                               |                          | Conversion factor    |           |              |
|                                                                                    |                          | $k_r$                |           | $k_a$        |
|                                                                                    |                          | $F_r \geq 0$         | $F_r < 0$ |              |
| C-Lube Linear Way ML                                                               | Ball retained type       | 1                    | 1         | 1.19         |
| Linear Way L                                                                       | Ball non-retained type   | 1                    | 1         | 0.84         |
| C-Lube Linear Way MLV                                                              |                          | 1                    | 1         | 1.19         |
| C-Lube Linear Way MV                                                               |                          | 1                    | 1.23      | 1.35         |
| C-Lube Linear Way ME                                                               | 15~30                    | 1                    | 1         | 1            |
| Linear Way E                                                                       | 35~45                    | 1                    | 1.19      | 1.28         |
|                                                                                    | Low Decibel Linear Way E | 1                    | 1         | 1            |
| C-Lube Linear Way MH<br>Linear Way H                                               | 8~12                     | 1                    | 1         | 1.19         |
|                                                                                    | 15~30                    | 1                    | 1         | 1            |
|                                                                                    | 35~65                    | 1                    | 1.19      | 1.28         |
|                                                                                    | Linear Way H             | 15~30                | 1         | 1            |
|                                                                                    | Horizontal mounting type | 35~45 <sup>(1)</sup> | 1         | 0.84<br>0.95 |
| Linear Way F                                                                       | 33~42                    | 1                    | 1         | 1            |
|                                                                                    | 69                       | 1                    | 1         | 1.19         |
|                                                                                    | LWFH                     | 1                    | 1.19      | 1.28         |
| C-Lube Linear Way MUL                                                              | 25, 30                   | 1                    | 1         | 1.19         |
| Linear Way U                                                                       | 40~130                   | 1                    | 1         | 1            |
| C-Lube Linear Roller Way Super MX                                                  |                          | 1                    | 1         | 1            |
| Linear Roller Way Super X                                                          |                          | 1                    | 1         | 1            |
| Linear Way Module                                                                  | LWLM                     | 1                    | 1         | 0.73         |
|                                                                                    | LWM                      | 1~5                  | 1         | 1.13         |
|                                                                                    |                          | 6                    | 1         | 1.28         |
|                                                                                    | LRWM                     | 1                    | 1         | 0.58         |

Note <sup>(1)</sup> The upper value of  $k_a$  columns represents the right direction and the lower value represents the left direction.

Obtain the dynamic equivalent load from the downward and lateral conversion loads.

$$P=XF_{re}+YF_{ae} \dots\dots\dots(9)$$

where,  $P$  : Dynamic equivalent load, N  
 $X, Y$  : Dynamic equivalent load factor (See Table 4)  
 $F_{re}$  : Downward conversion load, N  
 $F_{ae}$  : Lateral conversion load, N

Table 4 Dynamic equivalent load factor

| Class                    | X   | Y   |
|--------------------------|-----|-----|
| $ F_{re}  \geq  F_{ae} $ | 1   | 0.6 |
| $ F_{re}  <  F_{ae} $    | 0.6 | 1   |

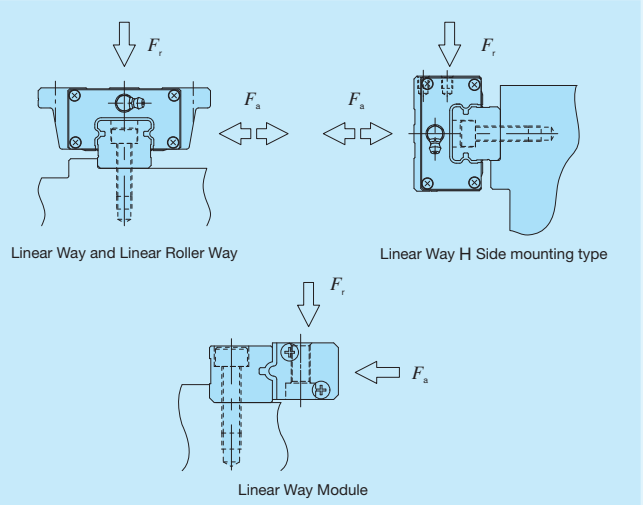
Static equivalent load

When a load is applied in a direction other than that of the basic static load rating or a complex load is applied, the static equivalent load must be calculated to obtain the static safety factor.

$$P_0=k_{or}|F_r|+k_{oa}|F_a|+\frac{C_0}{T_0}|M_0|+\frac{C_0}{T_x}|M_x|+\frac{C_0}{T_y}|M_y| \dots\dots(10)$$

where,  $P_0$  : Static equivalent load, N  
 $F_r$  : Downward load, N  
 $F_a$  : Lateral load, N  
 $M_0$  : Moment load in the  $T_0$  direction, N · m  
 $M_x$  : Moment load in the  $T_x$  direction, N · m  
 $M_y$  : Moment load in the  $T_y$  direction, N · m  
 $k_{or}, k_{oa}$  : Conversion factors for load direction  
(See Table 5)  
 $C_0$  : Basic static load rating, N  
 $T_0$  : Static moment rating in the  $T_0$  direction, N · m  
 $T_x$  : Static moment rating in the  $T_x$  direction, N · m  
 $T_y$  : Static moment rating in the  $T_y$  direction, N · m

Table 5 Conversion factor for load direction

|  |                          |                      |           |              |
|-------------------------------------------------------------------------------------|--------------------------|----------------------|-----------|--------------|
| Series name and size                                                                |                          | Conversion factor    |           |              |
|                                                                                     |                          | $k_{or}$             |           | $k_{oa}$     |
|                                                                                     |                          | $F_r \geq 0$         | $F_r < 0$ |              |
| C-Lube Linear Way ML                                                                | Ball retained type       | 1                    | 1         | 1.19         |
| Linear Way L                                                                        | Ball non-retained type   | 1                    | 1         | 0.84         |
| C-Lube Linear Way MLV                                                               |                          | 1                    | 1         | 1.19         |
| C-Lube Linear Way MV                                                                |                          | 1                    | 1.88      | 2.08         |
| C-Lube Linear Way ME                                                                | 15~30                    | 1                    | 1         | 1            |
| Linear Way E                                                                        | 35~45                    | 1                    | 1.19      | 1.28         |
|                                                                                     | Low Decibel Linear Way E | 1                    | 1         | 1            |
| C-Lube Linear Way MH<br>Linear Way H                                                | 8~12                     | 1                    | 1         | 1.19         |
|                                                                                     | 15~30                    | 1                    | 1         | 1            |
|                                                                                     | 35~65                    | 1                    | 1.19      | 1.28         |
|                                                                                     | Linear Way H             | 15~30                | 1         | 1            |
|                                                                                     | Horizontal mounting type | 35~45 <sup>(1)</sup> | 1         | 0.78<br>0.93 |
| Linear Way F                                                                        | 33~42                    | 1                    | 1         | 1            |
|                                                                                     | 69                       | 1                    | 1         | 1.19         |
|                                                                                     | LWFH                     | 1                    | 1.19      | 1.28         |
| C-Lube Linear Way MUL                                                               | 25, 30                   | 1                    | 1         | 1.19         |
| Linear Way U                                                                        | 40~130                   | 1                    | 1         | 1            |
| C-Lube Linear Roller Way Super MX                                                   |                          | 1                    | 1         | 1            |
| Linear Roller Way Super X                                                           |                          | 1                    | 1         | 1            |
| Linear Way Module                                                                   | LWLM                     | 1                    | 1         | 0.60         |
|                                                                                     | LWM                      | 1~5                  | 1         | 1.19         |
|                                                                                     |                          | 6                    | 1         | 1.43         |
|                                                                                     | LRWM                     | 1                    | 1         | 0.50         |

Note <sup>(1)</sup> The upper value of  $k_{oa}$  columns represents the right direction and the lower value represents the left direction.

# Calculated Load

Examples of calculation for the loads applied to Linear Way and Linear Roller Way that is incorporated in machine / equipment is shown in Table 6.1 to Table 6.6.

Table 6.1 One track rail and one slide unit

| Slide unit No. | Load applied on the slide unit |                       |                                             |                                             |                                             |
|----------------|--------------------------------|-----------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|
|                | Downward load<br>$F_r$         | Lateral load<br>$F_a$ | Moment load in the $T_0$ direction<br>$M_0$ | Moment load in the $T_x$ direction<br>$M_x$ | Moment load in the $T_y$ direction<br>$M_y$ |
| 1              | $F_z$                          | $F_y$                 | $M_r$                                       | $M_p$                                       | $M_y$                                       |

Remark: The moment loads in each direction  $M_r$ ,  $M_p$ ,  $M_y$  can be obtained by the following equation.

$$\begin{aligned}M_r &= F_y Z + F_z Y \\M_p &= F_x (Z - Z_d) + F_z X \\M_y &= -F_x (Y - Y_d) + F_y X\end{aligned}$$

Table 6.2 One track rail and two slide units

| Slide unit No. | Load applied on the slide unit     |                                    |                                             |
|----------------|------------------------------------|------------------------------------|---------------------------------------------|
|                | Downward load<br>$F_r$             | Lateral load<br>$F_a$              | Moment load in the $T_0$ direction<br>$M_0$ |
| 1              | $\frac{F_z}{2} + \frac{M_p}{\ell}$ | $\frac{F_y}{2} + \frac{M_r}{\ell}$ | $\frac{M_r}{2}$                             |
| 2              | $\frac{F_z}{2} - \frac{M_p}{\ell}$ | $\frac{F_y}{2} - \frac{M_r}{\ell}$ | $\frac{M_r}{2}$                             |

Remark: The moment loads in each direction  $M_r$ ,  $M_p$ ,  $M_y$  can be obtained by the following equation.

$$\begin{aligned}M_r &= F_y Z + F_z Y \\M_p &= F_x (Z - Z_d) + F_z X \\M_y &= -F_x (Y - Y_d) + F_y X\end{aligned}$$

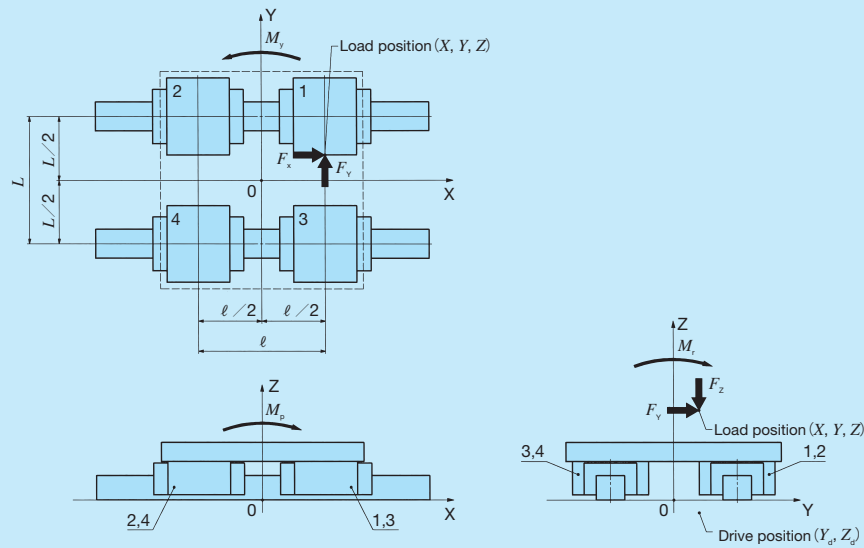
Table 6.3 Two track rails and one slide unit

| Slide unit No. | Load applied on the slide unit  |                       |                                             |                                             |
|----------------|---------------------------------|-----------------------|---------------------------------------------|---------------------------------------------|
|                | Downward load<br>$F_r$          | Lateral load<br>$F_a$ | Moment load in the $T_x$ direction<br>$M_x$ | Moment load in the $T_y$ direction<br>$M_y$ |
| 1              | $\frac{F_z}{2} + \frac{M_r}{L}$ | $\frac{F_y}{2}$       | $\frac{M_p}{2}$                             | $\frac{M_y}{2}$                             |
| 2              | $\frac{F_z}{2} - \frac{M_r}{L}$ | $\frac{F_y}{2}$       | $\frac{M_p}{2}$                             | $\frac{M_y}{2}$                             |

Remark: The moment loads in each direction  $M_r$ ,  $M_p$ ,  $M_y$  can be obtained by the following equation.

$$\begin{aligned}M_r &= F_y Z + F_z Y \\M_p &= F_x (Z - Z_d) + F_z X \\M_y &= -F_x (Y - Y_d) + F_y X\end{aligned}$$

Table 6.4 Two track rails and two slide units

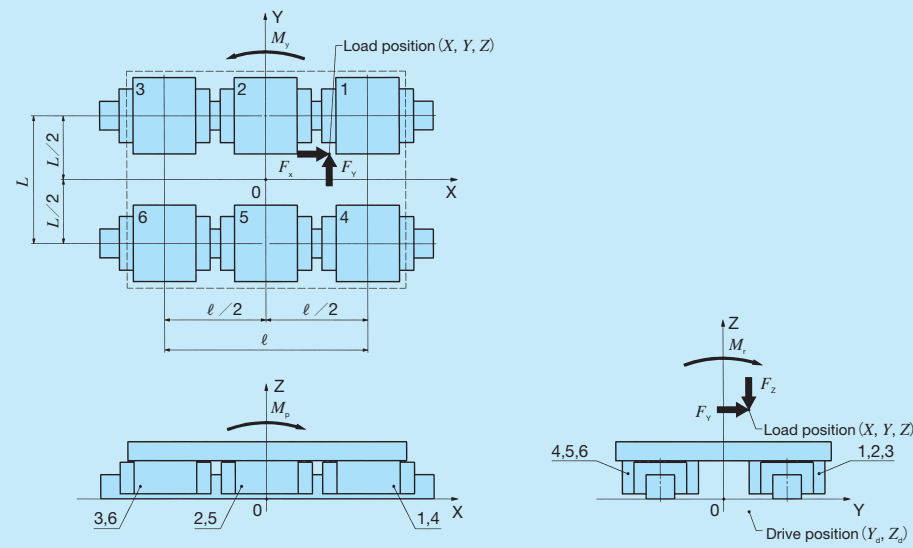


| Slide unit No. | Load applied on the slide unit                    |                                  |
|----------------|---------------------------------------------------|----------------------------------|
|                | Downward load<br>$F_r$                            | Lateral load<br>$F_a$            |
| 1              | $\frac{F_z}{4} + \frac{M_r}{2L} + \frac{M_p}{2l}$ | $\frac{F_y}{4} + \frac{M_y}{2l}$ |
| 2              | $\frac{F_z}{4} + \frac{M_r}{2L} - \frac{M_p}{2l}$ | $\frac{F_y}{4} - \frac{M_y}{2l}$ |
| 3              | $\frac{F_z}{4} - \frac{M_r}{2L} + \frac{M_p}{2l}$ | $\frac{F_y}{4} + \frac{M_y}{2l}$ |
| 4              | $\frac{F_z}{4} - \frac{M_r}{2L} - \frac{M_p}{2l}$ | $\frac{F_y}{4} - \frac{M_y}{2l}$ |

Remark: The moment loads in each direction  $M_r$ ,  $M_p$ ,  $M_y$  can be obtained by the following equation.

$M_r = F_y Z + F_z Y$   
 $M_p = F_x (Z - Z_d) + F_z X$   
 $M_y = -F_x (Y - Y_d) + F_y X$

Table 6.5 Two track rails and three slide units



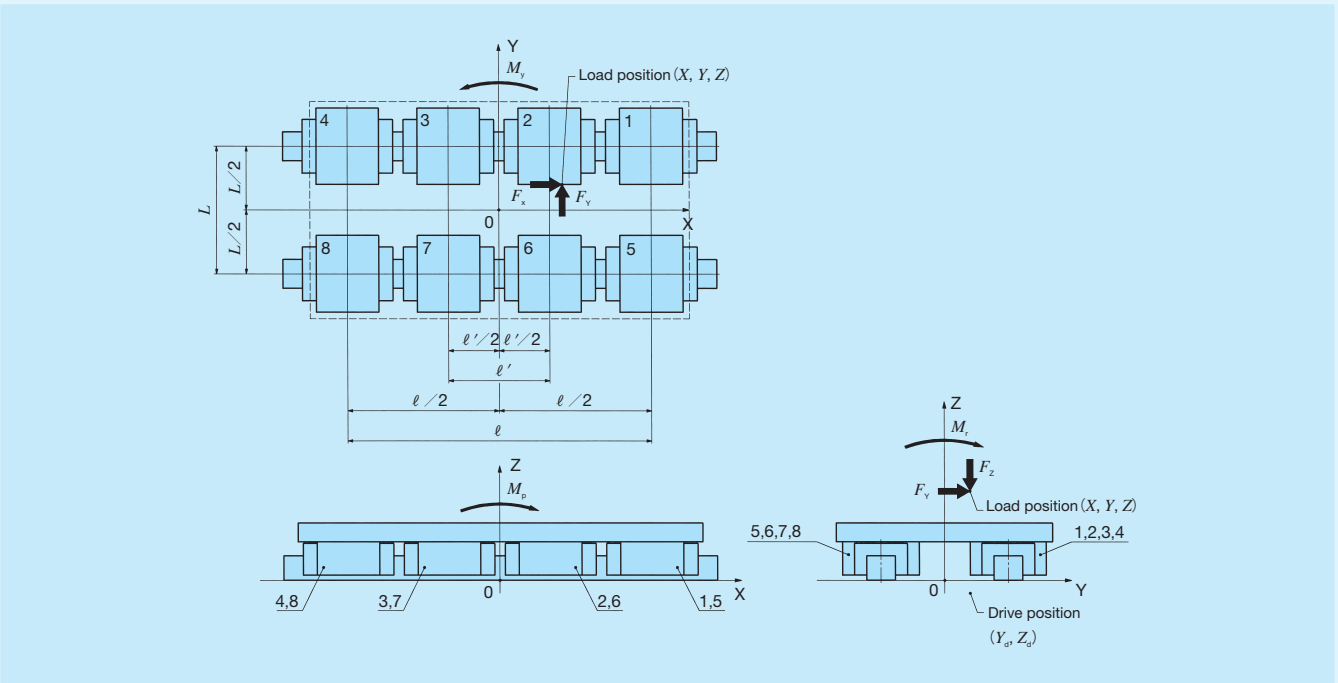
| Slide unit No. | Load applied on the slide unit                    |                                  |
|----------------|---------------------------------------------------|----------------------------------|
|                | Downward load<br>$F_r$                            | Lateral load<br>$F_a$            |
| 1              | $\frac{F_z}{6} + \frac{M_r}{3L} + \frac{M_p}{2l}$ | $\frac{F_y}{6} + \frac{M_y}{2l}$ |
| 2              | $\frac{F_z}{6} + \frac{M_r}{3L}$                  | $\frac{F_y}{6}$                  |
| 3              | $\frac{F_z}{6} + \frac{M_r}{3L} - \frac{M_p}{2l}$ | $\frac{F_y}{6} - \frac{M_y}{2l}$ |
| 4              | $\frac{F_z}{6} - \frac{M_r}{3L} + \frac{M_p}{2l}$ | $\frac{F_y}{6} + \frac{M_y}{2l}$ |
| 5              | $\frac{F_z}{6} - \frac{M_r}{3L}$                  | $\frac{F_y}{6}$                  |
| 6              | $\frac{F_z}{6} - \frac{M_r}{3L} - \frac{M_p}{2l}$ | $\frac{F_y}{6} - \frac{M_y}{2l}$ |

Remark: The moment loads in each direction  $M_r$ ,  $M_p$ ,  $M_y$  can be obtained by the following equation.

$M_r = F_y Z + F_z Y$   
 $M_p = F_x (Z - Z_d) + F_z X$   
 $M_y = -F_x (Y - Y_d) + F_y X$



Table 6.6 Two track rails and four slide units



| Slide unit No. | Load applied on the slide unit                                                  |                                                                |
|----------------|---------------------------------------------------------------------------------|----------------------------------------------------------------|
|                | Downward load<br>$F_r$                                                          | Lateral load<br>$F_a$                                          |
| 1              | $\frac{F_z}{8} + \frac{M_r}{4L} + \frac{M_p}{2} \frac{\ell}{\ell^2 + \ell'^2}$  | $\frac{F_y}{8} + \frac{M_y}{2} \frac{\ell}{\ell^2 + \ell'^2}$  |
| 2              | $\frac{F_z}{8} + \frac{M_r}{4L} + \frac{M_p}{2} \frac{\ell'}{\ell^2 + \ell'^2}$ | $\frac{F_y}{8} + \frac{M_y}{2} \frac{\ell'}{\ell^2 + \ell'^2}$ |
| 3              | $\frac{F_z}{8} + \frac{M_r}{4L} - \frac{M_p}{2} \frac{\ell'}{\ell^2 + \ell'^2}$ | $\frac{F_y}{8} - \frac{M_y}{2} \frac{\ell'}{\ell^2 + \ell'^2}$ |
| 4              | $\frac{F_z}{8} + \frac{M_r}{4L} - \frac{M_p}{2} \frac{\ell}{\ell^2 + \ell'^2}$  | $\frac{F_y}{8} - \frac{M_y}{2} \frac{\ell}{\ell^2 + \ell'^2}$  |
| 5              | $\frac{F_z}{8} - \frac{M_r}{4L} + \frac{M_p}{2} \frac{\ell}{\ell^2 + \ell'^2}$  | $\frac{F_y}{8} + \frac{M_y}{2} \frac{\ell}{\ell^2 + \ell'^2}$  |
| 6              | $\frac{F_z}{8} - \frac{M_r}{4L} + \frac{M_p}{2} \frac{\ell'}{\ell^2 + \ell'^2}$ | $\frac{F_y}{8} + \frac{M_y}{2} \frac{\ell'}{\ell^2 + \ell'^2}$ |
| 7              | $\frac{F_z}{8} - \frac{M_r}{4L} - \frac{M_p}{2} \frac{\ell'}{\ell^2 + \ell'^2}$ | $\frac{F_y}{8} - \frac{M_y}{2} \frac{\ell'}{\ell^2 + \ell'^2}$ |
| 8              | $\frac{F_z}{8} - \frac{M_r}{4L} - \frac{M_p}{2} \frac{\ell}{\ell^2 + \ell'^2}$  | $\frac{F_y}{8} - \frac{M_y}{2} \frac{\ell}{\ell^2 + \ell'^2}$  |

Remark: The moment loads in each direction  $M_r$ ,  $M_p$ ,  $M_y$  can be obtained by the following equation.

$M_r = F_y Z + F_z Y$   
 $M_p = F_x (Z - Z_d) + F_z X$   
 $M_y = -F_x (Y - Y_d) + F_y X$

Mean Equivalent Load for Fluctuating Load

When the load on the Linear Way and Linear Roller Way varies, instead of dynamic equivalent load  $P$ , the mean equivalent load  $P_m$  is used for calculating formula of life. The mean equivalent load is a load converted to give life equal to that for fluctuating load. It is obtained by the following formula:

$P_m = \sqrt[p]{\frac{1}{L} \int_0^L P_n^p dL} \dots\dots\dots (11)$

- where,  $P_m$  : Mean equivalent load, N
- $L$  : Total traveling distance, m
- $P_n$  : Fluctuating load, N
- $p$  : Exponent (ball type: 3, roller type: 10/3)

Table 7 gives calculation examples of the mean equivalent load for typical fluctuating loads.

Table 7 Mean equivalent load for fluctuating load

| Example                      |  | Mean equivalent load                                                                                                                                                                                                                                                                |
|------------------------------|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ① Stepwise changing load     |  | $P_m = \sqrt[p]{\frac{1}{L} (P_1^p L_1 + P_2^p L_2 + \dots + P_n^p L_n)}$<br>where, $L_1$ : Total traveling distance receiving the load $P_1$ , m<br>$L_2$ : Total traveling distance receiving the load $P_2$ , m<br>$L_n$ : Total traveling distance receiving the load $P_n$ , m |
| ② Monotonously changing load |  | $P_m \doteq \frac{1}{3} (2P_{max} + P_{min})$<br>where, $P_{max}$ : Maximum value of fluctuating load, N<br>$P_{min}$ : Minimum value of fluctuating load, N                                                                                                                        |



# Examples of Load and Life Calculation

## Example 1

Linear Way Model.....ME 25 C2 R640 H

Basic dynamic load

rating.....  $C = 18100 \text{ N}$

Basic static load

rating.....  $C_0 = 21100 \text{ N}$

Applied load.....  $F_{x1} = 1000 \text{ N}$

.....  $F_{y1} = 2000 \text{ N}$

.....  $F_{z1} = 1000 \text{ N}$

Load position.....  $X_1 = 60 \text{ mm}$

.....  $Y_1 = 50 \text{ mm}$

.....  $Z_1 = 83 \text{ mm}$

Table mass.....  $m_1 = 10 \text{ kg}$

Position of the center

of gravity of table.....  $X_2 = 0 \text{ mm}$

.....  $Y_2 = 0 \text{ mm}$

.....  $Z_2 = 43 \text{ mm}$

Work mass.....  $m_2 = 10 \text{ kg}$

Position of center of

gravity of work.....  $X_3 = 75 \text{ mm}$

.....  $Y_3 = 80 \text{ mm}$

.....  $Z_3 = 68 \text{ mm}$

Number of strokes per

minute.....  $n_1 = 5 \text{ cpm}$

Stroke length.....  $S = 100 \text{ mm}$

Distance between

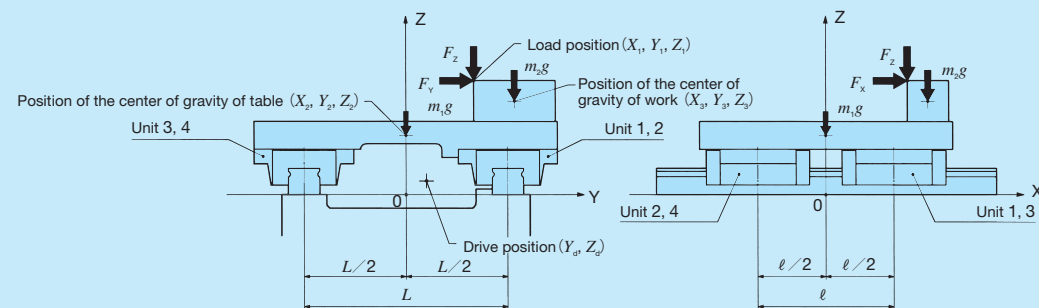
slide units.....  $\ell = 100 \text{ mm}$

Distance between the

track rails.....  $L = 150 \text{ mm}$

Drive position.....  $Y_d = 150 \text{ mm}$

.....  $Z_d = 10 \text{ mm}$



The life and static safety factor in the case of Example 1 is calculated. Load factor  $f_w$  is assumed to be 1.5.

## ① Calculation of load on the slide unit

Due to the applied load and the table weight, moment load occurs around each coordinate axis of the Linear Way as shown below.

$$\begin{aligned} M_r &= \Sigma (F_y Z) + \Sigma (F_z Y) = F_{y1} Z_1 + F_{z1} Y_1 + m_1 g Y_2 + m_2 g Y_3 \\ &= 2000 \times 83 + 1000 \times 50 + 10 \times 9.8 \times 0 + 10 \times 9.8 \times 80 \\ &\doteq 224000 \end{aligned}$$

$$\begin{aligned} M_p &= \Sigma \{F_x (Z - Z_d)\} + \Sigma (F_z X) = F_{x1} (Z_1 - Z_d) + F_{z1} X_1 + m_1 g X_2 \\ &\quad + m_2 g X_3 \\ &= 1000 \times (83 - 10) + 1000 \times 60 + 10 \times 9.8 \times 0 + 10 \times 9.8 \\ &\quad \times 75 \doteq 140000 \end{aligned}$$

$$\begin{aligned} M_y &= -\Sigma \{F_x (Y - Y_d)\} + \Sigma (F_y X) = -F_{x1} (Y_1 - Y_d) + F_{y1} X_1 \\ &= -1000 \times (50 - 150) + 2000 \times 60 = 220000 \end{aligned}$$

where,  $M_r$ : Moment load in the rolling direction, N · mm

$M_p$ : Moment load in the pitching direction, N · mm

$M_y$ : Moment load in the yawing direction, N · mm

The loads applied on each slide unit are calculated according to Table 6.4 on page III - 11.

$$\begin{aligned} F_{r1} &= \frac{\Sigma F_z}{4} + \frac{M_r}{2L} + \frac{M_p}{2\ell} = \frac{F_{z1} + m_1 g + m_2 g}{4} + \frac{M_r}{2L} + \frac{M_p}{2\ell} \\ &= \frac{1000 + 10 \times 9.8 + 10 \times 9.8}{4} + \frac{224000}{2 \times 150} + \frac{140000}{2 \times 100} \\ &\doteq 1750 \end{aligned}$$

$$F_{r2} = \frac{\Sigma F_z}{4} + \frac{M_r}{2L} - \frac{M_p}{2\ell} = \frac{F_{z1} + m_1 g + m_2 g}{4} + \frac{M_r}{2L} - \frac{M_p}{2\ell} \doteq 346$$

$$F_{r3} = \frac{\Sigma F_z}{4} - \frac{M_r}{2L} + \frac{M_p}{2\ell} = \frac{F_{z1} + m_1 g + m_2 g}{4} - \frac{M_r}{2L} + \frac{M_p}{2\ell} \doteq 252$$

$$\begin{aligned} F_{r4} &= \frac{\Sigma F_z}{4} - \frac{M_r}{2L} - \frac{M_p}{2\ell} = \frac{F_{z1} + m_1 g + m_2 g}{4} - \frac{M_r}{2L} - \frac{M_p}{2\ell} \\ &\doteq -1150 \end{aligned}$$

$$\begin{aligned} F_{a1} = F_{a3} &= \frac{\Sigma F_y}{4} + \frac{M_y}{2\ell} = \frac{F_{y1}}{4} + \frac{M_y}{2\ell} \\ &= \frac{2000}{4} + \frac{220000}{2 \times 100} = 1600 \end{aligned}$$

$$F_{a2} = F_{a4} = \frac{\Sigma F_y}{4} - \frac{M_y}{2\ell} = \frac{F_{y1}}{4} - \frac{M_y}{2\ell} = -600$$

## ② Calculating of rating life

The upward / downward load and lateral load are converted by formula (7) and (8) on page III - 7.

$$F_{re1} = k_r |F_{r1}| = 1 \times 1750 = 1750$$

$$F_{re2} = k_r |F_{r2}| = 1 \times 346 = 346$$

$$F_{re3} = k_r |F_{r3}| = 1 \times 252 = 252$$

$$F_{re4} = k_r |F_{r4}| = 1 \times 1150 = 1150$$

$$F_{ae1} = k_a |F_{a1}| = 1 \times 1600 = 1600$$

$$F_{ae2} = k_a |F_{a2}| = 1 \times 600 = 600$$

$$F_{ae3} = k_a |F_{a3}| = 1 \times 1600 = 1600$$

$$F_{ae4} = k_a |F_{a4}| = 1 \times 600 = 600$$

where,  $k_r, k_a$ : Conversion factors for load direction (See Table 3 on page III - 7.)

The dynamic equivalent load is calculated by formula (9) on page III - 7.

$$P_1 = X |F_{re1}| + Y |F_{ae1}| = 1 \times 1750 + 0.6 \times 1600 = 2710$$

$$P_2 = X |F_{re2}| + Y |F_{ae2}| = 0.6 \times 346 + 1 \times 600 \doteq 808$$

$$P_3 = X |F_{re3}| + Y |F_{ae3}| = 0.6 \times 252 + 1 \times 1600 \doteq 1750$$

$$P_4 = X |F_{re4}| + Y |F_{ae4}| = 1 \times 1150 + 0.6 \times 600 = 1510$$

The basic rating life of slide unit 1 receiving the largest dynamic equivalent load is calculated. The basic rating life is obtained by the formula (1) given on the page III - 6 considering the load factor  $f_w$  (see Table 1 on page III - 6).

$$L_1 = 50 \left( \frac{C}{f_w P_1} \right)^3 = 50 \times \left( \frac{18100}{1.5 \times 2710} \right)^3 \doteq 4410$$

$$L_{h1} = \frac{10^6 L_1}{2 S n_1 \times 60} = \frac{10^6 \times 4410}{2 \times 100 \times 5 \times 60} \doteq 73500$$

As the result of calculation above, the basic rating life is about 73,500 hours.

## ③ Calculating of static safety factor

The static equivalent load is calculated from the upward / downward load and lateral load by formula (10) on page III - 8.

$$P_{01} = k_{0r} |F_{r1}| + k_{0a} |F_{a1}| = 1 \times 1750 + 1 \times 1600 = 3350$$

$$P_{02} = k_{0r} |F_{r2}| + k_{0a} |F_{a2}| = 1 \times 346 + 1 \times 600 = 946$$

$$P_{03} = k_{0r} |F_{r3}| + k_{0a} |F_{a3}| = 1 \times 252 + 1 \times 1600 = 1852$$

$$P_{04} = k_{0r} |F_{r4}| + k_{0a} |F_{a4}| = 1 \times 1150 + 1 \times 600 = 1750$$

where,  $k_{0r}, k_{0a}$ : Conversion factors for load direction (See Table 5 on page III - 8.)

The static safety factor of slide unit 1 receiving the largest static equivalent load is calculated. The static safety factor is calculated by formula (5) on page III - 6.

$$f_{s1} = \frac{C_0}{P_{01}} = \frac{21100}{3350} \doteq 6.3$$

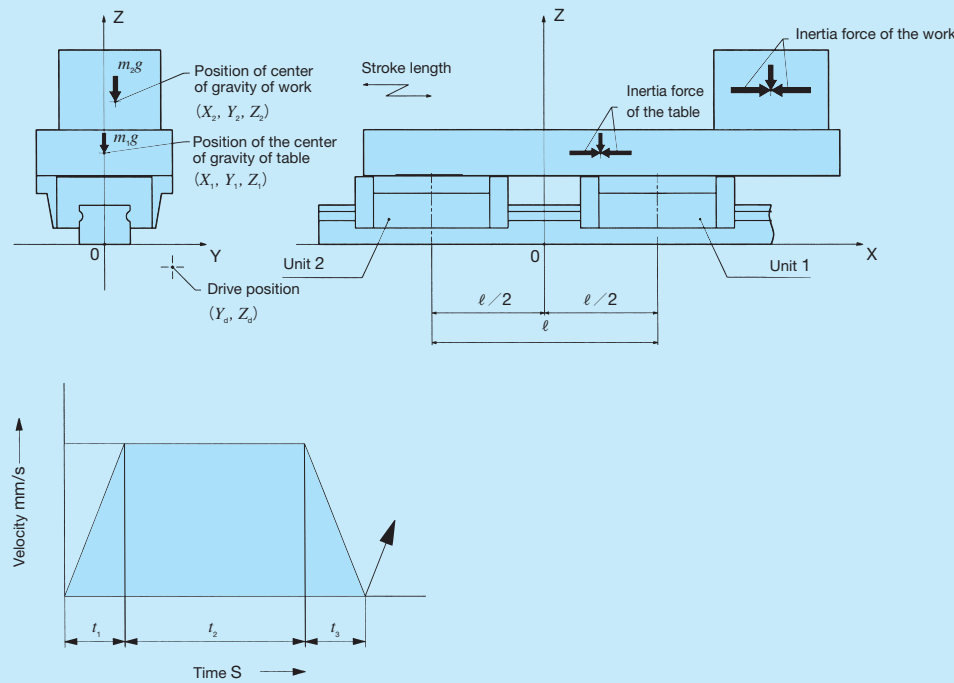
As the result of calculation above, the static safety factor is about 6.3.



### Example 2

Linear Way Model·····MH 45 C2 R1050 H  
Basic dynamic load rating····· $C = 74600$  N  
Basic static load rating····· $C_0 = 80200$  N  
Static moment rating in the  $T_0$  direction····· $T_0 = 1610$  N · m  
Table mass····· $m_1 = 100$  kg  
Position of the center of gravity of table····· $X_1 = 50$  mm  
····· $Y_1 = 0$  mm  
····· $Z_1 = 80$  mm  
Work mass····· $m_2 = 1000$  kg  
Position of center of gravity of work····· $X_2 = 200$  mm  
····· $Y_2 = 10$  mm  
····· $Z_2 = 130$  mm

Distance between slide units····· $\ell = 200$  mm  
Stroke length····· $S = 500$  mm  
Number of strokes per minute····· $n_1 = 6$  cpm  
Maximum traveling velocity····· $V = 100$  mm/s  
Time spent for acceleration····· $t_1 = 0.1$  s  
Time spent during constant speed motion····· $t_2 = 4.9$  s  
Time spent for deceleration····· $t_3 = 0.1$  s  
Drive position····· $Y_d = 60$  mm  
····· $Z_d = -20$  mm



The life and static safety factor in the case of Example 2 is calculated. Load factor  $f_w$  is assumed to be 1.5.

#### ① Calculation of load on the slide unit

Due to the applied load and the table mass and inertia force, moment load occurs around each coordinate axis of the Linear Way as shown below.

(During acceleration at the start of motion)

$$\begin{aligned} M_r &= \sum (F_y Z) + \sum (F_z Y) = m_1 g Y_1 + m_2 g Y_2 = 100 \times 9.8 \times 0 + 1000 \times 9.8 \times 10 \div 98000 \\ M_p &= \sum \{F_x (Z - Z_d)\} + \sum (F_z X) \\ &= m_1 \frac{V_{\max}}{1000 \times t_1} (Z_1 - Z_d) + m_2 \frac{V_{\max}}{1000 \times t_1} (Z_2 - Z_d) + m_1 g X_1 + m_2 g X_2 \\ &= 100 \times \frac{100}{1000 \times 0.1} \times (80 + 20) + 1000 \times \frac{100}{1000 \times 0.1} \times (130 + 20) + 100 \times 9.8 \times 50 + 1000 \times 9.8 \times 200 \\ &\div 2169000 \\ M_y &= -\sum \{F_x (Y - Y_d)\} + \sum (F_z Y) \\ &= -m_1 \frac{V_{\max}}{1000 \times t_1} (Y_1 - Y_d) - m_2 \frac{V_{\max}}{1000 \times t_1} (Y_2 - Y_d) \\ &= -100 \times \frac{100}{1000 \times 0.1} \times (0 - 60) - 1000 \times \frac{100}{1000 \times 0.1} \times (10 - 60) \div 56000 \end{aligned}$$

(During constant speed motion)

$$\begin{aligned} M_r &= m_1 g Y_1 + m_2 g Y_2 \div 98000 \\ M_p &= m_1 g X_1 + m_2 g X_2 \div 2010000 \\ M_y &= 0 \end{aligned}$$

(During deceleration at the end of motion)

$$\begin{aligned} M_r &= m_1 g Y_1 + m_2 g Y_2 \div 98000 \\ M_p &= -m_1 \frac{V_{\max}}{1000 \times t_3} (Z_1 - Z_d) - m_2 \frac{V_{\max}}{1000 \times t_3} (Z_2 - Z_d) + m_1 g X_1 + m_2 g X_2 \div 1850000 \\ M_y &= m_1 \frac{V_{\max}}{1000 \times t_3} (Y_1 - Y_d) + m_2 \frac{V_{\max}}{1000 \times t_3} (Y_2 - Y_d) \div -56000 \end{aligned}$$

where,  $M_r$ : Moment load in the rolling direction, N · mm  
 $M_p$ : Moment load in the pitching direction, N · mm  
 $M_y$ : Moment load in the yawing direction, N · mm

The loads applied on each slide unit are calculated according to Table 6.2 on page III-9.

(During acceleration at the start of motion)

$$\begin{aligned} F_{r1} &= \frac{\sum F_z}{2} + \frac{M_p}{\ell} = \frac{m_1 g + m_2 g}{2} + \frac{M_p}{\ell} \\ &= \frac{100 \times 9.8 + 1000 \times 9.8}{2} + \frac{2169000}{200} \div 16200 \\ F_{r2} &= \frac{\sum F_z}{2} + \frac{M_p}{\ell} = \frac{m_1 g + m_2 g}{2} - \frac{M_p}{\ell} \div -5460 \\ F_{a1} &= \frac{\sum F_y}{2} + \frac{M_y}{\ell} = 280 \\ F_{a2} &= \frac{\sum F_y}{2} - \frac{M_y}{\ell} = -280 \\ M_{01} &= M_{02} = \frac{M_r}{2} = 49000 \end{aligned}$$

(During constant speed motion)

$$\begin{aligned} F_{r1} &= \frac{100 \times 9.8 + 1000 \times 9.8}{2} + \frac{2010000}{200} \div 15400 \\ F_{r2} &\div -4660 \\ F_{a1} &= F_{a2} = 0 \\ M_{01} &= M_{02} = 49000 \end{aligned}$$

(During deceleration at the end of motion)

$$\begin{aligned} F_{r1} &= \frac{100 \times 9.8 + 1000 \times 9.8}{2} + \frac{1850000}{200} \div 14600 \\ F_{r2} &\div -3860 \\ F_{a1} &\div -280 \\ F_{a2} &\div 280 \\ M_{01} &= M_{02} = 49000 \end{aligned}$$

#### ② Calculating of rating life

The upward / downward load, lateral load and the moment load along  $T_0$  direction are calculated by the formula (7) and (8) on page III-7, and the dynamic equivalent load is calculated by formula (9).

(During acceleration at the start of motion)

$$\begin{aligned} F_{re1} &= k_r |F_{r1}| + \frac{C_0}{T_0} |M_{01}| = 1 \times 16200 + \frac{80200}{1610} \times \frac{49000}{1000} \\ &\div 18600 \\ F_{re2} &= 1 \times 5460 + \frac{80200}{1610} \times \frac{49000}{7900} \div 7900 \\ F_{ae1} &= k_a |F_{a1}| = 1.28 \times 280 \div 358 \\ F_{ae2} &= 1.28 \times 280 \div 358 \\ P_{1a} &= X F_{re1} + Y F_{ae1} = 1 \times 18600 + 0.6 \times 358 \div 18800 \\ P_{2a} &= X F_{re2} + Y F_{ae2} = 1 \times 7900 + 0.6 \times 358 \div 8110 \end{aligned}$$

(During constant speed motion)

$$\begin{aligned} F_{re1} &= 1 \times 15400 + \frac{80200}{1610} \times \frac{49000}{1000} \div 17800 \\ F_{re2} &= 1 \times 4660 + \frac{80200}{1610} \times \frac{49000}{1000} \div 7100 \\ F_{ae1} &= 0 \\ F_{ae2} &= 0 \\ P_{1b} &= 17800 \\ P_{2b} &= 7100 \end{aligned}$$

(During deceleration at the end of motion)

$$\begin{aligned} F_{re1} &= 1 \times 14600 + \frac{80200}{1610} \times \frac{49000}{1000} \div 17000 \\ F_{re2} &= 1 \times 3860 + \frac{80200}{1610} \times \frac{49000}{1000} \div 6300 \\ F_{ae1} &= 1.28 \times 280 \div 358 \\ F_{ae2} &= 1.28 \times 280 \div 358 \\ P_{1c} &= 1 \times 17000 + 0.6 \times 358 \div 17200 \\ P_{2c} &= 1 \times 6300 + 0.6 \times 358 \div 6510 \end{aligned}$$

Because the dynamic equivalent load changes stepwise along the traveling distance, the mean equivalent load is calculated from ① in Table 7 on page III-14.

$$\begin{aligned} P_{m1} &= \sqrt[3]{\frac{1}{S} \left( P_{1a}^3 \frac{V_{\max} t_1}{2} + P_{1b}^3 V_{\max} t_2 + P_{1c}^3 \frac{V_{\max} t_3}{2} \right)} \\ &= \left\{ \frac{1}{500} \times \left( 18800^3 \times \frac{100 \times 0.1}{2} + 17800^3 \times 100 \times 4.9 \right. \right. \\ &\quad \left. \left. + 17200^3 \times \frac{100 \times 0.1}{2} \right) \right\}^{1/3} \div 17800 \\ P_{m2} &= \left\{ \frac{1}{500} \times \left( 8110^3 \times \frac{100 \times 0.1}{2} + 7100^3 \times 100 \times 4.9 \right. \right. \\ &\quad \left. \left. + 6510^3 \times \frac{100 \times 0.1}{2} \right) \right\}^{1/3} \div 7110 \end{aligned}$$

The basic rating life of slide unit 1 receiving the largest dynamic equivalent load is calculated. The basic rating life is obtained by the formula (1) given on the page III-6 considering the load factor  $f_w$  (see Table 1 on page III-6).

$$\begin{aligned} L_1 &= 50 \left( \frac{C}{f_w P_{m1}} \right)^3 = 50 \left( \frac{74600}{1.5 \times 17800} \right)^3 \div 1090 \\ L_{h1} &= \frac{10^6 L_1}{2S n_1 \times 60} = \frac{10^6 \times 1090}{2 \times 500 \times 6 \times 60} \div 3030 \end{aligned}$$

As the result of calculation above, the basic rating life is about 3,030 hours.

#### ③ Calculating of static safety factor

The static equivalent load is calculated from the upward / downward load and lateral load by formula (10) on page III-8.

(During acceleration at the start of motion)

$$\begin{aligned} P_{01a} &= k_{0r} |F_{r1}| + k_{0a} |F_{a1}| + \frac{C_0}{T_0} |M_{01}| = 1 \times 16200 + 1.28 \times 280 \\ &\quad + \frac{80200}{1610} \times \frac{49000}{1000} \div 19000 \\ P_{02a} &= k_{0r} |F_{r2}| + k_{0a} |F_{a2}| + \frac{C_0}{T_0} |M_{02}| = 1.19 \times 5460 + 1.28 \\ &\quad \times 280 + \frac{80200}{1610} \times \frac{49000}{1000} \div 9300 \end{aligned}$$

(During constant speed motion)

$$\begin{aligned} P_{01b} &= 1 \times 15400 + 1.28 \times 0 + \frac{80200}{1610} \times \frac{49000}{1000} \div 19000 \\ P_{02b} &= 1.19 \times 4660 + 1.28 \times 0 + \frac{80200}{1610} \times \frac{49000}{1000} \div 7990 \end{aligned}$$

(During deceleration at the end of motion)

$$\begin{aligned} P_{01c} &= 1 \times 14600 + 1.28 \times 280 + \frac{80200}{1610} \times \frac{49000}{1000} \div 17400 \\ P_{02c} &= 1.19 \times 3860 + 1.28 \times 280 + \frac{80200}{1610} \times \frac{49000}{1000} \div 7390 \end{aligned}$$

The static safety factor of slide unit 1 during acceleration at the start of motion receiving the largest static equivalent load is calculated. The static safety factor is calculated by formula (5) on page III-6.

$$f_s = \frac{C_0}{P_{01a}} = \frac{80200}{19000} \div 4.2$$

As the result of calculation above, the static safety factor is about 4.2.

Accuracy

Five classes of accuracy, ordinary, high, precision, super precision, and ultra precision are specified for Linear Way and Linear Roller Way. The outline of applicable accuracy classes is shown in Table 8. For details, see an explanation of each series.

Table 8 Accuracy classes and series

| Class (classification symbol)                                  | Ordinary<br>(No symbol) | High<br>(H) | Precision<br>(P) | Super precision<br>(SP) | Ultra precision<br>(UP) |
|----------------------------------------------------------------|-------------------------|-------------|------------------|-------------------------|-------------------------|
| Series name                                                    |                         |             |                  |                         |                         |
| C-Lube Linear Way ML<br>Linear Way L                           | —                       | ○           | ○                | —                       | —                       |
| C-Lube Linear Way MLV                                          | —                       | ○           | —                | —                       | —                       |
| C-Lube Linear Way MV                                           | ○                       | ○           | ○                | ○                       | —                       |
| C-Lube Linear Way ME<br>Linear Way E                           | ○                       | ○           | ○                | ○                       | —                       |
| C-Lube Linear Way MH<br>Linear Way H                           | —                       | ○           | ○                | ○                       | —                       |
| Linear Way F                                                   | —                       | ○           | ○                | ○                       | —                       |
| C-Lube Linear Way MUL<br>Linear Way U                          | ○                       | ○           | —                | —                       | —                       |
| C-Lube Linear Roller Way Super MX<br>Linear Roller Way Super X | —                       | ○           | ○                | ○                       | ○                       |
| Linear Roller Way X                                            | —                       | ○           | ○                | ○                       | ○                       |
| Linear Way Module                                              | —                       | ○           | ○                | ○                       | —                       |

Preload

Objectives of preload

In some cases, the linear motion rolling guide is used with clearance given to the linear motion rolling guide when light motion with small load is required. However, for some applications, it may be used with play in the guiding mechanism removed or with preload to increase rigidity. Preload is applied to the contact parts of a raceway and rolling elements with internal stress generated in advance. When a external load is applied on the preloaded linear motion rolling guide, shock absorbing with this internal stress makes elastic deformation smaller, and its rigidity is increased. (See Fig. 3)

Preload setting

Preload amount is determined by considering the characteristics of the machines or equipments on which the linear motion rolling guide is mounted and the nature of load acting on the linear motion rolling guide. The standard amount of preload for linear motion rolling guides is, in general, approx. 1/3 of load when the rolling elements are balls (steel balls) and approx. 1/2 of load when they are rollers (cylindrical rollers). If the linear motion rolling guides are required to have very high rigidity to withstand vibration or fluctuating load, a larger preload may be applied. For applicable preload amount, see Table 9. For details, see an explanation of each series.

Precaution for preload selection

Even when high rigidity must be required, excessive preload should be avoided, because it will produce an excessive stress between rolling elements and raceways, and eventually result in short life of linear motion rolling guides. It is important to apply a proper amount of preload, considering the operational conditions. When using with a large preload, contact **IKO**.

Table 9 Series and preload amount

| Preload (preload symbol)                                       | Clearance<br>(Tc) | Clearance<br>(T0) | Standard<br>(No symbol) | Light preload<br>(T1) | Medium preload<br>(T2) | Heavy preload<br>(T3) |
|----------------------------------------------------------------|-------------------|-------------------|-------------------------|-----------------------|------------------------|-----------------------|
| Series name                                                    |                   |                   |                         |                       |                        |                       |
| C-Lube Linear Way ML<br>Linear Way L                           | —                 | ○                 | ○                       | ○                     | —                      | —                     |
| C-Lube Linear Way MLV <sup>(1)</sup>                           | —                 | —                 | —                       | —                     | —                      | —                     |
| C-Lube Linear Way MV                                           | ○                 | —                 | ○                       | ○                     | —                      | —                     |
| C-Lube Linear Way ME<br>Linear Way E                           | ○                 | —                 | ○                       | ○                     | ○                      | —                     |
| C-Lube Linear Way MH<br>Linear Way H                           | —                 | ○                 | ○                       | ○                     | ○                      | ○                     |
| Linear Way F                                                   | —                 | —                 | ○                       | ○                     | ○                      | —                     |
| C-Lube Linear Way MUL<br>Linear Way U                          | —                 | —                 | ○                       | ○                     | —                      | —                     |
| C-Lube Linear Roller Way Super MX<br>Linear Roller Way Super X | —                 | —                 | ○                       | ○                     | ○                      | ○                     |
| Linear Roller Way X                                            | —                 | —                 | ○                       | ○                     | ○                      | ○                     |

Note <sup>(1)</sup> Preload is adjusted to have subtle clearance or minimal amount of preload.

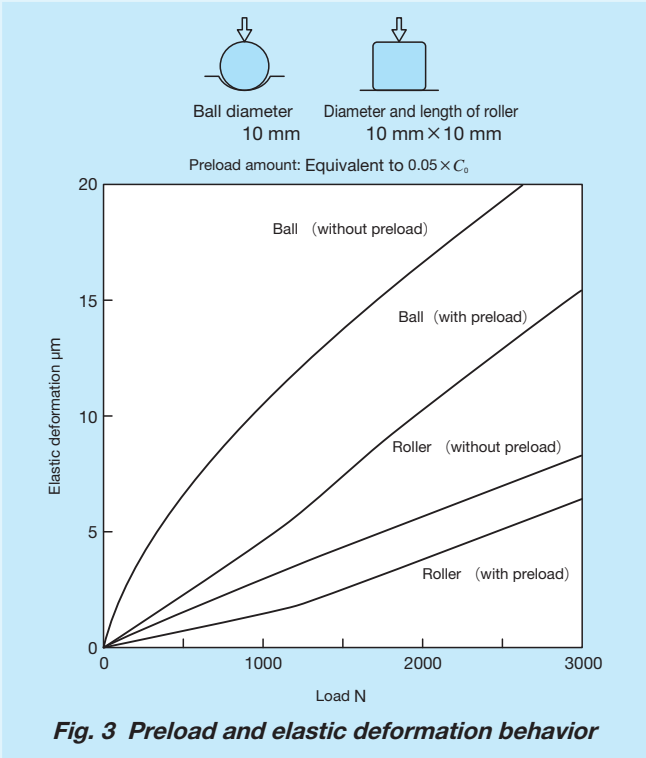


Fig. 3 Preload and elastic deformation behavior

# Friction

## Friction of linear motion rolling guide

The static friction (start-up friction) of linear motion rolling guides is much lower than that of conventional plain guides. Also, the difference between static friction and dynamic friction is small, and frictional resistance varies little when velocity changes. These are excellent features of linear motion rolling guides, and account for their ability to reduce power consumption, suppress operating temperature rise, and increase traveling speed. Since frictional resistance and variation are small, high-speed response characteristics to motion commands and high accuracy positioning can be achieved.

## Friction coefficient

The frictional resistance of linear motion rolling guides varies with their model, applied load, velocity and characteristics of lubricant. Generally, lubricant or seals are major factors in determining the frictional resistance in light load or high-speed operation, while the amount of load is the major factor in heavy load or low speed operation. The frictional resistance of linear motion rolling guides depends on various factors, but generally the following formula is used.

$$F = \mu P \cdots \cdots \cdots (11)$$

where,  $F$  : Frictional resistance, N  
 $\mu$  : Dynamic friction coefficient  
 $P$  : Applied load, N

For sealed guides, seal resistance is added to the above value, but this resistance varies greatly depending on the interference amount of seal lip and lubrication conditions. Where the lubrication and mounting condition are correct and the load is moderate, the friction coefficients of Linear Way and Linear Roller Way in operation are within the range shown in Table 10. Generally, friction coefficient is large under small load.

Table 10 Friction coefficient

| Series name       | Dynamic friction coefficient $\mu$ <sup>(1)</sup> |
|-------------------|---------------------------------------------------|
| Linear Way        | 0.0040～0.0060                                     |
| Linear Roller Way | 0.0020～0.0040                                     |

Note <sup>(1)</sup> These friction coefficients do not include seal.

# Lubrication

## Objectives of lubrication

The objectives of applying lubricant for linear motion rolling guides is to keep raceways, rolling elements, etc. in a linear motion rolling guide from metal contact, and thereby reduce friction and wear preventing heat generation and seizure. When an adequate oil film is formed at the rolling contact area between the raceways and rolling elements, the contact stress due to load can be reduced. To manage the formation of adequate oil film is important for ensuring the reliability of linear motion rolling mechanism.

## Selection of lubricant

To obtain the full performance of linear motion rolling guides, it is necessary to select an appropriate lubricant and lubrication method by considering the model, load and velocity of each linear motion rolling guide. However, as compared with plain guides, lubrication of linear motion rolling guides is much simpler. Only a small amount of lubrication oil is needed and replenishment interval is longer, so maintenance can be greatly reduced. Grease and oil are the two most commonly used lubricants for linear motion rolling guides.

## Grease lubrication

For linear motion rolling guides, lithium-soap base grease (Consistency No.2 of JIS) is commonly used. For rolling guides operating under heavy load conditions, grease containing extreme pressure additives is recommended. In clean and high-vacuum environments, where low dust generating performance and low vaporization characteristics are required, greases containing a synthetic-base oil or a soap other than the lithium-soap base are used. For applications in these environments, due consideration is necessary to select a grease that is suitable for the operating conditions of linear motion rolling guide and achieves satisfactory lubrication performance at the same time.

Table 11 Pre-packed grease list

| Series name                                                        | Pre-packed grease                                 |
|--------------------------------------------------------------------|---------------------------------------------------|
| C-Lube Linear Way ML<br>Linear Way L                               | MULTEMP PS No.2<br>[KYODO YUSHI CO., LTD.]        |
| C-Lube Linear Way MLV                                              |                                                   |
| C-Lube Linear Way MV                                               | Alvania EP Grease 2<br>[SHOWA SHELL SEKIYU K. K.] |
| C-Lube Linear Way ME<br>Linear Way E                               |                                                   |
| C-Lube Linear Way MH <sup>(1)</sup><br>Linear Way H <sup>(1)</sup> |                                                   |
| Linear Way F                                                       |                                                   |
| C-Lube Linear Way MUL<br>Linear Way U <sup>(2)</sup>               | MULTEMP PS No.2<br>[KYODO YUSHI CO., LTD.]        |
| C-Lube Linear Roller Way Super MX<br>Linear Roller Way Super X     | Alvania EP Grease 2<br>[SHOWA SHELL SEKIYU K. K.] |
| Linear Roller Way X                                                |                                                   |
| Linear Way Module                                                  |                                                   |

Notes <sup>(1)</sup> MULTEMP PS No.2 is pre-packed in size 8 to 12 series.  
<sup>(2)</sup> Alvania EP Grease 2 is pre-packed in size 40 to 130 series.

## Grease replenishment interval

The quality of any grease will gradually deteriorate as operating time passes. Therefore, periodic replenishment is necessary. Grease replenishment interval varies depending on the operating conditions. A six month interval is generally recommended, and if the machine operation consists of reciprocating motions with many cycles and long strokes, replenishment every three month is recommended. In addition, linear motion rolling guides in which the lubrication part "C-Lube" is built deliver long-term maintenance free performance. This eliminates the need for lubrication mechanism and workload which used to be necessary for linear motion rolling guides and significantly reduces maintenance cost.

## Grease replenishment method

New grease must be supplied through a grease feed device such as a grease nipple until old grease is discharged. After grease is replenished, running-in is performed and excess grease will be discharged to outside of the linear motion rolling guide. Discharged grease must then be removed before starting the operation. The amount of grease required for standard replenishment is about 1/3 to 1/2 of the free space inside the linear motion rolling guide. When grease is supplied from a grease nipple for the first time, there will be grease lost in the replenishment path. The amount lost should be taken into consideration. Generally, immediately after grease is replenished, frictional resistance tends to increase. If additional running-in is performed for 10 to 20 reciprocating cycles after excess grease is discharged, frictional resistance becomes small and stable. For applications where low frictional resistance is required, the replenishment amount of grease may be reduced, but it must be kept to an appropriate level so as not to give a bad influence on the lubrication performance.

Table 12 Grease brands used in linear motion rolling guide

| Brand                                                           |                             | Base oil                   | Thickener               | Range of operating temperature <sup>(2)</sup><br>℃ | Usage                                              |
|-----------------------------------------------------------------|-----------------------------|----------------------------|-------------------------|----------------------------------------------------|----------------------------------------------------|
| Alvania EP Grease 2                                             | [SHOWA SHELL SEKIYU K. K.]  | Mineral oil                | Lithium                 | -20～110                                            | General application with extreme-pressure additive |
| Alvania Grease S2                                               | [SHOWA SHELL SEKIYU K. K.]  | Mineral oil                | Lithium                 | -25～120                                            | General application                                |
| MULTEMP PS No.2                                                 | [KYODO YUSHI CO., LTD.]     | Synthetic oil, Mineral oil | Lithium                 | -50～130                                            | General application                                |
| <b>IKO</b> Low Dust-Generation Grease for Clean Environment CG2 | [NIPPON THOMPSON CO., LTD.] | Synthetic oil              | Urea                    | -40～200                                            | For clean environment<br>Long life                 |
| <b>IKO</b> Low Dust-Generation Grease for Clean Environment CGL | [NIPPON THOMPSON CO., LTD.] | Synthetic oil, Mineral oil | Lithium / Calcium       | -30～120                                            | For clean environment<br>Low sliding               |
| DEMNUM™ Grease L-200 <sup>(1)</sup>                             | [DAIKIN INDUSTRIES, LTD.]   | Synthetic oil              | Ethylene tetra-fluoride | -60～300                                            | For clean environment                              |
| FOMBLIN® Y-VAC3 <sup>(1)</sup>                                  | [SOLVAY SOLEXIS]            | Synthetic oil              | Ethylene tetra-fluoride | -20～250                                            | For vacuum                                         |
| <b>IKO</b> Anti-Fretting Corrosion Grease AF2                   | [NIPPON THOMPSON CO., LTD.] | Synthetic oil              | Urea                    | -50～170                                            | Fretting-proof                                     |
| 6459 Grease N                                                   | [SHOWA SHELL SEKIYU K. K.]  | Mineral oil                | Poly-urea               | —                                                  | Fretting-proof                                     |

Notes <sup>(1)</sup> Set replenishment intervals to short.  
<sup>(2)</sup> The ranges of operating temperature are quoted from the grease manufacturer's cataloged values, but do not guarantee regular use under high temperature environment.  
Remarks 1. FOMBLIN® is a registered trademark of SOLVAY SOLEXIS.  
2. Check with the chosen grease manufacturer's catalog before use.  
For grease for use other than listed, contact **IKO**.

## Mixing of different type of grease

Mixing different types of grease may result in changing the properties of base oil, soap base, or additives used, and, in some cases, severely deteriorate the lubrication performance or cause trouble due to chemical changes of additives. Old grease should therefore be removed thoroughly before filling with new grease.

## Lubrication part "C-Lube"

C-Lube is a porous resin with molding formed fine resin powder. It is a lubrication part impregnated with a large amount of lubrication oil in its open pores by capillary inside. Lubrication oil is supplied directly to balls (steel balls) or rollers (cylindrical rollers), not to the track rail. When the balls or rollers have contact with C-Lube built in the slide unit, lubrication oil is supplied to the surface of the balls or rollers. As the balls or rollers circulate, the lubricant is distributed to the loading area along the track rail. This results in adequate lubrication oil being properly maintained in the loading area and lubrication performance will last for a long time. The surface of C-Lube is always covered with the lubrication oil. Lubrication oil is continuously supplied to the surface of balls or rollers by surface tension in the contact of C-Lube surface and balls or rollers.

## Oil lubrication

For oil lubrication, heavy load requires high oil viscosity and high velocity requires low oil viscosity. Generally, for linear motion rolling guides operating under heavy load, lubrication oil with a viscosity of about 68 mm<sup>2</sup>/s is used. For linear motion rolling guides under light load at high-speed operation, lubrication oil with a viscosity of about 13 mm<sup>2</sup>/s is used.



## Miniature greaser

The miniature greaser is specially prepared for grease replenishment for Linear Way and Linear Roller Way with an oil hole. Table 13 shows types of grease and specifications of miniature greasers.



**Table 13 Grease type and miniature greaser**

| Identification number | Grease name                                                     | Amount | Outer diameter of grease feed needle |
|-----------------------|-----------------------------------------------------------------|--------|--------------------------------------|
| MG10 / MT2            | MULTEMP PS No.2<br>[KYODO YUSHI CO., LTD.]                      | 10 ml  | ø 1 mm                               |
| MG10 / CG2            | <b>IKO</b> Low Dust-Generation Grease for Clean Environment CG2 |        |                                      |
| MG2.5 / EP2           | Alvania EP Grease 2<br>[SHOWA SHELL SEKIYU K. K.]               | 2.5 ml |                                      |
| MG2.5 / CG2           | <b>IKO</b> Low Dust-Generation Grease for Clean Environment CG2 |        |                                      |
| MG2.5 / CGL           | <b>IKO</b> Low Dust-Generation Grease for Clean Environment CGL |        |                                      |
| MG2.5 / AF2           | <b>IKO</b> Anti-Fretting Corrosion Grease AF2                   |        |                                      |

## Grease nipple and supply nozzle

Tables 14.1 and 14.2 show the specifications of grease nipples and applicable types of supply nozzles, and Table 15 shows the specifications of supply nozzles.

**Table 14.1 Grease nipple and applicable supply nozzle type**

| Grease nipple |                                                                                                      | Applicable supply nozzle type            |                                            |
|---------------|------------------------------------------------------------------------------------------------------|------------------------------------------|--------------------------------------------|
| Type          | Dimensions and shape                                                                                 | Type                                     | Shape                                      |
| A-M3          | <p>Width across flats 4<br/>M3×0.5<br/>4.5<br/>4.2</p>                                               | A-5120V<br>A-5240V<br>B-5120V<br>B-5240V |                                            |
| A-M4          | <p>Width across flats 4.5<br/>M4×0.7<br/>6<br/>4</p>                                                 |                                          | Straight type<br><p>A-****V</p>            |
| B-M4          | <p>About 67.5°<br/>Width across flats 6<br/>M4×0.7<br/>5.1<br/>3.7<br/>10</p> <p>(Tapered screw)</p> |                                          | Straight type with angle<br><p>B-****V</p> |

**Table 14.2 Grease nipple and applicable supply nozzle type**

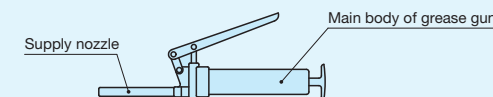
| Grease nipple |                                                                      | Applicable supply nozzle type    |               |
|---------------|----------------------------------------------------------------------|----------------------------------|---------------|
| Type          | Dimensions and shape                                                 | Type                             | Shape         |
| B-M6          | <p>JIS type 1 equivalent<br/>Width across flats 8<br/>MT6 × 0.75</p> | Products available on the market |               |
| JIS type 1    | <p>Width across flats 7<br/>M6 × 0.75<br/>5.4 or less</p>            |                                  | Straight type |
| JIS type 2    | <p>Width across flats 10<br/>PT1/8<br/>9.5 or less</p>               |                                  | Chuck type    |
| JIS type 4    | <p>JIS type 1 equivalent<br/>Width across flats 10<br/>PT1/8</p>     |                                  | Hose type     |
| A-PT 1/4      | <p>Width across flats 14<br/>PT1/4<br/>12.5 or less</p>              |                                  |               |

Note (1) For straight type, chuck type and hose type supply nozzles available on the market, it is recommended to use one with an outer diameter  $D$  of 13 mm or less.

**Table 15 Types and dimensions of supply nozzle**

| Type    | Dimensions and shape |
|---------|----------------------|
| A-5120V |                      |
| A-5240V |                      |
| B-5120V |                      |
| B-5240V |                      |
| A-8120V |                      |
| B-8120V |                      |

Remark: The supply nozzles shown in the table can be mounted on the main body of a common grease gun available on the market shown below. If needed, specify the supply nozzle type and place an order to **IICO**.



## Piping joint

When applying centralized grease or oil lubrication, detach the grease nipple or plug from the slide unit, and replace them with piping joints, which are prepared for various female threads for piping. Use them after confirming the dimensions of the piping joints and  $H_3$  dimensions in the dimensions table of each models, because the top face of some piping joints is at the same or higher level than the top face of slide unit. Fig. 4.1 and 4.2 and Tables 16.1, 16.2, 16.3, and 16.4 show identification number and dimensions of piping joints. Note that some of them are not applicable for the slide units of special specifications. Piping joints can be mounted on Linear Way and Linear Roller Way prior to delivery upon request. If needed, please contact **IKO**.

Identification number SC4-20S

Technical drawing of the SC4-20S connector. The drawing shows a side view of the connector with dimensions: total length 20, hexagonal section length 9, hexagonal section diameter 8, and thread diameter 5.2. The thread is M4 x 0.7. The inner diameter of the pipe is 1.5. A top view shows a square with side length 8 and a central circular hole with diameter 5. The connector is labeled M6 x 0.75 and Depth 5.

Remark: Not applicable to MX, LRX series.

**Fig. 4.1 Piping joint for M4×0.7 (Straight type)**

|                       |        |
|-----------------------|--------|
| Identification number | LC4-17 |
|-----------------------|--------|

Technical drawing of the LC4-17 component. The drawing includes two views: a front view and a side view.

**Front View (Left):**

- Width: 11
- Height: 7
- Radius: 3.5

**Side View (Right):**

- Total length: 17
- Length of tapered screw section: 7
- Outer diameter of tapered screw section:  $\phi 4.2$
- Inner diameter of tapered screw section: Inner diameter of pipe  $\phi 1.5$
- Threaded section:  $M6 \times 0.75$  Depth 6
- Threaded section diameter: 6
- Threaded section length: 19.6
- Threaded section thread:  $M4 \times 0.7$  (Tapered screw)

Remark: It is recommended to mount the straight type piping joint in Table 16.1 for female threads (M6×0.75).

**Fig. 4.2 Piping joint for M4×0.7 (L type)**

**Table 16.1 Piping joint for M6×0.75 (Straight type)**

unit: mm

| Identification number | $L_1$ | $L_2$ | $L_3$ | $D$ |
|-----------------------|-------|-------|-------|-----|
| SC6-16                | 22    | 12.4  | 16    | 9   |
| SC6-22S               | 28    | 12    | 22    | 6   |
| SC6-25S               | 31    | 12    | 25    | 6   |

Table 16.2 Piping joint for M6×0.75 (L type)

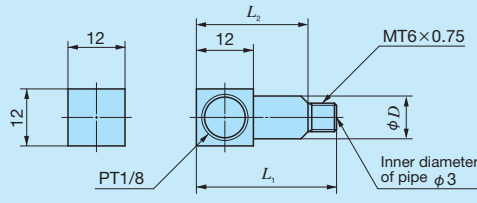
|  |       |       |     |
|-----------------------------------------------------------------------------------|-------|-------|-----|
| unit: mm                                                                          |       |       |     |
| Identification number                                                             | $L_1$ | $L_2$ | $D$ |
| LC6-18                                                                            | 25    | 18    | 9   |
| LC6-22S                                                                           | 28    | —     | 6   |
| LC6-24                                                                            | 30.5  | 23.5  | 9   |
| LC6-25S                                                                           | 31    | —     | 6   |

Table 16.3 Piping joint for PT1/8 (Straight type)

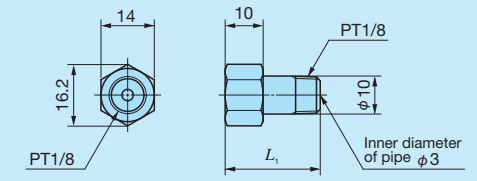
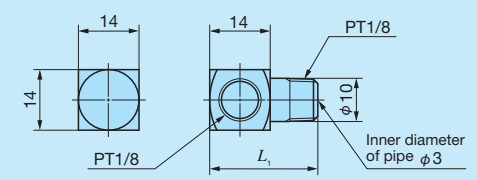
|  |       |
|-----------------------------------------------------------------------------------|-------|
| unit: mm                                                                          |       |
| Identification number                                                             | $L_1$ |
| SC1/8-19S                                                                         | 25    |
| SC1/8-34S                                                                         | 40    |

Table 16.4 Piping joint for PT1/8 (L type)

|  |       |
|-------------------------------------------------------------------------------------|-------|
| unit: mm                                                                            |       |
| Identification number                                                               | $L_1$ |
| LC1/8-19S                                                                           | 25    |
| LC1/8-34S                                                                           | 40    |

## Dust Protection

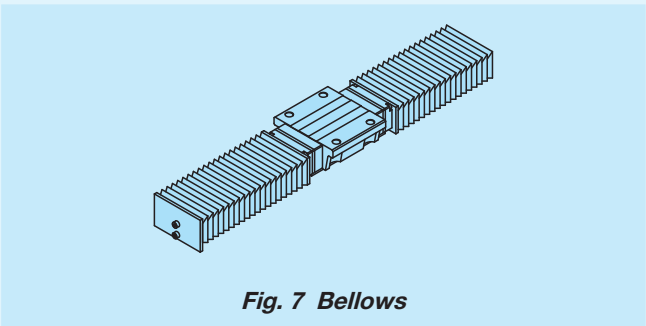
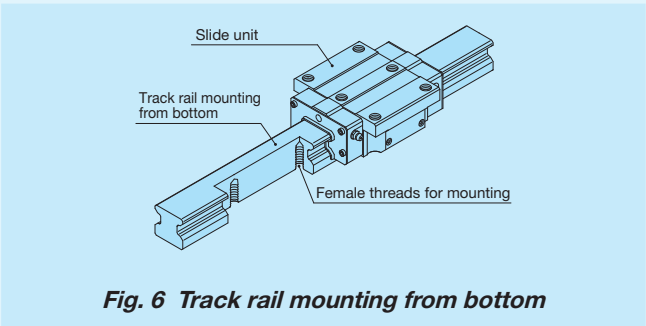
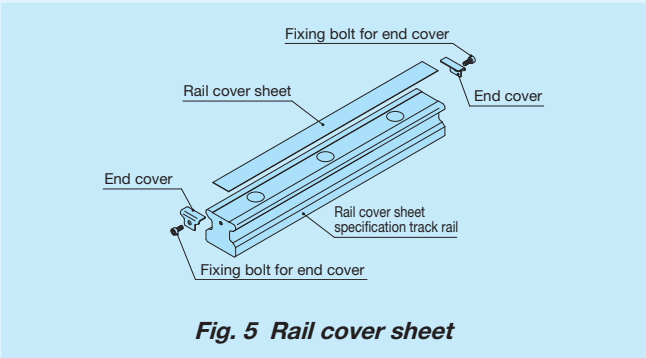
### Purpose of dust protection

To obtain the full performance of linear motion rolling guides, it is important to protect them from the intrusion of dust and other harmful foreign substances. Select an effective sealing or dust-protection device to withstand any operating conditions that might be imposed.

### Method of dust protection

Linear Way and Linear Roller Way have end seals as a standard specification. In addition, double seals or scrapers are provided as special specifications for improvement in dust protection performance. Also caps and a rail cover sheet to cover the mounting hole of track rail (Fig. 5) and track rail mounting from bottom with no mounting hole on the upper surface (Fig. 6) will further increase the reliability of dust protection.

However, if large amount of contaminant or dust are floating, or if large particles of foreign substances such as chips or sand may adhere to the raceway, complete dust protection becomes difficult. In this case, it is recommended to cover the whole unit with bellows (Fig. 7), telescope type shield, etc. When rail cover sheet or track rails mounting from bottom specification is needed, please contact **IKO**.

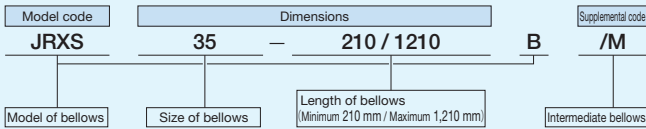


### Specific bellows

The specific bellows are manufactured to match the dimensions of Linear Way and Linear Roller Way for easy mounting and excellent dust protection. If special bellows to be used in an upside-down position or those made of heat-resistant material are needed, please contact **IKO**.

### Identification number of bellows

The identification number of bellows consists of a model code, dimensions, and any supplemental codes. Its standard arrangement is shown below.



### Calculation of minimum length of bellows

The minimum necessary length of specific bellows is determined, by first calculating the necessary number of accordion pleats as follows.

$$ns = \frac{S}{\ell s_{\max} - \ell s_{\min}}$$

where,  $ns$ : Number of pleats (Raise decimal fractions)  
 $S$ : Stroke length, mm  
 $\ell s_{\max}$ : Maximum length of one pleat (See Tables 18.1 and 18.2)  
 $\ell s_{\min}$ : Minimum length of one pleat (See Tables 18.1 and 18.2)

$$L_{\min} = ns \times \ell s_{\min} + m \times 5 + 10$$
$$L_{\max} = S + L_{\min}$$

where,  $L_{\min}$ : Minimum length of bellows, mm  
 $L_{\max}$ : Maximum length of bellows, mm  
 $m$ : Number of internal guide plates (See Table 17)

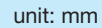
Table 17 Number of internal guide plates for bellows

| Model                                 | P dimensions of specific bellows (1) mm |       | Number of internal guide plates $m$                   |
|---------------------------------------|-----------------------------------------|-------|-------------------------------------------------------|
|                                       | Above                                   | Below |                                                       |
| JEF<br>JRES                           | —                                       | 35    | $m = \frac{ns}{7} - 1$                                |
| JES<br>JHS<br>JFS<br>JRXS···B<br>JFFS | —                                       | 22    | $m = \frac{ns}{16}$<br>when $ns \leq 20$ , then $m=0$ |
|                                       | 22                                      | 25    | $m = \frac{ns}{12}$<br>when $ns \leq 18$ , then $m=0$ |
|                                       | 25                                      | 35    | $m = \frac{ns}{8}$                                    |

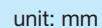
Note (1) For  $P$  dimensions, see Table 18.1 and Table 18.2.  
Remark: In calculating the number of internal guide plates  $m$ , raise the decimal fractions for JEF and JRES and omit the decimal fractions for others.

### Intermediate bellows

Since different type of mounting plate is used for mounting bellows between slide units, add supplemental code "/M" onto the identification number when ordering. Reinforced bellows are also available, which are specially designed for use on long track rails or for lateral mounting. The width  $A$  of reinforced bellows is greater than that of standard type bellows. If needed, please contact **IKO**.



Notes (1) Not applicable to horizontal mounting type LWHY.  
 (2) The height of bellows may become higher than the height  $H$  of dimensions of assembly of slide units. Check  $H$  dimensions of each series in dimension table.  
 (3) The width of bellows may become larger than the  $W_2$  dimensions of slide units. Check with  $W_2$  dimensions of each series in dimension table.



Notes (1) The height of bellows may become higher than the height  $H$  of dimensions of assembly of slide units. Check  $H$  dimensions of each series in dimension table.

(2) The width of bellows may become larger than the  $W$ , dimensions of slide units. Check  $W$ , dimensions of each series in dimension table.



1 set



Only C1 is specified. Please specify S1 or S2.



1 unit

Please specify S1 or S2.



1 set

- Please specify S1 or S2.



2 sets

(When 2 sets as 1 assembled group is needed)



2 set

(When 2 sets as 1 assembled group is needed)

# Special Specification

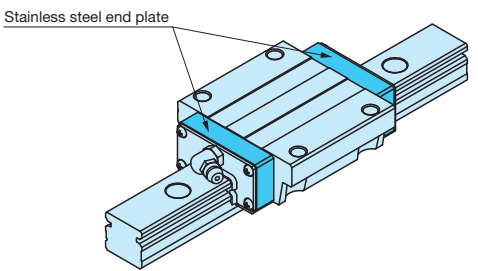
For Linear Way and Linear Roller Way, special specification described in pages III-29 through III-35 is available. There is limitation on applicable special specification. For details, see an explanation of each series.

## Butt-jointing track rails /A



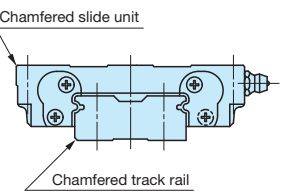
When the track rail of non-interchangeable specification is longer than the maximum length, two or more track rails should be butted in a linear motion direction. For length and number of track rails to butt, contact **IKO**.

## Stainless steel end plate /BS



The standard synthetic resin end plates are replaced with stainless steel end plates. The total length of the slide unit remains unchanged. In addition, for improvement of heat resistance, it is recommended to use "No end seal (supplemental code /N)" together.

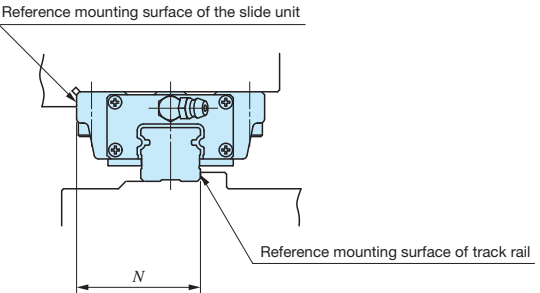
## Chamfered reference surface /C /CC



Add chamfer to the reference mounting surface of the slide unit and track rail.

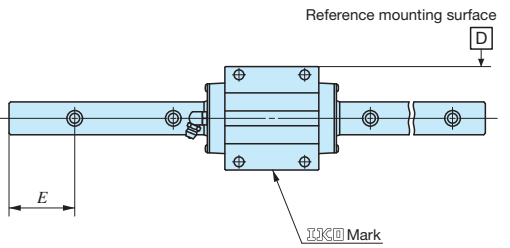
- ① /C Add chamfer to the reference mounting surface of the track rail.
- ② /CC Add chamfer to the reference mounting surface of the slide unit and track rail.

## Opposite reference surfaces arrangement /D



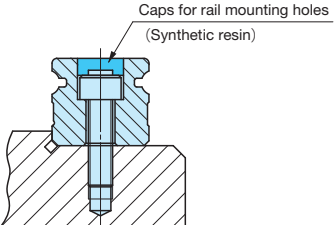
Reference mounting surface of the track rail should be the opposite of the standard position. Accuracy of  $N$  dimensions and parallelism during operation remain unchanged.

## Specified rail mounting hole positions /E



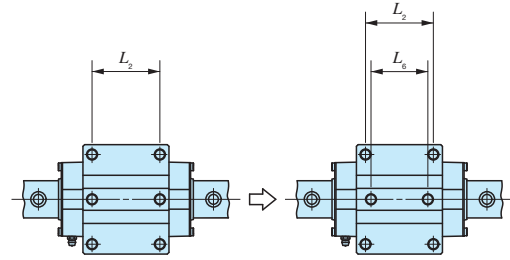
By specifying  $E$  dimensions from the mounting hole at the track rail left end to the left end surface when seen from **IKO** mark of the slide unit, specify the position of track rail mounting hole. Specify the dimensions (in mm) after "/E". In addition,  $E$  dimension range is limited. For details, please contact **IKO**. For Linear Way H horizontal mounting type and Linear Way Module series, see an explanation of each series.

## Caps for rail mounting holes /F



Dedicated caps for rail mounting holes are included. They close track rail mounting holes to improve sealing property in a motion direction. Contact **IKO** for aluminum alloy caps for rail mounting holes.

## Changed pitch of slide unit middle mounting holes /GE

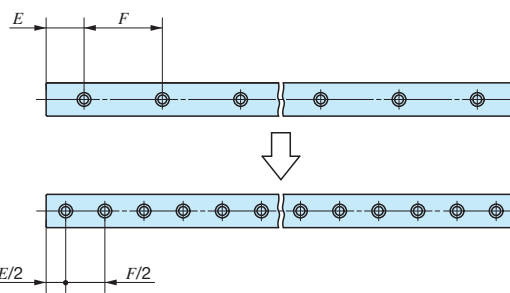


Change the dimension between mounting holes at the slide unit center.

## Hybrid C-Lube Linear Way /HB

Change the material of rolling elements built into the slide unit to silicon nitride ceramics.

## Half pitch mounting holes for track rail /HP



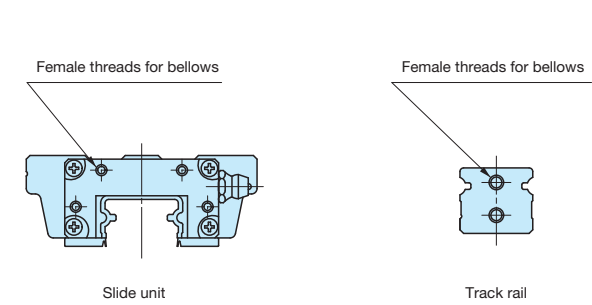
Set the pitch of track rail mounting holes to a half of the standard  $F$  dimension. The specification with bolts for track rail mounting holes are supplied with the required number of bolts.



Inspection sheet / I

Inspection sheet of *H* dimension, *N* dimension and parallelism during slide unit operation are appended in each set.

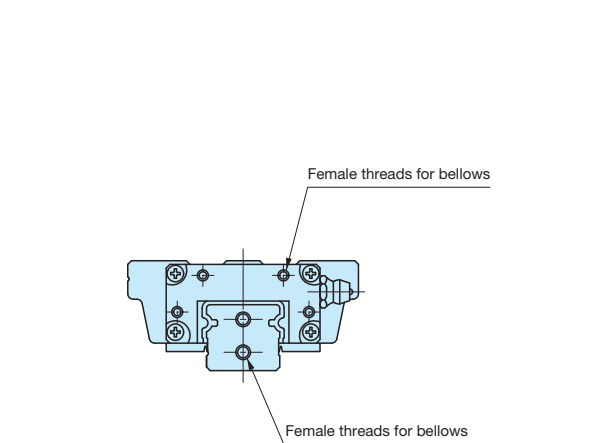
Female threads for bellows (Single unit) /J /JR /JL



For single slide unit or single track rail of the interchangeable specification, fit female threads for bellows.

- ① /J Fit female threads to both ends of the slide unit or track rail.
- ② /JR Fit female threads to a right end surface of the slide unit seen from mark of the slide unit.
- ③ /JL Fit female threads to a left end surface of the slide unit seen from mark of the slide unit.

Female threads for bellows (Assembled set) /J /JJ /JR /JS /JJS



For assembled set of the interchangeable specification or a non-interchangeable specification product, fit female threads for bellows to the slide unit and track rail.

- ① /J Fit female threads to both ends of the track rail and to slide unit end nearest to both ends of the track rail. (When only one slide unit is used, fit them to both ends of the track rail)
- ② /JJ When two or more slide units are used, fit female threads to both ends of the track rail and to both ends of each slide unit. (When only one slide unit is used, specify "/J")
- ③ /JR Fit female threads to both ends of the track rail.
- ④ /JS Fit female threads to slide unit end nearest to both ends of the track rail. (When only one slide unit is used, they are fitted to both ends of the track rail)
- ⑤ /JJS When two or more slide units are used, fit female threads to both ends of each slide unit. (When only one slide unit is used, specify "/JS")

Black chrome surface treatment /LC /LR /LCR

Acrylate resin coating is applied to improve the rust prevention property after black impregnated chrome surface treatment.

- ① /LC Perform casing treatment.
- ② /LR Perform track rail treatment.
- ③ /LCR Perform casing and track rail treatment.

Fluorine black chrome surface treatment /LFC /LFR /LFCR

Fluorinated resin coating is applied to improve the rust prevention property after black impregnated chrome surface treatment. In addition, this prevent foreign substances from sticking to the surface.

- ① /LFC Perform casing treatment.
- ② /LFR Perform track rail treatment.
- ③ /LFCR Perform casing and track rail treatment.

With track rail mounting bolt /MA

Recommended track rail mounting bolt is included. For bolt size, see the dimension table.

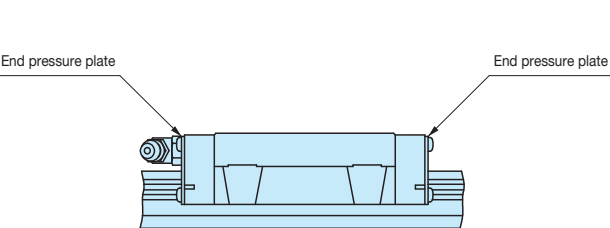
Without track rail mounting bolt /MN

Track rail mounting bolt is not included.

Changed size of mounting holes /M4

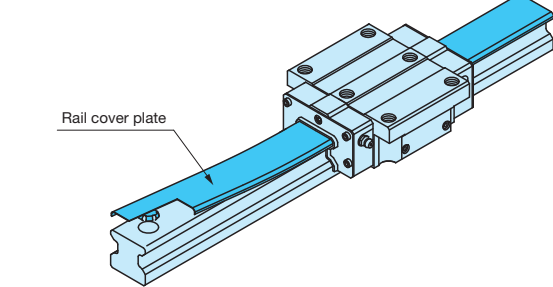
Set the M3 track rail mounting hole for ME15 to M4. For combination with track rail mounting bolt (supplemental code "/MA"), specify "/MA4".

No end seal /N



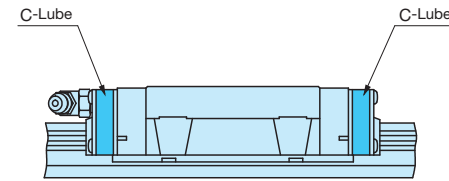
End seals at both ends of the slide unit can be replaced with end pressure plates, which do not come in contact with the track rail, to reduce frictional resistance. No under seal is attached. This specification is not effective for dust protection.

Rail cover plate for track rail /PS



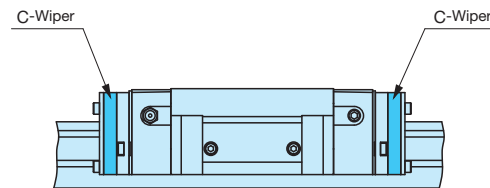
Deliver with the track rail cover plate mounted. Covering the upper surface with U-shape stainless steel thin plate after assembly of the track rail improves the sealing property further. Change the end seal to dedicated one. In addition, see the supplied rail cover plate instruction manual for mounting of rail cover plate.

With C-Lube plate /Q



The C-Lube impregnated with lubricant is attached inside the end seal of the slide unit, so that the interval for reapplying lubricant can be extended.

C-Wiper /RC /RCC



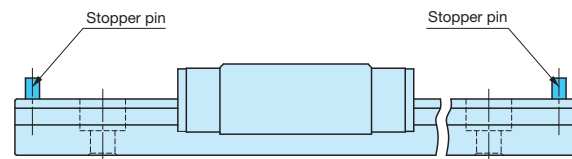
C-Wiper is mounted on the slide unit end to improve dust protection property. In addition, the slide unit with C-Wiper is equipped with inner seal (/UR) and scraper (/Z) together.

- ① /RC Fit C-Wiper to slide unit end nearest to both ends of the track rail. When only one slide unit is used, fit them to both ends of the track rail.
- ② /RCC When two or more slide units are used, fit C-Wiper to both ends of each slide unit.

Special environment seal /RE

The standard end seal and under seal are replaced with seals for special environment that can be used at high temperatures.

Track rail with stopper pins /S

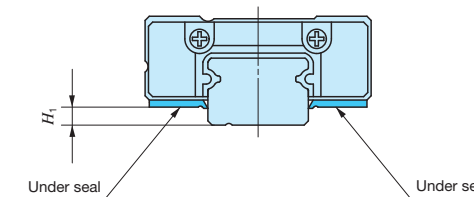


Mount stopper pins to both ends of the track rail as slide unit retainers.

Butt-jointing track rails (Interchangeable specification) /T

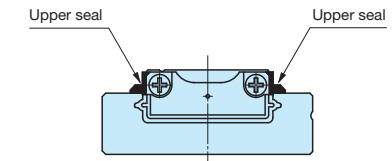
Finish the butted parts at both ends so as to set the interchangeable specification track rail in a linear motion direction. Butt the same interchangeable code for track rails. For non-interchangeable specification, specify butt-jointing track rails "/A".

Under seal <sup>(1)</sup> /U

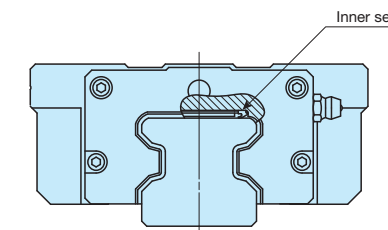


The seal is attached to the bottom of the slide unit to prevent foreign substances from entering from underneath.

Note <sup>(1)</sup> For C-Lube Linear Way UL and Linear Way U, attach "upper seal". The seal is attached to the upper end of the slide unit to prevent foreign substances from entering from above.

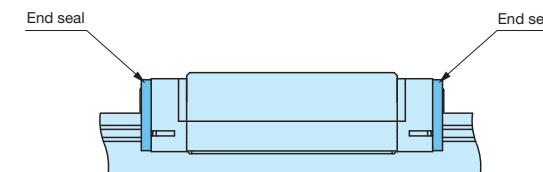


Inner seal /UR



Attach the inner seal to the inside of the slide unit. Inner seal improves dust protection property of the cylindrical roller circulation part against foreign substances from the upper surface of the track rail.

End seal /US



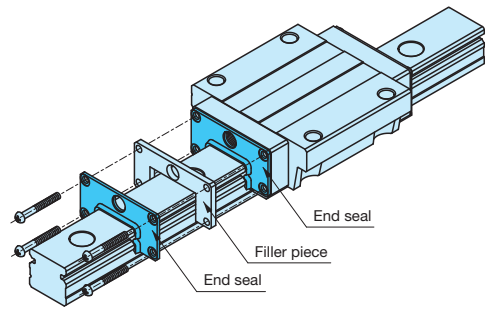
Attach end seals instead of scrapers on both sides of the slide unit in order to improve the dust protection performance.

Double seals (Single unit) /V /VR /VL

Double end seals are mounted to the interchangeable specification slide unit to improve the dust protection property.

- ① /V Apply double seals to both ends of the slide unit.
- ② /VR Apply double seals to a right end surface of the slide unit seen from the  mark of the slide unit.
- ③ /VL Apply double seals to a left end surface of the slide unit seen from the  mark of the slide unit.

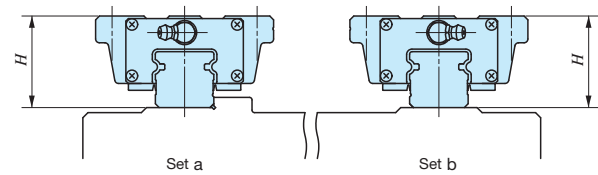
Double seals (Assembled set) /N /VV



Double end seals are mounted to the interchangeable specification assembled set or non-interchangeable specification product's slide unit to improve the dust protection property.

- ① /N Apply double seals to slide unit end nearest to both ends of the track rail. When only one slide unit is used, fit them to both ends of the track rail.
- ② /VV When two or more slide units are used, apply double seals to both ends of each slide unit.

A group of multiple assembled sets /W



Set the variation of  $H$  dimensions of the Linear Way and Linear Roller Way of multiple assembled sets on the same flat surface in the standard range. The variation of  $H$  dimensions of the multiple assembled sets is the same as the accuracy of one set. Indicate the number of sets after "/W" based on the number of units when specify.

Specified grease /YCG /YCL /YAF /YBR /YNG

The type of pre-packed grease can be changed by the supplemental code.

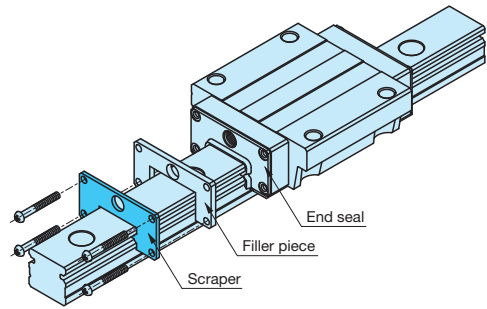
- ① /YCG Low Dust-Generation Grease for Clean Environment CG2 is pre-packed.
- ② /YCL Low Dust-Generation Grease for Clean Environment CGL is pre-packed.
- ③ /YAF Anti-Fretting Corrosion Grease AF2 is pre-packed.
- ④ /YBR MOLYCOTE BR2- Plus Grease [Dow Corning] is pre-packed.
- ⑤ /YNG No grease is pre-packed.

Scraper (Single unit) /Z /ZR /ZL

Mount a metal scraper to the interchangeable specification slide unit. The scraper is non-contact type and effectively eliminate large foreign substances adhering to the track rail.

- ① /Z Mount scrapers to both ends of the slide unit.
- ② /ZR Fit a scraper to a right end surface of the slide unit seen from IKO mark of the slide unit.
- ③ /ZL Fit a scraper to a left end surface of the slide unit seen from IKO mark of the slide unit.

Scraper (Assembled set) /Z /ZZ



Mount a metal scraper to the interchangeable specification assembled set or non-interchangeable specification product's slide unit. The scraper is non-contact type and effectively eliminate large foreign substances adhering to the track rail.

- ① /Z Fit a scraper to slide unit end nearest to both ends of the track rail. When only one slide unit is used, fit them to both ends of the track rail.
- ② /ZZ When two or more slide units are used, fit scrapers to both ends of each slide unit.

Precaution for Use

Operating temperature

The maximum operating temperature for linear motion rolling guide with integrated C-Lube is 80°C. The maximum operating temperature for linear motion rolling guide without integrated C-Lube is 120°C and temperature up to 100°C is allowed for continuous operation. When the temperature exceeds 100°C, contact IKO. When specifying special specification with C-Lube plate (supplemental code "/Q"), utilize it below 80°C.

Multiple slide units used in close proximity

When using multiple slide units in close proximity, greater load may be applied than the calculated value depending on the deviation of slide unit mounting accuracy for the machine or device. In such cases, allowance for greater applied load than the calculated value should be made.

Lateral or upside-down mounting

For lateral or upside-down mounting of the Linear Way E and Linear Way F, specify the special specification (supplemental code "/U") with under seal as necessary to prevent foreign substances from entering into the slide unit.

Operation velocity

Operation velocity limit value of the Linear Way and Linear Roller Way depends on operation conditions such as motion characteristics, applied load, lubrication status, mounting accuracy and environment temperature. Reference values based on actual performance and experienced values as a reference of maximum velocity under typical operating conditions are indicated in Table 19.

Table 19 Reference maximum velocity

| Size | Maximum velocity m/min |
|------|------------------------|
| 35   | 180                    |
| 45   | 120                    |
| 55   | 100                    |
| 65   | 75                     |

Cleaning and removing fat

Never clean up a linear motion rolling guide with integrated C-Lube with organic solvent or white kerosene with property of removing fat.

Lubrication oil supply point for oil lubrication

If the lubrication oil is supplied by a gravity drip system, enough lubrication oil may not be supplied to ways above the supply point, so lubrication path and supply point must be considered. For such applications, contact IKO.

Precaution for Mounting

When mounting multiple assembled sets at the same time

- Interchangeable specification products For interchangeable specification products, assemble a slide unit and a track rail with the same interchangeable code ("S1" or "S2").
- Non-interchangeable specification products Do not change the combination of delivered slide unit and track rail.
- Product including multiple assembled sets For special specification (supplemental code "/W") products with multiple assembled sets, the delivered combination is managed as a group for variation. So do not mix with different group for mounting.

Assembling of slide unit and track rail

When assembling the slide unit on the track rail, correctly fit the grooves of the slide unit and the track rail and move the slide unit softly in parallel direction. Rough handling may result in damaging of seals or dropping of steel balls and cylindrical roller. For product including a dummy rail as a standard accessory, operation of the slide unit to the track rail can be made easier by using the dummy rail. Though the dummy rail is included as an accessory of products indicated in Table 21.1 and Table 21.2, it is also available for other products. If these parts are necessary, please contact IKO.

Mounting accuracy

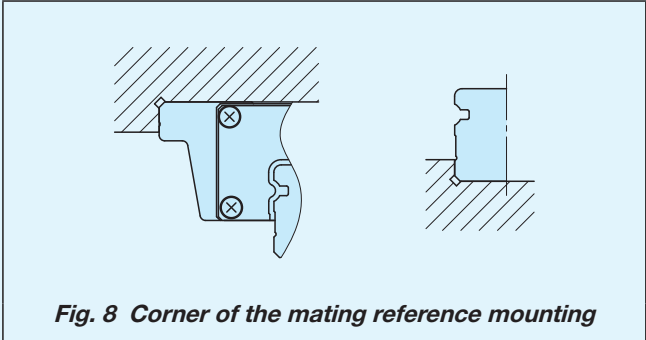
Deviation of accuracy of Linear Way and Linear Roller Way mounting surface or deviation of accuracy in mounting may generate large load over the calculated value. Note that such load could affect the life adversely. It enhances the reliability of Linear Way and Linear Roller Way to ensure high machining accuracy and assembly accuracy depending on operational conditions of the track rail and slide unit such as required motion accuracy and rigidity and to consider mounting structure that can maintain the accuracy and performance. Typical reference values for mounting parallelism between multiple assembled sets used are shown in Table 20.

Table 20 Parallelism between two mounting surfaces unit:  $\mu\text{m}$

| Classification | Ordinary<br>(No symbol) | High<br>(H) | Precision<br>(P) | Super<br>precision<br>(SP) | Ultra<br>precision<br>(UP) |
|----------------|-------------------------|-------------|------------------|----------------------------|----------------------------|
| Parallelism    | 30                      |             | 20               | 10                         | 6                          |

Shoulder height and corner radius of the reference mounting surface

For the shape of opposite corner of the reference surface, it is recommended to have relieved fillet as indicated in Fig. 8, but you may also use it with providing radius at the corner. For recommended values for the shoulder height and corner radius of the reference mounting surface, see an explanation of each series.



Precaution for Mounting

Table 21.1 Products appended with dummy rail

○: Appended

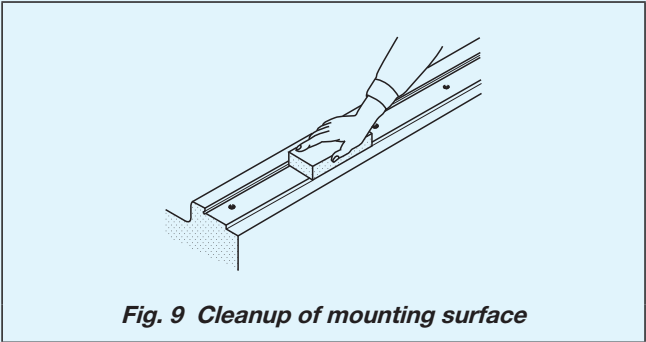
| Series name and size                                           |            | Interchangeable |                | Non-interchangeable specification |
|----------------------------------------------------------------|------------|-----------------|----------------|-----------------------------------|
|                                                                |            | Single unit     | Assembled set  | Assembled set                     |
| C-Lube Linear Way ML<br>Linear Way L                           |            | ○               | See Table 21.2 | See Table 21.2                    |
| C-Lube Linear Way MLV                                          |            | —               | —              | —                                 |
| C-Lube Linear Way MV                                           |            | —               | —              | —                                 |
| C-Lube Linear Way ME<br>Linear Way E                           |            | ○               | —              | —                                 |
| C-Lube Linear Way MH<br>Linear Way H                           | 8~12       | ○               | ○              | ○                                 |
|                                                                | 15~65      | ○               | —              | —                                 |
|                                                                | Extra long | ○               | ○              | ○                                 |
| Linear Way F                                                   |            | ○               | —              | —                                 |
| C-Lube Linear Way MUL<br>Linear Way U                          | 25, 30     | —               | —              | ○                                 |
|                                                                | 40~130     | —               | —              | —                                 |
| C-Lube Linear Roller Way Super MX<br>Linear Roller Way Super X | 10~30      | ○               | ○              | ○                                 |
|                                                                | 35~65      | ○               | —              | —                                 |
|                                                                | Extra long | ○               | ○              | ○                                 |
|                                                                | 85, 100    | —               | —              | —                                 |
| Linear Roller Way X                                            |            | —               | —              | —                                 |

Table 21.2 Appended dummy rail model number for C-Lube Linear Way ML, C-Lube Linear Way MLV and Linear Way L

| C-Lube Linear Way ML |           | C-Lube Linear Way MLV | Linear Way L  |            |
|----------------------|-----------|-----------------------|---------------|------------|
| Standard type        | Wide type | Standard type         | Standard type | Wide type  |
| —                    | —         | —                     | LWL 2         | LWLF 4     |
| MLC 3                | MLFC 6    | —                     | LWLC 3        | LWLFC 6    |
| ML 3                 | MLF 6     | —                     | LWL 3         | LWLF 6     |
| MLC 5                | MLFC 10   | —                     | LWLC 5…B      | LWLFC 10…B |
| ML 5                 | MLF 10    | —                     | LWL 5…B       | LWLF 10…B  |
| MLC 7                | MLFC 14   | MLV 7                 | LWLC 7…B      | LWLFC 14…B |
| ML 7                 | MLF 14    | —                     | LWL 7…B       | LWLF 14…B  |
| MLG 7                | MLFG 14   | —                     | LWLG 7…B      | LWLFG 14…B |
| MLC 9                | MLFC 18   | MLV 9                 | LWLC 9…B      | LWLFC 18…B |
| ML 9                 | MLF 18    | —                     | LWL 9…B       | LWLF 18…B  |
| MLG 9                | MLFG 18   | —                     | LWLG 9…B      | LWLFG 18…B |
| MLL 9                | —         | —                     | LWLG 12…B     | LWLFG 24…B |
| MLG 12               | MLFG 24   | —                     | LWLG 15…B     | LWLFG 30…B |
| MLL 12               | —         | —                     | LWLG 20…B     | LWLFG 42…B |
| MLG 15               | MLFG 30   | —                     | LWLG 25…B     | —          |
| MLL 15               | —         | —                     | —             | —          |
| MLG 20               | MLFG 42   | —                     | —             | —          |
| MLG 25               | —         | —                     | —             | —          |

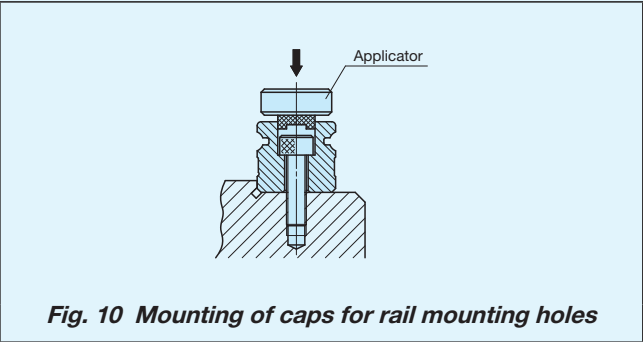
Cleanup of mounting surface

Remove burrs and blemishes by using oil-stone, etc. and wipe off rust prevention oil and dust with clean cloth from mounting surface and reference mounting surface of the machine or device to which the Linear Way or Linear Roller Way are mounted.



Mounting of caps for rail mounting holes

When mounting the special specification caps for rail mounting holes (supplemental code "/F") on the track rail, use a flat applicator and stamp it by bits until it becomes plane with the track rail upper surface.



Tightening torque for fixing screw

Typical fixing screw tightening torque to mount the Linear Way and Linear Roller Way is indicated in Table 22. When vibration and shock of the machine or device are large, fluctuating load is large, or moment load is applied, fix it by using the torque 1.2 to 1.5 times larger than the value indicated as necessary.

If the mating member material is cast iron or aluminum alloy, reduce the tightening torque depending on the strength characteristics of the mating member material.

For details, see an explanation of each series.

Though the track rail mounting bolts are appended as an accessory of products indicated in Table 23, it is also available for other products. If these parts are necessary, please contact **IKO**.

Table 22 Tightening torque for fixing screw

| Bolt size  | Tightening torque N · m                                 |                                                          |                                                          |                                                         |
|------------|---------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|---------------------------------------------------------|
|            | High carbon steel-made screw<br>(Strength division 8.8) | High carbon steel-made screw<br>(Strength division 10.9) | High carbon steel-made screw<br>(Strength division 12.9) | Stainless steel-made screw<br>(Property division A2-70) |
| M 1 ×0.25  | —                                                       | —                                                        | —                                                        | 0.04                                                    |
| M 1.4×0.3  | —                                                       | —                                                        | —                                                        | 0.10                                                    |
| M 1.6×0.35 | —                                                       | —                                                        | —                                                        | 0.15                                                    |
| M 2 ×0.4   | —                                                       | —                                                        | —                                                        | 0.31                                                    |
| M 2.3×0.4  | —                                                       | —                                                        | —                                                        | 0.49                                                    |
| M 2.5×0.45 | —                                                       | —                                                        | —                                                        | 0.62                                                    |
| M 2.6×0.45 | —                                                       | —                                                        | —                                                        | 0.70                                                    |
| M 3 ×0.5   | 1.3                                                     | —                                                        | 1.8                                                      | 1.1                                                     |
| M 4 ×0.7   | 2.9                                                     | —                                                        | 4.1                                                      | 2.5                                                     |
| M 5 ×0.8   | 5.7                                                     | —                                                        | 8.0                                                      | 5.0                                                     |
| M 6 ×1     | —                                                       | —                                                        | 13.6                                                     | 8.5                                                     |
| M 8 ×1.25  | —                                                       | —                                                        | 32.7                                                     | 20.4                                                    |
| M10 ×1.5   | —                                                       | —                                                        | 63.9                                                     | —                                                       |
| M12 ×1.75  | —                                                       | —                                                        | 110                                                      | —                                                       |
| M14 ×2     | —                                                       | —                                                        | 175                                                      | —                                                       |
| M16 ×2     | —                                                       | —                                                        | 268                                                      | —                                                       |
| M20 ×2.5   | —                                                       | —                                                        | 522                                                      | —                                                       |
| M24 ×3     | —                                                       | 749                                                      | —                                                        | —                                                       |
| M30 ×3.5   | —                                                       | 1 490                                                    | —                                                        | —                                                       |



Table 23 Specifications of appended track rail mounting bolts

| Series                                            | Specifications of appended bolts |                        |                                                                  |                        |                         |
|---------------------------------------------------|----------------------------------|------------------------|------------------------------------------------------------------|------------------------|-------------------------|
|                                                   | Size                             | Material type          | Type                                                             | Material               | Class                   |
| C-Lube Linear Way ML Standard type <sup>(1)</sup> | 1~ 3 <sup>(2)</sup>              | Stainless steel made   | JCIS 10-70 Cross-recessed pan head screw for precision equipment | Stainless steel made   | —                       |
| Linear Way L Standard type <sup>(1)</sup>         | 5                                | Stainless steel made   | JCIS 10-70 Cross-recessed pan head screw for precision equipment | Stainless steel made   | —                       |
|                                                   | 7~ 25                            | Stainless steel made   | JIS B 1176 Hexagon socket head bolt                              | Stainless steel made   | Property division A2-70 |
|                                                   | 9~ 20                            | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 8.8   |
| C-Lube Linear Way ML Wide type <sup>(1)</sup>     | 4~ 10                            | Stainless steel made   | JCIS 10-70 Cross-recessed pan head screw for precision equipment | Stainless steel made   | —                       |
| Linear Way L Wide type <sup>(1)</sup>             | 14~ 42                           | Stainless steel made   | JIS B 1176 Hexagon socket head bolt                              | Stainless steel made   | Property division A2-70 |
|                                                   | 18~ 42                           | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 8.8   |
| C-Lube Linear Way MLV                             |                                  | Stainless steel made   | JIS B 1176 Hexagon socket head bolt                              | Stainless steel made   | Property division A2-70 |
| C-Lube Linear Way MV <sup>(3)</sup>               |                                  | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 12.9  |
| C-Lube Linear Way ME <sup>(3)</sup>               |                                  | Stainless steel made   | JIS B 1176 Hexagon socket head bolt                              | Stainless steel made   | Property division A2-70 |
|                                                   |                                  | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 12.9  |
| C-Lube Linear Way MH <sup>(4)</sup>               | 8~ 30                            | Stainless steel made   | JIS B 1176 Hexagon socket head bolt                              | Stainless steel made   | Property division A2-70 |
|                                                   | 12                               | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 8.8   |
|                                                   | 15~ 65                           | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 12.9  |
| Linear Way F                                      |                                  | Stainless steel made   | JIS B 1176 Hexagon socket head bolt                              | Stainless steel made   | Property division A2-70 |
|                                                   |                                  | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 12.9  |
| C-Lube Linear Way MUL <sup>(3)</sup>              | 25                               | Stainless steel made   | JCIS 10-70 Cross-recessed pan head screw for precision equipment | Stainless steel made   | —                       |
|                                                   | 30                               | Stainless steel made   | JIS B 1176 Hexagon socket head bolt                              | Stainless steel made   | Property division A2-70 |
| Linear Way U                                      | 25                               | Stainless steel made   | JCIS 10-70 Cross-recessed pan head screw for precision equipment | Stainless steel made   | —                       |
|                                                   | 30                               | Stainless steel made   | JIS B 1176 Hexagon socket head bolt                              | Stainless steel made   | Property division A2-70 |
|                                                   | 40~130 <sup>(2)</sup>            | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 12.9  |
| C-Lube Linear Roller Way Super MX <sup>(4)</sup>  | 10~ 65                           | Stainless steel made   | JIS B 1176 Hexagon socket head bolt                              | Stainless steel made   | Property division A2-70 |
|                                                   |                                  | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 12.9  |
|                                                   | 85~100                           | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 10.9  |
| Linear Roller Way X                               | 25~ 55                           | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 12.9  |
|                                                   | 75                               | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 10.9  |
| Linear Way LM <sup>(6)</sup>                      |                                  | Stainless steel made   | JIS B 1176 Hexagon socket head bolt                              | Stainless steel made   | Property division A2-70 |
| Linear Way M <sup>(7)</sup>                       |                                  | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 12.9  |
| Linear Roller Way M <sup>(7)</sup>                |                                  | High carbon steel made | JIS B 1176 Hexagon socket head bolt                              | High carbon steel made | Strength division 12.9  |

Notes <sup>(1)</sup> The bolts are not appended for tapped rail specification.

<sup>(2)</sup> The bolts are not appended. Specifications in the table are the ones prepared by **IKO**.

<sup>(3)</sup> The bolts are not appended. Specifications in the table are the ones when special specification "/MA" (with track rail mounting bolts) is specified.

<sup>(4)</sup> The bolts are not appended in an assembled set. Specifications in the table are the ones when special specification "/MA" (with track rail mounting bolts) is specified.

<sup>(5)</sup> The bolts are not appended in LWH...MU.

<sup>(6)</sup> Slide member mounting bolts are not appended.

<sup>(7)</sup> Slide member mounting bolts are also appended.

## Mounting surface, reference mounting surface and typical mounting structure

When mounting Linear Way and Linear Roller Way, properly align the reference mounting surface B and D of the track rail and slide unit with the reference mounting surface of the table and bed and fix them. (See Fig. 11)

The reference mounting surfaces B and D and mounting surfaces A and C are precisely ground. Machining the mounting surface of the table and bed, such as machine or device, to high accuracy and mounting them properly will ensure stable linear motion with high accuracy.

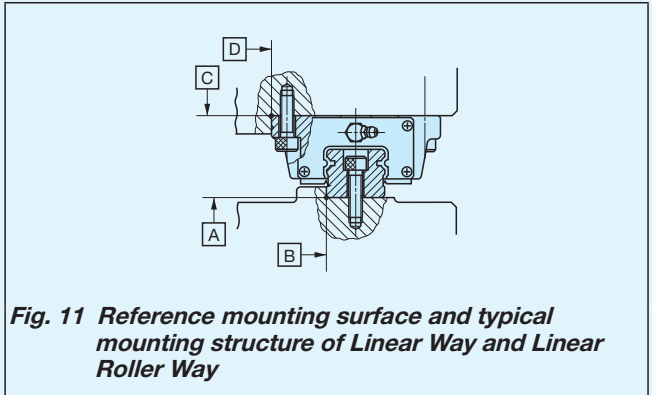


Fig. 11 Reference mounting surface and typical mounting structure of Linear Way and Linear Roller Way

Reference mounting surface of the slide unit is the opposite side of the **IKO** mark. The track rail reference mounting surface is identified by locating the **IKO** mark on the top surface of the track rail. It is the side surface above the mark (in the direction of the arrow). (See Fig. 12.)

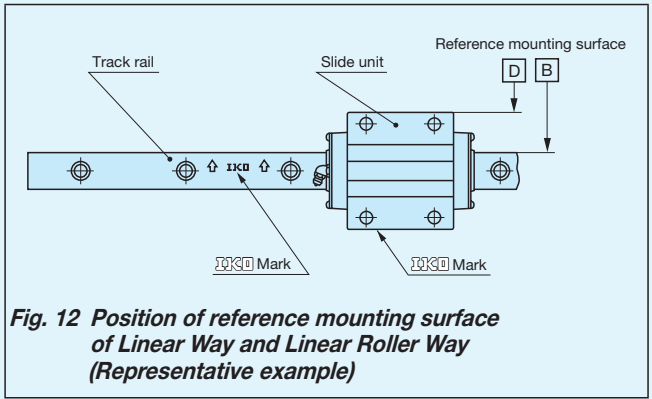


Fig. 12 Position of reference mounting surface of Linear Way and Linear Roller Way (Representative example)

## Load direction and mounting structure

When lateral load, alternate load, or fluctuating load is applied onto the Linear Way or Linear Roller Way, securely fix the ends of slide unit and track rail as indicated in the Fig. 13 and Fig. 14.

When the load is small or operational conditions are not harsh, mounting methods indicated in Fig. 15 and Fig. 16 may be used.

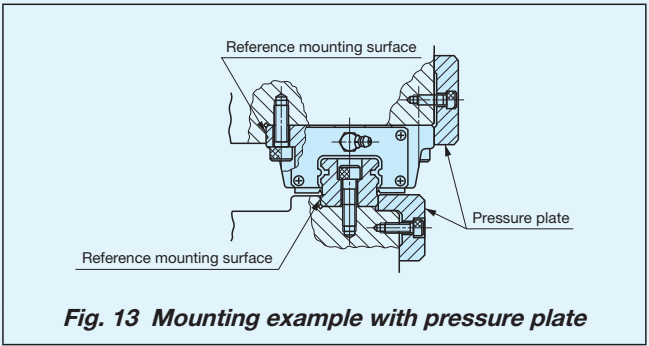


Fig. 13 Mounting example with pressure plate

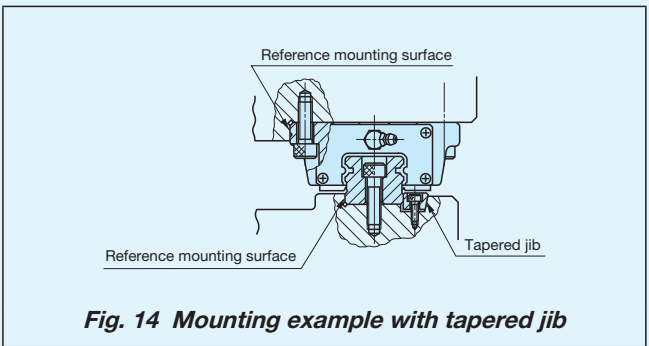


Fig. 14 Mounting example with tapered jib

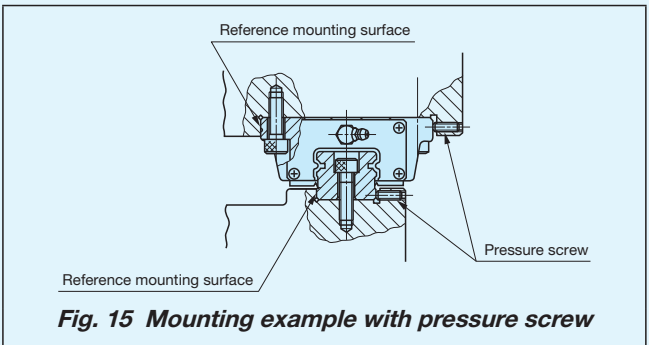


Fig. 15 Mounting example with pressure screw

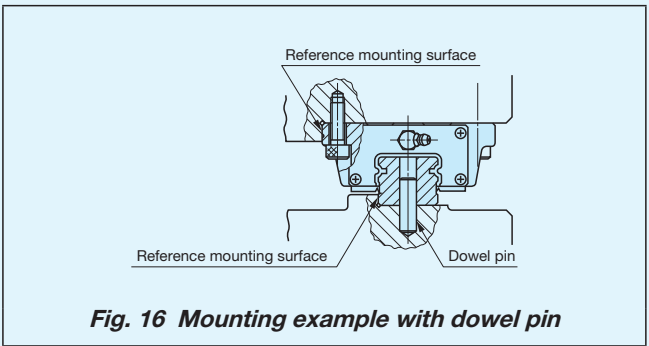


Fig. 16 Mounting example with dowel pin



# Mounting Examples

Typical procedures to mount Linear Way and Linear Roller Way are described in Examples 1 to 4 using a Linear Way as a representative case.

## Example 1. Typical operation

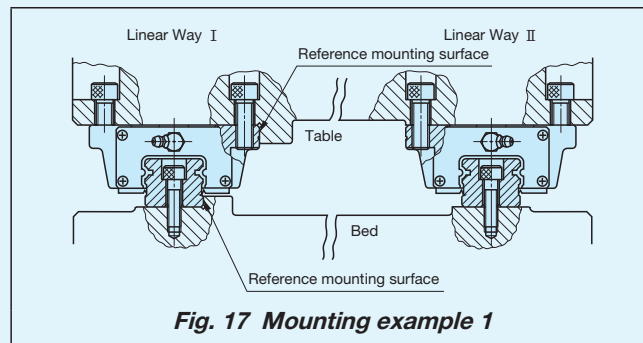


Fig. 17 Mounting example 1

For typical application without shock, reference mounting surface is prepared on each bed and table on the reference side. The mounting procedures are as follows. (See Fig. 17)

### 1 Cleanup of mounting surface and reference mounting surface

- Remove burrs and blemishes by using oil-stone, etc. from reference mounting surface and mounting surface of the machine or the device to which Linear Way is mounted and wipe off with clean cloth. (see Fig. 18)
- Wipe off rust prevention oil and dust on the reference mounting surface and the mounting surface of the Linear Way with clean cloth.

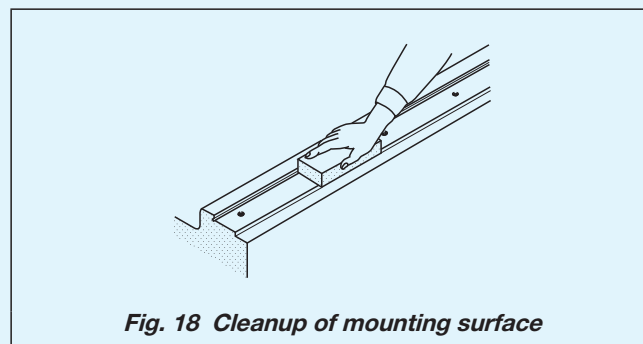


Fig. 18 Cleanup of mounting surface

### 2 Temporary fixing of Linear Way I and II track rails

- Align and temporarily fix them with reference mounting surface of each Linear Way track rail. (See Fig. 19)
- At this point, ensure that the fixing bolt does not interfere with the mounting hole.
- Fix the Linear Way II track rail to the bed.

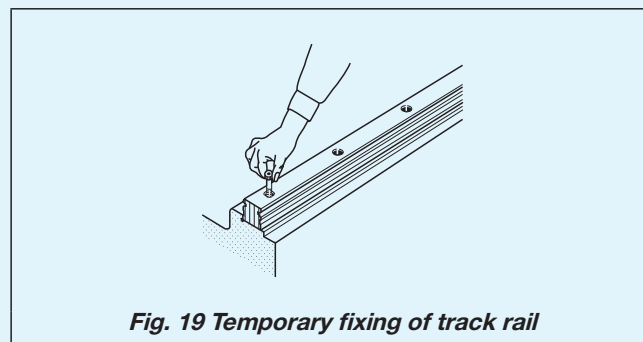


Fig. 19 Temporary fixing of track rail

### 3 Fixing of Linear Way I track rail

- Use small type vise or the like to stick track rail reference mounting surface to the reference mounting surface of the bed and tighten the fixing bolt at the same position. Repeat this method from one end to fix the track rail in order. (See Fig. 20)
- Linear Way II track rail should be left temporarily fixed.

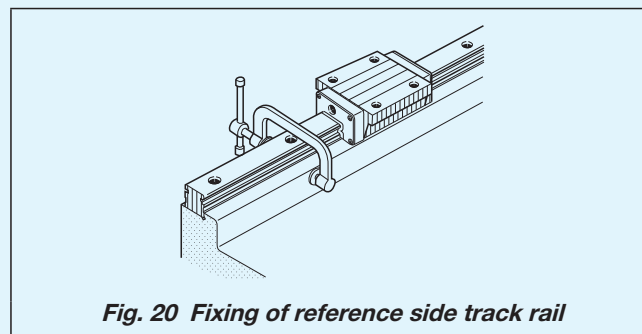


Fig. 20 Fixing of reference side track rail

### 4 Temporary fixing of Linear Way I and II slide units

- Align the Linear Way with the mounting position of the table and load the table gently.
- Temporarily fix the Linear Way I and II slide units to the table.

### 5 Fixing of Linear Way I slide unit

- Align the reference mounting surface of the Linear Way I slide unit with the reference mounting surface of the table correctly and fix them.

### 6 Fixing of Linear Way II slide unit

- Fix one of the Linear Way II slide units in a motion direction correctly and leave the other slide units temporarily fixed. (See Fig. 21)

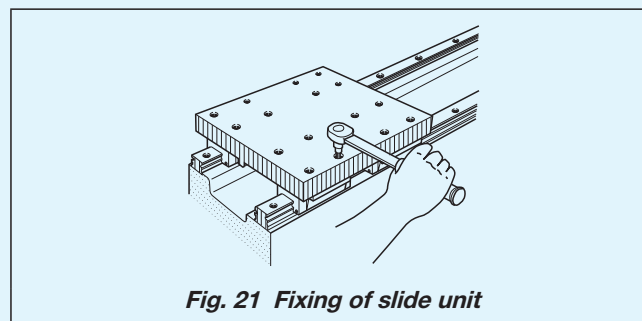


Fig. 21 Fixing of slide unit

### 7 Fixing of Linear Way II track rail

- Move the table and fix the Linear Way II track rail ensuring smooth motion status. At this point, tighten each fixing bolt immediately after the fixed slide unit of the Linear Way II passes on each of it. Repeat this method from one end to fix the track rail in order. (See Fig. 22)

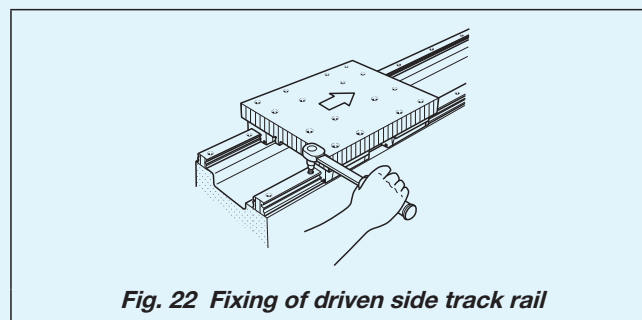


Fig. 22 Fixing of driven side track rail

### 8 Fixing of Linear Way II slide unit

- Fix the rest of the Linear Way II slide units.

## Example 2. Operation for linear motion with accuracy and rigidity

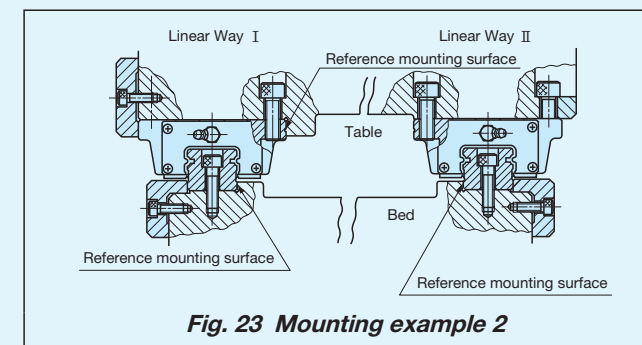


Fig. 23 Mounting example 2

If accuracy and rigidity of linear motion are required, prepare two reference mounting surfaces on the bed and one reference mounting surface on the table. The mounting procedures are as follows. (See Fig. 23)

### 1 Cleanup of mounting surface and reference mounting surface

- Remove burrs and blemishes by using oil-stone, etc. from reference mounting surface and mounting surface of the machine or the device to which Linear Way is mounted and wipe off with clean cloth. (see Fig. 24)
- Wipe off rust prevention oil and dust on the reference mounting surface and the mounting surface of the Linear Way with clean cloth.

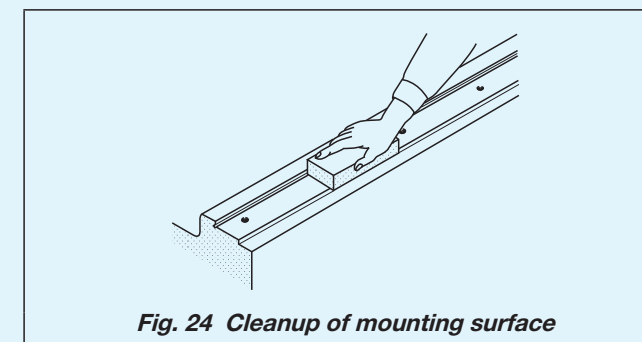


Fig. 24 Cleanup of mounting surface

### 2 Temporary fixing of Linear Way I and II track rails

- Align and temporarily fix them with reference mounting surface of each Linear Way track rail. (See Fig. 25)
- At this point, ensure that the fixing bolt does not interfere with the mounting hole.

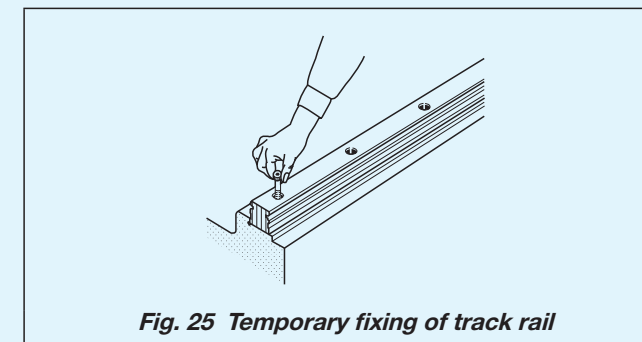


Fig. 25 Temporary fixing of track rail

### 3 Fixing of Linear Way I and II track rails

- Stick the track rail reference mounting surface of the Linear Way I to the reference mounting surface of the bed with pressure plate or pressure screws and tighten the track rail fixing bolt at the same position. Repeat this method from one end to fix the track rail in order. (See Fig. 26)

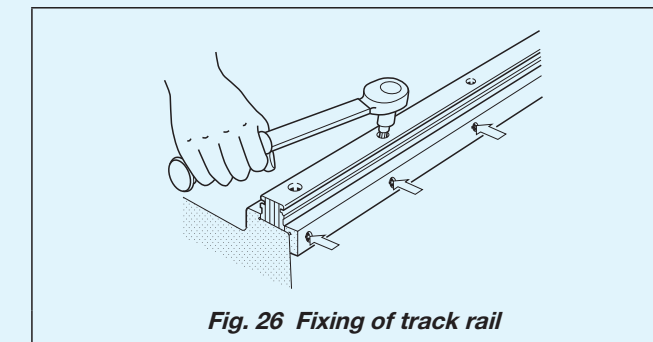


Fig. 26 Fixing of track rail

### 4 Temporary fixing of Linear Way I and II slide units

- Align the slide unit with the mounting position of the table and load the table gently. Temporarily fix the Linear Way I and II slide units to the table.

### 5 Fixing of Linear Way I slide unit

- Align the reference mounting surface of the Linear Way I slide unit with the reference mounting surface of the table correctly and fix them with pressure plate or pressure screws.

### 6 Fixing of Linear Way II slide unit

- Move the table ensuring smooth motion status, and fix the Linear Way II slide unit. (See Fig. 27)

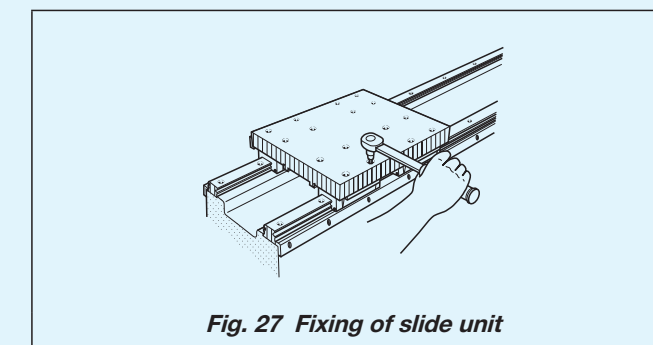
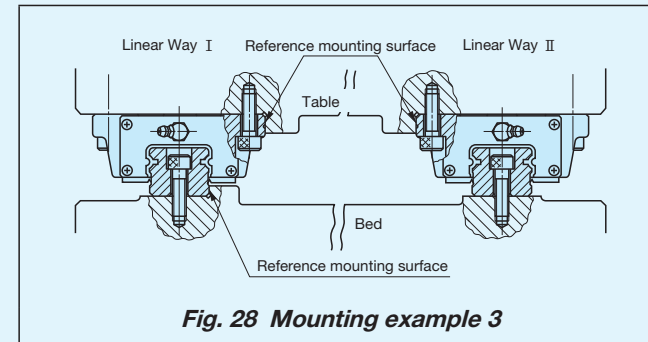


Fig. 27 Fixing of slide unit

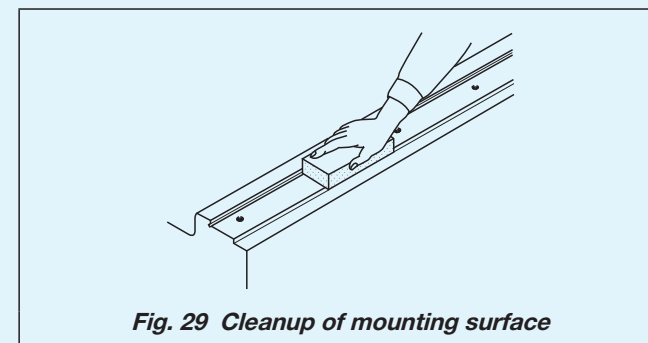
## Example 3 Operation in case the slide unit is fixed separated from the track rail



If it cannot be fixed securely with the table loaded, prepare one reference mounting surface on the bed and two reference mounting surfaces on the table. The mounting procedures are as follows. (See Fig. 28)

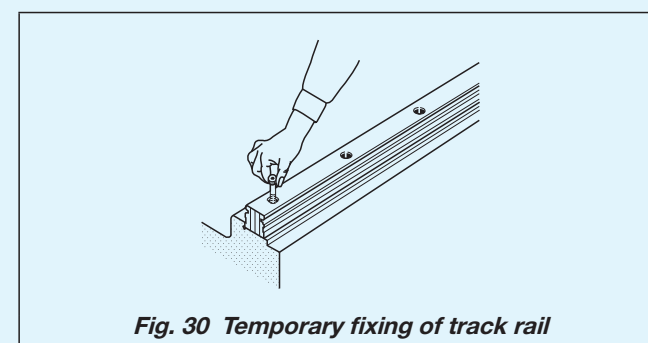
### ① Cleanup of mounting surface and reference mounting surface

- Remove burrs and blemishes by using oil-stone, etc. from reference mounting surface and mounting surface of the machine or the device to which Linear Way is mounted and wipe off with clean cloth. (see Fig. 29)
- Wipe off rust prevention oil and dust on the reference mounting surface and the mounting surface of the Linear Way with clean cloth.



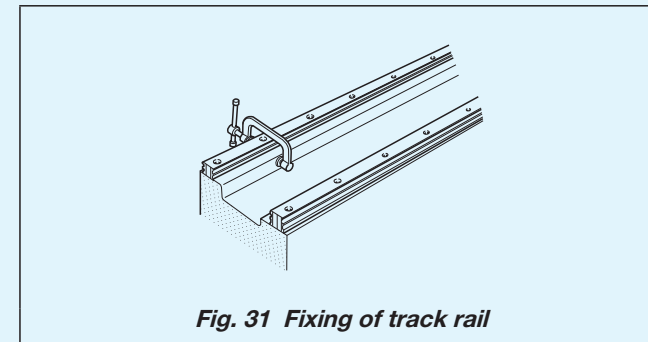
### ② Temporary fixing of Linear Way I and II track rails

- Align and temporarily fix them with reference mounting surface of each Linear Way track rail. (See Fig. 30)
- At this point, ensure that the fixing bolt does not interfere with the mounting hole.



### ③ Fixing of Linear Way I track rail

- Use small type vise or the like to stick track rail reference mounting surface to the reference mounting surface of the bed and tighten the fixing bolt at the same position. Repeat this method from one end to fix the track rail in order. (See Fig. 31)
- Linear Way II track rail should be left temporarily fixed.

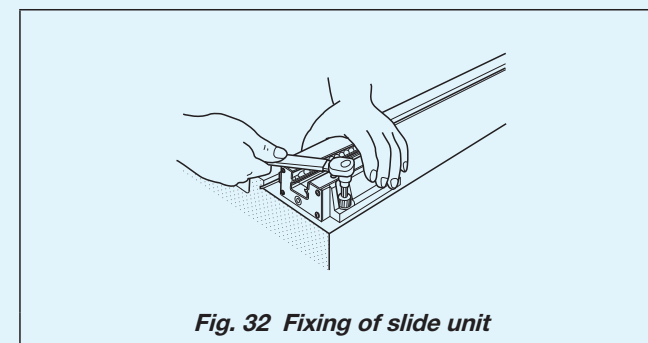


### ④ Separation of track rail and slide unit

- After checking the combination and positions of Linear Way I and II track rails and slide units, separate each slide unit from the track rail.

### ⑤ Fixing of Linear Way I and II slide units

- Align with the reference mounting surface of the Linear Way I and II slide units correctly, and fix them. (See Fig. 32)



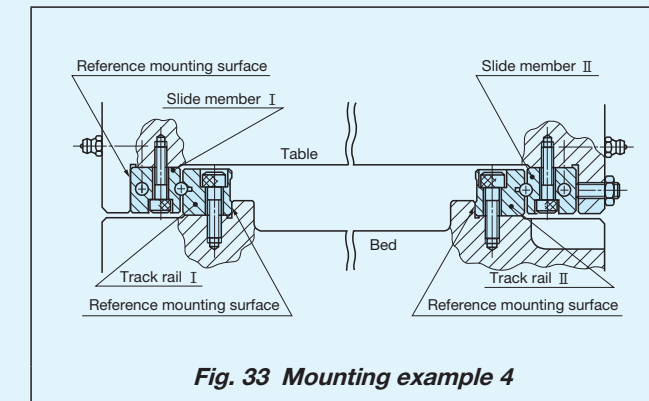
### ⑥ Setting of track rail and slide unit

- Insert and assemble the slide unit fixed to the table slowly with care while aligning it with the track rail fixed and temporarily fixed to the bed to maintain parallelism.

### ⑦ Fixing of Linear Way II track rail

- Move the table and fix the Linear Way II track rail ensuring smooth motion status. At this point, tighten each fixing bolt immediately after the fixed slide unit of the Linear Way II passes on each of it. Repeat this method from one end to fix the track rail in order.

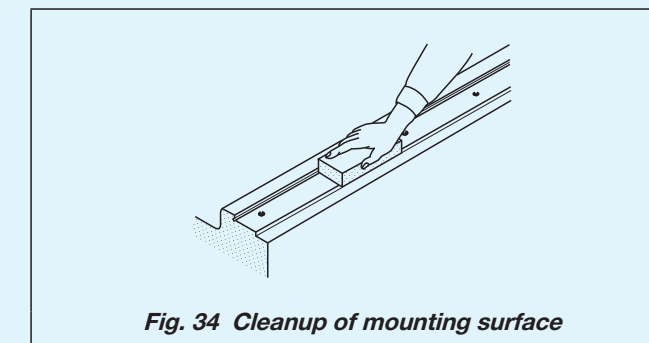
## Example 4. Operation of Linear Way Module



For the Linear Way Module, normally 2 sets are used in parallel as indicated in Fig. 33. For the mounting, typically follow the procedure below (see Fig. 33).

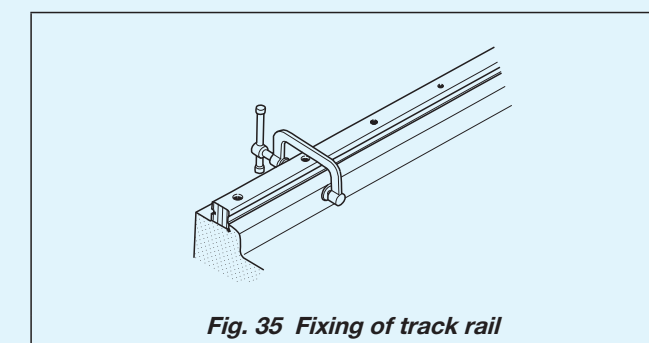
### ① Cleanup of mounting surface and reference mounting surface

- Remove burrs and blemishes by using oil-stone, etc. from reference mounting surface and mounting surface of the machine or the device to which Linear Way Module is mounted and wipe off with clean cloth (see Fig. 34).
- Wipe off rust prevention oil and dust on the reference mounting surface and the mounting surface of the Linear Way Module with clean cloth.



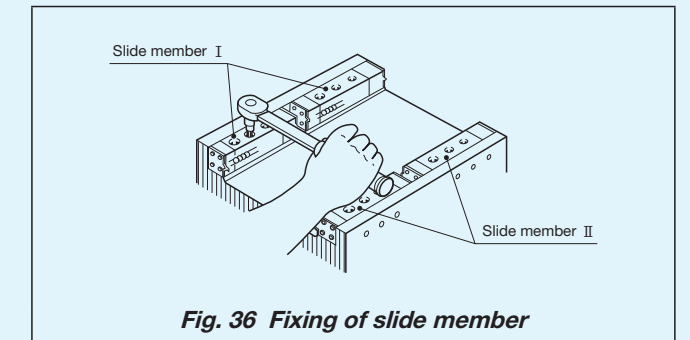
### ② Fixing of track rail

- Align the reference mounting surfaces of track rails I and II with the reference mounting surfaces of the bed correctly, stick them by using small type vise, and tighten the fixing bolts at the same position (see Fig. 35).



### ③ Fixing the slide member

- Align the reference mounting surface of the slide member I with the reference mounting surface of the table correctly, tighten the fixing bolt to fix them, and temporarily fix the slide member II (see Fig. 36).

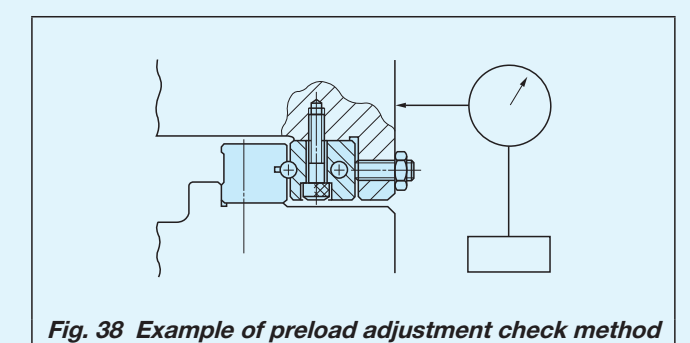
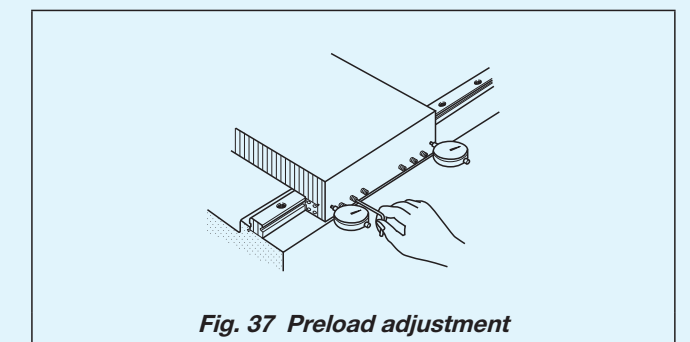


### ④ Setting of table and bed

- Insert and assemble the slide member fixed to the table slowly with care while aligning it with the track rail fixed to the bed to maintain parallelism.

### ⑤ Fixing the slide member II

- As indicated in Fig. 37, tighten the preload adjusting screw at the center first and then all the rest preload adjusting screws in order while measuring the clearance by using the dial gauge.
- The position where the dial gauge deflection stops after moving the table to right and left indicates zero preload or slight preload state.
- After preload adjustment, tighten the fixing bolt to fix them.



### Mounting of reference side track rail

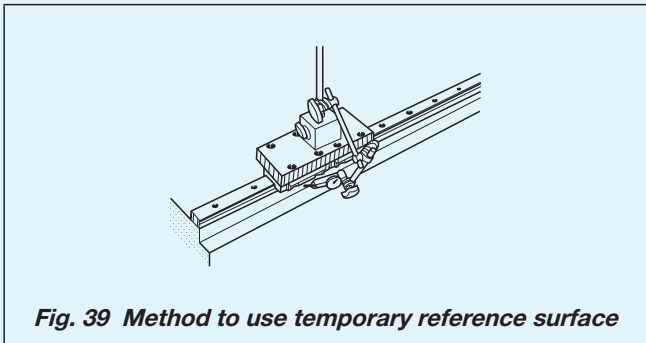
Mounting methods of reference side track rail are indicated below. Select a method suitable for the specifications of your machine or device.

**① Method to use reference mounting surface**

- Stick track rail reference mounting surface to the reference mounting surface of the bed by using a pressure plate or small type vise, and tighten the fixing bolt at the same position. Repeat this method from one end to fix the track rail in order.

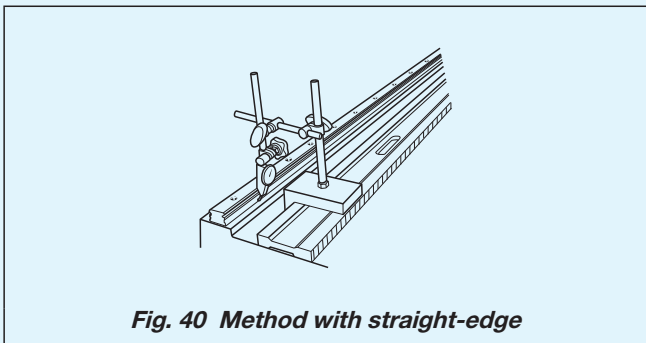
**② Method to use temporary reference surface**

- Prepare temporary reference surface around the mounting surface of the bed, temporarily fix the track rail, fix the measurement stand on the upper surface of the slide unit as indicated in Fig. 39, place an indicator onto the temporary reference surface, and fix them from one end of the track rail in order while maintaining straightness.



**③ Method with straight-edge**

- After temporary fixing of the track rail, apply an indicator to the reference mounting surface of the track rail as indicated in Fig. 40 and fix them from one end of the track rail in order referring to the straight-edge while maintaining straightness.



### Mounting of driven side track rail

Mounting methods of driven side track rail are indicated below. Select a method suitable for the specifications of your machine or device.

**① Method to use reference mounting surface**

- Stick track rail reference mounting surface to the reference mounting surface of the bed by using a pressure plate or small type vise, and tighten the fixing bolt at the same position. Repeat this method from one end to fix the track rail in order.

**② Method to follow the reference side track rail**

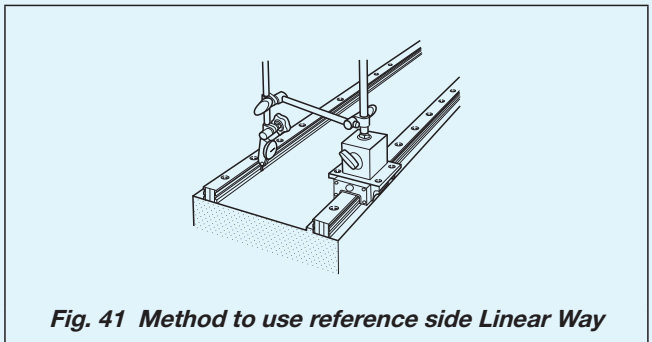
- Correctly mount the reference side track rail and one of the driven slide units in motion direction, temporarily fix the rest of slide units and track rails, and fix them from one end of the driven side track rail in order ensuring smooth motion status.

**③ Method with straight-edge**

- After temporary fixing of the track rail, apply an indicator to the reference mounting surface of the track rail as indicated in Fig. 40 and fix them from one end of the track rail in order referring to the straight-edge while maintaining straightness.

**④ Method to use reference side Linear Way**

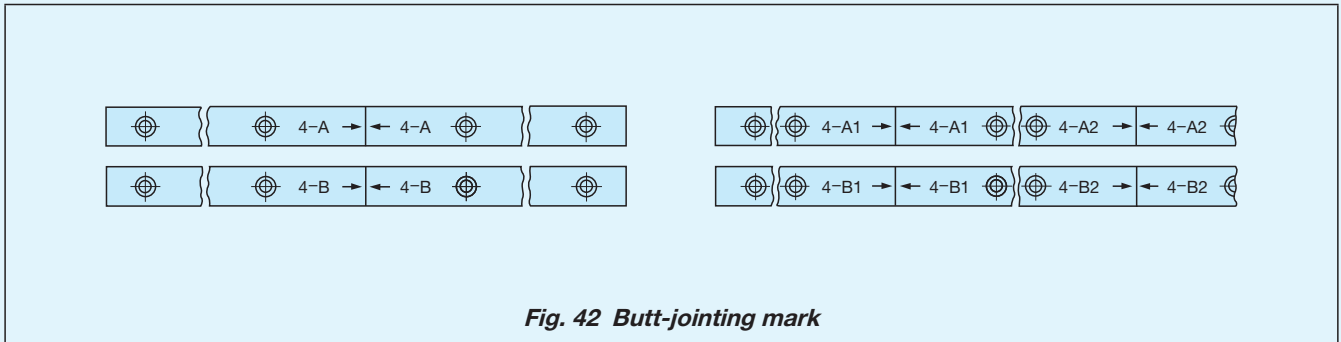
- Fix a measurement stand onto the upper surface of the reference side slide unit as indicated in Fig. 41, place an indicator onto the reference mounting surface of the driven side track rail, and fix them from one end in order while maintaining parallelism.



### Mounting procedures when track rails are butt-jointed

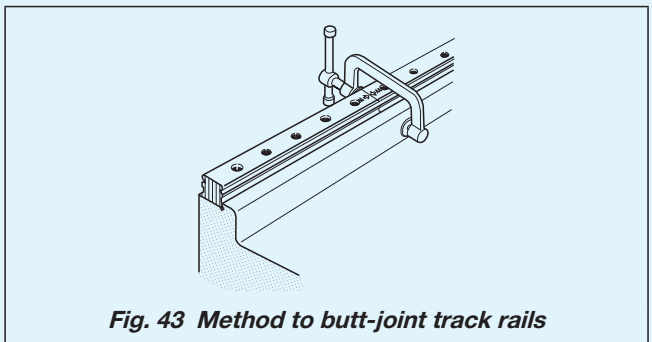
When multiple track rails are butt-jointed, it is necessary to specify special specification butted track rails (non-interchangeable specification, supplemental code "/A") or butt-jointing track rails (interchangeable specification, supplemental code "/T").

Butt-jointing track rails have a butt-jointing mark on the track rail end surface as indicated in Fig. 42. Typical method to butt-joint the track rails is as follows.



- ①** Align the butt-jointing mark on the track rail end surface and temporarily fix it. Since butt-jointing track rails are interchangeable, no butt-jointing position is specified.

- ②** Correctly align the reference mounting surface of the track rail with that of the bed in order. At this point, use a small type vise or the like to stick the reference mounting surfaces of the bed and track rail together so as to eliminate any step at the joint part of the track rail. (See Fig. 43)



## **Introduction of Application Examples**



Complex machining center

LRX



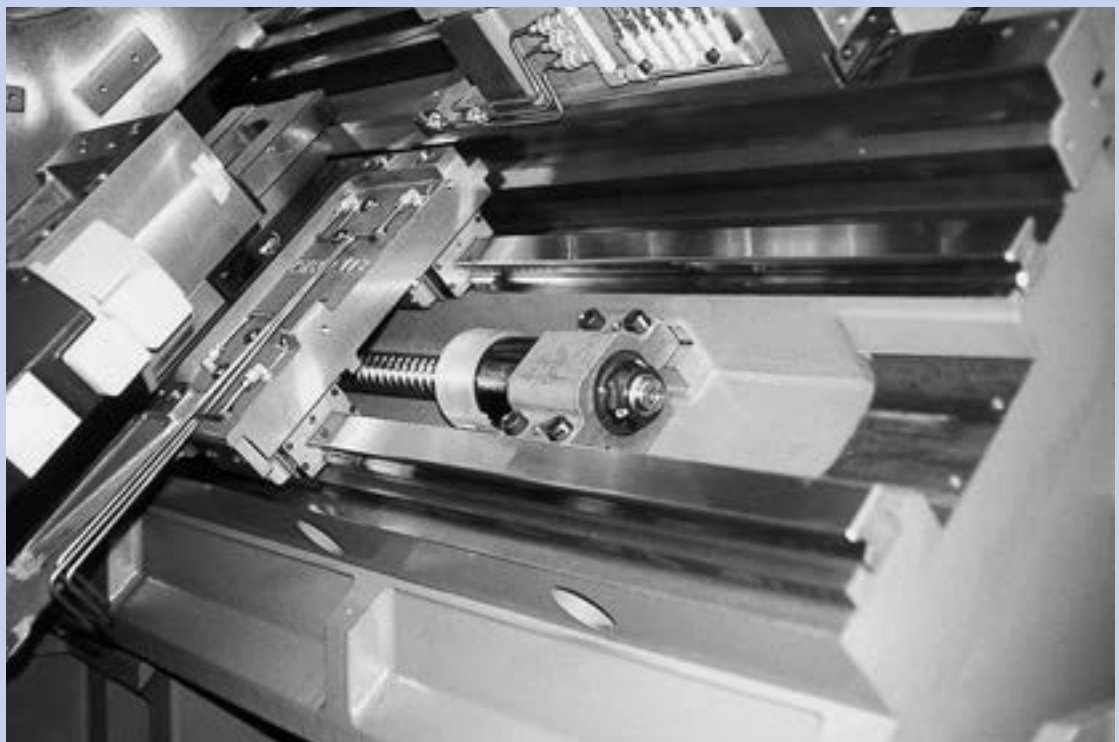
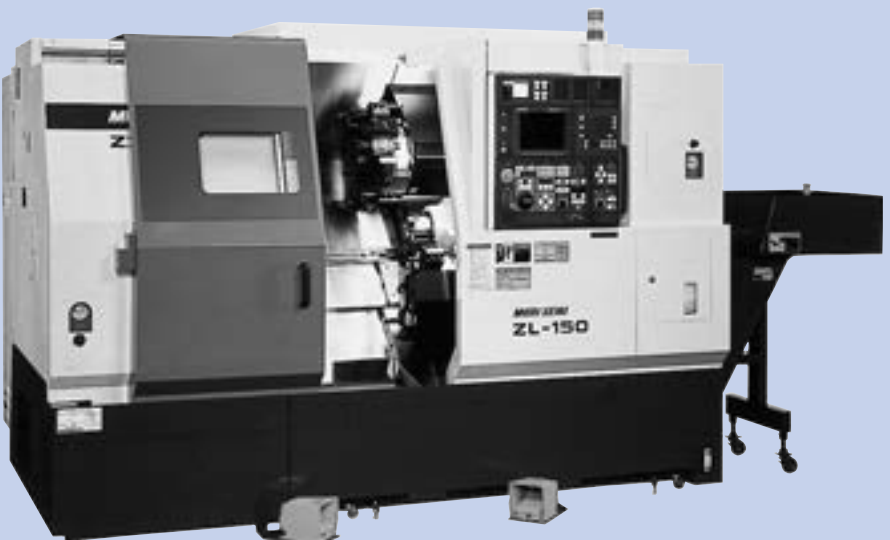
Lateral type complex machining center

LRX



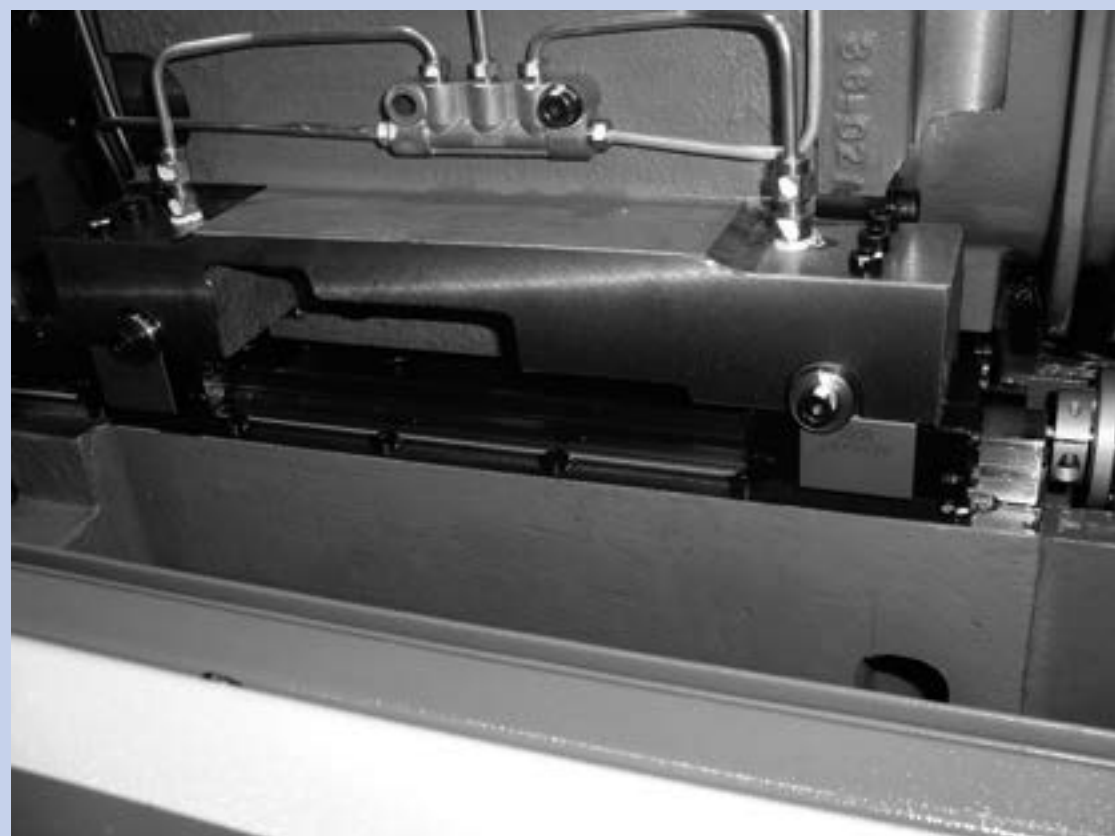
Four-axis control CNC lathe

LRX



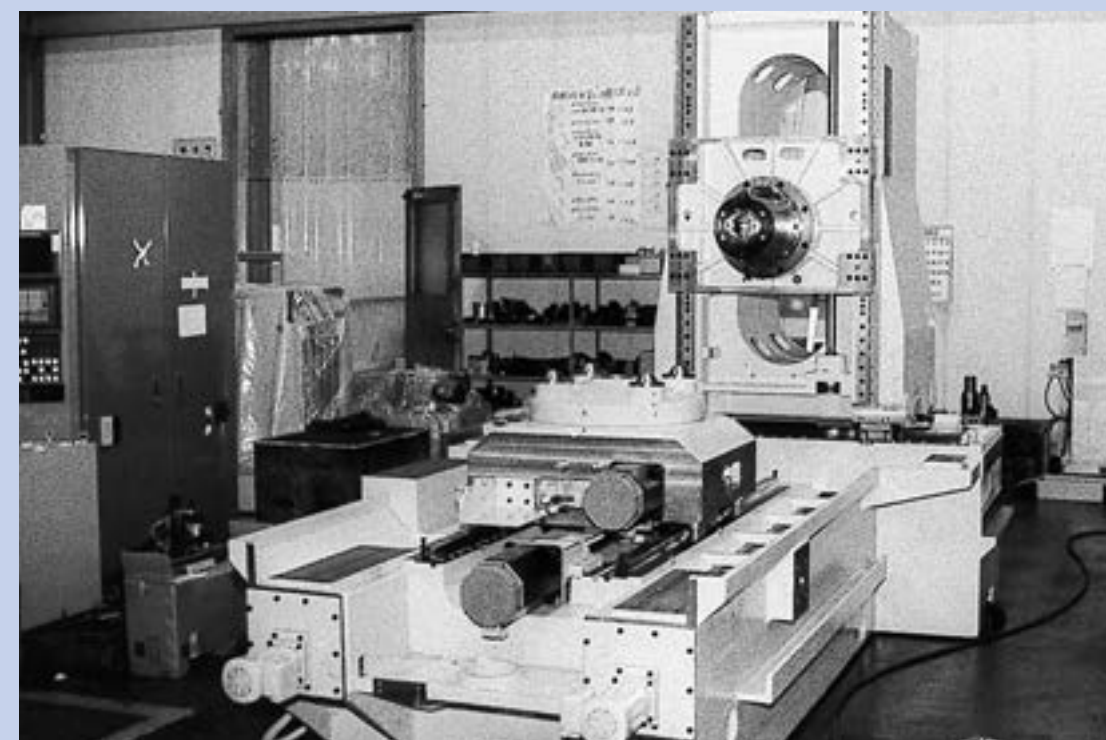
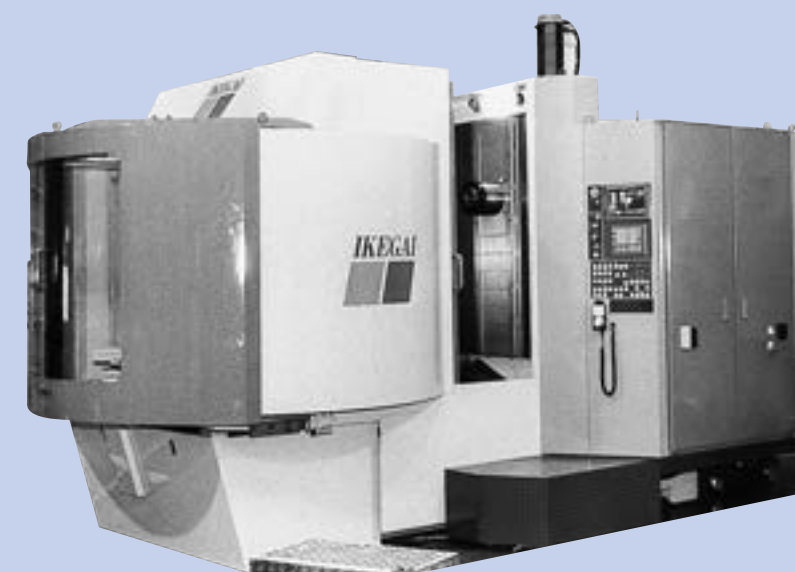
CNC compact type automatic lathe

LRXS · LRXSC



Lateral type machining center

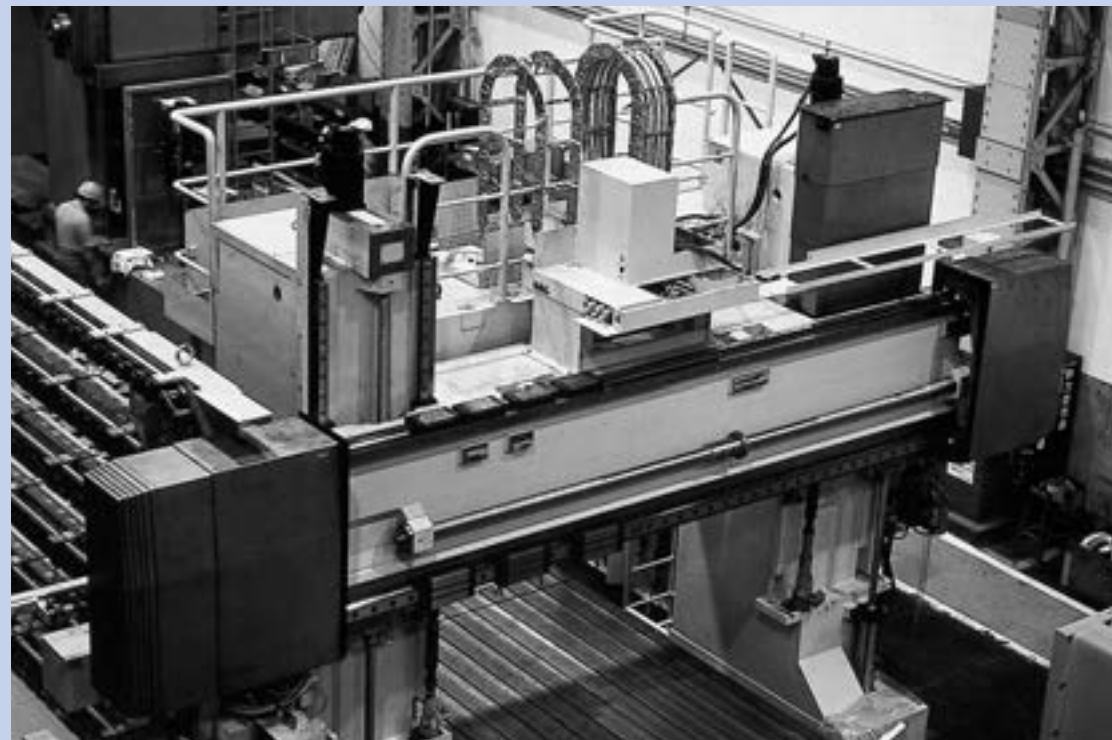
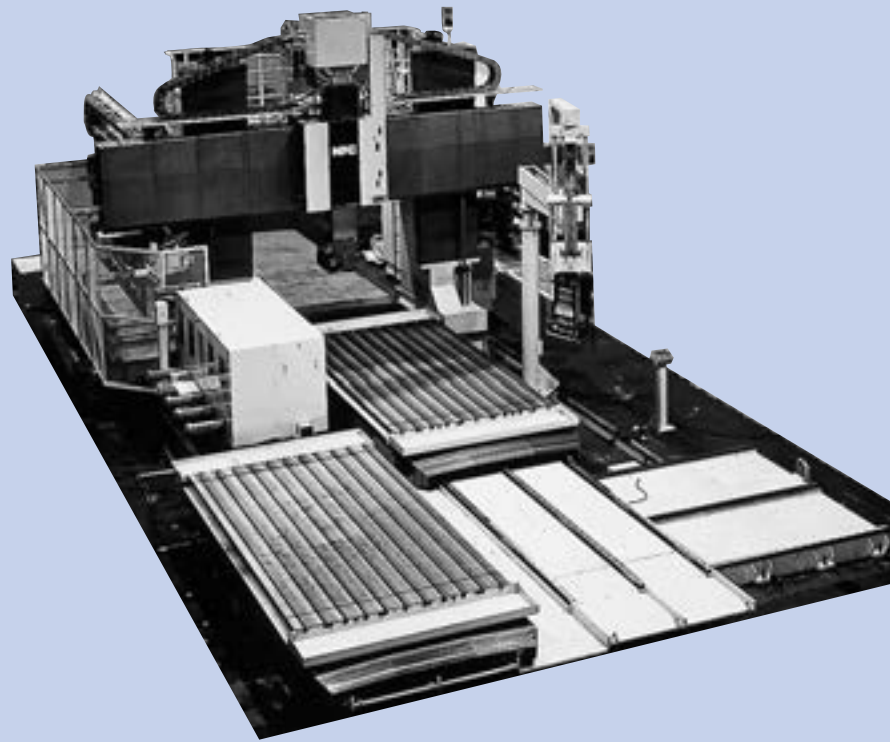
LRX · LRXDG





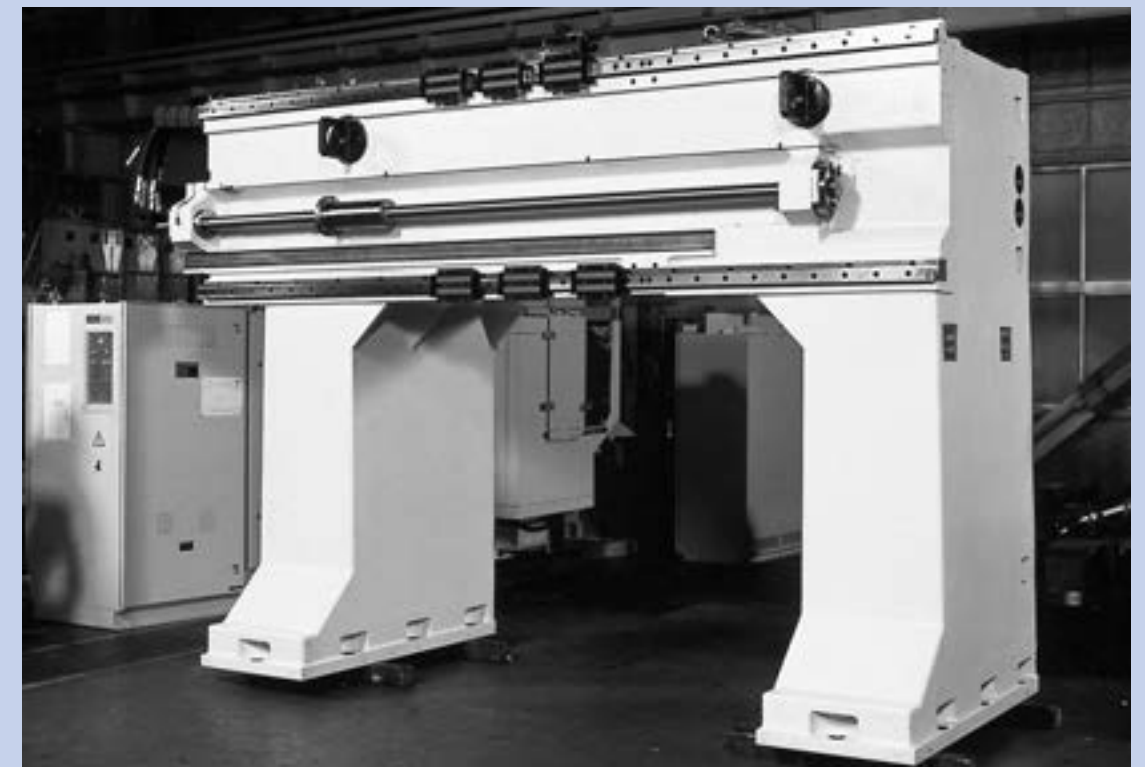
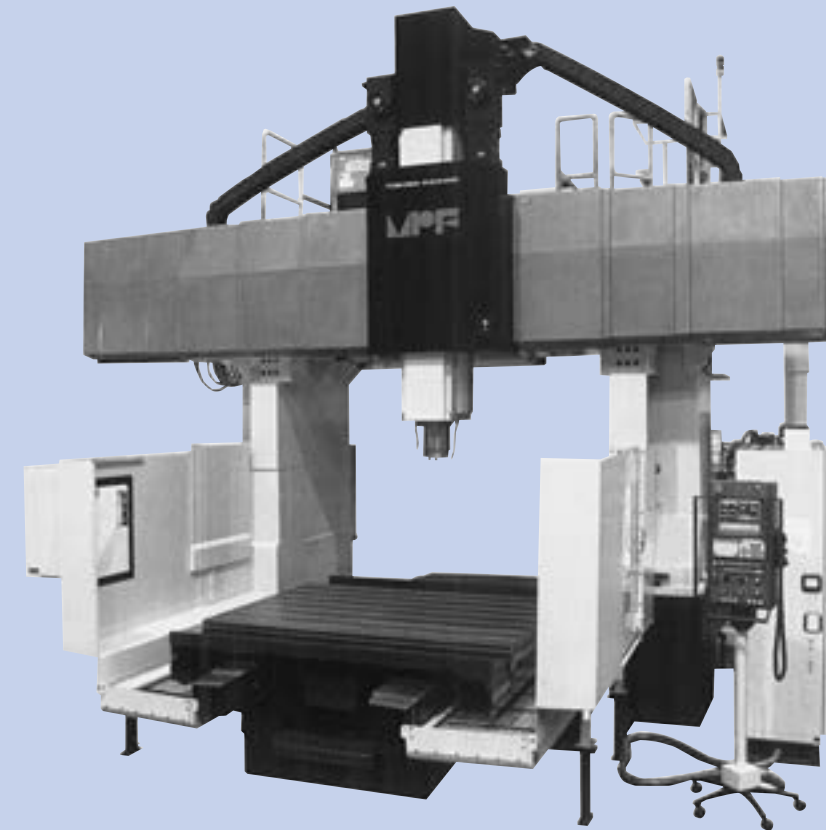
Gantry type machining center

LWHG



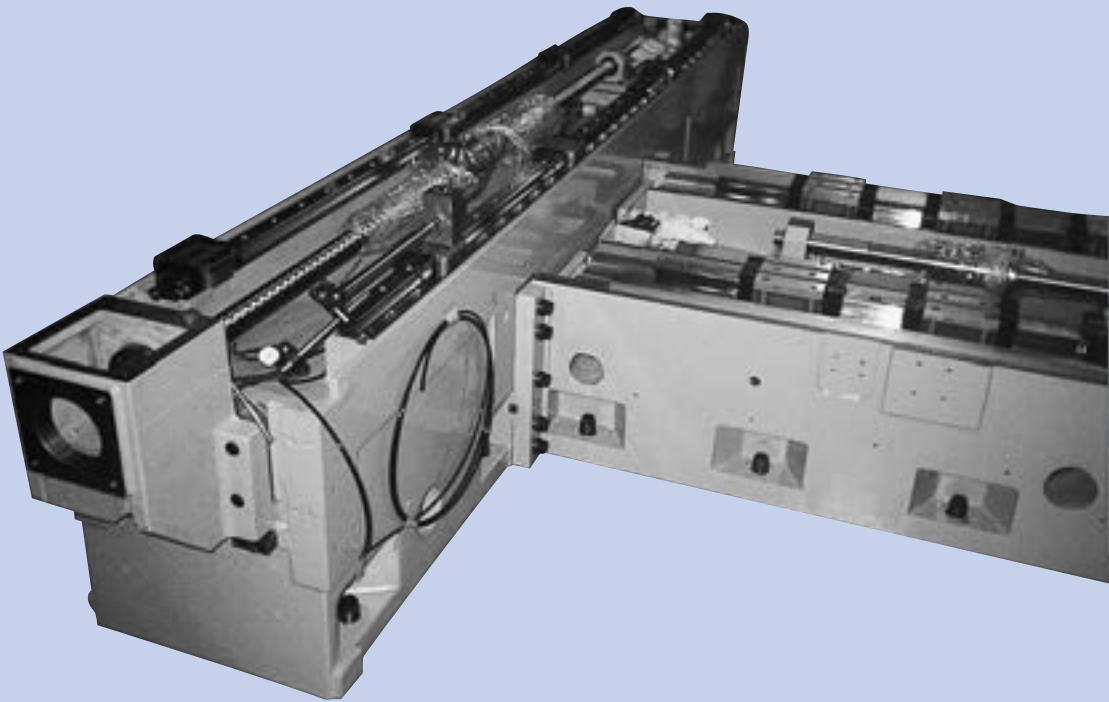
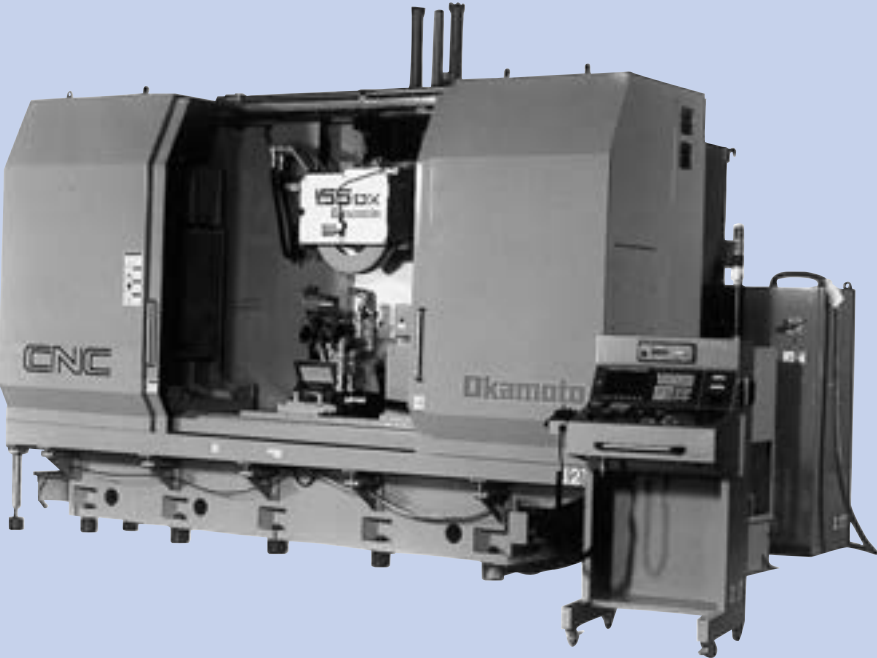
Gantry type machining center

MXG · MXDG



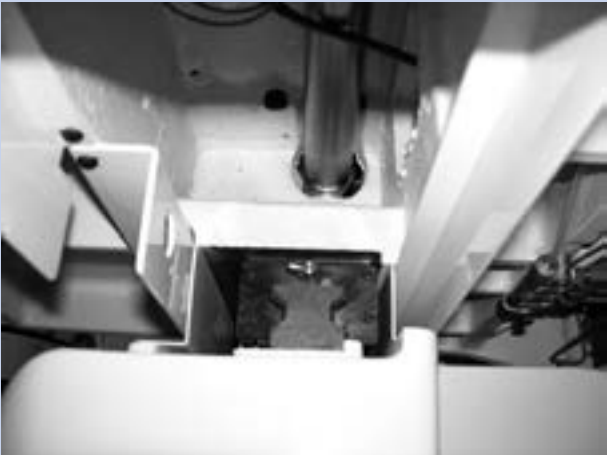
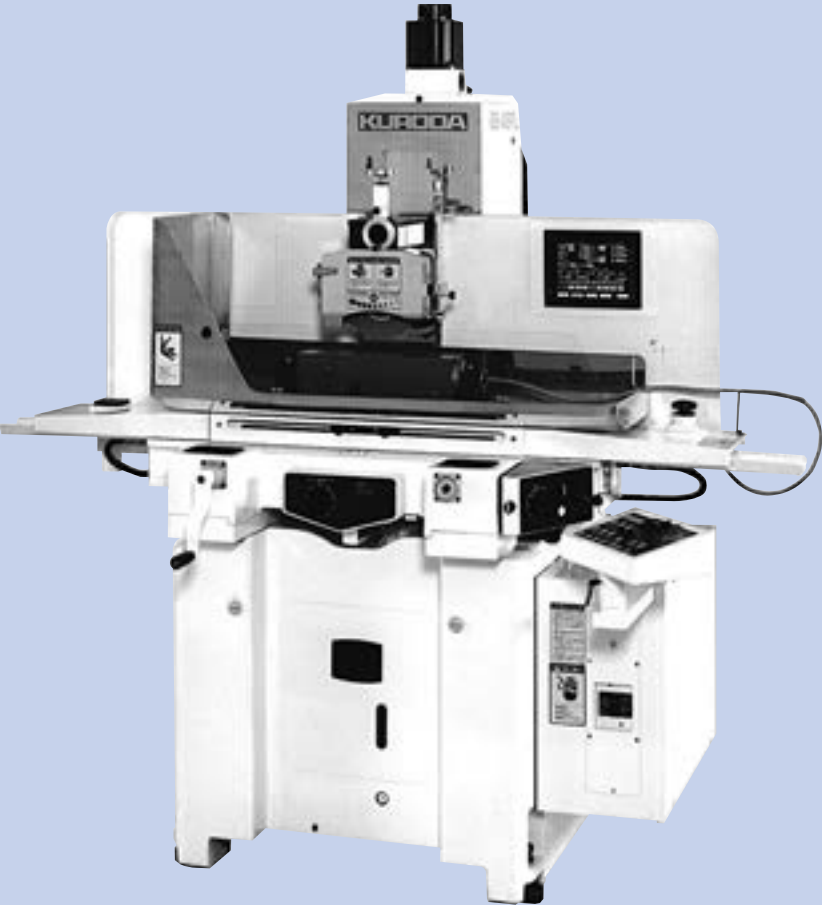
Surface grinding machine

LRX



Precision forming surface grinding machine

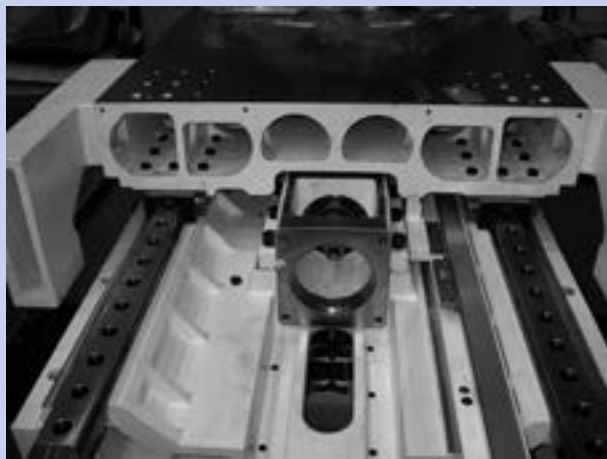
MXD • LRXDG • MHD





Vertical grinding machine

MX • MXL



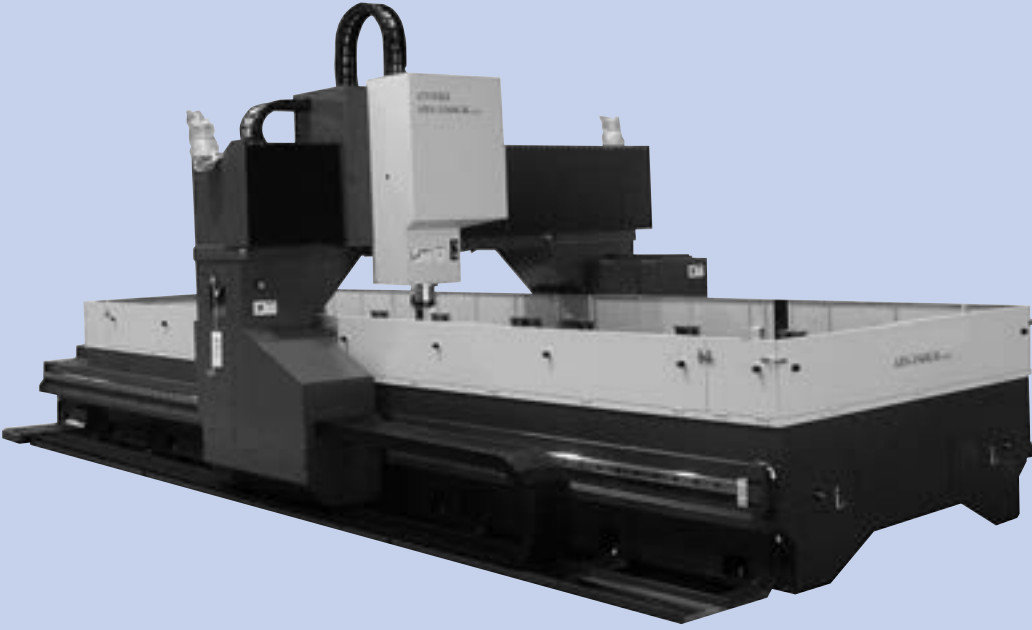
Tool grinding machine

LRXDG • LRXG



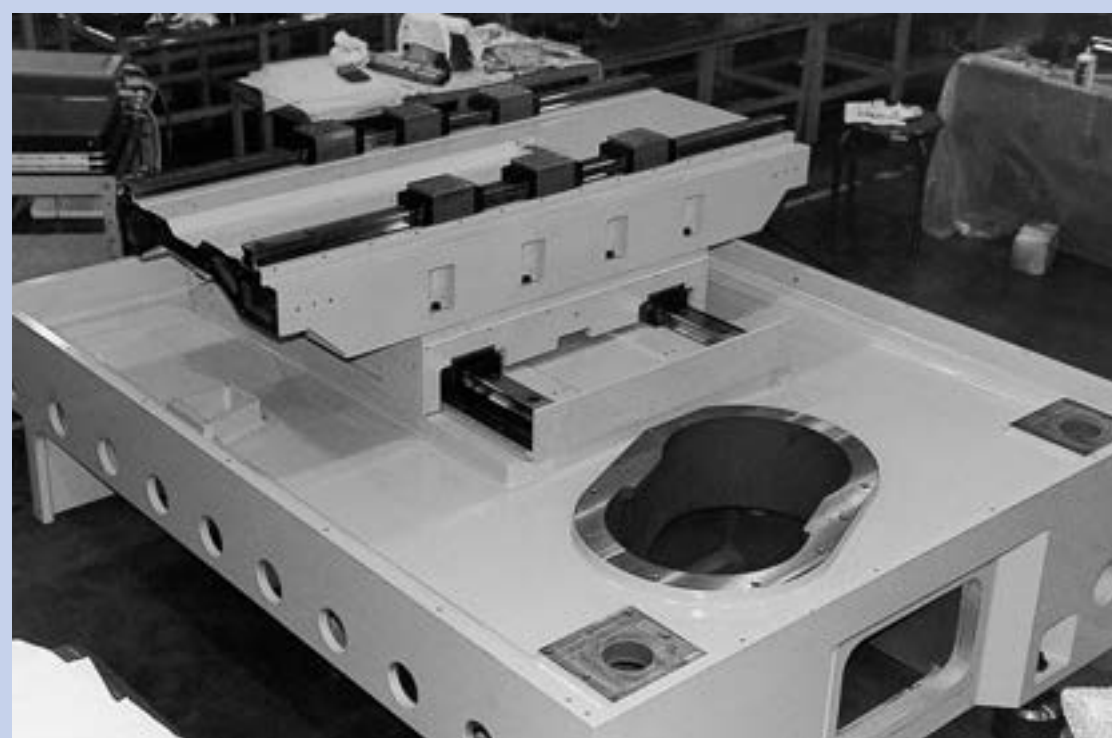
Multi-function drilling machine

MXG • MXNG • MXNSG



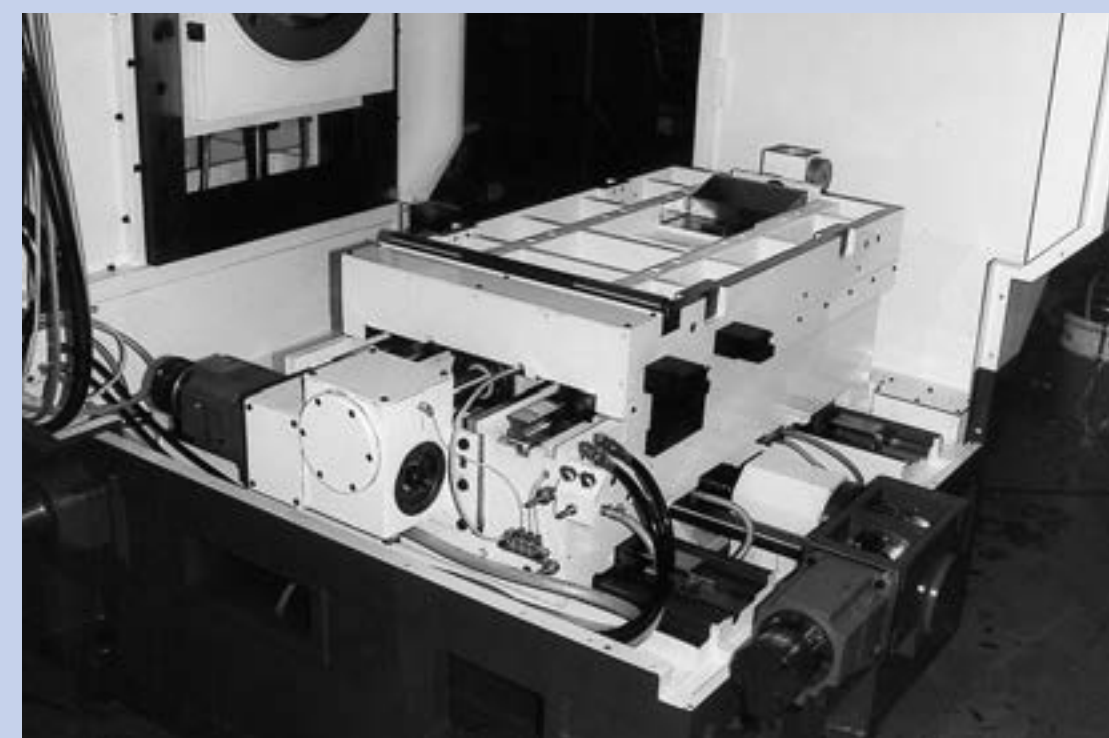
Tool grinding machine

LRXD · LRXDG



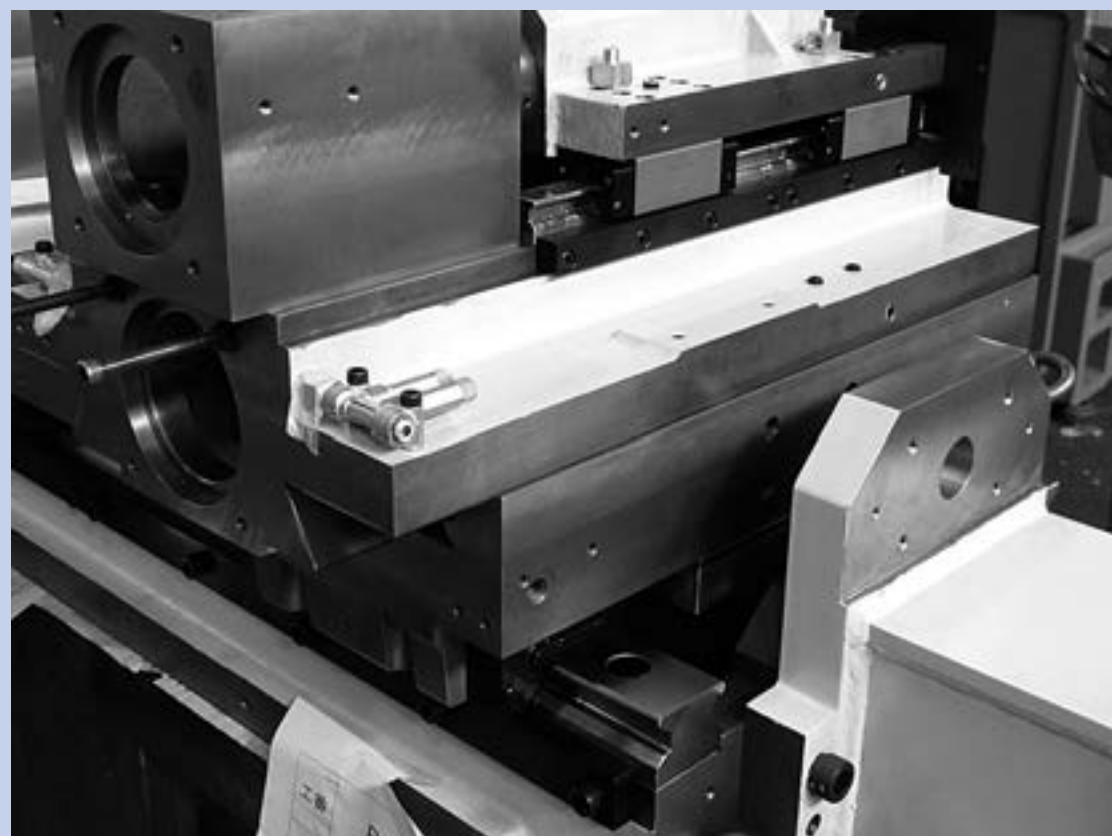
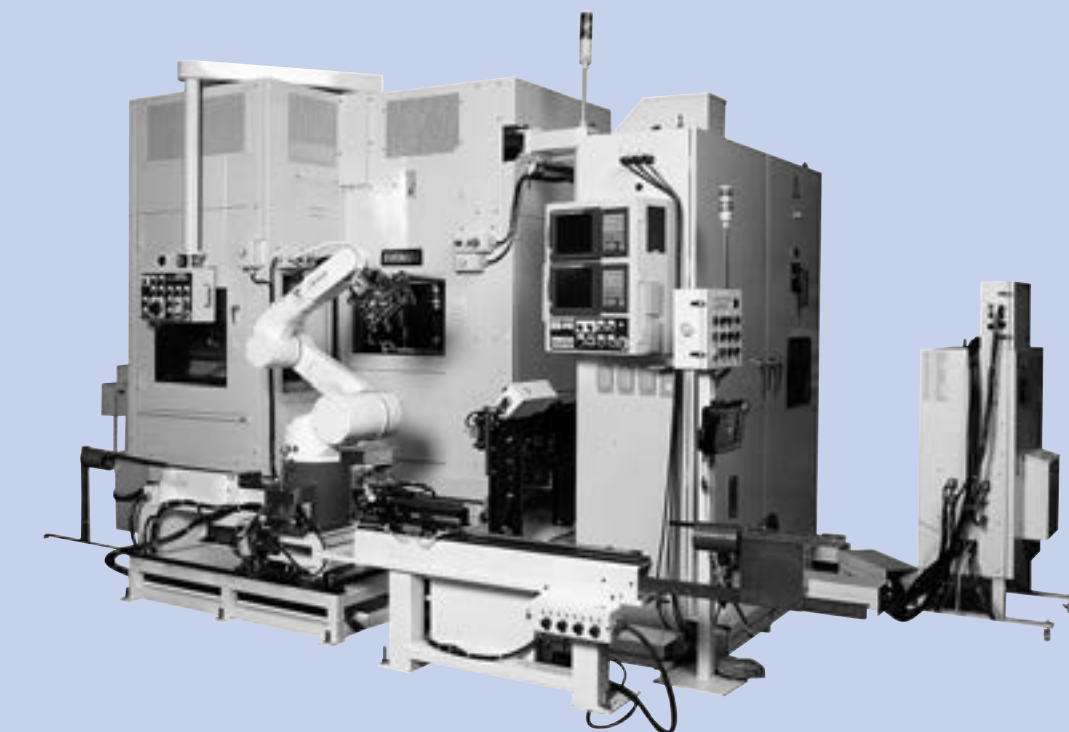
Synchronized control gear grinding machine

LRXG



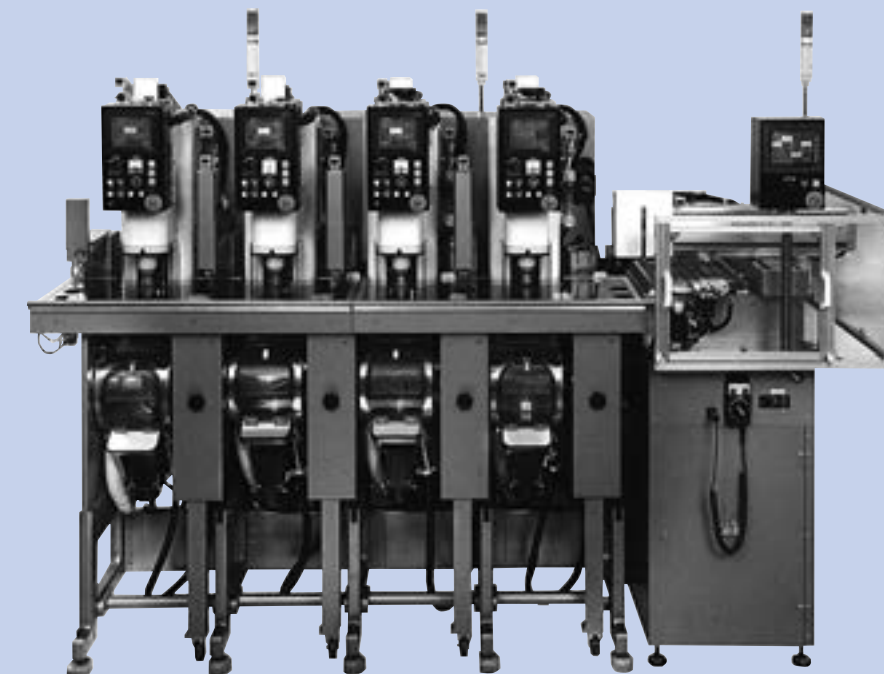
Piston ring grinding machine

LRXG · LRXD



High precision NC lens polishing machine

MXD · LRXS





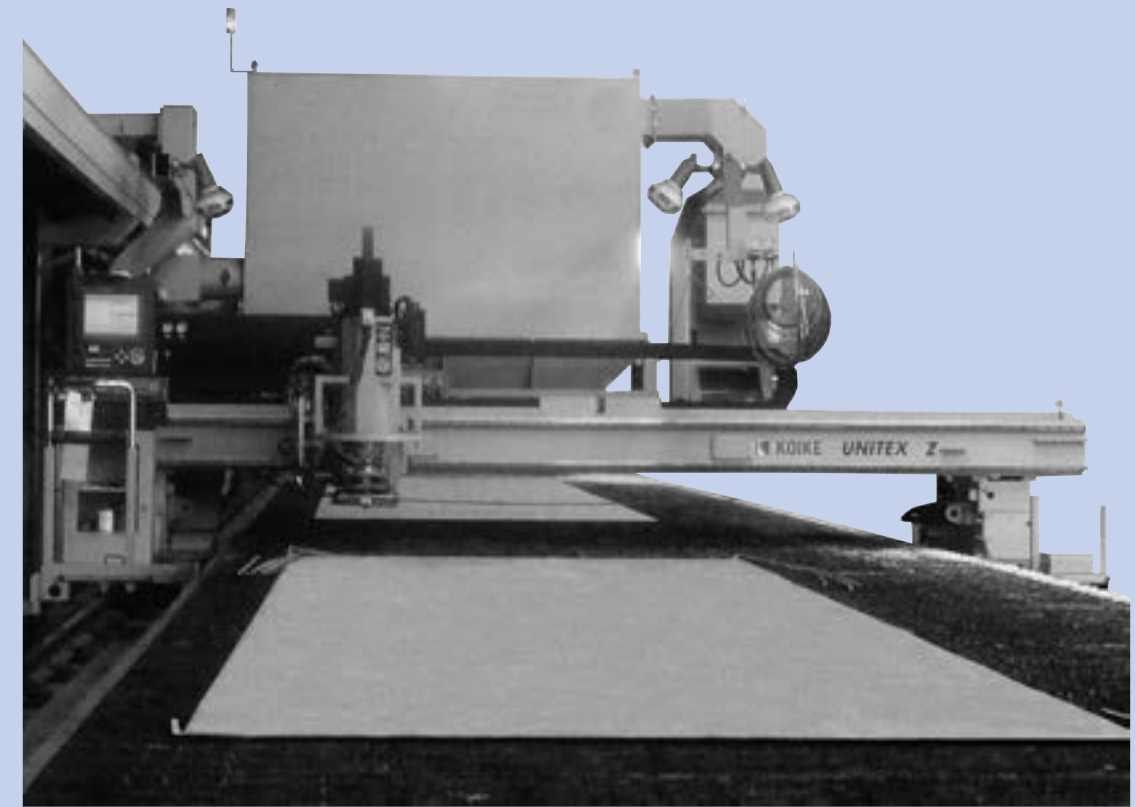
Roll forming machine

LRXG



Plasma cutting machine

MXG





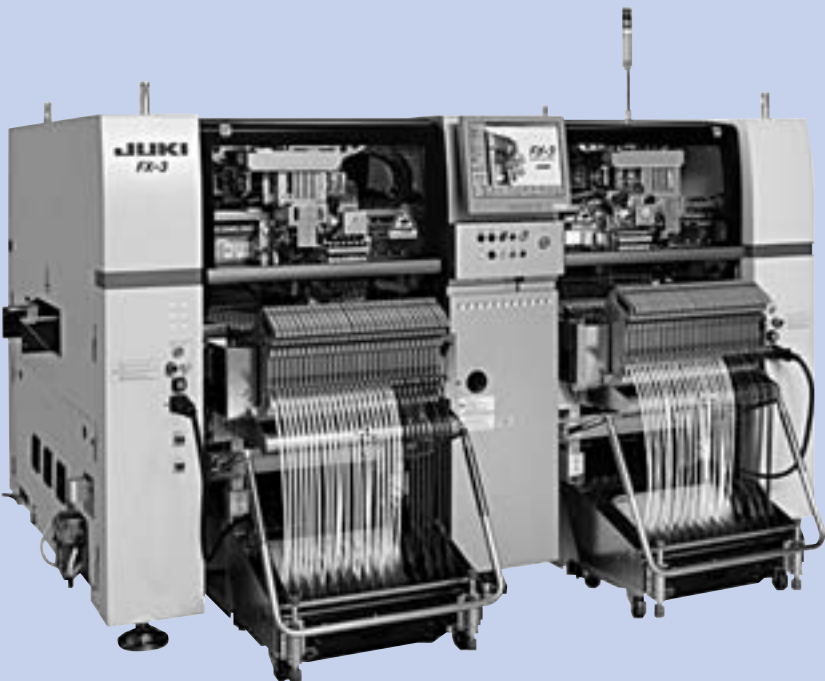
Automatic work changer for five-axis control vertical machining center

MXDG · MXDL



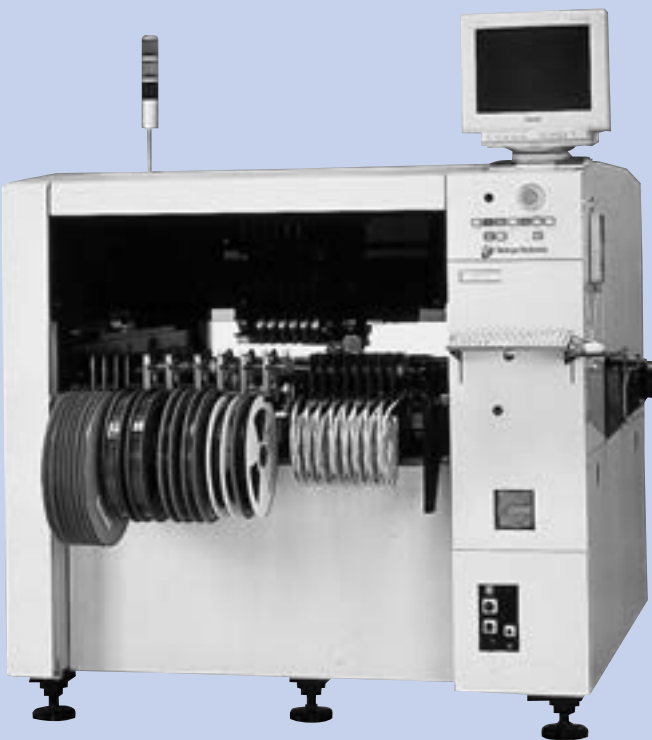
Chip mounter

MXSG · ML · MES · MHD



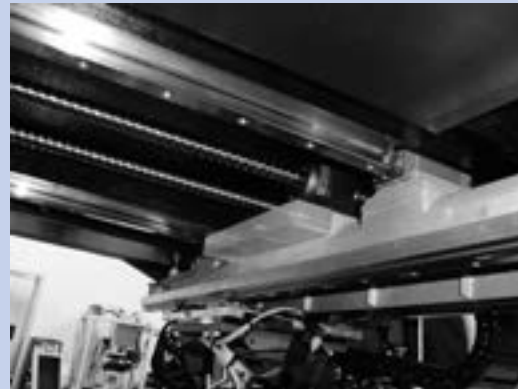
Chip mounter

LWLC



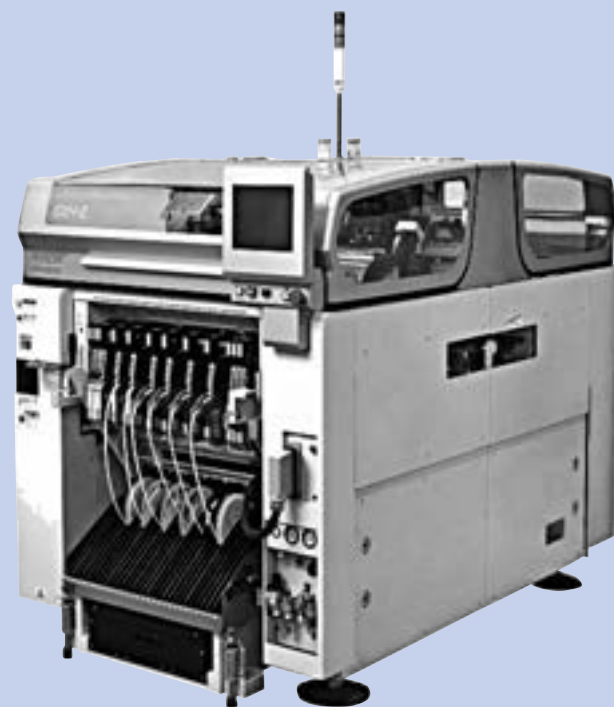
Twin head high-speed multi function mounter

MXS • MXSG • MLFG



High-speed modular mounter

LRXD • MLG • MLF



High-speed chip mounter

LWLF • LWHS • LWHS



Stepper

LWL • LWLF • LWHS



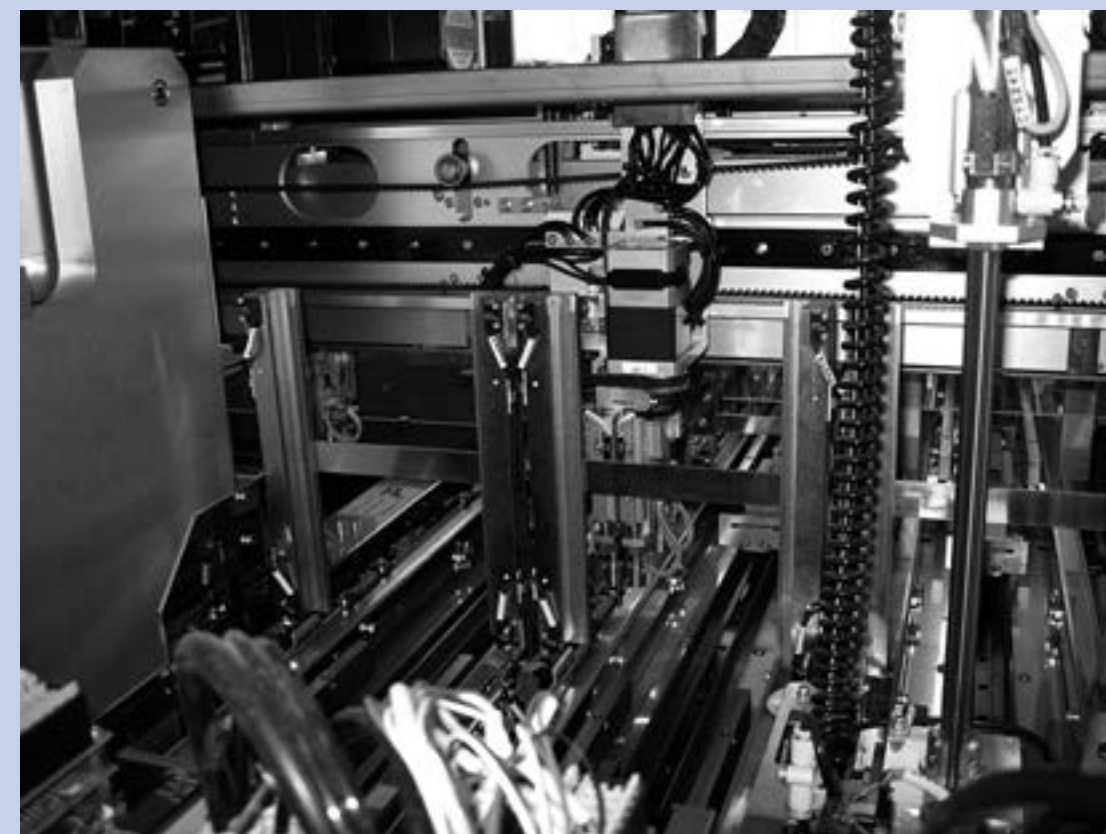
Burn-in handler

ML · LWHS



IC handler

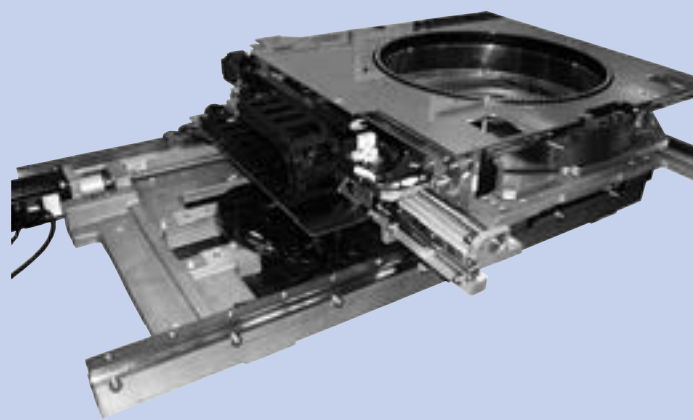
LWHD





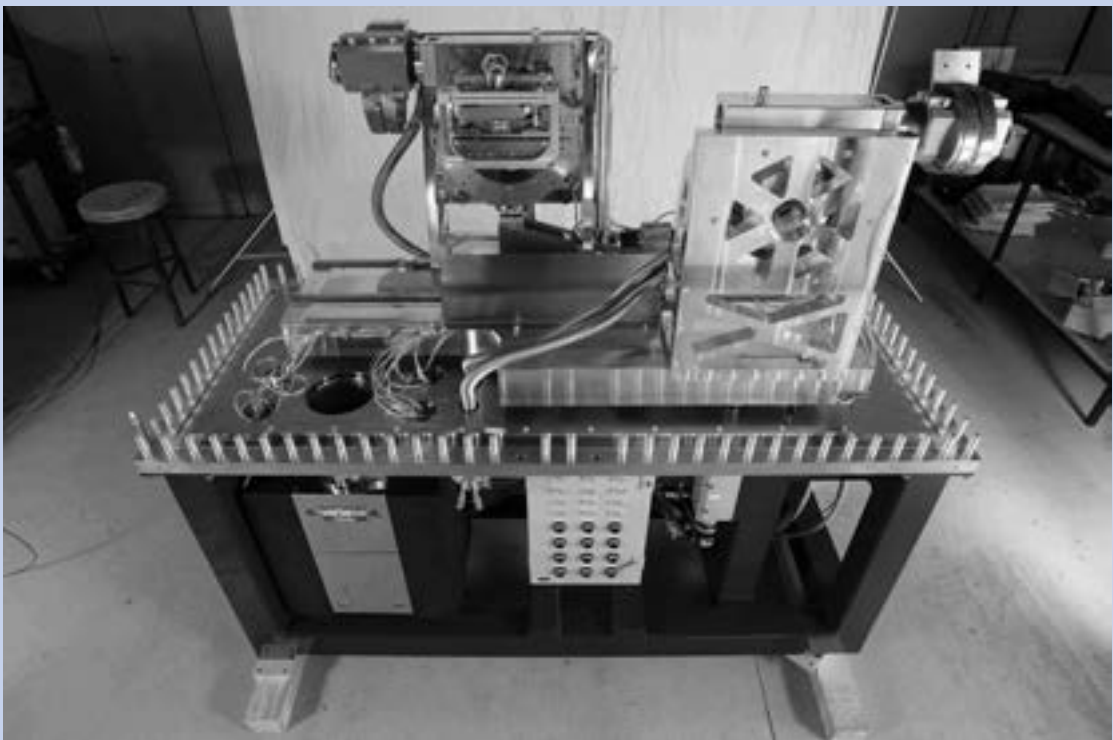
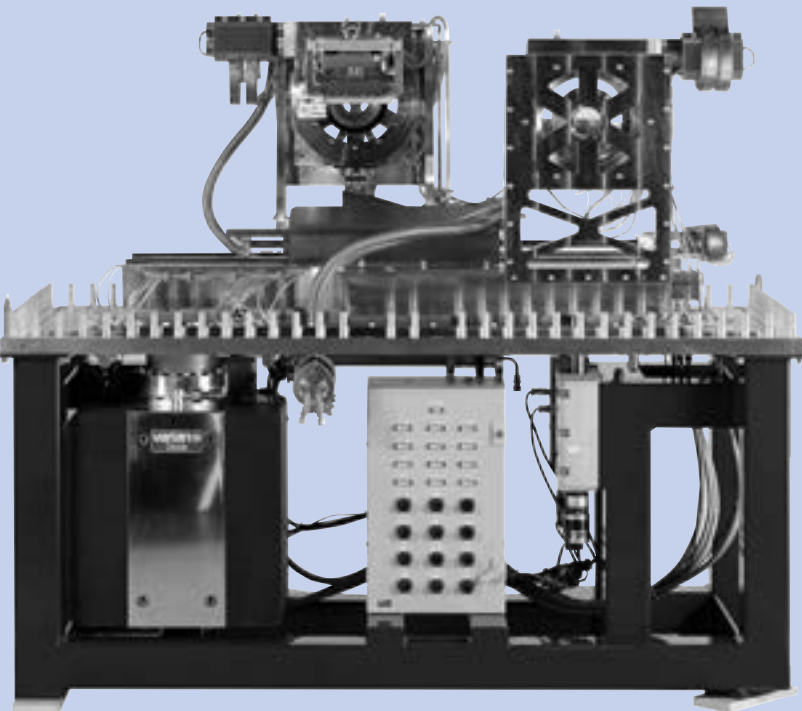
Die bonder

LRXD · LRXS



Spectroscope

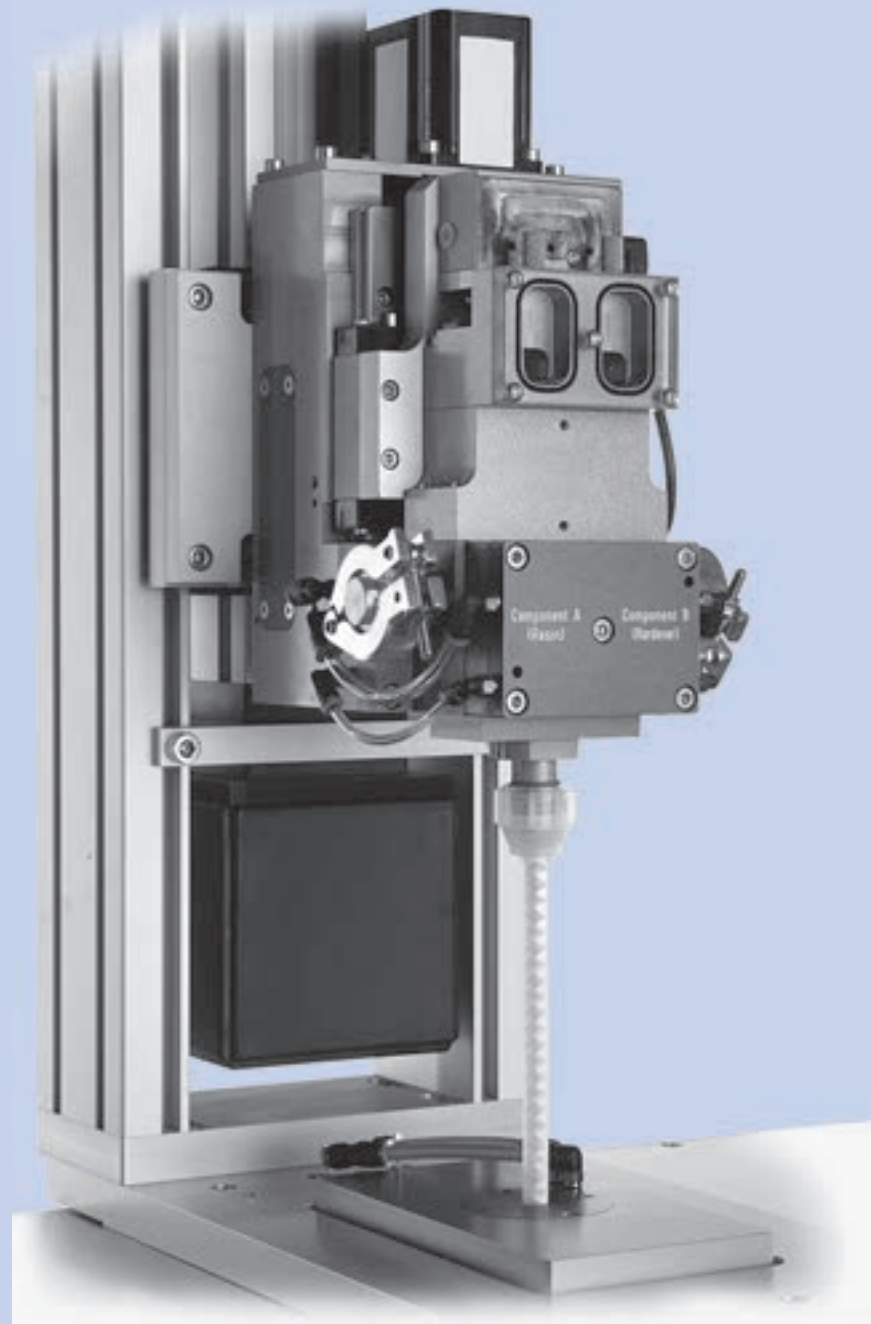
LWL





Resin forming machine for electronics devises

LRXDG



Rotary offset printing machine

LWH · LWHDG



Multi-head type electronic embroidery machine

LWL



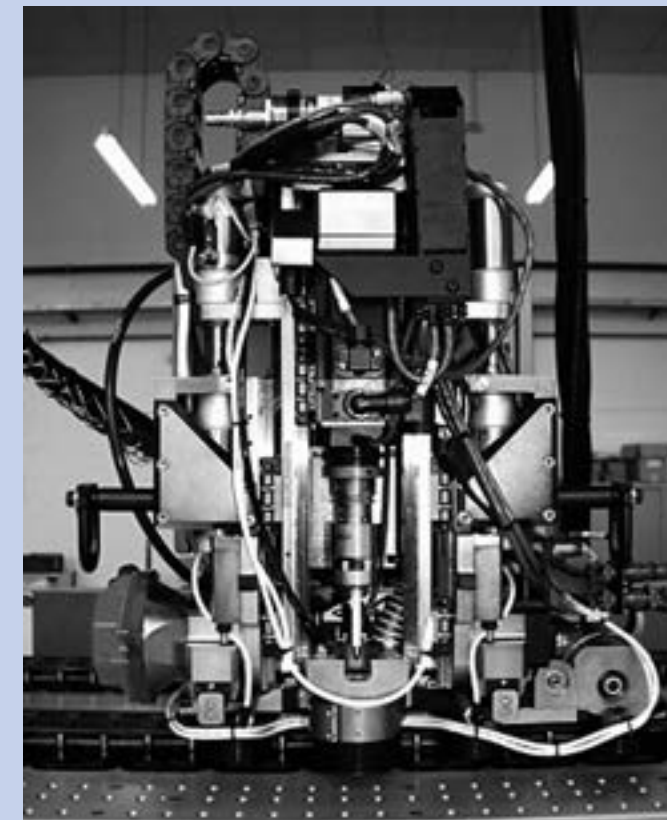
Newspaper packaging machine

LWHS



Welding machine for airplane body panels

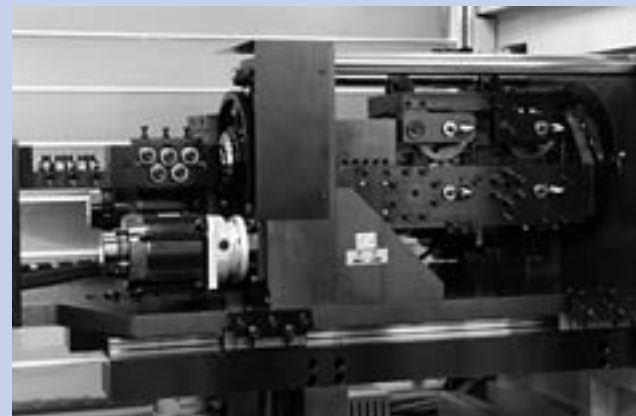
LRXD • LWL





Spring forming machine

MXG • MXDG • MXSG • MXNSG



Locating machines for airplane body panels

LRX



Injection molding machine

LWES



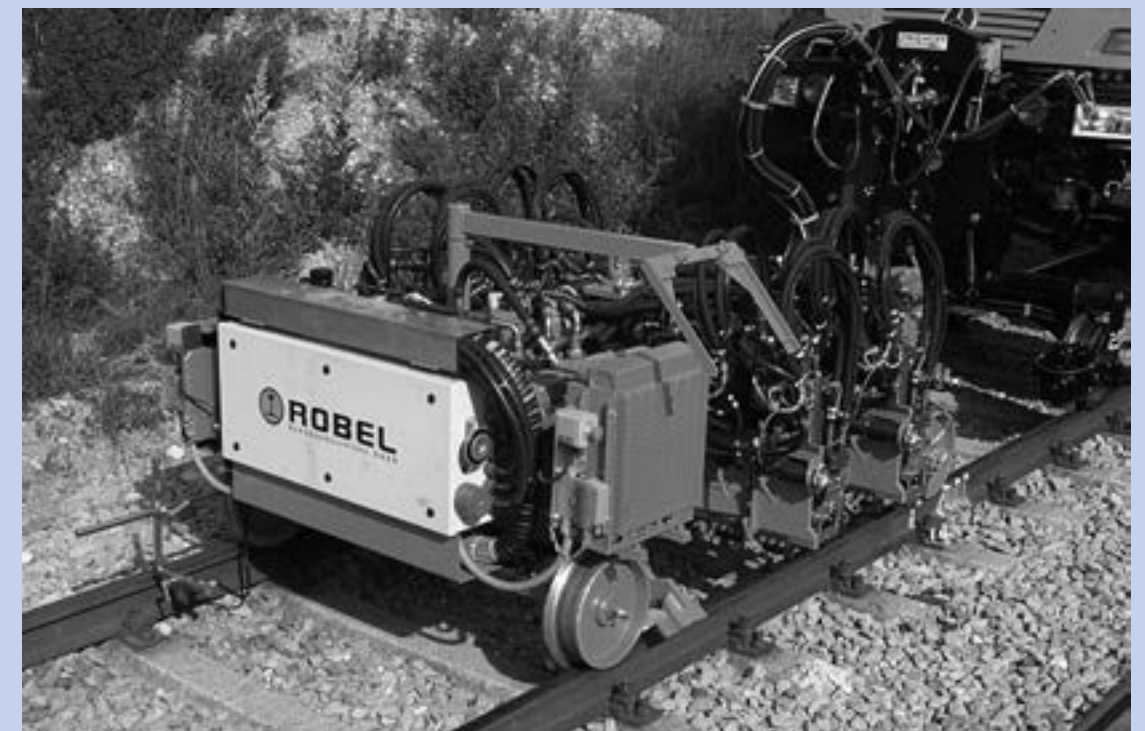
CNC gear profile inspection machine

LRX



Maintenance machine for railroad application

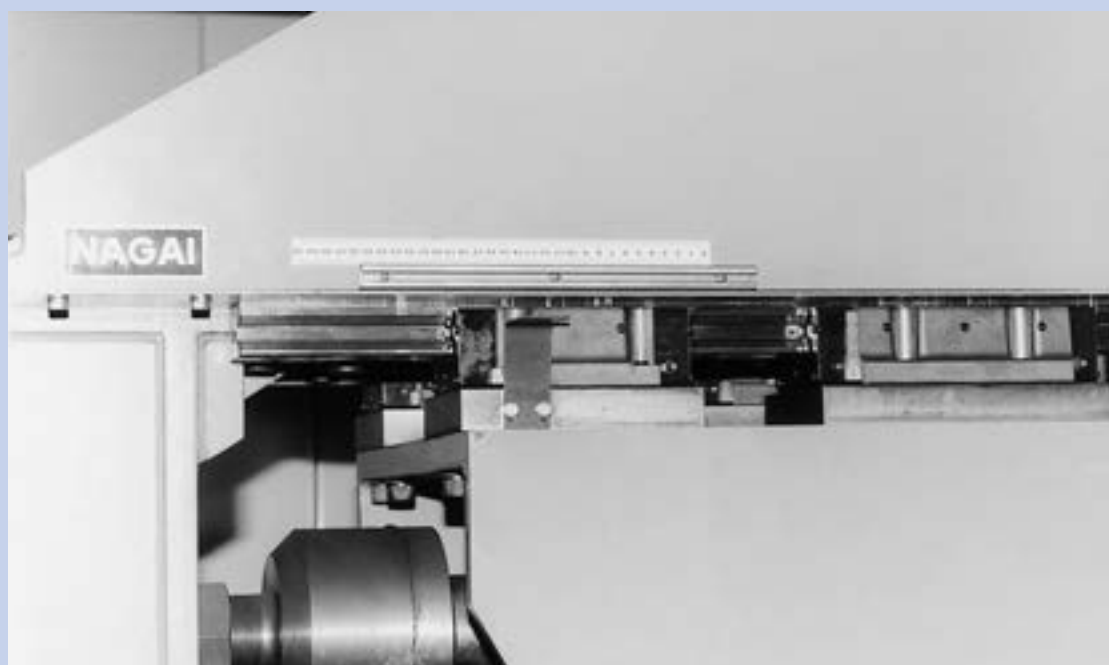
LRXG





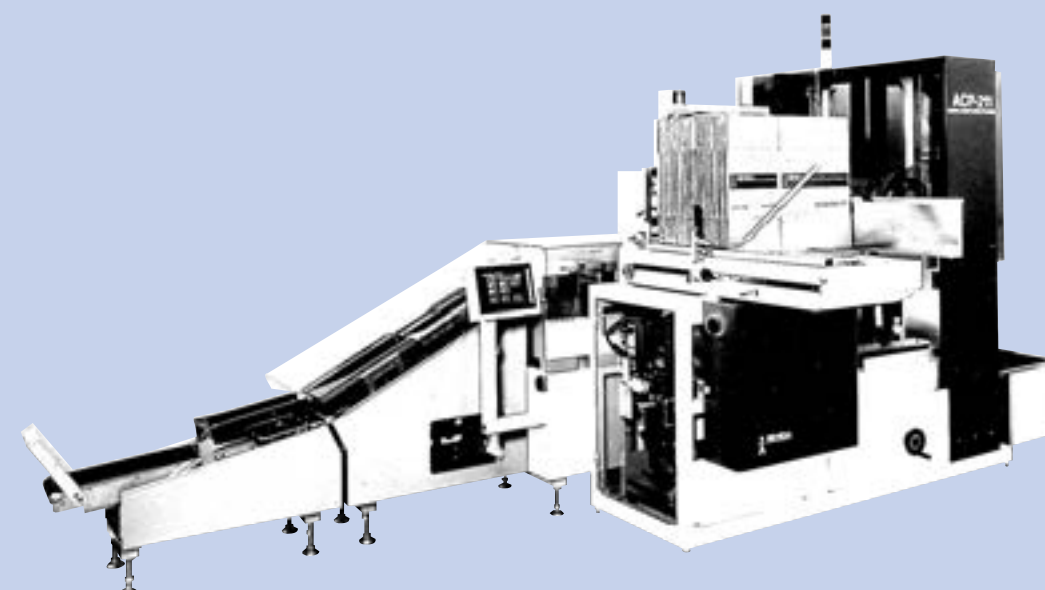
High pressure forming machine for wood materials

LRXG



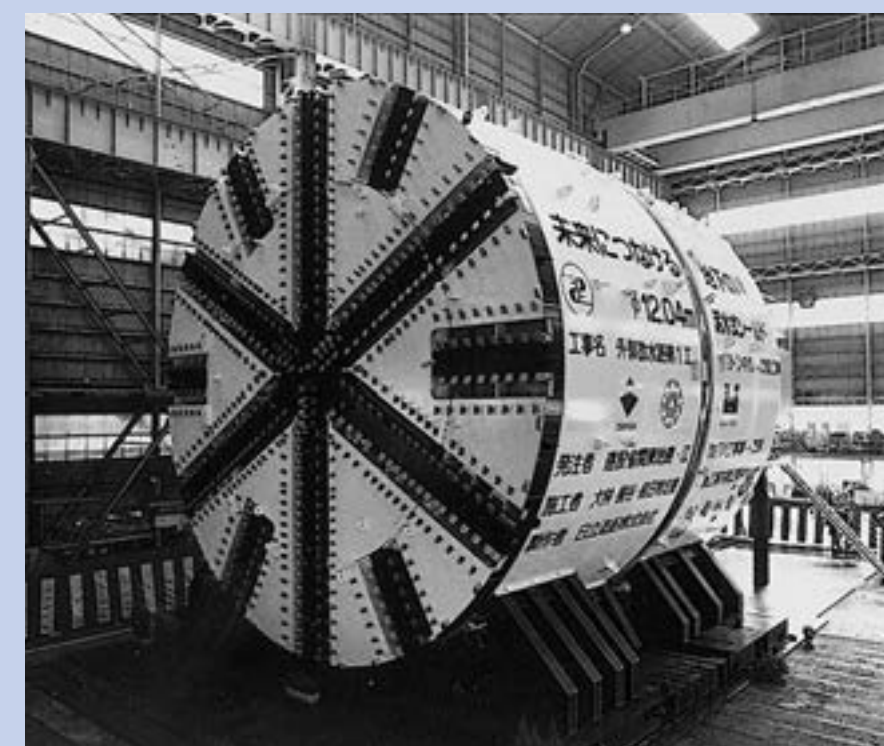
Automatic case packer

LWL • LWES • LWH • LWHS • LWHDG



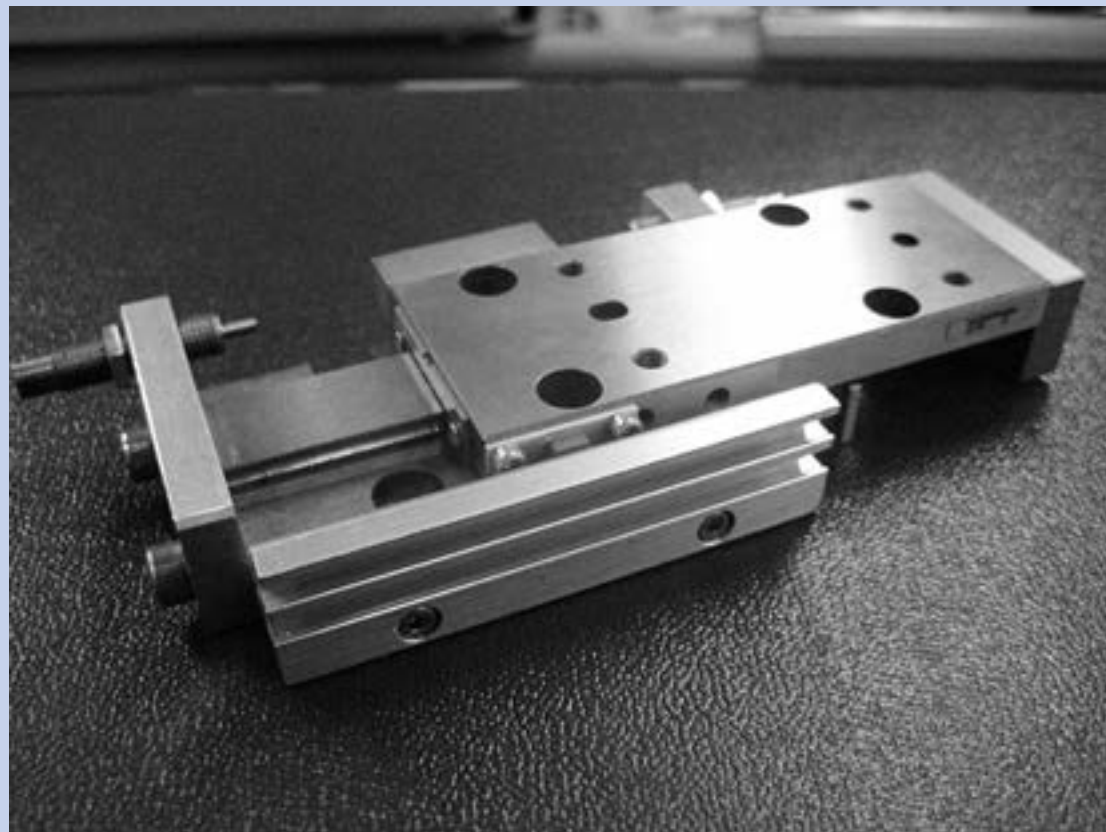
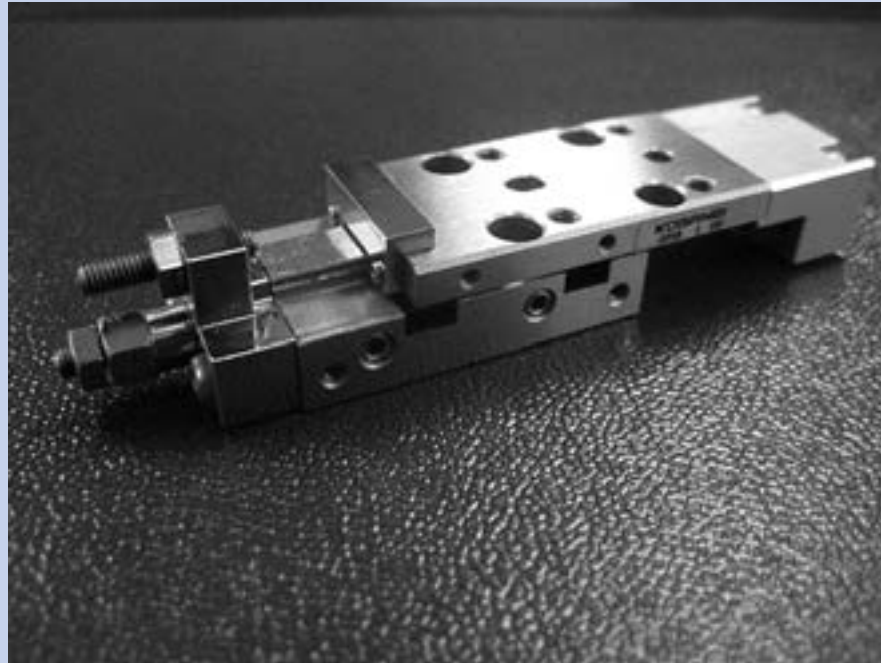
Shield type tunnel excavator

LRXDG • LWHS



Pneumatic cylinder unit

LWL



Pneumatic actuator

LWL



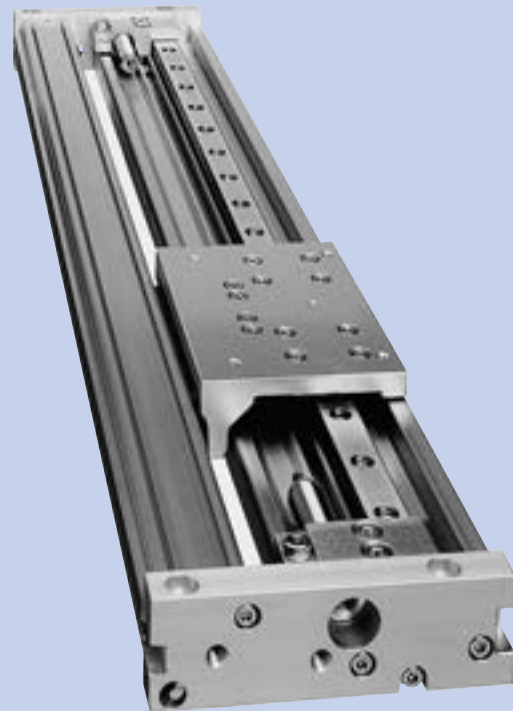
Pneumatic slide table

LWL



Rodless cylinder

LWL



XYZ-axis robot

LWHD





Statements

● Unit Conversion Rate Table

SI, CGS series and gravity system unit cross-reference table

| Amount<br>Unit system | Length | Mass                  | Time | Acceleration     | Force | Stress and pressure |
|-----------------------|--------|-----------------------|------|------------------|-------|---------------------|
| SI                    | m      | kg                    | s    | m/s <sup>2</sup> | N     | Pa                  |
| CGS series            | cm     | g                     | s    | Gal              | dyn   | dyn/cm <sup>2</sup> |
| Gravity system        | m      | kgf·s <sup>2</sup> /m | s    | m/s <sup>2</sup> | kgf   | kgf/m <sup>2</sup>  |

SI unit conversion

| Amount                  | Unit name                     | Code                | SI conversion rate                 | SI unit name      | Code             |
|-------------------------|-------------------------------|---------------------|------------------------------------|-------------------|------------------|
| Angle                   | D                             | °                   | $\pi/180$                          | Radian            | rad              |
|                         | Min                           | '                   | $\pi/10\ 800$                      |                   |                  |
|                         | Sec                           | ″                   | $\pi/648\ 000$                     |                   |                  |
|                         |                               |                     |                                    |                   |                  |
| Length                  | Meter                         | m                   | 1                                  | Meter             | m                |
|                         | Micron                        | $\mu$               | $10^{-6}$                          |                   |                  |
|                         | Angstrom                      | Å                   | $10^{-10}$                         |                   |                  |
|                         | X ray unit                    |                     | $\approx 1.002\ 08\times 10^{-13}$ |                   |                  |
|                         | Nautical mile                 | n mile              | 1852                               |                   |                  |
| Area                    | Square meter                  | m <sup>2</sup>      | 1                                  | Square meter      | m <sup>2</sup>   |
|                         | Are                           | a                   | $10^2$                             |                   |                  |
|                         | Hectare                       | ha                  | $10^4$                             |                   |                  |
|                         |                               |                     |                                    |                   |                  |
| Volume                  | Cubic meter                   | m <sup>3</sup>      | 1                                  | Cubic meter       | m <sup>3</sup>   |
|                         | Liter                         | l, L                | $10^{-3}$                          |                   |                  |
| Mass                    | Kilogram                      | kg                  | 1                                  | Kilogram          | kg               |
|                         | Ton                           | t                   | $10^3$                             |                   |                  |
|                         | Atomic mass unit              | u                   | $\approx 1.660\ 57\times 10^{-27}$ |                   |                  |
| Time                    | Sec                           | s                   | 1                                  | Sec               | s                |
|                         | Min                           | min                 | 60                                 |                   |                  |
|                         | Hr                            | h                   | 3 600                              |                   |                  |
|                         | Day                           | d                   | 86 400                             |                   |                  |
| Velocity                | Meter per second              | m/s                 | 1                                  | Meter per second  | m/s              |
|                         | Knot                          | kn                  | $1\ 852/3\ 600$                    |                   |                  |
| Frequency and vibration | Number of cycle               | s <sup>-1</sup>     | 1                                  | Hertz             | Hz               |
| Number of rotations     | Rotation per minute           | rpm                 | 1/60                               | Per second        | s <sup>-1</sup>  |
| Angular velocity        | Radian per second             | rad/s               | 1                                  | Radian per second | rad/s            |
| Acceleration            | Meter per second              | m/s <sup>2</sup>    | 1                                  | Meter per second  | m/s <sup>2</sup> |
|                         | G                             | G                   | 9.806 65                           |                   |                  |
| Force                   | Weight in kg                  | kgf                 | 9.806 65                           | Newton            | N                |
|                         | Weight in ton                 | tf                  | 9 806.65                           |                   |                  |
|                         | Dyne                          | dyn                 | $10^{-5}$                          |                   |                  |
| Force moment load       | Weight in kg meter            | kgf·m               | 9.806 65                           | Newton meter      | N·m              |
| Stress and pressure     | Weight in kg per square meter | kgf/m <sup>2</sup>  | 9.806 65                           | Pascal            | Pa               |
|                         | Weight in kg per square cm    | kgf/cm <sup>2</sup> | $9.806\ 65\times 10^4$             |                   |                  |
|                         | Weight in kg per square mm    | kgf/mm <sup>2</sup> | $9.806\ 65\times 10^6$             |                   |                  |

| Energy | Power   | Temperature | Viscosity            | Kinetic viscosity | Flux | Flux density | Magnetic field intensity |
|--------|---------|-------------|----------------------|-------------------|------|--------------|--------------------------|
| J      | W       | K           | Pa·s                 | m <sup>2</sup> /s | Wb   | T            | A/m                      |
| erg    | erg/s   | ℃           | P                    | St                | Mx   | Gs           | Oe                       |
| kgf·m  | kgf·m/s | ℃           | kgf·s/m <sup>2</sup> | m <sup>2</sup> /s | —    | —            | —                        |

| Amount                   | Unit name                            | Code                 | SI conversion rate                 | SI unit name            | Code              |
|--------------------------|--------------------------------------|----------------------|------------------------------------|-------------------------|-------------------|
| Pressure                 | Meter water column                   | mH <sub>2</sub> O    | 9 806.65                           | Pascal                  | Pa                |
|                          | millimeter of mercury column         | mmHg                 | $101\ 325/760$                     |                         |                   |
|                          | Torr                                 | Torr                 | $101\ 325/760$                     |                         |                   |
|                          | Air pressure                         | atm                  | 101 325                            |                         |                   |
|                          | Bar                                  | bar                  | $10^5$                             |                         |                   |
| Energy                   | Erg                                  | erg                  | $10^{-7}$                          | Joule                   | J                 |
|                          | IT calorie                           | cal <sub>IT</sub>    | 4.186 8                            |                         |                   |
|                          | Weight in kg meter                   | kgf·m                | 9.806 65                           |                         |                   |
|                          | Kilowatt per hour                    | kW·h                 | $3.600\times 10^6$                 |                         |                   |
|                          | French horse-power per hour          | PS·h                 | $\approx 2.647\ 79\times 10^6$     |                         |                   |
| Power and motivity       | Electron volt                        | eV                   | $\approx 1.602\ 19\times 10^{-19}$ | Watt                    | W                 |
|                          | Watt                                 | W                    | 1                                  |                         |                   |
|                          | French horse-power                   | PS                   | $\approx 735.5$                    |                         |                   |
|                          | Weight in kg meter per second        | kgf·m/s              | 9.806 65                           |                         |                   |
| Viscosity                | Poise                                | P                    | $10^{-1}$                          | Pascal second           | Pa·s              |
|                          | Centipoise                           | cP                   | $10^{-3}$                          |                         |                   |
|                          | Weight in kg second per square meter | kgf·s/m <sup>2</sup> | 9.806 65                           |                         |                   |
| Kinetic viscosity        | Stokes                               | St                   | $10^{-4}$                          | Square meter per second | m <sup>2</sup> /s |
|                          | Centistokes                          | cSt                  | $10^{-6}$                          |                         |                   |
| Temperature              | D                                    | ℃                    | +273.15                            | Kelvin                  | K                 |
| Radioactivity            | Curie                                | Ci                   | $3.7\times 10^{10}$                | Becquerel               | Bq                |
|                          | Exposure radiation dose              | Roentgen             | $2.58\times 10^{-4}$               |                         |                   |
|                          | Absorbed dose                        | Rad                  | $10^{-2}$                          |                         |                   |
|                          | Dose equivalent                      | Rem                  | $10^{-2}$                          |                         |                   |
| Flux                     | Maxwell                              | Mx                   | $10^{-8}$                          | Weber                   | Wb                |
| 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               |
| Electric charge          | Coulomb                              | C                    | 1                                  | Coulomb                 | C                 |
|                          | Electric potential difference        | V                    | 1                                  |                         |                   |
| Capacitance              | Farad                                | F                    | 1                                  | Farad                   | F                 |
|                          | (Electric) Resistance                | Ω                    | 1                                  |                         |                   |
| (Electric) Conductance   | Ohm                                  | Ω                    | 1                                  | Ohm                     | Ω                 |
|                          | Siemens                              | S                    | 1                                  |                         |                   |
| Inductance               | Henry                                | H                    | 1                                  | Henry                   | H                 |
|                          | Current                              | A                    | 1                                  |                         |                   |

● Inch-mm Conversion Table

1 inch=25.4mm

| inch              |                | 0"     | 1"     | 2"     | 3"     | 4"      | 5"      | 6"      | 7"      | 8"      |
|-------------------|----------------|--------|--------|--------|--------|---------|---------|---------|---------|---------|
| Fractional number | Decimal number |        |        |        |        |         |         |         |         |         |
|                   | 0              |        | 25.400 | 50.800 | 76.200 | 101.600 | 127.000 | 152.400 | 177.800 | 203.200 |
| 1 / 64"           | 0.015625       | 0.397  | 25.797 | 51.197 | 76.597 | 101.997 | 127.397 | 152.797 | 178.197 | 203.597 |
| 1 / 32"           | 0.031250       | 0.794  | 26.194 | 51.594 | 76.994 | 102.394 | 127.794 | 153.194 | 178.594 | 203.994 |
| 3 / 64"           | 0.046875       | 1.191  | 26.591 | 51.991 | 77.391 | 102.791 | 128.191 | 153.591 | 178.991 | 204.391 |
| 1 / 16"           | 0.062500       | 1.588  | 26.988 | 52.388 | 77.788 | 103.188 | 128.588 | 153.988 | 179.388 | 204.788 |
| 5 / 64"           | 0.078125       | 1.984  | 27.384 | 52.784 | 78.184 | 103.584 | 128.984 | 154.384 | 179.784 | 205.184 |
| 3 / 32"           | 0.093750       | 2.381  | 27.781 | 53.181 | 78.581 | 103.981 | 129.381 | 154.781 | 180.181 | 205.581 |
| 7 / 64"           | 0.109375       | 2.778  | 28.178 | 53.578 | 78.978 | 104.378 | 129.778 | 155.178 | 180.578 | 205.978 |
| 1 / 8"            | 0.125000       | 3.175  | 28.575 | 53.975 | 79.375 | 104.775 | 130.175 | 155.575 | 180.975 | 206.375 |
| 9 / 64"           | 0.140625       | 3.572  | 28.972 | 54.372 | 79.772 | 105.172 | 130.572 | 155.972 | 181.372 | 206.772 |
| 5 / 32"           | 0.156250       | 3.969  | 29.369 | 54.769 | 80.169 | 105.569 | 130.969 | 156.369 | 181.769 | 207.169 |
| 11 / 64"          | 0.171875       | 4.366  | 29.766 | 55.166 | 80.566 | 105.966 | 131.366 | 156.766 | 182.166 | 207.566 |
| 3 / 16"           | 0.187500       | 4.762  | 30.162 | 55.562 | 80.962 | 106.362 | 131.762 | 157.162 | 182.562 | 207.962 |
| 13 / 64"          | 0.203125       | 5.159  | 30.559 | 55.959 | 81.359 | 106.759 | 132.159 | 157.559 | 182.959 | 208.359 |
| 7 / 32"           | 0.218750       | 5.556  | 30.956 | 56.356 | 81.756 | 107.156 | 132.556 | 157.956 | 183.356 | 208.756 |
| 15 / 64"          | 0.234375       | 5.953  | 31.353 | 56.753 | 82.153 | 107.553 | 132.953 | 158.353 | 183.753 | 209.153 |
| 1 / 4"            | 0.250000       | 6.350  | 31.750 | 57.150 | 82.550 | 107.950 | 133.350 | 158.750 | 184.150 | 209.550 |
| 17 / 64"          | 0.265625       | 6.747  | 32.147 | 57.547 | 82.947 | 108.347 | 133.747 | 159.147 | 184.547 | 209.947 |
| 9 / 32"           | 0.281250       | 7.144  | 32.544 | 57.944 | 83.344 | 108.744 | 134.144 | 159.544 | 184.944 | 210.344 |
| 19 / 64"          | 0.296875       | 7.541  | 32.941 | 58.341 | 83.741 | 109.141 | 134.541 | 159.941 | 185.341 | 210.741 |
| 5 / 16"           | 0.312500       | 7.938  | 33.338 | 58.738 | 84.138 | 109.538 | 134.938 | 160.338 | 185.738 | 211.138 |
| 21 / 64"          | 0.328125       | 8.334  | 33.734 | 59.134 | 84.534 | 109.934 | 135.334 | 160.734 | 186.134 | 211.534 |
| 11 / 32"          | 0.343750       | 8.731  | 34.131 | 59.531 | 84.931 | 110.331 | 135.731 | 161.131 | 186.531 | 211.931 |
| 23 / 64"          | 0.359375       | 9.128  | 34.528 | 59.928 | 85.328 | 110.728 | 136.128 | 161.528 | 186.928 | 212.328 |
| 3 / 8"            | 0.375000       | 9.525  | 34.925 | 60.325 | 85.725 | 111.125 | 136.525 | 161.925 | 187.325 | 212.725 |
| 25 / 64"          | 0.390625       | 9.922  | 35.322 | 60.722 | 86.122 | 111.522 | 136.922 | 162.322 | 187.722 | 213.122 |
| 13 / 32"          | 0.406250       | 10.319 | 35.719 | 61.119 | 86.519 | 111.919 | 137.319 | 162.719 | 188.119 | 213.519 |
| 27 / 64"          | 0.421875       | 10.716 | 36.116 | 61.516 | 86.916 | 112.316 | 137.716 | 163.116 | 188.516 | 213.916 |
| 7 / 16"           | 0.437500       | 11.112 | 36.512 | 61.912 | 87.312 | 112.712 | 138.112 | 163.512 | 188.912 | 214.312 |
| 29 / 64"          | 0.453125       | 11.509 | 36.909 | 62.309 | 87.709 | 113.109 | 138.509 | 163.909 | 189.309 | 214.709 |
| 15 / 32"          | 0.468750       | 11.906 | 37.306 | 62.706 | 88.106 | 113.506 | 138.906 | 164.306 | 189.706 | 215.106 |
| 31 / 64"          | 0.484375       | 12.303 | 37.703 | 63.103 | 88.503 | 113.903 | 139.303 | 164.703 | 190.103 | 215.503 |
| 1 / 2"            | 0.500000       | 12.700 | 38.100 | 63.500 | 88.900 | 114.300 | 139.700 | 165.100 | 190.500 | 215.900 |

1 inch=25.4mm

| inch              |                | 0"     | 1"     | 2"     | 3"      | 4"      | 5"      | 6"      | 7"      | 8"      |
|-------------------|----------------|--------|--------|--------|---------|---------|---------|---------|---------|---------|
| Fractional number | Decimal number |        |        |        |         |         |         |         |         |         |
| 33 / 64"          | 0.515625       | 13.097 | 38.497 | 63.897 | 89.297  | 114.697 | 140.097 | 165.497 | 190.897 | 216.297 |
| 17 / 32"          | 0.531250       | 13.494 | 38.894 | 64.294 | 89.694  | 115.094 | 140.494 | 165.894 | 191.294 | 216.694 |
| 35 / 64"          | 0.546875       | 13.891 | 39.291 | 64.691 | 90.091  | 115.491 | 140.891 | 166.291 | 191.691 | 217.091 |
| 9 / 16"           | 0.562500       | 14.288 | 39.688 | 65.088 | 90.488  | 115.888 | 141.288 | 166.688 | 192.088 | 217.488 |
| 37 / 64"          | 0.578125       | 14.684 | 40.084 | 65.484 | 90.884  | 116.284 | 141.684 | 167.084 | 192.484 | 217.884 |
| 19 / 32"          | 0.593750       | 15.081 | 40.481 | 65.881 | 91.281  | 116.681 | 142.081 | 167.481 | 192.881 | 218.281 |
| 39 / 64"          | 0.609375       | 15.478 | 40.878 | 66.278 | 91.678  | 117.078 | 142.478 | 167.878 | 193.278 | 218.678 |
| 5 / 8"            | 0.625000       | 15.875 | 41.275 | 66.675 | 92.075  | 117.475 | 142.875 | 168.275 | 193.675 | 219.075 |
| 41 / 64"          | 0.640625       | 16.272 | 41.672 | 67.072 | 92.472  | 117.872 | 143.272 | 168.672 | 194.072 | 219.472 |
| 21 / 32"          | 0.656250       | 16.669 | 42.069 | 67.469 | 92.869  | 118.269 | 143.669 | 169.069 | 194.469 | 219.869 |
| 43 / 64"          | 0.671875       | 17.066 | 42.466 | 67.866 | 93.266  | 118.666 | 144.066 | 169.466 | 194.866 | 220.266 |
| 11 / 16"          | 0.687500       | 17.462 | 42.862 | 68.262 | 93.662  | 119.062 | 144.462 | 169.862 | 195.262 | 220.662 |
| 45 / 64"          | 0.703125       | 17.859 | 43.259 | 68.659 | 94.059  | 119.459 | 144.859 | 170.259 | 195.659 | 221.059 |
| 23 / 32"          | 0.718750       | 18.256 | 43.656 | 69.056 | 94.456  | 119.856 | 145.256 | 170.656 | 196.056 | 221.456 |
| 47 / 64"          | 0.734375       | 18.653 | 44.053 | 69.453 | 94.853  | 120.253 | 145.653 | 171.053 | 196.453 | 221.853 |
| 3 / 4"            | 0.750000       | 19.050 | 44.450 | 69.850 | 95.250  | 120.650 | 146.050 | 171.450 | 196.850 | 222.250 |
| 49 / 64"          | 0.765625       | 19.447 | 44.847 | 70.247 | 95.647  | 121.047 | 146.447 | 171.847 | 197.247 | 222.647 |
| 25 / 32"          | 0.781250       | 19.844 | 45.244 | 70.644 | 96.044  | 121.444 | 146.844 | 172.244 | 197.644 | 223.044 |
| 51 / 64"          | 0.796875       | 20.241 | 45.641 | 71.041 | 96.441  | 121.841 | 147.241 | 172.641 | 198.041 | 223.441 |
| 13 / 16"          | 0.812500       | 20.638 | 46.038 | 71.438 | 96.838  | 122.238 | 147.638 | 173.038 | 198.438 | 223.838 |
| 53 / 64"          | 0.828125       | 21.034 | 46.434 | 71.834 | 97.234  | 122.634 | 148.034 | 173.434 | 198.834 | 224.234 |
| 27 / 32"          | 0.843750       | 21.431 | 46.831 | 72.231 | 97.631  | 123.031 | 148.431 | 173.831 | 199.231 | 224.631 |
| 55 / 64"          | 0.859375       | 21.828 | 47.228 | 72.628 | 98.028  | 123.428 | 148.828 | 174.228 | 199.628 | 225.028 |
| 7 / 8"            | 0.875000       | 22.225 | 47.625 | 73.025 | 98.425  | 123.825 | 149.225 | 174.625 | 200.025 | 225.425 |
| 57 / 64"          | 0.890625       | 22.622 | 48.022 | 73.422 | 98.822  | 124.222 | 149.622 | 175.022 | 200.422 | 225.822 |
| 29 / 32"          | 0.906250       | 23.019 | 48.419 | 73.819 | 99.219  | 124.619 | 150.019 | 175.419 | 200.819 | 226.219 |
| 59 / 64"          | 0.921875       | 23.416 | 48.816 | 74.216 | 99.616  | 125.016 | 150.416 | 175.816 | 201.216 | 226.616 |
| 15 / 16"          | 0.937500       | 23.812 | 49.212 | 74.612 | 100.012 | 125.412 | 150.812 | 176.212 | 201.612 | 227.012 |
| 61 / 64"          | 0.953125       | 24.209 | 49.609 | 75.009 | 100.409 | 125.809 | 151.209 | 176.609 | 202.009 | 227.409 |
| 31 / 32"          | 0.968750       | 24.606 | 50.006 | 75.406 | 100.806 | 126.206 | 151.606 | 177.006 | 202.406 | 227.806 |
| 63 / 64"          | 0.984375       | 25.003 | 50.403 | 75.803 | 101.203 | 126.603 | 152.003 | 177.403 | 202.803 | 228.203 |

● Hardness Conversion Table (Reference)

| Rockwell<br>C scale<br>hardness<br>Load 1471N<br><br>HRC | Vickers<br>hardness<br><br>HV | Brinell hardness |                          | Rockwell hardness                       |                                        | Shore<br>hardness<br><br>HS |
|----------------------------------------------------------|-------------------------------|------------------|--------------------------|-----------------------------------------|----------------------------------------|-----------------------------|
|                                                          |                               | Standard ball    | Tungsten<br>Carbide ball | A scale                                 | B scale                                |                             |
|                                                          |                               |                  |                          | Load 588.4N<br>Diamond<br>circular cone | Load 980.7N<br>Diameter<br>1/16in ball |                             |
| 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                          |
| 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                          |

| Rockwell<br>C scale<br>hardness<br>Load 1471N<br><br>HRC | Vickers<br>hardness<br><br>HV | Brinell hardness |                          | Rockwell hardness                       |                                        | Shore<br>hardness<br><br>HS |
|----------------------------------------------------------|-------------------------------|------------------|--------------------------|-----------------------------------------|----------------------------------------|-----------------------------|
|                                                          |                               | Standard ball    | Tungsten<br>Carbide ball | A scale                                 | B scale                                |                             |
|                                                          |                               |                  |                          | Load 588.4N<br>Diamond<br>circular cone | Load 980.7N<br>Diameter<br>1/16in ball |                             |
| 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                          |



● Tolerances of Shaft Dimensions

| Classification of diameter mm |     | b12  |       | c12  |       | d6   |      | e6   |      | e12  |      | f5  |     | f6  |      | g5  |     |
|-------------------------------|-----|------|-------|------|-------|------|------|------|------|------|------|-----|-----|-----|------|-----|-----|
|                               |     | H    | L     | H    | L     | H    | L    | H    | L    | H    | L    | H   | L   | H   | L    | H   | L   |
| —                             | 3   | −140 | −240  | −60  | −160  | −20  | −26  | −14  | −20  | −14  | −114 | −6  | −10 | −6  | −12  | −2  | −6  |
| 3                             | 6   | −140 | −260  | −70  | −190  | −30  | −38  | −20  | −28  | −20  | −140 | −10 | −15 | −10 | −18  | −4  | −9  |
| 6                             | 10  | −150 | −300  | −80  | −230  | −40  | −49  | −25  | −34  | −25  | −175 | −13 | −19 | −13 | −22  | −5  | −11 |
| 10                            | 18  | −150 | −330  | −95  | −275  | −50  | −61  | −32  | −43  | −32  | −212 | −16 | −24 | −16 | −27  | −6  | −14 |
| 18                            | 30  | −160 | −370  | −110 | −320  | −65  | −78  | −40  | −53  | −40  | −250 | −20 | −29 | −20 | −33  | −7  | −16 |
| 30                            | 40  | −170 | −420  | −120 | −370  | −80  | −96  | −50  | −66  | −50  | −300 | −25 | −36 | −25 | −41  | −9  | −20 |
| 40                            | 50  | −180 | −430  | −130 | −380  |      |      |      |      |      |      |     |     |     |      |     |     |
| 50                            | 65  | −190 | −490  | −140 | −440  | −100 | −119 | −60  | −79  | −60  | −360 | −30 | −43 | −30 | −49  | −10 | −23 |
| 65                            | 80  | −200 | −500  | −150 | −450  |      |      |      |      |      |      |     |     |     |      |     |     |
| 80                            | 100 | −220 | −570  | −170 | −520  | −120 | −142 | −72  | −94  | −72  | −422 | −36 | −51 | −36 | −58  | −12 | −27 |
| 100                           | 120 | −240 | −590  | −180 | −530  |      |      |      |      |      |      |     |     |     |      |     |     |
| 120                           | 140 | −260 | −660  | −200 | −600  | −145 | −170 | −85  | −110 | −85  | −485 | −43 | −61 | −43 | −68  | −14 | −32 |
| 140                           | 160 | −280 | −680  | −210 | −610  |      |      |      |      |      |      |     |     |     |      |     |     |
| 160                           | 180 | −310 | −710  | −230 | −630  |      |      |      |      |      |      |     |     |     |      |     |     |
| 180                           | 200 | −340 | −800  | −240 | −700  | −170 | −199 | −100 | −129 | −100 | −560 | −50 | −70 | −50 | −79  | −15 | −35 |
| 200                           | 225 | −380 | −840  | −260 | −720  |      |      |      |      |      |      |     |     |     |      |     |     |
| 225                           | 250 | −420 | −880  | −280 | −740  |      |      |      |      |      |      |     |     |     |      |     |     |
| 250                           | 280 | −480 | −1000 | −300 | −820  | −190 | −222 | −110 | −142 | −110 | −630 | −56 | −79 | −56 | −88  | −17 | −40 |
| 280                           | 315 | −540 | −1060 | −330 | −850  |      |      |      |      |      |      |     |     |     |      |     |     |
| 315                           | 355 | −600 | −1170 | −360 | −930  | −210 | −246 | −125 | −161 | −125 | −695 | −62 | −87 | −62 | −98  | −18 | −43 |
| 355                           | 400 | −680 | −1250 | −400 | −970  |      |      |      |      |      |      |     |     |     |      |     |     |
| 400                           | 450 | −760 | −1390 | −440 | −1070 | −230 | −270 | −135 | −175 | −135 | −765 | −68 | −95 | −68 | −108 | −20 | −47 |
| 450                           | 500 | −840 | −1470 | −480 | −1110 |      |      |      |      |      |      |     |     |     |      |     |     |

| Classification of diameter mm |     | h12 |      | js5   |       | j5 |     | js6   |       | j6  |     | j7  |     | k5  |    | k6  |    |
|-------------------------------|-----|-----|------|-------|-------|----|-----|-------|-------|-----|-----|-----|-----|-----|----|-----|----|
|                               |     | H   | L    | H     | L     | H  | L   | H     | L     | H   | L   | H   | L   | H   | L  | H   | L  |
| —                             | 3   | 0   | −100 | +2    | −2    | +2 | −2  | +3    | −3    | +4  | −2  | +6  | −4  | +4  | 0  | +6  | 0  |
| 3                             | 6   | 0   | −120 | +2.5  | −2.5  | +3 | −2  | +4    | −4    | +6  | −2  | +8  | −4  | +6  | +1 | +9  | +1 |
| 6                             | 10  | 0   | −150 | +3    | −3    | +4 | −2  | +4.5  | −4.5  | +7  | −2  | +10 | −5  | +7  | +1 | +10 | +1 |
| 10                            | 18  | 0   | −180 | +4    | −4    | +5 | −3  | +5.5  | −5.5  | +8  | −3  | +12 | −6  | +9  | +1 | +12 | +1 |
| 18                            | 30  | 0   | −210 | +4.5  | −4.5  | +5 | −4  | +6.5  | −6.5  | +9  | −4  | +13 | −8  | +11 | +2 | +15 | +2 |
| 30                            | 40  | 0   | −250 | +5.5  | −5.5  | +6 | −5  | +8    | −8    | +11 | −5  | +15 | −10 | +13 | +2 | +18 | +2 |
| 40                            | 50  |     |      |       |       |    |     |       |       |     |     |     |     |     |    |     |    |
| 50                            | 65  | 0   | −300 | +6.5  | −6.5  | +6 | −7  | +9.5  | −9.5  | +12 | −7  | +18 | −12 | +15 | +2 | +21 | +2 |
| 65                            | 80  |     |      |       |       |    |     |       |       |     |     |     |     |     |    |     |    |
| 80                            | 100 | 0   | −350 | +7.5  | −7.5  | +6 | −9  | +11   | −11   | +13 | −9  | +20 | −15 | +18 | +3 | +25 | +3 |
| 100                           | 120 |     |      |       |       |    |     |       |       |     |     |     |     |     |    |     |    |
| 120                           | 140 | 0   | −400 | +9    | −9    | +7 | −11 | +12.5 | −12.5 | +14 | −11 | +22 | −18 | +21 | +3 | +28 | +3 |
| 140                           | 160 |     |      |       |       |    |     |       |       |     |     |     |     |     |    |     |    |
| 160                           | 180 |     |      |       |       |    |     |       |       |     |     |     |     |     |    |     |    |
| 180                           | 200 | 0   | −460 | +10   | −10   | +7 | −13 | +14.5 | −14.5 | +16 | −13 | +25 | −21 | +24 | +4 | +33 | +4 |
| 200                           | 225 |     |      |       |       |    |     |       |       |     |     |     |     |     |    |     |    |
| 225                           | 250 |     |      |       |       |    |     |       |       |     |     |     |     |     |    |     |    |
| 250                           | 280 | 0   | −520 | +11.5 | −11.5 | +7 | −16 | +16   | −16   | +16 | −16 | +26 | −26 | +27 | +4 | +36 | +4 |
| 280                           | 315 |     |      |       |       |    |     |       |       |     |     |     |     |     |    |     |    |
| 315                           | 355 | 0   | −570 | +12.5 | −12.5 | +7 | −18 | +18   | −18   | +18 | −18 | +29 | −28 | +29 | +4 | +40 | +4 |
| 355                           | 400 |     |      |       |       |    |     |       |       |     |     |     |     |     |    |     |    |
| 400                           | 450 | 0   | −630 | +13.5 | −13.5 | +7 | −20 | +20   | −20   | +20 | −20 | +31 | −32 | +32 | +5 | +45 | +5 |
| 450                           | 500 |     |      |       |       |    |     |       |       |     |     |     |     |     |    |     |    |

unit:  $\mu\text{m}$

| g6  |     | h5 |     | h6 |     | h7 |     | h8 |     | h9 |      | h10 |      | h11 |      | Classification of diameter mm |     |
|-----|-----|----|-----|----|-----|----|-----|----|-----|----|------|-----|------|-----|------|-------------------------------|-----|
|     |     | H  | L   | H  | L   | H  | L   | H  | L   | H  | L    | H   | L    | H   | L    |                               |     |
| −2  | −8  | 0  | −4  | 0  | −6  | 0  | −10 | 0  | −14 | 0  | −25  | 0   | −40  | 0   | −60  | —                             | 3   |
| −4  | −12 | 0  | −5  | 0  | −8  | 0  | −12 | 0  | −18 | 0  | −30  | 0   | −48  | 0   | −75  | 3                             | 6   |
| −5  | −14 | 0  | −6  | 0  | −9  | 0  | −15 | 0  | −22 | 0  | −36  | 0   | −58  | 0   | −90  | 6                             | 10  |
| −6  | −17 | 0  | −8  | 0  | −11 | 0  | −18 | 0  | −27 | 0  | −43  | 0   | −70  | 0   | −110 | 10                            | 18  |
| −7  | −20 | 0  | −9  | 0  | −13 | 0  | −21 | 0  | −33 | 0  | −52  | 0   | −84  | 0   | −130 | 18                            | 30  |
| −9  | −25 | 0  | −11 | 0  | −16 | 0  | −25 | 0  | −39 | 0  | −62  | 0   | −100 | 0   | −160 | 30                            | 40  |
|     |     |    |     |    |     |    |     |    |     |    |      |     |      |     |      | 40                            | 50  |
| −10 | −29 | 0  | −13 | 0  | −19 | 0  | −30 | 0  | −46 | 0  | −74  | 0   | −120 | 0   | −190 | 50                            | 65  |
|     |     |    |     |    |     |    |     |    |     |    |      |     |      |     |      | 65                            | 80  |
| −12 | −34 | 0  | −15 | 0  | −22 | 0  | −35 | 0  | −54 | 0  | −87  | 0   | −140 | 0   | −220 | 80                            | 100 |
|     |     |    |     |    |     |    |     |    |     |    |      |     |      |     |      | 100                           | 120 |
| −14 | −39 | 0  | −18 | 0  | −25 | 0  | −40 | 0  | −63 | 0  | −100 | 0   | −160 | 0   | −250 | 120                           | 140 |
|     |     |    |     |    |     |    |     |    |     |    |      |     |      |     |      | 140                           | 160 |
|     |     |    |     |    |     |    |     |    |     |    |      |     |      |     |      | 160                           | 180 |
| −15 | −44 | 0  | −20 | 0  | −29 | 0  | −46 | 0  | −72 | 0  | −115 | 0   | −185 | 0   | −290 | 180                           | 200 |
|     |     |    |     |    |     |    |     |    |     |    |      |     |      |     |      | 200                           | 225 |
|     |     |    |     |    |     |    |     |    |     |    |      |     |      |     |      | 225                           | 250 |
| −17 | −49 | 0  | −23 | 0  | −32 | 0  | −52 | 0  | −81 | 0  | −130 | 0   | −210 | 0   | −320 | 250                           | 280 |
|     |     |    |     |    |     |    |     |    |     |    |      |     |      |     |      | 280                           | 315 |
| −18 | −54 | 0  | −25 | 0  | −36 | 0  | −57 | 0  | −89 | 0  | −140 | 0   | −230 | 0   | −360 | 315                           | 355 |
|     |     |    |     |    |     |    |     |    |     |    |      |     |      |     |      | 355                           | 400 |
| −20 | −60 | 0  | −27 | 0  | −40 | 0  | −63 | 0  | −97 | 0  | −155 | 0   | −250 | 0   | −400 | 400                           | 450 |
|     |     |    |     |    |     |    |     |    |     |    |      |     |      |     |      | 450                           | 500 |

unit:  $\mu\text{m}$

| m5  |     | m6  |     | n5  |     | n6  |     | p6   |     | Classification of diameter mm |     |
|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-------------------------------|-----|
|     |     | H   | L   | H   | L   | H   | L   | H    | L   |                               |     |
| +6  | +2  | +8  | +2  | +8  | +4  | +10 | +4  | +12  | +6  | —                             | 3   |
| +9  | +4  | +12 | +4  | +13 | +8  | +16 | +8  | +20  | +12 | 3                             | 6   |
| +12 | +6  | +15 | +6  | +16 | +10 | +19 | +10 | +24  | +15 | 6                             | 10  |
| +15 | +7  | +18 | +7  | +20 | +12 | +23 | +12 | +29  | +18 | 10                            | 18  |
| +17 | +8  | +21 | +8  | +24 | +15 | +28 | +15 | +35  | +22 | 18                            | 30  |
| +20 | +9  | +25 | +9  | +28 | +17 | +33 | +17 | +42  | +26 | 30                            | 40  |
|     |     |     |     |     |     |     |     |      |     | 40                            | 50  |
| +24 | +11 | +30 | +11 | +33 | +20 | +39 | +20 | +51  | +32 | 50                            | 65  |
|     |     |     |     |     |     |     |     |      |     | 65                            | 80  |
| +28 | +13 | +35 | +13 | +38 | +23 | +45 | +23 | +59  | +37 | 80                            | 100 |
|     |     |     |     |     |     |     |     |      |     | 100                           | 120 |
| +33 | +15 | +40 | +15 | +45 | +27 | +52 | +27 | +68  | +43 | 120                           | 140 |
|     |     |     |     |     |     |     |     |      |     | 140                           | 160 |
|     |     |     |     |     |     |     |     |      |     | 160                           | 180 |
| +37 | +17 | +46 | +17 | +51 | +31 | +60 | +31 | +79  | +50 | 180                           | 200 |
|     |     |     |     |     |     |     |     |      |     | 200                           | 225 |
|     |     |     |     |     |     |     |     |      |     | 225                           | 250 |
| +43 | +20 | +52 | +20 | +57 | +34 | +66 | +34 | +88  | +56 | 250                           | 280 |
|     |     |     |     |     |     |     |     |      |     | 280                           | 315 |
| +46 | +21 | +57 | +21 | +62 | +37 | +73 | +37 | +98  | +62 | 315                           | 355 |
|     |     |     |     |     |     |     |     |      |     | 355                           | 400 |
| +50 | +23 | +63 | +23 | +67 | +40 | +80 | +40 | +108 | +68 | 400                           | 450 |
|     |     |     |     |     |     |     |     |      |     | 450                           | 500 |

● Tolerances of Housing Hole Dimensions

| Classification of diameter mm |     | B12   |       | E7    |      | E11  |      | E12  |      | F6   |      | F7   |     | G6   |     | G7  |     |
|-------------------------------|-----|-------|-------|-------|------|------|------|------|------|------|------|------|-----|------|-----|-----|-----|
|                               |     | Above | Below | H     | L    | H    | L    | H    | L    | H    | L    | H    | L   | H    | L   | H   | L   |
| —                             | 3   |       |       | + 240 | +140 | + 24 | + 14 | + 74 | + 14 | +114 | + 14 | + 12 | + 6 | + 16 | + 6 | + 8 | + 2 |
| 3                             | 6   |       |       | + 260 | +140 | + 32 | + 20 | + 95 | + 20 | +140 | + 20 | + 18 | +10 | + 22 | +10 | +12 | + 4 |
| 6                             | 10  |       |       | + 300 | +150 | + 40 | + 25 | +115 | + 25 | +175 | + 25 | + 22 | +13 | + 28 | +13 | +14 | + 5 |
| 10                            | 18  |       |       | + 330 | +150 | + 50 | + 32 | +142 | + 32 | +212 | + 32 | + 27 | +16 | + 34 | +16 | +17 | + 6 |
| 18                            | 30  |       |       | + 370 | +160 | + 61 | + 40 | +170 | + 40 | +250 | + 40 | + 33 | +20 | + 41 | +20 | +20 | + 7 |
| 30                            | 40  |       |       | + 420 | +170 | + 75 | + 50 | +210 | + 50 | +300 | + 50 | + 41 | +25 | + 50 | +25 | +25 | + 9 |
| 40                            | 50  |       |       | + 430 | +180 |      |      |      |      |      |      |      |     |      |     |     |     |
| 50                            | 65  |       |       | + 490 | +190 | + 90 | + 60 | +250 | + 60 | +360 | + 60 | + 49 | +30 | + 60 | +30 | +29 | +10 |
| 65                            | 80  |       |       | + 500 | +200 |      |      |      |      |      |      |      |     |      |     |     |     |
| 80                            | 100 |       |       | + 570 | +220 | +107 | + 72 | +292 | + 72 | +422 | + 72 | + 58 | +36 | + 71 | +36 | +34 | +12 |
| 100                           | 120 |       |       | + 590 | +240 |      |      |      |      |      |      |      |     |      |     |     |     |
| 120                           | 140 |       |       | + 660 | +260 | +125 | + 85 | +335 | + 85 | +485 | + 85 | + 68 | +43 | + 83 | +43 | +39 | +14 |
| 140                           | 160 |       |       | + 680 | +280 |      |      |      |      |      |      |      |     |      |     |     |     |
| 160                           | 180 |       |       | + 710 | +310 |      |      |      |      |      |      |      |     |      |     |     |     |
| 180                           | 200 |       |       | + 800 | +340 | +146 | +100 | +390 | +100 | +560 | +100 | + 79 | +50 | + 96 | +50 | +44 | +15 |
| 200                           | 225 |       |       | + 840 | +380 |      |      |      |      |      |      |      |     |      |     |     |     |
| 225                           | 250 |       |       | + 880 | +420 |      |      |      |      |      |      |      |     |      |     |     |     |
| 250                           | 280 |       |       | +1000 | +480 | +162 | +110 | +430 | +110 | +630 | +110 | + 88 | +56 | +108 | +56 | +49 | +17 |
| 280                           | 315 |       |       | +1060 | +540 |      |      |      |      |      |      |      |     |      |     |     |     |
| 315                           | 355 |       |       | +1170 | +600 | +182 | +125 | +485 | +125 | +695 | +125 | + 98 | +62 | +119 | +62 | +54 | +18 |
| 355                           | 400 |       |       | +1250 | +680 |      |      |      |      |      |      |      |     |      |     |     |     |
| 400                           | 450 |       |       | +1390 | +760 | +198 | +135 | +535 | +135 | +765 | +135 | +108 | +68 | +131 | +68 | +60 | +20 |
| 450                           | 500 |       |       | +1470 | +840 |      |      |      |      |      |      |      |     |      |     |     |     |

| Classification of diameter mm |     | JS7   |       | J7  |     | K5  |     | K6 |     | K7 |     | M6  |      | M7  |     | N6 |     |
|-------------------------------|-----|-------|-------|-----|-----|-----|-----|----|-----|----|-----|-----|------|-----|-----|----|-----|
|                               |     | Above | Below | H   | L   | H   | L   | H  | L   | H  | L   | H   | L    | H   | L   | H  | L   |
| —                             | 3   |       |       | + 5 | − 5 | + 4 | − 6 | 0  | − 4 | 0  | − 6 | 0   | − 10 | − 2 | − 8 | −2 | −12 |
| 3                             | 6   |       |       | + 6 | − 6 | + 6 | − 6 | 0  | − 5 | +2 | − 6 | + 3 | − 9  | − 1 | − 9 | 0  | −12 |
| 6                             | 10  |       |       | + 7 | − 7 | + 8 | − 7 | +1 | − 5 | +2 | − 7 | + 5 | −10  | − 3 | −12 | 0  | −15 |
| 10                            | 18  |       |       | + 9 | − 9 | +10 | − 8 | +2 | − 6 | +2 | − 9 | + 6 | −12  | − 4 | −15 | 0  | −18 |
| 18                            | 30  |       |       | +10 | −10 | +12 | − 9 | +1 | − 8 | +2 | −11 | + 6 | −15  | − 4 | −17 | 0  | −21 |
| 30                            | 40  |       |       | +12 | −12 | +14 | −11 | +2 | − 9 | +3 | −13 | + 7 | −18  | − 4 | −20 | 0  | −25 |
| 40                            | 50  |       |       |     |     |     |     |    |     |    |     |     |      |     |     |    |     |
| 50                            | 65  |       |       | +15 | −15 | +18 | −12 | +3 | −10 | +4 | −15 | + 9 | −21  | − 5 | −24 | 0  | −30 |
| 65                            | 80  |       |       |     |     |     |     |    |     |    |     |     |      |     |     |    |     |
| 80                            | 100 |       |       | +17 | −17 | +22 | −13 | +2 | −13 | +4 | −18 | +10 | −25  | − 6 | −28 | 0  | −35 |
| 100                           | 120 |       |       |     |     |     |     |    |     |    |     |     |      |     |     |    |     |
| 120                           | 140 |       |       | +20 | −20 | +26 | −14 | +3 | −15 | +4 | −21 | +12 | −28  | − 8 | −33 | 0  | −40 |
| 140                           | 160 |       |       |     |     |     |     |    |     |    |     |     |      |     |     |    |     |
| 160                           | 180 |       |       |     |     |     |     |    |     |    |     |     |      |     |     |    |     |
| 180                           | 200 |       |       | +23 | −23 | +30 | −16 | +2 | −18 | +5 | −24 | +13 | −33  | − 8 | −37 | 0  | −46 |
| 200                           | 225 |       |       |     |     |     |     |    |     |    |     |     |      |     |     |    |     |
| 225                           | 250 |       |       |     |     |     |     |    |     |    |     |     |      |     |     |    |     |
| 250                           | 280 |       |       | +26 | −26 | +36 | −16 | +3 | −20 | +5 | −27 | +16 | −36  | − 9 | −41 | 0  | −52 |
| 280                           | 315 |       |       |     |     |     |     |    |     |    |     |     |      |     |     |    |     |
| 315                           | 355 |       |       | +28 | −28 | +39 | −18 | +3 | −22 | +7 | −29 | +17 | −40  | −10 | −46 | 0  | −57 |
| 355                           | 400 |       |       |     |     |     |     |    |     |    |     |     |      |     |     |    |     |
| 400                           | 450 |       |       | +31 | −31 | +43 | −20 | +2 | −25 | +8 | −32 | +18 | −45  | −10 | −50 | 0  | −63 |
| 450                           | 500 |       |       |     |     |     |     |    |     |    |     |     |      |     |     |    |     |

unit:  $\mu\text{m}$

| H6  |   | H7  |   | H8  |   | H9   |   | H10  |   | H11  |   | JS6   |       | J6  |    | Classification of diameter mm |     |
|-----|---|-----|---|-----|---|------|---|------|---|------|---|-------|-------|-----|----|-------------------------------|-----|
|     |   | H   | L | H   | L | H    | L | H    | L | H    | L | H     | L     | H   | L  |                               |     |
| + 6 | 0 | +10 | 0 | +14 | 0 | + 25 | 0 | + 40 | 0 | + 60 | 0 | + 3   | − 3   | + 2 | −4 | —                             | 3   |
| + 8 | 0 | +12 | 0 | +18 | 0 | + 30 | 0 | + 48 | 0 | + 75 | 0 | + 4   | − 4   | + 5 | −3 | 3                             | 6   |
| + 9 | 0 | +15 | 0 | +22 | 0 | + 36 | 0 | + 58 | 0 | + 90 | 0 | + 4.5 | − 4.5 | + 5 | −4 | 6                             | 10  |
| +11 | 0 | +18 | 0 | +27 | 0 | + 43 | 0 | + 70 | 0 | +110 | 0 | + 5.5 | − 5.5 | + 6 | −5 | 10                            | 18  |
| +13 | 0 | +21 | 0 | +33 | 0 | + 52 | 0 | + 84 | 0 | +130 | 0 | + 6.5 | − 6.5 | + 8 | −5 | 18                            | 30  |
| +16 | 0 | +25 | 0 | +39 | 0 | + 62 | 0 | +100 | 0 | +160 | 0 | + 8   | − 8   | +10 | −6 | 30                            | 40  |
|     |   |     |   |     |   |      |   |      |   |      |   |       |       |     |    | 40                            | 50  |
| +19 | 0 | +30 | 0 | +46 | 0 | + 74 | 0 | +120 | 0 | +190 | 0 | + 9.5 | − 9.5 | +13 | −6 | 50                            | 65  |
|     |   |     |   |     |   |      |   |      |   |      |   |       |       |     |    | 65                            | 80  |
| +22 | 0 | +35 | 0 | +54 | 0 | + 87 | 0 | +140 | 0 | +220 | 0 | +11   | −11   | +16 | −6 | 80                            | 100 |
|     |   |     |   |     |   |      |   |      |   |      |   |       |       |     |    | 100                           | 120 |
| +25 | 0 | +40 | 0 | +63 | 0 | +100 | 0 | +160 | 0 | +250 | 0 | +12.5 | −12.5 | +18 | −7 | 120                           | 140 |
|     |   |     |   |     |   |      |   |      |   |      |   |       |       |     |    | 140                           | 160 |
| +29 | 0 | +46 | 0 | +72 | 0 | +115 | 0 | +185 | 0 | +290 | 0 | +14.5 | −14.5 | +22 | −7 | 160                           | 180 |
|     |   |     |   |     |   |      |   |      |   |      |   |       |       |     |    | 180                           | 200 |
| +32 | 0 | +52 | 0 | +81 | 0 | +130 | 0 | +210 | 0 | +320 | 0 | +16   | −16   | +25 | −7 | 200                           | 225 |
|     |   |     |   |     |   |      |   |      |   |      |   |       |       |     |    | 225                           | 250 |
| +36 | 0 | +57 | 0 | +89 | 0 | +140 | 0 | +230 | 0 | +360 | 0 | +18   | −18   | +29 | −7 | 250                           | 280 |
|     |   |     |   |     |   |      |   |      |   |      |   |       |       |     |    | 280                           | 315 |
| +40 | 0 | +63 | 0 | +97 | 0 | +155 | 0 | +250 | 0 | +400 | 0 | +20   | −20   | +33 | −7 | 315                           | 355 |
|     |   |     |   |     |   |      |   |      |   |      |   |       |       |     |    | 355                           | 400 |
|     |   |     |   |     |   |      |   |      |   |      |   |       |       |     |    | 400                           | 450 |
|     |   |     |   |     |   |      |   |      |   |      |   |       |       |     |    | 450                           | 500 |

unit:  $\mu\text{m}$

| N7  |     | P6  |     | P7  |      | R7   |      | S7   |      | Classification of diameter mm |     |
|-----|-----|-----|-----|-----|------|------|------|------|------|-------------------------------|-----|
|     |     | H   | L   | H   | L    | H    | L    | H    | L    |                               |     |
| − 4 | −14 | − 6 | −12 | − 6 | − 16 | − 10 | − 20 | − 14 | − 24 | —                             | 3   |
| − 4 | −16 | − 9 | −17 | − 8 | − 20 | − 11 | − 23 | − 15 | − 27 | 3                             | 6   |
| − 4 | −19 | −12 | −21 | − 9 | − 24 | − 13 | − 28 | − 17 | − 32 | 6                             | 10  |
| − 5 | −23 | −15 | −26 | −11 | − 29 | − 16 | − 34 | − 21 | − 39 | 10                            | 18  |
| − 7 | −28 | −18 | −31 | −14 | − 35 | − 20 | − 41 | − 27 | − 48 | 18                            | 30  |
| − 8 | −33 | −21 | −37 | −17 | − 42 | − 25 | − 50 | − 34 | − 59 | 30                            | 40  |
|     |     |     |     |     |      |      |      |      |      | 40                            | 50  |
| − 9 | −39 | −26 | −45 | −21 | − 51 | − 30 | − 60 | − 42 | − 72 | 50                            | 65  |
|     |     |     |     |     |      |      |      |      |      | 65                            | 80  |
| −10 | −45 | −30 | −52 | −24 | − 59 | − 38 | − 73 | − 58 | − 93 | 80                            | 100 |
|     |     |     |     |     |      |      |      |      |      | 100                           | 120 |
| −12 | −52 | −36 | −61 | −28 | − 68 | − 48 | − 88 | − 77 | −117 | 120                           | 140 |
|     |     |     |     |     |      |      |      |      |      | 140                           | 160 |
| −14 | −60 | −41 | −70 | −33 | − 79 | − 50 | − 90 | − 85 | −125 | 160                           | 180 |
|     |     |     |     |     |      |      |      |      |      | 160                           | 180 |
| −14 | −66 | −47 | −79 | −36 | − 88 | − 60 | −106 | −105 | −151 | 180                           | 200 |
|     |     |     |     |     |      |      |      |      |      | 200                           | 225 |
| −16 | −73 | −51 | −87 | −41 | − 98 | − 63 | −109 | −113 | −159 | 225                           | 250 |
|     |     |     |     |     |      |      |      |      |      | 225                           | 250 |
| −17 | −80 | −55 | −95 | −45 | −108 | − 74 | −126 | −138 | −190 | 250                           | 280 |
|     |     |     |     |     |      |      |      |      |      | 280                           | 315 |
|     |     |     |     |     |      |      |      |      |      | 315                           | 355 |
|     |     |     |     |     |      |      |      |      |      | 355                           | 400 |
|     |     |     |     |     |      |      |      |      |      | 400                           | 450 |
|     |     |     |     |     |      |      |      |      |      | 450                           | 500 |