

# Accuracy of the Ball Screw

## Lead Angle Accuracy

The lead angle accuracy of the ball screw is controlled in accordance with the JIS standard JIS B 1192 (ISO 3408).

Accuracy grades C0 to C5 are defined in the linearity and the directional property, and C7 to C10 in the travel distance error in relation to 300 mm.

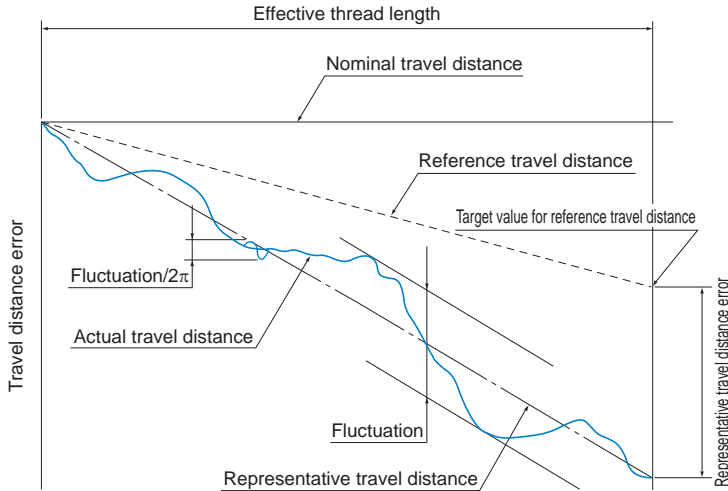


Fig.1 Terms on Lead Angle Accuracy

### [Actual Travel Distance]

An error in the travel distance measured with an actual Ball Screw.

### [Reference Travel Distance]

Generally, it is the same as nominal travel distance, but can be an intentionally corrected value of the nominal travel distance according to the intended use.

### [Target Value for Reference Travel Distance]

You may provide some tension in order to prevent the screw shaft from runout, or set the reference travel distance in “negative” or “positive” value in advance given the possible expansion/contraction from external load or temperature. In such cases, indicate a target value for the reference travel distance.

### [Representative Travel Distance]

It is a straight line representing the tendency in the actual travel distance, and obtained with the least squares method from the curve that indicates the actual travel distance.

### [Representative Travel Distance Error (in $\pm$ )]

Difference between the representative travel distance and the reference travel distance.

### [Fluctuation]

The maximum width of the actual travel distance between two straight lines drawn in parallel with the representative travel distance.

### [Fluctuation/300]

Indicates a fluctuation against a given thread length of 300 mm.

### [Fluctuation/2 $\pi$ ]

A fluctuation in one revolution of the screw shaft.

Table1 Lead Angle Accuracy (Permissible Value)

Unit:  $\mu\text{m}$ 

| Accuracy grades         |         | Precision Ball Screw                 |             |                                      |             |                                      |             |                                      |             |                                      |             | Rolled Ball Screw     |                       |                       |
|-------------------------|---------|--------------------------------------|-------------|--------------------------------------|-------------|--------------------------------------|-------------|--------------------------------------|-------------|--------------------------------------|-------------|-----------------------|-----------------------|-----------------------|
|                         |         | C0                                   |             | C1                                   |             | C2                                   |             | C3                                   |             | C5                                   |             | C7                    | C8                    | C10                   |
| Effective thread length |         | Representative travel distance error | Fluctuation | Representative travel distance error | Fluctuation | Representative travel distance error | Fluctuation | Representative travel distance error | Fluctuation | Representative travel distance error | Fluctuation | Travel distance error | Travel distance error | Travel distance error |
| Above                   | Or less |                                      |             |                                      |             |                                      |             |                                      |             |                                      |             |                       |                       |                       |
| —                       | 100     | 3                                    | 3           | 3.5                                  | 5           | 5                                    | 7           | 8                                    | 8           | 18                                   | 18          | ±50/<br>300mm         | ±100/<br>300mm        | ±210/<br>300mm        |
| 100                     | 200     | 3.5                                  | 3           | 4.5                                  | 5           | 7                                    | 7           | 10                                   | 8           | 20                                   | 18          |                       |                       |                       |
| 200                     | 315     | 4                                    | 3.5         | 6                                    | 5           | 8                                    | 7           | 12                                   | 8           | 23                                   | 18          |                       |                       |                       |
| 315                     | 400     | 5                                    | 3.5         | 7                                    | 5           | 9                                    | 7           | 13                                   | 10          | 25                                   | 20          |                       |                       |                       |
| 400                     | 500     | 6                                    | 4           | 8                                    | 5           | 10                                   | 7           | 15                                   | 10          | 27                                   | 20          |                       |                       |                       |
| 500                     | 630     | 6                                    | 4           | 9                                    | 6           | 11                                   | 8           | 16                                   | 12          | 30                                   | 23          |                       |                       |                       |
| 630                     | 800     | 7                                    | 5           | 10                                   | 7           | 13                                   | 9           | 18                                   | 13          | 35                                   | 25          |                       |                       |                       |
| 800                     | 1000    | 8                                    | 6           | 11                                   | 8           | 15                                   | 10          | 21                                   | 15          | 40                                   | 27          |                       |                       |                       |
| 1000                    | 1250    | 9                                    | 6           | 13                                   | 9           | 18                                   | 11          | 24                                   | 16          | 46                                   | 30          |                       |                       |                       |
| 1250                    | 1600    | 11                                   | 7           | 15                                   | 10          | 21                                   | 13          | 29                                   | 18          | 54                                   | 35          |                       |                       |                       |
| 1600                    | 2000    | —                                    | —           | 18                                   | 11          | 25                                   | 15          | 35                                   | 21          | 65                                   | 40          |                       |                       |                       |
| 2000                    | 2500    | —                                    | —           | 22                                   | 13          | 30                                   | 18          | 41                                   | 24          | 77                                   | 46          |                       |                       |                       |
| 2500                    | 3150    | —                                    | —           | 26                                   | 15          | 36                                   | 21          | 50                                   | 29          | 93                                   | 54          |                       |                       |                       |
| 3150                    | 4000    | —                                    | —           | 30                                   | 18          | 44                                   | 25          | 60                                   | 35          | 115                                  | 65          |                       |                       |                       |
| 4000                    | 5000    | —                                    | —           | —                                    | —           | 52                                   | 30          | 72                                   | 41          | 140                                  | 77          |                       |                       |                       |
| 5000                    | 6300    | —                                    | —           | —                                    | —           | 65                                   | 36          | 90                                   | 50          | 170                                  | 93          |                       |                       |                       |
| 6300                    | 8000    | —                                    | —           | —                                    | —           | —                                    | —           | 110                                  | 60          | 210                                  | 115         |                       |                       |                       |
| 8000                    | 10000   | —                                    | —           | —                                    | —           | —                                    | —           | —                                    | —           | 260                                  | 140         |                       |                       |                       |

Note) Unit of effective thread length: mm

Table2 Fluctuation in Thread Length of 300 mm and in One Revolution (permissible value)

Unit:  $\mu\text{m}$ 

| Accuracy grades     | C0  | C1 | C2 | C3 | C5 | C7 | C8 | C10 |
|---------------------|-----|----|----|----|----|----|----|-----|
| Fluctuation/300     | 3.5 | 5  | 7  | 8  | 18 | —  | —  | —   |
| Fluctuation/ $2\pi$ | 3   | 4  | 5  | 6  | 8  | —  | —  | —   |

Table3 Types and Grades

| Type            | Grade             | Remarks       |
|-----------------|-------------------|---------------|
| For positioning | 0, 1, 3, 5        | ISO compliant |
| For transport   | 0, 1, 3, 5, 7, 10 |               |

Example: When the lead of a Ball Screw manufactured is measured with a target value for the reference travel distance of  $-9\ \mu\text{m}/500\ \text{mm}$ , the following data are obtained.

Table4 Measurement Data on Travel Distance Error

Unit: mm

|                             |         |         |         |         |
|-----------------------------|---------|---------|---------|---------|
| Command position (A)        | 0       | 50      | 100     | 150     |
| Travel distance (B)         | 0       | 49.998  | 100.001 | 149.996 |
| Travel distance error (A-B) | 0       | -0.002  | +0.001  | -0.004  |
| Command position (A)        | 200     | 250     | 300     | 350     |
| Travel distance (B)         | 199.995 | 249.993 | 299.989 | 349.985 |
| Travel distance error (A-B) | -0.005  | -0.007  | -0.011  | -0.015  |
| Command position (A)        | 400     | 450     | 500     |         |
| Travel distance (B)         | 399.983 | 449.981 | 499.984 |         |
| Travel distance error (A-B) | -0.017  | -0.019  | -0.016  |         |

The measurement data are expressed in a graph as shown in Fig.2.

The positioning error (A-B) is indicated as the actual travel distance while the straight line representing the tendency of the (A-B) graph refers to the representative travel distance.

The difference between the reference travel distance and the representative travel distance appears as the representative travel distance error.

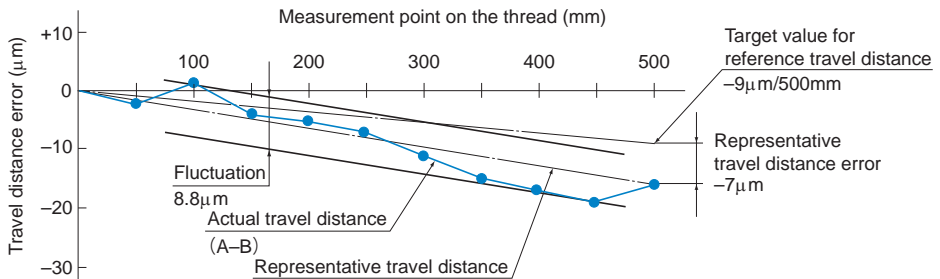


Fig.2 Measurement Data on Travel Distance Error

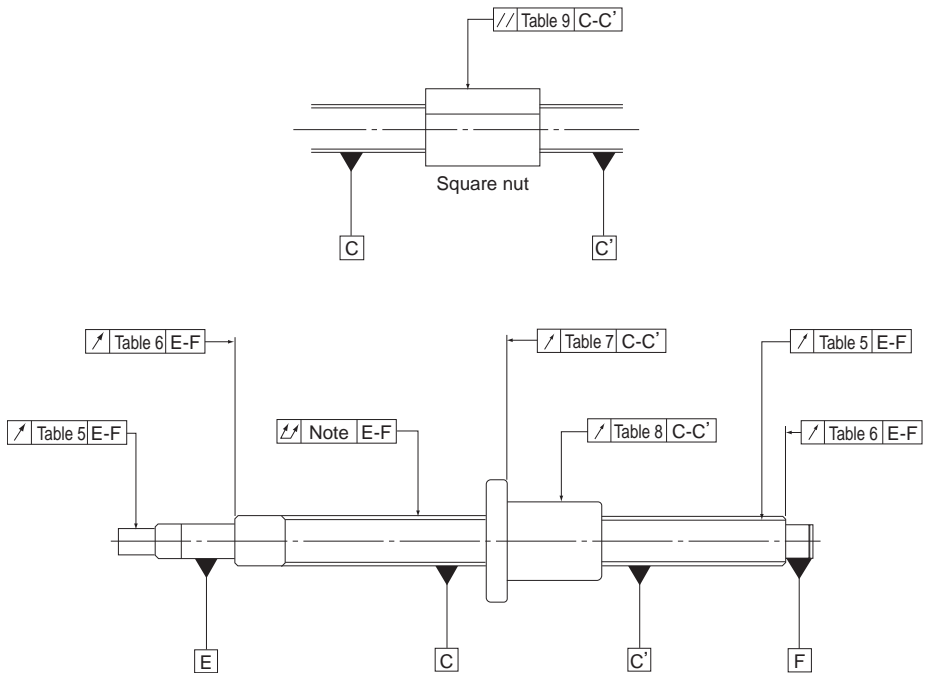
[Measurements]

Representative travel distance error:  $-7\ \mu\text{m}$

Fluctuation:  $8.8\ \mu\text{m}$

## Accuracy of the Mounting Surface

The accuracy of the Ball Screw mounting surface complies with the JIS standard JIS B 1192 (ISO 3408).



Note) For the permissible overall radial runout of the outer diameter of the screw in relation to the screw shaft support axis, refer to JIS B 1192 (ISO 3408).

Fig.3 Accuracy of the Mounting Surface of the Ball Screw

### [Accuracy Standards for the Mounting Surface]

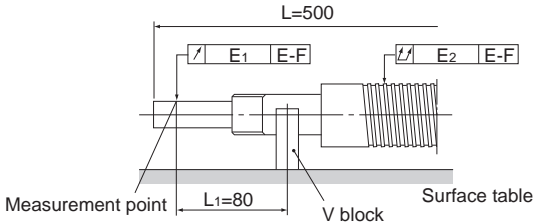
Table5 to Table9 show accuracy standards for the mounting surfaces of the precision Ball Screw.

Table5 Permissible Radial Runout of the Grooved Surface of the Screw in Relation to the Screw Shaft Support Axis and the Permissible Radial Runout of the Part-Mounting Surface  
Unit:  $\mu\text{m}$

| Screw shaft outer diameter (mm) |         | Runout (maximum) |    |    |    |    |    |
|---------------------------------|---------|------------------|----|----|----|----|----|
| Above                           | Or less | C0               | C1 | C2 | C3 | C5 | C7 |
| —                               | 8       | 3                | 5  | 7  | 8  | 10 | 14 |
| 8                               | 12      | 4                | 5  | 7  | 8  | 11 | 14 |
| 12                              | 20      | 4                | 6  | 8  | 9  | 12 | 14 |
| 20                              | 32      | 5                | 7  | 9  | 10 | 13 | 20 |
| 32                              | 50      | 6                | 8  | 10 | 12 | 15 | 20 |
| 50                              | 80      | 7                | 9  | 11 | 13 | 17 | 20 |
| 80                              | 100     | —                | 10 | 12 | 15 | 20 | 30 |

Note) The measurements on these items include the effect of the runout of the screw shaft diameter. Therefore, it is necessary to obtain the correction value from the overall runout of the screw shaft axis, using the ratio of the distance between the fulcrum and measurement point to the overall screw shaft length, and add the obtained value to the table above.

Example: model No. DIK2005-6RRGO+500LC5



$$E_1 = e + \Delta e$$

$e$  : Standard value in Table5(0.012)

$\Delta e$  : Correction value

$$\Delta e = \frac{L_1}{L} \times E_2$$

$$= \frac{80}{500} \times 0.06$$

$$= 0.01$$

$L$  : Overall screw shaft length

$L_1$  : Distance between the fulcrum and the measurement point

$E_2$  : Overall radial runout of the screw shaft axis (0.06)

$$E_1 = 0.012 + 0.01$$

$$= 0.022$$

Note) For the permissible overall radial runout of the outer diameter of the screw in relation to the screw shaft support axis, refer to JIS B 1192 (ISO 3408).

Table6 Permissible Radial Runout of the Support End Face in Relation to the Screw Shaft Support Axis

Unit:  $\mu\text{m}$ 

| Screw shaft outer diameter (mm) |         | Permissible radial runout (maximum) |    |    |    |    |    |
|---------------------------------|---------|-------------------------------------|----|----|----|----|----|
| Above                           | Or less | C0                                  | C1 | C2 | C3 | C5 | C7 |
| —                               | 8       | 2                                   | 3  | 3  | 4  | 5  | 7  |
| 8                               | 12      | 2                                   | 3  | 3  | 4  | 5  | 7  |
| 12                              | 20      | 2                                   | 3  | 3  | 4  | 5  | 7  |
| 20                              | 32      | 2                                   | 3  | 3  | 4  | 5  | 7  |
| 32                              | 50      | 2                                   | 3  | 3  | 4  | 5  | 8  |
| 50                              | 80      | 3                                   | 4  | 4  | 5  | 7  | 10 |
| 80                              | 100     | —                                   | 4  | 5  | 6  | 8  | 11 |

Table7 Permissible Radial Runout of the Flange Mounting Surface in Relation to the Screw Shaft Axis

Unit:  $\mu\text{m}$ 

| Nut diameter (mm) |         | Permissible radial runout (maximum) |    |    |    |    |    |
|-------------------|---------|-------------------------------------|----|----|----|----|----|
| Above             | Or less | C0                                  | C1 | C2 | C3 | C5 | C7 |
| —                 | 20      | 5                                   | 6  | 7  | 8  | 10 | 14 |
| 20                | 32      | 5                                   | 6  | 7  | 8  | 10 | 14 |
| 32                | 50      | 6                                   | 7  | 8  | 8  | 11 | 18 |
| 50                | 80      | 7                                   | 8  | 9  | 10 | 13 | 18 |
| 80                | 125     | 7                                   | 9  | 10 | 12 | 15 | 20 |
| 125               | 160     | 8                                   | 10 | 11 | 13 | 17 | 20 |
| 160               | 200     | —                                   | 11 | 12 | 14 | 18 | 25 |

Table8 Permissible Radial Runout of the Nut Circumference in Relation to the Screw Shaft Axis

Unit:  $\mu\text{m}$ 

| Nut diameter (mm) |         | Permissible radial runout |    |    |    |    |    |
|-------------------|---------|---------------------------|----|----|----|----|----|
| Above             | Or less | C0                        | C1 | C2 | C3 | C5 | C7 |
| —                 | 20      | 5                         | 6  | 7  | 9  | 12 | 20 |
| 20                | 32      | 6                         | 7  | 8  | 10 | 12 | 20 |
| 32                | 50      | 7                         | 8  | 10 | 12 | 15 | 30 |
| 50                | 80      | 8                         | 10 | 12 | 15 | 19 | 30 |
| 80                | 125     | 9                         | 12 | 16 | 20 | 27 | 40 |
| 125               | 160     | 10                        | 13 | 17 | 22 | 30 | 40 |
| 160               | 200     | —                         | 16 | 20 | 25 | 34 | 50 |

Table9 Permissible Parallelism of the Nut Circumference (Flat Mounting Surface) to the Screw Shaft Axis

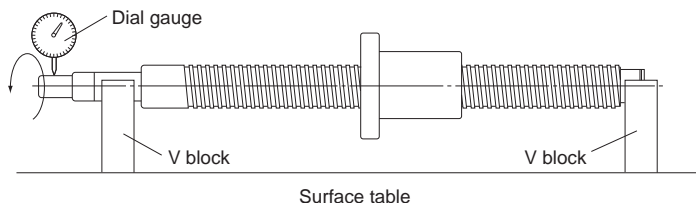
Unit:  $\mu\text{m}$ 

| Mounting reference length (mm) |         | Permissible parallelism |    |    |    |    |    |
|--------------------------------|---------|-------------------------|----|----|----|----|----|
| Above                          | Or less | C0                      | C1 | C2 | C3 | C5 | C7 |
| —                              | 50      | 5                       | 6  | 7  | 8  | 10 | 17 |
| 50                             | 100     | 7                       | 8  | 9  | 10 | 13 | 17 |
| 100                            | 200     | —                       | 10 | 11 | 13 | 17 | 30 |

### [Method for Measuring Accuracy of the Mounting Surface]

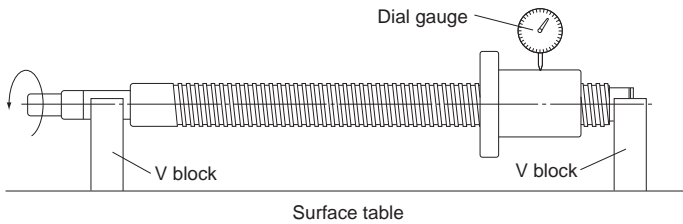
#### ● Radial Runout of the Circumference of the Motor-mounting Shaft-end in Relation to the Bearing Journals of the Screw Shaft (see Table5 on **A15-15**)

Support the end journal of the screw shaft on V blocks. Place a probe on the circumference of the motor-mounting shaft-end, and record the largest difference on the dial gauge as a measurement while rotating the screw shaft through one revolution.



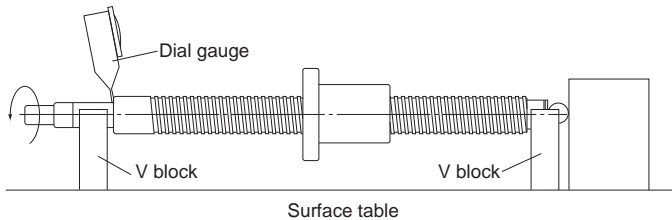
● **Radial Runout of the Circumference of the Raceway Threads in Relation to the Bearing Journals of the Screw Shaft (see Table5 on A15-15)**

Support the end journal of the screw shaft on V blocks. Place a probe on the circumference of the nut, and record the largest difference on the dial gauge as a measurement while rotating the screw shaft by one revolution without rotating the nut.



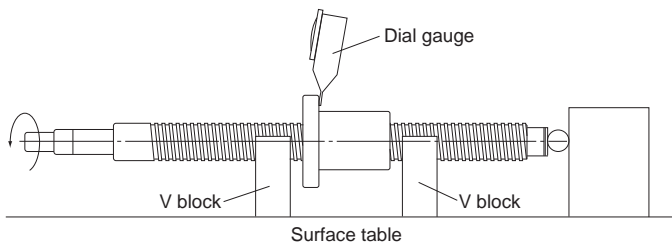
● **Radial Runout of the Support End Face in Relation to the Screw Shaft Axis Support (see Table6 on A15-16)**

Support the bearing journal portions of the screw shaft on V blocks. Place a probe on the screw shaft's supporting portion end, and record the largest difference on the dial gauge as a measurement while rotating the screw shaft through one revolution.



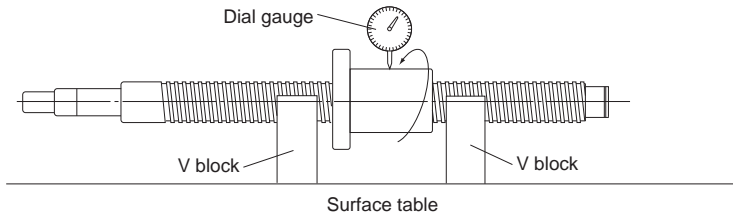
● **Radial Runout of the Flange Mounting Surface in Relation to the Screw Shaft Axis (see Table7 on A15-16)**

Support the thread of the screw shaft on V blocks near the nut. Place a probe on the flange end, and record the largest difference on the dial gauge as a measurement while simultaneously rotating the screw shaft and the nut through one revolution.



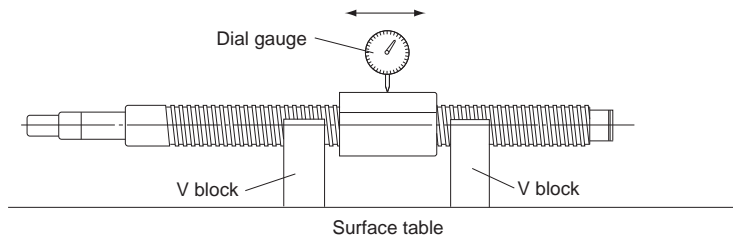
● **Radial Runout of the Nut Circumference in Relation to the Screw Shaft Axis (see Table 8 on A15-16)**

Support the thread of the screw shaft on V blocks near the nut. Place a probe on the circumference of the nut, and record the largest difference on the dial gauge as a measurement while rotating the nut through one revolution without rotating the screw shaft.



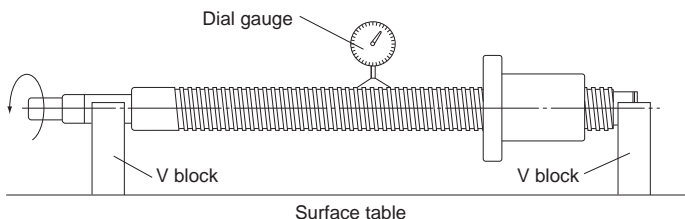
● **Parallelism of the Nut Circumference (Flat Mounting Surface) to the Screw Shaft Axis (see Table 9 on A15-16)**

Support the thread of the screw shaft on V blocks near the nut. Place a probe on the circumference of the nut (flat mounting surface), and record the largest difference on the dial gauge as a measurement while moving the dial gauge in parallel with the screw shaft.



● **Overall Radial Runout of the Screw Shaft Axis**

Support the supporting portion of the screw shaft on V blocks. Place a probe on the circumference of the screw shaft, and record the largest difference on the dial gauge at several points in the axial directions as a measurement while rotating the screw shaft through one revolution.



Note) For the permissible overall radial runout of the outer diameter of the screw in relation to the screw shaft support axis, refer to JIS B 1192 (ISO 3408).



## Axial Clearance

### [Axial Clearance of the Precision Ball Screw]

Table10 shows the axial clearance of the precision Ball Screw. If the manufacturing length exceeds the value in Table11, the resultant clearance may partially be negative (preload applied).

The manufacturing limit lengths of the Ball Screws compliant with the DIN standard are provided in Table12.

For the axial clearance of the Precision Caged Ball Screw, see **A15-76** to **A15-83**, **A15-102** to **A15-109**, **A15-210** to **A15-219**.

Table10 Axial Clearance of the Precision Ball Screw

Unit: mm

| Clearance symbol | G0        | GT         | G1        | G2        | G3        |
|------------------|-----------|------------|-----------|-----------|-----------|
| Axial Clearance  | 0 or less | 0 to 0.005 | 0 to 0.01 | 0 to 0.02 | 0 to 0.05 |

Table11 Maximum Manufacturing Length of Precision Ball Screws by Axial Clearance

Unit: mm

| Screw shaft<br>outer diameter | Clearance GT |      |       |      | Clearance G1 |      |       |      | Clearance G2 |      |      |      |      |      |  |
|-------------------------------|--------------|------|-------|------|--------------|------|-------|------|--------------|------|------|------|------|------|--|
|                               | C0           | C1   | C2•C3 | C5   | C0           | C1   | C2•C3 | C5   | C0           | C1   | C2   | C3   | C5   | C7   |  |
| 4•6                           | 80           | 80   | 80    | 100  | 80           | 80   | 80    | 100  | 80           | 80   | 80   | 80   | 100  | 120  |  |
| 8                             | 230          | 250  | 250   | 200  | 230          | 250  | 250   | 250  | 230          | 250  | 250  | 250  | 300  | 300  |  |
| 10                            | 250          | 250  | 250   | 200  | 250          | 250  | 250   | 250  | 250          | 250  | 250  | 250  | 300  | 300  |  |
| 12•13                         | 440          | 500  | 500   | 400  | 440          | 500  | 500   | 500  | 440          | 500  | 630  | 680  | 600  | 500  |  |
| 14                            | 500          | 500  | 500   | 400  | 500          | 500  | 500   | 500  | 530          | 620  | 700  | 700  | 600  | 500  |  |
| 15                            | 500          | 500  | 500   | 400  | 500          | 500  | 500   | 500  | 570          | 670  | 700  | 700  | 600  | 500  |  |
| 16                            | 500          | 500  | 500   | 400  | 500          | 500  | 500   | 500  | 620          | 700  | 700  | 700  | 600  | 500  |  |
| 18                            | 720          | 800  | 800   | 700  | 720          | 800  | 800   | 700  | 720          | 840  | 1000 | 1000 | 1000 | 1000 |  |
| 20                            | 800          | 800  | 800   | 700  | 800          | 800  | 800   | 700  | 820          | 950  | 1000 | 1000 | 1000 | 1000 |  |
| 25                            | 800          | 800  | 800   | 700  | 800          | 800  | 800   | 700  | 1000         | 1000 | 1000 | 1000 | 1000 | 1000 |  |
| 28                            | 900          | 900  | 900   | 800  | 1100         | 1100 | 1100  | 900  | 1300         | 1400 | 1400 | 1400 | 1200 | 1200 |  |
| 30•32                         | 900          | 900  | 900   | 800  | 1100         | 1100 | 1100  | 900  | 1400         | 1400 | 1400 | 1400 | 1200 | 1200 |  |
| 36•40•45                      | 1000         | 1000 | 1000  | 800  | 1300         | 1300 | 1300  | 1000 | 2000         | 2000 | 2000 | 2000 | 1500 | 1500 |  |
| 50•55•63•70                   | 1200         | 1200 | 1200  | 1000 | 1600         | 1600 | 1600  | 1300 | 2000         | 2500 | 2500 | 2500 | 2000 | 2000 |  |
| 80•100                        | —            | —    | —     | —    | 1800         | 1800 | 1800  | 1500 | 2000         | 4000 | 4000 | 4000 | 3000 | 3000 |  |

\*When manufacturing the Ball Screw of precision-grade accuracy C7 with clearance GT or G1, the resultant clearance is partially negative.

Table12 Manufacturing limit lengths of precision Ball Screws with axial clearances (DIN standard compliant Ball Screws)

Unit: mm

| Shaft<br>diameter | Clearance GT |              | Clearance G1 |              | Clearance G2 |              |         |
|-------------------|--------------|--------------|--------------|--------------|--------------|--------------|---------|
|                   | C3, Cp3      | C5, Cp5, Ct5 | C3, Cp3      | C5, Cp5, Ct5 | C3, Cp3      | C5, Cp5, Ct5 | C7, Cp7 |
| 16                | 500          | 400          | 500          | 500          | 700          | 600          | 500     |
| 20, 25            | 800          | 700          | 800          | 700          | 1000         | 1000         | 1000    |
| 32                | 900          | 800          | 1100         | 900          | 1400         | 1200         | 1200    |
| 40                | 1000         | 800          | 1300         | 1000         | 2000         | 1500         | 1500    |
| 50, 63            | 1200         | 1000         | 1600         | 1300         | 2500         | 2000         | 2000    |

\*When manufacturing the Ball Screw of precision-grade accuracy C7 (Ct7) with clearance GT or G1, the resultant clearance is partially negative.

### [Axial Clearance of the Rolled Ball Screw]

Table13 shows axial clearance of the rolled Ball Screw.

Table13 Axial Clearance of the Rolled Ball Screw

Unit: mm

| Screw shaft outer diameter | Axial clearance (maximum) |
|----------------------------|---------------------------|
| 6 to 12                    | 0.05                      |
| 14 to 28                   | 0.1                       |
| 30 to 32                   | 0.14                      |
| 36 to 45                   | 0.17                      |
| 50                         | 0.2                       |

## Preload

A preload is provided in order to eliminate the axial clearance and minimize the displacement under an axial load.

When performing a highly accurate positioning, a preload is generally provided.

### [Rigidity of the Ball Screw under a Preload]

When a preload is provided to the Ball Screw, the rigidity of the nut is increased.

Fig.4 shows elastic displacement curves of the Ball Screw under a preload and without a preload.

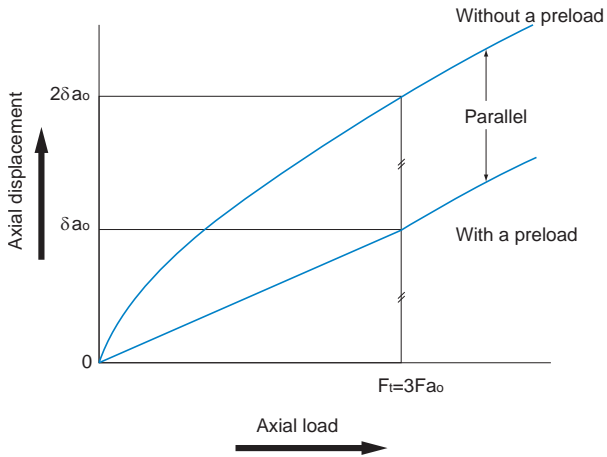
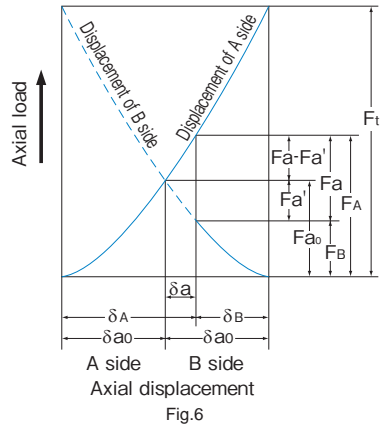
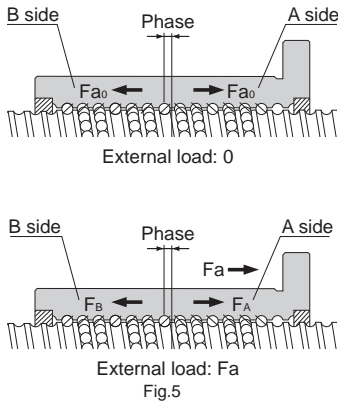


Fig.4 Elastic Displacement Curve of the Ball Screw

Fig.5 shows a single-nut type of the Ball Screw.



The A and B sides are provided with preload  $F_{a0}$  by changing the groove pitch in the center of the nut to create a phase. Because of the preload, the A and B sides are elastically displaced by  $\delta_{a0}$  each. If an axial load ( $F_a$ ) is applied from outside in this state, the displacement of the A and B sides is calculated as follows.

$$\delta_A = \delta_{a0} + \delta a \quad \delta_B = \delta_{a0} - \delta a$$

In other words, the loads on the A and B sides are expressed as follows:

$$F_A = F_{a0} + (F_a - F_{a'}) \quad F_B = F_{a0} - F_{a'}$$

Therefore, under a preload, the load that the A side receives equals to  $F_a - F_{a'}$ . This means that since load  $F_{a'}$ , which is applied when the A side receives no preload, is deducted from  $F_a$ , the displacement of the A side is smaller.

This effect extends to the point where the displacement ( $\delta_{a0}$ ) caused by the preload applied on the B side reaches zero.

To what extent is the elastic displacement reduced? The relationship between the axial load on the Ball Screw under no preload and the elastic displacement can be expressed by  $\delta_a \propto F_a^{2/3}$ . From Fig.6, the following equations are established.

$$\delta_{a0} = K F_{a0}^{2/3} \quad (K : \text{constant})$$

$$2\delta_{a0} = K F_t^{2/3}$$

$$\left(\frac{F_t}{F_{a0}}\right)^{2/3} = 2 \quad F_t = 2^{3/2} \times F_{a0} = 2.8F_{a0} \doteq 3F_{a0}$$

Thus, the Ball Screw under a preload is displaced by  $\delta_{a0}$  when an axial load ( $F_t$ ) approximately three times greater than the preload is provided from outside. As a result, the displacement of the Ball Screw under a preload is half the displacement ( $2\delta_{a0}$ ) of the Ball Screw without a preload.

As stated above, since the preloading is effective up to approximately three times the applied preload, the optimum preload is one third of the maximum axial load.

Note that an excessive preload adversely affects the service life and heat generation. The maximum preload should be set at 10% of the basic dynamic load rating ( $C_a$ ) in the axial direction.

### [Preload Torque]

The preload torque of the Ball Screw is controlled in accordance with the JIS standard JIS B 1192 (ISO 3408).

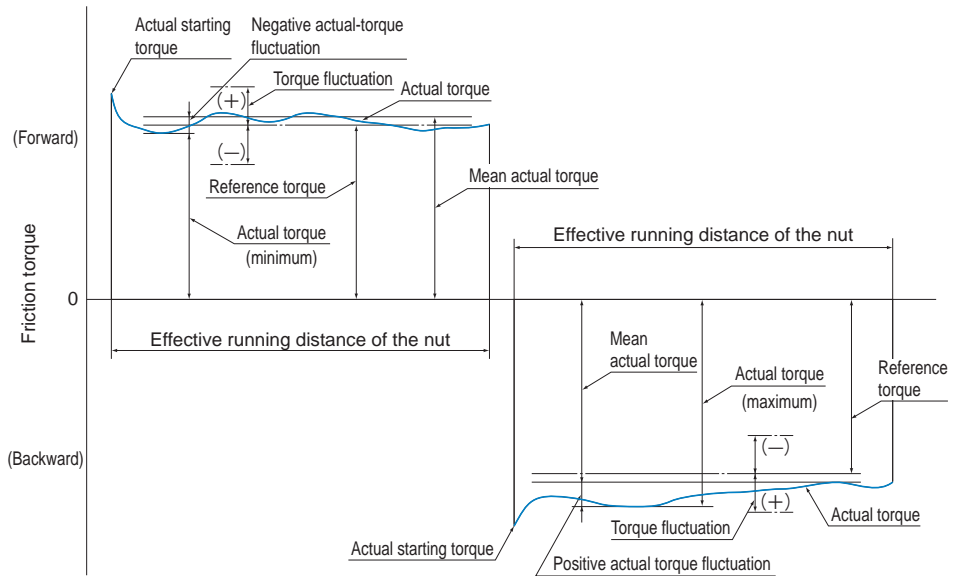


Fig.7 Terms on Preload Torque

#### ● Dynamic Preload Torque

A torque required to continuously rotate the screw shaft of a Ball Screw under a given preload without an external load applied.

#### ● Actual Torque

A dynamic preload torque measured with an actual Ball Screw.

#### ● Torque Fluctuation

Variation in a dynamic preload torque set at a target value. It can be positive or negative in relation to the reference torque.

#### ● Coefficient of Torque Fluctuation

Ratio of torque fluctuation to the reference torque.

#### ● Reference Torque

A dynamic preload torque set as a target.

#### ● Calculating the Reference Torque

The reference torque of a Ball Screw provided with a preload is obtained in the following equation (4).

$$T_p = 0.05 (\tan\beta)^{-0.5} \frac{F_{a0} \cdot Ph}{2\pi} \dots\dots\dots (4)$$

|          |                    |        |
|----------|--------------------|--------|
| $T_p$    | : Reference torque | (N•mm) |
| $\beta$  | : Lead angle       |        |
| $F_{a0}$ | : Applied preload  | (N)    |
| $Ph$     | : Lead             | (mm)   |

## Point of Selection

### Accuracy of the Ball Screw

Example: When a preload of 3,000 N is provided to the Ball Screw model BIF4010-10G0 + 1500LC3 with a thread length of 1,300 mm (shaft diameter: 40 mm; ball center-to-center diameter: 41.75 mm; lead: 10 mm), the preload torque of the Ball Screw is calculated in the steps below.

#### ■Calculating the Reference Torque

$\beta$  : Lead angle

$$\tan\beta = \frac{\text{lead}}{\pi \times \text{ball center-to-center diameter}} = \frac{10}{\pi \times 41.75} = 0.0762$$

$F_{a0}$  : Applied preload=3000N

$Ph$  : Lead = 10mm

$$T_p = 0.05 (\tan\beta)^{-0.5} \frac{F_{a0} \cdot Ph}{2\pi} = 0.05 (0.0762)^{-0.5} \frac{3000 \times 10}{2\pi} = 865\text{N} \cdot \text{mm}$$

#### ■Calculating the Torque Fluctuation

$$\frac{\text{thread length}}{\text{screw shaft outer diameter}} = \frac{1300}{40} = 32.5 \leq 40$$

Thus, with the reference torque in Table14 being between 600 and 1,000 N•mm, effective thread length 4,000 mm or less and accuracy grade C3, the coefficient of torque fluctuation is obtained as  $\pm 30\%$ .

As a result, the torque fluctuation is calculated as follows.

$$865 \times (1 \pm 0.3) = 606 \text{ N} \cdot \text{mm} \text{ to } 1125 \text{ N} \cdot \text{mm}$$

#### ■Result

Reference torque : 865 N•mm

Torque fluctuation : 606 N•mm to 1125 N•mm

Table14 Tolerance Range in Torque Fluctuation

| Reference torque<br>N•mm |         | Effective thread length  |      |      |      |      |      |  |      |      |      |      |   |      |
|--------------------------|---------|--|------|------|------|------|------|--|------|------|------|------|---|------|
|                          |         | 4000mm or less   |      |      |      |      |      |  |      |      |      |      | Above 4,000 mm and<br>10,000 mm or less |      |
|                          |         | $\frac{\text{thread length}}{\text{screw shaft outer diameter}} \leq 40$ |      |      |      |      |      | $40 < \frac{\text{thread length}}{\text{screw shaft outer diameter}} < 60$ |      |      |      |      | —                                       |      |
|                          |         | Accuracy grades  |      |      |      |      |      | Accuracy grades  |      |      |      |      | Accuracy grades                         |      |
| Above                    | Or less | C0   | C1   | C3   | C5   | C7   | C0   | C1   | C3   | C5   | C7   | C3   | C5                                      | C7   |
| 200                      | 400     | ±30%   | ±35% | ±40% | ±50% | —    | ±40% | ±40%   | ±50% | ±60% | —    | —    | —                                       | —    |
| 400                      | 600     | ±25%   | ±30% | ±35% | ±40% | —    | ±35% | ±35%   | ±40% | ±45% | —    | —    | —                                       | —    |
| 600                      | 1000    | ±20%   | ±25% | ±30% | ±35% | ±40% | ±30% | ±30%   | ±35% | ±40% | ±45% | ±40% | ±45%                                    | ±50% |
| 1000                     | 2500    | ±15%   | ±20% | ±25% | ±30% | ±35% | ±25% | ±25%   | ±30% | ±35% | ±40% | ±35% | ±40%                                    | ±45% |
| 2500                     | 6300    | ±10%   | ±15% | ±20% | ±25% | ±30% | ±20% | ±20%   | ±25% | ±30% | ±35% | ±30% | ±35%                                    | ±40% |
| 6300                     | 10000   | —  | ±15% | ±15% | ±20% | ±30% | —    | —  | ±20% | ±25% | ±35% | ±25% | ±30%                                    | ±35% |