B-Ⅱ-13 Installation of Ball Screw

B-Ⅱ-13.1 Installation

(1) Centering of the units

Align the centers of housings for the ball nut and the support bearing to which a ball screw is fixed. The centering is critical for life, smooth operation, and positioning accuracy of a ball screw.

We generally recommend the centering accuracy as follows for a precision grade ball screw.

- Inclination of center line: 1/2 000 or less (Target: 1/5 000 or less)
- Eccentricity: 0.020 mm or less

Follow the flowchart in Figure Ⅱ-13•1 for installation procedures.

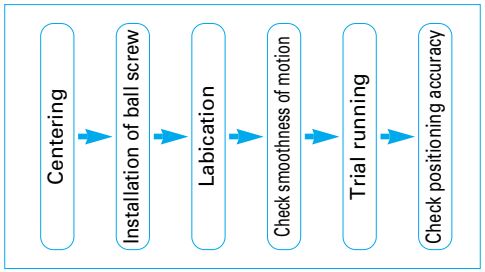


Fig. Ⅱ-13•1 Flowchart of ball screw installation

(2) Centering of ball nut housing

Photo Ⅱ-13•1 shows a centering procedure of the ball nut housing. Insert a jig (test bar) that has close fit clearance to a bore of the ball nut housing. Check vertical and horizontal parallelism of the test bar against the guide way (such as linear guides) with the dial indicator, that is fixed on the guide way bearing, and adjust the position of the housing so that the inclination of the center sets in 1/2 000 or less, and then, fix the housing to the table base.

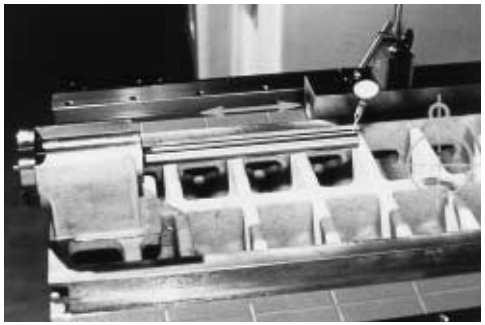


Photo Ⅱ-13•1

(3) Centering of the housing of support bearing

Photo Ⅱ-13•2 shows a centering procedure of the housing of support bearing. As the same way of the ball nut housing, set the jig (test bar) that has close fit clearance to bore of the housing and adjust the position of the housing so that the aligning inclination sets in 1/2 000 or less, then fix the housing to the table temporarily.

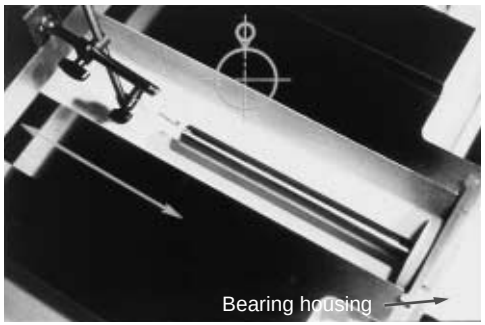


Photo Ⅱ-13•2

(4) Eccentricity of the housings

Measuring way of eccentricity between the two housings is shown in Figure Ⅱ-13•3. Set the table on the guide way (such as linear guides, etc), and fix a dial indicator on it. Check eccentricity of the test bar of support bearing housing against the test bar of ball nut housing. Adjust position of support unit housing so that the eccentricity gets in 0.020 mm or less, then fix the housing of support bearing.

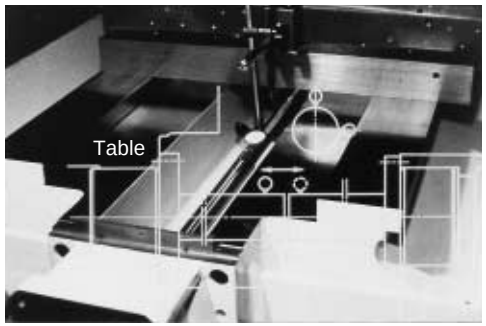


Photo Ⅱ-13•3

(5) Installation of ball nut

Photo Ⅱ-13•4 shows a procedure for installation of the ball nut to the housing. Wipe off outside of the ball nut and bore of the housing with thin rags. (Applying a small amount of machine oil with low viscosity to both parts is effective in rust prevention.) Insert the ball nut to the housing while holding the ball screw in horizontal position and fix it. Do not handle the ball screw roughly, like hammering ends of the ball screw, because it may induce failure of the ball screw.

Photo Ⅱ-13•4

(6) Installation of support bearings in ball screw

Photo Ⅱ-13•5 shows a procedure for installation of support bearings. Select bearings that have appropriate fitting tolerance to the screw shaft, then install them. We recommend using a special sleeve as shown in the photo not to apply impact to the bearings.

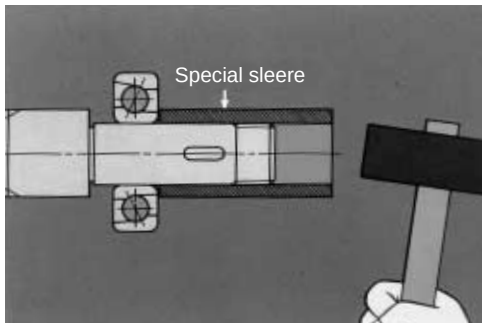


Photo Ⅱ-13•5

(7) Installation of bearings in the housing

Photo Ⅱ-13•6 shows the procedure for installing the support bearings to the bearing housing. When fixing the bearing with a lock nut, tighten the lock nut with specified tightening torque while checking run-out of screw shaft end. Take measures against loose lock nut. (Refer to assembly procedure of support bearing unit.)

For easy installation work of ball screws, NSK provides Support Unit (Page B294 ~ B295) that consists of bearings and Bearing Lock Nuts (Page B299) of which surface run-out is made to a specification.

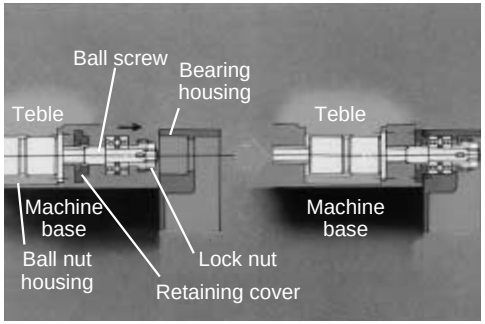


Photo Ⅱ-13•6

(8) Replenish lubrication grease

Photo Ⅱ-13•7 shows the replenishing procedure of lubrication grease. Applying grease prior to its operation is not necessary when the grease is packed into the ball nut. Please confirm it.

If grease is not used, we apply antirust oil to ball screws when shipping. Wipe off the oil and pack grease fully into the ball nut as shown in the photo.

Photo Ⅱ-13•7

(9) Check motion smoothness

Photo Ⅱ-13•8 shows a checking procedure for motion smoothness. This is to confirm if the table is assembled accurately. Use a torque wrench to measure starting torque of the ball screw for full stroke of the table. Check for abnormality in starting torque as well as unevenness of rotation by feeling.

Photo Ⅱ-13•8

(10) Trial operation

Photo Ⅱ-13•9 shows a seen of trail operation. Firstly operate the machine slowly and check noise and vibration, then do the same at medium and high speed. Operate the machine continuously for approximately 2 hours as a running in, and check for abnormality meanwhile. Remove over flown grease from the ball nut after a running in.

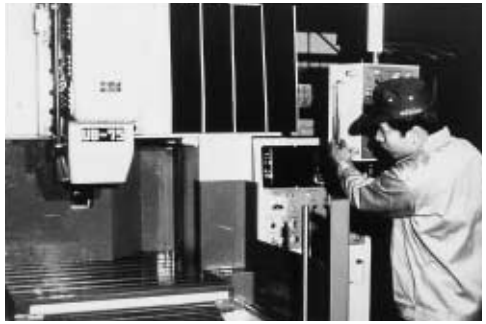


Photo Ⅱ-13•9

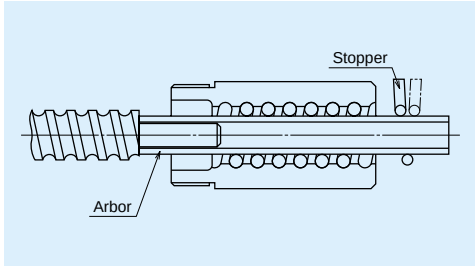


Fig. Ⅱ-13•2 Inserting nut into screwshaft

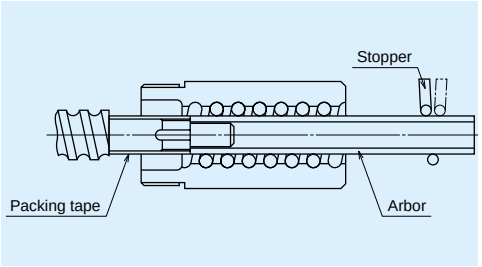


Fig. Ⅱ-13•3 Arbor and shaft end conbiguration

B-Ⅱ-13.2 Inserting Ball Nut into Rolled Screw Shaft

When delivered, the nut of rolled ball screw is separated from the screw shaft, and inserted into an arbor shaft.

(1) Consideration to end configuration of screw shaft

The balls may fall out during moving the assembled nut from the arbor to the screw shaft if the sizes and shapes of the arbor and the screw shaft are not appropriate.

If the end of the ball groove can touch the end of the arbor, connect both ends and move the assembled nut from the arbor to the screw shaft (Fig. Ⅱ-13•1).

If the end face of the arbor cannot connect to the end face of the screw because of configuration of both ends of screw shaft, wrap a tape outside of ball screw shaft so that the layers of tape is equal with the outside diameter of the arbor (Fig. Ⅱ-13•3).

If there is a key way or a nick along the way, fill such gaps prior to moving the ball nut.

(2) Installation of arbor

Confirm the correct nut orientation for installation. Remove the stop ring on the side from where the assembled nut is to be removed. Align the centers of the screw shaft and the arbor while pressing firmly the screw shaft end against the arbor.

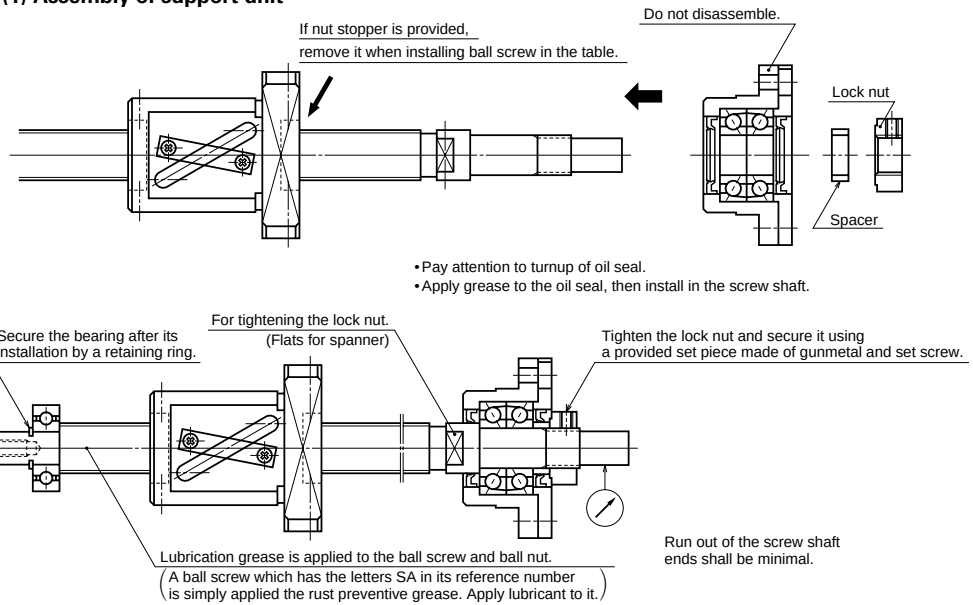
(3) Moving the nut

Slide the nut until it lightly touches the shoulder of the ball groove section, and stop it. Turn the ball nut to the direction so that it moves to the ball groves, while pressing the arbor to the screw shaft. Do not separate the arbor from the screw shaft until the ball groove end appears completely in the ball nut.

B-Ⅱ-13.3 Installation of Standard Ball Screw and Support Unit

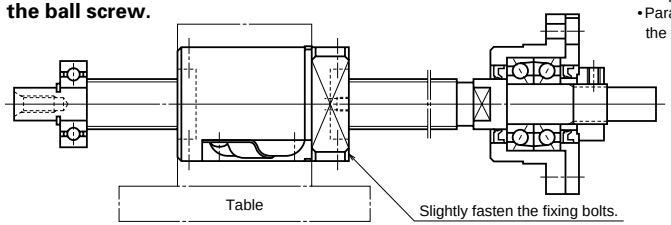
The illustrations below show typical installation procedures of a standard A Series ball screw and a support unit.

(1) Assembly of support unit



(2) Installation of ball nut to the table

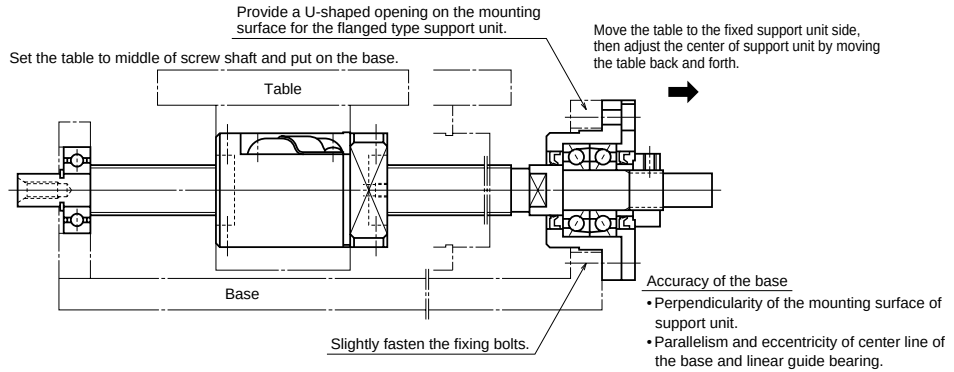
Installation example: Turn the table upside down, and install the ball screw.



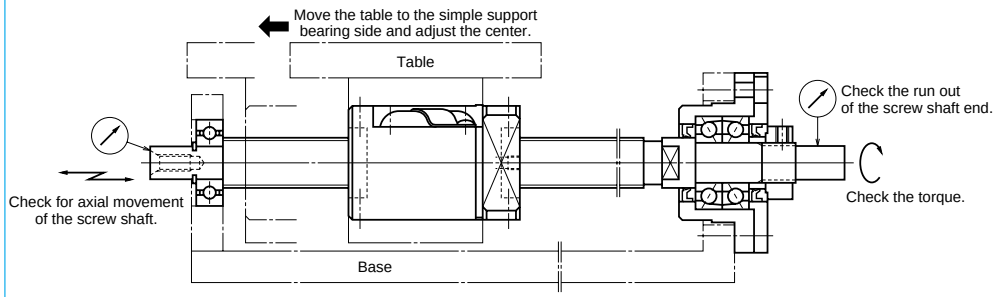
Accuracy of table
- Perpendicularity of nut housing
- Parallelism and center height deviation between the table center and the guide way bearings.

Install the ball screw so that the return tube is on the table side.

(3) Base, and the support unit installation on the fixed support side



(4) Base and bearing installation on simple support side, and confirming assembling accuracy.

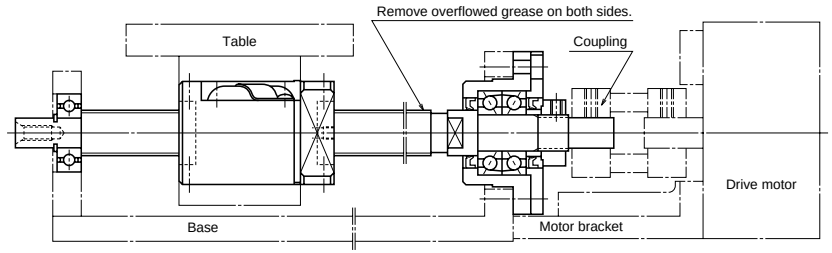


Adjust the center line by moving the table back and forth. Check for smooth operation of the table.
Repeat the same procedures described above if the table is not moving smoothly.
Tighten the fixing bolts checking the assembly accuracy.

(5) Assembly completed.

•Motor bracket / Motor / Coupling

•After the assembly, execute the running-in test entirely.



Assembling accuracy of the motor bracket and coupling affects the positioning accuracy of the table.
Pay great attention to it in the same manner as assembling ball screw.

B-Ⅱ-13.4 Shaft End Machining

Shaft end is machined in the following three occasions.

* Precision ball screws in S Series with blank shaft end.
* Rolled ball screws in R Series with blank shaft end.
* Additional machining of a completed ball screw

The following are summaries of machining of these shaft ends. For details, please contact NSK.

(1) Additional machining of S Series ball screw

① Cutting screw shaft

Use a cutting whetstone, etc. to cut the shaft, leaving stock for turning. Keep the nut in the assembled state to the screw shaft, and open only one side of the plastic wrapping bag, expose only the shaft end section to be machined, then cut the screw shaft. This prevents foreign matters from entering to the ball screw section. Do the same for other machining.

② Precautions in cutting shaft end

Outside of the screw shaft is ground with precision. There is a center hole in the ends. Use them for centering. Do not rotate the shaft quickly or stop it suddenly, or the nut might move along the shaft. Securing the nut with tape is a good idea. To machine a very long shaft, apply work rests to the screw shaft surface to suppress vibration (especially caused by critical speed).

③ Turning by lathe

Cut to the length, turn shaft end steps, turn thread screw, and provide the center hole. Refer to JIS B1192 which sets standards for shaft end accuracy.

④ Processing by grinding

Apply the same precautions as for cutting for centering, securing nut, and work rest. Grind sections where the bearings and a "Spann ring" are installed.

⑤ Milling processing

Process key way and lockwasher tooth seat.

⑥ Deburring, washing, rust prevention

Wash with clean white kerosene after processing. Apply lubricant for immediate use. For later use, apply rust preventive agent.

[Note]

Contact NSK if nut is accidentally removed.

(2) Additional machining of R Series rolled ball screw shaft end

① Cutting screw shaft

Carry out the same process as for S Series above.

② Annealing the shaft end (Heat the section of the shaft end to be machined with an acetylene torch. Then gradually cool it in ambient atmosphere.)

* The area not machined loses hardness if exposed to heat. This shortens ball screw life. Cool with water the areas where should not be heated to avoid heat conduction.

③ The following process is the same as S Series above.

B-Ⅱ-14 Precautions for Designing Ball Screw

B-Ⅱ-14.1 Safety System

As shown in the illustration on Page B300, a stopper is installed in some cases to prevent the nut from overrunning due to malfunction of the safety system of the machine itself, or human error during operation.

The travel stopper should be installed at a place where it will not come into contact with the nut when the nut reaches the designed stroke end.

An impact absorbing travel stopper (NSK patent, refer to Page B298) is available at NSK.

B-Ⅱ-14.2 Design Cautious to Assembling Ball Screw

(1) Cutting through the thread screw

For the deflector and end cap ball recirculation system ball screws, one end of the thread screw should be cut through. This is for convenience of assembly for ball nut to the screw shaft (Fig. Ⅱ-14•1). In this case, the shaft end diameter, where this thread cut through is made, should be 0.2 mm or smaller than the ball groove root diameter "d_r" (See the dimension table). A similar precaution is required when it is absolutely necessary to remove the nut from the screw shaft in order to install the ball screw to the machine. Also, in case using the cut-through end as the shoulder of the support bearing, make certain that a sufficient amount of the effective flat surface is left from the root diameter. If it is insufficient, the bearing cannot be installed in perpendicular to the bearing seat. (Fig. Ⅱ-14•2)

(2) Designing screw shaft end and the nut area

When installing a ball screw to the machine, avoid a design which makes it necessary to separate the nut from the screw shaft as shown in Fig. Ⅱ-14•3. If separated, the balls may fall out. Separation may also deteriorate the ball screw accuracy, or may damage the ball screw. If separating them is unavoidable, please furnish NSK with the component which is to be installed between the nut and screw shaft. NSK will install the component prior to delivery.

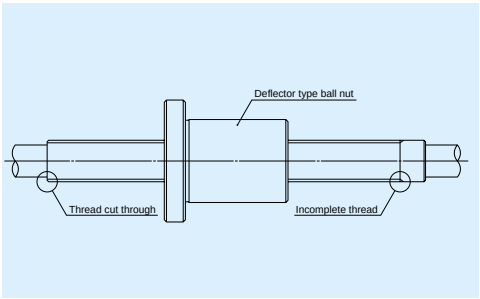


Fig. Ⅱ-14•1 Shaft end of a deflector recirculation system ball screw

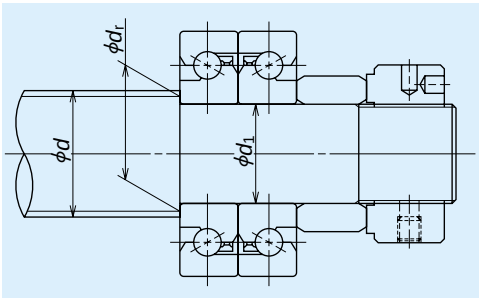


Fig. Ⅱ-14•2 Support bearing and end face (shoulder) for installation

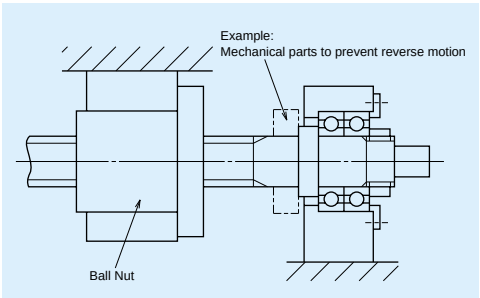


Fig. Ⅱ-14•3 Nut and ball screw are required to be separated when installing in this structure.

(3) Removing nut from the shaft at time of assembly

If it is unavoidable, use an arbor (Fig. Ⅱ-14•4), keeping the balls in the nut. In this case, the outside diameter of the arbor should be approximately 0.2 ~ 0.4 mm smaller than the ball groove root diameter "dr."

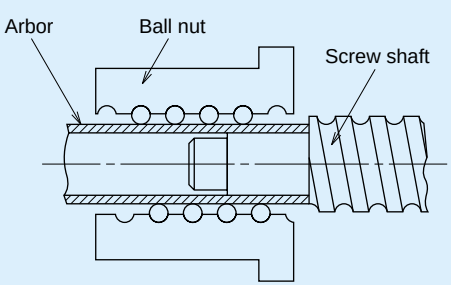
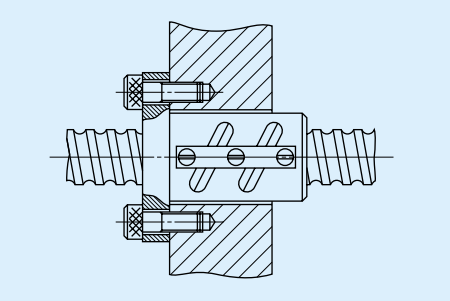


Fig. Ⅱ-14•4 Arbor to install and remove nut

(4) Centering of the ball nut when installing

When installing the nut as shown in Fig. Ⅱ-14•5, provide a space between the housing and the nut body diameter, allowing the centering to be performed.



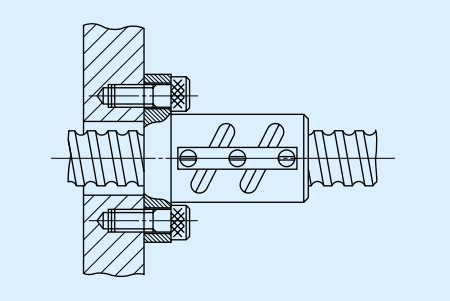


Fig. Ⅱ-14•5 Fixing a ball nut by flange

(5) Preventing the thread screw of nut from loosening

When installing and securing the nut to the housing at the thread screw section, as in the case for RNCT Series rolled ball screw, apply an agent which prevents the nut from loosening.

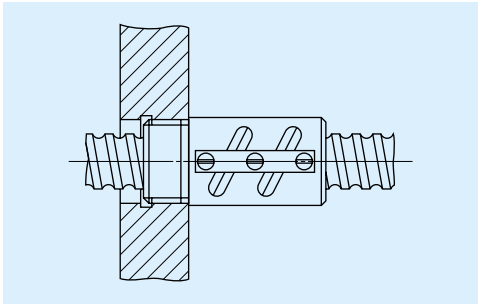


Fig. Ⅱ-14•6 Fixing a ball nut with thread screw

(6) Installation of brush-seal to the nut

If the brush-seal is installed at the thread screw side of the nut which comes with a thread screw, the brush-seal should be designed to be secured as shown in Fig. Ⅱ-14•7.

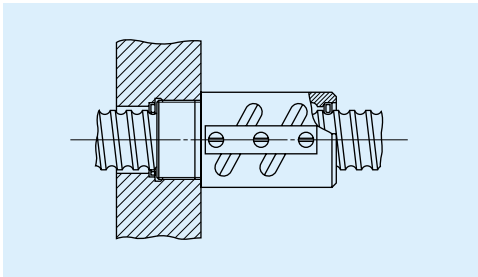


Fig. Ⅱ-14•7 Installation of brush-seal to a ball nut with thread screw

B-Ⅱ-14.3 Effective Stroke of Long, Very Large Ball Screw

Rigidity of a long and very large ball screw which is hardened by the induction hardening may be slightly low at both ends of the screw section. Consider this low hardness prior to determining the length of effective stroke. Please consult NSK for details.

B-Ⅱ-14.4 Matching after Delivery

Please inform NSK on the position and size if it is necessary to machine the screw shaft end, or if a knock pin at the nut installation section is needed after delivery.

NSK takes a measure and protects designated spots from heat treatment prior to delivery to make subsequent machining easy.

B-Ⅱ-15 Ball Screw Selection Exercise

[Drill 1] High-speed transporting system

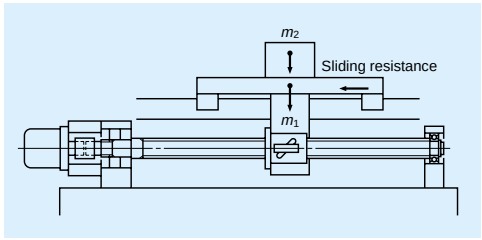


Fig. Ⅱ-15•1

* Design conditions

① Table design specifications

Table mass :	m_1=40kg
Mass of the transporting item :	m_2=20kg
Maximum stroke :	S_{max}=700mm
Rapid traverse speed :	Vmax=1000mm/sec(60m/min)
Positioning accuracy :	±0.05/700mm(0.005 mm/pulse)
Repeatability :	±0.005mm
Required life :	Lt=25000 h(5 years)
Guide way (rolling) :	μ=0.005(friction coefficient)
Drive motor :	AC servo motor (Nmax=3000rpm)

② Operating conditions

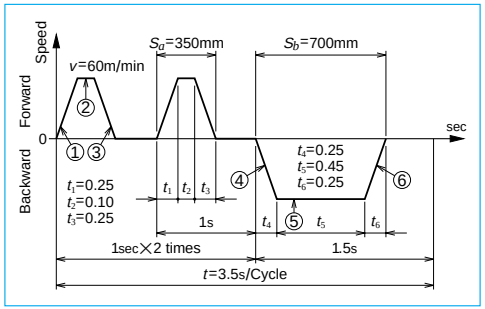


Fig. Ⅱ-15•2

① Selection of basic factors

(1) Selection of accuracy grade

Accuracy grade should be in the range of C5 to Ct10 according to "Table Ⅰ-4•1 Accuracy grades of ball screw and their application" on Page B17.

From the following conditions in design, the axial play should be 0.005 mm or less.

Repeatability : ±0.005 (mm)

Resolution : 0.005 mm/pulse

From "Table Ⅰ-4•2 Combinations of accuracy grades and axial play" on Page B18, select C5 accuracy grade, and axial play Z code (0 : preloaded).

(2) Selection of lead

From the maximum rotational speed of AC servo motor:

$$l \geqq \frac{V_{max}}{N_{max}} = \frac{1000 \times 60}{3000} = 20(\text{mm})$$

Select a lead of 20 mm or larger.

(3) Selection of screw shaft diameter

According to "Table Ⅰ-4•5 Standard stock ball screw: Combinations of screw shaft diameter and leads" on Page B19, the diameter of the shaft which has a lead larger than 20 mm should be in the range of 15 mm to 32 mm. Select the smallest 15 mm.

(4) Selection of stroke

From "Table Ⅰ-4•6 Maximum stroke of standard ball screw A&S Series" on Page B20, the shaft diameter 15 mm and lead 22 mm satisfy maximum stroke 700 mm.

Primary selection:

Shaft diameter :	15 mm
Lead :	22 mm
Stroke :	700 mm
Accuracy grade :	C5
Axial play :	Z