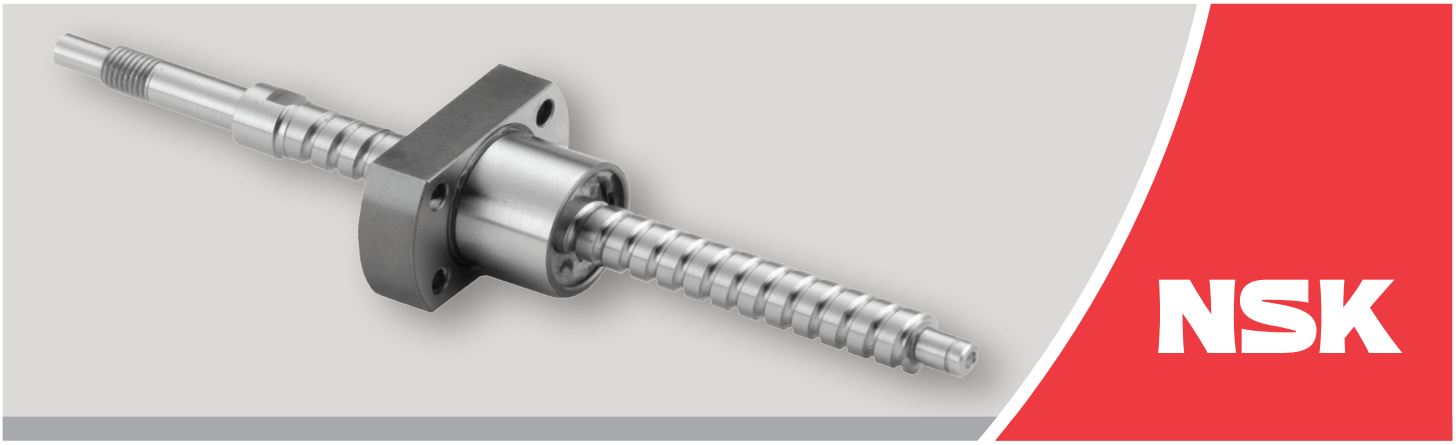


NSK Precision Ground Ball Screw:
Deliver the most efficient, precise performance

Ball screws are mechanical linear actuators that convert rotary movement into linear motion with little friction, which boosts efficiency. Due to this efficiency, ball screws are ideal for a variety of industrial and automotive applications such as milling-machine tables, robotics and semiconductor wafer transport systems.

This whitepaper will describe the benefits of selecting precision ground ball screws in addition to proper handling techniques to ensure long operating life.

The Design Challenge

Other types of linear motion technology exist, such as pneumatic, hydraulic, rack and pinion, or even a linear motor could be used as an alternative solution to a ball screw. However a ball screw performs better for the following reasons:

Pneumatic vs. Ball Screw
The ball screw can withstand a higher load with greater precision.

Hydraulic vs. Ball Screw
Ball screws achieve greater precision without the need for a tank, fluid, filter, piping and the maintenance required for hydraulic.

Rack & Pinion vs. Ball Screw
Reduced backlash in ball screw driven motion compared to rack & pinion. Ball screws also exhibit higher accuracy and precision.

Linear Motor vs. Ball Screw
A ball screw can move a heavier load and generally is less expensive than a linear motor.

Once the customer has determined that a ball screw is a suitable linear motion technology, many application factors are reviewed by NSK's Engineering department to ensure the ball screw design selected exceeds performance and accuracy expectations, while also adhering to NSK's quality standards.

Solution Overview

NSK manufactures a wide variety of ball screws including several standard series and custom designs. Considered the leading manufacturer of precision ground ball screws, NSK is recognized for supplying ball screws that demonstrate superb accuracy, extreme durability and unsurpassed quality.

Ball Screw Structure

A ball screw consists of a screw shaft, ball nut, recirculating system and balls. All of these components are required to maintain continuous ball movement within the ball screw. Ball screw performance is measured by four basic factors: accuracy grade, screw shaft diameter, lead and stroke.

Accuracy Grade:	range from C0 to C5 in ground series ball screws.
Screw Shaft Diameter:	based on allowable space needed/required for application.
Lead:	distance the nut travels linearly, when the shaft is rotated 360°.
Stroke:	allowable distance traveled along the length of the screw shaft.

These four factors are calculated and measured against customer application requirements - including load, speed, stroke, accuracy and performance life expectations.

For example, if an application is operating under a heavy load, NSK may recommend a preload. **Figure 1** and **Figure 2** illustrate a P-type preload. Oversized balls are used to preload the assembly up to 3% of dynamic capacity. A P-type preload is recommended for shorter nut lengths and has lower torque characteristics.

Figure 1

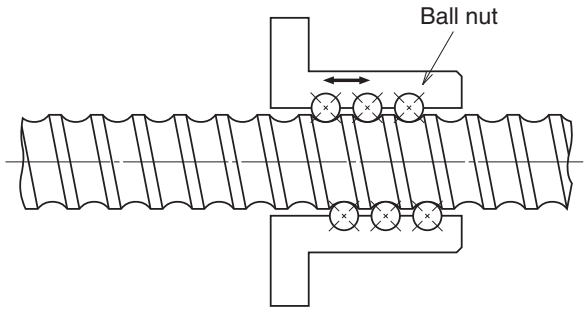
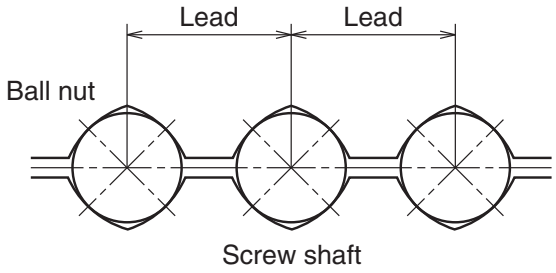


Figure 2



Applications requiring higher rigidity should consider using a Z-Type or D-Type preload. Both of these preloads types can use up to 10% of dynamic capacity. **Figure 3** and **Figure 4** illustrate a Z-type preload, featuring a single nut design with an offset to the center lead in the ball nut. It is a less expensive option compared to D-Type, offering excellent rigidity for medium nut lengths.

Figure 3

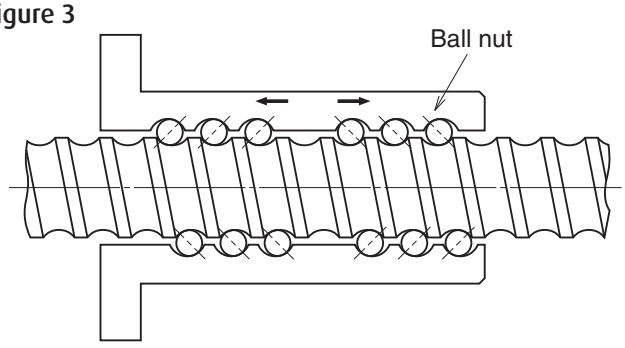
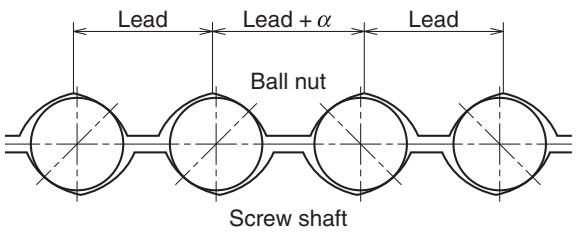


Figure 4



The D-Type preload is the most expensive choice because of its double-nut design. It also utilizes a precision spacer to get the required preload (**Figure 5** and **Figure 6**). More circuits can be added to double nut/spacer design than with the Z-type to achieve higher load carrying capabilities. NSK's D-Type preload design features a longer ball nut with excellent rigidity.

Figure 5

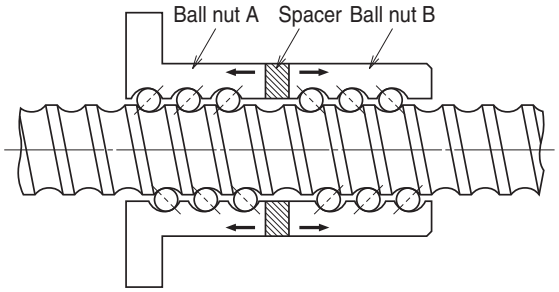
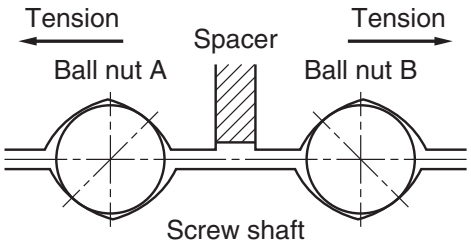


Figure 6

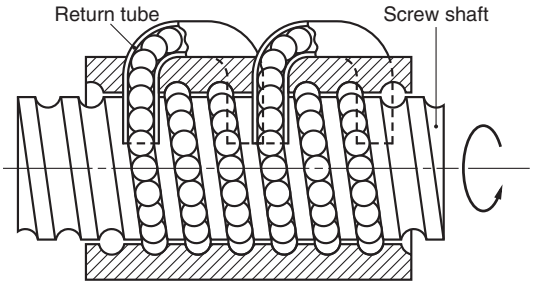


Once preload has been determined, there are four different types of recirculation that can be applied: tube, deflector, end cap or end deflector (BSS).

Tube Type

The standard and most economically priced option is the tube type recirculation. Balls are re-circulated through a ball return tube shown in **Figure 7**. With this type it's possible to get speeds of up to 100,000 dN. Note that the dN rating is an expression of the ball nut's maximum speed capacity. It's the nominal shaft diameter (in mm) multipled by maximum nut speed in rpm. Tube type recirculation is very versatile and can be applied to many diameter and lead combinations.

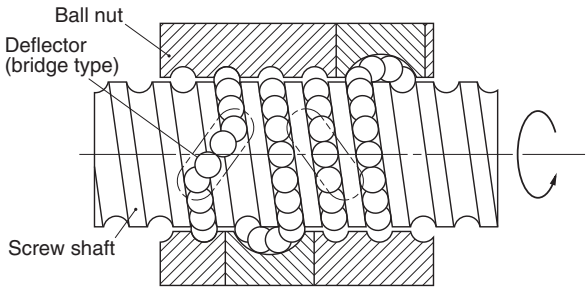
Figure 7



Deflector Type

The deflector type uses a horseshoe-shaped tube to bridge adjacent ball thread grooves. This allows for a compact nut design for all ball screws. Utilizing this method, applications can reach speeds to 150,000 dN, but isn't available for high lead requirements. See **Figure 8**.

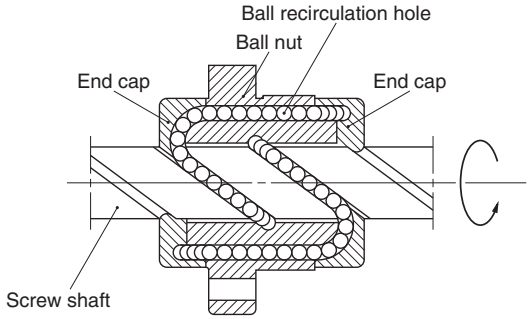
Figure 8



End Cap Type

For large leads, the end cap type is recommended. See **Figure 9.** End caps are placed at both ends of the ball nut, and balls are picked up and re-circulated through a hole in the ball nut. This method reaches speeds of up to 100,000 dN, but is the most expensive option due to double thread start and machining required to modify ball nut. End cap type recirculation is best for large lead ball screws in applications needing high linear speeds.

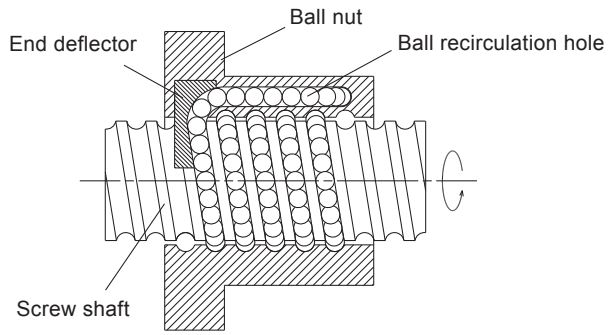
Figure 9



BSS End Deflector Type

To achieve the industry's highest speed, quietest sound and most compact design, NSK offers the end deflector (BSS) type recirculation. This option reaches speeds of up to 180,000 dN and is six decibels quieter than other recirculation methods. The nut shape and size are 30% smaller than those associated with tube type recirculation. To get all of these benefits, balls are picked up in the tangential direction at the end of the ball nut and re-circulated by a hole inside ball nut as shown in **Figure 10**.

Figure 10



Precautions when handling Ball Screws

Follow these handling instructions to ensure long operating life.

- Confirm ball screw is properly lubricated before use. Insufficient lubrication can lead to premature bearing failure.
  - Do not apply any lubrication if grease is already applied to ball screws.
  - If grease has been contaminated with dirt, wipe surface with clean white kerosene and then apply same type of lubricant before use. Avoid using different types of grease at the same time.
  - Consult NSK for special oil lubricant if required for your application.
  - Check grease every two to three months of operation and replenish as needed.
- Do not attempt to disassemble the ball screw. Send to NSK for repair or reassembly.
- Avoid overrunning the ball nut, as that can damage recirculation components.
- Before installation, store ballscrews in their original NSK package - on a flat surface - and in a clean environment to prevent potential entry of contaminants.
- Maximum operating temperature: 80° C (176° F). Consult NSK if it is necessary to use at a temperature higher than this.

Specifying Precision Ground Ball Screws

When selecting a ball screw, many conditions and requirements need to be evaluated. NSK manufactures standard and custom ball screws to meet each customer's specific application requirements. A wide variety of applications in food & beverage, factory automation, industrial equipment, machine tool, medical and semiconductor industries have benefited from the installation of a NSK precision ground ball screw.

For additional technical information, literature or assistance with machinery/equipment design requiring linear motion solutions, contact NSK Americas at 1.888.446.5675 or visit www.nskamericas.com.