



**APEX PRECISION
MECHATRONIX PVT.LTD.**

303-308, Krishna Bhuvan Annex, 22-B, Govandi
Station Road, Deonar, Mumbai - 400088,
Maharashtra,
INDIA.

PHONE NO.

61464444 / 9967550131

EMAIL

sales@apexprecision.co.in

Features of the Ball Spline

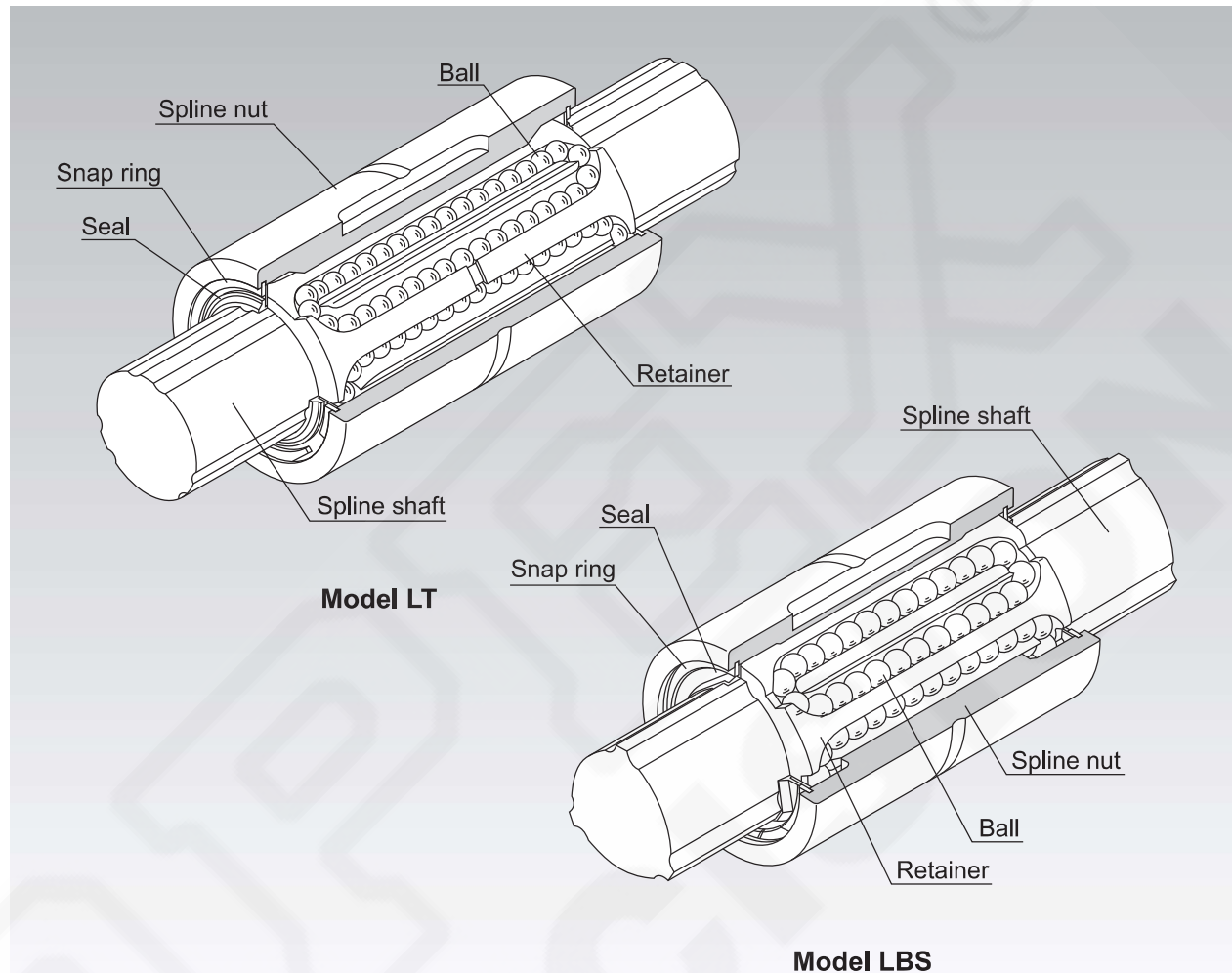


Fig.1 Structure of Ball Spline Models LBS and LT

Structure and Features

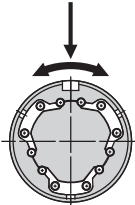
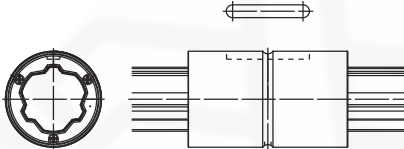
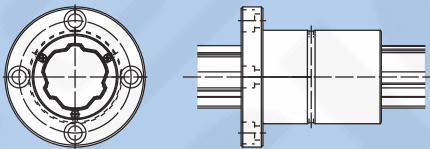
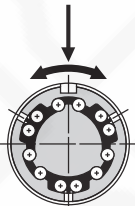

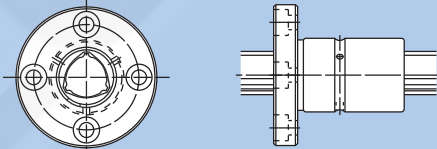
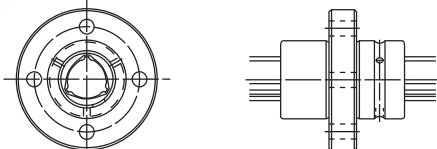

The Ball Spline is an innovative linear motion system in which balls accommodated in the spline nut transmit torque while linearly moving on precision-ground raceways on the spline shaft.

Unlike the conventional structure, a single spline nut can provide a preload with THK's Ball Spline. As a result, the Ball Spline demonstrates high performance in environments subject to vibrations and impact loads, locations where a high level of positioning accuracy is required or areas where high-speed kinetic performance is required.

In addition, even when used as an alternative to a linear bushing, the Ball Spline achieves a rated load more than 10 times greater than the linear bushing with the same shaft diameter, allowing it to compactly be designed and used in locations where an overhung load or a moment load is applied. Thus, the Ball Spline provides a high degree of safety factor and long service life.

Selecting a Type

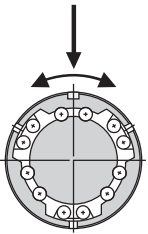
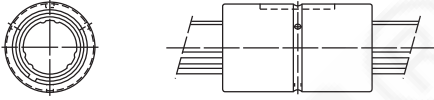
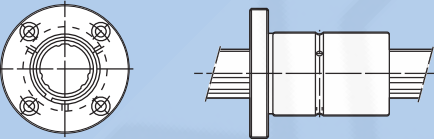
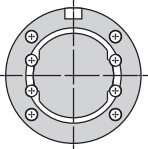
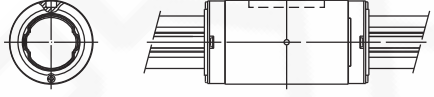
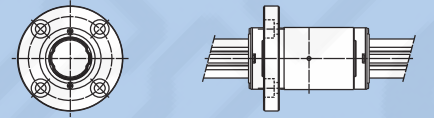
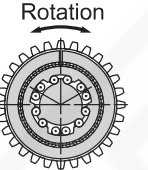
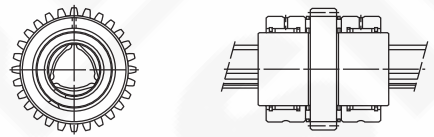

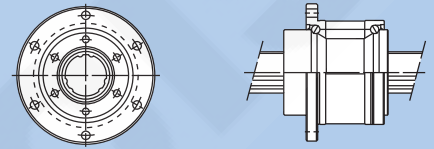
There are three types of the Ball Spline: high torque type, medium torque type and rotary type. You can choose a type according to the intended use. In addition, wide arrays of spline nut shapes are available for each type, enabling the user to choose a desired shape according to the mounting or service requirements.

Classification		Type	Shape	Shaft diameter
High torque Caged Ball type		Type SLS Type SLS-L		Nominal shaft diameter 25 to 100mm
		Type SLF		Nominal shaft diameter 25 to 100mm
High torque type		Type LBS Type LBST		Nominal shaft diameter 6 to 150mm
		Type LBF		Nominal shaft diameter 15 to 100mm
		Type LBR		Nominal shaft diameter 15 to 100mm
		Type LBH		Nominal shaft diameter 15 to 50mm

Point of Selection

Selecting a Type

Specification Table	Structure and features	Major application
A3-42	<ul style="list-style-type: none"> • Redesigning the shape of the conventional high torque type spline shaft to be more circular significantly improves its torsion and flexural rigidity. • Models SLS/SLF adopt the caged-ball technology to enable the circulating motion of evenly spaced balls to be maintained and high-speed response to be achieved, the cycle time of the machine can be improved. • Models SLS/SLF adopt the caged-ball technology, they eliminate collision and mutual friction between balls, and realize low noise, pleasant running sound and low particle generation. 	
A3-44	<ul style="list-style-type: none"> • Models SLS/SLF adopt the caged-ball technology to substantially increase the grease retention, thus achieving long-term maintenance-free operation. • Models SLS/SLF adopt the caged-ball technology and a new circulation method, thus achieving stable and smooth motion with small rolling fluctuation. 	<ul style="list-style-type: none"> • Column and arm of industrial robot • Automatic loader • Transfer machine • Automatic conveyance system • Tire molding machine • Spindle of spot-welding machine • Guide shaft of high-speed automatic coating machine
A3-56	<ul style="list-style-type: none"> • The spline shaft has three crests equidistantly formed at angles of 120°. On both sides of each crest, two rows (six rows in total) of balls are arranged to hold the crest from both sides. The angular-contact design of the ball contact areas allows an appropriate preload to be evenly applied. 	<ul style="list-style-type: none"> • Riveting machine • Wire winder • Work head of electric discharge machine • Spindle drive shaft of grinding machine • Speed gears • Precision indexing machine
A3-62	<ul style="list-style-type: none"> • Since the balls circulate inside the spline nut, the outer dimensions of the spline nut are compactly designed. 	
A3-64	<ul style="list-style-type: none"> • Even under a large preload, smooth straight motion is achieved. • Since the contact angle is large (45°) and the displacement is minimal, high rigidity is achieved. 	
A3-66	<ul style="list-style-type: none"> • No angular backlash occurs. • Capable of transmitting a large torque. 	

Classification		Type	Shape	Shaft diameter
Medium torque type		Type LT		Nominal shaft diameter 4 to 100mm
		Type LF		Nominal shaft diameter 6 to 50mm
		Type LT-X		Nominal shaft diameter 4 to 30mm
		Type LF-X		Nominal shaft diameter 4 to 30mm
Rotary type		Type LBG Type LBGT		Nominal shaft diameter 20 to 85mm
		Type LTR-A Type LTR		Nominal shaft diameter 8 to 60mm

Medium Torque Type Ball Spline

Models LT, LF, LT-X and LF-X

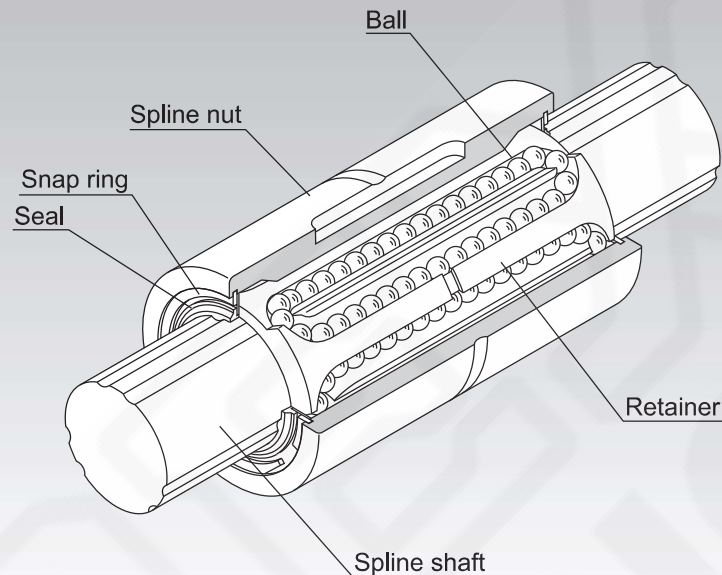


Fig.1 Structure of Medium Torque Type Ball Spline Model LT

Point of Selection	A3-6
Point of Design	A3-117
Options	A3-120
Model No.	A3-122
Precautions on Use	A3-123
Accessories for Lubrication	A24-1
Mounting Procedure and Maintenance	B3-31
Cross-sectional Characteristics of the Spline Shaft	A3-17
Equivalent factor	A3-27
Clearance in the Rotation Direction	A3-30
Accuracy Standards	A3-34
Maximum Manufacturing Length by Accuracy	A3-115

Structure and Features

With the medium torque type Ball Spline, the spline shaft has two to three crests on the circumference, and along both sides of each crest, two rows of balls (four or six rows in total) are arranged to hold the crest so that a reasonable preload is applied.

The rows of balls are held in a special resin retainer incorporated in the spline nut so that they smoothly roll and circulate. With this design, balls will not fall even if the nut is removed from the spline shaft.

[Large Load Capacity]

The raceways are formed into circular-arc grooves approximate to the ball curvature and ensure angular contact. Thus, this model has a large load capacity in the radial and torque directions.

[No Angular Backlash]

Two rows of balls facing one another hold a crest, formed on the circumference of the spline nut, at a contact angle of 20° to provide a preload in an angular-contact structure. This eliminates an angular backlash in the rotational direction and increases the rigidity.

[High Rigidity]

Since the contact angle is large and an appropriate preload is given, high rigidity against torque and moment is achieved.

[Ball Retaining Type]

Use of a retainer prevents the balls from falling even if the spline shaft is pulled out of the spline nut. (except for models LT4 and 5)

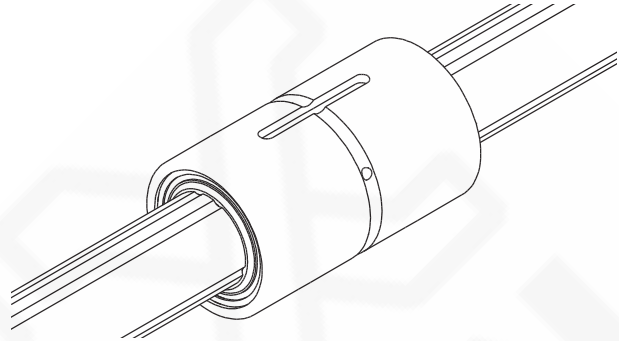
Types and Features

[Types of Spline Nuts]

Cylindrical Type Ball Spline Model LT

Specification Table⇒ **A3-78**

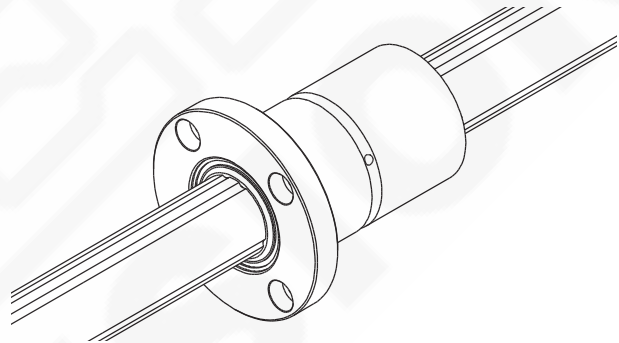
The most compact type with a straight cylindrical spline nut. When transmitting a torque, a key is driven into the body.



Flanged Type Ball Spline Model LF

Specification Table⇒ **A3-80**

The spline nut can be attached to the housing via the flange, making assembly simple. It is optimal for locations where the housing may be deformed if a keyway is machined on its surface, and where the housing width is small.



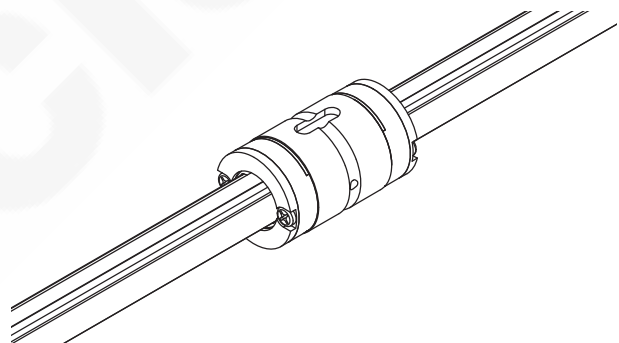
Model LT-X Miniature Ball Spline

Specification Table⇒ **A3-82**

The nut is more compact than that of the current Model LT thanks to the new circulating pathways.

The outer diameter of the nut is the same as that of the linear bushing.

The Model LT-XL is suitable for moment loads, torque, and overhung loads that exceed those tolerated by the Model LT-X.



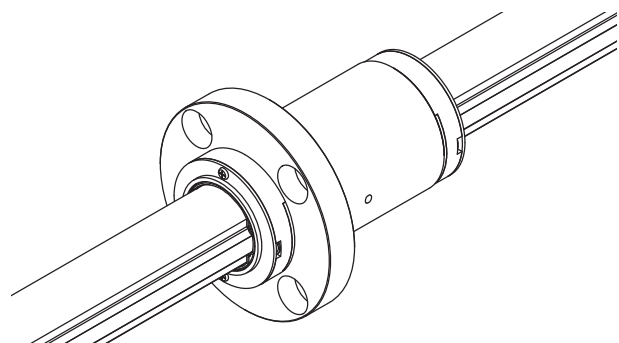
Model LF-X Miniature Ball Spline

Specification Table⇒ **A3-84**

The nut is more compact than that of the current Model LF thanks to the new circulating pathways.

The outer diameter of the nut is the same as that of the linear bushing.

The Model LF-XL is suitable for moment loads, torque, and overhung loads that exceed those tolerated by the Model LF-X.



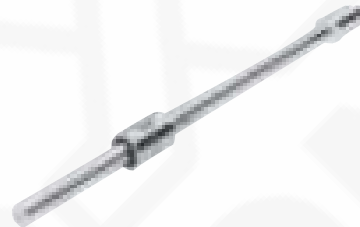
[Types of Spline Shafts]

Precision Solid Spline Shaft (Standard Type)

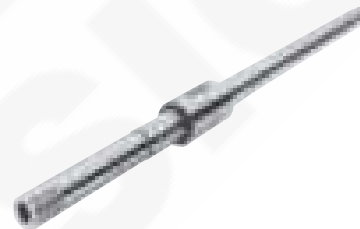
The raceway of the spline shaft is precision ground. It is used in combination with a spline nut.

**Special Spline Shaft**

THK manufactures a spline shaft with thicker ends or thicker middle area through special processing at your request.

**Hollow Spline Shaft (Type K)**

A drawn, hollow spline shaft is available for requirements such as piping, wiring, air-vent and weight reduction.



Thick

Hollow Spline Shaft (Type N)

A drawn, hollow spline shaft is available for requirements such as piping, wiring, air-vent and weight reduction.



Thin

Housing Inner-diameter Tolerance

When fitting the spline nut to the housing, transition fit is normally recommended. If the accuracy of the Ball Spline does not need to be very high, clearance fitting is also acceptable.

Table1 Housing Inner-diameter Tolerance

Housing Inner-diameter Tolerance	General conditions	H7
	When clearance needs to be small	J6

High Torque Type Ball Spline

Models LBS, LBST, LBF, LBR and LBH

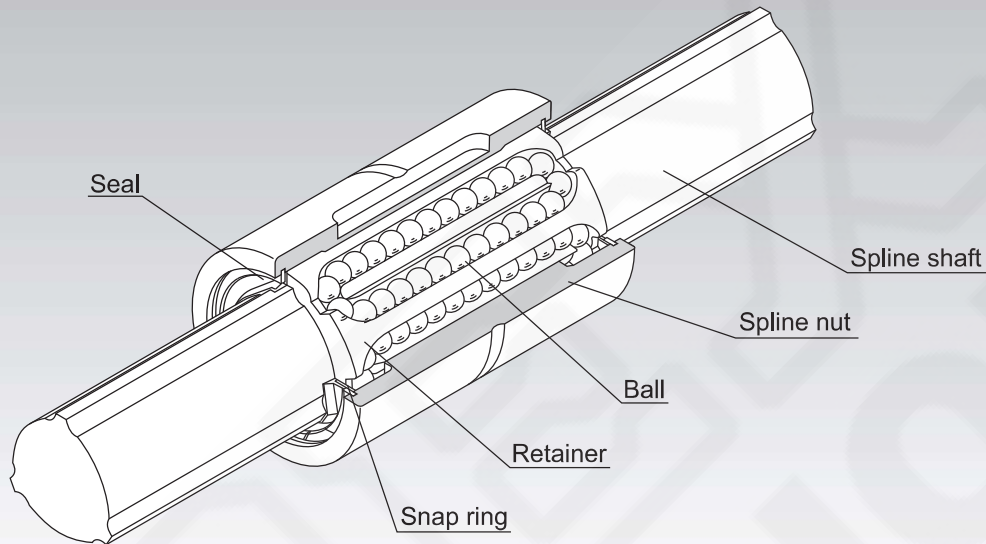


Fig.1 Structure of High Torque Type Ball Spline Model LBS

Point of Selection	A3-6
Point of Design	A3-117
Options	A3-120
Model No.	A3-122
Precautions on Use	A3-123
Accessories for Lubrication	A24-1
Mounting Procedure and Maintenance	B3-31
Cross-sectional Characteristics of the Spline Shaft	A3-17
Equivalent factor	A3-27
Clearance in the Rotation Direction	A3-30
Accuracy Standards	A3-34
Maximum Manufacturing Length by Accuracy	A3-115

Structure and Features

With the high torque type Ball Spline, the spline shaft has three crests positioned equidistantly at 120°, and along both sides of each crest, two rows of balls (six rows in total) are arranged so as to hold the crest, as shown in Fig.1.

The raceways are precision ground into R-shaped grooves whose diameters are approximate to the ball diameter. When a torque is generated from the spline shaft or the spline nut, the three rows of balls on the load-bearing side evenly receive the torque, and the center of rotation is automatically determined. When the rotation reverses, the remaining three rows of balls on the unloaded side receive the torque.

The rows of balls are held in a retainer incorporated in the spline nut so that they smoothly roll and circulate. With this design, balls will not fall even if the spline shaft is removed from the nut.

[No Angular Backlash]

With the high torque type Ball Spline, a single spline nut provides a preload to eliminate angular backlash and increase the rigidity.

Unlike conventional ball splines with circular-arc groove or Gothic-arch groove, the high torque type Ball Spline eliminates the need for twisting two spline nuts to provide a preload, thus allowing compact design to be achieved easily.

[High Rigidity and Accurate Positioning]

Since this model has a large contact angle and provides a preload from a single spline nut, the initial displacement is minimal and high rigidity and high positioning accuracy are achieved.

[High-speed Motion, High-speed Rotation]

Adoption of a structure with high grease retention and a rigid retainer enables the ball spline to operate over a long period with grease lubrication even in high-speed straight motion. Since the distance in the radius direction is almost uniform between the loaded balls and the unloaded balls, the balls are little affected by the centrifugal force and smooth straight motion is achieved even during high-speed rotation.

[Compact Design]

Unlike conventional ball splines, unloaded balls do not circulate on the outer surface of the spline nut with this model. As a result, the outer diameter of the spline nut is reduced and a space-saving and compact design is achieved.

[Ball Retaining Type]

Use of a retainer prevents the balls from falling even if the spline shaft is pulled out of the spline nut.

[Can be Used as a Linear Bushing for Heavy Loads]

Since the raceways are machined into R grooves whose diameter is almost equal to the ball diameter, the contact area of the ball is large and the load capacity is large also in the radial direction.

[Double, Parallel Shafts can be Replaced with a Single Shaft]

Since a single shaft is capable of receiving a load in the torque direction and the radial direction, double shafts in parallel configuration can be replaced with a single-shaft configuration. This allows easy installation and achieves space-saving design.

Applications

The high torque type Ball Spline is a reliable straight motion system used in a wide array of applications such as the columns and arms of industrial robot, automatic loader, transfer machine, automatic conveyance system, tire forming machine, spindle of spot welding machine, guide shaft of high-speed automatic coating machine, riveting machine, wire winder, work head of electric discharge machine, spindle drive shaft of grinding machine, speed gears and precision indexing shaft.

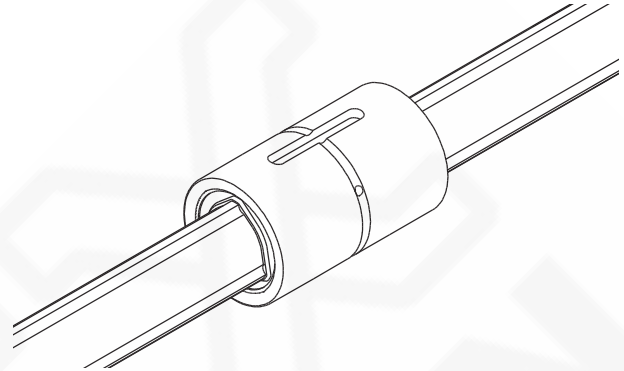
Types and Features

[Types of Spline Nuts]

Cylindrical Type Ball Spline Model LBS (Medium Load Type)

Specification Table⇒ **A3-56**

The most compact type with a straight cylindrical spline nut. When transmitting a torque, a key is driven into the body. The outer surface of the spline nut is provided with anti-carbonation treatment.

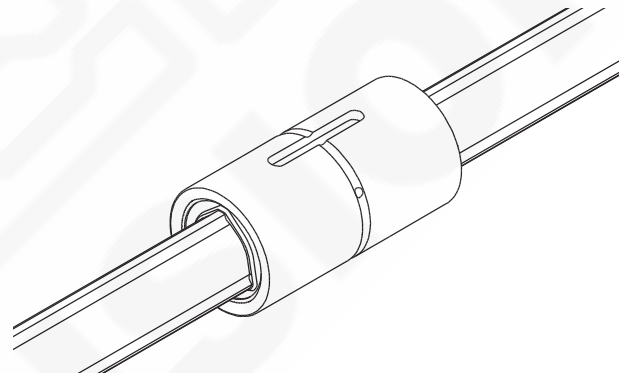


Ball Spline

Cylindrical Type Ball Spline Model LBST (Heavy Load Type)

Specification Table⇒ **A3-60**

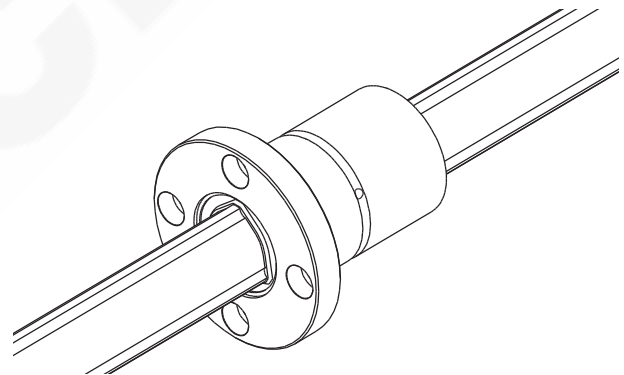
A heavy load type that has the same spline nut diameter as model LBS, but has a longer spline nut length. It is optimal for locations where the space is small, a large torque is applied, and an overhang load or moment load is applied.



Flanged Type Ball Spline Model LBF

Specification Table⇒ **A3-62**

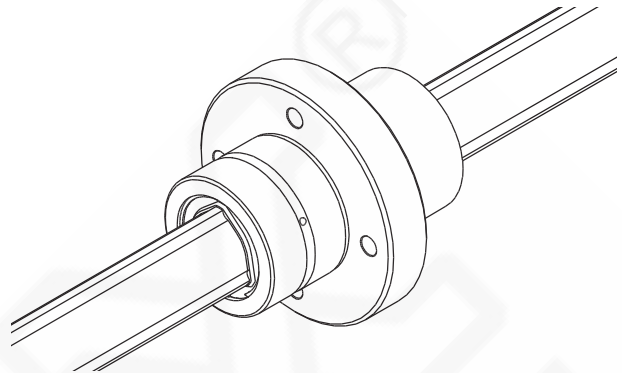
The spline nut can be attached to the housing via the flange, making assembly simple. It is optimal for locations where the housing may be deformed if a keyway is machined on its surface, and where the housing width is small.



Flanged Type Ball Spline Model LBR

Specification Table⇒ **A3-64**

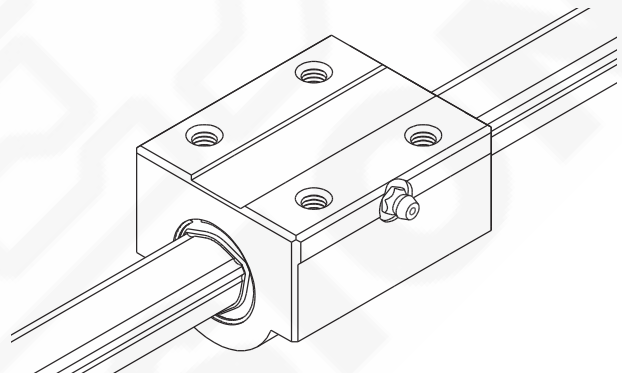
Based on the heavy load type model LBST, this model has a flange in the central area, making itself optimal for locations under a moment load such as arms of industrial robots.



Rectangular Type Ball Spline Model LBH

Specification Table⇒ **A3-66**

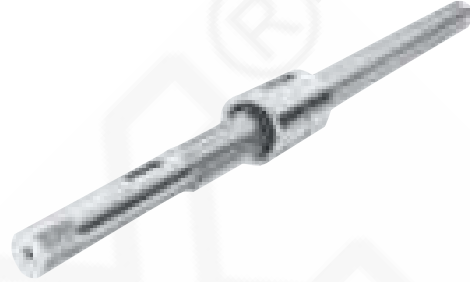
Its rigid rectangular spline nut does not require a housing and can be directly mounted on the machine body. Thus, a compact, highly rigid linear guide system is achieved.



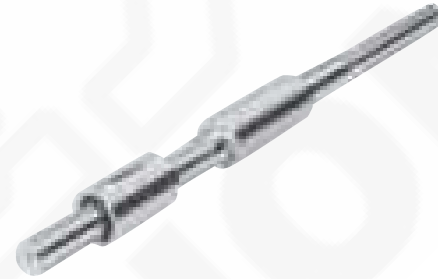
[Types of Spline Shafts]

Precision Solid Spline Shaft (Standard Type)

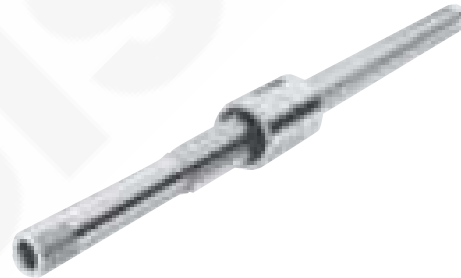
The spline shaft is cold-drawn and its raceway is precision ground. It is used in combination with a spline nut.

**Special Spline Shaft**

THK manufactures a spline shaft with thicker ends or thicker middle area through special processing at your request.

**Hollow Spline Shaft (Type K)**

A drawn, hollow spline shaft is available for requirements such as piping, wiring, air-vent and weight reduction.



Ball Spline

Housing Inner-diameter Tolerance

When fitting the spline nut to the housing, transition fit is normally recommended. If the accuracy of the Ball Spline does not need to be very high, clearance fitting is also acceptable.

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Housing Inner-diameter Tolerance	General conditions	H7
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