

**IKO**

**Stroke Ball Spline**

**LS**



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CAT-57155

# Unprecedented smoothness and for Saving energy

# compactness and Compact designing

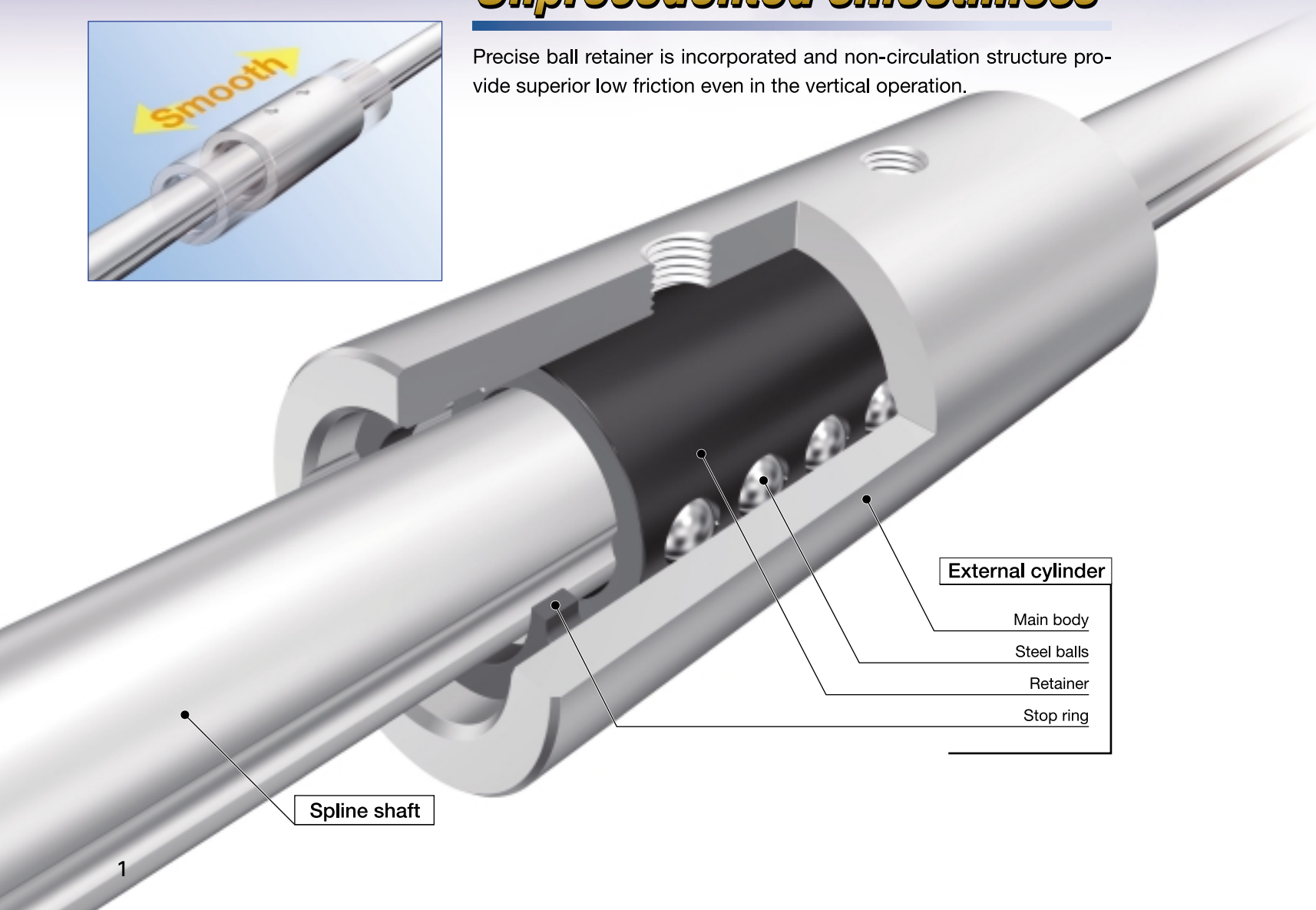
**IKO** Stroke Ball Spline

# LS

This is our new output for the manufacturing process of semiconductor and liquid crystal display requires high speed and high acceleration. As a regular leader of this industrial field.....

## Unprecedented smoothness

Precise ball retainer is incorporated and non-circulation structure provide superior low friction even in the vertical operation.

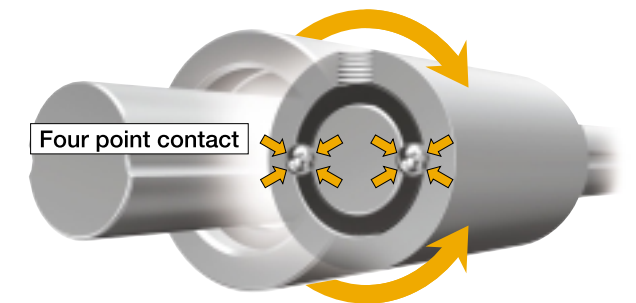
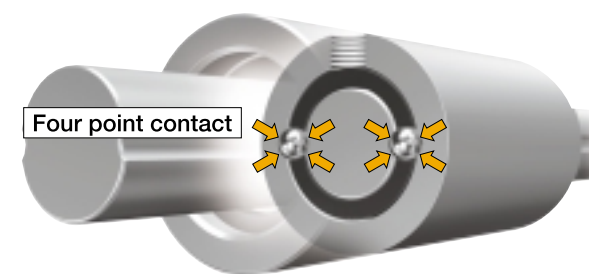


## Compact design with high rigidity

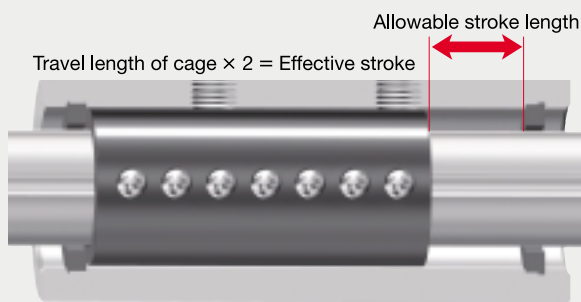
Large diameter steel balls are arranged in two rows and in four point contact with the raceways, achieving compact design with high rigidity under any direction of load and moment.

### Superior positioning accuracy

By applying suitable preload, clearance in the rotational direction is eliminated. So high positioning accuracy in the rotational direction has been obtained.

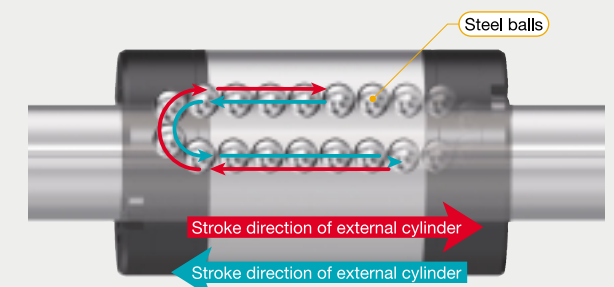


### Stroke Ball Spline LS (Limited Stroke length)



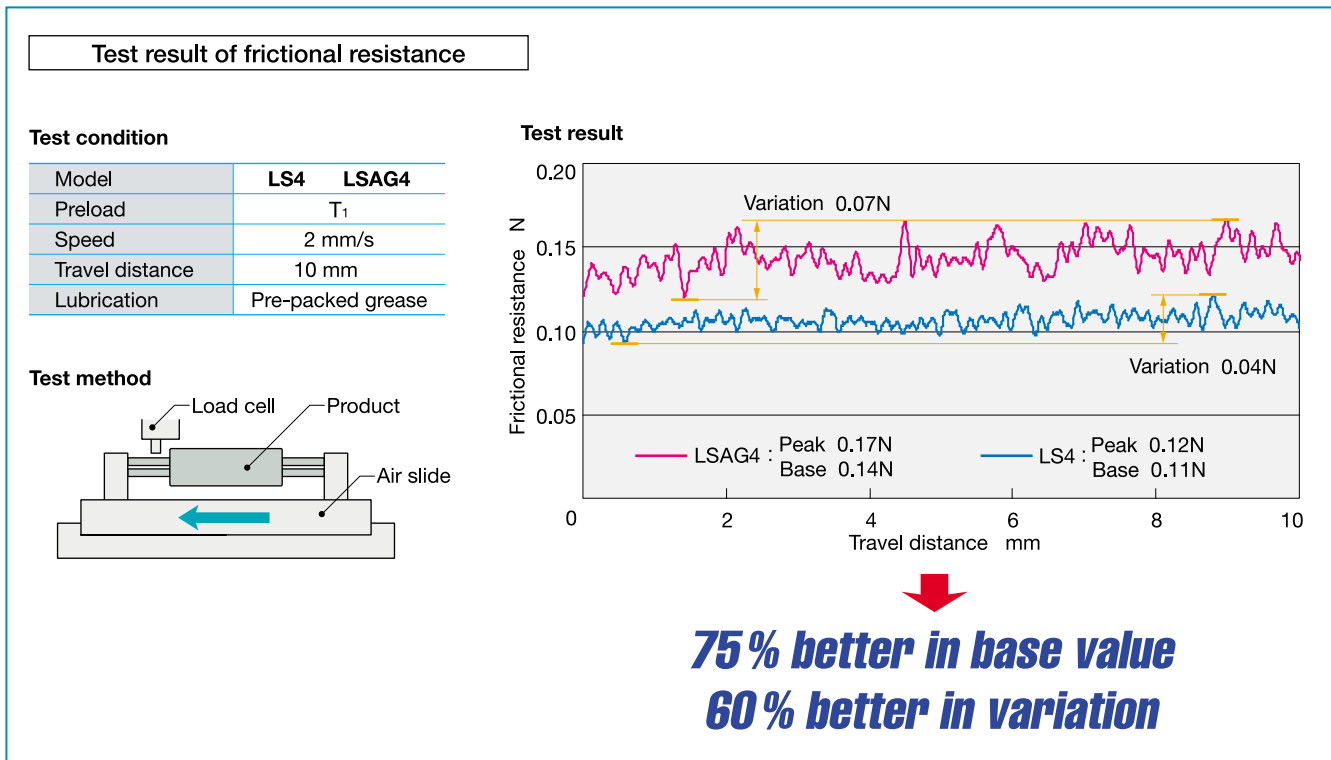
Available shaft diameter: 4mm to 6mm

### Linear Ball Spline G LSAG (Unlimited Stroke length)



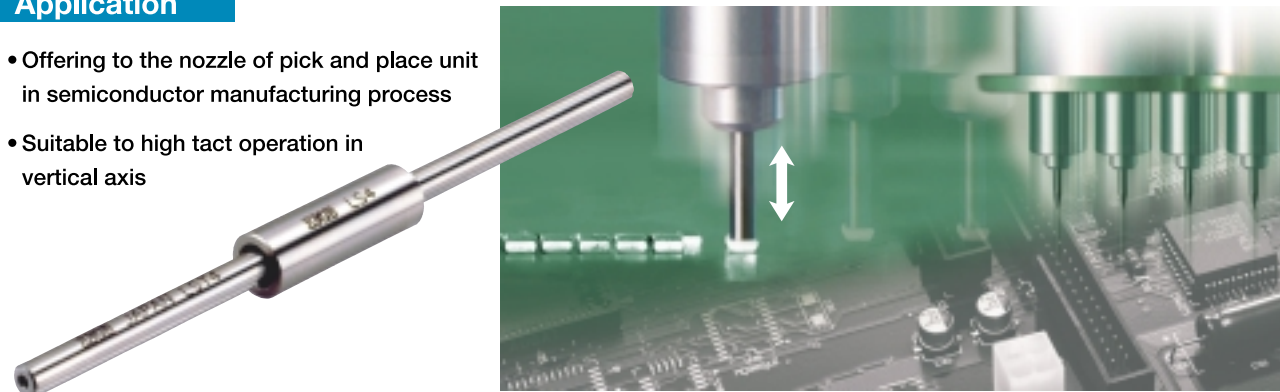
Available shaft diameter: 2mm to 50mm

# Features of Stroke Ball Spline LS ①



## Application

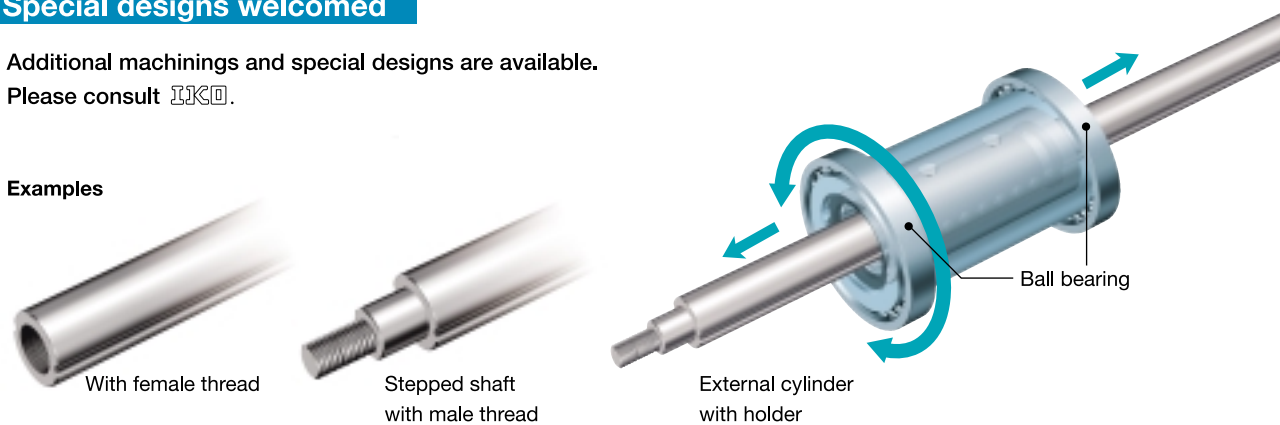
- Offering to the nozzle of pick and place unit in semiconductor manufacturing process
- Suitable to high tact operation in vertical axis



## Special designs welcomed

Additional machinings and special designs are available. Please consult **IKO**.

### Examples



# Identification Number

Identification numbers of **IKO** Stroke Ball Spline LS series consist of a model code, a size, a part code, a preload symbol, a classification symbol, and supplemental codes.

### Example of identification number

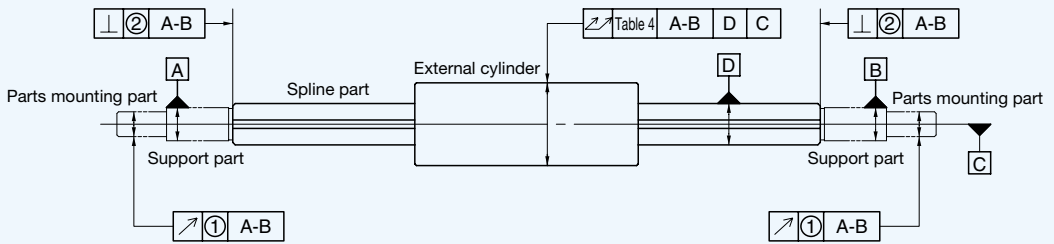
LS T 5 C1 R150 T<sub>1</sub> P /S  

①
②
③
④
⑤
⑥
⑦
⑧

① Series	Model code	Stroke Ball Spline LS
② Type of spline shaft	Model code	Solid shaft : No symbol Hollow shaft : T
③ Size	Size	4, 5, 6
④ Number of external cylinders	Part code	C1 One external cylinder paired with one spline shaft.
⑤ Length of spline shaft	Part code	R○ The length of spline shaft indicated by mm. For available standard length and maximum length, refer to dimension table.
⑥ Preload amount	Preload symbol	Light preload : T <sub>1</sub> Only T <sub>1</sub> preload is available and the amount of T <sub>1</sub> is approximately 0.02C <sub>0</sub> (C <sub>0</sub> =Basic static load rating)
⑦ Accuracy class	Classification symbol	Precision class : P Only P class is available and the detail of accuracy is shown in page 5.
⑧ Optional specification	Supplemental code	Spline shaft made of stainless steel : Applicable to solid type spline shaft only in size 5 and 6.  Spline shaft made of stainless steel /S The material of solid spline shaft of Stroke Ball Spline LS to be changed to stainless steel. The load rating will be obtained by multiplying that of high carbon steel by a factor of 0.8.

The accuracy of Stroke Ball Spline LS is shown in Table 1 and the accuracy of spline shaft is shown in Table 2 and 3.

**Table 1 Accuracy of each part of Stroke Ball Spline LS**



Model number	Relative to axial line of supporting part of spline shaft	
	①Radial runout of periphery of parts mounting part <sup>(1)</sup>	②Perpendicularity of spline shaft end surface <sup>(1)</sup>
	Precision class (P)	Precision class (P)
LS 4	8	6
LS 5		
LS 6		

unit :  $\mu\text{m}$

Note<sup>(1)</sup> : This accuracy is applicable when special machining is done to the shaft end.

Remark : The above table shows representative model numbers, and are also applicable to all models.

**Table 2 Twist of grooves with respect to effective length of the spline shaft** unit :  $\mu\text{m}$

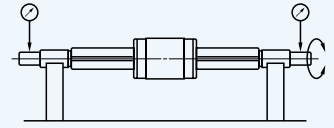
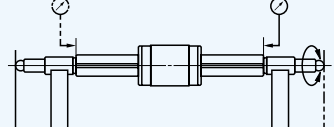
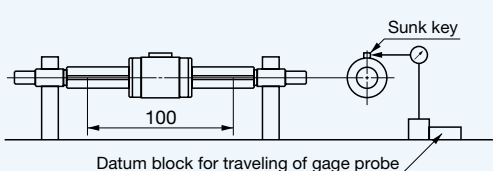
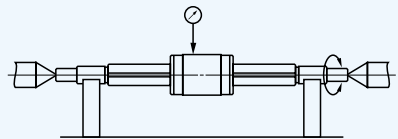
Accuracy class	Precision (P)
Allowable value	6

Remark : The value is applicable to any length of the effective length 100mm of spline part.

**Table 3 Total radial runout of axial line of spline shaft** unit :  $\mu\text{m}$

Overall length of spline shaft mm		Precision (P)
Over	Incl.	
—	200	26
200	300	57

**Table 4 Measuring method of accuracy**

Measuring item	Measuring method	Illustration of measuring method
(1) Radial runout of periphery of parts mounting part relative to axial line of supporting part of spline shaft. (See Table 1, ①)	While supporting the spline shaft at its supporting parts, place dial gage probes to the outer peripheral faces of the parts mounting part, and measure the runout from one rotation of the spline shaft.	
(1) Perpendicularity of spline end face relative to axial line of supporting part of spline shaft (See Table 1, ②)	While supporting the spline shaft at its supporting parts at one spline shaft end, place a dial gage probe to the spline end face and measure runout from one rotation of the spline shaft.	
Twist of grooves with respect to effective length of the spline part (See Table 2)	Fix and support the spline shaft. Then apply a unidirectional torsion moment on the external cylinder (for measurement purpose), before placing a dial gage probe to the side face of the sunk key attached on the external cylinder. Measure runout when the external cylinder and the gage probe have traveled together 100mm on any effective part of the spline shaft. However, the gage probe should be applied as near as possible to the outer periphery of the external cylinder.	
Total radial runout of axial line of spline shaft (See Table 3)	While supporting the spline shaft at its supporting parts or at both center holes, place a dial gage probe to the external peripheral face of the external cylinder (for measurement purpose), and measure runout at several positions in the axial direction while turning the spline shaft one rotation. Use the maximum value.	

Note<sup>(1)</sup> : This accuracy is applicable when special machining is done to the shaft ends.

## Basic dynamic load rating $C$

The basic dynamic load rating is defined as a constant load both in direction and magnitude under which a group of identical Stroke Ball Spline LS is individually operated and 90% of those in the group can travel  $50 \times 10^3\text{m}$  free from material damage due to rolling contact fatigue.

## Basic static load rating $C_0$

The basic static load rating is defined as a static load that gives a prescribed constant contact stress at the center of the contact area between rolling elements and raceways receiving the maximum load. Generally, the basic static load rating is used in combination with the static safety factor.

## Allowable load $F$

The allowable load is a load under which the sum of elastic deformations of the rolling element and the raceways in the contact area subjected to the maximum contact stress is small enough to guarantee accuracy and smooth rolling movement. Therefore, where very smooth and highly accurate linear motion is required, make sure to use Stroke Ball Spline LS well within the allowable load values.

## Dynamic rated torque $T$

The dynamic rated torque is defined as a rotational torque (See Fig.2) constant both in magnitude and direction under which 90% of a group of the same Stroke Ball Spline LS can travel  $50 \times 10^3\text{m}$  without suffering from material damage due to rolling contact fatigue when they are individually operated.

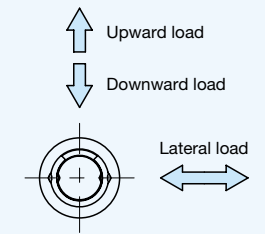
## Static rated torque and Static rated moment

### $T_0, T_x, T_y$

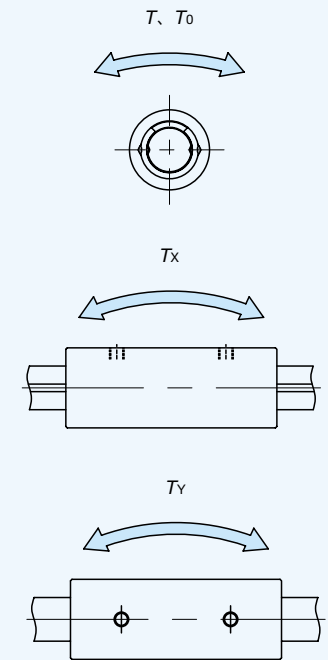
The static rated torque and static rated moment are defined as a static torque or static moment which gives a prescribed constant contact stress at the center of the contact area between the steel ball and raceway receiving the maximum load when a torque or moment (See Fig.2) is loaded. They are the allowable limit torque or moment that permits normal rolling motion. Generally, they are used in combination with the static safety factor.

## Load direction and Load rating

Since the load ratings of Stroke Ball Spline LS given in the dimension table are for upward/downward load, they must be corrected for the load direction for lateral load. The corrected basic dynamic load ratings and basic static load ratings are shown in Table 5.



**Fig.1 Direction of load**



**Fig.2 Direction of dynamic torque, Static rated torque and static torque rating**

**Table 5 Load ratings corrected for the load direction**

Size	Load direction	Upward and forward		Lateral	
		Basic dynamic load rating	Basic static load rating	Basic dynamic load rating	Basic static load rating
4~6		C	$C_0$	1.47C	1.73 $C_0$

# Load Rating and Life

## Life

The rating life of Stroke Ball Spline LS is obtained from the following formula.

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

$$L = 50 \left( \frac{T}{M} \right)^3 \dots\dots\dots (2)$$

where,  $L$  : Rating life,  $10^3$ m  
 $C$  : Basic dynamic load rating, N  
 $T$  : Dynamic rated torque,  $N \cdot m$   
 $P$  : Theoretically calculated radial load, N  
 $M$  : Theoretically calculated torque,  $N \cdot m$

If the stroke length and the number of strokes per minute are given, the life in hours can be obtained from the following formula.

$$L_h = \frac{10^6 L}{2S n_1 \times 60} \dots\dots\dots (3)$$

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

## Static safety factor

When excessive large or heavy loads are applied on Stroke Ball Spline LS, local permanent deformation will be made on balls or raceways, resulting in deterioration in running performance. In general, the allowable loads depend on the operating conditions and the requirements in the application, and the margin of safety is determined considering the above factors. The static safety factor,  $f_s$ , can be obtained from the following formula. General values of this factor are shown in Table 6.

$$f_s = \frac{C_0}{P_0} \dots\dots\dots (4)$$

$$f_s = \frac{T_0}{M_0} \dots\dots\dots (5)$$

where,  $f_s$  : Static safety factor  
 $C_0$  : Basic static load rating, N  
 $P_0$  : Static radial load (maximum load), N  
 $T_0$  : Static rated torque,  $N \cdot m$   
 $M_0$  : Static torque (maximum torque),  $N \cdot m$

**Table 6 Static safety factor**

Operating conditions	$f_s$
Operation with vibration and/or shocks	5 ~ 7
High operating performance is required.	4 ~ 6
Normal operation	3 ~ 5

## Load factor

Due to vibration and/or shocks during machine operation, the actual load on each rolling guide becomes greater in many cases than the theoretically calculated load. The applied load is generally calculated by multiplying the theoretically calculated load by the load factor shown in Table 7.

**Table 7 Load factor**

Operating conditions	$f_w$
Smooth operation free from vibration and/or shock	1 ~ 1.2
Normal operation	1.2 ~ 1.5
Operation with vibration and/or shocks	1.5 ~ 3

# Spline Shaft

Moment of inertia of sectional area and section modulus of the spline shaft are shown in Table 8.

**Table 8 Moment of inertia of sectional area and section modulus**

Model number	Moment of inertia of sectional area $mm^4$		Sectional modulus $mm^3$	
	Solid shaft	Hollow shaft	Solid shaft	Hollow shaft
LS 4	12	12	6	6
LS 5	29	29	12	12
LS 6	61	61	21	21

Remark : The table shows representative model numbers only, and are applicable to all models of the same size.

# Lubrication and Dust Protection

In Stroke Linear Ball Spline LS, grease is not pre-packed. In Cleaning of rust preventive oil and Initial lubrication with grease or oil is necessary by users before the operation. Quality lithium-soap base grease is recommended. Stroke Linear ball Spline LS does not have oil hole and grease nipple. Apply grease on the raceway part of spline shaft in case of relubrication.

# Precautions for use

## ①Fit of external cylinder

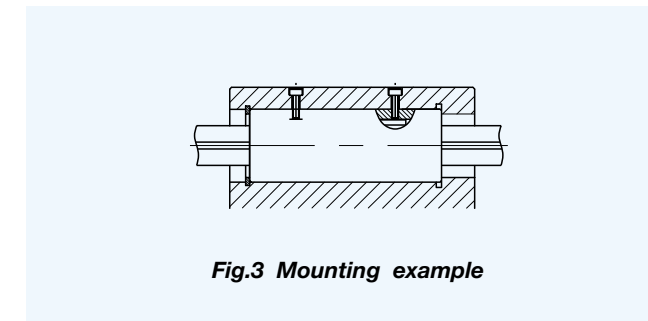
Generally, transition fit (J7) is applied between the external cylinder and the housing bore. When high accuracy and high rigidity are not required, clearance fit (H7) may also be applicable.

## ②Stopper mechanism

Stroke Linear Ball Spline LS does not have mechanical stopper. Prepare mechanical stopper if over stroking is concerned.

## ③Standard mounting example

Fig.3 shows standard mounting methods of external cylinder.



## ④Additional machining of spline shaft

The high carbon steel spline shaft is hardened by induction hardening. When additional machining on the shaft end is needed, make sure that the maximum diameter of the shaft end machining part does not exceed the dimension  $d_1$  shown in the dimension tables. Spline shafts with special end shapes can be prepared upon request. Consult for further information.

## ⑤Operating temperature

The maximum ambient temperature  $120^\circ\text{C}$ . In case of continuously operation, ambient temperature should not exceed  $100^\circ\text{C}$ .

## ⑥Caution in the operation

Stroke length should be within effective stroke length in dimension table.

Cage creeping may occur under unsteady high-speed operation and/or moment load condition. A full length of stroking is necessary to correct cage position in periodical operation interval.

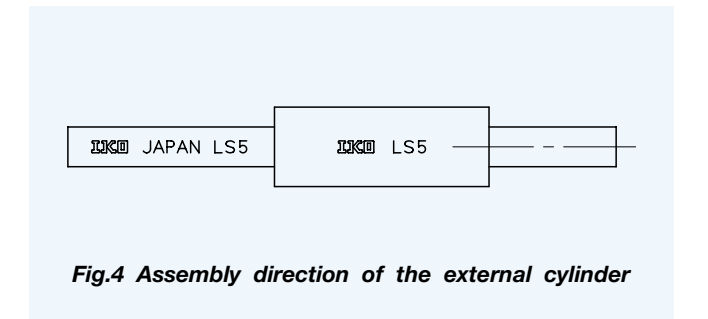
# Precaution for mounting

## ①Assembling an external cylinder and a spline shaft

When assembling the external cylinder on the spline shaft, correctly fit grooves of the external cylinder to the grooves of the spline shaft and move the external cylinder gently in parallel direction. Rough handling will result in dropping steel balls. The cage must be located in the middle position. After assemble the external cylinder to a spline shaft, push the spline shaft forward until the cage contacts to end part of external cylinder.

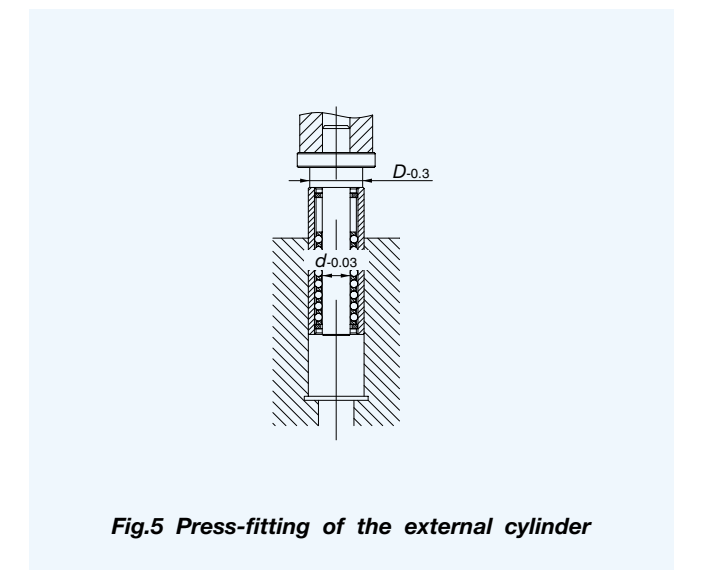
Furthermore, push the spline shaft until a half of the maximum stroke length and return it by the same length. Then the location of the cage can be located in the middle.

Products are assembled to provide the best accuracy when marks of external cylinder and spline shaft face the same direction.

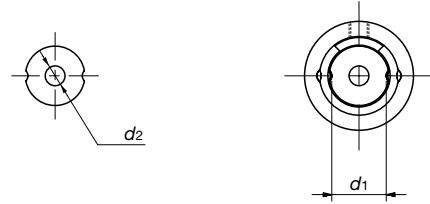


## ②Mounting the external cylinder

When press-fitting the external cylinder to the housing, assemble them correctly by using a pressing equipment and a suitable jig fixture, etc. (See Fig.5)



# IKO Stroke Ball Spline LS LS · LST



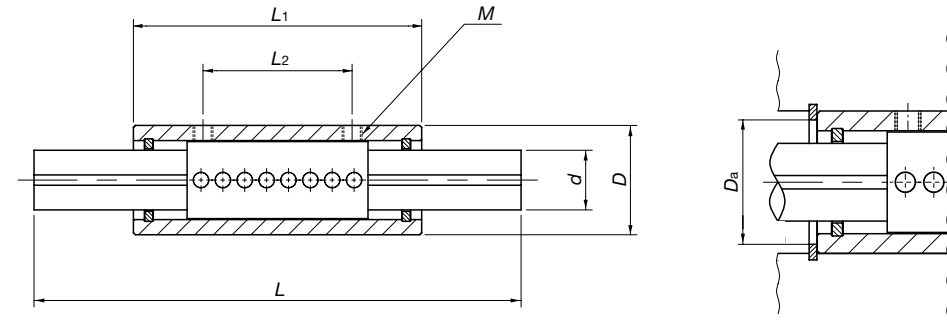
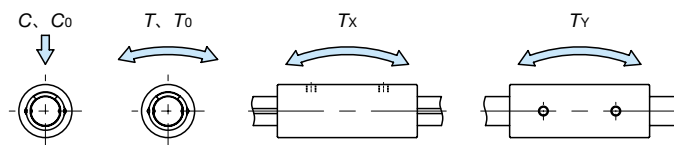
Model number	Mass (Ref.) g		Dimension and tolerance of external cylinder mm						Dimension and tolerance of spline shaft mm					
	External cylinder	Spline shaft (per 100mm)	D	Tolerance	L <sub>1</sub>	L <sub>2</sub>	M	Maximum depth of thread	d	Tolerance	d <sub>1</sub> ( <sup>1</sup> )	d <sub>2</sub>	L( <sup>2</sup> )	Maximum length
LS 4	5.65	9.6	8	0	24	10	M2	1.3	4	0	3.2	—	100 150	200
LST 4		8.6		-0.009										1.5
LS 5	8.90	14.9	10	0	27	12	M2	1.4	5	0	4.2	—	100 150	200
LST 5		12.4		-0.009										2
LS 6	10.90	19	11	0	29	15	M2	1.4	6	0	5.2	—	150 200	300
LST 6		16.5		-0.011										2

Note<sup>(1)</sup>: Dimension  $d_1$  indicates the maximum diameter when machining is done at the spline shaft ends.

<sup>(2)</sup>: Lengths indicated are standard lengths. Spline shafts in different lengths are also available. Simply indicate the necessary length of spline shaft (mm) in the identification number.

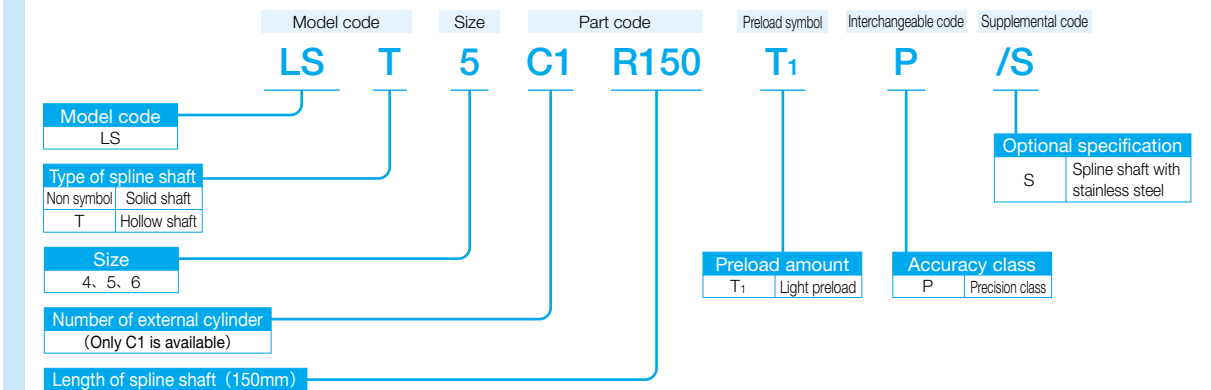
<sup>(3)</sup>: The directions of dynamic load rating (C), basic static load rating (C<sub>0</sub>), dynamic torque rating (T) and static torque/moment rating (T<sub>0</sub>, T<sub>x</sub> and T<sub>y</sub>) are shown in the sketches below.

Remark: Grease is not pre-packed. Initial lubrication with grease or oil is necessary before the operation.



Effective stroke length mm	Maximum stroke length mm	Mounting dimension D <sub>a</sub> mm	Basic dynamic load rating <sup>(3)</sup> C N	Basic static load rating <sup>(3)</sup> C <sub>0</sub> N	Allowable load <sup>(3)</sup> F N	Dynamic torque rating <sup>(3)</sup> T N · m	Static torque rating <sup>(3)</sup> T <sub>0</sub> N · m	Static moment rating <sup>(3)</sup>		Model number
								T <sub>x</sub> N · m	T <sub>y</sub> N · m	
10	13.2	5	285	380	127	0.66	0.87	0.88	1.5	LS 4
										LST 4
10	14	7	616	748	249	1.8	2.2	2.0	3.5	LS 5
										LST 5
10	13.6	8	673	855	285	2.4	3.0	2.6	4.4	LS 6
										LST 6

## Example of identification number of assembled set



# IKO

## C-Lube Linear Ball Spline MAG has launched.

### A large amount of lubricant is incorporated in the compact external cylinder

Incorporating the lubricating component C-Lube in the steel ball circulating path of the external cylinder has achieved maintenance free operation for 5 years or 20,000 km. This lubrication effect lasts for a long time and can reduce the cost of the whole system as a result of the reduction in the lubrication mechanism of the system and in the running cost as the result of reduction in man-hours for lubricational maintenance.

### High rigidity and high accuracy have been achieved in spite of the compact size

A simple two-row four-point contact structure using large-diameter steel balls has achieved compactness, high rigidity, high accuracy and low cost.

### Ultimate interchangeable system Interchangeable specification

The product conforms to the interchangeable specification in which the external cylinder and the spline shaft can be separately handled. This system allow us to meet customer requirements of short delivery term and selecting what is needed in desired quantity.

*Maintenance free for 20,000km or 5 years*

# The final answer to your lube requirement.

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