BALL SPLINE

ROTARY BALL SPLINE

STROKE BALL SPLINE

BALL SPLINE

The NB ball spline is a linear motion mechanism utilizing the rotational motion of ball elements that can sustain loads and at the same time can transfer torque. It can be used in a wide variety of applications including robotics and transport type equipment.

STRUCTURE AND ADVANTAGES

The NB ball spline consists of a spline shaft with raceway grooves and a spline nut. The spline nut consists of an outer cylinder (main body), retainer, side rings, and ball elements that is designed and manufactured to achieve a reliably smooth motion.

High Load Capacity and Long Travel Life

The raceway grooves are machined to a radius close to that of the ball elements. The large ball contact area results in high load capacity and long travel life.

Wide Variety of Configurations

Spline shaft sizes with diameters from 4mm to 100mm are available. Several types of Spline nut are available: cylindrical types (SSP/SSPM), and flange types (SSPF/SSPT). Material option of Stainless steel (SUS440C or equivalent) is also available. They can be specified to suit various applications.

High Accuracy Torque Transmission

Due to the effective contact angle between the raceway grooves and the balls, the NB ball spline can transfer large torque. By adjusting preload it is possible to give a higher rigidity and a higher positioning accuracy.

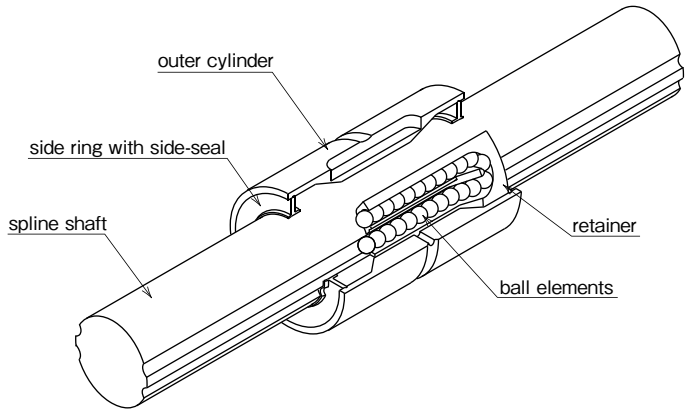
Ease of Additional Custom Machining

Since a round shaft with raceway grooves is used, NB ball spline shafts can be machined easily to customized specifications.

High-Speed Motion and High-Speed Rotation

The outer cylinder is compact and well balanced, resulting in good performance at high speed.

Figure B-1 Basic Structure of NB Ball Spline

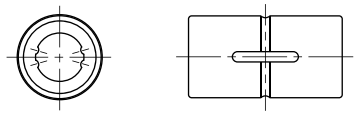
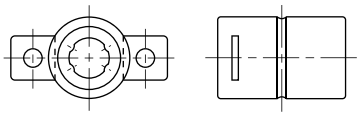
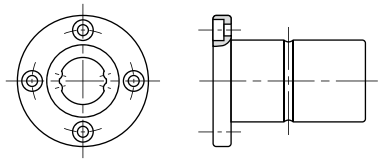
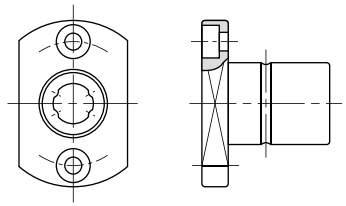


TYPES

TYPES OF SPLINE NUT

A wide variety of spline nut designs are available and all spline nuts come with side-seals as a standard feature.

Table B-1 Types of Spline Nut

type of nut		shape and advantage	page
cylindrical type	SSP SSPS	 ・cylindrical spline nut with key groove ・with special key ・nominal diameter: SSP4-100 : SSPS4-25	P.B-18
	SSPM	 ・cylindrical spline nut without key groove ・with two lock plates for fixing ・nominal diameter: 6-10	P.B-20
flange type	SSPF SSPFS	 ・spline nut with flange ・nominal diameter: SSPF6-60 : SSPFS6-25	P.B-22
	SSPT	 ・spline nut with a two side cut flange ・nominal diameter: 6-10	P.B-24

TYPES OF SPLINE SHAFT

Depending on the application requirements, either a ground spline shaft or a non-ground (commercial grade) spline shaft is available.

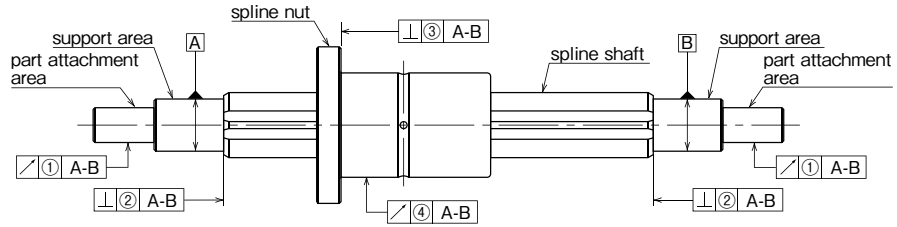
Table B-2

type of spline shaft	shape and advantage	
ground spline shaft		・precision ground and precision machined surface finish ・high precision ・possible to machine ends of spline shaft and surface treatment ・nominal diameter: 4-100
standard spline shaft		・standard dimension and shape ・accuracy grade: high grade ・short lead time ・nominal diameter: 4-60 (refer to page B-26)
commercial shaft (non-ground)		・for general industrial use ・cost effective ・possible to machine ends of spline shaft and surface treatment ・nominal diameter: 20-50 ・maximum length: 5000mm (refer to page B-27)

ACCURACY

The NB ball spline is measured for accuracy at the points shown in Figure B-2 and categorized as either high-grade (blank) or precision-grade (P). Contact NB for accuracy information on the commercial type ball spline.

Figure B-2 Accuracy Measurement Points



Note: The support area is the portion where, for example, radial bearings are attached in order to support the spline shaft.
The part attachment area is the portion to which other parts, such as gears are attached.

Tolerance of Spline Shaft Groove Torsion (Max.)

The groove torsion is indicated per 100mm, arbitrarily set as the effective length of the spline shaft section.

Table B-3
Tolerance of Spline Shaft Groove Torsion (Max.)

type of shaft	ground shaft	
accuracy grade	high	precision (P)
tolerance	13μm／100mm	6μm／100mm

Table B-4 Tolerance Relative to Spline Support Area (Max.) unit/μm

part number	radial runout of part attachment area ①		perpendicularity of the end of the spline shaft section ② (when grinding is requested on the drawing)		perpendicularity of the flange ③	
	high-grade	precision-grade	high-grade	precision-grade	high-grade	precision-grade
SSP 4	14	8	9	6	—	—
SSP 6					11	8
SSP 8						
SSP 10	17	10			13	9
SSP 13A	19	12	11	8		
SSP 16A						
SSP 20A						
SSP 25A	22	13	13	9	16	11
SSP 30A						
SSP 40A	25	15	16	11	19	13
SSP 50A						
SSP 60A	29	17	19	13	22	15
SSP 80					—	—
SSP 80L						
SSP100	34	20	22	15		
SSP100L						
SSP 20	19	12	11	8	13	9
SSP 25	22	13	13	9	16	11
SSP 30						
SSP 40	25	15	16	11	19	13
SSP 50						
SSP 60	29	17	19	13	22	15

Table B-5 ④Radial Runout of Outer Surface of Spline Nut Relative to Spline Shaft Support Area (Max.) unit/μm

total length of spline shaft (mm)		part number																	
		SSP4		SSP6		SSP8		SSP10		SSP13A SSP16A		SSP20A·20 SSP25A·25 SSP30A·30		SSP40A·40 SSP50A·50		SSP60A·60 SSP80 SSP80L		SSP100 SSP100L	
greater than	or less	high-grade	precision grade	high-grade	precision grade	high-grade	precision grade	high-grade	precision grade	high-grade	precision grade	high-grade	precision grade	high-grade	precision grade	high-grade	precision grade	high-grade	precision grade
—	200	46	26	46	26	46	26	36	20	34	18	32	18	32	16	30	16	30	16
200	315	89	—	89	57	89	57	54	32	45	25	39	21	36	19	34	17	32	17
315	400	—	—	126	—	126	82	68	41	53	31	44	25	39	21	36	19	34	17
400	500	—	—	—	—	163	—	82	51	62	38	50	29	43	24	38	21	35	19
500	630	—	—	—	—	—	—	102	65	75	46	57	34	47	27	41	23	37	20
630	800	—	—	—	—	—	—	—	—	92	58	68	42	54	32	45	26	40	22
800	1,000	—	—	—	—	—	—	—	—	115	75	83	52	63	38	51	30	43	24
1,000	1,250	—	—	—	—	—	—	—	—	153	97	102	65	76	47	59	35	48	28
1,250	1,600	—	—	—	—	—	—	—	—	195*	127*	130	85	93	59	70	43	55	33
1,600	2,000	—	—	—	—	—	—	—	—	—	—	171	116	118	77	86	54	65	40

★ SSP13A, 16A maximum length: 1500mm
★★ Please contact NB for shaft lengths exceeding 2000mm.

PRELOAD AND CLEARANCE IN ROTATIONAL DIRECTION

Both the clearance and preload are expressed in terms of clearance in the rotational direction. The preload is categorized into three different levels: standard, light (T1), and medium (T2). A preload cannot be specified with the commercial grade spline shaft.

Table B-6 Preload and Clearance in Rotational Direction unit/μm

part number	standard	light (T1)	medium (T2)
SSP 4	−2～+1	− 6～−2	−
SSP 6			
SSP 8			
SSP 10	−3～+1	− 8～−3	−13～− 8
SSP 13A			
SSP 16A			
SSP 20A	−4～+2	−12～−4	−20～−12
SSP 25A			
SSP 30A			
SSP 40A	−6～+3	−18～−6	−30～−18
SSP 50A			
SSP 60A			
SSP 80			
SSP 80L			
SSP100	−8～+4	−24～−8	−40～−24
SSP100L			
SSP 20	−4～+2	−12～−4	−20～−12
SSP 25			
SSP 30			
SSP 40	−6～+3	−18～−6	−30～−18
SSP 50			
SSP 60			

Table B-7 Operating Condition and Preload

preload	preload symbol	operating conditions
standard	blank	minute vibration is applied. a precise motion is required. a torque in a given direction is applied.
light	T1	slight vibration is applied. slight torsional load is applied. cyclic torque is applied.
medium	T2	shock/vibration is applied. over-hang load is applied. torsional load is applied.

STRENGTH OF SPLINE SHAFT

The ball spline has larger load ratings compared to ball bush. Also, the ball spline can sustain radial load, moment (bending moment) and torque (twisting moment) at the same time. Thus, it is necessary to consider the strength of ball spline shaft.

Using the following equations, select the size of ball

$$\sigma \geqq \frac{M}{Z} \quad \cdots\cdots (1)$$

σ: permissible bending stress of spline shaft (98N/mm²)
M: bending moment onto spline shaft (N·mm)
Z: modulus of section (mm³)
(refer to Table B-8 on page B-8)

Twisting Moment Only

$$\tau_a \geqq \frac{T}{Z_P} \quad \cdots\cdots (2)$$

Ta: permissible twisting stress of spline shaft (49N/mm²)
T: twisting moment onto spline shaft (N·mm)
Zp: polar modulus of section (mm³)
(refer to Table B-8 on page B-8)

Bending Moment and Twisting Moment Combined

Calculate equivalent bending moment (Me) by using equation (3).Then, substitute Me into equation (1) for shaft size selection.

$$M_e = \frac{1}{2}\left\{M + \sqrt{(M^2 + T^2)}\right\} \quad \cdots\cdots (3)$$

Me: equivalent bending moment (N·mm)
M: bending moment onto spline shaft
T: twisting moment onto spline shaft

Rigidity of Spline Shaft

The rigidity of spline shaft is expressed in the torsional angle (θ) caused by twisting moment.
For high accuracy smooth motion, it is necessary to keep the torsional angle within 0.25° per 1,000mm.

$$\theta = \frac{T \cdot L}{G \cdot I_P} \cdot \frac{360}{2\pi} \quad \cdots\cdots (4)$$

$$\text{Rigidity} = 0.25° \geqq \frac{1{,}000}{L}\theta \quad \cdots\cdots (5)$$

θ: torsional angle (°)
T: twisting moment onto spline shaft (N·mm)
L: spline shaft length (mm)
G: shearing modulus (SUJ2) 7.9×10^4 (N/mm²)
(SUS) 7.69×10^4 (N/mm²)
I_P: polar moment of inertia of area (mm⁴)
(refer to Table B-8 on page B-8)

Figure B-3 Bending Moment

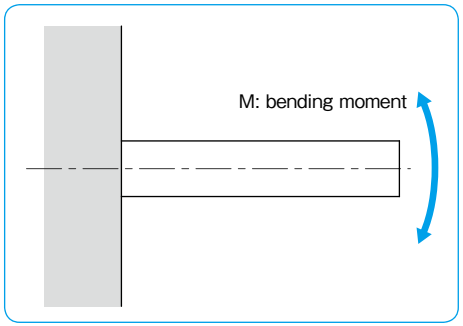


Figure B-4 Twisting Moment

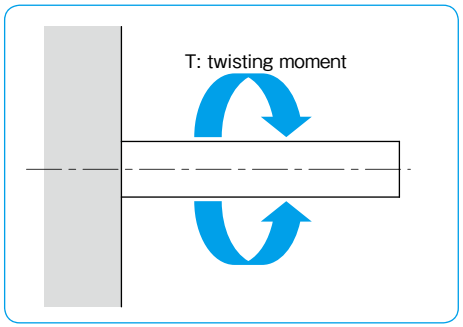


Figure B-5 Deformation of Spline Shaft by Twisting Moment

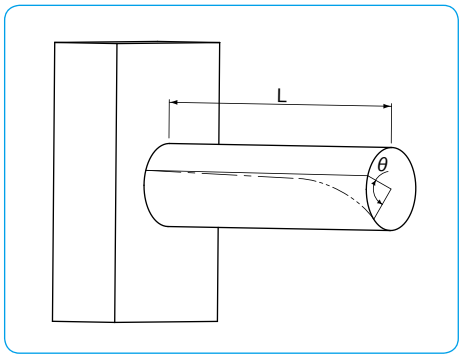


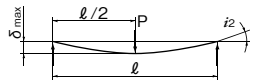
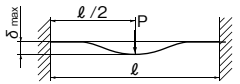
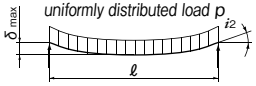
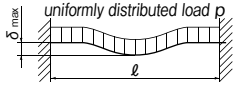
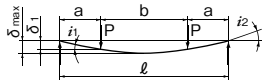
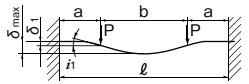
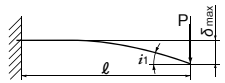
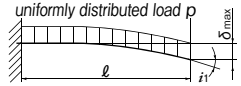
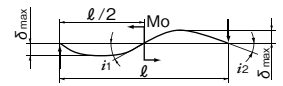
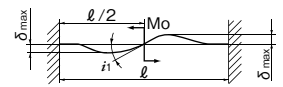
Table B-8 Cross-sectional Characteristics of Spline Shaft

part number	I moment of inertia of area mm⁴	Z modulus of section mm³	I_P polar moment of inertia of area mm⁴	Z_P polar modulus of section mm³	C=1/48EI 1/N·mm² SUJ2	C=1/48EI 1/N·mm² SUS440C
SSP 4	1.18×10	5.90	2.41×10	1.20×10	8.57×10^{-9}	8.83×10^{-9}
SSP 6	5.91×10	1.97×10	1.21×10^{2}	4.04×10	1.71×10^{-9}	1.76×10^{-9}
SSP 8	1.90×10^{2}	4.76×10	3.88×10^{2}	9.69×10	5.32×10^{-10}	5.47×10^{-10}
SSP 10	4.61×10^{2}	9.22×10	9.42×10^{2}	1.88×10^{2}	2.19×10^{-10}	2.26×10^{-10}
SSP 13A	1.32×10^{3}	2.03×10^{2}	2.70×10^{3}	4.16×10^{2}	7.66×10^{-11}	7.89×10^{-11}
SSP 16A	2.98×10^{3}	3.73×10^{2}	6.15×10^{3}	7.68×10^{2}	3.39×10^{-11}	3.49×10^{-11}
SSP 20A	7.35×10^{3}	7.35×10^{2}	1.51×10^{4}	1.51×10^{3}	1.38×10^{-11}	1.42×10^{-11}
SSP 25A	1.79×10^{4}	1.43×10^{3}	3.68×10^{4}	2.94×10^{3}	5.65×10^{-12}	5.82×10^{-12}
SSP 30A	3.63×10^{4}	2.42×10^{3}	7.57×10^{4}	5.05×10^{3}	2.79×10^{-12}	—
SSP 40A	1.15×10^{5}	5.73×10^{3}	2.39×10^{5}	1.20×10^{4}	8.83×10^{-13}	—
SSP 50A	2.81×10^{5}	1.12×10^{4}	5.86×10^{5}	2.34×10^{4}	3.60×10^{-13}	—
SSP 60A	5.91×10^{5}	1.97×10^{4}	1.22×10^{6}	4.08×10^{4}	1.71×10^{-13}	—
SSP 80	1.93×10^{6}	4.83×10^{4}	3.92×10^{6}	9.81×10^{4}	5.24×10^{-14}	—
SSP 80L						
SSP100	4.69×10^{6}	9.38×10^{4}	9.55×10^{6}	1.91×10^{5}	2.16×10^{-14}	—
SSP100L						
SSP 20	5.03×10^{3}	5.53×10^{2}	1.04×10^{4}	1.14×10^{3}	2.01×10^{-11}	2.07×10^{-11}
SSP 25	1.27×10^{4}	1.10×10^{3}	2.63×10^{4}	2.29×10^{3}	7.97×10^{-12}	8.21×10^{-12}
SSP 30	2.74×10^{4}	1.96×10^{3}	5.73×10^{4}	4.10×10^{3}	3.69×10^{-12}	—
SSP 40	8.71×10^{4}	4.66×10^{3}	1.82×10^{5}	9.75×10^{3}	1.16×10^{-12}	—
SSP 50	2.16×10^{5}	9.19×10^{3}	4.53×10^{5}	1.93×10^{4}	4.69×10^{-13}	—
SSP 60	4.50×10^{5}	1.59×10^{4}	9.46×10^{5}	3.35×10^{4}	2.25×10^{-13}	—

CALCULATION OF DEFLECTION AND DEFLECTION ANGLE OF SPLINE SHAFT

The following formulas are used to obtain the deflection and its angle of the ball spline shaft.
Typical conditions are listed in Table B-9.

Table B-9 Formulas for Calculating Deflection and Deflection Angle

	support method	specification	formula for deflection	formula for deflection angle
1	support | support		$\delta_{max}=\frac{P\ell^3}{48EI}=P\ell^3C$	$i_1=0$ $i_2=\frac{P\ell^2}{16EI}=3P\ell^2C$
2	fixed | fixed		$\delta_{max}=\frac{P\ell^3}{192EI}=\frac{1}{4}P\ell^3C$	$i_1=0$ $i_2=0$
3	support | support		$\delta_{max}=\frac{5p\ell^4}{384EI}=\frac{5}{8}p\ell^4C$	$i_2=\frac{p\ell^3}{24EI}=2p\ell^3C$
4	fixed | fixed		$\delta_{max}=\frac{p\ell^4}{384EI}=\frac{1}{8}p\ell^4C$	$i_2=0$
5	support | support		$\delta_1=\frac{Pa^3}{6EI}\left(2+\frac{3b}{a}\right)=8Pa^3\left(2+\frac{3b}{a}\right)C$ $\delta_{max}=\frac{Pa^3}{24EI}\left(\frac{3\ell^2}{a^2}-4\right)=2Pa^3\left(\frac{3\ell^2}{a^2}-4\right)C$	$i_1=\frac{Pab}{2EI}=24PabC$ $i_2=\frac{Pa(a+b)}{2EI}=24Pa(a+b)C$
6	fixed | fixed		$\delta_1=\frac{Pa^3}{6EI}\left(2-\frac{3a}{\ell}\right)=8Pa^3\left(2-\frac{3a}{\ell}\right)C$ $\delta_{max}=\frac{Pa^3}{24EI}\left(2+\frac{3b}{a}\right)=2Pa^3\left(2+\frac{3b}{a}\right)C$	$i_1=\frac{Pa^2b}{2EI\ell}=\frac{24Pa^2bC}{\ell}$ $i_2=0$
7	fixed | free		$\delta_{max}=\frac{P\ell^3}{3EI}=16P\ell^3C$	$i_1=\frac{P\ell^2}{2EI}=24P\ell^2C$ $i_2=0$
8	fixed | free		$\delta_{max}=\frac{p\ell^4}{8EI}=6p\ell^4C$	$i_1=\frac{p\ell^3}{6EI}=8p\ell^3C$ $i_2=0$
9	support | support		$\delta_{max}=\frac{\sqrt{3}Mo\,\ell^2}{216EI}=\frac{2\sqrt{3}}{9}Mo\,\ell^2C$	$i_1=\frac{Mo\,\ell}{12EI}=4Mo\,\ell C$ $i_2=\frac{Mo\,\ell}{24EI}=2Mo\,\ell C$
10	fixed | fixed		$\delta_{max}=\frac{Mo\,\ell^2}{216EI}=\frac{2}{9}Mo\,\ell^2C$	$i_1=\frac{Mo\,\ell}{16EI}=3Mo\,\ell C$ $i_2=0$

δ_1: deflection at the concentrated load point (mm) δ_{max}: maximum deflection (mm) i_1: deflection angle at the concentrated load point (rad) i_2: deflection angle at the support point (rad) Mo: moment (N·mm) P: concentrated load (N) p: uniformly distributed load (N/mm) a,b: concentrated load point distance (mm) ℓ: span (mm) I: moment of inertia of area (mm⁴) (refer to Table B-8 on page B-8) E: modulus of longitudinal elasticity (SUJ2) 2.06×10^5 (N/mm²) (SUS) 2.0×10^5 (N/mm²) C: 1/48EI (1/N·mm²)

ALLOWABLE ROTATIONAL SPEED OF SPLINE SHAFT

When the rotational speed is increased and approaches the spline shaft resonant frequency, the spline shaft is disabled from further operation. This speed is called the critical speed and can be obtained by the following equations. In order to leave a sufficient safety margin, the allowable operating speed should be set at about 80% of the calculated value.

Using the following equations, select the size of ball spline shaft. First, calculate I_d and A by equation (8) and (9) then, substitute the values into equation (7).

$$N_C = 60 \cdot \frac{\lambda^2}{2\pi \cdot L^2} \cdot \sqrt{\frac{E \cdot I_d \times 10^3}{\gamma \cdot A}} \quad \cdots\cdots (7)$$

Nc: critical speed (rpm)
L: support distance (mm)
E: modulus of longitudinal elasticity (SUJ2)2.06×10^5 (N/mm^2)
(SUS)2.0×10^5 (N/mm^2)
γ: density (SUJ2)7.85×10^{-6} (kg/mm^3)
(SUS)7.75×10^{-6} (kg/mm^3)

I_d: Minimum Moment of Inertia of Area (mm^4)

$$I_d = \frac{\pi \cdot d^4}{64} \quad \cdots\cdots (8)$$

d: maximum machined-down diameter with no spline grooves left (refer to Table B-10)

A: Minimum Cross-sectional Area of the Spline Shaft (mm^2)

$$A = \frac{\pi \cdot d^2}{4} \quad \cdots\cdots (9)$$

d: maximum machined-down diameter with no spline grooves left (refer to Table B-10)

λ: coefficient by mounting method
(refer to Figure B-6)
fixed-free λ=1.875
supported-supported λ=3.142
fixed-supported λ=3.927
fixed-fixed λ=4.730

Figure B-6 Mounting Method

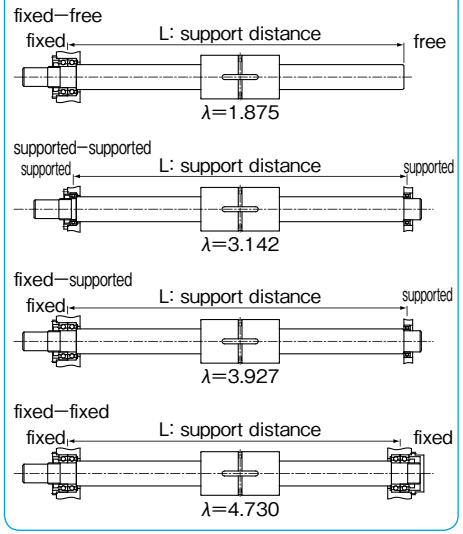
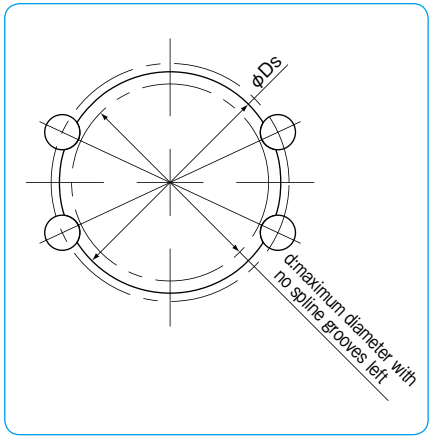


Table B-10 Spline Shaft Profile

part number	d: maximum diameter with no spline grooves left mm	part number	d: maximum diameter with no spline grooves left mm
SSP 4	3.5	SSP 80	73.9
SSP 6	5.3	SSP 80L	
SSP 8	7.2	SSP100	92
SSP 10	9	SSP100L	
SSP 13A	11.7		
SSP 16A	14.2	SSP 20	16.4
SSP 20A	17.9	SSP 25	20.6
SSP 25A	22.4	SSP 30	24.8
SSP 30A	26.8	SSP 40	33.1
SSP 40A	35.5	SSP 50	41.4
SSP 50A	44.6	SSP 60	49.7
SSP 60A	54		



The maximum diameter (d) is recommended as the shaft diameter of the support area leaving no spline grooves after end-machining.

RATED LIFE

When the ball elements are used as the rolling elements in ball splines, the following equations are used to calculate the life of ball spline.

For radial load

$$L = \left(\frac{f_C}{f_W} \cdot \frac{C}{P}\right)^3 \cdot 50$$

For torque load

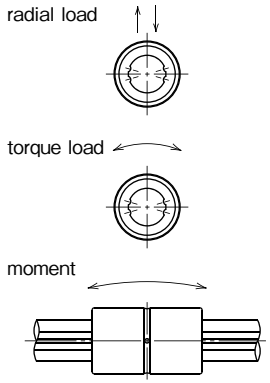
$$L = \left(\frac{f_C}{f_W} \cdot \frac{C_T}{T}\right)^3 \cdot 50$$

L: rated life (km) f_C: contact coefficient f_W: load coefficient
C: basic dynamic load rating (N) P: applied load (N)
C_T: basic dynamic torque rating (N·m) T: applied torque (N·m)
* Refer to page Eng-5 for the coefficients
** The load rating of the commercial spline is approximately 70% of the standard ball spline.

$$L_h = \frac{L \cdot 10^3}{2 \cdot \ell_S \cdot n_1 \cdot 60}$$

L_h: life time (hr) ℓ_S: stroke length (m)
L: rated life (km) n_1: number of cycles per minute (cpm)

Figure B-7 Radial Load and Torque Load



OPERATING CONDITIONS

The performance of the ball spline is affected by the operating conditions of the application. The operating conditions should therefore be carefully taken into consideration.

Dust Prevention

Foreign particles or dust in the ball spline nut affects the motion accuracy and shortens the life time. Standard seals will perform well for dust prevention under normal operating conditions, however, in a harsh environment it is necessary to attach bellows or protective covers.
(refer to Figure B-8)

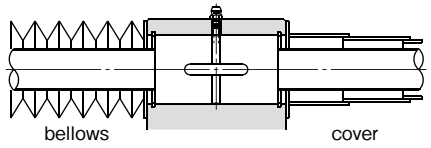
Operating Temperature

The retainer is made of resin, so the operating temperature should never exceed 80℃.

Excessive Moment

One spline nut can sustain high moment, however, excessive moment makes the spline nut unbalanced and unstable in motion. Please use more than one spline nut for high moment or high accuracy applications.

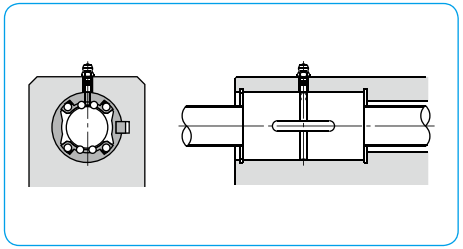
Figure B-8 Example of Dust Prevention



LUBRICATION

The spline nut is prelubricated with lithium soap based grease prior to shipment for immediate use. Please relubricate with a similar type of grease periodically depending on the operating conditions.
Low dust generation grease is available from NB standard grease. (refer to page Eng-39)
The NB spline nut has seals as standard. The seals work well to contain the grease inside the nut especially for the ground shaft, since the seal shape approximates the spline shaft profile.

Figure B-9 Example of Lubrication Mechanism



SPECIAL REQUIREMENTS

Based on customer drawings and requirements NB does shaft-end machining, spline nut machining, surface treatment, etc. Please contact NB for special requirements. Table B-11 shows a list of recommended inner diameters for hollow spline shaft.

Figure B-10 Example of Shaft-end Machining

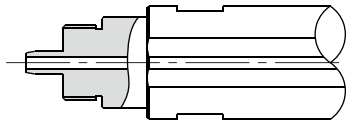
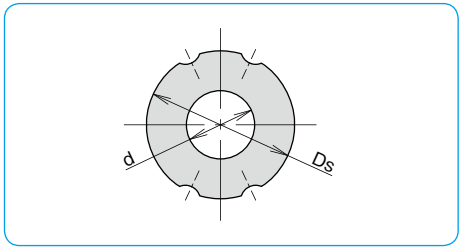


Table B-11
Recommended Inner Diameter for Hollow Spline Shaft

part number	shaft diameter Ds mm	inner diameter d mm	cross-sectional coefficient Z mm^3	second moment of inertia I mm^4
SSP 4	4	1.5	5.7	11
SSP 6	6	2	19.4	58
SSP 8	8	3	46.5	186
SSP10	10	4	89.6	448
SSP13A	13	6	193	1,260
SSP16A	16	8	348	2,780
SSP20A	20	10	686	6,860
SSP25A	25	15	1,230	15,400



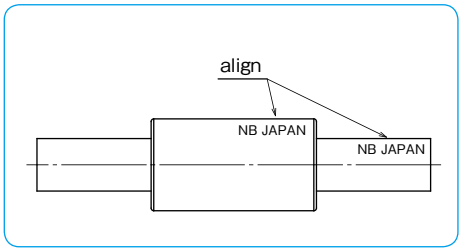
PRECAUTIONS ON MOUNTING

NB ball spline must be handled with care as a precision component. Please note the following points.

A Set of Spline Nut and Spline Shaft

The ball spline accuracy and preload is guaranteed when spline nut and shaft are aligned as shown in Figure B-11. Please make sure to align the NB marks when reinserting the shaft.
When inserting the spline shaft into the spline nut, ensure that the ball elements do not drop out. This is done by aligning the raceway grooves of the shaft with the rows of ball elements and the seal lip of the nut. Then carefully insert the spline shaft through the spline nut. In case that the nut is preloaded, please exercise added care.

Figure B-11 NB mark Alignment



Fit between Spline Nut and Housing

A transition fit is used for the SSP/SSPM-type spline nut and its housing bore to minimize the clearance. If high accuracy is not required, then a clearance fit can be used. For the SSPT/SSPF type spline nut, for a light load and little torque application a hole slightly larger than the outer diameter of the nut can suffice. The mounting surface for the flange influences the perpendicularity and parallelism. Please make sure of the accuracy of the mounting surface.

Table B-12 Fit for the Spline Nut

type of spline nut	clearance fit	transition fit
SSP	H7	J6
SSPM		

Insertion of Spline Nut

When inserting a spline nut into the housing, use a jig like the one shown in Figure B-12. Carefully insert the nut so as not to hit the side ring and seal.

Figure B-12 Insertion of Spline Nut into Housing

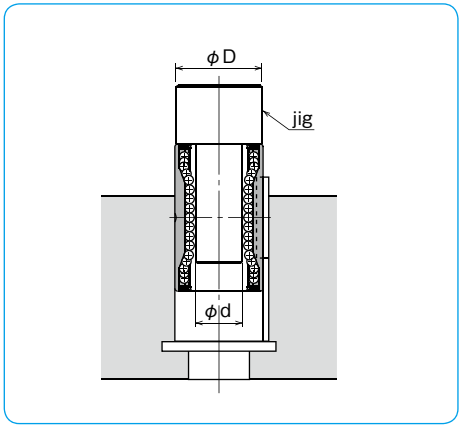


Table B-13 Recommended Jig Dimensions unit/mm

part number	D	d	part number	D	d
SSP 4	9.5	3.5	SSP 20	31.5	16.5
SSP 6	13.5	5	SSP 25	36.5	20.5
SSP 8	15.5	7	SSP 30	44.5	25
SSP 10	20.5	8.5	SSP 40	59.5	33
SSP 13A	23.5	12	SSP 50	74	41
SSP 16A	30.5	14.5	SSP 60	89	50
SSP 20A	34.5	18			
SSP 25A	41.5	22.5			
SSP 30A	46.5	27			
SSP 40A	63.5	35.6			
SSP 50A	79	44			
SSP 60A	89	53.5			
SSP 80 / SSP 80L	119	74			
SSP100 / SSP100L	149	92			

Mounting of SSP Type

Examples of installing the SSP type are shown in Figures B-13 and B-14.

Figure B-13 Using a Retaining Ring

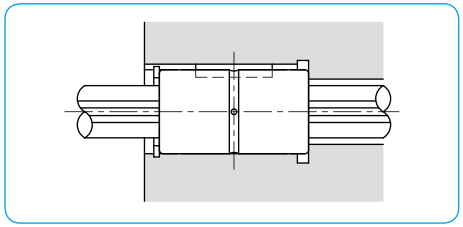
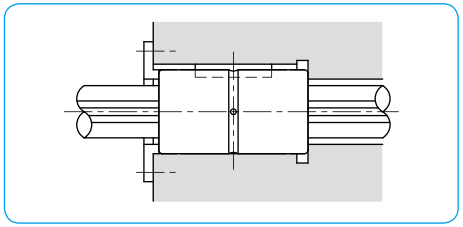


Figure B-14 Using a Push Plate



Key

The SSP type spline nut comes with a key shown in Figure B-15.

Figure B-15 Key for SSP Type

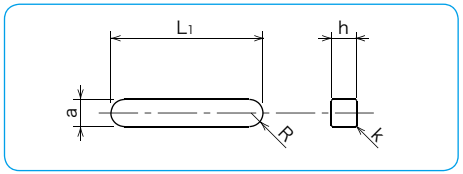


Table B-14 Major Dimensions of Key

part number	a		h		L1	R	k
	mm	tolerance μm	mm	tolerance μm	mm	mm	mm
SSP 4	2	+16 +6	2	0 −25	6	1	0.2
SSP 6	2.5		2.5		10.5	1.25	
SSP 8	2.5		2.5		10.5	1.25	
SSP 10	3		3		13	1.5	
SSP 13A	3		3		15	1.5	
SSP 16A	3.5	+24 +12	3.5	0 −30	17.5	1.75	
SSP 20A	4		4		29	2	0.5
SSP 25A	4		4		36	2	0.3
SSP 30A	4		4		42	2	0.5
SSP 40A	6		6		52	3	0.5
SSP 50A	8	+30/+15	7	0 −36	58	4	0.5
SSP 60A	12	+36 +18	8		67	6	0.8
SSP 80	16		10		76	8	0.5
SSP 80L					110		
SSP100	20	+43 +22	13	0 −43	110	10	0.8
SSP100L					160		
SSP 20	4	+24 +12	4	0 −30	26	2	0.2
SSP 25	5		5		33	2.5	0.3
SSP 30	7	+30 +15	7	0 −36	41	3.5	0.3
SSP 40	10		8		55	5	0.5
SSP 50	15	+36 +18	10		60	7.5	0.5
SSP 60	18		11	0/−43	68	9	0.5

Mounting of SSPM Type

Examples of installing the SSPM type are shown in Figures B-16 to B-19.

Figure B-16 Using F Type Lock Plates

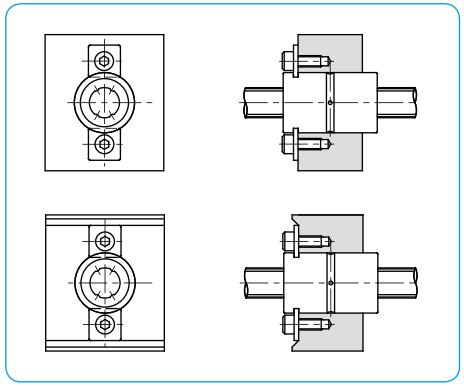


Figure B-17 Using LP Type Lock Plates

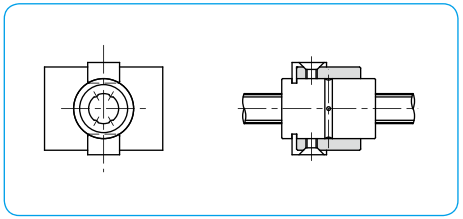


Figure B-18 Using Special Lock Plates (1)

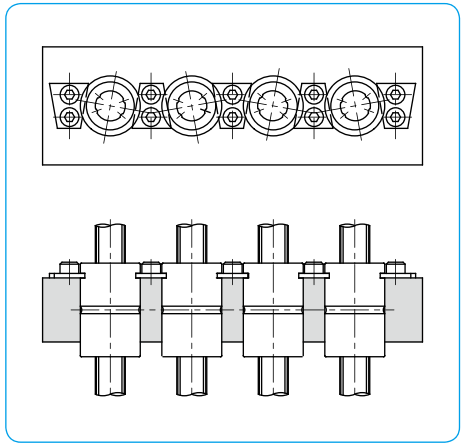
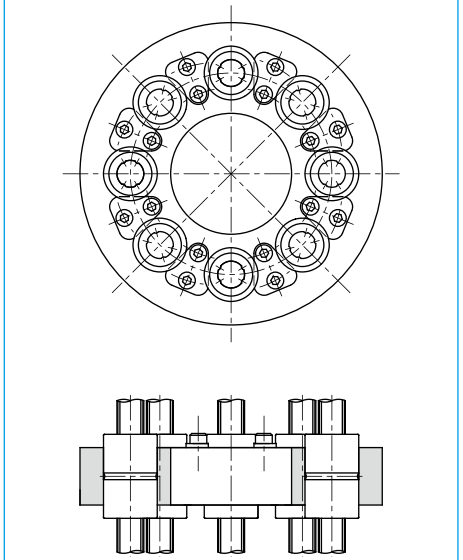


Figure B-19 Using Special Lock Plates (2)



F Type Lock Plate (Standard Plate)

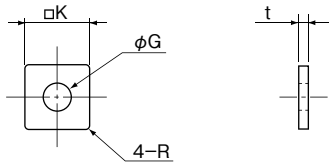
The lock plate shown in Figure B-20 is provided with the SSPM spline nut.

Material: SUS304CSP

Table B-15 F Type Lock Plate

part number	K mm	G mm	t mm	R mm	applicable spline nut
FP 6	6.8	2.9	1.0	0.5	SSPM 6
FP 8	8.5	3.5	1.2	0.5	SSPM 8
FP10	8.5	3.5	1.2	0.5	SSPM10

Figure B-20 F Type Lock Plate

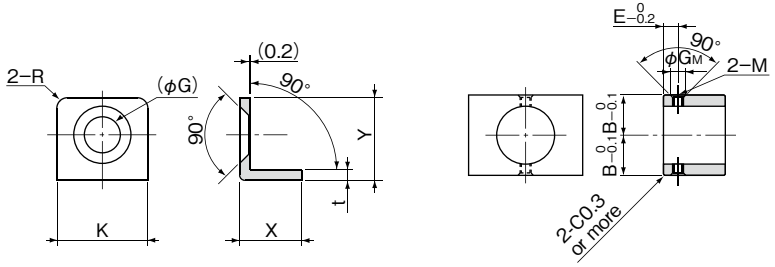


LP Type Lock Plate (Optional Plate)

The LP type lock plate is also available for purchase with the SSPM spline nut.

Material: SUS304CSP

Figure B-21 LP Type Lock Plate



When using the LP type lock plate, please machine the housing as shown above.

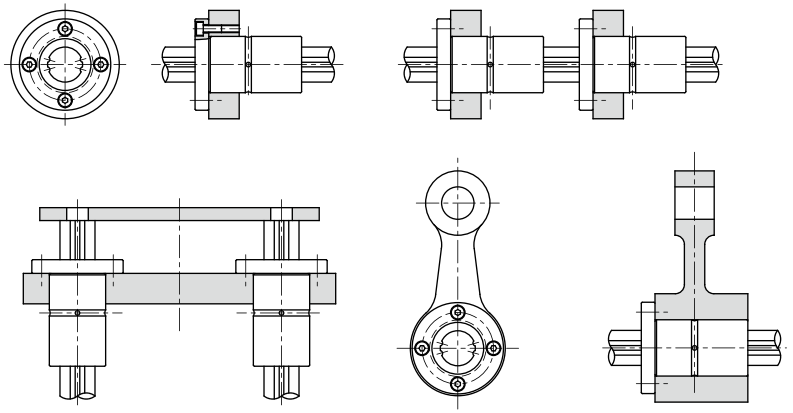
Table B-16 LP Type Lock Plate

part number	lock plate major dimensions						machined housing dimensions				applicable spline nut
	K mm	G mm	t mm	R mm	X mm	Y mm	B mm	E mm	GM mm	M	
LP 6	8.6	3.8	1.0	1	5.85	7.8	11.1	3.3	3.5	M2.5	SSPM 6
LP 8	9.15	4.5	1.2	1	6.45	9.2	12.3	4.0	4.2	M3	SSPM 8
LP10	9.15	4.5	1.2	1	6.45	9.2	14.8	4.0	4.2	M3	SSPM10

Mounting of SSPF Type

Examples of installing the SSPF type are shown in Figure B-22.

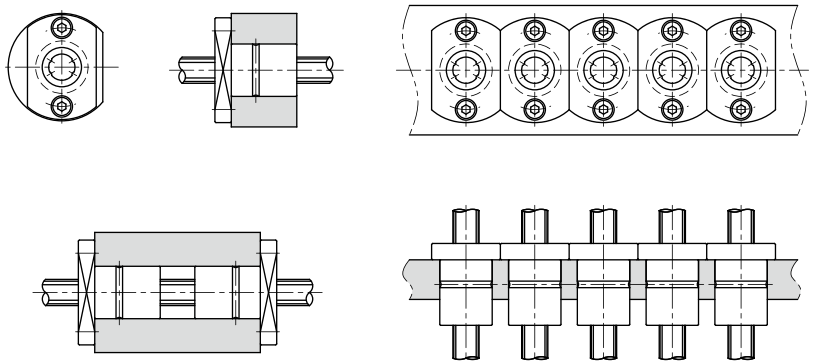
Figure B-22 Examples of installing SSPF Type



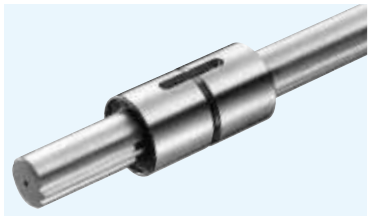
Mounting of SSPT Type

Examples of installing SSPT type are shown in Figure B-23.

Figure B-23 Examples of installing SSPT Type



SSP TYPE
– Cylindrical Spline Nut –

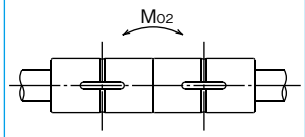


part number structure

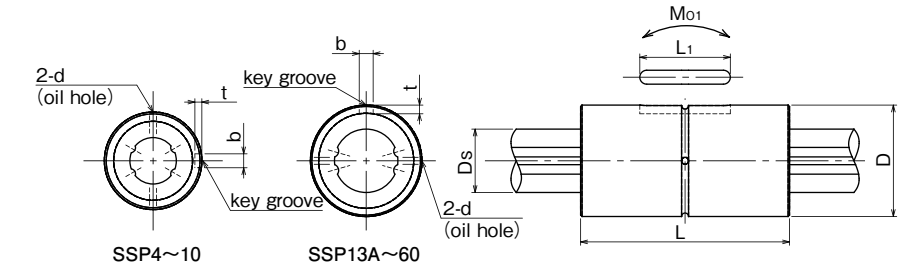
example **SSP 80 L - 2 - T1 - 600 - P / CU**

- specification — **SSP**: standard; **SSPS**: anti-corrosion
- nominal diameter
- nut length — **blank**: standard; **L**: long
- number of nuts attached to one shaft
- spline shaft total length
- preload symbol — **blank**: standard; **T1**: light; **T2**: medium
- accuracy grade — **blank**: high; **P**: precision
- with special specification

Note: retainer material is resin.

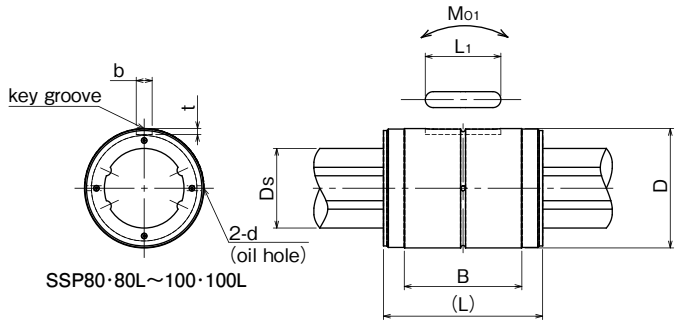


When two spline nuts are used in close contact.



SSP4～10　　SSP13A～60

※SSP4 spline nut does not come with any oil hole.



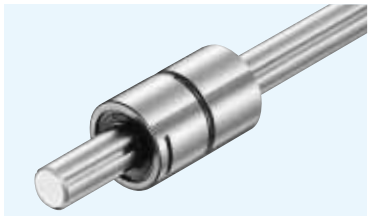
SSP80·80L～100·100L

part number		major dimensions										
		D		L		B	b		t +0.05 0	L1	d	
standard	anti-corrosion	mm	tolerance μm	mm	tolerance mm	mm	mm	tolerance μm	mm	mm	mm	
SSP 4	SSPS 4	10	0/−9	16	0 −0.2	–	2	+14 0	1.2	6	–	
SSP 6	SSPS 6	14	0 −11	25			2.5		1.2	10.5	1	
SSP 8	SSPS 8	16		25			2.5		1.2	10.5	1.5	
SSP 10	SSPS10	21	0 −13	33			3		1.5	13	1.5	
SSP 13A	SSPS13A	24		36			3		1.5	15	1.5	
SSP 16A	SSPS16A	31	0 −16	50			3.5	+18 0	2	17.5	2	
SSP 20A	SSPS20A	35		63			4		2.5	29	2	
SSP 25A	SSPS25A	42		71	0 −0.3		4		2.5	36	3	
SSP 30A	—	47		80			4		2.5	42	3	
SSP 40A	—	64	0 −19	100			6		3.5	52	4	
SSP 50A	—	80		125			8	+22/0	4	58	4	
SSP 60A	—	90	0 −22	140			12	+27 0	5	67	4	
SSP 80	—	120		160	–	118.2	16		6	76	5	
SSP 80L	—	120		217		175.2				110		
SSP100	—	150	0 −25	185		132.6	20	+33 0	7	110	5	
SSP100L	—	150		248		195.6				160		
SSP 20	SSPS20	32	0 −16	60	0/−0.2	–	4	+18 0	2.5	26	2	
SSP 25	SSPS25	37		70	0 −0.3		5		3	33	3	
SSP 30	—	45		80			7	+22 0	4	41	3	
SSP 40	—	60	0 −19	100			10		4.5	55	4	
SSP 50	—	75		112			15	+27 0	5	60	4	
SSP 60	—	90	0/−22	127			18		6	68	4	

Ds		basic torque rating		basic load rating		allowable static moment		mass		size
		dynamic	static	dynamic	static			nut	shaft	
mm	tolerance μm	CT N・m	COT N・m	C kN	Co kN	MO1 N・m	MO2 N・m	kg	kg/m	
4	0 −12	0.74	1.05	0.86	1.22	1.97	10.3	0.0065	0.10	4
6		1.5	2.4	1.22	2.28	5.1	40	0.019	0.21	6
8	0 −15	2.1	3.7	1.45	2.87	7.4	50	0.023	0.38	8
10		4.4	8.2	2.73	5.07	18.0	116	0.054	0.60	10
13	0 −18	21	39.2	2.67	4.89	13.7	109	0.07	1.0	13A
16		60	110	6.12	11.2	46	299	0.15	1.5	16A
20	0 −21	105	194	8.9	16.3	110	560	0.22	2.4	20A
25		189	346	12.8	23.4	171	1,029	0.33	3.7	25A
30		307	439	18.6	23.2	181	1,470	0.36	5.38	30A
40	0 −25	674	934	30.8	37.5	358	2,940	0.95	9.55	40A
50		1,290	2,950	40.3	64.9	690	4,080	1.9	15.0	50A
60	0 −30	1,570	2,620	47.7	79.5	881	5,470	2.3	21.6	60A
80		3,860	6,230	83.1	134	2,000	11,100	5.1	39	80
		5,120	9,340	110	201	4,410	21,100	7.6		80L
100	0 −35	6,750	11,500	135	199	3,360	19,300	9.7	61	100
		8,960	17,300	179	298	7,340	37,700	13.9		100L
18.2	0 −21	83	133	7.84	11.3	63	500	0.2	2.0	20
23		162	239	12.3	16.1	104	830	0.22	3.1	25
28		289	412	18.6	23.2	181	1,470	0.35	4.8	30
37.4	0 −25	637	882	30.8	37.5	358	2,940	0.81	8.6	40
47		1,390	3,180	46.1	74.2	696	4,400	1.5	13.1	50
56.5	0/−30	2,100	4,800	58.0	127	1,300	8,800	2.5	19	60

1kN≒102kgf　1N・m≒0.102kgf・m

SSPM TYPE
— Keyless Spline Nut —

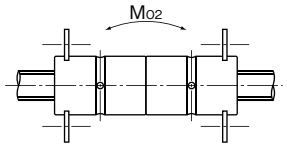


part number structure

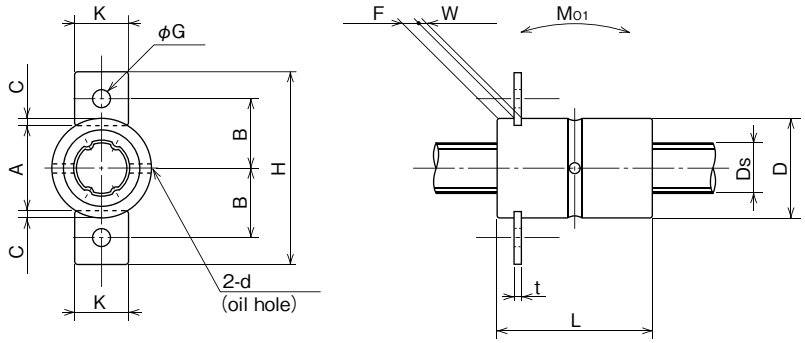
example **SSPM 10 - 2 - T1 - 200 - P / CU**

- SSPM: SSPM type
- 10: nominal diameter
- 2: number of nuts attached to one shaft
- T1: preload symbol — **blank**: standard, **T1**: light
- 200: spline shaft total length
- P: accuracy grade — **blank**: high, **P**: precision
- CU: with special specification

Note: retainer material is resin.



When two spline nuts are used in close contact.

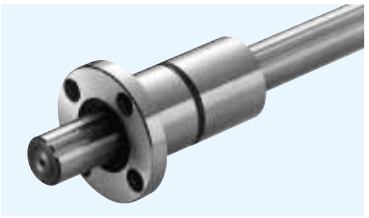


part number	major dimensions												size
	D	tolerance	L	tolerance	F	W	C	A	d	B	H	K	
	mm	μm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	
SSPM 6	14	0	25	0	2.2	1.1	1.0	12.0	1	9.4	25.6	6.8	6
SSPM 8	16	−11	25	−0.2	2.7	1.3	1.2	13.6	1.5	11	30.6	8.5	8
SSPM10	21	0/−13	33		2.7	1.3	1.2	18.6	1.5	13.5	35.6	8.5	10

G	t	Ds	tolerance	basic torque rating dynamic CT	basic torque rating static COT	basic load rating dynamic C	basic load rating static Co	allowable static moment MO1	allowable static moment MO2	mass nut	mass shaft	size
mm	mm	mm	μm	N・m	N・m	kN	kN	N・m	N・m	kg	kg/m	
2.9	1.0	6	0/−12	1.5	2.4	1.22	2.28	5.1	40	0.019	0.21	6
3.5	1.2	8	0	2.1	3.7	1.45	2.87	7.4	50	0.023	0.38	8
3.5	1.2	10	−15	4.4	8.2	2.73	5.07	18.0	116	0.054	0.60	10

1kN≒102kgf　1N・m≒0.102kgf・m

SSPF TYPE
– Flange Type Nut –

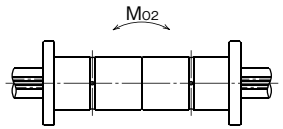


part number structure

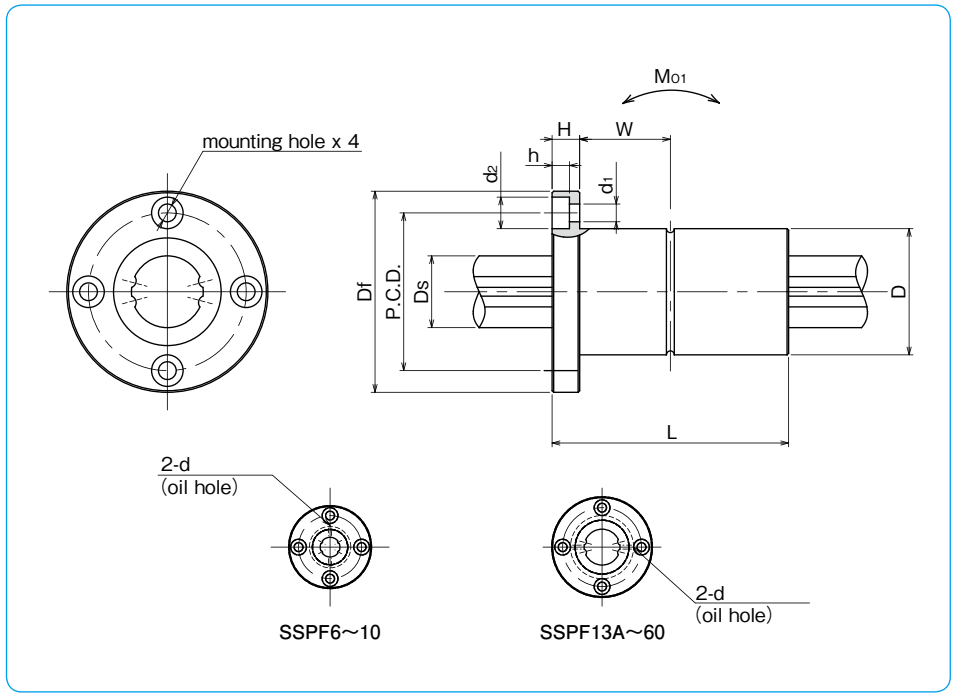
example **SSPF 25-2-T1-436-P/CU**

- specification — **SSPF**: standard; **SSPFS**: anti-corrosion
- nominal diameter — **25**
- number of nuts attached to one shaft — **2**
- preload symbol — **blank**: standard; **T1**: light; **T2**: medium
- spline shaft total length — **436**
- accuracy grade — **blank**: high; **P**: precision
- with special specification — **/CU**

Note: retainer material is resin.



When two spline nuts are used in close contact.



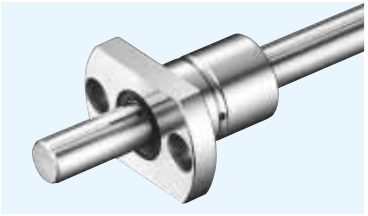
part number		major dimensions									
		D		L		Df	H	P.C.D.	d1×d2×h	W	
standard	anti-corrosion	mm	tolerance μm	mm	tolerance mm	mm	mm	mm	mm	mm	
SSPF 6	SSPFS 6	14	0 −11	25	0 −0.2	30	5	22	3.4×6.5×3.3	7.5	
SSPF 8	SSPFS 8	16		25		32	5	24	3.4×6.5×3.3	7.5	
SSPF10	SSPFS10	21	0 −13	33		42	6	32	4.5×8×4.4	10.5	
SSPF13A	SSPFS13A	24		36		43	7	33	4.5×8×4.4	11	
SSPF16A	SSPFS16A	31	0 −16	50		50	7	40	4.5×8×4.4	18	
SSPF20A	SSPFS20A	35		63		58	9	45	5.5×9.5×5.4	22.5	
SSPF25A	SSPFS25A	42		71	0 −0.3	65	9	52	5.5×9.5×5.4	26.5	
SSPF30A	—	47		80		75	10	60	6.6×11×6.5	30	
SSPF40A	—	64	0 −19	100		100	14	82	9×14×8.6	36	
SSPF50A	—	80		125		124	16	102	11×17.5×11	46.5	
SSPF60A	—	90	0/−22	140		129	18	107	11×17.5×11	52	
SSPF20	SSPFS20	32	0 −16	60	0/−0.2	51	7	40	4.5×8×4.4	23	
SSPF25	SSPFS25	37		70	0 −0.3	60	9	47	5.5×9.5×5.4	26	
SSPF30	—	45		80		70	10	54	6.6×11×6.5	30	
SSPF40	—	60	0 −19	100		90	14	72	9×14×8.6	36	
SSPF50	—	75		112		113	16	91	11×17.5×11	40	
SSPF60	—	90	0/−22	127		129	18	107	11×17.5×11	45.5	

d	Ds		basic torque rating		basic load rating		allowable static moment		mass		size
			dynamic	static	dynamic	static			nut	shaft	
mm	mm	tolerance μm	CT N・m	COT N・m	C kN	Co kN	M01 N・m	M02 N・m	kg	kg/m	
1	6	0/−12	1.5	2.4	1.22	2.28	5.1	40	0.037	0.21	6
1.5	8	0 −15	2.1	3.7	1.45	2.87	7.4	50	0.042	0.38	8
1.5	10		4.4	8.2	2.73	5.07	18.0	116	0.094	0.6	10
1.5	13	0 −18	21	39.2	2.67	4.89	13.7	109	0.1	1	13A
2	16		60	110	6.12	11.2	46	299	0.2	1.5	16A
2	20	0 −21	105	194	8.9	16.3	110	560	0.33	2.4	20A
3	25		189	346	12.8	23.4	171	1,029	0.45	3.7	25A
3	30		307	439	18.6	23.2	181	1,470	0.55	5.38	30A
4	40	0 −25	647	934	30.8	37.5	358	2,940	1.41	9.55	40A
4	50		1,290	2,950	40.3	64.9	690	4,080	2.73	15.0	50A
4	60	0/−30	1,570	2,620	47.7	79.5	881	5,470	3.2	21.6	60A
2	18.2	0 −21	83	133	7.84	11.3	63	500	0.22	2	20
3	23		162	239	12.3	16.1	104	830	0.32	3.1	25
3	28		289	412	18.6	23.2	181	1,470	0.51	4.8	30
4	37.4	0 −25	637	882	30.8	37.5	358	2,940	1.15	8.6	40
4	47		1,390	3,180	46.1	74.2	696	4,400	2.1	13.1	50
4	56.5	0/−30	2,100	4,800	58.0	127	1,300	8,800	3.3	19	60

1kN≒102kgf　1N・m≒0.102kgf・m

SSPT TYPE

– Two Side Cut Flange Type –

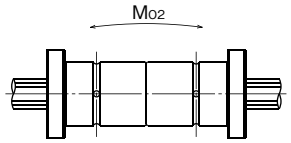


part number structure

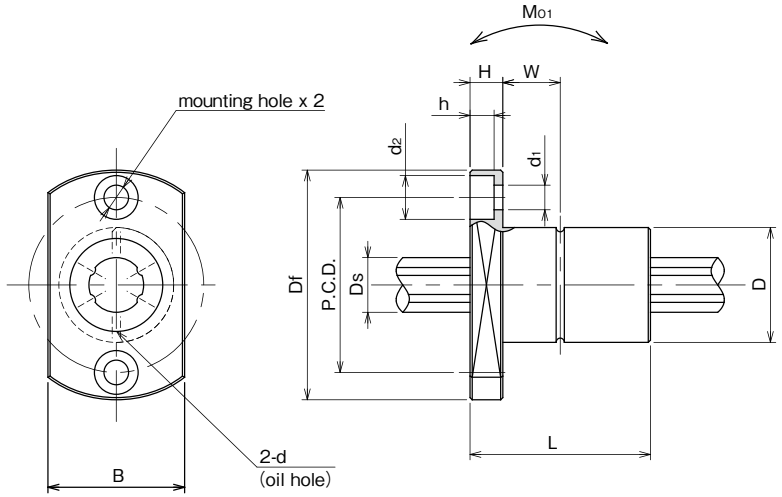
example **SSPT 10-2-T1-436-P/CU**

- SSPT type
- nominal diameter
- number of nuts attached to one shaft
- preload symbol **blank**: standard **T1**: light
- spline shaft total length
- accuracy grade **blank**: high **P**: precision
- with special specification

Note: retainer material is resin.



When two spline nuts are used in close contact.

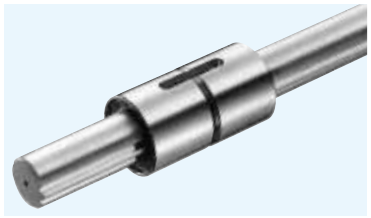


part number	major dimensions										
	D		L		Df	B	H	P.C.D.	d1×d2×h	W
	mm	tolerance μm	mm	tolerance mm	mm	mm	mm	mm	mm	mm
SSPT 6	14	0 −11	25	0 −0.2	30	18	5	22	3.4×6.5×3.3	7.5
SSPT 8	16		25		32	21	5	24	3.4×6.5×3.3	7.5
SSPT10	21	0/−13	33		42	25	6	32	4.5×8×4.4	10.5

d	Ds		basic torque rating		basic load rating		allowable static moment		mass		size
			dynamic	static	dynamic	static			nut	shaft	
		tolerance	CT	COT	C	Co	MO1	MO2			
mm	mm	μm	N・m	N・m	kN	kN	N・m	N・m	kg	kg/m	
1	6	0/−12	1.5	2.4	1.22	2.28	5.1	40	0.029	0.21	**6**
1.5	8	0 −15	2.1	3.7	1.45	2.87	7.4	50	0.035	0.38	**8**
1.5	10		4.4	8.2	2.73	5.07	18.0	116	0.075	0.6	**10**

1kN≒102kgf　1N・m≒0.102kgf・m

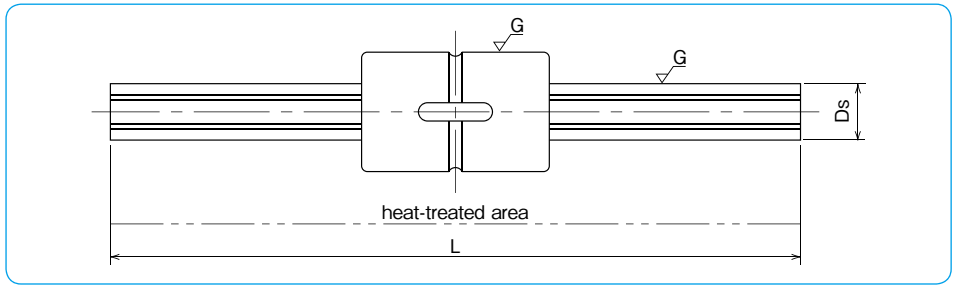
STANDARD BALL SPLINE



part number structure

example **SSP 10 S-2-T1-400**

- **SSP** / **SSPM** / **SSPF** / **SSPT** — nut shape
  - **SSP**: cylindrical type
  - **SSPM**: keyless type
  - **SSPF**: flange type
  - **SSPT**: two side cut flange type
- **10** — nominal diameter
- **S** — standard spline shaft
- **2** — number of nuts attached to one shaft
- **T1** — preload symbol
  - **blank**: standard
  - **T1**: light
  - **T2**: medium
- **400** — standard length L

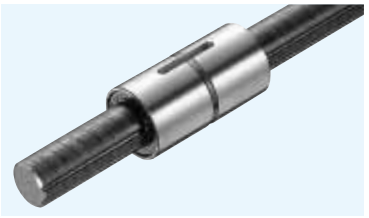


nominal diameter	Ds mm	tolerance μm	major dimensions standard length L mm					applicable nut SSP	SSPM	SSPF	SSPT
4	4	0 −12	100	150	200	300	—	○	—	—	—
6	6		150	200	300	400	—	○	○	○	○
8	8	0 −15	150	200	300	400	500	○	○	○	○
10	10		200	300	400	500	600	○	○	○	○
13A	13	0 −18	200	300	400	500	600	○	—	○	—
16A	16		200	300	400	500	600	○	—	○	—
20A	20	0 −21	300	500	1,000	—	—	○	—	○	—
25A	25		300	500	1,000	—	—	○	—	○	—
30A	30		300	500	1,000	—	—	○	—	○	—
40A	40	0 −25	500	1,000	—	—	—	○	—	○	—
50A	50		500	1,000	—	—	—	○	—	○	—
60A	60	0/−30	500	1,000	—	—	—	○	—	○	—
20	18.2	0 −21	300	500	1,000	—	—	○	—	○	—
25	23		300	500	1,000	—	—	○	—	○	—
30	28		300	500	1,000	—	—	○	—	○	—
40	37.4	0 −25	500	1,000	—	—	—	○	—	○	—
50	47		500	1,000	—	—	—	○	—	○	—
60	56.5	0/−30	500	1,000	—	—	—	○	—	○	—

・Tolerance of standard length L: JIS B0405 coarse grade.
・Please refer to dimension tables for nut shape and dimensions.

○ yes — none

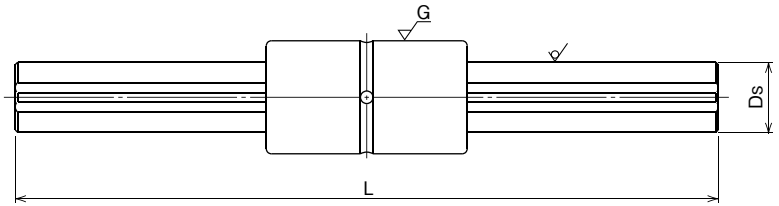
COMMERCIAL BALL SPLINE



part number structure

example **SSPF 25 C-2-436/CU**

- **SSP** / **SSPF** — nut shape
  - **SSP**: cylindrical type
  - **SSPF**: flange type
- **25** — nominal diameter
- **C** — commercial spline shaft
- **2** — number of nuts attached to one shaft
- **436** — spline shaft total length
- **CU** — with special specification



nominal diameter	Ds mm	major dimensions standard length L mm						applicable nut SSP	SSPF
20	18.2	500	1,000	2,000	3,000	4,000	5,000	○	○
25	23	500	1,000	2,000	3,000	4,000	5,000	○	○
30	28	500	1,000	2,000	3,000	4,000	5,000	○	○
40	37.4	500	1,000	2,000	3,000	4,000	5,000	○	○
50	47	500	1,000	2,000	3,000	4,000	5,000	○	○

・Tolerance of total length and length of splined portion
total length up to 4,000: JIS B0405 coarse grade
total length greater than 4,000: ±5.0mm
Please specify tolerances when required.
・Please refer to dimension tables for nut shape and dimensions.
・When a commercial shaft is used, the load rating of the nut is approximately 70% of indicated rating in the dimension tables.

○ yes — none

ROTARY BALL SPLINE

The NB rotary ball spline can be used for both rotational motion and linear motion. The applications include SCARA robots, the vertical shaft of assembly equipment, tool changers, and loaders, etc.

STRUCTURE AND ADVANTAGES

The NB Rotary Ball Spline nut consists of a spline nut and a rotating portion using either cross rollers for SPR or balls for SPB.

High Accuracy

Ball Splines transfer torque and achieve accurate positioning in the linear direction.
By adding rotating portion, Rotary Ball Splines can achieve accurate positioning in the linear and rotational directions.

Half the Parts, Reduction in Installation Cost

The Spline nut and rotary bearing are combined in order to reduce the number of parts greatly, compared to the one for conventional system.
The combination also reduces the housing thickness to a minimum, resulting in light weight and easy installation.

Compact and High Rigidity(SPR type)

The cross rollers are directly attached to the ball spline's outer cylinder, resulting in a compact and light design.
SPR type has high rigidity despite its compactness.
The tool changer is one of the typical applications.

High Rigidity and High Speed(SPB type)

SPB type is a combination of a spline nut and angular contact bearings.
The rotary portion is a set of angular contact bearings which are aligned in the back-to-back duplex manner.
SPB type can bear radial, axial, and moment loads in a well-balanced way, thus best suited to high speed rotational applications.

Figure B-24 Structure of SPR type

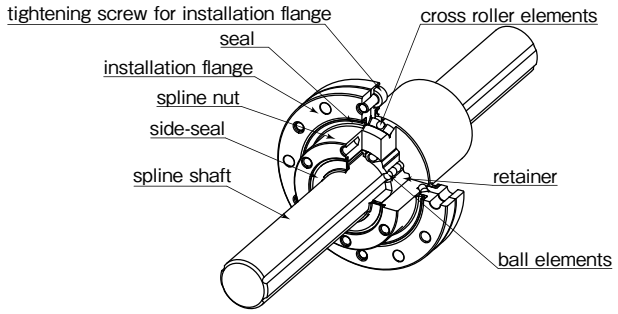
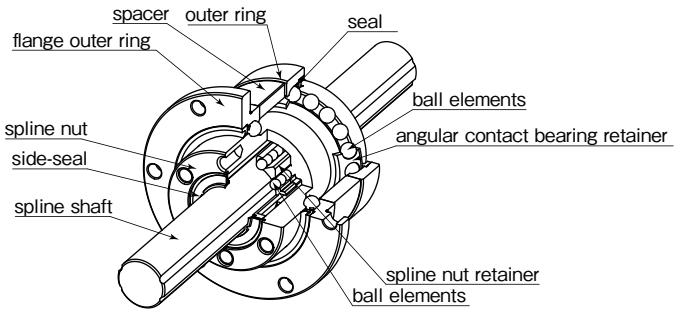


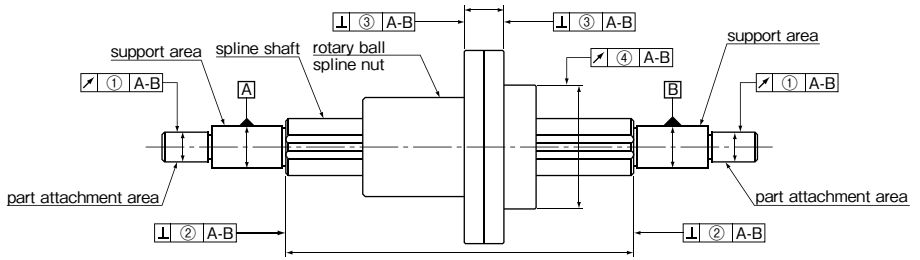
Figure B-25 Structure of SPB type



ACCURACY OF SPR TYPE

The accuracy of SPR type is measured at the points shown in Figure B-26.

Figure B-26 Accuracy Measurement Points



Note: The support area is the portion where, for example, radial bearings are attached in order to support the spline shaft.
The part attachment area is the portion to which other parts, such as gears are attached.

Tolerance of Spline Shaft Groove Torsion (Max.)

The groove torsion is indicated per 100㎜, arbitrarily set as the effective length of the spline shaft section.

Table B-17 Tolerance of Spline Shaft Groove Torsion (Max.)

tolerance
13μm／100mm

Table B-18 Tolerance Relative to Spline Support Area (Max.) unit／μm

part number	①radial runout of part attachment area	②perpendicularity of the end of the spline shaft section (when grinding is requested on the drawing)	③perpendicularity of the flange
SPR 6	14	9	14
SPR 8			
SPR10	17		
SPR13	19	11	18
SPR16			
SPR20A			
SPR25A	22	13	21
SPR30A			
SPR40A	25	16	25
SPR50A			
SPR60A	29	19	29
SPR20	19	11	18
SPR25	22	13	21
SPR30			
SPR40	25	16	25
SPR50			
SPR60	29	19	29

Table B-19 ④Radial Runout of Outer Surface of Rotary Spline Nut Relative to Spline Support Area (Max.) unit／μm

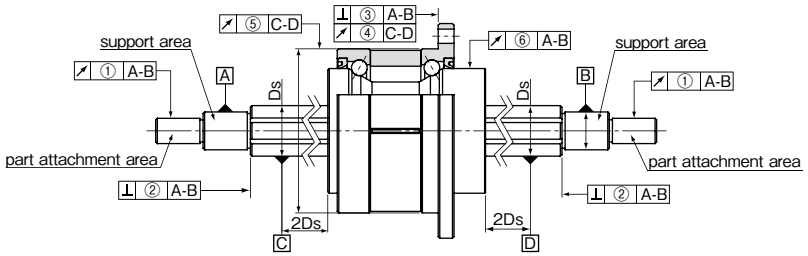
spline shaft total length (㎜) greater than	or less	part number SPR 6、8	SPR 10	SPR 13、16	SPR 20A, 20, 25A, 25, 30A, 30	SPR 40A, 40, 50A, 50	SPR 60A、60
–	200	46	36	34	32	32	30
200	315	89	54	45	39	36	34
315	400	126	68	53	44	39	36
400	500	163*	82	62	50	43	38
500	630	–	102	75	57	47	41
630	800	–	–	92	68	54	45
800	1,000	–	–	115	83	63	51
1,000	1,250	–	–	153	102	76	59
1,250	1,600	–	–	195*	130	93	70
1,600	2,000	–	–	–	171	118	86

※Please contact NB for spline shafts exceeding 2000㎜. * SPR6 shaft Max. length: 400㎜ SPR13, SPR16 Max.length: 1500㎜

ACCURACY OF SPB TYPE

The accuracy of SPB type is measured at the points shown in Figure B-27.

Figure B-27 Accuracy Measurement Points



Note: The support area is the portion where, for example, radial bearings are attached in order to support the spline shaft.
The part attachment area is the portion to which other parts, such as gears, are attached.
④ and ⑤ indicate radial runout during rotational motion.

Tolerance of Spline Shaft Groove Torsion (Max.)

The groove torsion is indicated per 100mm, arbitrarily set as the effective length of the spline shaft section.

Table B-20 Tolerance of Spline Shaft Groove Torsion (Max.)

accuracy grade	high	precision (P)
tolerance	13μm/100mm	6μm/100mm

Table B-21 Tolerance Relative to Spline Support Area (Max.)

part number	①radial runout of part attachment area		②perpendicularity of the end of the spline shaft section (when grinding is requested on the drawing)		③perpendicularity of the flange	
	high-grade	precision-grade(P)	high-grade	precision-grade(P)	high-grade	precision-grade(P)
SPB16	19	12	11	8	18	13
SPB20						
SPB25	22	13	13	9	21	16

Table B-22 Radial Runout of Outer Surface of Rotary Spline Nut Relative to Spline Shaft Area(Max.) unit／μm

part number	④lateral runout of flange mounting side		⑤radial runout of outer ring	
	high-grade	precision-grade(P)	high-grade	precision-grade(P)
SPB16	18	13	21	16
SPB20				
SPB25	21	16		

Table B-23 ⑥Radial Runout of Spline Nut Relative to Spline Support Area(Max.) unit／μm

spline shaft total length (mm)		part number			
		SPB16		SPB20・25	
greater than	or less	high-grade	precision-grade(P)	high-grade	precision-grade(P)
—	200	34	18	32	18
200	315	45	25	39	21
315	400	53	31	44	25
400	500	62	38	50	29
500	630	75	46	57	34
630	800	92	58	68	42
800	1,000	115	75	83	52
1,000	1,250	153	97	102	65
1,250	1,600	195*	127*	130	85
1,600	2,000	—	—	171	116

*SPB16 shaft maximum length : 1,500mm
※Please contact NB for spline shafts exceeding 2000mm.

PRELOAD AND CLEARANCE

The amount of clearance and preload for the spline portion and the cross roller portion are expressed in terms of the clearance in the rotational direction and the clearance in the radial direction, respectively. Three levels of preload are available: standard, light (T1), and medium (T2).

Table B-24 Preload and Clearance in Rotational and Radial Direction unit／μm

	part number	standard	light (T1)	medium (T2)
linear motion	SPR 6	−2～+1	− 6～−2	−
	SPR 8			
	SPR10	−3～+1	− 8～−3	−13～− 8
	SPR13			
	SPR16			
	SPR20A	−4～+2	−12～−4	−20～−12
	SPR25A			
	SPR30A			
	SPR40A	−6～+3	−18～−6	−30～−18
	SPR50A			
	SPR60A			
	SPR20	−4～+2	−12～−4	−20～−12
	SPR25			
	SPR30			
	SPR40	−6～+3	−18～−6	−30～−18
	SPR50			
	SPR60			
rotational motion	SPR 6 ～ SPR60	−1～+3		

Table B-25 Preload and Clearance in Rotational Direction(Linear Motion) unit／μm

part number	standard	light (T1)	midium (T2)
SPB16	−3～+1	− 8～−3	−13～− 8
SPB20	−4～+2	−12～−4	−20～−12
SPB25			

The preload is properly adjusted by the spacer for the angular contact bearings.

Table B-26 Operating Conditions and Preload

preload	symbol	operating conditions
standard	blank	minute vibration is applied. a precise motion is required. moment is applied in a given direction.
light	T1	light vibration is applied. light torsional load is applied. cyclic torque is applied.
medium	T2	shock/vibration is applied. over-hang load is applied. torsional load is applied.

SPECIAL REQUIREMENTS

NB provides customization such as shaft-end machining, spline nut machining, and surface treatment per customer requests. Table B-27 shows a list of recommended inner diameters for hollow spline shaft. Please contact NB for the inner diameter of SPR20～SPR60.

Figure B-28 Examples of Shaft-end Machining

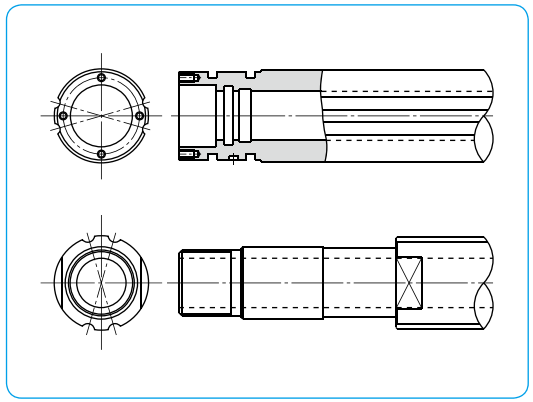
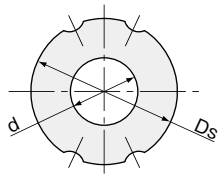


Table B-27 Recommended Inner Diameter for Hollow Spline Shaft

part number	outer diameter Ds mm	inner diameter d mm	cross-sectional coefficient Z mm	second moment of inertia I mm⁴
SPR 6	6	2	19.4	58
SPR 8	8	3	46.5	186
SPR10	10	4	89.6	448
SPR13	13	6	193	1,260
SPR16	16	8	348	2,780
SPR20A	20	10	686	6,860
SPR25A	25	15	1,230	15,400



MOUNTING

The flange attachment screws of SPR type have been pre-adjusted for smooth rotary movement and should never be loosened. Shock loading to the flange assembly should be avoided as this can degrade the accuracy of movement and deteriorate the overall performance.
The spacer of SPB type is properly adjusted to produce the best preload condition.
Shock loading to the spacer should be avoided as this can change the preload condition and deteriorate the accuracy.

Mounting of Rotary Ball Spline

When the flange of SPR type is to be used with a faucet joint (as shown in Figure B-29) the housing bore should be machined to a tolerance of H7 and to a minimum depth of 60% of the flange thickness. If only a light load is applied to the SPR in operation, the flange can be used without a pilot end.
The housing bore for the SPB type should be machined to a tolerance of H7 and keep the enough depth so that the outer ring is inside the housing. If not, the outer ring may drop off.
Please fix the mounting screws diagonally in steps with progressively applying more torque at each step. Please use a torque wrench for a uniform torque. The recommended torque values for medium-hardness steel screws are listed in Table B-28.

Insertion of Spline Shaft

When inserting the spline shaft into the rotary ball spline nut, ensure that the ball elements do not drop out. This is done by aligning the raceway grooves of the shaft with the rows of ball elements and the seal -lip of the nut. Then carefully insert the spline shaft through the spline nut.

LUBRICATION

Since NB rotary ball spline nuts are equipped with seals at both the spline portion and the rotational portion, the lubricant is retained for an extended period of time. The spline nut is prelubricated with lithium soap based grease prior to shipment for immediate use. Please relubricate with a similar type of grease periodically depending on the operating conditions.
Low dust generation grease is available from NB standard grease. (refer to page Eng-39)
However, an oil lubricant is recommended for high-speed applications. A grease fitting or machining oil holes is optional (Figure B-30,31), please contact NB for details.

Figure B-29 Flange Mounting Method

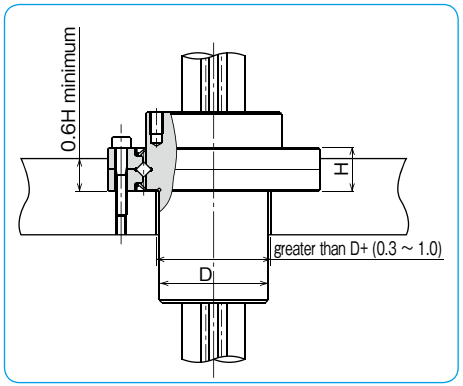


Table B-28 Recommended Torque unit／N・m

mounting screw	M2	M2.5	M3	M4	M5	M6	M8
recommended torque	0.4	0.9	1.4	3.2	6.6	11.2	27.6

(for alloy steel screw)

Figure B-30 Example of Installed Grease Fitting

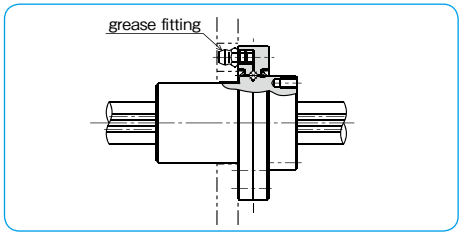
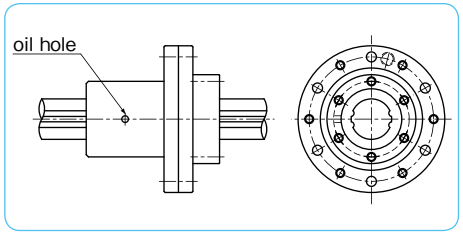


Figure B-31 Oil Hole



OPERATING CONDITIONS

The performance of the rotary ball spline is affected by the operating conditions of the application. The operating conditions should therefore be carefully taken into consideration.

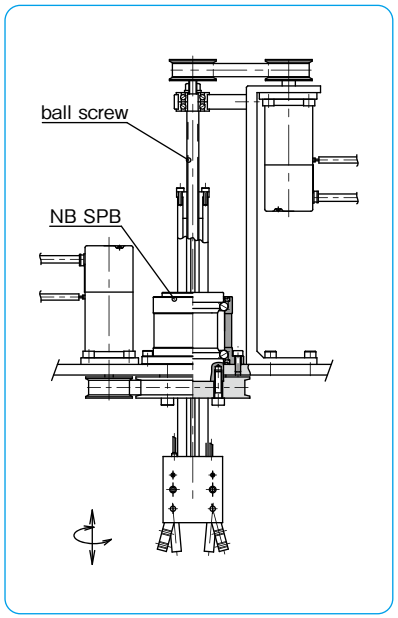
Operating Temperature

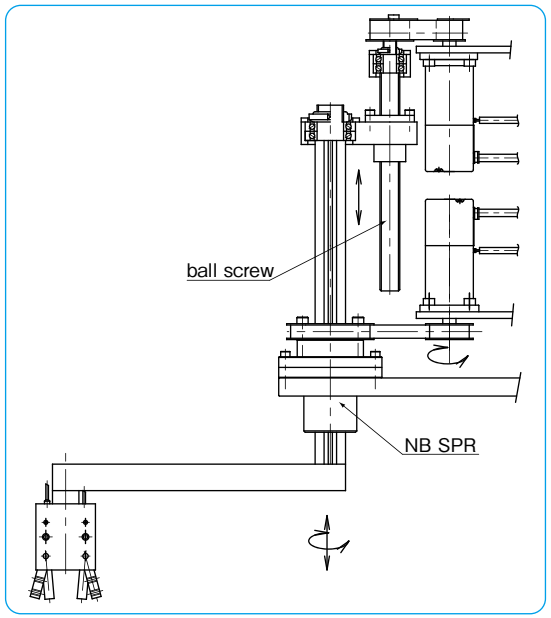
Resin retainers are used in the rotary ball spline, so the operating temperature should never exceed 80℃.

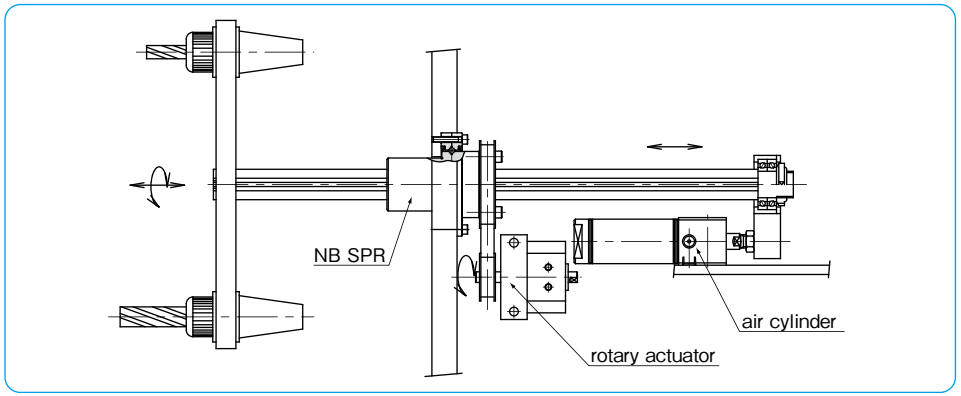
Dust Prevention

Foreign particles or dust in the rotary ball spline nut affects the motion accuracy and shortens the life time. Standard seals will perform well for dust prevention under normal operating conditions, however, in a harsh environment it is necessary to attach bellows or protective covers.

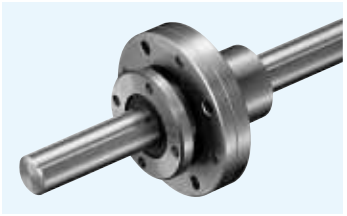
APPLICATION EXAMPLES

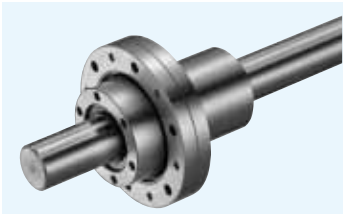






SPR TYPE



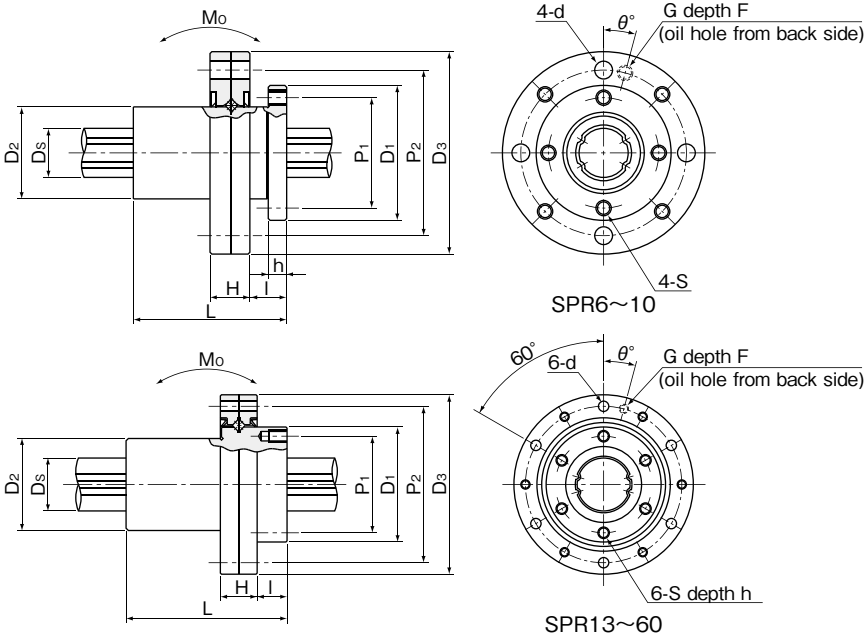


part number structure

example **SPR 25 - 2 - T1 - 436 / CU**

- SPR type
- nominal diameter
- number of nuts attached to one shaft
- preload symbol
  blank: standard
  T1: light
  T2: medium
- spline shaft total length
- with special specification

Note: retainer material is resin.



part number	major dimensions D1	tolerance	D2	L	tolerance	P1 P.C.D.	S	h	major dimensions of cross roller bearing l	H	D3	tolerance	P2 P.C.D.	d	G	F	θ
	mm	μm	mm	mm	mm	mm		mm	mm	mm	mm	μm	mm	mm		mm	
SPR 6	20		13	25		16	M2	2.5	5	6.5	30	0/−21	24	2.4	M3	2.6	20°
SPR 8	22	0	15	25		18	M2.5	3	6	6.5	33		27	2.9	M3	2.6	20°
SPR10	27	−21	19	33	0	22	M3	4	8	7	40	0	33	3.4	M3	2.8	20°
SPR13	29		24	36	−0.2	24	M3	5	8	9	50	−25	42	3.4	M3	3.6	15°
SPR16	36	0	31	50		30	M4	6	10	11	60		50	4.5	M3	4.4	15°
SPR20A	44	−25	35	63		38	M4	7	12	13	72	0	62	4.5	M6×0.75	5.2	15°
SPR25A	55		42	71		47	M5	8	13	16	82	−30	72	4.5	M6×0.75	6.4	15°
SPR30A	61	0	47	80		52	M6	10	17	17	100	0	86	6.6	M6×0.75	6.8	15°
SPR40A	76	−30	64	100	0	66	M6	10	23	20	120	−35	104	9	M6×0.75	8	15°
SPR50A	92	0	80	125	−0.3	80	M8	13	24	22	134	0	118	9	M6×0.75	8.8	15°
SPR60A	107	−35	90	140		95	M8	13	25	25	155	−40	137	9	M6×0.75	10	15°
SPR20	40	0	34	60	0/−0.2	34	M4	7	12	13	66	0	56	4.5	M6×0.75	5.2	15°
SPR25	50	−25	40	70		42	M5	8	13	16	78	−30	68	4.5	M6×0.75	6.4	15°
SPR30	61	0	47	80	0	52	M6	10	17	17	100	0	86	6.6	M6×0.75	6.8	15°
SPR40	76	−30	62	100	−0.3	64	M6	10	23	20	120	−35	104	9	M6×0.75	8	15°
SPR50	88	0	75	112		77	M8	13	24	22	130	0	114	9	M6×0.75	8.8	15°
SPR60	102	−35	90	127		90	M8	13	25	25	150	−40	132	9	M6×0.75	10	15°

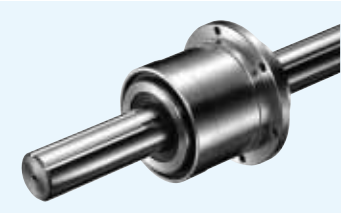
Please contact NB for the grease fitting and relubrication method.

spline shaft Ds	tolerance	ball spline basic torque rating dynamic CT	basic torque rating static COT	basic load rating dynamic C	basic load rating static Co	cross roller bearing basic load rating dynamic CR	basic load rating static COR	allowable static moment Mo	mass nut	mass shaft	※maximum revolutions	size
mm	μm	N・m	N・m	kN	kN	kN	kN	N・m	kg	kg/m	rpm	
6	0/−12	1.5	2.4	1.22	2.28	0.6	0.5	5.1	0.04	0.21	2,940	6
8	0	2.1	3.7	1.45	2.87	1.2	1.10	7.4	0.05	0.38	2,580	8
10	−15	4.4	8.2	2.73	5.07	2.4	2.45	18.0	0.09	0.60	2,060	10
13	0	21	39.2	2.67	4.89	2.9	3.70	13.7	0.17	1.0	1,350	13
16	−18	60	110	6.12	11.2	5.6	6.70	46	0.33	1.5	1,080	16
20	0	105	194	8.9	16.3	6.55	8.79	110	0.57	2.4	890	20A
25	−21	189	346	12.8	23.4	9.63	12.7	171	0.81	3.7	700	25A
30		307	439	18.6	23.2	11.8	17.1	181	1.19	5.38	640	30A
40	0	674	934	30.8	37.5	23.0	32.3	358	2.25	9.55	510	40A
50	−25	1,290	2,950	40.3	64.9	27.8	44.0	690	3.57	15.0	430	50A
60	0/−30	1,570	2,620	47.7	79.5	29.0	48.8	881	5.03	21.6	370	60A
18.2	0	83	133	7.84	11.3	5.90	7.35	63	0.45	2.0	980	20
23	−21	162	239	12.3	16.1	9.11	11.5	104	0.75	3.1	770	25
28		289	412	18.6	23.2	11.8	17.1	181	1.25	4.8	640	30
37.4	0	637	882	30.8	37.5	23.0	32.3	358	2.30	8.6	510	40
47	−25	1,390	3,180	46.1	74.2	27.2	42.1	696	3.10	13.1	450	50
56.5	0/−30	2,100	4,800	58.0	127.4	26.5	42.6	1,300	4.70	19	400	60

※Maximum revolutions for grease lubrication.
Contact NB for further information in case oil lubrication is required.

1kN≒102kgf　1N・m≒0.102kgf・m

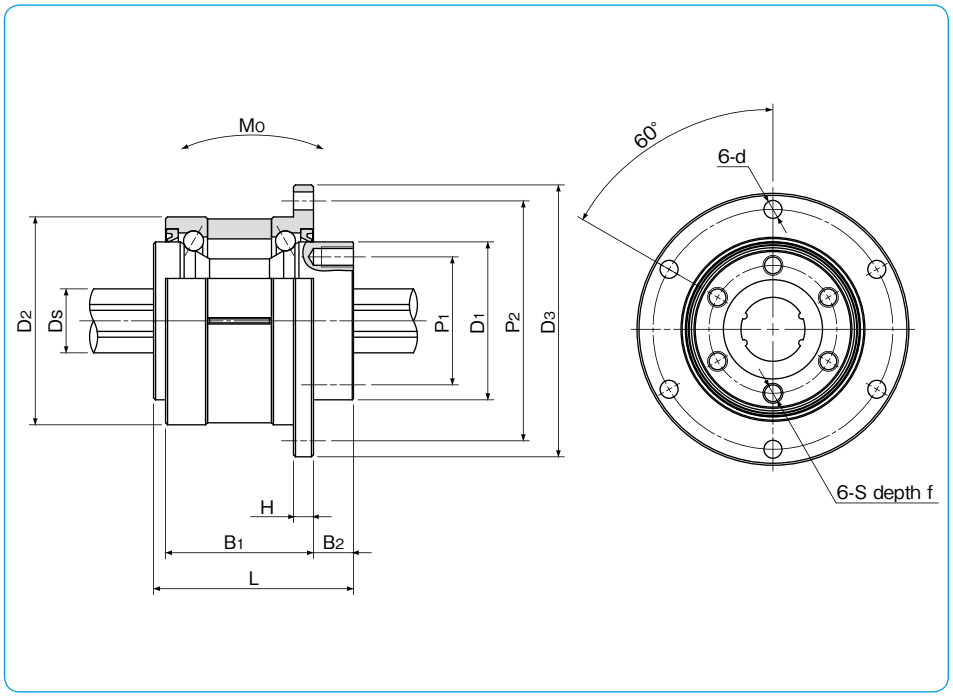
SPB TYPE



part number structure

example **SPB 16 - 2 - T1 - 600 - P / CU**

- SPB type
- nominal diameter
- number of nuts attached to one shaft
- preload symbol
  blank: standard
  T1: light
  T2: medium
- spline shaft total length
- accuracy grade
  blank : high
  P : precision
- with special specification



part number	major dimensions D1 h7	L	P1 P.C.D.	S	f	major dimensions of angular contact bearing D2	tolerance	D3	H	B1	B2	P2 P.C.D.	d
	mm	mm	mm		mm	mm	μm	mm	mm	mm	mm	mm	mm
SPB16	39.5	50	32	M5	8	52	0 −7	68	5	37	10	60	4.5
SPB20	43.5	63	36	M5	8	56		72	6	48	12	64	4.5
SPB25	53	71	45	M6	8	62		78	6	55	13	70	4.5

spline shaft Ds	tolerance	ball spline basic torque rating dynamic CT	basic torque rating static CoT	basic load rating dynamic C	basic load rating static Co	angular contact bearings dynamic C	angular contact bearings static Co	allowable static moment Mo	mass nut	mass shaft	※ maximum revolutions	size
mm	μm	N・m	N・m	kN	kN	kN	kN	N・m	kg	kg/m	rpm	
16	0/−18	60	110	6.12	11.2	13.0	12.8	46	0.45	1.5	4,000	**16**
20	0	105	194	8.9	16.3	17.4	17.2	110	0.69	2.4	3,600	**20**
25	−21	189	346	12.8	23.4	22.1	22.5	171	0.92	3.7	3,200	**25**

※Maximum revolutions for grease lubrication.(please contact NB in case of oil lubrication.) 1kN≒102kgf 1N・m≒0.102kgf・m

STROKE BALL SPLINE

The NB stroke ball spine SPLFS type is a high accuracy linear motion bearing with a limited stroke, to which both radial load and torque can be applied at the same time. It operates with extremely small dynamic friction.

STRUCTURE AND ADVANTAGES

The NB stroke ball spline consists of a nut and a shaft both with raceway grooves. The flanged spline nut consists of an outer cylinder, a retainer, side-rings, and ball elements.
Since the retainer in the nut is equipped with ball pockets, the ball elements do not contact each other, which allows for a smooth linear motion. The stroke is limited since the retainer is a non-circulating type. For normal operation, it is recommended to consider 80% of the maximum stroke shown in the dimension table as an actual stroke length.

Extremely Small Dynamic Friction and Low Noise

The rolling elements are separated by the ball pockets so that they do not contact each other. The stroke length is limited, but extremely small dynamic friction and low noise are realized because the rolling elements do not circulate.

Compact-Size

With the nut about 20% smaller than conventional ball splines, it contributes to space saving.

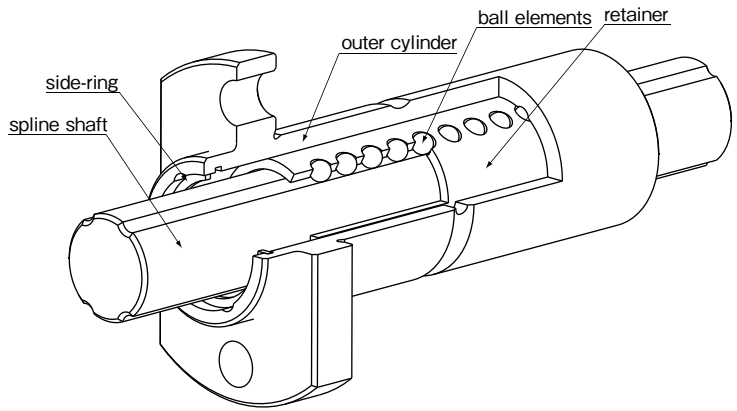
All Stainless Steel Type

Since all the components are made of stainless steel, this stroke ball spline has an excellent corrosion resistance and heat resistance (operating temperature: −20 to 140℃). It is ideal for clean room or vacuum applications.

Lubrication

A lubricant groove and two lubrication holes are provided on the outer surface of the nut, which allow for an easy designing of lubricant replenishment.

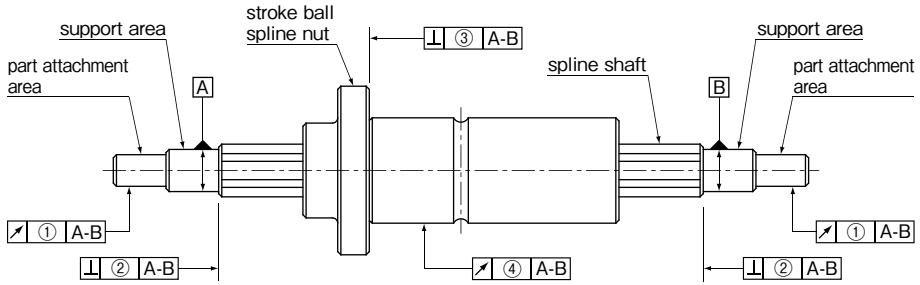
Figure B-32 Structure of SPLFS type



ACCURACY

The accuracy of the NB stroke ball spline is measured at the points shown in Figure B-33.

Figure B-33 Accuracy Measurement Points



Note: The support area is the portion where, for example, radial bearings are attached in order to support the spline shaft. The part attachment area is the portion to which other parts, such as gears are attached.

Tolerance of Spline Shaft Groove Torsion (Max.)

The groove torsion is indicated per 100㎜, arbitrarily set as the effective length of the spline shaft section.

Table B-29 Tolerance of Spline Shaft Groove Torsion (Max.)

tolerance
13μm/100mm

Table B-30 Tolerance Relative to Spline Support Area (Max.) unit／μm

part number	① radial runout of part attachment area	② perpendicularity of the end of the spline shaft section	③ perpendicularity of the flange
SPLFS 6	14	9	11
SPLFS 8	14	9	11
SPLFS10	17	9	13
SPLFS13	19	11	13
SPLFS16	19	11	13

Table B-31 ④Radial Runout of Outer Surface of Spline Nut Relative to Spline Support Area (Max.) unit／μm

spline shaft total length (㎜)		part number		
greater than	or less	SPLFS6、8	SPLFS10	SPLFS13、16
–	200	46	36	34
200	315	89	54	45
315	400	126*	68	53
400	500	163*	82	62
500	630	–	102	75
630	800	–	–	92
800	1,000	–	–	115
1,000	1,250	–	–	153
1,250	1,500	–	–	195

* SPLFS6 maximum shaft length: 400 mm

PRELOAD AND CLEARANCE

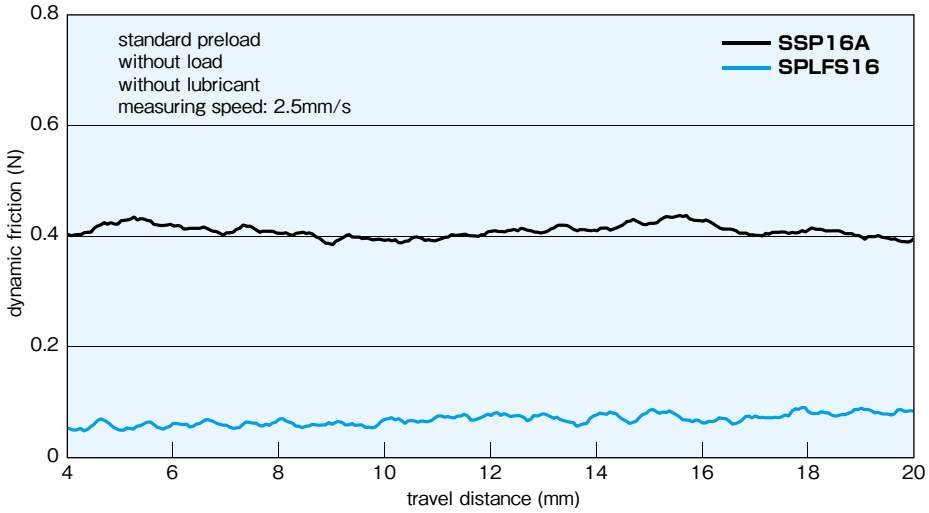
Preload and clearance are expressed in terms of clearance in the rotational direction. For the SPLFS type, only the standard preload is available as shown in Table B-32. Please contact NB if a special preload is required.

Table B-32 Preload and Clearance in Rotational Direction unit／μm

part number	standard
SPLFS 6	−4～0
SPLFS 8	−4～0
SPLFS10	−4～0
SPLFS13	−4～0
SPLFS16	−4～0

COMPARISON OF DYNAMIC FRICTIONAL RESISTANCE

Figure B-34 Comparison of Dynamic Friction



NOTES ON USE

Dust Prevention

Since the stroke ball spline is designed and manufactured for operation with an extremely small dynamic frictional resistance, seals that increase frictional resistance are not equipped as a standard feature. Please contact NB for a special requirement of seals. For use under harsh conditions, the stroke ball spline should be protected using bellows and protective covers.

Maximum Stroke

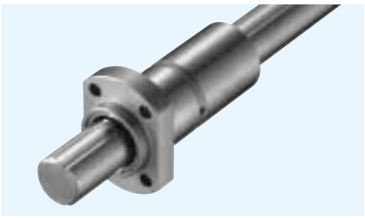
The maximum stroke in the dimension table is the stroke limit.

Retainer Slippage

If the stroke ball spline is used at a high speed or with a vertical shaft, or under an asymmetric load or oscillation, a retainer slippage may occur. For general operation, it is recommended to consider 80% of the maximum stroke length shown in the dimension table as a stroke length.
To prevent the retainer slippage, it is recommended to do a full-stroke movement of the nut whenever necessary in order for the retainer to be relocated to the center.

SPLFS TYPE

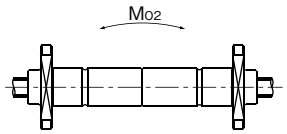
– Two Side Cut Flange Type –



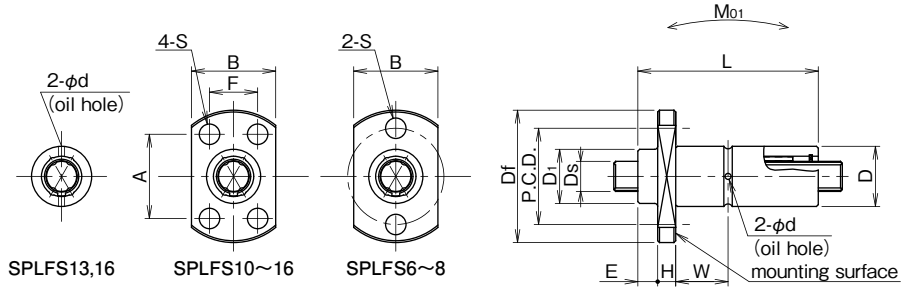
part number structure

example SPLFS 16 - 2 - 200 / CU

- SPLFS type
- nominal diameter
- number of nuts attached to one shaft
- spline shaft total length
- with special specification



When two spline nuts are used in close contact.



part number	maximum stroke	major dimensions												
		D		D1	L		E	Df	H	B	P.C.D.	A	F
	mm	mm	tolerance μm	mm	mm	tolerance mm	mm	mm	mm	mm	mm	mm	mm
SPLFS 6	22	11	0 −8	10	40	0 −0.2	3.3	23	4	14	17	—	—
SPLFS 8	20	13		12.5	40		3.3	25.5	4	16	19.5	—	—
SPLFS10	28	16		15.5	50		3.3	28.5	5	20	—	18	13
SPLFS13	24	20	0 −9	19.5	50		4.8	36	5	25	—	22	17
SPLFS16	26	24		23.5	60		4.8	40	7	29	—	25	19

S	W	d	Ds		basic torque rating		basic load rating		allowable static moment		mass		size
					dynamic	static	dynamic	static			nut	shaft	
				tolerance	CT	CoT	C	Co	M01	M02			
mm	mm	mm	mm	μm	N・m	N・m	kN	kN	N・m	N・m	g	kg/m	
3.4	12.7	1.2	6	0/−12	2.3	3.8	1.8	3.0	11.2	45	21.5	0.21	6
3.4	12.7	1.2	8	0 −15	3.3	5.5	2.02	3.37	13.1	52	27.0	0.38	8
3.4	16.7	1.5	10		6.5	10.9	3.21	5.35	25.6	102	47.7	0.6	10
3.4	15.2	1.5	13	0 −18	27.6	50.7	4.15	7.6	38.8	155	75.3	1.0	13
4.5	18.2	2.0	16		62.8	115	7.66	14	88.3	353	123.5	1.5	16

1kN≒102kgf　1N・m≒0.102kgf・m