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.

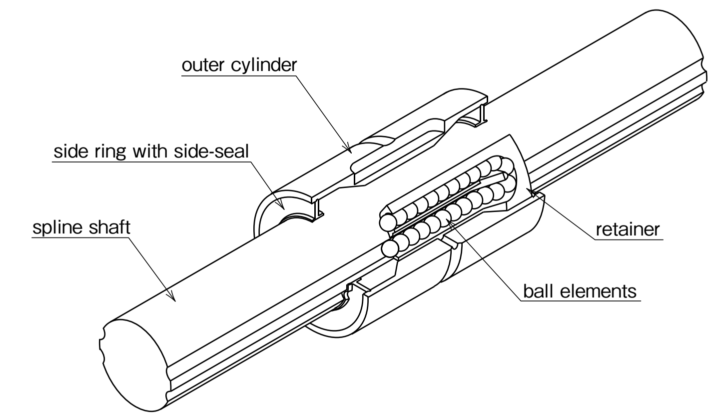
Ease of Additional Custom Machining

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

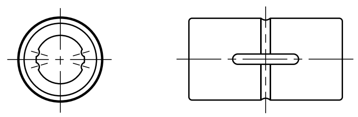
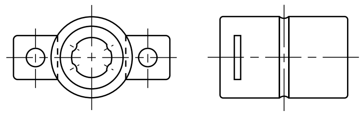
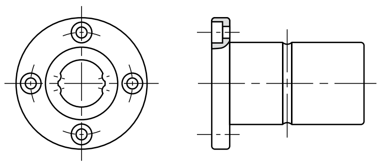
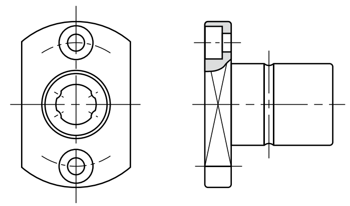


TYPES

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.

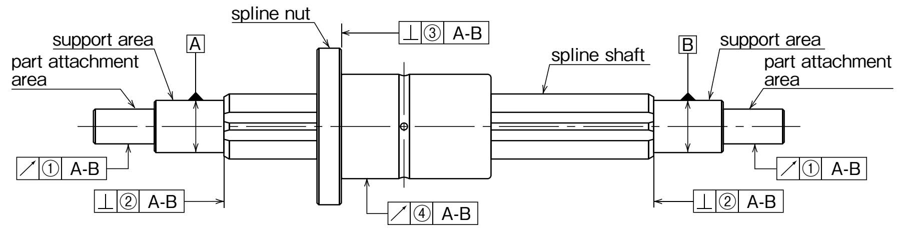
Table B-2

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	
SSP 13A			−13～− 8
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/mm^2)
M: bending moment onto spline shaft (N·mm)
Z: modulus of section (mm^3)
(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/mm^2)
T: twisting moment onto spline shaft (N·mm)
Zp: polar modulus of section (mm^3)
(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/mm^2)
(SUS) 7.69×10^4 (N/mm^2)
I_P: polar moment of inertia of area (mm^4)
(refer to Table B-8 on page B-8)

Figure B-3 Bending Moment

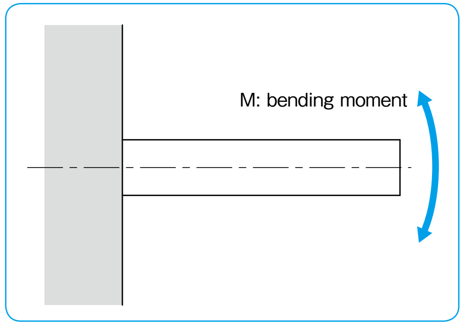


Figure B-4 Twisting Moment

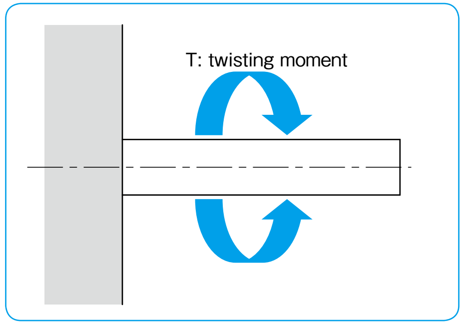


Figure B-5 Deformation of Spline Shaft by Twisting Moment

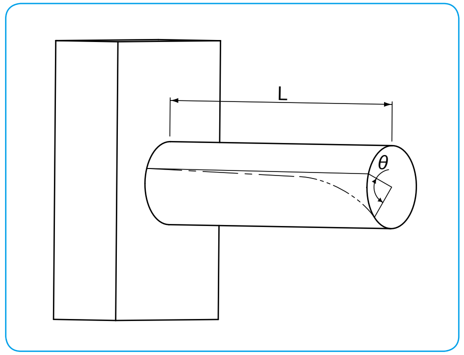


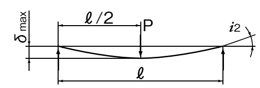
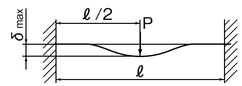
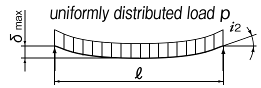
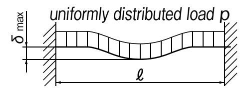
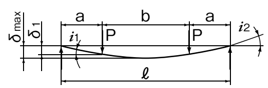
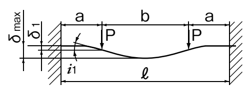
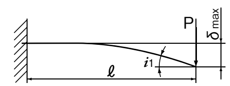
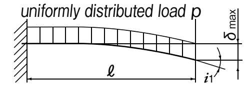
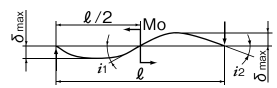
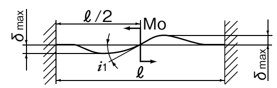
Table B-8 Cross-sectional Characteristics of Spline Shaft

part number	I moment of inertia of area mm^4	Z modulus of section mm^3	I_P polar moment of inertia of area mm^4	Z_P polar modulus of section mm^3	C=1/48EI 1/N·mm^2 SUJ2	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 SSP 80L	1.93×10^6	4.83×10^4	3.92×10^6	9.81×10^4	5.24×10^{-14}	–
SSP100 SSP100L	4.69×10^6	9.38×10^4	9.55×10^6	1.91×10^5	2.16×10^{-14}	–
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 (mm^4) (refer to Table B-8 on page B-8) E: modulus of longitudinal elasticity (SUJ2) 2.06×10^5 (N/mm^2) (SUS) 2.0×10^5 (N/mm^2) C: 1/48EI (1/N・mm^2)

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).

$$N_C=60\cdot\frac{\lambda^2}{2\pi\cdot L^2}\cdot\sqrt{\frac{E\cdot I_d\times10^3}{\gamma\cdot A}}\quad\cdots\cdots\cdots\cdots(7)$$

Nc: critical speed (rpm)
L: support distance (mm)
E: modulus of longitudinal elasticity (SUJ2)2.06×10⁵ (N/mm²)
(SUS)2.0 ×10⁵ (N/mm²)
γ: density (SUJ2)7.85×10⁻⁶ (kg/mm³)
(SUS)7.75×10⁻⁶ (kg/mm³)

I_d: Minimum Moment of Inertia of Area (mm⁴)

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

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

A: Minimum Cross-sectional Area of the Spline Shaft (mm²)

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

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

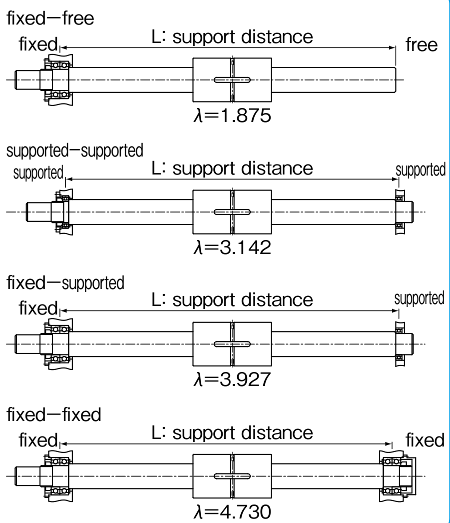
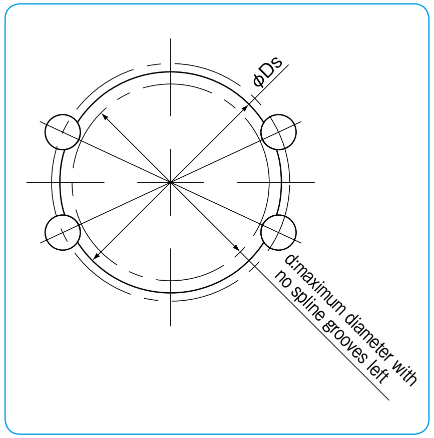


Table B-10 Spline Shaft Profile

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

$$L=\left(\frac{f_C}{f_W}\cdot\frac{C}{P}\right)^3\cdot50$$

For torque load

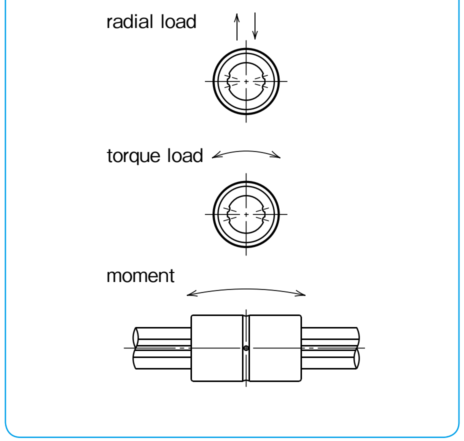
$$L=\left(\frac{f_C}{f_W}\cdot\frac{C_T}{T}\right)^3\cdot50$$

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.

$$L_h=\frac{L\cdot10^3}{2\cdot\ell_S\cdot n_1\cdot60}$$

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)

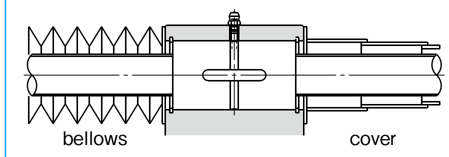
Operating Temperature

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

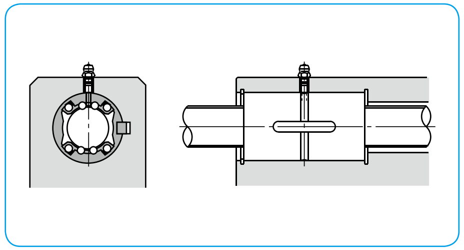


BALL SPLINE

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

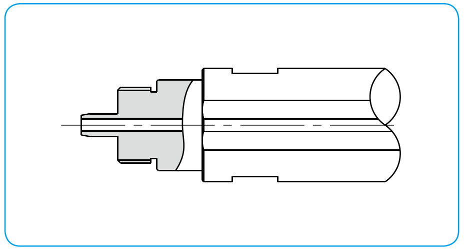
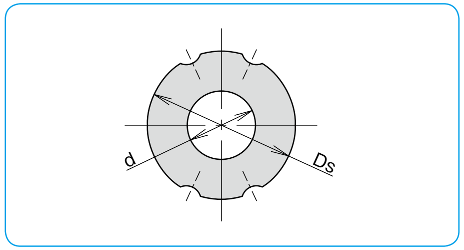


Table B-11
Recommended Inner Diameter for Hollow Spline Shaft

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



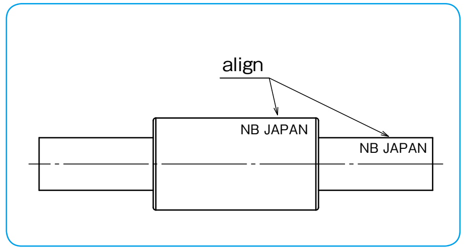
PRECAUTIONS ON MOUNTING

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		

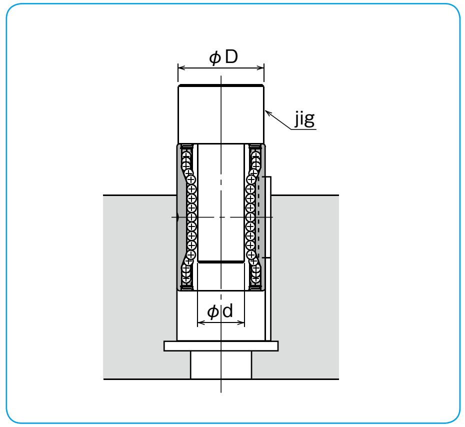
Insertion of Spline Nut

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.

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			

Figure B-12 Insertion of Spline Nut into Housing



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

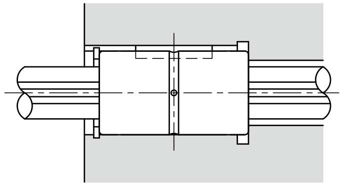
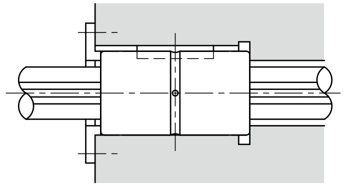


Figure B-14 Using a Push Plate



Key

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

Figure B-15 Key for SSP Type

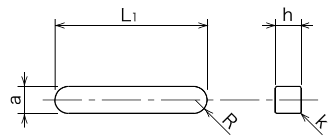


Table B-14 Major Dimensions of Key

part number	a mm	a tolerance µm	h mm	h tolerance µm	L_1 mm	R mm	k 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

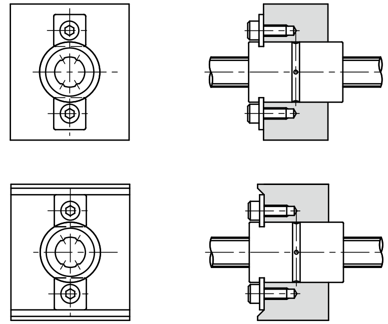


Figure B-17 Using LP Type Lock Plates

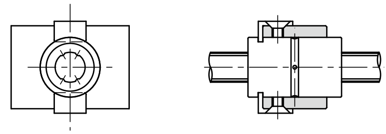


Figure B-18 Using Special Lock Plates (1)

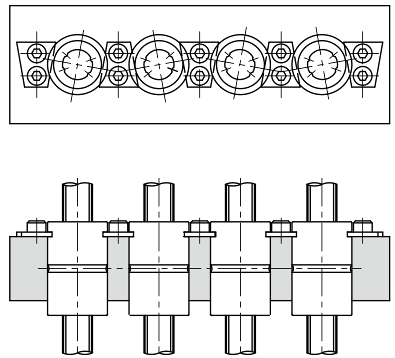
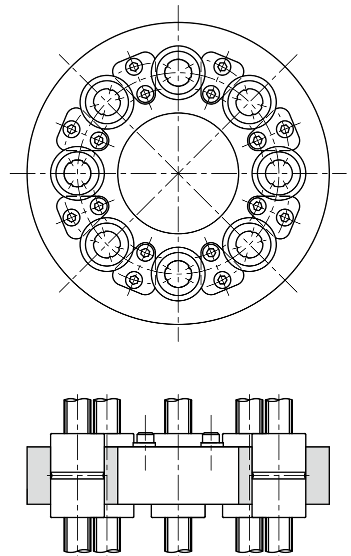


Figure B-19 Using Special Lock Plates (2)



F Type Lock Plate (Standard Plate)

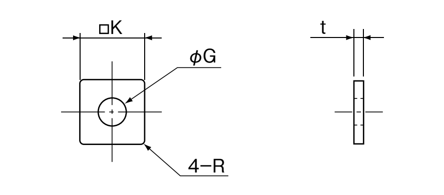
The lock plate shown in Figure B-20 is provided with the SSPM spline nut.

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

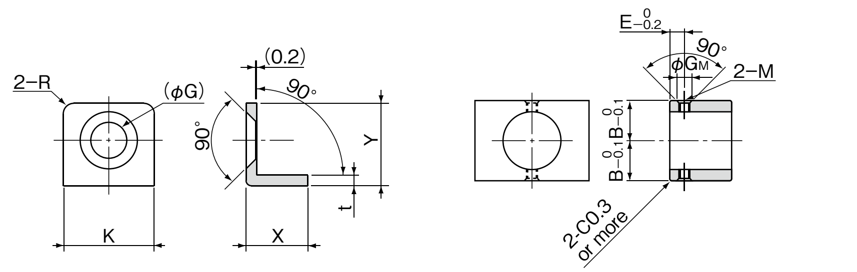


LP Type Lock Plate (Optional Plate)

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.

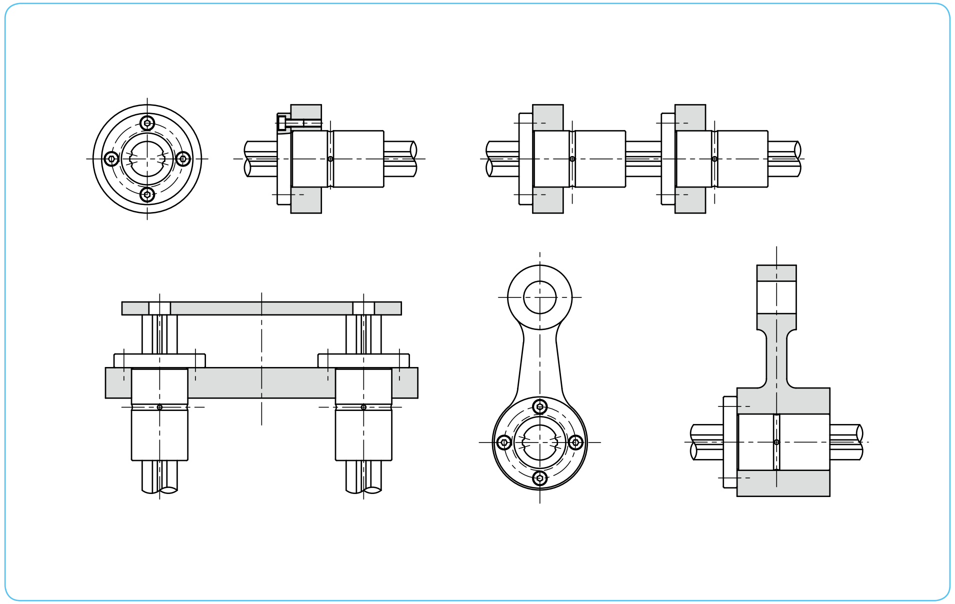
Table B-16 LP Type Lock Plate

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	G_M 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.

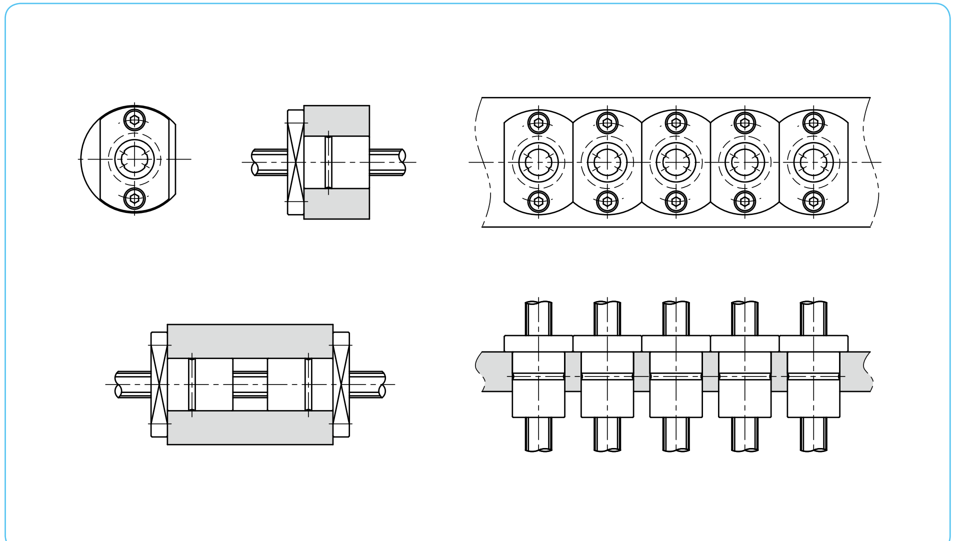
Figure B-22 Examples of installing SSPF Type



Mounting of SSPT Type

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

Figure B-23 Examples of installing SSPT Type



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.

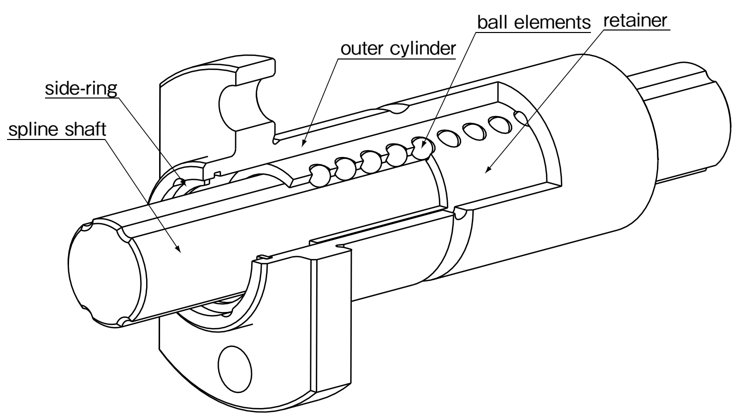
All Stainless Steel Type

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.

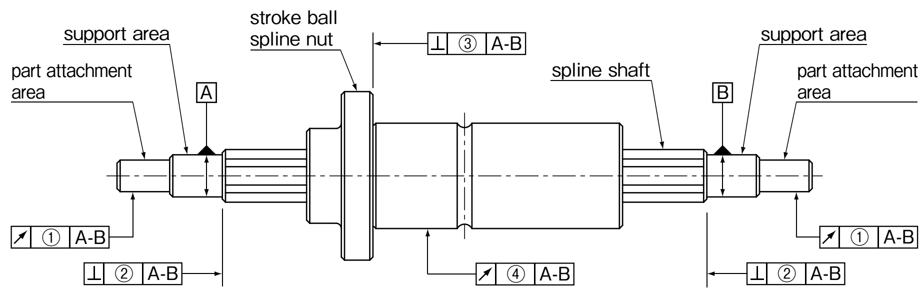
Figure B-32 Structure of SPLFS type



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 100mm, 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 (mm)		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

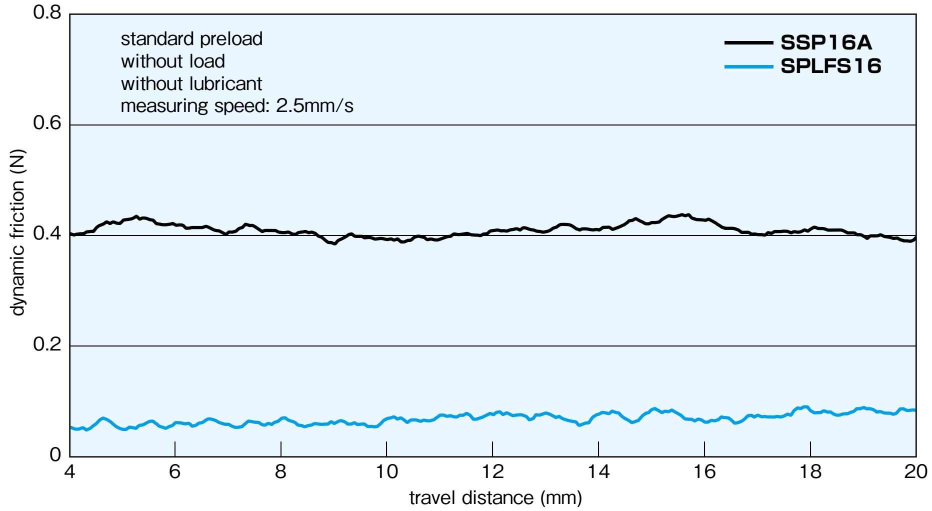
Preload and clearance are expressed in terms of clearance in the rotational direction. For the SPLFS type, only the standard preload is available as shown in Table B-32. Please contact NB if a special preload is required.

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

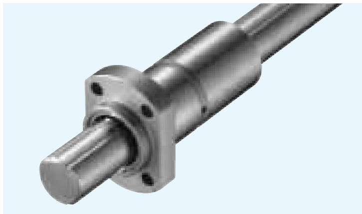
The maximum stroke in the dimension table is the stroke limit.

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.

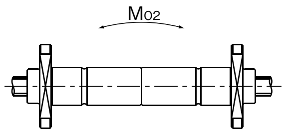
SPLFS TYPE
— Two Side Cut Flange Type —



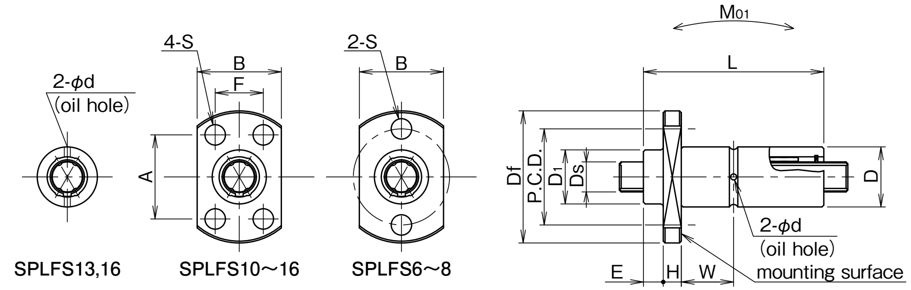
part number structure

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	D tolerance	D_1	L	L tolerance	E	Df	H	B	P.C.D.	A	F
	mm	mm	μm	mm	mm	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	Ds tolerance	basic torque rating dynamic C_T	basic torque rating static C_{OT}	basic load rating dynamic C	basic load rating static Co	allowable static moment M_{O1}	allowable static moment M_{O2}	mass nut	mass shaft	size
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