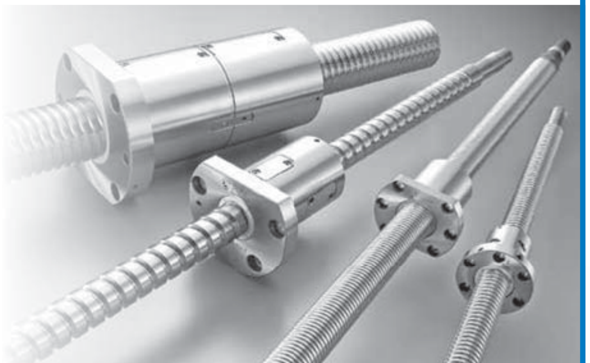
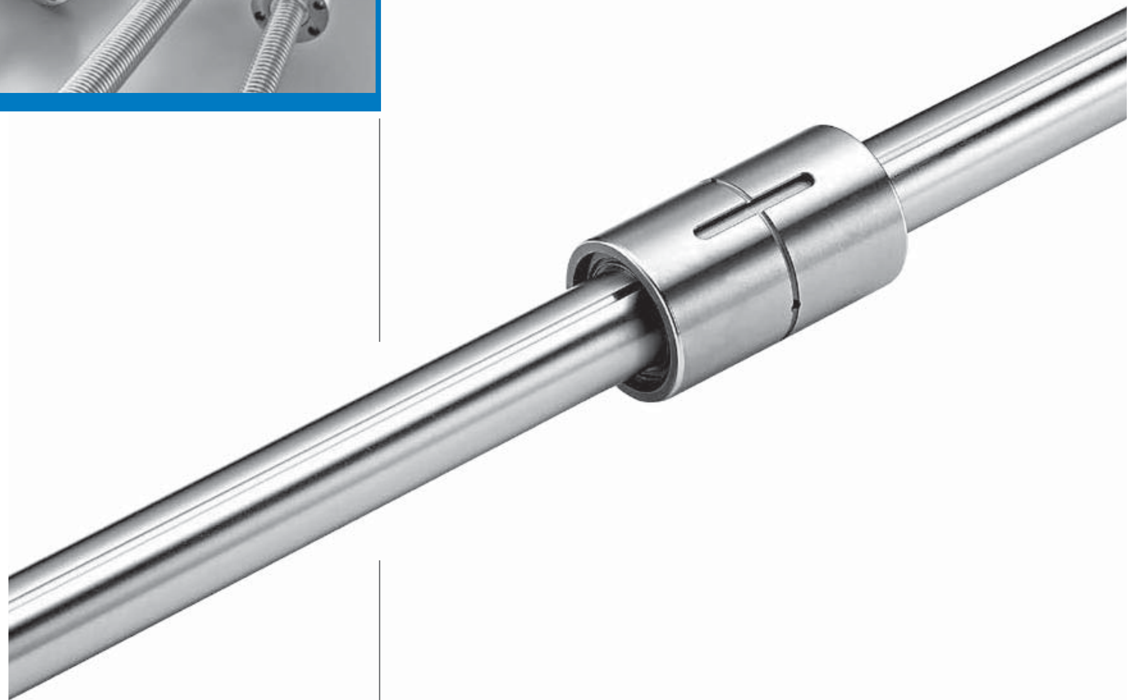


Ball Spline



Design Principle

The ball spline has load groove of three row on the outside diameter of shaft. Due to the Gothic arch groove design, it could be make sure three grooves withstand clockwise or Counterclockwise of torque at the same time, and then increase the service life and rigidity.
The balls recirculation in ball holder, prevent balls falling from the spline nut while assembling.

Features

Large Load Capacity

Every groove of the shaft is precision ground to form a 30° angular contact points. Thus, this model has large load capacities in the radial and torque directions

No Angular Backlash

At a contact angle of 30° to provide a preload in an angular-contact structure. This eliminates an angular backlash in the rotational direction and increases the rigidity.

High Rigidity

Due to large contact angle, it can give proper preload subject to availability. Thus, it can get high rigidity and large moment.

Ball Retaining Type

With ball holder, prevent balls falling from the spline nut while assembling.

Application

Robots, Transporting equipment, Wire winder, ACT (auto tools change)···etc.

Types and Features

Types of Spline Nuts

Cylindrical Type Ball Spline Model SLT

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

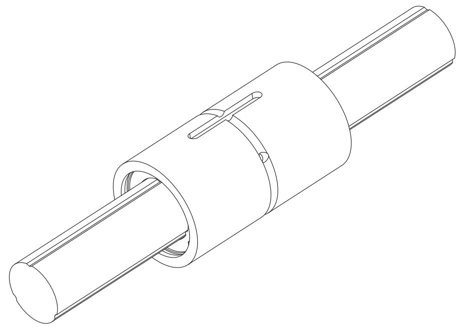


Fig.1 Cylindrical Type Ball Spline Model SLT

Flange Type Ball Spline Model SLF

The spline nut can be assembly to the housing via the flange, making assembly simple. Due to keyway is machined, thus it may be deformed, and where the housing width is small. It is most suitable for model SLF.

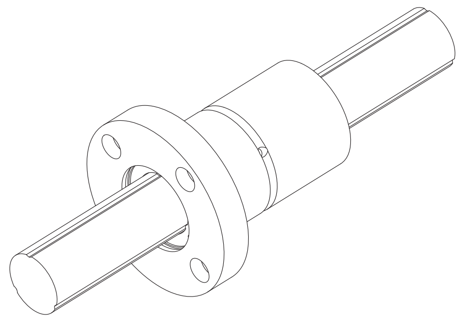


Fig.2 Flange Type Ball Spline Model SLF

Types of Spline Shafts

Precision Solid Spline Shaft (Standard Type)

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

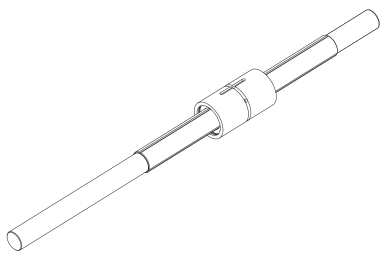


Fig.3 Precision Solid Spline Shaft

Special Spline Shaft

PMI manufactures a shaft with bigger dimension ends or bigger middle dimension through special processing at your request.

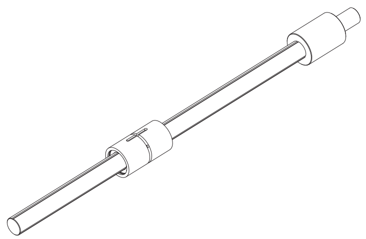


Fig.4 Special Spline Shaft

Hollow Spline Shaft

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

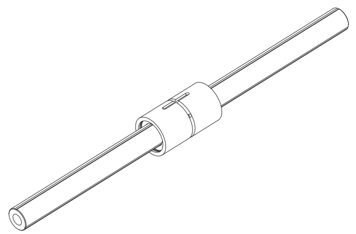


Fig.5 Hollow Spline Shaft

Housing inner-diameter Tolerance

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

Table.1 Housing inner-diameter Tolerance

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

Sectional Shape of the Spline Shaft

Table 2 shows the cross sectional of the spline shaft. If the spline shaft ends needs to be cylindrical, the root diameter (Ød) value should not be exceeded.

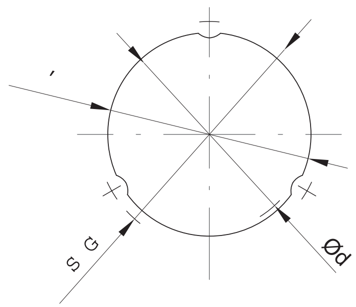


Fig.6 Sectional Shape of the Spline Shaft

Table 2 Sectional Shape of the Spline Shaft Unit:*mm*

Nominal shaft diameter	16	20	25
Root diameter Ød	15	19	23.9
Major diameter ØD_0	16	20	25
Ball center-to-center diameter Øpd	17.8	22.2	27.9
Mass (kg/m)	1.56	2.44	3.82

Hole dimension of the Standard Hollow Type Spline Shaft

Table 3 shows the hole dimension of the standard hollow type spline shaft. Use this table when a requirement such as piping, wiring, air-vent or weight reduction needs to be met.

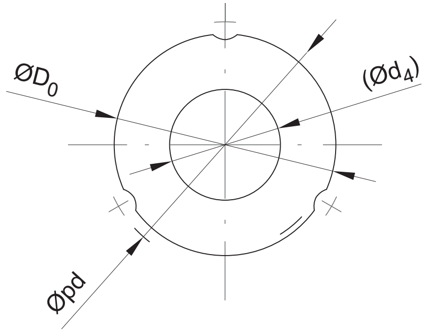


Fig.7 Hole dimension of the Standard Hollow Type Spline Shaft

Table 3 Hole dimension of the Standard Hollow Type Spline Shaft Unit:*mm*

Nominal shaft diameter	16	20	25
Major diameter $ØD_0$	16	20	25
Ball center-to-center diameter Øpd	17.8	22.2	27.9
Hole diameter ($Ød_4$)	11	14	18
Mass (kg/m)	1.17	1.83	2.44

Length of incomplete Area of a Special Spline Shaft

If the middle area or the end of a spline shaft is bigger dimension than the root diameter(Ød), an incomplete spline area is required for grinding. **Table 4** shows the relationship between the length of the incomplete length (*S*) and theØdf.

Note: This table does not apply to overall length of 1,500 mm or greater. Contact *PMI* for details.

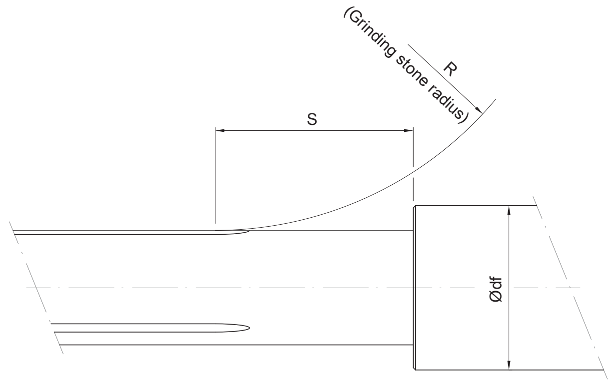
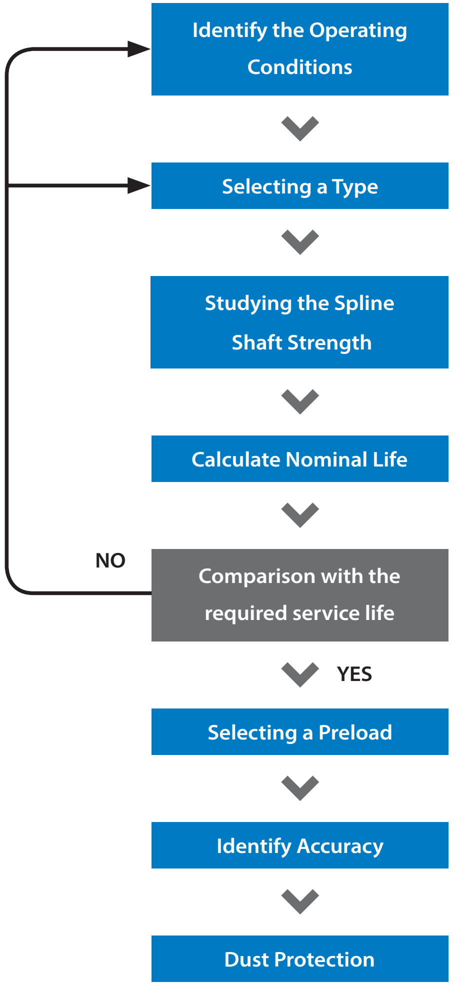


Fig.8 Length of Incomplete Area of a Special Spline Shaft

Table 4 Length of Imperfect Area of a Special Spline Shaft Unit:*mm*

S \ Ødf diameter	16	20	25	30	40	50
16	41	50	59	67	-	-
20	-	41	52	61	75	-
25	-	-	41	52	68	81

The Procedure of Select Ball Spline



Studying the Spline Shaft Strength

The shaft of the Ball Spline is a compound shaft capable of receiving radial load and torque. When the load and torque are large, the shaft strength must be taken into account.

Spline Shaft Receiving a Bending Load

When a bending load is applied to the shaft of a Ball Spline, calculate the maximum bending moment acting on the shaft. Obtain the shaft diameter using the equation **(1)** below.

$$M = \sigma \cdot Z \text{ and } Z = \frac{M}{\sigma} \quad \cdots\cdots\cdots\cdots\cdots (1)$$

M Maximum bending moment acting on the shaft（$N\text{-}mm$）
σ Permissible bending stress of the shaft（$98N / mm^2$）
Z Modulus section factor of the shaft（mm^3）
（see Table 6[B2-15]）

Note: $Z = \frac{\pi \cdot d^3}{32}$

Z Section modulus（mm^3）
d Shaft outer diameter（mm）

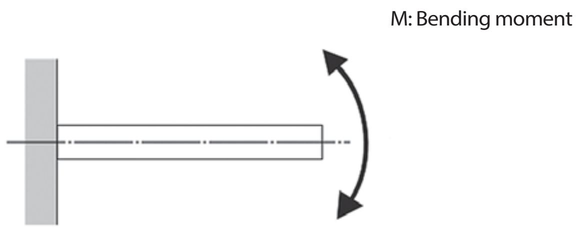


Fig.9

Spline Shaft Receiving a Torsion Load

When a torsion load is applied to the shaft of Ball Spline, calculate the maximum torsion load acting on the spline shaft. Obtain the spline shaft diameter with the equation **(2)**.

$$T = \tau_a \cdot Z_p \quad \therefore Z_p = \frac{T}{\tau_a} \quad \cdots\cdots(2)$$

T Maximum torsion moment（$N\text{-}mm$）
τ_a Permissible torsion stress of the spline shaft（$49N / mm^2$）
Z_p Polar modulus of section of the spline shaft（mm^3）
(see Table 6[B2-15])

Note: $Zp = \frac{\pi \cdot d^3}{16}$

Z_p Cross Section modulus（mm^3）
d Shaft outer diameter（mm）

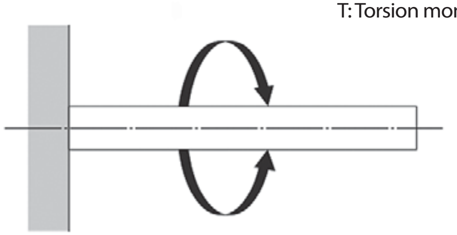


Fig.10

When the Shaft Simultaneously Receives a Bending Load and Torsion Load

When the shaft of Ball Spline receives bending load and torsion load simultaneously, shaft dimension calculate by equation **(3)** and **(4)** to get the equivalent bending moment(Me)and equivalent torsion moment(T_e). Get the greater value from equation **(3)** and **(4)** to determine the spline shaft diameter.

Equivalent bending moment

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

$$M_e = \sigma \cdot Z$$

Equivalent torsion moment

$$T_e = \sqrt{M^2+T^2} = M \cdot \sqrt{1+\left(\frac{T}{M}\right)^2} \quad \cdots\cdots(4)$$

$$T_e = \tau_a \cdot Z_p$$

Rigidity of the Spline Shaft

The rigidity of the shaft is expressed as a torsion angle per meter of shaft length. It's value should be limited within $\frac{1^\circ}{4}$.

$$\theta = 57.3 \times \frac{T \cdot L}{G \cdot I_p} \quad \cdots\cdots(5)$$

$$\text{Rigidity of the shaft} = \frac{\text{Torsion angle}}{\text{Unit length}} = \frac{\theta \cdot l}{L} < \frac{1^\circ}{4}$$

θ Torsion angle（°）
L Spline shaft length（mm）
G Transverse elastic modulus（$7.9 \times 10^4 N / mm^2$）
l Unit length（$1000mm$）
I_p Polar moment of inertia（mm^4）
(see Table 6[B2-15])

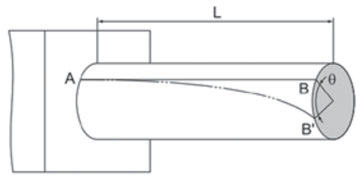
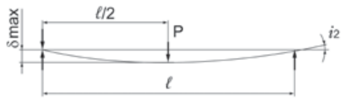
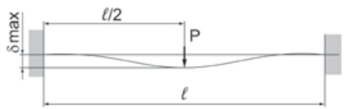
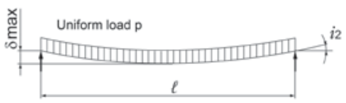
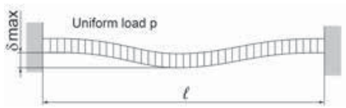
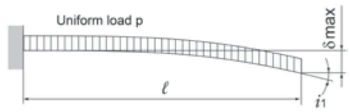
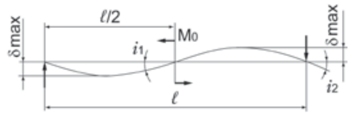
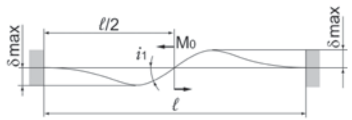


Fig.11

Deflection and Deflection Angle of the Spline Shaft

The deflection and deflection angle of the shaft need to be calculated using equations that meet the relevant conditions. **Table 5** represent these conditions and the corresponding equations. **Table 6[B2-15]** shows the cross section modulus (Z) and the geometrical moments of inertia (I) of the shaft. Using Z and I values in the tables, thus the strength and deflection of various Ball Spline specification can be obtained.

Table 5 Deflection and Deflection Angle Equations

Support method	Condition	Deflection Equations	Deflection Angle Equations
Both ends free		$\delta_{max}=\frac{Pl^3}{48EI}$	$i_1=0$ $i_2=\frac{Pl^2}{16EI}$
Both ends fastened		$\delta_{max}=\frac{Pl^3}{192EI}$	$i_1=0$ $i_2=0$
BBoth ends free		$\delta_{max}=\frac{5Pl^4}{384EI}$	$i_2=\frac{Pl^3}{24EI}$
Both ends fastened		$\delta_{max}=\frac{Pl^4}{384EI}$	$i_2=0$
One ends fastened		$\delta_{max}=\frac{Pl^3}{3EI}$	$i_1=\frac{Pl^2}{2EI}$ $i_2=0$
One ends fastened		$\delta_{max}=\frac{Pl^4}{8EI}$	$i_1=\frac{Pl^3}{6EI}$ $i_2=0$
Both ends free		$\delta_{max}=\frac{\sqrt{3}M_o l^2}{216EI}$	$i_1=\frac{M_o l}{12EI}$ $i_2=\frac{M_o l}{24EI}$
Both ends fastened		$\delta_{max}=\frac{M_o l^2}{216EI}$	$i_1=\frac{M_o l}{16EI}$ $i_2=0$

δ_{max} Maximum deflection（mm）
M_o Moment（$N\text{-}mm$）
l Span（mm）
I Geometrical moment of inertia（mm^4）
i_1 Deflection angle at loading point
i_2 Deflection angle at supporting point
P Concentrated load（N）
p Uniform load（N / mm）
E Young's modulus（$2.06\times10^5 N / mm^2$）

Critical Rotation Speed of the Spline Shaft

When a Ball Spline shaft is used to transmit power while rotating, if the rotational speed approaches the dangerous speed of the spline shaft may cause resonance of vibration. Therefore, the maximum rotational speed of the shaft must be limited to below the critical rotation speed that does not cause resonance of vibration. The critical rotation speed of the shaft is obtained using the equation **(6)**. (0.8 is multiplied as a safety factor)

Critical rotation speed

$$N_c = \frac{60\lambda^2}{2\pi \cdot l_b^2} \cdot \sqrt{\frac{E \times 10^3 \cdot I}{\gamma \cdot A}} \times 0.8 \cdots\cdots\cdots\cdots\cdots\cdots (6)$$

N_c Critical rotation speed （min^{-1} G

l_b Distance between mounting position Fmm G

E Young's modulus F$2.06 \times 10^5 N / mm^2$ G

I Minimum g eometrical moment of inertia of the shaft Fmm^4 G

γ Density (specific gravity) F$7.85 \times 10^{-6} kg / mm^3$ G

A Shaft cross-sectional area Fmm^2 G

λ Factor according to the mounting method

Fig.18.12 Fixed-free $\lambda = 1.875$
Fig.18.13 Supported-supported $\lambda = 3.142$
Fig.18.14 Fixed-supported $\lambda = 3.927$
Fig.18.15 Fixed-fixed $\lambda = 4.73$

Note: $I = \frac{\pi}{64} d^4$ d Root diameter（mm）

Fsee Table 2[B2-5], Table 3[B2-6] G

Note: $A = \frac{\pi}{4} d^2$ d Root diameter（mm）

Fsee Table 2[B2-5], Table 3[B2-6] G

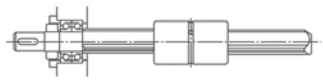


Fig.12 Fixed-free

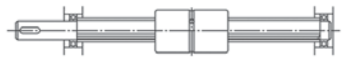


Fig.13 Supported-supported

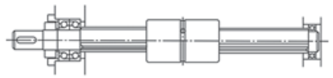


Fig.14 Fixed-supported

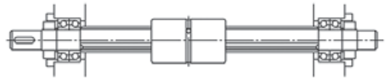


Fig.15 Fixed-fixed

Cross-sectional Characteristics of the Spline Shaft

Cross-sectional Characteristics of the Spline Shaft

Table 6 Cross-sectional Characteristics of the Spline Shaft

Nominal shaft diameter		I : Geometrical moment of inertia (mm^4)	Z : Section modulus (mm^3)	I_P : Polar moment of inertia (mm^4)	Z_P : Cross Section modulus (mm^3)
16	Solid shaft	3.15×10^3	4.02×10^2	6.3×10^3	8.04×10^2
	Hollow shaft	2.5×10^3	3.12×10^2	5.0×10^2	6.24×10^2
20	Solid shaft	7.74×10^3	7.85×10^2	1.55×10^4	1.57×10^3
	Hollow shaft	5.97×10^3	5.96×10^3	1.19×10^4	1.19×10^3
25	Solid shaft	1.19×10^4	1.53×10^3	3.80×10^4	3.06×10^3
	Hollow shaft	1.4×10^4	1.12×10^3	2.8×10^4	2.24×10^3

Predicting the Service Life

Service Life

The service life of a Ball Spline varies from unit to unit even if they are manufactured through the same process and in the same operating conditions.

Service life is the total travel distance that 90% of a group of identical ball splines independently operating under the same conditions can achieve without developing flaking (scale like pieces on a metal surface).

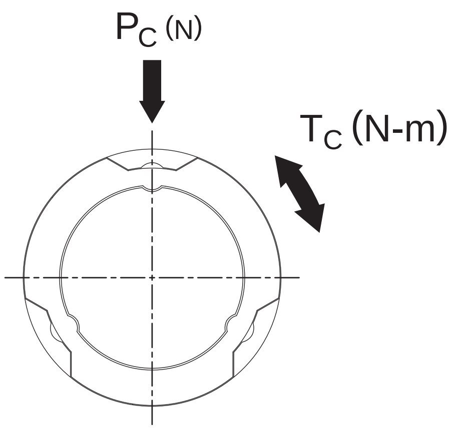


Fig.16 Applied Load of Ball Spline

Calculating the Service Life

The service life of a Ball Spline varies with types of loads applied during operation: torque load, radial load and moment load. The corresponding service life values are obtained using the equations **(7)[B2-17]** ~ **(10)[B2-18]** below.(The basic load ratings in these loading directions are indicated in the specification table for the corresponding model number.)

When a Torque Load is Applied

$$L = \left(\frac{f_T \cdot f_C}{f_W} \cdot \frac{C_T}{T_C}\right)^3 \times 50 \quad \cdots\cdots (7)$$

When a Radial Load is Applied

$$L = \left(\frac{f_T \cdot f_C}{f_W} \cdot \frac{C_a}{P_C}\right)^3 \times 50 \quad \cdots\cdots (8)$$

L Service life（km）
C_T Basic dynamic torque rating（$N\text{-}m$）
T_C Calculated torqu（$N\text{-}m$）
C_a Basic dynamic load rating（N）
P_C Basic dynamic load rating（N）
f_T Temperature factor（see Fig.17[B2-19]）
f_C Contact factor（see Table 7[B2-20]）
f_W Load factor（see Table 8[B2-20]）

When a Torque Load and a Radial Load are Simultaneously Applied

When a torque load and a radial load are simultaneously applied, calculate the service life by obtaining the equivalent radial load using the equation **(9)[B2-17]** below.

$$P_E = P_C + \frac{4 \cdot T_C \times 10^3}{i \cdot pd \cdot \cos\alpha} \quad \cdots\cdots (9)$$

P_E Equivalent radial load（N）
$\cos\alpha$ Contact angle
i Number of lows of balls under a load
Pd Ball center-to –center diameter（mm）
（see Table 2[B2-5], Table 3[B2-6]）

When a Moment Load is Applied to a Single Nut or Two Nuts in Close Contact with Each Other

Obtain the equivalent radial load using the equation **(10)** below.

$$Pu = K \cdot M \cdots\cdots\cdots\cdots\cdots\cdots (10)$$

P_u Equivalent radial load （N）(with a moment applied)

K Equivalent Factors （see Table.9[B2-23]）

M Applied moment （N-mm）

Note: M should be with in the range of the static permissible moment.

When a Moment Load and a Radial Load are Simultaneously Applied

To calculated the service life from the sum of the radial load and the equivalent radial load.

Calculating the Service Life Time

When the service life has been obtained in the equation above, if the stroke length and the number of reciprocations per minute are constant, the service life time is obtained using the equation **(11)**.

$$L_h = \frac{L \times 10^3}{2 \times l_s \times n_1 \times 60} \cdots\cdots\cdots\cdots\cdots\cdots (11)$$

L_h Service life time （hr）

l_s Stroke length （m）

n_1 Number of reciprocations per minute （min^{-1}）

f_T : **Temperature Factor**

When operating temperature higher than 100°C, the service life will be degraded. Therefore, the service life should be multiplied by temperature factor (f_T) indicated in **Fig.17**.

Note: If the environment temperature exceeds 80°C, high temperature types of seal and spacer are required. For special need ,please contact us.

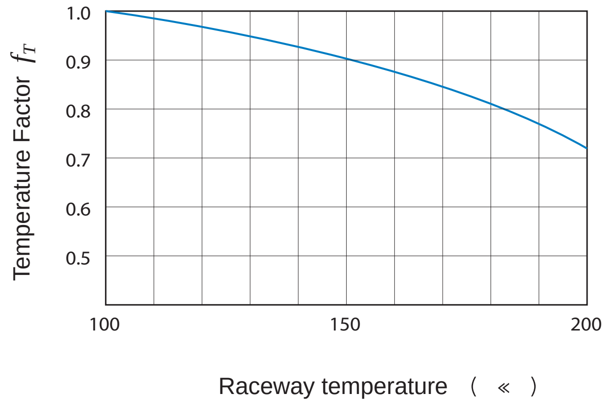


Fig.17 Temperature Factor f_T

f_C : **Contact Factor**

When multiple nuts are used in close contact with each other, their linear motion is affected by moments and mounting accuracy, making it difficult to achieve uniform load distribution. In such applications, multiply the basic load rating (C_a) and (C_0)by the corresponding contact factor (f_C) in **Table 7**.

Note: If uneven load distribution is expected in a large machine, take into account the respective contact factor indicated in **Table 7**.

Table 7 Contact Factor f_C

Number of spline nuts in close contact with each other	Contact factor f_C
2	0.81
3	0.72
4	0.66
5	0.61
Normal use	1

f_w : **Load Factor**

Although the working load of machine can be obtained by calculation, the actual load is mostly higher than calculated value. This is because the vibration and impact, caused by mechanical reciprocal motion, are difficult to be estimated. This is especially true when the vibration from high speed operation and the impact from repeated start and stop. Therefore, for consideration of speed and vibration, the basic dynamic load rating should be divided by the empirical load factor. See the **Table 8** below.

Table 8 Load Factor f_W

Motion Condition	Operating Speed	f_W
No impact & vibration	V≤15m/min	1~1.2
Slight impact & vibration	15<V≤60m/min	1.2~1.5
Moderate impact & vibration	60<V≤120m/min	1.5~2
Strong impact & vibration	V>120m/min	2~3.5

Calculating the Average Load

The average load (P_m) is a constant load under which the service life of an operating Ball Spline with its spline nut receiving a fluctuation load in varying conditions is equivalent to the service life under this varying load condition. The following is the basic equation.

$$P_m = \sqrt[3]{\frac{1}{L} \cdot \sum_{n=1}^{n} \left(P_n^3 \cdot L_n\right)} \quad \cdots\cdots (12)$$

P_m Average Load（N）

P_n Varying Load（N）

L Total travel distance（mm）

L_n Distance traveled under load P_n（mm）

Gradational variation curve (Fig.18). Average Load can be calculated by using equation (12).

$$P_m = \sqrt[3]{\frac{1}{L} \left(P_1^3 \cdot L_1 + P_2^3 \cdot L_2 \cdots\cdots + P_n^3 \cdot L_n\right)} \quad \cdots\cdots (12)$$

P_m Average Load（N）

P_n Varying load（N）

L Total travel distance（mm）

L_n Distance traveled under load P_n（mm）

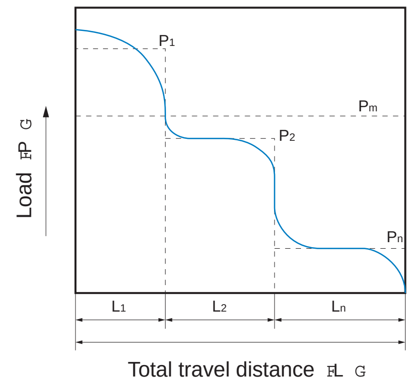


Fig.18 Gradational Variation Curve's Load

Similar straight line(Fig.19). Average Load can be calculated by using equation (13).

$$P_m \fallingdotseq \frac{1}{3}(P_{min}+2\cdot P_{max})\cdots\cdots\cdots(13)$$

P_{min} Minimum load (N)

P_{max} Maximum load (N)

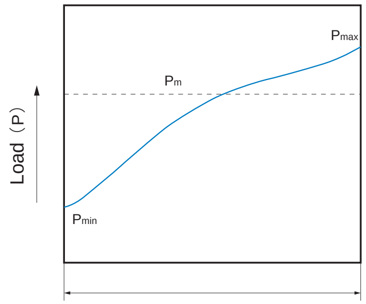


Fig.19 Similar Straight Line's Load

Sine curve there are two case

- When average load variation curve shown as the **Fig.20**. Average load can be calculated by using equation **(14)**.

$$P_m \fallingdotseq 0.65\,(P_{max})\cdots\cdots\cdots(14)$$

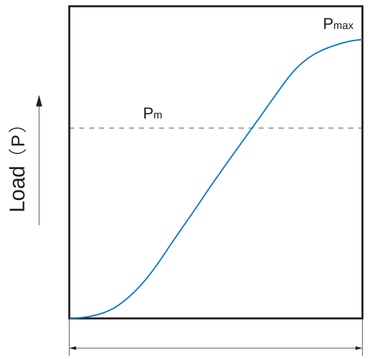


Fig.20 Variation like Sine curve's load (1)

- When average load variation curve shown as the **Fig.21**. Average load can be calculated by using equation **(15)**.

$$P_m \fallingdotseq 0.55\,(P_{max})\cdots\cdots\cdots(15)$$

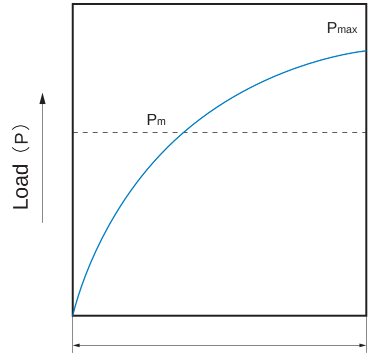


Fig.21 Variation like Sine curve's load (2)

Equivalent Factor

Table 9 show equivalent radial load factors calculated under a moment load.

Table 9 Table of Equivalent Factors For Ball Spline

Nominal shaft diameter	Equivalent factor (K)	
	Single nut	Two nuts in close contact with each other
16	0.21	0.035
20	0.17	0.028
25	0.15	0.023

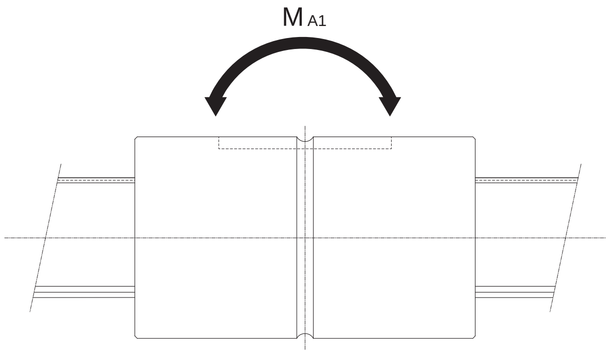


Fig.22 Single spline nut

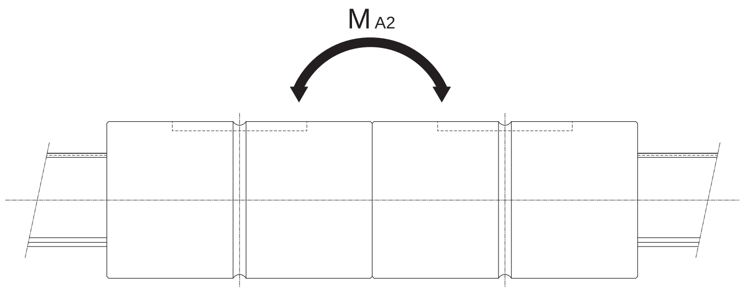


Fig.23 Two spline nuts in close contact with each other

Selecting a Preload

A preload on the Ball Spline significantly affects its accuracy, load resistance and rigidity. Thus, according to applications to select the most appropriate clearance. Specification clearance values are standardized for each model, allowing you to select a clearance that meets the conditions.

Clearance in the Rotation Direction

With the Ball Spline, the sum of clearance in the circumferential direction is standardized as the clearance in the rotational direction.

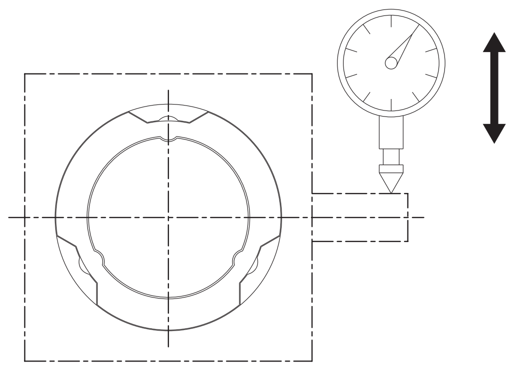


Fig.24 Measurement of Clearance in the Rotational Direction

Preload and Rigidity

The propose of preload is defined as the load preliminarily applied to the ball in order to eliminate angular radial play (clearance in the rotational direction) and increase rigidity. When given a preload, the Ball Spline is capable of increasing its rigidity by eliminating the angular backlash according to the magnitude of the preload. **Fig.25** shows the displacement in the rotational direction when a rotational torque is applied.

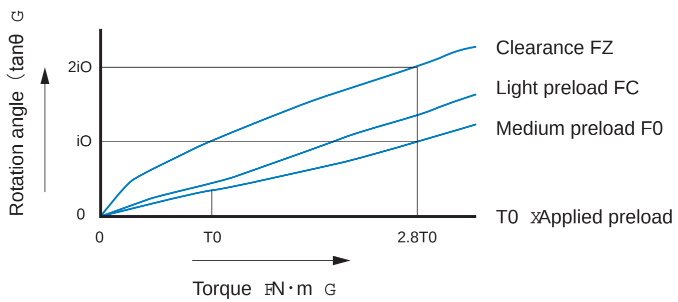


Fig.25 Applied Preload and Rotation Angle Diagram

The Selection of Preload

Table 10[B2-27] provides proper preload for selecting a clearance in the rotational direction with given conditions of the Ball Spline.

The rotational clearance of the Ball Spline significantly affects the accuracy and rigidity of the spline nut. Therefore, it is important to select a correct clearance according to the applications. Generally, the Ball Spline is provided with a preload. When it is used in repeated circular motion or reciprocating straight motion, the Ball Spline is subject to a large vibration impact, and therefore, its service life and accuracy are significantly increased with a preload.

Table 10 Guidelines for Selecting a Preload in the Rotational Direction for the Ball Spline

Clearance in the rotational direction	Condition	Application examples
Clearance (FZ)	• Smooth motion with a small force is desired. • A torque is always applied in the same direction.	Measuring instruments / Automatic drafting machine / Geometrical measuring equipment / Dynamometer / Wire winder. / Automatic welding machine / Main shaft of horning machine / Automatic packing machine
Light preload (FC)	• An overhang load or moment load is present. • High positioning repeatability is required. • Alternating load is applied.	Industrial robot arm / Automatic loaders / Guide shaft of automatic coating machine / Main shaft of electric discharge machine / Guide shaft for press die setting / Main shaft of drilling machine
Medium preload (F0)	• High rigidity is required and vibrations and impact are applied. • Receives a moment load with a single nut.	Steering shaft of construction vehicle / Shaft of spot-welding machine / Indexing shaft of automatic lathe tool rest

Table 11 Preload in the Rotational Direction for the Ball Spline

Preload / Nominal shaft diameter	Clearance (FZ)	Light preload (FC)	Medium preload (F0)
16	0~1μm	0~0.02C	0.03~0.05C
20	0~1μm	0~0.02C	0.03~0.05C
25	0~2μm	0~0.02C	0.03~0.05C

Accuracy Grade

The accuracy of the Ball Spline is classified into three grades: normal grade (N), high accuracy grade (H) and precision grade (P), according to the runout of spline nut circumference in relation to the support of the spline shaft. **Fig.26** shows measurement items.

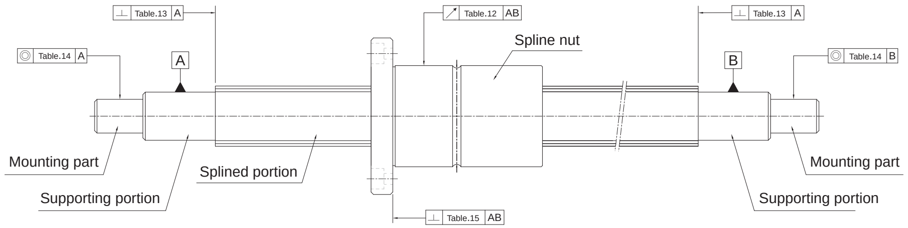


Fig.26 Accuracy Measurement Item of the Ball Spline

Accuracy Grade

Table 12[B2-28] to **Table 15[B2-29]** are show measurement item of the Ball Spline.

Table 12 Runout of the Spline Nut Circumference in Relation to the Support of the Spline Shaft Unit:μm

Accuracy		Runout(max)					
Nominal shaft diameter		16、20			25		
Spline shaft length		Normal(N)	High(H)	Precision(P)	Normal(N)	High(H)	Precision(P)
Over	Or less						
-	200	56	34	18	53	32	18
200	315	71	45	25	58	39	21
315	400	83	53	31	70	44	25
400	500	95	62	38	78	50	29
500	630	112	-	-	88	57	34
630	800	-	-	-	103	68	42

Table 13 Perpendicularity of the Spline Shaft End Face in Relation to the Support of the Spline Shaft Unit:μm

Accuracy	Perpendicularity(max)		
Nominal shaft diameter	Normal(N)	High(H)	Precision(P)
16	27	11	8
20			
25	33	13	9

Table 14 Concentricity of the Part-mounting in Relation to the Support of the Spline Shaft Unit:μm

Accuracy	Concentricity(max)		
Nominal shaft diameter	Normal(N)	High(H)	Precision(P)
16	46	19	12
20			
25	53	22	13

Table 15 Straightness of the Flange-mounting Surface of the Spline Nut in Relation to the Support of the Spline Shaft Unit:μm

Accuracy	Perpendicularity(max)		
Nominal shaft diameter	Normal(N)	High(H)	Precision(P)
16	39	16	11
20			
25			

Product Explanation of Ball Spline

Nomenclature

2-SLT-25-UU-F0-400-500-N-S

- Type of shaft
  - S : Solid
  - H : Hollow
- Accuracy grade
  - N : Normal
  - H : High
  - P : Precision
- Shaft length
- Splined length
- Preload grade
  - FZ : Clearance
  - FC : Light preload
  - F0 : Medium preload
- Contamination protection
  - UU : Rubber seal attached on both ends
  - U : Rubber seal attached on either end
  - No symbol-Without seal
- Outside diameter.
- Type
  - SLT : Cylindrical Type
  - SLF : Flanged Type
- Number of spline nuts

Keyway

Ball Spline model SLT is provided with a standard key as indicated in **Table 16**.

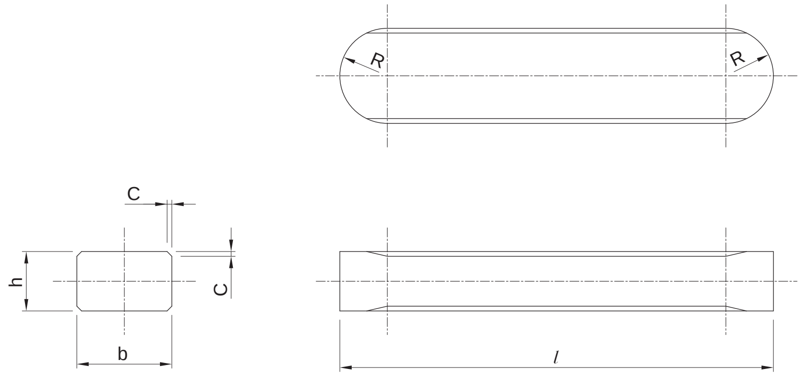


Fig.27 Spline Nut Keyway

Table 16 Standard Key for Model SLT

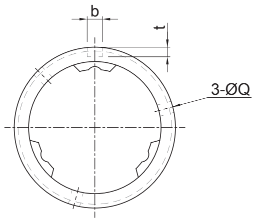
Unit: *mm*

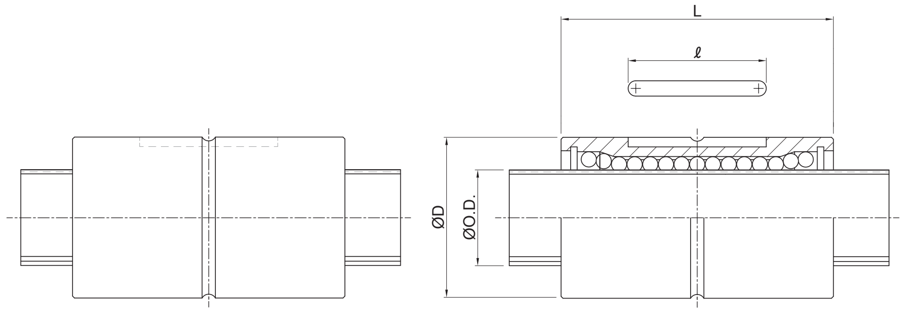
Nominal shaft diameter	Width		Height		Length		R	C
	b	Tolerance(p7)	h	Tolerance(h9)	*l*	Tolerance(h12)		
16	3.5		3.5		17.5	0 -0.180	1.75	
20	4	+0.024 +0.012	4	0 -0.030	29	0 -0.210	2	0.5
25	4		4		36	0 -0.250	2	

SLT

SLT

Product
BALL SPLINE
Specifications | Ball Spline



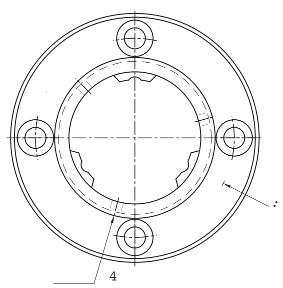


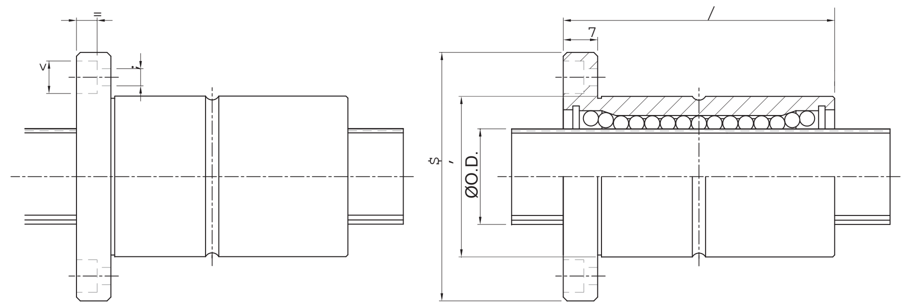
Unit: *mm*

Model No.	Size											Basic torque rating		Basic load rating		Static permissible moment		Mass	
	Diameter		Length		Keyway dimensions			Greasing hole	Shaft diameter	Rows of balls		C_T	C_{OT}	Ca	Co	M_{A1}	M_{A2}	Nut	Shaft
	D	Tolerance	L	Tolerance	b(H8)	$t^{+0.1}_{0}$	l	Q	O.D.			(N·m)	(N·m)	(kN)	(kN)	(N·m)	(N·m)	(g)	(kg/m)
16	31	0 -0.013	50	0 -0.2	3.5	2	17.5	3	16	3		31.4	34.3	6.9	12.4	60	360	145	1.56
20	35	0 -0.016	63		4	2.5	29	3	20	3		56.8	55.8	10.1	17.8	120	720	200	2.44
25	42		71	0 -0.3	4	2.5	36	3	25	3		105	103	15.2	25.3	180	1140	276	3.82

SLF

SLF





Unit: *mm*

Model No.	Size														Size	Basic torque rating		Basic load rating		Static permissible moment		Mass	
	Diameter		Length		Flange diameter			Bolt				Greasing hole	Shaft diameter		Rows of balls	C_T	C_{OT}	Ca	Co	M_{A1}	M_{A2}	Nut	Shaft
	D	Tolerance	L	Tolerance	T	A	Tolerance	W	X	Y	Z	Q	O.D.			(N·m)	(N·m)	(kN)	(kN)	(N·m)	(N·m)	(g)	(kg/m)
16	31	0 -0.013	50	0 -0.2	7	51	0 -0.2	40	4.5	8	4.5	3	16		3	31.4	34.3	6.95	12.41	60	360	207	1.56
20	35	0 -0.016	63	0 -0.3	9	58		45	5.5	9.5	5.4	3	20		3	56.8	55.8	10.09	17.83	120	720	303	2.44
25	42		71		9	65		52	5.5	9.5	5.4	3	25		3	105	103	15.18	25.33	180	1140	397	3.82

Model SLT with Recommended Shaft End Shape

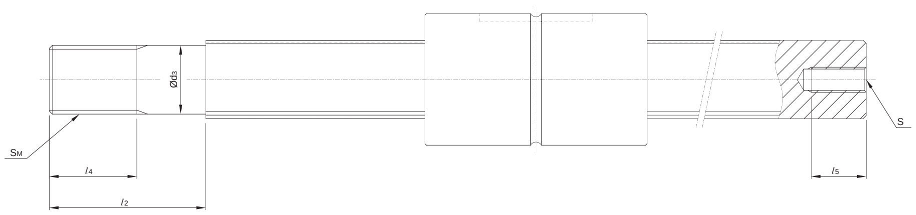


Fig.28 Shaft End Shape

Table 17 Model SLT with Recommended Shaft End Shape

Unit: *mm*

Model No.	d_3	Tolerance	l_2	S_M	l_4	$S \times l_5$
SLT 16	14	0 -0.018	30	M14×1.5	18	M6×10
SLT 20	16		38	M16×1.5	22	M8×15
SLT 25	22	0 -0.021	50	M22×1.5	28	M10×18

Design Principle

The ball spline has load groove of three row on the outside diameter of shaft. Due to the Gothic arch groove design, it could be make sure three grooves withstand clockwise or Counterclockwise of torque , and then increase the service life and rigidity.

The Spline nut has a special designed support bearing directly set up on the outer ring of the nuts. The Spline is capable of performing two modes of motions (rotational and linear) with a single shaft by rotating or stopping the spline nut.

The rows of balls are held in a special resin retainer incorporated in the spline nut so that they smoothly roll and circulate. The balls recirculation in ball holder, prevent balls falling from the spline nut while assembling.

Features

High Positioning Accuracy

The Ball Spline groove profile is designed Gothic arch. By applied preload, the backlash in the rotational direction is eliminated therefore having higher positioning accuracy.

Compact Design

Spline nut and the support bearing is integration structure. The Spline nut is designed lightweight. Therefore, the highly accurate and compact design is achieved.

Easy Installation

The spline nut and the support bearing are integrated, thus the Rotary Ball Spline can easily be mounted simply by securing it to the housing with bolts.

Support Bearing

The support bearing of the Ball Spline has a contact angle of 45°, thus it has the average force of axial and radial direction.

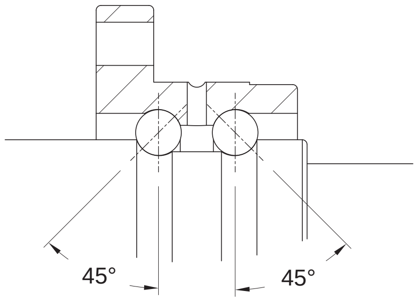


Fig.1 Model STRA Contact Angle

Types and Features

Types of Spline Nuts

Ball Spline Model STRA

Spline nut integrally formed with support bearings.

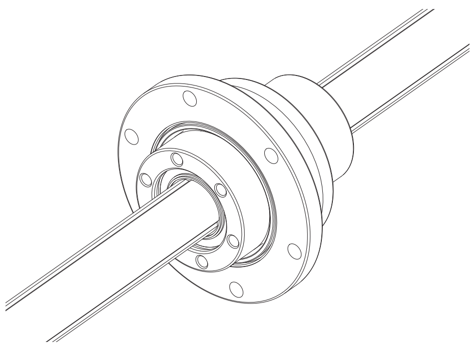


Fig.2 Ball Spline Model STRA

Types of Spline Shafts

Precision Solid Spline Shaft

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

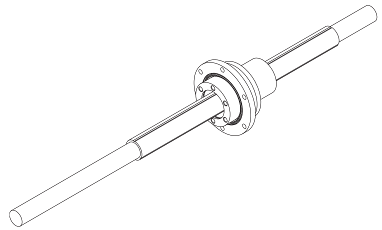


Fig.3 Precision Solid Spline Shaft

Special Spline Shaft

PMI manufactures a shaft with bigger dimension ends or bigger middle dimension through special processing at your request.

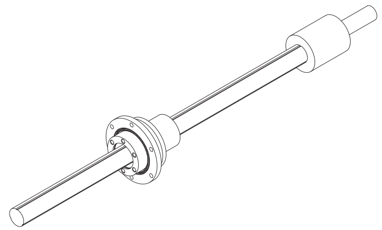


Fig.4 Special Spline Shaft

Hollow Spline Shaft

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

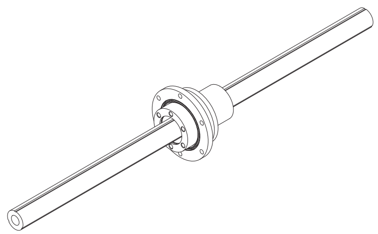


Fig.5 Hollow Spline Shaft

Product Explanation of Rotary Ball Spline

Nomenclature

2-STRA-25-UU-F0-400-500-N-S

- Type of shaft
  - S : Solid
  - H : Hollow
- Accuracy grade
  - N : Normal
  - H : High
  - P : Precision
- Shaft length
- Splined length
- Preload grade
  - FZ : Clearance
  - FC : Light preload
  - F0 : Medium preload
- Contamination protection
  - UU : Rubber seal attached on both ends
  - U : Rubber seal attached on either end
  - No symbol-Without seal
- Outside diameter.
- Nut Type
- Number of spline nuts

Accuracy Standards

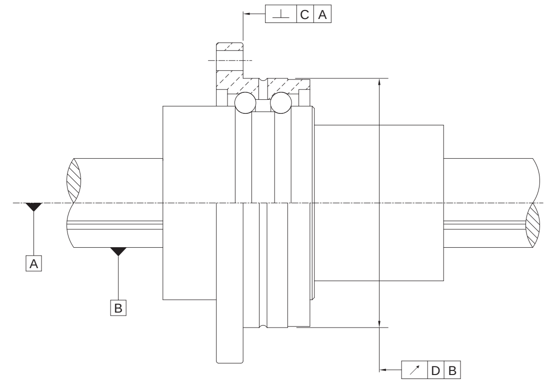


Fig.6 Accuracy Standards

Table 1 Accuracy Standards

Unit: *mm*

Accuracy grades	Normal grade (N)		High grade (H)		Precision grade (P)	
Model No.	C	D	C	D	C	D
STRA-1616	0.023	0.035	0.016	0.020	0.013	0.017
STRA-2020	0.023	0.035	0.016	0.020	0.013	0.017
STRA-2525	0.023	0.035	0.018	0.024	0.015	0.020

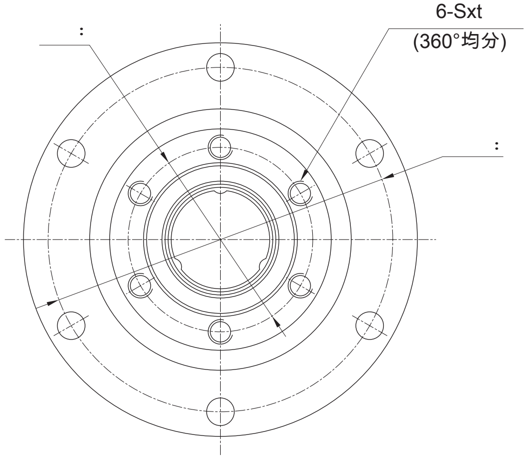
Permissible Rotational Speed for Rotary Ball Splines

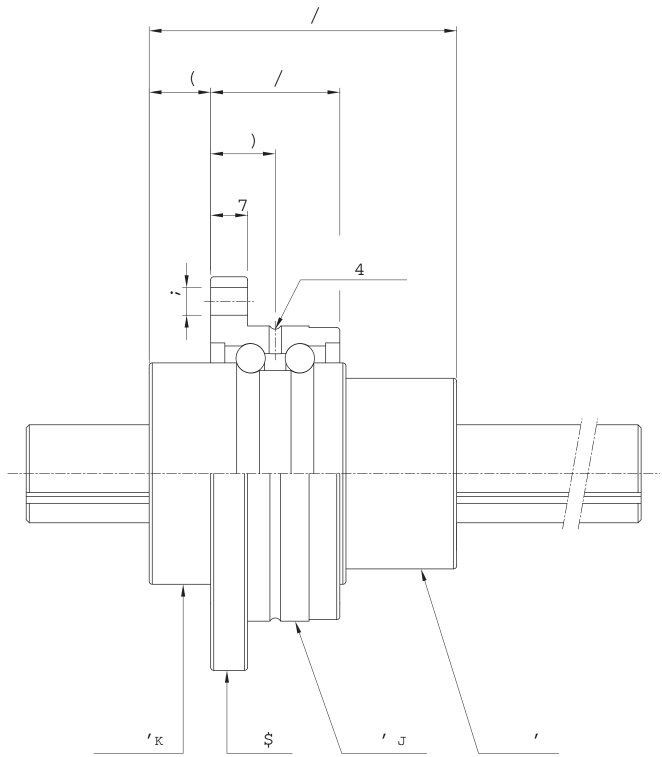
Table 2 Model STRA permissible rotational speed

Model No.	Permissible Rotational Speed		
	Ball spline	Support bearing	
	Calculated using shaft length	Grease Lubrication	Oil Lubrication
STRA 16	See critical speed of the spline shaft	4000	5400
STRA 20		3600	4900
STRA 25		3200	4300

STRA

STRA





Model No.	Size																	Basic torque rating		Basic load rating		Static permissible moment M_A (N·m)	Support bearing basic load rating		Mass	
	Diameter	O.D.				Length	Flange diameter			Bolt	Oil hole	Oil hole diameter	E	L1	Shaft diameter		Rows of balls	C_r (N·m)	C_{or} (N·m)	Ca (kN)	Co (kN)		Ca (kN)	Co (kN)	Nut	Shaft
	$D1_{g6}$	D_{h7}	W	S×t	D2	L	A	T	W_1	X	F	Q													(kg)	(kg/m)
16	48	36	30	M4×0.7P×6	31	50	64	6	56	4.5	10.5	2	10	21	16		3	31.4	34.3	6.9	12.4	60	6.74	6.36	0.33	1.56
20	56	43.5	36	M5×0.8P×8	35	63	72	6	64	4.5	10.5	2	12	21	20		3	56.8	55.8	10.1	17.8	120	7.49	8.16	0.48	2.44
25	66	52	44	M5×0.8P×8	42	71	86	7	75	5.5	12.5	2	13	25	25		3	105	103	15.2	25.3	180	9.45	10.65	0.75	3.82

Product
BALL SPLINE
Specifications | Rotary Ball Spline

Accuracy grade of maximum manufacturing Length

Table 3[B2-44] show the accuracy grade of maximum manufacturing lengths of ball spline shafts.

Table 3 Accuracy grade of maximum manufacturing Length

Unit: *mm*

Nominal shaft diameter	Accuracy		
	Normal grade(N)	High grade(H)	Precision grade(P)
16	630	500	500
20	630	500	500
25	800	800	800

Note: The length in the table represents the overall shaft length.

Note: With standard hollow shaft type, the available maximum length is up to the length defined for the precision grade in the table.