Precision Ball Screw Support Bearings

TPI®

Precision Ball Screw Support Bearings-
BS Series Bearings

Pacific International
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CAT NO:2261/TE

TUNE PEI INDUSTRIAL CO., LTD.

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1.Precision BS Bearing Structure and Its Arrangement

The BS bearing incorporates the maximum possible number of small balls and has thicker inner and outer rings, and a larger contact angle of 60° . Thus, this type of bearing boasts greater axial rigidity. Additionally, since balls are used as the rolling elements, the starting torque of a angular contact thrust ball bearing is less than that of a roller bearing.

Open and light-contact sealed type BS bearings are available. The special crown type cage made by molded resin is standard.

The side faces of BS bearings are flush-ground to provide the same face height difference for both the front and back faces. As a result, bearings of the same part number can be freely combined into DB, DBT, DTBT configurations, and the adjustment for a relevant preload is no longer necessary. For improving in material on raceways and grease, and sealing, please contact TPI for further information.

The BS bearing is mainly installed on ball screws of machine tool feed systems, and two to four row arrangements are used in many cases. Both back-to-back and face-to-face duplex arrangement are used in this application. The face-to-face duplex arrangement may be used if misalignment is un-avoidable as shown in Fig.1.1.

Fig.1.1 Two to four row arrangements are used on ball screws of machine tool feed systems

A “V-shaped” marking on the outside surface of the outer rings of matched bearing sets indicates how the bearings should be mounted to obtain the proper preload in the set. The marking also indicates how the bearing set should be mounted in relation to the axial load. The “V” should point in the direction in which the axial load will act on the inner ring. In applications where there are axial loads in both directions, the “V” should point toward the greater fo the two loads, refer to Fig. 1.2 ◦

For universal combination bearings, the “V” marking on the outside surface of the outer rings shown in Fig. 1.3, prevents “direction” mistakes, ensures correct matching when they are mounted.

Fig.1.2 A "V-shaped" marking on the outside surface of the outer rings of matched bearing sets

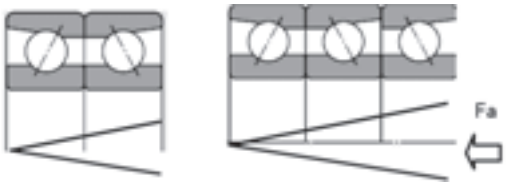
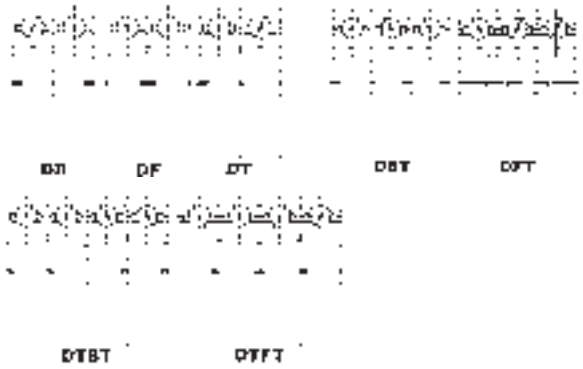


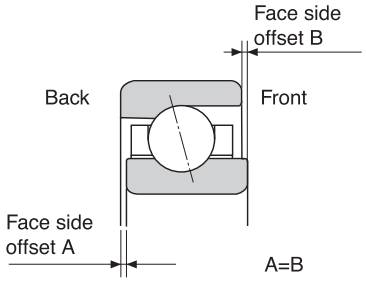
Fig.1.3 A “V-shaped” marking on the outside surface of the outer rings of universal combination bearings



1.2.3 Flush Grinding and Universal Combination

“Flush grinding” is a finishing technique in which the front and back faces of the inner and outer rings are aligned with each other to eliminate differences in face height(illustrated in Fig. 1.4). Such alignment can ensure the specified clearance and preload for DF, DB, and DT sets, but it is possible only if the combined bearings have the same clearance/preload symbols.

Fig.1.4 Flush grinding



If these combined bearings are used as part of multiple combined bearings. It is recommended that the variation of bore and outer diameter tolerance is within 1/3 of tolerance range. TPI bearings with special accuracy P4A that can accommodate small variations of bore and outer diameter tolerance. P4A bearings have the same running accuracy as P4 while has a narrower tolerance range. It is suitable for random matching on universal combination bearings. It also bring convenience for customers to optimize their inventory with more precision P4A bearings.

P4A bearings can control the bearing-to-bearing difference in the bore and outside diameters to no more than one third the tolerance (a minimum of 2 μm) as shown in Table 1.1. Their bearing code normally comes with flushed grinding and universal matching as follows:

Example：BS2562 G/GN P4A

Table 1.1 Tolerance of P4 and P4A Accuracy

Tolerance of bore diameter of inner ring unit: μm

Bore diameter (mm)		P4		P4A	
Over	Incl	High	Low	High	Low
17	30	0	-5	0	-3.5
30	50	0	-6	0	-5

Tolerance of outer diameter of outer ring unit: μm

Outer diameter (mm)		P4		P4A	
Over	Incl	High	Low	High	Low
30	50	0	-6	0	-5
50	80	0	-7	0	-5
80	120	0	-8	0	-7

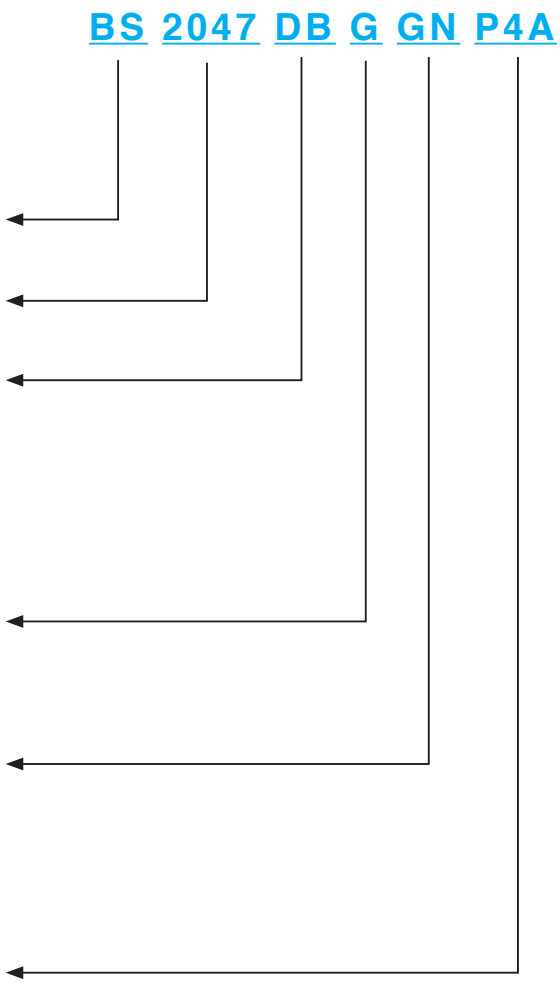
2 BS Bearing Number Codes

2.1 Bearing Designations

Rolling bearing part numbers indicate bearing type, dimensions, tolerances, internal construction, and other related specifications. Bearing numbers are comprised of a "basic number" followed by "supplementary codes." The makeup and order of bearing numbers is shown in Table 2.1.

Table 2.1 Number and code arrangement for deep groove and miniature ball bearings

Code			Explanation
Basic numbers	Ball material	blank	SUJ2
	Ring material	blank	SUJ2
	Bearing series	BS	Thrust ACBB (60° angle)
	Bore and outer diameter number	1747 : 4575	Shown (I.D.)(O.D.)
Supplementary suffix code	Matching code	DB	Back to back(double-row)
		DF	Face to face(double-row)
		DT	Tandem(double-row)
		DBT	Tandem and back to back (triple-row)
		DTBT	Tandem and back to back(quad-row)
	Flush grinding	G	Flush ground type
		blank	Without flush ground
	Preload codes	GL	Light preload
		GN	Normal preload
		GM	Medium preload
	Tolerance standard	P4	JIS standard Class 4
		UP	JIS standard UP
		P4A	JIS standard Class 4、special Class UP bore and outside diameter tolerance



2.2 Bearing Marking

Each TPI high precision bearing is marked with various identifiers on one side face of the inner and outer ring as shown in Fig. 2.1. Outer diameter and width deviation from the nominal diameter are marked on the outer ring, bore diameter and offset of flush side face on the inner ring. "\" marks the position of the maximum eccentricity.

Fig.2.1 Bearing marking designation

2.3 Comparison Table of TPI Bearings with Other Brand Bearings

For user's convenience, Table 2.2 lists TPI bearing number codes with those of other brand bearings side by side as quick reference to identify bearing characteristics including bearing series, dimensions, tolerance, and other internal structure etc.

Table 2.2 Comparison Table of TPI bearings with other brand bearings

Code							Explanation
Brand		TPI	NTN	NSK	FAG	SKF	
Basic numbers	Bearing series	BS	BST	TAC	(7602) BSB	BSD	Thrust ACBB (60° angle)
Supple-mentary suffix code	Bore and outer diameter number	2047	20X47-1B	20TAC47B	(020) 2047	2047	
		:	:	:	:	:	
		4072	40X72-1B	40TAC72B	(040) 4072	4072	
	Matching code	DB	DB	DB	DB	DB	Back to back(double-row)
		DF	DF	DF	DF	DF	Face to face(double-row)
		DT	DT	DT	DT	DT	Tandem(double-row)
		DBT	DBT	DBD	TBT	TBT	Tandem and back to back (triple-row)
		DTBT	DTBT	DBT	QBC	QBC	Tandem and back to back(quad-row)
	Preload codes	GL	/GL	C9	—	A	Light preload
		GN	/GN	C10	default	—	Normal preload
		GM	/GM	—	H	B	Medium preload
	Flush grinding	G	G	SU	U	G	Flush ground type
	Tolerance standard	P4	P4	P4	—	P4A,P7	No code for FAG(ABEC 7)

3 Bearing Stiffness and Preload

For axial loading applications, angular contact ball bearings are normally used. Their larger contact angle type provide higher axial rigidity. The stiffness of this type also depends on number and size of balls.

In Table 3.1, the (axial) rigidity is defined as the external axial load of a bearing set in DB or DF arrangement, which causes a deflection of 1 micron of the bearing rings to each other.

Table 3-1 Preload and Rigidity (DB and DF Arrangement) of BS standard series

Bearing Number	Bore d (mm)	Bearing Preload、Rigidity	
		Preload P_{ro} (N)	Rigidity R_{ao} (N/μm)
BS1747	17	2060	635
BS2047	20	2060	635
BS2562	25	3250	980
BS3062	30	3250	980
BS3572	35	3800	1130
BS4072	40	3800	1130
BS4090	40	7050	1470
BS4575	45	4200	1230

4 Bearing Limiting Speed

Angular contact ball bearings feature the highest rotation speed capabilities of all precision bearings. The limiting speeds listed in the precision bearing tables are guildline values. They are based on a single bearing that is lightly spring preloaded and subject to both grease and oil air lubrication. In situations where the lubricant is used as a mean to remove heat, higher speed can be achieved. Limiting temperature for grease lubricated bearings is lower than that for oil because of greater lubricant deterioration. Therefore, limiting speed for grease lubrication is consequently about 65% of the value achievable with oil.

Achievement of maximum speed is affected by internal configuration and correct assembly of the bearings. For bearing internal configuration, bearing arrangement, preload, bearing precision, contact angle and way of lubrication may influence bearing speed. Also, tolerance limits of shaft, housing, and spindle components, proper dynamic balancing of rotating parts, and efficient lubrication are external.

Accordingly, the limiting speed calculation can be performed based on the above consideration and the speed n_{max} is calculated as follows:

$$n_{max} = f_1 \cdot f_2 \cdot f_3 \cdot n_L \ min^{-1}$$

where， f_1 : Speed factor for bearing arrangement v.s. preload, refer to Fig. 4.1

f_2 : Speed factor for bearing precision, refer to Table 4.1

f_3 : Speed factor for contact angle, refer to Table 4.1

n_L : The limiting speed for grease and oil lubrications, refer to Precision Bearing Tables

The limiting speed for ball screw support BS thrust bearings are different from that for angular contact ball bearings. It accounts for the discrepancy for contact angle and preload between two types of bearings. The speed factor of limiting speed n_{max} for BS bearings are listed in Table 4.1.

Table 4.1 Speed factors for BS bearings f_1, f_2, f_3

Arrangement	DF DB	DFT DBT	DTFT DTBT
f_1	0.58	0.52	0.49
Precision	P4		P5
f_2	1.0		0.9
Contact angle	60°		
f_3	1.00		

5 Starting Torque

The BS type is mainly installed on ball screws of machine tool feed systems, and two to four row arrangements are used in many cases. This type is popular because greased sealed angular contact ball bearings are easy to handle. The starting torque can be altered depending on the bearing arrangement and preload. Reference starting torque values for BS bearings with normal preload are shown in Table 5.1.

Table 5.1 Starting torque of BS bearings with various arrangements

	Starting torque(reference) N·mm			
Bearing/ Arrangement	DF DB	DFT DBT	DTFT DTBT	DFTT DBTT
BS1747	175	245	355	275
BS2047	175	245	355	275
BS2562	305	420	615	470
BS3062	305	420	615	470
BS3572	380	510	755	590
BS4072	380	510	755	590
BS4090	960	1305	1930	1500
BS4575	430	580	860	665

6 Sealed Type BS Bearings

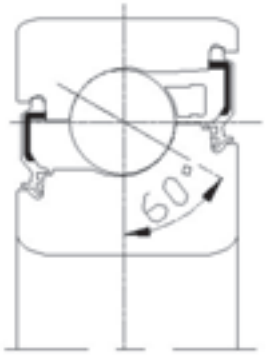
The sealed type BS bearing is pre-lubricated bearing with special long life grease. This bearing eliminates the need for further grease packing and allows easier handling. Both sides of the bearing are sealed to enhance contamination resistance and to preserve the grease.

This light contact LE seal shown in Fig.6.1 was first designed for automobile alternator application for years and approved to have excellent in sealing without compromising its light contact characteristics. That means, this LE seal provides low torque and therefore low heat generation, better grease preservation and contaimanation resistance.

In addition to the sealing performance, the seals for both front and back faces are different in clolors for easy handling. The front face(brown) and the back face(black) can be identified by the color of a seal, and one can easily check configuration during assembly.

PS: The material of BS bearing's seal is metal plate wraps synthetic rubber. Its allowable temperature of general material ranges from -25~120℃.

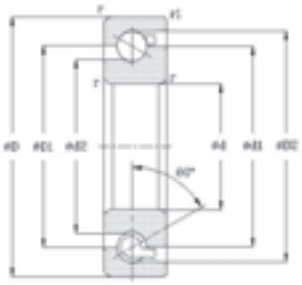
Fig.6.1 Illustration of the sealed type BS bearing



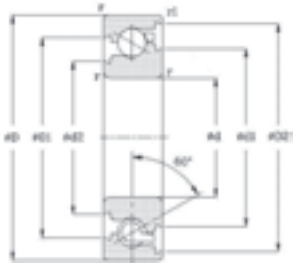
7 Request of Specification Investigation for BS Bearings

(1) Type of Machine	Ball screw support
(2) Ball screw support	Two-end support、small ball screw with one-end support、Pre-pulled
(3) Ball screw support bearing and installation	Fixed-Support, Fixed-Free, Fixed-Fixed Fixed-end(ACBB), Support(ACBB, DGBB, Needle roller bearing) Fixed-end (DB/DF, DBT/DFT, DTBT/DTFT) Support(Single, DB/DF, others) Shaft-bore: fit, Housing-O.D.: fit
(4) Load conditions (machining conditions)	Max. speed： min-1 Radial load Fr N Axial load Fa： N Moment： N-mm Unclamp force： N
(5) Shaft and housing	Material of shaft： Tolerance of shaft： mm Material of housing： Tolerance of housing： mm Outer diameter of housing： mm Bore diameter of hollow shaft： mm Spacer length： mm Ambient temperature： ℃
(6) Requirement value	Rigidity： N/μm Preload： N Starting torque N-mm Life： hour

8 BS Bearing Dimension Tables



Open Type



Sealed Type

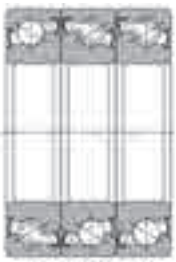
d 8~70mm

Boundary Dimensions (mm)					Basic Load Ratings				Static Axial Load Capacity		Bearing Numbers Type
d	D	B	$r_{s\ min}$	$r_{1s\ min}$	Dynamic		Static		(KN)	(Kgf)	
					C_a (KN)	C_a (Kgf)	C_{oa} (KN)	C_{oa} (Kgf)			
17	47	15	1	0.6	24.3	2470	37.5	3850	25.7	2620	BS1747 LLE* BS1747
20	47	15	1	0.6	24.3	2470	37.5	3850	25.7	2620	BS2047 LLE BS2047
25	62	15	1	0.6	29.2	2980	59.0	6050	40.0	4100	BS2562 LLE BS2562
30	62	15	1	0.6	29.2	2980	59.0	6050	40.0	4100	BS3062 LLE BS3062
35	72	15	1	0.6	31.0	3150	70.0	7150	47.5	4850	BS3572 LLE BS3572
40	72	15	1	0.6	31.0	3150	70.0	7150	47.5	4850	BS4072 LLE BS4072
40	90	20	1	0.6	58.5	6000	130	13300	88.5	9000	BS4090 LLE* BS4090
45	75	15	1	0.6	32.0	3300	77.5	7900	52.5	5350	BS4575 LLE* BS4575

Minimal allowable dimension for chamfer dimension r or r_1

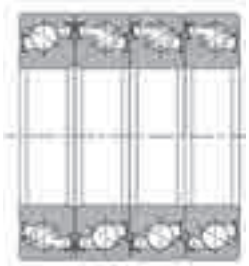
Bearings with * mark are not available but will be soon supplied. Please check with TPI

When one row bears axial load (DF)



When two rows bear axial load (DFT)

When two rows bear axial load (DTFT)



When three rows bear axial load (DFTT)

Dynamic equivalent axial load $P_a = XF_1 + YF_a$

Number of rows in bearing arrangement		2		3			4			
Number of rows subjected to axial load		1	2	1	2	3	1	2	3	4
$F_a/F_1 \leq 2.17$	X	1.90	–	1.43	2.32	–	1.17	1.90	2.52	–
	Y	0.55	–	0.76	0.35	–	0.88	0.55	0.26	–
$F_a/F_1 > 2.17$	X	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
	Y	1	1	1	1	1	1	1	1	1

Static equivalent axial load

$P_{0a} = F_a + 3.98F_1$

Load Center (mm)	Limiting Speeds n_L (min^{-1})		Reference Dimensions				Space Capacity (cm^3)	Weight (kg)	Bearing Numbers Type
a	Grease	Oil	d_1	d_2	D_1	D_2	Open (Approx)	Open (Approx)	
36.5	10300	13700	30.6 33.4	24.2 27.1	35.9 33.7	42.5 40.2	3.3	0.129	BS1747 LLE* BS1747
36.5	10300	13700	30.6 33.4	24.2 27.1	35.9 33.7	42.5 40.2	3.3	0.118	BS2047 LLE BS2047
49.2	7200	9600	45.0 47.9	38.7 41.6	50.4 48.2	57.3 55.2	4.6	0.231	BS2562 LLE BS2562
49.2	7200	9600	45.0 47.9	38.7 41.6	50.4 48.2	57.3 55.2	4.6	0.205	BS3062 LLE BS3062
53.8	6500	8600	53.0 55.8	46.7 49.5	58.6 56.3	65.0 63.2	5.4	0.284	BS3572 LLE BS3572
56.0	6500	8600	53.0 55.8	46.7 49.5	58.6 56.3	65.0 63.2	5.4	0.250	BS4072 LLE BS4072
64.8	5100	6800	65.1 68.0	54.1 57.0	70.2 68.0	82.1 80.3	12	0.636	BS4090 LLE* BS4090
58.4	5500	7400	59.4 62.2	52.8 55.6	64.4 62.2	70.9 69.1	6.0	0.254	BS4575 LLE* BS4575

9 Tolerance of Accuracy for BS Bearings

Inner rings

Unit：μm

Nominal bore diameter d		Single plane mean bore diameter deviation Δ_{dmp}						Width variation V_{Bs}			Radial runout K_{ia}			Face runout with bore S_d			Axial runout S_{ia}			Width deviation Δ_{Bs}					
mm		Class 5		Class 4❶		Class UP❶		Class 5	Class 4	Class UP	Class 5	Class 4	Class UP	Class 5	Class 4	Class UP	Class 5	Class 4	Class UP	Class 5		Class 4		Class UP	
over	incl.	high	low	high	low	high	low	max			max			max			max			high	low	high	low	high	low
10	18	0	-5	0	-4	0	-3.5	5	2.5	2	3.5	3	2	7	3	2	5	3	2	0	-120	0	-120	0	-100
18	30	0	-6	0	-5	0	-3.5	5	2.5	2	4	3	2	8	4	3	5	3	2	0	-120	0	-120	0	-100
30	50	0	-8	0	-6	0	-5	5	3	2	5	4	3	8	4	3	6	3	2	0	-120	0	-120	0	-100
50	80	0	-9	0	-7	0	-5	6	4	3	5	4	4	8	5	4	7	4	3	0	-150	0	-150	0	-150

❶The tolerance of outside diameter deviation Δds applicable to classes 4 and UP is the same as the tolerance of single plane mean outside diameter deviation Δdmp.

Outer rings

Unit：μm

Nominal bore diameter D		Single plane mean outside diameter deviation Δ_{Dmp}						Width variation V_{Cs}			Radial runout K_{ea}			Outside surface inclination S_D			Axial runout S_{ea}	Width deviation Δ_{Cs}
mm		Class 5		Class 4❷		Class UP❷		Class 5	Class 4	Class UP	Class 5	Class 4	Class UP	Class 5	Class 4	Class UP	All classes	All classes
over	incl.	high	low	high	low	high	low	max			max			max				
30	50	0	-7	0	-6	0	-5	5	2.5	2	7	5	4	8	4	3		
50	80	0	-9	0	-7	0	-5	6	3	2	8	5	4	8	4	3	Identical to Sia relative to d on the same bearing.	Identical to ΔBs relative to d on the same bearing.
80	120	0	-10	0	-8	0	-7	8	4	3	10	6	4	9	5	4		

❷The tolerance of outside diameter deviation ΔDs applicable to classes 4 and UP is the same as the tolerance of single plane mean outside diameter deviation ΔDmp.