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**Split Type Bushings
— Design and
Application**

SAE Standard
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**S. A. E.
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an American National Standard

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Ø SPLIT TYPE BUSHINGS - DESIGN AND APPLICATION

1. SCOPE:

This SAE Standard presents the standard sizes, important dimensions, specialized measurement techniques and tolerances for split type bushings. Both SI and inch sizes are shown; their dimensions are not exact equivalents. New designs shall use SI units.

Unless specifically stated as $\pm$, all tolerances are total.

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2. SPLIT BUSHINGS (FINISHED IN PLACE):2.1 Outside Diameter Tolerances^a:

A, O.D. Range	As Formed O.D. ^a	Ground or Sized O.D. ^a	As Formed O.D. With Graphite I.D. ^a
mm	mm	mm	mm
Up to 50	0.040	0.025	0.050
50- 80	0.045	0.035	0.055
80-120	0.050	0.040	0.065
120-152	0.085	0.070	0.100
in	in	in	in
Up to 1.95	0.0015	0.0010	0.0020
1.95-3.15	0.0015	0.0015	0.0020
3.15-4.70	0.0020	0.0015	0.0025
4.70-6.00	0.0035	0.0030	0.0040

^aRefer to O.D. checking procedures in 2.14 of this standard.

2.2 Wall Thickness:

Shaft Diameter	B, Recommended Nominal Wall
mm	mm
Up to 25	0.75 ^a
15- 75	1.50
40-115	2.50
50-145	3.00
80 and Over	3.50
in	in
Up to 1.00	0.031 ^a
0.50-3.00	0.062
1.50-4.50	0.094
2.00-5.70	0.125
3.15 and Over	0.156

^aAll 0.75 mm (0.031 in) wall bushings are furnished by manufacturer in solid bronze only.

2.3 Wall Thickness Tolerance: Furnished by manufacturer, as formed, for:

B, Wall	As-Formed Wall Tolerance for Finished-in- Place Bushings
mm	mm
0.75	0.08
1.50	0.08
2.50	0.10
3.00	0.14
3.50	0.18
in	in
0.031	0.003
0.062	0.003
0.094	0.004
0.125	0.005
0.156	0.007

NOTE: Choosing sizes in this table can expedite samples and small production runs, as partial tooling may be available.

2.4 Bushing Length Tolerance (See Fig. 1, Dimension C):

±0.25 mm (±0.010 in) for machined chamfer
 ±0.50 mm (±0.020 in) for die formed chamfer (plain)
 ±0.65 mm (±0.025 in) for die formed chamfer (with holes)

2.5 Chamfers:

2.5.1 Housing Bore Chamfers:

0.8 mm (0.03 in) x 40/60 deg included angle for up through 25 mm (1.00 in) diameter hole

1.5 mm (0.06 in) x 40/60 deg included angle for over 25 mm (1.00 in) diameter hole

2.5.2 Bushing (Endface Chamfers): Machined chamfers not recommended for 0.75 mm (0.031 in) wall.

Nominal Bushing Wall, B	Machined Chamfers		Die Formed Chamfers	
	Outside	Inside	Outside	Inside
mm	mm	mm	mm	mm
0.75	---	---	0.15-0.40	0.15-0.65
1.50	0.75-1.25	0.25-0.75	0.40-1.00	0.25-0.75
2.50	1.00-2.00	0.40-1.20	0.75-1.50	0.25-1.00
3.00	1.00-2.00	0.50-1.30	1.00-2.00	0.50-1.30
3.50	1.00-2.00	0.50-1.30	---	---
in	in	in	in	in
0.031	---	---	0.005-0.015	0.005-0.025
0.062	0.030-0.050	0.010-0.030	0.015-0.035	0.010-0.030
0.094	0.045-0.075	0.015-0.045	0.030-0.060	0.010-0.040
0.125	0.045-0.075	0.020-0.050	0.045-0.075	0.020-0.050
0.156	0.045-0.075	0.020-0.050	---	---

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2.6 Material Thickness and Stock Allowance for Finished-in-Place Bushings:

Nominal Wall	Actual Wall As Supplied, B	Min. Lining Thickness as Supplied	Min. Stock Allowance Per Side, As Supplied		
			Bored	Reamed	Burnished
mm	mm	mm	mm	mm	mm
0.75	0.86-0.94	--	0.13	0.08	0.025
1.50	1.66-1.74	0.40	0.13	0.08	0.025
2.50	2.65-2.75	0.45	0.15	0.10	0.025
3.00	3.23-3.37	0.50	0.25	0.13	0.025
3.50	3.81-3.99	0.55	0.30	0.15	0.025
in	in	in	in	in	in
0.031	0.036-0.039	--	0.005	0.003	0.001
0.062	0.068-0.071	0.015	0.005	0.003	0.001
0.094	0.100-0.104	0.017	0.006	0.004	0.001
0.125	0.135-0.140	0.020	0.010	0.005	0.001
0.156	0.168-0.175	0.022	0.012	0.006	0.001

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2.7 Seams:

2.7.1 Straight Seams:

Bushing O.D., A	Maximum Seam Opening (In Free State)
mm	mm
Up to 40	2.50
40-80	3.50
80 and over	6.50
in	in
Up to 1.5	0.100
1.5-3.0	0.125
3.0 and over	0.250

2.7.2 Clinched Seams (Fig. 3): Where the preceding seam openings cannot be tolerated because of assembly problems, clinched seams should be specified. Number of clinches, size and shape, are variable.

2.8 Grooves (Fig. 4):

2.8.1 Width: Width of groove will vary depending on the lubrication requirements of the specific application.

For an economical method of inspection, it is customary to dimension remaining wall from back of bushing to bottom of groove. Tolerance on this dimension to be 0.25 mm (0.010 in).

To have a common understanding between the inspection departments of both vendor and customer, the following note must appear on the bushing drawing: Slight cracks in groove allowable. No loose bearing material permissible.

Because of groove distortion in forming, groove dimensions are to be checked in the blank.

2.8.1 (Continued):

On bushings with coined grooves, the following note should appear: "Wall thickness build-up within 10 mm (0.40 in) of groove not to exceed 0.10 mm (0.004 in) (babitt and aluminum alloy) and 0.05 mm (0.002 in) (lead bronze) over maximum wall." The note also applies to reliefs stamped around holes and slots.

Grooving Patterns (Fig. 5) - Since numerous means of lubrication are employed, grooving design is quite varied. The following figures illustrate some of the more popular groove designs now in use.

2.9 Groove and Hole Location Tolerance (Fig. 6):

2.9.1 In Blank: ± 0.80 mm (± 0.030 in)

2.9.2 In Formed Bushing (Machined Chamfer): ± 0.50 mm (± 0.020 in) from end

2.10 Hole Size: Holes pierced in blank must have a minimum dimension of 3.0 mm (0.12 in). Avoid holes at 90 deg from either end of the seam split.

Distortion of holes due to forming is permissible as long as the minimum dimension is maintained.

Some special applications require odd-shaped lubricant cutouts; there is no limitation to the variations of these cutouts as long as manufacturing, gaging, and assembly considerations are satisfied.

2.11 Ball Indentations (Fig. 7): Ball indentations on the lining surface of the bushing provide small reservoirs which retain the lubricant and are very beneficial in grease-lubricated applications, ensuring good lubrication during engine starting.

This indenting of the bushing lining surface may be used to complement the lubricating grooves discussed in 2.8 of this standard.

Size and location of indents will vary slightly depending on the manufacturer.

2.12 Surface Finishes:

2.12.1 Housing Holes: Minimum: $1.5 \mu\text{m}$ (60 μin) R_a
Maximum: $3.0 \mu\text{m}$ (120 μin) R_a

2.12.2 Bushing Inside Diameter: The inside diameter surface finish of prebored bushings and those finished in place SHOULD NOT EXCEED $1.0 \mu\text{m}$ (40 μin) R_a .

- 2.12.3 Finishes on shafts SHOULD NOT EXCEED 0.4 μm (15 μin) R_a ; a MAXIMUM OF 0.25 μm (10 μin) R_a IS PREFERRED. On very severe applications, such as piston pins, a finer finish is required.

NOTE: The service life realized with any bushing material application depends very greatly on the finish condition of the shaft and bushing inside diameter.

- 2.13 Bushing Materials: For a complete discussion on the methods of manufacture, characteristics, and application of bushing materials, see SAE Standard, Bearing and Bushing Alloys - SAE J460 JUL74.

The steel backing generally specified for bushings is SAE 1010 FEB73.

- 2.14 O.D. Checking Procedures:

- 2.14.1 Split Block Method: The outside diameter is measured in a split gage block with a load F applied to the block.

Metric units:

$$F = K \sqrt{\frac{A}{D - T}}$$

F^1 = checking load in kN

K = Constant = 3.0 for steel back bushings
2.1 for solid bronze bushings
1.7 for solid aluminum bushings

A = Effective cross-sectional area in mm^2 (length x effective wall thickness)

D = Gage diameter in mm
= Maximum theoretical O.D. minus 0.013 mm

T = Effective wall thickness in mm
= Steel thickness + 1/2 lining thickness for steel backed bronze
= Wall thickness for solid bronze, aluminum or steel
= Steel thickness for babbitt-lined bushings

The indicator reading, when the load is applied, will be taken from zero as the high limit with the indicator tolerance being $\frac{\pi}{2}$ times the O.D. tolerance (refer to 1.1). The indicator is set at zero using a master gage of "D" diameter at an applied load of "F."

¹The basic method of checking outside diameter is the same as ISO standards. However, the checking load is calculated according to long established U.S.A. practice and is not the same as the ISO load.

2.14.1 (Continued):

Inch Units:

$$F = K \sqrt{\frac{A}{D - T}}$$

F = Checking load in lb

K = Constant = 3400 for steel back bushings
= 2400 for solid bronze bushings
= 1900 for solid aluminum bushings

A = Effective cross-sectional area in in²
(length x effective wall thickness, T)

D = Gage diameter in inches
= Maximum theoretical O.D. in free state minus 0.0005 in

T = Effective wall thickness in inches
= Steel thickness + 1/2 lining thickness for steel backed bronze
= Wall thickness for solid bronze, aluminum or steel
= Steel thickness for babbitt-lined bushings

2.14.2 Optional Solid Ring Go, No-Go Gaging Method: By hand push, the bushing must enter the go ring and must not enter the no-go ring.

2.14.2.1 If the maximum and minimum theoretical O.D. are specified:

Go Limit = Maximum O.D.
No-Go Limit = Minimum O.D.

2.14.2.2 If the master gage diameter (D) and the indicator tolerance under load (F) are specified:

Go Limit = D + 0.013 mm in metric units
Go Limit = D + 0.0005 inch in inch units
No-Go Limit = Go Limit - $\frac{2}{\pi}$ (Indicator Tolerance)

3. SPLIT BUSHINGS (PRECISION - PREBORED BY SUPPLIER):

- 3.1 Precision bushings are prebored by the bushing manufacturer to the following tolerances. It must be recognized that due to the accumulation of bushing and housing tolerances, this type of bushing does not give as close I.D. tolerance and alignment control as realized with finished-in-place bushings.

Except for the two variations noted as follows, all other previously discussed standards for finished-in-place bushings also apply for precision prebored bushings.

3.1 (Continued):

Wall Thickness Tolerance:

0.025 mm (0.001 in) up to 76 mm (3 in) diameter and less than 50 mm (2 in) length

0.040 mm (0.0015 in) over 76 mm (3 in) diameter and/or 50 mm (2 in) length

Lining Material Thickness

Nominal Wall Size, B	Min Lining Material Thickness
mm	mm
1.50	0.20
2.50	0.35
3.00	0.40
3.50	0.45
in	in
0.062	0.008
0.094	0.015
0.125	0.017
0.156	0.018

The phi (ϕ) symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.

TABLE 1A - Housing Bore Diameters and Bushing Lengths for Standard Bushings (mm)
Nominal Housing Diameter

Nom. ^a Shaft Size	0.75 Wall	1.5 Wall	2.5 Wall	3.0 Wall	3.5 Wall
7	8.5	--	--	--	--
8	9.5	--	--	--	--
9	10.5	--	--	--	--
10	11.5	--	--	--	--
11	12.5	--	--	--	--
12	13.5	--	--	--	--
13	14.5	16	--	--	--
14	15.5	17	--	--	--
15	16.5	18	--	--	--
16	17.5	19	--	--	--
17	18.5	20	--	--	--
18	19.5	21	--	--	--
19	20.5	22	--	--	--
20	21.5	23	--	--	--
21	22.5	24	--	--	--
22	23.5	25	--	--	--
23	24.5	26	--	--	--
24	25.5	27	--	--	--
25	26.5	28	--	--	--
27	--	30	--	--	--
29	--	32	--	--	--
31	--	34	--	--	--
33	--	36	--	--	--
35	--	38	--	--	--
37	--	40	--	--	--
39	--	42	44	--	--
41	--	44	46	--	--
43	--	46	48	--	--
45	--	48	50	--	--
47	--	50	52	--	--
49	--	52	54	--	--
51	--	54	56	57	--
55	--	58	60	61	--
59	--	62	64	65	--
63	--	66	68	69	--
67	--	70	72	73	--
71	--	74	76	77	--
75	--	78	80	81	--
79	--	--	84	85	86
83	--	--	88	89	90
87	--	--	92	93	94
91	--	--	96	97	98
95	--	--	100	101	102
99	--	--	104	105	106
103	--	--	108	109	110
107	--	--	112	113	114
111	--	--	116	117	118
115	--	--	--	121	122
119	--	--	--	125	126
123	--	--	--	129	130
127	--	--	--	133	134
131	--	--	--	137	138
135	--	--	--	141	142
140	--	--	--	146	147
145	--	--	--	151	152

TABLE 1B - Housing Bore Diameters and Bushing Lengths for Standard Bushings (in)
Nominal Housing Diameter

Nom. ^a Shaft Size	0.031 Wall	0.062 Wall	0.094 Wall	0.125 Wall	0.156 Wall
1/4	0.3125	---	---	---	---
9/32	0.3435	---	---	---	---
5/16	0.3750	---	---	---	---
11/32	0.4060	---	---	---	---
3/8	0.4375	---	---	---	---
13/32	0.4685	---	---	---	---
7/16	0.5000	---	---	---	---
15/32	0.5310	---	---	---	---
1/2	0.5625	0.6250	---	---	---
17/32	0.5935	0.6560	---	---	---
9/16	0.6250	0.6875	---	---	---
19/32	0.6560	0.7185	---	---	---
5/8	0.6875	0.7500	---	---	---
21/32	0.7185	0.7810	---	---	---
11/16	0.7500	0.8125	---	---	---
23/32	0.7810	0.8435	---	---	---
3/4	0.8125	0.8750	---	---	---
25/32	0.8435	0.9060	---	---	---
13/16	0.8750	0.9375	---	---	---
27/32	0.9060	0.9685	---	---	---
7/8	0.9375	1.0000	---	---	---
29/32	0.9685	1.0310	---	---	---
15/16	1.0000	1.0625	---	---	---
31/32	1.0310	1.0935	---	---	---
1	1.0625	1.1250	---	---	---
1- 1/16	---	1.1875	---	---	---
1- 1/8	---	1.2500	---	---	---
1- 3/16	---	1.3125	---	---	---
1- 1/4	---	1.3750	---	---	---
1- 5/16	---	1.4375	---	---	---
1- 3/8	---	1.5000	---	---	---
1- 7/16	---	1.5625	---	---	---
1- 1/2	---	1.6250	1.6875	---	---
1- 9/16	---	1.6875	1.7500	---	---
1- 5/8	---	1.7500	1.8125	---	---
1-11/16	---	1.8125	1.8750	---	---
1- 3/4	---	1.8750	1.9375	---	---
1-13/16	---	1.9375	2.0000	---	---
1- 7/8	---	2.0000	2.0625	---	---
1-15/16	---	2.0625	2.1250	---	---
2	---	2.1250	2.1875	2.2500	---
2- 1/8	---	2.2500	2.3125	2.3750	---
2- 1/4	---	2.3750	2.4375	2.5000	---
2- 3/8	---	2.5000	2.5625	2.6250	---
2- 1/2	---	2.6250	2.6875	2.7500	---
2- 5/8	---	2.7500	2.8125	2.8750	---
2- 3/4	---	2.8750	2.9375	3.0000	---
2- 7/8	---	3.0000	3.0625	3.1250	---
3	---	3.1875	3.2500	3.3125	---
3- 1/8	---	---	3.3125	3.3750	3.437
3- 1/4	---	---	3.4375	3.5000	3.562
3- 3/8	---	---	3.5625	3.6250	3.687
3- 1/2	---	---	3.6875	3.7500	3.812
3- 5/8	---	---	3.8125	3.8750	3.937
3- 3/4	---	---	3.9375	4.0000	4.062

TABLE 1B (Continued)

Nom. ^a Shaft Size	0.031 Wall	0.062 Wall	0.094 Wall	0.125 Wall	0.156 Wall
3- 7/8	--	--	4.0625	4.1250	4.187
4	--	--	4.1875	4.2500	4.312
4- 1/8	--	--	--	4.3750	4.437
4- 1/4	--	--	--	4.5000	4.562
4- 3/8	--	--	--	4.6250	4.687
4- 1/2	--	--	--	4.7500	4.812
4- 5/8	--	--	--	4.8750	4.937
4- 3/4	--	--	--	5.0000	5.062
4- 7/8	--	--	--	5.1250	5.187
5	--	--	--	5.2500	5.312
5- 1/4	--	--	--	5.5000	5.562
5- 1/2	--	--	--	5.7500	5.812
5- 3/4	--	--	--	6.0000	6.062
6	--	--	--	6.2500	6.312

^aThis SAE Standard uses nominal shaft diameters as a base. ISO Standards use nominal housing bores as a base. The two standards are in agreement as to dimensions and tolerances for bushings of the same size.

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TABLE 2A - Suggested Minimum Press Fit for Normal Steel or Cast Iron Housings^a (mm)

Nominal O.D.	Short Length (Equal to the Dia or Less)		Medium Length (Over Dia Including 2 x Diameter)		Long Length (Over 2 x Dia)	
	Solid Bronze	Bi-Metal ^b	Solid Bronze	Bi-Metal ^b	Solid Bronze	Bi-Metal ^b
7	0.025	0.025	0.025	0.025	0.025	0.013
10	0.025	0.025	0.025	0.025	0.025	0.013
13	0.040	0.040	0.040	0.040	0.025	0.025
16	0.050	0.040	0.050	0.040	0.040	0.025
19	0.065	0.050	0.050	0.040	0.040	0.025
22	0.075	0.065	0.065	0.050	0.050	0.040
25	0.090	0.065	0.075	0.050	0.050	0.040
28	0.100	0.075	0.090	0.065	0.065	0.040
31	0.100	0.075	0.090	0.065	0.065	0.040
35	0.115	0.090	0.100	0.075	0.075	0.050
39	0.115	0.090	0.100	0.075	0.075	0.050
45	0.125	0.100	0.100	0.090	0.075	0.050
51	0.125	0.100	0.100	0.090	0.075	0.050
57	0.140	0.115	0.115	0.090	---	---
64	0.140	0.115	0.115	0.090	---	---
70	0.150	0.125	0.125	0.100	---	---
76	0.150	0.125	0.125	0.100	---	---
89	0.180	0.150	---	---	---	---
102	0.200	0.180	---	---	---	---

^aNOTE: Bushing applications, in which any of the following conditions exist, should be given special considerations: 1. Aluminum housings. 2. Heavily-loaded applications. 3. Light section housings.

^bSteel-backed.

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TABLE 2B - Suggested Minimum Press Fit for Normal Steel or Cast Iron Housing^a (in)

Nominal O.D.	Short Length (Equal to the Dia or Less)		Medium Length (Over Dia Including 2 x Dia)		Nominal O.D.	Short Length (Equal to the Dia or Less)		Medium Length (Over Dia Including 2 x Dia)		Long Length (Over 2 x Dia)	
	Solid Bronze	Bi-Metal ^b	Solid Bronze	Bi-Metal ^b		Solid Bronze	Bi-Metal ^b	Solid Bronze	Bi-Metal ^b	Solid Bronze	Bi-Metal ^b
1/4	0.001	0.001	0.001	0.001	1-1/2	0.0045	0.0035	0.004	0.003	0.003	0.002
3/8	0.001	0.001	0.001	0.001	1-3/4	0.005	0.004	0.004	0.004	0.003	0.002
1/2	0.0015	0.0015	0.0015	0.001	2	0.005	0.004	0.004	0.004	0.003	0.002
5/8	0.002	0.0015	0.002	0.0015	2-1/4	0.0055	0.0045	0.0045	0.0045	—	—
3/4	0.0025	0.002	0.002	0.0015	2-1/2	0.0055	0.0045	0.0045	0.0045	—	—
7/8	0.003	0.0025	0.0025	0.002	2-3/4	0.006	0.005	0.005	0.004	—	—
1	0.0035	0.0025	0.003	0.002	3	0.006	0.005	0.005	0.004	—	—
1-1/8	0.004	0.003	0.0035	0.0025	3-1/2	0.007	0.006	—	—	—	—
1-1/4	0.004	0.003	0.0035	0.0025	4	0.008	0.007	—	—	—	—
1-3/8	0.0045	0.0035	0.004	0.003							

^aNOTE: Bushing applications, in which any of the following conditions exist, should be given special considerations:

1. Aluminum housings. 2. Heavily-loaded applications. 3. Light section housings.
- ^bSteel-backed.