

**SPLIT TYPE BUSHINGS—DESIGN AND APPLICATION**

**Foreword**—This reaffirmed document has been changed only to reflect the new SAE Technical Standards Board format.

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.

2. **References**

- 2.1 **Applicable Publications**—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

- 2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J459—Bearing and Bushing Alloys

SAE J460—Bearing and Bushing Alloys—Chemical Composition of SAE Bearing and Bushing Alloys

3. **Split Bushings (Finished in Place)**

- 3.1 **Outside Diameter Tolerances**—See Table 1.

**TABLE 1—OUTSIDE DIAMETER TOLERANCES**

A, OD Range mm	A, OD Range in	As Formed OD <sup>(1)</sup> mm	As Formed OD <sup>(1)</sup> in	Ground or Sized OD <sup>(1)</sup> mm	Ground or Sized OD <sup>(1)</sup> in	As Formed OD With Graphite ID <sup>(1)</sup> mm	As Formed OD With Graphite ID <sup>(1)</sup> in
Up to 50	Up to 1.95	0.040	0.0015	0.025	0.0010	0.050	0.0020
50– 80	1.95–3.15	0.045	0.0015	0.035	0.0015	0.055	0.0020
80–120	3.15–4.70	0.050	0.0020	0.040	0.0015	0.065	0.0025
120–152	4.70–6.00	0.085	0.0035	0.070	0.0030	0.100	0.0040

1. Refer to OD checking procedures in 3.14 of this document.

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3.2 Wall Thickness—(See Table 2.)

TABLE 2—WALL THICKNESS

Shaft Dia. mm	Shaft Dia. in	B, Recommended Nominal Wall mm	B, Recommended Nominal Wall in
Up to 25	Up to 1.00	0.75 <sup>(1)</sup>	0.031 <sup>(1)</sup>
15– 75	0.50–3.00	1.50	0.062
40–115	1.50–4.50	2.50	0.094
50–145	2.00–5.70	3.00	0.125
80 and Over	3.15 and Over	3.50	0.156

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

3.3 Wall Thickness Tolerance—Furnished by manufacturer, as formed (see Table 3), for:

TABLE 3—WALL THICKNESS TOLERANCE<sup>(1)</sup>

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

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

3.4 Bushing Length Tolerance—(See Figure 1, Dimension C)

- a.  $\pm 0.25$  mm ( $\pm 0.010$  in) for machined chamfer
- b.  $\pm 0.50$  mm ( $\pm 0.020$  in) for die formed chamfer (plain)
- c.  $\pm 0.65$  mm ( $\pm 0.025$  in) for die formed chamfer (with holes)

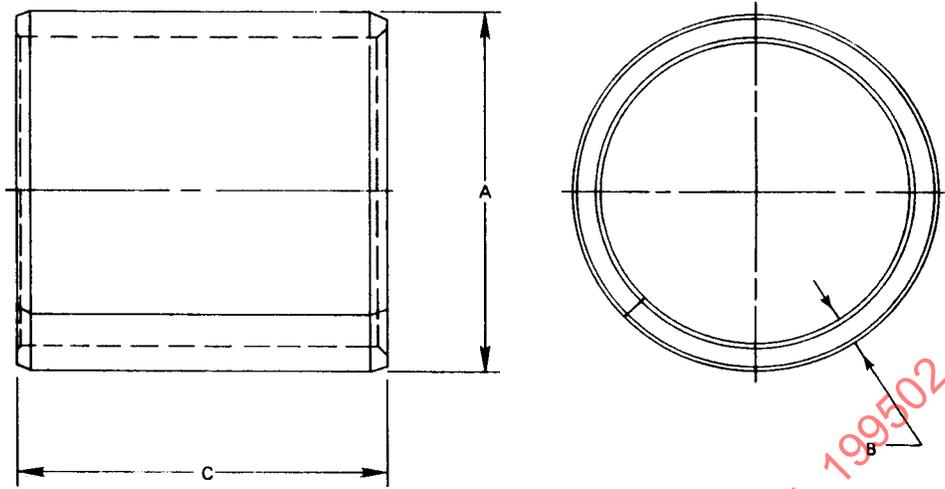


FIGURE 1—BASIC DIMENSIONS

3.5 Chamfers—(See Figure 2 and Table 4.)

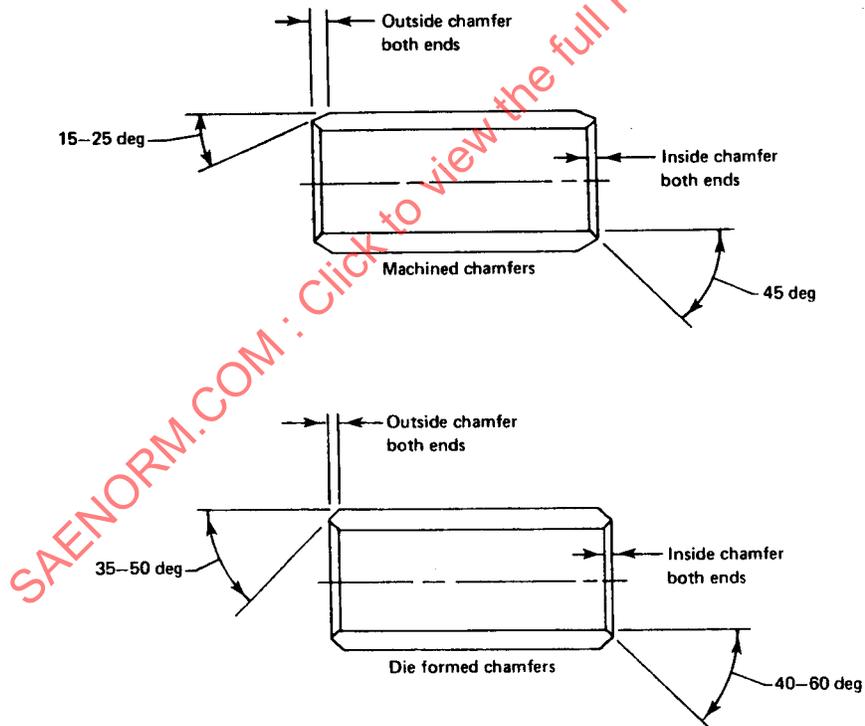


FIGURE 2—CHAMFERS

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TABLE 4—CHAMFER DIMENSIONS

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

3.5.1 HOUSING BORE CHAMFERS

- a. 0.8 mm (0.03 in) x 40/60 degree included angle for up through 25 mm (1.00 in) diameter hole
- b. 1.5 mm (0.06 in) x 40/60 degree included angle for over 25 mm (1.00 in) diameter hole

3.5.2 BUSHING (ENDFACE CHAMFERS)—Machined chamfers not recommended for 0.75 mm (0.031 in) wall.

3.6 Material Thickness and Stock Allowance for Finished-in-Place Bushings—(See Table 5.)

TABLE 5—MATERIAL THICKNESS AND STOCK ALLOWANCE FOR FINISHED-IN-PLACE BUSHINGS

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

3.7 Seams

3.7.1 STRAIGHT SEAMS—(See Table 6.)

TABLE 6—STRAIGHT SEAMS

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

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3.7.2 CLINCHED SEAMS—(See Figure 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.

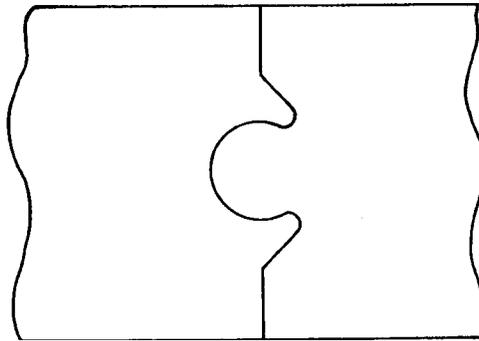
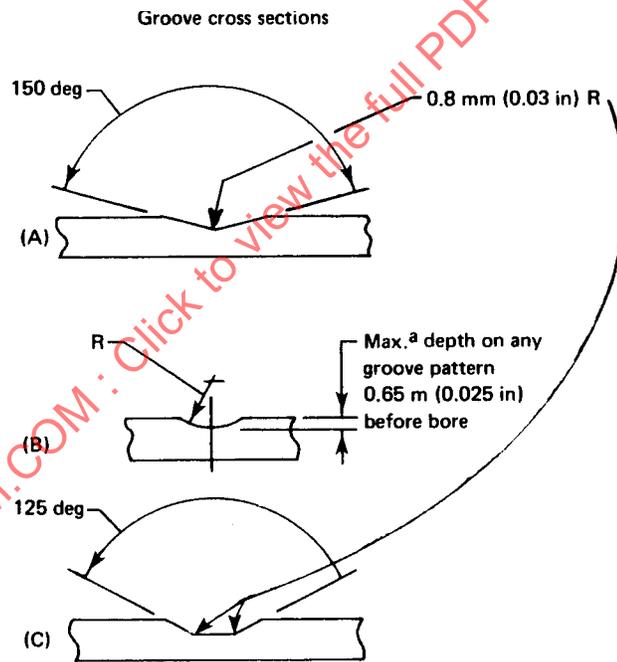


FIGURE 3—CLINCHED SEAMS

3.8 Grooves—(Figure 4)



<sup>a</sup>Grooves not recommended for walls less than 1.5 mm (0.062 in)

FIGURE 4—GROOVES

3.8.1 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).

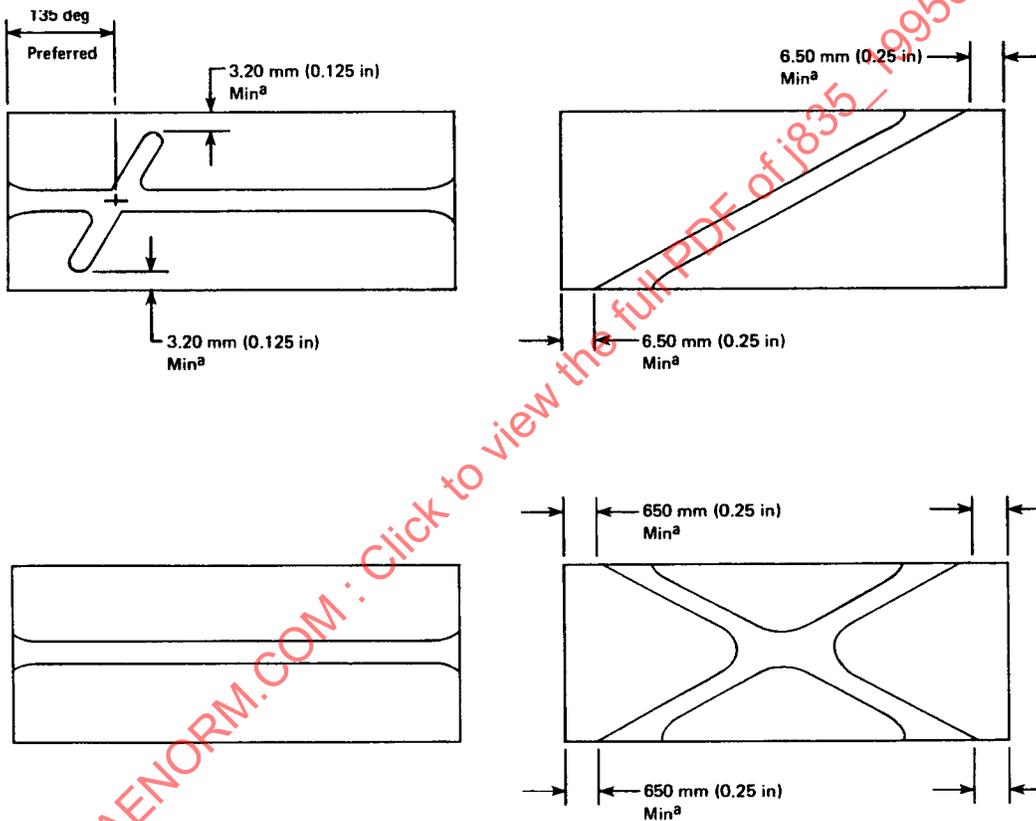
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To have a common understanding between the inspection departments of both vendor and customer, the following note must appear on the bushing drawing: *Slight cracks in groove allowable. No loose bearing material permissible.*

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

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) (babbitt 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.

3.8.1.1 Grooving Patterns—(Figure 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.



<sup>a</sup>Tolerance on actual dimension to be  $\pm 0.80$  mm ( $\pm 0.03$  in)

FIGURE 5—GROOVING PATTERNS

### 3.9 Groove and Hole Location Tolerance—(Figure 6)

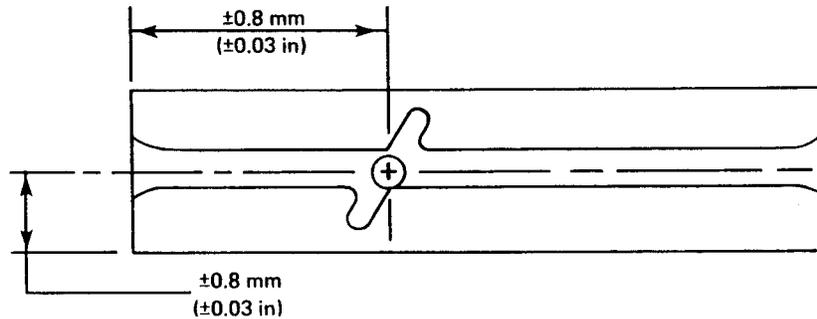


FIGURE 6—GROOVE AND HOLE LOCATION TOLERANCE

3.9.1 IN BLANK— $\pm 0.80$  mm ( $\pm 0.030$  in)

3.9.2 IN FORMED BUSHING (MACHINED CHAMFER)— $\pm 0.50$  mm ( $\pm 0.020$  in) from end

**3.10 Hole Size**—Holes pierced in blank must have a minimum dimension of 3.0 mm (0.12 in). Avoid holes at 90 degrees 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.

**3.11 Ball Indentations**—(Figure 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 3.8 of this document.

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

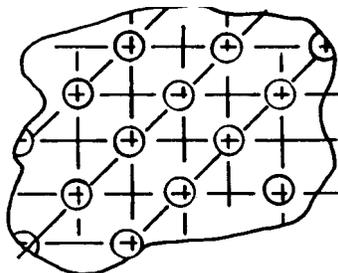


FIGURE 7—BALL INDENTATIONS

**3.12 Surface Finishes**

3.12.1 HOUSING HOLES

- a. Minimum— $1.5\ \mu\text{m}$  ( $60\ \mu\text{in}$ )  $R_a$
- b. Maximum— $3.0\ \mu\text{m}$  ( $120\ \mu\text{in}$ )  $R_a$

3.12.2 BUSHING INSIDE DIAMETER—The inside diameter surface finish of prebored bushings and those finished in place *SHOULD NOT EXCEED*  $1.0\ \mu\text{m}$  ( $40\ \mu\text{in}$ )  $R_a$ .

3.12.3 Finishes on Shafts *SHOULD NOT EXCEED*  $0.4\ \mu\text{m}$  ( $15\ \mu\text{in}$ )  $R_a$ ; a *MAXIMUM OF*  $0.25\ \mu\text{m}$  ( $10\ \mu\text{in}$ )  $R_a$  *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.

**3.13 Bushing Materials**—For a complete discussion on the methods of manufacture, characteristics, and application of bushing materials, see SAE J460.

The steel backing generally specified for bushings is SAE 1010 (February 1973).

**3.14 OD Checking Procedures**

3.14.1 SPLIT BLOCK METHOD—The outside diameter is measured in a split gage block with a load  $F$  applied to the block. (See Figure 8.)

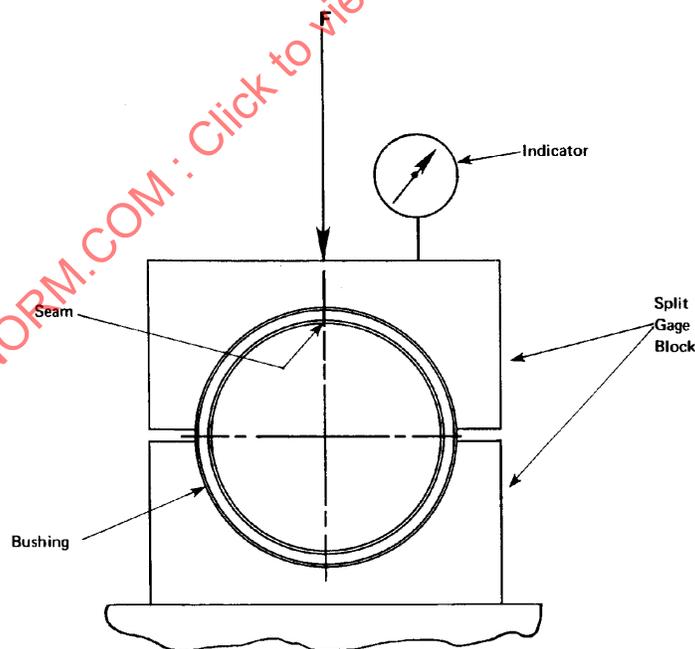


FIGURE 8—OD FIXTURE

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### 3.14.1.1 Metric Units—(See Equation 1)

$$F = K \sqrt{\frac{A}{D-T}} \quad (\text{Eq. 1})$$

where:

F = Checking load in kN

K = Constant = 3.0 for steel back bushings  
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<sup>2</sup> (length x effective wall thickness, T)

D = Gage diameter in millimeters

= Maximum theoretical OD in free state minus 0.013 mm

T = Effective wall thickness in millimeters

= Steel thickness + 1/2 lining thickness for steel backed bronze

= Steel thickness + 1/3 lining thickness for steel backed aluminum

= 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  $\pi/2$  times the OD tolerance (refer to 3.1). The indicator is set at zero using a master gage of "D" diameter at an applied load of "F."

### 3.14.1.2 Inch Units—(See Equation 2)

$$F = K \sqrt{\frac{A}{D-T}} \quad (\text{Eq. 2})$$

where:

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 in<sup>2</sup> (length x effective wall thickness, T)

D = Gage diameter in inches

= Maximum theoretical OD in free state minus 0.0005 in

T = Effective wall thickness in inches

= Steel thickness + 1/2 lining thickness for steel backed bronze

= Steel thickness + 1/3 lining thickness for steel backed aluminum

= Wall thickness for solid bronze, aluminum, or steel

= Steel thickness for babbitt-lined bushings

3.14.2 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.

3.14.2.1 If the maximum and minimum theoretical OD are specified:

- a. Go Limit = Maximum OD
- b. No-Go Limit = Minimum OD

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

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

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

**4. Split Bushings (Precision—Prebored by Supplier)**

4.1 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 ID 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.

4.1.1 WALL THICKNESS TOLERANCE

- a. 0.025 mm (0.001 in) up to 76 mm (3 in) diameter and less than 50 mm (2 in) length
- b. 0.040 mm (0.0015 in) over 76 mm (3 in) diameter and/or 50 mm (2 in) length

4.1.2 LINING MATERIAL THICKNESS—(See Tables 7 to 9B.)

**TABLE 7—LINING MATERIAL THICKNESS**

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

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TABLE 8A—HOUSING BORE DIAMETERS AND BUSHING LENGTHS FOR STANDARD BUSHINGS (MM)  
NOMINAL HOUSING DIAMETER

Nominal <sup>(1)</sup> 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

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TABLE 8A—HOUSING BORE DIAMETERS AND BUSHING LENGTHS FOR STANDARD BUSHINGS (MM)  
NOMINAL HOUSING DIAMETER (CONTINUED)

Nominal <sup>(1)</sup> Shaft Size	0.75 Wall	1.5 Wall	2.5 Wall	3.0 Wall	3.5 Wall
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

1. This 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 8B—HOUSING BORE DIAMETERS AND BUSHING LENGTHS FOR STANDARD BUSHINGS (IN)  
NOMINAL HOUSING DIAMETER

Nominal <sup>(1)</sup> 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	0.6874	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	—	—

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