Bronze oil-retaining bushes and thrust washers —

For aircraft

Foreword

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BS SP 94:1964 + A2:2012 supersedes BS SP 94:1964 (incorporating Amendment No. 1: 2002), which is withdrawn.

Text introduced or altered by Amendment No. 2 is indicated in the text by tags A₂ and A₂. Previous amendments are not indicated.

This British Standard has been prepared to provide a distinctive identification for bushes and thrust washers, impregnated with the oil required in bushes for aircraft use.

Reference is made in the standard to the following:

BS 1131, *Plain bearings (metal) — Part 5: Bronze oil-retaining bushes and thrust washers.*

BS 1916, *Limits and fits for engineering — Part 1: Limits and tolerances. Ministry of Aviation aircraft material specification*

Def Stan 91-49 (latest issue): *Lubricating oil instrument: Synthetic code no.: O-147 Joint services designation OX-14.*

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 6 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Amendments issued since publication

Amd. No.	Date of issue	Comments
5640	September 1965	See foreword
A2	July 2012	

Contents

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Section 1. General

1 Scope

This British Standard specifies materials, dimensions, tolerances, characteristics and identification of plain and flanged oil-retaining bushes and oil-retaining thrust washers for aircraft use. The bushes are charged with lubricating oil and have a normal oil content of from 25 to 30 per cent by volume, within the size range from $^3/_{16}$ in (4.8 mm) to $2^1/_2$ in (63.5 mm) nominal bore.

2 Definitions

For the purposes of this British Standard, A2⟩ the following terms and definitions apply.

2.1
oil-retaining bush
bush made by sintering compressed metal powder such that the pores left between the grains serve as a reservoir for oil for the working surface during service ⟨A2

3 Corrosion prevention and packaging

A2⟩ Bushes shall be packed so that they are not damaged in transit. They shall be protected against humidity, corrosion, dirt and other harmful agents. The packaging material in contact with the bush shall provide this protection and be grease resistant.

The specification number and part number shall be legibly marked on the package. ⟨A2

Section 2. Bushes

4 Material and manufacture

The bushes shall be manufactured by sintering compressed metal powder of the following composition:

Material	Per cent
Tin	9.5 to 10.5
Graphite	1.5 maximum
Total other elements	0.5 maximum
Copper	The remainder

5 Density

The density of the material shall be between 5.8 and 6.2 grammes per cubic centimetre.

6 Radial crushing strength

a) The radial crushing strength shall be not less than the value calculated as follows:

$$P = \frac{KWT^2}{D - T}$$

where

P = radial crushing strength in pounds

D = outside diameter of bush in inches

T = wall thickness of bush in inches

W = bush width in inches, and

K = 17 500

NOTE   Owing to slight variations between products of different manufacturers, exact dimensions and limits for diameters are not given in this standard as these dimensions are declared by respective manufacturers. Bushes supplied to this standard will, however, give correct bores when fitted in housings as specified.

b) Radial crushing strength shall be determined by compressing the test specimen between two flat surfaces, the direction of the load being normal to the longitudinal axis of the specimen. The point at which the load drops due to the first crack shall be considered the crushing strength. This test shall be applied to plain bushes.

Flanged bushes shall be tested by cutting off the flange from the body section and compressing the body section. This section shall satisfy the minimum strength requirements specified in Clause **6** a).

7 Oil content

a) The bushes shall be impregnated with oil OX-14 complying with the requirements of Def Stan 91-49.

b) The oil content shall be not less than 25 per cent by volume when calculated as follows:

$$P = \frac{B - A}{(B - C) \times S} \times 100$$

where

P = oil content by volume of interconnected void space in per cent

A = weight of lubricant-free sample, in grammes

B = weight of oil-impregnated sample, in grammes

C = weight of oil-impregnated sample immersed in water, in grammes

S = specific gravity of lubricant at the temperature of test.

c) Samples which are to be freed of lubricant for oil content determination shall be extracted in a Soxhlet apparatus of suitable size using toluol or petroleum ether as a solvent. After extraction, residual solvent shall be removed by heating samples for one hour at 250 °F. Alternate extraction and drying shall be continued until the dry weight is constant to 0.1 per cent.

8 Bush dimensions

The dimensions of the bushes shall be as shown in Table 1 or Table 2, as appropriate.

9 Housings

The limits on housings shall be BS 1916[1] "H8" limits, as shown in Column 5 of Table 1 or Column 9 of Table 2, as appropriate. The housing shall be of adequate mechanical strength and rigidity. An adequate chamfer shall be provided at the entry of the housing, to provide a lead-in for, and to prevent damage to, the bush.

10 Bore limits

The bushes are intended to provide a bore, after assembly, complying with BS 1916[1] "H8" limits, as given in Column 6 of Table 1 or Column 10 of Table 2, as appropriate. The bore diameter is controlled by the size of the fitting pin used; to achieve a bore as near as practicable to the low limit the fitting pin shall be of diameter 0.000 5 in (0.013 mm) greater than the low limit of the assembled bore. Normally, BS 1916[1] "f7" shaft limits are suitable for these bushes.

11 Concentricity[2]

The departure from concentricity shall be not greater than the following:

Nominal journal diameter	Eccentricity
in	in
Up to and including $\frac{1}{2}$ (12.7 mm)	0.001 (0.03 mm) [0.002 (0.05 mm) total indicator movement]
Over $\frac{1}{2}$ up to and including $1\frac{1}{2}$ (38.1 mm)	0.001 5 (0.04 mm) [0.003 (0.08 mm) total indicator movement]
Over $1\frac{1}{2}$ up to and including $2\frac{1}{2}$ (63.5 mm)	0.002 (0.05 mm) [0.004 (0.10 mm) total indicator movement]

12 Flange dimensions and limits

Flange dimensions and limits shall be as given in Columns 5, 6, 7 and 8 of Table 2.

13 Chamfers

Chamfers shall be provided on flanged bushes in accordance with Table 2, Column 12. All other corners on flanged bushes and on plain bushes shall be removed 0.010 in min. to 0.020 in max.

14 Identification

The bushes shall be identified for ordering purposes by the number of this British Standard, together with the appropriate reference number shown in the tables. A2) *Text deleted*. (A2 Each reference number consists of six digits, the first two representing the bore, the second two the outside diameter, and the last two the width, all expressed in sixteenths of an inch. The first four digits of the reference number are given in Column 1 of the tables; to these must be added two further digits representing the required standard width (Column 4) expressed in sixteenths of an inch. Thus, the full identification for a plain bush $\frac{3}{16}$ in bore, $\frac{5}{16}$ in outside diameter, $\frac{5}{8}$ in wide, would be SP94-030510 and for a flanged bush, SP94-F030510.

Section 3. Thrust washers

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a) The dimensions, tolerances and identification of thrust washers shall be in accordance with Table 3.

b) Material shall be as specified in Clause **4** Section 2.

c) Density of the material for washers shall be between 6.1 and 6.5 grammes per cubic centimetre.

d) The oil content shall be not less than 20 per cent by volume when calculated as shown in Clause **7** b) Section 2.

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[1] BS 1916, *"Limits and fits for general engineering"*, Part 1, *"Limits and tolerances"*.
[2] Concentricity is a measure of uniformity of wall thickness and is not to be confused with out-of-roundness.

Table 1 — Dimensions of plain bronze oil-retaining bushes

All dimensions are in inches

1	2	3	4									5	6
Reference No.	Nominal bore	Nominal outside diameter	Widths ± 0.005									Limits on housing ("H8" limits)[b]	Limits on bore of bush after assembly ("H8" limits)[b]
0305	3/16	5/16	1/8[a]	3/16[a]	1/4[a]	5/16[a]	3/8	7/16	1/2	5/8	3/4	+ 0.0009 − 0	+ 0.0007 − 0
0406	1/4	3/8	3/16[a]	1/4	5/16	3/8[a]	7/16	1/2	5/8	3/4		+ 0.0009 − 0	+ 0.0009 − 0
0407	1/4	7/16	3/16[a]	1/4	5/16	3/8[a]	7/16	1/2	5/8	3/4		+ 0.0010 − 0	+ 0.0009 − 0
0507	5/16	7/16	1/4[a]	5/16[a]	3/8[a]	7/16[a]	1/2[a]	9/16	5/8	3/4		+ 0.0010 − 0	+ 0.0009 − 0
0508	5/16	1/2	1/4[a]	5/16[a]	3/8[a]	7/16[a]	1/2[a]	9/16	5/8	3/4		+ 0.0010 − 0	+ 0.0009 − 0
0608	3/8	1/2	5/16[a]	3/8[a]	7/16[a]	1/2[a]	9/16[a]	5/8	3/4			+ 0.0010 − 0	+ 0.0009 − 0
0610	3/8	5/8	5/16[a]	3/8[a]	7/16[a]	1/2[a]	9/16[a]	5/8	3/4			+ 0.0010 − 0	+ 0.0009 − 0
0810	1/2	5/8	3/8[a]	1/2[a]	5/8[a]	3/4[a]						+ 0.0010 − 0	+ 0.0010 − 0
0812	1/2	3/4	3/8[a]	1/2[a]	5/8[a]	3/4[a]						+ 0.0012 − 0	+ 0.0010 − 0
1012	5/8	3/4	1/2[a]	5/8[a]	3/4[a]	7/8[a]	1[a]					+ 0.0012 − 0	+ 0.0010 − 0
1014	5/8	7/8	1/2[a]	5/8[a]	3/4[a]	7/8[a]	1[a]					+ 0.0012 − 0	+ 0.0010 − 0
1214	3/4	7/8	5/8[a]	3/4[a]	7/8[a]	1[a]	1 1/8[a]	1 1/4				+ 0.0012 − 0	+ 0.0012 − 0
1216	3/4	1	5/8[a]	3/4[a]	7/8[a]	1[a]	1 1/8[a]	1 1/4				+ 0.0012 − 0	+ 0.0012 − 0
1416	7/8	1	3/4[a]	7/8[a]	1[a]	1 1/4[a]	1 1/2					+ 0.0012 − 0	+ 0.0012 − 0
1418	7/8	1 1/8	3/4[a]	7/8[a]	1[a]	1 1/4[a]	1 1/2					+ 0.0012 − 0	+ 0.0012 − 0
1618	1	1 1/8	3/4[a]	1[a]	1 1/4[a]	1 1/2[a]						+ 0.0012 − 0	+ 0.0012 − 0
1620	1	1 1/4	3/4[a]	1[a]	1 1/4[a]	1 1/2[a]						+ 0.0016 − 0	+ 0.0012 − 0
1822	1 1/8	1 3/8	3/4[a]	1[a]	1 1/4[a]	1 1/2[a]						+ 0.0016 − 0	+ 0.0012 − 0
2024	1 1/4	1 1/2	1[a]	1 1/4[a]	1 1/2[a]	1 3/4[a]						+ 0.0016 − 0	+ 0.0016 − 0
2026	1 1/4	1 5/8	1[a]	1 1/4[a]	1 1/2[a]	1 3/4[a]						+ 0.0016 − 0	+ 0.0016 − 0
2226	1 3/8	1 5/8	1[a]	1 1/4[a]	1 1/2[a]	1 3/4[a]	2[a]					+ 0.0016 − 0	+ 0.0016 − 0
2428	1 1/2	1 3/4	1 1/4[a]	1 1/2[a]	1 3/4[a]	2[a]	2 1/4[a]					+ 0.0016 − 0	+ 0.0016 − 0
2430	1 1/2	1 7/8	1 1/4[a]	1 1/2[a]	1 3/4[a]	2[a]	2 1/4[a]					+ 0.0016 − 0	+ 0.0016 − 0
2832	1 3/4	2	1 1/4[a]	1 1/2[a]	1 3/4[a]	2[a]	2 1/4[a]					+ 0.0018 − 0	+ 0.0016 − 0
2836	1 3/4	2 1/4	1 1/4[a]	1 1/2[a]	1 3/4[a]	2[a]	2 1/4[a]					+ 0.0018 − 0	+ 0.0016 − 0
3236	2	2 1/4	1 1/2[a]	2[a]	2 1/2[a]							+ 0.0018 − 0	+ 0.0018 − 0
3240	2	2 1/2	1 1/2[a]	2[a]	2 1/2[a]							+ 0.0018 − 0	+ 0.0018 − 0
3644	2 1/4	2 3/4	1 1/2[a]	2[a]	2 1/2[a]							+ 0.0018 − 0	+ 0.0018 − 0
4048	2 1/2	3	1 1/2[a]	2[a]	2 1/2[a]	3[a]						+ 0.0018 − 0	+ 0.0018 − 0

NOTE   Bushes wider than the standard bushes may often be built-up by assembling together two narrower standard bushes.

[a] Preferred widths.

[b] From BS 1916, *"Limits and fits for engineering"*, Part 1, *"Limits and tolerances"*.

Table 2 — Dimensions of flanged bronze oil-retaining bushes

All dimensions are in inches

1	2	3	4					5	6	7	8	9	10	11	12
Reference No.	Nominal bore	Nominal outside diameter	Widths ± 0.005 (including flange thickness)					Nominal flange diameter	Nominal flange thickness	Limits on flange diameter	Limits on flange thickness	Radius between flange and O.D. max	Limits on housing ("H8" limits)[a]	Limits on bore of bush after assembly ("H8" limits)[a]	Chamfer of the bore at thrust end at 45° (nom.)
F0305	3/16	5/16	1/4	3/8				3/8	1/16	± 0.003	± 0.002	0.010	+ 0.0009 / − 0	+ 0.0007 / − 0	
F0406	1/4	3/8	1/4	3/8	1/2			1/2	1/16	± 0.003	± 0.002	0.020	+ 0.0009 / − 0	+ 0.0009 / − 0	0.030
F0508	5/16	1/2	1/4	3/8	1/2			5/8	1/16	± 0.003	± 0.002	0.020	+ 0.0010 / − 0	+ 0.0009 / − 0	0.040
F0610	3/8	5/8	3/8	1/2	5/8			3/4	1/8	± 0.003	± 0.002	0.020	+ 0.0010 / − 0	+ 0.0009 / − 0	
F0812	1/2	3/4	1/2	3/4	1			1	1/8	± 0.003	± 0.002	0.030	+ 0.0012 / − 0	+ 0.0010 / − 0	
F1014	5/8	7/8	1/2	3/4	1			1 1/4	1/8	± 0.005	± 0.003	0.030	+ 0.0012 / − 0	+ 0.0010 / − 0	
F1216	3/4	1	3/4	1	1 1/4			1 3/8	1/8	± 0.005	± 0.003	0.030	+ 0.0012 / − 0	+ 0.0012 / − 0	0.060
F1418	7/8	1 1/8	3/4	1	1 1/4			1 5/8	1/8	± 0.005	± 0.003	0.030	+ 0.0012 / − 0	+ 0.0012 / − 0	0.070
F1620	1	1 1/4	1	1 1/4	1 1/2	1 3/4		1 3/4	1/8	± 0.005	± 0.003	0.030	+ 0.0016 / − 0	+ 0.0012 / − 0	
F1822	1 1/8	1 3/8	1	1 1/4	1 1/2	1 3/4		1 7/8	1/8	± 0.005	± 0.003	0.030	+ 0.0016 / − 0	+ 0.0012 / − 0	
F2026	1 1/4	1 5/8	1	1 1/4	1 1/2	1 3/4		2	1/8	± 0.005	± 0.003	0.030	+ 0.0016 / − 0	+ 0.0016 / − 0	
F2228	1 3/8	1 3/4	1 1/4	1 1/2	1 3/4	2		2 1/4	3/16	± 0.005	± 0.003	0.065	+ 0.0016 / − 0	+ 0.0016 / − 0	
F2430	1 1/2	1 7/8	1 1/4	1 1/2	1 3/4	2		2 1/2	3/16	± 0.005	± 0.003	0.065	+ 0.0016 / − 0	+ 0.0016 / − 0	
F2836	1 3/4	2 1/4	1 1/2	1 3/4	2	2 1/4		2 3/4	3/16	± 0.010	± 0.005	0.065	+ 0.0018 / − 0	+ 0.0016 / − 0	0.090
F3240	2	2 1/2	1 1/2	1 3/4	2	2 1/4		3	3/16	± 0.010	± 0.005	0.065	+ 0.0018 / − 0	+ 0.0018 / − 0	0.100
F3644	2 1/4	2 3/4	1 1/2	1 3/4	2	2 1/4	2 1/2	3 1/4	3/16	± 0.010	± 0.005	0.065	+ 0.0018 / − 0	+ 0.0018 / − 0	
F4048	2 1/2	3	1 1/2	1 3/4	2	2 1/4	2 1/2	3 1/2	3/16	± 0.010	± 0.005	0.065	+ 0.0018 / − 0	+ 0.0018 / − 0	

[a] From BS 1916, "Limits and fits for engineering", Part 1, "Limits and tolerances".

Table 3 — Dimensions of bronze oil-retaining thrust washers

All dimensions are in inches

Reference No.	Nominal journal diameter	Bore + 0.010 − 0	Outside diameter	Tolerance	Thickness	Tolerance
OW03	$3/16$	$7/32$	$1/2$			
OW04	$1/4$	$9/32$	$5/8$			
OW05	$5/16$	$11/32$	$3/4$	+ 0 − 0.005	0.062 ($1/16$)	± 0.002
OW06	$3/8$	$13/32$	$7/8$			
OW08	$1/2$	$17/32$	$1 1/8$			
OW10	$5/8$	$21/32$	$1 1/4$		0.094 ($3/32$)	
OW12	$3/4$	$25/32$	$1 1/4$	+ 0 − 0.005	0.125 ($1/8$)	± 0.003
OW14	$7/8$	$29/32$	$1 3/4$			
OW16	1	$1 1/32$	2			
OW18	$1 1/8$	$1 5/32$	$2 1/8$			
OW20	$1 1/4$	$1 9/32$	$2 1/4$			
OW22	$1 3/8$	$1 13/32$	$2 1/2$	+ 0 − 0.005	0.156 ($5/32$)	± 0.003
OW24	$1 1/2$	$1 17/32$	$2 5/8$			
OW28	$1 3/4$	$1 25/32$	$2 7/8$			± 0.005
OW32	2	$2 1/16$	$3 1/4$			
OW36	$2 1/4$	$2 5/16$	$3 1/2$	+ 0 − 0.010	0.188 ($3/16$)	± 0.005
OW40	$2 1/2$	$2 9/16$	4			

Appendix Table for conversion of inches to approximate millimetre equivalents

in	mm	in	mm
$1/4$	6.4	1	25.4
$5/16$	7.9	2	50.8
$3/8$	9.5	3	76.2
$7/16$	11.1	4	101.6
$1/2$	12.7	5	127.0
$9/16$	14.3	6	152.4
$5/8$	15.9	7	177.8
$3/4$	19.1	8	203.2
$7/8$	22.2	9	228.6
		10	254.0

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