Thrust Washers – Design and Application – SAE J924 JAN81

SAE Standard
Completely Revised January 1981

THIS IS A PREPRINT WHICH IS SUBJECT TO REVISIONS AND CORRECTIONS. THE FINAL VERSION WILL APPEAR IN THE 1982 EDITION OF THE SAE HANDBOOK.

PREPRINT

φ THRUST WASHERS—DESIGN AND APPLICATION—SAE J924 JAN81

SAE Standard

Report of the Engine Committee, approved July 1965, completely revised January 1981.

1. Scope—This SAE Standard presents the basic size and tolerance information for the design and manufacture of thrust washers. In most cases the standard employs nominal figures in both metric and inch-pound units and, therefore, does not necessarily provide exact equivalents.

2. Full Round Washers

2.1 Outside Diameter and Inside Diameter Tolerances—Stamped

Thickness	Outside Diameter	Type of Grooves	I.D. and O.D. Tolerance
mm	mm		mm
0.75 thru 3	up to 75	none	±0.13
0.75 thru 3	up to 75	machined	±0.13
0.75 thru 3	up to 75	coined	±0.25
0.75 thru 3	over 75	any	±0.25
over 3	all	any	±0.25
in	in		in
0.03 thru 0.12	up to 3	none	±0.005
0.03 thru 0.12	up to 3	machined	±0.005
0.03 thru 0.12	up to 3	coined	±0.010
0.03 thru 0.12	over 3	any	±0.010
over 0.12	all	any	±0.010

Washers requiring closer outside or inside diameter tolerances than shown require machine finishing.

2.2 Thickness and Parallel Tolerances—Stamped

Thickness	Bimetal Roll Finish		Solid Bronze Roll Finish		Bimetal or Solid Bronze Ground Finish	
	Thickness Tolerance	Parallel Tolerance	Thickness Tolerance	Parallel Tolerance	Thickness Tolerance	Parallel Tolerance
mm	mm	mm	mm	mm	mm	mm
0.75	–	–	±0.025	0.03	–	–
1.5	±0.025	0.03	±0.025	0.03	–	–
2.5	±0.025	0.04	±0.025	0.04	–	–
3.0	±0.04	0.05	±0.04	0.08	±0.02	0.03
4.0	±0.05	0.08	±0.05	0.10	±0.02	0.03
5.0	–	–	±0.05	0.10	±0.025	0.03
6.5	–	–	±0.08	0.15	±0.025	0.05
in	in	in	in	in	in	in
0.03	–	–	±0.001	0.001	–	–
0.06	±0.001	0.001	±0.001	0.001	–	–
0.09	±0.001	0.002	±0.001	0.002	–	–
0.12	±0.002	0.002	±0.002	0.003	±0.001	0.001
0.16	±0.002	0.003	±0.002	0.004	±0.001	0.001
0.19	–	–	±0.002	0.004	±0.001	0.001
0.25	–	–	±0.003	0.006	±0.001	0.002

Washers are generally used as fabricated from strip stock. For applications requiring closer tolerances than shown, a ground finish is necessary.

2.3 Flatness Tolerances—A thrust load, when exerted against a thrust surface solidly backed up, will flatten or straighten the washer surface to a degree dependent upon the relative strength of the two. Washers of a thickness through 4 mm (0.16 in) are, therefore, used as stamped. Washers of 5 and 6.5 mm (0.19 and 0.25 in) thickness are supplied with a ground finish. Following are standard commercial washer flatness tolerances:

Description	Thickness	Flatness Tolerance
	mm	mm
Plain (no grooves)	0.75	0.20 up to 55 mm O.D. 0.23 up to 75 mm O.D. 0.25 over 75 mm O.D.
Plain or with machined grooves	1.5 and 2.5	0.07 + 0.03 for each 25 mm of O.D. or portion over 75
	3 and 4	0.07 + 0.015 for each 25 mm of O.D. or portion over 75
	5 and 6.5 (ground finish only)	0.03 + 0.015 for each 25 mm of O.D. or portion over 75
With bent lugs and/or coined grooves	1.5 and 2.5	0.12 + 0.03 for each 25 mm of O.D. or portion over 75
	3 and 4	0.12 + 0.015 for each 25 mm of O.D. or portion over 75
	5 and 6.5 (ground finish only)	0.03 + 0.015 for each 25 mm of O.D. or portion over 75
	in	in
Plain (no grooves)	0.03	0.008 up to 2 in O.D. 0.009 up to 3 in O.D. 0.010 over 3 in O.D.
Plain or with machined grooves	0.06 and 0.09	0.003 + 0.001 per in of O.D. or portion over 3
	0.12 and 0.16	0.003 + 0.0005 per in of O.D. or portion over 3
	0.19 and 0.25 (ground finish only)	0.001 + 0.0005 per in of O.D. or portion over 3
With bent lugs and/or coined grooves	0.06 and 0.09	0.005 + 0.001 per in of O.D. or portion over 3
	0.12 and 0.16	0.005 + 0.0005 per in of O.D. or portion over 3
	0.19 and 0.25 (ground finish only)	0.001 + 0.0005 per in of O.D. or portion over 3

2.4 Flatness Check—Parallel Plate Method—Pieces must drop by their own weight between vertical parallel plates spaced a distance apart equal to the tolerance shown in paragraph 2.3 plus the maximum washer thickness.

2.5 Surface Finish

2.5.1 Non-Ground—Surfaces may be rolled, matted, or specially prepared as required, and should be free of nicks and gouges with raised metal and other imperfections which would adversely affect performance. The degree of surface imperfections allowable should be agreed to between vendor and customer.

2.5.2 Ground—When grinding is required, faces will be ground to 0.8 μm (30 μin) R_a on the thrust face and 1.8 μm (72 μin) R_a on the back face. Mating thrust faces should have 0.2—0.3 μm (8—12 μin) R_a surface finish ground and polished on a circumferential pattern.

2.6 Lining Thickness—Bimetal Washers—It is advisable to keep lining thickness low for ease of manufacture and economy. A lining thickness of 0.20—0.40 mm (0.008—0.016 in) is recommended in both cast and sintered materials.

2.7 Thrust Washer Materials—A complete discussion of the materials commonly used in thrust washer applications can be found in the SAE Standard "Bearing and Bushing Alloys," SAE J460.

2.8 Steel Backing—The steel backing commonly specified for bimetal thrust washers is SAE 1008 or 1010.

The 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.

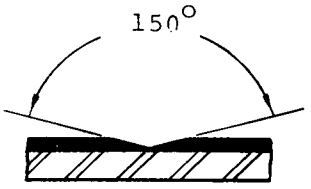
2.9 Chamfers—Normally washers are not machine chamfered, only tumbled to remove burrs and sharp edges. Specific chamfers require additional machining and add to the cost of the part.

2.10 Grooves—The major portion of thrust washer applications can be accommodated by simple type grooving (see paragraphs 2.11, 2.12, and 2.13). In cases of marginal and difficult lubrication or high loading, special grooves can be utilized to improve washer life (for example see paragraph 2.14). Typical groove types are listed below in order of increasing effectiveness and cost with approximate load carrying capacities. The load capacities shown were developed under specific test conditions and are not intended to be absolute maximums, but rather show relative differences at real magnitudes. Applications with load values approaching or exceeding the values shown should be undertaken only after thorough bearing analysis.

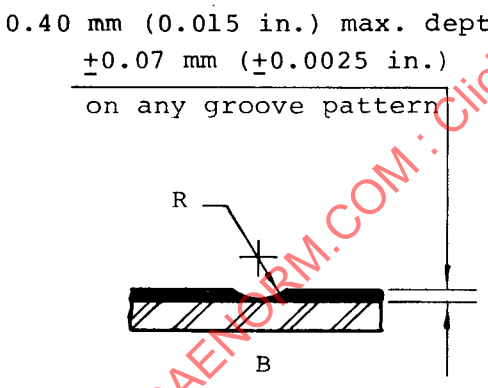
(a) Straight through "V" type and plain tear drops coined—1400 kPa (200 psi) maximum.
(b) Blended tear drops—machined—2100 kPa (300 psi) maximum.
(c) Tapered land type—machined—3500 kPa (500 psi) maximum.

2.11 Standard Groove Cross Sections—The figure illustrates the typical cross sections of coined oil grooves preferred for all thrust washer materials. Only groove sections "A" and "B" should be used in high lead alloys.

To have a common understanding between the inspection departments of both vendor and customer, the following note must appear on bimetal washer drawings: "Cracks in the lining material in the grooved area allowable. No loose material permissible."



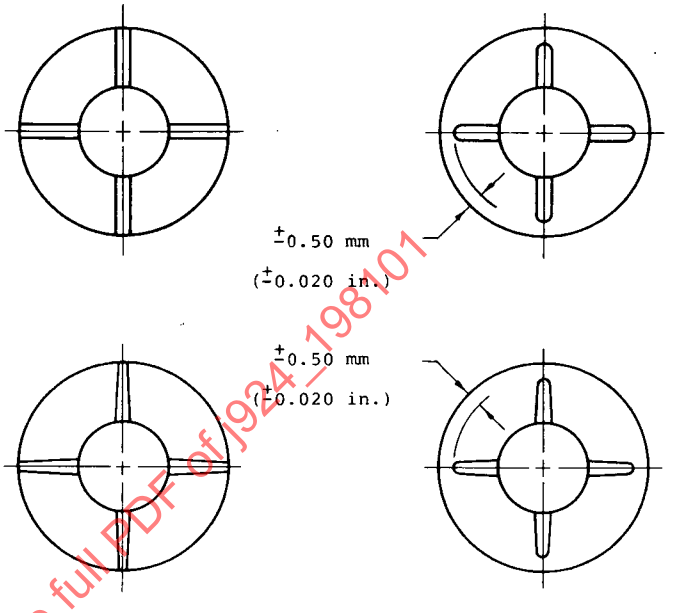
A



2.12 Groove Depth—The maximum depth for coined grooves is 0.40 mm (0.015 in). If greater depth is required, a machining operation is necessary. Tolerance on groove depth is ±0.07 mm (±0.0025 in).

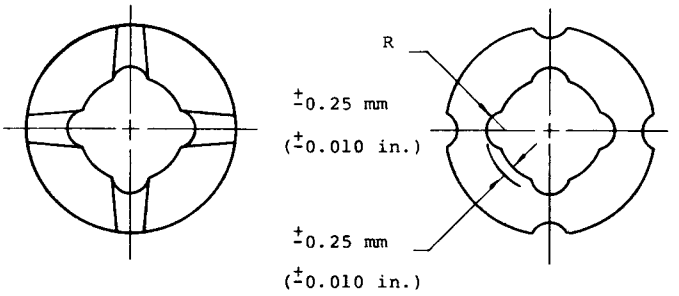
From the standpoint of maintaining flatness in a washer with coined grooves, it is advisable to keep the number of grooves and groove depth to a minimum.

2.13 Groove Patterns—Grooves can be made either stopped off or run through as shown. If stopped off, the tolerances shown for location should be used for most economical manufacture.

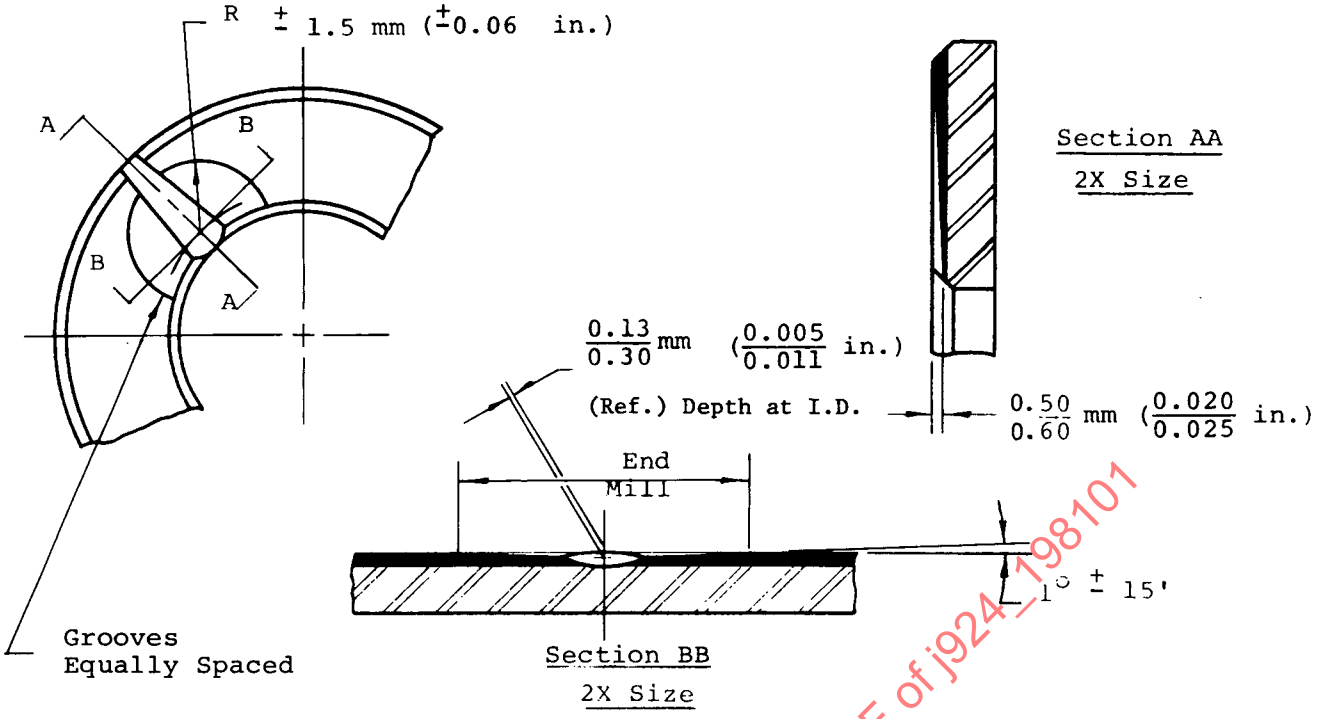


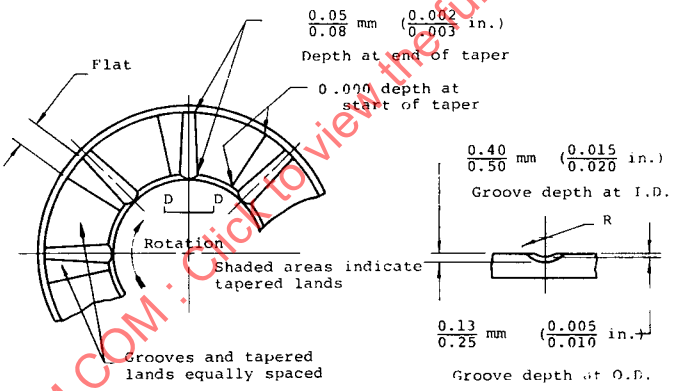
Most grooves may be furnished on one or both sides and may vary in number depending upon material and specific job requirements.

Frequently, it is desirable to provide more than ordinary means of oil flow to a thrust surface. To do this, scallops can be used. These can be punched on either the inside diameter, outside diameter, or both, with a tolerance of ±0.25 mm (±0.010 in) on the radius and depth.



2.14 Special Grooving and Thrust Face Contour—For applications having higher loads, washers employing blended tear drop grooves or tapered lands can be used. Applications of this type should be referred to a bearing designer for analysis.

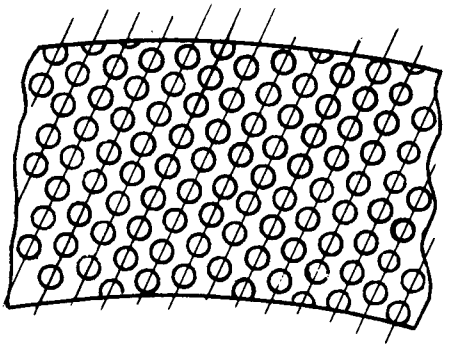




TAPERED LAND TYPE

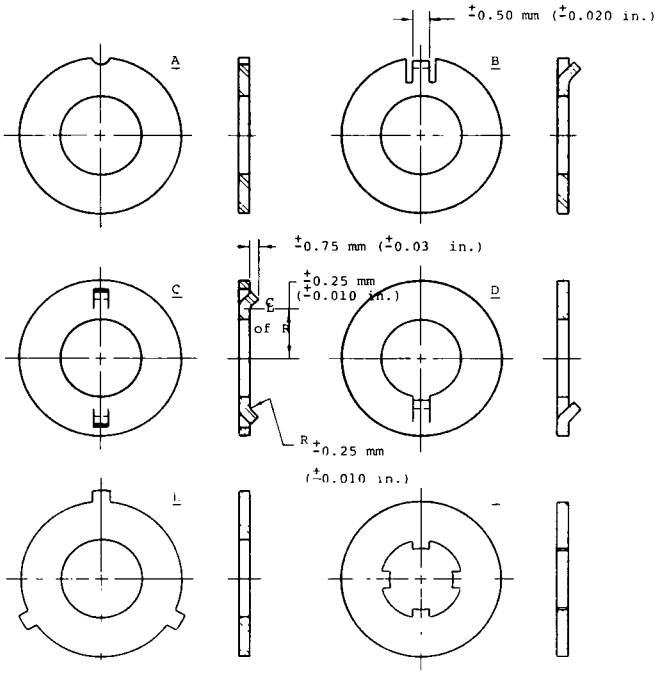
View D
2X Size

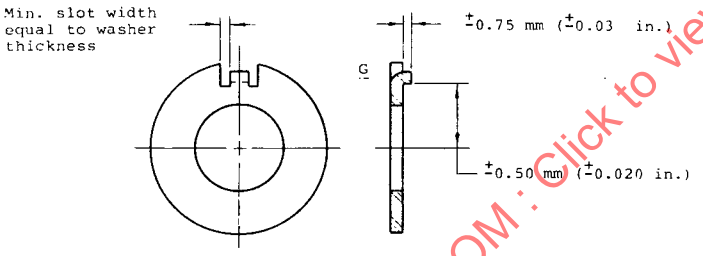
For applications having marginal lubrication, it is possible to provide lubricant retention by using ball indented or graphited stock.



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

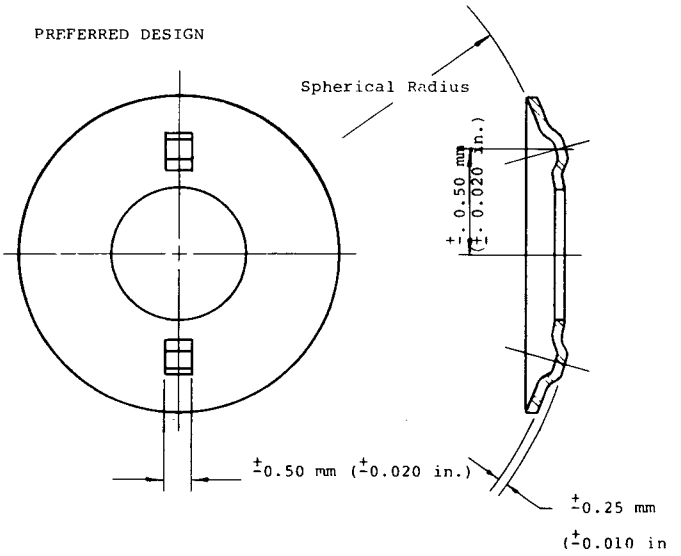
2.15 **Locating and Retention Features**—Locating or locking features, used except in the case of floating washers, can be supplied in the form of notches or tabs with standard manufacturing tolerances as shown.





Thickness	Thickness Tolerance
mm	mm
0.75—steel or solid bronze only	±0.025
1.5	±0.025
2.5	±0.025
3.0	±0.04
4.0	±0.05
in	in
0.03—steel or solid bronze only	±0.001
0.06	±0.001
0.09	±0.001
0.12	±0.002
0.16	±0.002

Outside Diameter	I.D. and O.D. Tolerance	Spherical Radius Tolerance
mm	mm	mm
up to 75	±0.25	0.08
over 75	±0.40	0.13
in	in	in
up to 3	±0.010	0.003
over 3	±0.015	0.005



Design A shows a notched outside diameter which receives a dowel pin to prevent rotation.

Designs B, C, and D show formed tabs which can be located either on the inside diameter, outside diameter, or on the face.

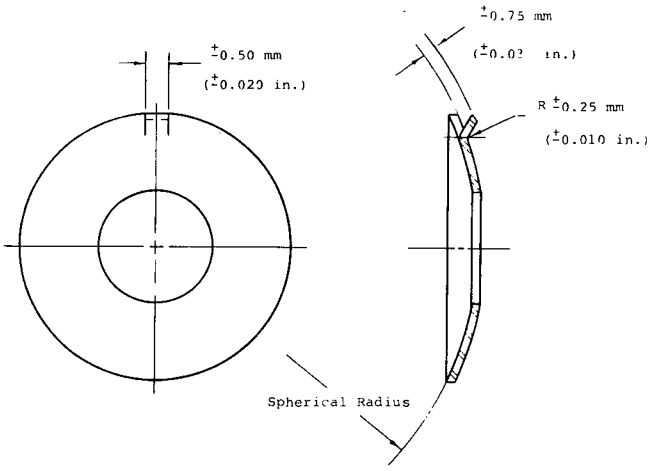
Designs E and F show flat inside and outside diameter tabs which fit into slots, notches, keyways, or splines which offer positive locking with a minimum of cost.

Design G shows a 90 deg formed tab which can be located either on the inside or outside diameter.

Cracks at bend of lug which are free of loose and foreign material and do not significantly affect strength are permissable.

2.16 Spherical washers can be produced from plain steel, solid bronze, or steel backed bronze. All materials may be ball indented for added oil retention and steel washers may be case hardened.

Tolerances for spherical washers are as follows:



3. *Half Washers*

3.1 Outside Diameter and Inside Diameter Tolerances—Stamped

Thickness	Outside Diameter	Type of Grooves	I.D. and O.D. Tolerance
mm	mm		mm
0.75 thru 3	up to 100	none	±0.13
0.75 thru 3	up to 100	machined	±0.13
0.75 thru 3	up to 100	coined	±0.25
0.75 thru 3	over 100	any	±0.25
over 3	all	any	±0.25
in	in		in
0.03 thru 0.12	up to 4	none	±0.005
0.03 thru 0.12	up to 4	machined	±0.005
0.03 thru 0.12	up to 4	coined	±0.010
0.03 thru 0.12	over 4	any	±0.010
over 0.12	all	any	±0.010

Half washers requiring closer outside or inside diameter tolerances than shown require machine finishing.

3.2 Thickness and Parallel Tolerances—Stamped

Thickness	Bimetal Roll Finish		Solid Bronze Roll Finish		Bimetal or Solid Bronze Ground Finish	
	Thickness Tolerance	Parallel Tolerance	Thickness Tolerance	Parallel Tolerance	Thickness Tolerance	Parallel Tolerance
mm	mm	mm	mm	mm	mm	mm
1.5	±0.025	0.03	±0.04	0.03	–	–
2.5	±0.025	0.04	±0.04	0.04	–	–
3.0	±0.04	0.05	±0.05	0.08	±0.025	0.03
4.0	±0.05	0.08	±0.05	0.10	±0.025	0.03
5.0	–	–	±0.05	0.10	±0.025	0.03
6.5	–	–	±0.08	0.15	±0.025	0.05
in	in	in	in	in	in	in
0.06	±0.001	0.001	±0.0015	0.001	–	–
0.09	±0.001	0.002	±0.0015	0.002	–	–
0.12	±0.002	0.002	±0.002	0.003	±0.001	0.001
0.16	±0.002	0.003	±0.002	0.004	±0.001	0.001
0.19	–	–	±0.002	0.004	±0.001	0.001
0.25	–	–	±0.003	0.006	±0.001	0.002

3.3 Flatness Tolerances

Description	Thickness	Flatness Tolerance
	mm	mm
Plain or with machined grooves	1.5 and 2.5	0.05 + 0.03 for each 25 mm of O.D. or portion over 75
	3 and 4	0.05 + 0.015 for each 25 mm of O.D. or portion over 75
	5 and 6.5 (ground finish only)	0.03 + 0.015 for each 25 mm of O.D. or portion over 75
With coined grooves	1.5 and 2.5	0.08 + 0.03 for each 25 mm of O.D. or portion over 75
	3 and 4	0.08 + 0.015 for each 25 mm of O.D. or portion over 75
	5 and 6.5 (ground finish only)	0.03 + 0.015 for each 25 mm of O.D. or portion over 75
	in	in
Plain or with machined grooves	0.06 and 0.09	0.002 + 0.001 per in of O.D. or portion over 3
	0.12 and 0.16	0.002 + 0.0005 per in of O.D. or portion over 3
	0.19 and 0.25 (ground finish only)	0.001 + 0.0005 per in of O.D. or portion over 3
With coined grooves	0.06 and 0.09	0.003 + 0.001 per in of O.D. or portion over 3
	0.12 and 0.16	0.003 + 0.0005 per in of O.D. or portion over 3
	0.19 and 0.25 (ground finish only)	0.001 + 0.0005 per in of O.D. or portion over 3

3.4 Flatness Check—Parallel Plate Method—See paragraph 2.4.

3.5 Surface Finish—Ground—See paragraph 2.5.

3.6 Lining Thickness—Bimetal

Lining Material	Minimum Lining Thickness	
	mm	in
Babbitt	0.25	0.010
Aluminum	0.25	0.010
Bronze	0.20	0.008

3.7 See paragraph 2.7.

3.8 See paragraph 2.8.

3.9 See paragraph 2.9.

3.10 See paragraph 2.10.

3.11 See paragraph 2.11.

3.12 See paragraph 2.12.

3.13 Groove Patterns—Grooves can be made either stopped off or run through as shown. If stopped off, the tolerances shown should be used for most economical manufacture.