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|----------------------------------------------------------------------------------|-----------------------------------------|--------------------------|---------------------|
|  | <b>SURFACE<br/>VEHICLE<br/>STANDARD</b> | <b>SAE</b>               | <b>J924 JUN2011</b> |
|                                                                                  |                                         | Issued                   | 1965-07             |
|                                                                                  |                                         | Stabilized               | 2011-06             |
| Thrust Washers – Design and Application                                          |                                         | Superseding J924 FEB1995 |                     |

## RATIONALE

The technical report covers technology, products, or processes which are mature and not likely to change in the foreseeable future.

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

**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. References**

**2.1 Applicable Publication**—The following publication forms 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 J460—Bearing and Bushing Alloys—Chemical Composition of SAE Bearing and Bushing Alloys

**3. Full Round Washers**

**3.1 Outside Diameter and Inside Diameter Tolerances—Stamped**—(See Tables 1A and 1B.)

**TABLE 1A—OUTSIDE DIAMETER AND INSIDE DIAMETER TOLERANCES—STAMPED (mm)**

| Thickness   | Outside Diameter | Type of Grooves | ID and OD Tolerance |
|-------------|------------------|-----------------|---------------------|
| 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               |

**TABLE 1B—OUTSIDE DIAMETER AND INSIDE DIAMETER TOLERANCES—STAMPED (in)**

| Thickness      | Outside Diameter | Type of Grooves | ID and OD Tolerance |
|----------------|------------------|-----------------|---------------------|
| 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.

### 3.2 Thickness and Parallel Tolerances—Stamped—See Tables 2A and 2B.

**TABLE 2A—THICKNESS AND PARALLEL TOLERANCES—STAMPED (mm)**

| Thickness | Bimetal Roll Finish Thickness Tolerance | Bimetal Roll Finish Parallel Tolerance | Solid Bronze Roll Finish Thickness Tolerance | Solid Bronze Roll Finish Parallel Tolerance | Bimetal or Solid Bronze Ground Finish Thickness Tolerance | Bimetal or Solid Bronze Ground Finish Parallel Tolerance |
|-----------|-----------------------------------------|----------------------------------------|----------------------------------------------|---------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------|
| 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                                                     |

**TABLE 2B—THICKNESS AND PARALLEL TOLERANCES—STAMPED (in)**

| Thickness | Bimetal Roll Finish Thickness Tolerance | Bimetal Roll Finish Parallel Tolerance | Solid Bronze Roll Finish Thickness Tolerance | Solid Bronze Roll Finish Parallel Tolerance | Bimetal or Solid Bronze Ground Finish Thickness Tolerance | Bimetal or Solid Bronze Ground Finish Parallel Tolerance |
|-----------|-----------------------------------------|----------------------------------------|----------------------------------------------|---------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------|
| 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.

- 3.3 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. Tables 3B and 3A list standard commercial washer flatness tolerances:

**TABLE 3A—FLATNESS TOLERANCES (mm)**

| Description                          | Thickness                      | Flatness Tolerance                                               |
|--------------------------------------|--------------------------------|------------------------------------------------------------------|
| Plain (no grooves)                   | 0.75                           | 0.20 up to 55 mm OD<br>0.23 up to 75 mm OD<br>0.25 over 75 mm OD |
| Plain or with machined grooves       | 1.5 and 2.5                    | 0.07 + 0.03 for each 25 mm of OD or portion over 75              |
|                                      | 3 and 4                        | 0.07 + 0.015 for each 25 mm of OD or portion over 75             |
|                                      | 5 and 6.5 (ground finish only) | 0.03 + 0.015 for each 25 mm of OD 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 OD or portion over 75              |
|                                      | 3 and 4                        | 0.12 + 0.015 for each 25 mm of OD or portion over 75             |
|                                      | 5 and 6.5 (ground finish only) | 0.03 + 0.015 for each 25 mm of OD or portion over 75             |

**TABLE 3B—FLATNESS TOLERANCES (in)**

| Description                          | Thickness                          | Flatness Tolerance                                               |
|--------------------------------------|------------------------------------|------------------------------------------------------------------|
| Plain (no grooves)                   | 0.03                               | 0.008 up to 2 in OD<br>0.009 up to 3 in OD<br>0.010 over 3 in OD |
| Plain or with machined grooves       | 0.06 and 0.09                      | 0.003 + 0.001 per in of OD or portion over 3                     |
|                                      | 0.12 and 0.16                      | 0.003 + 0.0005 per in of OD or portion over 3                    |
|                                      | 0.19 and 0.25 (ground finish only) | 0.001 + 0.0005 per in of OD or portion over 3                    |
| With bent lugs and/or coined grooves | 0.06 and 0.09                      | 0.005 + 0.001 per in of OD or portion over 3                     |
|                                      | 0.12 and 0.16                      | 0.005 + 0.0005 per in of OD or portion over 3                    |
|                                      | 0.19 and 0.25 (ground finish only) | 0.001 + 0.0005 per in of OD or portion over 3                    |

**3.4 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 3.3 plus the maximum washer thickness.

### 3.5 Surface Finish

**3.5.1 NONGROUND**—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.

**3.5.2 GROUND**—When grinding is required, faces will be ground to  $0.8\text{ }\mu\text{m}$  ( $30\text{ }\mu\text{in}$ )  $R_a$  on the thrust face and  $1.8\text{ }\mu\text{m}$  ( $72\text{ }\mu\text{in}$ )  $R_a$  on the back face. Mating thrust faces should have  $0.2$  to  $0.3\text{ }\mu\text{m}$  ( $8$  to  $12\text{ }\mu\text{in}$ )  $R_a$  surface finish ground and polished on a circumferential pattern.

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

**3.7 Thrust Washer Materials**—A complete discussion of the materials commonly used in thrust washer applications can be found in SAE J460.

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

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

**3.10 Grooves**—The major portion of thrust washer applications can be accommodated by simple type grooving 3.11, 3.12, and 3.13. In cases of marginal and difficult lubrication or high loading, special grooves can be utilized to improve washer life (for example see 3.14). Typical groove types are listed as follows 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— $1400\text{ kPa}$  ( $200\text{ psi}$ ) maximum
- b. Blended tear drops—machined— $2100\text{ kPa}$  ( $300\text{ psi}$ ) maximum
- c. Tapered land type—machined— $3500\text{ kPa}$  ( $500\text{ psi}$ ) maximum

**3.11 Standard Groove Cross Sections**—Figure 1 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."

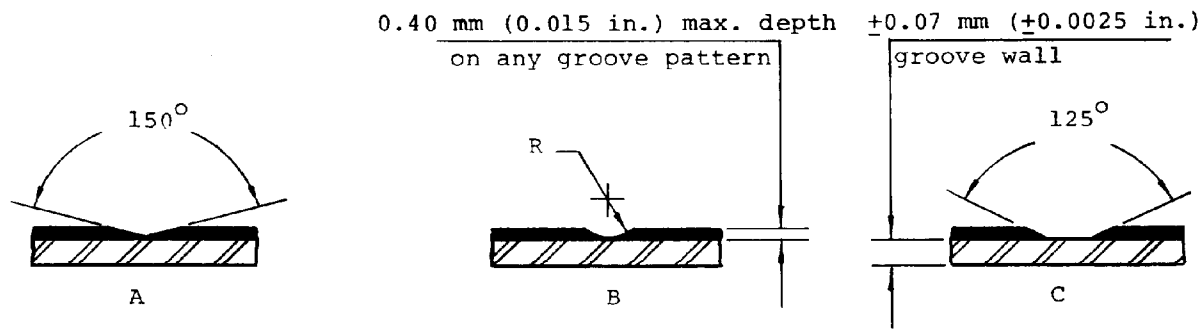


FIGURE 1—TYPICAL CROSS SECTIONS OF COINED OIL GROOVES

**3.12 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  $\pm 0.07$  mm ( $\pm 0.0025$  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.

**3.13 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. See Figure 2.

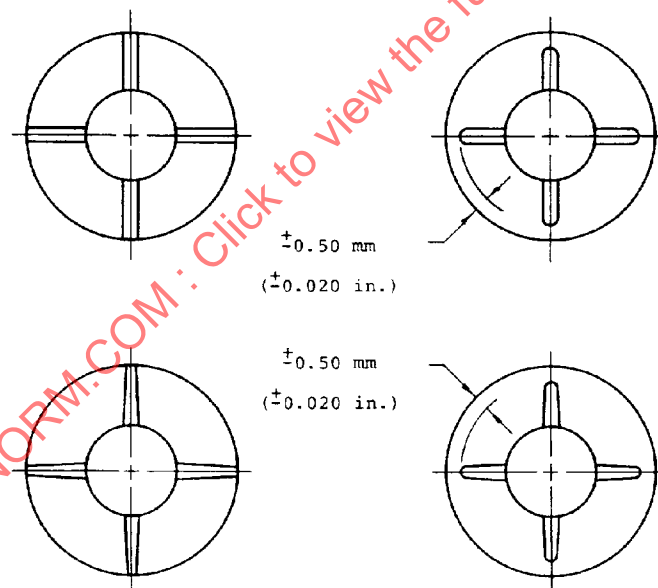


FIGURE 2—GROOVE PATTERNS

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  $\pm 0.25$  mm ( $\pm 0.010$  in) on the radius and depth. See Figure 3.

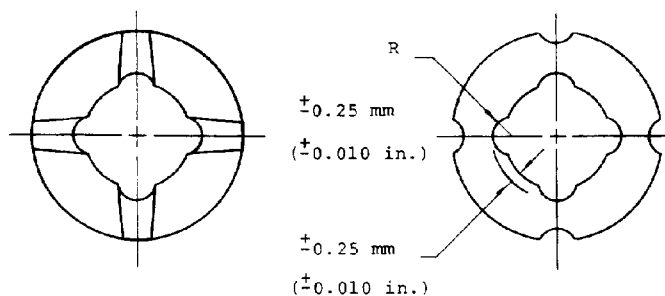


FIGURE 3—SCALLOPS

**3.14 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. See Figures 4 and 5.

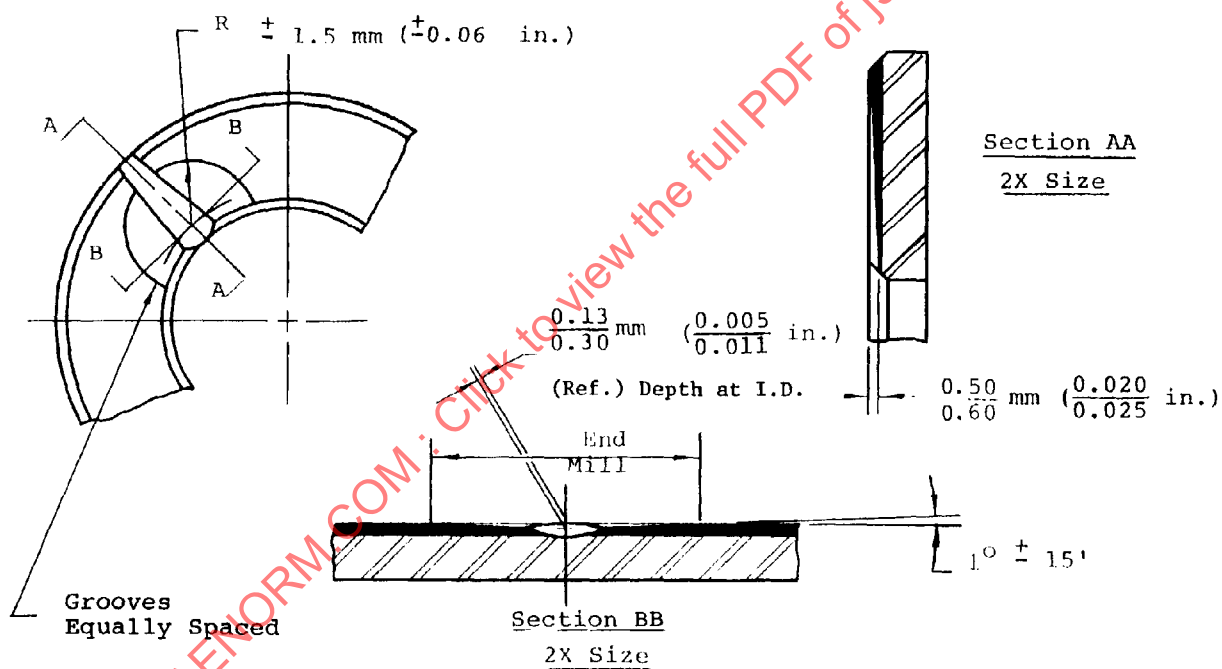


FIGURE 4—SPECIAL GROOVING AND THRUST FACE CONTOUR

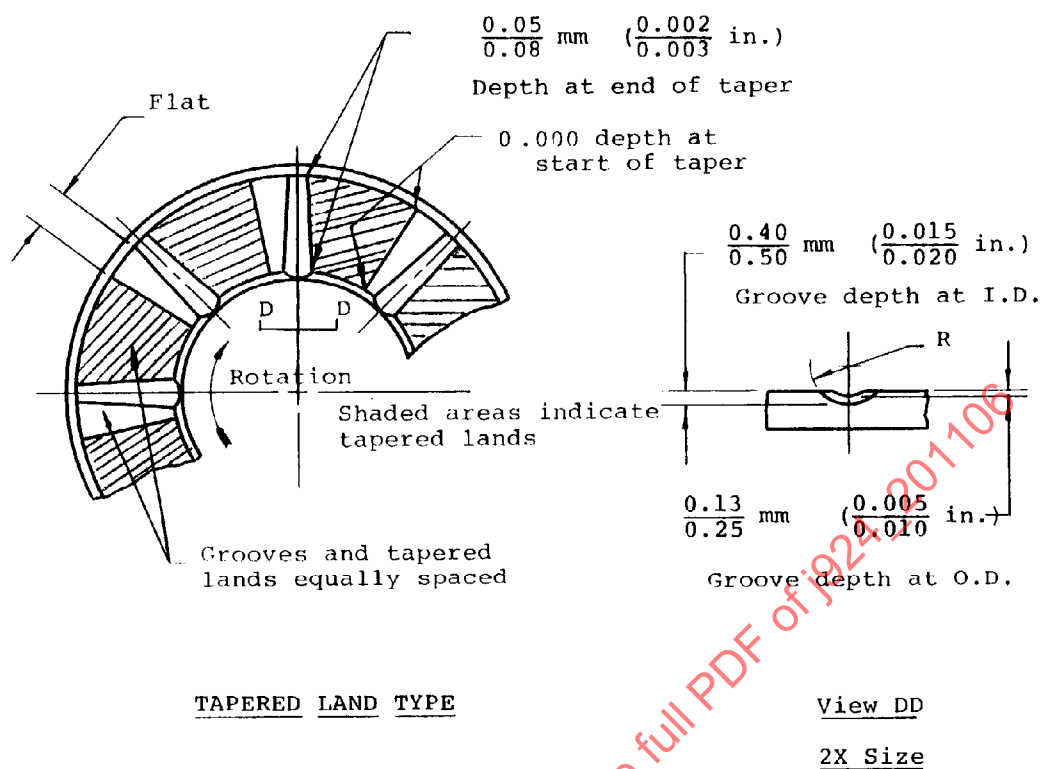


FIGURE 5—TAPER LANDS

For applications having marginal lubrication, it is possible to provide lubricant retention by using ball indented or graphited stock. See Figure 6.

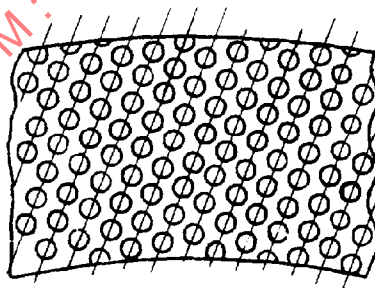


FIGURE 6—BALL INDENTED LINING

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

**3.15 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 in Figure 7.

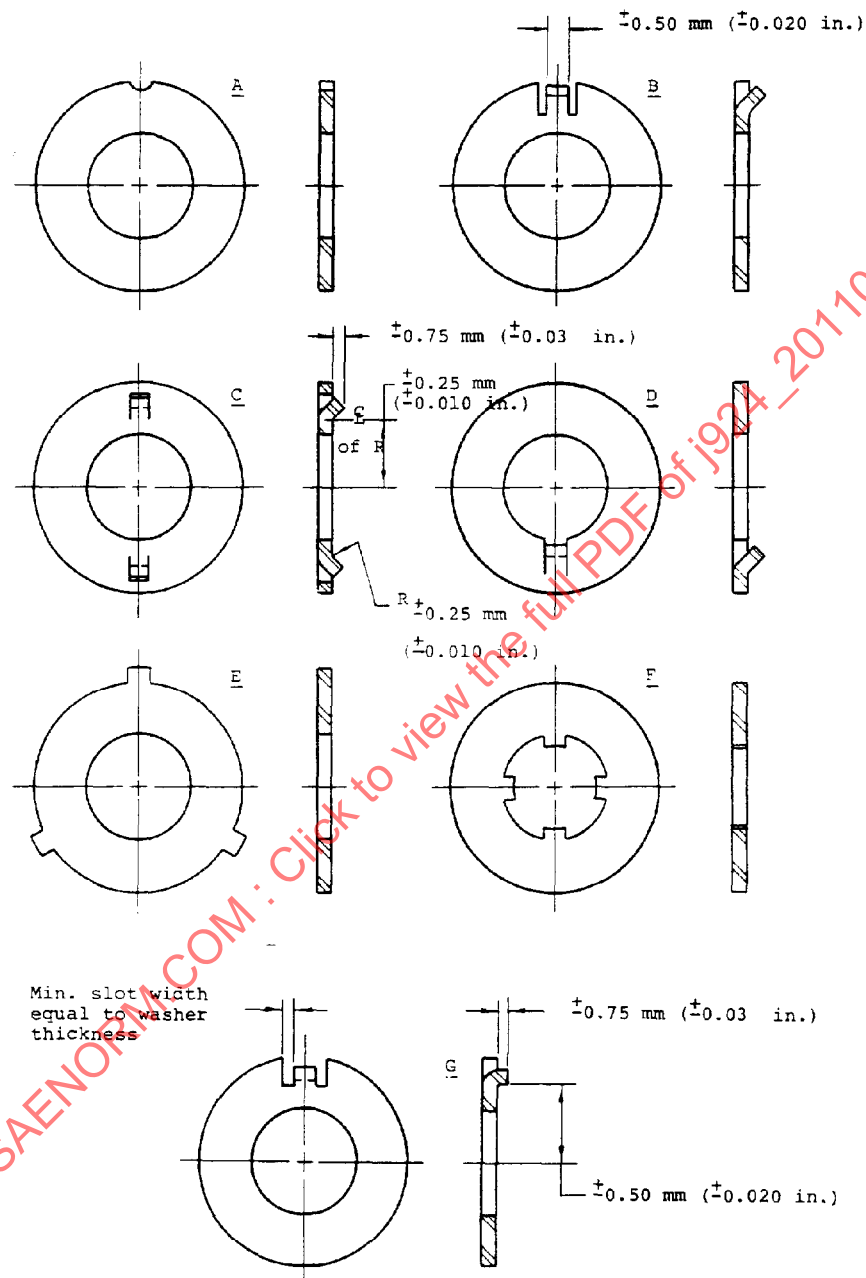


FIGURE 7—LOCATING AND RETENTION FEATURES

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 degree 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 permissible.

- 3.16** 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 in Tables 4A, 4B, 5A, and 5B and Figures 8 and 8B:

**TABLE 4A—THICKNESS TOLERANCES (mm)**

| Thickness                       | Thickness Tolerance |
|---------------------------------|---------------------|
| 0.75—steel or solid bronze only | $\pm 0.025$         |
| 1.5                             | $\pm 0.025$         |
| 2.5                             | $\pm 0.025$         |
| 3.0                             | $\pm 0.04$          |
| 4.0                             | $\pm 0.05$          |

**TABLE 4B—THICKNESS TOLERANCES (in)**

| Thickness                       | Thickness Tolerance |
|---------------------------------|---------------------|
| 0.03—steel or solid bronze only | $\pm 0.001$         |
| 0.06                            | $\pm 0.001$         |
| 0.09                            | $\pm 0.001$         |
| 0.12                            | $\pm 0.002$         |
| 0.16                            | $\pm 0.002$         |

**TABLE 5A—ID, OD, AND SPHERICAL RADIUS TOLERANCES (mm)**

| Outside Diameter | ID and OD Tolerance | Spherical Radius Tolerance |
|------------------|---------------------|----------------------------|
| up to 75         | $\pm 0.25$          | 0.08                       |
| over 75          | $\pm 0.40$          | 0.13                       |

**TABLE 5B—ID, OD, AND SPHERICAL RADIUS TOLERANCES (in)**

| Outside Diameter | ID and OD Tolerance | Spherical Radius Tolerance |
|------------------|---------------------|----------------------------|
| up to 3          | $\pm 0.010$         | 0.003                      |
| over 3           | $\pm 0.015$         | 0.005                      |

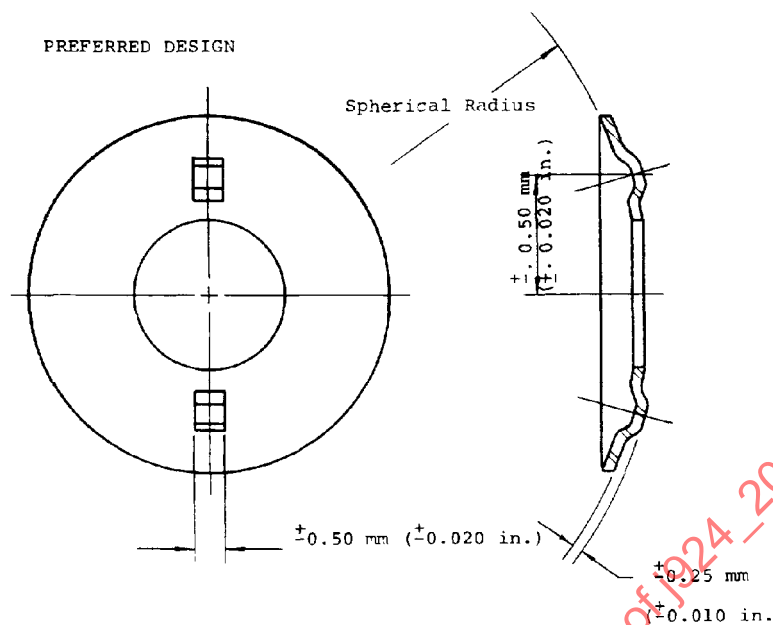


FIGURE 8A—DEPRESSION RETENTION

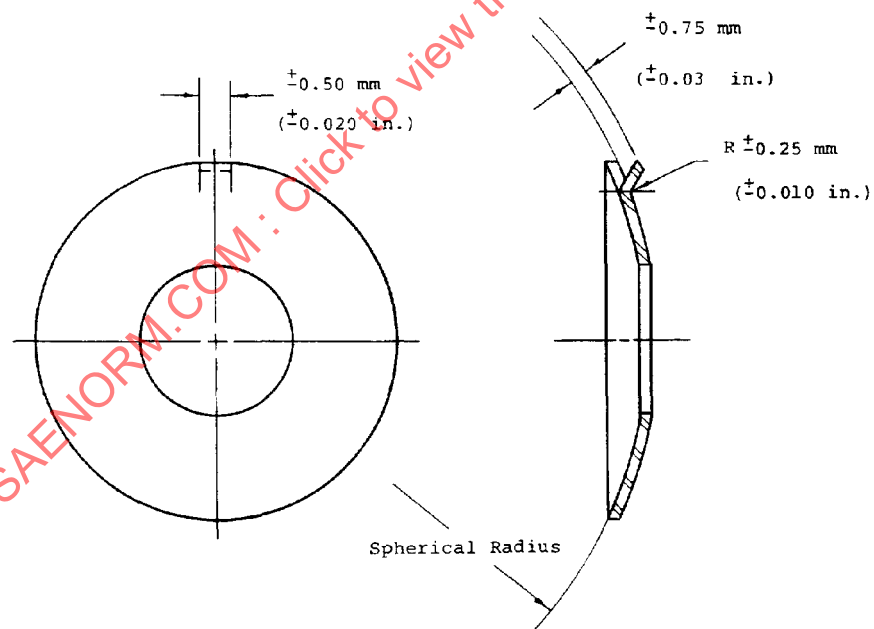


FIGURE 8B—TAB RETENTION

#### 4. Half Washers

##### 4.1 Outside Diameter and Inside Diameter Tolerances—Stamped— (See Tables 6A and 6B.)

**TABLE 6A—OUTSIDE DIAMETER AND INSIDE DIAMETER TOLERANCES—STAMPED (mm)**

| Thickness   | Outside Diameter | Type of Grooves | ID and OD Tolerance |
|-------------|------------------|-----------------|---------------------|
| 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               |

**TABLE 6B—OUTSIDE DIAMETER AND INSIDE DIAMETER TOLERANCES—STAMPED (in)**

| Thickness      | Outside Diameter | Type of Grooves | ID and OD Tolerance |
|----------------|------------------|-----------------|---------------------|
| 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.

##### 4.2 Thickness and Parallel Tolerances—Stamped—(See Tables 7A and 7B.)

**TABLE 7A—THICKNESS AND PARALLEL TOLERANCES—STAMPED (mm)**

| Thickness | Bimetal<br>Roll Finish<br>Thickness<br>Tolerance | Bimetal<br>Roll Finish<br>Parallel<br>Tolerance | Solid Bronze<br>Roll Finish<br>Thickness<br>Tolerance | Solid Bronze<br>Roll Finish<br>Parallel<br>Tolerance | Bimetal or<br>Solid Bronze<br>Ground Finish<br>Thickness<br>Tolerance | Bimetal or<br>Solid Bronze<br>Ground Finish<br>Parallel<br>Tolerance |
|-----------|--------------------------------------------------|-------------------------------------------------|-------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------------------|----------------------------------------------------------------------|
| 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                                                                 |

**TABLE 7B—THICKNESS AND PARALLEL TOLERANCES—STAMPED (in)**

| Thickness | Bimetal<br>Roll Finish<br>Thickness<br>Tolerance | Bimetal<br>Roll Finish<br>Parallel<br>Tolerance | Solid Bronze<br>Roll Finish<br>Thickness<br>Tolerance | Solid Bronze<br>Roll Finish<br>Parallel<br>Tolerance | Bimetal or<br>Solid Bronze<br>Ground Finish<br>Thickness<br>Tolerance | Bimetal or<br>Solid Bronze<br>Ground Finish<br>Parallel<br>Tolerance |
|-----------|--------------------------------------------------|-------------------------------------------------|-------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------------------|----------------------------------------------------------------------|
| 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                                                                |

**4.3 Flatness Tolerances—** (See Tables 8A and 8B.)**TABLE 8A—FLATNESS TOLERANCES (mm)**

| Description                    | Thickness                         | Flatness Tolerance                                   |
|--------------------------------|-----------------------------------|------------------------------------------------------|
| Plain or with machined grooves | 1.5 and 2.5                       | 0.05 + 0.03 for each 25 mm of OD or portion over 75  |
|                                | 3 and 4                           | 0.05 + 0.015 for each 25 mm of OD or portion over 75 |
|                                | 5 and 6.5<br>(ground finish only) | 0.03 + 0.015 for each 25 mm of OD or portion over 75 |
| With coined grooves            | 1.5 and 2.5                       | 0.08 + 0.03 for each 25 mm of OD or portion over 75  |
|                                | 3 and 4                           | 0.08 + 0.015 for each 25 mm of OD or portion over 75 |
|                                | 5 and 6.5<br>(ground finish only) | 0.03 + 0.015 for each 25 mm of OD or portion over 75 |

**TABLE 8B—FLATNESS TOLERANCES (in)**

| Description                    | Thickness                             | Flatness Tolerance                            |
|--------------------------------|---------------------------------------|-----------------------------------------------|
| Plain or with machined grooves | 0.06 and 0.09                         | 0.002 + 0.001 per in of OD or portion over 3  |
|                                | 0.12 and 0.16                         | 0.002 + 0.0005 per in of OD or portion over 3 |
|                                | 0.19 and 0.25<br>(ground finish only) | 0.001 + 0.0005 per in of OD or portion over 3 |
| With coined grooves            | 0.06 and 0.09                         | 0.003 + 0.001 per in of OD or portion over 3  |
|                                | 0.12 and 0.16                         | 0.003 + 0.0005 per in of OD or portion over 3 |
|                                | 0.19 and 0.25<br>(ground finish only) | 0.001 + 0.0005 per in of OD or portion over 3 |

**4.4 Flatness Check—Parallel Plate Method—**See 3.4.

**4.5 Surface Finish—Ground—**See 3.5.

**4.6 Lining Thickness—Bimetal—**(See Table 9.)

**TABLE 9—LINING THICKNESS—BIMETAL**

| Lining Material | Minimum Lining Thickness<br>mm | Minimum Lining Thickness<br>in |
|-----------------|--------------------------------|--------------------------------|
| Babbitt         | 0.25                           | 0.010                          |
| Aluminum        | 0.25                           | 0.010                          |
| Bronze          | 0.20                           | 0.008                          |

**4.7** See 3.7.

**4.8** See 3.8.

**4.9** See 3.9.

**4.10** See 3.10.

**4.11** See 3.11.

**4.12** See 3.12.