



# AEROSPACE STANDARD

**AS4299™****REV. B**

Issued 1991-10  
Revised 2018-07  
Reaffirmed 2024-04

Superseding AS4299A

Rings, Retaining – Spiral Wound, Uniform Section  
Corrosion and Heat Resistant, UNS S66286

FSC 5365

## RATIONALE

Revise QQ-P-35 TO AMS2700, add minimum to FPI Sensitivity Level, error corrected in Table 5 for ØC (nom. bore 5.905), update references and titles throughout (NASM, ASTM, ANSI/ASME), general editorial update.

AS4299B has been reaffirmed to comply with the SAE Five-Year Review policy.

### 1. SCOPE

#### 1.1 Type

This procurement specification covers retaining rings of the spiral wound type with uniform rectangular cross-section, made of a corrosion and heat resistant age hardenable iron base alloy of the type identified under the Unified Numbering System as UNS S66286, work strengthened and heat treated to a tensile strength of 185 to 240 ksi at room temperature.

#### 1.2 Classification

Retaining rings shall be of the types and classes shown in Table 1.

**Table 1**

| Type               | Class | Description |
|--------------------|-------|-------------|
| I - External Ring  | 1     | Medium Duty |
|                    | 2     | Heavy Duty  |
| II - Internal Ring | 1     | Medium Duty |
|                    | 2     | Heavy Duty  |

#### 1.3 Application

Intended for use on aerospace propulsion systems for retaining parts on shafts and in housing bores where high strength at temperatures up to approximately 900 °F is required.

#### 1.4 Dimensions and Tolerances

Unless otherwise specified herein, dimensions and tolerances are in inches.

SAE Executive Standards Committee Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2024 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, or used for text and data mining, AI training, or similar technologies, without the prior written permission of SAE.

**TO PLACE A DOCUMENT ORDER:** Tel: 877-606-7323 (inside USA and Canada)  
Tel: +1 724-776-4970 (outside USA)  
Fax: 724-776-0790  
Email: CustomerService@sae.org  
http://www.sae.org

SAE WEB ADDRESS:

**For more information on this standard, visit**  
<https://www.sae.org/standards/content/AS4299B/>

## 2. REFERENCES

### 2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

#### 2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

|         |                                                                                                                                                                                                    |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AMS2700 | Passivation of Corrosion Resistant Steels                                                                                                                                                          |
| AMS5525 | Steel, Corrosion and Heat-Resistant, Sheet, Strip, and Plate, 15Cr - 25.5Ni - 1.2Mo - 2.1Ti - 0.006B - 0.30V 1800 °F (982 °C) Solution Heat Treated                                                |
| AMS5810 | Steel, Corrosion and Heat Resistant, Flat Wire, 15Cr - 25.5Ni - 1.2Mo - 2.1Ti - 0.006B - 0.30V, 1800 °F (982 °C) Solution Treated, Cold Drawn or Cold Rolled and Aged, Consumable Electrode Melted |
| AS3219  | Ring, Retaining, Spiral, Minimum Distortion, Dimensional and Acceptance Standard For                                                                                                               |
| AS3472  | Ring, Retaining - Internal, Spiral Wound, Heavy and Medium Duty, UNS S66286                                                                                                                        |

#### 2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, [www.astm.org](http://www.astm.org).

|                  |                                                                   |
|------------------|-------------------------------------------------------------------|
| ASTM D3951       | Standard Practice for Commercial Packaging                        |
| ASTM E8/E8M      | Standard Test Methods for Tension Testing of Metallic Materials   |
| ASTM E18         | Standard Test Methods for Rockwell Hardness of Metallic Materials |
| ASTM E140        | Standard Hardness Conversion Tables for Metals                    |
| ASTM E1417/1417M | Standard Practice for Liquid Penetrant Testing                    |

#### 2.1.3 ASME Publications

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), [www.asme.org](http://www.asme.org).

|                         |                                                        |
|-------------------------|--------------------------------------------------------|
| ASME B46.1              | Surface Texture (Surface Roughness, Waviness, and Lay) |
| (ASME) ANSI Y14.5M-1982 | Dimensioning and Tolerancing                           |

#### 2.1.4 NAS Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, [www.aia-aerospace.org](http://www.aia-aerospace.org).

|            |                                             |
|------------|---------------------------------------------|
| NASM1312-1 | Fastener Test Methods, Method 1, Salt Spray |
|------------|---------------------------------------------|

## 2.2 Definitions

### 2.2.1 DEFECT

Any nonconformance of the unit of product with specified requirements.

### 2.2.2 DEFECTIVE

A unit of product which contains one or more defects.

### 2.2.3 PRODUCTION INSPECTION LOT

Shall be all finished parts of the same part number, made from a single heat of alloy, heat treated at the same time to the same specified condition, produced as one continuous run, and submitted for vendor's inspection at the same time.

## 2.3 Unit Symbols

% - percent ( $1\% = 1/100$ )

ksi - kips (1000 pounds) per square inch

°C - degree Celsius

°F - degree Fahrenheit

in<sup>2</sup> - square inch

## 3. TECHNICAL REQUIREMENTS

### 3.1 Material

Shall be AMS5810 or AMS5525 steel, corrosion and heat resistant, flat wire.

### 3.2 Design

Finished (completely manufactured) parts shall conform to the following requirements:

#### 3.2.1 Design and Dimensions

Unless otherwise specified on the part drawing, retaining rings furnished to this specification shall conform to the design, shape, dimensions, and other requirements specified on the applicable AS standard drawing as in AS3219 and AS3472. Dimensions shall conform to finished unplated rings, unless otherwise specified on the part drawing.

#### 3.2.2 Surface Roughness

Surface texture of finished parts shall conform to the requirements as specified on the part drawing, determined in accordance with ASME B46.1.

#### 3.2.3 Crimp

Retaining rings that are required to be crimped (offset at ring ends) shall meet the requirements in AS3219.

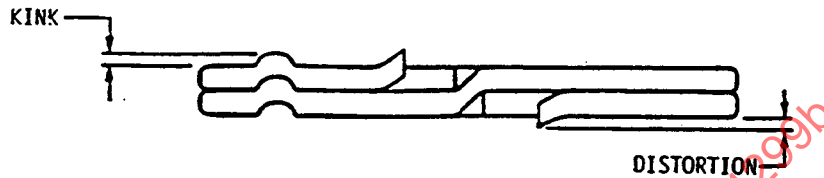
### 3.2.4 Irregularity of Form

The following ring form irregularities shall be not greater than that specified in AS3219:

Dish and parallelism  
Misalignment  
Radial deformation

#### 3.2.4.1 Distortion

Distortion due to notching shall be no greater than one-half the total tolerance of the ring thickness. See Figure 1.



**Figure 1 - Distortion**

#### 3.2.4.2 Kinking

Axial kinking shall not exceed the total thickness tolerance, and shall not cause the ring to exceed the maximum thickness. See Figure 1.

#### 3.2.5 Removal Provision

All rings shall be notched to facilitate their removal from the ring groove. Dimensioning of the notch shall be in accordance with the part drawing.

#### 3.2.6 Edges

The edges of the ring material shall be rounded except at the ends and at the removal notches. The edge radius shall be as specified on the part drawing. All edges, including those at the retaining ring ends and at the removal notches, shall be free from burrs, slivers, dents, nicks, cracks, and other irregularities.

### 3.3 Fabrication

3.3.1 Rings shall be wound as a spiral of two or more turns from flat wire as in 3.1; finished rings shall meet the requirements of 3.4.2.

#### 3.3.2 Passivation

Finished rings after forming as in 3.3.1 shall be degreased and then subjected to the passivation treatment and copper sulfate test in accordance with AMS2700.

### 3.4 Mechanical Properties

#### 3.4.1 Hardness

Shall be used as a reference to approximate tensile strength, and shall be within the following values for the thickness indicated in Table 2 and determined in accordance with ASTM E18 (see 8.1).

**Table 2**

| Material Thickness, Inch | Hardness          |
|--------------------------|-------------------|
| 0.0067 to 0.0141, incl.  | 81.0 - 85.0 HR15N |
| 0.0142 to 0.0212, incl.  | 60.5 - 67.5 HR30N |
| 0.0213 to 0.0432, incl.  | 71.0 - 75.5 HRA   |
| over 0.0432              | 41.0 - 49.0 HRC   |

#### 3.4.2 Tensile Strength

Rings rectangular section flat wire shall have a tensile strength within the range 185 to 240 ksi, determined in accordance with ASTM E8/E8M.

3.4.3 Rings shall not be rejected on the basis of hardness if the tensile strength properties in 3.4.2 are met.

#### 3.4.4 Performance

All retaining rings shall be capable of undergoing the test of 4.6 without showing indications of cracks, excessive permanent set or distortion, or other conditions detrimental to the use of the rings. Distortion or permanent set shall not be to the extent where the minimum diametral interference fit between the ring diameter and the groove diameter, under the stack-up of tolerances is less than 0.003 times the groove diameter as specified in Tables 4 and 5, calculated as follows:

$$F = \varnothing A - \varnothing C \geq 0.003\varnothing C \quad (\text{Eq. 1})$$

where:

F = minimum interference fit between ring and groove after performance test

$\varnothing A$  = maximum ID, external ring as measured after performance test

$\varnothing A$  = minimum OD, internal ring as measured after performance test

$\varnothing C$  = minimum groove diameter, external ring

$\varnothing C$  = maximum groove diameter, internal ring

### 3.5 Quality

Parts shall be uniform in quality and condition, free from burrs and foreign materials, and free from imperfections detrimental to usage of the parts.

#### 3.5.1 Fluorescent Penetrant Inspection

Parts shall be subject to fluorescent penetrant inspection in accordance with ASTM E1417/E1417M, Type I, Sensitivity Level 2 Minimum. There shall be no evidence of cracks, seams, laminations, blanking tears, or laps.

### 3.5.2 Corrosion Resistance

Rings tested by continuous exposure to salt spray specified in Section 4 shall show no rust when viewed by the unaided eye at normal reading distance.

## 4. QUALITY ASSURANCE PROVISIONS

### 4.1 Responsibility for Inspection

The vendor of parts shall supply all samples for vendor's test and shall be responsible for performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the parts conform to the requirements of this specification.

### 4.2 Responsibility for Compliance

The manufacturer's system for parts production shall be based on preventing product defects, rather than detecting the defects at final inspection and then requiring corrective action to be invoked. An effective manufacturing in-process control system shall be established, subject to the approval of the purchaser, and used during production of parts.

### 4.3 Production Acceptance Tests

The purpose of production acceptance tests is to check, as simply as possible, using a method which is inexpensive and representative of the part usage, with the uncertainty inherent in random sampling, that the parts comprising a production inspection lot satisfy the requirements of this specification.

### 4.4 Classification of Tests

- a. Acceptance tests which are to be performed on each production inspection lot. A summary of acceptance tests is specified in Table 6.
- b. Periodic tests which are to be performed periodically on production lots at the discretion of the vendor or purchaser. Corrosion resistance test as in 3.5.2 is classified as a periodic test and shall be performed when requested by the purchaser.

### 4.5 Acceptance Test Sampling

#### 4.5.1 Material

Sampling for material composition on each heat shall be in accordance with AMS5810 or AMS5525, as applicable.

#### 4.5.2 Nondestructive Tests - Visual and Dimensional

A random sample of parts shall be taken from each production inspection lot; the size of the sample to be as specified in Table 7. The classification of dimensional characteristics shall be as specified in Table 8. All dimensional characteristics are considered defective when out of tolerance.

#### 4.5.3 Fluorescent Penetrant Inspection

A random sample shall be selected from each production inspection lot; the size of the sample shall be as specified in Table 7 and classified as in Table 8. The sample units may be selected from those that have been subjected to and passed the visual and dimensional inspection, with additional units selected at random from the production inspection lot as necessary.

#### 4.5.4 Destructive Tests

A random sample shall be selected from each production inspection lot; the size of the sample shall be as specified in Table 9. The sample units may be selected from those that have been subjected to and passed the nondestructive tests and the fluorescent penetrant inspection with additional units selected at random from the production inspection lot as necessary.

#### 4.5.5 Acceptance Quality

Of random samples tested, acceptance quality shall be based on zero defectives.

### 4.6 Tests

#### 4.6.1 Performance Tests

Prior to the hardness test of 4.6.2, the sample retaining rings selected in accordance with 4.5.4 shall be subjected to the tests of 4.6.1.1 and 4.6.1.2 as applicable.

##### 4.6.1.1 Type I, Classes 1 and 2

External retaining rings shall be expanded over and removed from a groove having a nominal shaft diameter and groove dimensions as specified in Figure 2 and Table 4 for the applicable retaining ring size. After repeating this test five times, the ring shall be visually and dimensionally inspected for conformance to the requirements of 3.4.4.

##### 4.6.1.2 Type II, Classes 1 and 2

Internal retaining rings shall be compressed into and removed from a groove having a nominal bore diameter and groove dimensions as specified in Figure 3 and Table 5 for the applicable retaining ring size. After repeating this test five times, the rings shall be visually and dimensionally inspected for conformance to the requirements of 3.4.4.

#### 4.6.2 Hardness Test

After the tests of 4.6.1, each sample retaining ring selected in accordance with 4.5.4 shall be tested for conformance to the hardness requirements specified in 3.4.1. The surfaces of both sides of each sample shall be prepared for hardness testing by removal of surface conditions which may affect the hardness reading. Hardness readings shall be taken as close as practicable to the center of the surface width of the ring.

#### 4.6.3 Tensile Strength Test

Tensile strength test shall be conducted in accordance with ASTM E8/E8M on three specimens of wire material of the same lot of alloy used to produce the production inspection lot of the finished parts. Such specimens shall withstand the tensile strength stress specified in 3.4.2. The rectangular cross-section area of the wire specimen shall be determined from measurements of thickness and width taken prior to the test. The tensile test load shall be determined as follows:

$$A = T \times W - .12 T^2 \quad (\text{Eq. 2})$$

$$F = S_t \times A \quad (\text{Eq. 3})$$

where:

A = area of wire specimen cross-section, in<sup>2</sup>

T = thickness of wire specimen, inch

W = width of wire specimen, inch

F = tensile test load, lbf

$S_t$  = tensile stress specified in 3.4.2, psi

#### 4.6.4 Packaging, Packing, and Marking

Samples of packaging and packing containers selected in accordance with Tables 7 and 8 shall be examined for compliance with 5.1.

#### 4.6.5 Corrosion Resistance Test

Rings shall be tested by continuous exposure to salt spray in accordance with MIL-STD-1312-1 in accordance with NASM1312-1 for a duration of 300 hours  $\pm$  0.5 hour. After testing, rings shall be examined for compliance with the requirements specified in 3.5.2.

#### 4.7 Periodic Test Sampling

As agreed upon by purchaser and vendor.

#### 4.8 Reports

The vendor of parts shall furnish with each shipment a report stating that the chemical composition conforms to 3.1.1, showing the results of tests to determine conformance to the acceptance examination and acceptance tests requirements and, when performed, the corrosion resistance test requirements, and stating that the parts conform to the other technical requirements of this specification. This report shall include the purchase order number, lot number, AS4299B, contractor or other direct supplier of material, part number, nominal size, and quantity.

#### 4.9 Rejected Lots

If a production inspection lot is rejected, the vendor of parts shall perform corrective action to screen out or rework the defective parts and resubmit for acceptance tests inspection as in Table 6, or scrap the entire lot. Resubmitted lots shall be clearly identified as reinspected lots.

### 5. PREPARATION FOR DELIVERY

#### 5.1 Packaging and Identification

5.1.1 Packaging shall be in accordance with ASTM D3951.

5.1.2 Parts having different part numbers shall be packed in separate containers.

5.1.3 Each container of parts shall be marked to show not less than the following information:

- a. RETAINING RINGS, STEEL, CORROSION AND HEAT RESISTANT
  - b. AS4299B
  - c. PART NUMBER
  - d. PURCHASE ORDER NUMBER
  - e. QUANTITY
  - f. MANUFACTURER'S IDENTIFICATION
  - g. LOT NUMBER
- #### 6. ACKNOWLEDGMENT

A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

## 7. REJECTIONS

Parts not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

## 8. NOTES

8.1 Hardness conversion tables for metals are presented in ASTM E140.

### 8.2 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

SAENORM.COM : Click to view the full PDF of as4299b

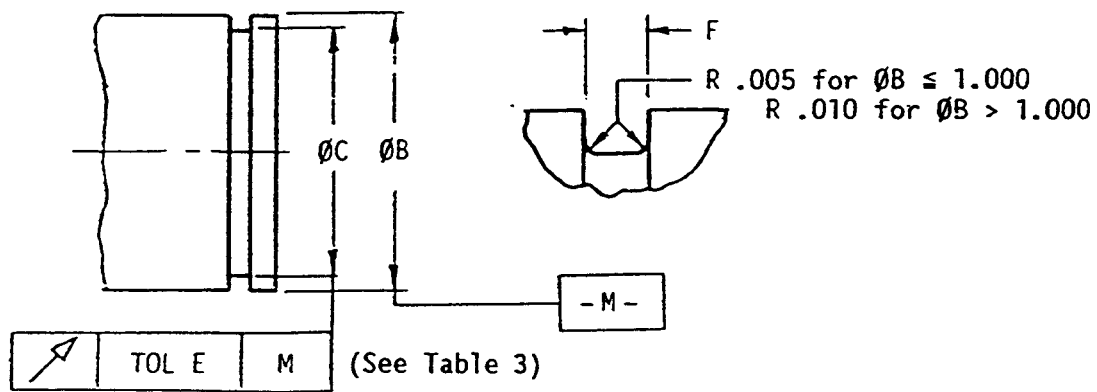


Figure 2 - Groove dimensions, Type I, Classes 1 and 2 retaining rings  
(see Table 4)

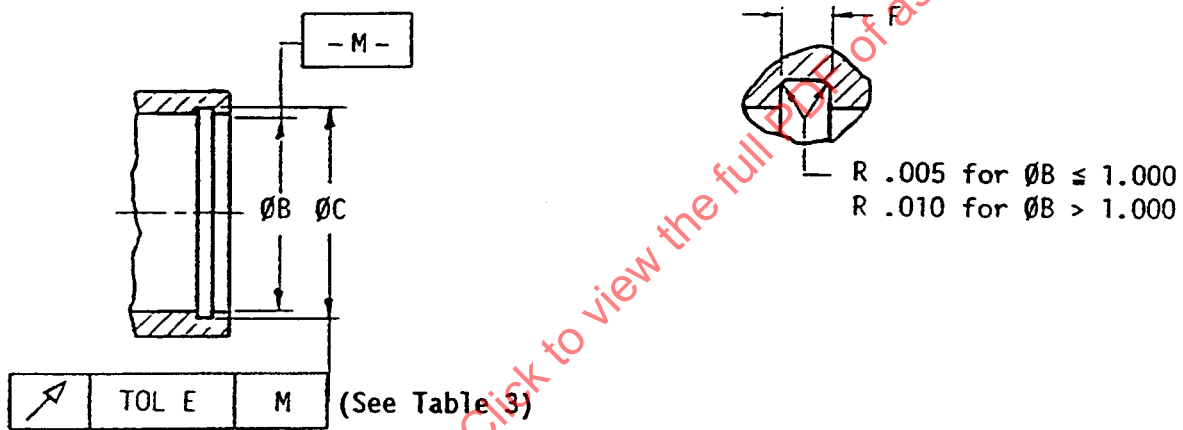


Figure 3 - Groove dimensions, Type II, Classes 1 and 2 retaining rings  
(see Table 5)

**Table 3 - Groove runout tolerance (inches)**

| E     | ØB                     |
|-------|------------------------|
| 0.004 | 0.469 thru 1.094       |
| 0.006 | Over 1.094 thru 2.165  |
| 0.008 | Over 2.165 thru 3.149  |
| 0.010 | Over 3.149 thru 5.907  |
| 0.012 | Over 5.907 thru 15.000 |

NOTE: Dimensioning and tolerancing in accordance with ANSI Y14.5M-1982.

**Table 4 - Groove dimensions, external rings (inches)**

| Type/Class      | Nom Shaft<br>ØB | Groove<br>Diameter<br>ØC | Groove<br>Width<br>F |
|-----------------|-----------------|--------------------------|----------------------|
| Type I, Class 2 | 0.469           | 0.441 - 0.445            | 0.029 - 0.032        |
|                 | 0.500           | 0.466 - 0.470            | 0.039 - 0.042        |
|                 | 0.551           | 0.517 - 0.521            | 0.039 - 0.042        |
|                 | 0.562           | 0.528 - 0.532            | 0.039 - 0.042        |
|                 | 0.594           | 0.556 - 0.562            | 0.039 - 0.042        |
|                 | 0.625           | 0.585 - 0.591            | 0.039 - 0.042        |
|                 | 0.669           | 0.626 - 0.632            | 0.039 - 0.042        |
|                 | 0.688           | 0.643 - 0.649            | 0.046 - 0.049        |
|                 | 0.750           | 0.701 - 0.707            | 0.046 - 0.049        |
|                 | 0.781           | 0.730 - 0.736            | 0.046 - 0.049        |
|                 | 0.812           | 0.759 - 0.765            | 0.046 - 0.049        |
|                 | 0.875           | 0.818 - 0.824            | 0.046 - 0.049        |
|                 | 0.938           | 0.879 - 0.885            | 0.046 - 0.049        |
|                 | 0.984           | 0.923 - 0.929            | 0.046 - 0.049        |
|                 | 1.000           | 0.937 - 0.943            | 0.046 - 0.049        |
|                 | 1.023           | 0.958 - 0.964            | 0.046 - 0.049        |
|                 | 1.062           | 0.994 - 1.002            | 0.056 - 0.060        |
|                 | 1.125           | 1.055 - 1.063            | 0.056 - 0.060        |
|                 | 1.188           | 1.114 - 1.122            | 0.056 - 0.060        |
|                 | 1.250           | 1.172 - 1.180            | 0.056 - 0.060        |
|                 | 1.312           | 1.228 - 1.236            | 0.056 - 0.060        |
|                 | 1.375           | 1.287 - 1.295            | 0.056 - 0.060        |
|                 | 1.438           | 1.346 - 1.354            | 0.056 - 0.060        |
|                 | 1.500           | 1.402 - 1.410            | 0.056 - 0.060        |
|                 | 1.562           | 1.463 - 1.473            | 0.068 - 0.072        |

|       |               |               |
|-------|---------------|---------------|
| 1.625 | 1.524 - 1.534 | 0.068 - 0.072 |
| 1.687 | 1.584 - 1.594 | 0.068 - 0.072 |
| 1.750 | 1.645 - 1.655 | 0.068 - 0.072 |
| 1.771 | 1.664 - 1.674 | 0.068 - 0.072 |
| 1.812 | 1.703 - 1.713 | 0.068 - 0.072 |
| 1.875 | 1.764 - 1.774 | 0.068 - 0.072 |
| 1.969 | 1.852 - 1.862 | 0.068 - 0.072 |
| 2.000 | 1.881 - 1.891 | 0.068 - 0.072 |

SAENORM.COM : Click to view the full PDF of as4299b

**Table 4 - Groove dimensions, external rings (inches) (continued)**

| Type/Class      | Nom<br>Shaft<br>ØB | Groove<br>Diameter<br>ØC | Groove<br>Width<br>F |
|-----------------|--------------------|--------------------------|----------------------|
| Type I, Class 1 | 2.062              | 1.986 - 1.998            | 0.056 - 0.060        |
|                 | 2.125              | 2.045 - 2.057            | 0.056 - 0.060        |
|                 | 2.156              | 2.076 - 2.088            | 0.056 - 0.060        |
|                 | 2.165              | 2.085 - 2.097            | 0.056 - 0.060        |
|                 | 2.188              | 2.107 - 2.119            | 0.056 - 0.060        |
|                 | 2.250              | 2.170 - 2.182            | 0.056 - 0.060        |
|                 | 2.312              | 2.228 - 2.240            | 0.056 - 0.060        |
|                 | 2.362              | 2.278 - 2.290            | 0.056 - 0.060        |
|                 | 2.375              | 2.291 - 2.303            | 0.056 - 0.060        |
|                 | 2.437              | 2.349 - 2.361            | 0.056 - 0.060        |
|                 | 2.500              | 2.412 - 2.424            | 0.056 - 0.060        |
|                 | 2.559              | 2.467 - 2.479            | 0.056 - 0.060        |
|                 | 2.562              | 2.470 - 2.482            | 0.056 - 0.060        |
|                 | 2.625              | 2.533 - 2.545            | 0.056 - 0.060        |
|                 | 2.688              | 2.591 - 2.603            | 0.056 - 0.060        |
|                 | 2.750              | 2.654 - 2.666            | 0.056 - 0.060        |
|                 | 2.813              | 2.716 - 2.728            | 0.056 - 0.060        |
|                 | 2.875              | 2.775 - 2.787            | 0.056 - 0.060        |
|                 | 2.937              | 2.837 - 2.849            | 0.056 - 0.060        |
|                 | 2.952              | 2.852 - 2.864            | 0.056 - 0.060        |
|                 | 3.000              | 2.898 - 2.910            | 0.068 - 0.073        |
|                 | 3.062              | 2.960 - 2.972            | 0.068 - 0.073        |
|                 | 3.125              | 3.021 - 3.033            | 0.068 - 0.073        |
|                 | 3.149              | 3.045 - 3.057            | 0.068 - 0.073        |
|                 | 3.187              | 3.083 - 3.095            | 0.068 - 0.073        |
|                 | 3.250              | 3.144 - 3.156            | 0.068 - 0.073        |
|                 | 3.312              | 3.202 - 3.214            | 0.068 - 0.073        |
|                 | 3.343              | 3.233 - 3.245            | 0.068 - 0.073        |
|                 | 3.375              | 3.265 - 3.277            | 0.068 - 0.073        |
|                 | 3.437              | 3.325 - 3.337            | 0.068 - 0.073        |
|                 | 3.500              | 3.338 - 3.400            | 0.068 - 0.073        |
|                 | 3.543              | 3.427 - 3.439            | 0.068 - 0.073        |
|                 | 3.562              | 3.446 - 3.458            | 0.068 - 0.073        |
|                 | 3.625              | 3.509 - 3.521            | 0.068 - 0.073        |
|                 | 3.687              | 3.569 - 3.581            | 0.068 - 0.073        |

**Table 4 - Groove dimensions, external rings (inches) (continued)**

| Type/Class                     | Nom<br>Shaft<br>ØB | Groove<br>Diameter<br>ØC | Groove<br>Width<br>F |
|--------------------------------|--------------------|--------------------------|----------------------|
| Type I, Class 1<br>(Continued) | 3.740              | 3.622 - 3.634            | 0.068 - 0.073        |
|                                | 3.750              | 3.632 - 3.644            | 0.068 - 0.073        |
|                                | 3.812              | 3.694 - 3.706            | 0.068 - 0.073        |
|                                | 3.875              | 3.751 - 3.763            | 0.068 - 0.073        |
|                                | 3.938              | 3.814 - 3.826            | 0.068 - 0.073        |
|                                | 4.000              | 3.870 - 3.882            | 0.068 - 0.073        |
|                                | 4.063              | 3.933 - 3.945            | 0.068 - 0.073        |
|                                | 4.125              | 3.994 - 4.006            | 0.068 - 0.073        |
|                                | 4.134              | 4.004 - 4.016            | 0.068 - 0.073        |
|                                | 4.188              | 4.052 - 4.064            | 0.068 - 0.073        |
|                                | 4.250              | 4.114 - 4.126            | 0.068 - 0.073        |
|                                | 4.312              | 4.176 - 4.188            | 0.068 - 0.073        |
|                                | 4.331              | 4.194 - 4.206            | 0.068 - 0.073        |
|                                | 4.375              | 4.239 - 4.251            | 0.068 - 0.073        |
|                                | 4.437              | 4.301 - 4.313            | 0.068 - 0.073        |
|                                | 4.500              | 4.358 - 4.370            | 0.068 - 0.073        |
|                                | 4.562              | 4.416 - 4.428            | 0.079 - 0.084        |
|                                | 4.625              | 4.479 - 4.491            | 0.079 - 0.084        |
|                                | 4.687              | 4.541 - 4.553            | 0.079 - 0.084        |
|                                | 4.724              | 4.578 - 4.590            | 0.079 - 0.084        |
|                                | 4.750              | 4.604 - 4.616            | 0.079 - 0.084        |
|                                | 4.812              | 4.666 - 4.678            | 0.070 - 0.084        |
|                                | 4.875              | 4.729 - 4.741            | 0.079 - 0.084        |
|                                | 4.937              | 4.791 - 4.803            | 0.079 - 0.084        |
|                                | 5.000              | 4.850 - 4.862            | 0.079 - 0.084        |
|                                | 5.118              | 4.968 - 4.980            | 0.079 - 0.084        |
|                                | 5.125              | 4.975 - 4.987            | 0.079 - 0.084        |
|                                | 5.250              | 5.100 - 5.114            | 0.079 - 0.084        |
|                                | 5.375              | 5.221 - 5.235            | 0.079 - 0.084        |
|                                | 5.500              | 5.346 - 5.360            | 0.079 - 0.084        |
|                                | 5.511              | 5.357 - 5.371            | 0.079 - 0.084        |
|                                | 5.625              | 5.471 - 5.485            | 0.079 - 0.084        |
|                                | 5.750              | 5.590 - 5.604            | 0.079 - 0.084        |
|                                | 5.875              | 5.715 - 5.729            | 0.079 - 0.084        |
|                                | 5.905              | 5.745 - 5.759            | 0.079 - 0.084        |

**Table 4 - Groove dimensions, external rings (inches) (continued)**

| Type/Class                     | Nom<br>Shaft<br>ØB | Groove<br>Diameter<br>ØC | Groove<br>Width<br>F |
|--------------------------------|--------------------|--------------------------|----------------------|
| Type I, Class 1<br>(Continued) | 6.000              | 5.840 - 5.854            | 0.079 - 0.084        |
|                                | 6.125              | 5.945 - 5.961            | 0.094 - 0.100        |
|                                | 6.250              | 6.070 - 6.086            | 0.094 - 0.100        |
|                                | 6.299              | 6.119 - 6.135            | 0.094 - 0.100        |
|                                | 6.375              | 6.195 - 6.211            | 0.094 - 0.100        |
|                                | 6.500              | 6.320 - 6.336            | 0.094 - 0.100        |
|                                | 6.625              | 6.435 - 6.451            | 0.094 - 0.100        |
|                                | 6.750              | 6.560 - 6.576            | 0.094 - 0.100        |
|                                | 6.875              | 6.685 - 6.701            | 0.094 - 0.100        |
|                                | 7.000              | 6.810 - 6.826            | 0.094 - 0.100        |
|                                | 7.125              | 6.925 - 6.941            | 0.094 - 0.100        |
|                                | 7.250              | 7.050 - 7.066            | 0.094 - 0.100        |
|                                | 7.375              | 7.175 - 7.191            | 0.094 - 0.100        |
|                                | 7.500              | 7.300 - 7.316            | 0.094 - 0.100        |
|                                | 7.625              | 7.415 - 7.431            | 0.094 - 0.100        |
|                                | 7.750              | 7.540 - 7.556            | 0.094 - 0.100        |
|                                | 7.875              | 7.665 - 7.681            | 0.094 - 0.100        |
|                                | 8.000              | 7.790 - 7.806            | 0.094 - 0.100        |
|                                | 8.250              | 8.030 - 8.046            | 0.094 - 0.100        |
|                                | 8.500              | 8.280 - 8.296            | 0.094 - 0.100        |
|                                | 8.750              | 8.520 - 8.536            | 0.094 - 0.100        |
|                                | 9.000              | 8.770 - 8.786            | 0.094 - 0.100        |
|                                | 9.250              | 9.010 - 9.026            | 0.094 - 0.100        |
|                                | 9.500              | 9.260 - 9.276            | 0.094 - 0.100        |
|                                | 9.750              | 9.500 - 9.516            | 0.094 - 0.100        |
|                                | 10.000             | 9.750 - 9.766            | 0.094 - 0.100        |
|                                | 10.250             | 9.990 - 10.006           | 0.094 - 0.100        |
|                                | 10.500             | 10.240 - 10.256          | 0.094 - 0.100        |
|                                | 10.750             | 10.480 - 10.496          | 0.094 - 0.100        |
|                                | 11.000             | 10.730 - 10.746          | 0.094 - 0.100        |

**Table 5 - Groove dimensions, internal rings (inches)**

| Type/Class       | Nom<br>Bore<br>ØB | Groove<br>Diameter<br>ØC | Groove<br>Width<br>F |
|------------------|-------------------|--------------------------|----------------------|
| Type II, Class 2 | 0.500             | 0.528 - 0.532            | 0.039 - 0.042        |
|                  | 0.512             | 0.540 - 0.544            | 0.039 - 0.042        |
|                  | 0.562             | 0.594 - 0.598            | 0.039 - 0.042        |
|                  | 0.625             | 0.663 - 0.667            | 0.039 - 0.042        |
|                  | 0.688             | 0.730 - 0.734            | 0.039 - 0.042        |
|                  | 0.750             | 0.794 - 0.798            | 0.039 - 0.042        |
|                  | 0.777             | 0.822 - 0.828            | 0.046 - 0.049        |
|                  | 0.812             | 0.859 - 0.865            | 0.046 - 0.049        |
|                  | 0.866             | 0.917 - 0.923            | 0.046 - 0.049        |
|                  | 0.875             | 0.928 - 0.934            | 0.046 - 0.049        |
|                  | 0.901             | 0.956 - 0.962            | 0.046 - 0.049        |
|                  | 0.938             | 0.997 - 1.003            | 0.046 - 0.049        |
|                  | 1.000             | 1.063 - 1.069            | 0.046 - 0.049        |
|                  | 1.023             | 1.088 - 1.094            | 0.046 - 0.049        |
|                  | 1.062             | 1.126 - 1.134            | 0.056 - 0.060        |
|                  | 1.125             | 1.193 - 1.201            | 0.056 - 0.060        |
|                  | 1.188             | 1.258 - 1.266            | 0.056 - 0.060        |
|                  | 1.250             | 1.326 - 1.334            | 0.056 - 0.060        |
|                  | 1.312             | 1.392 - 1.400            | 0.056 - 0.060        |
|                  | 1.375             | 1.457 - 1.465            | 0.056 - 0.060        |
|                  | 1.439             | 1.524 - 1.532            | 0.056 - 0.060        |
|                  | 1.456             | 1.544 - 1.552            | 0.056 - 0.060        |
|                  | 1.500             | 1.590 - 1.598            | 0.056 - 0.060        |
|                  | 1.562             | 1.653 - 1.663            | 0.068 - 0.072        |
|                  | 1.625             | 1.720 - 1.730            | 0.068 - 0.072        |
|                  | 1.653             | 1.750 - 1.760            | 0.068 - 0.072        |
|                  | 1.688             | 1.787 - 1.797            | 0.068 - 0.072        |
|                  | 1.750             | 1.853 - 1.863            | 0.068 - 0.072        |
|                  | 1.812             | 1.917 - 1.927            | 0.068 - 0.072        |
|                  | 1.850             | 1.957 - 1.967            | 0.068 - 0.072        |
|                  | 1.875             | 1.984 - 1.994            | 0.068 - 0.072        |
|                  | 1.938             | 2.051 - 2.061            | 0.068 - 0.072        |
|                  | 2.000             | 2.117 - 2.127            | 0.068 - 0.072        |

**Table 5 - Groove dimensions, internal rings (inches) (continued)**

| Type/Class       | Nom<br>Bore<br>ØB | Groove<br>Diameter<br>ØC | Groove<br>Width<br>F |
|------------------|-------------------|--------------------------|----------------------|
| Type II, Class 1 | 2.047             | 2.113 - 2.123            | 0.056 - 0.060        |
|                  | 2.062             | 2.126 - 2.138            | 0.056 - 0.060        |
|                  | 2.125             | 2.189 - 2.201            | 0.056 - 0.060        |
|                  | 2.165             | 2.233 - 2.245            | 0.056 - 0.060        |
|                  | 2.188             | 2.256 - 2.268            | 0.056 - 0.060        |
|                  | 2.250             | 2.318 - 2.330            | 0.056 - 0.060        |
|                  | 2.312             | 2.384 - 2.396            | 0.056 - 0.060        |
|                  | 2.375             | 2.447 - 2.459            | 0.056 - 0.060        |
|                  | 2.437             | 2.513 - 2.525            | 0.056 - 0.060        |
|                  | 2.440             | 2.516 - 2.528            | 0.056 - 0.060        |
|                  | 2.500             | 2.576 - 2.588            | 0.056 - 0.060        |
|                  | 2.531             | 2.611 - 2.623            | 0.056 - 0.060        |
|                  | 2.562             | 2.642 - 2.654            | 0.056 - 0.060        |
|                  | 2.625             | 2.705 - 2.717            | 0.056 - 0.060        |
|                  | 2.677             | 2.761 - 2.773            | 0.056 - 0.060        |
|                  | 2.688             | 2.772 - 2.784            | 0.056 - 0.060        |
|                  | 2.750             | 2.835 - 2.847            | 0.056 - 0.060        |
|                  | 2.813             | 2.897 - 2.909            | 0.056 - 0.060        |
|                  | 2.834             | 2.922 - 2.934            | 0.056 - 0.060        |
|                  | 2.875             | 2.963 - 2.975            | 0.056 - 0.060        |
|                  | 2.937             | 3.025 - 3.037            | 0.056 - 0.060        |
|                  | 2.952             | 3.040 - 3.052            | 0.056 - 0.060        |
|                  | 3.000             | 3.090 - 3.102            | 0.068 - 0.073        |
|                  | 3.062             | 3.152 - 3.164            | 0.068 - 0.073        |
|                  | 3.125             | 3.217 - 3.229            | 0.068 - 0.073        |
|                  | 3.149             | 3.241 - 3.253            | 0.068 - 0.073        |
|                  | 3.187             | 3.277 - 3.289            | 0.068 - 0.073        |
|                  | 3.250             | 3.344 - 3.356            | 0.068 - 0.073        |
|                  | 3.312             | 3.410 - 3.422            | 0.068 - 0.073        |
|                  | 3.346             | 3.444 - 3.456            | 0.068 - 0.073        |
|                  | 3.375             | 3.473 - 3.485            | 0.068 - 0.073        |
|                  | 3.437             | 3.537 - 3.549            | 0.068 - 0.073        |
|                  | 3.500             | 3.600 - 3.612            | 0.068 - 0.073        |
|                  | 3.543             | 3.647 - 3.659            | 0.068 - 0.073        |
|                  | 3.562             | 3.666 - 3.678            | 0.068 - 0.073        |