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Superseding AS81819

(R) Bearings, Plain, Self-Aligning, Self-Lubricating,
High Speed Oscillation -65 to +160 °F General Specification For**RATIONALE**

The reason for updating this document is to bring qualification testing in line with current industry test capabilities. This procurement document deletes the class of products for sleeve and thrust bearings as well as the bearing dash numbers of -1, -3, and -4, only the -2 remains. Other sizes with liner thickness less than 0.015" will be offered in a new standard.

Under Department of Defense (DoD) Policies and Procedures, any qualification requirements and associated Qualified Products List (QPLs) are mandatory for DoD contracts. Any materials relating to QPLs have not been adopted by SAE and are not part of this SAE technical document.

1. SCOPE**1.1 Scope**

This standard covers the requirements for spherical, self-aligning, self-lubricating bearings which are for use in the ambient temperature range -65 to +160 °F (-54 to +71 °C) at high cyclic speeds. The scope of the standard is to provide a liner system qualification procedure for helicopter sliding bearings defined and controlled by source control drawings. Once a liner system is qualified the source-controlled bearings are further tested under application conditions.

1.2 Classification**1.2.1 Types**

Bearings covered by this standard shall be of the following types:

Type I - Self-Aligning Bearings with liners of a fabric, composite or molded polytetrafluoroethylene (PTFE) material.

Type II - Self-Aligning Bearings with machined liners of self-lubricating solids mechanically retained in the race.

2. APPLICABLE DOCUMENTS**2.1 SAE Publications**

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada), Tel: 724-776-4970 (outside USA), www.sae.org.

AMS-QQ-P-416 Plating, Cadmium (Electrodeposited)

AMS2417 Plating, Zinc-Nickel Alloy

ARP5448/2 Plain Bearing High Speed Oscillation Test

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on this Technical Report, please visit
<http://www.sae.org/technical/standards/AS81819A>**

AS8243 Anti-Icing and Deicing - Defrosting Fluids

AS81819/1 Bearings, Plain, Self-Aligning, Self-Lubricating, High Speed Oscillation General Standard For

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM A 967 Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts

ASTM C 794 Standard Test Method for Adhesion in Peel of Elastomeric Joint Sealant

ASTM F 25 Standard Test Method for Sizing and Counting Airborne Particulate Contamination in Clean Rooms and Other Dust Controlled Areas Designed for Electronic and Similar Applications

ASTM F 50 Standard Practice for Continuous Sizing and Counting of Airborne Particles in Dust Controlled Areas Using Instruments Based Upon Light Scattering Principles

2.3 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <https://assist.daps.dla.mil/quicksearch/>.

MIL-DTL-197 Packaging of Bearings, Anti-Friction, Associated Parts and Sub-Assemblies

MIL-PRF-5606 Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordnance

MIL-DTL-5624 Turbine Fuel, Aviation, Grades JP-4, JP-5 and JP-5/JP-8 ST

MIL-PRF-7808 Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number 0-148

MIL-PRF-83282 Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft, Metric, NATO Code Number H-537

MIL-STD-129 DoD Standard Practice Military Marking for Shipment and Storage

MIL-STD-2073-1 Standard Practice for Military Packaging

2.4 ANSI/ASME Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 202-293-8020, www.ansi.org, or ASME, 22 Law Drive, Box 2900, Fairfield, NJ 07007-2900, Tel: 800-843-2763, www.asme.org.

ANSI/ASME B46.1 Surface Texture (Surface Roughness, Waviness, and Lay)

ANSI/ASQ Z1.4 Sampling Procedures and Tables for Inspection by Attributes

3. REQUIREMENTS

3.1 Drawing Package

The individual item requirements shall be as specified in this main document and the associated product definition data located in AS81819/1. In the event of any conflict between the requirements of this main document and the product definition data, the latter shall govern.

3.2 Qualification

Bearings furnished under this standard shall be products which are authorized by the qualifying activity for listing on the applicable Qualified Products Database (listed under the Qualified Products List, QPL-AS81819) at the time of award of contract (see 6.3).

3.2.1 Retention of Qualification

To maintain status on a Qualified Products List (QPL), certification shall be submitted at two year intervals to indicate continued compliance with the requirements of this standard (see 4.3.1 and 6.3).

3.2.2 Requirements for Qualification Approval

Qualification approval of a self-lubricating liner material is based on the satisfactory performance of test bearings to the requirements of this standard. The test conditions and the associated test bearing dimensions are specified in the product definition data in AS81819/1. Prior to initiating the liner system evaluation tests, the manufacturer shall notify the qualifying agency (Naval Air Systems Command, Code 4.3.5.4) of the intention to submit for qualification approval. The letter of notification shall state the proposed date of initiation of the tests, the liner system identification (see 3.6) and that qualification approval is desired.

Upon completion of the test program, the test data shall be reported in accordance with 3.2.3. (Note: Data generated during the development phase of the liner system is not acceptable.) The test data shall be analyzed in accordance with the methodology described in 4.8 and shall meet the qualification test criteria listed in Table 1 of AS81819/1 and 3.17.4.5. Additional qualification submittal information is located in 3.17, 4.3 and 6.3. The report shall be submitted to the Naval Air Systems Command, Code 435400A, 48110 Shaw Road, Unit 5, Patuxent River, MD 20670-1906, along with 12 test verification samples (-2 size) and an associated test fee specified by the above qualification activity.

3.2.3 Requirements for Recording Performance Data

The data recorded for 3.12, 3.13, 3.15, and 3.16 and the performance data for 3.17 shall be summarized in report form. To ensure statistical accuracy of test data, the bearing suppliers (or the testing laboratory) shall certify that the data presented is the performance data for all bearings tested and that no data has been deleted. Any test malfunction resulting in an invalid test shall be noted in the report. A dated drawing completely describing the bearing(s), the dimensions, heat treatment, surface finish, platings or coatings, and liner system identification shall be included. The manufacturer's liner material identification, whether by trade name or numerical designation, shall be unique to that liner material and its processing.

TABLE 1 – CONSTANT LOAD DYNAMIC TEST QUALIFICATION APPROVAL CRITERIA

AS81819/1 DASH No.		-2
MAXIMUM ALLOWABLE AVERAGE WEAR RATE (WR) (10^{-6} inches/hours)		6.0
MINIMUM B-10 LIFE	HOURS	400 hours
	RATED WEAR	0.005 inch
VERIFICATION TEST SAMPLES		10

3.3 First Article

When specified in the contract or purchase order, a sample shall be subjected to first article inspection (see 4.4 and 6.4).

3.4 Product Manufacture

Except for the bonding and swaging operations, the manufacturer is permitted to subcontract manufacturing operations without violating the requirements of 3.2.1. The bonding and swaging operations shall be performed in the plant listed in the Qualified Products List (QPL-AS81819). Manufacture of the self-lubricating liner material may also be subcontracted. Any change in (1) the liner manufacturer, (2) the liner manufacturing procedures, or (3) the materials used in manufacture of the liner will require requalification to an extent determined by the qualifying activity.

3.4.1 Product Change

Unless written approval is given by the Naval Air Systems Command, Code 4.3.5.4., any change in product design, materials, source of materials used in self-lubricating liner, liner manufacturer, or bonding related operations shall require resubmittal of bearings to qualification inspection and/or first article inspection.

3.5 Materials

Materials shall be as specified on the product definition data located in AS81819/1.

3.5.1 Plating and Coating

Unless otherwise specified in the product definition data, plating or coating of the mating surface for the liner system shall be an option of the manufacturer. The mating material to the liner is part of the liner system and if changed would require requalification. If plating or coating is used, it must be identified in the test report and drawings. Plating of the outer diameter of the outer ring shall be in accordance with CAD plating per AMS-QQ-P-416 Type II, Class 2 or Zinc-nickel plating per AMS2417, Type 2.

3.5.2 Usable liner thickness

The liner used in these bearings shall have a minimum usable thickness of 0.015-inch.

3.5.3 Passivation

Passivation is at the option of the manufacturer. Passivation, if used, should be in accordance with ASTM A 967.

3.6 Liner System Identification

The liner material and any bonding and curing processes shall be established by the manufacturer and maintained by their in-house manufacturing and quality control documents. The manufacturer's liner system identification, whether by trade name or numerical designation, shall identify the liner material and the associated bonding and curing process requirements. In addition to the trade name or numerical designation, the manufacturer shall specify in their test report (see 3.2.3) the classification type and for Type I bearings the maximum liner thickness in a finished bearing.

3.7 Design

Bearing design shall conform to the dimensional requirements in the product definition data. All other design features shall be shown on the manufacturers drawings and shall be sent to the Qualifying Activity. Drawings shall show in detail the manufacturers product by specifying all dimensions, tolerances, materials, liners, plating, heat treatment and passivations. Any information the manufacturer deems proprietary must be so indicated. Bearings shall not have loading slots.

3.8 Construction

Bearing construction shall conform to the requirements in the product definition data. Details of the parts shall be shown on the manufacturers drawings and shall be sent to the Qualifying Activity.

3.9 Dimensions and Tolerances

Dimensions and tolerances shall be as specified in the product definition data. Dimensions not shown in the product definition data or specified herein shall be shown on the manufacturers drawings and shall be sent to the Qualifying Activity.

3.10 Surface Texture

The specified surface texture shall be in accordance with ANSI/ASME B46.1. The mating surface for the liner system shall have a roughness height rating of R_a 8 maximum. This rating also applies to pins and shafts. These shafts, pins and mating surfaces may be supplied by the bearing user. The inner bore, all faces and outer ring periphery shall have a surface texture of R_a 32 maximum. All other surfaces shall have a texture of R_a 125 maximum.

3.11 Lubrication

The self-lubricating bearings covered by this standard shall operate without subsequent relubrication. Dry film lubrication is acceptable during manufacture if part of the normal manufacturing process. Grease and oil lubrication are not permitted.

3.12 Conformity

The spherical surface of the ball shall be in proper contact (conformity) with its mating surface (see 3.12.1 or 3.12.2).

3.12.1 Conformity Measurement (Type I Bearings)

For spherical bearings with fabric or fabric composite liners, the conformity of the liner and outer rings shall be measured normally. For bearings with molded liners, the conformity of the liner and the outer rings shall be measured both normally and circumferentially.

3.12.1.1 Normal Conformity of Fabric or Fabric Composite Spherical Bearings (Type I Bearings)

When inspected in accordance with 4.7.8.1, the values of "t measured" shall be within the appropriate range specified in Table 2. Measurements shall be taken at a minimum of five uniformly spaced positions across the width of the bearing. When radial looseness is specified, the process used to generate looseness shall not distort the ball-to-outer ring contour beyond the conformity limits specified in Table 2. When overforming of the outer ring is observed during inspection in accordance with 4.7.8.1, two additional measurements shall be taken in the outer 10% of the outer ring width (one measurement on each side). These additional values shall not vary from the center value by more than 0.001 inch. Overforming is allowed in the outer 10% of the ring as long as the minimum liner thickness is greater than or equal to 0.015 inches. Underforming is not controlled. These values apply to bearings whose outer ring width (H) to ball diameter (d) ratio is in the range of 0.44 to 0.62.

TABLE 2 - ALLOWABLE VARIATIONS

Ball Diameter (d) (inches)	Allowable Variation of Conformity Measurements (Type I Bearings)
	Swaged Bearings
0 → 2	$t_{\min} \leq t \text{ measured} \leq (t_{\min} + 0.0030 \text{ inch})$
2+ → 3	$t_{\min} \leq t \text{ measured} \leq (t_{\min} + 0.0035 \text{ inch})$
3+ → 4	$t_{\min} \leq t \text{ measured} \leq (t_{\min} + 0.0040 \text{ inch})$
4+ → 10	$t_{\min} \leq t \text{ measured} \leq (t_{\min} + 0.0050 \text{ inch})$
	Non-Swaged Bearings
0 → 10	$t_{\min} \leq t \text{ measured} \leq (t_{\min} + 0.0030 \text{ inch})$

3.12.1.2 Normal Conformity of Molded Liner Spherical Bearings (Type I Bearings)

Normal conformity of spherical bearings with molded liners shall be measured in accordance with 4.7.8.1. The precise shape of the cavity containing the liner material is not defined. However, the cavity shall not exhibit sharp angular changes in curvature across the width of the bearing. Dimension "t" shall be measured initially at the midpoint and H/10 positions (see Figure 4(b)). The allowable values at the H/10 positions shall be at least 0.017 ± 0.002 inches for all sizes. The maximum liner thickness shall occur at the midpoint. The allowable values of "t" at the midpoint shall be equal to, or greater than, the H/10 values but not greater than 0.022 inch. In addition to the three initial measurements, the outer 10% of the outer ring width shall be checked for overforming in accordance with 3.12.1.1.

3.12.1.3 Circumferential Conformity of Molded Liner Spherical Bearings (Type I Bearings)

In molded liner bearings, the circumferential conformity shall be measured in accordance with 4.7.8.1.1. Variation in the values of "t" shall not be greater than 0.003 inch.

3.12.2 Conformity Measurement (Type II Bearings)

When inspected in accordance with 4.7.8.2, the variation between measured values shall be not greater than 0.003 inch. Unless otherwise specified in the product definition data, the liner surface shall have a radius of curvature greater than that of the ball. The liner surface shall be machined and installed so that contact between the liner material and the ball occurs in the sector of the liner between positions 1 and 3 (see Figure 5).

3.13 Liner Integrity

The material(s) used in the liner shall be free of defects or foreign matter which decrease the serviceability of the bearing.

3.13.1 PTFE Liner Condition and Bond Integrity (Type I Bearings)

3.13.1.1 Visual Examination

The visual appearance of the bonded liner shall exhibit a degree of workmanship consistent with proper manufacturing process controls, as checked per 4.7.9.1.1. The liner shall be uniform in texture and shall contain no imbedded contaminants. The liner set-back shall meet the applicable drawing requirements. There shall be no separation or lifting of the liner at any of the edges. There shall be no unraveling or excessive fraying of the liner at any of the edges. Molded liners shall completely fill the cavity between the ball and outer ring and shall not contain embedded contaminants, cracks or bubbles.

3.13.1.2 Bond Integrity and Peel Strength

When tested in accordance with 4.7.9.1.2, the liner shall be tightly adherent to the metallic substrate over at least 90% of the contact area and shall exhibit an average peel strength of 2.0 pounds per inch or greater. The adhesive remaining on the metal substrate shall have no void or unbonded area which cannot be included within a circumscribing circle with a diameter equal to 25% of the outer ring width or 0.250 inch, whichever is smaller.

3.13.1.2.1 Processing Controls

All fabrication of the PTFE liner involving application or mixing of adhesive, and all liner bonding procedures involving application of adhesive, shall be conducted in a controlled area.

3.13.1.2.2 Controlled Area

The controlled area shall be maintained at a temperature of 75 ± 10 °F with a maximum relative humidity of 75%. The enclosed atmosphere of the work area shall be well ventilated and maintained so that a maximum count of 2500/ft³ is allowed for particles 5.0 microns or larger when measured per ASTM F 25 or ASTM F 50. The particle count measurement shall be performed annually (minimum). There shall be no eating or smoking in the controlled area and no process which produces uncontrolled spray, dust, fumes or particulate matter.

3.13.1.3 Liner Peelability

Each manufacturer shall establish during qualification testing whether the liner is peelable or non-peelable. If peelable, the manufacturer shall determine the mean and standard deviation peel strength values for the liner based upon a minimum of six peel strength tests conducted in accordance with 4.7.9.1.2. This data shall be recorded in the qualification test report. A liner originally qualified as peelable shall remain peelable in production. A liner originally qualified as non-peelable shall remain non-peelable in production.

3.13.2 PTFE Liner Condition (Type II Bearings)

The bearing outer ring shall be inspected for fractured liner elements (see 4.7.9.2). There shall be no fractures through the liner element. Small chips on the edges of an element are acceptable provided they do not exceed 0.050 inch depth, 0.030 inch width, 0.050 inch length, and do not have a cumulative length exceeding 0.200 inch on any side.

3.14 Alignment

Bearings shall be self-aligning. Angular misalignment shall be as specified in the product definition data.

3.15 No-Load Rotational Breakaway Torque

Bearings designed with no clearance between mating surfaces shall have a no-load breakaway torque specified in the product definition data (see 4.7.4).

3.16 Internal Clearance

Bearings designed with clearance (internal play) between mating surfaces shall have the allowable clearance specified in the product definition data (4.7.4.1).

3.17 Performance

The performance requirements of this standard are intended for qualification testing purposes and are applicable only to the associated test bearings listed in the product definition data located in AS81819/1. The test bearings are intended to provide a means of evaluating and qualifying a liner system to be used in production bearings. The various test conditions in the product definition data were chosen to represent typical size and motion regimes associated with main rotor components of helicopters but are not presumed to describe actual operational conditions which production bearings will experience in the aircraft.

The bearing manufacturer shall fabricate test bearings to the dimensions shown in the product definition data for which qualification approval is sought. The test bearings shall be produced in accordance with the manufacturer's in-house manufacturing and quality control requirements and with the liner system identified in accordance with 3.6. The bearing manufacturer shall subject the test bearings to the qualification inspections specified in Table 3 and report the results in accordance with 3.2.3. The dynamic and static test loads are given in the product definition data located in AS81819/1.

3.17.1 Radial Static Limit Load

The radial static limit load test shall be performed at the load specified in the product definition data located in AS81819/1 (also see 4.7.1). A load deflection curve shall be prepared and permanent set shall be recorded at the completion of the test. The permanent set shall be not greater than 0.006 inch.

3.17.2 Axial Static Limit Load

The axial static limit load test shall be performed at the load specified in the product definition data located in AS81819/1 (also see 4.7.2). A load deflection curve shall be prepared and permanent set shall be recorded at the completion of the test. The permanent set shall be not greater than 0.006 inch.

3.17.3 Static Ultimate Load

There shall be no fracture of any component or push-out of the ball when subjected to the radial static test (see 4.7.1) and the axial static test (see 4.7.2). These loads are 1.5 times the radial and axial static limit loads specified in 3.17.1 or 3.17.2. The radial and axial static ultimate load and the permanent set shall be recorded upon completion of the test. Bearings from the limit load tests can be used for the ultimate load tests in regards to both axial and radial. Permanent set data can be observed by the addition of the limit and the ultimate figures.

3.17.4 Requirements for Dynamic Test

The samples specified in Table 3 shall meet the requirements of 3.17.4.1 through 3.17.4.5. Test data shall be analyzed in accordance with the methodology described in 4.8 and shall meet the qualification approval criteria listed in Table 1. Data indicating the progress of the test shall be recorded at sufficient intervals to produce an accurate plot of wear and bearing housing temperature versus hours. If fan cooling is utilized to maintain the bearing housing temperature at a lower operating level, then the volume of cooling shall be similarly recorded indicating the cubic feet per minute (CFM) of air cooling and the bearing. Before and after testing, the static breakaway torque of the bearing under load shall be measured and recorded. After the test, the bearing liner shall be inspected and the observations recorded. Note: Criteria for qualification should include a Weibull analysis and minimum B-10 life calculation (See Section 4.8 and Table 1).

3.17.4.1 Water Contaminant Requirement

The sample bearings shall be tested in accordance with 4.7.3. At the conclusion of the 600 hour test the liner shall not exhibit wear exceeding the lower of the three following values, (1) no metal to metal contact, (2) no more than the usable liner thickness as specified in para 4.7.3 or (3) no more than 0.015 inch. Testing on one bearing shall be continued until one of the following occurs: (1) 0.020 in wear; (2) three times the duration requirements of Table 1 of AS81819/1 have been reached; (3) metal to metal contact.

3.17.4.2 Fluid Compatibility Requirement

Sample bearings shall be tested in accordance with 4.7.5. The bearings shall be compatible with the fluids listed. No corrosion of the bearings shall result. (Superficial tarnish that can be removed with a damp cloth shall not be cause for rejection.) At the conclusion of the 200 hour test the liner shall not exhibit wear exceeding the lower of the three following values, (1) no metal to metal contact, (2) no more than the usable liner thickness as specified in para 4.7.3 or (3) no more than 0.010 inch.

3.17.4.3 Temperature Extremes Requirement

The sample bearings shall be tested in accordance with 4.7.6. At the conclusion of the 600 hour test the liner shall not exhibit wear exceeding the lower of the three following values, (1) no metal to metal contact, (2) no more than the usable liner thickness as specified in para 4.7.3 or (3) no more than 0.015 inch.

3.17.4.4 Solid Contaminant (Dust) Requirement

Sample bearings shall be tested in accordance with 4.7.7. Procurement information for test dust is as follows:

NOMENCLATURE	"SAE Fine Test Dust, NIST traceable"
PART NUMBER:	ISO 12103-1, A2 Fine Test Dust
ADDRESS:	Powder Technology Inc., P. O. Box 1464, Burnsville, MN 55337

At the conclusion of the 600 hour test the liner shall not exhibit wear exceeding the lower of the three following values, (1) no metal to metal contact, (2) no more than the usable liner thickness as specified in para 4.7.3 or (3) no more than 0.015 inch.

3.17.4.5 Cyclic Load Oscillation Wear Test

Four M81819/1-2 bearings shall be tested in accordance with 4.7.3.1 and the product definition data located in AS81819/1. Two bearings shall be tested at 300 CPM, ± 10 degree oscillation, ± 2300 pounds cyclic load for 600 hours (Test Condition I). The other two bearings shall be tested at 300 CPM, ± 10 degree oscillation, 2300 ± 2300 pounds cyclic load for 600 hours (Test Condition II). Synchronization of the load with the ball oscillation shall be such that the maximum load and maximum ball surface speed occur at the same time. Ball oscillation is defined as ball rotating about the axis of the ball bore and not as misalignment movement. For qualification approval purposes, these bearings shall operate for a minimum of 600 hours with a maximum allowable liner wear of 0.013 inch for Test Condition I and 0.008 inch for Test Condition II.

TABLE 3 - QUALIFICATION REQUIREMENTS

Test	Requirement Paragraph	Test Method Paragraph	Samples to be Tested
Static Tests			
Radial Test	3.17.1, 3.17.3	4.7.1	3
Axial Test	3.17.2, 3.17.3	4.7.2	3
Dynamic Tests			
Constant Load	3.17.4	4.7.3	
Water Contaminant Test	3.17.4, 3.17.4.1	4.7.3	3
Fluid Compatability	3.17.4, 3.17.4.2	4.7.5	6
Temperature Extremes	3.17.4, 3.17.4.3	4.7.6	2
Solid Contaminants (Dust)	3.17.4, 3.17.4.4	4.7.7	3
Cyclic Load			
Test Condition I	3.17.4, 3.17.4.5	4.7.3.1	2
Test Condition II	3.17.4, 3.17.4.5	4.7.3.1	2
Conformity	3.12	4.7.8	2
Liner Integrity	3.13	4.7.9	5
No-Load Rotational	3.15	4.7.4	5
Internal Clearance	3.16	4.7.4.1	5

3.18 Test Records

During normal production, the bearing manufacturer shall maintain a record showing quantitative results of all inspections and tests for five years. This record shall be available to the procuring activity and shall be signed by an authorized representative of the manufacturer or the testing laboratory. Test samples shall be retained for not less than five years.

3.19 Identification of Product

Each test bearing shall be permanently and legibly marked with the part number given in the product definition data, the bearing manufacturer's name or trademark, and part number of the bearing. Identification shall appear in the location specified in the product definition data. Metal impression stamping is prohibited.

3.20 Workmanship

3.20.1 General Requirements

All workmanship shall be such as to result in a first quality bearing which meets the requirements of this standard. The bearing shall be free from defects which may affect its durability and serviceability.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the contractor may use their own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the standard where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for Compliance

All items must meet all requirements of Sections 3 and 5. The inspection set forth in this standard shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the standard shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Classification of Inspections

The inspection and testing requirements specified herein are classified as follows:

- a. Qualification inspection (4.3).
- b. First article inspection (4.4).
- c. Quality conformance inspection (4.5).

4.3 Qualification Inspection

Qualification inspection shall consist of the inspections in Table 3 (see 3.2, 3.2.2, and 6.3).

4.3.1 Retention of Qualification

The continued listing of a product on the Qualified Products List is dependent upon a periodic verification of the manufacturer's continued compliance with the requirements of this standard and with standardization regulations. As part of that verification process, each manufacturer must complete DD Form 1718 during October of each odd numbered year. This form, supplied by the qualifying activity, is to be signed by a responsible official of management and sent to the Naval Air Systems Command, Code 435400A, 48110 Shaw Road, Unit 5, Patuxent River, MD 20670-1906.

4.3.1.1 Product Change

Any change in product design, description, materials or bonding related operations shall be reported to the qualifying activity and shall require requalification of the product to an extent determined by the qualifying activity.

4.3.1.2 Product Manufacture

Except for the bonding and swaging operations, the manufacturer is permitted to subcontract manufacturing operations without violating the requirements of 4.3.1.1. The bonding and swaging operations shall be performed in the plant listed on the QPL-AS81819. Manufacture of the self-lubricating liner material may also be subcontracted. Any change in (1) the liner manufacturer, (2) the liner manufacturing procedures, or (3) the materials used in manufacture of the liner shall require requalification as determined by the qualifying activity.

4.3.1.3 Periodic Retest for Retention of Qualification

In addition to the certification requirement of 4.3.1, each manufacturer shall retest a sample of bearings from recent production at five year intervals beginning in 2011. The tests to be performed shall be as follows:

- a. 4.7.3.1 Cyclic Load Oscillation Wear Test.
- b. 4.7.5 Fluid Compatibility, Using MIL-PRF-83282 Hydraulic Fluid.
- c. 4.7.6 Temperature Extremes.
- d. 4.7.8 Conformity Test.
- e. 4.7.9 Liner Integrity.

The test bearings shall be a –2 size from normal production. One sample each of tests (a) through (c) and two samples each of tests (d) and (e) are required. The test data shall be assembled in report form, certified by the Chief Engineer or other responsible official of management and forwarded to the qualifying activity in October of the appropriate year (see 6.3).

4.4 First Article Inspection

The first article inspection shall consist of the inspections listed in Table 4. The requirements of Table 4 may be satisfied only by actual data from tests on the first lot of bearings produced (see 3.3). Five bearings shall be selected from this lot and subjected to the tests in Table 4 in the order in which they are listed. Unless otherwise specified, the first article inspection report format shall be in accordance with Table 8.

TABLE 4 - FIRST ARTICLE INSPECTIONS

Test	Requirement Paragraph	Test Method Paragraph	Samples to be Tested
No-Load Rotational Breakaway Torque	3.15	4.7.4	5
Internal Clearance	3.16	4.7.4.1	5
Conformity	3.12	4.7.8	5
Liner Integrity	3.13	4.7.9	5

4.5 Quality Conformance Inspections

The quality conformance tests of the bearings shall consist of the examinations and tests of Table 5 to determine conformance to the requirements of this standard and the product definition data located in AS81819/1. Unless otherwise specified (see 6.2), inspections shall be conducted in accordance with ANSI/ASQ Z1.4 , Inspection Level II, Table 2A. Satisfactory results from first article inspection (see Table 4) may be applied toward satisfying the requirements of quality conformance inspections (see Table 5, (f), (g), (h)) for the lot from which the samples were obtained. Unless otherwise specified by the procuring activity, the quality conformance inspection report format shall be in accordance with Table 9.

TABLE 5- QUALITY CONFORMANCE INSPECTION

Examinations and Tests	Requirement Paragraph	Test Method Paragraph	AQL
(a) Dimensions	3.9	4.6	4.0
(b) Identification of Product	3.19	4.6	1.0
(c) Workmanship	3.20	4.6	1.0
(d) Packaging	5.0	4.9	1.0
(e) Internal Clearance	3.16	4.7.4.1	*
(f) No-Load Rotational Breakaway Torque	3.15	4.7.4	*
(g) Conformity	3.12	4.7.8	**
(h) Liner Integrity	3.13	4.7.9	**
(i) Surface Texture	3.10	4.6	1.0
(j) Alignment	3.14	4.6	4.0
* Acceptance number should be zero. See 4.5.2.3.			
** Special inspection plan. See 4.5.2.2.			

4.5.1 Inspection Lot

The inspection lot shall consist of finished bearings having the same part number. The bearings shall be manufactured using the procedures established for the first article inspection. The bearings shall be swaged or formed on the same tool setup, produced as one continuous run, purchase order or portion thereof, and from one or more liner bonding runs which can be identified by means of in-house processing records.

4.5.2 Sampling

4.5.2.1 Sample for Quality Conformance Inspection (a) through (d), (i) and (j)

The sample bearings shall be selected from each inspection lot in accordance with ANSI/ASQC Z1.4 , Inspection Level II.

4.5.2.2 Sample for Quality Conformance Inspection (g) and (h)

The sample bearings shall be selected from each inspection lot in accordance with Table 6. The sample bearings shall be selected at random from the lot of finished bearings. A lot that was rejected under Normal Inspection shall be scrapped.

TABLE 6 - DESTRUCTIVE INSPECTION SAMPLING PLAN

Lot Size	Normal Inspection Sample Size	A	R
5 - 50	4	0	1
51 - 500	6	0	1
501 - 5000	10	1	2
5001 - 50 000	16	1	2
A = Acceptance Number R = Rejection Number			

4.5.2.3 Sample for Quality Conformance Inspection (e) and (f)

The inspection lot shall be 100% inspected. Defective bearings shall be removed from the inspection lot and reworked or scrapped. If rework entails mechanical adjustments that could change the conformity of the bearing, the reworked bearings shall be reinspected as a new inspection lot.

4.5.3 Quality Assurance Certification

For each inspection lot the manufacturer shall maintain, for not less than five years, and supply to the purchaser upon demand, certified copies of all records of quality conformance inspections. These records and certifications shall identify the manufacturer of the bearings, the address of the manufacturing plant, the procuring activity and the purchase order number (see 6.2.1e).

4.5.4 Resubmitted Inspection Lots for Quality Conformance Tests (a) through (d), (i) and (j) (see Table 5)

The paragraph titled "Resubmitted Lots or Batches" of ANSI/ASQC Z1.4 shall apply. A resubmitted inspection lot shall be inspected using tightened inspection. Where the original acceptance number was zero, a sample size represented by the next higher sample size code letter shall be selected. When an inspection lot is resubmitted, full particulars concerning the cause of previous rejection and the action taken to correct the defects shall be furnished by the contractor to the procuring activity.

4.6 Examination of Product

The bearings shall be examined to determine conformance to the requirements of this standard and the product definition data located in AS81819/1 for plating, dimensions, finish, texture, identification of product, workmanship and requirements not covered by tests.

4.7 Test Methods

Unless otherwise specified, all tests shall be conducted at room temperature.

4.7.1 Radial Static Test

The bearings shall be installed in a test fixture as shown on Figure 1. Differential temperatures for installation are not allowed. A preload of 4 to 6% of the radial static limit load shall be applied to the bearing for 3 minutes (see product definition data located in AS81819/1), and the measuring device set at zero. Increase the load at a rate of 1% per second of the specified load until it equals the radial static limit load. Maintain the load for 2 minutes. Reduce the load at the same rate to the preload value. The permanent set is the reading at preload. The radial static ultimate load shall be applied at the rate of 1% per second of the specified load.

4.7.2 Axial Static Test

The bearings shall be installed in a test fixture as shown in Figure 2. The hole diameter in the support fixture shall be the nominal diameter of the ball plus 0.025 inch. A preload of 4 to 6% of the axial static limit load shall be applied to the bearing for 3 minutes (see product definition data located in AS81819/1). Set the measuring device at zero. Increase the load at the rate of 1% per second of the specified load until it equals the axial static limit load. Hold for 2 minutes, then reduce at the same rate to the preload value. The permanent set is the reading at preload. The axial static ultimate load shall be applied at the rate of 1% per second of the specified load.

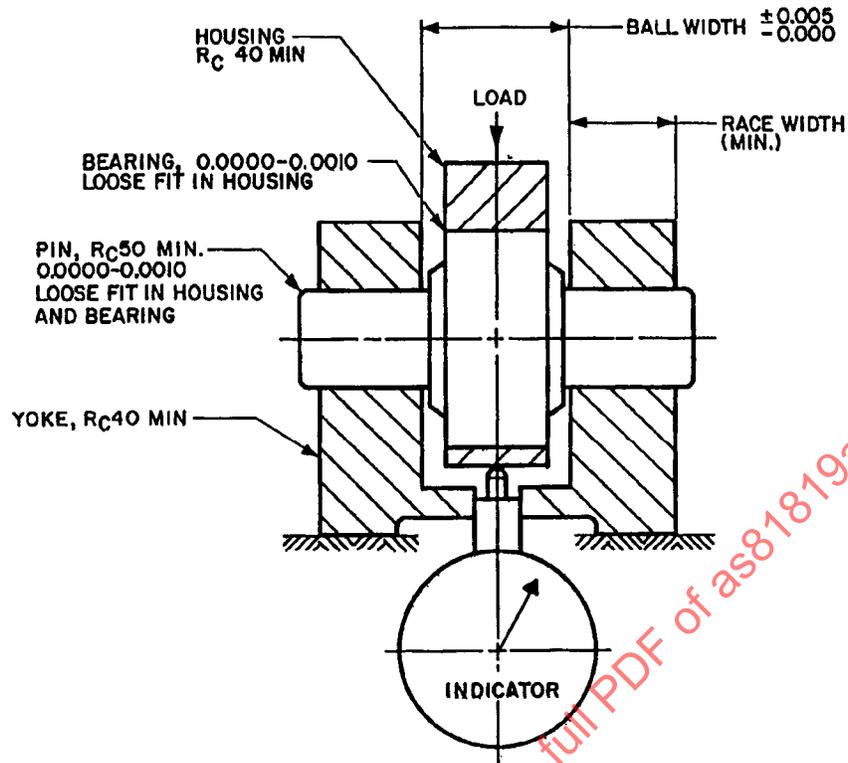


FIGURE 1 - RADIAL STATIC TEST LOAD TEST FIXTURE

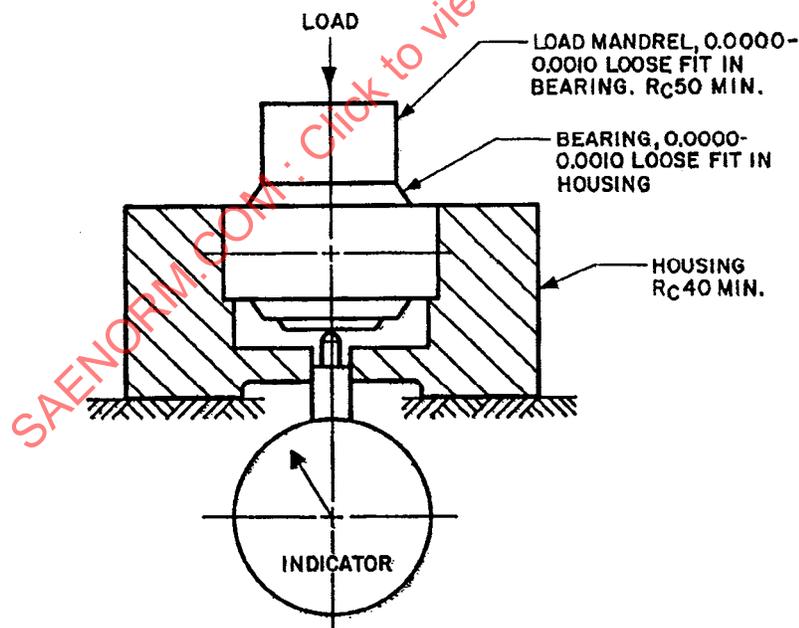
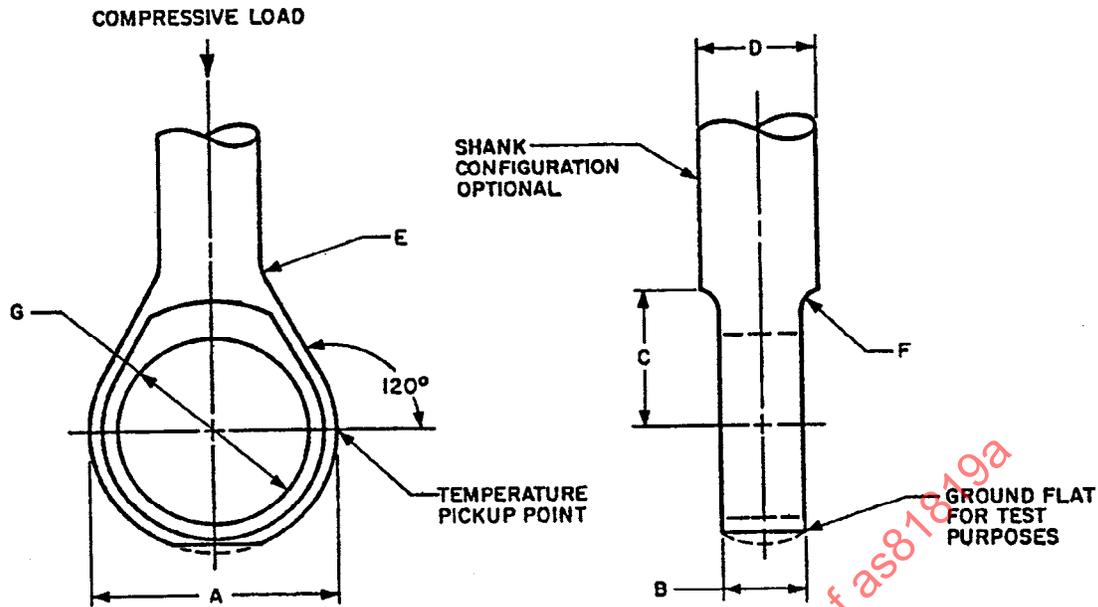


FIGURE 2 - AXIAL STATIC TEST LOAD TEST FIXTURE

4.7.3 Dynamic Test

The bearing shall be installed in a steel housing (see Figure 3). A standard close tolerance aircraft bolt or pin (125 000 psi minimum) shall be used as a shaft for the bearing. The clearance between the bearing I.D. and the bolt (or pin) shall not be greater than 0.0015. The bearing shaft shall be placed in double shear with a minimum of bending and permit rotation of the ball with respect to the outer ring. Prior to and upon completion of the test, the breakaway torque and the static coefficient of friction of the bearing under the test load shall be recorded.



Test Conditions	A (Dia) ±.010	B ±.005	C ±.010	D (Dia) ±.010	E (Radius) Min	F (Radius) Min	G (Dia)	Test Bearing O.D.
#1	4.000	1.375	2.250	2.000	2.250	.375	3.2490 3.2480	3.2500 3.2490
#2	2.150	.797	1.125	1.000	1.125	.125	1.7495 1.7490	1.7500 1.7495
#3	1.468	.500	.875	.625	.750	.093	1.1870 1.1865	1.1875 1.1870
#4	1.000	.312	.625	.375	.500	.062	.8123 .8118	.8125 .8120

Material: Steel (CRES Recommended)
Heat Treatment: Optional

FIGURE 3 - BEARING HOUSING CONFIGURATIONS FOR DYNAMIC TESTS

The dynamic load shall be applied so that the shank of the bearing housing is in compression as shown in Figure 3. (The shank of the bearing housing may be placed in a horizontal position.) The bearing shall be loaded statically for 15 minutes. After this time, the indicating device shall be set to zero and the test started. As the ball of the bearing is oscillated, the bearing shall be contaminated with water (tap water, "bottled water" or distilled water at the manufacturers option), applied at the juncture of the upper side of the ball and outer ring. The water shall be applied (metered stream sprayed on) six times per day in the amount of 30 ml (1 fluid ounce) minimum to each side of the bearing. Due to the length of the dynamic tests, it is permissible for the test machine to be allowed to run unattended overnight and up to three successive days provided that the water contamination is applied at least six times per calendar day of attended testing for a minimum of thirty times per calendar week. The test conditions are shown in Table 1 of the product definition data located in AS81819/1.

The wear shall be recorded at time intervals close enough to produce a graph showing wear in thousandths of an inch versus life in hours. There shall be a minimum of one reading per normal work day. The bearing housing temperature shall be measured as shown in Figure 3 at intervals close enough to produce a graph of temperature versus hours.

The usable liner thickness shall be established from the recorded data. The usable liner thickness is defined as the smaller of the following two quantities: (1) the value determined from the graph of wear versus hours where a sudden increase in wear rate is exhibited which results in rapid loss of bearing serviceability; (2) the value determined from the graph of wear versus hours at which time there is metal-to-metal contact.

4.7.3.1 Cyclic Load Oscillation Wear Test

Install M81819/1-2 bearings in the same manner as in 4.7.3 and test according to the requirements shown under "Cyclic Load Oscillation Wear Test Conditions" in Table 1 of the product definition data located in AS81819/1. The load application rate and ball oscillation shall approximate a sinusoidal curve. Water shall be applied as specified in 4.7.3. Wear readings shall be taken once per normal work day with a bearing under a load of 200 pounds. At the completion of the specified test time, the bearing shall be removed and sectioned through the maximum load zone and the amount of liner material remaining shall be measured so that the amount of wear can be calculated.

4.7.4 No-Load Rotational Breakaway Torque Test

The no-load rotational breakaway torque shall be determined by holding the outer ring/sleeve member of the bearing fixed while rotating the ball/sleeve about the bearing axis. The outer ring/sleeve shall be held in such a manner as to minimize bearing distortion and resultant effect on the bearing preload torque. The use of excessive ball clamping forces to drive the ball/sleeve must also be avoided. The ball/sleeve shall be misaligned in two mutually perpendicular planes and rotated through two to three revolutions immediately prior to testing. This operation is mandatory and may require some simple fixturing. The test shall then be conducted by gradually applying torque to the ball/sleeve; the minimum torque required to start the ball/sleeve moving shall be recorded. The no-load rotational breakaway torque shall be as specified in the product definition data in AS81819/1.

4.7.4.1 Internal Clearance

The radial and axial clearance shall be measured in accordance with 4.7.4.1.1 or 4.7.4.1.2 as applicable. The gage loads shall be as follows:

TABLE 7 – GAGE LOADS

Inner Member Diameter (inches)	Gage Load (pounds)
0 to 1	10
1+ to 2	20
2+ to 3	30
3+ to 4	40
Over 4	50

4.7.4.1.1 Radial Clearance in Spherical Bearings

Radial clearance shall be measured with the load applied to one member (inner or outer) perpendicular to the bore axis alternately in opposite directions. The other member shall be rigidly clamped. Radial clearance shall be the full dial movement less shaft clearance.

4.7.4.1.2 Axial Clearance in Spherical Bearings

Axial clearance shall be measured with the gage load applied to the inner member parallel to the bore axis alternately in opposite directions. The outer member shall be rigidly clamped. The axial clearance is equal to the full dial movement.

4.7.5 Fluid Compatibility

Six bearings (one for each fluid, with an additional bearing performed on the AS8243 anti-icing) shall be tested in the following fluids. These fluids are to be applied as per 4.7.3. The fluid temperature at the time of application is to be 160 ± 5 °F, except for (b) which shall be at 110 ± 5 °F.

- a. MIL-PRF-83282 hydraulic fluid.
- b. MIL-DTL-5624 turbine fuel, Grades JP-4 or JP-5.
- c. MIL-PRF-7808 lubricating oil.
- d. MIL-PRF-5606 hydraulic oil.
- e. AS8243 anti-icing fluid.

These bearings shall be tested in accordance with 4.7.3 except that no water contamination will be applied and the test shall be run for 200 hours. Upon completion of these tests, the bearings shall be examined to determine conformance to 3.12.

4.7.6 Temperature Extremes

Two bearings shall be subjected to the test of 4.7.3 except that no water contamination will be applied. Before testing, the bearing and housing shall be placed in an air circulating oven at a temperature at or above +160 °F followed by a cold soak at or below -65 °F. The bearing and housing shall be held at each temperature for 4 hours. After soaking at each temperature extreme, the no-load breakaway torque shall be measured and recorded within 2 minutes of removal from the oven or cold box. Upon completion of the dynamic test, the bearing shall be examined to determine conformance to 3.17.4.3.

4.7.7 Solid Contaminant (Dust)

Three bearings shall be tested in accordance with 4.7.3 except that the test bearings shall be contaminated with a powdery earth or a matter in bits fine enough to be easily suspended (i.e., Arizona road dust, Red China clay or silica flour) without water contamination. The dust shall be applied once per hour in the amount of 0.5 gram to each side of the bearing. Due to the length of the dynamic tests, it is permissible for the test machine to be allowed to run unattended overnight up to three successive days provided that the dust contamination is applied at least six but not more than ten times per calendar day of attended testing for not less than thirty and not more than sixty times per calendar week.

4.7.8 Conformity Test

Test samples shall be selected in accordance with 4.5.2.2.

4.7.8.1 Normal Conformity (Type I Bearings)

Encapsulate the bearing in plastic material, as used in metallurgical mounts, to prevent motion of the ball with respect to the outer ring. Section the bearing on a diameter and normal to the outer ring side face to produce a surface as in Figure 4(a) or 4(b). Grind and polish the face to obtain a true view of the edges of the curved portions of the ball and outer ring. By use of an optical comparator or other suitably accurate technique, measure dimension "t" radially from the ball to the outer ring. The measurements need not be taken closer to the outer ring face than 10% of "H" (0.025 inch minimum) except when overforming of the outer ring has occurred. The normal conformity must meet the applicable requirements of 3.12.1.1 or 3.12.1.2. Conformity in the 10% of "H" regions (see H/10 in Figure 4(a) or 4(b)) is not controlled by this standard except when overforming of the outer ring has occurred. Overforming of the outer ring is defined as the condition when a side portion of the outer ring is in closer proximity to the ball surface than the center of the outer ring. When overforming is observed, then two additional measurements (one in each H/10 region) shall be taken to determine if the amount of overforming meets the requirements of 3.12.1.1 or 3.12.1.2, as applicable.

4.7.9 Liner Integrity

Test samples shall be selected in accordance with 4.5.2.2. The unused half-bearing from the test in 4.7.8.1 or 4.7.8.2 may be broken out of the mount and used to determine material integrity in accordance with 4.7.9.1 or 4.7.9.2, as applicable. At the manufacturer's option, the tests may be performed on a part which has not been encapsulated. In the case where a disagreement exists between the manufacturer and the procuring activity, an unencapsulated bearing shall be used for final resolution.

4.7.9.1 Type I Bearings

Prepare the sample(s) for the evaluation of 4.7.9.1.1 and 4.7.9.1.2 by exposing the liner surface to make it accessible for inspection. When cutting spherical bearings, care should be taken to avoid damage or contamination of the liner material.

4.7.9.1.1 Liner Condition – (Type I Bearings)

Visually examine the exposed liner surface for conformance to the liner condition requirements of 3.13.1 and the product definition data located in AS81819/1.

4.7.9.1.2 Bond Integrity and Peel Strength (Type I Bearings)

Peel the liner away from the metal substrate and evaluate the peel strength and adhesive bond appearance per 3.13.1.2. A blade or scribe may be used to initiate the peel. To determine peel strength, the liner shall be attached to a calibrated spring scale or tension testing machine of the type described in ASTM C 794 and the liner peeled back from the substrate at 140 ± 40 degree angle to the bond surface at a speed of 0.5 to 1.0 inch per minute (see Figure 6). The average peel strength value shall be recorded and included in the test report. Where possible, the peel shall be conducted on the entire width of the bonded liner. When the peel is conducted on the entire width of the outer ring, the width for calculating peel strength in pounds per inch shall be the machined width minus 0.050 inch to account for chamfers and edge effects.

At the manufacturer's option, or when peeling of the full outer ring width is impractical, the liner may be cut through to the metal substrate to form a peel sample with a minimum width of 0.500 inch. This peel sample may be cut either parallel to or perpendicular to the outer ring side face. This sample shall be peeled as previously described. The peel strength test shall be waived for 0.688 inch outer diameter and smaller bearings, but the liner shall be peeled by hand to permit visual examination of the bond line for voids. Following liner peel, the adhesive bond appearance shall be evaluated to determine the location and size of any voids or unbonded areas as specified in 3.13.1.2. A void is an area where the metal substrate is smooth and shiny with no visible adhesive. An unbonded area is where the adhesive remaining on the metal substrate is smooth and shiny indicating a lack of bonding pressure. In the event the liner cannot be removed without employing chipping, scraping, or abrasive techniques, the liners shall be considered to be properly bonded and free of voids, and shall be classed as nonpeelable.