SAE Aerospace
An SAE International Group

AEROSPACE RECOMMENDED PRACTICE

SAE ARP671 REV. A

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Bearing, Ball Annular

RATIONALE

This document has been reaffirmed to comply with the SAE 5-year Review policy.

1. PURPOSE:

This recommended practice provides certain design requirements and quality assurance provisions for anti-friction bearings intended for use by the aircraft industry.

2. SCOPE:

This recommended practice covers single row, radial, deep groove, non-filling slot type ball bearings having tolerance grades 1, 3, 5 and 7, and having varying radial clearances.

3. APPLICABLE DOCUMENTS:

3.1 The following specifications form a part of this recommended practice:

SPECIFICATIONS

ASTM-A295-46T	Carbon-Chromium Ball and Roller Bearing Steels (Tentative)
AMS 2640	Magnetic Particle Inspection
AMS 2645	Fluorescent Penetrant Inspection
AMS 2800	Identification - Finished Parts
AS291	Surface Roughness (AA)

4. REQUIREMENTS:

4.1 Materials:

Materials should conform to the applicable specifications noted on the drawing. The manufacturer should use due care in subjecting this metal to metallographic examination in accordance with ASTM-A295-46T and to other suitable check analyses and physical tests to satisfy the purchaser as to the uniformity of the material being used.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
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4.1.1 The metal employed for balls and rings should be homogenous in structure, free from pipes, seams, laminations, excessive inclusion of nonmetallic impurities as specified in the quality section herein, and such other internal defects as would render the material unsuitable for the purpose for which intended.

4.2 Drawing Requirements:

The bearing and component parts should conform to all the requirements shown on the applicable drawing. Figure 1 illustrates recommended drawing format. The applicable tolerance grade of the bearing defined should be stated in the title block of the drawing as well as in the heading of the table shown in Figure 1A.

4.2.1 Marking: Unless otherwise specified, each bearing should be identified by the applicable bearing manufacturer's complete part number marked on either the inner or outer ring face. Additional manufacturer's symbols are permissible on any surface not detrimental to the bearing performance. For applications requiring identification by contractor's part number, due to necessity for insuring adequate interchangeability physically and performance wise, this marking shall take precedence over identification of manufacturer's part number if space does not permit the marking of both part numbers.

4.2.1.1 Method of Marking: Identification markings of bearings should be applied as specified by the contractor's applicable drawing. All markings should be legible and durable.

4.2.2 Surface Roughness: Surface roughness should be determined in accordance with AS291.

4.3 Reconditioned Parts:

New ball bearings should not contain reconditioned component parts.

4.4 Ball Diameter Variation and Sphericity:

Variation of the average diameter of each ball between the extreme values found in any one bearing assembly should not exceed .000050 inch in grades 1 and 3 and .000020 inch in grades 5 and 7. Ball sphericity or variation in ball diameter between the extreme values found in any one ball should not exceed .000025 inch in grades 1 and 3 and .000010 inch in grades 5 and 7.

4.5 Tolerances for Assembled Bearings:

Tolerances for assembled bearings should not exceed the applicable tolerances shown in Table 1 and Table 2.

4.6 Retainers:

Retainer tabs and rivets should not exhibit cracks, looseness or burrs after assembly. After assembly, retainers should not exhibit deformities and should be free of protrusions and dents on functional surfaces.

4.7 Surface Imperfections:

All surfaces should be free from tool marks, chatter waves, grinding scratches, pits, rust, soft spots, and other surface imperfections to the extent specified herein.

TABLE 1 - Tolerances for Assembled Bearings
(All tolerances in 0.0001-inch units)

Inner Rings															
Bore (mm)		*Bore Tolerance				Eccentricity FIR				Parallelism of Sides FIR		Side Runout With Bore FIR		Groove Parallelism With Sides FIR	
		Grade				Grade				Grade		Grade		Grade	
Over	Incl	1	3	5	7	1	3	5	7	5	7	5	7	5	7
0	9	1 -4	1 -3	0 -2	0 -1-1/2	3	2	2	1	2	1	3	1	3	1
9	18	1 -4	1 -3	0 -2	0 -1-1/2	4	3	2	1	2	1	3	1	3	1
18	30	1 -5	1 -3	0 -2	0 -1-1/2	5	3	2	1-1/2	2	1	3	1-1/2	3	1-1/2
30	50	2 -7	2 -5	0 -2	0 -2	6	4	2	1-1/2	2	1	3	1-1/2	3	1-1/2
50	80	2 -8	2 -6	0 -3	0 -2	8	4	2	1-1/2	2	1-1/2	3	2	3	1-1/2
80	120	3 -11	3 -8	0 -3	0 -2-1/2	10	5	3	2	3	1-1/2	3	2	4	2
120	180	3 -13	3 -9	0 -4	0 -3	12	6	3	3	3	2	4	3	4	3
180	250	4 -16	4 -11	0 -5	0 -4	16	8	4	3	4	2	4	3	5	3

*Extreme variations including errors of taper and roundness which are permitted within two-point diameter measurement. These tolerances are applied to the maximum B_m diameter listed on the applicable drawing.

TABLE 2 - Tolerances for Assembled Bearings
(All tolerances in 0.0001-inch units)

Outer Rings															
O.D. (mm)		*O.D. Tolerance				Eccentricity FIR				Parallelism of Sides FIR		Side Runout With O. D. FIR		Groove Parallelism With Sides FIR	
		Grade				Grade				Grade		Grade		Grade	
Over	Incl	1	3	5	7	1	3	5	7	5	7	5	7	5	7
0	18	1 -5	1 -4	0 -2	0 -2	6	4	2	2	2	1	3	1-1/2	3	2
18	30	1 -5	1 -4	0 -2	0 -2	6	4	2	2	2	1	3	1-1/2	3	2
30	50	2 -7	2 -5	0 -2	0 -2	8	4	2	2	2	1	3	1-1/2	3	2
50	80	2 -7	2 -6	0 -3	0 -2	10	5	3	2	2	1	3	1-1/2	4	2
80	120	3 -9	3 -7	0 -3	0 -3	14	7	4	2	3	2	3	2	5	2
120	150	3 -11	3 -8	0 -4	0 -4	16	8	4	3	3	2	4	2	5	3
150	180	3 -13	3 -9	0 -5	0 -4	18	9	5	3	3	2	4	2	6	3
180	250	4 -16	4 -11	0 -5	0 -4	20	10	5	4	4	3	4	3	6	4
250	315	4 -18	4 -12	0 -5	0 -5	24	12	6	4	5	3	5	3	7	4

*Extreme variations including areas of taper and roundness which are permitted within two-point diameter measurement. These tolerances are aplied to the D_m diameter listed on the applicable drawing.

5. QUALITY ASSURANCE PROVISIONS:

5.1 Lot Acceptance Tests:

A lot of bearings consists of the quantity of bearings manufactured essentially under the same conditions, and having the same part number and submitted for acceptance at the same time. Each lot of bearings should be subjected to the following tests:

5.1.1 Hardness Test, Balls and Rings: The true hardness of steel balls and rings should be determined at room temperature.

5.1.2 Fracture Tests of Balls and Rings: Sample balls and rings should be fractured, examined and should meet the applicable material requirements specified herein. The metal should show a fine grain size and should be free from signs of overheating.

5.2 Individual Acceptance Tests:

Each assembled bearing or component part as applicable, should be subjected to the following tests:

5.2.1 Inspection: Each bearing should be subjected to a visual surface inspection for finish, imperfections, and markings. Examination of the surface of bearing components should be done without magnification by an inspector possessing normal or corrected to normal vision. For small diameter balls and rings the values stated may be changed to read "no visible defects".

5.2.1.1 Magnification may be used where necessary for determination of dimensions or types of irregularities.

5.2.1.2 Use of scribers should be limited to light finger pressure. Where the ball or ring minimum hardness, as specified on a particular drawing, is below 60 Rockwell C, inspection should be as below with the exception that a 0.040 inch radius scriber should be substituted for the specified 0.020 inch radius scriber in checks of scratches, dents, nicks, indentations and scuffs.

5.2.2 Any of the following surface irregularities on following parts are cause for rejection of the part. Rejection limits are applicable only to bearings or component parts prior to roughness test specified in paragraph 5.2.3.

5.2.2.1 Balls:

a. A single scratch extending more than half a circumference length, or multiple scratches that extend more than 1/4 the circumference or scratches that cross each other if any of them can be felt with a 0.020 inch radius scriber.

b. A pit larger than 0.008 inch in its greatest dimension.

c. Dents, nicks, or indentations for diameters 1/2 inch or less -- larger than 0.015 inch long by 0.004 inch wide; for diameters more than 1/2 inch -- larger than 0.024 inch by 0.004 inch wide.

d. Residual surface abrasions or indentations due to grinding, honing, polishing or similar operation, that can be felt by a 0.020 inch radius scriber.

e. Stains, if not readily removable by light polishing.

f. Any rust or corrosion.

g. Any irregularities having edges raised above the surrounding surface.

5.2.2.2 Rings:

5.2.2.2.1 Raceways of Rings:

a. Multiple scratches extending more than one-half the distance across the raceway, or scratches that cross each other, or single circumferential scratches longer than one inch if any of them can be felt with a 0.020 inch radius scriber.

b. Scuffs, if they can be felt with a 0.020 inch radius scriber.

c. A pit 0.010 inch or more in its greatest dimension and which can be felt with a 0.020 inch radius scriber.

d. Cluster of 3 or more pits which are in a 1/4-inch circle, each pit being more than 0.006 inch in its greatest dimension and which can be felt with a 0.020 inch radius scriber.

e. Nicks, dents, and indentations longer than 0.010 inch and which can be felt with a 0.020 inch radius scriber.

f. Marks, due to grinding, honing, polishing or similar operations, than can be felt with a 0.020 inch radius scriber.

g. Stains, if not readily removable by light polishing.

h. Rust or corrosion.

i. Any irregularities having edges raised above the surrounding surface.

5.2.2.2.2 Ring Surfaces Other Than Raceways:

a. A pit larger than 1/32 inch in its greatest dimension.

b. Cluster of 3 or more pits which are in a 1/4-inch circle, any one pit more than 0.015 inch long.

c. Dents, nicks, or indentations more than 1/16-inch long. Dents, nicks, or indentations without raised edges are acceptable on corner radii and chamfers provided that they do not protrude above the intersection of the bore, O. D., and faces.

d. Any irregularities having edges raised above the surrounding surface.

e. Stains if not readily removable by light polishing.

f. Areas of discoloration caused by rust or corrosion.

5.2.2.3 Retainers:

a. Cracks, deformation or visible damage.

b. Protrusions or dents on functional surfaces.

c. Flaking off of surface plating.

d. Loose or missing rivets.

5.2.3 Roughness Test: Prior to checking roughness the bearing should be lubricated with oil having an approximate viscosity of 12 centipoises at 70 °F and an approximate viscosity of 10 centipoises at 100 °F. Roughness should be determined on a comparative basis by experienced personnel and may be determined by feel, sound, or mechanical means. This test should be performed subsequent to all visual inspection of balls and rings.

5.2.4 Dimensions: Each component bearing part should be checked to determine conformance to specified dimensions and tolerances.

5.3 Measurement Procedures:

5.3.1 Gages: The standard for measurements should be gage blocks, plug gages, indicators, or other special gages calibrated by the National Bureau of Standards at a temperature of 68 °F or checked as agreed upon by the buyer and the vendor.

5.3.1.1 Measurements may be made at room temperature other than 68 °F provided the measurements are corrected to 68 °F.

5.3.1.2 Gaging Loads: Gaging loads used in making measurements of bore, outside diameter, radial internal clearance and end play should be as specified in Table 3.

TABLE 3

Gaging Loads

Bore and Outside Diameter Gaging Loads

	Nominal Diameter MM Over	Incl.	Gage Load Ozs.	Gage Point Radius Inches
Inner Ring Bore	0	9	not exceeding 7	.032
	9	30	not exceeding 7	.098
	30 and up		12	.098
Outer Ring O. D.	0 and up		not exceeding 7	.098

Radial Internal Clearance Gaging Loads

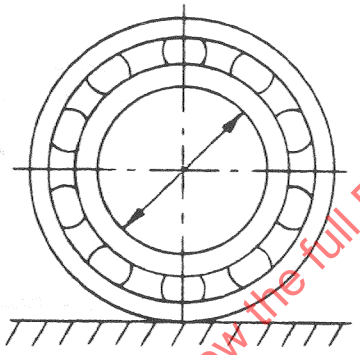
For Bearings with Outer Diameter	Load
Over 0 mm. and including 9 mm.	1/2 kg. or 1.1 lb.
Over 9 mm. and including 18 mm.	1 kg. or 2.2 lb.
Over 18 mm. and including 30 mm.	2-1/2 kg. or 5-1/2 lb.
Over 30 mm. and including 90 mm.	5 kg. or 11 lb.
Over 90 mm. and including 180 mm.	15 kg. or 33 lb.

Axial Play Gaging Loads

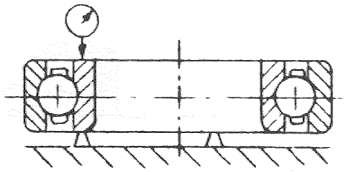
For Bearings with Outside Diameter MM	Load Lbs.
Over 0 to and including 50	5-1/2
Over 50 to and including 120	11
Over 120 to and including 200	22
Over 200	44

5.3.2 Inner Ring:

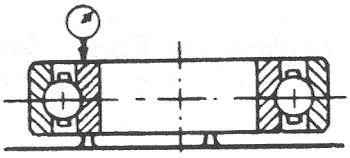
5.3.2.1 Bore: For determining bore diameter, use apparatus arranged for two-point measuring. If out-of-roundness and taper exist in a particular bearing, a minimum diameter reading B_{min} and a maximum diameter reading B_{max} may be obtained. The bore diameter, B_m, of the bearing in question is defined as the arithmetical average of these two readings B_{min} and B_{max}. Large diameter rings with thin section should be placed in a horizontal position when measuring.



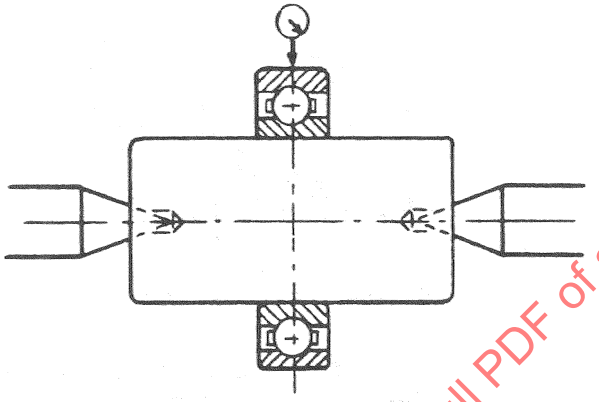
5.3.2.2 Width: The tolerances for width of the bearings apply to individual rings and not to the total width of the bearing. Outer ring is free and the inner ring that is to be measured is supported on one side by three buttons. Apply calibrated indicator against other side directly over one button and take reading while rotating the ring.



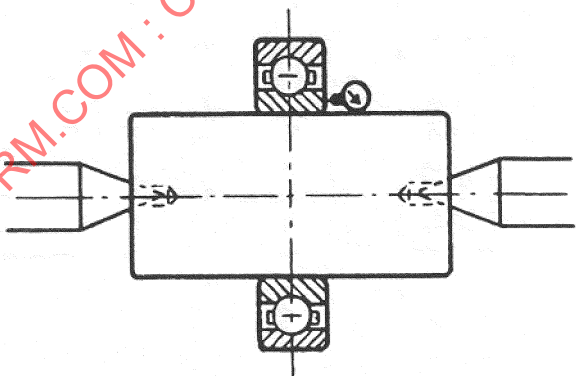
5.3.2.3 Parallelism of Sides: The deviation from parallelism of sides is the difference between the largest and smallest width. Outer ring is free and the inner ring that is to be measured is supported on one side by three buttons. Apply calibrated indicator against other side directly over one button and take reading while rotating the ring.



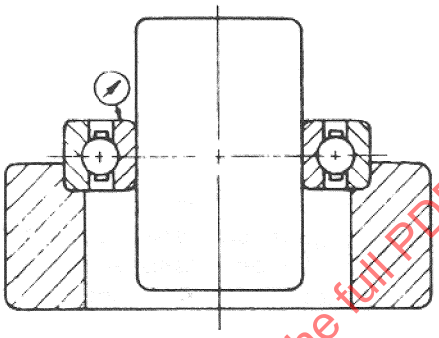
5.3.2.4 Radial Runout: Mount bearing on arbor having a very slight taper (.0001 to .0002 inch on diameter per inch of length). Apply calibrated indicator on center of stationary outer ring. The radial runout is the difference between the minimum and maximum reading when rotating the arbor one revolution. Corrections should be made for the inaccuracy of the arbor.



5.3.2.5 Side Runout: Mount bearing on arbor having a very slight taper (.0001 to .0002 inch on diameter per inch of length). Apply calibrated indicator against side of inner ring. The side runout is the difference between the maximum and minimum reading when rotating the arbor one revolution.

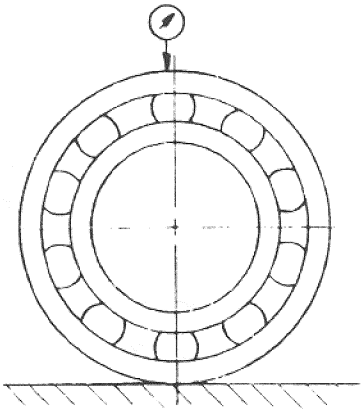


5.3.2.6 Groove Parallelism with Side: Mount bearing on arbor having a very slight taper (preferably .0001 to .0002 inch on the diameter per inch of length) or use true running weight of magnitude to seat balls on races. Support outer ring in horizontal position and apply calibrated indicator to side of inner ring. The deviation from groove parallelism with side is the difference between the maximum and minimum readings when rotating arbor one revolution.

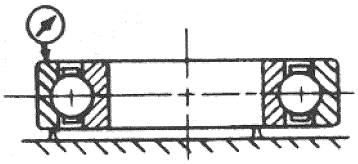


5.3.3 Outer Ring:

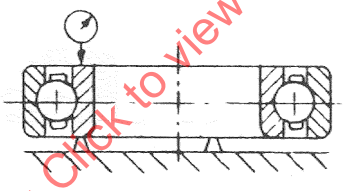
5.3.3.1 Outside Diameter: For determining the outside diameter, use apparatus arranged for measuring between a flat surface and a rounded calibrated indicator point. If out-of-roundness and taper exist in a particular bearing, a minimum diameter reading D_{min} and a maximum diameter reading D_{max} may be obtained. The outside diameter, D_m, of the bearing in question is defined as the arithmetical average of these two readings D_{min} and D_{max}. When measuring thin section rings, the measuring pressure should be small so as to avoid distortion of the rings. Large diameter rings with thin sections should be placed in a horizontal position when measuring.



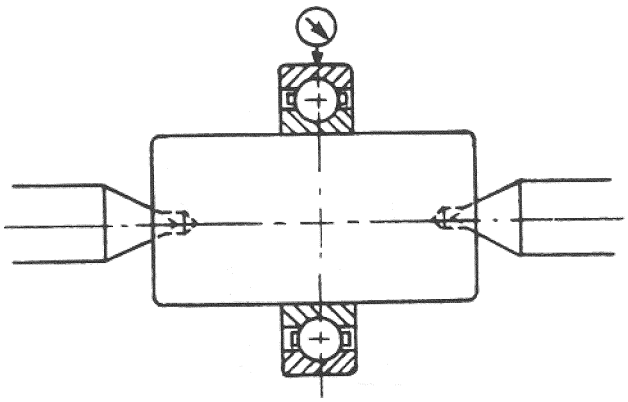
5.3.3.2 Width: The tolerances for width of the bearings apply to the individual rings and not to the total width of the bearing. Inner ring is free and the outer ring that is to be measured is supported on one side by tree buttons. Apply calibrated indicator against other side directly over one button and take reading while rotating the ring.



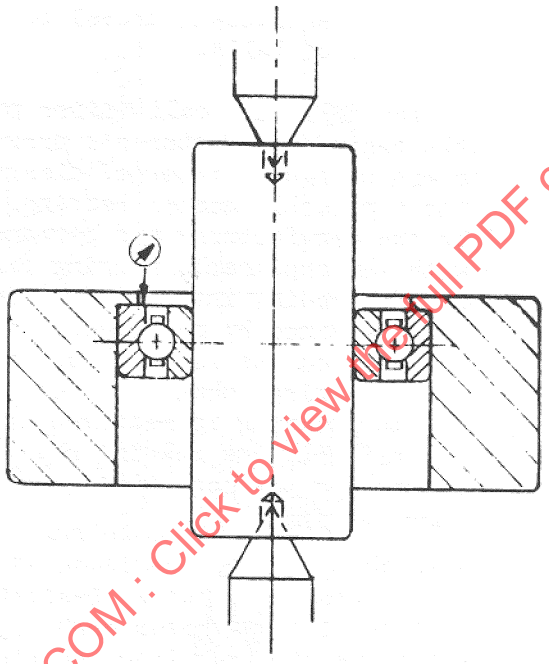
5.3.3.3 Parallelism of Sides: The deviation from parallelism of sides is the difference between the largest and smallest width. Inner ring is free and the outer ring that is to be measured is supported on one side by three buttons. Apply calibrated indicator against other side directly over one button and take reading while rotating the ring.



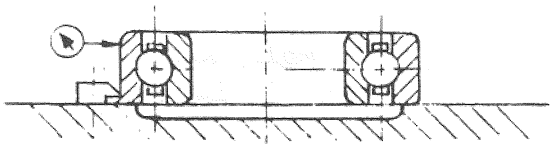
5.3.3.4 Radial Runout: Mount bearing on arbor having a very slight taper (.0001 to .0002 inch on diameter per inch of length). Apply calibrated indicator on center of outer ring. The radial runout is the difference between the minimum and maximum reading when rotating outer ring one revolution with arbor stationary.



5.3.3.5 Groove Parallelism with Side: Mount bearing on arbor having a taper of .0001 to .0002 inch on the diameter per inch of length. Apply a true running weight to the outer ring, or use true running weight of magnitude to seat balls on races. Support arbor in a vertical position and apply calibrated indicator to side of outer ring. The deviation from groove parallelism with side is the difference between the maximum and minimum reading when rotating outer ring one revolution.

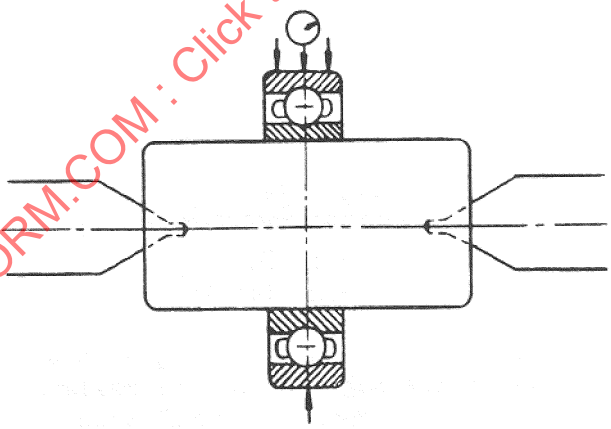


5.3.3.6 Outside Diameter Squareness With Side: One side of the outer ring to be supported on a flat plate of suitable dimensions (with inner ring free) and held against a stop located close to the lower corner of the outside diameter. The calibrated indicator is applied directly above the stop close to the upper corner of the outside diameter. The deviation from outside diameter squareness with side is the difference between the minimum and the maximum reading of the indicator when rotating the outer ring one revolution.



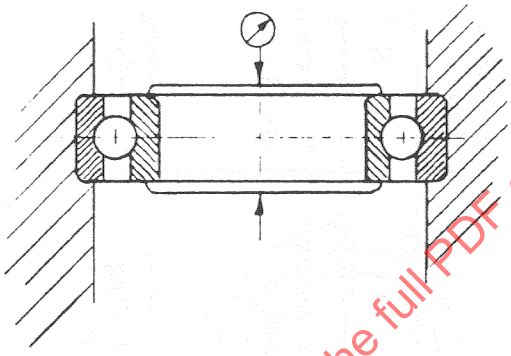
5.3.4 Radial Internal Clearances: Radial play in single-row ball bearings should be determined by mounting the bearing, lubricated with light oil, with one of its rings supported to prevent movement, and with the bearing axis in a horizontal position with gage calibrated as specified in 5.3.4.1. The unsupported ring must float both axially and radially while the specified reversing measuring load moves this member upward and downward. Radial internal clearance is the total movement of the unsupported ring diametrically, when the radial internal clearance gaging load specified in Table 3 is reversed, and is the average of readings taken at different relative angular positions of the inner rings, outer rings, and balls, and with sufficient travel between readings to provide a full rotation of the set of balls.

5.3.4.1 Gage Calibration: The following calibration procedure applies only when the applicable engine manufacturer's drawing specifies "no-load" values. For determining radial internal clearance, the gage shall be calibrated with the applicable master bearing. Master bearings are to be furnished by the manufacturer and permanently marked on the outer ring face with the applicable bearing part number, the word "Master", the amount of radial internal clearance in 0.0001 inch units under "no-load" as determined by measurement of the individual bearing components, and an arrow on the face of each ring indicating the relative location of the rings when used for calibration. When setting up the gage, the master bearing is measured in accordance with Paragraph 5.3.4 except that only one reading need be taken with the location arrows positioned and the gage indicator adjusted to the value marked on the master bearing.



Gaging Load

5.3.5 Axial Play: The bearing is to be lubricated with light oil and one of its rings clamped to prevent axial movement. The specified reversing measuring load is so applied to the unclamped ring that resultant movement of that ring is parallel to the bearing axis. The axial play is the total movement of the unclamped ring when the load is applied first in one direction and then in the other direction.



5.3.6 Retainer-out-of-roundness: Retainers assembled in bearings should be checked for maximum and minimum clearance at three places 120° apart.

5.4 Magentic Particle Inspection: Rings subjected to magnetic particle inspection should be inspected per AMS 2640 using 1000 to 1200 amperes per square inch of cross sectional area as enclosed by the rings. Any indications of cracks, flaws, folds, seams, and inclusion in excess of that specified in Table 4 shall be cause for rejection.

5.5 Flourescent Penetrant Inspection: Unplated copper alloy parts subjected to flourescent penetrant inspection should be inspected per AMS 2645. Indications greater than 0.031 inch in any dimension may be cause for rejection. Porosity indication greater than 10 per any 1/4 inch diameter circle may be cause for rejection.

6. PREPARATION FOR DELIVERY:

6.1 Preservation, packaging and packing of bearings should be as specified in the contract or order.

TABLE 4 - Permissible Magnetic Particle Test Indications

Area	Max. number of sub-surface inclusions in area, all well dispersed, and max. length of each.	Total number of surface inclusions well dispersed in area and max. length of each.	Total no. and spacing of indications from A & B combinations not to exceed.	Total length of separate sub-surface inclusions in same axial plane.	Total length of combinations or groups of sub-surface & surface inclusions in same axial plane.	Max. depth of low spot permissible to stone to remove or relieve surface inclusions.
	A	B	C	D	E	F
Raceways	2 per inch of circumference per race. .060" Max. length	2 per inch of circumference per race. .031" Max. length	6 at min. spacing .10 inch per inch of circumference	1/3 raceway width	1/3 raceway width	0
All other Areas	1-1/2 per inch of circumference per ring. .250" Max. length	2 per inch of circumference per ring. .250" Max. length	12 at min. spacing .10 inch per inch of circumference.	1/2 ring width	1/2 ring width	0.001"
	3 per inch of circumference per ring. .125" Max. length	4 per inch of circumference per ring. .125" Max. length	12 at min. spacing .10 inch per inch of circumference.	1/2 ring width	1/2 ring width	0.001"
	5 per inch of circumference per ring. .031" Max. length	6 per inch of circumference per ring. .031" Max. length	12 at min. spacing .10 inch per inch of circumference	1/2 ring width	1/2 ring width	0.001"

7. REPORTS:

Unless otherwise specified, the vendor of ball bearings should furnish with each shipment three copies of a report showing the purchase order numer, material specification number, supplier of material, part number and quantity. When materials for making parts are produced or purchased by the parts vendor, that vendor should inspect each lot of material to determine conformance to the requirements of the applicable material specification, and should include in the report a statement that the material conforms, or should include copies of laboratory reports showing the results of tests to determine conformance.

8. APPROVAL:

8.1 To assure adequate performance characteristics and durability, sample bearings should be approved by the appropriate engineering organization of the equipment manufacturer.

8.2 Vendor should use the same detailed design, material, manufacturing procedures, and processes for subsequent parts as for approved sample parts. If changes of any kind are necessary, vendor should obtain permission from purchaser prior to incorporating such changes and should furnish descriptive information to the Engine and Propeller Standard Utility Parts Committee of the Society of Automotive Engineers for consideration of changes to this recommended practice.

9. REJECTION:

Individual components and assembled bearings not meeting applicable requirements should be rejected. Samples failing to meet the applicable requirements may be cause for rejection of the lot represented.

10. APPENDIX 1:

Reference information follows:

10.1 Life Calculations:

The rating life of a group of apparently identical ball bearings is defined as the number of revolutions (or hours at some given constant speed) that 90 percent of a group of bearings will complete or exceed before the first evidence of fatigue develops. As presently determined for ball bearings, this rating life is approximately one-fifth of the life which 50 percent of the group of bearings will complete or exceed.

10.1.1 The rating life in hours may be calculated for ball bearings by the formula

$$L = \frac{16,\ 667}{N}\left(\frac{C}{P}\right)^3$$

10.1.1.1 The rating life may be read directly from the Nomogram in Figure 2.