MILITARY STANDARD

BEARINGS, CONTROL SYSTEM COMPONENTS, AND ASSOCIATED HARDWARE USED IN THE DESIGN AND CONSTRUCTION OF AEROSPACE MECHANICAL SYSTEMS AND SUBSYSTEMS

TO ALL HOLDERS OF MIL-STD-1599:

1. REPLACE OR ADD THE FOLLOWING PAGES TO MIL-STD-1599:

NEW PAGES	DATE	SUPERSEDED PAGES	DATE
v thru vi	7 Oct 82	v thru vi	31 Jan 80
202.1 thru 202.24	7 Oct 82	N/A	
301.1 thru 301.2	7 Oct 82	N/A	
302.1	7 Oct 82	N/A	
308.1 thru 308.3	7 Oct 82	N/A	

2. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

3. Holders of MIL-STD-1599 will verify that page changes and additions indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate "publication. Each notice is to be retained by stocking points until the Military Standard is completely revised or cancelled.

Custodians:
Army - AV
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Review activities:
DLA - IS

Preparing activity:
Air Force - 11

Project 31GP-0014

SECTION 200 - GENERAL DESIGN REQUIREMENTS

SECTION 300 - AIRFRAME BEARINGS

SECTION 400 - BEARING RETAINER RINGS. WASHERS. NUTS

*Requirement not as yet published

1/ Due to the length of this requirement, a table of contents is included for convenience.

SECTION 500 - GREASE/OIL SEALS, NON-INTEGRAL

SECTION 600 - CONTROL CABLE SYSTEMS

SECTION 700 - LATCH COMPONENTS

SECTION 800 - BALL SCREWS AND SHAFTS

SECTION 900 - MECHANICAL DRIVE COMPONENTS

*Requirement not as yet published

BEARING RETENTION

1. Scope. This requirement establishes engineering criteria and design information relative to the installation and retention of bearings to facilitate their proper airframe usage (see requirement 201). Included in the text will be information concerning the various techniques for installing each class of airframe bearings in the various housing materials which may be encountered in an airframe. Where applicable, this requirement will also present engineering criteria and design information relative to the removal and replacement of airframe control bearings.

2. Documents applicable to requirement 202

QQ-P-416	Plating, Cadmium (Electrodeposited)
MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-STD-889	Dissimilar Metals
MS14101	Bearing, Plain, Self-Lubricating, Self-Aligning, Low-Speed, Narrow, Grooved Outer Ring, -65°F to 350°F
MS14102	Bearing, Plain, Self-Lubricating, Self-Aligning, Low-Speed, Wide, Grooved Outer Ring, -67°F to 325°F
MS14103	Bearing, Plain, Self-Lubricating, Self-Aligning, Low-Speed, Wide, Grooved Outer Ring, -65°F to 325°F
MS14104	Bearing, Roller, Rod End, Internal Thread, Self-Aligning, Low-Speed, Narrow, Chamfered Outer Ring, -65°F to 325°F
MS21220	Bearing, Roller, Rod End, Internal Thread, Self-Aligning, Anti-Friction, Airframe, Heavy Duty, Type II, -67°F to 250°F, Sealed
MS21221	Bearing, Roller, Rod End, External Thread, Self-Aligning, Anti-Friction, Airframe, Heavy Duty, Type I, -67°F to 250°F
MS21429	Bearing, Roller, Anti-Friction, Rod End, External Thread, Self-Aligning, Airframe, -67°F to 350°F, Type I, Heavy Duty, Sealed
MS21431	Bearing, Roller, Self-Aligning, Single Row Anti-Friction, Sealed, -65°F to 350°F, Type I
MS21432	Bearing, Roller, Needle, Track Roller, Integral Stud, Type VII, Anti-Friction, Inch
MS21438	Bearing, Roller, Needle, Single Row, Heavy Duty, Self-Aligning, Type III, Anti-Friction, Inch, Sealed
MS21439	Bearing, Roller, Needle, Double Row, Heavy Duty, Track Roller, Type VI, Anti-Friction, Inch, Sealed
MS34461	Bearing, Roller, Needle, Single Row, Heavy Duty, Type I, Anti-Friction, Inch
MS24463	Bearing, Roller, Needle, Single Row, Heavy Duty, Self-Aligning, Type III, Anti-Friction, Inch
MS24464	Bearing, Roller, Needle, Double Row, Heavy Duty, Self-Aligning, Type IV, Anti-Friction, Inch
MS27640	Bearing, Ball, Airframe, Anti-Friction, Heavy Duty,
MS27641	Bearing, Ball, Airframe, Anti-Friction, Intermediate Duty
MS27642	Bearing, Ball, Airframe, Extra Light Duty
MS27643	Bearing, Ball, Airframe, Anti-Friction, Self-Aligning, Double Row, Heavy Duty,

MS27644	Bearing, Ball, Airframe, Anti-Friction, Double Row, Heavy Duty,
MS27645	Bearing, Ball, Airframe, Anti-Friction, Self-Aligning, Light and Heavy Duty,
MS27646	Bearing, Ball, Airframe, Anti-Friction, Extra Light Duty,
MS 27647	Bearing, Ball, Airframe, Anti-Friction, Extra Wide, Double Row, Intermediate Duty,
MS27648	Bearing, Ball, Airframe, Anti-Friction, Externally Self-Aligning, Extra Light Duty,
MS27649	Bearing, Ball, Airframe, Anti-Friction, Intermediate Duty,
MS28912	Bearing, Roller, Self-Aligning, Single Row, Airframe, Anti-Friction, Sealed, Type I
MS28913	Bearing, Roller, Self-Aligning, Double Row, Airframe, Anti-Friction, Sealed, Type II
MS28914	Bearing, Roller, Self-Aligning, Double Row, Wide Inner Ring, Airframe, Anti-Friction, Sealed, Type III
MS28915	Bearing, Roller, Self-Aligning, Double Row, Torque Tube, Airframe, Anti-Friction, Sealed, Type IV

3. General. A bearing is a machine element intended to permit a load to be transmitted from one structural member to another, while at the same time permitting relative movement between the two structural members. Incorrect bearing installation and retention can result in a reduction in bearing useful life, an increase in bearing operating torque, or irreparable damage to the housing or bearing components. Proper installation and retention techniques and processes shall be used to assure proper bearing performance. Regardless of the type of bearing being installed, preinstallation precautions shall be taken as follows:

a. The installation area shall be clean so that contaminants do not come into contact with the bearing.

b. Assembly tools and fixtures shall be maintained in good working condition.

c. Bearing shall be kept in their protective packaging until time of installation.

d. The housing bore shall be free from all metal chips, filings, and other foreign material.

3.1 Corrosion considerations. Galvanic corrosion occurs when two dissimilar materials are in contact in a medium capable of carrying electrical current. Requirement 105 of this document describes the procedures for preventing galvanic corrosion. In addition, table 202-1 of this requirement outlines some recommended treatments.

3.2 High temperature considerations - differences in expansion coefficient. Expansion coefficients of bearings, shafts, and housing materials are, in many cases, radically different and must be carefully considered when mounting bearings. Some typical ranges for expansion coefficients are shown in table 202-11. Figure 202-1 demonstrates the expansion differences that occur when bearings, housings, and shafts of different expansion characteristics are used at elevated or cryogenic temperatures. In many cases, the expansion coefficient match determine the bearing material selection. The selection of materials of similar expansion characteristics of bearings, housings, and shafts is preferable to using complicated mechanical retention methods. Bearing, shaft, and housing materials can be divided into two classes according to their expansion characteristics. In general, materials in the same class can be used together without expansion mismatch problems if bearing diameters are small, if operating temperatures are not extreme, or if radial play requirements are not critical. Care must also be used in selecting rolling element materials which vary in expansion coefficient from the race materials. A change in bearing radial play will be evident as the temperature is raised or lowered. Spherical bearings constructed of different ball and outer race materials must also be provided with the proper radial play to compensate for expansion differences. The usefulness of the interference fit method of mounting for high temperature bearings depends on the difference between the expansion coefficients of the bearing and the shaft or housing. The practical maximum that can be tolerated is a difference in expansion coefficient of approximately 1.0×10^{-6} in/in/°F. This expansion difference could give a relief of 0.0005/in of diameter to a press fit at an operating temperature of 600°F and 0.0018 at an operating temperature of 1900°F.

4. Installation

4.1 Method of installation. Use the proper tools and procedures to install bearings. Apply pressure only on the race of a bearing in contact with the housing or shaft. Figure 202-2 shows proper methods of installing bearings.

4.2 Shaft and housing fits - rolling element bearings

4.2.1 Proper fit of a rolling element (anti-friction) bearing is a critical factor in bearing life. Most bearings have sufficient internal clearance to permit an interference on either shaft or housing. An interference fit in both places may preload the bearing. A slight preload can improve bearing performance as it improves the load distribution within the bearing while a large preload could reduce bearing life.

4.2.2 Airframe ball and roller bearings (see requirements 301 and 302) are customarily mounted with a clearance fit between the shaft or pin and the bore of the inner ring. With the exception of torque tube bearings (see requirement 201, Bearing Usage), the outer ring is press fit into the housing and retained in the axial direction by staking or other mechanical means. When light alloy housings are used, the axial restraint mechanism used becomes extremely significant due to the difference in thermal properties between the bearing and housing materials.

4.2.3 Press fit installation should be avoided when mounting either the inner or outer rings of a torque tube bearing (see requirement 201, Bearing Usage) in order to prevent an excessive bearing preload. A line-to-line or clearance fit should be used between the housing bore and bearing outer ring with suitable axial restraint by staking or other mechanical means.

4.2.4 In many airframe bearing applications, the shaft revolves (or oscillates) and the housing remains stationary in relation to the direction of the radial load. Recommended shaft and housing fits for this type of application, for average operating conditions are shown in tables 202-111 through 202-IX.

4.2.5 The required fit of the inner ring on the shaft will vary with the application and the service. In some series only housing fits are shown, as the bearings listed do not require a precise fitting on the shaft.

4.2.6 Recommended housing fit varies with bearing series, and varies with housing material within any series. Also both shaft and housing fits are recommended for some series since these bearings have a wider range of application than most airframe bearings.

4.2.7 Recommended housing bore tolerances shown in tables 202-111 and 202-VI through 202-IX will usually result in satisfactory installation when used in conjunction with the internal clearances shown in the bearing listings of the military standards shown in the requirement 302 for this type of bearing. The final running fit, within a bearing of this nature, is dependent on many factors, such as: the individual housing design, bearing internal clearance, housing material, operating temperature and the amount of interference between the bearing and the housing.

4.2.8 The outer ring sections of many annular bearings are thin enough to be easily distorted during installation. The final shape of the bearings depends largely on the roundness of the housing bores (see table 202-VI and 202-IX for the recommended roundness of housing bores).

4.2.9 The normal fit-up practice for non-press or loose fits, between an anti-friction roller bearing and housing requires that the tolerance range for the bearing O.D. be on the minus side of the nominal diameter and that the tolerance range for the bearing O.D. be on the minus side of the nominal diameter and that the tolerance range for the housing bore be on the plus side of the nominal diameter. Thus, the resulting fit-up range is line-to-line to slightly loose.

4.3 Shrink fits (anti-friction bearings)

4.3.1 A bearing may be installed by cooling or heating so that the thermal contraction or expansion permits assembly without metal-to-metal interference. When the asembly returns to room temperature, the desired interference is obtained. In general, airframe bearings can be heated to +250°F safely and in many cases to +350°F.

4.3.2 High temperature bearings can usually be heated to at least 600°F without damage if no lubricants are present. A dry ice and methanol bath is capable of chilling parts to -120°F, but suitable ventilation must be used. Liquid nitrogen is the preferred coolant when available and is capable of providing temperatures to -320°F. Deep freezing may be prohibited by some manufacturers as it can affect the crystalline structure of some steels.

4.3.3 When using high temperatures to cause thermal expansion to permit bearing installation, it must be remembered that the temperatures may effect the heat treat condition of the bearing shaft or housing.

CAUTION

A. Do not use force or impact to complete or correct an improper installation after the bushing or bearing has warmed sufficiently to create an appreciable interference.

B. Do not reuse a bearing or bushing which has been installed with a shrink fit and then has been forcibly removed.

4.3.4 Many of the materials used for high temperature bearings, shafts, and housings are nickle-based alloys which tend to gall readily either in making a press fit or in removal of the bearing. When press-fits are made, the fact that MoS_2 oxidizes to $Mo0_3$ when exposed to temperatures over 7500 should be remembered. This oxide occupies a larger volume than the original MoS_2 and may tend to jam the mating parts. Graphite is the preferable lubricant when operating temperatures are over 750°. In designing shrink fits for high temperature bearings, there is a tendency to specify very tight fits at room temperature in order to overcome the effects of varied expansion coefficients and high operating temperature. This may stress the housing past its elastic limit or bind the bearing so that it will not turn freely at room temperature. Housing fits suitable for steel housings and shafts at normal temperatures can be used as a basis for computing dimensions necessary, at installation temperatures, to obtain correct fits at elevated or low temperatures.

4.4 Shaft and housing fits plain bearings). The housing bore fit should be from line-to-line to .001 inch loose to prevent lock-up or bind. In order to obtain this fit, the housing bore shall be equal to the bearing outside diameter plus .0005 inch. Plated or anodized housings may require secondary machining. The pin fit should be from line-to-line to .0030 inch loose.

5. Bearing retention

5.1 Methods. Examples of axial retention methods for bearings on the shaft are shaft shoulders, interference fits, and nuts holding the bearing against a shaft shoulder. This last method is not advised in heavily loaded airframe bearing applications due to weakening of the shaft by the threads. Shaft shoulders should be provided with a fillet (generally undercut) at their base, compatible with the chamfer or radius on the bearing bore. Axial retention of the bearing in the housing can be accomplished by one of the methods listed in table 202-X, which shows the advantages of each method.

Table 202-I. Treatment to prevent galvanic corrosion. (see requirement 105)

BEARING MATERIAL (BORE & OD SURFACE	HOUSING OR SHAFT MATERIAL					
	ALUMINUM ALLOYS	LOW ALLOY STEELS	TITANIUM	CORROSION RESISTANT STEELS	SUPER ALLOYS	REFRACTORY METALS
Aluminum alloys	A	A,C	A	A	1	1
Bronze & brass	1	1	G	S	S	1
Bronze & brass Cadium plated	A	C	1	I	I	I
52100 and low alloy steels	A,C	C	N	I	I	I
440C Stainless steel	A	I	G	S	S	I
440C with wet primer	A	C	G	S	I	I
Corrosion-resistant steels	A	I	G	S	S	I
300 series steels (17-4, etc)	A	C	G	S	I	I
Superalloys Rene 41,etc)	1	I	G	S	S	O
Cermets (LT-2, TiC, etc.	1	I	G	S	S	O
Ceramics Al_2O_3, ZrO_2)	1	I	G	S	S	O

I - Incompatible
A - Anodize aluminum per MIL-A-8625, type I or type II
C - Cadmium plate low alloy steels per Fed-Spec QQ-P-416, type II, class 2
G - Use dry film on bearing OD and in titanium bore
N - Nickel plate per MIL-C-26074, grade C, class I or equivalent
O - Oxidation-resistant coating normally used will provide galvanic protection
S - Satisfactory for use with no surface treatment.
Note: If plating or anodizing are required it will be necessary to re-establish the housing tolerance
*See MIL-STD-889 for other combinations

Table 202-II. Expansion classes of materials.

BEARING MATERIALS	SHAFT MATERIALS	HOUSING MATERIALS
Low Expansion Class (4.5×10^{-6} to 6.2×10^{-6} in/in/^{o}F		
Stainless steels Tool steels 400 Series SS Los alloy steels MoS_2-metal compacts Titanium alloys	Stainless steels Tool steels 400 Series SS Titanium alloys	Stainless steels 400 Series SS Titanium alloys
High Expansion Class (6.2×10^{-6} to 15×10^{-6} in/in/^{o}F		
A-286 Rene 41 Stellites, 3,19 & 25 M-252 Waspaloy Inconels Other super-alloys Aluminum Magnesium	A-286 Rene 41 Other super-alloys Inconels	A-286 Rene 41 Inconels Aluminum Magnesium
Copper Based Alloys (Bearing Material Only)		
Beryllium copper	9.5×10^{-6} in/in/^{o}F	
Aluminum bronze	9.5×10^{-6} in/in/^{o}F	
Aluminum nickel bronze	9.0×10^{-6} in/in/^{o}F	
Aluminum silicon bronze	10.0×10^{-6} in/in/^{o}F	

NOTE : See MIL-HDBK-5 for actual coefficients if necessary.

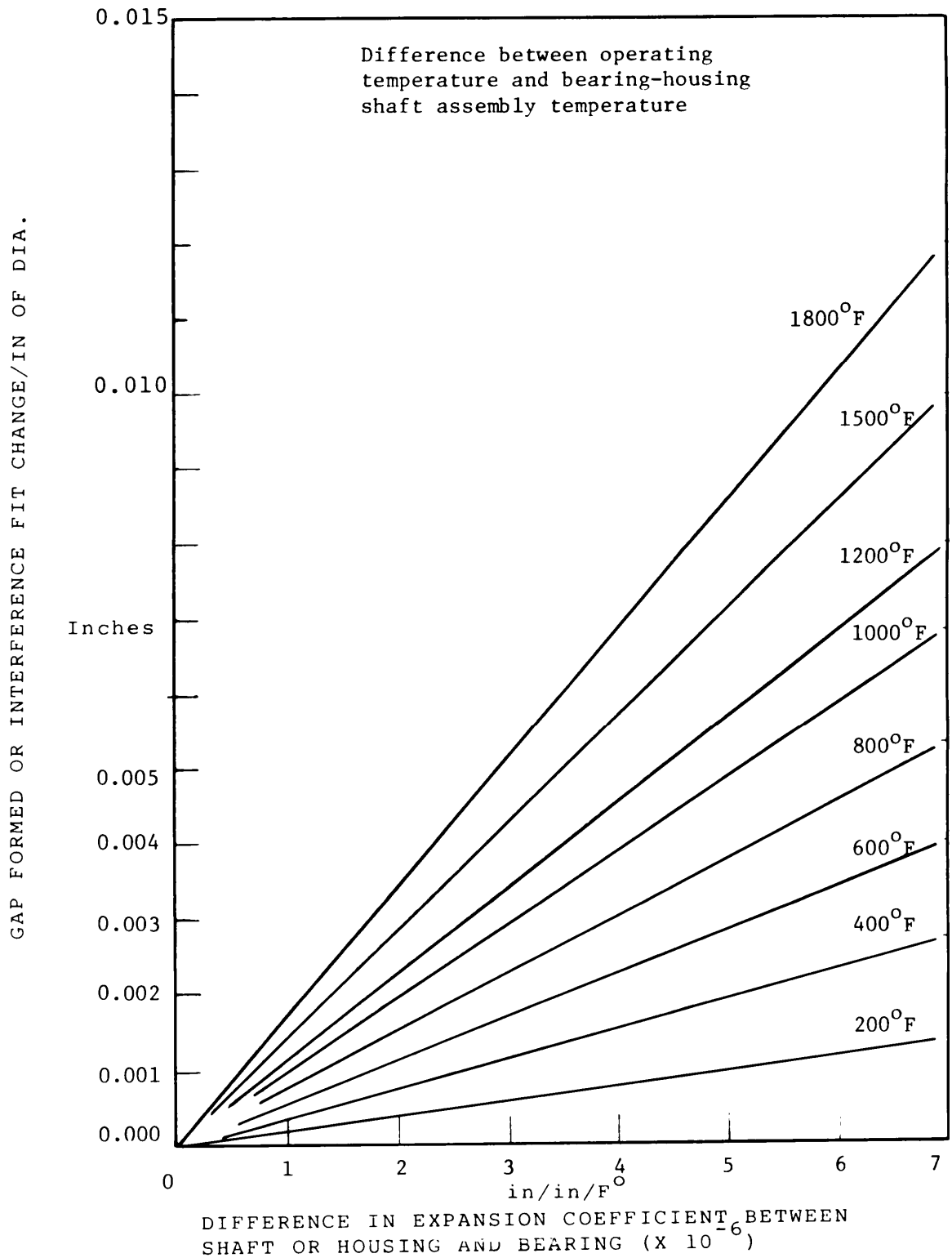


Figure 202-1. Expansion difference between bearings, shafts, and housings.

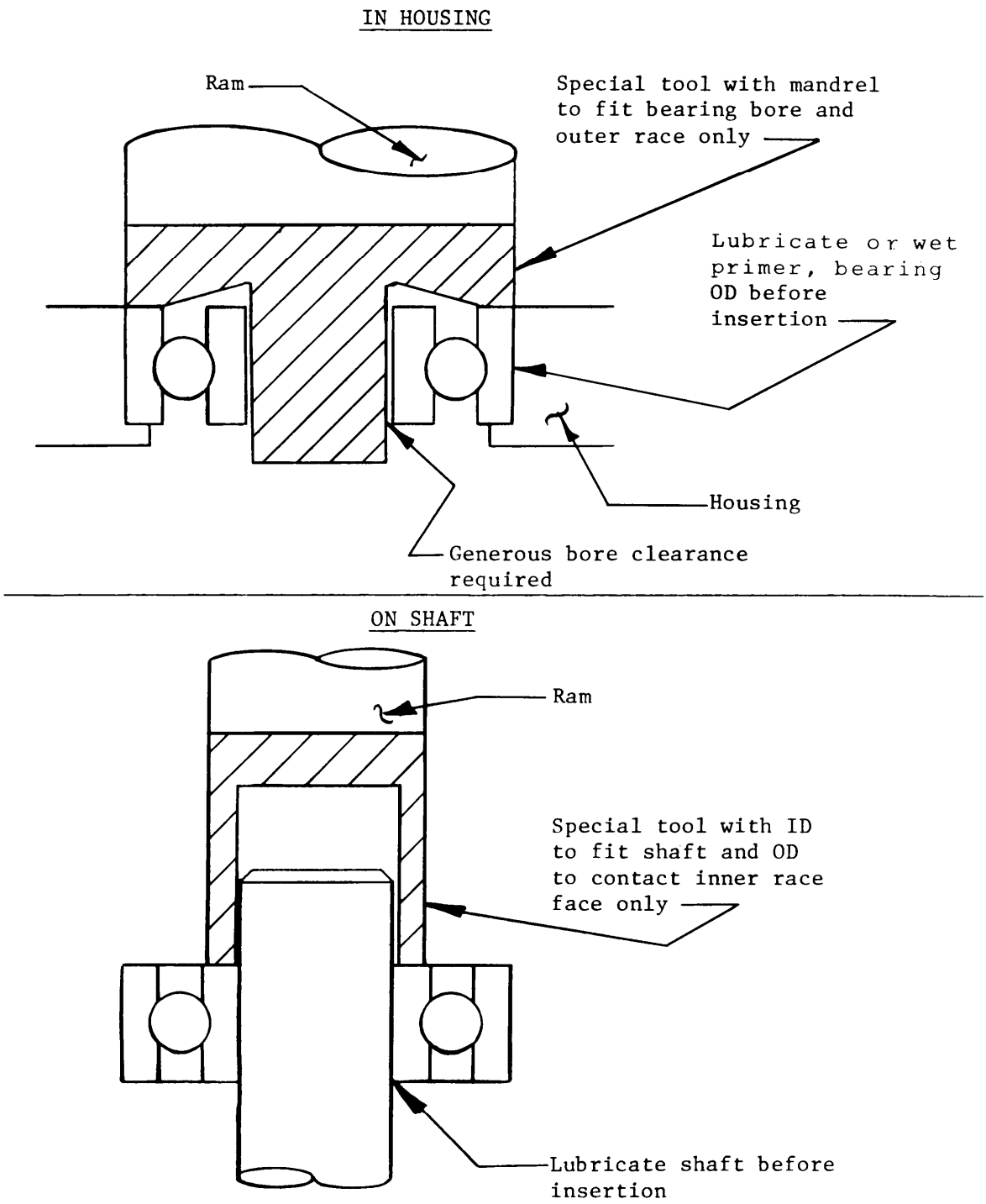


Figure 202-2. Method of installation.

Table 202-III. Recommend shaft and housing bore tolerance limits airframe needle roller bearings MS24461 (NBC); MS24463 (NBE); MS24464 (NBK).

Deviations in 0.0001 Inch

Outside Diameter D (Inches)		Housing Bore Deviation From D			
		Transition Fit (Tight Range)		Transition Fit (Loose Range)	
Over	Incl	Low	High	Low	High
0.6250	1.2500	-8	-3	-1	+4
1.2500	2.0000	-9	-3	-1	+5
2.0000	3.0000	-12	-4	-1	+7
3.0000	6.0000	-15	-5	-2	+8

Bore d (Inches)		Shaft Diameter Deviation from d			
		Transition Fit (Loose Range)		Transition Fit (Tight Range)	
Over	Incl	High	Low	High	Low
0.1250	1.0000	-6	-11	+2	-3
1.0000	1.7500	-6	-12	+3	-3
1.7500	3.0000	-6	-13	+3	-4
3.0000	4.0000	-6	-14	+4	-4
4.0000	5.0000	-6	-15	+4	-5

The tight range shaft diameters and the tight range housing bore should not be used in conjunction as all radial clearance in the bearing may be removed.

For clamping surface diameters see applicable MS.

Table 202-IV. Recommended shaft diameter tolerance limits. airframe needle roller bearings, track roller, yoke type (MS21438 and MS21439).

Deviations in 0.0001 inch

BORE (inches)		SHAFT DIAMETER DEVIATION FROM d			
		TRANSITION FIT (LOOSE RANGE)		TRANSITION FIT (TIGHT RANGE)	
OVER	INCL	HIGH	LOW	HIGH	LOW
0.1250	1.0000	-6	-11	+2	-3
1.0000	1.7500	-6	-12	+3	-3
1.7500	3.0000	-6	-13	+3	-4

For clamping surface diameters see applicable MS.

Table 202-V. Recommended mounting dimensions, airframe needle roller bearings, track roller, stud type (MS21432 (HRS).

Dimensions in inches

BEARING NUMBER	HOUSING BORE		CLAMPING TORQUE 1/ INCH-POUNDS MAX	BRACKET SHOULDER DIAMETER MIN	MOUNTING OVERHANG SPACE 2/ MIN	FILLET RADIUS MAX
	LOW	HIGH				
HRS1C	0.1900	0.1905	8	0.297	0.313	0.010
HRS2C	0.2500	0.2505	20	0.359	0.313	0.010
HRS3C	0.3120	0.3125	43	0.422	0.376	0.010
HRS4C	0.3750	0.3755	55	0.500	0.501	0.025
HRS4C	0.4370	0.4375	150	0.562	0.563	0.025
HRS6C	0.5000	0.5005	205	0.625	0.688	0.040

1/ Add 0.050 inch when the HRS1CF or the HRS2CF versions are used.

2/ Clamping torque based on lubricated threads.

Table 202-VI. Recommended shaft and housing tolerance, airframe roller bearings, other than torque tube type MS28914 MS28913 (DAS); MS21431 (SA); MS21220*(SF); MS21221*(SM): MS21429*(DM).

RECOMMENDED HOUSING BORE TOLERANCE

Limits in 0.0001 inch

OUTSIDE DIAMETER D (inches)		DEVIATION FROM D				
		STEEL		LIGHT ALLOY		ROUNDNESS
OVER	INCL	LOW	HIGH	LOW	HIGH	(TIR)
--	2	-5	-10	-9	-14	4
2	4	-7	-14	-11	-18	5
4	7	-10	-20	-14	-24	6

RECOMMENDED SHAFT TOLERANCE

BORE d (inch)		SHAFT DIAMETER DEVIATION FROM d	
OVER	INCL	LOW	HIGH
--	2	-10	-5

* Shaft fit only

HOUSING BORE TOLERANCE AND ROUNDNESS (IN INCHES) FOR ANNULAR OUTER RING ROLLER BEARINGS

BEARING			HOUSING BORE		
STYLE	OUTSIDE DIAMETER		TOLERANCES*		Roundness (T.I.R.)
	Over	Incl.	Steel	Light Alloy	
Other Than Torque Tube Type	.....	2.0000	$-.0005$ / $-.0010$	$-.0009$ / $-.0014$	.0004
	2.0000	4.0000	$-.0007$ / $-.0014$	$-.0011$ / $-.0018$	.0005
	4.0000	7.0000	$-.0010$ / $-.0020$	$-.0014$ / $-.0024$	.0006
Torque Tube Type (DAT Series)	.....	2.0000	$+.0008$ / $-.0000$	$+.0006$ / $-.0000$	.0004
	2.0000	4.0000	$+.0009$ / $-.0000$	$+.0007$ / $-.0000$	.0005
	4.0000	7.0000	$+.0010$ / $-.0000$	$+.0008$ / $-.0000$	.0006
	7.0000	10.0000	$+.0011$ / $-.0000$	$+.0009$ / $-.0000$	.0007

* These tolerances should be applied to the nominal bearing O.D.

Table 202-VII. Recommended shaft and housing fits for mounting MS27642 (KP-B, & MK-B); MS27648 (KP-BS & MKP-BS); MS27644 (B500 & MB-500).

Dimensions in inches

	FOR STEEL SHAFTS						HOUSING FITS					
BEARING	BEARING BORE		SHAFT O.D.		RESULTING FIT		BEARING O.D.		HOUSING BORE		RESULTING FIT	
NUMBER	MAX.	MIN.	MAX.	MIN.	TIGHT	LOOSE	MAX.	MIN.	MAX.	MIN.	LOOSE	TIGHT
KP16B	1.0000	0.9995	0.9995	0.9990	0.0000	0.0010	1.7500	1.7490	1.7510	1.7500	0.0020	0.0000
KP16BS	1.0000	0.9995	0.9995	0.9990	0.0000	0.0010	1.9375	1.9365	1.9385	1.9375	0.0020	0.0000
KP21B	1.3130	1.3120	1.3120	1.3110	0.0000	0.0020	2.0625	2.0615	2.0635	2.0625	0.0020	0.0000
KP21BS	1.3130	1.3120	1.3120	1.3110	0.0000	0.0020	2.2500	2.2490	2.2510	2.2500	0.0020	0.0000
KP23B	1.4380	1.4370	1.4370	1.4360	0.0000	0.0020	2.1875	2.1865	2.1885	2.1875	0.0020	0.0000
KP23BS	1.4380	1.4370	1.4370	14.360	0.0000	0.0020	2.3750	2.3740	2.3760	2.3750	0.0020	0.0000
KP25B	1.5630	1.5620	1.5620	1.5610	0.0000	0.0020	2.3125	2.3115	2.3135	2.3125	0.0020	0.0000
KP25BS	1.5630	1.5620	1.5620	1.5610	0.0000	0.0020	2.5000	2.4990	2.5010	2.5000	0.0020	0.0000
KP29B	1.8130	1.8120	1.8120	1.8110	0.0000	0.0020	2.5625	2.5615	2.5635	2.5625	0.0020	0.0000
KP29BS	1.8130	1.8120	1.8120	1.8110	0.0000	0.0020	2.7500	2.7490	2.7510	2.7500	0.0020	0.0000
KP33B	2.0630	2.0620	2.0620	2.0610	0.0000	0.0020	2.8125	2.8115	2.8135	2.8125	0.0020	0.0000
KP33BS	2.0630	2.0620	2.0620	2.0610	0.0000	0.0020	3.0000	2.9990	3.0010	3.0000	0.0020	0.0000
KP37B	2.3130	2.3120	2.3120	2.3110	0.0000	0.0020	3.0625	3.0615	3.0635	3.0625	0.0020	0.0000
KP37BS	2.3130	2.3120	2.3120	2.3110	0.0000	0.0020	3.2500	3.2490	3.2510	3.2500	0.0020	0.0000
KP47B	2.9380	2.9370	2.9370	2.9360	0.0000	0.0020	3.8750	3.8740	3.8760	4.8750	0.0020	0.0000
KP47BS	2.9380	2.9370	2.9370	2.9360	0.0000	0.0020	4.1250	4.1240	4.1260	4.1250	0.0020	0.0000
KP48BS	3.0000	2.9990	2.9990	2.9980	0.0000	0.0020	4.2500	4.2490	4.2510	4.2500	0.0020	0.0000
KP49B	3.0630	3.0620	3.0620	3.0610	0.0000	0.0020	4.0000	3.9990	4.0010	4.0000	0.0020	0.0000
KP49BS	3.0630	3.0620	3.0620	3.0610	0.0000	0.0020	4.2500	4.2490	4.2510	4.2500	0.0020	0.0000
B538	0.6257	0.6243	0.6243	0.6233	0.0000	0.0024	1.0625	1.0615	1.0635	1.0625	0.0020	0.0000
B539	0.7507	0.7493	0.7493	0.7483	0.0000	0.0024	1.1875	1.1865	1.1885	1.1875	0.0020	0.0000
B540	0.8757	0.8743	0.8743	0.8733	0.0000	0.0024	1.3125	1.3115	1.3135	1.3125	0.0020	0.0000
B541	1.0632	1.0618	1.0618	1.0608	0.0000	0.0024	1.5000	1.4990	1.5010	1.5000	0.0020	0.0000
B542	1.3132	1.3118	1.3118	1.3108	0.0000	0.0024	1.7500	1.7490	1.7510	1.7500	0.0020	0.0000
B543	1.5632	1.5618	1.5618	1.5608	0.0000	0.0024	2.0000	1.9990	2.0010	2.0000	0.0020	0.0000
B544	1.8135	1.8115	1.8115	1.8105	0.0000	0.0030	2.2500	2.2485	2.2510	2.2500	0.0025	0.0000
B545	2.0635	2.0615	2.0615	2.0605	0.0000	0.0030	2.6250	2.6235	2.6260	2.6250	0.0025	0.0000
B546	2.3135	2.3115	2.3115	2.3105	0.0000	0.0030	2.8750	2.8735	2.8760	2.8750	0.0025	0.0000

For M Series use same shaft O.D. and housing bore dimensions

Table 202-VIII. Recommended housing fits for mounting AW-AK, DPP, DSP, DSRP, GDSRP, DW, KP, KP-A, KSP and P series MS28912 (DSRP&GDSRP); MS27647 (DW, GDW, MDW); MS27641 (DP-A, MKP-A); MS27640 (KP&MKP); MS27645 (KSP&MKSP).

BEARING NUMBER				BEARING O.D.		STEEL HOUSING				DURAL OR MAGNESIUM HOUSING			
IT						HOUSING BORE		RESULTING FIT		HOUSING BORE		RESULTING FIT	
DSP(1) (G)DSRP DPP, DW	KP KP-A	KSP	P AW-AK	MAX.	MIN.	MAX.	MIN.	LOOSE	TIGHT	MAX.	MIN.	MIN. TIGHT	MAX. TIGHT
DW4K2	KP3A(3)	KSP3L(2)	AW3AK	0.6250	0.6245	0.6245	0.6240	0.0000	0.0010	0.6243	0.6238	0.0002	0.0012
DW4(4)	KP4A	KSP4A	AW4AK	0.7500	0.7495	0.7495	0.7490	0.0000	0.0010	0.7493	0.7488	0.0002	0.0012
DPP3	KP3	KSP3	—	0.7774	0.7769	0.7769	0.7764	0.0000	0.0010	0.7767	0.7762	0.0002	0.0012
—	KP5A	KSP5A	AW5AK	0.8125	0.8120	0.8120	0.8115	0.0000	0.0010	0.8118	0.8113	0.0002	0.0012
DW5	KP6A	KSP6A	P4K(5)	0.8750	0.8745	0.8745	0.8740	0.0000	0.0010	0.8743	0.8738	0.0002	0.0012
DPP4(G)D	KP4(6)	KSP4	—	0.9014	0.9009	0.9009	0.9004	0.0000	0.0010	0.9007	0.9002	0.0002	0.0012
—	—	—	P5K	0.9375	0.9370	0.9370	0.9365	0.0000	0.0010	0.9368	0.9363	0.0002	0.0012
DW6	—	—	—	1.0625	1.0620	1.0620	1.0615	0.0000	0.0010	1.0618	1.0613	0.0002	0.0012
—	KP8A	—	AW8AK	1.1250	1.1245	1.1245	1.1240	0.0000	0.0010	1.1243	1.1238	0.0002	0.0012
—	—	—	P10K	1.1875	1.1870	1.1870	1.1865	0.0000	0.0010	1.1869	1.1863	0.0002	0.0012
DPP5(G)D	KP5	KSP5	—	1.2500	1.2495	1.2495	1.2490	0.0000	0.0010	1.2493	1.2488	0.0002	0.0012
—	KP10A	—	AW10AK	1.3750	1.3745	1.3745	1.3740	0.0000	0.0010	1.3743	1.3738	0.0002	0.0012
DPP6	—	—	—	1.4375	1.4370	1.4370	1.4365	0.0000	0.0010	1.4368	1.4363	0.0002	0.0012
DW8(G)D	KP6	KSP6	—	1.4375	1.4370	1.4370	1.4365	0.0000	0.0010	1.4368	1.4363	0.0002	0.0012
—	KP12A	—	AW12AK	1.6250	1.6245	1.6245	1.6240	0.0000	0.0010	1.6243	1.6238	0.0002	0.0012
DPP8(G)D	KP8	KSP8	P8	1.6875	1.6870	1.6870	1.6865	0.0000	0.0010	1.6868	1.6863	0.0002	0.0012
DPP10(G)	KP10	KSP10	—	1.9375	1.9370	1.9370	1.9365	0.0000	0.0010	1.9938	1.9363	0.0002	0.0012
—	KP16A	—	AW16AK2	2.0000	1.9995	1.9995	1.9990	0.0000	0.0010	1.9999	1.9988	0.0007	0.0012
—	KP20A	—	AW20AK	2.2500	2.2495	2.2495	2.2490	0.0000	0.0010	2.2493	2.2488	0.0002	0.0012

For M Series use same housing bore dimensions.

(1) Use fits shown for DPP Series (2) And K3L (3) And KP3AK (4) Also DW4-3 and DW4K (5) And P5K (6) Also KP4K

Table 202-IX. Recommended shaft and housing tolerance, airframe roller bearing - torque tube type MS28915 (DAT).

RECOMMENDED HOUSING BORE TOLERANCE

Limits in 0.0001 inch

OUTSIDE DIAMETER D (INCH)		DEVIATION FROM D				
		STEEL		LIGHT ALLOY		ROUNDNESS
OVER	INCL.	LOW	HIGH	LOW	HIGH	(TIR)
--	2	0	+8	0	+6	4
2	4	0	+9	0	+7	5
4	7	0	+10	0	+8	6

RECOMMENDED SHAFT TOLERANCE

BORE d (inch)		SHAFT DIAMETER DEVIATION FROM d	
OVER	INCL	LOW	HIGH
--	1	-10	-5
1	2	-13	-8
2	4	-16	-11

5.1.1 Bolted plate. Can be used with a shoulder in the housing to hold a bearing against thrust loads in either direction. This method can be used when an interference fit is not desired. Disadvantages are the required bolt holes and added weight and space requirements (see figure 202-3).

5.1.2 Anvil or roller staked bearing outer race. This method is used where the outer race is soft enough (RC24-36) to be deformed over a chamfer machined in the housing. The outer race has a special groove to facilitate operation. This method does not harm housing and permits unlimited replacement of bearings. This method shall not be used with anti-friction bearings (see figure 202-4).

Groove depth	Anvil staking force (steel)	Push-out force (steel)
.030	17,400	3,000
.040	18,200	3,475
.060	26,400	3,750
	Lbs. x Groove dia.	Lbs. x Bearing OD

Groove depth	Anvil staking force (Aluminum bronze>	Push-out force (Aluminum bronze)
.030	7,200	1,200
.040	7,500	1,400
.060	11,000	1,550
	Lbs. x Groove dia.	Lbs. x Bearing OD

5.1.3 Sleeve-staked or swaged. Full or split sleeve of aluminum is placed between bearings and enlarged bore of housing. Swaging the extended part of sleeve provides axial retention and radial tightness (see figure 202-5).

5.1.4 Roller swaged housing. Bearing housing is deformed by swaging rollers (surface speed of 40 to 150 ft/min) so that a section of the housing is forced into the chamfer on the edges of the bearing outer race (see figure 202-6).

5.1.5 Segment staked housing. A smaller ball or point, or a line die is pushed into the housing near the edge of the bearing, forcing the metal into the recess formed by the chamfer on the edge of the bearing and of the housing. This method is usually used with an interference fit of the bearing into the housing (see figure 202-7), and is the preferred method for anti-friction bearings.

NOTE : For groove staked bearing, the housing width and tolerance is the same as the outer race width and tolerance. For 3/16 to 7/16 bore bearings the chamfer depth is .020/.025 x 45°. For all larger bearings the chamfer depth is .040/.045 x 45°.

CAUTION

The preceding four retention methods require deformation of the bearing race or housing, and if improperly performed, they can damage the bearing components.

5.1.6 Adhesive bonding. The bearing may be placed against a shoulder in the housing. This method requires a clearance between the bearing and housing to establish a proper “bond line” thickness. Rigorous cleaning of the surface is essential. Several adhesive components are available. Anaerobic and epoxies are the most commonly used. If heat cured epoxies are used with aluminum bearings or housings, care must be taken to assure that the temper of the aluminum is not affected.

5.1.7 Threaded ring. This retention technique requires a specially designed bearing with a flange at one race face to accommodate a threaded retention ring (see figure 202-8).

5.2 Proof testing. Most of the retention systems require metal deformation. If the staking is not done correctly, the retention capability may not be adequate. In cases where loss of retention strength may result in a catastrophic loss of a system, it may be desirable to perform a proof test on the staked bearing assembly. Proof tests should be performed at the design load for the assembly. The load should be maintained long enough so that any axial movement between the bearing and its housing ceases. Axial movement generally is acceptable if kept within prescribed limits dictated by the application. This is the preferred method for anvil staked bearings. This technique may also be required for arbor staked bearings in critical applications.

5.3 Staking inspection. When properly installed, bearings which have had the outer race roller staked over a housing chamfer shall exhibit the following characteristics:

a. Any gap between the bearing’s staked lip and housing chamfer shall not exceed .005 inches (see figure 202-9).

b. The bearing's staked lips shall not exhibit cracks in the material. This includes a crack through the staked lip, a partial crack not through the lip, or a circumferential crack on the staked lip (see figure 202-10).

It is recommended that an illuminated magnifying glass or other suitable equipment be used when inspecting for these characteristics.

c. The bearinq's staked lip shall not exhibit deeply scratched, gouged, or score marks on the inner side or unstaked side of the bearing staking groove (see figure 202-11).

d. The bearing’s staked lip shall not be over-staked, that is, the staking lip shall not be feathered to a knife edge beyond the face of the housing (see fiqure 202-12).

e. Gouges, chips and dirt in the bearing's staked lip are not acceptable. Minor impressions or contaminants, such as dust, in the bearing's staked lip are acceptable.

6. Bearing removal and replacement

6.1 When a bearing has been retained in its housing by any of the techniques that require bearing or sleeve staking, removal of the deformed metal will be required before the bearing can be removed from the housing. This machining operation must be performed carefully so that excess material will not be removed.

6.2 When a bearing is pushed out of the housing, it may score the I.D. The degree of scoring will be determined by the interference conditions which exist and by the adequacy of removal of the staked metal.

6.3 In many instances, the scoring in the housing could result in fatigue problems and cannot be tolerated.

6.4 In cases where a bearing is assembled into its housing with clearance, the scoring will, in all probability, be q inor and need only be removed by brush honing or polishing. The material removed should not increase the housing bore beyond the original blueprint requirements. If the scoring cannot be removed without causing the bore to go out of the original tolerance, the bore must be remachined to a new size, and either a special bearing must be refabricated to fit the new bore, or a staking ring should be installed with the bearing. Plating or hard anodize can also be used to restore the housing dimension. When polishing or re-machining chamfered housings, care must be taken to preserve the sharp edge at the bottom of the chamfer. The retention strength of the staked bearing is dependent upon these chamfers being sharp enough to “bite into" the staked bearing race. When an interrupted housing stake is used, it will be necessary to index the staking tool, so that during bearing replacement only virgin housing material will be staked.

6.5 Individual company policy may require MRB approval of any housing rework.

Table 202-X. Advantages of various bearing retention methods.

	BOLTED PLATE	ANVIL OR ROLLER STAKED BEARING OUTER RACE	SLEEVE-STAKED OR SWAGED	ROLLER SWAGED HOUSING	BALL POINT/ LINE STAKED HOUSING	ADHESIVE BONDING
Added space and weight	High	None	Oversized bore needed	None	None	None
Effect on bearing internal clearance	None	None	None	High	Irregular	None
Retention capabilities	High	Medium	Staked-medium Swaged high	Medium	Low	High
Introduction of residual stress in housing	Low	None	None	High	High	None
Can replacement damage housing	No	No	No	Yes	Yes	No
Possible no. of bearing replacements	No Limit	No Limit	No Limit	None	Three or more	No Limit
Ease of installation	Good	Fair	Fair	Poor	Good	Poor

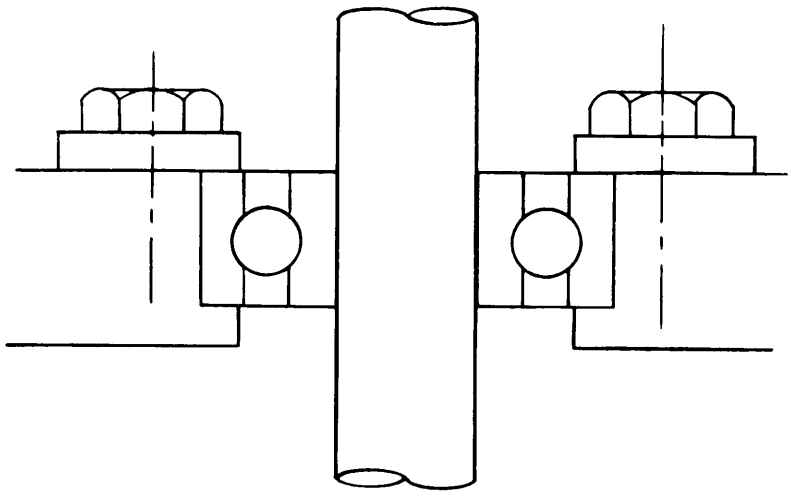
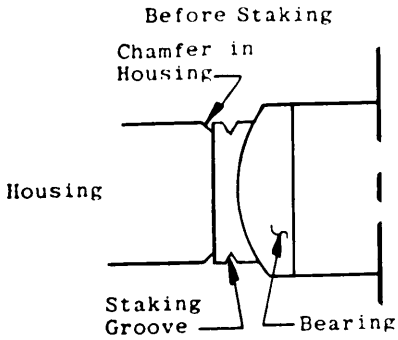
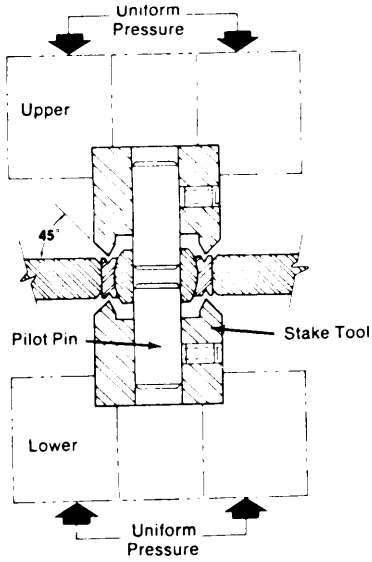
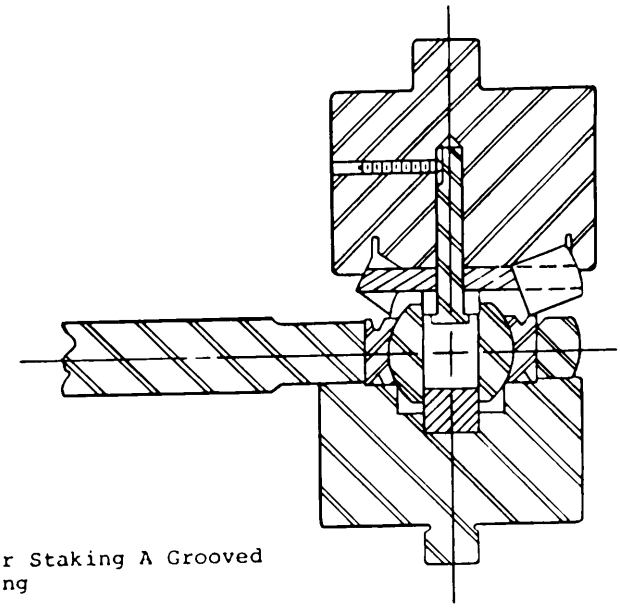


Figure 202-3. Bolted plate.





Anvil Staking A Grooved Bearing



Roller Staking A Grooved Bearing

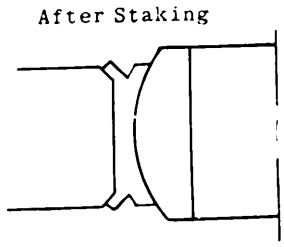


Figure 202-4. Anvil or roller staked bearing outer race.

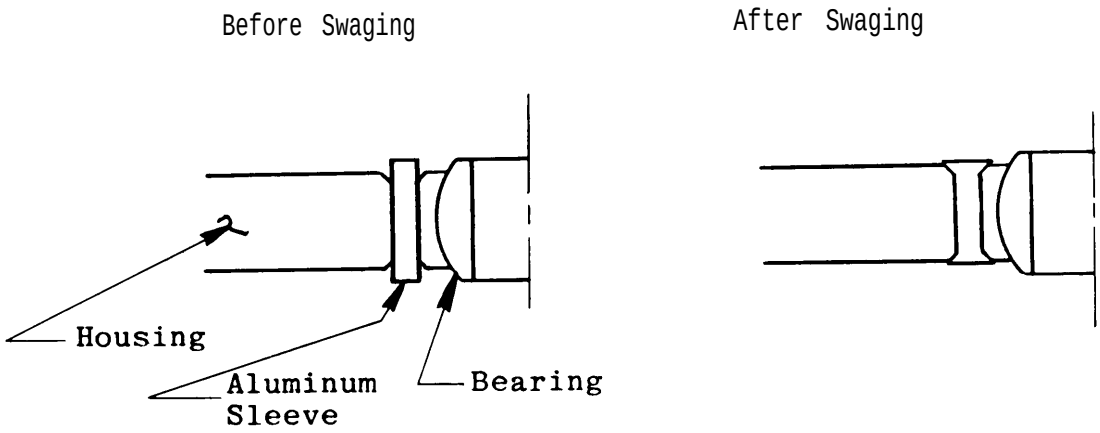
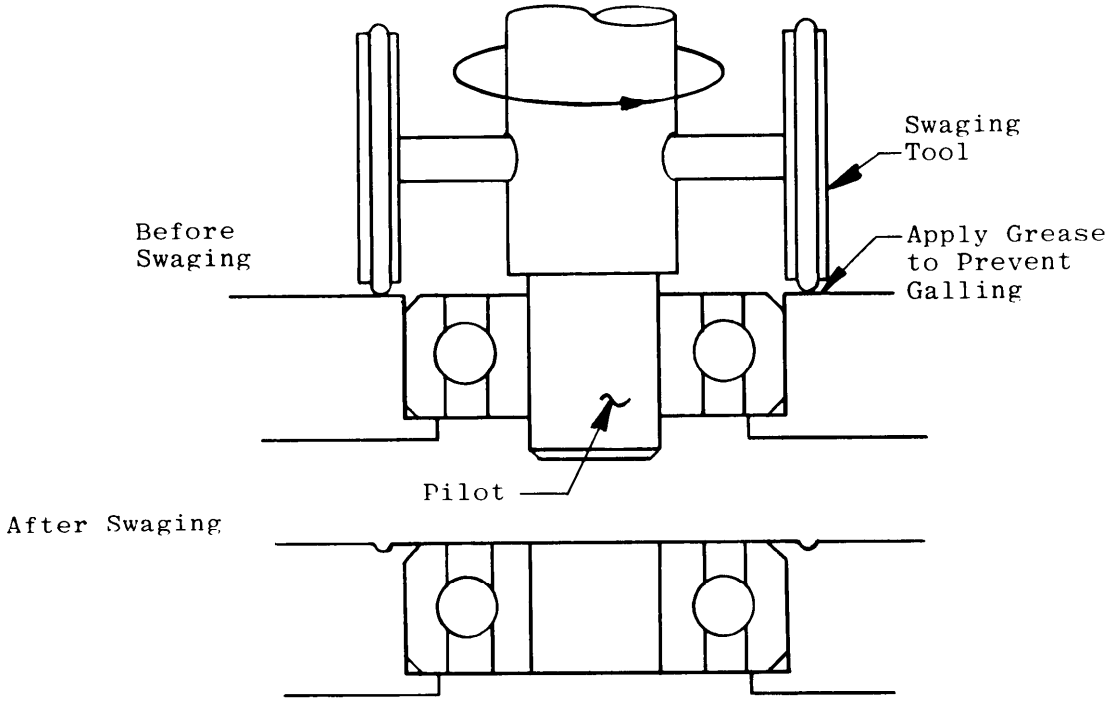


Figure 202-5. Sleeve staked or swaged.



NOTE : Both sides may also be roller staked
Figure 202-6. Roller swaged housing.

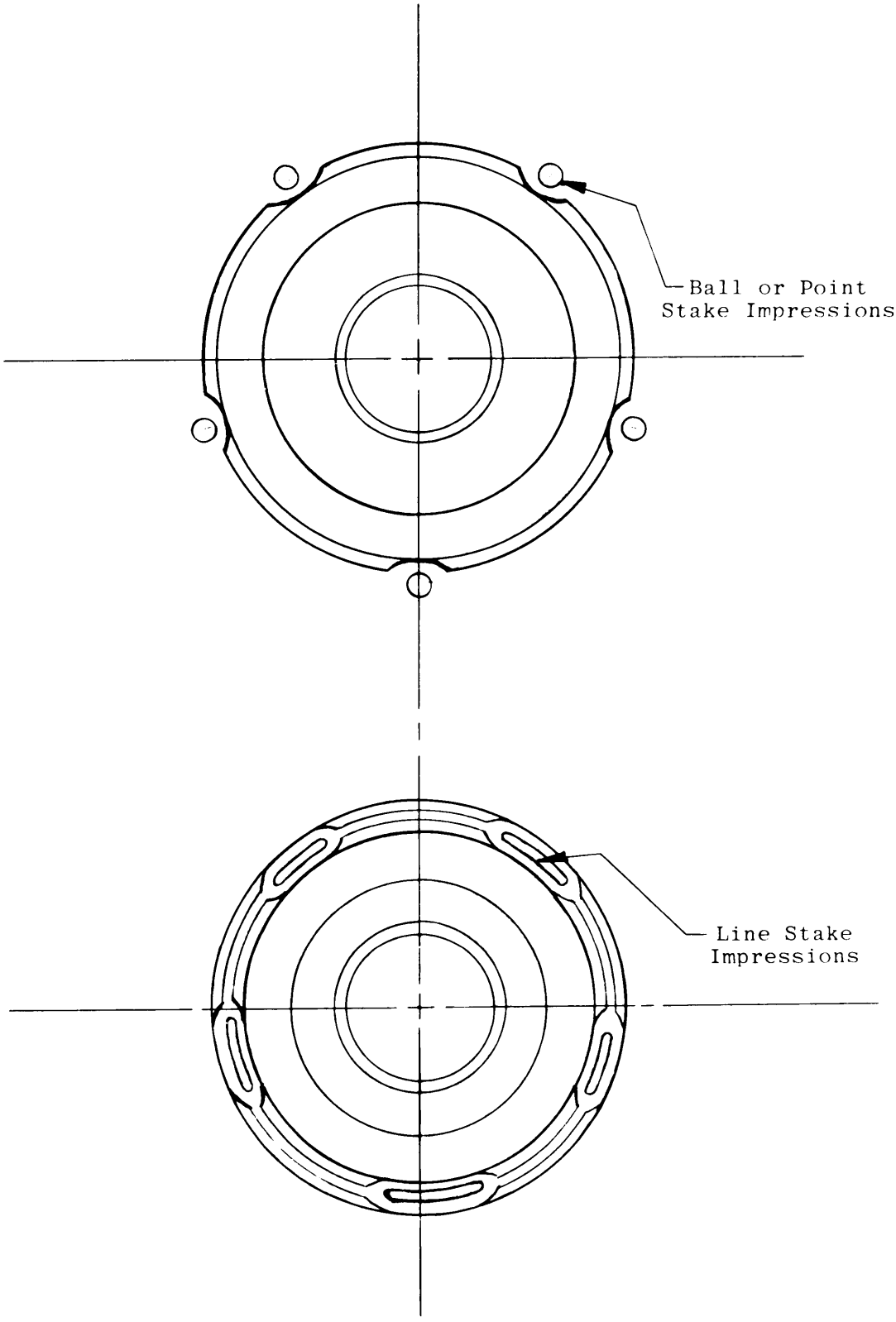
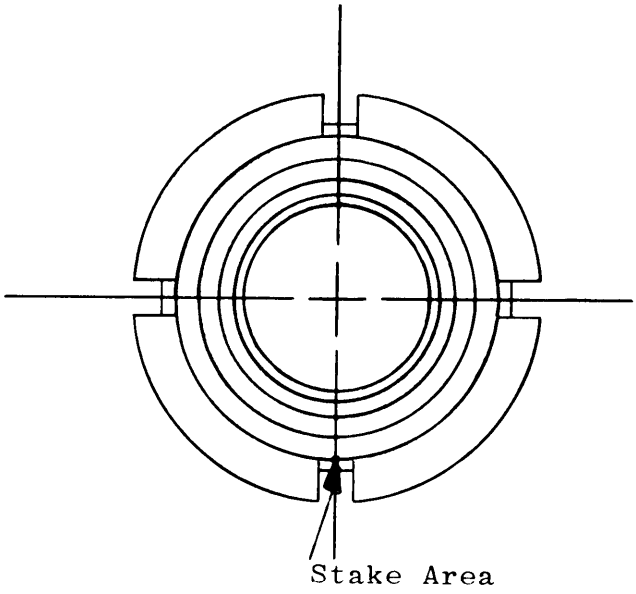
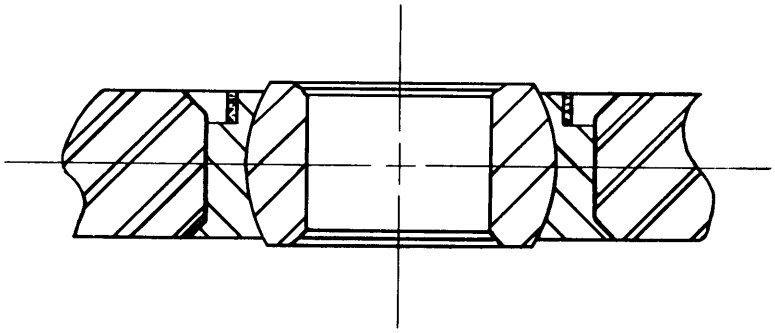


Figure 202-7. Segment staked housing.





Threaded Race Bearing

NOTE: The flange and nut configurations are optional and need not be as shown.

Figure 202-8. Threaded ring.

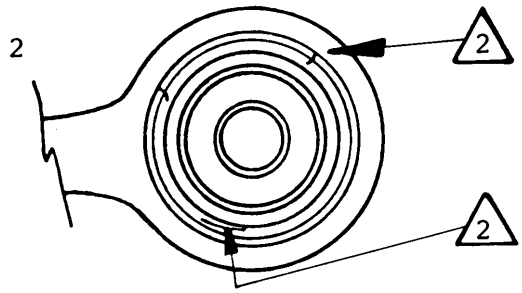


Figure 202-9. Gap between staked lip and housing chamfer.

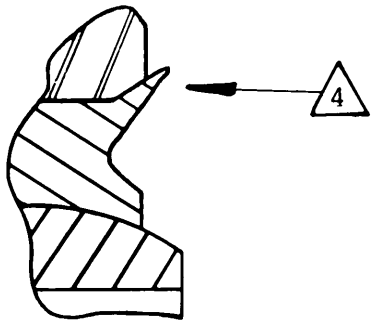


Figure 202-10. Cracks in staked lips.

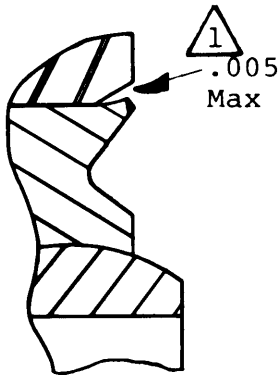


Figure 202-11. Scratched. gouged or score marks on staking groove.

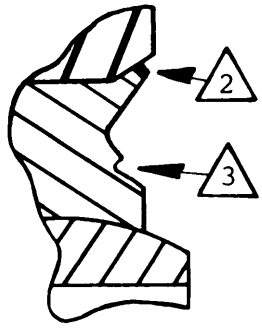


Figure 202-12. Over-staking.

AIRFRAME BEARINGS, BALL, ANTI-FRICTION

1. Scope

1.1 This requirement establishes engineering criteria and requirements for the selection and application of rolling element anti-friction ball bearings for aerospace systems.

1.2 Classification. Anti-friction ball bearings covered by this requirement are of the following classes:

a. Extra light duty
b. Intermediate duty
c. Heavy duty
d. Double row
e. Double row, self-aligning
f. Extra wide
g. Single row
h. Single row, self-aligning

2. Documents applicable to requirement 301

MIL-B-7949	Bearing, Ball, Airframe, Anti-Friction
MS21428	Bearing, Ball, Airframe, Anti-Friction, Extra Light Duty Precision
MS27640	Bearing, Ball, Airframe, Anti-Friction, Heavy Duty
MS27641	Bearing, Ball, Airframe, Anti-Friction, Heavy Duty, Intermediate Duty
MS27642	Bearing, Ball, Airframe, Extra Light Duty
MS27643	Bearing, Ball, Airframe, Anti-Friction, Self-Aligning, Double Row, Heavy Duty
MS27644	Bearing, Ball, Airframe, Anti-Friction, Double Row, Heavy Duty
MS27645	Bearing, Ball, Airframe, Anti-Friction, Self-Aligning, Light and Heavy Duty
MS27646	Bearing, Ball, Airframe, Anti-Friction, Extra Light Duty
MS27647	Bearing, Ball, Airframe, Anti-Friction, Extra Wide, Double Row, Intermediate Duty
MS27648	Bearing, Ball, Airframe, Anti-Friction, Externally Self-Aligning, Extra Light Duty
MS27649	Bearing, Ball, Airframe, Anti-Friction, Intermediate Duty

3. General.

Anti-friction ball bearings are used throughout airframe systems in many different types of applications and environmental conditions. For selection and usage guidelines, see requirement 201. For shaft, housing, and installation, see requirement 202.

4. Requirement

4.1 Qualification. Anti-friction ball bearings defined under this requirement shall be products which are qualified for listing on the applicable qualified products list of MIL-B-7949.

4.2 Desire and construction. These bearings conform to the requirements of MIL-B-7949, MS21428, MS27640, MS27641, MS27642, MS27643, MS27644, MS27645, MS27646, MS27647, MS27648, and MS27649.

4.3 Performance

4.3.1. Radial limit load rating. These bearings have a minimum limit load rating as specified on the applicable MS.

4.3.2 Radial fracture load. The minimum static fracture load is not less than 1 1/2 times the radial limit load value specified on the applicable MS.

4.3.3 Axial limit load rating. These bearings have a minimum limit load rating as specified on the applicable MS.

4.3.4 Axial fracture load. The minimum axial fracture load is not less than 1 1/2 times the axial limit load values specified on the applicable MS.

4.3.5 Radial dynamic load rating

4.3.5.1 These bearings have a radial dynamic load rating, at 250°F, as specified on the applicable MS for an average life of 10,000 cycles when oscillated through an arc of 90°F.

4.3.5.2 These bearings have a radial dynamic load rating, at 350°F, of not less than 80 percent of the value specified on the applicable MS for an average life of 10,000 cycles when oscillated through an arc of 90°F.

AIRFRAME BEARINGS, ANTI-FRICTION ROLLER

1. Scope. This requirement establishes engineering criteria and requirements for the selection and application of self-aligning, anti-friction sealed, airframe roller bearings for aerospace systems.

2. Documents applicable to requirement 302.

MIL-B-8914	Bearings, Roller, Self-Aligning Airframe, Anti-Friction
MS28912	Bearings, Roller, Self-Aligning, Single Row, Airframe, Anti-Friction, Sealed, Type I
MS28913	Bearings, Roller, Self-Aligning, Double Row, Airframe, Anti-Friction, Sealed, Type II
MS28914	Bearings, Roller, Self-Aligning, Double Row, Wide Inner Ring, Airframe, Anti-Friction, Sealed, Type III
MS28915	Bearings, Roller, Self-Aligning, Double Row, Torque Tube, Airframe, Anti-Friction, Sealed, Type IV
MS21431	Bearings, Roller, Self-Aligning, Single Row, Anti-Friction, Sealed, -65°F - 350°F, Type I

3. General. Typical airframe roller bearings utilize a compliment of rollers separating an outer ring and an inner ring. The outer ring is usually mounted in the housing and the inner ring on the shaft. Other elements of these bearings may be rolling element separators, shields or seals, and seal retainers.

3.1 Usage. Guidelines on selection are contained in requirement 201.

4. Design requirements. Design and construction of these bearings shall conform to the requirements of MIL-F-8914, MS28912, MS28913, MS28914, MS28915, and MS21431.

5. Performance requirements. Engineering criteria on friction, torque, temperature capabilities, and rotational and alignment capabilities are contained in requirement 201.

6. Installation and retention. Guidelines on installation and retention are contained in requirement 201 and requirement 202.

ROD ENDS

1. Scope

1.1 This requirement defines plain, spherical, self-lubricating rod ends, roller bearing rod ends, and ball bearing rod ends for aerospace systems.

1.2 Classifications. Rod ends shall be classified as follows:

a. Type I - Plain spherical self-lubricating rod ends
b. Type II - Roller bearing rod ends
c. Type III - Ball bearing rod ends
d. Class 1 - Externally threaded
e. Class 2 - Internally threaded
f. Class 3 - Solid shank
g. Class 4 - Hollow shank
h. Composition A - Fabric bearing liner of uniform thickness which is bonded to the inside diameter of the outer race
i. Composition B - Molded composition liner system

2. Documents applicable to requirement 308.

MIL-B-6039	Bearing, Double Row, Ball, Sealed Rod End, Anti-Friction, Self-Aligning
MIL-B-8952	Bearing, Roller, Rod End, Anti-Friction, Self-Aligning
MIL-B-81935	Bearing, Plain, Rod End, Self-Aligning, Self-Lubricating
M81935/1	Bearing, Plain, Rod End, Self-Aligning, Self-Lubricating, Externally Threaded, -65°F to +325°F
M81935/2	Bearing, Plain, Rod End, Self-Aligning, Self-Lubricating, Internally Threaded, -65°F to +325°F
MS14103	Bearings, Plain, Self-Lubricating, Self-Aligning, Low Speed, Wide, Grooved Outer Ring, -65°F to 325°F
MS21150	Bearing, Double Row, Ball, Rod End, Precision, Solid Shank, Self-Aligning, Anti-Friction, Airframe, Type I, -65°F to +350°F
MS21151	Bearing, Double Row, Ball, Rod End, Precision, External Thread, Self-Aligning, Anti-Friction, Airframe, -65°F to +350°F
MS21152	Bearing, Double Row, Ball, Rod End, Precision, Hollow Shank, Self-Aligning, Anti-Friction, Airframe, Type III, -65°F to +350°F
MS21153	Bearing, Ball, Rod End, Precision, Internal Thread, Self-Aligning, Anti-Friction, Airframe, Type IV, -65°F to +350°F
MS21220	Bearing, Roller, Rod End, Internal Thread, Self-Aligning, Anti-Friction, Airframe, Heavy Duty, Type II, -67°F to +350°F, Sealed
MS21221	Bearing, Roller, Rod End, External Thread, Self-Aligning, Anti-Friction, Airframe, Heavy Duty, Type I, -67°F to +350°F, Sealed
MS21223	Bearing, Roller, Rod End, External Thread, Self-Aligning, Anti-Friction, Airframe, Heavy Duty, Type II, -67°F to +350°F, Sealed
MS21429	Bearing, Roller, Rod End, External Thread, Self-Aligning, Anti-Friction, Airframe, Heavy Duty, Type I, -67°F to +350°F, Sealed

3. Intended use. Types I, II, and III rod ends are for use in aerospace systems in many different applications and environments.

4. Requirements

4.1 Qualifications

4.1.1 Type I, class 1 and class 2, composition A and composition B rod ends are products that conform to the requirements of MIL-B-81935.

4.1.2 Type II, class 1 and class 2 rod ends are products that conform to the requirements of MIL-B-8952.

4.1.3 Type III, class 1, class 2, class 3, and class 4 rod ends are products that conform to the requirements of MIL-B-6039.

4.2 Desire and construction

4.2.1 Type I, class 1 and class 2, composition A and composition B rod ends are products that conform to the requirements of MIL-B-81935, M81935/1, M81935/2, and MS14103.

4.2.2 Type II, class 1 and class 2 rod ends are products that conform to the requirements of MIL-B-8952, MS21220, MS21221, MS21223, and MS21429.

4.2.3 Type III, class 1, class 2, class 3, and class 4 rod ends are products that conform to the requirements of MIL-B-6039, MS21150, MS21151, MS21152, and MS21153.

4.3 Performance

4.3.1 Load ratings for type I, class 1 and class 2, composition A and composition B rod ends

4.3.1.1 Static radial ultimate load. Static radial ultimate load is defined in MIL-B-81935. After application of this load, there may be significant permanent deformation of the rod end and bearing cartridge components. However, application of the ultimate loads specified on M81935/1 and M81935/2 shall not result in cracked or broken components.

4.3.1.2 Axial static proof load. There shall be no pushout of the bearing cartridge when the axial proof loads specified on M81935/1 and M81935/2 are applied.

4.3.1.3 Fatigue load. Rod ends covered by MIL-B-81935 are capable of withstanding a minimum of 50,000 cycles of the fatigue loads specified on M81935/1 and M81935/2 when applied at a rate not exceeding 2800 cycles per minute.

4.3.2 Load ratings for type II, class 1 and class 2 rod ends

4.3.2.1 Limit load rating. Limit load rating is defined as the maximum static load that can be applied to the bearing without seriously affecting the predicted life. These loads are specified on Ms21220, MS21221, MS21223, and MS21429.

4.3.2.2 Ultimate load rating. This is defined as the load which can be applied and held for 3 minutes without structural failure of the bearing. The ultimate load rating is calculated as the limit load rating, as specified on MS21220, MS21221, MS21223, and MS21429, multiplied by a factor of 1.5. In application, brinelling will occur or. the race surface if subjected to a load equal to the ultimate load rating. The bearing will still be operative even though the races may be brinelled, but the bearing should be replaced.

4.3.2.3 Dynamic load rating. The dynamic load rating is defined on the basis of a unidirectional load that will result in an average bearing life (L_{50}) of 10,000 cycles at 90° oscillation before evidence of contact fatigue occurs. The angle of oscillation is defined as 180° of angular travel within an included arc of 90°. These loads are specified on MS21220, MS21221, MS21223, and MS21429.

4.3.3 Load ratings for type III, class 1. Class 2, class 3, and class 4

4.3.3.1 Radial limit load rating. The bearings have a minimum radial limit load rating as specified on MS21150, MS21151, MS21152, and MS21153.

4.3.3.2 Radial static fracture load. The minimum radial static fracture load is not less than 1 1/2 times the radial limit load specified on MS21150, MS21151, MS21152, and MS21153.

4.3.3.3 Axial limit load rating. The bearings have a minimum axial limit load rating as specified on Ms21150, MS21151, MS21152, and MS21153.

4.3.3.4 Axial fracture load. The minimum axial fracture load is not less than 1 1/2 times the axial limit load specified on MS21150, MS21151, MS21152, and MS21153.

4.3.3.5 Radial dynamic load rating at 250°F. The bearings have a radial dynamic load rating at 250°F as specified on MS21150, MS21151, MS21152, and MS21153 for an average life of 15,000 cycles when oscillated through an arc of 90°.

4.3.3.6 Radial dynamic load rating at 350°F. The bearings have a radial dynamic load at 350°F of not less than 80 percent of the value specified on MS21150, MS21151, MS21152, and MS2115 for an average life of 10,000 cycles when oscillated through an arc of 90°.

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