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FLIGHT CONTROL SYSTEM RELIABILITY AND MAINTAINABILITY INVESTIGATIONS. APPENDIX F. DESIGN HANDBOOK CHANGE RECOMMENDATIONS, AFSC DESIGN HANDBOOK, DH-2-1, DH-2-X

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Bell Helicopter Company

Prepared for:

Army Air Mobility Research and Development Laboratory

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SUPPLEMENT TO USAAMRDL-TR-74-57

FLIGHT CONTROL SYSTEM RELIABILITY AND MAINTAINABILITY INVESTIGATIONS

Appendix F - Design Handbook Change Recommendations, AFSC Design Handbook, DH-2-1, DH-2-X

Bell Helicopter Company
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March 1975

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Prepared for

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U. S. ARMY AIR MOBILITY RESEARCH AND DEVELOPMENT LABORATORY
Fort Eustis, Va. 23604

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This supplement to USAAMRDL-TR-74-57 includes recommended changes to Design Handbooks DH-21, DH-2-X. The changes recommended would help to improve requirements affecting system and mission reliability and maintainability.

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APPENDIX F

DESIGN HANDBOOK CHANGE RECOMMENDATIONS, AFSC DESIGN HANDBOOK, DH 2-1 ,DH 2-X

DESIGN NOTE 3B1 MECHANICAL FLIGHT CONTROLS

1. CABLE ACTUATED SYSTEMS

Crowded installations and identical cable connections contribute to the possibility of cross-connecting control cables. Ensure that adjacent cable connections are keyed, sized, or sufficiently different so that cross connection is impossible. Cable linkages tend to become slack and catch on nearby objects. Ensure that cable systems and their components are compatible with adjacent structure from the standpoint of wear, deflection, or durability to prevent any possibility of creating a hazard by their proximity. Avoid cable routing near systems where moving contact can result in fuel, hydraulic, or electrical failure. Ensure that a mechanical control failure (sudden release of cable tension) does not cause control transients in excess of those allowed in MIL-F-8785. If a cable wear problem is a possibility, consider using nylon clad cables. Design coated flight control cables so that subjection to cold soaking will not produce appreciable stiffness in the flight controls. Use MIL-W-5424 cables for flight controls. When necessary, use MIL-C-18375 non-magnetic control cables. Provide a 3-inch clearance between adjacent cables. ~~Use MS20218 (MIL-B-6038) bearings in bellcranks.~~ Use MIL-B-6038, MIL-B-6039, MIL-B-7949 or equivalent bearings in bell-cranks. See MIL-F-9490 for additional information.

> Rationale:
>
> The MS20218 Bearing is of special design to be riveted to a sheet metal bellcrank. By using specification numbers, the manufacturing application is not limited to specific bearings.

1.1. Pulleys

Provide pulleys of adequate capacity and diameter to assure optimum cable life. A pulley too small for a large wrap angle causes overstressing of the cable strands. ~~Avoid the use of loose spacers between pulleys, bearings, and pulley brackets. Spot welded spacers, flanged bushings, or dimpled brackets are preferred. Use AN565 (hex head) and NAS1081 setscrews.~~ Eliminate all lateral chuck from pulleys. Brackets may be machined to a maximum of 0.010 inch lateral clearance and the pivot bolt tightened to remove this clearance. Sheet metal brackets should have flanged bushings and be fabricated so the clearance at the pivot is 0.030 inch maximum, and the pivot bolt tightened this motion must not exceed 2°. Limit misalignment due to catenary effect or slackening of cable by using cable guide tubes or fairleads placed close to the pulleys.

1.1.4 Guards

Install guards at the approximate point of tangency of the cable to the pulley. When the wrap angle exceeds 90°, install at least one intermediate guard.

1.2 Fairleads and turnbuckles

In designing cable operated systems, consider the possibility of structural deflection and its effect on attached components. When contact is likely, use fairleads or rubbing strips. If possible, provide a cable to fairlead clearance of 1/4 inch. Use MIL-T-8878 turnbuckles in flight control systems. Design turnbuckle end fittings so that they are not subject to a bending force that can cause fatigue failure as shown in SN 1.2(1). Do not expose more than three threads at the ends of turnbuckle assemblies. Safety turnbuckle assemblies according to MS33736.

SUB-NOTE 1.1.2(1) Standard Pulleys

DRAWING NO.	ALLOWABLE LOAD ON PULLEY IN POUNDS	USE	MAXIMUM LIMIT LOAD IN POUNDS ON CABLE (Independent of Wrap Angle)						
			CABLE DIAMETER (Inch)						
			1/16	3/32	1/8	5/32	3/16	7/32	1/4
MS20219									
-2	480		307	460					
-3	480	Secondary	307	460					
-4	920	Control	307	460					
-5	920	Pulleys	307	460					
MS20220									
-1	500				830	1,040	1,250		
-2	1,680	Flight			830	1,040	1,250		
-3	2,500	Control			830	1,040	1,250		
-4	2,500	Pulleys			830	1,040	1,250		
MS20221									
-1	2,800	Heavy Duty					2,620	3,060	3,500
-2	4,900	Control					2,620	3,060	3,500
-3	7,000	Pulleys					2,620	3,060	3,500
MS24566									
-1B	300								
-2B	500								
-3B	1,500	Flight							
-4B	2,000	Control							
-5B	3,000	Pulleys							
-6B	4,000								
-10B	10,000								
-14B	17,500								

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1.3 Cable. The wire stock from which flight control system cables are fabricated is usually stainless steel (MIL-C-5424 or MIL-C-18375). Assuming that the bending stress is made small by the use of adequately large sheaves (D_s/d_c of at least 400), then the failure of wire rope occurs primarily by fatigue due to pressure against the sheave, and to a lesser extent by abrasion. This pressure is given by

$$P_s = \frac{2F}{D_s d_c}$$

where F = the tensile force

d_c = the cable diameter

D_s = the sheave diameter

and where the contact angle is taken at 180°, as illustrated in Figure 1.

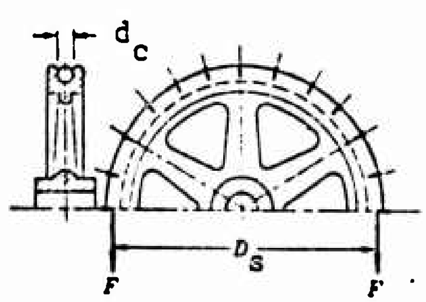

Figure 1. Cables (7)

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The Figure 2 curves of the number of bends to failure versus the ratio of p to S_{ult} (ultimate strength) indicate that failure by fatigue is unlikely ($N > 10^6$), if p/S_{ult} is equal to or less than 0.001. The substitution of this experimental value in the expression above yields

$$F = \frac{d_c D_s S_{ult}}{2000}$$

relating all the necessary parameters for the design of a cable of indefinitely long life.

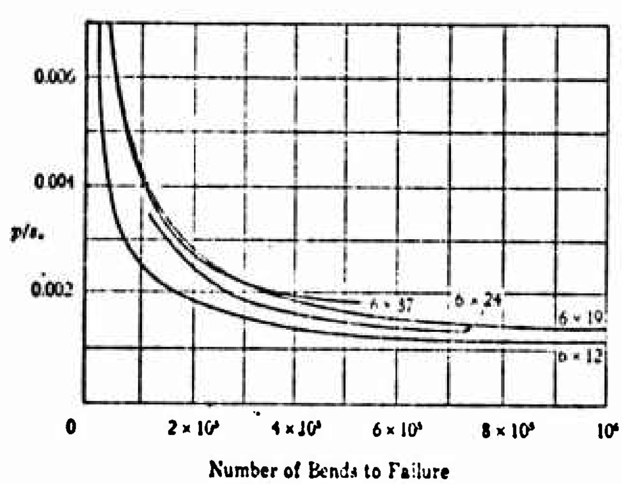

Figure 2. Pressure Ratio Vs. Number of Bends (7)

Cables, particularly in the smaller sizes, may be coated to improve both fatigue life and wear resistance. Nylon, polyolefin, vinly, and urethanes are used in thicknesses ranging from 0.015 inch on a 1/32-inch cable to 0.045 on a 3/8-inch cable. Figure 3 gives typical values for expected life under design conditions.

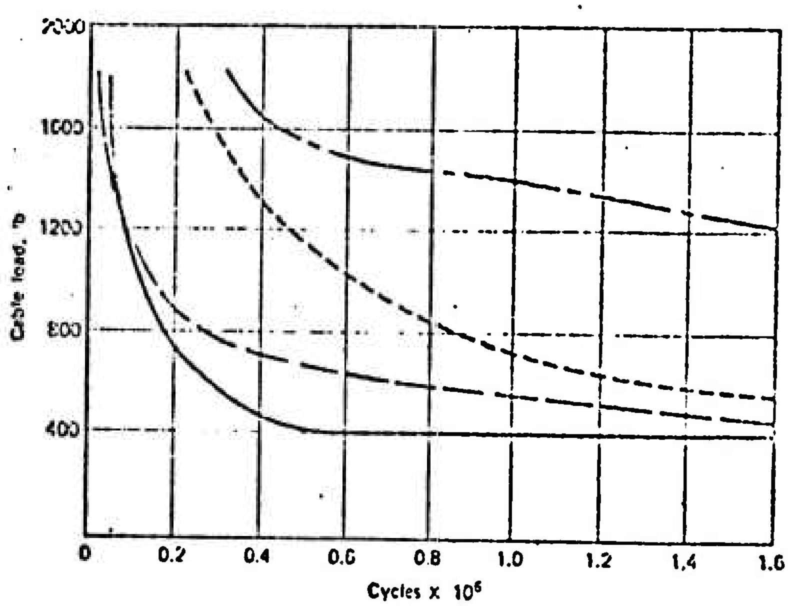

Fig. 3 Fatigue life of small cables. ---- 7 x 7 cable, nylon-jacketed; —— 7 x 7 cable, bare; — — — 7 x 19 cable, nylon-jacketed; —— — — 7 x 19 cable, bare. Reprinted from *Product Engineering*, Oct. 10, 1966.

The relative motion of the wires, particularly during bending, together with the high contact stresses, causes fretting to occur at points where fatigue cracks are observed to start and propagate. If corrosion or other unfavorable operating environmental conditions are also involved, fatigue life will be shortened considerably.

Rationale:

Design guide for cable missing from section.

2. Tube Actuated Systems

2.1 Push-Pull Rods

~~Sufficient clearance may, in time, be reduced to rubbing contact by structural deflection, deterioration of supports, or unintentional bending of the rod during normal use and wear. Whenever interference is likely to develop reroute tubing or relocate components. In many cases, push-pull rods are designed with cutaways portions to allow for rotational movement of attachment points.~~ Sufficient clearance should be designed into push-pull rod systems to permit structural deflections of supports and joints. Push-pull components of the flight control system must be located in their most optimum position in relation to other aircraft subsystems including the structure. If a push-pull rod is design unsymmetrically, incorrect installation can cause control system jamming. Design the rod so that it cannot be installed incorrectly. Route push-pull rods through structural openings with sufficient clearance to avoid the possibility of their jamming at the end fitting during structural deflection. ~~Ensure that push-pull rods do not carry heavy compressive loads. Prevent rotation of the rod at all times.~~ The lever and bellcrank system should be so designed that the push-pull rods carry the minimum compressive loads. Ensure that self-aligning bearings have freedom-of-movement at all times.

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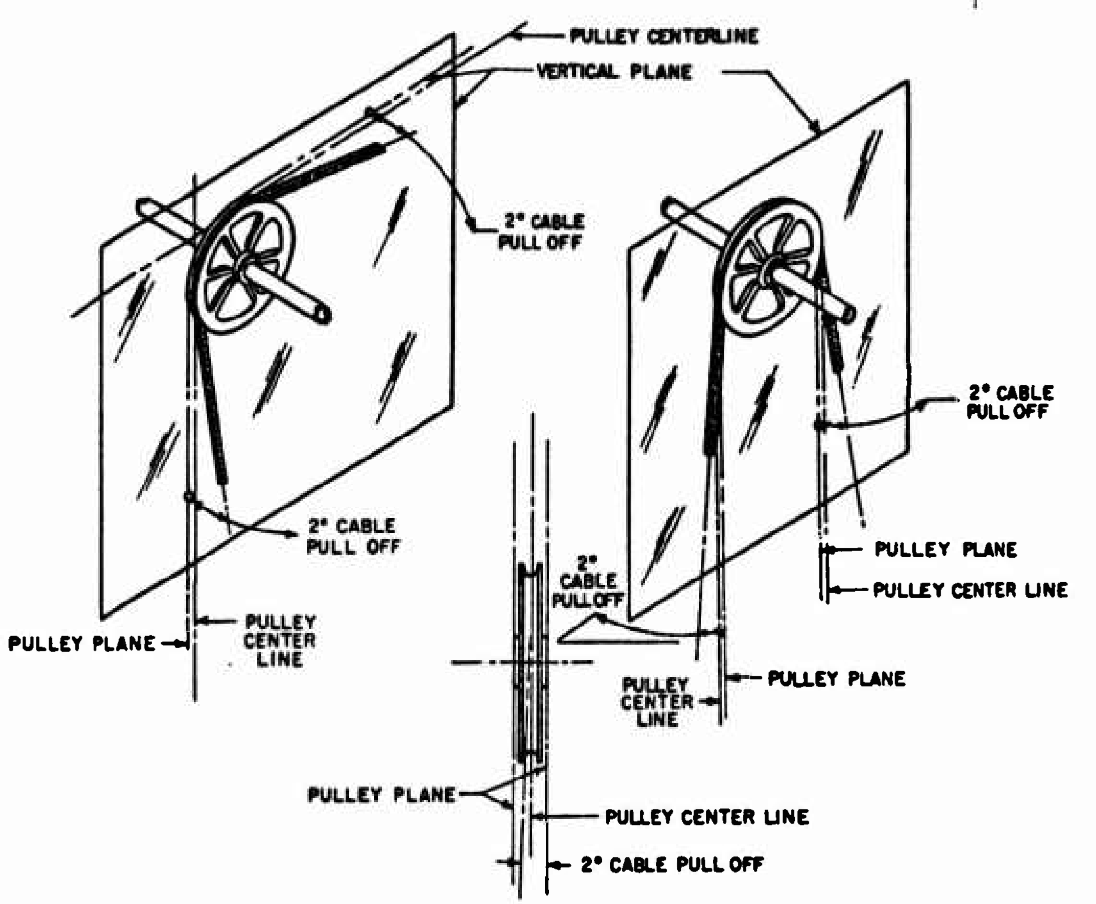
SUB-NOTE 1.1.3(1) Cable Pull



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2.2 Rod Ends

When the length adjusting portions of the rods are designed with sharp V-threads, rod ends exposed to vibration fail frequently. Stress concentrations occur in the thread roots resulting in eventual fatigue failure. Rounded threads or threads with rounded roots, as specified in MIL-S-8879, are better suited for this type of service. Bushings are preferred to spacers in rod end fittings (see SN 2.2(1)). Often spacer installation is neglected during maintenance. ~~Specify shear bolts instead of rivets for attaching rod ends to hollow tubes (see SN 2.2(2)).~~ When hollow rod ends are riveted into tube ends the maximum unsupported shank length should not exceed 1 1/2 times the rivet diameter. The driven rivet tends to buckle inside the hollow rod ends as shown in SN 2.2(2). Some ways of eliminating this problem may be (a) use shear bolts, (b) use non-driven type rivets, (c) use solid rod ends. This problem can be averted by threading the tube and bonding a rod end in place. However control of the tube wall thickness (during swaging) must be maintained and thread form per MIL-S-8879 is preferred. Steel tubes are difficult to thread and usually must be cut.

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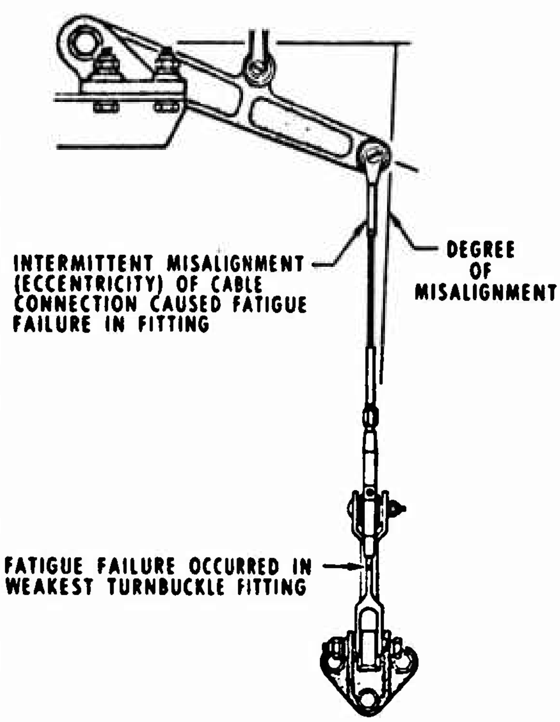
Rationale:

Using rivets for attaching end connections is an old and unreliable method, mostly because the shank is unsupported. Bolts are acceptable for low quantity items but are too expensive for large quantities. Bolts should have special washers to provide surface contact over round tube.

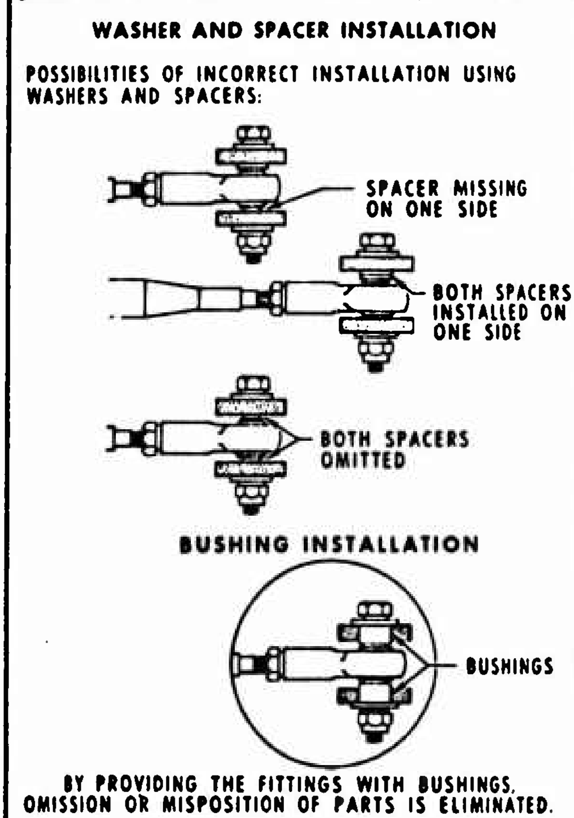
2.3 Torque Tubes

Design torque tube systems giving consideration to: (1) airframe deflections, (2) expansion by temperature differences, (3) impact loads, (4) ease of removal for repair, and (5) attachment bolt size. Insufficient clearance around rotating tubes can cause excessive wear and eventual breakage. Provide torque tube clearances for maximum structural deflections. Mount tubes on antifriction bearings spaced to prevent whipping or bending. Do not use tubing with a wall thickness less than 0.035 inch.

SUB-NOTE 1.2(1) Fatigue Failure Turnbuckle



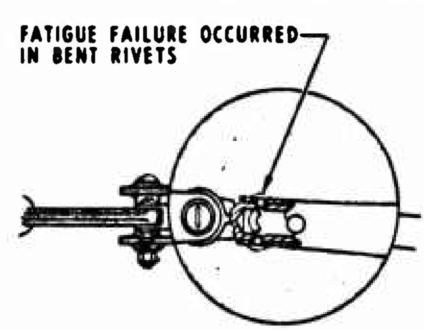
SUB-NOTE 2.2(1) Benefit of Bushings for Rod End Installation



3. POWER TRANSMISSION

Design powershafts so that the shear strength is greater than that of the driving and the driven section. Support shaft over 36 inches long at intervals along the entire length of the shaft and at both ends. Mount gearboxes so that the only misalignment that can occur will be from relative motion of the driving and driven components if such relative motion is possible (see MIL-G-6641). Provide flexible or universal joints to prevent excessive forces being applied (see DH 1-2, Sect 4C).

SUB-NOTE 2.2(2) Example of Why Shear Bolts are Preferred When Installing Rod Ends



4. Self-Retaining Bolts

Use self-retaining bolts (SRB) conforming to MIL-B-83050 in all critical flight control linkage joints. A linkage joint is defined as critical if it meets both of the following requirements:

a. Separation could prevent pilot control of the aircraft resulting in flying qualities less than Level 3 as defined in MIL-F-8785. (Separation in this requirement involves any flight control including mechanical connections between the crew station manipulators and primary control moment producers, connections of secondary flight controls such as flaps and slats, and connections of any augmentation devices.)

b. If the linkage joint requires disassembly to perform any aircraft field maintenance, or rigging on the flight control systems, or to provide access for maintenance on other subsystems.

5. Bearings.

The bearings utilized in flight control systems are of the following types:

Needle Roller	MIL-B-3990
Airframe Ball Bearings	MIL-B-7949
Rod End Ball Bearings	MIL-B-6038
Rod End Ball Bearings	MIL-B-6039
Rod End TFE Lined Bearings	MIL-B-8948
Plain TFE Lined Bearings	MIL-B-8942
Plain TFE Lined Bearing	MIL-B-81820
Sleeve Plain and Flanged Bearings	MIL-B-8943

In flight control system application, bearings are characteristically lightly loaded, operating intermittently at low speed over few or partial revolutions (cyclic and oscillatory motion). The environment includes a wide range of temperature, humidity, and vibration. Sand and dust is particularly deleterious to utility vehicles such as helicopters. These environmental factors particularly affect life and necessitate the use of adequate seals to keep lubricant in and dirt out.

A multitude of load, life, and speed capacities combinations available provide the designer with a wide latitude for choosing configurations and it is not often that a design needs to be modified by bearing restrictions. To provide these capacities, bearings have become assemblies of relatively high precision, which are therefore more susceptible to damage.

DESIGN NOTE 6A2 BEARING SIZING

1. STATIC CAPACITY

The next step is to determine the proper size. In many airframe applications, the ability of the bearing to accept momentary loads greater than the normal operating load (when the bearing is stationary or starting to move) is the primary consideration in sizing the bearing. The ability of the bearing to accept these loads is known as the static capacity and is listed in DN 6F2 for each size of airframe bearing. Sub-Notes 1(1) and 1(2) compare various rolling element bearings based on static capacity and outside diameter. Bushings can be sized by determining the projected area and from this (Eq 1) the unit loading (Eq 2):

$$\text{Projected area, in}^2 = \text{diameter} \times \text{length} \qquad \text{(Eq 1)}$$

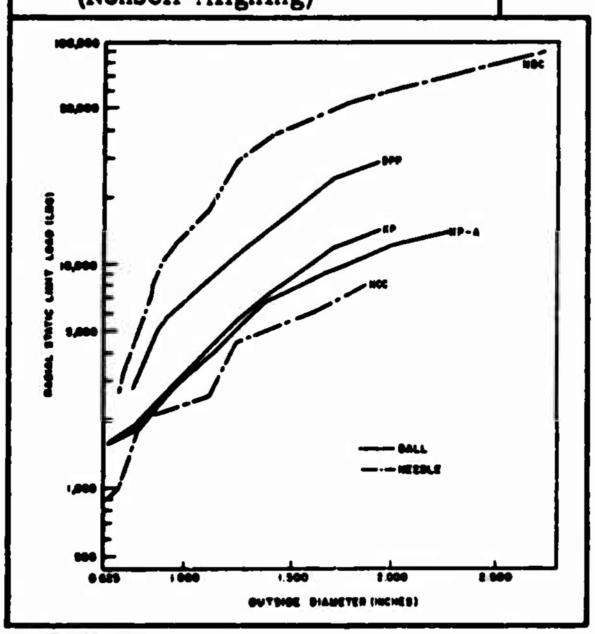
Due to shaft bending in large length-to-diameter ratio bushings, only a portion of the shaft will be in contact with the bearing surface. Therefore, in computing the effective projected area, the length used in computation should not exceed the bushing diameter even though (in actuality) the length of the bushing may exceed the diameter.

$$\text{Unit load, psi} = \frac{\text{total load on bushing, lb}}{\text{projected area, in}^2} \qquad \text{(Eq 2)}$$

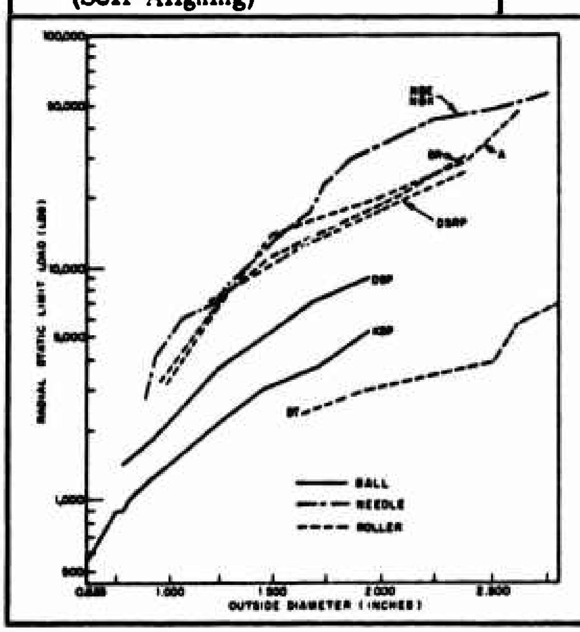
The unit loading should not exceed the static capacity ratings of the various bushing materials shown in DN 6B4, SN 1.1(1). A slightly different method of calculating the effective projected area of TFE bushings is used in MS21240 and MS21241 (see DN 6F2, SN 6(5) and SN 6(6).

Comment: Static capacity curves should be in distributional form for design for reliability.

SUB-NOTE 1(1) Static Capacity of Rolling Element Bearings (Nonself-Aligning)



SUB-NOTE 1(2) Static Capacity of Rolling Element Bearings (Self-Aligning)



2. DYNAMIC CAPACITY

After a tentative selection has been made on the basis of static capacity, the size selected must be reviewed to determine if it has adequate life for the rotation or oscillation desired. If loads are primarily radial, they can be used directly in the life versus load curves shown for rolling element bearings. If an appreciable thrust component is present, in addition to the radial load, an equivalent radial load must be calculated, using the method outlined in DN 6B1. Methods are also given for calculating the average load if the dynamic load varies appreciably during the life of the bearing. Bushings selected on the basis of static load limits, if used in dynamic applications, must also be reviewed to be sure that the desired wear rate is compatible with the unit loading on the bushing. If the wear rate is too high, the unit loading on the bearing must be reduced by making the projected area of the bushing larger. The length-to-diameter ratio of the bushing should not exceed 2:1 if excessive edge loading of the bushing due to shaft bending is to be avoided. Unit load-life curves are available for bronze bushings and TFE-lined bushings (see DN 6F2, Para 6). No standard load-life relationships have been developed for dry film-lubricated bearings, due to the large variation in life that can occur because of differences in application and dry films used.

DESIGN NOTE 6A3 HIGH TEMPERATURE CONSIDERATIONS

1. MATERIAL SELECTION

Standard bearings made of E52100 and 4130 steels begin to lose their hardness when temperatures over 350°F are encountered for periods of time exceeding one hour (see DN 6D1). Therefore, it may be necessary for the design engineer to use a bearing employing other than standard materials. In this case, a bearing specialist should be consulted, if possible. However, if it is necessary for the design engineer to specify a high temperature bearing, the following guidelines should be followed:

a. Bearings of high temperature metallic materials can be constructed using standard MS configurations and dimensions.

b. Rolling element and plain bearings of 440C steel are available from manufacturers. When lubricated with high temperature greases and dry film lubricants these bearings can be used to approximately 600°F.

c. When bearings with higher temperature capabilities than 600°F are desired, consult the list of high temperature materials in DN 6D1. In addition, a number of high temperature bearings are illustrated in DN 6F1 together with performance data. Bearings similar to these high temperature designs can be selected using the same ND^2 (where N = no. of balls and D = ball diameter) values or unit loads to obtain a life similar to that of the bearings shown.

2. LOADS

The values obtained in load spectrum tests can be used as the basis for static limit loads. A value of 75% of the average failure load obtained in dynamic load spectrum tests is generally a safe limit load.

However, safe limit loads should be selected for a target reliability utilizing the failure governing strength and stress distributions respectively.

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Design Note 6B1, Ball Bearings

1. STATIC CAPACITY

The static limit load ratings, given on the pages accompanying each MS series bearings, represent the standards adopted by the Anti-Friction Bearing Manufacturers' Association (AFBMA) (see Ref 26) and the military services. The radial static limit load (SL_r) ratings for ball bearings are based on the formula:

$$SL_r = K \times N \times D^2 \qquad \text{(Eq 1)}$$

where

K = design factor
N = number of balls
D = ball diameter, in.

Allowable "K" factors are 10,000 for deep groove bearings, 4800 for single-row self-aligning bearings, 3800 for double-row self-aligning bearings, and 3200 for rod-end bearings. The static limit load can be applied to the bearing for a short period of time without affecting the smooth operation or endurance under the normal loads and oscillatory motion encountered in airframe applications. The minimum static fracture load (where an actual breakage of the bearing occurs) is not less than 1.5 times the static limit load and may be three to four times this value. Axial static capacity varies from approximately 50 to 60% of radial capacity for nonself-aligning ball bearings and 13 to 20% for self-aligning types. Both axial and static capacities can be found in the data following the MS series of bearings in Sect 6F.

Comment: Static capacities should be presented in statistical distribution form indicating parameters and values.

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DESIGN NOTE 6B1 — BALL BEARINGS

2. DYNAMIC CAPACITY

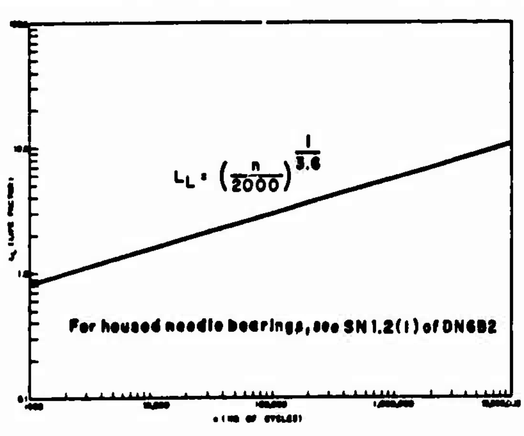
The basic dynamic capacity of an airframe bearing is the constant radial load at which 10% of the bearings tested will fail through fatigue of the ball or race material within 2000 cycles. A cycle is defined as either one slow rotation (<100 rpm) or as a 90° rotation from a fixed point and return. However, any degree of oscillation, more than the angular ball spacing of the bearing, can be considered one oscillatory cycle. If a bearing life of more than 2000 cycles is desired, the constant radial load must be reduced to values below the basic dynamic capacity. The dynamic capacity of an airframe ball bearing at other than 2000 cycles can be obtained from the equation:

$$DL = \frac{C}{L_L} \qquad \text{(Eq 2)}$$

where

DL = the dynamic capacity desired
C = basic dynamic capacity from data sheets accompanying each MS series of bearings
L_L = life factor from SN 2(1)

SUB-NOTE 2(1) Life Factors for Rolling Element Bearings



The basic dynamic capacity is based on the inner race moving and the outer race stationary. If the inner race is stationary and the outer race is moving, the dynamic capacity should be divided by 1.20. Load-life curves for MS bearings have been computed using the formula in Eq 2 and can be found after the basic sheet describing each series of MS bearings in Sect 6F. However, the fatigue load-life data given in conjunction with the MS series of standard bearings is invalid under the following conditions:

a. Where airframe bearings are rotated over 100 rpm

b. Where angles of oscillation, smaller than the angle of ball spacing are being imposed on the bearing.

However, safe limit loads should be selected for a target reliability utilizing the failure governing strength and stress distributions respectively.

3. EQUIVALENT RADIAL LOAD

It is sometimes desired to determine the equivalent radial load experienced by a bearing operating for various portions of life at various loads. The equivalent radial load (P_r) is equal to:

$$P_r = \left[\sum f(F_r)^{3.6}\right]^{1/3.6} \quad \text{(Eq3)}$$

where

P_r = equivalent radial load, lb

f = fraction of time spent at F_r condition

F_r = radial load, lb.

As an example, a bearing has a load of 1900 lb applied for 5% of the time, 1200 lb applied for 40% of the time, and 700 lb for 55% of the time. The equivalent load on the bearing is:

$$P_r = \left[0.05(1900)^{3.6} + 0.40(1200)^{3.6} + 0.55(700)^{3.6}\right]^{1/3.6} = 1100 \text{ lb.}$$

The equivalent radial load is used in connection with the load-life curves following the MS series of bearing. In no case should the radial loads exceed the radial limit load value of the bearing.

Comment: Source of equation should be stated; prefer accumulative damage-type equation.

4. MOMENT LOADING

In some cases a moment or overturning load is present in an airframe bearing application. This moment loading should not exceed the limit moment rating given for each nonself-aligning bearing in the MS series. Self-aligning bearings are not designed to carry any moment loading.

5. COMBINED LOADING

An airframe bearing may be subjected to radial, axial, and moment loading at the same time. It is then necessary to calculate the equivalent thrust load and to determine the proper size bearing by a comparison of the calculated equivalent load and the limit thrust loads (found on the data sheets in Sect 6F). The equivalent thrust load (P_a) is calculated from the formula:

$$P_a = \frac{\text{Thrust Limit Load}}{\text{Radial Limit Load}} \times F_r + F_a + K_M \times M \quad \text{(Eq 4)}$$

where

F_r = radial load, lb

F_a = thrust or axial load, lb

K_M = moment constant (obtained from data following each MS series of bearings)

M = moment, in-lb.

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1. NEEDLE ROLLER BEARINGS

1.1 Aircraft Static Capacity

The Aircraft Static Capacity (ASC) listed in DN 6F2 for the MS series bearings is based on the rolling elements of the bearing only. For properly housed bearings, the ASC corresponds to the ultimate or static fracture load rating. The limit load or working load rating is two-thirds of the ASC. Airframe designers commonly use the terms, "limit load rating" and "ultimate or static fracture load rating." The limit load rating (or working load) can be defined as the maximum radial load which can be applied to a bearing in airframe applications. The ultimate or static fracture load rating is not less than 1.5 times the limit load rating and may be several times greater. The ASC for all needle bearings with the exception of the NCC type is computed from the formula:

$$ASC = 12{,}000 \times L \times D \times (N-3) \qquad \text{(Eq 1)}$$

where

ASC = Aircraft Static Capacity, lb
L = roller contact length, in.
D = roller diameter, in.
N = number of rollers.

The limit load for the NCC series (MS24462) is computed from:

$$SL = 7900 \times L \times D_p \qquad \text{(Eq 2)}$$

where

SL = limit load capacity, lb.
D_p = pitch diameter in inches (distance from roller center to roller center across bearing)
L = roller length in contact with race, in.

Needle bearings are not capable of handling thrust loads.

Comment: Static capacity distribution preferred. The reliability goal associated with load ratings should be defined.

1.2 Dynamic Capacity and Load Life

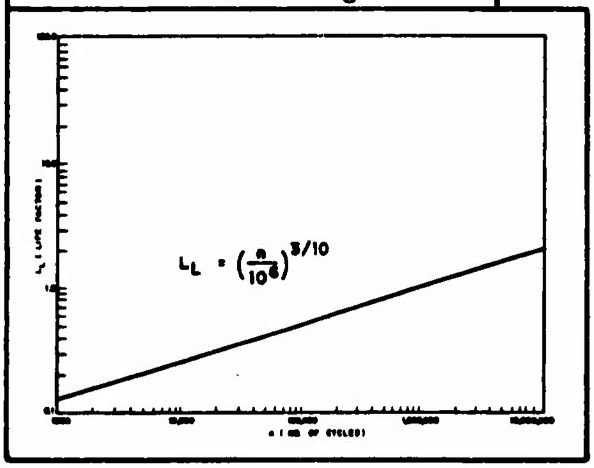
The life of the bearing (when failure is due to fatigue) can be determined from the basic dynamic capacity and the life factor relationship shown in SN 1.2(1). The maximum load for any life can be determined by the relationship:

$$DL = \frac{C}{L_L} \qquad \text{(Eq 3)}$$

where

DL = maximum load (for given life)
C = basic dynamic capacity from the graphs in DN 6F2
L_L = life factor from SN 1.2(1).

SUB-NOTE 1.2(1) Life Factors for Housed Needle Roller Bearings



Comment: Distributional Dynamic Capacity curves preferred for reliability design.

1.3 Equivalent Radial Load

It is sometimes desired to determine the equivalent radial load experienced by a bearing operating for various portions of life at various loads. The equivalent load is equal to:

$$P_r = \left[\sum f(F_r)^{10/3}\right]^{3/10} \qquad \text{(Eq 4)}$$

where

P_r = equivalent radial load, lb
f = fraction of time spent at F_r condition
F_r = radial load, lb

The equivalent radial load is used in connection with the load life curves following the MS series of bearing. In no case should the radial loads exceed the indicated limit load (working load) value of the bearing.

Comment: Prefer cumulative damage curves.

2. TRACK ROLLERS

2.1 Static Capacity

Certain needle bearings are fitted with thick chrome-plated outer races and are designed to be used as track rollers. Because the outer race is unsupported by a housing, the static capacity of the bearing as a track roller is considerably less than the same needle roller unit used as a bearing with a supported outer race. The track roller capacities of the MS24465, MS24466 and NAS 562 series are given in Sub-Notes 3(5), 3(6), and 3(7) in DN 6F2. Another factor in the use of track rollers is the capacity of the supporting track to resist indentation by the track roller. The load on the roller that the track can support (a 180,000 psi UTS, R_c = 40 track) is considerably less than the capacity of the needle bearing as a track roller. When using a 180,000 psi (or less) tensile sheet track, the track capacity, given on the MS or NAS562 data sheets, is the determining static capacity factor rather than any characteristic of the bearing. The track capacity can be increased by hardening the track or conversely if the track is made of aluminum or steel softer than R_c = 40 the capacity will be reduced. The relationship between track hardness and capacity is shown in SN 2.1(1).

2.2 Dynamic Capacity

The dynamic capacity (load-carrying ability while rotating) versus life relationship is shown in DN 6F2 on the graphs for the MS24465 bearings, for the MS24466 bearings, and for the NAS562 cam followers. Use these graphs to determine the load life relationship. A limiting value is shown on the load life graph.

Comment: Dynamic capacity curves preferred in distributional form.

3. CONCAVE AND BARREL ROLLER BEARINGS

3.1 Static Capacity

The radial static capacity of both single- and double-row self-aligning concave and barrel roller bearings is given by the following formula:

$$SL_r = 12{,}000 \times N \times D \times L \times \cos \alpha$$

where

SL_r = radial static capacity, lb
N = number of rollers
D = mean roller diameter, in.
L = roller contact length, in. (area in contact with race, excluding end radii)
α = roller inclination angle to bore axis

The axial static capacity ranges from 30% of the radial static capacity for single-row bearings to a high of 72% for some of the wide series double-row bearings. It is difficult to compute static capacities of self-aligning roller bearings without a thorough

SUB-NOTE 2.1(1) Strength Factors for Tracks of Different Hardness

$T = T_{40} \times F_T$

where

- T = track capacity for a specific bearing, lb
- T_{40} = capacity of R_c = 40 track (standard MS sheets), lb
- F_T = track strength factor from graph

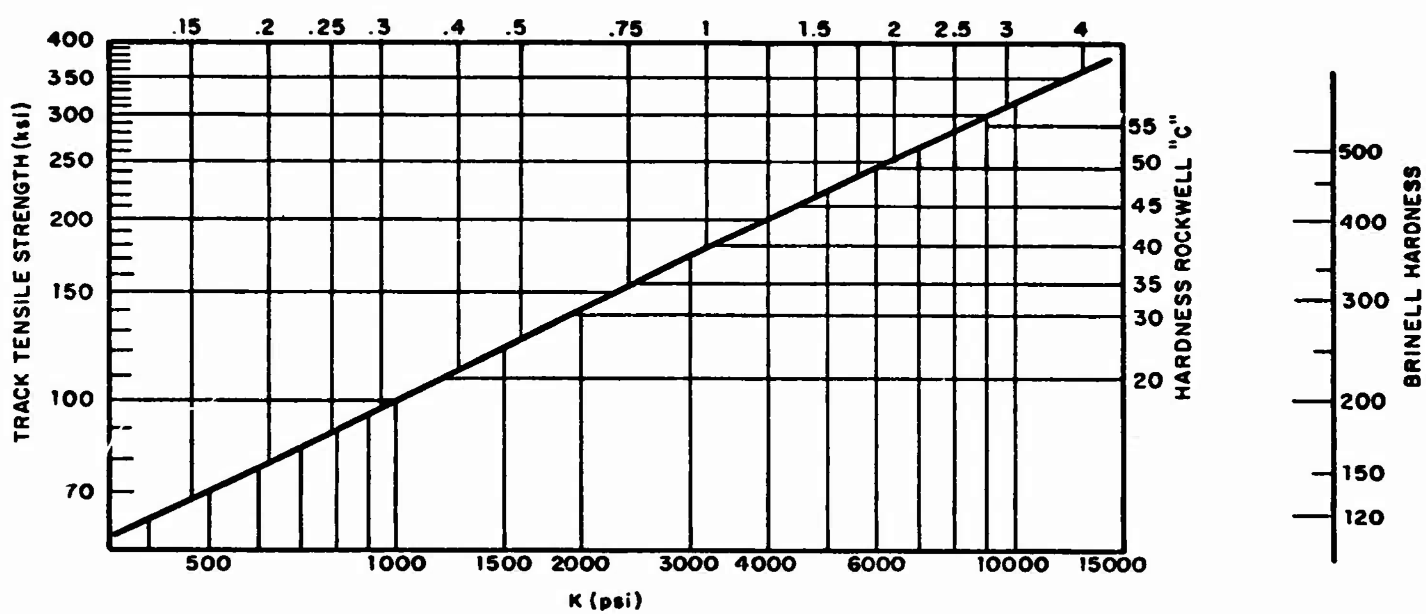
If T_{40} is not known:

$T = D \times L \times K$

where

- T = track capacity for a specific bearing, lb
- D = OD of track roller, in.
- L = contact length of track roller, in.
- K = constant, psi, from graph

TRACK STRENGTH FACTOR (F_T) FOR STEEL TRACKS



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knowledge of the bearing geometry. However, radial and axial static capacities are given in the MS bearing data sheets in DN 6F2, Sub-Notes 4(1) through 4(4). The fracture load is at least 1.5 times the limit load. See Ref 111 for additional information.

Comment: Static capacity needed in distributional form.

3.2 Dynamic Capacity

Load-life relationships follow the equation graphed in DN 6B1, SN 2(1). The dynamic capacity is the B_{10} life at 2000 cycles (shown on the MS bearing sheets in DN 6F2, Sub-Notes 4(1) through 4(4).

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1. TFE-LINED SPHERICAL BEARINGS

1.1 Loads

Axial and limit static load values are given in DN 6F2, Sub-Notes 5(1) through 5(4). Qualification loads are defined in MIL-B-81820 as follows:

a. The radial static limit load is that load (when applied for two minutes to the bearing) which will not cause a permanent set of more than 0.003 in.

b. The axial static limit load is that load (when applied for two minutes to the bearing) which will not cause a permanent set of more than .005 inch.

c. The ultimate load (sometimes called the fracture load) occurs when a load 1.5 times the limit load, radial or axial, is applied to the bearing without resulting in ball or race fracture or ball push-out.

Comment: Limit load should be defined in terms of reliability.

1.2 Load-Life Relationships

Load-life relationships of TFE-lined plain spherical bearings are not as well characterized as those of rolling element bearings. The normal mechanism of failure of TFE-lined bearings is a gradual wearing out of the TFE lining. This wear is more rapid when movement is first started and gradually decreases in rate until very low values are reached near the end of the bearing life. A maximum wear of .0045 inch has been selected for rating TFE-lined spherical bearings. Qualification tests described in MIL-B-81820 are based on this figure. Bearings qualified under this specification must pass an oscillation load test of 25,000 cycles (±25°, 10 cpm) at loads listed in the MS specifications. These oscillating load test values can be found in DN 6F2, Sub-Notes 5(1) through 5(4). To determine the life of a TFE-lined bearing under all conditions found in aerospace applications, consider the following factors:

a. Load

b. Angle of oscillation

c. Projected area of race on ball (bearing size)

d. Speed of oscillation

e. Temperature

f. Contamination with hydraulic and deicing fluids.

Because of the numerous factors involved in the prediction of bearing life, no comprehensive methods of calculation are available that are applicable to all makes of bearings and that take into account the temperature of the application. Some manufacturers of spherical bearings have developed methods for calculating life under various conditions. These methods can be found in the manufacturers' literature.

Comment: S-N or L-N curves, distributional form, needed.

1.3 Unit Load

The unit load (psi) is a convenient method of comparing the load on spherical bearings of different sizes. The unit load is based on the projected area of either the bore or the outer race on the ball, depending on the location where movement is taking place.

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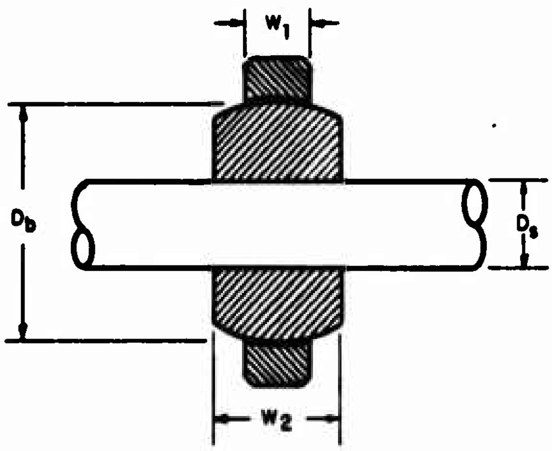
For a given load, L, the unit loading is determined as follows:

$$\text{Unit Load on bore, psi} = \frac{\text{Load, lb}}{W_2 \times D_s} \quad \text{(Eq 1)}$$

$$\text{Unit Load on ball, psi} = \frac{\text{Load, lb}}{W_1 \times D_b} \quad \text{(Eq 2)}$$



1.4 Limiting Speeds

While most TFE-lined spherical bearings are used for low speed oscillation or rotation, an occasional high speed application is encountered where the ability of the bearing to dissipate frictional heat is in doubt.

2. GREASE AND DRY FILM-LUBRICATED SPHERICAL BEARINGS

2.1 Loads

The nondeformation load is defined as that which when applied to the bearing will not cause enough set or deformation so that the bearing is difficult to turn. The ultimate (fracture) load is double the nondeformation load and must not cause fracture of the bearing. In addition, the permanent set after application of the ultimate load is limited. Nondeformation and ultimate loads and maximum permanent sets are shown on MS21154 and MS21155 bearing sheets in DN 6F2.

Comment: Need distribution.

2.2 Load-Life Relationships

Dry film-lubricated bearings of MS21154 and MS21155 configurations have variable lives due to the difficulty of applying the dry films uniformly to the rubbing areas of the bearing. Dry film-lubricated bearings have a high dynamic load capacity, up to 50,000 psi, but an unpredictable wear life when compared to grease lubricated or TFE-lined bearings. Load-life relationships of several spherical bearings lubricated with various high temperature dry films can be found in DN 6F1.

Comment: Need distribution.

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1. GREASE-LUBRICATED METAL BUSHINGS

1.1 Static Capacity

Steel bushings are used primarily to handle static loads and can be loaded to values that are approximately one-half of the compressive yield strength of the material. Sub-Note 1.1(1) shows the suggested allowable yield strengths for various types of bushing materials. The projected area of the bushing (length times diameter) should be used with the total load to calculate the unit load which should not exceed the values in SN 1.1(1).

Comment: Allowances loads should be based on distributions and reliability goods.

SUB-NOTE 1.1(1) Static Capacity of Bushings

MATERIAL	MAXIMUM STATIC CAPACITY, KSI	MAXIMUM TEMPERATURE* (°F)
4130 Steel (180 KSI UTS)	115	350
17-4 Steel (AMS 5643)	90	500
Beryllium Copper (Fed Spec QQ-C-530)	90	350
Al-Ni-Bronze (AMS 4640 and 4880)	60	350
Al-Bronze (Fed Spec QQ-C-465)	60	350

*Maximum temperature at which bushing can be used without loss of static capacity.

1.2 Load-Life Values

Although steel bushings (if generously lubricated) can be used for a few cycles without galling or excessive wear taking place, bronze bushings should be employed if an appreciable amount of motion is expected between the shaft and the bushing. Under dynamic conditions, excessive wear of the bronze bushing is the mode of failure. Sub-Note 1.2(1) is a plot of life versus unit load under well-lubricated (MIL-G-81322 grease) conditions.

Comment: Distributional L-N curve required.

2. TFE-LINED BUSHINGS

2.1 Static Capacity

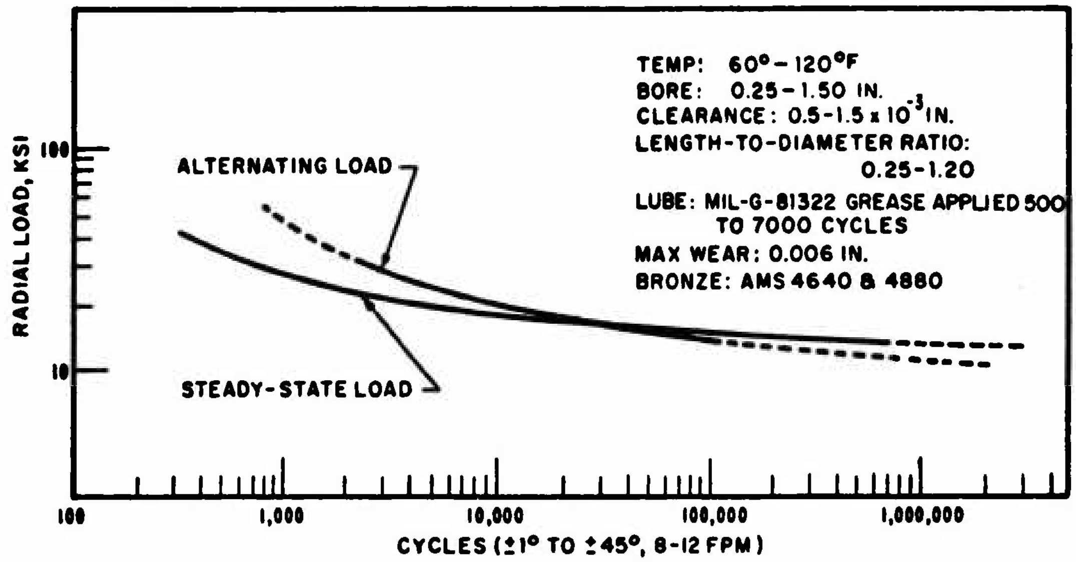
The unit static capacity of TFE-lined bushings is approximately 60,000 psi. A unit load of this magnitude can be tolerated by the bushing without impairing its functioning.

Comment: 100 percent distribution required.

2.2 Dynamic Capacity and Load Life

A nomograph can be found in DN 6F2, SN 6(5) or 6(6), describing straight and flanged TFE bushings (MS21240 and MS21241) that relates life (before 0.005 in. wear occurs), load, angle of oscillation, and projected area of the bushing. Elevated temperatures, surface speeds in excess of 150 ft/min on the bore surface, and contamination by hydraulic oils and de-icing fluids all lower the predicted life. The dynamic unit-load rating (25,000 psi) shown is a unit load that will permit more than 25,000 cycles of life (0.006 in. wear) ±25° oscillation at ten cycles per minute.

SUB-NOTE 1.2(1) Load Life of Plain Bronze Bushings



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DESIGN NOTE 6D2 ROLLING ELEMENT MATERIALS

1. COMPOSITION

Sub-Note 1(1) shows the material composition of alloys used in airframe bearings (races and rolling elements).

2. MECHANICAL AND PHYSICAL PROPERTIES

Sub-Note 2(1) lists some of the mechanical and physical properties of alloys used in airframe bearings. The symbols in the chart are defined as follows:

- E = modulus of elasticity, psi x 10^6
- F_c = compressive strength, ksi
- F_t = tensile strength, ksi
- B_H = Brinell hardness
- R_c = Rockwell hardness
- α = coefficient of thermal expansion, in/in/°F x 10^{-6}
- ϵ = percent elongation in 2 in.
- μ = Poisson's ratio
- ρ = density, lb/in^3

For additional information see Ref 587.

SUB-NOTE 1(1) Material Composition of Bearing Alloys

MATERIAL	C	Co	Cr	Fe	Mn	Mo	Ni	P	S	Si	V	W	OTHER
E51100 steel	0.98 - 1.10		0.90 - 1.15		0.25 - 0.45			0.025 MAX	0.025 MAX	0.20 - 0.35			
E52100 steel	0.98 - 1.10		1.30 - 1.60		0.25 - 0.45			0.025 MAX	0.025 MAX	0.20 - 0.35			
440C stainless	0.95 - 1.20		16.0 - 18.0		1.0 MAX	0.75 MAX		0.040 MAX	1.0 MAX	1.0 MAX			
M-2 tool steel	0.85		4.0		0.30					0.30	2.0	6.0	
M-50 tool steel	0.80		4.1		0.30	4.25				0.25	1.1		
Stellite 25	0.05 - 0.15	Bal	19.0 - 21.0	3.0 MAX	1.0 - 2.0		9.0 - 11.0			1.0 MAX		14.0 - 16.0	
Stellite 3	2.45	Bal	30.5	3.0	1.0		3.0			1.0		12.5	1.0
Stellite 6B	1.1	Bal	30.0	3.0	2.0	1.5	3.0			2.0		4.5	
Stellite 19	1.7	Bal	31.0	3.0	1.0		3.0			1.0		10.5	2.0
Stellite Star J	2.5	Bal	32.0	3.0	1.0		2.5			1.0		17.0	2.0
Titanium carbide	Titanium carbide (TiC), grains bonded with Ni-Mo binder												
Alumina	99.9% pure alpha alumina (Al_2O_3), polycrystalline												
Zirconia	ZrO_2 stabilized with small amounts of refractory oxides												

SUB-NOTE 2(1) Mechanical and Physical Properties of Bearing Alloys

MATERIAL	E	F_c	F_t	R_c	α	ϵ	μ	ρ
E51100 steel	30.0	400	250	60–63	6.0		0.33	
E52100 steel	30.0	400	250	58–63	6.0		0.33	
440C stainless	29.5	350	285	60.0	5.6	2.0	0.33	0.280
M-2 tool steel	29.5			65.5	6.6	2.5	0.33	
M-50 tool steel	29.5			62.0	7.4		0.33	
Stellite 25	33.0		150–240	45–55	8.24	6–10	0.25	0.330
Stellite 3	36.1	310	55	55.0	7.8	0–1.0		0.312
Stellite 6B	31.1	347	91.6	39.0	8.5	11.0		0.303
Stellite 19	33.8	310	105	52.0	7.9	0–1.0		0.302
Stellite Star J	37.5	335	62	58.0	7.0	0–1.0		0.316
Titanium carbide	59.0	520		89.0 (1)	4.6		0.236	0.217
Alumina	56.1			85.0 (1)	4.35		0.205	0.144
Zirconia	22.0	88		88.0 (1)	2.60 (2)			0.202

Notes: (1) These values are Rockwell "A" scale hardness.
(2) Erratic expansion due to phase changes.

Comment: Present properties in terms of statistical parameters.

3. CORROSION RESISTANCE

Sub-Note 3(1) shows the corrosion resistance of the alloys to the common liquids encountered by airframe bearings.

4. CAGE MATERIALS

Many airframe bearings contain a full complement of rollers or balls to obtain the maximum load capacity. However, certain bearing types do require cages for roller guidance or to reduce internal friction. When cages are used, the materials from which they are made need to have the qualities of moderate to high tensile and compressive strength, toughness, and must be compatible from a friction standpoint with the rolling element. High temperature materials used for bearing cages are Rene' 41, A-286, and Inconel X-750 (see DN 6D3).

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SUB-NOTE 3(1) Corrosion Resistance of Bearing Alloys

MATERIAL	WATER	SALT WATER	MILD ACID	MILD ALKALI
E51100 steel	Poor	Poor	Poor	Fair
E52100 steel	Poor	Poor	Poor	Fair
440C stainless	Good	Fair-Poor	Good	Good
M-2 tool steel	Poor	Poor	Fair	Good
M-50 tool steel	Poor	Poor	Fair	Good
Stellite 25	Excellent	Excellent	Excellent	Excellent
Stellite 3	Excellent	Excellent	Excellent	Excellent
Stellite 6B	Excellent	Excellent	Excellent	Excellent
Stellite 19	Excellent	Excellent	Excellent	Excellent
Stellite Star J	Excellent	Excellent	Excellent	Excellent
Titanium carbide	Good	Good	Good	Good
Alumina	Good	Good	Good	Good
Zirconia	Good	Good	Good	Good

DESIGN NOTE 6D3 PLAIN BEARING MATERIALS

1. SELECTION

A variety of materials can be used for plain bearings. Unit loads are low compared to the very high contact stresses encountered in rolling element bearings. Most high temperature alloys, steels and some bronzes have sufficient strength for plain bearing use. Materials for plain bearing use should have sufficient impact resistance to withstand the rapidly applied loads that may occur. One of the most important considerations in a sliding surface bearing is the frictional compatibility of the rubbing surfaces. For low temperature applications, compatible metals like bronze and steel can be used, and oil or grease lubricants are generally employed. At higher operating temperatures, stainless alloys of poor frictional and galling characteristics must be used, and the selection and maintenance of a lubricating film on the rubbing surface is of great importance.

1.1 Plastics and Porous Materials

The plastics used in bearings are nylon (2% water), Delrin, and filled Teflon (TFE). The Teflon properties refer to a solid section and not the thin woven linings used in spherical and plain bearings. The woven linings have a much higher compressive strength due to support from the bearing shell. The major uses for the plastics and porous materials are shown in SN 1.1(1) along with the installation methods.

2. COMPOSITION

Sub-Note 2(1) shows the material compositions of alloys used in plain bearings.

3. MECHANICAL AND PHYSICAL PROPERTIES

Mechanical and physical properties can be found in SN 3(1) for alloys and in SN 3(2) for plastics and porous materials. The symbols in the charts are defined as follows:

- E = modulus of elasticity, psi x 10^6
- F_b = flexural strength, ksi
- F_c = compressive strength, ksi
- F_t = tensile strength, ksi
- k = thermal conductivity, BTU/hr/ft^2/°F/ft
- T_A = operating temperature range in air, °F
- T_V = operating temperature range in a non-oxidizing atmosphere, an inert gas, or in a vacuum
- v = maximum surface speed, ft/min
- α = coefficient of thermal expansion, in/in/°F x 10^{-6}
- μ = coefficient of friction
- ρ = density, lb/ft^3

4. CORROSION RESISTANCE

Sub-Note 4(1) shows the corrosion resistance of the alloys to the common liquids encountered by airframe bearings. The corrosion resistance of plastics and porous materials is shown in SN 4(2).

SUB-NOTE 1.1(1) Uses and Installation Methods

MATERIAL	MAJOR USE	PRESS FIT	BOND	BRAZE
Filled Teflon	Plain bearings, slides, cages for rolling element bearings	Yes	No	No
Nylon	Gears, plain bearings, slides, cams, cages for lightly loaded bearings	Yes	Yes	No
Delrin	Gears, plain bearings, slides, rolling element bearing cages	Yes	Yes	No
Carbon-graphite	Dynamic seals, sleeve bearings, sliding electrical contacts	Yes	Yes	Yes
Impregnated sintered bronze	Self-lubricating plain bearings, rolling element bearing cages	Yes	Yes	Yes

SUB-NOTE 2(1) Material Composition of Plain Bearing Alloys

MATERIAL	Al	C	Cr	Cu	Fe	Mn	Mo	Ni	P	S	Si	OTHER
Bronze (AMS 4640)	10.25			81.0	2.75	1.0		5.0				
17-4PH stainless		0.07 Max	15.5 - 17.5		Bal	1.0 Max		3.0 - 5.0	0.040 Max	0.03 Max	1.0 Max	
17-7PH stainless	Bal	0.09 Max	16.0 - 18.0		Bal	1.0 Max		6.5 - 7.75	0.040 Max	0.03 Max	-	
410 stainless	Bal	0.15 Max	11.5 - 13.0		Bal	1.0 Max			0.040 Max	0.03 Max	0.5 Max	
René 41		0.06 - 12.0	18.0 - 20.0			0.5 Max	9.0 - 10.5	Bal			0.5 Max	Al, B, Co, Fe, Ti
A-286		0.08 Max	13.5 - 16.0			1.0 - 2.0	1.0 - 1.75	24.0 - 27.0			0.4 - 1.0	Al, B, Fe, Ti, V
Inconel X-750		0.08 Max	14.0 - 17.0			1.0 Max		70.0			0.5 Max	Al, Cb, Fe, Ti
LT-2 metal ceramic	15% Al_2O_3, 25% Cr, 60% W											

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SUB-NOTE 3(1) Mechanical and Physical Properties of Plain Bearing Alloys

MATERIAL	E	F_c	F_t	R_c	B_H	α	ϵ	ρ
Bronze (AMS 4640)	17.5		110.0		187 - 241		15.0	0.273
17-4PH stainless	29.0	170	190	40 - 47		6.5	10.0	0.282
17-7PH stainless	28.0	180	200	44		5.7	7.0	0.282
410 stainless	30.0		110		20	7.5	23.0	0.280
René 41	30.0	145	180 - 191	39 - 41		7.8	14.0	0.298
A-286	29.0	100	145	34		9.9	24.0	0.298
Inconel X-750	31.0	100	170	36.5		8.5	25.0	0.298
LT-2 metal ceramic	38.0			52.0		4.6		0.320

Comment: Present properties in terms of statistical parameters.

SUB-NOTE 3(2) Mechanical and Physical Properties of Plastics and Porous Materials

MATERIAL	E	F_b	F_c	F_t	k	T_A	T_V	V	α	μ	ρ
Teflon	14	9.0	20.0	2.7	2.3	-320 to 550	-320 to 550	70	33	0.05 - 0.24	0.0814
Nylon	15	13.3	35.0	4.5	1.9	-320 to 250	-320 to 200	Low	82	0.15 - 0.33	0.394
Delrin	-	-	-	-	1.6	-320 to 250	-320 to 200	Med	45	0.10 - 0.30	0.0515
Carbon-graphite	15	28.0	175.0	8.4	18.0	-420 to 1000	-420 to 3000	12,000	3.5	0.07 - 0.60	0.0543
Impregnated Sintered Bronze	14	13.5	27.8	4.5	-	-65 to 200	Oil evaporates in vacuum	200	10.5	0.02 - 0.30	0.242

Comment: Present properties in terms of statistical parameters.

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SUB-NOTE 4(1) Corrosion Resistance of Plain Bearing Alloys

MATERIAL	WATER	SALT WATER	MILD ACID	MILD ALKALI
Bronze (AMS 4640)	Good	Good	Fair	Fair
17-4PH stainless	Excellent	Good	Good	Good
17-7PH stainless	Excellent	Good	Good	Good
410 stainless	Good	Poor	Fair	Fair
René 41	Excellent	Good	Good	Good
A-286	Excellent	Good	Good	Good
Inconel X-750	Excellent	Good	Good	Good
LT-2 metal ceramic	Excellent	Excellent	Excellent	Excellent

SUB-NOTE 4(2) Corrosion Resistance of Plastics and Porous Materials

Teflon	Inert except in perfluorinated liquids above 570°F
Nylon	Good except to strong acids and oxidizing agents
Delrin	Good resistance to organic solvents, oils, and moisture. Poor to acids, caustics, and bleaches.
Carbon-graphite	Excellent except to strong oxidizers
Impregnated sintered bronze	Resistant to salt water. Poor resistance to concentrated acids and bases.

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1. TYPES OF LUBRICANTS

Depending on their use, materials of construction, and environment, bearings may require various lubricants, or they may operate unlubricated. Where temperature permits, lubricants are used to reduce friction and wear of the bearing. In addition, lubricants are often required for cooling, corrosion protection, sealing, lubrication of seals, and flushing out debris formed by friction and wear. Lubrication for airframe bearings may be accomplished with grease, oil, dry film lubricants, or plastic linings. The advantages of each type are shown in SN 1(1).

MIL-HDBK-275 presents a more comprehensive selection of lubricants.

2. LUBRICATORS

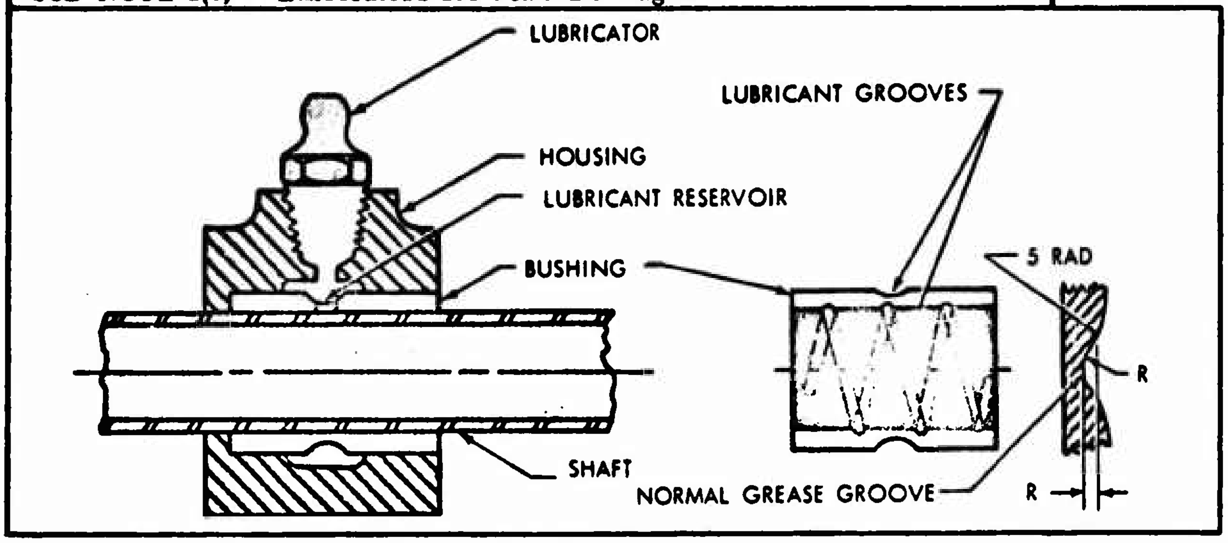
Provide lubricators and lubrication reservoirs for all types of plain annular and plain self-aligning bearing installations. Where plain bearings are used at the connection of structural members having a relative motion exceeding 3° during service operation, install lubricators in the portions surrounding the bolt or shaft as shown in SN 2(1) and 2(2). Include instructions as the proper MIL specification lubricant and relubricating periods in the maintenance manual of the aircraft or accessory in which the bearing is used. Use lubricators in accordance with those shown in MIL-F-3541, MS15001, -1 and -3 of MS15002, and MS15004. For coupling and uncoupling the grease gun connector, allow clearance space of 25° in any radial direction from the axis, normal to the head of the lubricator fitting (ABC 17/8B, Grease Nipples). This requires a cone of clearance with an included vertex angle of 50° and a slant side as long as the overall length of the grease gun, when the axes of the grease outlet head and the body of the grease gun coincide. Plain bearings fabricated of oil-impregnated sintered metal, bronze, or iron in accordance with MIL-B-5687 need not be provided with lubricators if they will not be expected to maintain lubricity beyond the physical-chemical life of the lubricant with which they are impregnated. In applications in which the amount of lubricant contained in the bearing is not sufficient to last for the service life required, provide lubricators or lubricant reservoirs that will contact outer surface of the sintered bearing.

Comment: What is the physical-chemical life distribution. This should be defined and statistical parameters published.

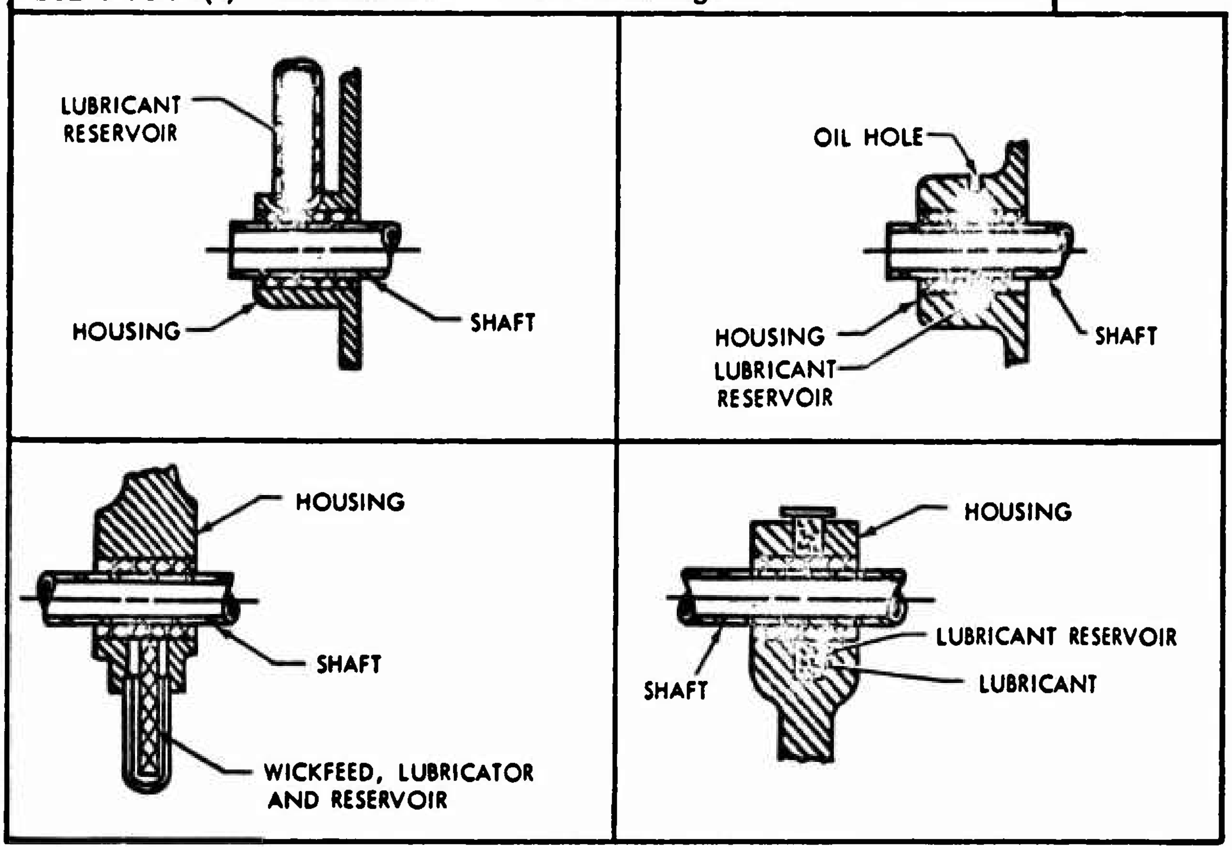
SUB-NOTE 1(1) Selection Chart for Lubricants (Plain Bearings)

	GREASE	DRY FILM LUBRICANT	TFE-LINED BEARING
TEMPERATURE RANGE, °F	-100 to +600	-100 to +375 Organic binders -320 to +800 Inorganic binders	-320 to +550 TFE-glass fabric types -100 to +275 Military spec materials
BEARING LIFE	Excellent	Poor to fair (Depends on stress level)	Good
LOAD CAPACITY	Good	Excellent	Good
NEED FOR REPLENISHMENT DURING BEARING LIFE	Yes	No	No
CORROSION PREVENTIVE ABILITY	Good	Poor	TFE liner excellent (Bearings made from corrosion resistant metals or plated)

SUB-NOTE 2(1) Lubricators for Plain Bearings



SUB-NOTE 2(2) Lubricators for Sintered Bearings



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DESIGN NOTE 6E2

GREASES

1. CHARACTERISTICS

The majority of rolling element and some sliding surface bearings are grease-lubricated. This type of lubrication has the advantage of sealing simplicity, low torque at normal temperatures, long life, and if proper greases are used, good protection against corrosion. Grease-lubricated rolling element bearings for airframe use normally operate best when packed so that about two-thirds of the capacity of the bearing is filled. Where relubrication is required, the bearings must be filled with grease and some loss of lubricant can be expected due to churning. Bearings which never or seldom oscillate or rotate should be packed full of grease to provide a maximum reservoir for lubricant and to give corrosion protection. Most grease-lubricated airframe rolling element bearings are received from the manufacturer lubricated, sealed, and ready for installation. They have a shelf life of approximately two years. Many prepacked bearings need no relubrication during their service life and are discarded at component overhaul. Design to avoid the necessity of component overhaul for the express purpose of bearing lubrication. All bearings which require relubrication must have devices, such as grease fittings, included in their installation so that application of grease to the bearing can be made without disassembly of the bearing housing or removal of the bearing from the shaft. (See DN 6E1, Para 2.)

1.1 Military Specification Greases

A large number of military specification greases are available that can be used in airframe bearings. Caution must be exercised in the selection of these greases because some of the lubricants are designed primarily for use in lightly loaded high speed ball bearings. They may be inadequate in load-carrying capacity for heavily loaded airframe bearing use. The greases listed in SN 1.1(1) will handle practically all airframe bearing requirements. The preferred grease for airframe bearing use is MIL-G-81322. It has good storage (two years minimum) stability, excellent load-carrying capacity, and good low temperature properties. Greases other than those in MIL-G-81322 are needed only when its high temperature capability has been exceeded (350°F for continuous operation). Other greases are needed when airframe bearings are required to operate in unusual conditions such as high vacuum, lack of lubrication, radiation, and chemicals such as phosphate ester fluids or propellants.

2. GREASE TESTING

Comment: What is the physical-chemical life distribution? This should be defined and statistical parameters published.

2.1 New Grease

A number of laboratory tests are used to evaluate greases. Exercise some care in the use of these values to predict service performance, for these laboratory tests were designed originally as quality control tests for the manufacture of grease. Tests commonly used for the evaluation of grease used for airframe bearing applications are as follows.

2.1.1 Penetration

The penetration test (ASTM D217, Fed Std 791, Method 311) consists of dropping a weighted metal cone into the grease and allowing it to sink for five seconds. The depth of penetration is then measured by means of a penetrometer. An unworked penetration refers to measurements made

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SUB-NOTE 1.1(1) Greases for Airframe Bearings

TYPE OR NAME	SPECIFICATION OR DESIGNATION	OPERATING RANGE, °F	CHARACTERISTICS AND USES	DROP POINT, °F	PENETRATION, WORKED	RUST PROTECTION	COMPOSITION
Grease, Aircraft and Instrument, Gear and Actuator Screw	MIL-G-23827	-100 to 250 (300 short term)	Extreme pressure properties, good water resistance.	325	270-310	Excellent	Lithium soap, ester oil, anti-rust and E.P. agents
Grease, MoS_2 for High and Low Temperatures	MIL-G-21164	-100 to 250	Similar to MIL-G-23827 but has added MoS_2 for extra E.P. properties and antiwear action under marginal lubrication conditions.	325	260-310	Excellent	Same as MIL-G-23827 except 5% MoS_2 added
Grease, Aircraft Helicopter Oscillating Bearing	MIL-G-25537	-65 to 160	Stable grease for rapidly oscillating bearings. (1)	280	265-305	Excellent	Generally soap and petroleum oil
Grease, Aircraft Fuel and Oil Resistant	MIL-G-27617	-30 to 400	Stable grease with resistance to oils, fuels, and LOX. (2)	450	280-340	Poor	Synthetic oil and thickener
Grease, Aircraft, High Speed, Ball and Roller Bearing, 600°F	MIL-G-38277	+25 to 600	High temperature grease. Do not use in preference to other greases unless temperature capability is needed. Should be used in corrosion-resistant high temperature bearings. Fairly water resistant.	650	350-400	Fair	Synthetic oil, nonsoap thickener
Grease, Aircraft, General Purpose, Wide Temperature Range	MIL-G-81322	-65 to 350	High temperature grease for high speed applications. (3)	450	265-320	Excellent	Synthetic oil and thickener
General Electric Versilube Grease	G-300	-100 to 450	Excellent wide temperature grease. Low evaporation rate for use in vacuum application. Good water resistance.	500	270-300	Fair	Chlorinated silicone oil, lithium soap thickener

(1) Not for anti-friction bearings used at high speed or high temperature.

(2) Not recommended for general anti-friction bearing lubrication.

(3) Not to used in lieu of MIL-G-21164 or MIL-G-23549.

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Type or Name	Specification or Designation	Operating Range of	Characteristics And Uses	Drop Point °F	Penetration Worked	Rust Protection	Composition
Grease, Aircraft, Ball and Roller Bearings	MIL-G-25013	-100 to +450	For High Temp. Bearing use where soap-type thickener is not applicable. Not for journal brgs (sliding friction) etc. * DN< $2X10^5$	450	260-330	Fair to Excellent	Liquid Lubricant with gelling agent plus additives to meet specification. (Silicone oil)
Grease, Aircraft, High Speed, Ball and Roller Bearing	MIL-G-38220	-40 to +400	Use in such applications as aircraft actuators, gear boxes *DN< $4.0X10^5$	400	270-340	-	Liquid Lubricant and a non-soap gelling agent

$$*DN = DIA_{(BORE\ MM)} \times RPM$$

Rationale:

(1) Same as for MIL-G-25537 Operating-range above.

(2) Ref: MIL-HDBK-275 Para 1.9(b) limitations. It is suggested that lube may be replaced by MIL-G-25013 or MIL-G-38220.

(3) See MIL-HDBK-275 Para. 1.11(b)

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of the undisturbed grease as it comes from the can. After the grease has been pumped back and forth for double strokes in a mechanical worker, a worked penetration value is determined. Greases employed for airframe bearing use have worked penetrations of from 260 to 340.

2.1.2 Dropping Point

The dropping point (ASTM D566, Fed Std 791, Method 142) of a grease is essentially a melting point run under controlled conditions. In most cases, it defines the top temperature to which the grease should be exposed in service. However, in many cases, greases are unsatisfactory for long-term use at temperatures below their dropping point, due to effects such as bleeding and oxidation.

2.1.3 Bomb Oxidation and Corrosion

The bomb oxidation and corrosion test (ASTM D942 and D1261) consists of subjecting the grease to oxygen at a controlled temperature (210°F) in a bomb. Copper is sometimes added as it acts as a catalyst for grease deterioration. The deterioration of the grease is measured by the drop in oxygen pressure due to its reaction with the grease. This same test is repeated with strips of copper immersed in the grease and after test the strips are examined for corrosion. These tests correlate to some degree with the long-term storage stability of greases. They do not correlate with the dynamic oxidation of a grease that occurs in a high temperature bearing.

2.1.4 Low Temperature Torque

In the low temperature torque test (ASTM D1478, Fed Std 791, Method 334), a 204 bearing is filled with the test grease, soaked at the desired temperature, usually -65° or -100°F, and the breakway and running torques determined. Although the results on the 204 bearings cannot always be extrapolated to other kinds of bearings, especially full complement types, this serves as a useful comparison of the low temperature properties of greases.

2.1.5 Rust Prevention

To test the rust preventive properties of greases (ASTM D1743), clean, tapered roller bearings are lubricated with the test grease under carefully controlled conditions and stored for two weeks at 77°F and 100% relative humidity. The bearings are cleaned, inspected, and rated after this exposure. Corrosion in excess of three small spots is not allowed.

2.1.6 High Temperature Performance

In the high temperature performance test (Fed Std 791, Method 331), a 204 bearing made of either E52100 or M-50 steel is filled with the test grease and run in a standard Pope spindle at 10,000 rpm and a light radial and axial load. The bearing is artificially heated to the desired test temperature, is run the desired length of time, or to failure, as indicated by a temperature rise over the stabilized bearing temperature. Failure in this test is almost always due to grease deterioration caused by oxidation, bleeding, or evaporation of the fluid constituent. This test is used extensively in military specifications for determining the top temperature limit of a grease. Because conditions are so different in a high speed, lightly loaded bearing and a heavily loaded airframe type, service tests should be run at high temperature with an airframe bearing to determine the upper limit of a grease for airframe use in critical applications.

2.2 Used Grease

The following tests are useful in determining the suitability of used grease removed from bearings.

2.2.1 Penetration

Normally, not enough used grease is available for a penetration test using a full-size cone, so a quarter-scale cone must be used. Grease, which is originally in the 260 to 340 range, should not decrease in penetration past 220 due to oil loss or be thinned by mechanical working to a penetration above 400.

2.2.2 Loss of Oil

Oil content should be determined, by a hexane extraction in a Soxhlet apparatus, on both the new and the used grease from the bearing. A loss of more than 40% of the original oil in the grease usually means that the bearing will show wear due to lack of oil.

2.2.3 Neutralization Number

The oil from the Soxhlet extraction in Para 2.2.2 can be subjected to the neutralization number test described in ASTM D974-58T. Neutralization numbers over 1.0 (with petroleum oils and esters) indicate overheating of the grease and oxidation of its oil.

DESIGN NOTE 6E3 OILS

1. APPLICATIONS

With the exception of oil-impregnated sintered metal bearings, oils are not usually employed for airframe bearing lubrication. This is not due to any deficiency in oil lubrication, but to the difficulty of either feeding oils to a bearing or containing them in a housing surrounding an airframe bearing. However, when these application difficulties can be surmounted, oils provide excellent lubrication for airframe bearings. Some of the properties of oils suitable for use are listed in SN 1(1). It is often desirable to lubricate high temperature bearings for one time use in missiles and reentry vehicles with an oil that will protect and lubricate the bearing during storage, installation, and preflight checkout before the high temperature service occurs. Military specification MIL-L-7870 oil will perform these functions and will evaporate without leaving any residue to jam the bearing after it is exposed to temperatures over approximately 450°F. Teflon (TFE) seals can be used to contain the oil before use and will also sublime without leaving a residue at temperatures over 600°F.

2. OILS FOR SINTERED SELF-LUBRICATING BEARINGS

Sintered metal porous bearings are used in lightly loaded airframe bearing applications. After these bearings are machined and degreased, they are immersed in a bath of either MIL-L-6085 or MIL-L-7870 oil, maintained at a temperature of 130° to 140°F for 20 min, removed and cooled to room temperature before insertion into their housing.

SUB-NOTE 1(1) Oils for Airframe Bearings

TYPE OR NAME	SPECIFICATION OR DESIGNATION	USE AND SPECIAL PROPERTIES	FLASH POINT, °F MIN.	USEFUL RANGE, °F	BASE OIL
General Purpose Oil	MIL-L-7870	Low viscosity corrosion preventive oil useful for preservation of bearings used at high temperatures. Oil will evaporate without residue.	265	-65 to 160	Petroleum
Airframe Turbine Engine Oil	MIL-L-7808	Good load carrying capacity, good oxidative stability. Wide distribution and aircraft use.	400	-65 to 250	Diester
Instrument Oil	MIL-L-6085	Very stable oil, low dirt count for small bearings.	365	-65 to 250	Diester
High Temperature Turbine Oil	MIL-L-27502	Good load carrying capacity, excellent oxidative stability.	475	-40 to 500	Ester
Methyl Phenyl Silicone Oil	Dow Corning DC 550	Wide temperature range oil. Good thermal and oxidative stability but poor lubricity. This oil has one of the best high temperature capabilities.	600	-40 to 550	Silicone

DESIGN NOTE 6E4 DRY FILM LUBRICANTS

1. CHARACTERISTICS

Dry film lubricants suitable for use on bearings consist of a thin layer (0.0002-0.0007") of MoS_2, with smaller amounts of other solids, bound to the bearing surface either by organic resins or inorganic binders such as aluminum phosphate, sodium silicate, or other glass compositions. Most dry films must be hardened or cured by heating to between 300° and 1000°F, depending on the binder. Dry film lubricants have good tenacity, a low coefficient of friction (0.05 to 0.25), chemical inertness and excellent resistance to high bearing pressures (up to 90,000 psi on hard substrates). They are useful in the range from -320° to approximately +800°F in air but should be used with caution above 600°F. Dry film lubricants generally used for airframe bearing applications are shown in SN 1(1).

2. USES

The major use of dry film lubricants in bearings is for the lubrication of sliding surface units of the plain bushing or spherical type. On plain bushings, the dry film lubricant is applied to the bore and to the face of the thrust flange if one is present. Dry films are used in the bore in some cases, on the spherical surface of the ball, and on the inside of the outer race when spherical bearings are coated. In some cases, the shaft is also coated because applying dry film to two contacting surfaces increases the wear life up to 300%.

3. PRETREATMENT

3.1 Aluminum

Aluminum bearings should be anodized (MIL-A-8625) if possible, but chemical conversion coatings such as MIL-C-5541 can be used where anodizing is not possible. These pretreatments add corrosion resistance and harden the soft aluminum on the surface so that the dry film can carry more load.

3.2 Low Alloy Steel

Low alloy steel bearings are best treated before application of dry films by applying iron-manganese phosphate coating according to MIL-P-16232, Type M. The phosphate coating adds some corrosion resistance to the steel substrate and enhances the wear resistance of the dry film lubricant. For additional corrosion protection, a nickel or chromium plate can be substituted for the phosphate coating under the dry film lubricant.

3.3 Stainless Steel

Stainless steel or other noncorrodible alloys should be abrasive cleaned to remove oxides and to roughen the surface before dry film lubricants are applied.

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SUB-NOTE 1(1) Dry Film Lubricants for Airframe Bearings

SPECIFICATION	TITLE	LUBRICANT	BINDER	TEMP. RANGE	USE & REMARKS
(1) MIL-H-8937	Lubricant, Solid Film, Heat Cured	MoS_2 and graphite (small percent)	Organic Resins	-65° to 500°F	Good wear life and is used for most bearing applications other than extreme temperature situations.
MIL-L-46010	Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting	MoS_2 (no graphite or powdered metals) and corrosion inhibitors	Organic Resins	-90° to 400°F	(2) Similar to MIL-H-8937 except will provide added corrosion protection to substrate. Must have phosphate coating pretreatment for effective use on steel.
MIL-L-81329	Lubricant, Solid Film, Extreme Environment	MoS_2 + other solid lubricants.	Inorganic binders	-300° to 750°F	(3) To be used in extreme environments, i.e., vacuum, liquid oxygen*, high temperatures. Wear life not as good as resin bonded types.
MIL-L-23398	Lubricant Solid Film Air Drying	MoS_2 + Lubricant and Drying Agent	Organic	-65 to +500°F	Dry solid film lubricant bonds to steel, titanium, aluminum and it's alloys. May be applied by spraying - use adequate ventilation.

*Before using any dry film lubricant in liquid oxygen impact sensitivity should be determined by actual test.

Rationale:

(1) Typing error, should read MIL-L-8937.

(2), (3) 300°F temp may affect some materials, therefore, they require curing at 300°F for one hour. Comment (3) shall not be used with oils or grease.

DESIGN NOTE 6F1 HIGH TEMPERATURE BEARINGS

1. ZONE II BEARINGS

Bearings evaluated and found suitable for this zone (-150° to 1200°F) are as follows:

a. B-542 Torque Tube Ball Bearing (see SN 1(1))

b. Self-Aligning Ball Bearing (see SN 1(2))

c. KP-21B Type Stellite 19 Ball Bearing (see SN 1(3))

d. KP-21B Type Stellite 25 Ball Bearing (see SN 1(4))

e. KP-33-BS Type Ball Bearing (see SN 1(5))

f. Needle Bearing (see SN 1(6))

g. Spherical Bearing (see SN 1(7))

h. Spherical Loader Slot Bearing (see SN 1(8))

i. Metal Compact Plain Bearing (see SN 1(9))

j. Graphite Bushing (see SN 1(10))

k. Flexural Pivots (see SN 1(11)).

1.1 Evaluation of Bearings

High temperature bearings were evaluated in three types of tests: load spectrum, temperature spectrum and life tests. In the load spectrum and temperature spectrum tests, the points on the graphs represent friction at one load point. Where two bearings were tested, two curves are shown on the data sheets. Individual life tests are not generally shown but composite load-life curves have been plotted showing life at a specific temperature and load. Each point, unless otherwise stated, represents the results of one life test. Much of the data shown has come from Ref 79.

1.2 High Temperature Bearing Evaluation

The designer can feel safe in using bearings similar in materials and dimensions to the bearings shown in this DN, providing the operational temperatures and loads do not exceed those shown in the test data. Bearings similar in configuration, but different in dimensions to the test bearings shown, should be limited to the workable ND^2, NDL, or psi values, in addition to the safe test temperatures shown on the high temperature bearing data sheets. Static limit loads of about 75% of the dynamic load spectrum test values can be used for bearings that failed due to high friction. A value of 50% of the dynamic load determined should be used as a static limit load for brittle bearing types that fail by fracture.

2. ZONE III BEARINGS

The bearings shown in this zone (-150° to 2000°F) are included to demonstrate the type of materials and bearing configurations that are needed for ultrahigh temperature operation. Design data should not be taken from these bearings without first running a confirming test program. Bearings shown are:

a. Ceramic Ball Bearing (see SN 2(1))

b. Plain Spherical Bearing (see SN 2(2))

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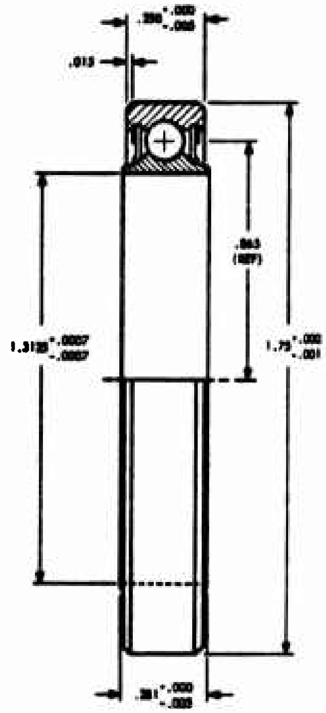
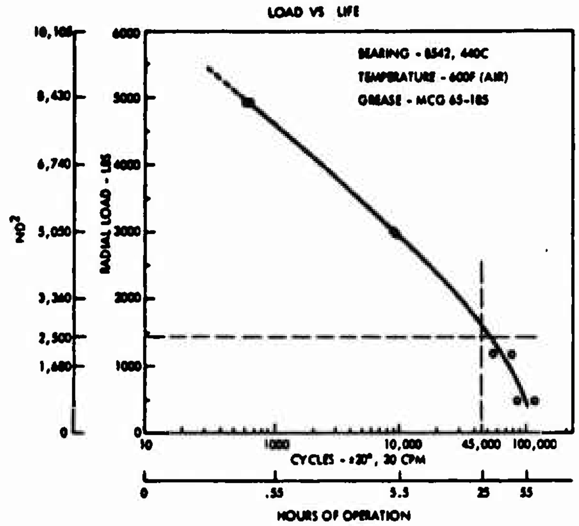
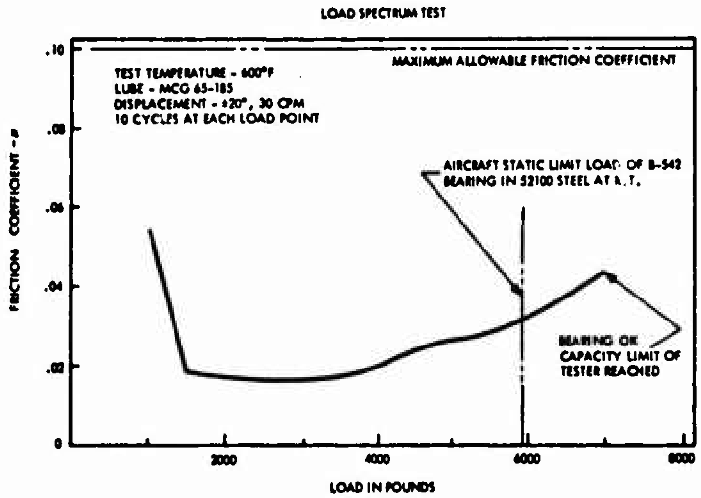
SUB-NOTE 1(1) B-542 Torque Tube Ball Bearing



BALL COMPLEMENT: 38-1/8" DIA
RADIAL CLEARANCE: .001-.0015





MATERIAL: RACEWAYS - AISI 440C STAINLESS STEEL
BALLS - AISI 440C STAINLESS STEEL
SEALS - TEFLON TFE
SNAP RINGS - 300 SERIES STAINLESS STEEL

LOAD RATINGS: RECOMMENDED LIMIT LOAD - 5950 LBS RADIAL

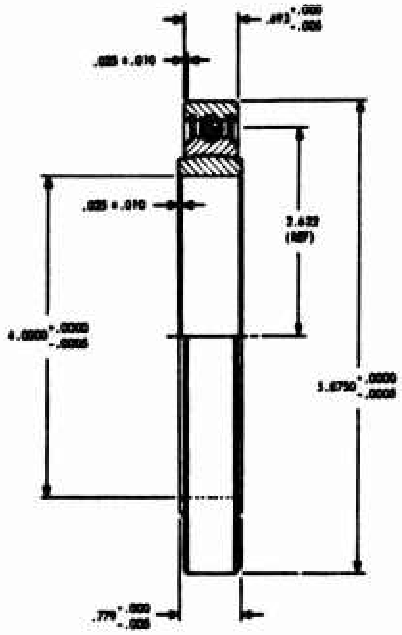
RACE CURVATURES: INNER, 51.0 TO 51.5% OF BALL DIAMETER
OUTER, 51.5 TO 52.0% OF BALL DIAMETER

SHOULDER HEIGHTS: BOTH SHOULDERS 17 TO 19% OF BALL DIAMETER

LUBRICATION: MCG 65-185 (AMMELINE THICKENED SILICONE GREASE)

Comment: Load life curve should be distributional for design for reliability usage.

SUB-NOTE 1(2) (Sheet 1 of 2 Sheets) Self-Aligning Ball Bearing



BALL COMPLEMENT: 47-11/32" DIA
RADIAL CLEARANCE:
BALL ASSEMBLY: .0008-.0012
ALIGNMENT SLEEVE: .0002-.0006

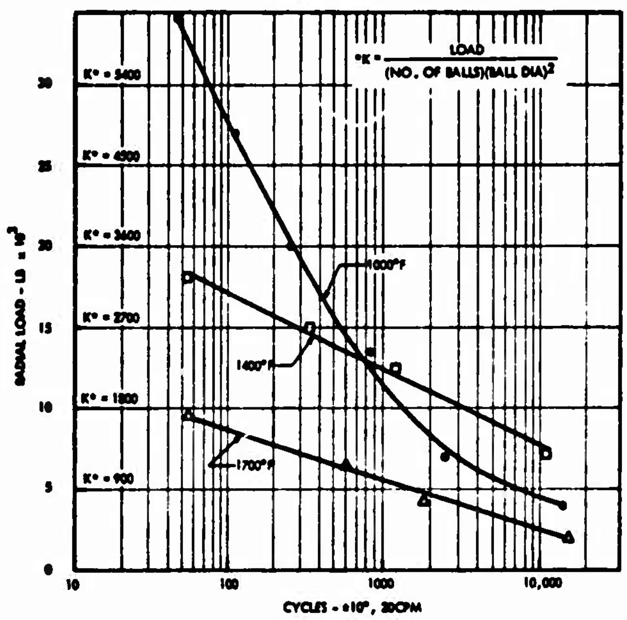
MATERIAL:	RACEWAYS AND ALIGNING SLEEVE - HAYNES STELLITE NO. 19, Rc - 50 MINIMUM
	BALLS - HAYNES STELLITE STAR J, Rc - 50 MINIMUM
	SNAP WASHERS - INCONEL
	SEALS - TEFLON UP TO 600°F, STAINLESS STEEL 600°F AND OVER
RACE CURVATURE:	INNER RING BALL RACE TO HAVE GROOVE RADIUS EQUAL TO 51.0% TO 51.5% OF BALL DIAMETER
	OUTER RING BALL RACE TO HAVE GROOVE RADIUS EQUAL TO 51.5% TO 52.0% OF BALL DIAMETER
SHOULDER HEIGHTS:	BALL RACEWAYS TO HAVE BALL RACE GROOVE DEPTH (SHOULDERS) EQUAL TO 17 TO 19% OF BALL DIAMETER
SLEEVE ASSEMBLY:	OPTIONAL - SNAP ASSEMBLY OR MESSERSCHMIDT TYPE LOADER SLOT
CLOSURE:	TEFLON SEAL AND SNAP WASHERS FOR STORAGE AND PRE-FLIGHT SEALING ONLY
LUBRICATION:	RACEWAYS AND BALLS TO BE DIPPED IN MIL-L-7870 OIL IMMEDIATELY BEFORE INSTALLATION OF SEALS FOR PRESERVATION AND ROOM TEMPERATURE OPERATION. OIL WILL EVAPORATE AT HIGH TEMPERATURE AND BEARING WILL OPERATE DRY.

USAGE AND APPLICATION INFORMATION

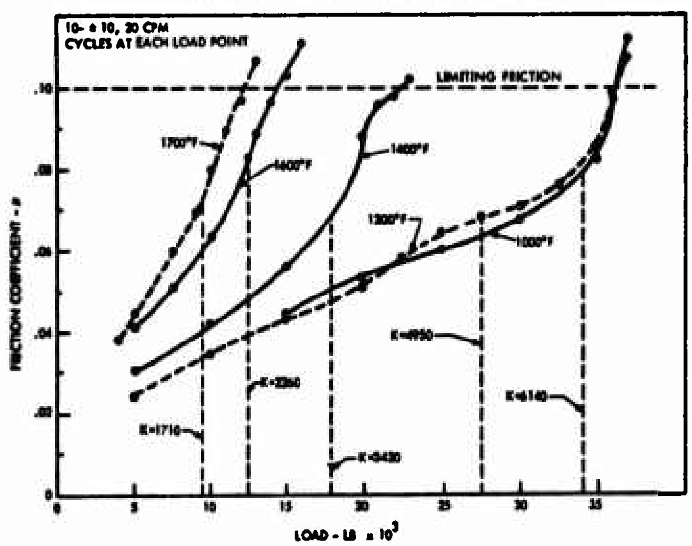
MOUNTING:	ROLLER STAKE
APPLICATION:	SEE PERFORMANCE DATA

SUB-NOTE 1(2) (Sheet 2 of 2 Sheets) Self-Aligning Ball Bearing

LOAD VS LIFE

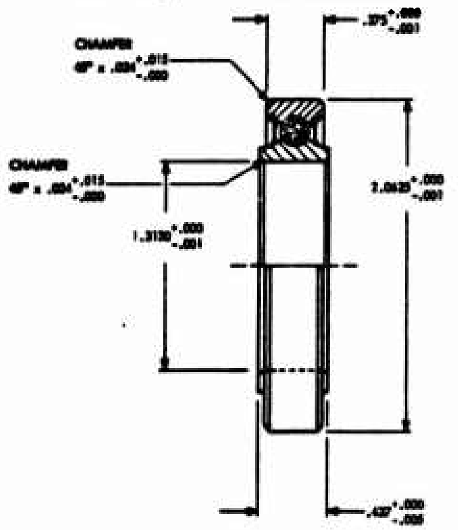


LOAD SPECTRUM TESTS - 1000, 1200, 1400, 1600 AND 1700°F



Comment: Load life curve should be distributional for design for reliability usage.

SUB-NOTE 1(3) (Sheet 1 of 2 Sheets) KP-21B Type, Stellite 19, Ball Bearing



BALLS - 20 3/16" DIA
RADIAL PLAY - .0015-.0020

MATERIAL: BALLS - STELLITE 3, R_c 55 MIN
RACES - STELLITE 19, R_c 52 MIN
SEALS - TEFLON FIBERGLAS BONDED TO S.S. BACKING, RETAINED BY S.S. SNAP RINGS

RACE CURVATURE: OUTER - 52.5 TO 53.5% OF BALL DIAMETER
INNER - 51.5 TO 52.5% OF BALL DIAMETER

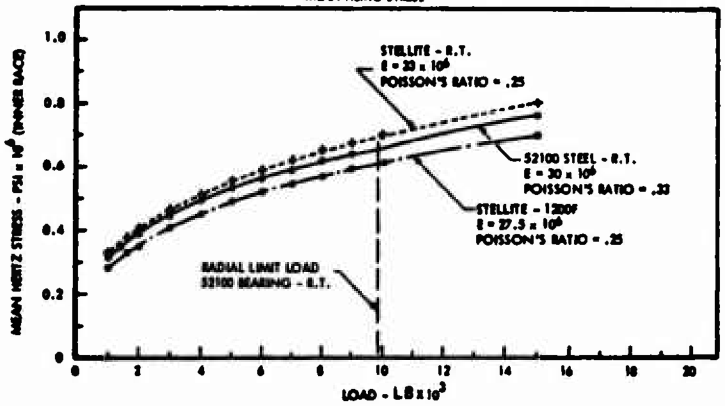
LUBRICATION: DESIGNED TO OPERATE DRY

USAGE AND APPLICATION

MOUNTING: PRESS FIT IN ALLOYS OF COMPARABLE EXPANSION COEFFICIENT

APPLICATION: SEE PERFORMANCE DATA

MEAN HERTZ STRESS



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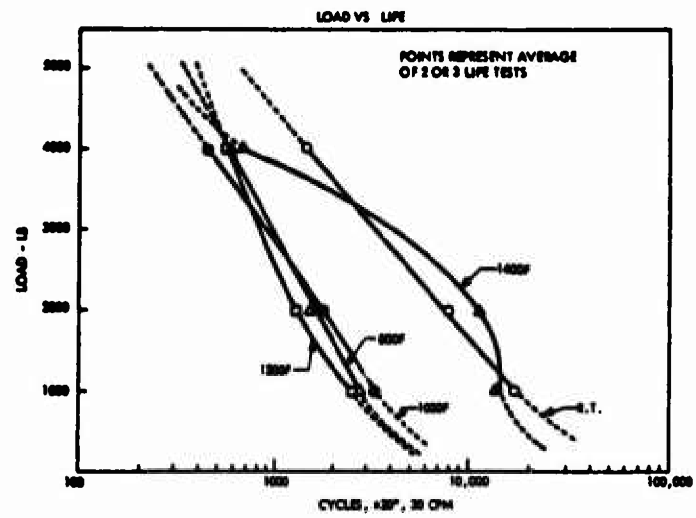
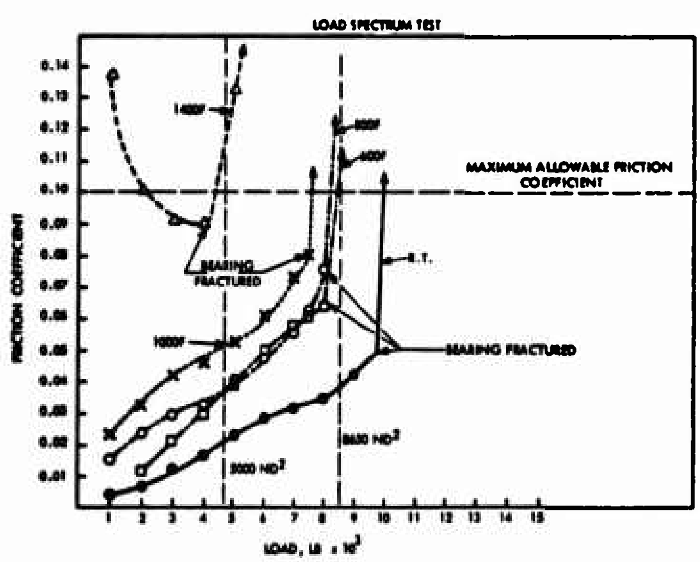
SUB-NOTE 1(3) (Sheet 2 of 2 Sheets) KP-21B
Type, Stellite 19, Ball Bearing





Comment: Load life curve should be distributional for design for reliability usage.

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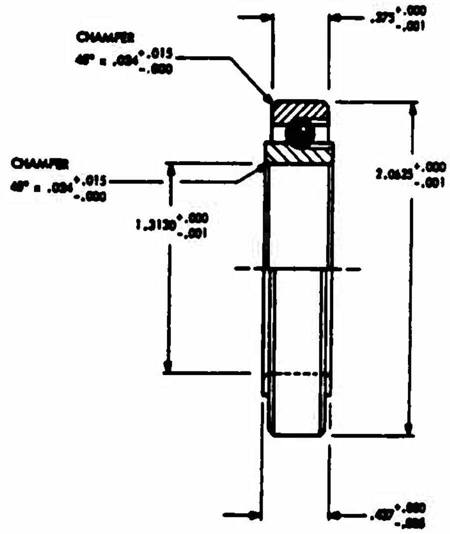
SUB-NOTE 1(4) (Sheet 1 of 2 Sheets) KP-21B Type, Stellite 25, Ball Bearing



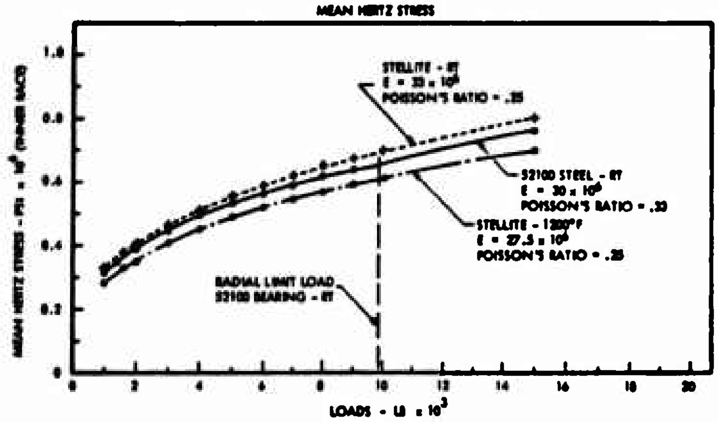
BALLS - 20 3/16" DIA.

RADIAL PLAY - .0015-.0020

MATERIAL:	RACES & BALLS - STELLITE 25 COLD WORKED TO R_c 52 MIN
RACE CURVATURE:	OUTER RACE - 52.5 TO 53.5% OF BALL DIA
LUBRICANT:	NONE

USAGE AND APPLICATION INFORMATION

MOUNTING:	PRESS FIT
APPLICATION:	SEE PERFORMANCE DATA



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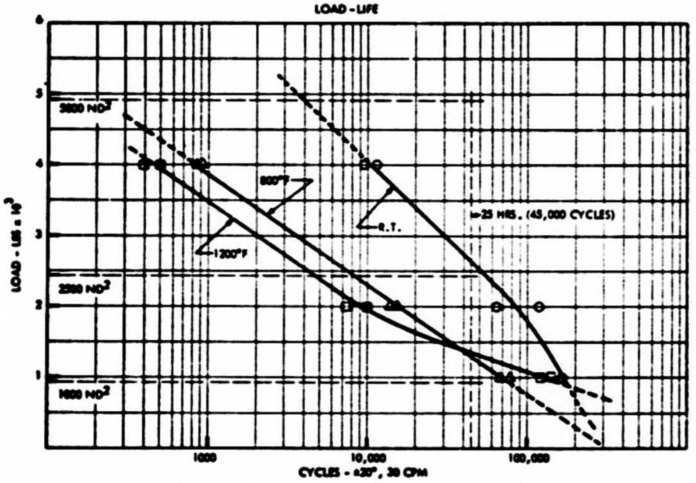
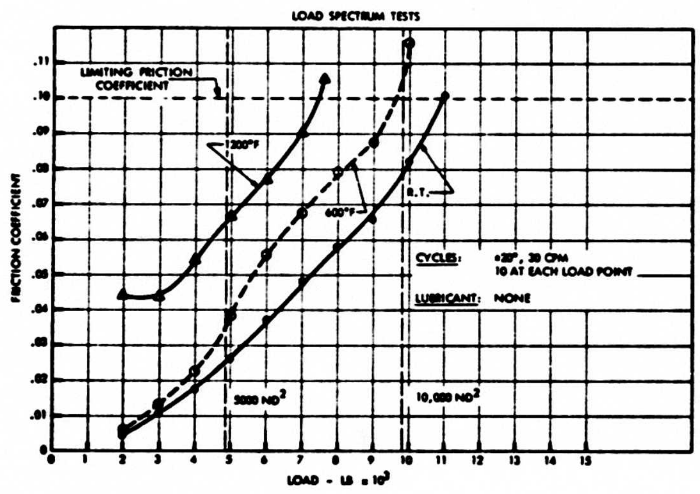
SUB-NOTE 1(4) (Sheet 2 of 2 Sheets) KP-21B Type, Stellite 25, Ball Bearing





Comment: Load life curve should be distributional for design for reliability usage.

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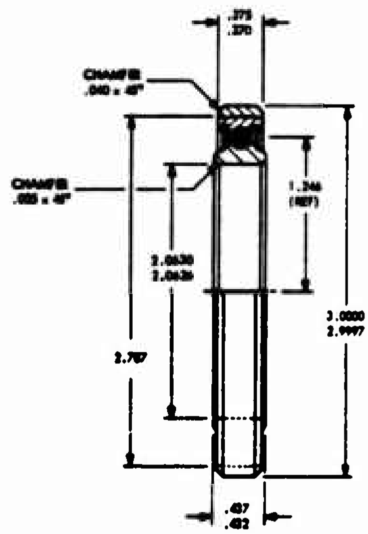
SUB-NOTE 1(5) (Sheet 1 of 2 Sheets) KP-33-BS Type Ball Bearing



BALLS: 41 3/16" DIA

RADIAL CLEARANCE: .0008-.0012 (BALL ASSEMBLY)
.0002-.0006 (SLEEVE)
.0010-.0018 TOTAL

MATERIAL:	ALL COMPONENTS EXCEPT SEALS - M-2 TOOL STEEL 62 R_c MIN SEALS: TEFLON TFE SEALS INCONEL X SNAP WASHERS
RACE CURVATURE:	INNER RACE - 51.0-51.5% OF BALL DIA OUTER RACE - 51.5-52.0% OF BALL DIA
SHOULDER HEIGHTS:	ALL RACEWAYS - 17-19% OF BALL DIA
CLOSURES:	TEFLON AND INCONEL WASHERS USED FOR PREFLIGHT SEALING
LUBRICATION:	RACEWAYS AND BALLS TO BE LUBRICATED WITH MIL-L-7870 BEFORE INSTALLATION OF SEALS. TFE SEALS AND OIL VAPORIZES AT TEMPERATURES 600°F WHERE BEARING OPERATES DRY.

USAGE AND APPLICATION INFORMATION

MOUNTING:	ROLLER STAKE HOUSING OR MECHANICAL RETENTION METHODS
APPLICATION:	SEE PERFORMANCE DATA

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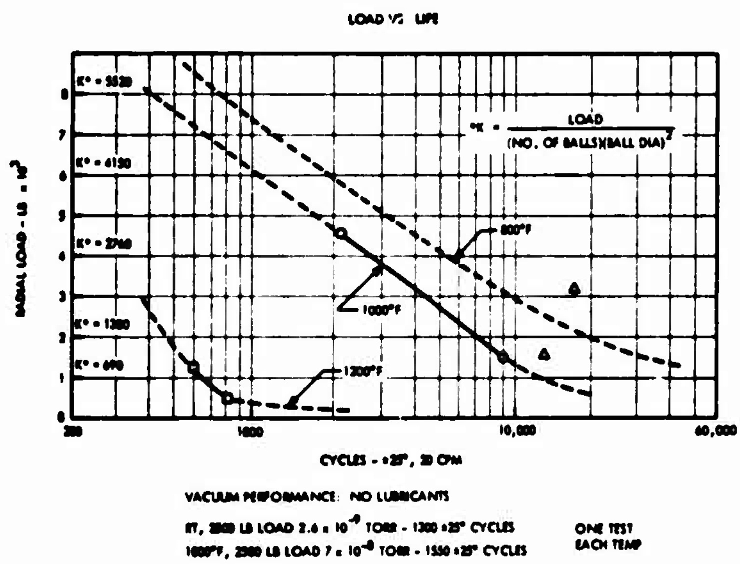
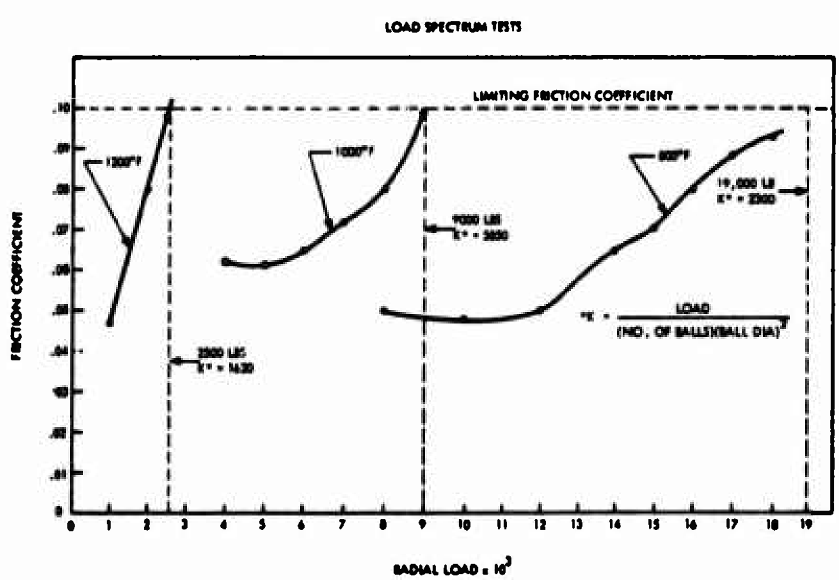
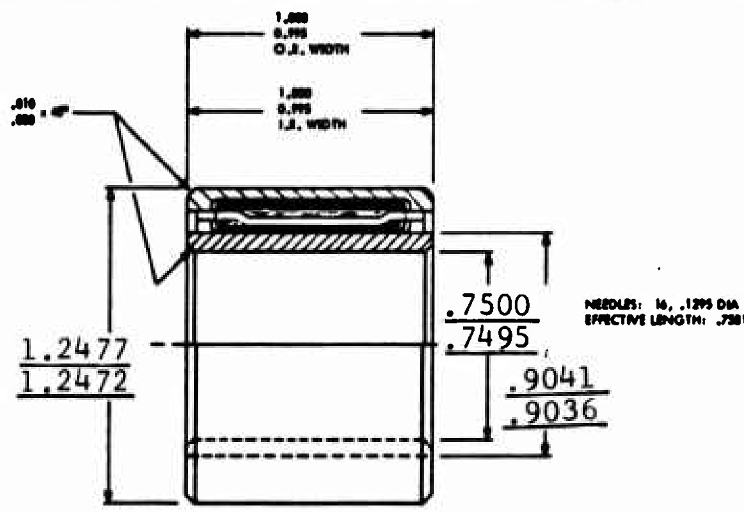
SUB-NOTE 1(5) (Sheet 2 of 2 Sheets) KP-33-BS Type Ball Bearing





Comment: Load life curve should be distributional for design for reliability usage.

SUB-NOTE 1(6) (Sheet 1 of 2 Sheets) Needle Bearing



MATERIAL: OUTER RACE, INNER RACE & ROLLERS.
HAYNES ALLOY #25 PER AMS 5759
COLD REDUCED & AGE HARDENED TO R_c 45 MIN

RETAINER: PH-15-7Mo STAINLESS STEEL
HEAT TREAT TO R_c 38-45

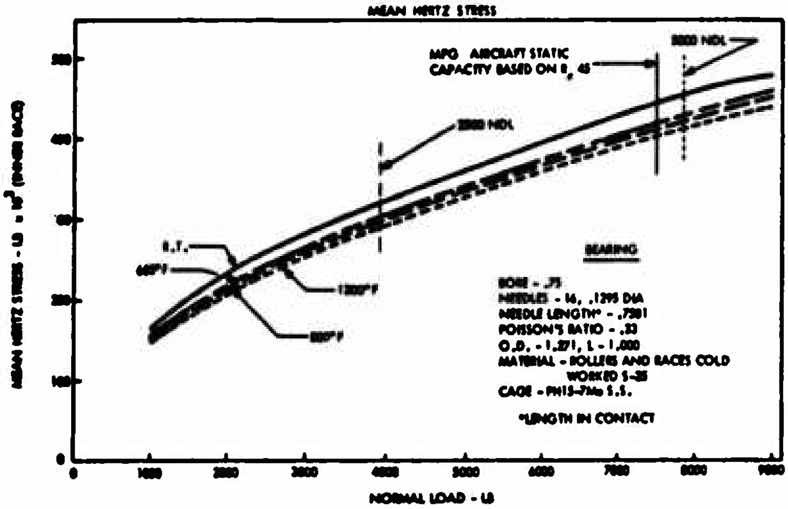
LUBRICATION: NONE

USAGE & APPLICATION INFORMATION

MOUNTING: PRESS FIT

APPLICATION: SEE PERFORMANCE DATA.

MEAN HERTZ STRESS

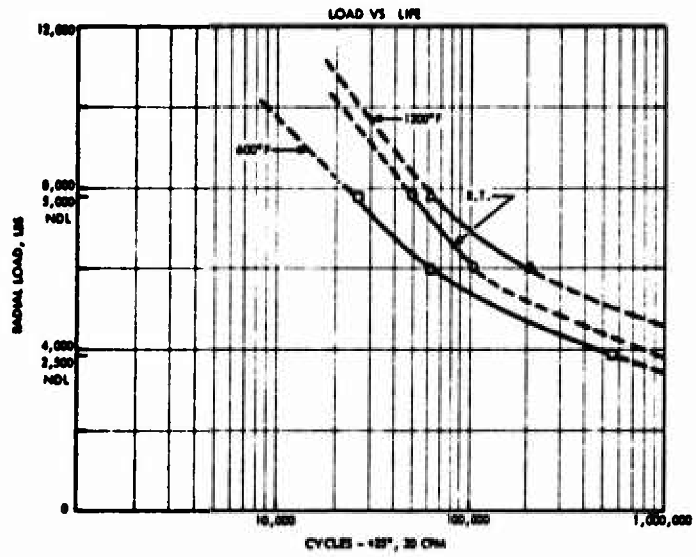


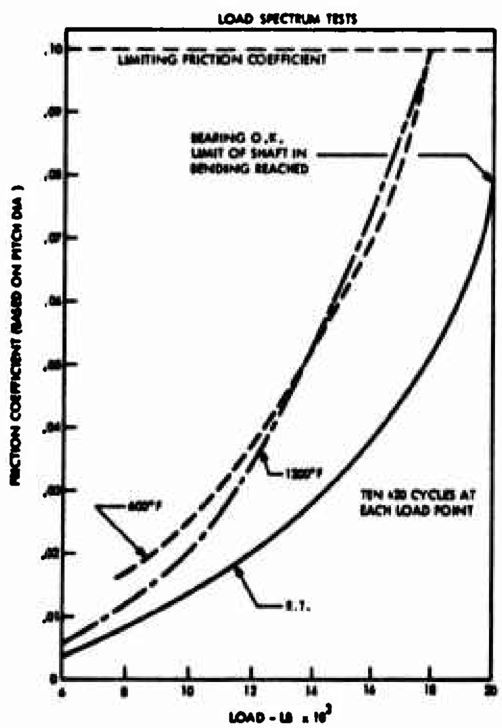
60

Comment: Change dimensions as shown above.

Rationale: Dimensions of bearing diameter are not compatible.

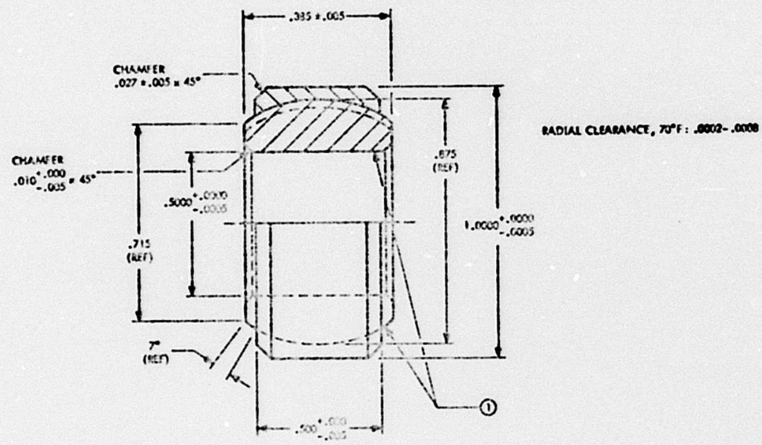
SUB-NOTE 1(6) (Sheet 2 of 2 Sheets) Needle Bearing





Comment: Load life curve should be distributional for design for reliability usage.

SUB-NOTE 1(7) (Sheet 1 of 2 Sheets) Spherical Bearing

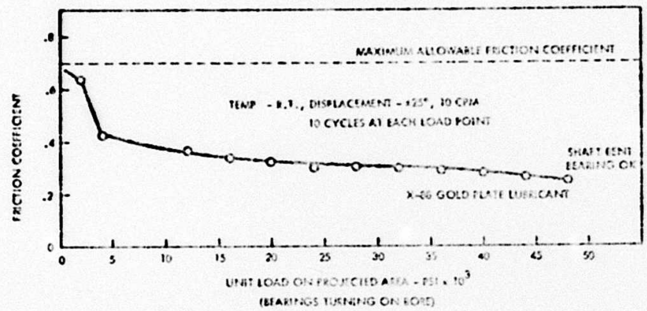


MATERIAL:	RENE' 41
HEAT TREATMENT:	R_c 37-41 (AFTER HEAT TREATMENT AND OXIDIZING). THE FOLLOWING HEAT TREAT PROCEDURE SHALL BE USED ON BEARING COMPONENTS. ROUGH MACHINE PARTS; SOLUTION TREAT AT 1975° FOR 30 MINUTES, WATER QUENCH (7 SECONDS MAXIMUM DELAY) AND AGE AT 1650°F FOR ONE HOUR. FINISH MACHINE OR GRIND. APPLY A UNIFORM OXIDE COATING BY THE FOLLOWING PROCEDURE AFTER VAPOR BLAST OR LIQUID HONE (HANDLE WITH GLOVES AND DO NOT CONTAMINATE WITH GREASE, SWEAT, ETC.). AGE AT 1650°F FOR ONE HOUR, THEN AT 1400°F FOR 10 HOURS. (OXIDE FORMS AT THIS STAGE). AIR COOL.
FINISH:	UNIFORM OXIDE FILM AS RESULT OF THE ABOVE HEAT TREATMENT
DIMENSIONS:	ALL DIMENSIONS SHALL BE MET AFTER HEAT TREATMENT AND OXIDIZING PROCESS DESCRIBED ABOVE
QUALITY:	BEARINGS SHALL BE FREE OF MATERIAL IMPERFECTIONS, TOOL MARKS, SHARP EDGES AND SCRATCHES, AND SHALL NOT CATCH OR BIND WHEN MANUALLY OSCILLATED OR MISALIGNED
LUBRICATION:	1 X-98 GOLD PLATE ON BORE AND BALL. RENE' 41 OXIDE ON INSIDE OF OUTER RACE
ASSEMBLY METHOD:	SCREW THREADS ON BALL AND INNER RACE

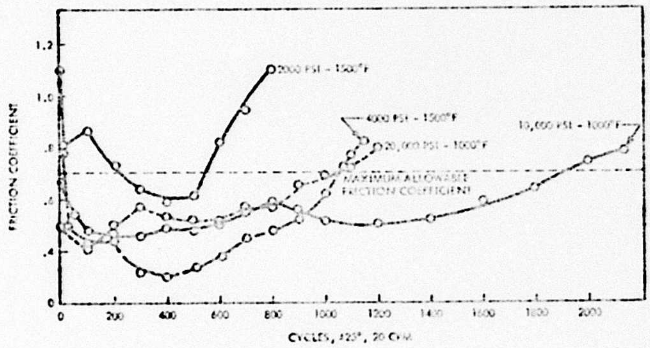
62

SUB-NOTE 1(7) (Sheet 2 of 2 Sheets) Spherical Bearing

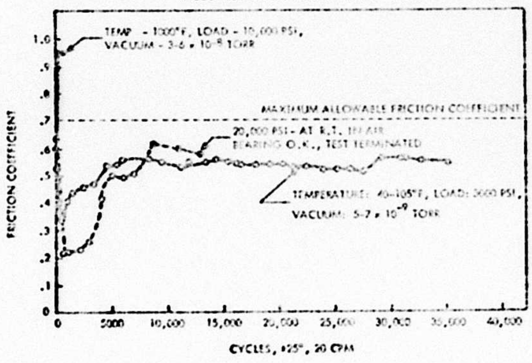
LOAD SPECTRUM TEST



LIFE TESTS



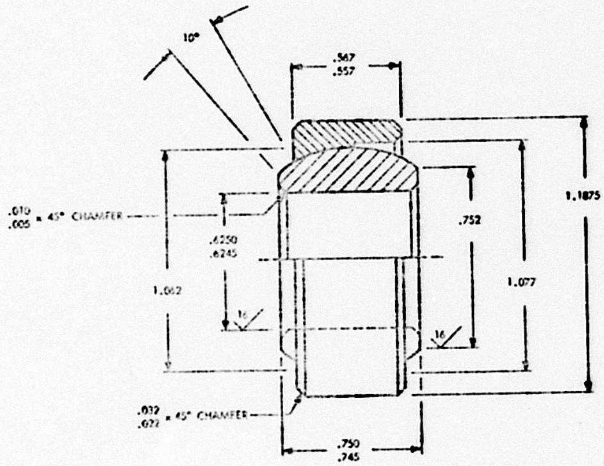
VACUUM LIFE TESTS AND ONE LIFE TEST



Comment: Load life curve should be distributional for design for reliability usage.

63

SUB-NOTE 1(8) (Sheet 1 of 2 Sheets) **Spherical Loader Slot Bearing**

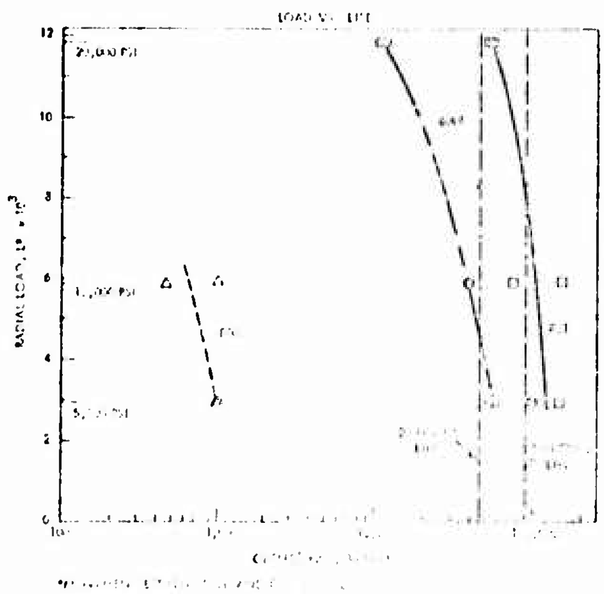


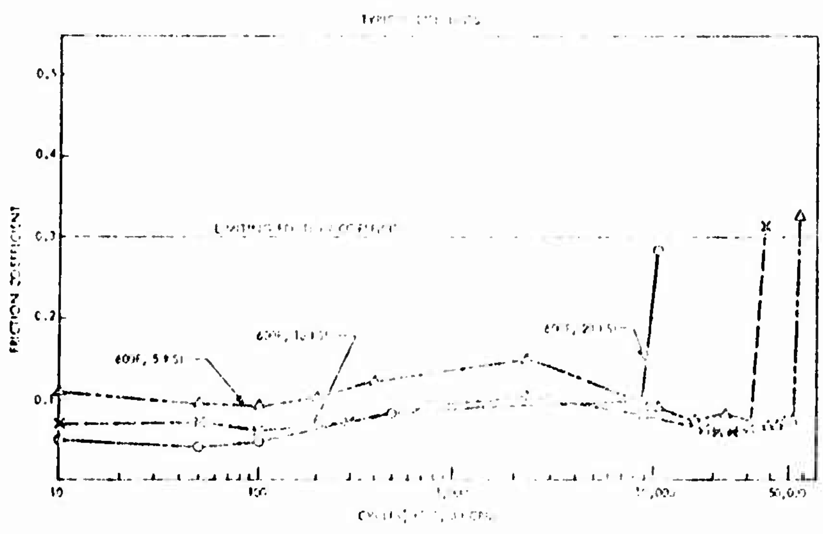
RADIAL CLEARANCE: .004 / .003

MATERIALS:
OUTER RACE: RENE' 41 HEAT TREATED TO 39 R_c MIN
BALL: RENE' 41 HEAT TREATED TO 39 R_c MIN
LUBRICATION: VITROLUBE 1220 CERAMIC BONDED DRY FILM LUBRICANT APPLIED TO BALL SURFACES

64<

SUB-NOTE 1(8) (Sheet 2 of 2 Sheets) Spherical Loader Slot Bearing

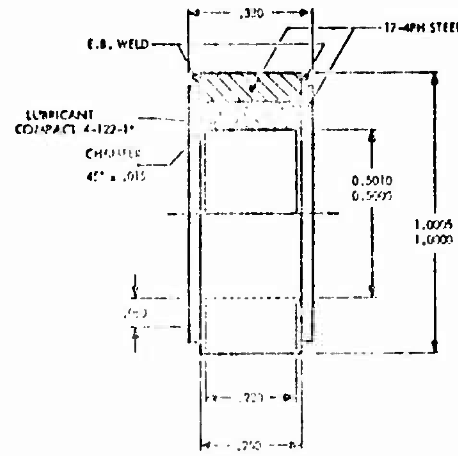




Comment: Load life curve should be distributional for design for reliability usage.

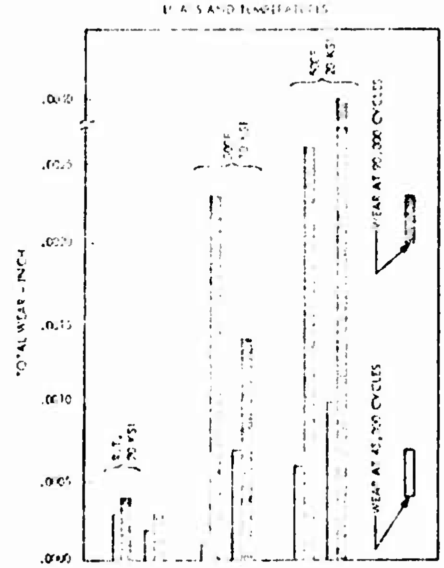
C5<

SUB-NOTE 1(9) (Sheet 1 of 2 Sheets) Metal Compact
Plain Bearing

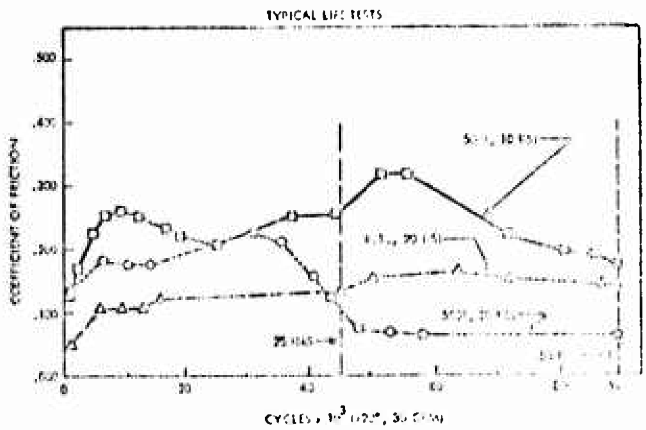


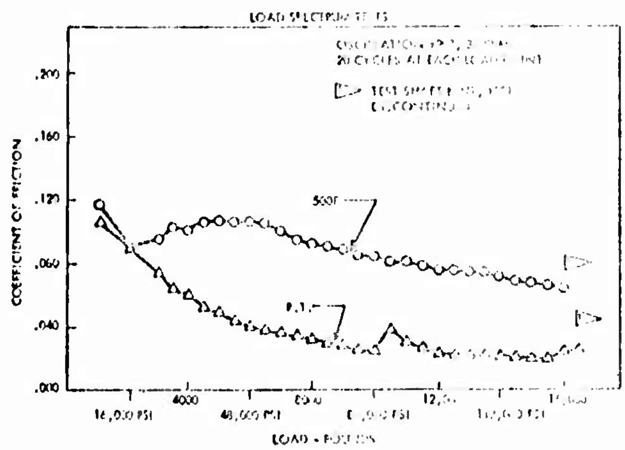
*CO[illegible] 4-122-1

[illegible]	MoS_2 [illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
ELECTRICAL [illegible]	3.7 [illegible] $\times 10^{-4}$



SUB-NOTE 1(9) (Sheet 2 of 2 Sheets) Metal Compact Plain Bearing

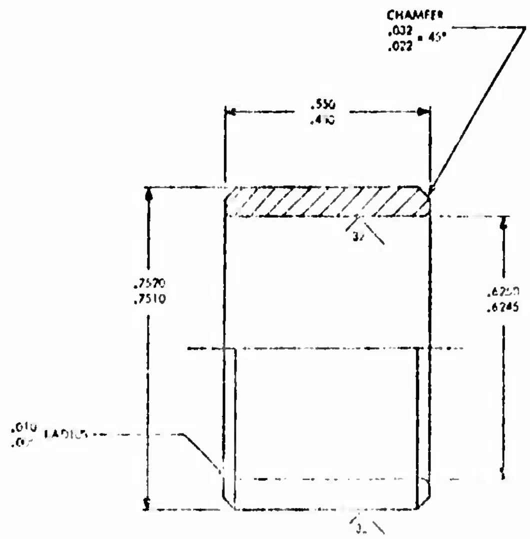




Comment: Load life curve should be distributional for design for reliability usage.

C7<

SUB-NOTE 1(10) (Sheet 1 of 2 Sheets) Graphite Bushing



MATERIAL: HIGH STRENGTH GRAPHITE WITH THE FOLLOWING PROPERTIES:

DENSITY, gm/cc 1.84-1.88

COEFF. THERMAL EXPANSION R.T. - 212F, [illegible] $\times 10^{-6}$ in/in/°F
R.T. - 300°F, 4.9 $\times 10^{-6}$ in/in/°F

COMPRESSIVE STRENGTH, PSI 20,000

FLEXURAL STRENGTH, PSI 14,000

TENSILE STRENGTH, PSI 4,800

HARDNESS (SHORE SCLEROSCOPE): 84

POROSITY, % 17

LUBRICATION: NONE REQUIRED

USAGE & APPLICATION DATA

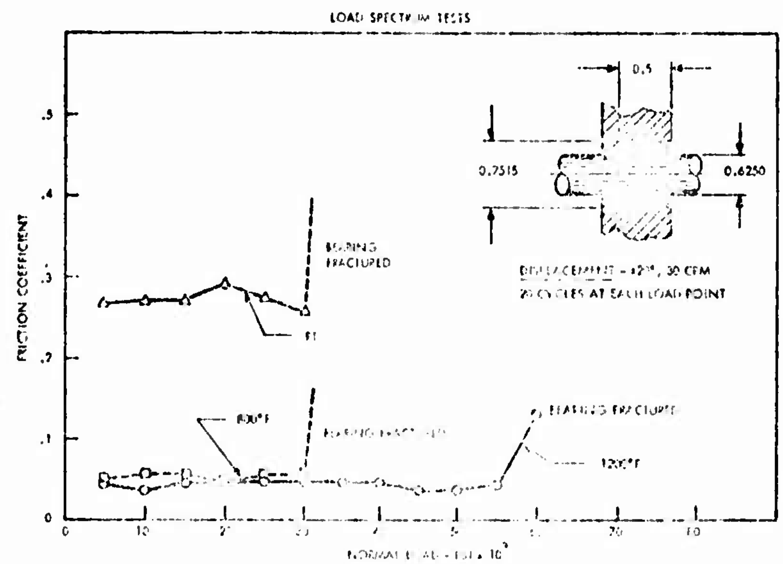
MOUNTING: LIGHT PRESS OR SLIP FIT

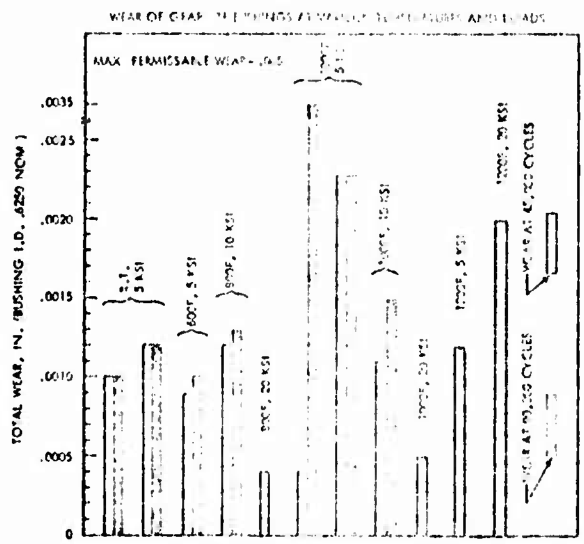
SHAFT: 16 RMS MAX. SURFACE FINISH Rc 39

APPLICATION: SEE PERFORMANCE DATA

68<

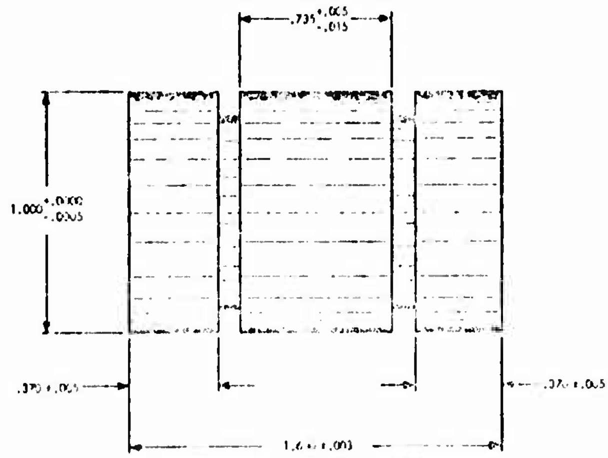
SUB-NOTE 1(10) (Sheet 2 of 2 Sheets) Graphite Bushing

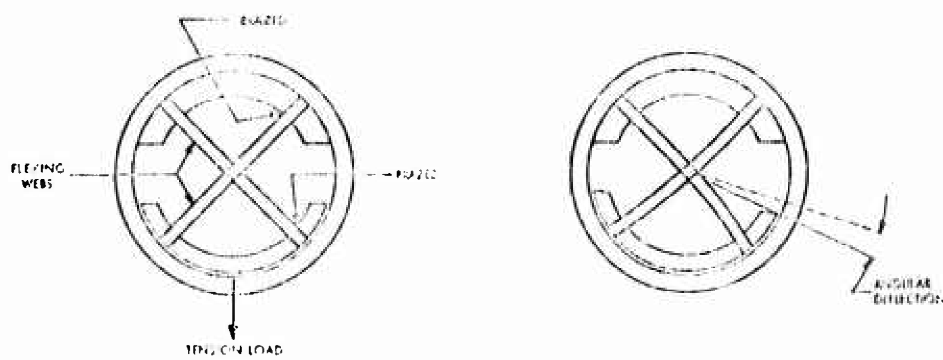




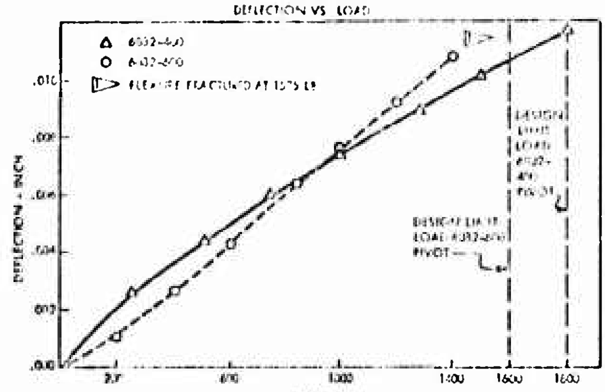
Comment: Load life curve should be distributional for design for reliability usage.

SUB-NOTE 1(11) (Sheet 1 of 2 Sheets) Flexural Pivots



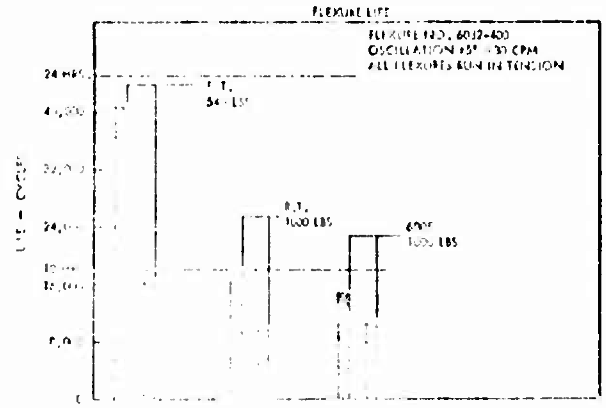


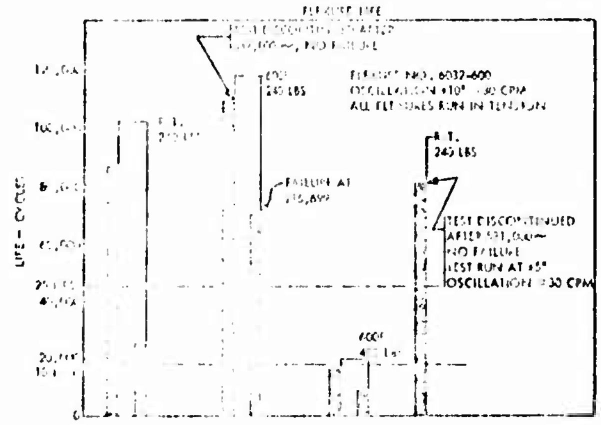
	6032-400	6032-600
TORSIONAL SPRING RATE, LB-IN/RAD	431.0	53.8
LIMIT LOAD TENSION, LB	[illegible]	1600
LIMIT LOAD COMPRESSION, LB	[illegible]	1131
WEB THICKNESS, IN (APPROX)	[illegible]	[illegible]



70<

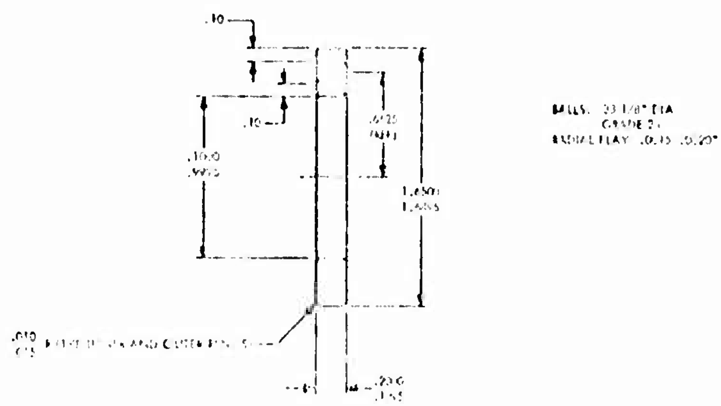
SUB-NOTE 1(11) (Sheet 2 of 2 Sheets) Flexural Pivots





Comment: Load life curve should be distributional for design for reliability usage.

SUB-NOTE 2(1) (Sheet 1 of 2 Sheets) Ceramic Ball Bearing



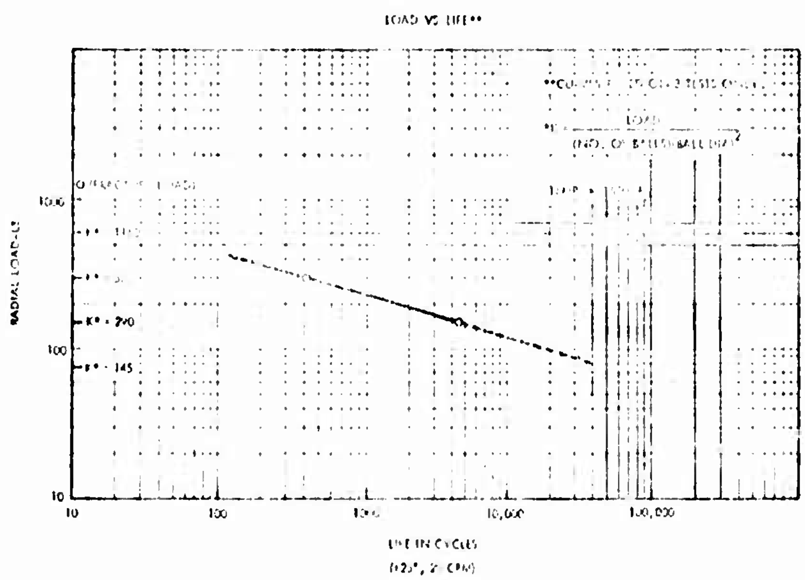
MATERIAL	RACEWAYS – [illegible] BALLS – [illegible] SURFACE FINISH – [illegible] ON BALLS & RACES
RACE CURVATURE	INNER & OUTER RACES TO HAVE GROOVE [illegible] OF BALL DIAMETER
SHOULDER HEIGHTS	BOTH RACES TO HAVE SHOULDER HEIGHTS EQUAL TO [illegible] OF BALL DIAMETER
TOLERANCES	ABEC 5 TOLERANCES FOR [illegible] TO APPLY EXCEPT AS NOTED
LUBRICATION	NONE

USAGE AND APPLICATION DATA

MOUNTING	MECHANICAL RETENTION ONLY (BEARING SOMEWHAT BRITTLE)
APPLICATION	FOR TEMPERATURES OF [illegible]°F AND OVER. SEE PERFORMANCE DATA

75

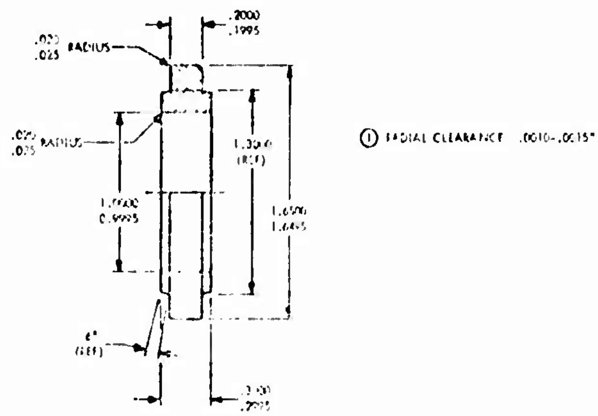
SUB-NOTE 2(1) (Sheet 2 of 2 Sheets) Ceramic Ball Bearing



Comment: Load life curve should be distributional for design for reliability usage.

73<

SUB-NOTE 2(2) (Sheet 1 of 2 Sheets) Plain Spherical Bearing



MATERIAL:	SPHERICAL SECTION & OUTER RACE - HAYNES LT-2 CERMET SURFACE FINISH - [illegible] ON BORE, BALL & OUTER RACE CONTACT AREAS
ASSEMBLY:	LOADER SLOT
LUBRICATION:	NONE. BEARING SHOULD BE PRE-OXIDIZED IF USED AT TEMPERATURES BELOW 1200°F TO PROVIDE FILM OF LUBRICATING OXIDE
SEALS:	NONE

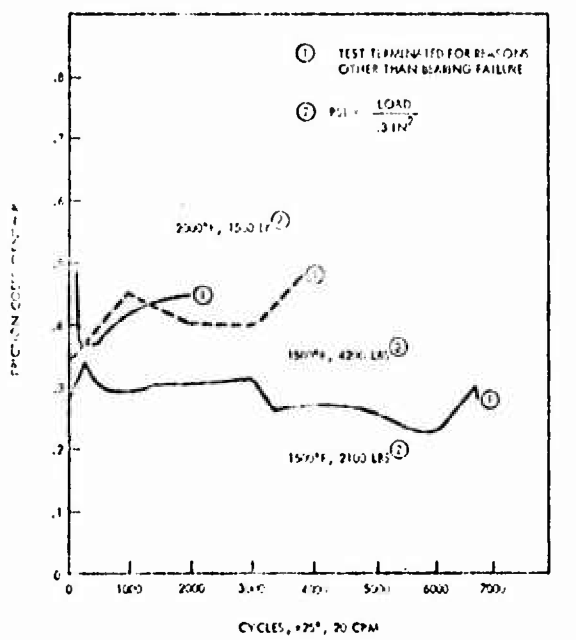
USAGE AND APPLICATION DATA

MOUNTING:	MECHANICAL RETENTION OR ROLLER SWAGING OF HOUSING
APPLICATION:	① RADIAL CLEARANCE SHOULD BE .002-.004 FOR OPERATION AT TEMPERATURES ABOVE 1500°F LIMIT LOADS - 2000°F - 2[illegible] LBS MIN, 1[illegible]°F - 7000 LBS MIN SEE PERFORMANCE DATA

7.4<

SUB-NOTE 2(?) (Sheet 2 of 2 Sheets) Plain Spherical Bearing

FRICTION COEFFICIENT VS CYCLES AT VARIOUS LOADS



Comment: Load life curve should be distributional for design for reliability usage.

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DESIGN NOTE 6F2 — STANDARD BEARINGS

1. INTRODUCTION

To aid the designer in bearing selection, this Design Note presents the standard MS bearings with supplemental dimensions and load data. In addition, correct housing bore and shaft dimensions are given for the proper mounting of each bearing. With proper lubrication, the bearings are useful for a temperature range of -65°F to 350°F except the MS21220, MS21221, and MS21223 bearings which are useful for a range of -67° to 250°F.

2. BALL BEARINGS

The standard airframe ball bearings are shown in SN 2(1) through SN 2(10).

3. NEEDLE BEARINGS

The standard airframe needle roller bearings are shown in SN 3(1) through SN 3(7).

4. ROLLER BEARINGS

The standard airframe self-aligning roller bearings are shown in SN 4(1) through SN 4(4).

5. SPHERICAL BEARINGS

The standard airframe plain spherical bearings are shown in SN 5(1) through SN 5(7).

6. BUSHINGS

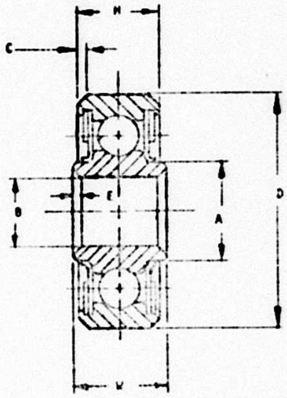
The standard airframe bushings are shown in SN 6(1) through SN 6(6).

7. ROD ENDS

The standard rod end bearings are shown in SN 7(1) through SN 7(9).

'70'

SUB-NOTE 2(1) (Sheet 1 of 2 Sheets) Heavy Duty Ball Bearings (MS27640)



MS DASH NO	MFG P/N	B BORE (b) +.0000 -.0005	D OUTSIDE DIAMETER (a) (b) +.0000 -.0005	W WIDTH INNER RING (a) +.000 -.005	H WIDTH OUTER RING (a) +.000 -.005	A SHOULDER DIAMETER INNER APPROX.	E CORNER CHAMFER X 45° INNER (d) RING BORE +.015 -.000	G CORNER CHAMFER X 45° OUTER (c) RING OD	RADIAL LIMIT LOAD RATING LBS	THRUST LIMIT LOAD RATING LBS	(e) (f) RADIAL LOAD RATING (LBS) FOR AVERAGE LIFE OF 10,000 COMPLETE 90° CYCLES CASE I	CASE II	WEIGHT POUNDS APPROX
-3A(g)	K3L	.1900	.6250	.245	.203	.280	.005	.010	1560	700	1520	1260	.01
-3	KP3	.1900	.7774	.297	.270	.331		.022	1830	900	1700	1450	.03
-4	KP4	.2500	.9014	.484	.335	.390		.032	2680	1200	2410	2030	.04
-5	KP5	.3125	1.2500	.558	.375	.469	.015		5630	2500	4900	3920	.09
-6	KP6	.3750	1.4375	.620	.469	.591			7910	3500	6540	5410	.15
-8	KP8	.5000	1.6875	.620	.500	.768		.044	11800	5200	9320	7700	.21
-10	KP10	.6250	1.9375	.620	.500	.850			14100	6200	11000	9060	.28

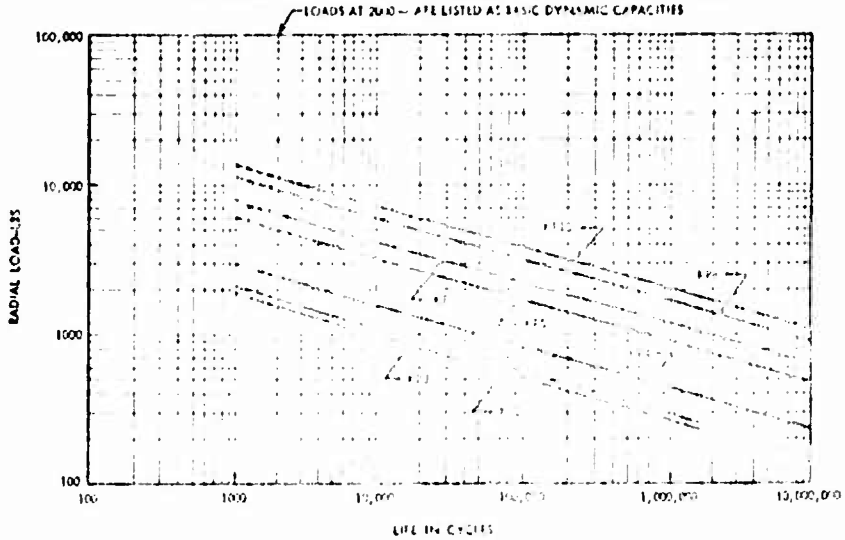
(a) ALL DIMENSIONS TO BE MET AFTER PLATING
(b) OUT-OF-ROUND TOLERANCES, BORE: +.0002, -.0007
OUTER DIA: +.0005, -.0010
(c) A RADIUS GIVING APPROXIMATELY THE SAME GRIP FOR STAKING THE BEARING IN THE HOUSING WILL BE ACCEPTABLE.
(d) A RADIUS GIVING APPROXIMATELY THE SAME FILLET CLEARANCE WILL BE ACCEPTABLE.
(e) CASE I = LOAD FIXED WITH RESPECT TO OUTER RACE
CASE II = LOAD FIXED WITH RESPECT TO INNER RACE
(f) THESE RATINGS ARE FOR OPERATION UP TO 250°F MAX. WHEN SUBJECTED TO OPERATION AT 350°F, THE RATINGS SHOULD BE REDUCED BY 20%.
(g) METAL SHIELDS ARE PERMITTED FOR -3A.

1. MATERIALS: RINGS, STEEL, FED-STD-66, E52100.
BALLS, STEEL, FED-STD-66, E51100 or E52100
2. SEALS: POLYTETRAFLUOROETHYLENE PER AMS3652 OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER AMS3666.
3. SEAL RETAINERS, STEEL, CORROSION RESISTANT
4. LUBRICANT, MIL-G-81322, FILLED 80% MIN
5. SURFACE ROUGHNESS: RACEWAYS AND BALLS - 8 MICROINCHES AA PER ANSI B46.1
6. PLATING: ALL EXTERNAL SURFACES EXCEPT BORE, SEALS AND SEAL RETAINERS, CADMIUM PLATED PER QQ-P-416, TYPE I, CLASS 2.
7. INTERNAL RADIAL CLEARANCE: .0004" TO .0010"
8. HARDNESS: HEAT TREATMENT: HEAT TREAT RINGS AND BALLS TO ROCKWELL "C" 60 TO 66 AND STABILIZED FOR OPERATION AT 250°F.
9. RADIAL AND LATERAL ECCENTRICITY: INNER RING .0010" MAX
OUTER RING .0015" MAX

77<

SUB-NOTE 2(1) (Sheet 2 of 2 Sheets) Heavy Duty Ball Bearings (MS27640)

INNER RACE MOVING
(WHEN OUTER RACE IS MOVING, DIVIDE RADIAL LOADS BY 1.20)



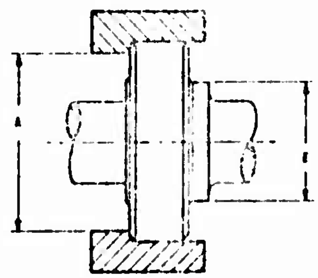
BEARING	BALL DIAMETER	NO.	LIMIT MOMENT, IN-LBS	INHERENT CONSTANT, 1 INCH	APPROX. WEIGHT, LBS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0
KP3	[illegible]	12	[illegible]	[illegible]	[illegible]
KP4	[illegible]	[illegible]	[illegible]	[illegible]	04
KP5	[illegible]	9	[illegible]	[illegible]	[illegible]
KP6	[illegible]	[illegible]	[illegible]	[illegible]	15
KP8	11 32	10	[illegible]	4 4[illegible]	[illegible]
KP10	[illegible]	[illegible]	[illegible]	4 [illegible]	[illegible]

SHAFT AND HOUSING SHOULDER DIAMETERS

BEARING	A, MAX., IN.	B, MIN., IN.
[illegible]	[illegible]	[illegible]
KP3	[illegible]	301
KP4	[illegible]	[illegible]
KP5	1 [illegible]	4[illegible]
KP6	1 [illegible]	[illegible]
KP8	1 4[illegible]4	[illegible]
KP10	1 646	835

SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

BEARING	O.D. INCHES	STEEL HOUSING BORE, IN.	ALLOY HOUSING BORE, IN.	SHAFT DIAMETER
K3L	[illegible]	[illegible]	[illegible]	[illegible]
KP3	7774 [illegible]	[illegible]	[illegible]	[illegible]
KP4	9[illegible]	[illegible]	[illegible]	[illegible]
KP5	1 2[illegible]	[illegible]	[illegible]	[illegible]
KP6	1 [illegible]	[illegible]	[illegible] 4[illegible]3	[illegible]
KP8	[illegible]	[illegible]	[illegible]	[illegible]
KP10	1 9[illegible]	1 5[illegible]5	[illegible]	[illegible]

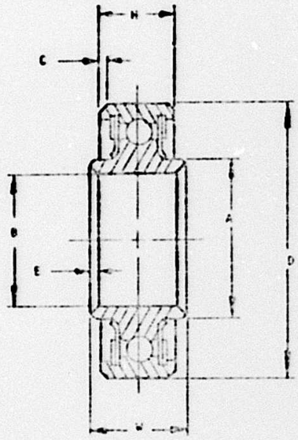


USAGE & APPLICATION DATA

MS27640 BEARINGS ARE USED IN APPLICATIONS WHERE A HEAVY DUTY BALL BEARING CAPABLE OF TAKING EITHER RADIAL OR THRUST LOADS IS REQUIRED. THESE BEARINGS ARE NOT SELF-ALIGNING AND SHOULD NOT BE USED IF MISALIGNMENT EXCEEDS 1/4°.

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 2(2) (Sheet 1 of 2 Sheets) Medium Duty Ball Bearings (MS27641)



MS DASH NO.	MFG P/N	B: BORE (b) +.0000 -.0005	D: OUTSIDE DIAMETER (a) (b) +.0000 -.0005	W: WIDTH INNER RING (a) +.000 -.005	H: WIDTH OUTER RING (a) +.000 -.005	A: SHOULDER DIAMETER INNER RING (APPROX.)	E: CORNER CHAMFER X 45° — INNER (d) RING BORE +.015 -.000	G: CORNER CHAMFER X 45° — OUTER (c) RING O.D. +.015 -.000	RADIAL LIMIT LOAD RATING LBS	THRUST LIMIT LOAD RATING, LBS	(f) RADIAL LOAD RATING (LBS) FOR AVERAGE LIFE OF 10,000 COMPLETE 90° CYCLES — (e) CASE I	(e) CASE II	WEIGHT POUNDS (APPROX)
-3	KP3A	.1900	.6250	.297	.234	.297	.005	.016	1560	700	1500	1250	.01
-4	KP4A	.2500	.7500	.281	.219	.380			1580	900	1690	1450	.02
-5	KP5A	.3125	.8125	.297	.234	.415	.015	.016	2190	1000	1820	1600	.02
-6	KP6A	.3750	.8750	.313	.250	.495			2500	1100	1920	1710	.03
-8	KP8A	.5000	1.1250	.375	.313	.616			3910	1700	2870	2550	.05
-10	KP10A	.6250	1.3750	.406	.344	.768	.015	.032	6200	3000	4980	4360	.08
-12	KP12A	.7500	1.6250	.437	.375	.919			8790	3500	5980	5320	.13
-16	KP16A	1.0000	2.0000	.500	.438	1.241			11900	5200	7070	6400	.22
-20	KP20A	1.2500	2.2500	.500	.438	1.478	.015	.032	13800	6100	7400	6810	.26

(a) ALL DIMENSIONS TO BE MET AFTER PLATING.
(b) OUT-OF-ROUND TOLERANCES. BORE: +.0002, -.0007
OUTER DIA.: +.0005, -.0010
(c) A RADIUS GIVING APPROXIMATELY THE SAME GRIP FOR STAKING THE BEARING IN THE HOUSING WILL BE ACCEPTABLE.
(d) A RADIUS GIVING APPROXIMATELY THE SAME FILLET CLEARANCE WILL BE ACCEPTABLE.
(e) CASE I = LOAD FIXED WITH RESPECT TO OUTER RACE.
CASE II = LOAD FIXED WITH RESPECT TO INNER RACE.
(f) THESE RATINGS ARE FOR OPERATION UP TO 250°F MAX. WHEN SUBJECTED TO OPERATION AT 350°F, THE RATINGS SHOULD BE REDUCED BY 20%.

1. MATERIALS: RINGS: STEEL, FED-STD-66, E52100
BALLS: STEEL, FED-STD-66, E51100 or E52100
2. SEALS: POLYTETRAFLUOROETHYLENE PER AMS3652 OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER AMS3666.
3. SEAL RETAINERS: STEEL, CORROSION RESISTANT
4. LUBRICANT: MIL-G-81322, FILLED 80% MIN.

5. HARDNESS: HEAT TREAT RINGS AND BALLS TO ROCKWELL "C" 60 TO 66 AND STABILIZED FOR OPERATION AT 250°F.

6. SURFACE ROUGHNESS: RACEWAYS AND BALLS - 8 MICROINCHES AA PER ANSI B46.1
7. PLATING: ALL EXTERNAL SURFACES EXCEPT BORE, AND SEAL RETAINERS, CADMIUM PLATED PER QQ-P-416, TYPE I, CLASS 2.

8. INTERNAL RADIAL CLEARANCE: .0004" TO .0010"
9. RADIAL AND LATERAL ECCENTRICITY: INNER RACE .0010"
OUTER RACE .0016"

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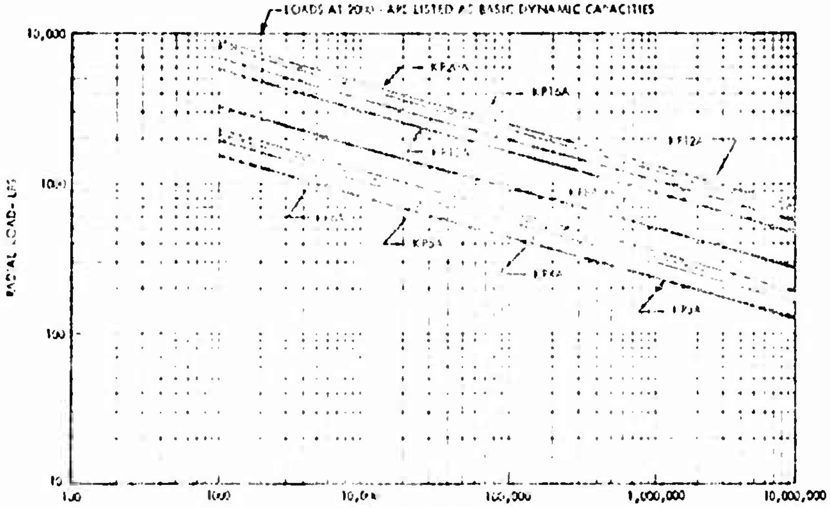
SUB-NOTE 2(2) (Sheet 2 of 2 Sheets) Medium Duty Ball Bearings (MS27641)

INNER RACE MOVING
(WHEN OUTER RACE IS MOVING DIVIDE RADIAL LOADS BY 1.20)



LIFE IN CYCLES
(SLOW ROTATION < 10 RPM OR OSCILLATION GREATER THAN BALL SPACING)

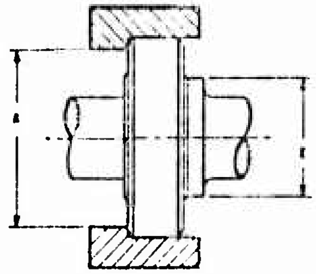
BEARING	BALL DIAMETER	NO.	LIMIT MOMENT, IN-LB	MOMENT CONSTANT 1/INCH	APPROX. WEIGHT LBS
KP3A	[illegible]	[illegible]	[illegible] 6	12.10	.01
KP4A	[illegible]	[illegible]	[illegible] 6	10.25	.02
KP5A	[illegible]	[illegible]	114.0	8.75	.02
KP6A	[illegible]	[illegible]	[illegible]	7.46	[illegible]
KP8A	[illegible]	16	[illegible]	6.15	[illegible]
KP10A	[illegible]	14	[illegible]	5.02	[illegible]
KP12A	[illegible]	15	[illegible]	4.13	13
KP16A	[illegible]	17	[illegible]	3.25	22
KP20A	[illegible]	[illegible]	[illegible]	2.81	26

SHAFT AND HOUSING SHOULDER DIAMETERS

BEARING	A, MAX., IN	B, MIN., IN
KP3A	.520	.292
KP4A	.620	.375
KP5A	.664	.415
KP6A	.754	.496
KP8A	.976	[illegible]
KP10A	1.214	.758
KP12A	1.444	.919
KP16A	1.764	1.241
KP20A	2.026	1.478

SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

BEARING	O.D., INCHES	STEEL HOUSING BORE, IN	ALUMINUM HOUSING BORE, IN	SHAFT DIAMETER
KP3A	[illegible] - .6245	[illegible]	[illegible]	[illegible]
KP4A	[illegible]	[illegible]	[illegible]	[illegible]
KP5A	[illegible]	[illegible]	[illegible]	[illegible]
KP6A	[illegible]	[illegible]	[illegible]	.3745 - .374
KP8A	[illegible] - 1.1245	[illegible]	[illegible]	[illegible]
KP10A	[illegible]	[illegible]	[illegible]	[illegible]
KP12A	[illegible]	[illegible]	[illegible]	[illegible]
KP16A	[illegible]	[illegible]	[illegible]	[illegible]
KP20A	[illegible]	[illegible]	[illegible]	[illegible]

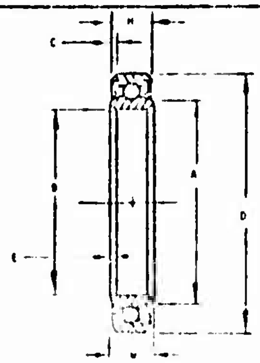


USAGE & APPLICATION DATA

MS27641 BEARINGS ARE USED IN LIGHT DUTY APPLICATIONS. THEY CAN TAKE EITHER RADIAL OR THRUST LOADS BUT SHOULD NOT BE USED IN APPLICATIONS WHERE MISALIGNMENT OVER 1/4° IS EXPECTED.

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 2(3) (Sheet 1 of 2 Sheets) Extra-Light Duty Ball Bearings (MS27642)



RADIAL AND LATERAL ECCENTRICITIES:				
SIZES (Inclusive)	RADIAL ECCENTRICITIES		LATERAL ECCENTRICITIES	
	[illegible]	[illegible]	[illegible]	[illegible]
16 - 45	.0010	.0016	.0010	[illegible]
52 - 72	.0012	.0016	.0010	[illegible]
76 - 92	.0014	.0018	.0012	[illegible]
96	.0014	.0020	.0016	.0020

MS DASH NO	MFG PART NO	B BORE (e) +.0000 -.00[illegible]	D OUTSIDE DIAMETER (a) +.0000 -.0010	W WIDTH INNER RING (a) +.000 -.005	H WIDTH OUTER RING (a) +.000 -.005	A [illegible]	E AND C INNER & OUTER RING CORNER CHAMFER x 45°	RADIAL CLEARANCE	RADIAL LIMIT LOAD RATING	[illegible]	[illegible]	[illegible]	[illegible]
-16	[illegible]	[illegible]	[illegible]			[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-21	[illegible]	[illegible]	2.?25	.437	.375	[illegible]	.02?	3 TO [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-23	[illegible]	[illegible]	2.[illegible]			1.575			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-25	[illegible]	[illegible]	2.31[illegible]			[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-29	[illegible]	[illegible]	2.[illegible]	.437	.375	[illegible]	.02?	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-31	[illegible]	[illegible]	2.[illegible]			[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-37	[illegible]	[illegible]	[illegible]			[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-4?	[illegible]	[illegible]	3.[illegible]	.531	.469	3.[illegible]	.039	3 TO 10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-49	[illegible]	3.?530	4.0000			3.222			22500	[illegible]	[illegible]	[illegible]	[illegible]
-52	[illegible]	[illegible]	4.1875			3.[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-56	[illegible]	3.[illegible]	4.4375	.531	.469	3.[illegible]	.039	3 TO ?5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-60	[illegible]	[illegible]	4.6875			4.014			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-64	[illegible]	[illegible]	4.9375	.531	.469	4.2[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-68	[illegible]	[illegible]	5.[illegible]	.593	.531	4.[illegible]	.039	3 TO ?5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-72	[illegible]	[illegible]	5.5625			4.774			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-76	[illegible]	[illegible]	5.8125			5.046			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-80	[illegible]	[illegible]	6.06??	.593	.531	5.?46	.039	3 TO 15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-84	[illegible]	[illegible]	6.3125			5.5?6			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-88	[illegible]	[illegible]	6.5625			5.[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-92	[illegible]	[illegible]	6.8125	.593	.531	[illegible]	.039	3 TO ?5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-96	[illegible]	6.[illegible]	7.0625			6.301			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

** +.0000 -.0005

(a) ALL DIMENSIONS TO BE MET AFTER PLATING.
(b) OUT-OF-ROUND TOLERANCES, BORE: +.0003, -.0013 THRU -49, +.0005 -.0015 THRU -96
OUTER DIA.: +.0010, -.0020
(c) A RADIUS GIVING APPROXIMATELY THE SAME GRIP FOR STAKING THE BEARING IN THE HOUSING WILL BE ACCEPTABLE
(d) A RADIUS GIVING APPROXIMATELY THE SAME FILLET CLEARANCE WILL BE ACCEPTABLE
(e) CASE I = LOAD FIXED WITH RESPECT TO OUTER RACE.
CASE II = LOAD FIXED WITH RESPECT TO INNER RACE.
(f) THESE RATINGS ARE FOR OPERATION UP TO 250° F MAX. WHEN SUBJECTED TO OPERATION AT 300° F, THE RATINGS SHOULD BE REDUCED BY 20%.

1. MATERIALS RINGS, STEEL, FED-STD-66, E52100
BALLS, STEEL, FED-STD-66, E52100 or E52100
2. SEALS, POLYTETRAFLUOROETHYLENE PER AMS[illegible] OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER AMS[illegible]
3. SEAL RETAINERS, STEEL, CORROSION RESISTANT
4. LUBRICANT MIL-G-81322, FILLED ?? MIN
5. HARDNESS HEAT TREAT RINGS AND BALLS TO ROCKWELL "C" 60 TO 66 AND STABILIZED FOR OPERATION AT ???°F.
6. SURFACE ROUGHNESS RACEWAYS AND BALLS - 8 MICROINCHES AA PER ASA B46.1.
7. PLATING ALL EXTERNAL SURFACES EXCEPT BORE, AND SEAL RETAINERS, CADMIUM PLATED PER QQ-P-416, TYPE I, CLASS 2.

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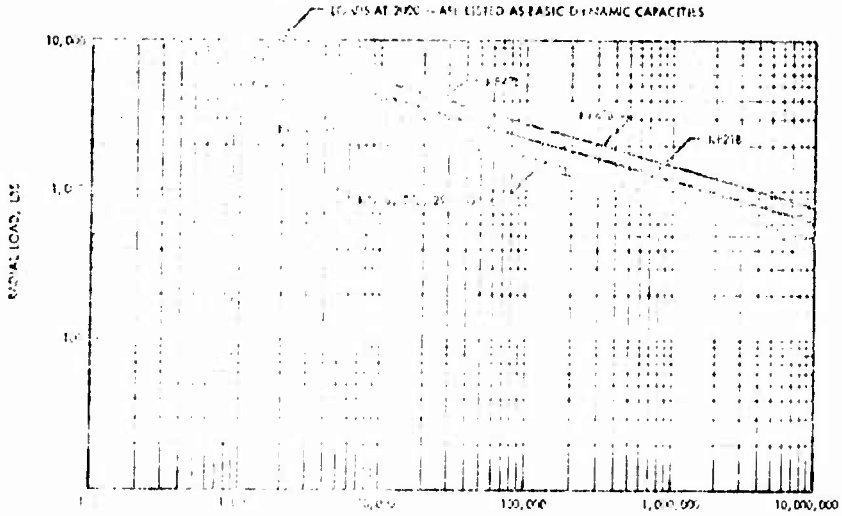
SUB-NOTE 2(3) (Sheet 2 of 2 Sheets) Extra-Light Duty Ball Bearings (MS27642)



DATA FOR [illegible]

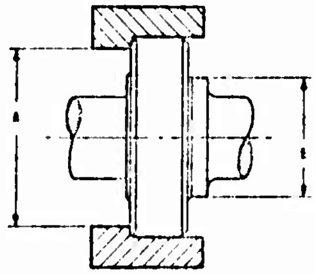
BEARING	BALL DIAMETER	[illegible]	[illegible]	[illegible]	APPROX WEIGHT, LB
[illegible]	[illegible]	[illegible]	1	[illegible]	15
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17
[illegible]	[illegible]	[illegible]	1	[illegible]	15
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2
KP27B	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1.45	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	53

SHAFT AND HOUSING SHOULDER DIAMETERS

BEARING	A, MAX, IN.	B, MIN, IN.
KP21B	1.874	1.454
KP23B	2.016	1.574
KP25B	2.132	1.673
KP27B	2.372	1.931
KP31B	2.472	2.231
KP37B	2.910	2.462
KP47B	3.600	2.970
KP45B	3.766	3.222

SHAFT AND [illegible] (OSCILLATORY [illegible])

BEARING	O.D., INCHES	[illegible]	[illegible]	SHAFT DIAMETER,* IN.
[illegible]	[illegible]	[illegible]	[illegible]	1.3127-1.3110
[illegible]	[illegible]	[illegible]		[illegible]
KP25B	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]		[illegible]
KP37B	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]		2.9170-2.[illegible]
[illegible]	4.0[illegible]	[illegible]		3.0620-3.0[illegible]

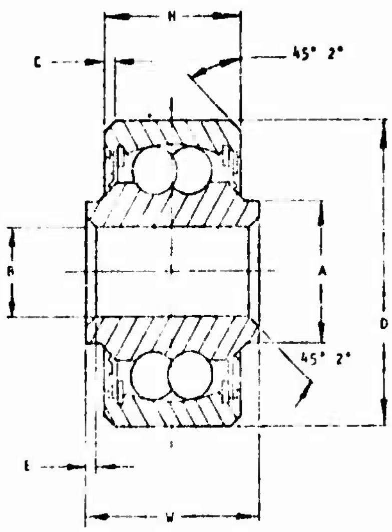


USAGE & APPLICATION DATA

[illegible] APPLICATIONS ON SHAFTS OF LARGE [illegible] RADIAL OR THRUST LOADS BUT SHOULD BE USED IF [illegible]

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 2(4) (Sheet 1 of 2 Sheets) Double-Row Heavy Duty Self-Aligning Ball Bearings (MS27643)



MS DASH NO.	MFG P/N	B BORE (b)	D OUTSIDE DIAMETER (c) (d) +.0000 -.0005	W WIDTH INNER RING	H WIDTH OUTER RING	A SHOULDER DIAMETER INNER RING	C CORNER CHAMFER 45° (a) OUTER RACE +.015 -.020	E CORNER CHAMFER 45° (b) INNER RACE +.015 -.020	LIMIT LOAD RATING RADIAL LB	LIMIT LOAD RATING THRUST LB	AXIAL PLAY INCH (MAX)	(f) RADIAL LOAD RATING (LBS) FOR AVERAGE LIFE OF 10,000 COMPLETE 90° CYCLES (e) CASE I	(e) CASE II	WEIGHT POUNDS (APPROX)
-3	[illegible]	[illegible]	[illegible]	[illegible]	.392	[illegible]	.022	.005	1420	[illegible]	.0055	[illegible]	[illegible]	.04
-4	[illegible]	[illegible]	[illegible]	[illegible]	.444	[illegible]	.032	.005	1280	[illegible]	.006	1250	[illegible]	.06
-5	[illegible]	[illegible]	1.2500	.812	.656	.515	.032	.015	3740	600	.006	3760	3300	.16
-6	[illegible]	.3750	1.4375	.937	.750	.564	.032	.015	5100	[illegible]	.006	[illegible]	4370	.24
-8	[illegible]	[illegible]	1.6875	[illegible]	.812	.775	.044	.015	7120	1000		6240	5570	.36
-10	[illegible]	[illegible]	1.9375	1.125	.937	.869	.044	.015	9000	1300	.007	[illegible]	[illegible]	.53

THESE BEARINGS ARE INTERNAL SELF-ALIGNING FOR 10° IN EITHER DIRECTION.

(a) A RADIUS GIVING APPROXIMATELY THE SAME GRIP FOR STAKING THE BEARING IN THE HOUSING WILL BE ACCEPTABLE.
(b) A RADIUS GIVING APPROXIMATELY THE SAME FILLET CLEARANCE WILL BE ACCEPTABLE.
(c) DIMENSIONS TO BE MET AFTER PLATING.
(d) OUT-OF-ROUND TOLERANCES BORE +.0002, -.0007
OUTSIDE DIA. +.0005, -.0010
(e) CASE I = LOAD FIXED WITH RESPECT TO OUTER RACE.
CASE II = LOAD FIXED WITH RESPECT TO INNER RACE.
(f) THESE RATINGS ARE FOR OPERATION UP TO 250°F MAX. WHEN SUBJECTED TO OPERATION AT 350° F, THE RATINGS SHOULD BE REDUCED BY 20%.

1. MATERIALS: RINGS; STEEL, FED-STD-66, E52100
BALLS, STEEL, FED-STD-66, E51100 OR E52100.
2. SEALS; POLYTETRAFLUOROETHYLENE PER AMS3652 OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER AMS 3666.
3. SEAL RETAINERS, STEEL, CORROSION RESISTANT
4. LUBRICANT; MIL-G-81322 FILLED 80% MIN.

5. HARDNESS: HEAT TREAT RINGS AND BALLS TO ROCKWELL "C" 60 TO 66 AND STABILIZED FOR OPERATION AT 250°F.
6. SURFACE ROUGHNESS: RACEWAYS NOT EXCEEDING 8 MICROINCHES, AA PER ANSI B46.1.
7. PLATING: ALL EXTERNAL STEEL SURFACES EXCEPT BORE OF INNER RACE, AND SEAL RETAINER, CADMIUM PLATE, QQ-P-416, TYPE I, CLASS 2

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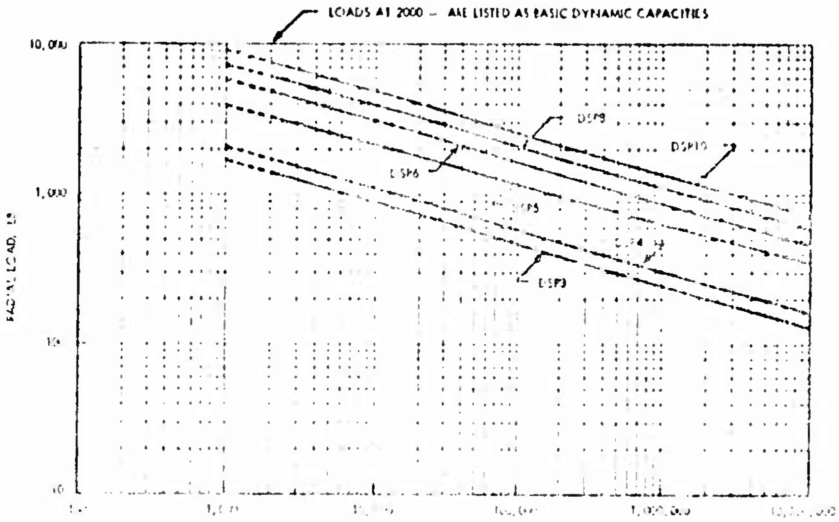
SUB-NOTE 2(4) (Sheet 2 of 2 Sheets) Double-Row Heavy Duty Self-Aligning Ball Bearings (MS27643)

INNER RACE MOVING

(WHEN OUTER RACE IS MOVING, DIVIDE RADIAL LOADS BY 1.20)



LIFE IN CYCLES

(SLOW ROTATION <100 RPM OR OSCILLATION GREATER THAN BALL SPACING)

DATA FROM TYPICAL MS 27643 SERIES BEARING

BEARING	BALL DIA. [illegible]	NO.	RADIAL LOAD RATING* [illegible] OUTER RACE MOVING	INNER RACE MOVING	APPROX. WT., LBS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.04
[illegible]	[illegible]	[illegible]	[illegible]	1740	.07
[illegible]	[illegible]	[illegible]	[illegible]	3740	.16
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.24
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.36
[illegible]	[illegible]	[illegible]	[illegible]	7790	.51

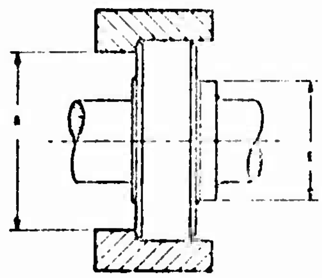
*ALSO CALLED BASIC DYNAMIC CAPACITIES

SHAFT AND HOUSING SHOULDER DIAMETER

BEARING	A, MAX., IN.	B, [illegible] IN.
DSP3	.610	[illegible]
DSP4	.772	[illegible]
DSP5	.924	.515
DSP6	1.166	[illegible]
DSP8	1.430	[illegible]
DSP10	1.618	[illegible]

SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

BEARING	O.D. [illegible]	[illegible] HOUSING BORE, IN.	[illegible] HOUSING BORE, IN.	SHAFT DIAMETER
DSP3	[illegible]	.7729-.7744	[illegible]	[illegible]
DSP4	.9214-[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.2[illegible]	[illegible]	1.2[illegible]	[illegible]
[illegible]	1.4375-1.4[illegible]	1.4[illegible]-1.4[illegible]	1.4[illegible]-1.4[illegible]	.3745-.3740
[illegible]	1.6[illegible]	1.6[illegible]	1.6[illegible]	[illegible]
[illegible]	1.[illegible]	1.[illegible]-1.[illegible]	1.[illegible]-1.[illegible]	.6245-.6240

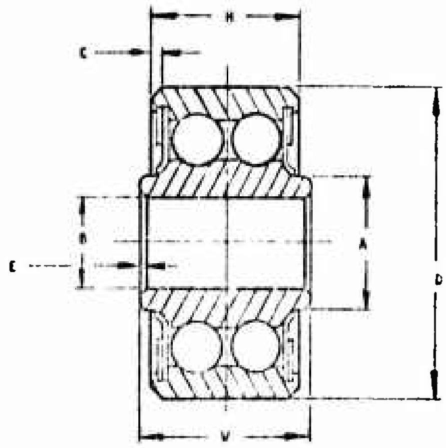


USAGE & APPLICATION DATA

THE MS27643 SERIES ARE HEAVY DUTY DOUBLE ROW BALL BEARINGS CAPABLE OF MISALIGNMENT

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 2(5) (Sheet 1 of 2 Sheets) Double-Row Heavy Duty Ball Bearings (MS27644)



MS DASH NO.	MRC PART NO.	B BORE (b) +.0000 -.0005	D OUTSIDE DIAMETER (b)	W WIDTH INNER RING (b)	V WIDTH OUTER RING (b)	A SHOULDER DIAMETER INNER RING	C CORNER CHAMFER x 45° (c) INNER RING BORE +.015-.000	E (c) OUTER RING O.D. +.015-.000	AXIAL PLAY INCH (MAX)	RADIAL LIMIT LOAD RATING LBS.	THRUST LIMIT LOAD RATING LBS.	(f) RADIAL LOAD RATING (LBS.) FOR AVERAGE LIFE OF 10,000 COMPLETE 90° CYCLES (e) CASE I	(e) CASE II	WEIGHT POUNDS (APPROX)
(g)-3	DPP3	.1900	.7774	.495	.473	.302	.005	.018	.005	2950	1700	2550	2830	.04
(h)-4	DPP4	.2500	[illegible]	.620	[illegible]	.410				5370	1800	3550	3020	.06
(g)-5	DPP5	.3125	1.2500	.745	.657	.469		.032	.006	11000	4000	7360	6250	.17
(g)-6	DPP6	.3750	1.4375	.870	[illegible]	.551	.015			15700	5300	9690	8120	.26
-8	DPP8	[illegible]	[illegible]	.932	.816	.735		.044	.007	23500	7800	14100	11600	.36
-10	DPP10	[illegible]	1.5372	.995	.927	.850				28400	9400	15300	13100	.53

(a) ALL DIMENSIONS TO BE MET AFTER PLATING.
(b) OUT OF ROUND TOLERANCES, BORE +.0002, -.0002
OUTER DIA. +.0005, -.0015
(c) A RADIUS GIVING APPROXIMATELY THE SAME CAVITY FOR STAKING THE BEARING IN THE HOUSING WILL BE ACCEPTABLE.
(d) A RADIUS GIVING APPROXIMATELY THE SAME FILLET CLEARANCE WILL BE ACCEPTABLE.
(e) CASE I = LOAD FIXED WITH RESPECT TO OUTER RACE.
CASE II = LOAD FIXED WITH RESPECT TO INNER RACE.
(f) THESE RATINGS ARE FOR OPERATION UP TO 250°F MAX. WHEN SUBJECTED TO OPERATION AT 350° F, THE RATINGS SHOULD BE REDUCED BY 20%.
(g) BOLTS OF 150,000 PSI TENSILE STRENGTH ARE REQUIRED TO DEVELOP THE RADIAL LIMIT LOAD SHOWN.
(h) BOLTS OF 160,000 PSI TENSILE STRENGTH ARE REQUIRED TO DEVELOP THE RADIAL LIMIT LOAD SHOWN.

1. MATERIALS RINGS, STEEL, FED-STD-66, E52100
BALLS, STEEL, FED-STD-66, E51100 or E52100
2. SEALS, POLYTETRAFLUOROETHYLENE PER AMS3652 or POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER AMS3666-
3. SEAL RETAINERS, STEEL, CORROSION RESISTANT
4. LUBRICANT, MIL-G-81322, FILLED 80% MIN.

5. HARDNESS HEAT TREATMENT: HEAT TREAT RINGS AND BALLS TO ROCKWELL "C" 60 TO 66 AND STABILIZED FOR OPERATION AT 250°F.

6. SURFACE ROUGHNESS: RACEWAYS AND BALLS - 8 MICROINCHES AS PER ANSI B46.1.

7. PLATING: ALL EXTERNAL SURFACES EXCEPT BORE, AND SEAL RETAINERS, CADMIUM PLATED PER QQ-P-416, TYPE I, CLASS 2.

8. RADIAL AND LATERAL ECCENTRICITY: INNER RACE 0.0010"
OUTER RACE 0.0010"

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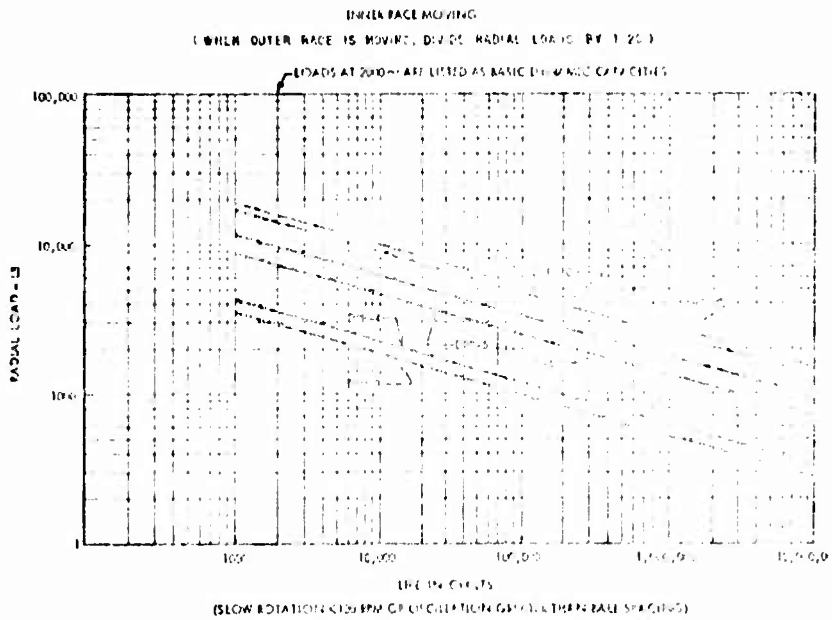
SUB-NOTE 2(5) (Sheet 2 of 2 Sheets) Double-Row Heavy Duty Ball Bearings (MS27644)



DATA FROM TYPICAL MS 27644 SERIES BEARINGS

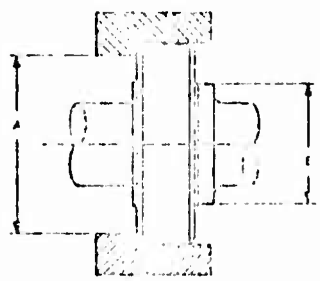
BEARING	BALL DIAMETER	NO.	LIMIT MOMENT, [illegible]	MOMENT CONSTANT, [illegible]	APPROX. WEIGHT, LB
DPP3	[illegible]/32	2[illegible]	33.3	44.4	.04
DPP4	[illegible]	22	[illegible]	[illegible]	[illegible]
DPP5	1/4 - 15/64	2[illegible]	[illegible]	[illegible]	.1[illegible]
DPP6	5/16 - 9/32	[illegible]	2[illegible]	19.[illegible]	.2[illegible]
DPP8	11/32	2[illegible]	[illegible]	[illegible]	.3[illegible]
DPP10	11/32	24	[illegible]	5.[illegible]	.53

[illegible]

BEARING	A, MAX., IN.	B, MIN., IN.
DPP3	.4[illegible]	.2[illegible]
DPP4	.71	[illegible]
DPP5	1.[illegible]	.45[illegible]
DPP6	1.2[illegible]	.551
DPP8	1.4[illegible]	.7[illegible]
DPP10	1.6[illegible]	.820

SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

BEARING	O.D., INCHES	STEEL HOUSING BORE, IN.	AL OR MG HOUSING BORE, IN.	SHAFT [illegible]
DPP3	.7774	.7769-.7764	[illegible]-.7762	[illegible]
DPP4	.9[illegible]	[illegible]	[illegible]	.24[illegible]
DPP5	1.2[illegible]	[illegible]-1.2495	1.1243-1.1234	.312[illegible]-.3115
DPP6	1.4[illegible]75	[illegible]	1.43[illegible]	[illegible]
DPP8	1.6[illegible]5	[illegible]	1.6[illegible]	.4[illegible]
DPP10	1.5[illegible]	[illegible]	1.93[illegible]-1.9[illegible]	.6245-.6240

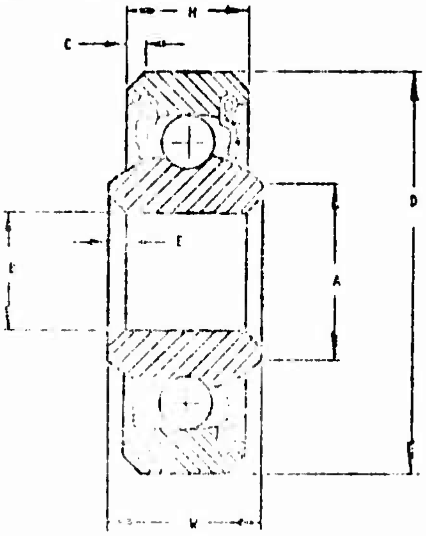


USAGE & APPLICATION DATA

DPP SERIES BEARINGS ARE USED IN APPLICATIONS WHERE RADIAL LOADS ARE LARGE AND MISALIGNMENT LESS THAN [illegible]. THEY CAN [illegible] STATIC THRUST LOADS BUT SHOULD NOT BE USED WHEN DYNAMIC THRUST LOADS ARE ENCOUNTERED.

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 2(6) (Sheet 1 of 2 Sheets) Self-Aligning Ball Bearings (MS27645)



MS DASH NO	MFG P/N	BORE (B) [illegible]	OUTER [illegible] (a) (b) [illegible]	[illegible]	[illegible]	[illegible] DIA [illegible]	[illegible] RATING [illegible]	(c) [illegible]	RADIAL LIMIT LOAD RATING LBS	THRUST LIMIT LOAD RATING LBS	(f) RADIAL LOAD RATING (LBS) FOR AVERAGE LIFE 10,000 COMPLETE 90° CYCLES (e) CASE I	(e) CASE II	AXIAL PLAY INCH (MAX)	WEIGHT POUNDS (APPROX.)
-3A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			550	150	550	480	.023	.01
-4A	KSP4A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.005	.016	900	200	900	770	.025	.02
-5A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.015		1000		950	815	.026	
-6A	[illegible]	[illegible]	.87	.313	[illegible]	[illegible]	.030		1120		1120	990	.030	.03
-3	KSP3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.005	.022	900		900	770	.023	
-4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.032	1410	300	1230	1230	.025	.04
-5	KSP5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			2100		2190	1800	.028	.10
-6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.015		2950	400	2980	2540	.030	.15
-8	KSP8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.034	3670	500	3670	3050	.032	.23
-10	KSP10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			5320	600	4580	4360	.034	.37

THESE BEARINGS ARE SELF-ALIGNING FOR 10° IN EITHER DIRECTION EXCEPT MS-4A, -5A, and -6A WHICH ARE SELF ALIGNING FOR 8° IN EITHER DIRECTION

(a) ALL DIMENSIONS TO BE MET AFTER PLATING
(b) OUT-OF-ROUND [illegible] + .0005, -.0010, [illegible] DIA [illegible] -.0010
(c) A RADIUS [illegible] FOR STAKING THE BEARING IN THE HOUSING WILL BE ACCEPTABLE.
(d) A RADIUS [illegible] FILLET CLEARANCE WILL BE ACCEPTABLE.
(e) CASE I = [illegible]
CASE II = [illegible]
(f) THESE RATINGS [illegible] 250°F MAX. WHEN SUBJECTED TO OPERATION AT 350° F, THE RATING SHOULD BE REDUCED BY 2

1. MATERIALS: RINGS, STEEL, [illegible] E52100
BALLS, STEEL, [illegible] E52100
2. SEALS, [illegible] AMS3652 OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED [illegible]
3. SEAL RETAINER, STEEL CORROSION RESISTANT
4. [illegible] MIN
5. HARDNESS: [illegible] RINGS AND BALLS TO ROCKWELL "C" 60 TO 66 AND STABILIZED FOR OPERATION AT 250°F.
6. SURFACE [illegible] AA PER ASA B46.1.
7. PLATING: ALL EXTERNAL SURFACES [illegible] AND SEAL RETAINER, CADMIUM PLATED PER QQ-P-416, TYPE I, CLASS 2.

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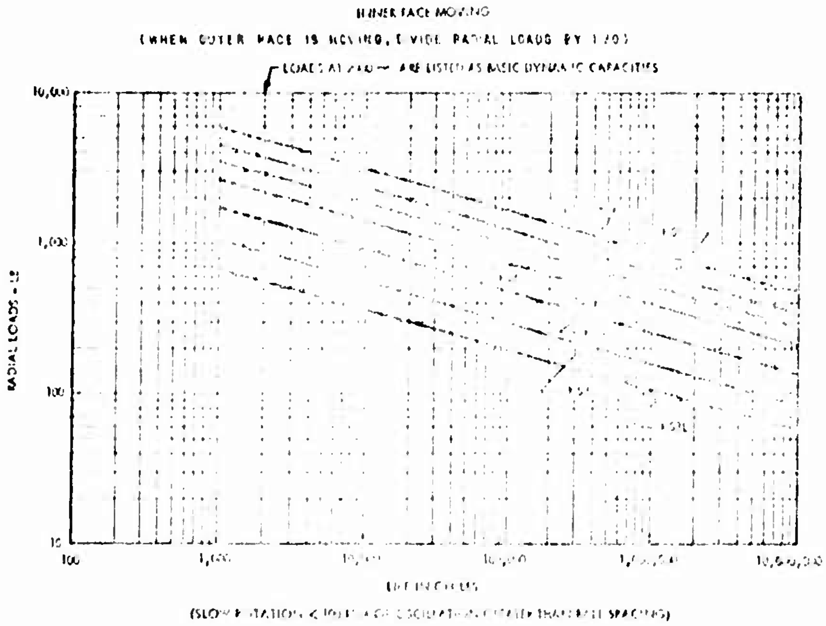
SUB-NOTE 2(6) (Sheet 2 of 2 Sheets) Self-Aligning Ball Bearings (MS27645)



DATA FROM TYPICAL MS27645 SERIES BEARING

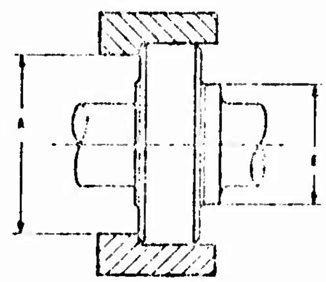
BEARING	BALL DIAMETER	NO.	BASIC ... RATING [illegible]	[illegible]	APPROX WEIGHT LB.
KSP3L	3/32	13	[illegible]	[illegible]	[illegible]
KSP4A	1/8	12	[illegible]	[illegible]	.02
KSP5A	1/8	14	[illegible]	[illegible]	.02
KSP6A	1/8	[illegible]	[illegible]	[illegible]	.03
KSP3	1/8	[illegible]	[illegible]	770	.03
KSP4	9/64	13	[illegible]	[illegible]	.04
KSP5	3/16	13	[illegible]	[illegible]	.10
KSP6	7/32	11	[illegible]	[illegible]	.15
KSP8	7/32	16	[illegible]	[illegible]	.21
KSP10	9/32	14	[illegible]	[illegible]	.32

SHAFT AND HOUSING SHOULDER DIAMETERS

BEARING	A MAX., IN.	B MAX., IN.
KSP3L	.514	.250
KSP4A	.702	.340
KSP5A	1.050	[illegible]
KSP6A	1.242	.550
KSP3	[illegible]	[illegible]
KSP4	.732	[illegible]
KSP5	1.050	[illegible]
KSP6	1.202	[illegible]
KSP8	[illegible]	.724
KSP10	[illegible]	.815

SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

BEARING	O.D., INCHES	STEEL HOUSING BORE, IN.	ALUMINUM HOUSING BORE, IN.	SHAFT DIAMETER
KSP3L	[illegible]	[illegible]	[illegible]	[illegible]
KSP4A	[illegible]	[illegible]	[illegible]	[illegible]
KSP5A	[illegible]	[illegible]	[illegible]	.3120-.3115
KSP6A	[illegible]	[illegible]	[illegible]	[illegible]
KSP3	[illegible]	[illegible]	[illegible]	[illegible]
KSP4	[illegible]	[illegible]	[illegible]	[illegible]
KSP5	1.2500-1.2497	[illegible]	[illegible]	[illegible]
KSP6	[illegible]	[illegible]	[illegible]	[illegible]
KSP8	[illegible]	[illegible]	[illegible]	[illegible]
KSP10	[illegible]	[illegible]	[illegible]	[illegible]

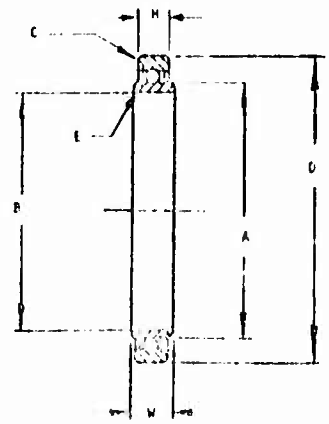


USAGE & APPLICATION DATA

MS27645 SERIES BEARINGS ARE INTENDED FOR LIGHT DUTY APPLICATIONS WHERE MISALIGNMENT IS EXPECTED. THEY CAN HANDLE RADIAL AND THRUST LOADS.

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 2(7) Extra Light Duty Ball Bearings (MS27646)



MS DASH NO.	[illegible]	B BORE (a) +.0000 -.0002	D OUTSIDE DIAMETER (a) (b)	W WIDTH (a)	F WIDTH OUTER RING (a) +.000 -.005	A SHOULDER DIAMETER INNER RING APPROX.	E AND C CORNER CHAMFER X 45° (c) (e) +.000 -.010	RADIAL LIMIT LOAD RATING LBS.	THRUST LIMIT LOAD RATING LBS.	(f) RADIAL LOAD RATING LBS. FOR AVERAGE LIFE OF 10,000 COMPLETE 90° CYCLES (d) CASE I	(e) CASE II	WEIGHT POUNDS (APPROX)
[illegible]	[illegible]	[illegible]	[illegible]	.281	.250	.777	.015	[illegible]	1500	[illegible]	[illegible]	.03
[illegible]	[illegible]	[illegible]	[illegible]			.826		3750	1700	2050	[illegible]	.04
[illegible]	[illegible]	[illegible]	[illegible]			1.016		[illegible]	1900	2110	1970	.05
-41	[illegible]	[illegible]	[illegible]			1.210		5000	2200	2170	[illegible]	.05
[illegible]	[illegible]	[illegible]	[illegible]			1.451		5550	2700	2270	2130	.09
-43	[illegible]	[illegible]	[illegible]			[illegible]		[illegible]	3200	2260	2180	.10
[illegible]	[illegible]	[illegible]	[illegible]			[illegible]		7950	3600	2300	2220	.11
[illegible]	[illegible]	[illegible]	[illegible]			2.268		9220	4000	2340	2260	.15
[illegible]	[illegible]	[illegible]	[illegible]			[illegible]		10150	4400	2360	2280	.17

* [illegible] ** [illegible]
-.0010 -.0015

(a) ALL DIMENSIONS TO BE MET AFTER PLATING.
(b) A RADIUS GIVING [illegible] THE SAME GRIP FOR STAKING THE BEARING IN THE HOUSING WILL BE ACCEPTABLE.
(c) A RADIUS GIVING [illegible] THE SAME FILLET CLEARANCE WILL BE ACCEPTABLE.
(d) CASE I [illegible] WITH RESPECT TO OUTER FACE.
(e) CASE II [illegible] WITH RESPECT TO INNER FACE.
(f) THESE RATINGS ARE FOR OPERATION UP TO 250° F MAX. WHEN SUBJECTED TO OPERATION AT 350° F, THE RATINGS SHOULD BE REDUCED BY 25%.

1. MATERIALS: RINGS; STEEL, [illegible] 52100
BALLS; STEEL, [illegible] 52100 OR [illegible] 52100
2. SEALS, POLYTETRAFLUOROETHYLENE PER AMS3652 OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER AMS3656.
3. LUBRICANT, MIL-G-81322, FILLED 80% MIN.

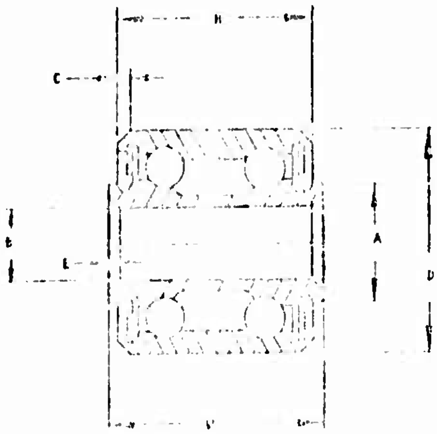
4. HARDNESS: HEAT TREAT RINGS AND BALLS TO ROCKWELL "C" 60 TO 66 AND STABILIZED FOR OPERATION AT 250°F.

5. SURFACE ROUGHNESS: RACEWAYS AND BALLS - 8 MICROINCHES AA PER ANSI B46.1.
6. PLATING: ALL EXTERNAL SURFACES EXCEPT BORE, AND SEAL RETAINERS, CADMIUM PLATED PER QQ-P-416, TYPE I, CLASS 2.

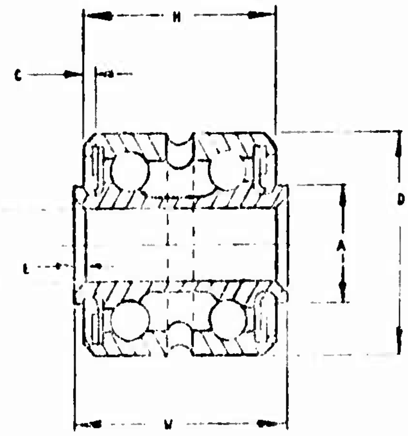
7. INTERNAL RADIAL CLEARANCE: [illegible] TO .0018
8. RADIAL AND LATERAL ECCENTRICITY: INNER RING .0020
OUTER RING .0016

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 2(8) Extra Wide, Double-Row Intermediate Duty Ball Bearings (MS27647)



DW - WITHOUT [illegible] GROOVE



DGW - WITH RELUBRICATION GROOVE

MS DASH NO.	P/N BEARING CODE WITHOUT	P/N BEARING CODE WITH	B BORE (b) +.0000 -.0005	D OUTSIDE DIAMETER (a) (b) +.0000 -.0005	W WIDTH OUTER RING (a) +.000 -.005	W WIDTH INNER RING (a) +.000 -.005	A DIAMETER INNER RING (MIN.)	E FILLET CHAMFER X 45° (d) INNER RING BORE +.015 -.000	C FILLET CHAMFER X 45° (c) OUTER RING O.D. +.015 -.000	RADIAL LIMIT LOAD RATING LBS.	THRUST LIMIT LOAD RATING LBS.	(f) RADIAL LOAD RATING (LBS.) FOR AVERAGE LIFE OF 10,000 COMPLETE 90° CYCLES (e) CASE I	(e) CASE II	WEIGHT POUNDS APPROX.
-4A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			1400	500	1050	[illegible]	.025
[illegible]	DW[illegible]	[illegible]	[illegible]	[illegible]	.875	[illegible]	.430			2730	900	2070	1850	.04
-5	DW5	[illegible]	.31[illegible]	[illegible]	.938	.813	.456	.035	.016	5140	1600	2600	2320	.07
-6	DW6	[illegible]	[illegible]	1.[illegible]	1.1[illegible]	1.063	.570			8450	2600	4220	3740	.12
-8	DW8	[illegible]	[illegible]	1.4[illegible]	1.5[illegible]	1.375	.709		.032	15570	4700	7610	6570	.29

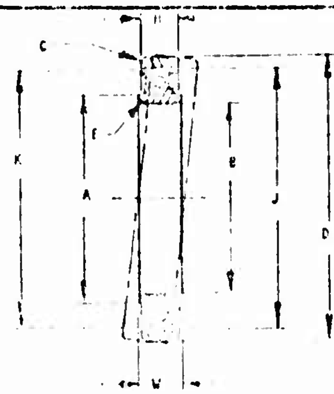
(a) ALL DIMENSIONS [illegible] AFTER PLATING.
(b) OUT-OF-ROUND [illegible] +.0002, -.0007
OUTER [illegible] +.0015, -.0010
(c) A [illegible] GIVING [illegible] THE SAME GRIP FOR STAKING THE BEARING IN THE HOUSING WILL BE ACCEPTABLE.
(d) A [illegible] THE SAME FILLET CLEARANCE WILL BE ACCEPTABLE.
(e) CASE I = [illegible] TO OUTER RACE.
CASE II = [illegible] TO INNER RACE.
(f) [illegible] TO 250°F MAX. WHEN SUBJECTED TO OPERATION AT 350° F, THE RATINGS SHOULD BE [illegible] BY 2.[illegible]

1. MATERIALS [illegible] STEEL, [illegible] 52100
BALLS, STEEL, [illegible] 52100 OR E52100
2. SEALS, [illegible] FER AMS [illegible] OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER AMS3666.
3. SEAL [illegible] STEEL, [illegible] RESISTANT
4. LUBRICANT, MIL-G-[illegible], FILLED 80% MIN
5. HARDENING: HEAT TREAT RINGS AND BALLS TO ROCKWELL "C" 60 TO 65 AND STABILIZED FOR OPERATION AT 250°F.
6. SURFACE [illegible] RACEWAYS AND BALLS - 6 MICROINCHES AA PER ANSI B46.1.
7. PLATING [illegible] ALL [illegible] SURFACES EXCEPT BORE, AND SEAL RETAINERS, CADMIUM PLATED PER QQ-P-416, TYPE I, CLASS 2.
8. INTERNAL AXIAL [illegible] .001 TO .003 INCH
9. RADIAL AND LATERAL [illegible] INNER RING .0010" MAX.
OUTER RING .0016" MAX.

NOTE. ADD LETTER "G" FOR GREASE GROOVE TYPE.

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 2(9) Externally Self-Aligning, Extra Light Duty Bearings (MS27648)



MS DASH NO.	BRG PART NO.	[illegible]	[illegible]	[illegible]	[illegible]	A [illegible]	E AND F [illegible]	K TO SHAFT COLLAR (REF)	J BRG CENTER O.D.	PERMISSIBLE MISALIGNMENT EITHER DIRECTION	RADIAL LIMIT LOAD RATING (LB)	THRUST LIMIT LOAD RATING (LB)	(f) RADIAL LOAD RATING (LBS.) FOR AVERAGE LIFE OF 10,000 COMPLETE 90° CYCLES (e) CASE I	(e) CASE II	WEIGHT POUNDS APPROX.
[illegible]	[illegible]					[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5200	3540	.18
-21	[illegible]					[illegible]	[illegible]	2.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.20
-23	[illegible]	[illegible]				[illegible]		2.145	[illegible].173	6°	10500	[illegible]	4650	4350	.22
[illegible]	[illegible]	[illegible]				1.453		2.2[illegible]	2.3[illegible]	5° 40'	11300	2300	4590	4420	.25
-29	[illegible]			[illegible]	[illegible]	1.531	.025	2.535	2.554	5°	12700	2600	4260	4230	.27
-33	[illegible]					[illegible].247		2.787	[illegible]	5°	14[illegible]	2860	4320	4630	.3[illegible]
-22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.039	3.[illegible]2	4° 30'	[illegible]	3[illegible]	4[illegible]0	46[illegible]	.33
-4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.033	3.[illegible]	3.[illegible]	4° 30'	24700	5[illegible]00	6600	6330	.64
[illegible]	[illegible]		[illegible]			3.[illegible]22		3.572	3.[illegible]	4°	27500	[illegible]	8150	7540	.69
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.572	3.5[illegible]	4°	27500	5500	8150	7840	.69

* [illegible] +0.000 -0.00[illegible]

(a) ALL [illegible] AFTER PLATING.
(b) [illegible] +.0003, -.0013
[illegible] DIA.: +.00[illegible], -.0020
(c) A RADIUS [illegible] APPROXIMATELY THE [illegible] FOR STAKING THE BEARING IN THE HOUSING WILL BE ACCEPTABLE.
(d) A RADIUS [illegible] FILLET CLEARANCE WILL BE ACCEPTABLE.
(e) CASE I - [illegible] OUTER RACE.
CASE II - [illegible] RESPECT TO [illegible] RACE.
(f) [illegible] 250° F MAX. WHEN SUBJECTED TO OPERATION AT 350° F, THE RATINGS SHOULD BE [illegible] BY 20%.

1. MATERIALS [illegible] STEEL, [illegible] E52100
[illegible] STEEL, [illegible] E52100
2. SEALS, POLYTE[illegible] OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER AMS3666.
3. SEAL RETAINERS: STEEL, CORROSION RESISTANT
4. LUBRICANT, MIL-G-21?22, FILLED [illegible] MIN.

5. HARDNESS: [illegible] HEAT TREAT [illegible] BALLS TO ROCKWELL "C" 60 TO 6[illegible] AND STABILIZED FOR OPERATION AT 250°F.

6. SURFACE ROUGHNESS [illegible] 8 MICROINCHES AA PER ASA B46.1.

7. PLATING ALL EXTERNAL SURFACES EXCEPT [illegible], ID OF SELF-ALIGNING OUTER RING AND OD OF OUTER RACE SEALS AND SEAL RETAINERS, CADMIUM PLATING PER [illegible], TYPE I, CLASS 2.
8 INTERNAL RADIAL CLEARANCE: [illegible] (DOES NOT INCLUDE RADIAL LOOSENESS BETWEEN BEARING OUTER RING AND SELF ALIGNING RING.)

Rational: Make title agree with MS title.

Comment: Picture seems to be in error, the self-aligning ring should not be shown tilted over same as bearing inner and outer ring.

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

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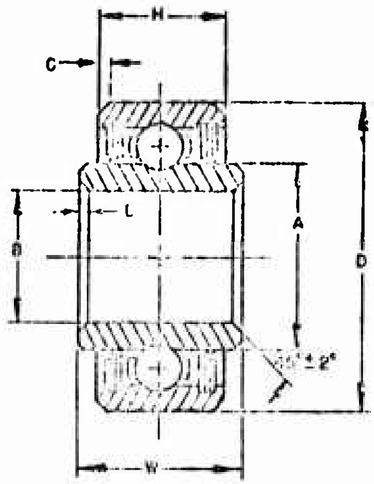
SUB-NOTE 2(10) Intermediate Duty High Temperature (-65° to +350°F) Ball Bearings (MS27649)



Dash No.	MFG Part No.	B	D	W	H	A Shoulder Diameter Inner Ring (Approx.)	E Inner Ring (b)	C Outer Ring (c)	Radial Limit Load (d) Rating Lbs.	Thrust Limit Load (d) Rating Lbs.	(e) Case I	(e) Case II	Weight Pounds (Approx.)
-3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.317	.005	.016	440	350	440	440	.015
-4	[illegible]	[illegible]	[illegible]	435	[illegible]	.415			510	410	510	510	.028
-5	[illegible]	.3125	[illegible]	[illegible]	[illegible]	.462	.015		800	640	800	800	.033
-6	[illegible]	.375	[illegible]	[illegible]	[illegible]	.520							.034
-8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.651			1310	1050	1310	1310	.075
-10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.848		.032	1790	1430	1790	1790	.119
-12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.052			2340	1870	2340	2340	.189
-16	[illegible]	[illegible]	[illegible]	.669	.562	1.334			2920	2340	2920	2920	.296
-20	[illegible]	[illegible]	[illegible]			1.615			3500	2800	3500	3270	.355

(a) OUT-OF-ROUND TOLERANCES, BORE: +.0002, -.0007
OUTER DIA.: +.0005, -.0010
(b) A RADIUS GIVING APPROXIMATELY THE SAME GRIP FOR STAKING THE BEARING IN THE HOUSING WILL BE ACCEPTABLE.
(c) A RADIUS GIVING APPROXIMATELY THE SAME FILLET CLEARANCE WILL BE ACCEPTABLE.
(d) LIMIT LOAD RATINGS SHOWN APPLY AT ROOM TEMPERATURE. THESE VALUES SHOULD BE REDUCED BY 15% FOR EACH 100°F INCREASE IN OPERATING TEMPERATURE. DYNAMIC RATINGS SHOULD BE REDUCED BY 20% FOR EACH 100°F INCREASE ABOVE 250°F.
(e) CASE I = LOAD FIXED WITH RESPECT TO OUTER RACE.
CASE II = LOAD FIXED WITH RESPECT TO INNER RACE.

1. MATERIALS: RINGS, 440C STAINLESS STEEL
BALLS, 440C STAINLESS STEEL
2. SEALS, POLYTETRAFLUOROETHYLENE PER AMS3652 OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER AMS3666.
3. SEAL RETAINERS, STEEL, CORROSION RESISTANT
4. LUBRICANT, MIL-G-81322, FILLED 60% MIN

5. HARDNESS: HEAT TREATMENT. HEAT TREAT RINGS AND BALLS TO ROCKWELL "C" 57 TO 63 AND STABILIZED FOR OPERATION AT 250°F.

6. SURFACE ROUGHNESS: RACEWAYS AND BALLS - 8 MICROINCHES AA PER ANSI B46.1.

7. INTERNAL RADIAL CLEARANCE: .0003 TO .0009 INCH

8. RADIAL AND LATERAL ECCENTRICITY: INNER RACE .0010"
OUTER RACE .0016"

Rationale: Temperature limit should be added to high temperature interference.

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

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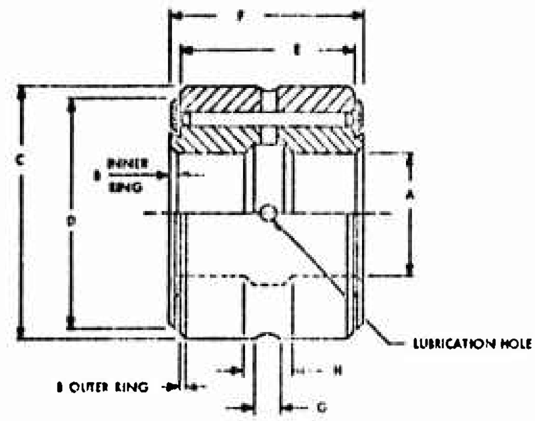
SUB-NOTE 3(1) (Sheet 1 of 2 Sheets) Heavy Duty Needle Bearings (MS24461)



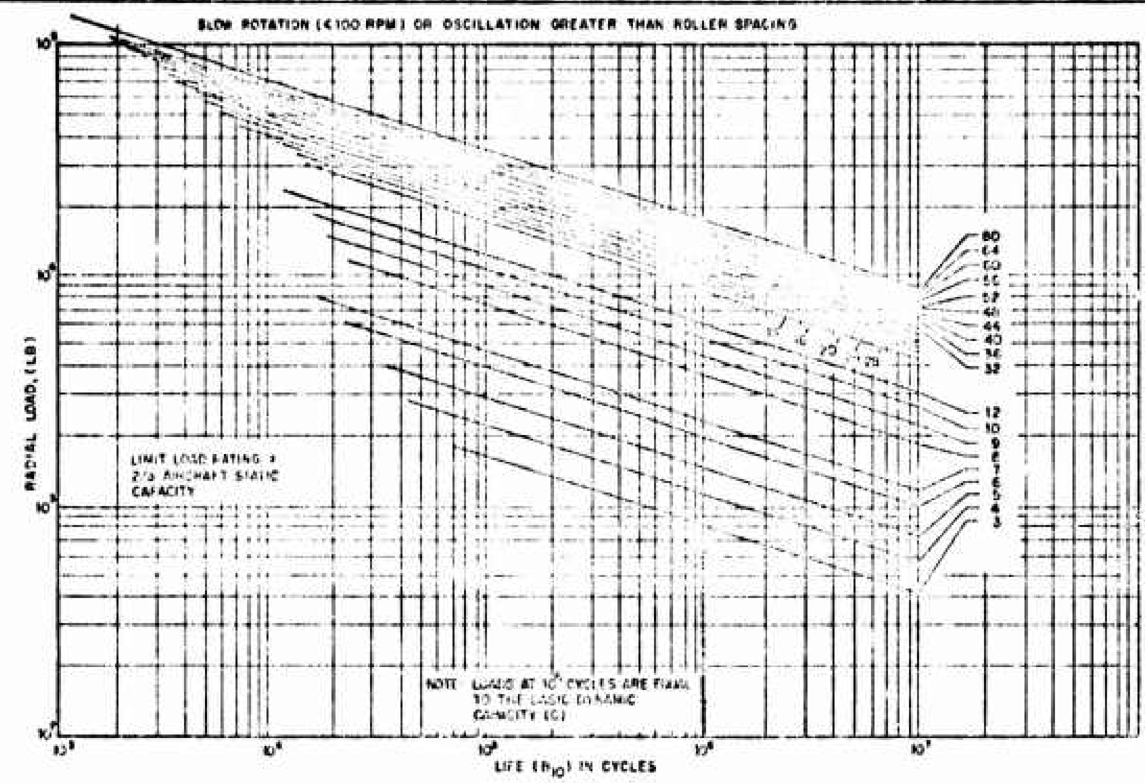
DASH NO.	A BORE INNER RACE	A tol.	B +.015 -.000 RAD OR 45° MAX BEVEL	C	C tol.	D ±.010	E +.000 -.005	F +.000 -.005	G ±.001	H +.000 -.062	CLAMPING MIN DIA	AIRCRAFT STATIC CAPACITY LB	WEIGHT LB APPROX	TOTAL RADIAL PLAY MAX
-3	.1900			.6875		.625	.219	.312	.062		.468	[illegible]	.028	
-4	.2500		.022	.7500		.687	.281	.375	.093	NONE	.516	4,300	.040	.0017
-5	.3125			.8125		.750	.344	.437			.578	6,100	.057	
-6	.3750			.8750		.812	.469	.562		.169	.641	9,500	.075	
-7	.4375			.9375		.875	.531	.625	.125		.703	12,000	.097	.0018
-8	.5000			1.1250	+.0000 -.0005	1.031	.656	.750			.844	17,400	.165	
-9	.5625			1.1875		1.094	.781	.875			.891	22,500	.212	
-10	.6250			1.2500		1.156	.906	1.000			.953	31,200	[illegible]	.0019
-12	.7500			1.3750		1.281	1.000	1.125		.250	1.078	35,900	[illegible]	
-14	.8750			1.6250		1.500					1.250	45,600	.423	.0022
-16	1.0000	+.0000 -.0007		1.7500		1.625	1.125				1.375	50,900	.510	
-20	1.2500			2.0000		1.906					1.625	57,600	[illegible]	.0026
-24	1.5000		.032	2.2500	+.0000 -.0006	2.156					1.875	66,300	.712	
-28	1.7500			2.5000		2.406					2.125	75,700	.760	.0027
-32	2.0000			2.7500		2.656			.156	.375	2.375	85,200	.850	.0029
-36	2.2500			3.0000		2.906					2.625	94,600	.950	.0032
-40	2.5000			3.2500		3.155	1.049	1.250			2.875	104,100	1.040	.0037
-44	2.7500			3.5000		3.406					3.125	113,500	1.150	
-48	3.0000			3.7500	+.0000 -.0008	3.656					3.375	123,000	1.240	.0039
-52	3.2500			4.0000		3.906					3.641	132,500	1.340	
-56	3.5000			4.3750		4.219					3.969	145,100	1.730	.0041
-60	3.7500	+.0000 -.0008	.014	4.6250		4.468					4.218	154,500	1.840	
-64	4.0000			4.8750	+.0000 -.0010	4.719					4.469	164,000	1.970	.0045
-80	5.0000	+.0000 -.0010		5.8750		5.637	1.044				5.437	201,000	2.750	.0045

OIL HOLE DATA		
BORE SIZE	NO. OF HOLES INNER RING	NO. OF HOLES OUTER RING
-3 THRU -5	NONE	2
-6 THRU -10	2	4
-12 THRU -80	4	4

MATERIAL: STEEL, MIL-S-7420, MIL-S-6490, MIL-S-7493, QQ-S-631
FED STD NO. 66 STEEL NO. 51000, 51100, AND 52100
PLATING: CADMIUM PLATE, QQ-P-416, TYPE I, CLASS 2
MACHINE FINISH: ANSI B46.1 - 1962
LUBRICATION: BEARINGS FURNISHED SHALL BE LUBRICATED WITH GREASE CONFORMING TO MIL-G-23827
DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS ±.005
DIMENSIONS TO BE MET AFTER PLATING. REMOVE ALL BURRS AND SHARP EDGES

THE AIRCRAFT STATIC BEARING CAPACITY RATINGS AS NOTED REPRESENT ULTIMATE LOAD OF THE HIGHEST LOAD WHICH CAN BE PLACED ON THE BEARING WITHIN AN ALLOWABLE .0001 INCH BRINELL OF THE INNER RACE. HIGHER LOADS WILL DANGEROUSLY BRINELL THE RACES AND PERMANENTLY DEFORM THE ROLLERS. THE LIMIT OR WORKING LOAD OF THE BEARING SHOULD BE TAKEN AS 2/3 OF THE AIRCRAFT STATIC CAPACITY.

SUB-NOTE 3(1) (Sheet 2 of 2 Sheets) Heavy Duty Needle Bearings (MS24461)



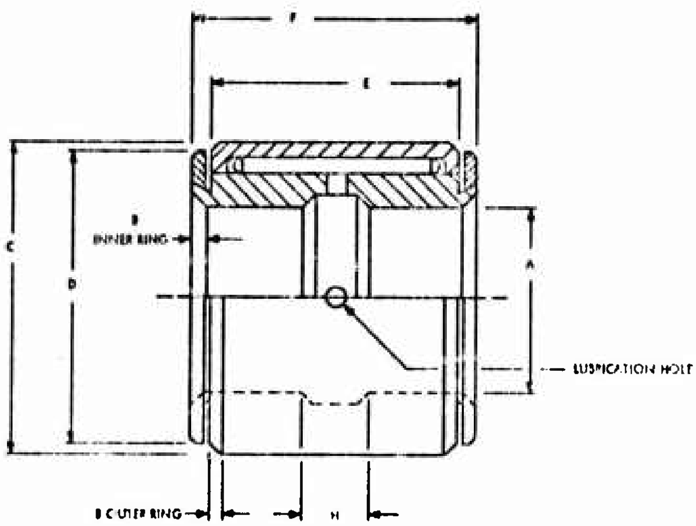
SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

BEARING	HOUSING BORE SIZE ①		SHAFT DIAMETER		CLAMPING DIAMETER SIZE
	[illegible]	[illegible]	[illegible]	[illegible]	
-3	[illegible]	[illegible]	.3176-[illegible]	[illegible]	[illegible]
-4	.74[illegible]-.7[illegible]	[illegible]-.7409	[illegible]	[illegible]	33/64
-5	.8122-.8117	.8127-.81[illegible]	.3116-.3114	.3119-.3114	37/64
-6	.8747-.8742	.8754-.8749	.3744-.3739	.37[illegible]-.3747	41/64
-7	.9372-.9367	.9379-.9374	.4369-.4364	.4377-.4372	45/64
-8	1.1247-1.1242	1.1254-1.1247	.4994-.4989	.5002-.4997	27/32
-9	1.1872-1.1867	1.1879-1.1874	.5619-.5614	.5627-.5622	57/64
-10	1.2497-1.2492	1.2504-1.2499	.6244-.6239	.6252-.6247	61/64
-12	1.3747-1.3741	1.3754-1.3749	.7494-.7489	.7502-.7497	1 5/64
-14	1.6247-1.6241	1.6254-1.6249	.8744-.8739	.8752-.8747	1 1/4
-16	1.7497-1.7491	1.7504-1.7499	.9994-.9989	1.0002-.9997	1 3/8
-20	1.9997-1.9991	2.0004-1.9999	1.2494-1.2489	1.2502-1.2497	1 5/8
-24	2.2496-2.2490	2.2503-2.2497	1.4994-1.4989	1.5002-1.4997	1 7/8
-28	2.4996-2.4990	2.5003-2.4997	1.7494-1.7489	1.7502-1.7497	2 1/8
-32	2.7496-2.7490	2.7503-2.7497	1.9994-1.9989	2.0002-1.9997	2 3/8
-36	2.9996-2.9990	3.0003-2.9997	2.2494-2.2487	2.2501-2.2494	2 5/8
-40	3.2495-3.2485	3.2502-3.2492	2.4994-2.4987	2.5001-2.4995	2 7/8
-44	3.4995-3.4985	3.5002-3.4992	2.7494-2.7487	2.7501-2.7494	3 1/8
-48	3.7495-3.7485	3.7502-3.7492	2.9994-2.9987	3.0001-2.9994	3 3/8
-52	3.9995-3.9985	4.0002-3.9992	3.2494-3.2487	3.2501-3.2494	3 41/64
-56	4.3745-4.3735	4.3752-4.3742	3.4994-3.4987	3.5001-3.4994	3 31/32
-60	4.6245-4.6235	4.6252-4.6242	3.7494-3.7487	3.7501-3.7494	4 7/32
-64	4.8745-4.8735	4.8752-4.8742	3.9994-3.9987	4.0001-3.9994	4 15/32
-80					

① FOR ALUMINUM HOUSINGS REDUCE ALL DIMENSIONS .0002

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 3(2) (Sheet 1 of 2 Sheets) Light Duty Needle Bearings (MS24462)



DASH NO.	A +.0000 -.0005 BORE INNER RACE	B +.015 -.000 RAD OR 45° MAX BEVEL	(A) C ±.0005	D ±.010	E +.000 -.010	F +.000 -.005	H +.000 -.062	CLAMPING MIN DIA	LIMIT LOAD LB	WEIGHT LB APPROX	TOTAL RADIAL PLAY MAX
-3	.1950		.6250	.562		.625		.469	675	.040	
-4	.2500	.022			.500	.562	NONE	.500	[illegible]	.025	
-5	.3125		.6875	.625		.625		.562	[illegible]	.050	
-6	.3750		.7500	.688		.812		.625	[illegible]	.060	
-7	.4375		.8125	.750	.750		.188	1.062	[illegible]	.090	.0015
-8	.5000		1.0000	.938		.875		.844	2,350	.120	
-10	.6250		1.1250	1.062			.250	.959	[illegible]	.150	
-12	.7500	.032	1.2500	1.188				1.094	[illegible]	.210	
-14	.8750		1.3750	1.312	1.000	1.125		1.219	[illegible]	.240	
-16	1.0000		1.5000	1.436			.375	1.344	5,510	.270	
-20	1.2500		1.8750	1.812	1.250	1.375		1.641	8,160	.300	.0017

OIL HOLE DATA		
BORE SIZE	NO. OF HOLES INNER RING	NO. OF HOLES OUTER RING
-3 THRU -5	NONE	NONE
-6 THRU -10	2	•
-12 THRU -20	4	•

(A) HOUSING DIMENSION FOR BEARING

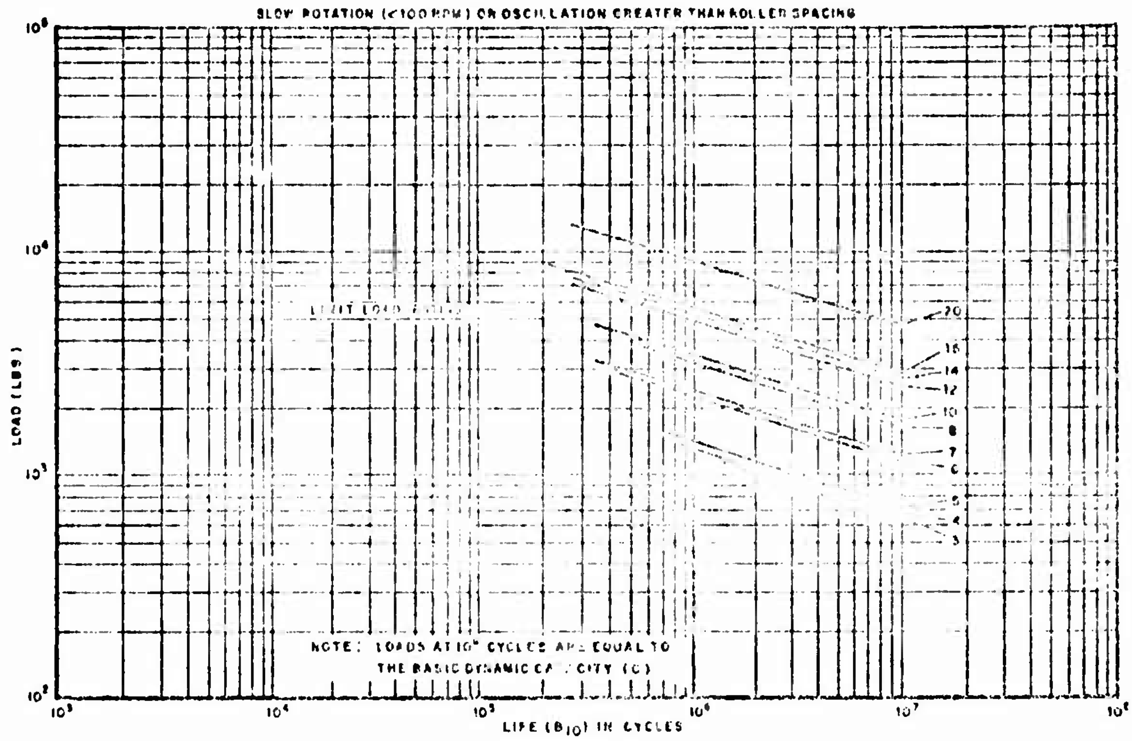
MATERIAL: STEEL, MIL-S-7420, MIL-S-6590, MIL-S-7493, QQ-S-631
FED STD No. 66 STEEL NO. 50100, 51100, AND 52100
PLATING: CADMIUM PLATE, QQ-P-416, TYPE I, CLASS 3
MACHINE FINISH: ANSI B46.1 - 1962

LUBRICATION: BEARINGS FURNISHED SHALL BE LUBRICATED WITH GREASE CONFORMING TO MIL-G-21927
DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS ±.005
DIMENSIONS TO BE MET AFTER PLATING
REMOVE ALL BURRS AND SHARP EDGES

THE LIMIT LOAD IS THE MAXIMUM LOAD THAT CAN BE APPLIED WITHOUT FAILING THE OUTER RACE

074

SUB-NOTE 3(2) (Sheet 2 of 2 Sheets) Light Duty Needle Bearings (MS24462)



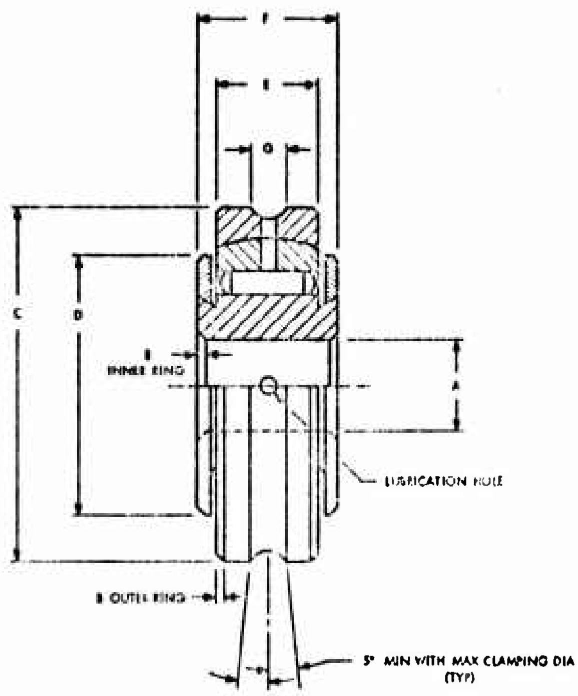
SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

BEARING	HOUSING BORE SIZE (1) PRESS FIT	HOUSING BORE SIZE (1) SLIP FIT	SHAFT DIAMETER SLIP FIT	SHAFT DIAMETER PRESS FIT	CLAMPING DIA. MIN.
-3	[illegible]	PRESS FIT	.1897-[illegible]	[illegible]	15/32
-4	.6255-.6245	ONLY	.2497-.2492	.2501-.2496	1/2
-5	[illegible]	ON	.3122-.3117	.3126-.3121	9/16
-6	.7505-.7495	OUTER	.3747-.3742	.3751-.3746	5/8
-7	.8130-.8120	RACE	.4372-.4367	.4376-.4371	11/16
-8	1.0005-.9995		.4997-.4992	.5001-.4996	27/32
-10	1.1255-1.1245		.6247-.6242	.6251-.6246	31/32
-12	1.2505-1.2495		.7497-.7492	.7501-.7496	1 [illegible]
-14	1.3755-1.3745		.8747-.8742	.8751-.8746	1 7/32
-16	1.5005-1.4995		.9997-.9992	1.0001-.9996	1 11/32
-20	1.8755-1.8745		1.2497-1.2492	1.2501-1.2496	1 41/64

(1) FOR ALUMINUM HOUSINGS REDUCE ALL DIMENSIONS .0002

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 3(3) (Sheet 1 of 2 Sheets) Heavy Duty Self-Aligning Needle Bearings (MS24463)



DASH NO.	A +.0000 -.0007 BORE INNER RACE	B +.015 -.000 RAD OF 45° MAX BEVEL	C +.0000 -.0005	D ±.010	E +.000 -.005	F +.000 -.005	G ±.031	CLAMPING DIA		AIRCRAFT STATIC CAPACITY LB	WEIGHT LB APPROX	TOTAL RADIAL PLAY MAX	HOUSING SIZE GAGE +.0000 -.0001	
								MAX	MIN				LOW	HIGH
-3	.1900	.022	.8750	.625	.218	.312	.067	.625	.433	2700	.041	.0029	.8742	.8747
-4	.2500		.9375	.687	.281	.375	.073	.684	.516	4300	.053		.9367	.9372
-5	.3125		1.0625	.750	.344	.437		.734	.518	6100	.079		1.0617	1.0622

OIL HOLE DATA			
	NO. OF HOLES		
BORE SIZE	INNER RING	OUTER RING	SPHERICAL HOUSING
-3 THRU -5	NONE	2	2

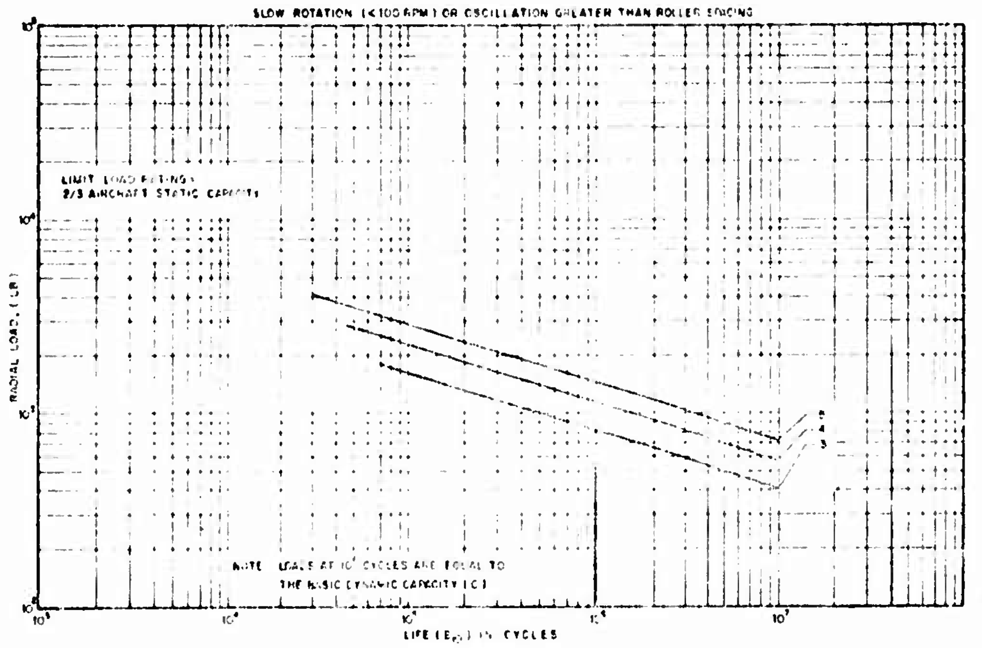
MATERIAL: STEEL, MIL-S-7420, MIL-S-8690, MIL-S-7493, QQ-S-624, QQ-S-631, FED STD NO. 66 STEEL NO. 50100, 51100, AND 52100
PLATING: CADMIUM PLATE, QQ-P-416, TYPE I, CLASS 2
MACHINE FINISH: ANSI B46.1 - 1962

LUBRICATION: BEARINGS FURNISHED SHALL BE LUBRICATED WITH GREASE CONFORMING TO MIL-G-23827
REMOVE ALL BURRS AND SHARP EDGES

DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS ±.005
DIMENSIONS TO BE MET AFTER PLATING

THE AIRCRAFT STATIC BEARING CAPACITY RATINGS AS NOTED REPRESENT THE ULTIMATE LOAD OR THE HIGHEST LOAD WHICH CAN BE PLACED ON THE BEARING WITHIN AN ALLOWABLE .0001 INCH BRINELL OF THE INNER RACE. HIGHER LOADS WILL DANGEROUSLY BRINELL THE RACES AND PERMANENTLY DEFORM THE ROLLERS. THE LIMIT OR WORKING LOAD OF THE BEARING SHOULD BE TAKEN AS 2/3 OF THE AIRCRAFT STATIC CAPACITY.

SUB-NOTE 3(3) (Sheet 2 of 2 Sheets) Heavy Duty Self-Aligning Needle Bearings (MS24463)



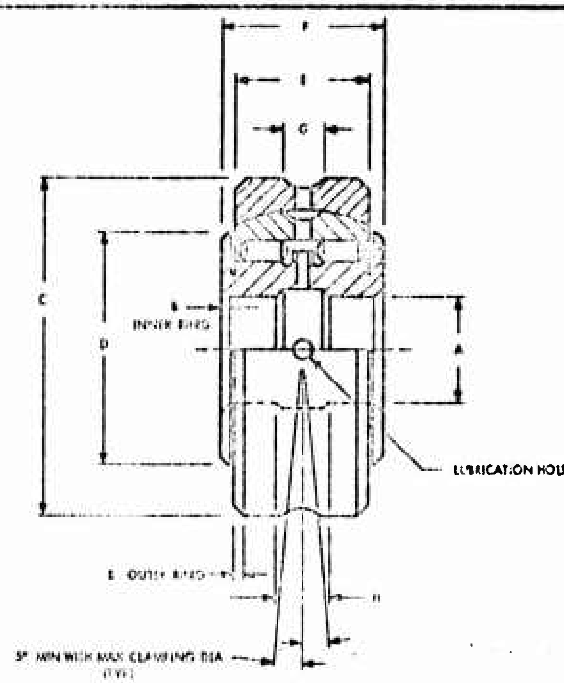
SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

BEARING	HOUSING BORE STEEL (1)		SHAFT DIAMETER		CLEARING DIAMETER
	PRESS FIT	SLIP FIT	SLIP FIT	PRESS FIT	
-3	.8742-.874[illegible]	.8754-.8749	.18[illegible]4-.1869	.1882-.1877	5/[illegible] - 2/[illegible]
-4	.9372-.9[illegible]	.9379-.9374	.2494-.24[illegible]	.25[illegible]2-.2497	11/16 - 33/64
-5	1.0622-1.0617	1.0629-1.0624	.3119-.3114	.3127-.3122	47/64 - 37/64

(1) WHEN MOUNTING BEARINGS IN ALUMINUM HOUSINGS REDUCE ALL DIMENSIONS .0002

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 3(4) (Sheet 1 of 2 Sheets) Heavy Duty Self-Aligning Double Row Needle Bearings (MS24464)



DASH NO.	A +.0000 -.0007 BORE	B +.015 -.000 RAD OR .... MAX	C	C tol.	D ±.010	E +.000 -.005	F +.000 -.005	G ±.031	H +.000 -.062	CLAMPING DIA MAX	CLAMPING DIA MIN	AIRCRAFT STATIC CAPACITY LB	WEIGHT LB APPROX	TOTAL RADIAL PLAY MAX	HOUSING SIZE GAGE +.0000 -.0001 LOW	HOUSING SIZE GAGE +.0000 -.0001 HIGH
-6	.3750	.02	1.1875		.812	.459	.55	.125	.188	.761	.641	6[illegible]	.130	.0030	1.1867	1.1872
-7	.4375		1.3125		.875	.531	.67			.844	.703	9600	.174	.0031	1.3116	1.3122
-8	.5000		1.5000	+.0000 -.0005	1.0[illegible]	.656	.750			1.0[illegible]	.944	13300	.273		1.4991	1.4997
-9	.5625		1.6875		1.0[illegible]	.781	.875			1.062	.891	17,[illegible]	.420		1.6866	1.6872
-10	.6250		1.7500		1.1[illegible]	.906	1.000	.156	.250	1.094	.953	23[illegible]	.520	.0032	1.7491	1.7497
-12	.7500		1.8750		1.2[illegible]	1.000	1.125			1.156	1.078	30000	.630	.0034	1.6741	1.6747
-14	.8750	.037	2.1250		1.5[illegible]	1.125			.375	1.375	1.25[illegible]	32700	.870	.0037	2.1738	2.1246
-16	1.0000		2.2500	[illegible]	1.6[illegible]					1.500	1.375	43000	.950	.0041	2.2458	2.2496
-20	1.2500		2.5000		1.9[illegible]	1.649	1.250			1.781	1.625	47100	1.070		2.4988	2.4996
-24	1.5000		2.7500		2.1[illegible]					2.062	1.875	54[illegible]	1.230		2.7483	2.7496
-32	2.0000		3.2500	[illegible]	2.756					2.593	2.375	70400	1.490	.0045	3.2485	3.2496
-40	2.5000		3.7500		3.156					3.052	2.875	85200	1.780	.0046	3.7435	3.7495
-48	3.0000		4.2500		3.6[illegible]					3.562	3.375	101900	2.050	.0056	4.2465	4.2495
-56	3.5000	.044	4.8750	[illegible]	4.219					4.141	3.969	120200	2.650	.0057	4.8735	4.8745

OIL HOLE DATA	NO. OF HOLES		
BORE SIZE	INNER RING	[illegible] RING	[illegible] HOUSING
-6 THRU -10	2	4	2
-12 THRU -56	4	4	2

MATERIAL: STEEL, MIL-S-7420, MIL-S-8690, MIL-S-7493, QQ-S-631
STEEL NO. 50100, 51100, AND 52100
PLATING: CADMIUM PLATE, QQ-P-416, TYPE I, CLASS 2
MACHINE FINISH: ANSI B46.1-1962
LUBRICATION: BEARINGS FURNISHED SHALL BE LUBRICATED WITH GREASE CONFORMING TO MIL-G-23827
DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS ± .005
DIMENSIONS TO BE MET AFTER PLATING
REMOVE ALL BURRS AND SHARP EDGES

THE AIRCRAFT STATIC BEARING CAPACITY RATINGS AS NOTED REPRESENT THE ULTIMATE LOAD OR THE HIGHEST LOAD WHICH CAN BE PLACED ON THE BEARING WITHIN AN ALLOWABLE .0001 INCH BRINELL OF THE INNER RACE. HIGHER LOADS WILL DANGEROUSLY BRINELL THE RACES AND PERMANENTLY DEFORM THE ROLLERS. THE LIMIT OR WORKING LOAD OF THE BEARING SHOULD BE TAKEN 2/3 OF THE AIRCRAFT STATIC CAPACITY.

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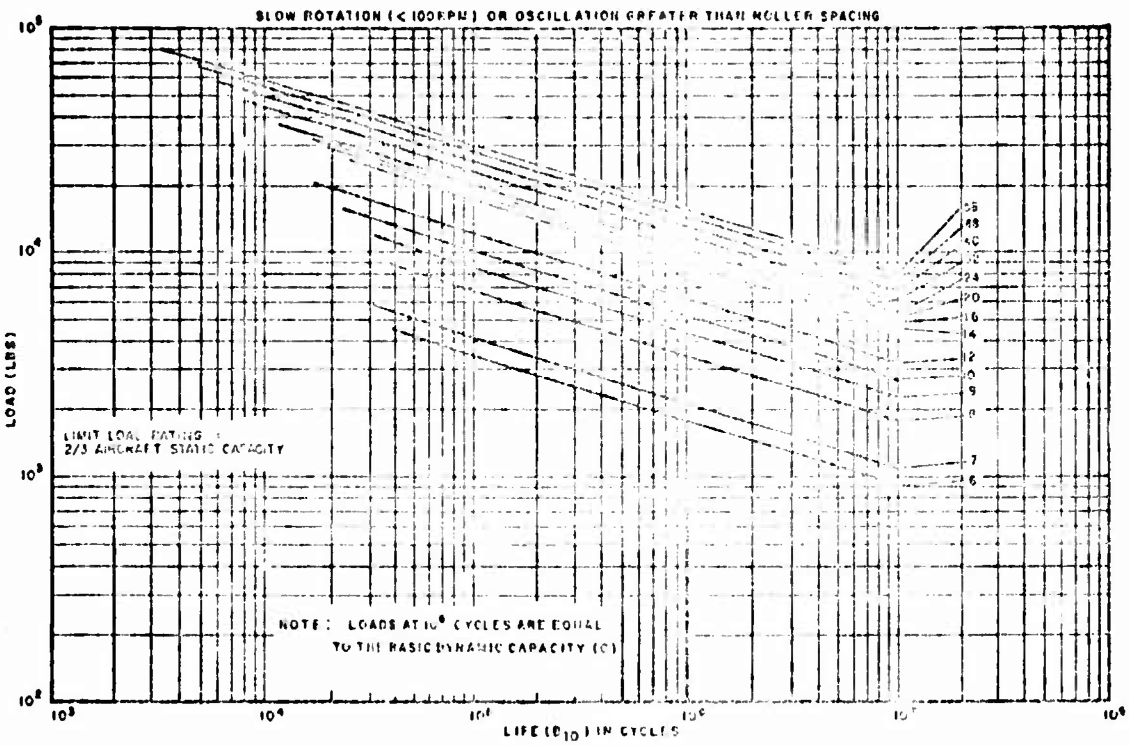
SUB-NOTE 3(4) (Sheet 2 of 2 Sheets) Heavy Duty Self-Aligning Double Row Needle Bearings (MS24464)



SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

BEARING	HOUSING BORE SIZE (1) PRESS FIT	HOUSING BORE SIZE (1) SLIP FIT	SHAFT DIA SLIP FIT	SHAFT DIA [illegible]	CLAMPING [illegible]
-6	1.1872-1.1867	1.1879-1.1874	.3744-.3739	[illegible]	[illegible]
-7	1.3122-1.3116	1.3124-1.3130	[illegible]	[illegible]-.4372	[illegible]
-8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-9	[illegible]	1.6880-1.6874	.5619-.5614	[illegible]	[illegible]
-10	1.7497-1.7491	[illegible]	.6244-.6239	[illegible]	[illegible]
-12	1.8747-1.8741	1.8755-1.8749	[illegible]	[illegible]	[illegible]
-14	[illegible]-2.1239	[illegible]-2.1249	[illegible]	[illegible]	[illegible]
-16	[illegible]	[illegible]-2.2499	.9994-.9989	[illegible]	[illegible]
-20	[illegible]-2.4988	[illegible]	[illegible]	[illegible]	[illegible]
-24	[illegible]	[illegible]-2.7499	[illegible]	[illegible]	[illegible]
-32	[illegible]-3.2485	[illegible]-3.2498	[illegible]-1.9997	[illegible]	[illegible]
-40	[illegible]-3.7485	[illegible]	[illegible]	[illegible]	[illegible]
-48	[illegible]-4.2485	[illegible]	[illegible]	[illegible]	[illegible]
-56	4.8745-4.8735	[illegible]-4.8748	[illegible]	[illegible]	[illegible]

(1) WHEN MOUNTING BEARINGS IN ALUMINUM HOUSINGS REDUCE ALL DIMENSIONS .0002

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

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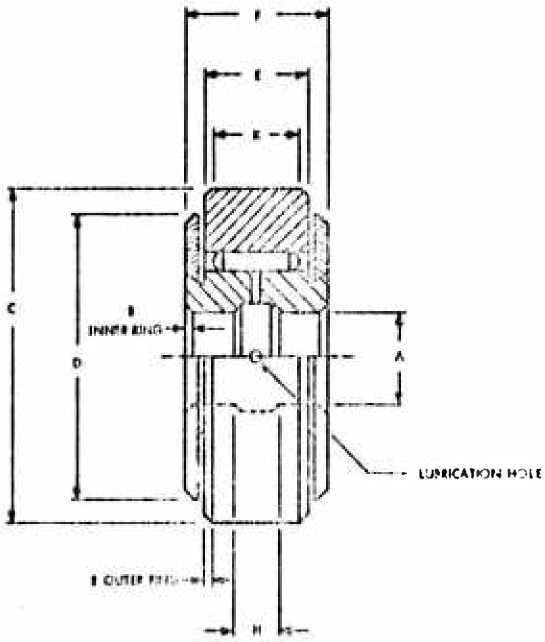
SUB-NOTE 3(5) (Sheet 1 of 2 Sheets) Single Row Track Rollers (MS24465)



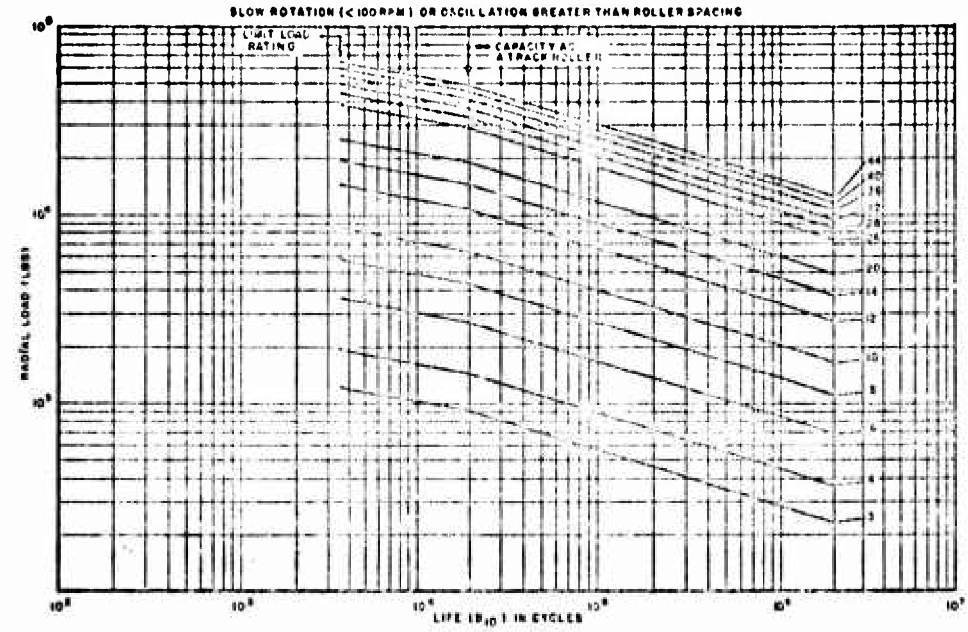
DASH NO.	A +.0000 -.0007 BORE INNER RACE	B +.015 -.010 RAD OR 45° MAX BEVEL	C +.0000 -.0010	D ±.010	E +.000 -.005	F +.000 -.005	H +.000 -.062	K TRACK CONTACT WIDTH MIN	CLAMPING MIN DIA	CAPACITY AS TRACK ROLLER LB	AIRCRAFT STATIC CAPACITY LB	WEIGHT LB APPROX	TOTAL RADIAL PLAY MAX	TRACK CAPACITY 160,000 PSI STEEL
-3	.1900		[illegible]	[illegible]	.218	.312	.093	[illegible]	[illegible]	900	2,700	[illegible]	.0015	270
-4	.2500	.022	.9750	.750	.281	[illegible]	.125	.187	.516	1,400	4,300	[illegible]		575
-6	.3750		1.0625	[illegible]	.375	[illegible]	.187	[illegible]	.672	[illegible]	[illegible]	.090		1,000
-8	.5000		1.3125	1.167	.500	[illegible]		.312	.844	[illegible]	13,000	.176	.0014	1,785
-10	.6250		1.5000	1.375	.625	.750		.437	.953	[illegible]	[illegible]	.266		2,600
-12	.7500		1.7500	1.625	[illegible]	1.000	.250	[illegible]	1.109	10,700	32,000	[illegible]		4,050
-14	.8750		2.0000	1.875	1.000	[illegible]		.812	1.219	13,700	[illegible]	.712		5,350
-20	[illegible]	.032	2.5000	[illegible]	1.040	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.0014	7,100
-24	1.5000		3.0000	2.878					1.684	23,400	[illegible]	2.85		10,600
-28	1.7500		3.4375	3.312					2.201	[illegible]	[illegible]	[illegible]		[illegible]
-32	2.0000		[illegible]	3.750	1.250	1.500	.375	1.172	2.562	[illegible]	[illegible]	3.22	.0018	13,600
-36	2.2500		[illegible]	[illegible]					[illegible]	[illegible]	[illegible]	4.81		[illegible]
-40	2.5000		4.7500	[illegible]					3.109	[illegible]	[illegible]	6.24		17,100
-44	2.7500		5.0000	4.875					3.545	45,600	[illegible]	7.20		18,000

OIL HOLE DATA	
BORE SIZE	NO. OF HOLES INNER RING
-3 THRU -10	2
-12 THRU -44	4

MATERIAL: STEEL, MIL-S-7420, MIL-S-6590, MIL-S-7493, QQ-S-624, QQ-S-631, FED STD NO. 66 STEEL NO. 50100, 51100, AND 52100
PLATING: O.D. AND SIDES OF OUTER RACE, CHROMIUM PLATE, QQ-C-320, CLASS 2, THICKNESS .0005 TO .0010
OTHER SURFACES, CADMIUM PLATE, QQ-P-416, TYPE I, CLASS 2
MACHINE FINISH: ANSI B46.1 - 1962
LUBRICATION: BEARINGS FURNISHED SHALL BE LUBRICATED WITH GREASE CONFORMING TO MIL-G-23827
REMOVE ALL BURRS AND SHARP EDGES
DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS ±.005
DIMENSIONS TO BE MET AFTER PLATING

IF MOUNTED IN A HOUSING AND LOADED AS A BEARING, NOT A TRACK ROLLER, A LOAD EQUAL TO THE AIRCRAFT STATIC CAPACITY WILL BRINELL THE RACES TO A MAX DEPTH OF .0001 INCHES. THE CAPACITY AS A TRACK ROLLER IS THE HIGHEST LOAD WHICH CAN BE PLACED ON THE BEARING FOR AN AVERAGE LIFE OF 100,000 REVOLUTIONS OR 20,000 MIN MEAN REVOLUTIONS. THE TRACK BRINELL CAPACITY IS CRITICAL WITH RESPECT TO THE TRACK ROLLER CAPACITY OF THE BEARINGS. AN INCREASE IN TRACK HARDNESS WILL INCREASE THE BRINELL CAPACITY OF THE TRACK; HOWEVER, THE BEARING TRACK ROLLER CAPACITY SHOULD NOT BE EXCEEDED.

SUB-NOTE 3(5) (Sheet 2 of 2 Sheets) Single Row Track Rollers (MS24465)



SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

BEARING	SHAFT DIAMETER		CLAMPING DIA MIN	CAPACITY AS TRACK ROLLER, LBS	TRACK CAPACITY LBS (1)
	SLIP FIT	PRESS FIT			
-3	.1894-.1889	.1902-.1897	7/16	900	290
-4	.2494-.2489	[illegible]-.2497	33/64	[illegible]	575
-6	.3744-.3739	.3752-.3747	43/64	[illegible]	1000
-8	.4994-.4989	[illegible]-.4997	27/32	[illegible]	[illegible]
-10	.6244-.6239	.6252-.6247	61/64	[illegible]	2600
-12	.7494-.7489	.7502-.7497	1 7/64	10700	[illegible]
-14	.8744-.8739	.8752-.8747	1 7/32	[illegible]	5350
-20	1.2494-1.2484	1.2503-1.2497	1 5/8	[illegible]	7100
-24	1.4994-1.4984	1.5003-1.4997	1 63/64	[illegible]	[illegible]
-28	1.7494-1.7484	1.7503-1.7497	2 [illegible]	[illegible]	12400
-32	1.9994-1.9984	2.0003-1.9997	2 [illegible]	35100	[illegible]
-36	2.2494-2.2484	2.2503-2.2497	2 13/64	[illegible]	[illegible]
-40	2.4994-2.4984	2.5003-2.4997	2 7/64	[illegible]	17100
-44	2.7494-2.7484	2.7503-2.7497	3 11/32	[illegible]	18000

(1) MAXIMUM BEARING LOAD THAT CAN BE USED ON TRACK OF [illegible] PSI (R_c 40) WITHOUT BRINELLING TRACK. IF TRACK IS HARDENED BEYOND R_c 40 INCREASED LOADS CAN BE CARRIED (SEE TRACK CAPACITY CHART IN DN 6B2-[illegible]) BUT IN NO CASE CAN LOADS EXCEED CAPACITY AS TRACK ROLLER.

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

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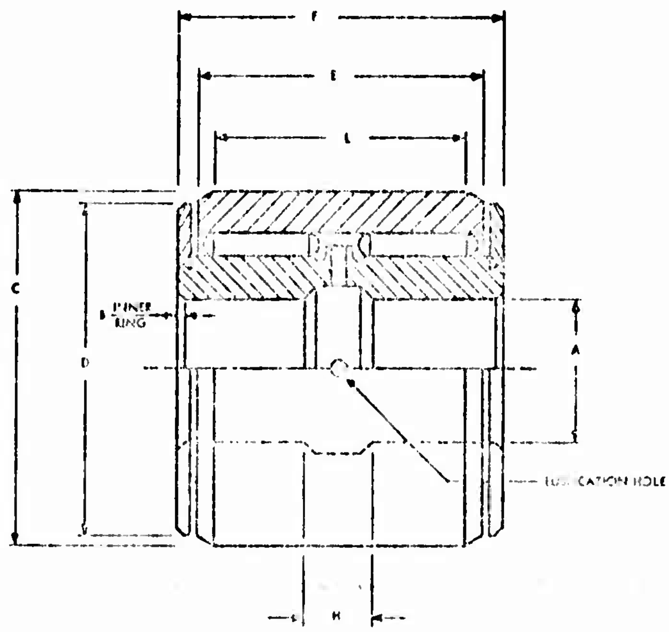
SUB-NOTE 3(6) (Sheet 1 of 2 Sheets) Double Row Track Rollers (MS24466)



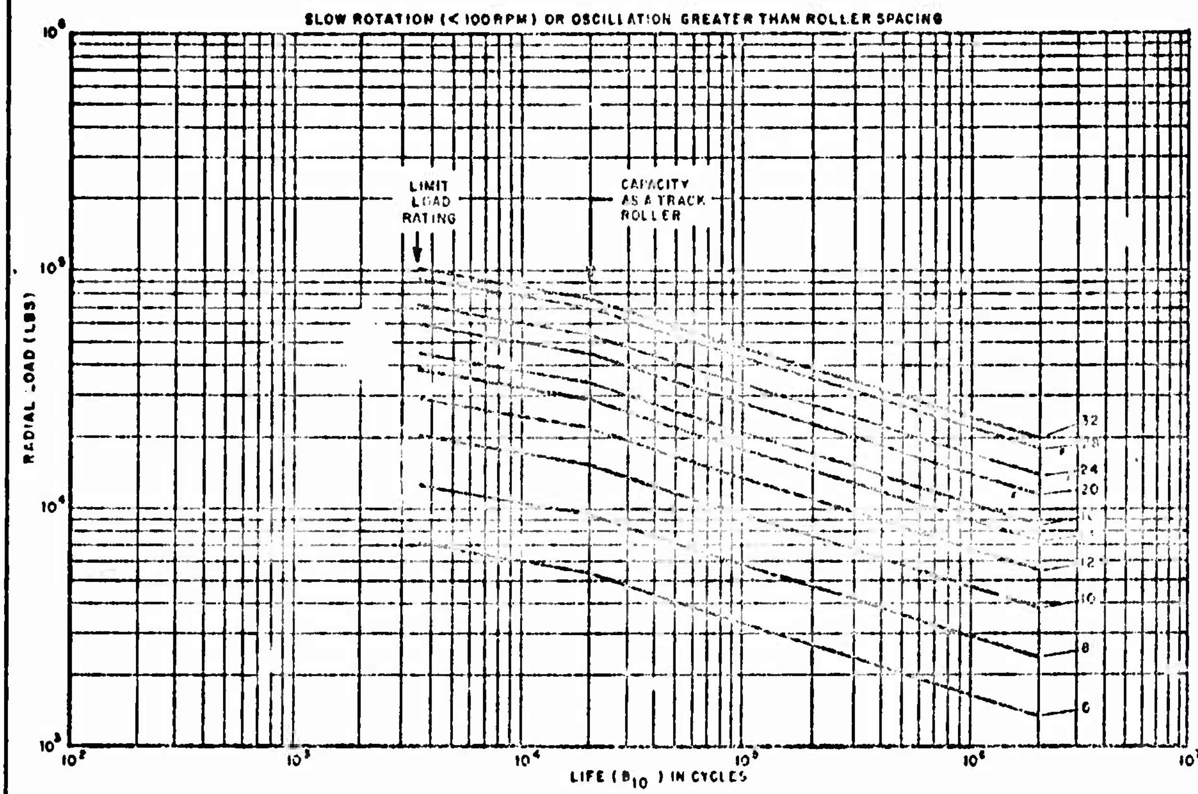
DASH NO.	A +.0000 -.0007 BORE INNER RACE	B +.015 -.000 RAD OR 45° MAX BEVEL	C +.000 -.001	D +.010	E +.000 -.005	F +.000 -.005	H +.020 -.007	L MIN TRACK CONTACT WIDTH	CLAMPING MIN DIA	CAPACITY AS TRACK ROLLER LB	AIRCRAFT STATIC CAPACITY LB	WEIGHT LB APPROX	TOTAL RADIAL PLAY MAX	TRACK CAPACITY 300,000 PSI STEEL
-6	[illegible]	.022	1.125	1.000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5,370	[illegible]	[illegible]	.0014	2,600
-8	[illegible]	.032	1.375	[illegible]	[illegible]	1.250	[illegible]	[illegible]	[illegible]	9,370	[illegible]	.416		4,250
-10	[illegible]		[illegible]	1.500	[illegible]	[illegible]		[illegible]	[illegible]	15,000	[illegible]	[illegible]		[illegible]
-12	[illegible]		1.875	1.750	[illegible]	[illegible]	.375	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		7,550
-14	[illegible]		[illegible]	2.000	[illegible]	2.000		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–	[illegible]
-16	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
-20	[illegible]		[illegible]	2.500	[illegible]	[illegible]		2.044	[illegible]	[illegible]	[illegible]	[illegible]		17,500
-24	[illegible]		[illegible]	2.750	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.0018	[illegible]
-28	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
-32	2.0000		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	76,000	[illegible]	[illegible]		[illegible]

OIL HOLE DATA	
BORE SIZE	NO. OF HOLES (INNER RING)
-6 THRU -32	4

MATERIAL: STEEL, MIL-S-[illegible], MIL-S-[illegible], MIL-S-[illegible], [illegible]
FED STD NO. AS STEEL NO. [illegible], 51100, AND 52100
PLATING: O.D. AND SIDES OF OUTER RACE, CHROMIUM PLATE, QQ-C-320, CLASS 2, THICKNESS [illegible]
OTHER SURFACES, CADMIUM PLATE, QQ-P-416, TYPE 1, CLASS 2
MACHINE FINISH: ASA B46.1-1962
LUBRICATION: BEARINGS FURNISHED SHALL BE LUBRICATED WITH GREASE CONFORMING TO MIL-G-23827
REMOVE ALL BURRS AND SHARP EDGES
DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS ±.005
DIMENSIONS TO BE MET AFTER PLATING

IF MOUNTED IN A HOUSING AND LOADED AS A BEARING, NOT A TRACK ROLLER, A LOAD EQUAL TO THE AIRCRAFT STATIC CAPACITY WILL BRINELL THE RACES TO A MAX. [illegible] INCHES. THE CAPACITY AS A TRACK ROLLER IS THE HIGHEST LOAD WHICH CAN BE PLACED ON THE BEARING FOR AN AVERAGE LIFE OF 100,000 REVOLUTIONS OR [illegible] REVOLUTIONS. THE TRACK BRINELL CAPACITY IS CRITICAL WITH RESPECT TO THE TRACK ROLLER CAPACITY OF THE BEARING. AN INCREASE IN TRACK HARDNESS WILL INCREASE THE BRINELL CAPACITY OF THE TRACK, HOWEVER, THE BEARING TRACK ROLLER CAPACITY SHOULD NOT BE EXCEEDED.

SUB-NOTE 3(6) (Sheet 2 of 2 Sheets) Double Row Track Rollers (MS24466)



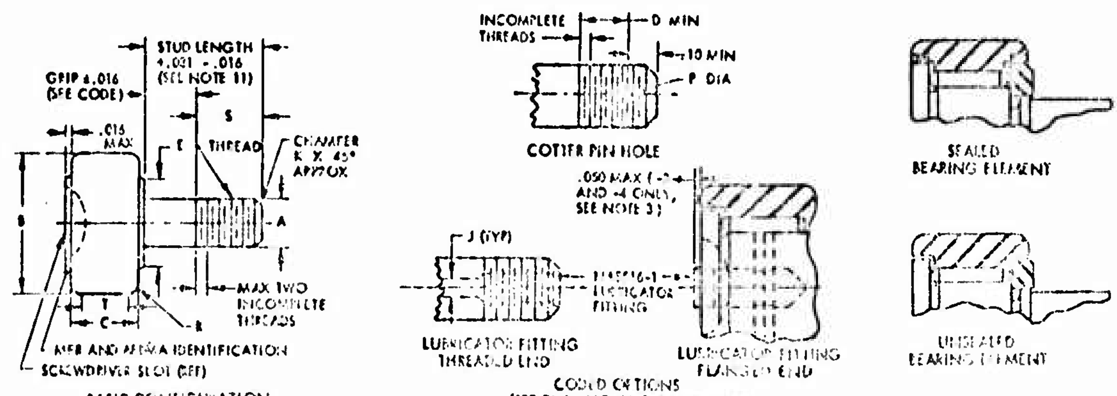
SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

BEARING	SHAFT DIAMETER SLIP FIT	SHAFT DIAMETER PRESS FIT	CLAMPING DIA, MIN	CAPACITY AS TRACK ROLLER, LBS	TRACK CAPACITY LBS ①
-6	.3744-.3739	.3752-.3747	43/64	5070	25[illegible]
-8	.4994-.4989	.5002-.4997	57/64	9370	42[illegible]
-10	.6244-.6239	.6252-.6247	1 7/64	15000	5650
-12	.7494-.7489	.7502-.7497	1 9/32	21400	7450
-14	.8744-.8739	.8752-.8747	1 15/32	26900	10650
-16	.9994-.9989	1.0002-.9997	1 31/64	33[illegible]	12200
-20	1.2494-1.2489	1.2503-1.2497	1 27/32	44000	17300
-24	1.4994-1.4989	1.[illegible]-1.[illegible]	1 63/64	53000	21200
-28	1.7494-1.7488	1.7503-1.7497	2 9/32	63000	27[illegible]
-32	1.9994-1.9987	2.0003-1.9996	2 [illegible]/16	7[illegible]000	30400

① MAXIMUM BEARING LOAD THAT CAN BE USED ON TRACK OF 180,000 PSI (R_c 40) WITHOUT BRINELLING TRACK. IF TRACK IS HARDENED BEYOND R_c 40 INCREASED LOADS CAN BE CARRIED (SEE TRACK CAPACITY CHART IN DN 6D2-2) BUT IN NO CASE CAN LOADS EXCEED CAPACITY AS TRACK ROLLER.

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 3(7) (Sheet 1 of 2 Sheets) Cam Follower Track Rollers (NAS562)



BASIC CONFIGURATION

CODED OPTIONS
(SEE EXAMPLE OF PART NUMBER)

FIRST DASH NO.	MFR AFBMA NO. (SEE NOTES 1&2)	A STUD DIA +.0000 -.0015	THREAD CLASS 3A PER MIL-S-7742	B ROLLER OD +.0000 -.0010	C ROLLER WIDTH +.000 -.005	D (MIN)	E STUD FLANGE [illegible] (REF)	J DIA (REF)	K ±.015	P DIA +.010 -.000	R CORNER RADIUS (REF)	F THREAD LENGTH (REF)
3	HR310	.190	10-32	[illegible]	.252	.211	.37[illegible]	NONE	.031	[illegible]	[illegible]	.344
4	HRS20	.250	1/4-28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.031	[illegible]	[illegible]	[illegible]
5	HR530	.31[illegible]	5/16-24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.35[illegible]
6	[illegible]	[illegible]	3/8-24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	HR550	.4[illegible]	7/16-20	1.00[illegible]	.541	.253	.750	.1[illegible]	[illegible]	.1[illegible]	.062	.422
8	HR560	.500	1/2-20	1.1250	.656	.314	.812	.156	.047	.156	.062	.422

FIRST DASH NO.	T TRACK CONTACT LENGTH (MIN)	STEEL TRACK CAPACITY RC-40 (LB) (SEE NOTE 4)	CAPACITY AS A ROLLER (LB) (SEE NOTE 5)	LIMIT LOAD (SEE NOTE 6)	WEIGHT - POUNDS (MAXIMUM)
3	.23[illegible]	355	395	79[illegible]	.014 + GRIP LENGTH NUMBER X [illegible]
4	.2[illegible]	525	470	940	.031 + GRIP LENGTH NUMBER X [illegible]
5	.29[illegible]	725	83[illegible]	1660	.043 + GRIP LENGTH NUMBER X .0014
6	.35	1100	13[illegible]	272[illegible]	.051 + GRIP LENGTH NUMBER X .0020
7	.43[illegible]	1425	19[illegible]	[illegible]	.125 + GRIP LENGTH NUMBER X .0026
8	.53[illegible]	1775	[illegible]	[illegible]	.19[illegible] + GRIP LENGTH NUMBER X .0035

NOTES:

1. All Cam Follower Bearings will be identified with the Anti-Friction Bearing Manufacturers Association (AFBMA) identification [illegible]. The container in which each individual bearing is packed [illegible] be marked with the NAS number.

2. The complete AFBMA identification may be obtained by adding the following suffix code letters to the basic AFBMA number shown in the tabulation.
"F" designates lubricator in flanged end of stud
"T" designates lubricator in threaded end of stud and cotter pin hole omitted.
"A" designates cotter pin hole omitted
"R" designates a sealed bearing
Third dash number designates grip length in 1/16 inch increments (See example).

3. NAS562-3 may be coded for lubrication fitting in the flanged end only. Lubricator fitting for the [illegible] may be shipped separately and installed on assembly. Lubricators installed in the threaded end of stud shall be flush. [illegible] installed in the flanged end of stud of NAS562-3 and [illegible] beyond the flanged end thereby [illegible] an increase in "E" of [illegible] all other sizes the lubricator shall be flush or indented.

4. The track Brinell capacity is critical in respect to the rolling capacity of the bearing. An increase in hardness of the track will increase the Brinell capacity of the track, but in no case should the rolling capacity of the bearing be exceeded.

5. Rolling capacity [illegible] is the [illegible] limit load of the bearing during an average life of [illegible] revolutions.

6. To fully realize this rating, [illegible] must be provided for [illegible] deflection [illegible] contact [illegible].

7. The bearings shall be [illegible] with grease per MIL-[illegible].

8. Bearings to be wrapped in grease proof paper, individually packaged and marked with the date of [illegible].

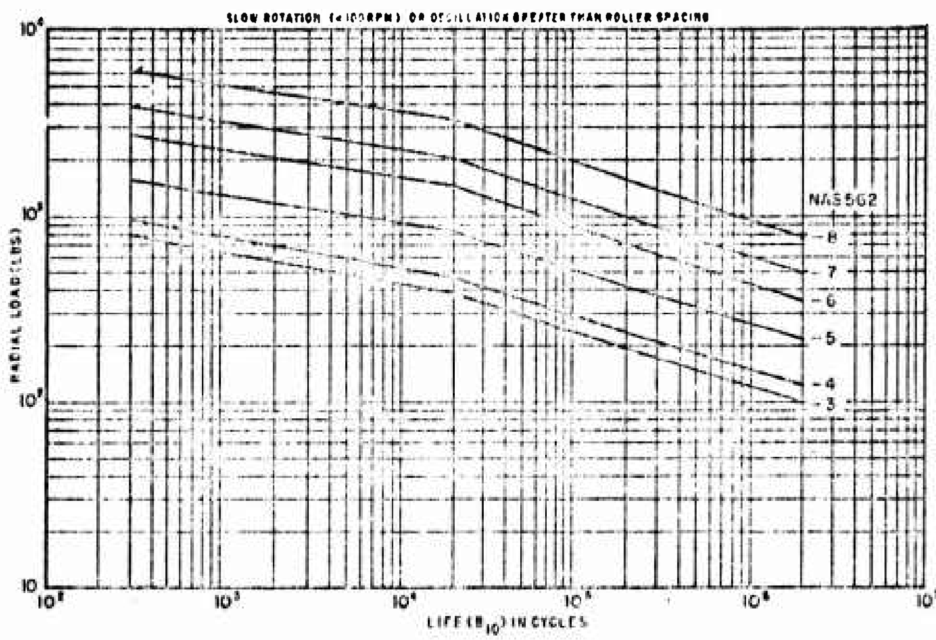
9. All dimensions [illegible] after plating.

10. The manufacturer of these bearings shall certify that all components of the bearings, [illegible], are [illegible] magnetically inspected per MIL-I-6868 prior to assembly.

11. For inspection purposes nominal stud length is the sum of nominal grip and the thread length [illegible] dimension.

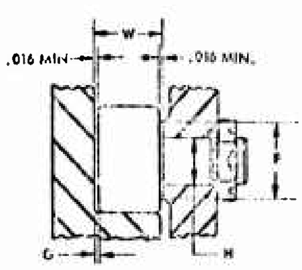
12. Cam followers to be supplied as NAS562 parts shall not be manufactured with [illegible] grip areas after [illegible]. Parts [illegible] with [illegible] plated grip areas [illegible] prior to that date may be supplied and used under the NAS [illegible] are depleted unless specifically prohibited on the purchase order. [illegible] grip areas shall be treated with [illegible] preventive compound per MIL-[illegible], MIL-[illegible] or grease per MIL-G-[illegible].

SUB-NOTE 3(7) (Sheet 2 of 2 Sheets) Cam Follower Track Rollers (NAS562)



RECOMMENDED MOUNTING DIMENSIONS

NAS562	E MOUNTING HOLE DIA	F MIN SHOULDER DIAM (IN)	[illegible]	G MAX FILLET RAD [illegible]	MAX INSTALLATION TORQUE (IN. LB.) UNLUBRICATED THREAD	LUBRICATED THREAD
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



MATERIALS: Outer Race and Rollers. SAE 52100 or steel suitable for bearing applications.
End Plate. Steel hardened and drawn to Rockwell "C" 51-59.
Stud. SAE [illegible] or steel suitable for bearing applications.
Raceway heat treated to Rockwell "C" [illegible], minimum.
Core and stud length. Heat treated to Rockwell "C" 36-44.
Seals. Acetal resin, carbon-filled nylon or equivalent. Construction optional.

FINISH: Roller OD and sides chrome plated in accordance with QQ-C-[illegible], Class 2, except thickness to be [illegible] to [illegible] inches. Exposed surfaces of other parts of [illegible], cadmium plated in accordance with Spec. QQ-P-[illegible], Type I, Class 2, including the unthreaded portion of the stud (See Note 12).

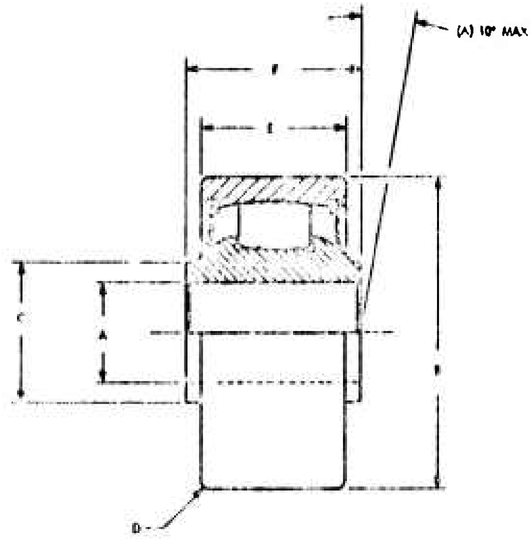
EXAMPLE OF PART NUMBER:

NAS562-8-18FD A = Cam follower needle bearing, 1.125 roller .500 stud, sealed bearing, lubricator in flanged end of stud, 1.25 grip length, 1.672 stud length without cotter pin hole.

- A = No cotter pin hole (not required for Types T or TEE) omit for cotter pin hole
- Grip length in .06(1/16) inch increments
- Bearing
  - E = unsealed with lubricator in flanged end of stud
  - T = unsealed with lubricator in threaded end of stud, no cotter pin hole
  - "-" = unsealed without lubricator
  - FEE = sealed with lubricator in flanged end of stud
  - TEE = no cotter pin hole with lubricator in threaded end of stud
- Stud diameter in .06(1/16) inch increments
- Document number

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 4(1) (Sheet 1 of 2 Sheets) Self-Aligning Roller Bearings (MS28912)



DASH NO.	A +.0000 -.0005 BORE	B +.0000 -.0005 OD	C MIN DIA	D +.015 -.010 RAD	E +.000 -.005 WIDTH OUTER RING	F +.000 -.005 WIDTH INNER RING	WEIGHT MAX LB	POUNDS LIMIT LOAD	
								RADIAL	AXIAL
-4	.2500	.9014	[illegible]		.666	.625	[illegible]	3000	910
-5	.3125	1.2500	.515	.032	.656	.612	.17	7350	2210
-6	.3750	1.4375	[illegible]		.750	.537	.26	5590	2230
-8	.5000	1.6875	.775		.812	1.000	.38	12400	3700
-10	.6250	1.9375	.669	.044	.937	1.125	.60	17200	5310
-12	.7500	2.3750	1.020		1.125	1.312	1.04	25000	8000

(A) SELF ALIGNMENT 10° IN EITHER DIRECTION

MATERIAL: RETAINERS: STEEL, MIL-S-5626 COPPER, QQ-C-390
RINGS AND ROLLERS: STEEL, MIL-S-7420
FINISH: CADMIUM PLATE, QQ-P-416, TYPE I, CLASS 2
SURFACE ROUGHNESS: RACEWAYS 8/, ROLLERS 6/, IN ACCORDANCE WITH ANSI B46.1-1962

REMOVE BURRS AND SHARP EDGES

DIMENSIONS IN INCHES
DIMENSIONS TO BE MET AFTER PLATING

INTERNAL CLEARANCE: TOTAL PLAY, RADIAL .0002 TO .0010, AXIAL .003 TO .010

LUBRICANT IDENTIFICATION: ADD LETTER AFTER DASH NUMBER TO INDICATE TYPE OF LUBRICANT
A = MIL-G-23827
B = MIL-G-25537
C = MIL-G-81322

EXAMPLE OF PART NO. MS28912-4 = BEARING, ROLLER, SELF-ALIGNING, .2500 BORE WITH MIL-G-23827 LUBRICANT

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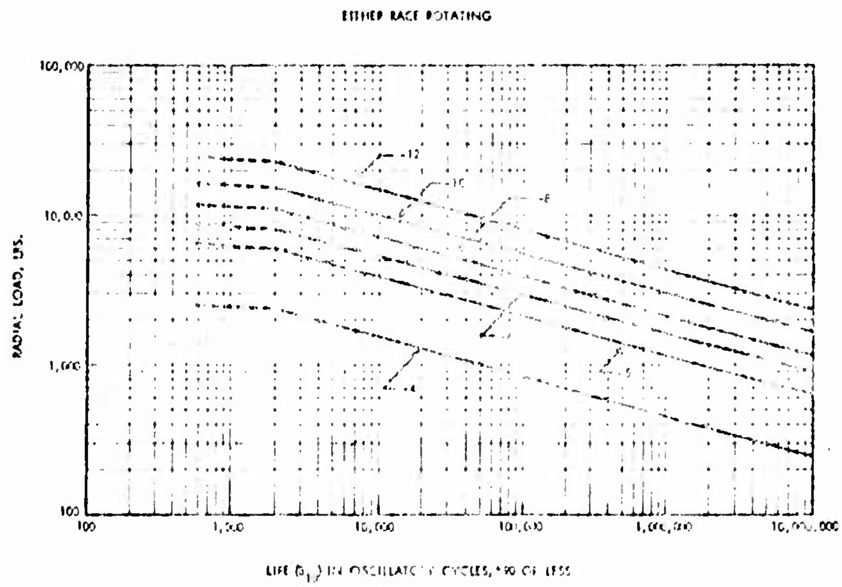
SUB-NOTE 4(1) (Sheet 2 of 2 Sheets) Self-Aligning Roller Bearings (MS28912)



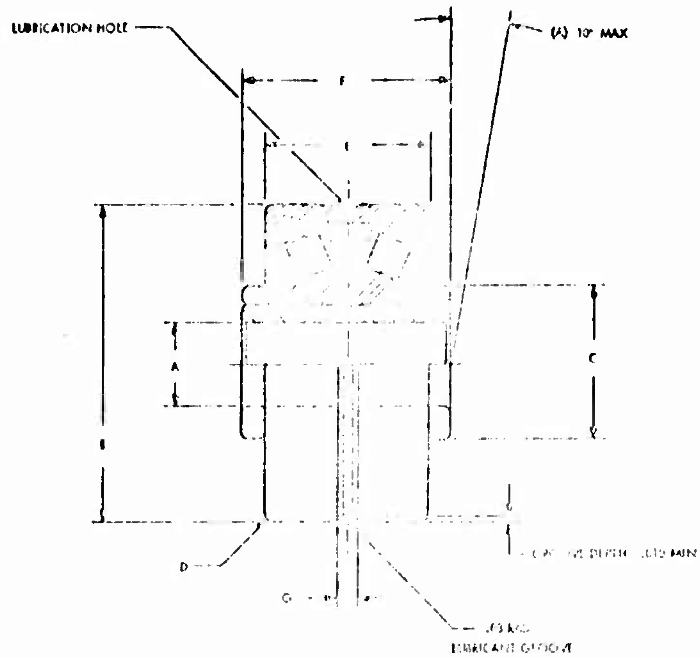
BEARING	O.D., INCHES	STEEL HOUSING BORE, IN.	AL HOUSING BORE, IN.
-4	[illegible]	[illegible]	[illegible]
-5	1.2500	1.2495 - [illegible]	[illegible]
-6	[illegible]	[illegible]	[illegible]
-8	1.6875	[illegible]	[illegible]
-10	1.9375	[illegible]	[illegible]
-12	2.3750	2.3745 - [illegible]	2.3743 - [illegible]

SHAFT DIA - NOMINAL BORE SIZE, - .0005 to -.0010

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

110

SUB-NOTE 4(2) (Sheet 1 of 2 Sheets) Heavy Duty Self-Aligning Roller Bearings (MS28913)



DASH NO.	A +.0000 -.0005 BORE	B +.0000 -.0005 OD	C [illegible]	D +.015 -.000 [illegible]	E [illegible]	F [illegible]	G [illegible]	LUBRICATION HOLE		WT MAX LB	POUNDS LIMIT LOAD	
								[illegible]	[illegible]		RADIAL	AXIAL
-4	.2500	.9?14	[illegible]	.0?0	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]
-5	.3125	1.2??	[illegible]		[illegible]	[illegible]			.0?	.17	75?0	[illegible]
-6	.3750	1.4375	[illegible]	.050	[illegible]	[illegible]	.0?	1		[illegible]	1?1??	[illegible]
-8	.5000	1.?375	.6?		[illegible]	[illegible]				.40	12?00	6400
-10	.6250	1.9375	.940		[illegible]	[illegible]	.1?		.0?	.?3	16???	5???
-12	.7500	2.3750	1.12?		[illegible]	[illegible]				1.04	2????	[illegible]

(A) SELF ALIGNMENT 10° IN EITHER DIRECTION

MATERIAL: RETAINERS, STEEL [illegible]
RINGS AND [illegible] STEEL [illegible]

FINISH: CADMIUM PLATE, [illegible] TYPE I, CLASS [illegible]

SURFACE ROUGHNESS [illegible], ROLLERS [illegible] WITH ANSI B46.1-1962

REMOVE BURRS AND SHARP EDGES

DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS +.010, -.010

DIMENSIONS TO BE MET AFTER PLATING

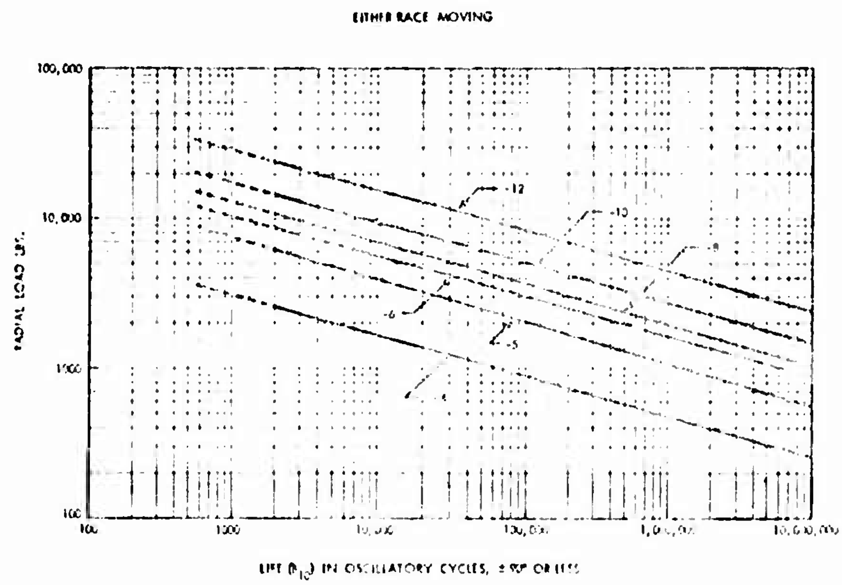
INTERNAL CLEARANCE: TOTAL PLAY, RADIAL [illegible] TO [illegible], AXIAL .0005 TO .00?

LUBRICANT IDENTIFICATION: ADD LETTER AFTER DASH NO. TO INDICATE TYPE OF LUBRICANT:

- A = MIL-G-[illegible]
- B = MIL-G-[illegible]
- C = MIL-G-[illegible]

EXAMPLE OF PART NO. MS28913-4A = BEARING, ROLLER, SELF-ALIGNING, .2500 BORE WITH MIL-G-23827 LUBRICANT

SUB-NOTE 4(2) (Sheet 2 of 2 Sheets) Heavy Duty Self-Aligning Roller Bearings (MS28913)



BEARING	O.D., INCHES	STEEL HOUSING BORE, IN.	AL. HOUSING BORE, IN.
-4	[illegible]	[illegible]	[illegible]
-5	[illegible]	[illegible]	[illegible]
-6	[illegible]	[illegible]	[illegible]
-8	[illegible]	[illegible]	[illegible]
-10	1.9375	[illegible]	[illegible]
-12	[illegible]	[illegible]	[illegible]

SHAFT DIA.- MAX. BEARING BORE -.0005 to -.0010

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

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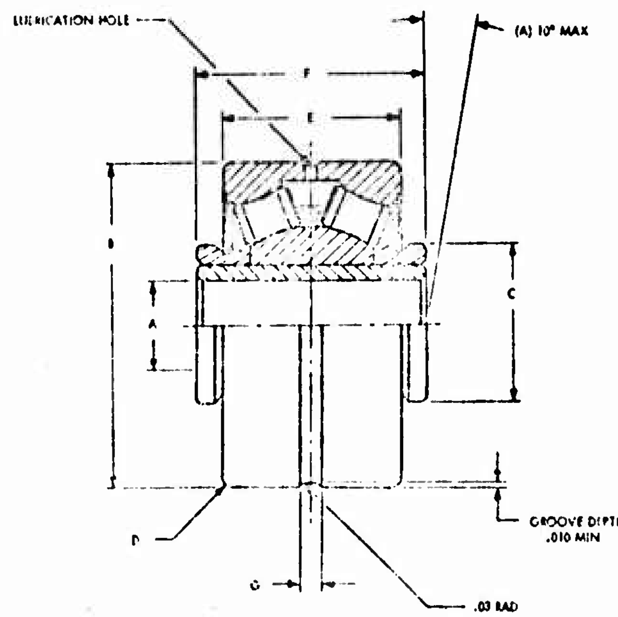
SUB-NOTE 4(3) (Sheet 1 of 2 Sheets) Extra-Heavy Duty Self-Aligning Roller Bearings (MS28914)



DASH NO.	A +.0000 -.0005 BORE	B +.0000 -.0005 OD	C ±.005 DIA	D +.015 -.000 RAD	E +.000 -.005 WIDTH OUTER RING	F +.000 -.005 WIDTH INNER RING	G GROOVE WIDTH MIN	LUBRICATION HOLE NO.	LUBRICATION HOLE SIZE	WEIGHT MAX LB	POUNDS LIMIT LOAD RADIAL	POUNDS LIMIT LOAD AXIAL
-4	.2500	1.2500	.44		.750	1.000				.21	6,800	4,900
-5	.3125	1.5625	.670		.844	1.187	.06		.06	.33	12,400	8,300
-6	.3750							1		.36		
-7	.4375	2.0000	.9[illegible]	.050	1.000	1.500				.74	19,100	12,100
-8	[illegible]											
-9	[illegible]	2.3[illegible]	1.060		1.125	1.687	.11		.09	1.15	28,800	16,700
-10	[illegible]									1.14		
-12	.7[illegible]	2.6[illegible]	[illegible]		1.250	1.875		2		1.50	38,000	21,400
-14	.8750	[illegible]	1.310		1.500	2.000				2.2[illegible]	56,800	30,300

(A) SELF ALIGNMENT 10° IN EITHER DIRECTION

MATERIAL: RETAINERS, STEEL, MIL-S-5676
[illegible]
RINGS AND ROLLERS, STEEL, MIL-S-7420

FINISH: CADMIUM PLATE, QQ-P-416, TYPE I, CLASS 2

SURFACE ROUGHNESS: RACEWAYS [illegible] ROLLERS [illegible] IN ACCORDANCE WITH ANSI B46.1-1962

REMOVE BURRS AND SHARP EDGES

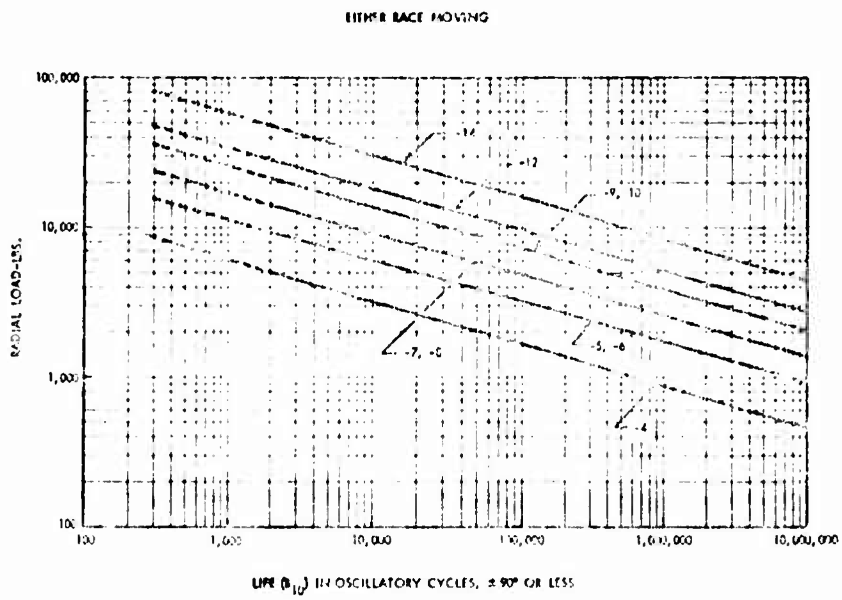
DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS +.010, -.000
DIMENSIONS TO BE MET AFTER PLATING.

INTERNAL CLEARANCE: -4, -5, AND -6 TOTAL PLAY, RADIAL .0002 TO .0010, AXIAL .0005 TO .0025
-7, -8, -9, -10, -12, AND -14 TOTAL PLAY, RADIAL .0002 TO .0010, AXIAL .0007 TO .0030

LUBRICANT IDENTIFICATION: ADD LETTER AFTER DASH NO. TO INDICATE TYPE OF LUBRICANT
A = MIL-G-23827
B = MIL-G-25537
C = MIL-G-81322

EXAMPLE OF PART NO.: MS28914-4A = BEARING, ROLLER, SELF-ALIGNING, .2500 BORE WITH MIL-G-23827 LUBRICANT

SUB-NOTE 4(3) (Sheet 2 of 2 Sheets) Extra-Heavy Duty Self-Aligning Roller Bearings (MS28914)



BEARING	O.D., INCHES	STEEL HOUSING BORE, IN.	AL. HOUSING BORE, IN.
-4	1.2500	1.2475 - 1.2490	1.2472 - 1.2484
-5	1.5625	1.5620 - 1.5615	1.5617 - 1.5609
-6	1.5625	1.5620 - 1.5615	1.5617 - 1.5609
-7	2.0000	1.9995 - 1.9980	[illegible] - 1.9984
-8	2.0000	1.9995 - 1.9990	1.9992 - 1.9984
-9	2.3750	2.3744 - 2.3735	2.3740 - 2.3734
-10	2.3750	2.3744 - 2.3735	2.3740 - 2.3734
-12	2.6250	2.6244 - 2.6239	[illegible] - 2.6234
-14	3.0000	2.9992 - 2.9984	2.9990 - 2.9980

SHAFT DIA. MAX. BEARING BORE, -.0005 to -.0010

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

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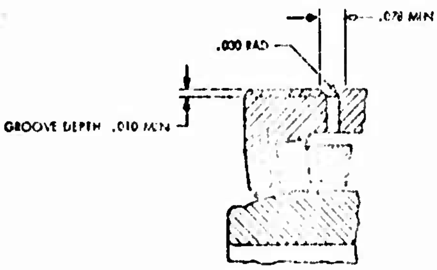
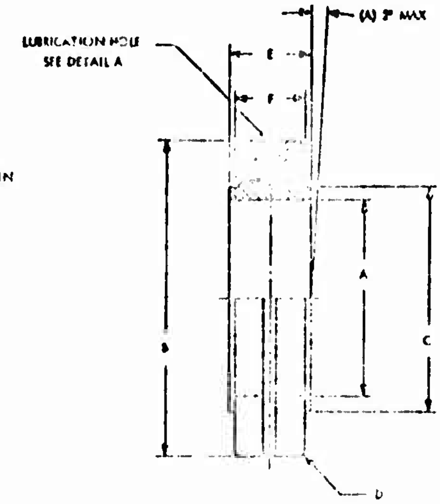
SUB-NOTE 4(4) (Sheet 1 of 2 Sheets) Light Duty Self-Aligning Roller Bearings (MS28915)



LUBRICANT GROOVE
DETAIL A



DASH NO.	A +.0000 -.0005 BORE	B +.0000 -.0005 O.D.	C +.005 -DIA	D +.015 -.000 RAD	E +.000 -.005 WIDTH INNER RING	F +.000 -.005 WIDTH OUTER RING	LUBRICATION HOLES		WT APPROX LB	POUNDS LIMIT LOAD	
							[illegible]	[illegible]		[illegible]	[illegible]
-16	1.0000	1.6250	1.120	.020	.500	.450	1	.06	.16	[illegible]	[illegible]
-20	1.2500	1.8750	1.370						.19	[illegible]	550
-25	1.5360	2.5000	1.670	.030	.670	.520	2		.41	[illegible]	[illegible]
-28	1.7500	2.[illegible]	1.[illegible]						.[illegible]	5[illegible]	1[illegible]
-33	2.0630	[illegible]	2.130						.54	6615	1[illegible]
-37	2.3130	3.2500	2.[illegible]						.59	74[illegible]	11[illegible]
-47	2.9160	3.8750	3.2[illegible]						.75	9550	11[illegible]
-49	3.0630	4.[illegible]	3.3[illegible]						.7[illegible]	10,[illegible]	11[illegible]

(A) SELF-ALIGNMENT 2° IN EITHER DIRECTION

MATERIAL: RETAINERS, STEEL MIL-S-5626. COPPER, QQ-C-390
RINGS AND ROLLERS, STEEL, MIL-S-7420
FINISH: CADMIUM PLATE, QQ-P-416, TYPE I, CLASS 2
SURFACE ROUGHNESS: RACEWAYS [illegible], ROLLERS [illegible], IN ACCORDANCE WITH ANSI B46.1-1962
REMOVE BURRS AND SHARP EDGES

DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS +.010, -.000
DIMENSIONS TO BE MET AFTER PLATING

INTERNAL CLEARANCE: TOTAL PLAY; RADIAL .0002 TO .0006, AXIAL .002 TO .00[illegible]

LUBRICANT IDENTIFICATION: ADD LETTER AFTER DASH NO. TO INDICATE TYPE OF LUBRICANT:
A = MIL-G-23827
B = MIL-G-25537
C = MIL-G-81322
EXAMPLE OF PART NO. MS28915-16A = BEARING, ROLLER, SELF ALIGNING, 1.000 BORE WITH MIL-G-23827 LUBRICANT

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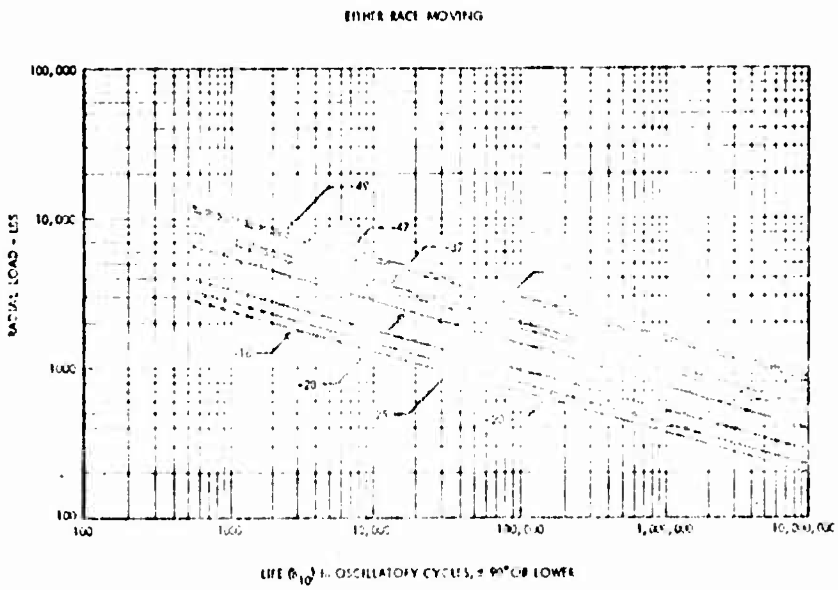
SUB-NOTE 4(4) (Sheet 2 of 2 Sheets) Light Duty Self-Aligning Roller Bearings (MS28915)



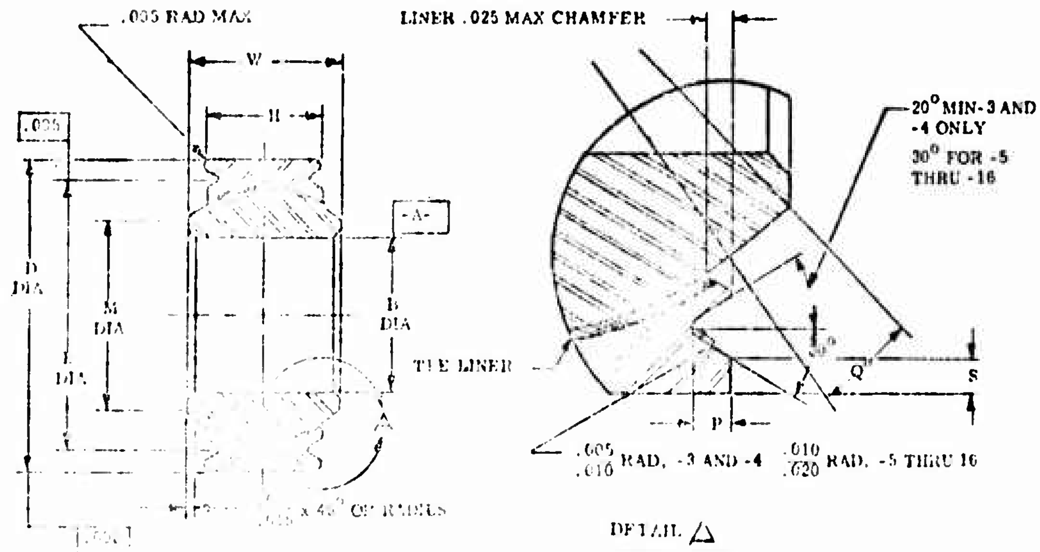
BEARING	O.D., INCHES	STEEL HOUSING BORE, IN.	AL HOUSING BORE, IN.
-16	1.[illegible]	1.6245 - 1.6[illegible]	1.[illegible] - 1.[illegible]4
-20	1.87[illegible]	1.8745 - 1.87[illegible]	1.8747 [illegible]
-25	2.500[illegible]	2.4[illegible] - 2.4[illegible]	2.4[illegible] - 2.4[illegible]
-25	2.6[illegible]	2.[illegible] - 2.[illegible]	2.[illegible] - 2.[illegible]
-31	3.0[illegible]	2.9[illegible]2 - 2.[illegible]	2.[illegible]3 - 2.9[illegible]
-37	3.2[illegible]	3.2[illegible] - 3.24[illegible]4	3.24[illegible] - 3.2[illegible]
-47	3.[illegible]	3.[illegible] - 3.[illegible]	3.[illegible] - 3.[illegible]
-49	4.[illegible]	3.9[illegible] - 3.9[illegible]4	3.9[illegible] - 3.[illegible]

SHAFT DIA. MAX. BEARING BORE, -.0005 to -.0010

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

116

SUB-NOTE 5(J) (Sheet 1 of 2 Sheets) TFE-Lined Plain Spherical Bearings (MS14101)



DETAIL △

DASH NO	B	D	H	M	P	Q	S	W	E	STATIC LIMIT LOAD RADIAL LB	STATIC LIMIT LOAD AXIAL LB	OSCIL-LATING LOAD LB	NO-LOAD ROTATIONAL BREAKAWAY TORQUE IN. LB	WT LB MAX
-3	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	2575	150	1500	0.25-5	.020
-4	[illegible]	[illegible]	[illegible]	[illegible]	.020		[illegible]	[illegible]	[illegible]	6040	[illegible]	[illegible]		
-5	[illegible]	[illegible]	[illegible]	[illegible]		10		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.030
-6	.3750	[illegible]	[illegible]	[illegible]	.040	9		[illegible]	[illegible]	10540	[illegible]	[illegible]	1-15	.040
7	[illegible]	[illegible]	[illegible]	[illegible]				.437	[illegible]	[illegible]	[illegible]	[illegible]		.050
-8	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.070
-9	[illegible]	[illegible]	[illegible]	[illegible]			.020	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.090
-10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8		.625	[illegible]	[illegible]	[illegible]	[illegible]		.120
-12	[illegible]	[illegible]	[illegible]	[illegible]				.750	[illegible]	[illegible]	[illegible]	[illegible]		.210
-14	[illegible]	[illegible]	[illegible]	[illegible]				.875	1.440	[illegible]	[illegible]	30200	1-24	.270
-16	1.0000	[illegible]	[illegible]	[illegible]		9		1.000	[illegible]	[illegible]	[illegible]	[illegible]		.390

NOTES

1. MATERIAL: (a) BALL 440C [illegible]
   (b) OUTER RING [illegible] (17-4PH)
   (c) LINER - [illegible] IN THE LINER.
2. LINER [illegible] MAX BORE, BALL FACE, AND OUTER RACE DIA RHR 32 MAX; ALL OTHERS [illegible]
3. HARDNESS [illegible] BALL [illegible], OUTER RING [illegible] MIN. Rc [illegible] MAX.
4. DIMENSIONS IN INCHES [illegible] OTHERWISE SPECIFIED, TOLERANCES DECIMALS ± .010 ANGLES ± 1/2°.
5. BREAK SHARP EDGES AND CORNERS AND REMOVE ALL BURRS AND SLIVERS.
6. THE -3 SIZE [illegible] FROM THE 'RADIAL STATIC LIMIT LOAD' TEST BECAUSE THE LOAD CAPABILITY OF [illegible] CRITICAL.
7. WHEN [illegible] TO THE [illegible] COMPATIBILITY OR HIGH TEMPERATURE REQUIREMENTS OF THE PROCUREMENT SPECIFICATION, THE OSCILLATING LOAD SHALL BE DECREASED TO 75% OF SPECIFIED LOAD.

DASH NUMBER DESIGNATES NOMINAL BORE DIAMETER IN SIXTEENTHS OF AN INCH.
EXAMPLE OF PART NO MS14101-6 = .3750 BORE.

SUB-NOTE 5(1) (Sheet 2 of 2 Sheets) TFE-Lined Plain Spherical Bearings (MS14101)

QUALIFICATION LOAD LIFE DATA

DASH NO.	BORE +.0000 -.0005	OSCILLATING LOAD ①, LB FOR 25,000 CYCLE LIFE AT 325°F, 10 CPM
3	.1900	1,5[illegible]
4	.2500	[illegible]
5	.3125	5,6[illegible]
6	.3750	6,[illegible]
7	.4375	8,[illegible]
8	.5000	10,4[illegible]
9	.5625	13,000
10	.6250	16,[illegible]
12	.7500	2[illegible]
14	.8750	30,[illegible]
16	1.0000	28,[illegible]

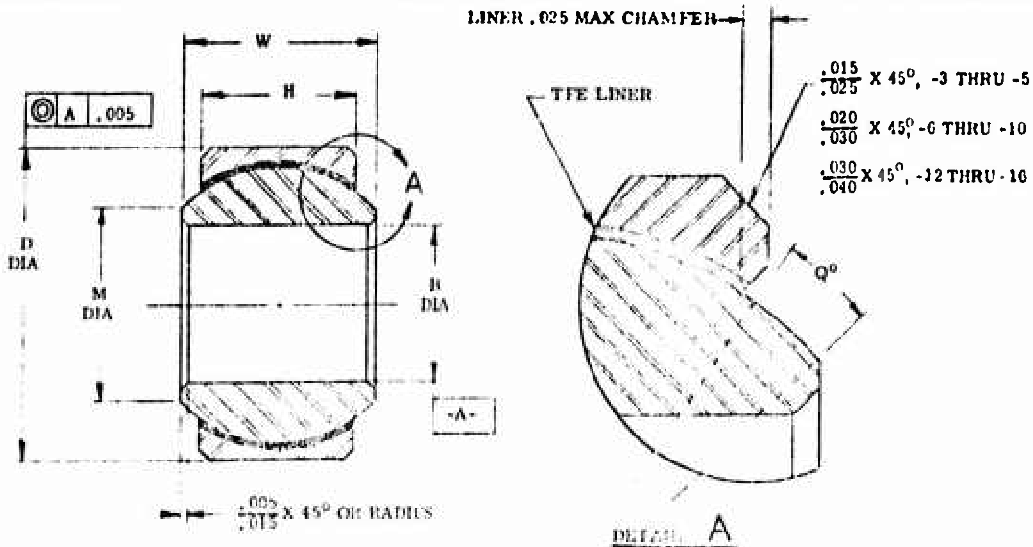
① SEE MIL-B-81820 FOR OTHER CONDITIONS OF LOADING

SHAFT AND HOUSING FITS

DASH NO.	O.D. +.000[illegible] -.0005	HOUSING BORE	SHAFT DIAMETER
3	.5625	.5615-.5620	BORE DIA +.0000 -.0005
4	.6562	.6551-.6556	
5	.7500	.7490-.74[illegible]	
6	.8125	.8114-.8119	
7	.9062	.9051-.9056	
8	1.0000	.9989-.9994	
9	1.0937	1.0926-1.0931	
10	1.1875	1.1864-1.1869	
12	1.4375	1.4363-1.4368	
14	1.5625	1.5614-1.5619	
16	1.7500	1.7489-1.7494	

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 5(2) (Sheet 1 of 2 Sheets) TFE-Lined Plain Spherical Bearings (MS14102)



DASH NO	B +.0000 -.0005	D +.0000 -.0005	H ±.005	M MIN	Q MIN	W +.000 -.002	STATIC LIMIT LOAD RADIAL LB	STATIC LIMIT LOAD AXIAL LB	OSCILLATING LOAD LB	NO-LOAD ROTATIONAL BREAKAWAY TORQUE IN. LB	WT LB MAX
-3	.1900	.6250	.327	.300	15	.437	9000	1770	4900	0.25-5	.031
-4	.2500										
-5	.3125	.6875	.317	.369	14	.437	9400	1040	6050	1-15	.035
-6	.3750	.8125	.406	.466	6	.500	[illegible]	2630	8310		.060
-7	.4375	.9375	.442	.537	10	.562	20700	3650	11750		.060
-8	.5000	[illegible]	.505	.607	9	.625	27500	4970	14950		.100
-9	.5625	1.1250	.536	.721	10	.687	[illegible]	5370	18100		.135
-10	.6250	1.1875	.567	.747	12	[illegible]	[illegible]	6130	20250		.160
-12	.7500	1.3750	.630	.845	13	.875	[illegible]	7730	26200		.240
-14	.8750	1.6250	.755	.995	6	.875	[illegible]	10800	33600	1-24	.350
-16	1.0000	2.1250	1.005	1.269	12	1.375	137000	19500	56250		.970

NOTES:

(A)

1-MATERIAL: (a) BALL 440C AMS 5630.
(b) OUTER RING AMS 5643 (17-4PH).
(c) LINER - TFE SHALL BE INCLUDED IN THE LINER.

2-FINISH: SURFACE FINISH BALL DIA RHR 8 MAX; BORE, BALL FACE, AND OUTER RACE DIA RHR 32 MAX; ALL OTHERS RHR 125 MAX.

3-HARDNESS: BALL 55-62 Rc OUTER RING Rc 23 MIN Rc 35 MAX.

4-DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES. DECIMALS ±.010 ANGLES ±1/2°.

5-BREAK SHARP EDGES AND CORNERS AND REMOVE ALL BURRS AND SLIVERS.

6-THE -3 SIZE BEARING IS EXEMPT FROM THE "RADIAL STATIC LIMIT LOAD" TEST AND THE "OSCILLATION UNDER RADIAL LOAD" TEST BECAUSE THE LOAD CAPACITY OF BEARING IS PIN CRITICAL.

7-WHEN TESTED TO THE FLUID COMPATIBILITY OR HIGH TEMPERATURE REQUIREMENTS OF THE PROCUREMENT SPECIFICATION, THE OSCILLATING LOAD SHALL BE DECREASED TO 75% OF SPECIFIED LOAD.

DASH NUMBER DESIGNATES NOMINAL BORE DIAMETER IN SIXTEENTHS OF AN INCH.
EXAMPLE OF PART NO. MS 14102-6 = .3750 BORE.

SUB-NOTE 5(2) (Sheet 2 of 2 Sheets) TFE-Lined Plain Spherical Bearings (MS14102)

QUALIFICATION LOAD LIFE DATA

DASH NO.	BORE +.0000 -.0005	OSCILLATING LOAD (1), LB FOR 25,000 CYCLE LIFE AT ±25°, 10 CPM
3	.1900	4,900
4	.2500	4,500
5	.3125	6,050
6	.3750	8,510
7	.4375	11,750
8	.5000	14,950
9	.5625	16,100
10	.6250	20,250
12	.7500	26,200
14	.8750	33,600
16	1.0000	56,250

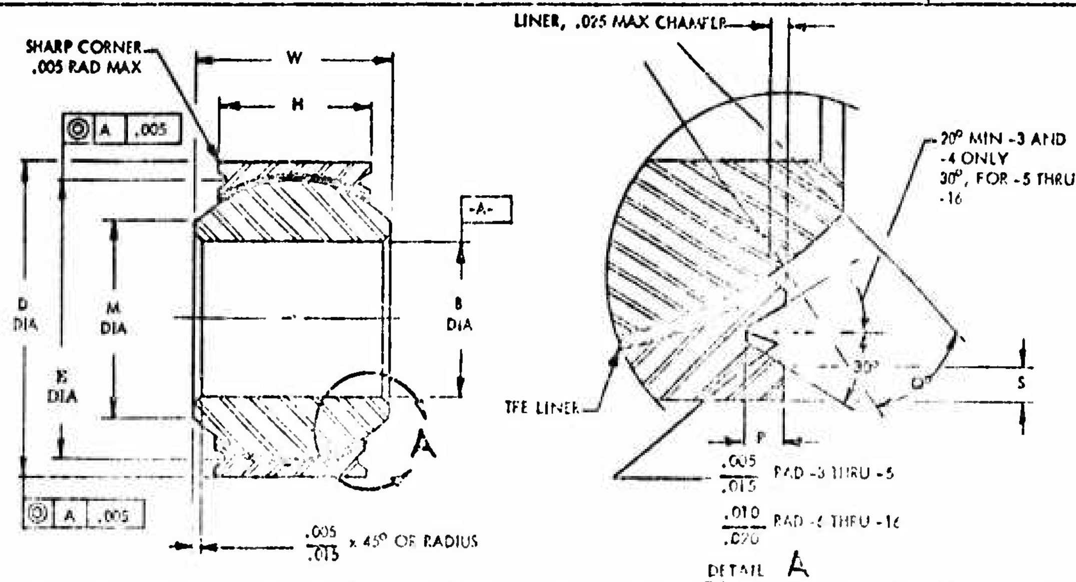
(1) SEE MIL-B-81820 FOR OTHER CONDITIONS OF LOADING

SHAFT AND HOUSING FITS

DASH NO.	O.D. +.0000 -.0005	HOUSING BORE	SHAFT DIAMETER
3	.6250	.6244 - .6239	BORE DIA +.0000 -.0005
4	.6250	.6244 - .6239	
5	.6875	.6869 - .6864	
6	.8125	.8119 .8114	
7	.9375	.9369 - .9364	
8	1.0000	.9994 - .9989	
9	1.1250	1.1244 - 1.1239	
10	1.1875	1.1869 - 1.1864	
12	1.3750	1.3744 - 1.3739	
14	1.6250	1.6244 - 1.6239	
16	2.1250	2.1244 - 2.1239	

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 5(3) (Sheet 1 of 2 Sheets) TFE-Lined Plain Spherical Bearings (MS14103)



DASH NO	B +.0000 -.0005	D +.0000 -.0005	E ±.005	M MIN	P +.000 -.015	O MIN	S MIN	W +.000 -.002	L +.000 -.010	STATIC LIMIT LOAD RADIAL LB	STATIC LIMIT LOAD AXIAL LB	OSCILLATING LOAD LB	NO-LOAD ROTATIONAL BREAKAWAY TORQUE IN-LB	WT LB MAX
-3	.1900	.6250	.327	.300	.030	15	.010	.437	.565	9000	1770	4900	0.25-5	.031
-4	.2500													
-5	.3125	.6875	.317	.360		14			.627	5400	1640	6550		.035
-6	.3750	.8125	[illegible]	.466		8		.500	.714	13700	2630	8910		.050
-7	.4375	.9375	.442	.537		10		.562	.839	20700	3650	11750		.080
-7A	.4375	.9062	.442	.537	.040	10		.562	.806	20700	3650		1-15	.080
-8	.5000	1.0000	.505	.607		9		.625	.902	27500	4970	14950		.100
-9	.5625	1.1250	.536	.721		10	.020	.687	1.027	34400	5370	16100		.135
-10	.6250	1.1875	.567	.747		12		.750	1.057	39000	6130	20250		.160
-12	.7500	1.3750	.630	.845		13		.875	1.253	52300	7730	26200		.240
-14	.8750	1.6250	.755	.995	.060	6		.875	1.503	67300	10000	33500	1-24	.350
-16	1.0000	2.1250	1.005	1.269		12		1.375	2.003	137000	19300	54250		.970

(A

NOTES:

1-MATERIAL: (a) BALL 440C AMS 5630.
(b) OUTER RING AMS 5643 (17-4PH).
(c) LINER - TFE SHALL BE INCLUDED IN THE LINER.

2-FINISH: SURFACE FINISH BALL DIA RHR 8 MAX; BORE, BALL FACE, AND OUTER RACE DIA RHR 32 MAX; ALL OTHER RHR 125 MAX.

3-HARDNESS: BALL 55-62 Rc, OUTER RING Rc 23 MIN Rc 35 MAX.

4-DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS ±.010 ANGLES ±1/2°

5-BREAK SHARP EDGES AND CORNERS AND REMOVE ALL BURRS AND SLIVERS.

6-THE -3 SIZE BEARING IS EXEMPT FROM THE "RADIAL STATIC LIMIT LOAD" TEST AND THE "OSCILLATION UNDER RADIAL LOAD" TEST BECAUSE THE LOAD CAPACITY OF BEARING IS PIN CRITICAL.

7-WHEN TESTED TO THE FLUID COMPATIBILITY OR HIGH TEMPERATURE REQUIREMENTS OF THE PROCUREMENT SPECIFICATION, THE OSCILLATING LOAD SHALL BE DECREASED TO 75% OF SPECIFIED LOAD.

DASH NUMBER DESIGNATES NOMINAL BORE DIAMETER IN SIXTEENTHS OF AN INCH.
EXAMPLE OF PART NO. MS 14103-6 = .3750 BORE.

SUB-NOTE 5(3) (Sheet 2 of 2 Sheets) TFE-Lined Plain Spherical Bearings (MS14103)

QUALIFICATION LOAD LIFE DATA

DASH NO.	BORE +.0000 -.0005	OSCILLATING LOAD (1), LB FOR 25,000 CYCLE LIFE AT ±25°, 10 CPM
3	.1900	4,900
4	.2500	4,900
5	.3125	6,050
6	.3750	6,310
7 AND 7A	.4375	11,750
8	.5000	14,950
9	.5625	18,100
10	.6250	20,250
12	[illegible]	[illegible]
14	[illegible]	35,650
16	1.000[illegible]	56,250

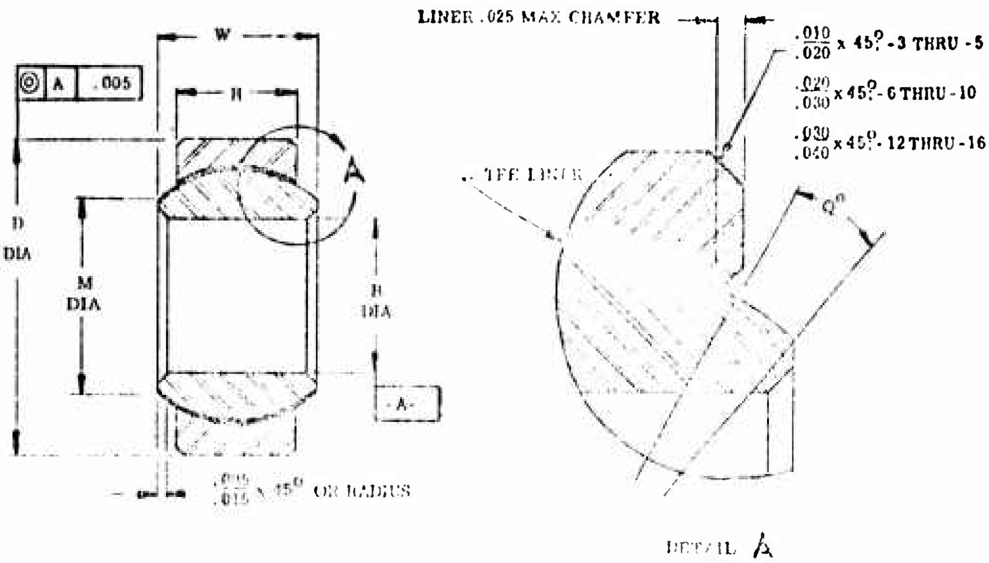
(1) SEE MIL-B-81820 FOR OTHER CONDITIONS OF LOADING

SHAFT AND HOUSING FITS

DASH NO.	O.D. +.0000 -.0005	HOUSING BORE	SHAFT DIAMETER
3	.6250	.6244 - .6239	BORE DIA +.0000 -.0005
4	.6250	.6244 - .6239	
5	.6875	.6869 - .6864	
6	.8125	.8119 - .8114	
7	.9375	.9369 - .9364	
8	1.0000	.9994 - .9989	
9	1.1250	1.1244 - 1.1239	
10	1.1875	1.1869 - 1.1864	
12	1.3750	1.3744 - 1.3739	
14	1.6250	1.6244 - 1.6239	
16	2.1250	2.1244 - 2.1239	

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 5(4) (Sheet 1 of 2 Sheets) TFE-Lined Plain Spherical Bearings (MS14104)



DASH NO.	B +.0000 -.0005	D +.0000 -.0005	H ±.005	M MIN	Q MIN	W +.000 -.002	STATIC LIMIT LOAD RADIAL LB	STATIC LIMIT LOAD AXIAL LB	OSCILLATING LOAD LB	NO LOAD ROTATIONAL BREAKAWAY TORQUE IN LB	WT. LB MAX
-3	.1900	.5625	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]	[illegible]	0.25-5	.020
-4	.2500	.6562	.250	[illegible]	10	.317	[illegible]	[illegible]	[illegible]		
-5	.3125	.7500	.281	.459	10	.355	[illegible]	[illegible]	[illegible]	1-15	.030
-6	.3750	.8125	.312	.455	9	[illegible]	[illegible]	[illegible]	[illegible]		.040
-7	.4375	.9062	[illegible]	[illegible]	8	[illegible]	[illegible]	[illegible]	[illegible]		.050
-8	.5000	1.0000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.070
-9	.5625	1.0937	.437	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.090
-10	.6250	1.1875	.500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.120
-12	.7500	1.4375	.593	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.210
-14	.8750	1.5625	.703	[illegible]	6	[illegible]	[illegible]	[illegible]	[illegible]	1-24	.270
-16	1.0000	1.7500	[illegible]	1.178	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.390

NOTES:

1. MATERIAL: (a) BALL 440C AMS 5630
   (b) OUTER RING AMS 5643(17-4PH).
   (c) LINER - TFE SHALL BE INCLUDED IN THE LINER.
2. FINISH: SURFACE FINISH, BALL DIA RHR [illegible] MAX, BORE, [illegible] FACE, AND OUTER RACE DIA RHR 32 MAX, ALL OTHERS RHR 125 MAX.
3. HARDNESS: BALL 55-62Rc, OUTER RING 23 Rc MIN. [illegible]
4. DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES DECIMALS ± .010 ANGLES ± 1/2°.
5. BREAK ALL SHARP EDGES AND CORNERS AND REMOVE ALL BURRS AND SLIVERS.
6. THE -3 SIZE BEARING IS EXEMPT FROM THE RADIAL STATIC LIMIT LOAD TEST BECAUSE THE LOAD CAPACITY OF BEARING IS PIN CRITICAL.
7. WHEN TESTED TO THE FLUID COMPATIBILITY OR HIGH TEMPERATURE REQUIREMENTS OF THE PROCUREMENT SPECIFICATION, THE OSCILLATING LOAD SHALL BE [illegible] OF SPECIFIED LOAD.

DASH NUMBER DESIGNATES NOMINAL BORE DIAMETER IN SIXTEENTHS OF AN INCH.
EXAMPLE OF PART NO. MS 14104-6 = .3750 BORE.

123<

SUB-NOTE 5(4) (Sheet 2 of 2 Sheets) TFE-Lined Plain Spherical Bearings (MS14104)

QUALIFICATION LOAD LIFE DATA

DASH NO.	BORE +.0000 -.0005	OSCILLATING LOAD ①, LB FOR 25,000 CYCLE LIFE AT ±25°, 10 CPM
3	.1900	1,500
4	.2500	3,320
5	.3125	5,460
6	.3750	6,600
7	.4375	8,050
8	.5000	10,400
9	.5625	13,000
10	.6250	16,450
12	.7500	23,[illegible]
14	.8750	[illegible]
16	1.0000	35,000

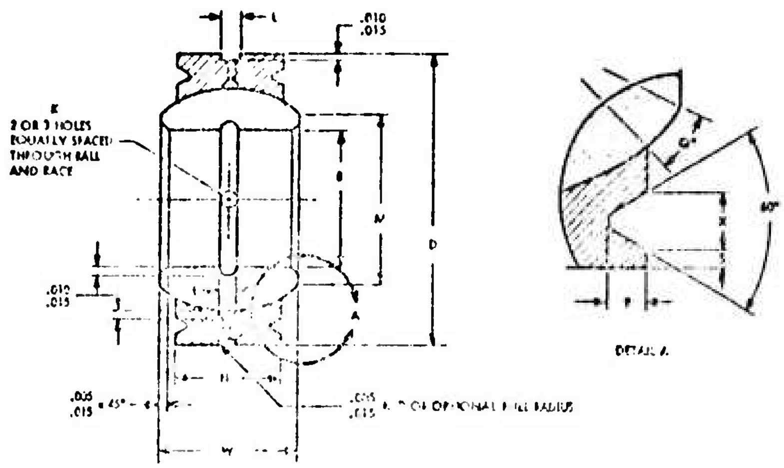
① SEE MIL-B-81820 FOR OTHER CONDITIONS OF LOADING

SHAFT AND HOUSING FITS

DASH NO.	O.D. +.0000 -.0005	HOUSING BORE	SHAFT DIAMETER
3	.5625	[illegible]	BORE DIA [illegible] -.0005
4	.6562	[illegible]-.65[illegible]	
5	.7500	.7490-.7495	
6	.8125	.8114-.8119	
7	.9062	.9051-.9056	
8	1.0000	.9989-.[illegible]	
9	1.0937	1.0926-1.0931	
10	1.1875	1.1864-1.1869	
12	1.4375	1.4363-1.4368	
14	1.5625	1.5614-1.5619	
16	1.7500	1.7489-1.7494	

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 5(5) Plain Spherical Bearings (MS21154)



DASH NO.	B	D	H	F	L	M	P	G°	T	W	Y	ALLOY STEEL RADIAL STATIC LIMIT LOAD	ALLOY STEEL AXIAL STATIC LIMIT LOAD	ALUM. BRONZE RADIAL STATIC LIMIT LOAD	ALUM. BRONZE AXIAL STATIC LIMIT LOAD
3	[illegible]	.562	[illegible]	.047	.06?	[illegible]	.093		.020	[illegible]	.045	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]			[illegible]		10		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]			[illegible]				.375		[illegible]	[illegible]	[illegible]	[illegible]
6	.3750	.8125	[illegible]			[illegible]	[illegible]	9		[illegible]	.055	[illegible]	4400	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	.062	[illegible]	[illegible]				[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]			[illegible]				[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]			[illegible]		8	.030	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]			.625	.060	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	.076	.093	[illegible]				[illegible]		[illegible]	[illegible]	[illegible]	6575
14	[illegible]	[illegible]	[illegible]			[illegible]				[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]			[illegible]		7		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]

(a) INNER DIMENSION AND BOLT DIAMETER TO BE MEASURED AFTER SWAGING

MATERIAL: BALL - SAE [illegible] OR [illegible], AMS [illegible]
RACE - [illegible] "S" ALLOY STEEL, MIL-S-[illegible], MIL-S-6756 OR MIL-S-6050, "B" ALUMINUM BRONZE

FINISH: BALL - CHROME PLATE QQ-C-320, CLASS 2, .0002 MINIMUM ON SPHERICAL SURFACES, .0005 ON FACES
RACE - CADMIUM PLATING QQ-P-416, TYPE I, CLASS 2.

HARDNESS: BALL - Rc [illegible] MIN
RACE - ALLOY STEEL, Rc [illegible]

LUBRICATION: PREPACKED WITH MIL-G-21164 GREASE

SURFACE FINISH: SPHERICAL SURFACE OF BALL & RACE, BORE, BALL FACE AND OUTER RACE O.D. 32 RHR. ALL OTHER SURFACES 125 RHR

TEMPERATURE RANGE: -65°F to +250°F

DIMENSIONS IN INCHES, UNLESS OTHERWISE SPECIFIED

TOLERANCES: DECIMALS ±.010, ANGLES ±1/2°

BREAK SHARP EDGES AND CORNERS AND REMOVE ALL BURRS AND SLIVERS

EXAMPLE OF PART NUMBER: MS21154 X XX

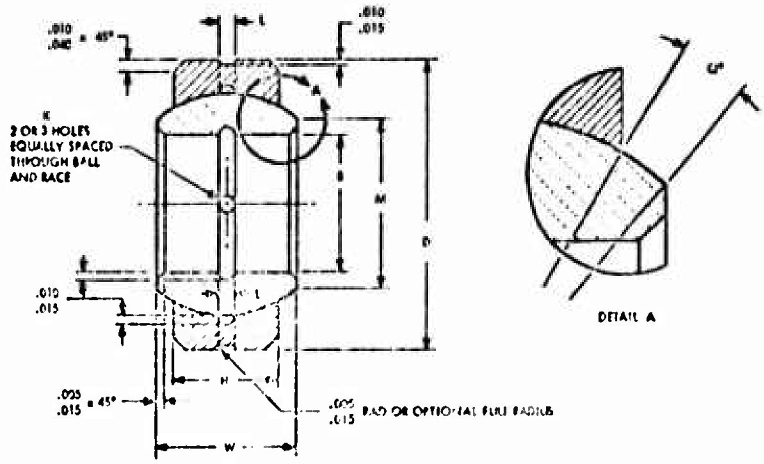
XX — BORE DIAMETER CODE IN MULTIPLES OF 1/16 INCH

X — OUTER RACE MATERIAL CODE

MS21154 — BASIC MS PART NUMBER

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 5(6) Plain Spherical Bearings (MS21155)



DASH NO.	B +.000 -.00?	D	H ±.005	F	L ±.015	M	G° MIN	W +.00? -.002	ALLOY STEEL RADIAL STATIC LIMIT LOAD	ALLOY STEEL AXIAL STATIC LIMIT LOAD	ALUMINUM BRONZE RADIAL STATIC LIMIT LOAD	ALUMINUM BRONZE AXIAL STATIC LIMIT LOAD
3	[illegible]	[illegible]	[illegible]	[illegible]	.042	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]			.344?	10	.343	[illegible]	[illegible]	[illegible]	[illegible]
5	.3125?	[illegible]	[illegible]			.415?		.375	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]			[illegible]	5	[illegible]	[illegible]	[illegible]	[illegible]	1760?
7	[illegible]	[illegible]	[illegible]	.042?	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	215?
8	[illegible]	[illegible]	[illegible]			[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]			.67?	6	.5?2	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]			.735?		.625	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	.07?	.093?	[illegible]		.750	[illegible]	16500?	[illegible]	6375?
14	[illegible]	[illegible]	[illegible]			[illegible]		.875?	[illegible]	[illegible]	[illegible]	[illegible]
16	1.0000?	[illegible]	[illegible]			1.118?	9	1.000	[illegible]	[illegible]	[illegible]	[illegible]

(a) L DIMENSION AND HOLE DIAMETER TO BE MEASURED AFTER SWAGING

MATERIAL: BALL - 52100, 440C AMS 5630
RACE - CODES: "S" ALLOY STEEL, MIL-S-5000, MIL-S-6758 OR MIL-S-6050. "B" ALUMINUM BRONZE

FINISH: BALL - CHROME PLATE, QQ-C-320, CLASS 2, .0007 MINIMUM ON SPHERICAL SURFACES, .0005 ON FACES
RACE - CADMIUM PLATE PER QQ-P-416, TYPE 1, CLASS 2

HARDNESS: BALL - Rc 56 MIN
RACE - Rc 27-36 ALLOY STEEL

LUBRICATION: PREPACKED WITH MIL-G-21164

SURFACE FINISH: SPHERICAL SURFACE OF BALL & RHR BORE, BALL FACE AND OUTER RACE O.D. 32 RHR. ALL OTHER SURFACES 125 RHR

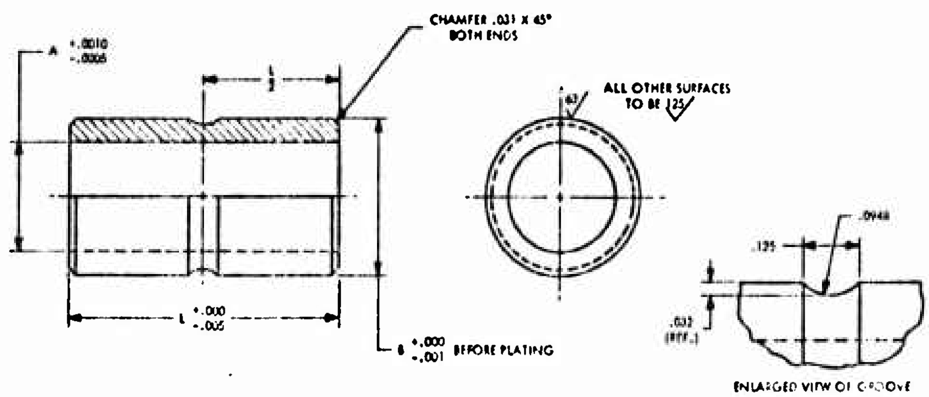
TEMPERATURE RANGE: -65°F to +250°F

DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED
TOLERANCES: DECIMALS ±.010, ANGLES ±1/2°
BREAK ALL SHARP EDGES AND CORNERS AND REMOVE ALL BURRS AND SLIVERS

EXAMPLE OF PART NUMBER: MS21155 X XX
- XX — BORE CODE IN MULTIPLES OF 1/16 INCHES
- X — RACE MATERIAL CODE
- MS21155 — BASIC MS NUMBER

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 6(1) (Sheet 1 of 2 Sheets) Clamp-Up Bushings
(NAS72, 73, 74)



SIZE DASH NO.	A	B	WT. IN LBS/IN. (BRONZE)	WT. IN LBS/IN. (STEEL)
3	.190	[illegible]	.024	[illegible]
4	.250	.4375	.030	.028
5	.3125	[illegible]	[illegible]	.033
6	.375	.5635	.041	.039
7	.4375	[illegible]	.046	.044
8	.500	.6855	[illegible]	[illegible]
9	.5625	.748	.057	.054
10	.625	.873	.068	.062
12	.750	.998	.103	[illegible]
14	.875	1.123	.118	.110
16	1.000	1.248	.139	.124

LENGTH DASH NO.	L	LENGTH DASH NO.	L	LENGTH DASH NO.	L	LENGTH DASH NO.	L
		100	1.010	200	2.010	300	3.010
		101	1.072	201	2.072	301	3.072
002	.135	102	1.135	202	2.135	302	3.135
003	.197	103	1.197	203	2.197	303	3.197
004	.260	104	1.260	204	2.260	304	3.260
005	.322	105	[illegible]	205	2.322	305	3.322
006	.385	106	1.385	206	2.385	306	3.385
007	.447	107	1.447	207	2.447	307	3.447
008	.510	108	1.510	208	2.510	308	3.510
009	.572	109	1.572	209	2.572	309	3.572
010	.635	110	1.635	210	2.635	310	3.635
011	.697	111	1.697	211	2.697	311	3.697
012	.760	112	1.760	212	2.760	312	3.760
013	.822	113	1.822	213	2.822	313	3.822
014	.885	114	1.885	214	2.885	314	3.885
015	.947	115	1.947	215	2.947	315	3.947

NOTES NAS-72
1. BUSHINGS UNDER .375 IN LENGTH SHALL NOT BE GROOVED
2. INSIDE AND OUTSIDE DIAMETER TO BE PARALLEL AND CONCENTRIC WITHIN .003 TOTAL INDICATOR READING
3. BREAK ALL SHARP EDGES .016.
4. THESE BUSHINGS NOT INTENDED FOR REAMING ON ASSEMBLY
5. THESE BUSHINGS ARE DESIGNED FOR CLAMPING TO THE SHAFT, WITH RELATIVE MOTION OCCURRING ON THE BUSHING O.D. ONLY.

CODE
FIRST DASH NO. DESIGNATES SIZE AS SHOWN IN ABOVE TABLE
SECOND DASH NO. DESIGNATES LENGTH AS SHOWN IN ABOVE TABLE.
FOR BUSHING LENGTHS .375 AND LONGER, LETTER E AFTER FIRST DASH NUMBER DESIGNATES BUSHING WITHOUT GROOVE

EXAMPLES
NAS 72-8-012 = BUSHING, .500 I.D. X .760 LONG WITH GROOVE
NAS 72-8E012 = BUSHING, .500 I.D. X .760 LONG WITHOUT GROOVE

MATERIAL
ALLOY STEEL HEAT TREATED TO 125,000 - 145,000 P.S.I. MAY BE MADE FROM 4130 STEEL BAR, SPEC. MIL-S-6758, 8620 STEEL BAR SPEC MIL-S-5050 OR EQUIVALENT. SEAMLESS ALLOY STEEL TUBING MAY BE USED AS AN OPTIONAL MATERIAL PROVIDED THE FINISHED PRODUCT MEETS ALL OTHER REQUIREMENTS OF THIS DRAWING.

FINISH
CHROME PLATE O.D. AND ENDS IN ACCORDANCE WITH QQ-C-320, CLASS 2, EXCEPT TO A SINGLE THICKNESS OF .0005 MIN (.0010 MIN. ON THE O.D.)

SURFACE FINISH:
SURFACE ROUGHNESS DESIGNATIONS IN ACCORDANCE WITH ANSI B46.1-1962

ALL DIMENSIONS IN INCHES

LIMITS
UNLESS OTHERWISE SPECIFIED DECIMALS ± .010, ANGLES ± 5°

127<

SUB-NOTE 6(1) (Sheet 2 of 2 Sheets) Clamp-Up Bushings (NAS72, 73, 74)

NOTES NAS-73
1. BUSHINGS UNDER .375 IN LENGTH SHALL NOT BE GROOVED.
2. INSIDE AND OUTSIDE DIAMETER TO BE PARALLEL AND CONCENTRIC WITHIN .003 TOTAL INDICATOR READING.
3. BREAK ALL SHARP EDGES .016
4. THESE BUSHINGS [illegible] NOT INTENDED FOR REAMING ON ASSEMBLY.
5. THESE BUSHINGS ARE DESIGNED FOR CLAMPING TO THE SHAFT, WITH RELATIVE MOTION OCCURRING ON THE BUSHING O.D., ONLY.

CODE
FIRST DASH NO. DESIGNATES SIZE AS SHOWN IN ABOVE TABLE.
SECOND DASH NO. DESIGNATES LENGTH AS SHOWN IN ABOVE TABLE.
FOR BUSHINGS LENGTH [illegible] 375 AND LONGER, LETTER E AFTER FIRST DASH NUMBER DESIGNATES BUSHING WITHOUT GROOVE.

EXAMPLES
NAS73-6-012 = BUSHING, .[illegible] I.D. X .750 LONG WITH GROOVE
NAS73-6E012 = BUSHING, .500 I.D. X .750 LONG WITHOUT GROOVE

MATERIAL
ALLOY STEEL HEAT TREATED TO 125,000 - 145,000 P.S.I. MAY BE MADE FROM 4130 STEEL BAR, SPEC MIL-S-6758, [illegible] STEEL BAR, SPEC MIL-S-6050 OR EQUIVALENT. SEAMLESS ALLOY STEEL TUBING MAY BE USED AS AN OPTIONAL MATERIAL PROVIDED THE FINISHED PRODUCT MEETS ALL OTHER REQUIREMENTS OF THIS DRAWING.

FINISH
CADMIUM PLATE PER SPEC QQ-P-416, TYPE II, CLASS 3

SURFACE FINISH
SURFACE ROUGHNESS DESIGNATIONS IN ACCORDANCE WITH ANSI B46.1-1962

ALL DIMENSIONS IN INCHES.

LIMITS
UNLESS OTHERWISE SPECIFIED DECIMALS ±.010, ANGLES ±5°

NOTES NAS-74
1. BUSHINGS UNDER .375 IN LENGTH SHALL NOT BE GROOVED.
2. INSIDE AND OUTSIDE DIA. TO BE PARALLEL AND CONCENTRIC WITHIN .003 TOTAL INDICATOR READING.
3. BREAK ALL SHARP EDGES .016
4. IF PLATED [illegible] AFTER PLATING
5. THESE BUSHINGS [illegible] ON ASSEMBLY.
6. THESE BUSHINGS [illegible] CLAMPING TO THE SHAFT, WITH RELATIVE MOTION OCCURRING ON THE BUSHING O.D. ONLY.

MATERIAL CODE:
FOR ALUMINUM BRONZE MATERIAL SUFFIX THE LETTER "A" TO THE BASIC PART NUMBER

FINISH CODE
FOR CADMIUM PLATED FINISH SUFFIX THE LETTER "P" TO THE LAST DASH NO.

GENERAL CODE
FIRST DASH NO. DESIGNATES SIZE AS SHOWN IN ABOVE TABLE.
SECOND DASH NO. DESIGNATES LENGTH AS SHOWN IN ABOVE TABLE.
FOR BUSHING LENGTHS .375 AND LONGER, LETTER E AFTER FIRST DASH NUMBER DESIGNATES BUSHING WITHOUT GROOVE.

EXAMPLES
NAS74-8-012 = BUSHING .500 [illegible] X .750 LONG WITH GROOVE
NAS74A-8E012 = BUSHING .500 I.D. X .750 LONG WITHOUT GROOVE
NAS74A8-012P BUSHING .500 I.D. X .750 LONG WITH GROOVE, CADMIUM PLATED

MATERIAL:
ALUMINUM BRONZE BAR, PER SPEC. QQ-C-465

FINISH:
CADMIUM PLATE PER SPEC. QQ-P-416, TYPE I, CLASS 3. IN ADDITION CADMIUM PLATED BRONZE BUSHINGS ARE TO BE DYED A LIGHT YELLOW COLOR WHICH WILL NOT RUB OFF OR BE SMEARED BY CONTACT INCIDENTAL TO HANDLING AND SERVICE AND SHALL NOT BE INJURIOUS TO THE MATERIAL.

SURFACE FINISH
SURFACE ROUGHNESS DESIGNATIONS IN ACCORDANCE WITH ANSI B46.1-1962

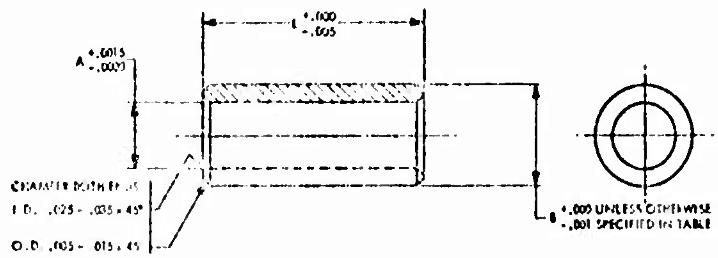
ALL DIMENSIONS IN INCHES.

LIMITS
UNLESS OTHERWISE SPECIFIED DECIMALS ±.010, ANGLES ±5°

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

128<

SUB-NOTE 6(2) (Sheet 1 of 2 Sheets) Press-Fit Bushings (NAS75, 76)



SIZE DASH NO.	BOLT SIZE (REF.)	A	B	NAS-75 WEIGHT LBS./IN. (STEEL)	NAS-76 WEIGHT LBS./IN. (BRONZE)
3	10	.190	[illegible]	.013	.014
4	1/4	.250	[illegible]	.019	.021
5	5/16	.3125	[illegible]	.022	.024
6	3/8	[illegible]	.5013 [illegible]	.026	.028
7	7/16	.4375	[illegible]	.029	.031
8	1/2	.500	.6265 +.0010 -.0008	.033	.036
9	9/16	[illegible]	[illegible]92	.035	.039
10	5/8	.625	.8142	.063	.068
11	-	.6875	.8767	.065	.070
12	3/4	.750	[illegible]	.075	.081
14	7/8	.875	1.0646	.088	.093
16	1	1.000	[illegible]	.097	.105
18	-	1.125	[illegible]	.102	.111
20	-	1.250	[illegible]	.112	.122

129<

SUB-NOTE 6(2) (Sheet 2 of 2 Sheets) Press-Fit Bushings (NAS75, 76)

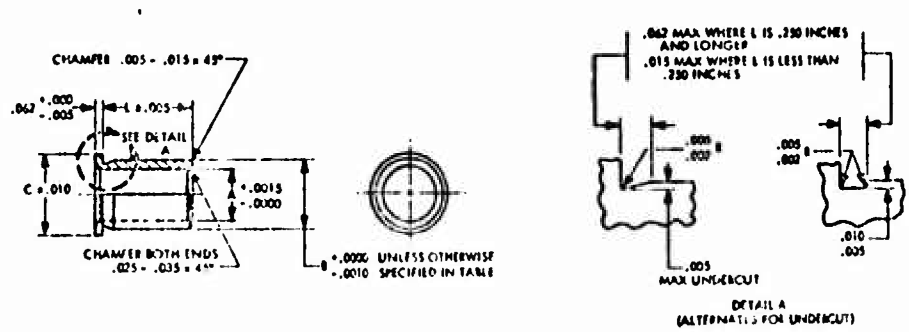
NOTES: NAS-75	1. INSIDE DIA. TO BE PARALLEL AND CONCENTRIC WITH OUTSIDE DIA. WITHIN .003 TOTAL INDICATOR READING. 2. ALL DIMENSIONS TO BE MET AFTER PLATING. 3. THESE BUSHINGS NOT INTENDED FOR REAMING ON ASSEMBLY.
LENGTH CODE	LENGTH TO BE SPECIFIED IN INCHES AND 1/32 NDS OF AN INCH
GENERAL CODE	NAS75 - (SIZE DASH NO.) - (LENGTH DASH NO.)
EXAMPLES	NAS75-8-009 = STEEL BUSHING - .500 INSIDE DIA., 9/32 LONG NAS75-8-015 = STEEL BUSHING - .500 INSIDE DIA., 15/32 LONG NAS75-8-309 = STEEL BUSHING - .500 INSIDE DIA., 3-9/32 LONG NAS75-8-315 = STEEL BUSHING - .500 INSIDE DIA., 3-15/32 LONG
MATERIAL	ALLOY STEEL HEAT TREATED TO 125,000-145,000 PSI MAY BE MADE FROM 4130 STEEL BAR, SPEC. MIL-S-6758, 8630 STEEL BAR, SPEC. [illegible] OR EQUIVALENT. SEAMLESS ALLOY STEEL TUBING MAY BE [illegible] AS AN OPTIONAL MATERIAL PROVIDED THE FINISHED PRODUCT MEETS ALL OTHER REQUIREMENTS OF THIS DRAWING.
FINISH	CADMIUM PLATE [illegible] THICKNESS PER QQ-P-416 TYPE II, CLASS 3
SURFACE FINISH	ALL SURFACES 125 [illegible] PER ASA B46.1-1962
DIMENSIONS IN INCHES	TOLERANCES: ANGLES ±5°

NOTES: NAS-76	1. INSIDE DIA. TO BE PARALLEL AND CONCENTRIC WITH OUTSIDE DIA. WITHIN .003 TOTAL INDICATOR READING. 2. IF PLATING [illegible] ALL DIMENSIONS ARE TO BE MET AFTER PLATING. 3. THESE BUSHINGS NOT INTENDED FOR REAMING ON ASSEMBLY.
LENGTH CODE	LENGTH TO BE SPECIFIED IN INCHES AND 1/32 NDS OF AN INCH
MATERIAL CODE	FOR ALUMINUM BRONZE MATERIAL, SUFFIX THE LETTER "A" TO BASIC PART NO.
FINISH CODE	FOR CADMIUM PLATED FINISH SUFFIX THE LETTER "P" TO THE LAST DASH NO.
GENERAL CODE	NAS76A (SIZE DASH NO.) (LENGTH DASH NO.) ("P" IF REQ.)
EXAMPLES	NAS76A8-009P = ALUMINUM BRONZE BUSHING - .500 INSIDE DIA., 9/32 LONG, CADMIUM PLATED NAS76A8-309 = ALUMINUM BRONZE BUSHING - .500 INSIDE DIA., 3-9/32 LONG NAS76A8-315 = ALUMINUM BRONZE BUSHING - .500 INSIDE DIA., 3-15/32 LONG
MATERIAL	ALUMINUM BRONZE BAR, SPEC. QQ-C-465
FINISH	CADMIUM PLATE PER QQ-P-416, TYPE II, CLASS 3. IN ADDITION, CADMIUM PLATED BRONZE BUSHINGS ARE TO BE [illegible] A LIGHT YELLOW COLOR WHICH WILL NOT RUB OFF OR BE SMEARED BY CONTACT INCIDENTAL TO HANDLING AND SERVICE AND SHALL NOT BE INJURIOUS TO THE MATERIAL
SURFACE FINISH	ALL SURFACES 125 [illegible] PER ANSI B46.1-1962
DIMENSIONS IN INCHES	TOLERANCES: ANGLES ±5°

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

120<

SUB-NOTE 6(3) Flanged Press-Fit Bushings (NAS77)



SIZE DASH NO	BOLT SIZE REF	A	B	C	WEIGHT LB/IN.	
					STEEL	BRONZE
3	#10	1900	3136 + [illegible] − [illegible]	437	016	017
4	1/4	2500	3761 + [illegible] − [illegible]	500	020	021
5	5/16	3125	4386 + [illegible] − [illegible]	562	025	027
6	3/8	[illegible]	[illegible] + [illegible] − [illegible]	625	[illegible]	030
7	7/16	4375	[illegible] + [illegible] − [illegible]	687	.032	034
8	1/2	5000	.6265 + [illegible] − .0008	.750	.036	.038
9	9/16	5625	6892	812	.040	042
10	5/8	6250	8142	1.000	[illegible]	072
11	-	6875	8767	1.062	.079	084
12	3/4	7500	[illegible]	1.125	091	096
14	7/8	8750	1.0648	1.250	104	110
16	1	1.0000	1.1898	1.375	117	124
18	1-1/8	1.1250	1.3148	1.500	125	132
20	1-1/4	1.2500	1.4397	1.625	137	146

NOTES:
1. ALL DIMENSIONS TO BE MET AFTER PLATING.
2. ID & OD TO BE CONCENTRIC WITHIN .003 TOTAL INDICATOR READING.
3. BREAK SHARP EDGES .005 - .025
4. THESE BUSHINGS NOT INTENDED FOR REAMING ON ASSEMBLY.

LENGTH CODE: LENGTH L TO BE SPECIFIED IN .01 INCH INCREMENTS

MATERIAL CODE: FOR ALUMINUM BRONZE MATERIAL, SUFFIX THE LETTER "A" TO THE BASIC PART NUMBER. NO LETTER INDICATES ALLOY STEEL MATERIAL

FINISH CODE: ALL STEEL BUSHINGS SHALL BE CAD. PLATED. FOR A CAD. PLATED FINISH ON BRONZE BUSHINGS SUFFIX THE LETTER "P" TO THE LAST DASH NUMBER

GENERAL CODE: NAS77 ("A" IF REQD.) - SIZE DASH NO.) - (LENGTH DASH NO.) - ("P" IF REQD.)

EXAMPLES: NAS77-8-15 = CAD. PLATED STEEL BUSHING - .500 INSIDE DIA - .150 LONG
NAS77A8-167P = ALUMINUM BRONZE BUSHING - .500 INSIDE DIA - 1.670 LONG, CAD. PLATED

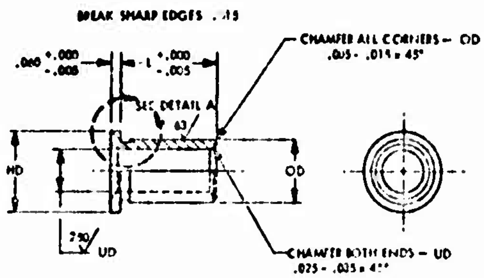
MATERIAL: ALUMINUM BRONZE BAR, QQ-C-465, ALLOY 642
ALLOY STEEL HEAT TREATED TO 125,000 - 145,000 PSI MAY BE MADE FROM 4130 STEEL BAR SPEC MIL-S-6758, 8630 STEEL BAR SPEC MIL-S-6050
SEAMLESS ALLOY STEEL TUBING MAY BE USED AS AN OPTIONAL MATERIAL PROVIDED THE FINISHED PRODUCT MEETS ALL OTHER REQUIREMENTS OF THIS DRAWING

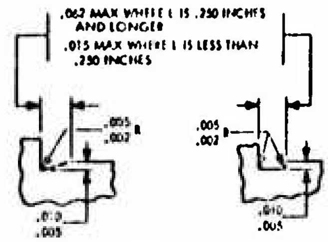
FINISH: CAD. PLATE PER SPEC QQ-P-416 TYPE II, CLASS 3. IN ADDITION, CAD. PLATED BRONZE BUSHINGS ARE TO BE DYED A LIGHT YELLOW COLOR WHICH WILL NOT RUB OFF OR BE SMEARED BY CONTACT INCIDENTAL TO HANDLING AND SERVICE AND SHALL NOT BE INJURIOUS TO THE MATERIAL.

SURFACE TEXTURE: PER ANSI B46.1-1962, ALL SURFACES 100 MICROINCHES

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 6(4) Flanged Press-Fit Bushings (NAS538)





DETAIL A
(ALTERNATES FOR UNDERCUT)

SIZE FIRST DASH NO.	NOM DIA FOR REAM FINISH	DIMENSIONS						REFERENCE DATA			
		INSIDE DIA		OUTSIDE DIA		FLANGE DIA		WEIGHT IN LBS = F + (L X S)			
		UD (UNDER-SIZE)		OD		HD		STEEL		ALUMINUM BRONZE	
		DIA	TOL	DIA	TOL	DIA	TOL	FLANGE	SHANK	FLANGE	SHANK
		DIA	+.0000	DIA	+.0000	DIA	+.000	F	S	F	S
-3	[illegible]	[illegible]	+.0050	.3136	[illegible]	.447	-.020	[illegible]	.0136	[illegible]	[illegible]
-4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-.020	[illegible]	.0176	[illegible]	[illegible]
-5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-.020	[illegible]	[illegible]	.0030	[illegible]
-6	.3750	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-.020	[illegible]	[illegible]	[illegible]	[illegible]
-7	.4375	.4220	+.0070	.5636	-.0007	.697	-.020	[illegible]	.0262	[illegible]	.0278
-8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-.020	.0042	[illegible]	.0042	[illegible]
-9	[illegible]	.5460	[illegible]	[illegible]	[illegible]	[illegible]	-.020	[illegible]	[illegible]	[illegible]	[illegible]
-10	[illegible]	.6070	[illegible]	.6142	-.0010	[illegible]	-.020	[illegible]	[illegible]	.0072	[illegible]
-11	[illegible]	[illegible]	+.0070	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.0040	[illegible]	[illegible]
-12	[illegible]	.7340	[illegible]	[illegible]	-.0010	[illegible]	-.020	[illegible]	.0112	[illegible]	[illegible]
-14	[illegible]	[illegible]	[illegible]	[illegible]	-.0010	[illegible]	-.020	.0110	[illegible]	[illegible]	[illegible]
-16	[illegible]	[illegible]	[illegible]	[illegible]	-.0010	[illegible]	-.020	[illegible]	[illegible]	.0120	[illegible]
-18	[illegible]	[illegible]	+.0120	[illegible]	-.0010	[illegible]	[illegible]	.0136	.1032	[illegible]	.1016
-20	[illegible]	1.2160	+.0120	1.4097	-.0010	1.735	-.020	[illegible]	[illegible]	.0146	[illegible]

CODE:

MATERIAL: IS INDICATED BY THE LETTER FOLLOWING THE BASIC NUMBER.
"-" (NO LETTER) INDICATES ALLOY STEEL 4130 BAR, SPECIFICATION MIL-S-6758 OR 8630 STEEL BAR SPECIFICATION MIL-S-6050, HEAT TREAT FOR ALLOY STEEL 125,000 TO 145,000 PSI PER MIL-H-6875.
"B" INDICATES ALUMINUM BRONZE BAR, SPECIFICATION QQ-C-465

DIAMETER: IS INDICATED BY THE SIZE FIRST DASH NUMBER FOLLOWING THE BASIC NUMBER AND MATERIAL CODE IF USED, AS SHOWN IN TABLE

FINISH: IS INDICATED BY THE LETTER FOLLOWING THE SIZE FIRST DASH NUMBER
"P" INDICATES CADMIUM PLATING PER SPEC. QQ-P-416, TYPE II, CLASS 3, FOR ALL SURFACES

CADMIUM PLATED BRONZE BUSHINGS SHALL BE DYED A LIGHT YELLOW COLOR WHICH WILL NOT RUB OFF BY CONTACT INCIDENTAL TO HANDLING AND SERVICE AND SHALL NOT BE INJURIOUS TO THE MATERIAL

LENGTH L SHALL BE SPECIFIED IN .01 INCH INCREMENTS, FOLLOWING THE SIZE FIRST DASH NUMBER AND THE FINISH CODE IF USED

EXAMPLES:
NAS538-8-175 = .5000 INCH STEEL BUSHING - 1.75 LONG
NAS538B8-175 = .5000 INCH ALUMINUM BRONZE BUSHING - 1.75 LONG
NAS538-8P175 = .5000 INCH STEEL BUSHING - CAD. PLATED - 1.75 LONG
NAS538B8P175 = .5000 INCH ALUMINUM BRONZE BUSHING - CAD. PLATED - 1.75 LONG

WEIGHT IN LB = .0042 + 1.75 X .0314 = .059 LB/PIECE

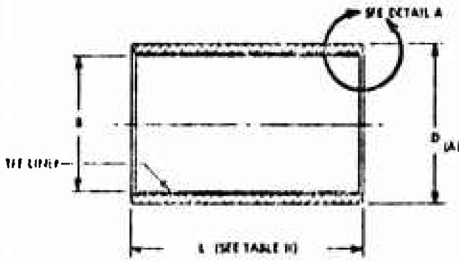
NOTES:

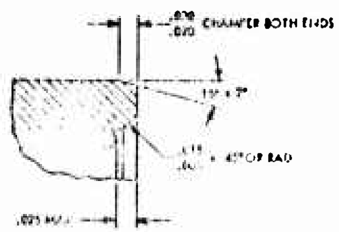
1. THESE BUSHINGS ARE INTENDED FOR REAMING AFTER INSTALLATION.
2. TOLERANCE SHALL BE ± .010 UNLESS OTHERWISE STATED.
3. INSIDE DIAMETER AND OUTSIDE DIAMETER TO BE PARALLEL AND CONCENTRIC WITHIN .003 TOTAL INDICATOR READING.
4. ALL DIMENSIONS TO BE MET AFTER PLATING.
5. REFERENCE DIMENSIONS ARE FOR DESIGN PURPOSES ONLY AND ARE NOT AN INSPECTION REQUIREMENT.
6. SURFACE TEXTURE PER ANSI B46.1-1962. ALL SURFACES 125 MICROINCHES EXCEPT AS NOTED.

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 6(5) (Sheet 1 of 2 Sheets) TFE-Lined Bushings (MS21240)

CONCENTRICITY TOLERANCE BETWEEN B AND D DIA SHALL NOT EXCEED .003 T.I.R.





DETAIL A

TABLE I

DASH NO.	NOMINAL SIZE	B DIA +.0000 -.0010	D DIA (A)	WEIGHT LB/IN (REF) L = 1.000 AL	CRES
-04	1/4	.2215	.3760	.005	.017
-05	5/16	.3140	.4386	.008	.022
-06	3/8	.3765	.5012	.009	.025
-07	7/16	.4390	.5638	.010	.028
-08	1/2	.5015	.6265	.011	.031
-09	9/16	.5640	.6892	.013	.036
-10	5/8	.6265	.8142	.022	.061
-11	11/16	.6890	.8767	.023	.064
-12	3/4	.7515	.9393	.025	.070
-14	7/8	.8765	1.0645	.029	.080
-16	1	1.0015	1.1898	.033	.091
-18	1 1/8	1.1265	1.3148	.037	.101
-20	1 1/4	1.2515	1.4400	.040	.111
-22	1 3/8	1.3765	1.5648	.044	.122
-24	1 1/2	1.5015	1.7020	.065	.179
-26	1 5/8	1.6265	1.8273	.070	.193
-28	1 3/4	1.7515	2.0023	.075	.207
-32	2	2.0015	2.2523	.085	.234

(A) D TOLERANCE ALUMINUM, ±.0005, CRES, +.0000, -.0005

TABLE II

DASH NO.	NOM SIZE	* LENGTH L +.000 -.010 1/4	9/32	5/16	11/32	3/8	7/16	1/2	9/16	5/8	11/16	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8	2 1/2	2 3/4	3
-04	1/4	08	09	10	11	12	14																					
-05	5/16	08	09	10	11	12	14	16	18																			
-06	3/8	08	09	10	11	12	14	16	18	20	22																	
-07	7/16	08	09	10	11	12	14	16	18	20	22	24	28															
-08	1/2	08	09	10	11	12	14	16	18	20	22	24	28															
-09	9/16	08	09	10	11	12	14	16	18	20	22	24	28	32	36													
-10	5/8	08	09	10	11	12	14	16	18	20	22	24	28	32	36	40	44											
-11	11/16	08	09	10	11	12	14	16	18	20	22	24	28	32	36	40	44	48	52									
-12	3/4	08	09	10	11	12	14	16	18	20	22	24	28	32	36	40	44	48	52									
-14	7/8	08	09	10	11	12	14	16	18	20	22	24	28	32	36	40	44	48	52									
-16	1	08	09	10	11	12	14	16	18	20	22	24	28	32	36	40	44	48	52	56	60							
-18	1 1/8			10	11	12	14	16	18	20	22	24	28	32	36	40	44	48	52	56	60							
-20	1 1/4					12	14	16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68					
-22	1 3/8					12	14	16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68					
-24	1 1/2					12	14	16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	88	
-26	1 5/8							16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	88	
-28	1 3/4							16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	88	96
-32	2							16	18	20	22	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	88	96

* LENGTH DESIGNATION SHOULD HAVE "0" DIGIT BEFORE NUMBER SHOWN

EXAMPLE :

-04	1/4	008	009	010	011	012	014

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SUB-NOTE 6(5) (Sheet 2 of 2 Sheets) TFE-Lined Bushings (MS21240)

MATERIAL: CODE

BEARING: "A" = ALUMINUM ALLOY, QQ-A-200/11 OR QQ-A-225/9
"C" = CORROSION RESISTANT STEEL, AMS 5643 (17-4PH), AISI 410 OR 416

LINER: SEE PROCUREMENT SPECIFICATION
HARDNESS: 17-4PH COND H-1150 AS PER MIL-H-6875
410, 416 R_c 27-32 AS PER MIL-H-6875

FINISH: ALUMINUM TO BE ANODIZED PER MIL-A-8625

SURFACE FINISH: SMOOTH MACHINE FINISH 63 MICRO-INCH RHR ON O.D., 125 MICRO-INCH RHR ON ALL OTHER SURFACES PER ANSI B46.1 - 1962, UNLESS OTHERWISE SPECIFIED

TEMPERATURE RANGE: -65° F TO +250° F

BREAK SHARP EDGES AND CORNERS AND REMOVE ALL BURRS AND SLIVERS

DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED

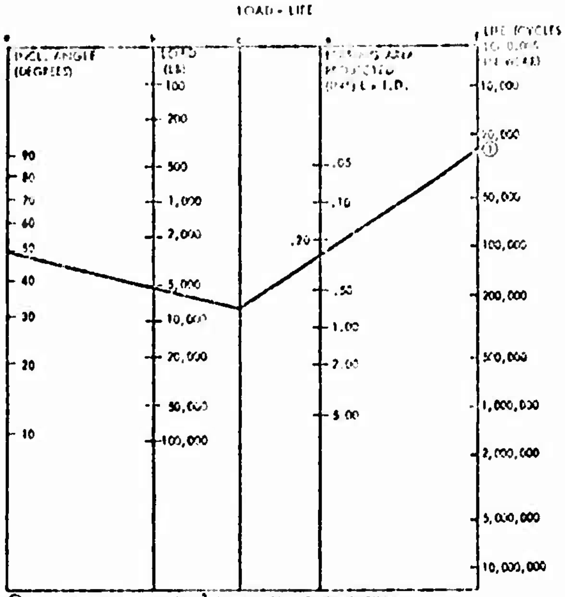
EXAMPLE OF PART NUMBER:

```
MS21240 -    04     A      008 = 1/4 INCH BORE DIA ALUMINUM X 1/4 LONG
   |          |     |       |_______ LENGTH CODE IN MULTIPLES OF 1/32 INCH
   |          |     |_______ MATERIAL CODE
   |          |_______ BORE DIAMETER CODE IN MULTIPLES OF 1/16 INCH
   |_______ BASIC MS PART NUMBER
```

LOAD RATINGS: DYNAMIC CAPACITY 25,000 B X L LBS OR 25,000 B^2 LB WHICHEVER IS LESSER
STATIC LIMIT LOAD [illegible] B X L LBS OR [illegible] B^2 LB WHICHEVER IS LESSER.

PERFORMANCE DATA

LOAD - LIFE



① PLAIN BEARING WITH 0.3 IN² PROJECTED AREA OPERATING AT ±25°, 6,000 LBS LOAD WILL GIVE 26,000 CYCLES LIFE BEFORE 0.005 WEAR OCCURS

SHAFT & HOUSING FITS

BEARING	BEARING BORE DIA +.0030 -.0010	SHAFT DIA ②	O.D. Inches +.0000 -.0005	HOUSING BORE, IN (A)
-04	[illegible]	[illegible] – .2495	[illegible]	.3756 – [illegible]
-05	.3142	.3120 – .3110	[illegible]	[illegible]
-06	[illegible]	.3745 – .3735	[illegible]	.5010 – [illegible]
-07	.43[illegible]	[illegible] – .4360	[illegible]	.5636 – [illegible]
-08	[illegible]	[illegible] – .4975	[illegible]	.6261 – [illegible]
-09	.564[illegible]	[illegible]	[illegible]	.6890 – [illegible]
-10	[illegible]	.6745 – .6735	.8142	.8140 – [illegible]
-11	.6950	[illegible] – .6860	.8767	.8765 – [illegible]
-12	.7515	.7495 – .7485	[illegible]	.9391 – [illegible]
-14	[illegible]	.8645 – .8635	1.0645	1.0640 – [illegible]
-16	1.0015	[illegible] – .9975	1.1895	1.1893 – [illegible]
-18	1.1265	1.1245 – 1.1235	1.3149	1.3143 – 1.3153
-20	1.2515	1.2495 – 1.2485	[illegible]	1.4393 – [illegible]
-22	1.3765	1.3745 – 1.3735	[illegible]	1.5643 – [illegible]
-24	1.5015	1.4995 – 1.4985	[illegible]	1.7516 – [illegible]
-26	1.6265	1.6245 – 1.6235	[illegible]	1.8766 – [illegible]
-28	1.7515	1.7495 – 1.7485	2.0023	2.0015 – [illegible]
-32	2.0015	1.9975 – 1.9965	[illegible]	2.2518 – [illegible]

② SHAFT FINISH < 10 RHR FOR MAXIMUM BEARING LIFE
SHAFT HARDNESS > R_c 50 FOR MAXIMUM SHAFT LIFE

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

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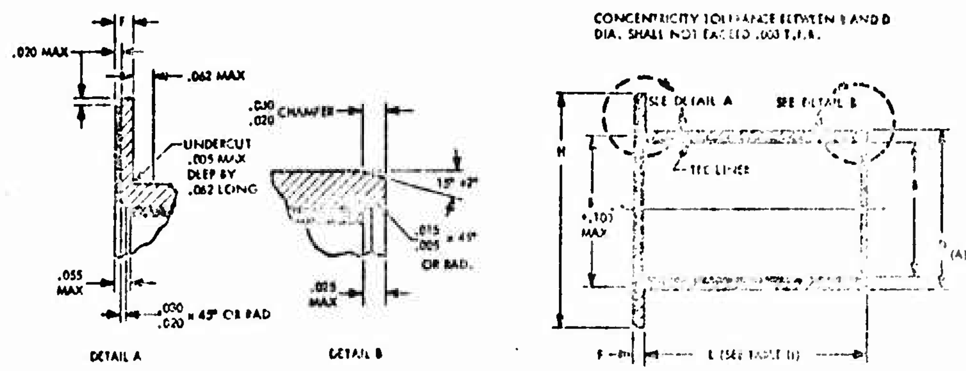
SUB-NOTE 6(6) (Sheet 1 of 2 Sheets) TFE-Lined Flanged Bushings (MS21241)



DASH NO.	NOMINAL SIZE	B DIA +.0005 -.0010	D DIA (A)	F +.000 -.005	H DIA +.000 -.020	WEIGHT LB/IN (REF) L = 1.000 AL	CRES	FLANGE WEIGHT AL	CRES	BODY (B) WEIGHT PER INCH AL	CRES
-04	1/4	.2515	[illegible]	.0625	[illegible]	[illegible]	[illegible]		.007	[illegible]	[illegible]
-05	5/16	[illegible]	[illegible]	[illegible]	[illegible]	.011	[illegible]	.003		[illegible]	[illegible]
-06	3/8	.3765	.5012	[illegible]	[illegible]	.012	[illegible]			[illegible]	[illegible]
-07	7/16	[illegible]	[illegible]	[illegible]	.937	.013	[illegible]		[illegible]	[illegible]	[illegible]
-08	1/2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.041	.004	[illegible]	[illegible]	[illegible]
-09	9/16	[illegible]	[illegible]	[illegible]	[illegible]	.017	[illegible]		[illegible]	[illegible]	[illegible]
-10	5/8	[illegible]	.8142	[illegible]	1.250	.027	.075	[illegible]	[illegible]	[illegible]	[illegible]
-11	11/16	[illegible]	[illegible]	[illegible]	[illegible]	.030	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-12	3/4	.7515	[illegible]	.0625	1.500	[illegible]	[illegible]	.008	[illegible]	[illegible]	[illegible]
-14	7/8	[illegible]	1.0645	.0625	1.625	[illegible]	.105		[illegible]	[illegible]	[illegible]
-16	1	[illegible]	[illegible]	[illegible]	[illegible]	.043	.118	[illegible]	[illegible]	[illegible]	[illegible]
-18	1 1/8	1.1265	1.3143	[illegible]	[illegible]	.051	.142	[illegible]	[illegible]	[illegible]	[illegible]
-20	1 1/4	[illegible]	[illegible]	[illegible]	2.000	[illegible]	.161	[illegible]	[illegible]	[illegible]	[illegible]
-22	1 3/8	[illegible]	1.5041	[illegible]	2.125	.063	[illegible]	.019	[illegible]	[illegible]	[illegible]
-24	1 1/2	[illegible]	[illegible]	[illegible]	2.250	.064	[illegible]		[illegible]	[illegible]	[illegible]
-26	1 5/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-28	1 3/4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-32	2	[illegible]	[illegible]	[illegible]	[illegible]	.111	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(A) D TOLERANCE ALUMINUM, +.0005, CORROSION RESISTANT STEEL, +.0000, -.0005

(B) EXAMPLE OF WEIGHT CALCULATION:
MS21241-16A08 = .010 + .0?? x .5 = .010 + .0165 = .0?65 LB

MATERIAL CODE
BEARING "A" = ALUMINUM ALLOY, QQ-A-200/11, QQ-A-225/9
"C" = CORROSION RESISTANT STEEL, AMS 5643 (17-4PH), AISI 410 OR 416

LINER SEE PROCUREMENT SPECIFICATION
HARDNESS: 17-4PH COND. H-1150 AS PER MIL-H-6875
410, 416 R_c 27-32 AS PER MIL-H-6875

FINISH ALUMINUM TO BE ANODIZED PER MIL-A-8625

SURFACE FINISH: SMOOTH MACHINE FINISH 63 MICRO-INCH PER RHR ON O.D., 125 MICRO-INCH RHR ON ALL OTHER SURFACES PER ANSI B46.1-1962, UNLESS OTHERWISE SPECIFIED

TEMPERATURE RANGE -65° F TO +250° F

BREAK SHARP EDGES AND CORNERS AND REMOVE ALL BURRS AND SLIVERS.

DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED.

EXAMPLE OF PART NUMBER

MS21241 - 04 A 008 - 1/4 INCH BORE DIA ALUMINUM X 1/4 LONG
008: LENGTH CODE IN MULTIPLES OF 1/32 INCH
A: MATERIAL CODE
04: BORE DIAMETER CODE IN MULTIPLES OF 1/16 INCH
MS21241: BASIC MS PART NUMBER

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SUB-NOTE 6(6) (Sheet 2 of 2 Sheets) TFE-Lined Flanged Bushings (MS21241)

LOAD RATINGS

DYNAMIC CAPACITY 25,000 B X L LBS., OR 25,000 B² LB., WHICHEVER IS THE LESSER
STATIC LIMIT LOAD 60,000 B X L LBS., OR 60,000 B² LB., WHICHEVER IS THE LESSER

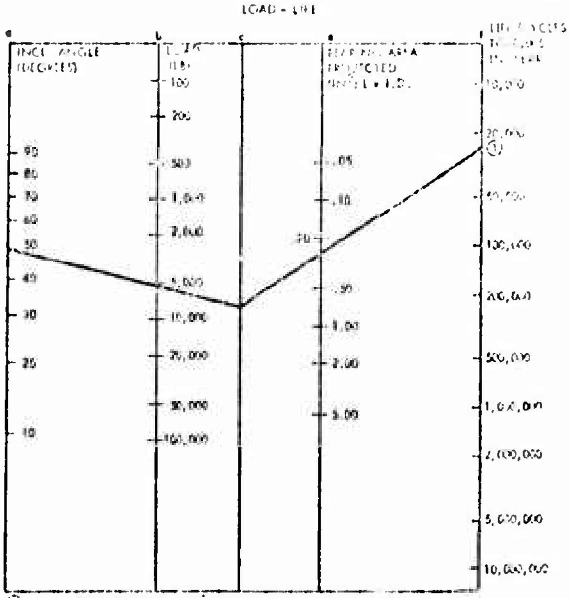
DASH NO.	NOM SIZE	* LENGTH L +.000 -.010																										
		1/4	9/32	5/16	11/32	3/8	7/16	1/2	9/16	5/8	11/16	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8	2 1/2	2 3/4	3
* -04	1/4	06	[illegible]	10	11	12	14																					
-05	5/16	[illegible]	09	10	11	12	14	16	18																			
-06	3/8	06	09	[illegible]	[illegible]	12	14	16	18	20	22																	
-07	7/16	06	09	10	11	12	14	[illegible]	[illegible]	20	22	24	[illegible]															
-08	1/2	06	09	10	11	12	14	[illegible]	18	20	22	24	[illegible]															
-09	9/16	06	09	10	11	12	14	16	[illegible]	20	22	24	[illegible]	[illegible]	36													
-10	5/8	06	09	10	11	12	14	16	18	20	22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	44											
-11	11/16	[illegible]	[illegible]	10	11	12	14	16	18	20	[illegible]	[illegible]	[illegible]	32	[illegible]	[illegible]	44	[illegible]	52									
-12	3/4	[illegible]	[illegible]	10	11	12	[illegible]	[illegible]	[illegible]	[illegible]	22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	52									
-14	7/8	[illegible]	[illegible]	10	11	12	14	16	[illegible]	[illegible]	22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									
-16	1	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]							
[illegible]	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]							
-20	1 1/4					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	44	[illegible]	[illegible]	56	[illegible]	[illegible]	[illegible]					
-22	[illegible]					12	14	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	56	[illegible]	[illegible]	[illegible]					
-24	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1 3/4						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-32	2						16	18	20	22	24	[illegible]	[illegible]	[illegible]	36	40	44	48	52	56	[illegible]	[illegible]	[illegible]	72	76	[illegible]	88	96

* LENGTH DESIGNATION [illegible]
EXAMPLE :

-04	1/4	006	[illegible]	010	011	012	014

PERFORMANCE DATA

LOAD - LIFE



(1) PLAIN BEARING WITH 0.3 IN² PROJECTED AREA OPERATING AT ±20°, 2,000 LBS LOAD WILL GIVE 26,000 CYCLES LIFE BEFORE 0.005 WEAR OCCURS

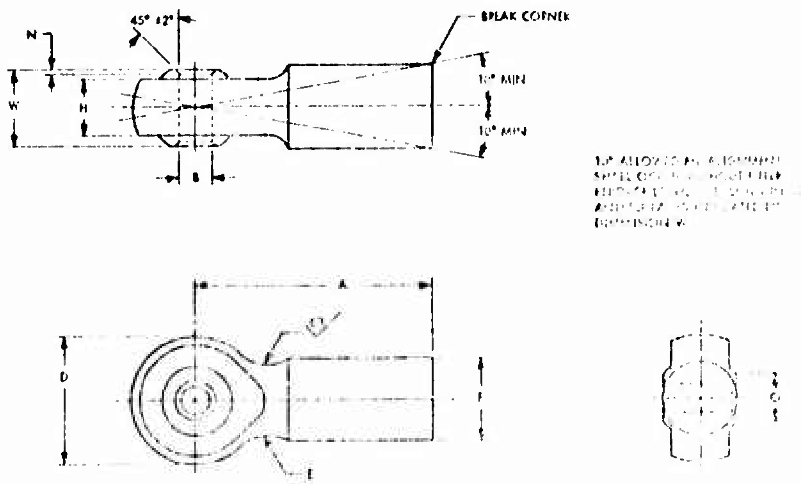
SHAFT & HOUSING FIT

BEARING NO.	BEARING SIZE [illegible]	SHAFT DIA. (2)	O.D. [illegible]	HOUSING BORE, IN.
-04	.2515	[illegible]	[illegible]	[illegible]
-05	.3140	.3120 – [illegible]	[illegible]	[illegible] – .4376
-06	[illegible]	.3745 – [illegible]	[illegible]	[illegible]
-07	[illegible]	[illegible] – [illegible]	[illegible]	[illegible] – [illegible]
-08	.5015	[illegible] – [illegible]	.6265	[illegible] – [illegible]
-09	.5640	[illegible] – [illegible]	[illegible]	[illegible] – [illegible]
-10	.6265	[illegible] – [illegible]	.8142	[illegible] – .8132
-11	[illegible]	[illegible] – [illegible]	.8767	[illegible] – .8757
-12	[illegible]	[illegible] – [illegible]	[illegible]	[illegible] – [illegible]
-14	[illegible]	[illegible] – [illegible]	1.0645	[illegible] – [illegible]
-16	[illegible]	[illegible] – [illegible]	[illegible]	[illegible] – [illegible]
-18	[illegible]	1.1245 – [illegible]	[illegible]	[illegible] – [illegible]
-20	[illegible]	[illegible] – [illegible]	[illegible]	[illegible] – [illegible]
-22	[illegible]	[illegible] – 1.3735	1.5648	[illegible] – 1.5633
-24	[illegible]	[illegible] – [illegible]	[illegible]	[illegible] – [illegible]
-26	[illegible]	[illegible] – [illegible]	[illegible]	[illegible] – [illegible]
-28	1.7515	[illegible] – [illegible]	[illegible]	[illegible] – [illegible]
-32	2.0015	[illegible] – [illegible]	2.2523	[illegible] – 2.2508

(2) SHAFT FINISH < [illegible] FOR MAXIMUM BEARING LIFE
SHAFT HARDNESS > [illegible] FOR MAXIMUM SHAFT LIFE

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 7(1) Solid Shank Ball-Bearing Rod Ends (MS21150)



DASH NUMBER	BORE SIZE NOM	A	B +.000 -.002 DIA	C DIA	E MIN RAD	F +.000 -.002 DIA	H	N +.015 -.010 (a)	G REF DIA	W	[illegible]
3-7	3/16	1.3[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.[illegible]	[illegible]	[illegible]	[illegible]
4-10	1/4	1.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]

ENGINEERING DATA						
	RADIAL STRENGTH		AXIAL STRENGTH		[illegible]	
DASH NUMBER	LIMIT LOAD POUNDS	FRACTURE LOAD POUNDS	LIMIT LOAD POUNDS	FRACTURE LOAD POUNDS	CASE I	CASE II
3-7	[illegible]	15[illegible]	2[illegible]	3[illegible]	[illegible]	1[illegible]
4-10	17[illegible]	2[illegible]	34[illegible]	520	17[illegible]	1[illegible]

(a) A RADIUS GIVING THE SAME FILLET CLEARANCE WILL BE ACCEPTABLE.

(b) CASE I = LOAD FIXED WITH RESPECT TO OUTER RACE
CASE II = LOAD FIXED WITH RESPECT TO INNER RACE

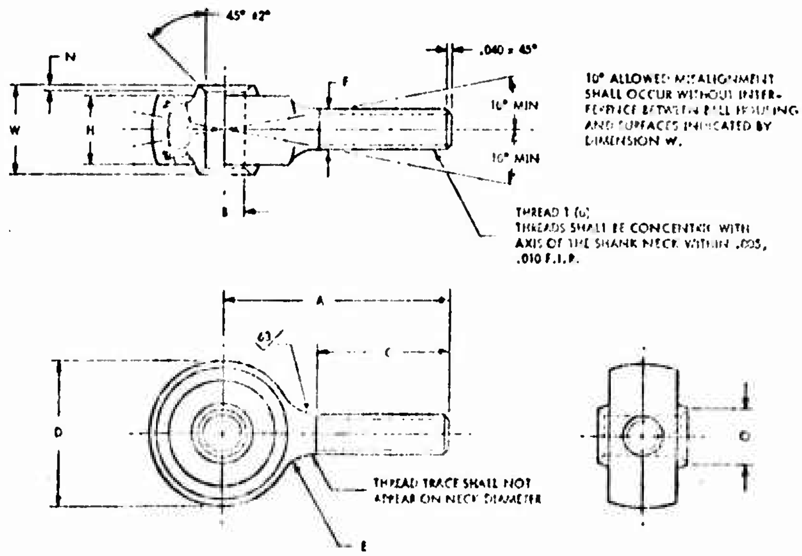
FOR DEFINITION AND APPLICATION OF [illegible] STATUS NOTES, SEE MIL-STD-[illegible]
RADIAL PLAY: .000[illegible] UNDER 5.5 POUND [illegible] LOAD
AXIAL PLAY: .00[illegible] UNDER 5.5 POUND [illegible] LOAD
MATERIAL: STEEL, [illegible]
LUBRICATION: GREASE, [illegible]
FINISH: CADMIUM PLATE, SPECIFICATION [illegible], TYPE I, CLASS [illegible]
SURFACE [illegible] SHALL NOT EXCEED [illegible]
REMOVE ALL BURRS AND SHARP EDGES
DIMENSIONS IN INCHES, UNLESS OTHERWISE SPECIFIED, TOLERANCE: DECIMALS ±.0[illegible]
DIMENSIONS TO BE MET AFTER PLATING

EXAMPLE OF COMPLETE PART NUMBER: MS21150-4-10 BEARING, BALL, ROD END, PRECISION, [illegible],
SELF-ALIGNING, CONTACT SEAL, METAL SHIELD, SIZE 4 [illegible]

MS21150 BEARINGS ARE SUBSTITUTABLE FOR MS26[illegible] BEARINGS OF THE SAME BORE AND SHANK DIAMETER.

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 7(2) (Sheet 1 of 2 Sheets) External Thread Ball-Bearing Rod Ends (MS21151)



DASH NUMBER	BORE SIZE NOM	A	B +.0000 -.0005 DIA	C ±.031	D DIA	E MIN RAD	F +.000 -.010 DIA	H	N +.015 -.000 (a)	C' MIN DIA	THREAD T (b) UNF - 3A	W +.000 -.005	WGT lb APPROX
3M3	No. 10	1.375	.1900	.750	.781	.427	.190	.328	.005	.276	10-32 LH	.437	.04
3M3											10-32 RH		
3M6A		2.031		1.313	.969	.500	.375	.437		.219	3/8-24 RH	.500	.05
3M6-24		1.375		.750	.781	.390		.328		.276		.437	
3M16-24											3/8-24 LH		
3M4-2		1.812		.938		.562	.250	.438		.307	1/4-28 RH	.500	.10
3M4-6		1.563		1.000		.344		.370		.276		.437	.05
4M4	1/4	1.875	.2500	1.125	.938	.469	.375	.438	.005	.340	3/8-24 RH	.593	.10
4M4A											3/8-24 LH		
5M6	5/16	2.438	.3125	1.563	1.250	.500	.375	.656	.015	.561	3/8-24 RH	.870	.24
5M7							.437				7/16-20 RH		
5M10							.625				5/8-18 RH		
10M10	5/8	2.750	.6250	1.500	2.000	.500	.625	.928	.015	.875	5/8-18 RH	1.125	.71

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SUB-NOTE 7(2) (Sheet 2 of 2 Sheets) External Thread Ball-Bearing Rod Ends (MS21151)

TOL. = +.000 - .015

(a) A RADIUS [illegible] FILLET CLEARANCE WILL BE ACCEPTABLE
(b) THREADS [illegible]
SCREW-THREAD [illegible] SERVICE
(c) LOCKING SLOT [illegible]

MS21151 BEARINGS ARE [illegible]
FOR DEFINITION AND APPLICATION OF [illegible]
RADIAL PLAY [illegible]
AXIAL PLAY [illegible]
MATERIAL [illegible]
FINISH [illegible] TYPE I, CLASS [illegible]
LUBRICATION [illegible]
REMOVE ALL BURRS [illegible]

SURFACE [illegible]
[illegible]
[illegible]
EXAMPLE OF [illegible] PART NUMBER [illegible]
[illegible] CONTACT [illegible] BEARING

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1360	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] 3M4-2 3M4-5	[illegible]	[illegible]	200	30	[illegible]	[illegible]
4M6 [illegible]	1720	[illegible]	345	[illegible]	1220	[illegible]
5M5 [illegible] 5M10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10M10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(d) CASE I - LOAD FIXED WITH RESPECT TO OUTER RACE
CASE II - LOAD FIXED WITH RESPECT TO INNER RACE

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

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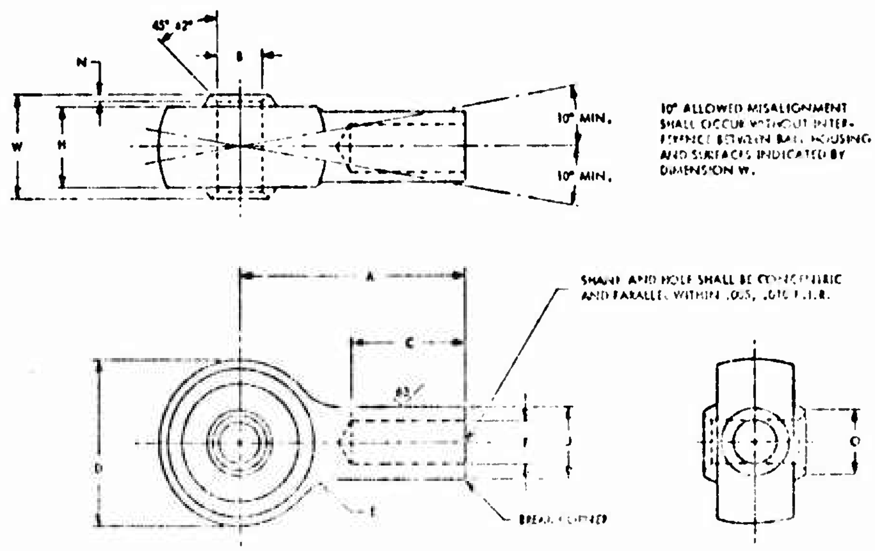
SUB-NOTE 7(3) Hollow Shank Ball-Bearing Rod Ends (MS21152)



DASH NUMBER	BORE SIZE	A	B DIA	C	D	E MIN RAD	F	H	J DIA		[illegible]	G MIN	W	WGT LB
3H5	No. 10	1.375	.1900	[illegible]	[illegible]	[illegible]	.272	.328	.43[illegible]	.475		.276	.437	.06
4H6	1/4	[illegible]	.2500	1.2[illegible]	.532	.4[illegible]	[illegible]	.435	.625	.473	.005	.34	.593	.12
4H8		1.625		[illegible]		.5[illegible]	.51[illegible]							.0[illegible]
4H5-2		1.875		.75		.4[illegible]	[illegible]		.4[illegible]	.4[illegible]				.12
4H6-2				1.125		.5[illegible]	[illegible]		.625	.62[illegible]				.0[illegible]

ENGINEERING DATA						
DASH NUMBER	RADIAL STRENGTH: LIMIT LOAD POUNDS	RADIAL STRENGTH: FRACTURE LOAD POUNDS	AXIAL STRENGTH: LIMIT LOAD POUNDS	AXIAL STRENGTH: FRACTURE LOAD POUNDS	RADIAL LOAD RATING [illegible]: CASE I	RADIAL LOAD RATING [illegible]: CASE II
3H5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10[illegible]
4H6	1720	2580	345	[illegible]	172[illegible]	172[illegible]
4H8						
4H5-2						
4H6-2						

(a) A RADIUS GIVING THE SAME FILLET CLEARANCE WILL BE ACCEPTABLE

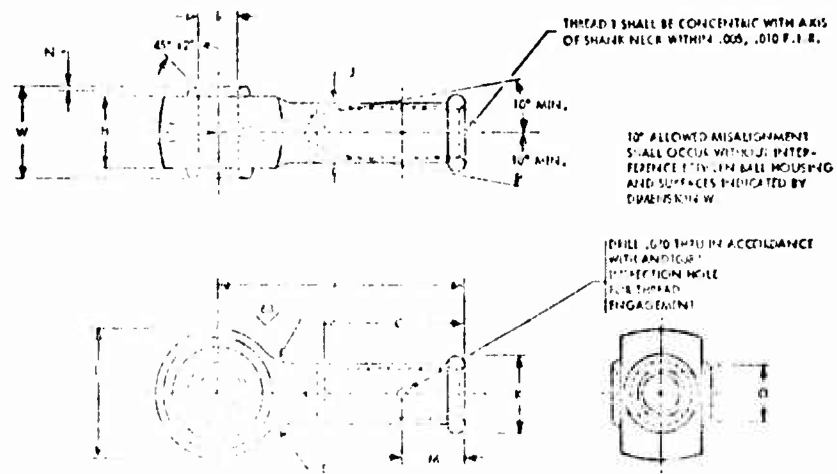
(b) CASE I - LOAD FIXED WITH RESPECT TO OUTER RACE
CASE II - LOAD FIXED WITH RESPECT TO INNER RACE

FOR DEFINITION & APPLICATION OF DRAWING STATUS NOTES, SEE MIL-STD-[illegible]
RADIAL PLAY: [illegible]
AXIAL PLAY: [illegible]
MATERIALS: STEEL, [illegible]
FINISH: CADMIUM PLATE, SPECIFICATION [illegible], TYPE I, CLASS II
LUBRICATION: GREASE [illegible]
REMOVE ALL BURRS AND SHARP EDGES
SURFACE ROUGHNESS: [illegible] SHALL NOT EXCEED [illegible] MICRO INCHES, SHANK 63 MICRO INCHES
DIMENSIONS IN INCHES, UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS ±.010
DIMENSIONS TO BE MET AFTER PLATING
EXAMPLE OF COMPLETE PART NUMBER: MS21152 - 3H5 BEARING, BALL, ROD END, HOLLOW SHANK, CONTACT SEAL, SIZE 3 BEARING

MS21152 BEARINGS ARE SUBSTITUTABLE FOR [illegible] BEARINGS OF THE SAME BORE AND SHANK DIAMETERS

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 7(4) (Sheet 1 of 2 Sheets) Internal Thread Ball-Bearing Rod Ends (MS21153)



DASH NUMBER	[illegible]	A	B	C	D	E	H	J	K	M	N	O	THREAD T	W	WGT LB APPROX
[illegible]								[illegible]					[illegible]	.437	.05
[illegible]								[illegible]					[illegible]		
3F4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	.500	.06
[illegible]								.375					[illegible]		
[illegible]										.312			[illegible]	.437	.05
4F5		[illegible]						[illegible]					[illegible]		[illegible]
[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]					.340	[illegible]	[illegible]	
4F7				[illegible]				.625	.625				[illegible]		.16
[illegible]		[illegible]											[illegible]		
5F5	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.015	.501	[illegible]	[illegible]	.10
[illegible]													[illegible]		

(a) A [illegible] THE SAME [illegible] ACCEPTABLE.
(b) [illegible]
(c) THIS [illegible] WIDTH ACROSS THE [illegible] FLATS.
(d) [illegible] TO BE IN ACCORDANCE [illegible] 559.

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SUB-NOTE 7(4) (Sheet 2 of 2 Sheets) Internal Thread Ball-Bearing Rod Ends (MS21153)

ROD ENDS ARE [illegible] WITH A COMPOSITION SEAL.
[illegible], SEE MIL-STD-[illegible]32.
RADIAL PLAY: [illegible]
AXIAL PLAY: [illegible]
MATERIAL: [illegible]
CONTACT [illegible] MICROINCHES, SHAFT [illegible] MICROINCHES.
FINISH: [illegible], TYPE I, CLASS I.
LUBRICATION: [illegible]
[illegible]
DIMENSIONS [illegible] TOLERANCES [illegible] .010.
[illegible]
EXAMPLE OF [illegible] PART NUMBER: [illegible]21153-3[illegible]4 - BEARING, BALL, ROD END, INTERNAL LEFT-HAND THREAD, CONTACT SEAL, SIZE 3 BEARING.

[illegible]

ENGINEERING DATA						
DASH NUMBER	RADIAL STRENGTH		AXIAL STRENGTH		[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]	CASE I	CASE II
[illegible]	1[illegible]	1500	[illegible]	300	1000	1[illegible]30
[illegible]	1720	2900	385	520	1720	1720
5[illegible]	2[illegible]	4325	565	600	2920	2600

(a) CASE I - LOAD FIXED WITH RESPECT TO OUTER RACE
CASE II - LOAD FIXED WITH RESPECT TO INNER RACE

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

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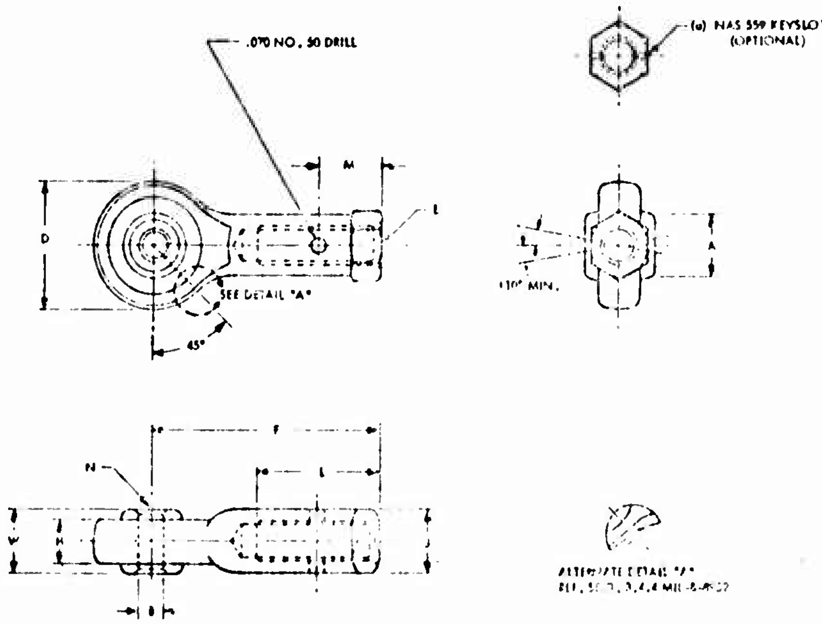
SUB-NOTE 7(5) Internal Thread Roller-Bearing Rod Ends (MS21220)



DASH NO.	A DIA MIN	B +.0000 -.0005	C DIA MAX	E UNJF-3 THREAD	F ±.010	H ±.010	J HEX FLATS	L ±.0[illegible]	N [illegible]	R [illegible]	V [illegible]	LIMIT LOAD RATING RADIAL	LIMIT LOAD RATING AXIAL	DYNAMIC RADIAL LOAD RATING	REF WT LB
4	.47	.2500	1.0[illegible]	[illegible]-24	1.6[illegible]	.3	.5	.81	.43		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	.56	.3125	1.41	[illegible]-20	2.30	.4	.69	1.31	[illegible]	.015	[illegible]	[illegible]	500	4.[illegible]	[illegible]
6	.66	.3750	1.66	5/8-18	3.00	.5[illegible]	.8[illegible]	1.75	.81		.812	[illegible]	[illegible]	[illegible]	[illegible]

THESE BEARINGS ARE SELF-ALIGNING FOR 10° IN EITHER DIRECTION.

MATERIAL: INNER RING AND ROLLERS E52100, FED-STD-66
OUTER RING ROD END, 4130, MIL-S-6758, 4140, MIL-S-5626, 8620, MIL-S-8690, E52100 FED-STD-66

PLATING: ALL EXTERNAL STEEL SURFACES EXCEPT BORE OF INNER RING, QQ-P-416, TYPE I, CLASS 2

DIMENSIONS TO BE MET AFTER PLATING

SURFACE ROUGHNESS: RACEWAYS 8, ROLLERS 6 IN ACCORDANCE WITH ANSI B46.1-1962

REMOVE BURRS AND SHARP EDGES

INTERNAL CLEARANCE: RADIAL .0002 TO .0010, AXIAL .0010 TO .005

LUBRICANT IDENTIFICATION: ADD APPROPRIATE SUFFIX LETTER TO INDICATE TYPE OF LUBRICANT
A = MIL-G-23827 B = MIL-G-25537
C = MIL-G-81322 D = MIL-G-3278

(a) ADD SUFFIX LETTER K WHEN NAS 559 KEYSLOT IS REQUIRED
ADD SUFFIX LETTER L WHEN LEFT HAND THREAD IS REQUIRED
ADD SUFFIX LETTER G WHEN LUBRICATOR PER DETAIL "A" IS REQUIRED

EXAMPLE OF PART NUMBER: MS21220-4AKL = BEARING, ROD END, ROLLER, SELF-ALIGNING, INTERNAL THREAD, .2500 BORE, WITH MIL-G-23827 LUBRICANT, NAS 559 KEYWAY, LEFT HAND THREAD

DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

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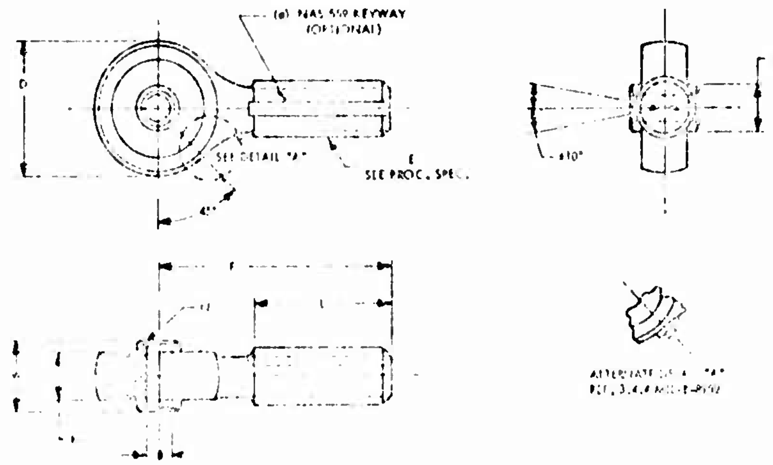
SUB-NOTE 7(6) External Thread Roller-Bearing Rod Ends (MS21221)



DASH NO.	A	B	D	E	F	H	L		W	ULT LOAD RATING		DYNAMIC RADIAL LOAD	WT LB
										[illegible]	[illegible]		
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	.4
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

THESE BEARINGS ARE SELF-ALIGNING FOR 10° IN EITHER DIRECTION.

MATERIAL: [illegible]
[illegible] 52100 [illegible]

PLATING: ALL EXTERNAL STEEL SURFACE [illegible], QQ-P-416, TYPE I, CLASS 2

DIMENSIONS TO BE MET AFTER PLATING

SURFACE ROUGHNESS [illegible] IN ACCORDANCE WITH ANS [illegible]

REMOVE BURRS AND SHARP EDGES

INTERNAL CLEARANCE [illegible], AXIAL [illegible]

LUBRICANT IDENTIFICATION: [illegible] TYPE OF LUBRICANT
A - MIL-G-[illegible] B - MIL-G-[illegible]
D - MIL-G-[illegible] E - MIL-G-[illegible]

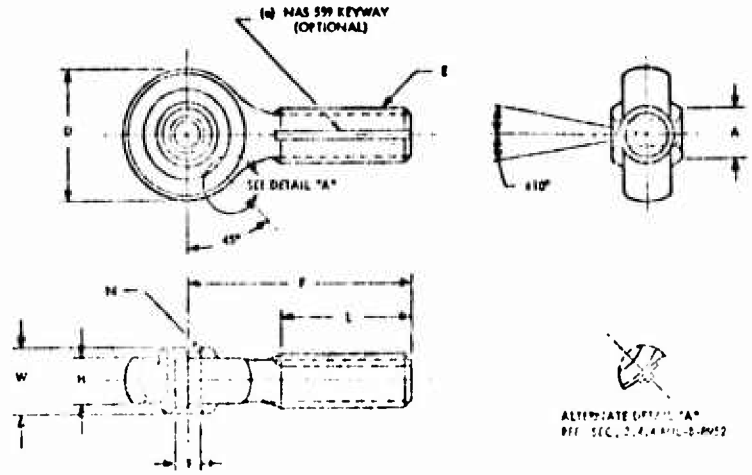
(a) [illegible] NAS 559 KEYWAY [illegible] REQUIRED.
[illegible] LEFT HAND [illegible] REQUIRED.
[illegible]

EXAMPLE OF PART NUMBER: MS21221-[illegible] BEARING, ROD END, ROLLER, SELF ALIGNING, EXTERNAL THREAD, [illegible] BORE, WITH MIL-G-[illegible] LUBRICANT, NAS 559 KEYWAY, LEFT HAND THREAD

DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

SUB-NOTE 7(7) External Thread Roller-Bearing Rod Ends (MS21223)



DASH NO.	A DIA MIN	B +.0000 -.0005	D DIA MAX	E UNF-3A THREAD	F ±.010	H ±.010	L ±.020	N CORNER CHAMFER ±.005	W +.000 -.005	LIMIT LOAD RATING		DYNAMIC RADIAL LOAD RATING	WT LB
										RADIAL	AXIAL		
4	.43	[illegible]	[illegible]	3/8-24	1.22	.36	[illegible]	.015	.500	[illegible]	[illegible]	2250	[illegible]
5	.56	.3125	[illegible]	7/16-20	1.91	.34	.87		.593	3650	315	[illegible]	.13
6	.66	.3750	[illegible]		2.56	.45	1.31		[illegible]	[illegible]	[illegible]	[illegible]	.31

THESE BEARINGS ARE SELF-ALIGNING FOR 10° IN EITHER DIRECTION.

MATERIAL: INNER RING AND ROLLERS: E52100, FED-STD-66
OUTER RING ROD END: 4130, MIL-S-6758, 4140, MIL-S-5626, 8630, MIL-S-6690, E52100 FED STD 66

PLATING: ALL EXTERNAL STEEL SURFACES EXCEPT BORE OF INNER RING, QQ-P-416, TYPE I, CLASS 2

DIMENSIONS TO BE MET AFTER PLATING.

SURFACE ROUGHNESS: RACEWAYS 8/, ROLLERS 6/, IN ACCORDANCE WITH MIL-STD-10 [illegible]

REMOVE BURRS AND SHARP EDGES

INTERNAL CLEARANCE: RADIAL .0002 TO .0010, AXIAL .001 TO .005

LUBRICANT IDENTIFICATION: ADD APPROPRIATE SUFFIX LETTER TO INDICATE TYPE OF LUBRICANT
A = MIL-G-23827 B = MIL-G-25537
C = MIL-G-81322 D = MIL-G-18709

(a) ADD SUFFIX LETTER K WHEN NAS 559 KEYWAY IS REQUIRED
ADD SUFFIX LETTER L WHEN LEFT HAND THREAD IS REQUIRED
ADD SUFFIX LETTER G WHEN LUBRICATOR PER DETAIL "A" IS REQUIRED

EXAMPLE OF PART NUMBER: MS21223-4AKL = BEARING, ROD END, ROLLER, SELF-ALIGNING, INTERNAL THREAD, .2500 BORE, WITH MIL-G-23827 LUBRICANT, NAS 559 KEYWAY, LEFT HAND THREAD

DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

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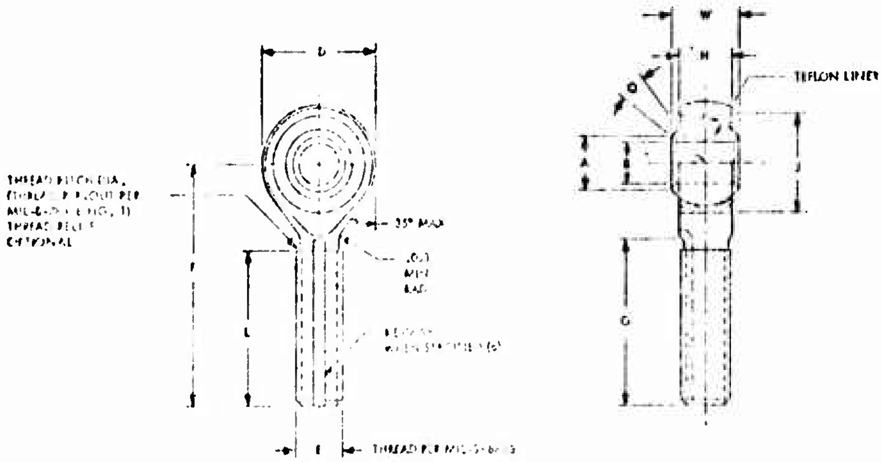
SUB-NOTE 7(8) (Sheet 1 of 2 Sheets) External Thread TFE-Lined Plain Bearing Rod Ends (MS21242)



DASH NO.	B	D	L	E	F	W	H	A	C	J	G*
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	BALL WIDTH [illegible]	[illegible]	MIN	[illegible]	[illegible]	MIN
3	[illegible]	[illegible]	[illegible]	5/16-24	[illegible]	.437	[illegible]	[illegible]	[illegible]	.625	15
4	[illegible]										
5	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	14
6	[illegible]	[illegible]		3/8-24	[illegible]	[illegible]	[illegible]	.47	[illegible]	[illegible]	8
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.61	[illegible]	[illegible]	5
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.765	[illegible]	[illegible]	[illegible]	6
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12

(6) WHEN SPECIFIED, KEYWAY SHALL BE IN ACCORDANCE WITH NAS [illegible] EXCEPT LENGTH AS TABULATED.

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SUB-NOTE 7(8) (Sheet 2 of 2 Sheets) External Thread TFE-Lined Plain Bearing Rod Ends (MS21242)

DASH NUMBER	OSCILLATING LOAD, LB	ULTIMATE STATIC LOAD, LB	FATIGUE LOAD, LB	AXIAL PROOF LOAD, LB	WEIGHT MAX LB	NO LOAD BREAKAWAY TORQUE, IN/LBS MIN	MAX
3	1,470 (c)	[illegible]	[illegible]	[illegible]	.072	.5	6
4	2,420	4,840	[illegible]	[illegible]			
5	3,590	7,160	[illegible] (d)	1100	.087	1	10
6	5,150	[illegible]	[illegible]	1600	.136		
7	6,130	12,000	[illegible]	1850	.183		
8	8,270	19,500	[illegible] (d)	[illegible]	.278		
10	10,700	21,900	[illegible]	[illegible]	.424		
12	13,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
14	14,5[illegible]	34,500	[illegible]	3220	.563	2	16
16	25,600	[illegible]	[illegible]	4345	2.545		

(c) BASED ON BOLT [illegible] FATIGUE STRENGTH [illegible] PSI

(d) SHANK LIMITATION

MATERIAL:

BODY CODE:
"C" CORROSION RESISTING STEEL, AMS 5643 (17-4PH)
"S" ALLOY STEEL, MIL-S-5000 (4340)
BALL: AMS [illegible], 440C
CARTRIDGE [illegible] AMS 5643 (17-4PH), AMS 5528 (17-7), AISI 410
LINER: SEE PROCUREMENT SPEC

PLATING: ALLOY STEEL, CADMIUM PLATING QQ-P-416, TYPE I, CLASS 2
HARDNESS:
ROD END BODY: 17-4 PH, Rc [illegible]
4340, [illegible]
PASSIVATION: CORROSION RESISTING STEEL, QQ-P-35, TYPE II OR III
SURFACE FINISH: [illegible]
ALL OTHER [illegible] SURFACES, RHR 125 MAX
HEAT TREATMENT: IN ACCORDANCE WITH MIL-H-6875
TEMPERATURE RANGE: [illegible]
DIMENSIONS IN INCHES, UNLESS OTHERWISE SPECIFIED
TOLERANCES: DECIMALS [illegible] ANGLES ±1/2°
BREAK SHARP EDGES AND CORNERS AND REMOVE ALL BURRS AND SLIVERS

EXAMPLE OF PART NUMBER: MS21242 X XX X X
- ADD L FOR LEFT HAND THREAD WHEN SPECIFIED
- KEYWAY (CODE K) WHEN SPECIFIED
- BORE DIAMETER CODE IN MULTIPLES OF 1/16 INCH
- ROD END BODY MATERIAL CODE
- BASIC MS PART NUMBER

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

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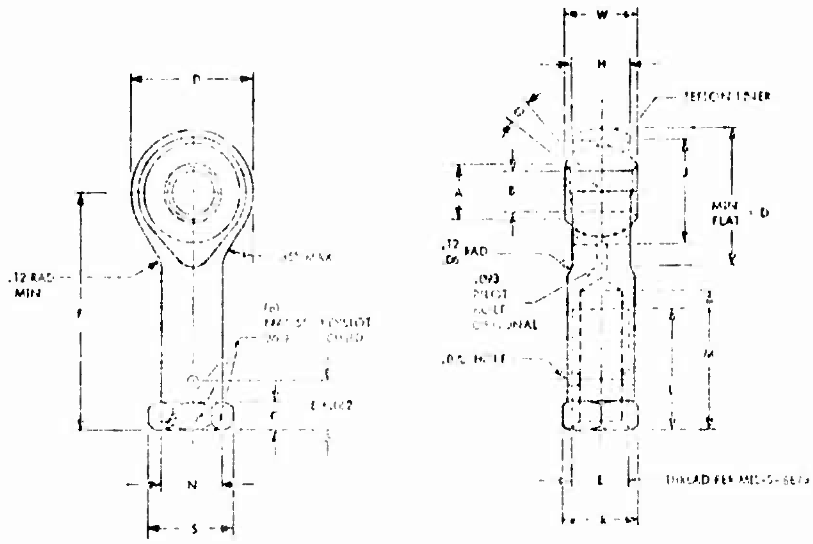
SUB-NOTE 7(9) (Sheet 1 of 2 Sheets) Internal Thread
TFE-Lined Plain Bearing Rod Ends (MS21243)



DASH NO.	B +.0000 -.0005	D DIA. ±.010	L COMPLETE THREAD MIN	E THREAD SIZE UNJF-3B	F ±.010	H SHANK DIA. ±.010	W BALL WIDTH	H BODY WIDTH	Z MIN	J MAX	M MAX	C	K	C° MIN	S REF ACROSS CORNERS CIR DIA.
3	.1900	.502	.750	5/16-24	[illegible]	.422	.437	.337		.6250	.875	.108	.437	15	.500
4	.2500				[illegible]										
5	.3125	.500	[illegible]	3/8-24	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	1.000		.500	14	[illegible]
6	.3750	[illegible]	1.000		[illegible]	.547	.510	.416	.47	[illegible]	[illegible]	.250	[illegible]	8	[illegible]
7	.4375	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.452	.54	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
8	.5000	[illegible]	[illegible]	[illegible]	[illegible]	.735	[illegible]	[illegible]	.61	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
10	.6250	[illegible]	1.375	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.500	.375	.875	[illegible]	1.020
12	.7500	1.775	[illegible]	3/4-16	[illegible]	[illegible]	.875	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	1.160
14	.8750	[illegible]	[illegible]	7/8-14	[illegible]	[illegible]	[illegible]	.765	1.00	[illegible]	2.062	.500	[illegible]	6	[illegible]
16	1.0000	2.775	2.125	[illegible]	[illegible]	[illegible]	1.375	[illegible]	[illegible]	[illegible]	2.312	[illegible]	[illegible]	12	[illegible]

(a) WHEN SPECIFIED KEYSLOT SHALL BE IN ACCORDANCE WITH NAS 559.

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SUB-NOTE 7(9) (Sheet 2 of 2 Sheets) Internal Thread TFE-Lined Plain Bearing Rod Ends (MS21243)

DASH NUMBER	OSCILLATING LOAD, LB	ULTIMATE STATIC LOAD, LB	FATIGUE LOAD, LB	AXIAL PROOF LOAD, LB	WEIGHT MAX LB	NO LOAD BREAKAWAY TORQUE, IN-LBS	
						MIN	MAX
3	1,470 (c)	2,3[illegible]0	1,470 [illegible]	1000	.0[illegible]	.5	6
4	3,470	4,[illegible]	2,3[illegible]	1000	.064		
5	3,590	7,1[illegible]	3,02[illegible]	1100	.102		
6	[illegible],120	6,55[illegible]	3,5[illegible]0	1[illegible]	.161		
7	[illegible],130	1[illegible]	4,3[illegible]	1850	.212	1	10
8	8,370	1[illegible]	[illegible]	2[illegible]	.325		
10	1[illegible]	2[illegible]	[illegible]	2[illegible]	.4[illegible]		
12	13,2[illegible]	[illegible]	1[illegible]	2[illegible]10	[illegible]		
14	1[illegible],5[illegible]	34,5[illegible]	[illegible]	33[illegible]	.9[illegible]	2	16
16	2[illegible]	[illegible]	2[illegible],4[illegible]	4[illegible]	2,717		

(c) BASED ON BOLT BENDING FATIGUE STRENGTH 1[illegible],000 PSI

MATERIAL:
BODY CODE
"C" CORROSION RESISTING STEEL, AMS 5643 (17-4PH)
"S" ALLOY STEEL, MIL-[illegible] 4340
BALL AMS [illegible], 440C
CARTRIDGE OUTER RING: AMS [illegible] 17-4PH, AMS [illegible] (17-7), AISI 410
LINER: SEE PROCUREMENT SPEC

PLATING: ALLOY STEEL, CADMIUM PLATING QQ-P-416, TYPE I, CLASS 2
HARDNESS:
ROD END BODY: 17-4PH, R[illegible] 39-44
4340, R[illegible] 35-4[illegible]
PASSIVATION: CORROSION RESISTING STEEL ROD END BODY QQ-P-35, TYPE II OR III
SURFACE FINISH: ALL MACHINED SURFACES, RHR [illegible]
HEAT TREATMENT: IN ACCORDANCE WITH MIL-H-6875
TEMPERATURE RANGE: [illegible]
DIMENSIONS IN INCHES, UNLESS OTHERWISE SPECIFIED
TOLERANCES: DECIMALS [illegible], ANGLES [illegible]
BREAK SHARP EDGES AND CORNERS AND REMOVE ALL BURRS AND SLIVERS

EXAMPLE OF PART NUMBER: MS21243 X XX X X
- X — AND L FOR LEFT HAND THREAD WHEN SPECIFIED
- X — KEYWAY (CODE K) WHEN SPECIFIED
- XX — BORE DIAMETER CODE IN MULTIPLES OF 1/16 INCH
- X — ROD END BODY MATERIAL CODE
- MS21243 — BASIC MS PART NUMBER

Comment: Load life curve should be distributional for design for reliability usage. Engineering strength data should be presented in statistical terms (parameters).

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Section 6G - Bearing application for reliability.

1. Parameters for life and reliability.

Parameters for calculation of ball and roller bearing performance are:

(1) The basic load rating, C, defined as the load that 90 percent of a group of apparently similar bearings will endure for 1,000,000 revolutions of the inner race. Note that it has been found experimentally that life "L" varies inversely to the "a" power of the load "C" ($L \propto \frac{1}{C^a}$). Values of "a" varies between 3 and 4; 3 is recommended for ball bearings and 10/3 for roller bearings. Note that for "a" = 3; if the load is halved the life increases by a factor of 8.

(2) The median life of a group of bearings, L_{50} defined as the life resulting in a 50 percent survival rate.

(3) The rating or catalog life, L_{10}, defined as the life resulting in a 90 percent survival rate. Note that if given a rated load for 50 percent survival "L_{50}" (median life), the relationship which may be assumed with L_{10} median life is that $L_{50} \approx 5L_{10}$.

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2. Bearing failure distribution.

The results of standard calculations for life and load involving various catalogue factors are characterized by a high degree of conservatism and the validity of results is supported by a very large amount of data and experience.

The usual assumption is that bearing failures are fatigue failures. Since the latter are random in nature, they will follow one of the statistical failure distributions. The distribution found most applicable is the Welbull curve expressed by the relation

$$Ps = e^{-\left(\frac{t}{\theta}\right)^{b}} \qquad (1)$$

where Ps = probability of bearing survival without failure for a given time

t = time

θ = multiplier for design life in hours, a constant

b = Weibull function exponent

If $b=1$, the Poisson equation results

The Weibull curve is established with the coordinates of failure percent (ordinate), and the ratio of operating time to the B_{10} design life (absicissa). The two ordinate values are available from catalogue data on life, Ps = 0.90 and Ps = 0.50; and two corresponding abscissa values known for each ordinate.

3. Determination of bearing reliability.

Many manufacturers and the USASI Standard B3.11 give the ratio of median to design life as 5/1, but data from the National Bureau of Standards (3) indicate the acceptable, but slightly less conservative, value of 4.08/1. The two curves are drawn as in Figure 1. Then the probability of survival of the bearing for which the median life of 5 (or 4.08) times the B_{10} design life, d, has already been determined, is given as

$$\frac{t}{d} = (9.49 \log_e Ps)^{0.746} \qquad \text{for } \frac{t}{d} = 4.08\ B_{10} \tag{2}$$

and

$$\frac{t}{d} = (9.49 \log_e Ps)^{0.856} \qquad \text{for } \frac{t}{d} = 5.00\ B_{10} \tag{3}$$

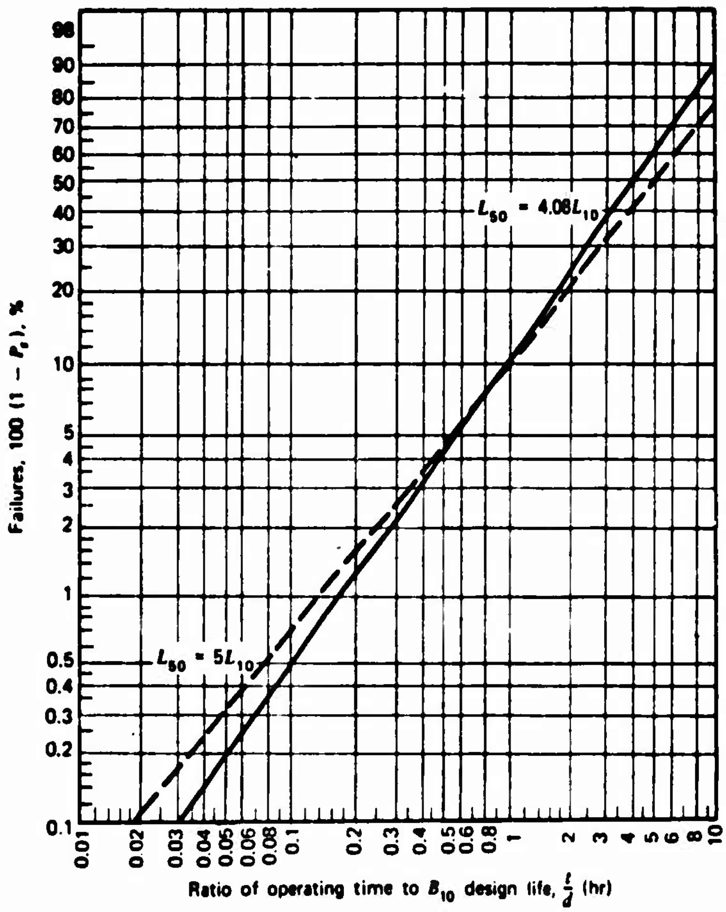

Fig. 1 Weibull plot of operating life of bearings. From E. Schube (4)

The required design life B_{10} in hours is,

$$d = \frac{t}{(t/d)} \tag{4}$$

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4. Determination of design life.

Normally, the reliability Ps and the required time t are known. The curves of Figure 1 and Table 1 are set up for convenience in determining the design life.

TABLE 1 Ratio of Operating Time to B_{10} Design Life for Various Probabilities of Survival

Probability of Survival for Time t P_s	Ratio of Operating Time to Design Life	
	t/d for median life = 4.08d	t/d for median life = 5d
0.995	0.1030	0.0740
0.99	0.1785	0.1395
0.98	0.2910	0.2440
0.97	0.396	0.3460
0.96	0.492	0.4445
0.95	0.584	0.5405
0.94	0.672	0.6341
0.93	0.756	0.7261
0.92	0.840	0.8191
0.91	0.921	0.9101
0.90	1.000	1.000
0.85	1.383	1.450
0.80	1.750	1.900
0.75	2.120	2.364
0.70	2.435	2.835
0.65	2.860	3.331
0.60	3.250	3.850
0.55	3.600	4.340
0.50	4.080	5.000
0.45	4.540	5.650
0.40	5.03	6.345
0.35	5.56	7.150
0.30	6.16	8.040
0.25	6.84	9.040
0.20	7.65	10.06
0.15	8.64	11.80
0.10	10.00	14.00
0.05	12.40	17.55
0.01	16.40	25.15

SOURCE: E. Schube [4], Table 1.

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Another common requirement is the relation of the reliability and equivalent radial load at required life, to the catalog tabulation of basis load ratings.

The Weibull equation in the following form permits evaluation,

$$\frac{Re}{C} = \left(\frac{\theta}{L_1}\right)^{1/a} \cdot \left(\text{Ln} \quad \frac{1}{Ps}\right)^{1/ab} \qquad (5)$$

For a ratio of median to rating life of 5, and Ps = 0.50 and 0.10, θ has been evaluated as 6.84 and b as 1.17. For ball bearings, a = 3.00; for roller bearings, a = 3.33. Then Equation (5) becomes:

for ball bearings,

$$\frac{Re}{C} = \frac{1.393}{0.333} \left(\text{Ln} \quad \frac{1}{Ps}\right)^{0.285} \qquad (6)$$

for roller bearings

$$\frac{Re}{C} = \frac{1.730}{0.3} \left(\text{Ln} \quad \frac{1}{Ps}\right)^{0.257} \qquad (7)$$

These relations are plotted in Figures 2, (a) and (b).

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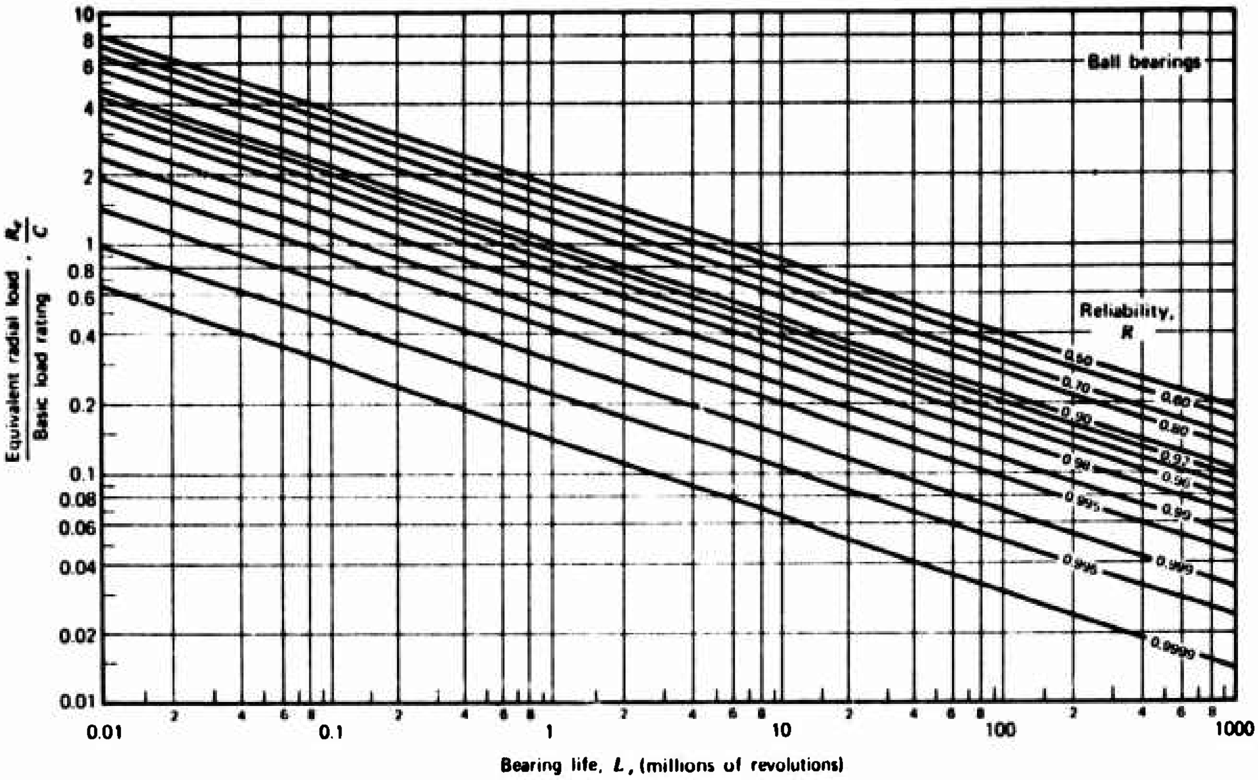
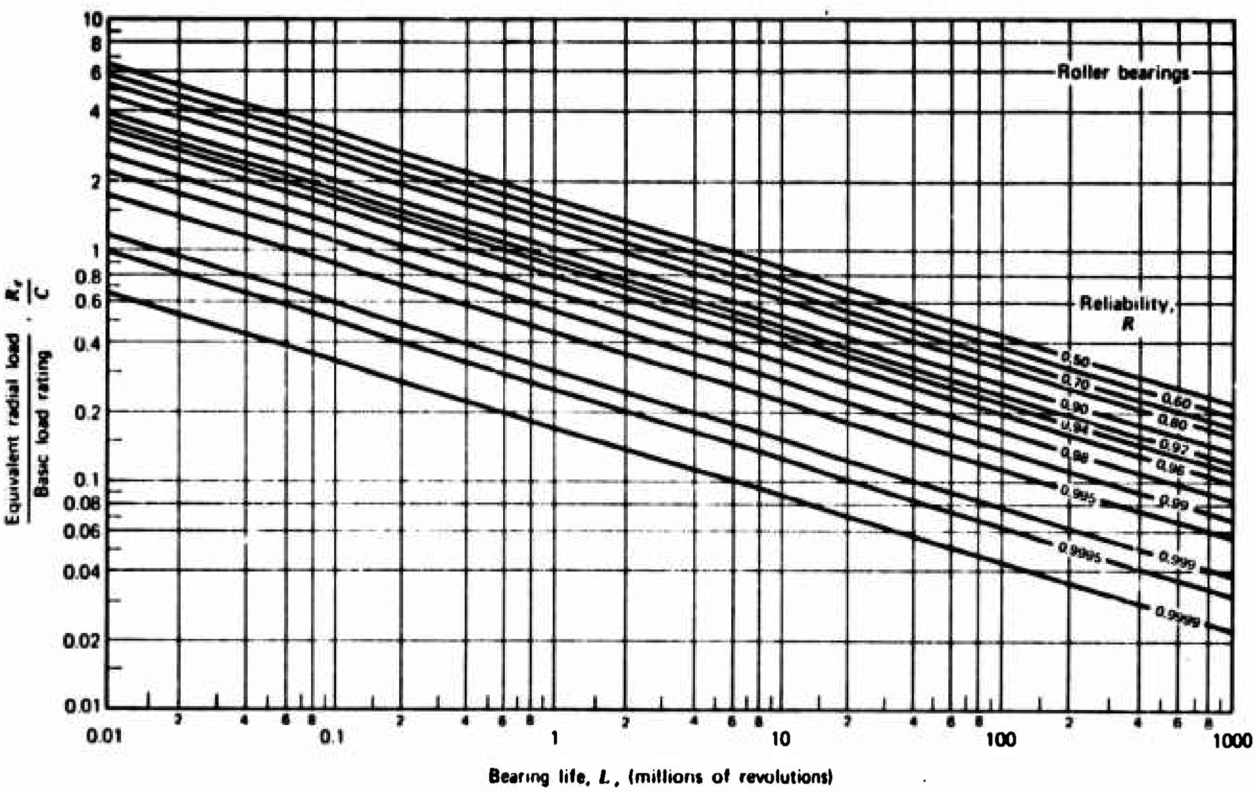


(a)



(b)

Fig. 2 Life curves for anti-friction bearings. (a) Ball bearings; (b) Roller bearings. From C. Mischke [5], Figs. 1, 2.

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4. E. Schube, "Ball Bearing Survival", Machine Design, 129-32, January 3, 1963

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7. V. M. Faires "Design of Machine Elements", 1965

Rationale: The above information is available for design of FCS bearing applications from the references above and should be available in the AFSC Design Handbook for Design for Reliability.

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COMMENTS TO AFSC DH 2-X

5. ELECTRICAL/ELECTRONIC SYSTEMS CHECKLIST

5.1 System Design

5.1.1 When redundant systems are provided, are the systems separated as far as possible to avoid loss of both systems from a single failure or gunfire?

5.1.2 Will failure of any component or assembly result in additional failures? If so, what are the effects?

5.1.3 Have the effects of variation in power supply on the system been investigated?

5.1.4 Are system circuit tolerances adequate?

5.1.5 Are circuits designed to prevent shorts caused by high voltage and overloads?

5.1.6 Have interlocks been provided where necessary?

5.1.7 Is circuit stable over entire operating range?

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5.1.8 Is a means of detecting improper operation incorporated?

5.1.9 Are all external parts at ground potential?

5.1.10 Are systems electrically deactivated during functional checkout to prevent inadverent operation?

5.1.11 Is each piece of equipment in the system compatible with associated equipment from a system viewpoint?

5.1.12 Are effects of electromagnetic interference minimized?

5.2 Component Installation

5.2.1 Are mounting brackets rigid enough to prevent excessive deflection at limit load and strong enough to prevent fatigue under repeated loads?

5.2.2 Have cantilever mountings been eliminated where possible?

5.2.3 Has the equipment center-of-gravity location been considered in designing shock mounts for each equipment item?

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5.2.4 Will shock or vibration mounts support the weight of the equipment during shock or vibration conditions without bottoming?

5.2.5 Have vibration mounts been protected from deterioration due to exposure to hydraulic fluid, fuel, etc.?

5.2.6 For equipment items which use leads, have lead weight, length, thermal expansion, supplementary support, bend rate, and other mounting considerations been evaluated?

5.2.7 Have installations been designed to prevent damage to components during removal or replacement of components?

5.2.8 Have installations been designed such that it is impossible to install parts improperly or to insert the wrong plug into a receptacle?

5.2.9 Are components and assemblies which are mounted in areas subject to adverse environmental conditions either sealed, protected by sealed covers, or mounted in such a way that water, fuel, and dirt cannot enter the unit?

5.2.10 Have water traps formed by brackets, components, shelves, etc., been eliminated?

5.2.11 Are lock washers of a type which can break through protective films?

5.2.12 Are locking features provided for all critical connections?

5.2.13 Are indexed assemblies required and provided for?

5.2.14 Have suitable designs, processes, and finishes been specified to protect against corrosion?

5.2.15 Have dissimilar metal interfaces been avoided?

5.2.16 Has the possibility of finish flaking been considered?

5.2.17 Are all materials satisfactory for the temperature range expected?

5.2.18 Is moisture protection provided where necessary?

5.2.19 Are all materials fungus-resistant or inert?

5.2.20 Are electrically conductive finishes provided where necessary?

5.2.21 Has full consideration been given during initial design to the effect that heat dissipated by heat-producing equipment will have on other components?

5.2.22 Is volume of air flow adequate to cool heat-producing equipment?

5.2.23 Is air flow to heat-producing equipment free of interference?

5.2.24 Is air flow prevented from escaping through lightening and access holes?

5.2.25 Are critical items located to receive best air flow?

5.2.26 Where forced air cooling is used, are suitable dust filters incorporated?

5.2.27 Will battery leakage cause damage?

5.2.28 Are electrical components, wires, insulation, and cables mounted in such a manner that they will not become overheated by the engine?

5.2.29 In determining clearances between structure and equipment, have the effects of airframe and support deflections, vibration, tolerance build-up, wear, etc., been considered?

5.2.30 Are equipment items, wire bundles, and cables located such that they cannot be used as steps or handholds? If not, are they strong enough to withstand this use?

5.2.31 Are bonding requirements adequate to give a good conductive path for electrical assemblies?

5.2.32 Are mating metal surfaces, which are required to be clean, properly identified on drawings?

5.2.33 Are connector installations adequate to withstand the stresses produced by high cable weight and by coupling and uncoupling of the connectors?

5.3 Relays and Switches

5.3.1 Are relays not hermetically sealed protected from freezing during altitude cycling?

5.3.2 Will contacts resist chattering due to vibration?

5.3.3 Are adjustments for relay contact gaps (power circuits) protected from misadjustment due to vibration and improper maintenance?

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5.3.4 Has an arc-suppression network been installed across the contacts to absorb the magnetic surge and reduce contact failure?

5.3.5 Vibrational forces can induce rotational movement of the coil bobbin and result in lead wire breakage. Has adequate consideration been given to prevent excessive movements of relay part?

5.3.6 Have the contacts been sealed or isolated from contaminating vapors and organic materials?

5.3.7 Does the switch configuration lend itself easily to positive actuating and release action?

5.3.8 If transient suppression components are used within a sealed unit, will the internal operating temperature have any degrading effect on the suppression component?

5.3.9 Are the terminals of a sealed unit adequately identified to prevent the possibility of misapplication of coil polarity voltage?

5.4 Cables and Wiring

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5.4.1 Is protection of wires and cables passing over and through partitions or through lightening holes adequate to prevent isulation wear and breakage due to wires rubbing on metal surfaces?

5.4.2 Will slack in cables or wires

(a) Allow structural flexing or temperature expansion?

(b) Eliminate stretching and pulling of wires or cables when disconnecting and connecting service subassemblies?

5.4.3 Has decomposition of insulating materials been considered?

5.4.4 Will all clamps used in supporting cabling withstand the vibration environment in which they are to be used and not damage wire insulation?

5.4.5 Is insulation or cables or proper design and material to withstand damage from water, abrasives, footsteps, vehicles, and other abuse when laying on the ground or floor?

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