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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

John Zipperer, et al

Bell Helicopter Company

Prepared for:

Army Air Mobility Research and Development Laboratory

March 1975

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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

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March 1975

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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 | | | | | | | | |

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.

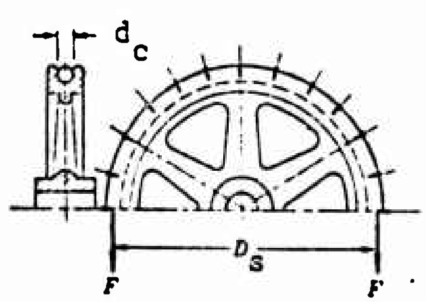


Figure 1. Cables (7)

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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.

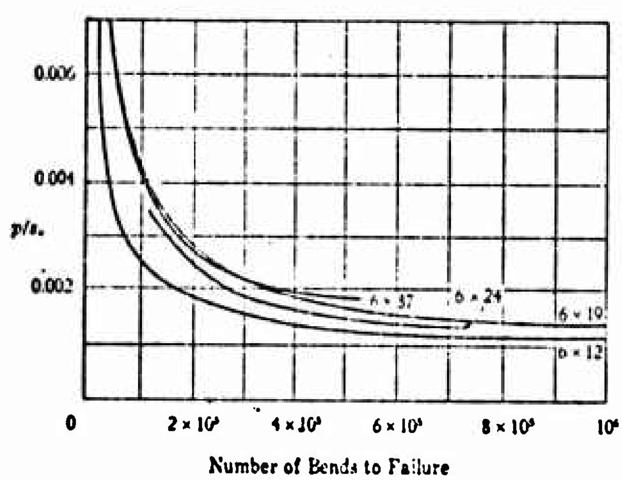



Figure 2. Pressure Ratio Vs. Number of Bends (7)

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.

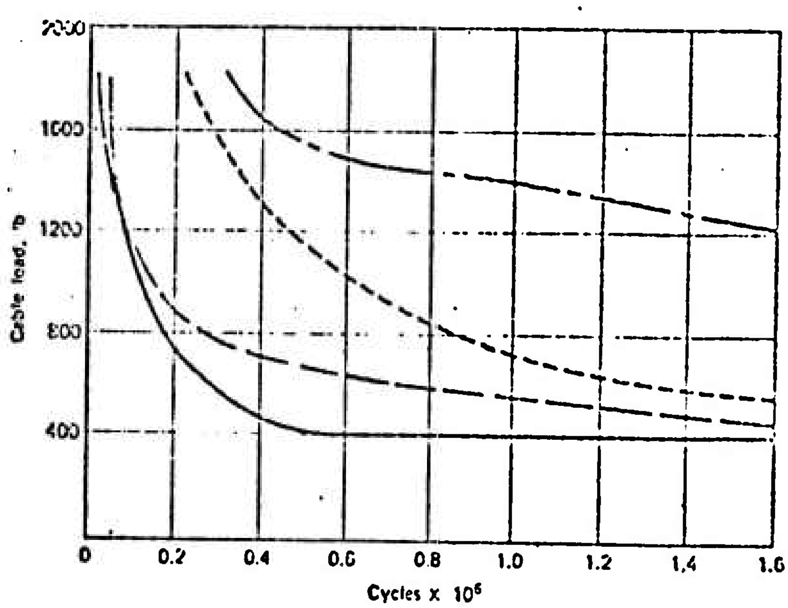



Fig. 3 Fatigue life of small cables. ---- 7 x 7 cable, nylon-jacketed; —— 7 x 7 cable, bare; — — — 7 x 19 cable, nylon-jacketed; —— —— 7 x 19 cable, bare. Reprinted from *Product Engineering*, Oct. 10, 1966.

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.

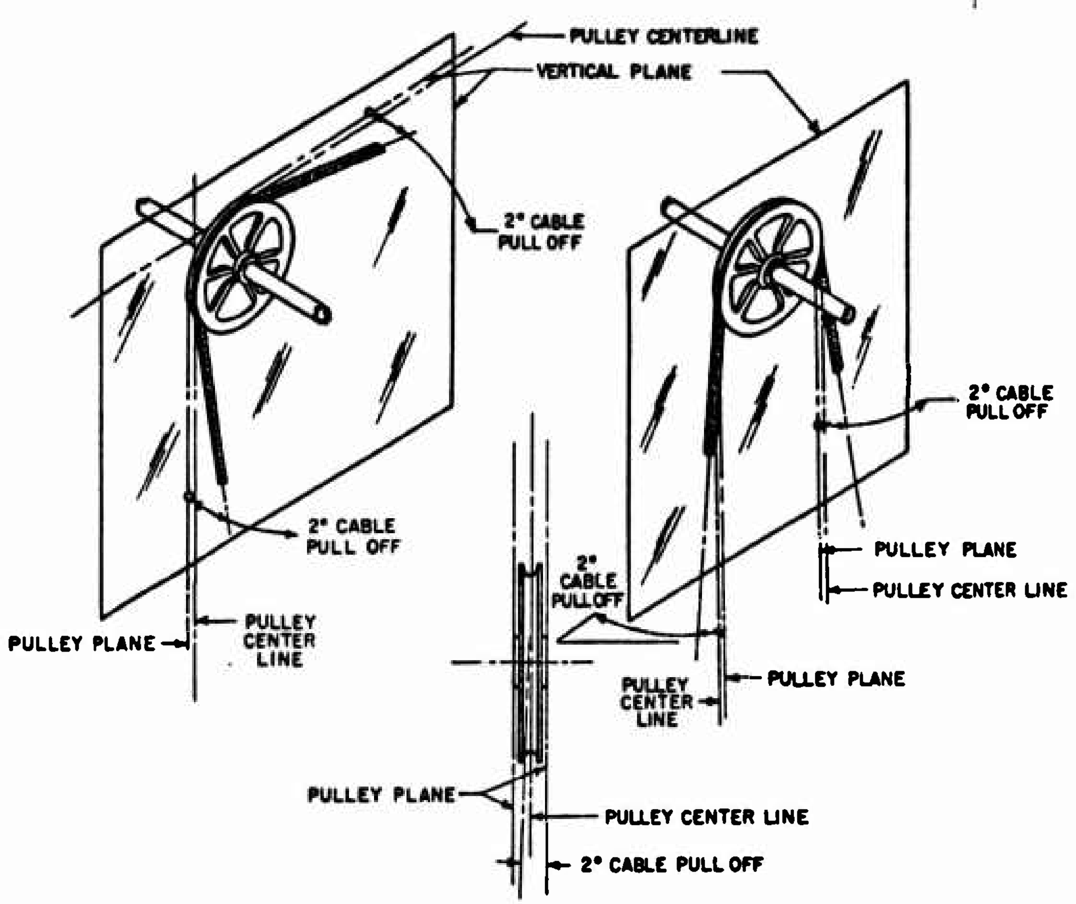
> Rationale:
>
> Design guide for cable missing from section.

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.

**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.

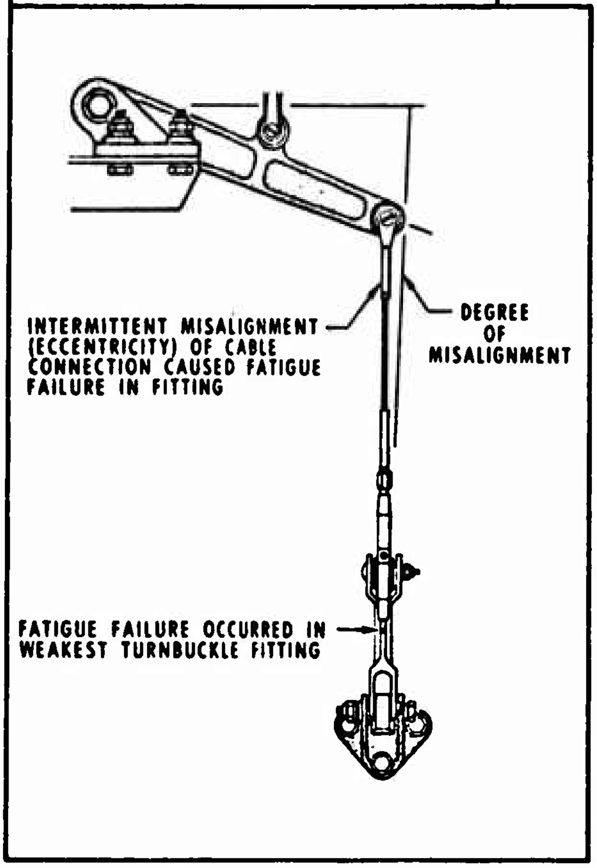
Rationale:

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.

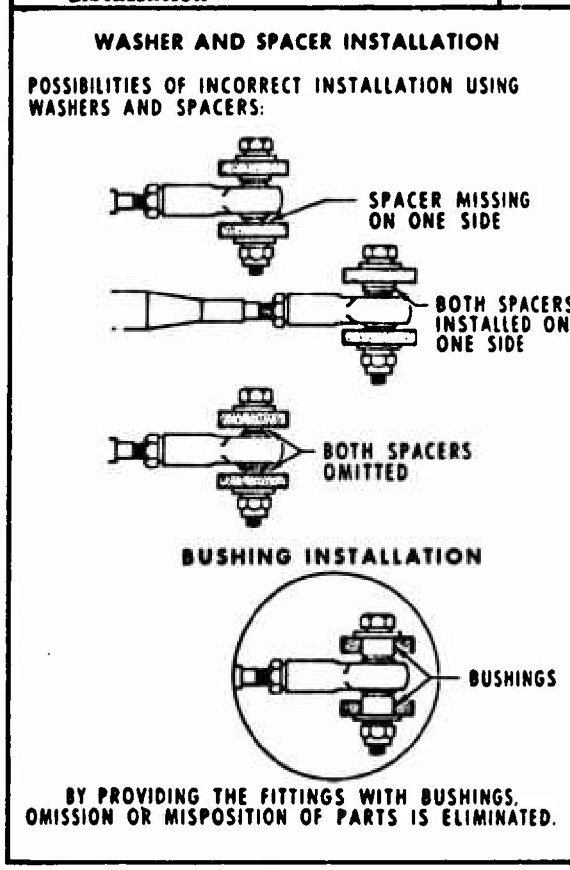
2.3 Torque Tubes

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



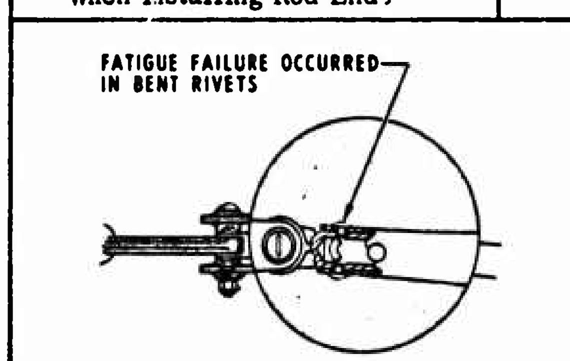

SUB-NOTE 2.2(1) Benefit of Bushings for Rod End Installation




## 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):

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

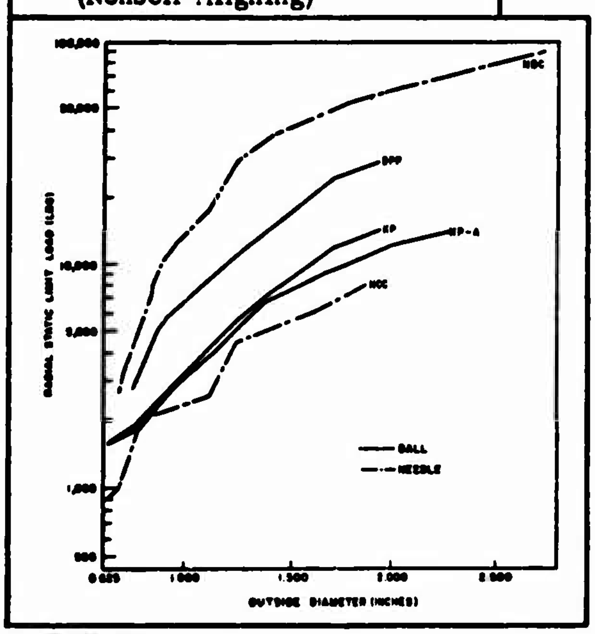
Due to shaft bending in large length-to-diameter ratio bushings, only a portion of the shaft will be in contact with the bearing surface. Therefore, in computing the effective projected area, the length used in computation should not exceed the bushing diameter even though (in actuality) the length of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

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

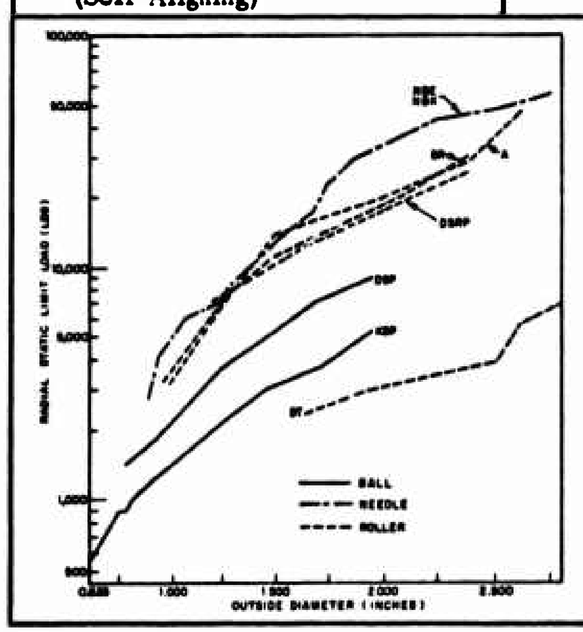
The unit loading should not exceed the static capacity ratings of the various bushing materials shown in DN 6B4, SN 1.1(1). A slightly different method of calculating the effective projected area of TFE bushings is used in MS21240 and MS21241 (see DN 6F2, SN 6(5) and SN 6(6).

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.

## DESIGN NOTE 6B1 — BALL BEARINGS

### 2. DYNAMIC CAPACITY

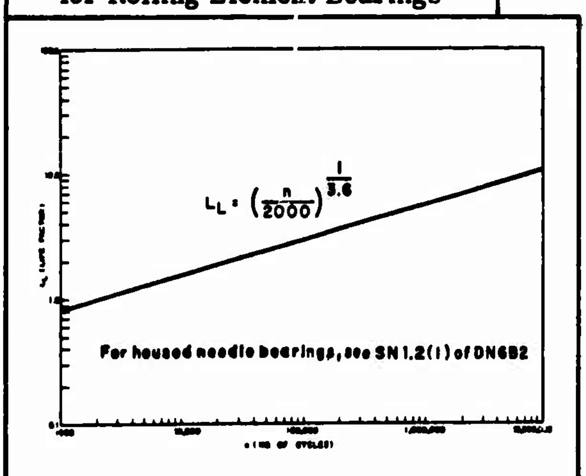
The basic dynamic capacity of an airframe bearing is the constant radial load at which 10% of the bearings tested will fail through fatigue of the ball or race material within 2000 cycles. A cycle is defined as either one slow rotation (<100 rpm) or as a 90° rotation from a fixed point and return. However, 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.

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

## 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

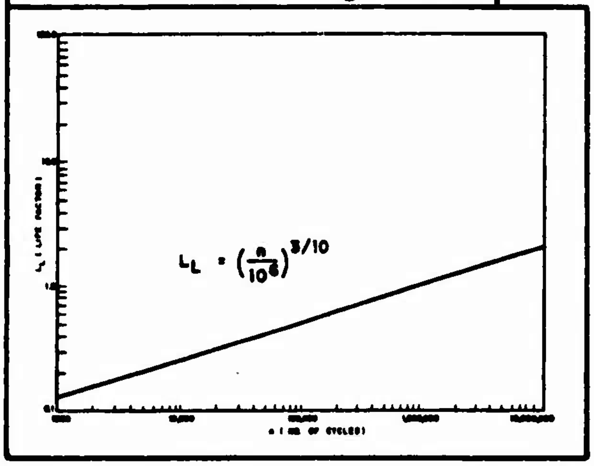
The life of the bearing (when failure is due to fatigue) can be determined from the basic dynamic capacity and the life factor relationship shown in SN 1.2(1). The maximum load for any life can be determined by the relationship:

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

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)
$\alpha$ = 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

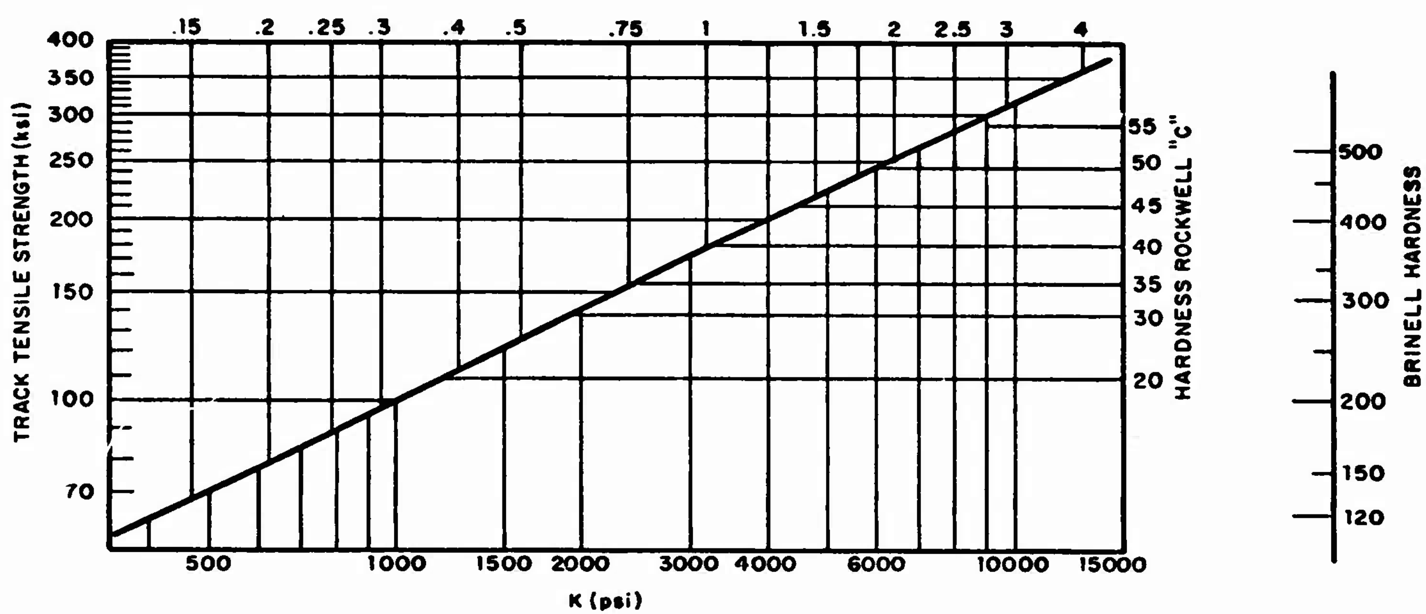
If $T_{40}$ is not known:

$T = D \times L \times K$

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



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.

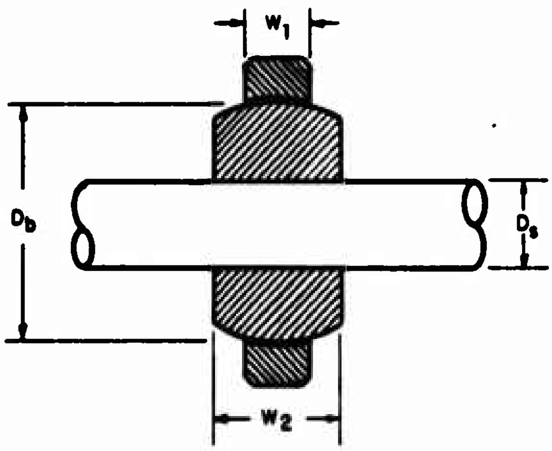
### 1.3 Unit Load

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.

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

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

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




### 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

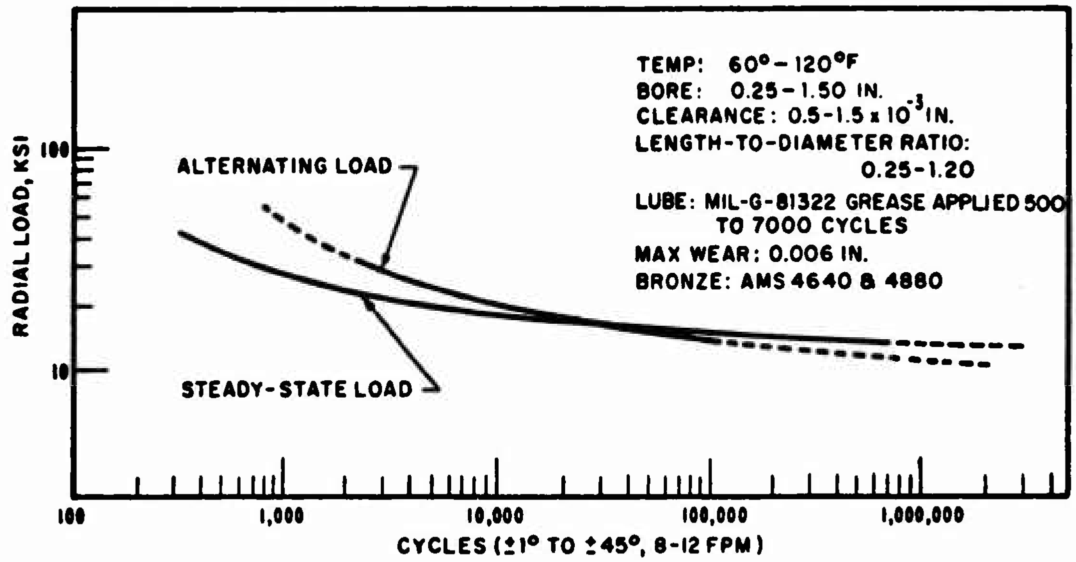
The unit static capacity of TFE-lined bushings is approximately 60,000 psi. A unit load of this magnitude can be tolerated by the bushing without impairing its functioning.

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
$\alpha$ = coefficient of thermal expansion, in/in/°F x $10^{-6}$
$\epsilon$ = percent elongation in 2 in.
$\mu$ = Poisson's ratio
$\rho$ = 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 | $E$ | $F_c$ | $F_t$ | $R_c$ | $\alpha$ | $\epsilon$ | $\mu$ | $\rho$ |
|---|---|---|---|---|---|---|---|---|
| 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/ft²/°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
- $\alpha$ = coefficient of thermal expansion, in/in/°F x $10^{-6}$
- $\mu$ = coefficient of friction
- $\rho$ = density, lb/ft³

### 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).

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**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 | $F_c$ | $F_t$ | $R_c$ | $B_H$ | $\alpha$ | $\epsilon$ | $\rho$ |
|---|---|---|---|---|---|---|---|---|
| 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 | $\alpha$ | $\mu$ | $\rho$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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.

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

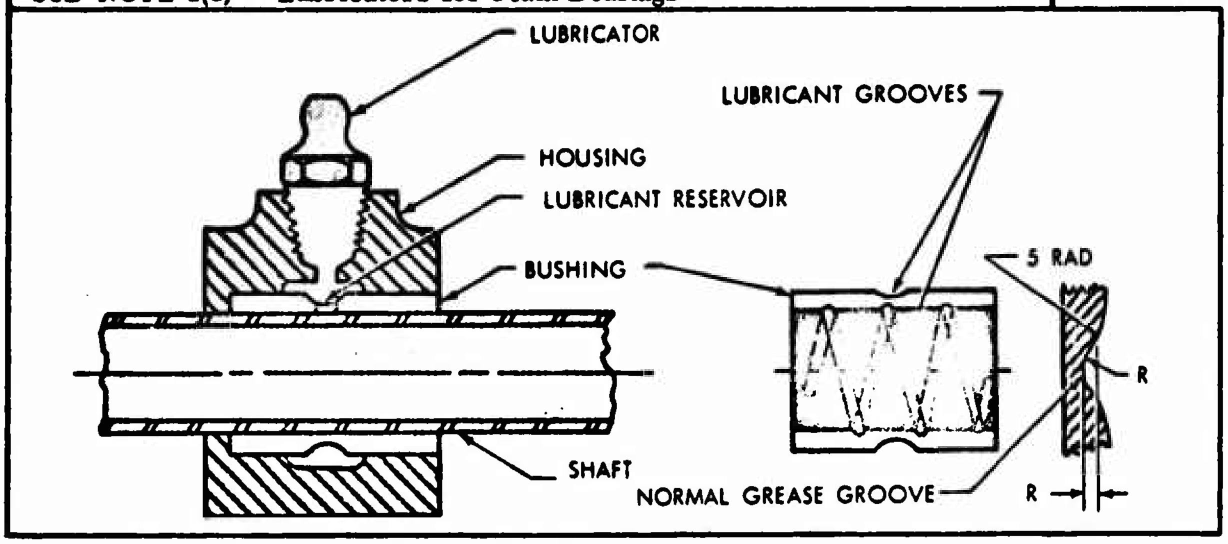
Provide lubricators and lubrication reservoirs for all types of plain annular and plain self-aligning bearing installations. Where plain bearings are used at the connection of structural members having a relative motion exceeding 3° during service operation, install lubricators in the portions surrounding 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.

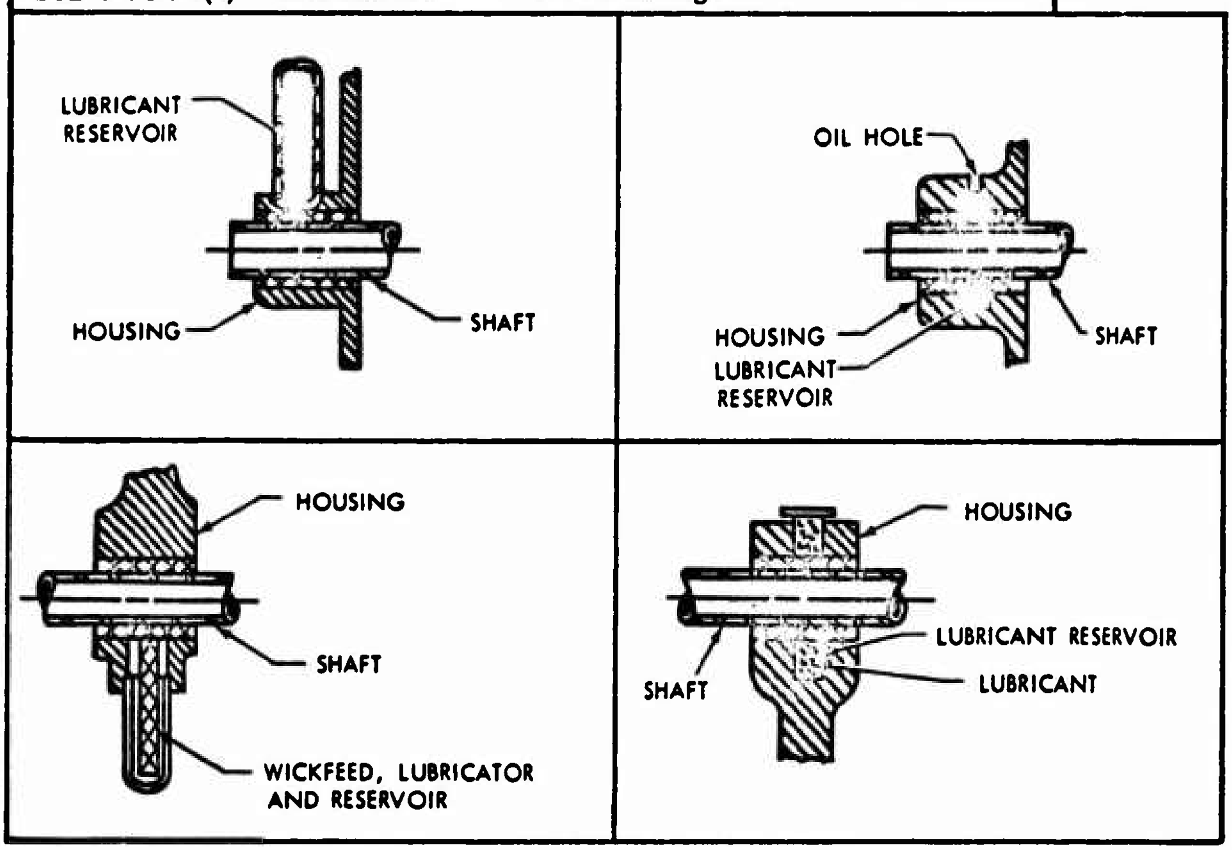
SUB-NOTE 1(1) Selection Chart for Lubricants (Plain Bearings)

| | GREASE | DRY FILM LUBRICANT | TFE-LINED BEARING |
|---|---|---|---|
| TEMPERATURE RANGE, °F | -100 to +600 | -100 to +375 Organic binders<br>-320 to +800 Inorganic binders | -320 to +550 TFE-glass fabric types<br>-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**



## 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)

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-G-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.

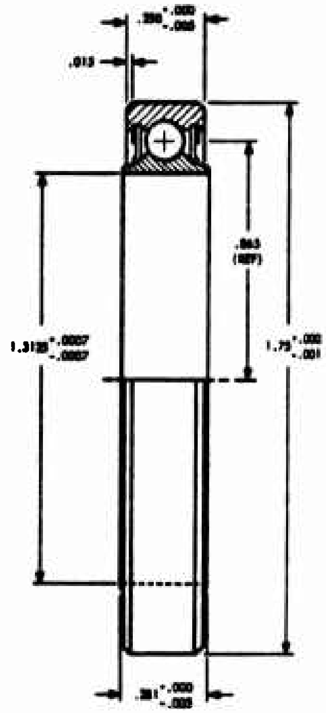
### 2. ZONE III BEARINGS

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:

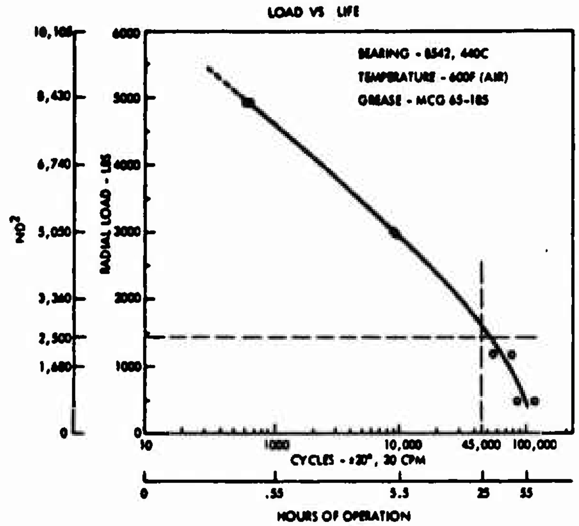
a. Ceramic Ball Bearing (see SN 2(1))

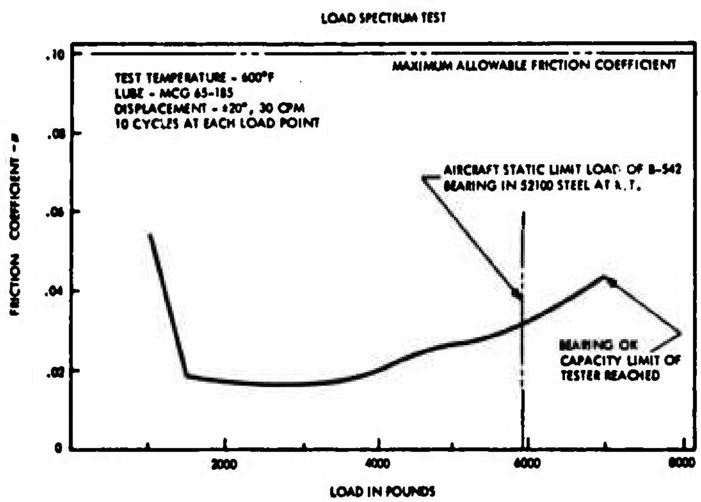
b. Plain Spherical Bearing (see SN 2(2))

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




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

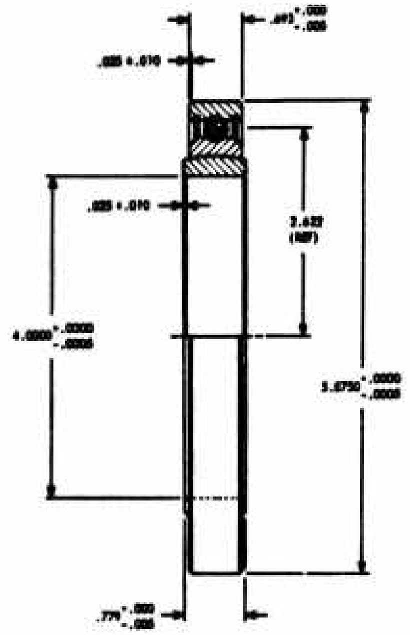



| | |
|---|---|
| MATERIAL: | RACEWAYS - AISI 440C STAINLESS STEEL<br>BALLS - AISI 440C STAINLESS STEEL<br>SEALS - TEFLON TFE<br>SNAP RINGS - 300 SERIES STAINLESS STEEL |
| LOAD RATINGS: | RECOMMENDED LIMIT LOAD - 5950 LBS RADIAL |
| RACE CURVATURES: | INNER, 51.0 TO 51.5% OF BALL DIAMETER<br>OUTER, 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 |

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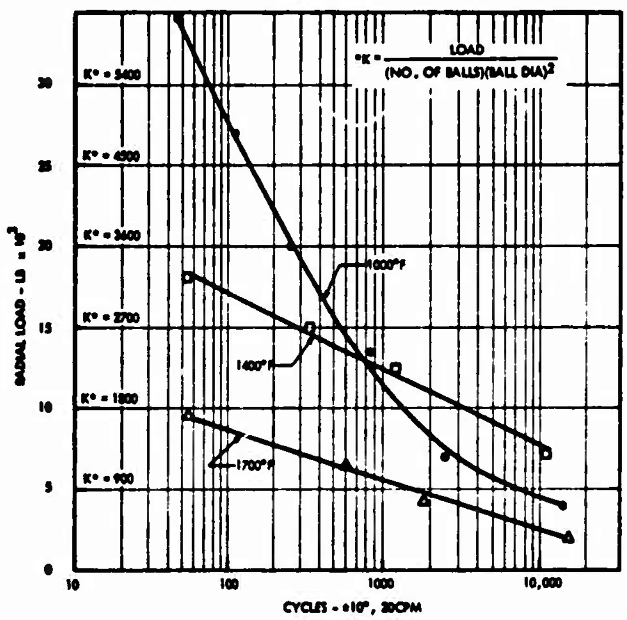
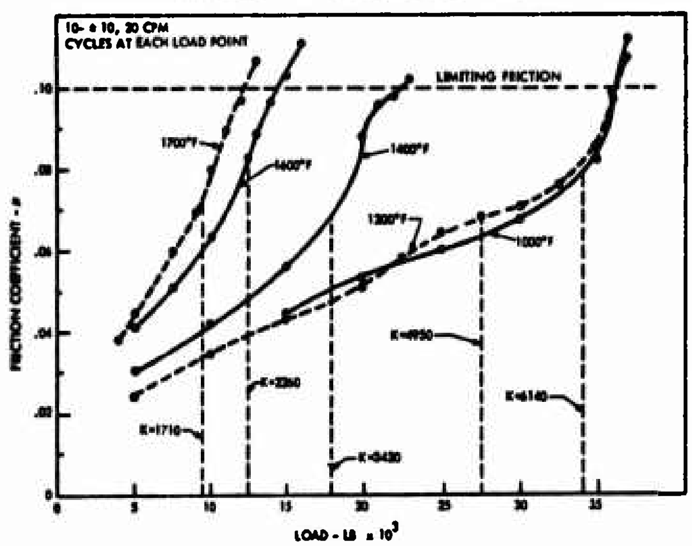
SUB-NOTE 1(2) (Sheet 2 of 2 Sheets) Self-Aligning Ball Bearing

LOAD VS LIFE

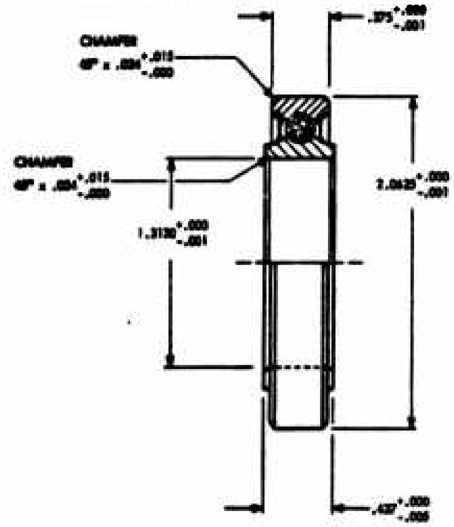



LOAD SPECTRUM TESTS - 1000, 1200, 1400, 1600 AND 1700°F




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

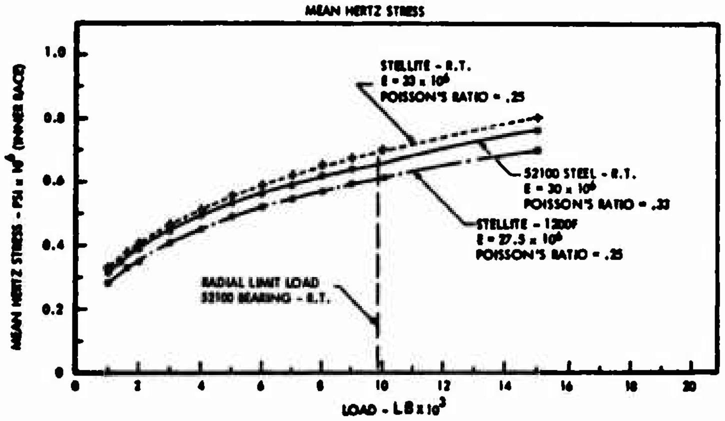
LUBRICATION: DESIGNED TO OPERATE DRY

USAGE AND APPLICATION

MOUNTING: PRESS FIT IN ALLOYS OF COMPARABLE EXPANSION COEFFICIENT

APPLICATION: SEE PERFORMANCE DATA

MEAN HERTZ STRESS

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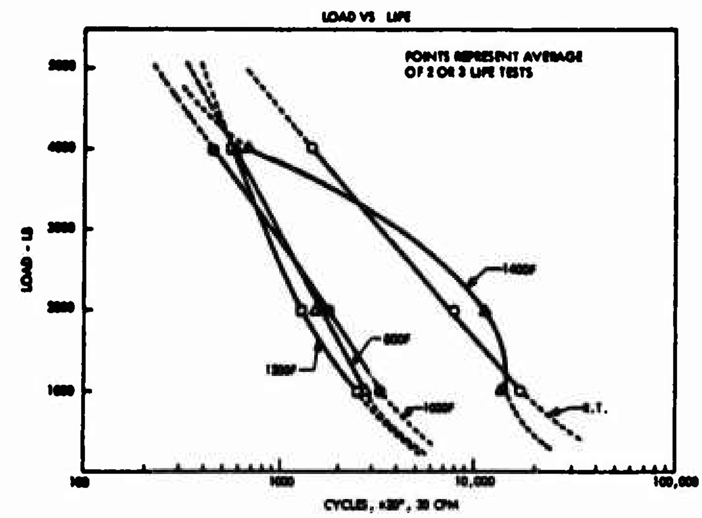
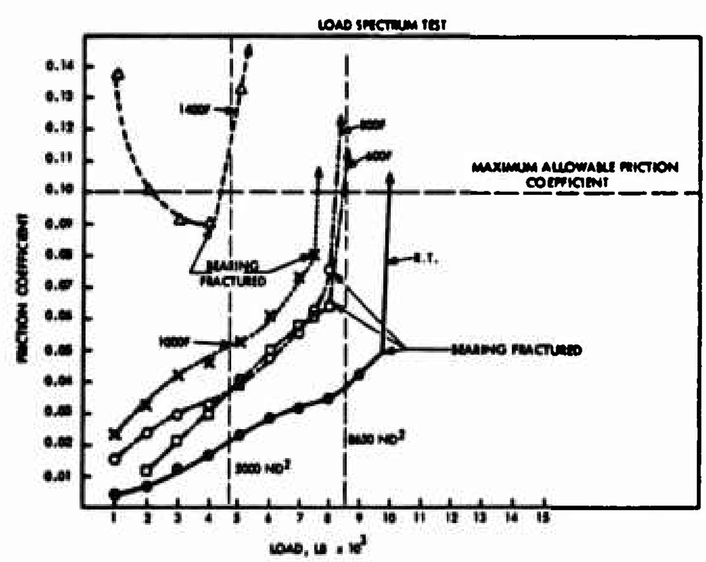
SUB-NOTE 1(3) (Sheet 2 of 2 Sheets) KP-21B
Type, Stellite 19, Ball Bearing




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

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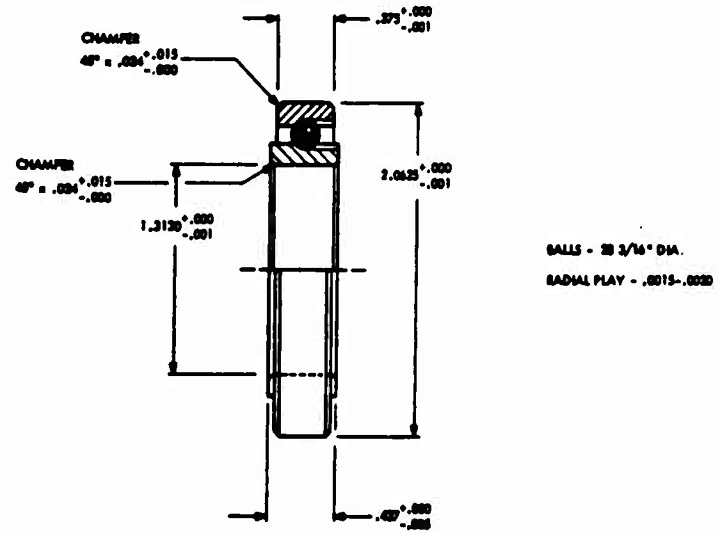
**SUB-NOTE 1(4) (Sheet 1 of 2 Sheets) KP-21B Type, Stellite 25, Ball Bearing**




MATERIAL: RACES & BALLS - STELLITE 25 COLD WORKED TO $R_c$ 52 MIN

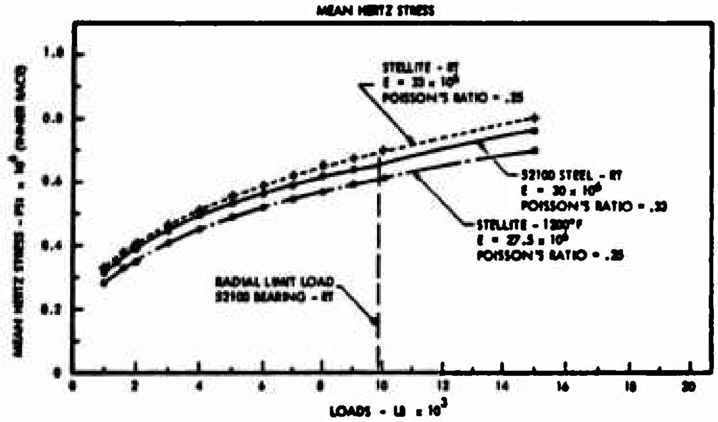
RACE CURVATURE: OUTER RACE - 52.5 TO 53.5% OF BALL DIA

LUBRICANT: NONE

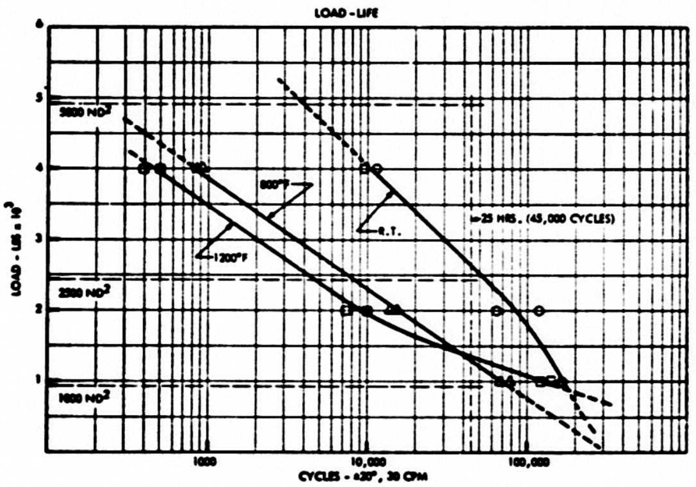
USAGE AND APPLICATION INFORMATION

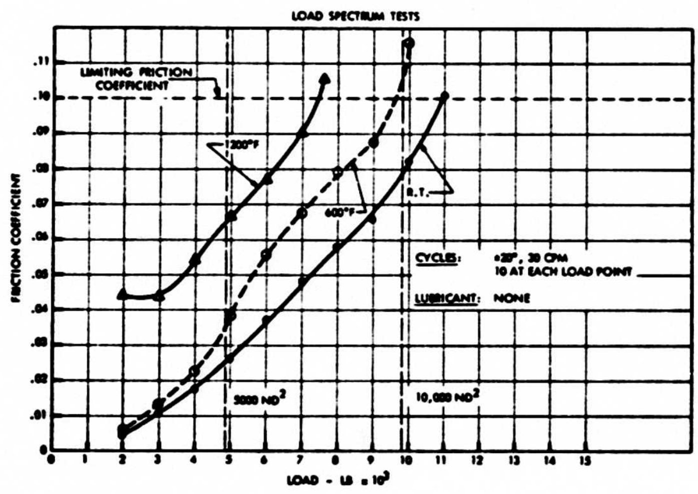
MOUNTING: PRESS FIT

APPLICATION: SEE PERFORMANCE DATA



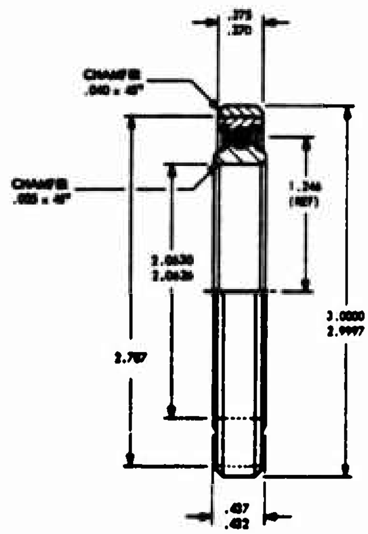
**SUB-NOTE 1(4) (Sheet 2 of 2 Sheets) KP-21B Type, Stellite 25, Ball Bearing**




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

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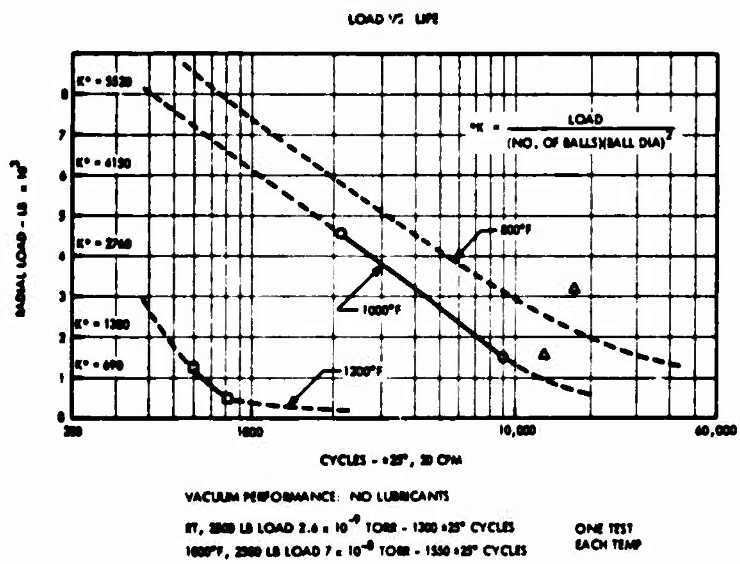
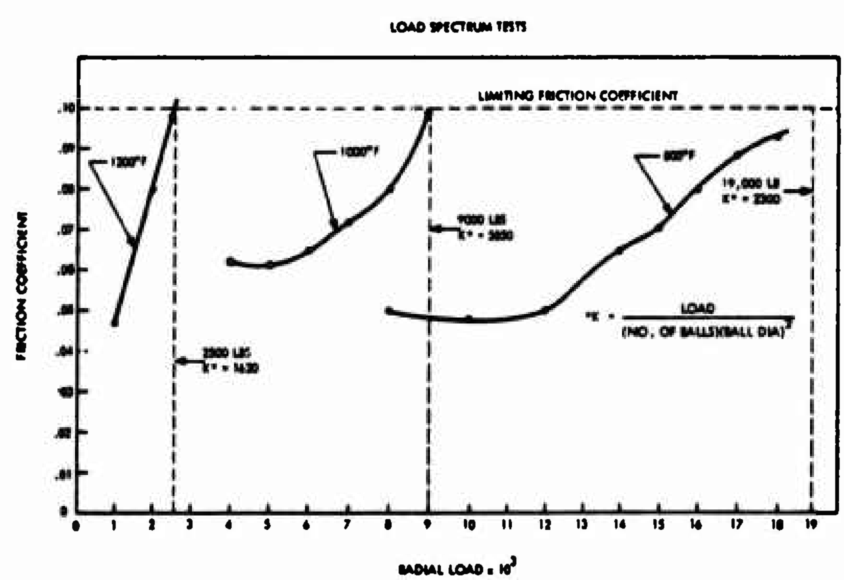
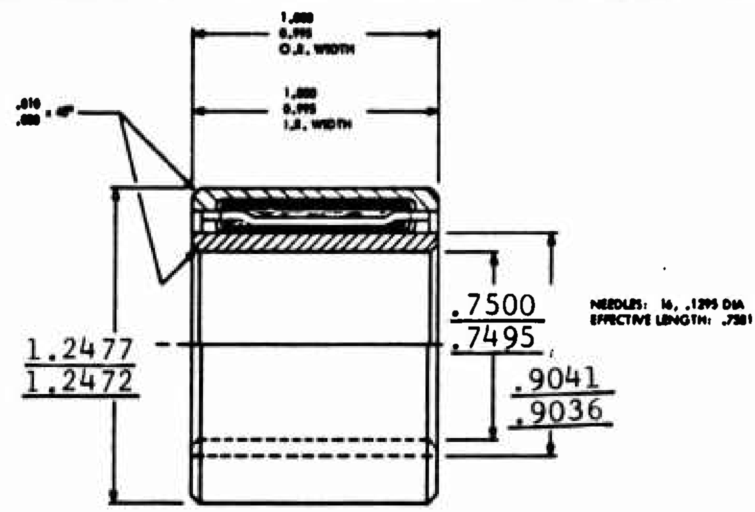
**SUB-NOTE 1(5) (Sheet 2 of 2 Sheets) KP-33-BS Type Ball Bearing**




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 $R_c$ 36-45

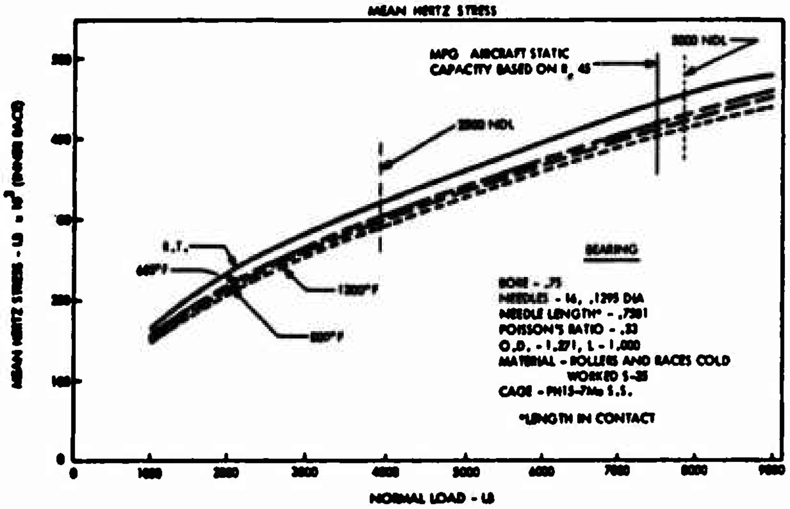
LUBRICATION: NONE

USAGE & APPLICATION INFORMATION

MOUNTING: PRESS FIT

APPLICATION: SEE PERFORMANCE DATA.

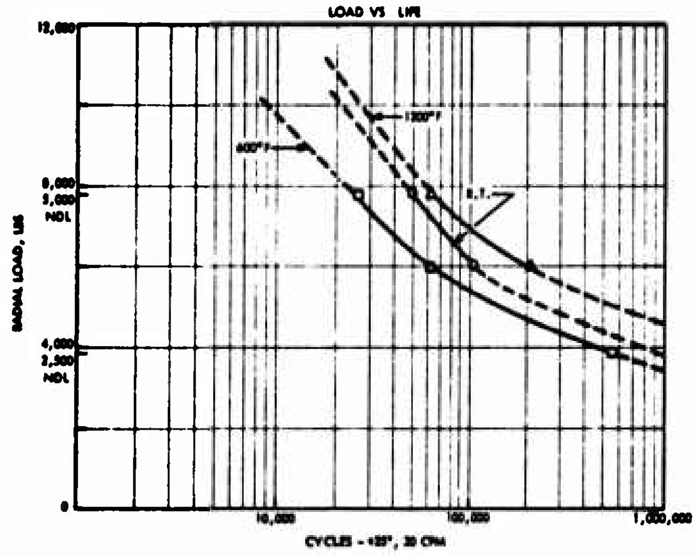
MEAN HERTZ STRESS

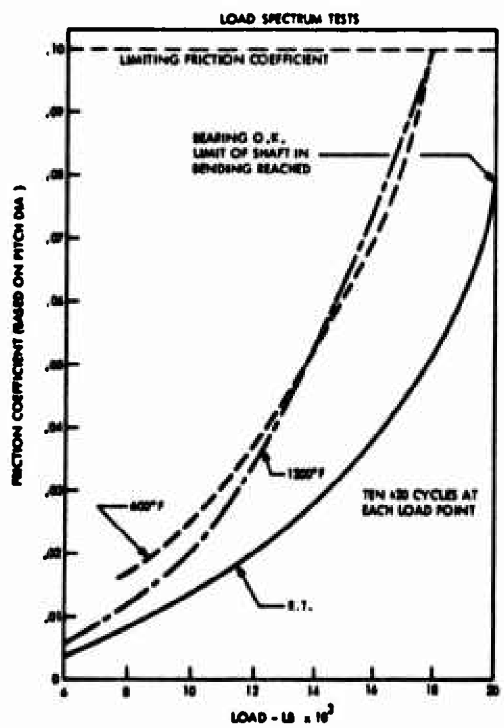



Comment: Change dimensions as shown above.

Rationale: Dimensions of bearing diameter are not compatible.

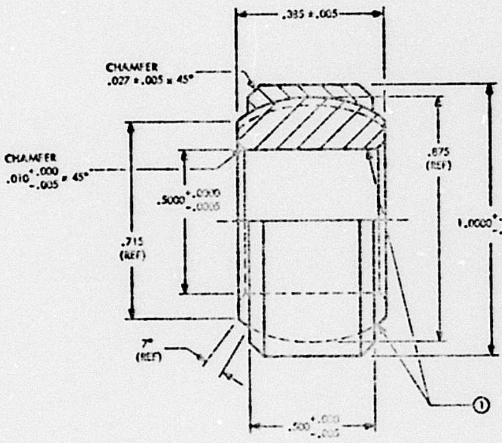
**SUB-NOTE 1(6)** (Sheet 2 of 2 Sheets) **Needle Bearing**




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

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




RADIAL CLEARANCE, 70°F : .0002- .0008

| | |
|---|---|
| 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 |

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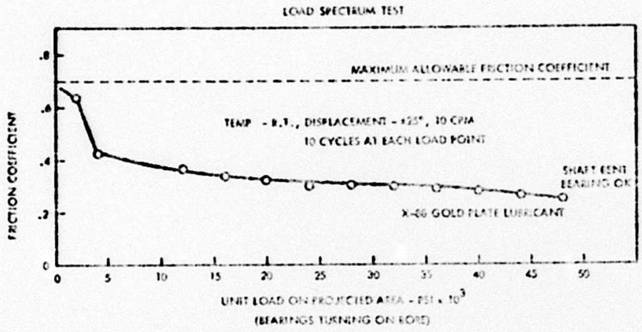
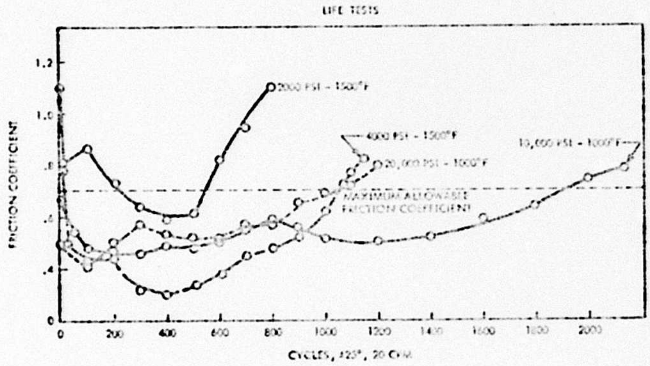
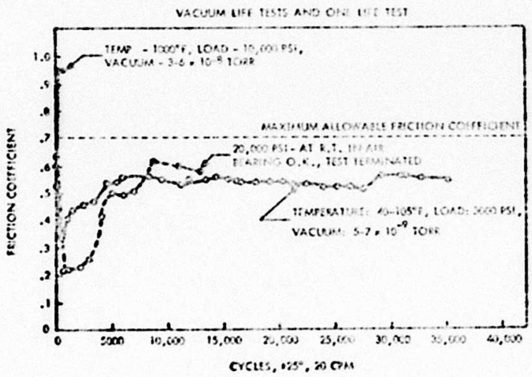
SUB-NOTE 1(7) (Sheet 2 of 2 Sheets) Spherical Bearing



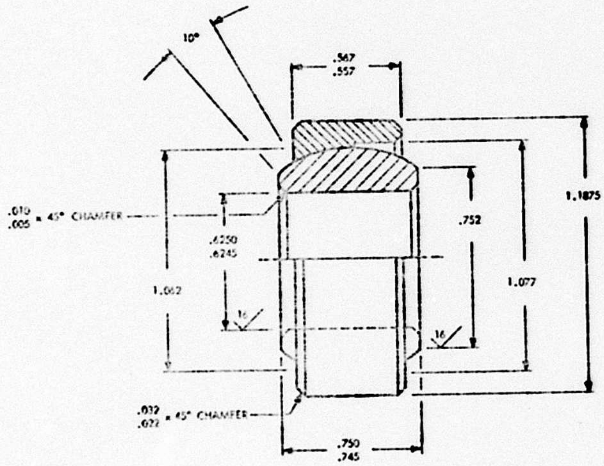




**Comment: Load life curve should be distributional for design for reliability usage.**

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

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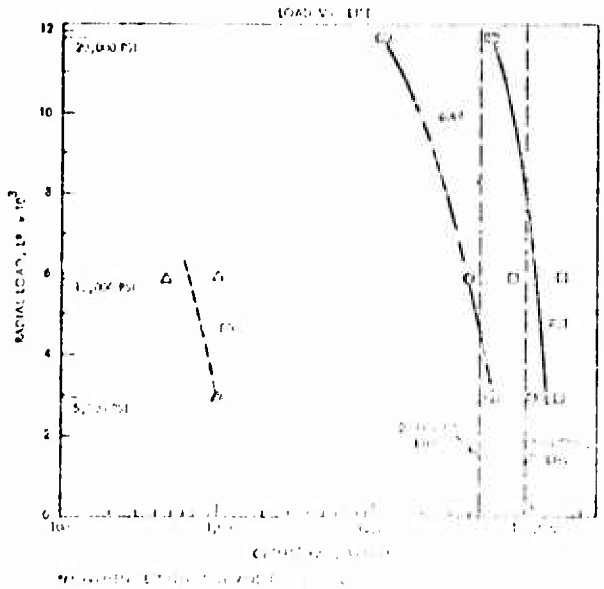
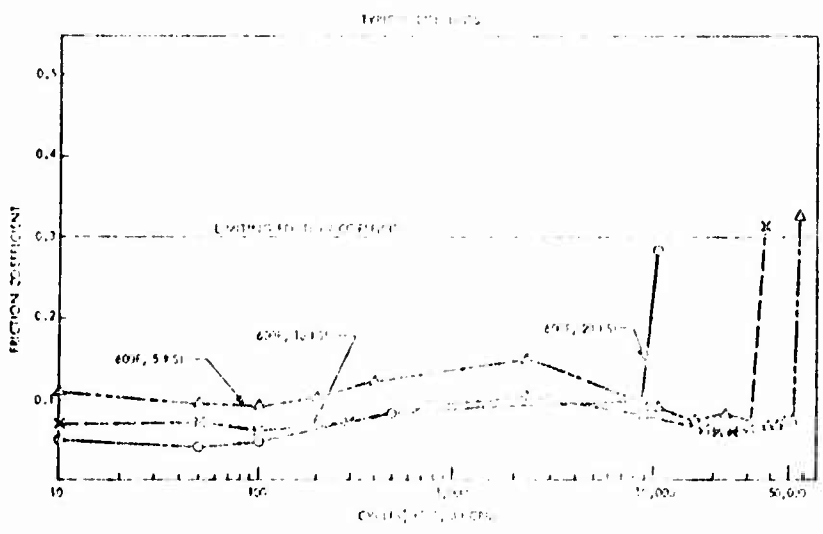
SUB-NOTE 1(8) (Sheet 2 of 2 Sheets) Spherical Loader Slot Bearing

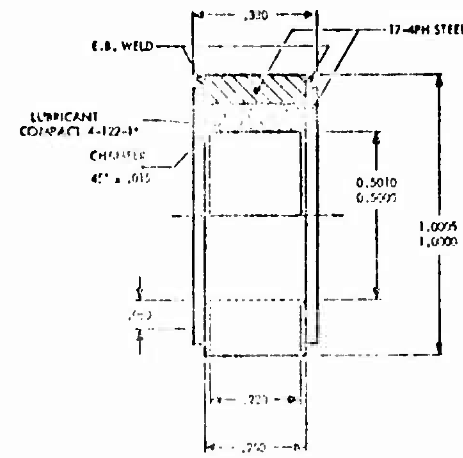




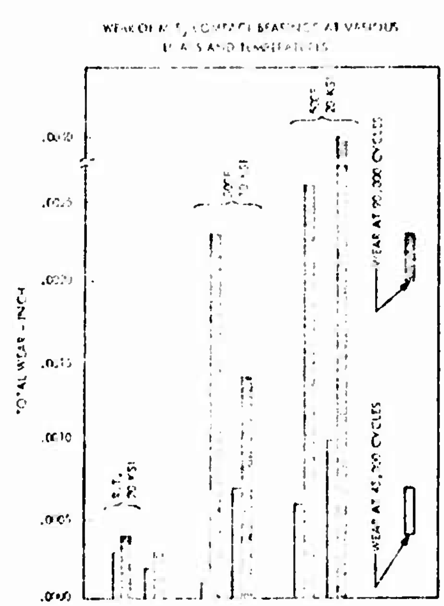

Comment: Load life curve should be distributional for design for reliability usage.

C5<

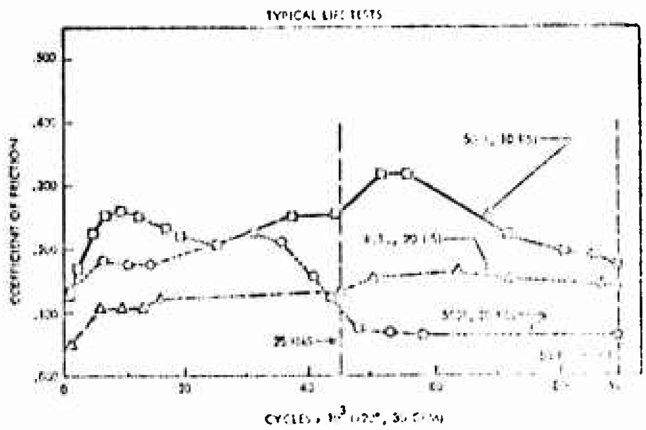
SUB-NOTE 1(9) (Sheet 1 of 2 Sheets) Metal Compact Plain Bearing

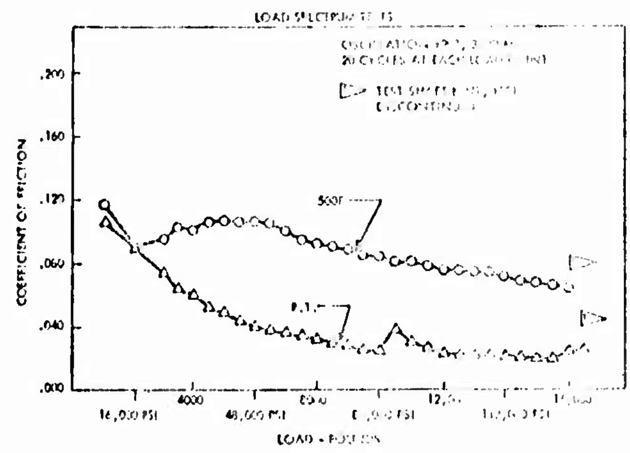



| | |
|---|---|
| *[illegible] 4-122-1 | |
| [illegible] | $MoS_2$ [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| ELECTRICAL [illegible] | 3.7 [illegible] x $10^{-4}$ |



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

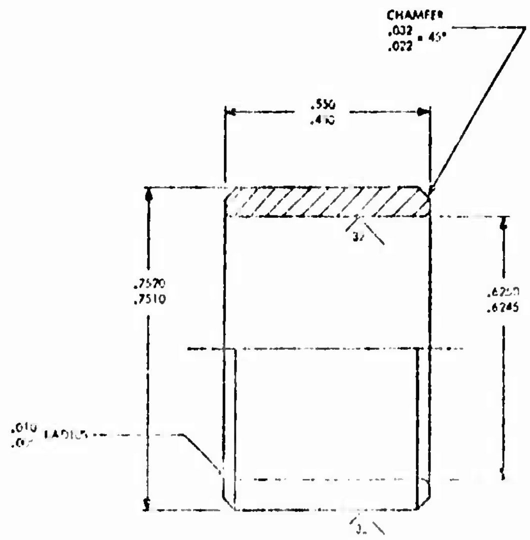



Comment: Load life curve should be distributional for design for reliability usage.

C7<

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




| | |
|---|---|
| MATERIAL: | HIGH STRENGTH GRAPHITE WITH THE FOLLOWING PROPERTIES: |
| | DENSITY, gm/cc: [illegible] |
| | COEFF. THERMAL EXPANSION: [illegible] |
| | [illegible], 4.9 x [illegible] in/in/°F |
| | COMPRESSIVE STRENGTH, PSI: 20,000 |
| | FLEXURAL STRENGTH, PSI: 14,000 |
| | TENSILE STRENGTH, PSI: 4,800 |
| | HARDNESS (SHORE SCLEROSCOPE): 64 |
| | 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 |

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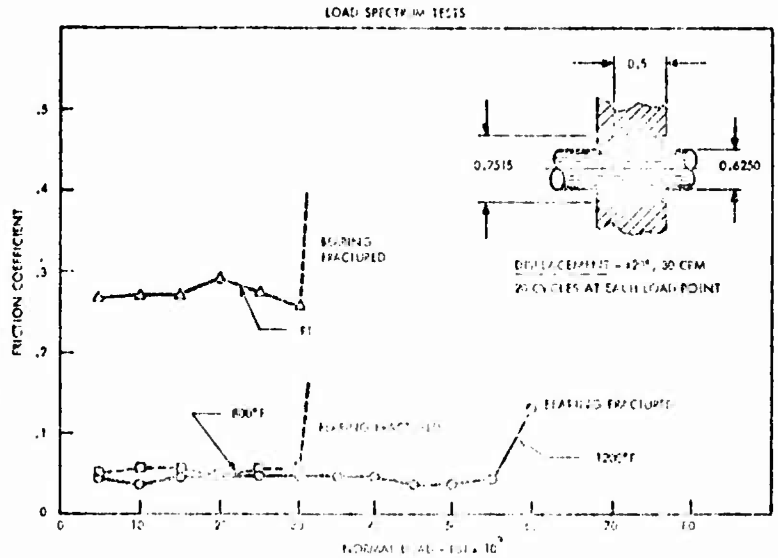
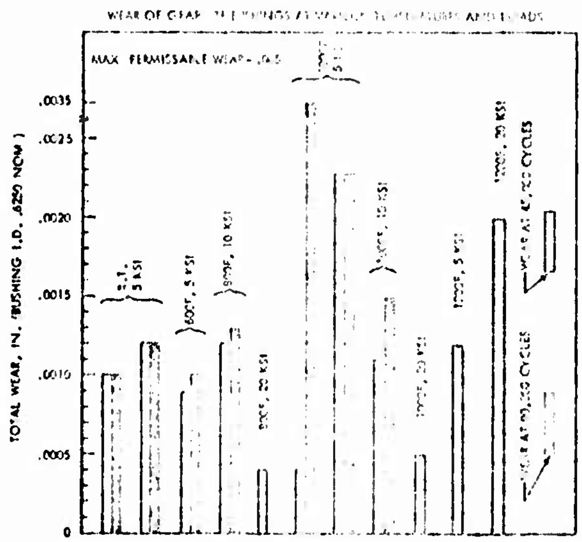
SUB-NOTE 1(10) (Sheet 2 of 2 Sheets) Graphite Bushing

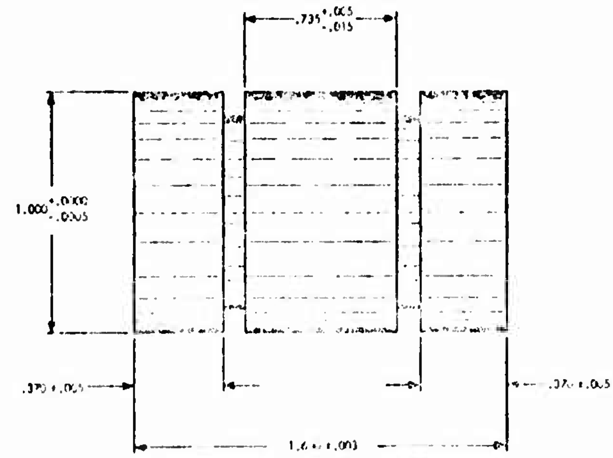


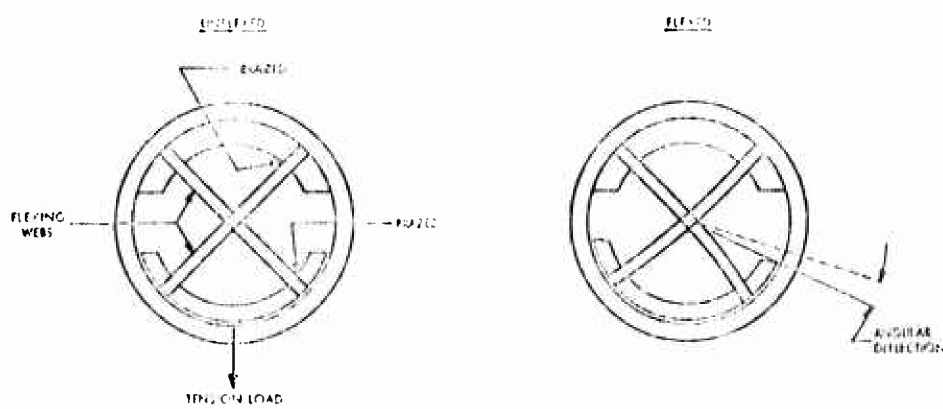




Comment: Load life curve should be distributional for design for reliability usage.

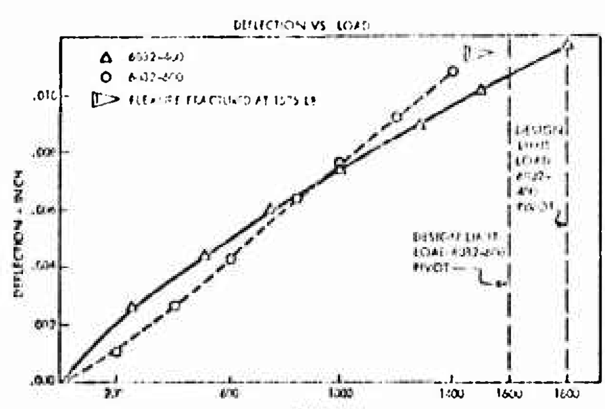
C9<

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

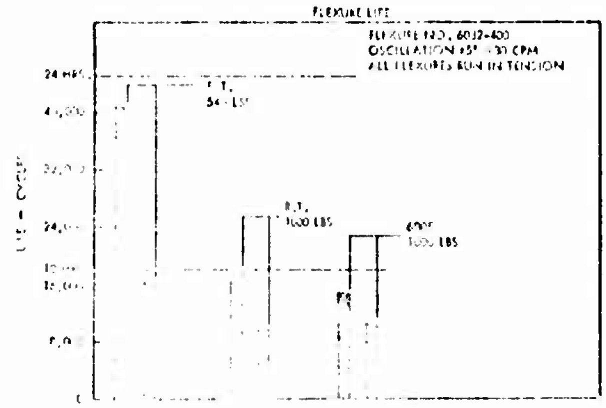


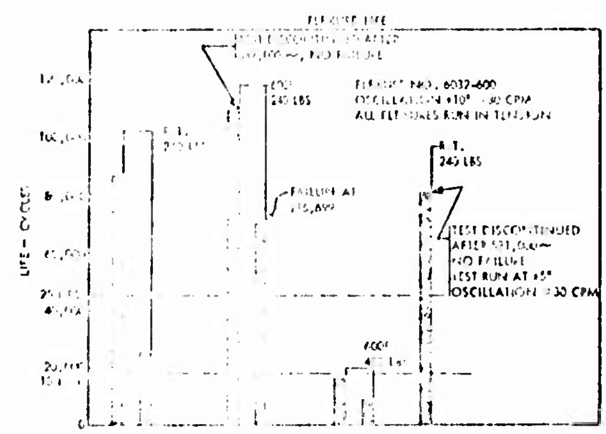




| | 6032-400 | 6032-600 |
|---|---|---|
| TORSIONAL SPRING RATE, LB-IN/RAD | 401.0 | 53.8 |
| LIMIT LOAD TENSION, LB | [illegible] | 1600 |
| LIMIT LOAD COMPRESSION, LB | [illegible] | 1131 |
| WEB THICKNESS, IN (APPROX) | [illegible] | 0.025 |



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

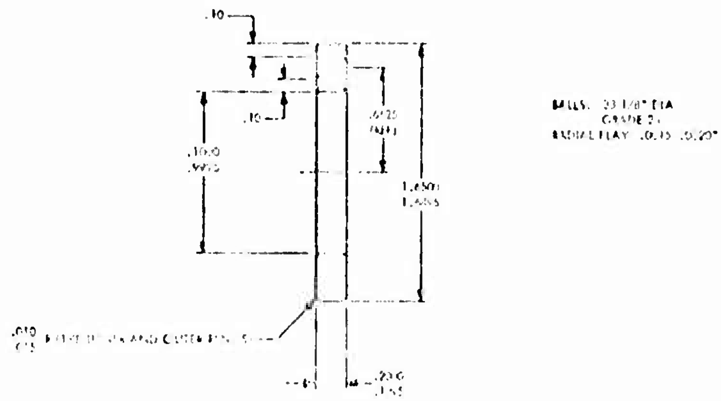



Comment: Load life curve should be distributional for design for reliability usage.

71<

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

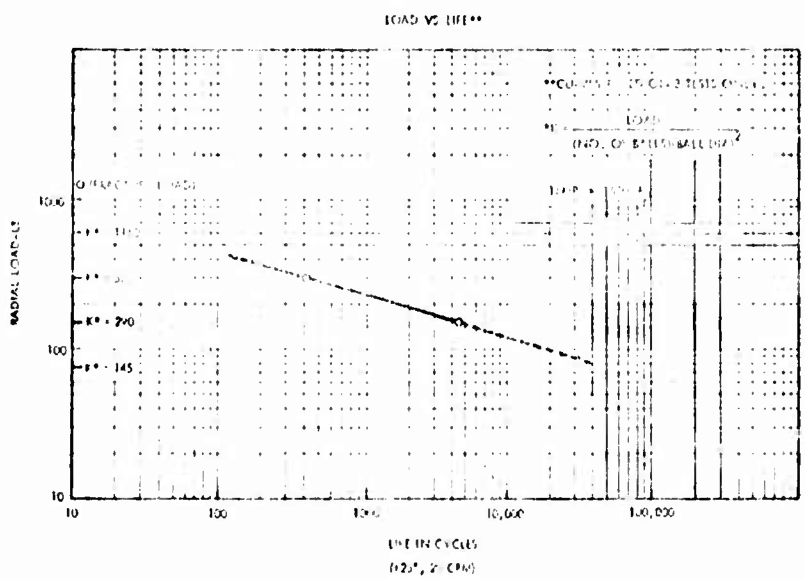



| | |
|---|---|
| MATERIAL | RACEWAYS - [illegible]<br>BALLS - [illegible]<br>SURFACE FINISH [illegible] |
| RACE CURVATURE | INNER & OUTER RACES TO HAVE GROOVE [illegible] TO 51-[illegible] OF BALL DIAMETER |
| SHOULDER HEIGHTS | BOTH [illegible] TO HAVE SHOULDER HEIGHTS EQUAL TO [illegible] TO [illegible] OF BALL DIAMETER |
| TOLERANCES | ABEC 5 TOLERANCES FOR [illegible] TO BEARINGS TO APPLY EXCEPT AS NOTED |
| LUBRICATION | NONE |

USAGE AND APPLICATION DATA

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

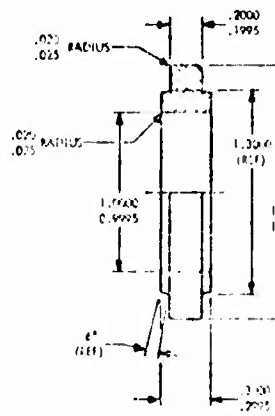
**SUB-NOTE 2(1)** (Sheet 2 of 2 Sheets) Ceramic Ball Bearing




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

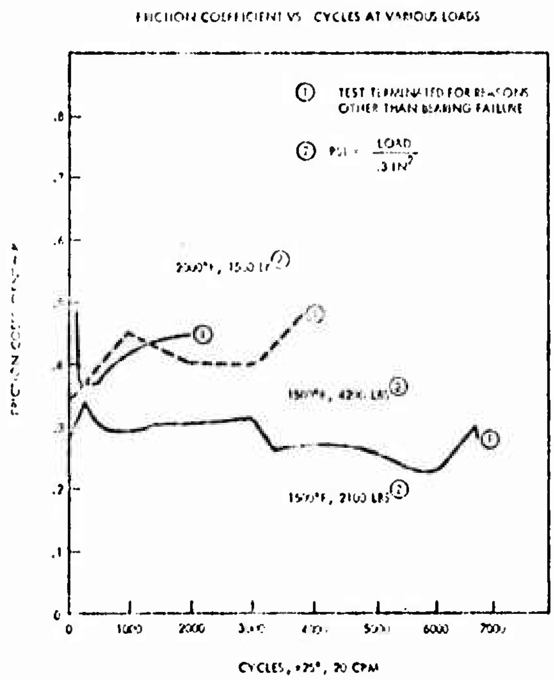
MOUNTING: MECHANICAL RETENTION OR ROLLER SWAGING OF HOUSING

APPLICATION: ① RADIAL CLEARANCE SHOULD BE .002-.004 FOR OPERATION AT TEMPERATURES ABOVE 1500°F

LIMIT LOADS - 2000°F - [illegible] LBS MIN, [illegible]°F - [illegible] LBS MIN

SEE PERFORMANCE DATA

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




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

## 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

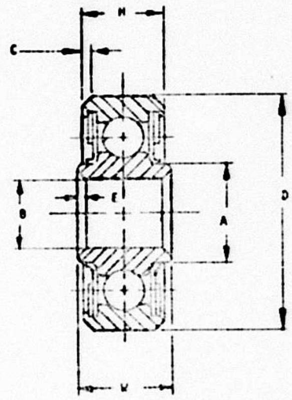
The standard airframe bushings are shown in SN 6(1) through SN 6(6).

### 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<br>BORE (b)<br>+.0000<br>-.0005 | D<br>OUTSIDE DIAMETER (a) (b)<br>+.0000<br>-.0005 | W<br>WIDTH INNER RING (a)<br>+.000<br>-.005 | H<br>WIDTH OUTER RING (a)<br>+.000<br>-.005 | A<br>SHOULDER DIAMETER INNER APPROX. | E<br>CORNER CHAMFER X 45°<br>INNER (d) RING BORE<br>+.015<br>-.000 | C<br>CORNER CHAMFER X 45°<br>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<br>CASE I | CASE II | WEIGHT POUNDS APPROX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -3A[g] | K3L | .1900 | .6250 | .245 | .203 | .280 | | .010 | 1560 | 700 | 1520 | 1260 | .01 |
| -3 | KP3 | .1900 | .7774 | .297 | .279 | .331 | .005 | .022 | 1830 | 900 | 1700 | 1450 | .03 |
| -4 | KP4 | .2500 | .9014 | .484 | .335 | .390 | | | 2680 | 1200 | 2410 | 2030 | .04 |
| -5 | KP5 | .3125 | 1.2500 | .558 | .375 | .469 | | .032 | 5630 | 2500 | 4900 | 3020 | .09 |
| -6 | KP6 | .3750 | 1.4375 | .620 | .469 | .591 | | | 7910 | 3500 | 6540 | 5610 | .15 |
| -8 | KP8 | .5000 | 1.6875 | .620 | .500 | .768 | .015 | .044 | 11800 | 5200 | 9320 | 7700 | .21 |
| -10 | KP10 | .6250 | 1.9375 | .620 | .500 | .650 | | | 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

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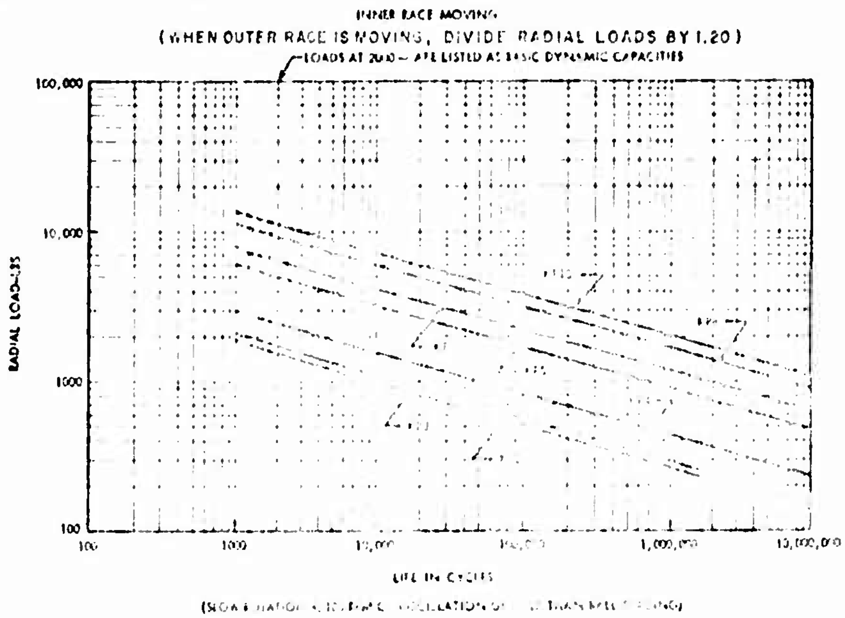
SUB-NOTE 2(1) (Sheet 2 of 2 Sheets) Heavy Duty Ball Bearings (MS27640)



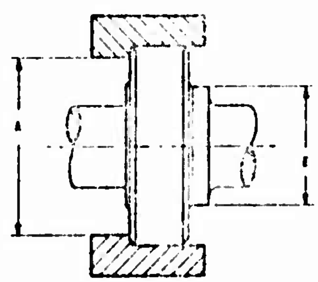

| BEARING | BALL DIAMETER | NO. | LIMIT MOMENT, IN-LBS | DEFLECTION CONSTANT, 1/INCH | APPROX. WEIGHT, LBS |
|---|---|---|---|---|---|
| K3L | 1/8 | 10 | [illegible] | [illegible] | 0 |
| KP3 | 1/8 | 12 | [illegible] | 10.15 | [illegible] |
| KP4 | [illegible] | [illegible] | [illegible] | [illegible] | 04 |
| KP5 | 1/4 | 9 | [illegible] | 6.76 | [illegible] |
| KP6 | 9/32 | [illegible] | [illegible] | 5.44 | 15 |
| KP8 | 11/32 | 10 | [illegible] | 4.45 | [illegible] |
| KP10 | 3/8 | [illegible] | [illegible] | [illegible] | [illegible] |

SHAFT AND HOUSING SHOULDER DIAMETERS

| BEARING | A, MAX., IN | B, MIN., IN |
|---|---|---|
| K3L | [illegible] | 260 |
| KP3 | [illegible] | 301 |
| KP4 | 752 | [illegible] |
| KP5 | 1.0[illegible]4 | 459 |
| KP6 | 1.224 | 550 |
| KP8 | 1.454 | 742 |
| KP10 | 1.646 | 835 |

SHAFT AND HOUSING FITS FOR [illegible] SERVICE

| BEARING | O.D. INCHES | STEEL HOUSING BORE, IN | ALLOY HOUSING BORE, IN | SHAFT DIAMETER |
|---|---|---|---|---|
| K3L | .6250-.624[illegible] | [illegible] | [illegible] | [illegible] |
| KP3 | .7774-.7[illegible] | [illegible] | [illegible] | [illegible] |
| KP4 | .9.14-[illegible] | [illegible] | [illegible] | [illegible] |
| KP5 | 1.2[illegible]-1.24[illegible] | [illegible] | [illegible] | [illegible] |
| KP6 | 1.4375-1.41[illegible] | [illegible] | [illegible] | [illegible] |
| KP8 | [illegible] | [illegible] | [illegible] | [illegible] |
| KP10 | 1.9[illegible] | [illegible] | [illegible] | [illegible] |



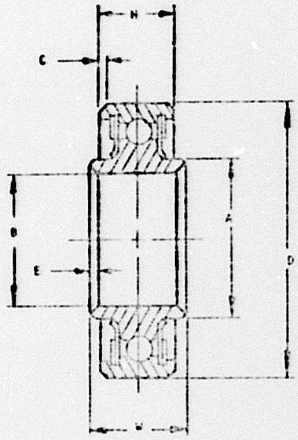

USAGE & APPLICATION DATA

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).

TDS

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




| MS DASH NO. | MFG P/N | B<br>BORE (b) +.0000 -.0005 | D<br>OUTSIDE DIAMETER (a) (b) +.0000 -.0005 | W<br>WIDTH INNER RING (a) +.000 -.005 | H<br>WIDTH OUTER RING (a) +.000 -.005 | A<br>SHOULDER DIAMETER INNER RING (APPROX.) | E<br>CORNER CHAMFER X 45°<br>INNER (d) RING BORE<br>+.015 -.000 | G<br>CORNER CHAMFER X 45°<br>OUTER (c) RING O.D.<br>+.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<br>(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 | 3900 | 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 |

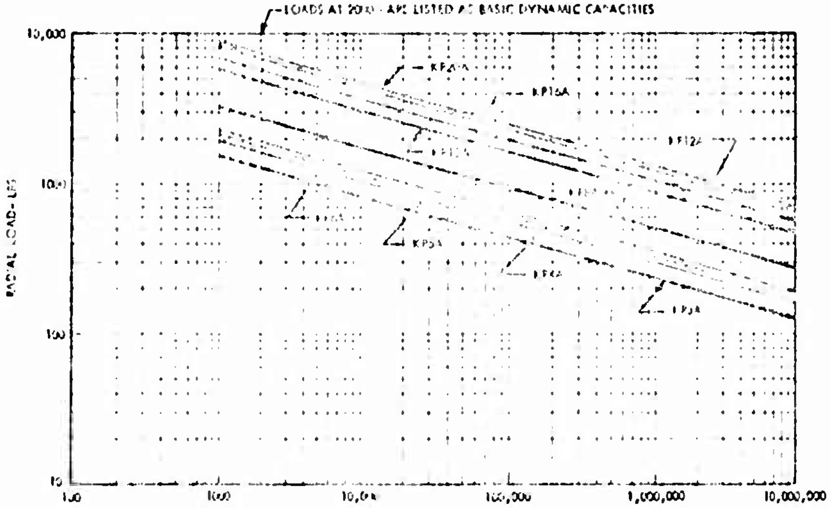
(a) ALL DIMENSIONS TO BE MET AFTER PLATING.
(b) OUT-OF-ROUND TOLERANCES. BORE: +.0002, -.0007
OUTER DIA.: +.0005, -.0010
(c) A RADIUS GIVING APPROXIMATELY THE SAME GRIP FOR STAKING THE BEARING IN THE HOUSING WILL BE ACCEPTABLE.
(d) A RADIUS GIVING APPROXIMATELY THE SAME FILLET CLEARANCE WILL BE ACCEPTABLE.
(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"

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)




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

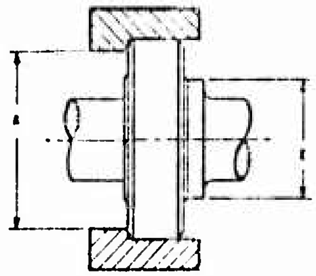
| BEARING | BALL DIAMETER | NO. | LIMIT MOMENT, IN-LB | MOMENT CONSTANT 1/INCH | APPROX. WEIGHT LBS |
|---|---|---|---|---|---|
| KP3A | [illegible] | [illegible] | [illegible] 6 | 12.10 | .01 |
| KP4A | [illegible] | [illegible] | 58.6 | 10.29 | .02 |
| KP5A | [illegible] | 14 | 114.0 | 8.75 | .02 |
| KP6A | [illegible] | 15 | 143.0 | 7.66 | .0[illegible] |
| KP8A | [illegible] | 16 | 277.[illegible] | 6.15 | .0[illegible] |
| KP10A | 2[illegible] | 14 | 5[illegible].0 | 5.07 | .0[illegible] |
| KP12A | [illegible] | 15 | 945.0 | 4.13 | .13 |
| KP16A | 1/4 | 17 | 1600.0 | 3.25 | .22 |
| KP20A | 1/4 | 2[illegible] | 2[illegible]0.0 | 2.81 | .26 |

SHAFT AND HOUSING SHOULDER DIAMETERS

| BEARING | A, MAX., IN | E, MIN., IN. |
|---|---|---|
| KP3A | .520 | .272 |
| KP4A | .620 | .375 |
| KP5A | .664 | .415 |
| KP6A | .754 | .498 |
| KP8A | .976 | .6[illegible] |
| KP10A | 1.214 | .758 |
| KP12A | 1.464 | .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 | .6250-.6245 | [illegible] | [illegible] | .1875-.1870 |
| KP4A | [illegible] | [illegible] | [illegible] | [illegible] |
| KP5A | .8125-.8120 | [illegible] | [illegible] | .3120-.3115 |
| KP6A | .8750-.8745 | [illegible]-.8745 | .8742-[illegible] | .3745-.374 |
| KP8A | 1.1250-1.1245 | [illegible] | 1.1244-1.1239 | .4995-[illegible] |
| KP10A | 1.3750-1.3745 | [illegible] | 1.3744-[illegible] | .6245-[illegible] |
| KP12A | 1.6250-1.6245 | [illegible] | [illegible] | .7495-.749 |
| KP16A | 2.[illegible]-1.9995 | [illegible] | [illegible] | [illegible] |
| KP20A | 2.2500-2.2495 | [illegible] | 1.9994-1.9989 | 1.2495-1.2490 |

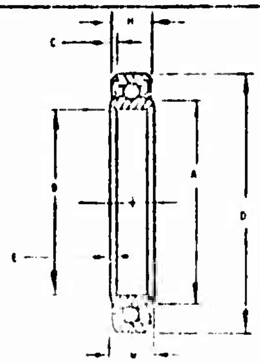



USAGE & APPLICATION DATA

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 - 49 | .0010 | .0016 | [illegible] | [illegible] |
| 52 - 72 | .0012 | .0016 | .0010 | [illegible] |
| 76 - 92 | .0014 | .0018 | [illegible] | [illegible] |
| 96 | .0014 | .0020 | .0010 | .0020 |

| MS DASH NO | MFG PART NO | B BORE (e) +.0000 -.00[illegible] | D OUTSIDE DIAMETER (a) +.0000 -.0010 | W WIDTH INNER RING | H WIDTH OUTER RING | A SHOULDER DIAMETER INNER RING | E & C INNER & OUTER RING CHAMFER X 45° | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -16 | [illegible] | [illegible] | [illegible] | | | [illegible] | | | [illegible] | | | | |
| -21 | [illegible] | [illegible] | 2 .125 | .437 | .375 | [illegible] | [illegible] | 3 [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| -23 | [illegible] | [illegible] | 2 .[illegible] | | | 1 .575 | | | | | | | |
| -25 | [illegible] | [illegible] | 2 .31[illegible] | | | [illegible] | | | [illegible] | | [illegible] | | |
| -29 | [illegible] | [illegible] | 2 .[illegible] | .437 | .375 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| -33 | [illegible] | [illegible] | 2 [illegible] | | | [illegible] | | | [illegible] | | | | |
| -37 | [illegible] | [illegible] | [illegible] | | | [illegible] | | | [illegible] | | [illegible] | | |
| -42 | [illegible] | [illegible] | 3 [illegible] | .531 | .469 | 3 [illegible] | .039 | 3 TO 10 | 242[illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| -49 | [illegible] | 3 .0630 | 4 .0000 | | | 3 .222 | | | 22500 | [illegible] | [illegible] | [illegible] | [illegible] |
| -52 | [illegible] | [illegible] | 4 .1875 | | | 3 .[illegible] | | | [illegible] | [illegible] | [illegible] | | [illegible] |
| -56 | [illegible] | 3 .[illegible] | 4 .4375 | .531 | .469 | 3 .[illegible] | .039 | 3 TO 5 | [illegible] | [illegible] | [illegible] | | [illegible] |
| -60 | [illegible] | [illegible] | 4 .6875 | | | 4 .014 | | | [illegible] | [illegible] | [illegible] | | [illegible] |
| -64 | [illegible] | [illegible] | 4 .9375 | .531 | .469 | 4 .2[illegible] | | | [illegible] | [illegible] | | | |
| -68 | [illegible] | [illegible] | 5 .[illegible] | .593 | .531 | 4 .[illegible] | .039 | 3 TO 15 | [illegible] | [illegible] | [illegible] | | |
| -72 | [illegible] | [illegible] | 5 .5625 | | | 4 .774 | | | [illegible] | [illegible] | | | |
| -76 | [illegible] | [illegible] | 5 .8125 | | | 5 .046 | | | [illegible] | | [illegible] | | |
| -80 | [illegible] | [illegible] | 6 .0625 | .593 | .531 | 5 .246 | .039 | 3 TO 15 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| -84 | [illegible] | [illegible] | 6 .3125 | | | 5 .596 | | | [illegible] | [illegible] | | | |
| -88 | [illegible] | [illegible] | 6 .5625 | | | 5 .[illegible] | | | [illegible] | [illegible] | | | [illegible] |
| -92 | [illegible] | [illegible] | 6 .8125 | .593 | .531 | [illegible] | .039 | 3 TO 15 | [illegible] | [illegible] | | | [illegible] |
| -96 | [illegible] | 6 .[illegible] | 7 .[illegible] | | | 6 .301 | | | [illegible] | [illegible] | | | [illegible] |

** [illegible] - .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 [illegible] MIN

5 HARDNESS HEAT TREAT RINGS AND BALLS TO ROCKWELL "C" 60 TO 66 AND STABILIZED FOR OPERATION AT [illegible]°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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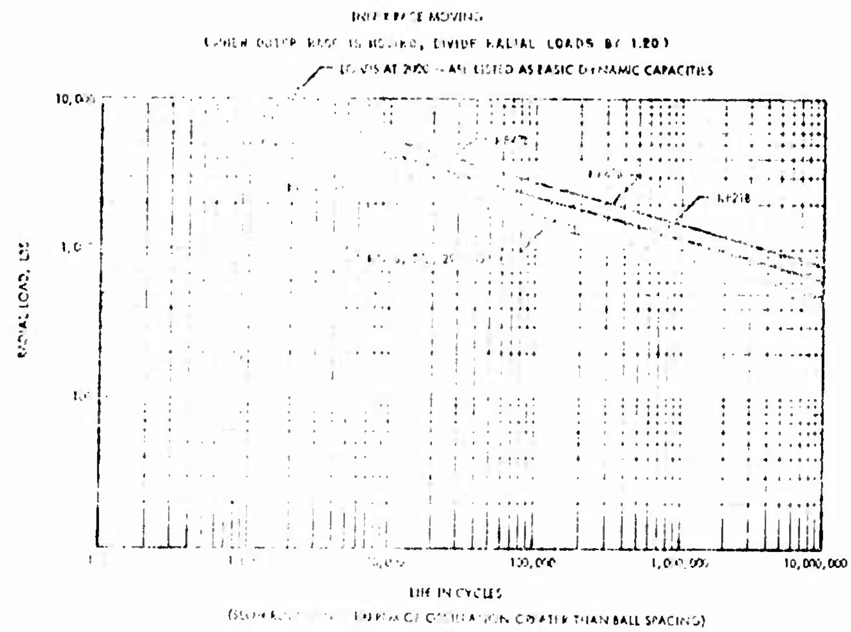
SUB-NOTE 2(3) (Sheet 2 of 2 Sheets) Extra-Light Duty Ball Bearings (MS27642)




DATA FOR [illegible]

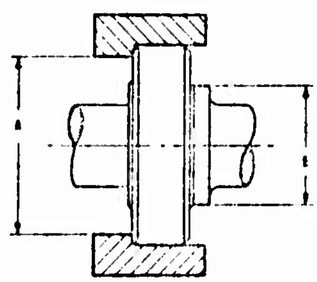
| BEARING | [illegible] | [illegible] | [illegible] | [illegible] | APPROX. WEIGHT, LB |
|---|---|---|---|---|---|
| [illegible] | [illegible] | | 1 | [illegible] | 15 |
| [illegible] | [illegible] | | [illegible] | | 17 |
| [illegible] | [illegible] | | 1 | [illegible] | 15 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 2 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | 1.49 | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

SHAFT AND HOUSING SHOULDER DIAMETERS

| BEARING | A, MAX., IN. | B, MIN., IN. |
|---|---|---|
| KP218 | 1.694 | 1.454 |
| KP[illegible] | 2.016 | 1.574 |
| KP[illegible] | 2.132 | 1.673 |
| KP2[illegible] | 2.372 | 1.931 |
| KP338 | 2.[illegible]72 | 2.231 |
| KP378 | 2.910 | 2.462 |
| KP476 | 3.600 | 2.970 |
| KP458 | 3.766 | 3.222 |

SHAFT AND [illegible]

| BEARING | O.D. [illegible] | [illegible] | [illegible] | SHAFT DIAMETER,* IN. |
|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | 1.3[illegible]-1.3110 |
| [illegible] | [illegible] | [illegible] | | [illegible] |
| [illegible] | [illegible] | [illegible] | | [illegible] |
| [illegible] | [illegible] | [illegible] | | [illegible] |
| [illegible] | [illegible] | [illegible] | | [illegible] |
| [illegible] | [illegible] | [illegible] | | [illegible] |
| [illegible] | [illegible] | [illegible] | | 2.9170-2.[illegible] |
| [illegible] | [illegible] | [illegible] | | 3.0620-3.[illegible] |

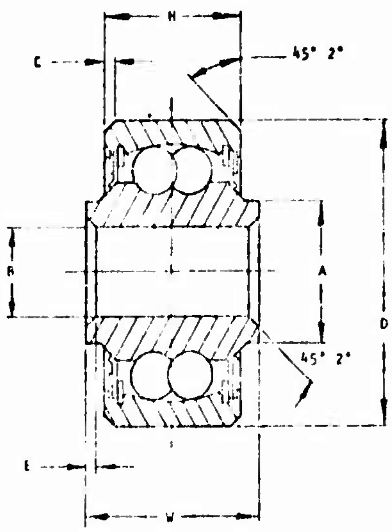


USAGE & APPLICATION DATA

MS27[illegible] [illegible] ARE INTENDED FOR LIGHT DUTY APPLICATIONS ON SHAFTS OF LARGE [illegible] DIRECT 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) +[illegible] -[illegible] | D OUTSIDE DIAMETER (c) (d) +.0000 -.0005 | W WIDTH INNER RING +[illegible] -[illegible] | H WIDTH OUTER RING +[illegible] -[illegible] | A SHOULDER DIAMETER INNER RING [illegible] | C CORNER CHAMFER 45° (a) OUTER RACE +.015 -.030 | E (b) INNER RACE | 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] | .9014 | [illegible] | .464 | .435 | .032 | | 1280 | [illegible] | .006 | 1250 | 1600 | .06 |
| -5 | [illegible] | [illegible] | 1.2500 | .812 | .656 | .515 | | .015 | 3740 | 600 | | 3760 | [illegible] | .16 |
| -6 | [illegible] | .3750 | 1.4375 | .937 | .750 | .564 | | | 5100 | [illegible] | | [illegible] | 4370 | .24 |
| -8 | [illegible] | [illegible] | 1.6875 | [illegible] | .812 | .775 | .044 | | 7120 | 1000 | | 6340 | 5570 | .36 |
| -10 | [illegible] | [illegible] | [illegible] | 1.125 | .937 | .869 | | | [illegible] | 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%.

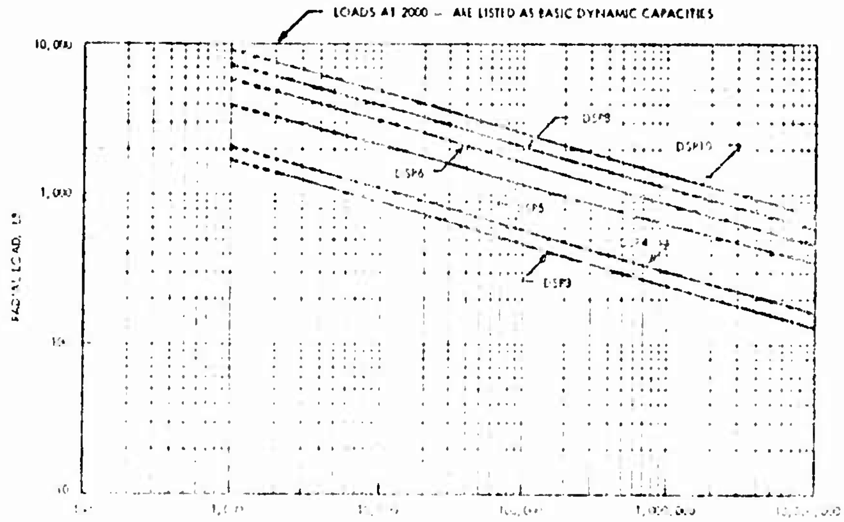
1. MATERIALS: RINGS; STEEL, FED-STD-66, E52100
BALLS; STEEL, FED-STD-66, E51100 OR E52100.
2. SEALS; POLYTETRAFLUOROETHYLENE PER AMS3652 OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER AMS 3666.
3. SEAL RETAINERS, STEEL, CORROSION RESISTANT
4. LUBRICANT; MIL-G-81322 FILLED 80% MIN.

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

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)




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

DATA FROM TYPICAL MS 27643 SERIES BEARING

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

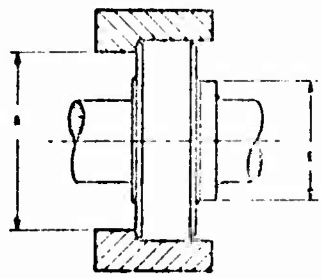
*ALSO CALLED BASIC DYNAMIC CAPACITIES

SHAFT AND HOUSING SHOULDER DIAMETER

| BEARING | A, MAX., IN | B, [illegible], IN |
|---|---|---|
| DSP3 | .610 | [illegible] |
| DSP4 | .712 | [illegible] |
| DSP5 | .914 | .515 |
| DSP6 | 1.166 | [illegible] |
| DSP8 | 1.4?0 | [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] | .7779-.7784 | [illegible] | [illegible] |
| DSP4 | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | 1.4375-[illegible] | 1.4370-1.4365 | [illegible] | .3745-.3740 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | 1.9370-1.9365 | 1.9358-1.9363 | .6245-.6240 |

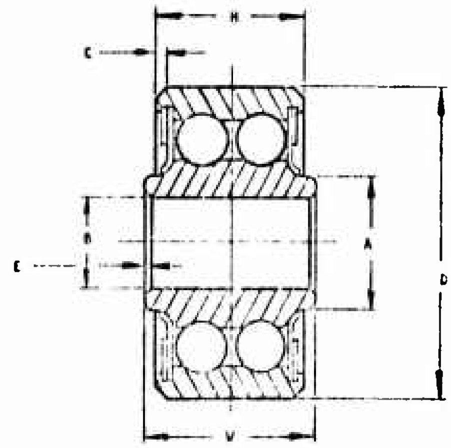


USAGE & APPLICATION DATA

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. | MFG PART NO. | B BORE (b) +.0000 -.0005 | D OUTSIDE DIAMETER (a) (b) | W WIDTH INNER RING (b) | H WIDTH OUTER RING (b) | A SHOULDER DIAMETER INNER RING (APPROX) | E CORNER CHAMFER x 45° (c) INNER RING BORE +.015-.000 | C CORNER CHAMFER x 45° (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 |
| (g)-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 | [illegible] | [illegible] | [illegible] | .932 | .816 | .735 | | .044 | .007 | 23500 | 7800 | 14100 | 11690 | .38 |
| -10 | [illegible] | [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, -.0007
OUTER DIA +.0005, -.0015
(c) A RADIUS GIVING APPROXIMATELY THE SAME GAIN 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 [illegible].
(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 [illegible] MIN

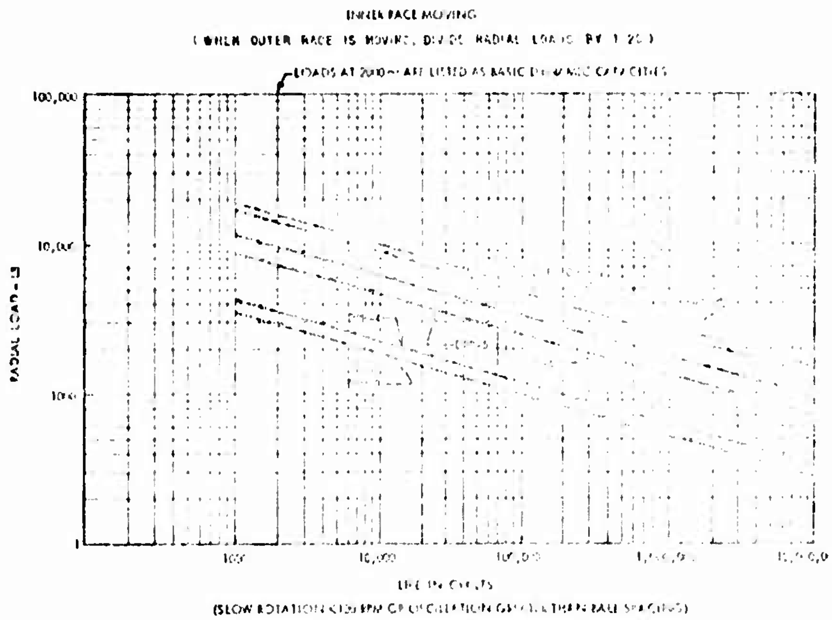
5. HARDNESS HEAT TREATMENT: HEAT TREAT RINGS AND BALLS TO ROCKWELL "C" 60 TO 66 AND STABILIZED FOR OPERATION AT 250°F.

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"

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




DATA FROM TYPICAL MS 27644 SERIES BEARINGS

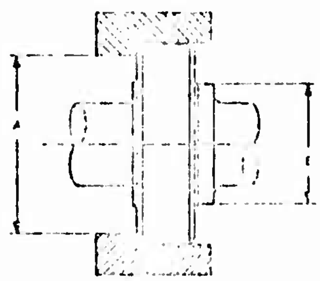
| BEARING | BALL DIAMETER | NO. | LIMIT MOMENT, [illegible] | MOMENT CONSTANT, [illegible] | APPROX. WEIGHT, LB |
|---|---|---|---|---|---|
| DPP3 | [illegible] | 2[illegible] | 33.3 | 44.4 | .07 |
| DPP4 | 5/32 | 22 | [illegible] | [illegible] | [illegible] |
| DPP5 | 1/4 - 15/64 | 20-2[illegible] | [illegible] | [illegible] | .1[illegible] |
| DPP6 | 5/16 - 9/32 | [illegible] | 2[illegible] | 19.1 | .2[illegible] |
| DPP8 | 11/32 | 2[illegible] | [illegible] | [illegible] | .3[illegible] |
| DPP10 | 11/32 | 24 | [illegible] | 5.[illegible] | .53 |

SHAFT AND HOUSING SHOULDER DIAMETERS

| BEARING | A, MAX., IN. | B, MIN., IN. |
|---|---|---|
| DPP3 | .4[illegible] | [illegible] |
| DPP4 | .71 | [illegible] |
| DPP5 | 1.[illegible] | .457 |
| DPP6 | 1.2[illegible] | .551 |
| DPP8 | 1.4[illegible] | [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 DIAMETER |
|---|---|---|---|---|
| DPP3 | .7774 | .7769-.7764 | [illegible] | [illegible] |
| DPP4 | .9[illegible] | [illegible] | [illegible] | [illegible] |
| DPP5 | 1.2[illegible] | [illegible]-1.2490 | 1.1243-1.1234 | .312[illegible]-.3115 |
| DPP6 | 1.4[illegible]75 | [illegible] | [illegible] | [illegible] |
| DPP8 | 1.6[illegible]5 | [illegible] | [illegible] | [illegible] |
| DPP10 | 1.9[illegible] | [illegible] | 1.9[illegible]-1.9[illegible] | .6245-.6240 |

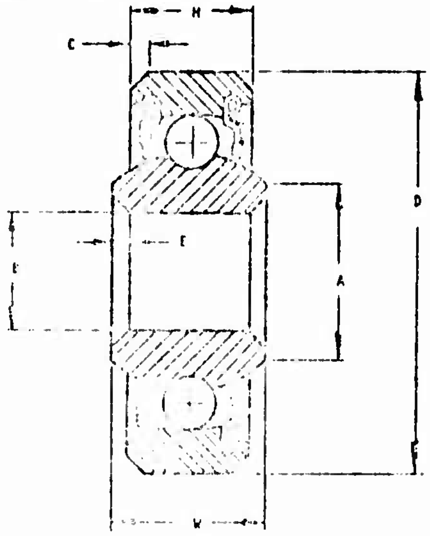



USAGE & APPLICATION DATA

DPP SERIES BEARINGS ARE USED IN APPLICATIONS WHERE RADIAL LOADS ARE LARGE AND [illegible] THEY CAN [illegible] STATIC THRUST LOADS BUT SHOULD NOT BE USED WHERE 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 | [illegible] (B) +.000 -.0[illegible] | OUTER [illegible] (a) (b) +.000 -.000[illegible] | [illegible] | [illegible] | [illegible] DIA [illegible] | FILLET CLEARANCE BEARING +.015 | FILLET CLEARANCE (c) RING -.0[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] | | .010 | 550 | 100 | 550 | 480 | .023 | .01 |
| -4A | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .005 | | 900 | 200 | 900 | 770 | .025 | .02 |
| -5A | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .015 | | 1000 | | 950 | 815 | .026 | |
| -6A | [illegible] | [illegible] | [illegible] | .31[illegible] | [illegible] | [illegible] | .010 | | 1120 | | 1120 | 990 | .030 | .03 |
| -3 | [illegible] | [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 | [illegible] | [illegible] | 1.[illegible] | [illegible] | [illegible] | [illegible] | .015 | | 2190 | | 2190 | 1[illegible] | .028 | .10 |
| -6 | [illegible] | [illegible] | 1.[illegible] | [illegible] | [illegible] | [illegible] | | | 2950 | 400 | 2980 | [illegible] | .030 | .15 |
| -8 | [illegible] | [illegible] | 1.[illegible] | [illegible] | [illegible] | .7[illegible] | | .034 | 3670 | 500 | 3670 | [illegible] | .032 | .23 |
| -10 | [illegible] | .[illegible] | 1.[illegible] | [illegible] | [illegible] | [illegible] | | | 5320 | 600 | 4980 | 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] + .00[illegible] - .00[illegible], [illegible] DIA + .00[illegible], - .0010
(c) A RADIUS [illegible] 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]
CASE II = [illegible]
(f) THESE RATINGS ARE FOR [illegible] 250°F MAX. WHEN SUBJECTED TO OPERATION AT 350° F. THE RATING SHOULD BE REDUCED BY 2

1. MATERIALS: RINGS, STEEL, PER [illegible], [illegible]
BALLS, STEEL, PER [illegible]
2. SEALS, [illegible] PER AMS3652 OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER [illegible]
3. SEAL RETAINER, STEEL CORROSION RESISTANT
4. [illegible]
5. HARDNESS: [illegible] RINGS AND BALLS TO ROCKWELL "C" 60 TO 6[illegible] AND STABILIZED FOR OPERATION AT 250°F.
6 SURFACE [illegible] AA PER ANSI 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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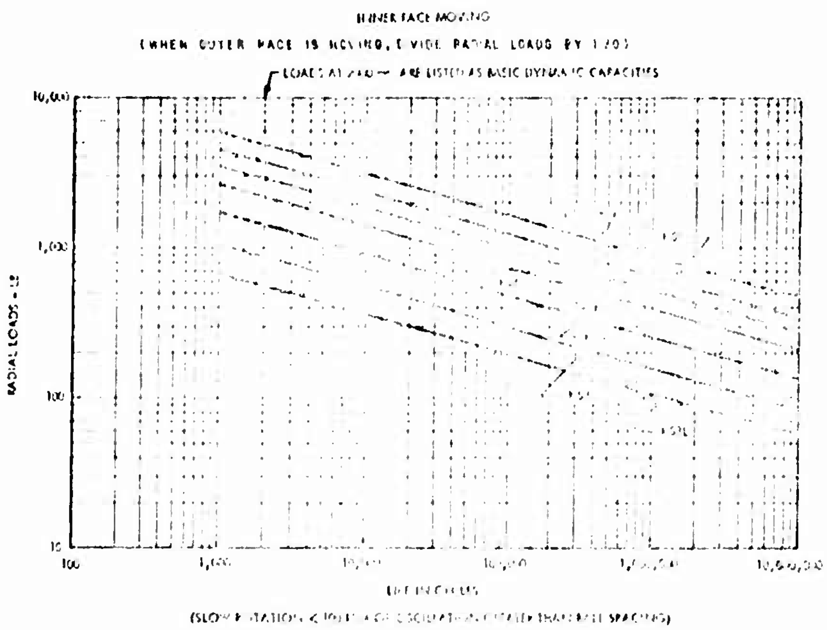
SUB-NOTE 2(6) (Sheet 2 of 2 Sheets) Self-Aligning Ball Bearings (MS27645)




DATA FROM TYPICAL MS27645 SERIES BEARING

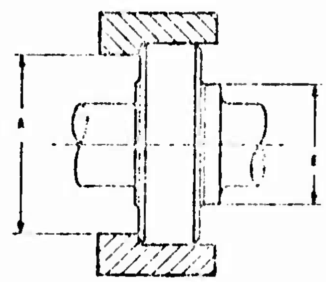
| BEARING | BALL DIAMETER | [illegible] | BASIC ... RATING [illegible] | [illegible] | APPROX WEIGHT LB |
|---|---|---|---|---|---|
| KSP3L | 3/32 | 13 | [illegible] | [illegible] | .02 |
| KSP4A | 1/8 | 12 | [illegible] | [illegible] | .02 |
| KSP5A | 1/8 | 14 | [illegible] | [illegible] | .02 |
| KSP6A | 1/8 | 1[illegible] | [illegible] | [illegible] | .03 |
| KSP3 | 1/8 | 1[illegible] | 5[illegible] | 770 | .03 |
| KSP4 | 5/64 | 13 | [illegible] | [illegible] | .04 |
| KSP5 | 3/16 | 13 | [illegible] | [illegible] | .10 |
| KSP6 | 7/32 | 11 | [illegible] | [illegible] | .15 |
| KSP8 | 7/32 | 16 | [illegible] | 32[illegible] | .21 |
| KSP10 | 9/32 | 14 | [illegible] | 4[illegible] | .32 |

SHAFT AND HOUSING SHOULDER DIAMETERS

| BEARING | A, MAX., IN. | B, MAX., IN. |
|---|---|---|
| KSP3L | .504 | .250 |
| KSP4A | .702 | .340 |
| KSP5A | 1.050 | [illegible] |
| KSP6A | 1.292 | .550 |
| KSP3 | .[illegible] | .[illegible] |
| KSP4 | .732 | .3[illegible] |
| KSP5 | 1.050 | .540 |
| KSP6 | 1.202 | .550 |
| KSP8 | 1.552 | .704 |
| KSP10 | 1.6[illegible] | .815 |

SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

| BEARING | O.D., INCHES | STEEL HOUSING BORE, IN. | ALUMINUM HOUSING BORE, IN. | SHAFT DIAMETER |
|---|---|---|---|---|
| KSP3L | .6[illegible] | [illegible] | [illegible] | [illegible] |
| KSP4A | .7[illegible] | .7[illegible] | .7[illegible] | [illegible] |
| KSP5A | [illegible] | [illegible] | [illegible] | .3120-.3115 |
| KSP6A | .875[illegible] | .8745-.8740 | [illegible] | .3745-.3740 |
| KSP3 | .7[illegible] | [illegible] | .7761-.7762 | .18[illegible] |
| KSP4 | .9[illegible] | [illegible] | [illegible] | .2495-.2490 |
| KSP5 | 1.2500-1.2[illegible] | 1.2[illegible] | 1.2[illegible] | .3[illegible] |
| KSP6 | 1.4375-1.4370 | 1.4[illegible] | 1.4[illegible] | .3745-.3740 |
| KSP8 | 1.6875-1.6870 | 1.6[illegible] | 1.6[illegible] | .4995-.4990 |
| KSP10 | 1.9375-1.9370 | 1.9370-1.9365 | 1.9[illegible] | .6245-.6240 |

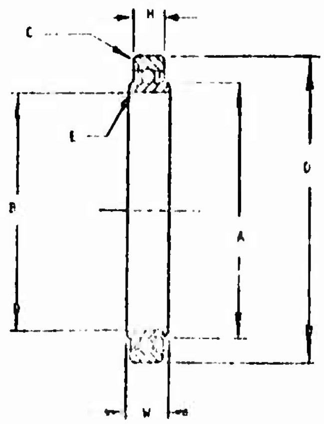



USAGE & APPLICATION DATA

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 | D | W | H | A | E AND C CORNER CHAMFER X 45° (c) (b) +.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] | | | [illegible] | | [illegible] | 1700 | 2050 | [illegible] | .04 |
| [illegible] | [illegible] | [illegible] | [illegible] | | | 1.015 | | [illegible] | [illegible] | 2110 | 1970 | [illegible] |
| -41 | [illegible] | [illegible] | [illegible] | | | 1.210 | | 5000 | 2200 | 2170 | [illegible] | .05 |
| [illegible] | [illegible] | [illegible] | [illegible] | | | 1.451 | | [illegible] | 2700 | 2270 | 2130 | .09 |
| -43 | [illegible] | [illegible] | [illegible] | | | [illegible] | | [illegible] | 3200 | 2250 | 2180 | .10 |
| [illegible] | [illegible] | [illegible] | [illegible] | | | [illegible] | | 7950 | 3600 | 2300 | 2220 | .11 |
| [illegible] | [illegible] | [illegible] | [illegible] | | | 2.266 | | 9220 | 4000 | 2340 | 2260 | .15 |
| [illegible] | [illegible] | [illegible] | [illegible] | | | [illegible] | | 10150 | 4400 | [illegible] | 2280 | .17 |

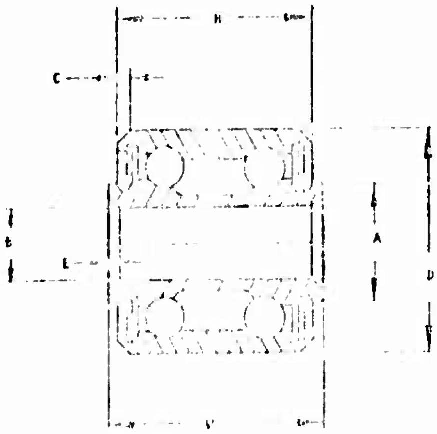
* [illegible] -.0010   ** [illegible] -.0015

(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 [illegible] TO OUTER FACE.
(e) CASE II = [illegible] WITH [illegible] 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 [illegible]

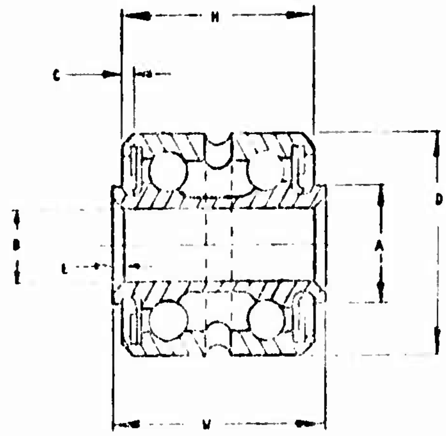
1. MATERIALS: RINGS, STEEL, [illegible] 66, E52100
   BALLS, STEEL, [illegible] E51100 OR E52100
   2. SEALS, POLYTETRAFLUOROETHYLENE PER AMS3652 OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER [illegible].
   3. LUBRICANT, MIL-G [illegible], FILLED [illegible] MIN.
4. HARDNESS: HEAT TREAT RINGS AND BALLS TO ROCKWELL "C" 60 TO 66 AND STABILIZED FOR OPERATION AT 250°F.
5. [illegible] 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 - [illegible]




DGW - WITH RELUBRICATION GROOVE

| MS DASH NO. | PART NO. (RELUBRICATION GROOVE) WITHOUT | PART NO. (RELUBRICATION GROOVE) WITH | B BORE (b) | D OUTER DIA. (b) | W WIDTH INNER RING (a) | V WIDTH OUTER RING (a) | A DIAMETER INNER RING (MIN.) | E CORNER CHAMFER (d) INNER RING BORE +.015 -.005 | C CORNER CHAMFER (c) OUTER RING O.D. +.015 -.005 | 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 | 9?0 | .025 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .675 | [illegible] | [illegible] | | | 2730 | 900 | 2020 | 1650 | .04 |
| -5 | DW5 | [illegible] | [illegible] | [illegible] | .938 | .813 | .466 | .035 | .016 | 5140 | 1600 | 2600 | 2320 | .07 |
| -6 | DW6 | [illegible] | [illegible] | [illegible] | [illegible] | 1.063 | .570 | | | 8450 | 2600 | 4220 | 3740 | .12 |
| -8 | DW8 | [illegible] | [illegible] | [illegible] | 1.500 | 1.375 | .709 | | .032 | 15520 | 4700 | 7610 | 6520 | .29 |

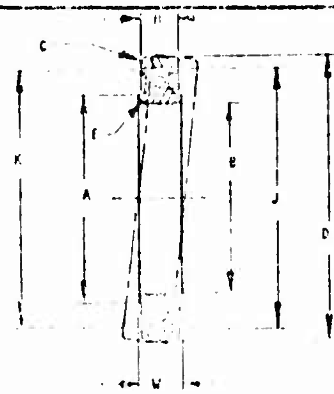
(a) ALL DIMENSIONS [illegible] PLATING.
(b) OUT-OF-ROUND [illegible] BORE [illegible] +.0002, -.0007
OUTER DIA. +.0015, -.0010
(c) A [illegible] GIVING [illegible] THE SAME GRIP FOR STAKING THE BEARING IN THE HOUSING WILL BE ACCEPTABLE.
(d) A RADIUS [illegible] THE SAME FILLET CLEARANCE WILL BE ACCEPTABLE.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

1. MATERIALS: RINGS: STEEL, [illegible] 66, E52100
BALLS, STEEL, [illegible] E51100 OR E52100
2. SEALS, [illegible] PER AMS [illegible] OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER AMS3666.
3. SEAL [illegible], STEEL, CORROSION 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 ASA B46.1.
7. PLATING: 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 | E and C | K To Shaft Corner | J Brg Center O.D. | Permissible Misalignment Either Direction | Radial Limit Load Rating | Thrust Limit Load Rating | (f) Radial Load Rating (Lbs.) For Average Life of 10,000 Complete Cycles (e) Case I | (e) Case II | Weight Pounds Approx. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | [illegible] | | | | | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 3560 | .18 |
| -21 | [illegible] | | | | | [illegible] | [illegible] | 2.[illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .20 |
| -23 | [illegible] | | | | | [illegible] | | 2.1?? | ?.173 | 6° | 13500 | [illegible] | 4650 | 4350 | .22 |
| [illegible] | [illegible] | | | | | 1.?03 | | 2.2?? | 2.3?? | 5° 40' | 11300 | 2300 | 4690 | 4420 | .25 |
| -29 | [illegible] | | | | | 1.431 | .025 | 2.535 | 2.552 | 5° | 12700 | 2600 | 4260 | 4230 | .27 |
| -33 | [illegible] | | | | | ?.247 | | 2.787 | [illegible] | 5° | 14600 | 2860 | 4320 | 4630 | .30 |
| -32 | [illegible] | | | | | [illegible] | [illegible] | 3.039 | 3.0?2 | 4° 30' | [illegible] | 3?00 | 4560 | 4650 | .33 |
| -4? | [illegible] | | | | | 3.0?? | .033 | 3.0?? | 3.??? | 4° 30' | 24700 | 5?00 | 6600 | 6330 | .64 |
| [illegible] | [illegible] | | | | | 3.?22 | | 3.572 | 3.5?? | 4° | 27500 | [illegible] | 8150 | 7540 | .69 |
| [illegible] | [illegible] | | | | | [illegible] | [illegible] | 3.572 | 3.5?? | 4° | 27500 | 5500 | 8150 | 7540 | .69 |

* [illegible] +.0000 -.0005

(a) ALL [illegible] AFTER PLATING.
(b) OUT OF [illegible] +.0003, -.0013
[illegible] DIA. +.0010, +.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]
CASE II [illegible] TO [illegible] RACE.
(f) [illegible] 250° F MAX. WHEN SUBJECTED TO OPERATION AT 350° F, THE RATINGS SHOULD BE [illegible] 20%.

1. MATERIALS [illegible] STEEL, [illegible] E52100
[illegible] STEEL, [illegible] E52100
2. SEALS, POLYE[illegible] OR POLYTETRAFLUOROETHYLENE SHEET, GLASS FABRIC REINFORCED PER AMS3666.
3. SEAL RETAINERS: STEEL, CORROSION RESISTANT
4. LUBRICANT, MIL-[illegible], FILLED [illegible] MIN.
5. HARDNESS: [illegible] TO ROCKWELL "C" 60 TO 6? AND STABILIZED FOR OPERATION AT 250°F.
6. SURFACE ROUGHNESS [illegible] 8 MICROINCHES AA PER ASA B46.1.
7. PLATING: ALL EXTERNAL SURFACES [illegible] SELF-ALIGNING OUTER RING AND OD OF OUTER RACE SEALS AND SEAL RETAINERS, [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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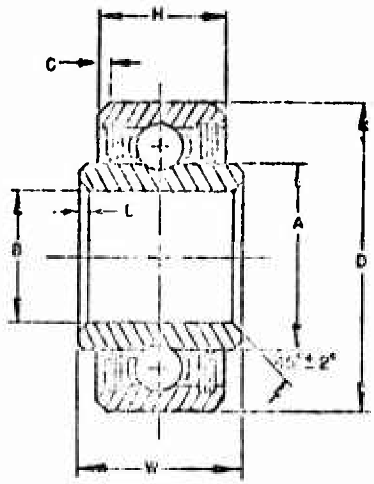
SUB-NOTE 2(10) Intermediate Duty High Temperature (-65° to +350 °F)
Ball Bearings (MS2[illegible]649)




| DASH NO. | MFG PATTERN | B [illegible] (a) | D [illegible] (a) | W WIDTH INNER [illegible] | H WIDTH [illegible] | A SHOULDER DIAMETER INNER RING (APPROX.) | E [illegible] INNER RING (b) | C [illegible] OUTER RING (c) | RADIAL LIMIT LOAD(d) RATING LBS. | THRUST LIMIT LOAD(d) RATING LBS. | [illegible] (e) CASE I | LIFE [illegible] (e) CASE II | WEIGHT POUNDS (APPROX.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | +.015 -.0[illegible] | | | | | | |
| -3 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .317 | .005 | .016 | 440 | 3[illegible] | 440 | 440 | .015 |
| -4 | [illegible] | [illegible] | [illegible] | .435 | [illegible] | .415 | | | 510 | 410 | 510 | 510 | .028 |
| -5 | [illegible] | .2[illegible] | [illegible] | [illegible] | [illegible] | .462 | .015 | | 800 | 640 | 800 | 800 | .033 |
| -6 | [illegible] | .32[illegible] | [illegible] | [illegible] | [illegible] | .52[illegible] | | | | | | | .034 |
| -8 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .651 | | | 1310 | 1050 | 1310 | 1310 | .075 |
| [illegible] | [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] | .6[illegible] | .5[illegible] | 1.334 | | | 2920 | 2340 | 2920 | 2920 | .256 |
| -20 | [illegible] | [illegible] | [illegible] | | | 1.615 | | | 3500 | [illegible] | 3500 | 3270 | .355 |

(a) OUT-OF-ROUND TOLERANCES, [illegible]: +.0002, -.0007
OUTER DIA.: +.0005, -.0010
(b) A RADIUS [illegible] THE SAME GRIP FOR STAKING THE BEARING IN THE HOUSING WILL BE ACCEPTABLE.
(c) A RADIUS [illegible] 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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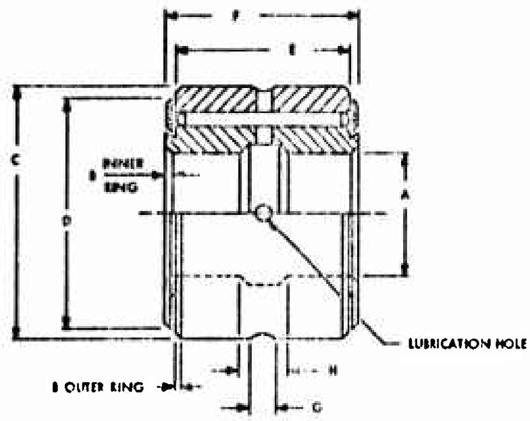
## SUB-NOTE 3(1) (Sheet 1 of 2 Sheets) Heavy Duty Needle Bearings (MS24461)




| DASH NO. | A BORE INNER RACE | | B +.015 -.000 RAD OR 45° MAX BEVEL | C | | 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 | [illegible] | | | .6875 | | .625 | .219 | .312 | .062 | | .468 | [illegible] | [illegible] | |
| -4 | .2500 | | .022 | .7500 | | [illegible] | .281 | .375 | .093 | NONE | .516 | 4,3[illegible] | .040 | .0017 |
| -5 | .3125 | | | .8125 | | [illegible] | .344 | .437 | | | .578 | 6,1[illegible] | .057 | |
| -6 | .3750 | | | .8750 | | .812 | [illegible] | .562 | | .169 | .641 | 9,500 | .075 | |
| -7 | .4375 | | | .9375 | | .875 | .531 | .625 | .125 | | .703 | 12,000 | .097 | .0016 |
| -8 | .5000 | | | 1.1250 | +.0000 -.0005 | 1.031 | .656 | .750 | | | .844 | 17,400 | .165 | |
| -9 | .5625 | | | 1.1875 | | 1.094 | .781 | .875 | | | .891 | [illegible] | .207 | |
| -10 | .6250 | | | 1.2500 | | 1.156 | [illegible] | 1.000 | | | .953 | [illegible] | [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 | 45,800 | .423 | .0022 |
| -16 | 1.0000 | +.0000 -.0007 | | 1.7500 | | 1.625 | 1.125 | | | | 1.375 | 50,900 | .510 | |
| -20 | 1.2500 | | | 2.0000 | | [illegible] | | | | | 1.625 | [illegible] | [illegible] | .0026 |
| -24 | 1.5000 | | .032 | 2.2500 | +.0000 -.0006 | 2.156 | | | | | 1.875 | [illegible] | .710 | |
| -28 | 1.7500 | | | 2.5000 | | 2.406 | | | | | 2.125 | 75,700 | [illegible] | .0027 |
| -32 | 2.0000 | | | 2.7500 | | 2.656 | | | .156 | .375 | 2.375 | 85,200 | [illegible] | .0029 |
| -36 | 2.2500 | | | 3.0000 | | 2.906 | | | | | 2.625 | 94,600 | [illegible] | .0032 |
| -40 | 2.5000 | | | 3.2500 | | 3.155 | 1.049 | 1.250 | | | 2.875 | 104,100 | [illegible] | .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 | [illegible] | 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 | [illegible] | | 4.468 | | | | | 4.218 | 154,500 | [illegible] | |
| -64 | 4.0000 | | | [illegible] | +.0000 -.0010 | 4.719 | | | | | 4.469 | [illegible] | 1.970 | .0045 |
| -80 | 5.0000 | +.0000 -.0010 | | 5.8750 | | 5.637 | 1.044 | | | | 5.437 | 201,000 | 2.750 | .0045 |

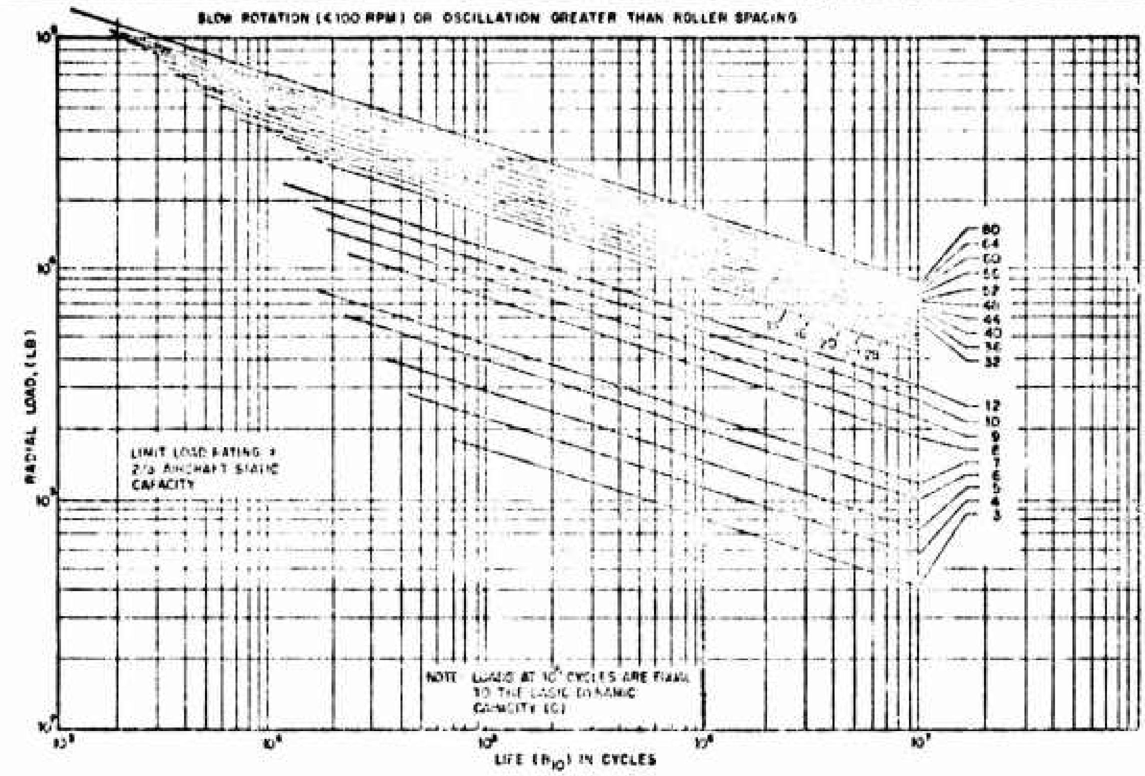
| BORE SIZE | NO. OF HOLES INNER RING | NO. OF HOLES OUTER RING |
|---|---|---|
| -3 THRU -5 | NONE | 2 |
| -6 THRU -10 | 2 | 4 |
| -12 THRU -80 | 4 | 4 |

OIL HOLE DATA

MATERIAL: STEEL, MIL-S-7420, MIL-S-6490, MIL-S-7493, QQ-S-[illegible]31
FED STD NO. 66 STEEL NO. 51100, 5[illegible], 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 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(1) (Sheet 2 of 2 Sheets) Heavy Duty Needle Bearings (MS24461)**




SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

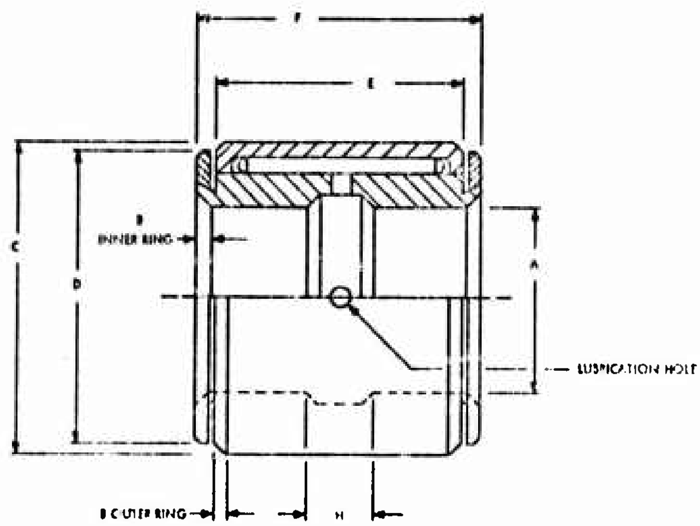
| BEARING | HOUSING BORE SIZE (1) | | SHAFT DIAMETER | | CLAMPING DIAMETER MIN. |
|---|---|---|---|---|---|
| | [illegible] | [illegible] | [illegible] | [illegible] | |
| -3 | [illegible] | [illegible] | .3276-[illegible] | [illegible] | 7/16 |
| -4 | .74[illegible] | [illegible]-.7499 | [illegible] | [illegible] | 33/64 |
| -5 | .8122-.8117 | .81[illegible] | .3116-.3114 | .3119-.3114 | 37/64 |
| -6 | .874[illegible]-.8742 | .8754-.8749 | .3744-.37[illegible] | .37[illegible]-.3747 | 41/64 |
| -7 | .9372-.9[illegible] | .9[illegible] | .4[illegible] | .4[illegible] | 45/64 |
| -8 | 1.1247-1.1242 | 1.1254-1.1249 | .4996-.4989 | .5007-.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-.6237 | .6252-.6247 | 61/64 |
| -12 | 1.3747-1.3741 | 1.3[illegible]-1.3748 | .7494-.7487 | .7502-.7497 | 1 5/64 |
| -14 | 1.6247-1.6241 | 1.6253-1.6248 | .8744-.8738 | .8752-.8747 | 1 1/4 |
| -16 | 1.7497-1.7491 | 1.7[illegible] | .9994-.9988 | 1.0002-.9997 | 1 3/8 |
| -20 | 1.999[illegible]-1.99[illegible] | [illegible]-1.99[illegible] | 1.2494-1.2[illegible] | 1.2502-1.2497 | 1 5/8 |
| -24 | 2.2496-2.2490 | 2.2503-2.2497 | 1.4994-1.4[illegible] | 1.5002-1.4997 | 1 7/8 |
| -28 | 2.4996-2.4990 | 2.5003-2.4997 | 1.7494-1.74[illegible] | 1.7502-1.7497 | 2 1/8 |
| -32 | 2.7496-2.74[illegible] | 2.7503-2.7[illegible] | 1.9994-1.99[illegible] | 2.0002-1.9997 | 2 3/8 |
| -36 | 2.9996-2.99[illegible] | [illegible] | 2.2494-2.2487 | 2.2502-2.2496 | 2 5/8 |
| -40 | 3.2495-3.2485 | 3.2[illegible] | 2.4994-2.49[illegible] | 2.5002-2.4996 | 2 7/8 |
| -44 | 3.4995-3.4985 | 3.5[illegible]-3.49[illegible] | 2.7494-2.7487 | 2.7502-2.7496 | 3 1/8 |
| -48 | 3.7495-3.7485 | 3.7[illegible] | 2.9994-2.9987 | 3.0002-2.9996 | 3 3/8 |
| -52 | 3.9995-3.9985 | 4.0[illegible]-3.9[illegible] | 3.2494-3.2[illegible] | 3.2504-3.2496 | 3 41/64 |
| -56 | 4.3745-4.3735 | 4.37[illegible]-4.37[illegible] | 3.4994-3.4986 | 3.5004-3.4996 | 3 31/32 |
| -60 | 4.6245-4.6235 | 4.62[illegible]-4.6245 | 3.7494-3.74[illegible] | 3.7504-3.7496 | 4 7/32 |
| -64 | 4.8745-4.8735 | 4.87[illegible]-4.87[illegible] | 3.9994-3.9986 | 4.0004-3.9996 | 4 15/32 |
| -80 | | | | | |

(1) FOR ALUMINUM HOUSINGS REDUCE ALL DIMENSIONS .0002

NOTE: LOADS AT $10^6$ CYCLES ARE EQUAL TO THE BASIC DYNAMIC CAPACITY (C)

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 | .1900 | .022 | .6250 | .562 | .500 | .625 | NONE | .469 | 675 | .040 | .0015 |
| -4 | .2500 | | | | | .562 | | .500 | [illegible] | .025 | |
| -5 | .3125 | | .6875 | .625 | | .625 | | .562 | [illegible] | .050 | |
| -6 | .3750 | | .7500 | .688 | .750 | .812 | .188 | .625 | 1,920 | .060 | |
| -7 | .4375 | .032 | .8125 | .750 | | .875 | | 1.062 | [illegible] | .090 | |
| -8 | .5000 | | 1.0000 | .938 | | | | .844 | 2,350 | .120 | |
| -10 | .6250 | | 1.1250 | 1.062 | | | .250 | .959 | 2,650 | .150 | |
| -12 | .7500 | | 1.2500 | 1.188 | 1.000 | 1.125 | | 1.094 | 4,4[illegible] | .210 | |
| -14 | .8750 | | 1.3750 | 1.312 | | | .375 | 1.219 | 5,0[illegible] | .240 | |
| -16 | 1.0000 | | 1.5000 | 1.436 | | | | 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 | • |

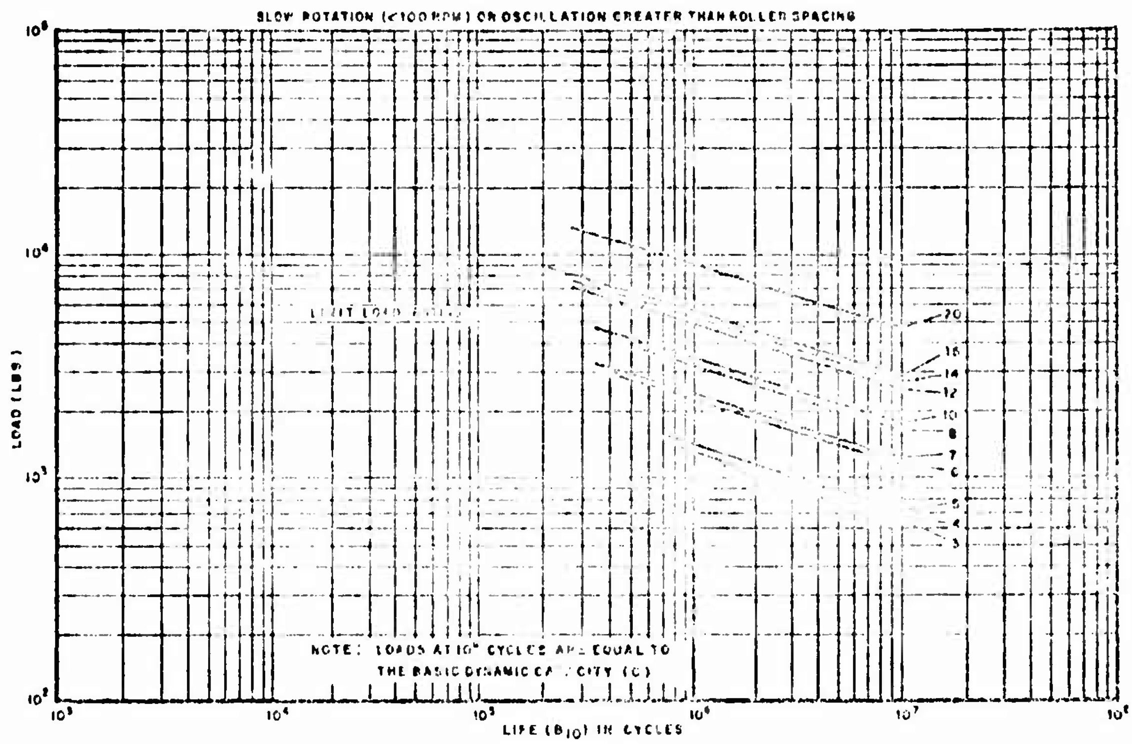
(A) HOUSING DIMENSION FOR BEARING

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

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



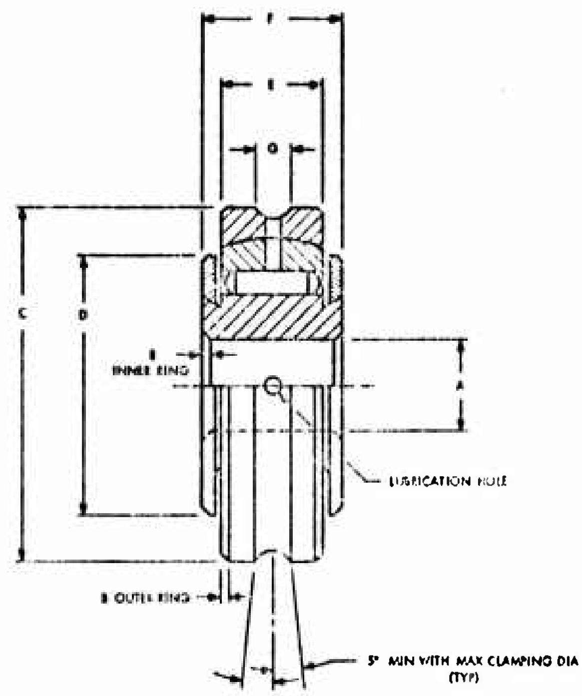

SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

| BEARING | HOUSING BORES SIZE (1) PRESS FIT | SLIP FIT | SHAFT DIAMETER SLIP FIT | PRESS FIT | CLAMPING DIA. MIN |
|---|---|---|---|---|---|
| -3 | [illegible] | PRESS FIT | .1867-[illegible] | [illegible] | 15/32 |
| -4 | .6255-.6245 | ONLY | .2497-.2492 | .2501-.2496 | 1/2 |
| -5 | .6880-.6870 | ON | .3122-.3117 | .3125-.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 | [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 | | .8750 | .625 | .218 | .312 | .067 | .625 | .433 | 2700 | .041 | | .8742 | .8747 |
| -4 | .2500 | .022 | .9375 | .687 | .281 | .375 | .073 | .684 | .516 | 4300 | .053 | .0029 | .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 |

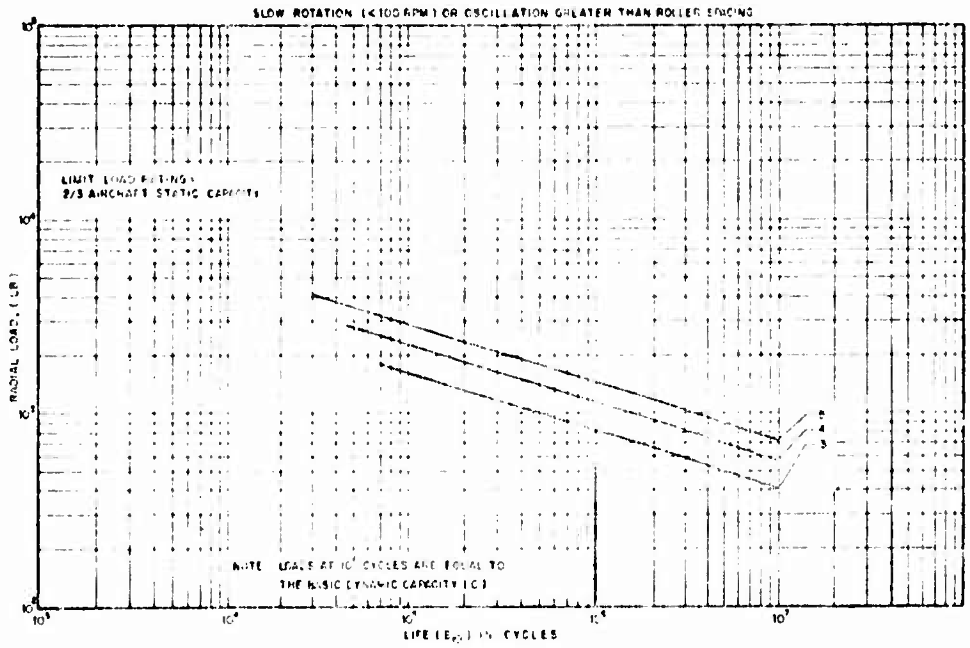
MATERIAL: STEEL, MIL-S-7420, MIL-S-8690, MIL-S-7493, QQ-S-624, QQ-S-631, FED STD NO. 66 STEEL NO. 50100, 51100, AND 52100
PLATING: CADMIUM PLATE, QQ-P-416, TYPE I, CLASS 2
MACHINE FINISH: ANSI B46.1 - 1962

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)



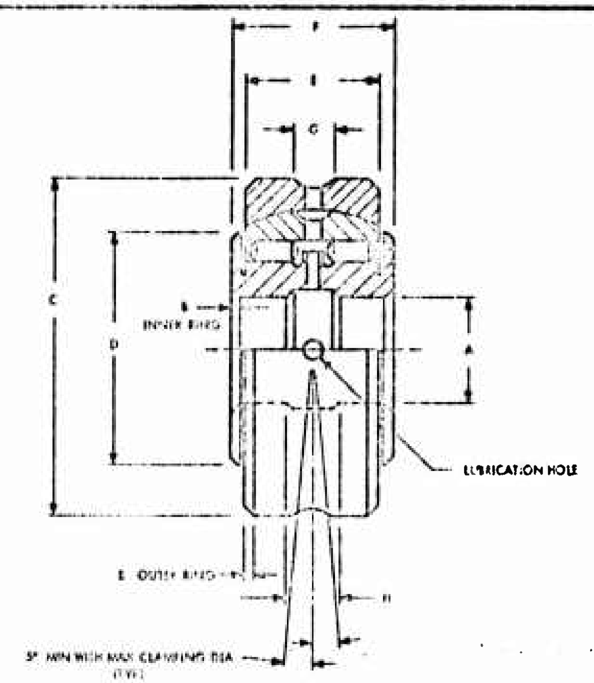

SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

| BEARING | HOUSING BORE STEEL (1) | | SHAFT DIAMETER | | CLEARING DIAMETER |
|---|---|---|---|---|---|
| | PRESS FIT | SLIP FIT | SLIP FIT | PRESS FIT | |
| -3 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| -4 | .9372-[illegible] | [illegible]-.9374 | .2494-[illegible] | [illegible]-.2497 | 11/16 - 33/64 |
| -5 | 1.0622-1.0617 | [illegible] | .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 [illegible] | B +.015 -.005 RAD OR [illegible] MAX [illegible] | C | | D ±.010 | E +.000 -.005 | F +.000 -.005 | G ±.031 | H +.000 -.062 | CLAMPING DIA | | AIRCRAFT STATIC CAPACITY LB | WEIGHT LB APPROX | TOTAL RADIAL PLAY MAX | HOUSING SIZE GAGE +.0000 -.0001 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | MAX | MIN | | | | LOW | HIGH |
| -6 | .3750 | [illegible] | 1.1875 | | .812 | .459 | .5[illegible] | .125 | .100 | .761 | .641 | [illegible] | .130 | .0030 | 1.1867 | 1.1872 |
| -7 | .4375 | .037 | 1.3125 | | .875 | .531 | .62[illegible] | | | .844 | .703 | [illegible] | .174 | .0031 | 1.3116 | 1.3122 |
| -8 | .5000 | | 1.5000 | +.0000 -.0005 | 1.0[illegible] | .656 | .75[illegible] | | | 1.0[illegible] | .944 | 13300 | .273 | | 1.4991 | 1.4997 |
| -9 | .5625 | | 1.6875 | | 1.093 | .781 | .875 | .156 | | 1.062 | .871 | 17.0[illegible] | .420 | | 1.6866 | 1.6872 |
| -10 | .6250 | | 1.7500 | | 1.1[illegible] | .906 | 1.000 | | .250 | 1.094 | .953 | [illegible] | .520 | .0032 | 1.7491 | 1.7497 |
| -12 | .7500 | | 1.8750 | | 1.2[illegible] | 1.000 | 1.125 | | | 1.156 | 1.073 | 30000 | .630 | .0034 | 1.6741 | 1.6747 |
| -14 | .8750 | | 2.1250 | | 1.5[illegible] | 1.125 | 1.250 | | .375 | 1.375 | 1.25[illegible] | 32[illegible] | .870 | .0037 | 2.1738 | 2.1246 |
| -15 | 1.0000 | | 2.2500 | +.0000 -.0007 | 1.6[illegible]5 | | | | | 1.500 | 1.375 | 43000 | .950 | .0041 | 2.2458 | 2.2496 |
| -20 | 1.2500 | | 2.5000 | | 1.9[illegible] | 1.047 | | | | 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]00 | 1.230 | | 2.7483 | 2.7496 |
| -32 | 2.0000 | | 3.250 | +.0000 -.0010 | 2.756 | | | | | 2.593 | 2.375 | 70[illegible]00 | 1.490 | .0045 | 3.2485 | 3.2496 |
| -40 | [illegible] | | 3.750 | | 3.156 | | | | | 3.052 | 2.875 | 85200 | 1.780 | .0046 | 3.7435 | 3.7495 |
| -48 | [illegible] | | 4.250 | | 3.6[illegible] | | | | | 3.562 | 3.375 | 101900 | 2.050 | .0056 | 4.2465 | 4.2495 |
| -56 | 3.5000 | .044 | 4.8750 | [illegible] -.0010 | 4.219 | | | | | 4.141 | 3.959 | 120200 | 2.650 | .0057 | 4.8735 | 4.8745 |

| OIL HOLE DATA | NO. OF HOLES | | |
|---|---|---|---|
| BORE SIZE | INNER RING | OUTER 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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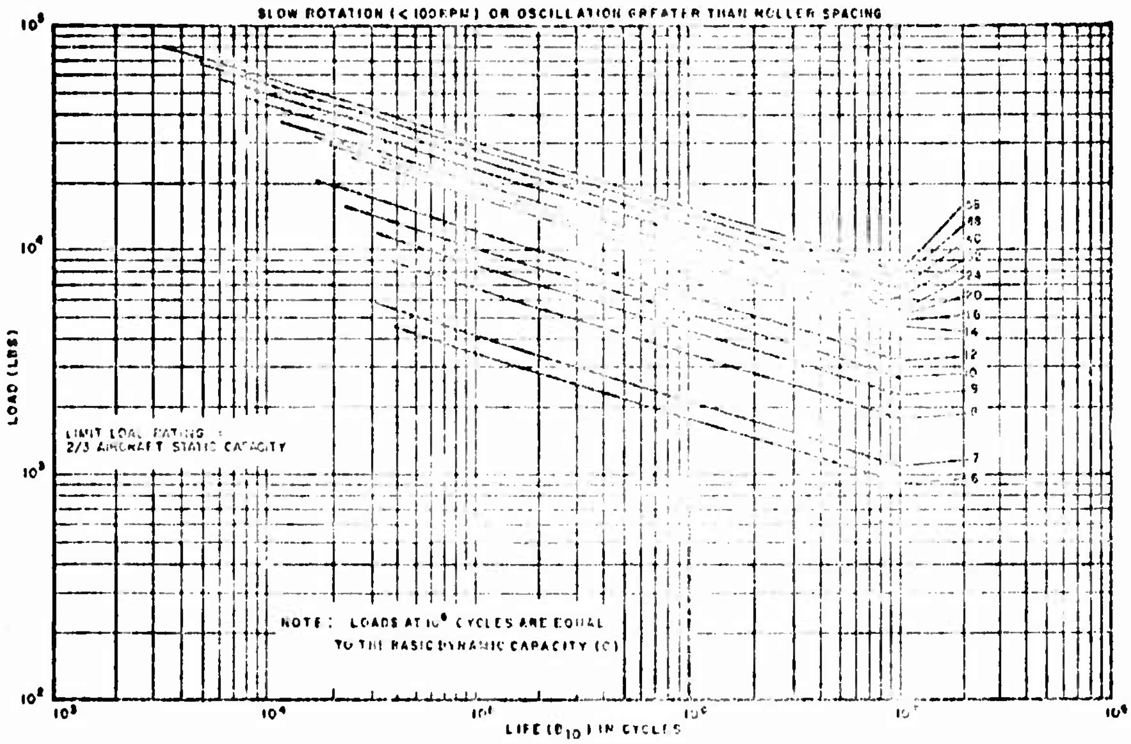
SUB-NOTE 3(4) (Sheet 2 of 2 Sheets) Heavy Duty Self-Aligning Double Row Needle Bearings (MS24464)




SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

| BEARING | HOUSING BORE SIZE ① PRESS FIT | SLIP FIT | SHAFT D[illegible] SLIP FIT | [illegible] | CLAMPING [illegible] |
|---|---|---|---|---|---|
| -6 | 1.1872-1.1867 | 1.1879-1.1874 | .3744-.3739 | [illegible]-.3747 | [illegible] |
| -7 | 1.3122-1.3116 | 1.3124-1.3130 | [illegible] | [illegible]-.4372 | [illegible] |
| -8 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| -9 | 1.[illegible]-1.[illegible] | 1.[illegible]-1.6974 | .[illegible]19-.5614 | [illegible] | [illegible] |
| -10 | 1.7497-1.7491 | 1.7[illegible]-1.7497 | .6244-.6239 | [illegible] | [illegible] |
| -12 | 1.8747-1.8741 | 1.8755-1.8749 | .7494-.7[illegible] | [illegible] | [illegible] |
| -14 | 2.1246-2.1239 | 2.1257-2.1249 | .8744-.8737 | [illegible] | [illegible] |
| -16 | 2.2496-2.2488 | 2.2[illegible]-2.2499 | .99[illegible]-.9989 | 1.00[illegible]-.9997 | [illegible] |
| -20 | 2.4[illegible]-2.4988 | [illegible] | 1.24[illegible]-1.2[illegible] | [illegible] | [illegible] |
| -24 | 2.74[illegible]-2.74[illegible] | 2.7[illegible]-2.7499 | 1.4[illegible]-1.4[illegible] | [illegible] | [illegible] |
| -32 | 3.24[illegible]-3.2485 | 3.2[illegible]-3.2498 | 1.9[illegible]-1.9987 | [illegible] | [illegible] |
| -40 | 3.74[illegible]-3.7485 | 3.7495-3.7508 | 2.4[illegible]-2.4[illegible] | [illegible] | [illegible] |
| -48 | 4.24[illegible]-4.2485 | 4.2504-4.2498 | 2.9[illegible]-2.99[illegible] | [illegible] | [illegible] |
| -56 | 4.8745-4.8735 | 4.8755-4.8748 | 3.4[illegible]-3.4[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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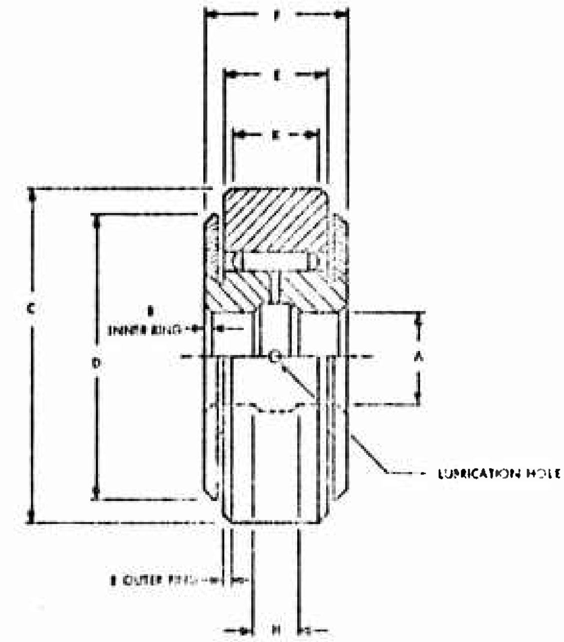
SUB-NOTE 3(5) (Sheet 1 of 2 Sheets) Single Row Track Rollers (MS24465)




| 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 | .022 | .7500 | .437 | .218 | .312 | .093 | .125 | .438 | 900 | 2,700 | .022 | .0015 | 270 |
| -4 | .2500 | | .8750 | .750 | .281 | .375 | .125 | .187 | .516 | 1,400 | 4,300 | .049 | | 575 |
| -6 | .3750 | | 1.0625 | .922 | .375 | .500 | .187 | .250 | .672 | 2,200 | 8,100 | .093 | | 1,000 |
| -8 | .5000 | .032 | 1.3125 | 1.167 | .500 | .625 | | .312 | .844 | 4,300 | 13,000 | .176 | .0014 | 1,785 |
| -10 | .6250 | | 1.5000 | 1.375 | .625 | .750 | | .437 | .953 | 6,400 | 19,200 | .266 | | 2,600 |
| -12 | .7500 | | 1.7500 | 1.625 | .775 | 1.000 | .250 | .687 | 1.109 | 10,700 | 32,000 | .475 | | 4,050 |
| -14 | .8750 | | 2.0000 | 1.875 | 1.000 | 1.125 | | .812 | 1.219 | 13,700 | 41,000 | .712 | | 5,350 |
| -20 | 1.2500 | | 2.5000 | 1.875 | 1.040 | 1.250 | | [illegible] | 1.825 | 16,600 | 56,000 | 1.105 | .0014 | 7,100 |
| -24 | 1.5000 | | 3.0000 | 2.218 | 1.280 | 1.500 | .375 | 1.172 | 1.684 | 23,400 | 69,400 | 2.65 | .0015 | 10,600 |
| -28 | 1.7500 | | 3.4375 | 2.812 | | | | | 2.281 | 35,000 | [illegible] | 3.33 | | 12,400 |
| -32 | 2.0000 | | 3.6250 | 3.750 | | | | | 2.562 | 38,700 | 110,000 | 5.22 | | 13,600 |
| -36 | 2.2500 | | 4.1525 | [illegible] | | | | | 2.750 | 41,300 | 124,000 | 4.51 | | 15,500 |
| -40 | 2.5000 | | 4.7500 | 4.625 | | | | | 3.109 | 44,500 | 136,000 | 6.94 | | 17,100 |
| -44 | 2.7500 | | 5.0000 | 4.875 | | | | | 3.545 | 45,600 | 148,000 | 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

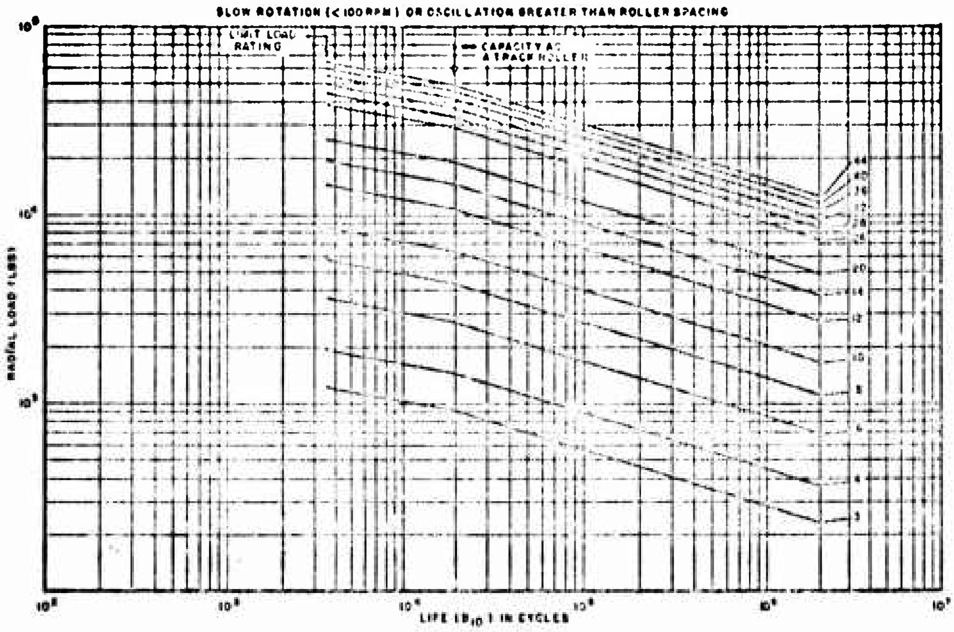
REMOVE ALL BURRS AND SHARP EDGES

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 MINIMUM 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(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 | 920 | 290 |
| -4 | .2494-.2489 | .2502-.2497 | 33/64 | 1[illegible] | 575 |
| -6 | .3744-.3739 | .3752-.3747 | 43/64 | 2[illegible] | 1000 |
| -8 | .4994-.4989 | [illegible]-.4997 | 27/32 | 4[illegible] | 17[illegible] |
| -10 | .6244-.6239 | .6252-.6247 | 61/64 | 64[illegible] | 2600 |
| -12 | .7494-.7489 | .7502-.7497 | 1 7/64 | 10700 | 4350 |
| -14 | .8744-.8739 | .8752-.8747 | 1 7/32 | 13[illegible] | 5350 |
| -20 | 1.2494-1.2484 | 1.2503-1.2497 | 1 5/8 | 1[illegible] | 7100 |
| -24 | 1.4994-1.4984 | 1.5003-1.4997 | 1 63/64 | 2[illegible] | 10900 |
| -28 | 1.7494-1.7484 | 1.7503-1.7497 | 2 8/32 | 25000 | 12400 |
| -32 | 1.9994-1.9987 | 2.0003-1.9986 | 2 9/16 | 35700 | 15000 |
| -36 | 2.2494-2.2487 | 2.2503-2.2480 | 2 13/64 | 41[illegible] | 15500 |
| -40 | 2.4994-2.4987 | 2.5003-2.4996 | 2 7/64 | 44[illegible] | 17100 |
| -44 | 2.7494-2.7487 | 2.7503-2.7495 | 3 11/32 | 48500 | 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-?) 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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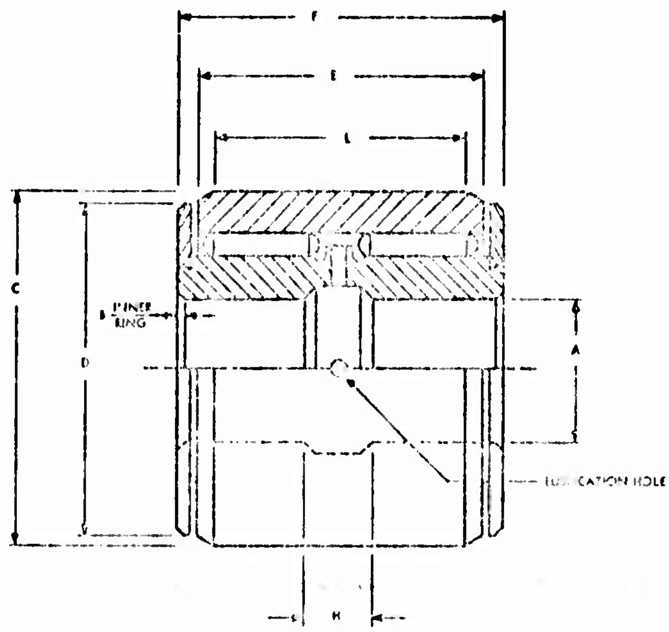
SUB-NOTE 3(6) (Sheet 1 of 2 Sheets) Double Row Track Rollers (MS24466)




| 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 +.030 -.062 | 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 100,000 PSI STEEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -6 | [illegible] | .022 | 1.125 | 1.000 | [illegible] | 1.000 | [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] | | [illegible] |
| -14 | [illegible] | | [illegible] | [illegible] | [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 | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | | 2.544 | [illegible] | 76,000 | [illegible] | [illegible] | | [illegible] |

| OIL HOLE DATA | |
|---|---|
| BORE SIZE | NO. OF HOLES [illegible] |
| -6 THRU -32 | 4 |

MATERIAL: STEEL, MIL-S-[illegible], MIL-S-[illegible], MIL-S-[illegible], [illegible] FED STD [illegible], AS STEEL NO. [illegible], 51100, AND 52100

PLATING: O.D. AND SIDES OF OUTER RACE, CHROMIUM PLATE, QQ-C-320, CLASS 2, THICKNESS [illegible] TO [illegible]
OTHER SURFACES, CADMIUM PLATE, QQ-P-416, TYPE 1, CLASS 2

MACHINE FINISH: [illegible] B46.1-1962

LUBRICATION: BEARINGS FURNISHED SHALL BE LUBRICATED WITH GREASE CONFORMING TO MIL-G-23827

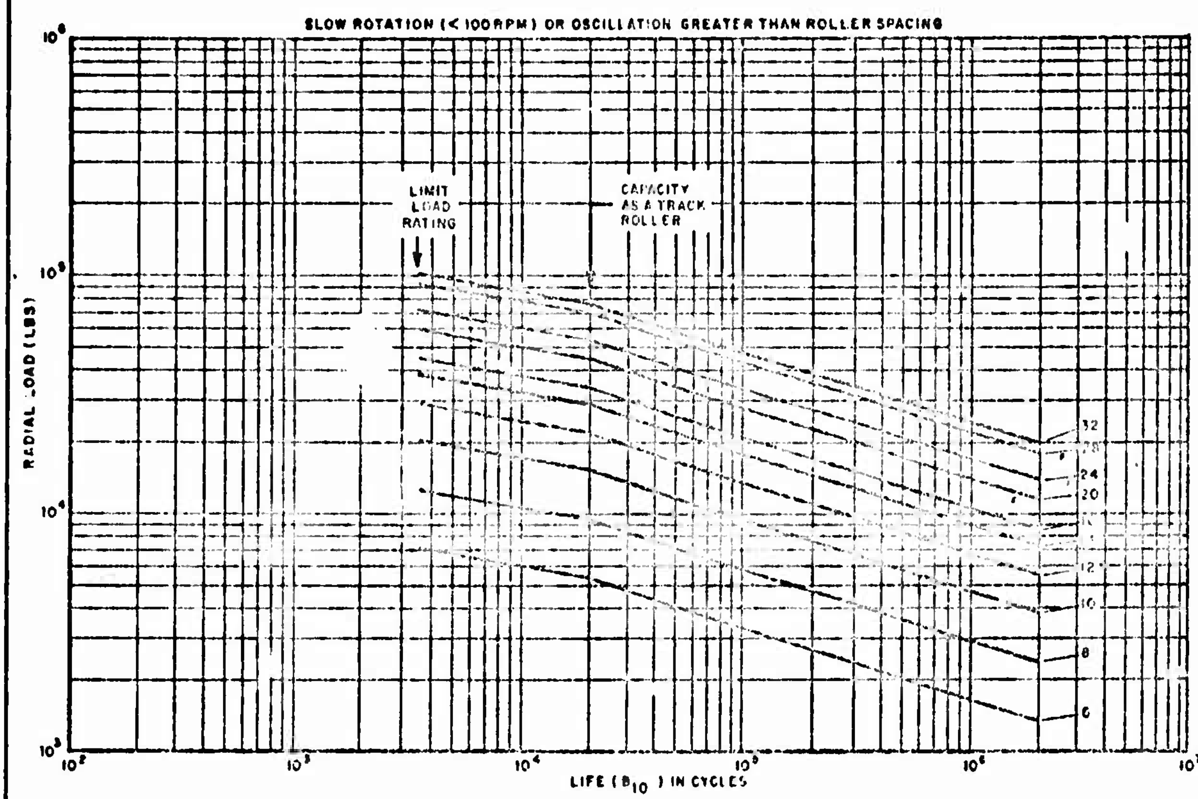
REMOVE ALL BURRS AND SHARP EDGES

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 [illegible] INCHES. THE CAPACITY AS A TRACK ROLLER [illegible] 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)



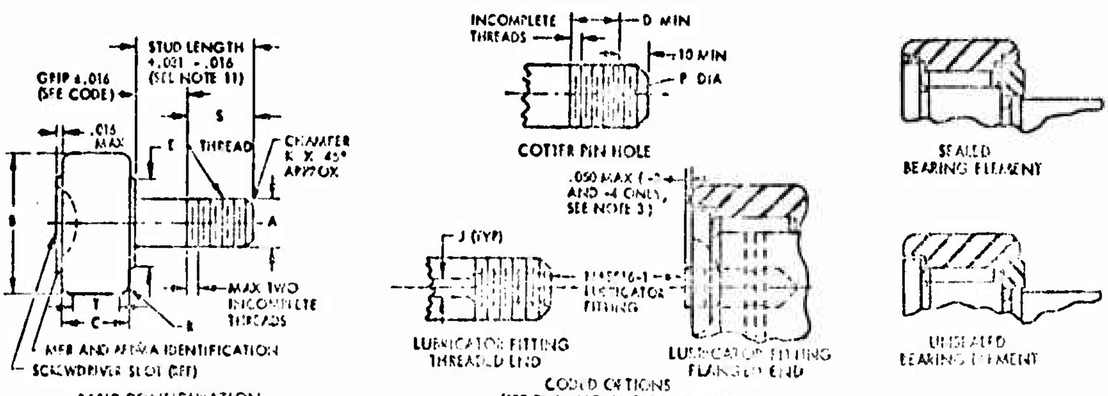

SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE

| BEARING | SHAFT DIAMETER | | CLAMPING DIA, MIN | CAPACITY AS TRACK ROLLER, LBS | TRACK CAPACITY LBS (1) |
|---|---|---|---|---|---|
| | SLIP FIT | PRESS FIT | | | |
| -6 | .3744-.3739 | .3752-.3747 | 43/64 | 5070 | [illegible] |
| -8 | .4994-.4989 | .5002-.4997 | 57/64 | 9370 | [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 37/64 | [illegible] | [illegible] |
| -20 | 1.2494-1.2489 | 1.2503-1.2497 | 1 27/32 | 44000 | [illegible] |
| -24 | [illegible] | [illegible] | 1 [illegible] | 55000 | [illegible] |
| -28 | 1.7494-1.7488 | 1.7503-1.7497 | 2 9/32 | [illegible] | [illegible] |
| -32 | [illegible] | [illegible] | 2 [illegible] | [illegible] | [illegible] |

(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)



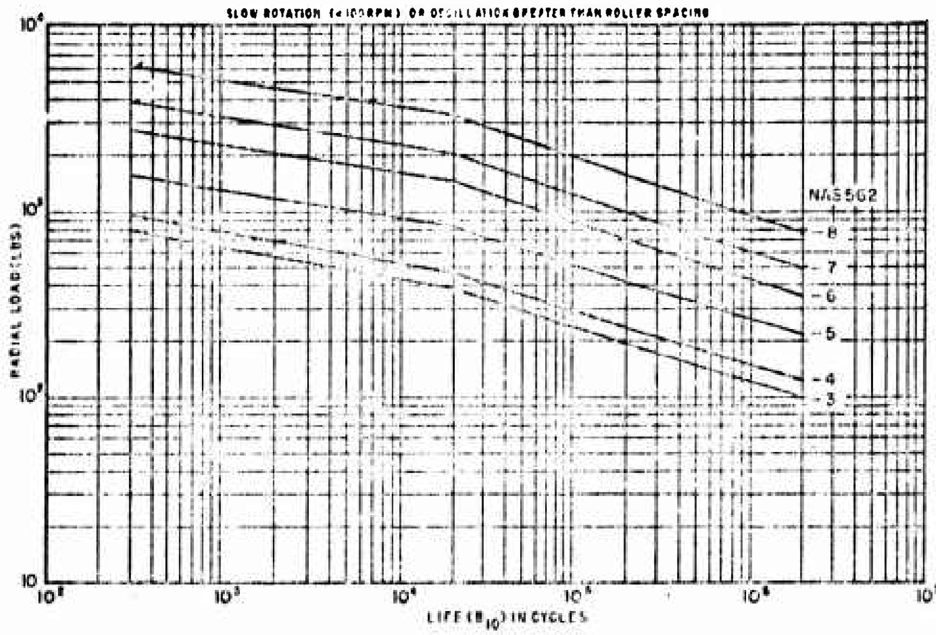

| FIRST DASH NO. | MFR AFBMA NO. (SEE NOTES 1&2) | A STUD DIA +.0000 -.0015 | THREAD CLASS 3A PER MIL-S-7742 | B ROLLER OD +.0000 -.0010 | C ROLLER WIDTH +.000 -.005 | D (MIN) | E STUD FLANGE [illegible] (REF) | J DIA (REF) | K ±.015 | P DIA +.010 -.000 | R CORNER RADIUS (REF) | T THREAD LENGTH (REF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | HR310 | .190 | 10-32 | [illegible] | .252 | .211 | .374 | NONE | .031 | [illegible] | [illegible] | .344 |
| 4 | HR320 | .250 | 1/4-28 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .031 | [illegible] | [illegible] | [illegible] |
| 5 | HR330 | [illegible] | 5/16-24 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 6 | HR340 | [illegible] | 3/8-24 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 7 | HR350 | [illegible] | 7/16-20 | 1.0000 | .541 | .265 | .750 | [illegible] | .047 | [illegible] | .062 | .422 |
| 8 | HR360 | [illegible] | 1/2-20 | 1.1250 | .656 | .314 | .812 | [illegible] | .047 | [illegible] | .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 | [illegible] | 355 | 395 | 790 | .014 + GRIP LENGTH NUMBER X [illegible] |
| 4 | [illegible] | 525 | 470 | 940 | .031 + GRIP LENGTH NUMBER X [illegible] |
| 5 | [illegible] | 725 | [illegible] | 1650 | .043 + GRIP LENGTH NUMBER X [illegible] |
| 6 | .35 | 1100 | [illegible] | [illegible] | .051 + GRIP LENGTH NUMBER X .0022 |
| 7 | [illegible] | 1425 | [illegible] | [illegible] | .125 + GRIP LENGTH NUMBER X .0026 |
| 8 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] + GRIP LENGTH NUMBER X .0025 |

NOTES:

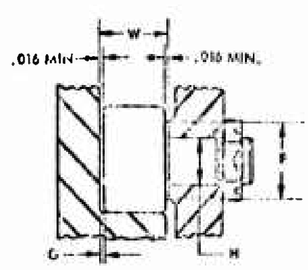
1. All Cam Follower Bearings will be identified with the Anti-Friction Bearing Manufacturers Association (AFBMA) [illegible] The container in which each individual bearing is packed [illegible] the NAS number.
2. The complete AFBMA [illegible] suffix code letters [illegible]
   "F" designates lubricator in flanged end of stud.
   "T" designates lubricator in threaded end of stud and cotter pin hole omitted.
   "A" designates [illegible] pin hole [illegible]
   "R" designates [illegible] bearing.
   Third dash number designates grip length in 1/16 inch increments (See example).
3. NAS562-3 may be coded for [illegible] in the flanged end only. [illegible]
4. The track Brinell capacity [illegible]
5. Rolling capacity [illegible]
6. To fully realize this rating, [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 [illegible]
9. All [illegible] after plating.
10. The manufacturer of these bearings [illegible]
11. For inspection purposes [illegible] stud length is the sum of nominal grip and the thread length [illegible]
12. Cam followers to be supplied as NAS[illegible] parts shall not be manufactured [illegible]

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




RECOMMENDED MOUNTING DIMENSIONS

| NAS562 | H MOUNTING HOLE DIA [illegible] | F MIN SHOULDER DIAM [illegible] | A [illegible] | G MAX FILLET RAD [illegible] | MAX INSTALLATION TORQUE (IN. LB.) NONLUBRICATED 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] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |




MATERIALS: Outer Race and Rollers. SAE52100 or steel suitable for bearing applications.
End Plate. Steel hardened and drawn to Rockwell "C" 51-59.
Stud. [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 [illegible], cadmium plated in accordance with Spec. QQ-P-[illegible], Type I, Class 2, including the unthreaded portion of the stud (See Note 12).

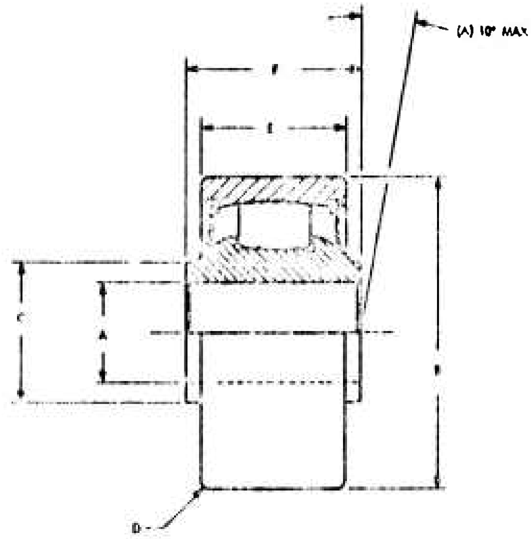
EXAMPLE OF PART NUMBER:

NAS562-[illegible] A = Cam follower needle bearing, 1.125 roller .500 stud, sealed bearing, lubricator in flanged end of stud, 1.25 grip length, 1.677 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:
  - F = 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 -.000 RAD | E +.000 -.005 WIDTH OUTER RING | F +.000 -.005 WIDTH INNER RING | WEIGHT MAX LB | POUNDS LIMIT LOAD | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | AXIAL | RADIAL |
| -4 | [illegible] | .9014 | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | 910 |
| -5 | .3125 | 1.2500 | .515 | .032 | [illegible] | [illegible] | .17 | [illegible] | 2210 |
| -6 | .3750 | 1.4375 | [illegible] | | .750 | .537 | .26 | [illegible] | [illegible] |
| -8 | .5000 | 1.6875 | [illegible] | | .812 | [illegible] | .38 | [illegible] | [illegible] |
| -10 | .6250 | 1.9375 | [illegible] | .044 | .937 | 1.125 | .60 | [illegible] | [illegible] |
| -12 | .7500 | 2.3750 | [illegible] | | 1.125 | 1.312 | 1.04 | [illegible] | [illegible] |

(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

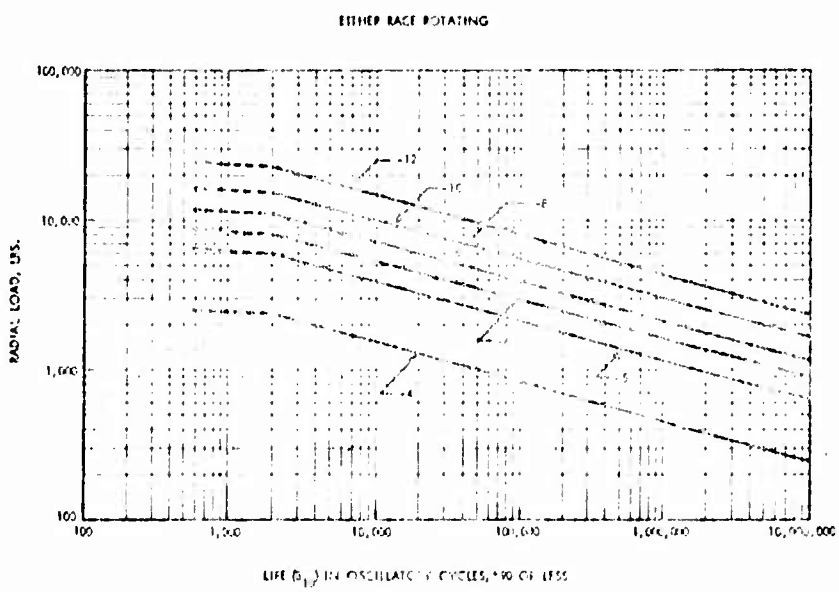
DIMENSIONS IN INCHES
DIMENSIONS TO BE MET AFTER PLATING

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

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 | 1.24[illegible] - 1.2[illegible] | [illegible] - 1.2[illegible] |
| -6 | 1.4[illegible] | [illegible] - 1.4[illegible] | [illegible] |
| -8 | 1.6875 | 1.6[illegible] - [illegible] | [illegible] |
| -10 | 1.9375 | [illegible] - 1.93[illegible] | 1.93[illegible] - 1.93[illegible] |
| -12 | 2.3750 | 2.3745 - 2.37[illegible] | 2.3743 - 2.37[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).

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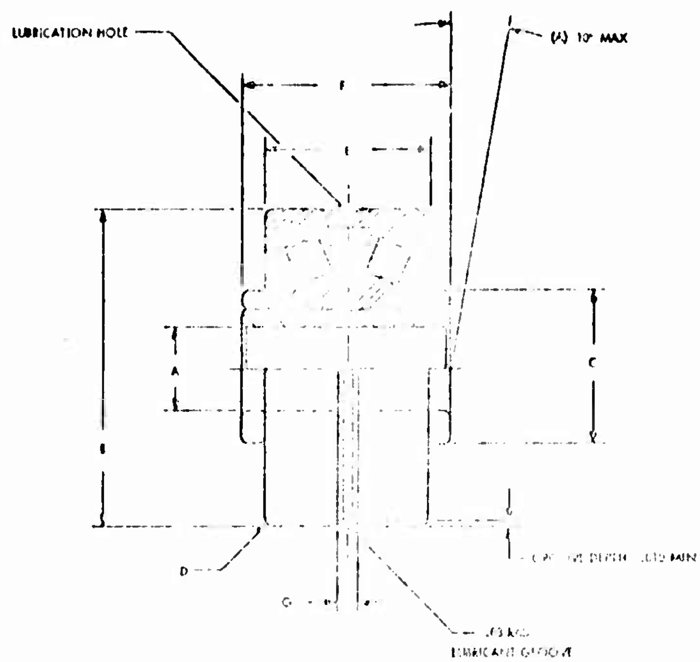
**SUB-NOTE 4(2)** (Sheet 1 of 2 Sheets) Heavy Duty Self-Aligning Roller Bearings (MS28913)




| DASH NO. | A +.0000 -.0005 BORE | B +.0000 -.0005 (O.D.) | 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 | [illegible] | [illegible] | .030 | [illegible] | [illegible] | [illegible] | | | [illegible] | [illegible] | [illegible] |
| -5 | .3125 | 1.2[illegible] | [illegible] | | [illegible] | [illegible] | | | .06 | .17 | 7350 | [illegible] |
| -6 | .3750 | 1.4375 | [illegible] | | [illegible] | [illegible] | .06 | 1 | | [illegible] | [illegible] | [illegible] |
| -8 | .5000 | [illegible] | [illegible] | .050 | [illegible] | [illegible] | | | | .48 | [illegible] | 6400 |
| -10 | .6250 | 1.9375 | .940 | | [illegible] | [illegible] | .13 | | .09 | .70 | [illegible] | [illegible] |
| -12 | .7500 | [illegible] | 1.125 | | [illegible] | [illegible] | | | | 1.04 | [illegible] | [illegible] |

(A) SELF ALIGNMENT 10° IN EITHER DIRECTION.

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

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

SURFACE ROUGHNESS: [illegible] 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

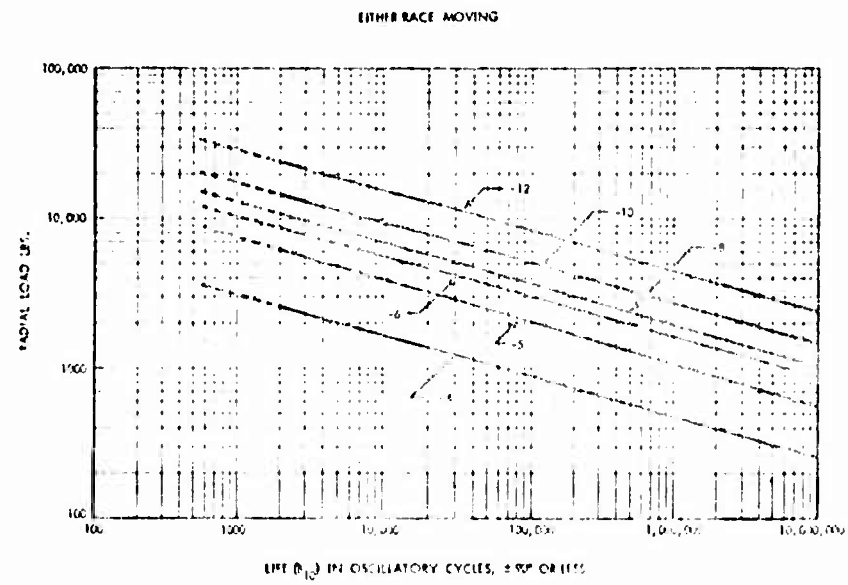
INTERNAL CLEARANCE: TOTAL PLAY, RADIAL [illegible] AXIAL .0005 TO .0012

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-[illegible] LUBRICANT

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



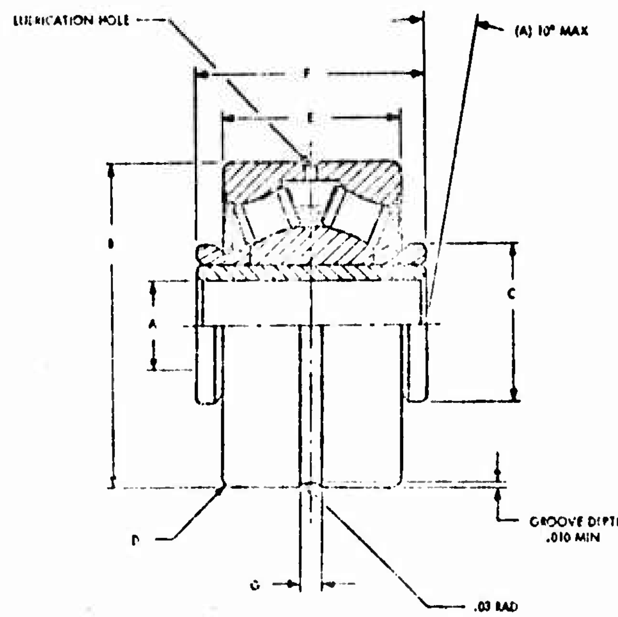

| BEARING | O.D., INCHES | STEEL HOUSING BORE, IN. | AL. HOUSING BORE, IN. |
|---|---|---|---|
| -4 | [illegible] | [illegible] | [illegible] |
| -5 | [illegible] | [illegible] | [illegible] |
| -6 | [illegible] | [illegible] | [illegible] |
| -8 | [illegible] | [illegible] | [illegible] |
| -10 | 1.9375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

112<

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




| DASH NO. | A +.0000 -[illegible] BORE | B +.0000 -[illegible] OD | C ±.005 DIA | D +.015 -.000 RAD | E +.000 -[illegible] WIDTH OUTER RING | F +.000 -[illegible] 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 | .4[illegible] | .050 | .750 | 1.000 | .06 | 1 | .06 | .21 | 6,800 | 4,900 |
| -5 | .3125 | 1.5625 | .670 | | .844 | 1.187 | | | | .33 | 12,400 | 8,300 |
| -6 | [illegible] | | | | | | | | | .36 | | |
| -7 | [illegible] | 2.0000 | [illegible] | | 1.000 | 1.500 | | | .09 | .74 | 19,100 | 12,100 |
| -8 | [illegible] | | | | | | | | | | | |
| -9 | [illegible] | 2.[illegible] | 1.060 | | 1.125 | 1.687 | .11 | 2 | | 1.15 | 28,800 | 16,700 |
| -10 | [illegible] | | | | | | | | | 1.14 | | |
| -12 | .7[illegible] | 2.625[illegible] | [illegible] | | 1.2[illegible] | 1.875 | | | | 1.50 | 38,000 | 21,400 |
| -14 | [illegible] | [illegible] | 1.350 | | 1.500 | 2.000 | | | | 2.26 | 56,800 | 30,300 |

(A) SELF ALIGNMENT 10° IN EITHER DIRECTION

MATERIAL: RETAINERS, STEEL, MIL-S-5696
[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

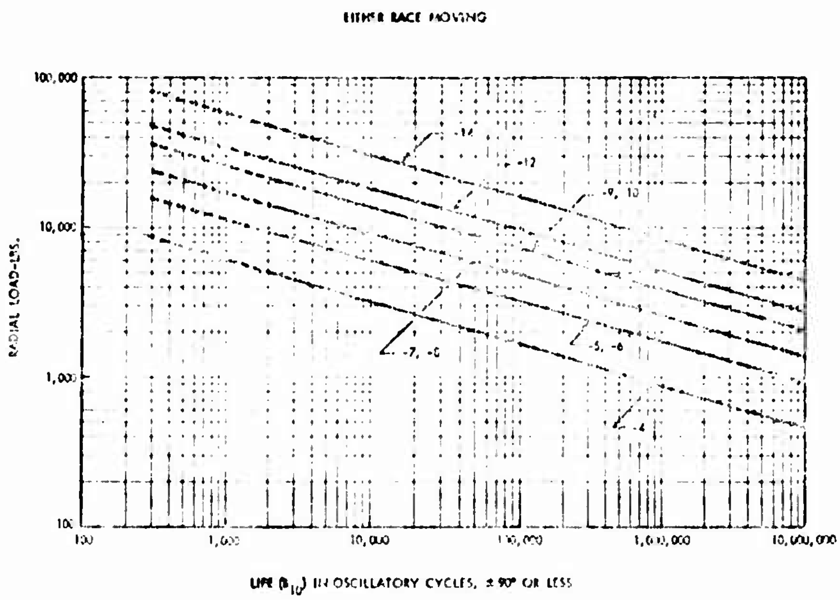
DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS +.010, -.000
DIMENSIONS TO BE MET AFTER PLATING.

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 - 1.9990 | 1.9992 - 1.9984 |
| -8 | 2.0000 | 1.9995 - 1.9990 | 1.9992 - 1.9984 |
| -9 | 2.3750 | 2.3744 - 2.3739 | 2.3740 - 2.3734 |
| -10 | 2.3750 | 2.3744 - 2.3739 | 2.3740 - 2.3734 |
| -12 | 2.6250 | 2.6244 - 2.6239 | 2.6240 - 2.6234 |
| -14 | 3.0000 | 2.9992 - 2.9984 | 2.9992 - 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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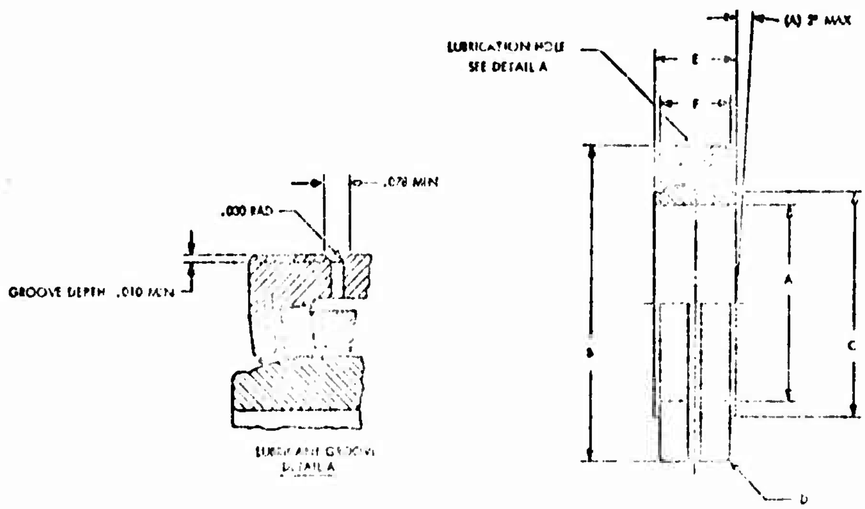
SUB-NOTE 4(4) (Sheet 1 of 2 Sheets) Light Duty Self-Aligning Roller Bearings (MS28915)




| DASH NO. | A +.0000 -.0005 BORE | B +.0000 -.0005 O.D | C +.005 -.015 DIA | D +.015 -.000 RAD | E +.000 -.005 WIDTH INNER RING | F +.000 -.005 WIDTH INNER RING | LUBRICATION HOLE | | WT MAX LB | POUNDS LIMIT LOAD | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | [illegible] | [illegible] | | [illegible] | [illegible] |
| -16 | 1.0000 | [illegible] | 1.12[illegible] | .0[illegible]0 | .500 | .450 | 1 | .06 | .1[illegible] | [illegible] | [illegible] |
| -20 | 1.2500 | 1.67[illegible] | 1.370 | | | | | | .19 | [illegible] | 550 |
| -25 | 1.5360 | 2.5[illegible] | 1.[illegible] | .030 | .670 | .550 | 2 | | .4[illegible] | [illegible] | [illegible] |
| -28 | 1.7500 | 2.[illegible] | 1.[illegible] | | | | | | .[illegible] | 5[illegible]0 | 1[illegible] |
| -33 | 2.0[illegible]30 | [illegible] | 2.3[illegible]0 | | | | | | .54 | [illegible]615 | 1[illegible] |
| -37 | 2.3130 | 3.2[illegible] | 2.[illegible] | | | | | | .59 | [illegible] | 11[illegible] |
| -47 | 2.7[illegible]0 | 3.87[illegible] | 3.2[illegible] | | | | | | .75 | 9550 | 11[illegible] |
| -49 | 3.0[illegible]30 | 4.[illegible] | [illegible] | | | | | | .7[illegible] | 1[illegible]50 | 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 .00[illegible] 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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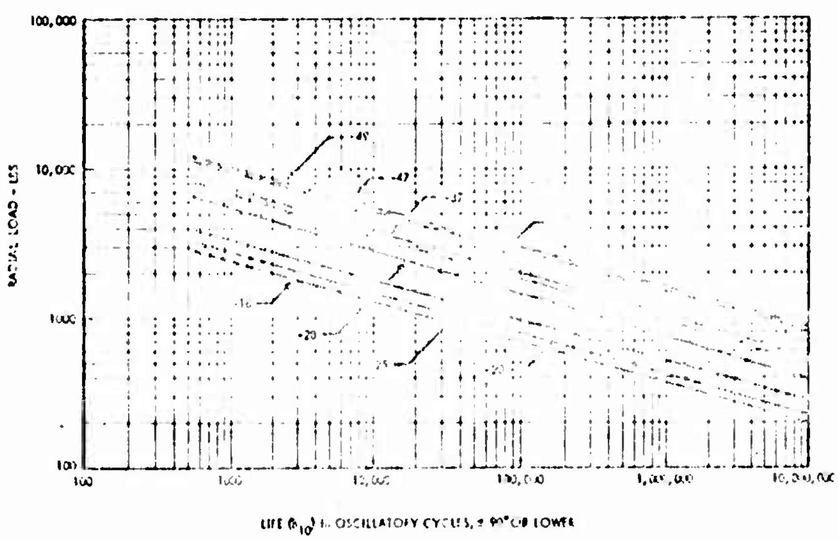
SUB-NOTE 4(4) (Sheet 2 of 2 Sheets) Light Duty Self-Aligning Roller Bearings (MS28915)




| BEARING | O.D., INCHES | STEEL HOUSING BORE, IN. | AL HOUSING BORE, IN. |
|---|---|---|---|
| -16 | 1.[illegible] | 1.6245 - 1.[illegible] | 1.[illegible] - 1.[illegible] |
| -20 | [illegible] | 1.8745 - 1.8760 | 1.8742 [illegible] |
| -25 | 2.50[illegible] | 2.4[illegible] - 2.4[illegible] | 2.4[illegible] - 2.4[illegible] |
| -2[illegible] | 2.6[illegible] | 2.[illegible] - 2.[illegible] | 2.[illegible] - 2.[illegible] |
| -31 | 3.0[illegible] | 2.9[illegible]92 - 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] | 3.99[illegible] - 3.[illegible]4 | 3.[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).

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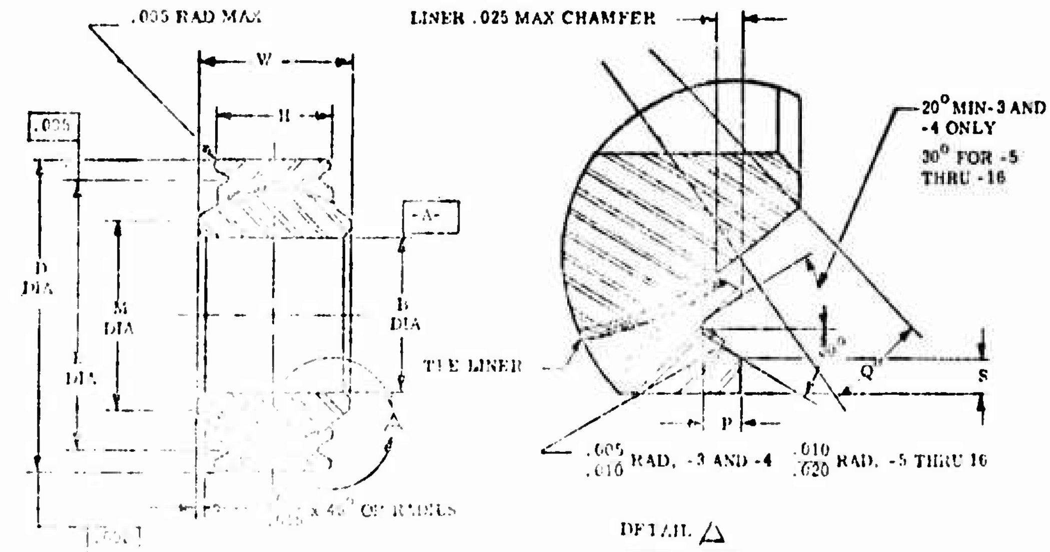
SUB-NOTE 5(J) (Sheet 1 of 2 Sheets) TFE-Lined Plain Spherical Bearings (MS14101)




| DASH NO | B | D | H | M | P | Q | S | W +.000 -.002 | 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] | | | | .281 | .402 | 3375 | 150 | 1500 | 0.25-5 | .020 |
| -4 | [illegible] | [illegible] | [illegible] | [illegible] | .020 | | .010 | .343 | [illegible] | 6040 | [illegible] | 3300 | | |
| -5 | .3125 | [illegible] | [illegible] | [illegible] | | 10 | | .375 | [illegible] | [illegible] | [illegible] | [illegible] | | .030 |
| -6 | .3750 | .125 | [illegible] | [illegible] | .040 | 9 | | [illegible] | .71 | 10540 | 1100 | 6600 | 1-15 | .040 |
| 7 | .4375 | [illegible] | [illegible] | [illegible] | | | | .437 | [illegible] | 13200 | [illegible] | 8050 | | .050 |
| -8 | [illegible] | 1.0000 | [illegible] | [illegible] | | | | [illegible] | [illegible] | [illegible] | 2100 | 12100 | | .070 |
| -9 | [illegible] | [illegible] | [illegible] | [illegible] | | | .020 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | .090 |
| -10 | [illegible] | [illegible] | [illegible] | [illegible] | .060 | [illegible] | | .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] | 30250 | | .270 |
| -16 | 1.0000 | [illegible] | [illegible] | [illegible] | | 9 | | 1.000 | [illegible] | [illegible] | [illegible] | [illegible] | 1-24 | .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 RHR 125 [illegible]
3. HARDNESS [illegible] BALL [illegible] OUTER RING [illegible] MIN. Rc [illegible] MAX.
4. DIMENSIONS IN INCHES [illegible] 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 [illegible] FROM THE "RADIAL STATIC LIMIT LOAD" TEST BECAUSE THE LOAD CAPABILITY OF [illegible] IS 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 ±25°, 10 CPM |
|---|---|---|
| 3 | .1900 | 1,5[illegible] |
| 4 | .2500 | [illegible] |
| 5 | .3125 | 5,6[illegible] |
| 6 | .3750 | [illegible] |
| 7 | .4375 | 8,[illegible] |
| 8 | .5000 | 10,4[illegible] |
| 9 | .5625 | 13,000 |
| 10 | .6250 | 16,45[illegible] |
| 12 | .7500 | 2[illegible] |
| 14 | .8750 | 30,[illegible] |
| 16 | [illegible] | [illegible] |

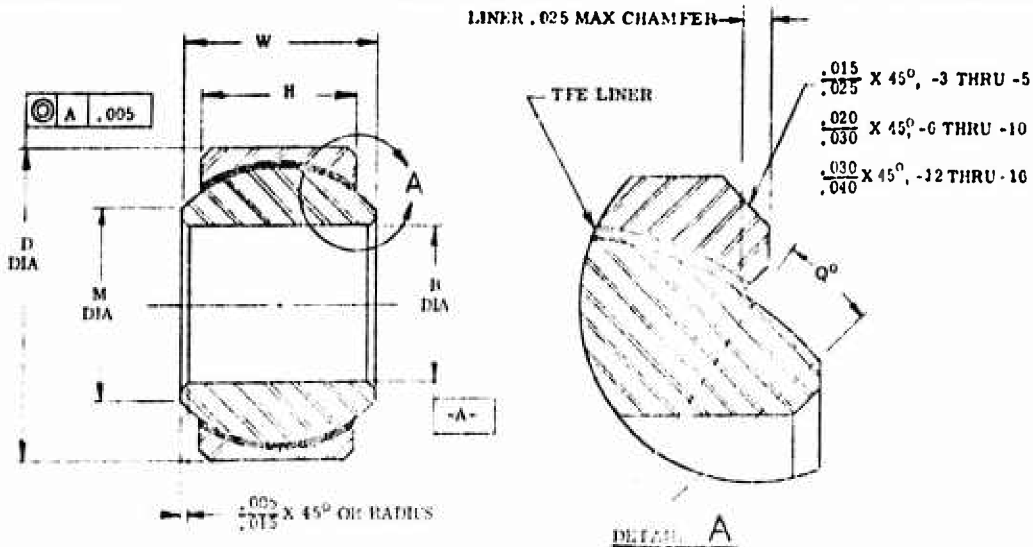
(1) SEE [illegible] FOR OTHER CONDITIONS OF LOADING

SHAFT AND HOUSING FITS

| DASH NO. | O.D. +.0007 -.0005 | HOUSING BORE | SHAFT DIAMETER |
|---|---|---|---|
| 3 | [illegible] | .5615-.562[illegible] | BORE DIA [illegible] |
| 4 | [illegible] | [illegible] | ↓ |
| 5 | [illegible] | .7490-.74[illegible] | ↓ |
| 6 | .8125 | .8114-.8119 | ↓ |
| 7 | [illegible] | .9051-.9056 | ↓ |
| 8 | 1.[illegible] | [illegible]-.9994 | ↓ |
| 9 | [illegible] | [illegible] | ↓ |
| 10 | 1.1875 | 1.1864-1.1869 | ↓ |
| 12 | 1.4375 | 1.4363-1.4368 | ↓ |
| 14 | 1.5625 | 1.5614-1.5619 | ↓ |
| 16 | [illegible] | [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 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 | .379 | 14 | .437 | 9400 | 1040 | 6050 | 1-15 | .035 |
| -6 | .3750 | .8125 | .406 | .466 | 6 | .500 | 13700 | 2630 | 8310 | | .060 |
| -7 | .4375 | .9375 | .442 | .537 | 10 | .562 | 20700 | 3650 | 11750 | | .080 |
| -8 | .5000 | 1.0000 | .505 | .607 | 9 | .625 | 27500 | 4970 | 14950 | | .100 |
| -9 | .5625 | 1.1250 | .536 | .721 | 10 | .687 | 34400 | 5370 | 18100 | | .135 |
| -10 | .6250 | 1.1875 | .567 | .747 | 12 | .750 | 33050 | 6130 | 20250 | | .160 |
| -12 | .7500 | 1.3750 | .630 | .845 | 13 | .875 | 52350 | 7730 | 26200 | | .240 |
| -14 | .8750 | 1.6250 | .755 | .995 | 6 | .875 | 67300 | 10800 | 33600 | 1-24 | .350 |
| -16 | 1.0000 | 2.1250 | 1.005 | 1.269 | 12 | 1.375 | 137000 | 19300 | 56250 | | .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 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.

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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 | 8,810 |
| 7 | .4375 | 11,750 |
| 8 | .5000 | 14,850 |
| 9 | .5625 | 16,100 |
| 10 | .6250 | 20,250 |
| 12 | .7500 | 26,200 |
| 14 | .8750 | 33,600 |
| 16 | 1.0000 | 55,250 |

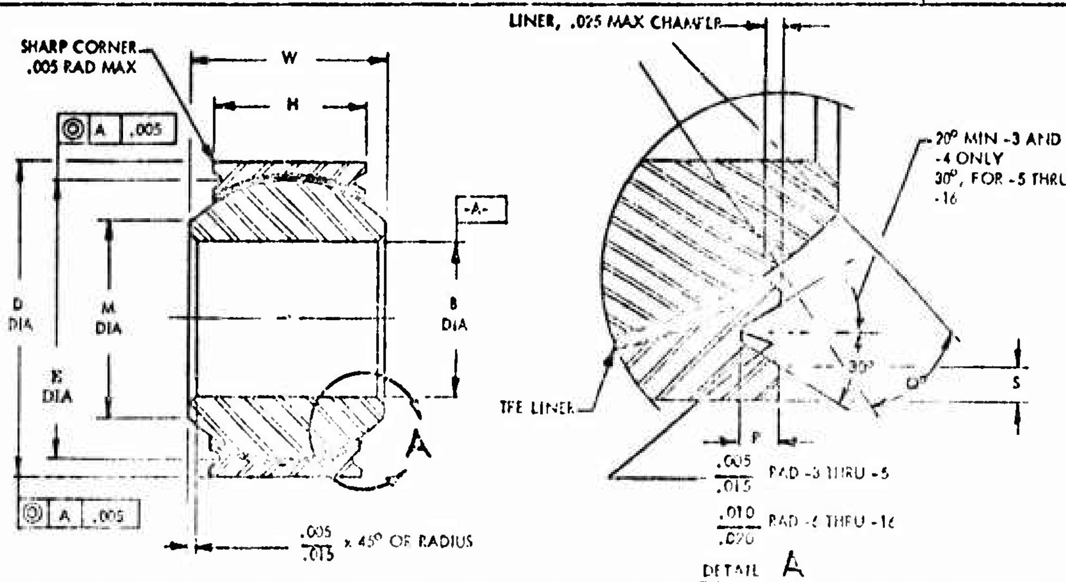
(1) SEE MIL-B-81820 FOR OTHER CONDITIONS OF LOADING

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 | H ±.005 | M MIN | P +.000 -.015 | O MIN | S MIN | W +.000 -.002 | E +.000 -.010 | STATIC LIMIT LOAD RADIAL LB | STATIC LIMIT LOAD AXIAL LB | OSCILLATING LOAD LB | NO-LOAD [illegible] BREAKAWAY TORQUE [illegible] | 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 | 9400 | 1640 | 6550 | 1-16 | .035 |
| -6 | .3750 | .8125 | [illegible] | .466 | .040 | 8 | .020 | .500 | .714 | 13700 | 2630 | [illegible] | | [illegible] |
| -7 | .4375 | .9375 | .442 | .537 | | 10 | | [illegible] | .839 | [illegible] | [illegible] | 11750 | | [illegible] |
| -7A | .4375 | .9062 | .442 | .537 | | 10 | | .562 | .806 | 20700 | 3650 | | | [illegible] |
| -8 | .5000 | 1.0000 | .565 | .607 | | 9 | | .625 | .902 | 27500 | 4970 | 14950 | | .100 |
| -9 | .5625 | 1.1250 | [illegible] | .721 | | 10 | | .687 | 1.027 | 34400 | 5370 | [illegible] | | .135 |
| -10 | .6250 | 1.1875 | [illegible] | .747 | | 12 | | .750 | [illegible] | 39000 | [illegible] | 20250 | | .160 |
| -12 | .7500 | 1.3750 | [illegible] | .845 | .060 | 13 | | .875 | 1.253 | 52300 | 7730 | [illegible] | | .240 |
| -14 | .8750 | 1.6250 | .755 | .995 | | 6 | | .875 | 1.503 | 67300 | 10000 | [illegible] | 1-24 | .350 |
| -16 | 1.0000 | 2.1250 | 1.005 | 1.269 | | 12 | | 1.375 | 2.003 | 137000 | [illegible] | 54250 | | .970 |

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 | .7[illegible] | [illegible] |
| 14 | .87[illegible] | 35,650 |
| 16 | 1.0000 | 56,250 |

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

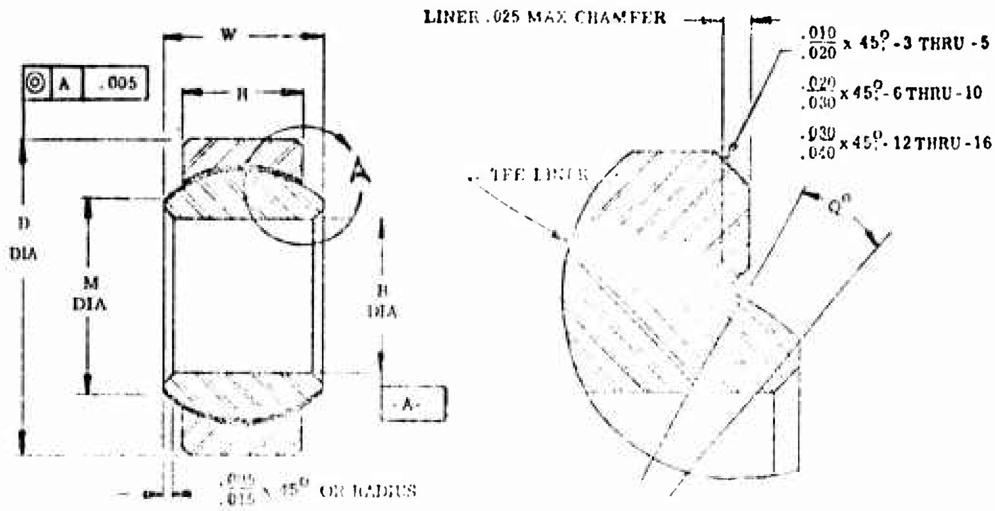
SHAFT AND HOUSING FITS

| DASH NO. | O.D. +.0000 -.0005 | HOUSING BORE | SHAFT DIAMETER |
|---|---|---|---|
| 3 | .6250 | .6244 - .6239 | BORE DIA +.0000 -.0005 |
| 4 | .6750 | .6744 - .6739 | ↓ |
| 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).

122<

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




DETAIL A

| DASH NO. | B +.0000 -.0005 | D +.0000 -.0005 | H ±.005 | M REF | 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 | .1500 | .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 | .375 | [illegible] | [illegible] | [illegible] | 1-15 | .030 |
| -6 | .3750 | [illegible] | .312 | .455 | 9 | .406 | [illegible] | [illegible] | [illegible] | | .040 |
| -7 | .4375 | [illegible] | [illegible] | .520 | 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] | .625 | [illegible] | [illegible] | [illegible] | | .120 |
| -12 | .7500 | 1.4375 | .593 | [illegible] | 6 | [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] | 1.118 | 5 | 1.000 | [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 8 MAX, BORE, BALL FACE, AND OUTER RACE DIA RHR 32 MAX, ALL OTHERS RHR 125 MAX.
3. HARDNESS. BALL 55-62Rc, OUTER RING 23 Rc MIN. Rc 35 MAX
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 DECREASED TO [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 | .1[illegible] | 1,5[illegible] |
| 4 | .2[illegible] | 3,320 |
| 5 | .3125 | 5,460 |
| 6 | .3750 | 6,600 |
| 7 | .43[illegible] | 8,050 |
| 8 | .5[illegible] | 10,400 |
| 9 | .5625 | 13,000 |
| 10 | .6[illegible] | 1[illegible],450 |
| 12 | .7[illegible] | 23,[illegible] |
| 14 | .8750 | [illegible] |
| 16 | 1.0[illegible] | [illegible] |

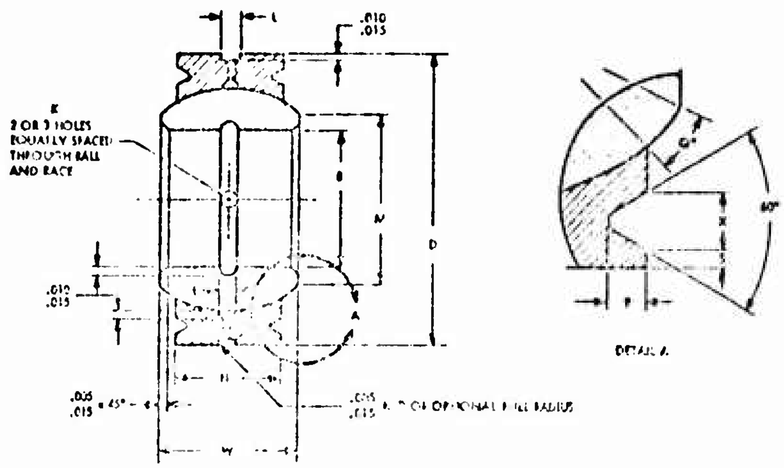
(1) SEE MIL-B-81820 FOR OTHER CONDITIONS OF LOADING

SHAFT AND HOUSING FITS

| DASH NO. | O.D. +.0000 -.0005 | HOUSING BORE | SHAFT DIAMETER |
|---|---|---|---|
| 3 | .5625 | .5[illegible] | BORE DIA +.0000 -.0005 ↓ |
| 4 | .6562 | .6551-.65[illegible] | |
| 5 | .7500 | .7490-.7495 | |
| 6 | .8125 | .8114-.8119 | |
| 7 | .9062 | .9051-.9056 | |
| 8 | 1.0000 | .9989-.9[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 RADIAL STATIC LIMIT LOAD | ALLOY AXIAL STATIC LIMIT LOAD | ALUMINUM RADIAL STATIC LIMIT LOAD | ALUMINUM AXIAL STATIC LIMIT LOAD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | [illegible] | .562 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | .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 | [illegible] | [illegible] | | | [illegible] | [illegible] | 9 | | [illegible] | .055 | [illegible] | [illegible] | [illegible] | [illegible] |
| 7 | [illegible] | [illegible] | [illegible] | [illegible] | [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] | | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 12 | [illegible] | [illegible] | [illegible] | [illegible] | .063 | [illegible] | | | | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] |
| 14 | [illegible] | [illegible] | [illegible] | | | [illegible] | | | | .875 | | [illegible] | [illegible] | [illegible] | [illegible] |
| 16 | [illegible] | [illegible] | [illegible] | | | [illegible] | | 7 | | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] |

(a) INNER [illegible] DIMENSION AND [illegible] DIAMETER TO BE MEASURED AFTER SWAGING

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

FINISH: BALL - CHROME PLATE QQ-C-[illegible], CLASS 2, [illegible] MINIMUM ON SPHERICAL SURFACES, [illegible] 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-[illegible] 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

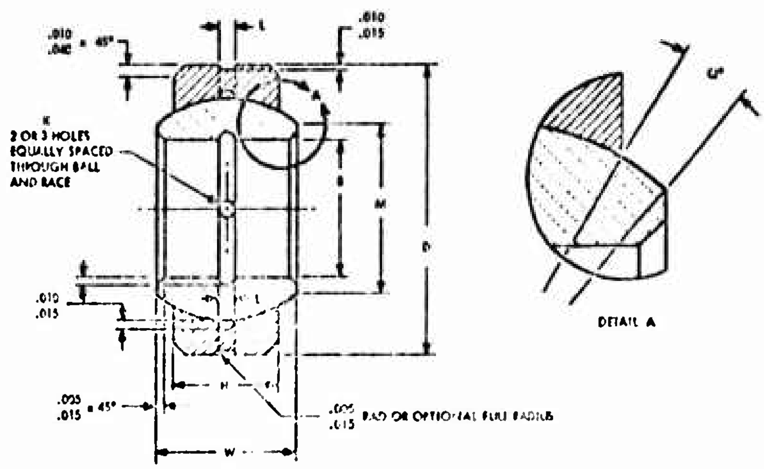
TOLERANCES: DECIMALS ±.010, ANGLES ±1/2°

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 -.002 | D | H ±.005 | P | L ±.005 | M | G° MIN | W +.000 -.002 | ALLOY STEEL: RADIAL STATIC ULT 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] | [illegible] |
| 4 | [illegible] | [illegible] | [illegible] | | | [illegible] | | .343 | [illegible] | [illegible] | [illegible] | [illegible] |
| 5 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .415 | | .375 | [illegible] | [illegible] | [illegible] | [illegible] |
| 6 | [illegible] | [illegible] | [illegible] | | | [illegible] | 5 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 7 | [illegible] | [illegible] | [illegible] | | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 8 | [illegible] | [illegible] | [illegible] | | | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 9 | [illegible] | [illegible] | [illegible] | | | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 10 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | .625 | [illegible] | [illegible] | [illegible] | [illegible] |
| 12 | [illegible] | [illegible] | [illegible] | | | [illegible] | | .750 | [illegible] | 16500 | [illegible] | [illegible] |
| 14 | [illegible] | [illegible] | [illegible] | | | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 16 | [illegible] | [illegible] | [illegible] | | | 1.110 | 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 58 MIN
RACE - Rc 27-36 ALLOY STEEL

LUBRICATION: PREPACKED WITH MIL-G-21164

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

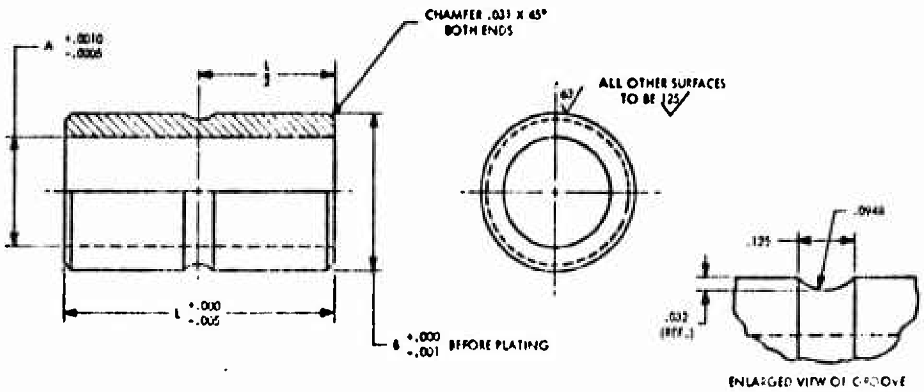
TEMPERATURE RANGE: -65°F to +250°F

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 | [illegible] | .030 | .026 |
| 5 | .3125 | [illegible] | [illegible] | [illegible] |
| 6 | .375 | .5635 | .041 | .039 |
| 7 | .4375 | .623 | .046 | .044 |
| 8 | .500 | .6855 | [illegible] | [illegible] |
| 9 | .5625 | .748 | .057 | .054 |
| 10 | .625 | .873 | .068 | .062 |
| 12 | .750 | .998 | .103 | .095 |
| 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 | 1.260 | 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 [illegible] .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. [illegible] LENGTH AS SHOWN IN ABOVE TABLE.
FOR BUSHING LENGTH [illegible] .375 AND LONGER, LETTER E AFTER FIRST DASH NUMBER DESIGNATES BUSHING WITHOUT GROOVE.

EXAMPLES
NAS73-[illegible]-012 = BUSHING, [illegible] X .750 LONG WITH GROOVE
NAS73 8E012 = 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 [illegible] MATERIAL PROVIDED THE FINISHED PRODUCT MEETS ALL OTHER [illegible] OF THIS DRAWING.

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

SURFACE FINISH
SURFACE ROUGHNESS [illegible] 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 [illegible]
4. IF PLATED [illegible] AFTER PLATING
5. THESE [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 [illegible] 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 LENGTH [illegible] .375 AND LONGER, LETTER E AFTER FIRST DASH NUMBER DESIGNATES BUSHING WITHOUT GROOVE.

EXAMPLES
NAS74[illegible]-012 = BUSHING, .500 [illegible] X .750 LONG WITH GROOVE
NAS74A-[illegible]012 = 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

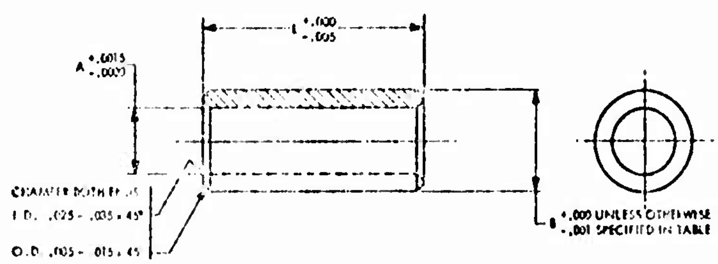
ALL DIMENSIONS IN INCHES.

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. | [illegible] | A | B | NAS-75 WEIGHT LBS./IN. (STEEL) | NAS-76 WEIGHT LBS./IN. (BRONZE) |
|---|---|---|---|---|---|
| 3 | 10 | [illegible] | [illegible] | .013 | .014 |
| 4 | 1/4 | .250 | [illegible] | [illegible] | .021 |
| 5 | 5/16 | .3125 | [illegible] | .022 | .024 |
| 6 | 3/8 | [illegible] | .5013 [illegible] | .026 | .028 |
| 7 | 7/16 | [illegible] | [illegible] | .029 | .031 |
| 8 | 1/2 | .500 | .6265 [illegible] | .033 | .036 |
| 9 | [illegible] | [illegible] | [illegible] | .035 | [illegible] |
| 10 | 5/8 | .625 | [illegible] | .063 | .068 |
| 11 | - | [illegible] | [illegible] | .065 | .070 |
| 12 | 3/4 | .750 | [illegible] | .075 | .081 |
| 14 | 7/8 | .875 | [illegible] | .086 | .093 |
| [illegible] | 1 | 1.000 | [illegible] | .097 | .105 |
| 16 | - | 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)

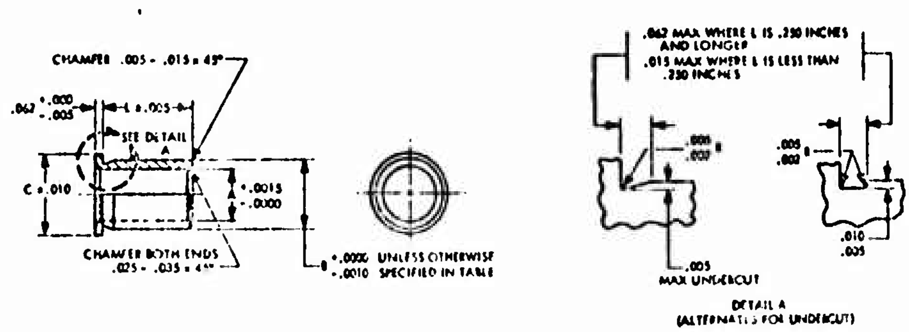
| | |
|---|---|
| NOTES: NAS-75 | 1. INSIDE DIA. TO BE PARALLEL AND CONCENTRIC WITH OUTSIDE DIA. WITHIN .003 TOTAL INDICATOR READING.<br>2. ALL DIMENSIONS TO BE MET AFTER PLATING.<br>3. THESE BUSHINGS NOT INTENDED FOR REAMING ON ASSEMBLY. |
| LENGTH CODE | LENGTH TO BE SPECIFIED IN INCHES AND 1/32 NDS OF AN INCH |
| GENERAL CODE | NAS75 - (SIZE DASH NO.) - (LENGTH DASH NO.) |
| EXAMPLES | NAS75-8-009 = STEEL BUSHING - .500 INSIDE DIA., 9/32 LONG<br>NAS75-[illegible]-015 = STEEL BUSHING - .500 INSIDE DIA., 15/32 LONG<br>NAS75-[illegible] = STEEL BUSHING - .500 INSIDE DIA., 3-9/32 LONG<br>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, [illegible] STEEL BAR, SPEC. [illegible] OR EQUIVALENT. SEAMLESS ALLOY STEEL TUBING MAY BE [illegible] 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] |
| 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.<br>2. IF PLATING IS [illegible] ALL DIMENSIONS ARE TO BE MET AFTER PLATING.<br>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<br>NAS76A8-309 = ALUMINUM BRONZE BUSHING - .500 INSIDE DIA., 3-9/32 LONG<br>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] | 437 | 016 | 017 |
| 4 | 1/4 | 2500 | 3761 [illegible] | 500 | 020 | 021 |
| 5 | 5/16 | 3125 | 4386 [illegible] | 562 | 025 | 027 |
| 6 | 3/8 | [illegible] | [illegible] | 625 | [illegible] | 030 |
| 7 | 7/16 | 4375 | [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 [illegible] | [illegible] | 072 |
| 11 | - | 6875 | 8767 | 1 [illegible] | .079 | 084 |
| 12 | 3/4 | 7500 | [illegible] | 1 125 | [illegible] | 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

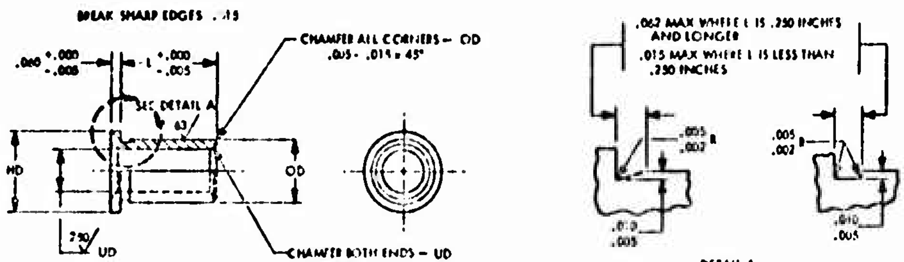
MATERIAL: ALUMINUM BRONZE BAR, QQ-C-455, ALLOY 642
ALLOY STEEL HEAT TREATED TO 125,000 - 145,000 PSI MAY BE MADE FROM 4130 STEEL BAR SPEC MIL-S-6758, 8630 STEEL BAR SPEC MIL-S-6050
SEAMLESS ALLOY STEEL TUBING MAY BE USED AS AN OPTIONAL MATERIAL PROVIDED THE FINISHED PRODUCT MEETS ALL OTHER REQUIREMENTS 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 HOLE | DIMENSIONS — INSIDE DIA — UD (UNDER SIZE) DIA | TOL [illegible] | OUTSIDE DIA — OD DIA | TOL [illegible] | FLANGE DIA — HD DIA | TOL [illegible] | REFERENCE DATA — WEIGHT IN LBS — STEEL FLANGE F | STEEL SHANK | ALUMINUM BRONZE FLANGE F | ALUMINUM BRONZE SHANK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -3 | [illegible] | [illegible] | [illegible] | .3136 | [illegible] | .447 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| -4 | [illegible] | .2490 | [illegible] | .3761 | [illegible] | [illegible] | [illegible] | [illegible] | .0176 | [illegible] | [illegible] |
| -5 | .3125 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | +.020 | [illegible] | [illegible] | .0030 | [illegible] |
| -6 | .3750 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| -7 | .4375 | .4220 | +.0070 | .5636 | +.0007 | .697 | +.020 | [illegible] | .0262 | [illegible] | .0278 |
| -8 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .0042 | [illegible] | .0042 | [illegible] |
| -9 | [illegible] | .5460 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| -10 | [illegible] | [illegible] | [illegible] | .6142 | +.0010 | [illegible] | +.020 | [illegible] | [illegible] | [illegible] | [illegible] |
| -11 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| -12 | [illegible] | .7340 | [illegible] | [illegible] | +.0010 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| -14 | [illegible] | [illegible] | [illegible] | [illegible] | +.0010 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| -16 | [illegible] | [illegible] | [illegible] | [illegible] | +.0010 | [illegible] | [illegible] | [illegible] | [illegible] | .0120 | [illegible] |
| -18 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .0136 | [illegible] | [illegible] | [illegible] |
| -20 | [illegible] | [illegible] | [illegible] | [illegible] | +.0010 | [illegible] | [illegible] | [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 [illegible] 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

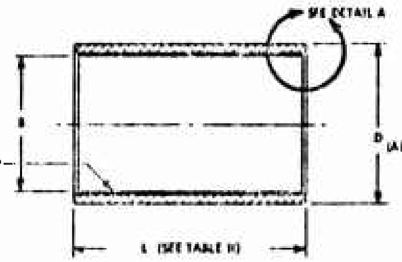
NOTES:

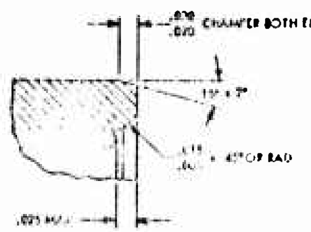
1. THESE BUSHINGS ARE INTENDED FOR REAMING AFTER INSTALLATION.
2. TOLERANCE SHALL BE ± .010 UNLESS OTHERWISE STATED.
3. INSIDE DIAMETER AND OUTSIDE DIAMETER TO BE PARALLEL AND CONCENTRIC WITHIN .003 TOTAL INDICATOR READING.
4. ALL DIMENSIONS TO BE MET AFTER PLATING.
5. REFERENCE DIMENSIONS ARE FOR DESIGN 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 (A) DIA | WEIGHT LB/IN (REF) L = 1.000 AL | WEIGHT LB/IN (REF) L = 1.000 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 | [illegible] | .101 |
| -20 | 1 1/4 | 1.2515 | 1.4398 | .040 | .111 |
| -22 | 1 3/8 | [illegible] | 1.5648 | .044 | .122 |
| -24 | 1 1/2 | 1.5015 | [illegible] | [illegible] | [illegible] |
| -26 | 1 5/8 | [illegible] | [illegible] | [illegible] | .163 |
| -28 | 1 3/4 | 1.7515 | 2.0023 | .075 | .207 |
| -32 | 2 | [illegible] | 2.2523 | [illegible] | .224 |

(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:

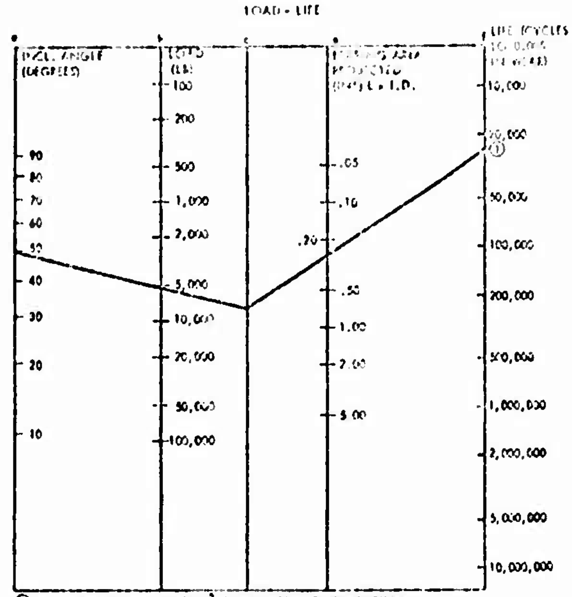
MS21240 - 04 A 008 = 1/4 INCH BORE DIA ALUMINUM X 1/4 LONG

- 008 — LENGTH CODE IN MULTIPLES OF 1/32 INCH
- A — MATERIAL CODE
- 04 — BORE DIAMETER CODE IN MULTIPLES OF 1/16 INCH
- MS21240 — BASIC MS PART NUMBER

LOAD RATINGS: DYNAMIC CAPACITY 25,000 B × L LBS OR 25,000 B² LB WHICHEVER IS LESSER.
STATIC LIMIT LOAD 65,000 B × L LBS OR 65,000 B² 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 | .2515 | .2495 – .2485 | [illegible] | .3758 – [illegible] |
| -05 | .3142 | .3120 – .3110 | [illegible] | [illegible] |
| -06 | .3765 | .3745 – .3735 | [illegible] | .5010 – [illegible] |
| -07 | .4390 | [illegible] – .4360 | [illegible] | .5636 – [illegible] |
| -08 | .5015 | [illegible] – .4985 | [illegible] | .6261 – [illegible] |
| -09 | .5640 | .5620 – .5610 | [illegible] | .6890 – [illegible] |
| -10 | .6265 | .6745 – .6735 | .8142 | .8140 – [illegible] |
| -11 | .6890 | .6870 – .6860 | .8767 | .8765 – [illegible] |
| -12 | .7515 | .7495 – .7485 | .9393 | .9391 – [illegible] |
| -14 | .8765 | .8745 – .8735 | 1.0645 | 1.0640 – 1.0650 |
| -16 | 1.0015 | [illegible] – .9975 | 1.1895 | 1.1893 – 1.1903 |
| -18 | 1.1265 | 1.1245 – 1.1235 | 1.3142 | 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 | 1.8773 | 1.8766 – [illegible] |
| -28 | 1.7515 | 1.7495 – 1.7485 | 2.0023 | 2.0015 – [illegible] |
| -32 | 2.0015 | 1.9995 – 1.9985 | 2.2573 | 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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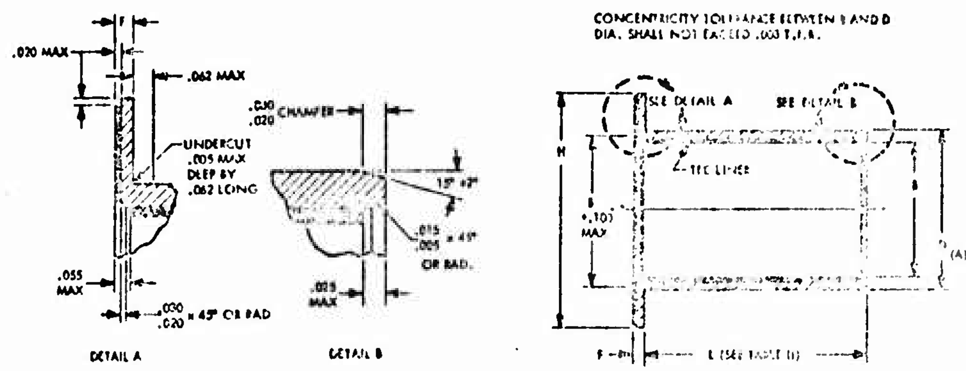
SUB-NOTE 6(6) (Sheet 1 of 2 Sheets) TFE-Lined Flanged Bushings (MS21241)




| DASH NO. | NOMINAL SIZE | B DIA +.0005 -.0010 | D DIA (A) | F +.010 -.005 | H DIA +.000 -.020 | WEIGHT LB/IN (REF) L = 1.000 | | FLANGE WEIGHT | | BODY (B) WEIGHT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | AL | CRES | AL | CRES | AL | CRES |
| -04 | 1/4 | .2515 | [illegible] | .0625 | [illegible] | [illegible] | [illegible] | | .007 | [illegible] | [illegible] |
| -05 | 5/16 | [illegible] | [illegible] | [illegible] | [illegible] | .011 | [illegible] | .013 | | [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 | .077 | .075 | .005 | [illegible] | [illegible] | [illegible] |
| -11 | 11/16 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [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] | 1.750 | .043 | .118 | [illegible] | [illegible] | [illegible] | [illegible] |
| -18 | 1 1/8 | 1.1265 | 1.3143 | .0937 | 1.875 | .051 | .142 | [illegible] | [illegible] | [illegible] | [illegible] |
| -20 | 1 1/4 | 1.2515 | [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 +.033 X .5 = .010 +.0165 = .0265 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 08 - 1/4 INCH BORE DIA ALUMINUM X 1/4 LONG
08 — 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

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 B$^2$ LB, WHICHEVER IS THE LESSER
STATIC LIMIT LOAD 60,000 B X L LBS, OR 60,000 B$^2$ LB, WHICHEVER IS THE LESSER

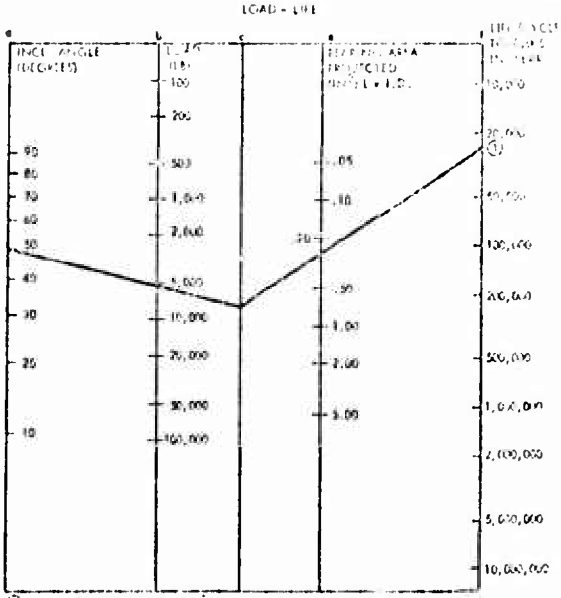
| DASH NO. | NOM SIZE | * LENGTH L +.000 −.010 | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1/4 | 9/32 | 5/16 | 11/32 | 3/8 | 7/16 | 1/2 | 9/16 | 5/8 | 11/16 | 3/4 | 7/8 | 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 | 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 | [illegible] | | | | | | | | | |
| -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 | | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 44 | [illegible] | 52 | 56 | [illegible] | | | | | | | |
| -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 | [illegible] | [illegible] | 44 | [illegible] | [illegible] | 56 | 60 | 64 | 68 | | | | | |
| -24 | 1 1/2 | | | | | 12 | [illegible] | 16 | 18 | 20 | 22 | 24 | 28 | [illegible] | [illegible] | [illegible] | 44 | 48 | 52 | 56 | 60 | 64 | 68 | 72 | 76 | [illegible] | 88 | |
| -26 | 1 5/8 | | | | | | | 16 | 18 | [illegible] | 22 | 24 | 28 | 32 | 36 | [illegible] | 44 | 48 | 52 | 56 | 60 | 64 | 68 | 72 | 76 | [illegible] | 88 | 96 |
| -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 |
|---|---|---|---|---|---|---|---|

PERFORMANCE DATA

LOAD - LIFE




① PLAIN BEARING WITH 0.3 IN$^2$ PROJECTED AREA OPERATING AT ±20°, 2000 LBS LOAD WILL GIVE 26,000 CYCLES LIFE BEFORE 0.005 WEAR OCCURS

SHAFT & HOUSING FIT

| BEARING | [illegible] | SHAFT DIA ② | O.D. (INCHES) | HOUSING BORE, IN. |
|---|---|---|---|---|
| -04 | .2515 | [illegible] | [illegible] | [illegible] |
| -05 | [illegible] | [illegible] | [illegible] | [illegible] – .4376 |
| -06 | [illegible] | .3745 – [illegible] | [illegible] | [illegible] |
| -07 | [illegible] | [illegible] | [illegible] | [illegible] – .5?4 |
| -08 | .5015 | [illegible] – .4995 | .6265 | [illegible] – .6255 |
| -09 | .5640 | [illegible] | .6892 | [illegible] – .6882 |
| -10 | .6265 | [illegible] | .8142 | [illegible] – .8132 |
| -11 | .6890 | [illegible] | .8767 | [illegible] – .8757 |
| -12 | .7515 | [illegible] | .9392 | .9391 – .9382 |
| -14 | [illegible] | [illegible] | 1.0645 | [illegible] – 1.0630 |
| -16 | 1.0015 | [illegible] – .9975 | 1.1896 | [illegible] – 1.1883 |
| -18 | 1.1265 | [illegible] – 1.1235 | 1.3148 | [illegible] – 1.3133 |
| -20 | [illegible] | [illegible] | 1.4398 | [illegible] – 1.4383 |
| -22 | 1.3765 | [illegible] – 1.3755 | 1.5648 | [illegible] – 1.5633 |
| -24 | 1.5015 | [illegible] | [illegible] | [illegible] – 1.7508 |
| -26 | 1.6265 | [illegible] | 1.8773 | [illegible] – 1.8758 |
| -28 | 1.7515 | [illegible] | 2.0023 | [illegible] |
| -32 | 2.0015 | [illegible] | 2.2523 | 2.2518 – 2.2508 |

② SHAFT FINISH < 10 RMS 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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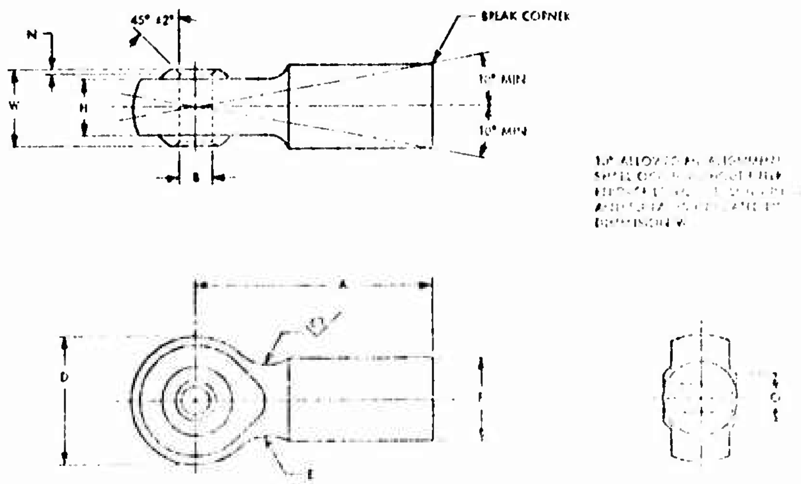
SUB-NOTE 7(1) Solid Shank Ball-Bearing Rod Ends (MS21150)




| DASH NUMBER | BORE SIZE NOM | A | B | E DIA | [illegible] MIN RAD | F | H | N (a) | [illegible] 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] | [illegible] |

| ENGINEERING DATA | | | | | | |
|---|---|---|---|---|---|---|
| | RADIAL STRENGTH | | AXIAL STRENGTH | | [illegible] (b) | |
| DASH NUMBER | LIMIT LOAD POUNDS | FRACTURE LOAD POUNDS | LIMIT LOAD POUNDS | FRACTURE LOAD POUNDS | CASE I | CASE II |
| 3[illegible] | 1[illegible] | 1[illegible] | 2[illegible] | 3[illegible] | [illegible] | 1[illegible] |
| 4[illegible] | 1[illegible] | 2[illegible] | 34[illegible] | 520 | 1[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

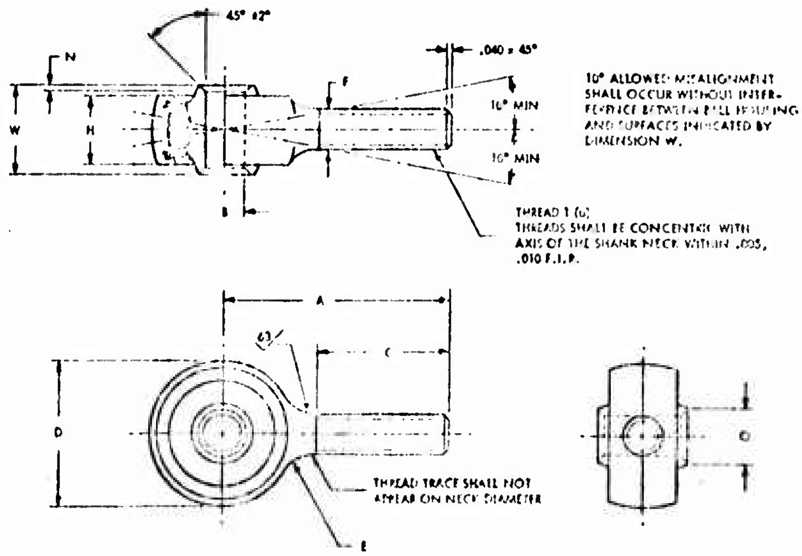
FOR DEFINITION AND APPLICATION OF [illegible] NOTES, SEE MIL-STD-[illegible]
[illegible]

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

MS21150 BEARINGS ARE SUBSTITUTABLE FOR MS2[illegible] BEARINGS OF THE SAME BORE AND SHANK [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 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) | G MIN DIA | THREAD T (b) UNJF - 3A | W +.000 -.005 | WGT LB APPROX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3M3 | No. 10 | 1.375 | .1900 | .750 | .781 | .427 | .190 | [illegible] | .005 | .276 | 10-32 LH | .437 | .04 |
| 3M3 [illegible] | | | | | | | | | | | 10-32 RH | | |
| 3M6A | | 2.031 | | 1.313 | .969 | [illegible] | .375 | .437 | | [illegible] | 3/8-24 RH | .500 | .05 |
| 3M6-2RH | | 1.375 | | .750 | .781 | .390 | | .320 | | .276 | | .437 | |
| 3M6-2LH | | | | | | | | | | | 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 | | .320 | | .276 | | .437 | .05 |
| 4M6 | 1/4 | 1.875 | .2500 | 1.125 | .938 | .469 | .375 | .438 | .005 | .340 | 3/8-24 RH | .593 | .10 |
| 4M6A | | | | | | | | | | | 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 | .938 | .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] PER [illegible]
SCREW-THREAD [illegible] SERVICE
(c) LOCKING SLOT [illegible]

MS21151 BEARINGS ARE [illegible]
FOR DEFINITION AND APPLICATION OF [illegible] STATUS NOTES, SEE [illegible]
RADIAL PLAY [illegible]
AXIAL PLAY [illegible]
MATERIAL [illegible]
FINISH [illegible] CADMIUM [illegible] SPECIFICATION QQ-P-416, TYPE I, CLASS [illegible]
LUBRICATION [illegible]
REMOVE ALL BURRS AND SHARP EDGES

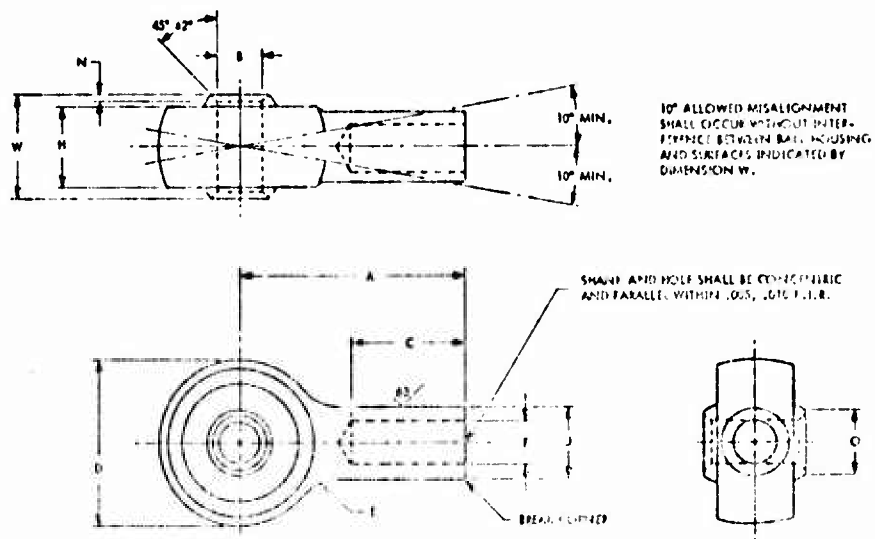
SURFACE ROUGHNESS [illegible]
[illegible]
[illegible]
EXAMPLE OF COMPLETE PART NUMBER [illegible] CONTACT SEAL, SELF [illegible] BEARING

| | ENGINEERING DATA | | | | | |
|---|---|---|---|---|---|---|
| | RADIAL STRENGTH | | AXIAL STRENGTH | | [illegible] | |
| DASH NUMBER | LIMIT LOAD [illegible] | ULTIMATE LOAD [illegible] | LIMIT LOAD [illegible] | ULTIMATE LOAD [illegible] | C? | [illegible] |
| 3M12 <br> 3M[illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 3M[illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 3M4-2[illegible] <br> 3M[illegible]-2[illegible] <br> 3M4-2 <br> 3M4-5 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 4M6 <br> 4M16 | 1720 | [illegible] | 34[illegible] | [illegible] | 1220 | [illegible] |
| 5M5 <br> 5M7 <br> 5M10 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 10M10 | [illegible] | 10,[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).

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




| DASH NUMBER | BORE SIZE [illegible] | A | B DIA +.0000 -.0005 | C ±.010 | D | E MIN RAD | F | H | J DIA | | [illegible] | G MIN DIA | W +.000 -.005 | WGT LB APPROX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | [illegible] | [illegible] | | | | |
| 3H5 | No. 10 | 1.375 | .1900 | [illegible] | [illegible] | [illegible] | .272 | .328 | .43[illegible] | .475 | | .276 | .437 | .06 |
| 4H6 | 1/4 | 1.[illegible] | .2500 | 1.2[illegible] | .532 | .4[illegible] | [illegible] | .475 | .625 | .473 | .005 | .34 | .593 | .12 |
| 4H8 | | 1.625 | | .[illegible]75 | | .5[illegible] | .51[illegible] | | | | | | | .0[illegible] |
| 4H5-2 | | 1.875 | | .75 | | .4[illegible] | [illegible] | | .44[illegible] | .4[illegible] | | | | .12 |
| 4H6-2 | | | | 1.125 | | .5[illegible] | [illegible] | | .625 | .62[illegible] | | | | .0[illegible] |

| ENGINEERING DATA | | | | | | |
|---|---|---|---|---|---|---|
| DASH NUMBER | RADIAL STRENGTH | | AXIAL STRENGTH | | RADIAL LOAD RATING 10,000 CYCLES 90° [illegible] | |
| | LIMIT LOAD POUNDS | FRACTURE LOAD POUNDS | LIMIT LOAD POUNDS | FRACTURE LOAD POUNDS | CASE I | CASE II |
| 3H5 | 10[illegible] | [illegible] | [illegible] | 3[illegible] | [illegible] | 10[illegible] |
| 4H6 | 1720 | 2590 | 345 | 5[illegible] | 172[illegible] | 172[illegible] |
| 4H8 | | | | | | |
| 4H5-2 | | | | | | |
| 4H6-2 | | | | | | |

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

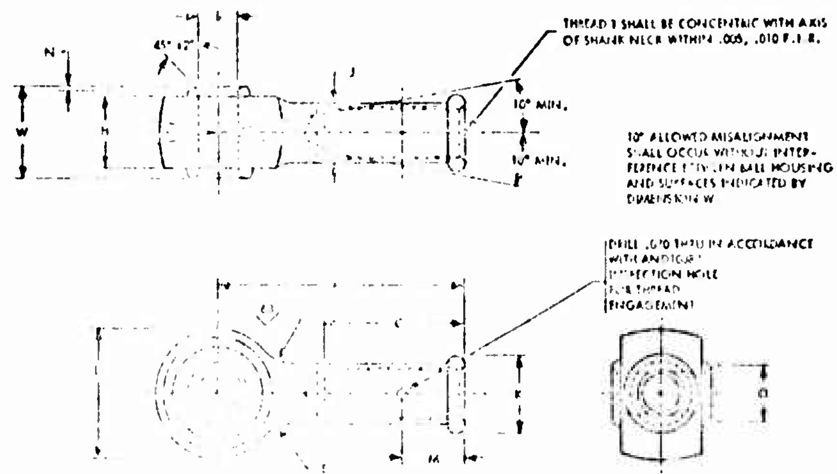
(b) CASE I - LOAD FIXED WITH RESPECT TO OUTER RACE
CASE II - LOAD FIXED WITH RESPECT TO INNER RACE

FOR DEFINITION & APPLICATION OF DRAWING STANDARD NOTES, SEE MIL-STD-[illegible]
RADIAL PLAY: [illegible]
AXIAL PLAY: [illegible]
MATERIALS: STEEL, [illegible]
FINISH: CADMIUM PLATE, [illegible] TYPE I, CLASS II
LUBRICATION: GREASE, [illegible]
REMOVE ALL BURRS AND SHARP EDGES
SURFACE ROUGHNESS: [illegible] AND BALLS 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 AN[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 End (MS21153)




| DASH NUMBER | [illegible] | A | B | C | [illegible] | [illegible] | H | J | K | M | N | G | THREAD T | W | WGT LB APPROX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | | | | | | | | [illegible] | | | | | [illegible] | 437 | .05 |
| [illegible] | | | | | | | | [illegible] | | | | | [illegible] | | |
| 3F4 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .378 | | [illegible] | | [illegible] | .277 | [illegible] | .500 | .06 |
| [illegible] | | | | | | | | .375 | | | | | [illegible] | | |
| [illegible] | | | | | | | | | | .312 | | | [illegible] | 437 | .05 |
| 4F5 | | | | | | | | [illegible] | | | | | [illegible] | | .07 |
| [illegible] | 1/4 | 1.4?7 | [illegible] | | .53 | [illegible] | [illegible] | | | | | .340 | [illegible] | .573 | |
| 4F7 | | | | 1.175 | | | | .625 | .625 | | | | [illegible] | | .16 |
| [illegible] | | 1.5?5 | | | | | | | | | | | [illegible] | | |
| 5F5 | 5/16 | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | .015 | .501 | [illegible] | .870 | .10 |
| [illegible] | | | | | | | | | | | | | 5/16-24 [illegible] | | |

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

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

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

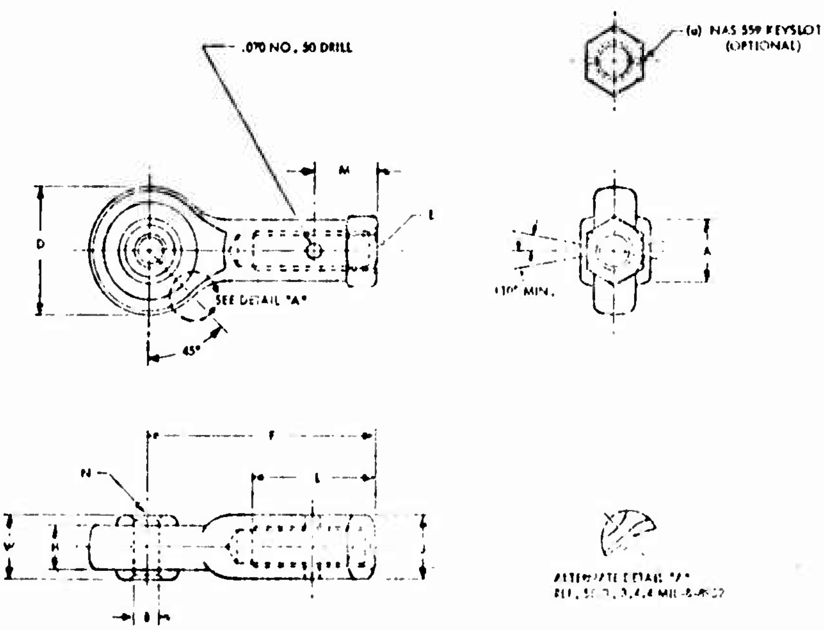
[illegible]

| [illegible] | ENGINEERING DATA | | | | | |
|---|---|---|---|---|---|---|
| | RADIAL STRENGTH | | AXIAL STRENGTH | | [illegible] (a) | |
| DASH NUMBER | [illegible] | [illegible] | [illegible] | [illegible] | CASE I | CASE II |
| [illegible] | [illegible] | 1500 | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | 1720 | [illegible] | 345 | 520 | 1720 | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 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).

## 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] | W [illegible] | LIMIT LOAD RATING | | DYNAMIC RADIAL LOAD RATING | WT LB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | RADIAL | AXIAL | | |
| 4 | .4[illegible] | .2500 | 1.0 | [illegible]-24 | 1.6[illegible] | .3 | .5 | .8[illegible] | .4[illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | .1[illegible] |
| 5 | .56 | .3125 | 1.41 | [illegible] | 2.3[illegible] | .4 | .6[illegible] | 1.31 | [illegible] | .0[illegible] | [illegible] | [illegible] | [illegible] | 4[illegible] | [illegible] |
| 6 | .6[illegible] | .3750 | 1.46 | 5/8-18 | 3.0[illegible] | .5[illegible] | .5[illegible] | 1.75 | .[illegible] | | .612 | [illegible] | [illegible] | [illegible] | .5[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, 4130, MIL-S-7493, 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-[illegible]

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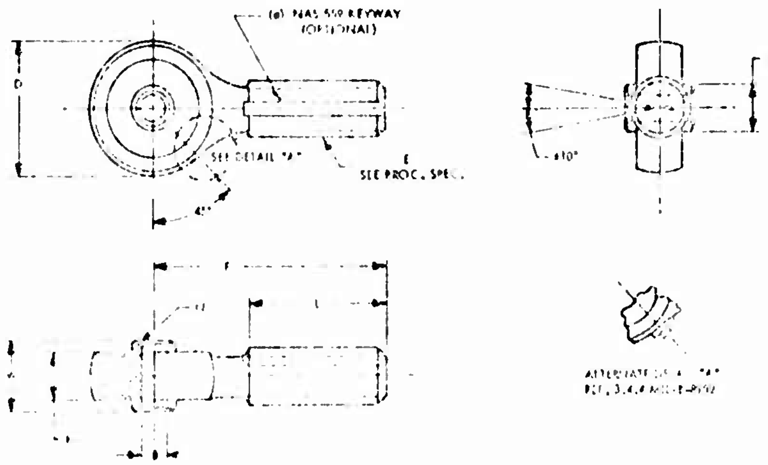
## SUB-NOTE 7(6) External Thread Roller-Bearing Rod Ends (MS21221)




| [illegible] | A | B | D | E | F | H | L | [illegible] | W | Limit load rating | | Dynamic radial load rating | 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] | [illegible] | 4 |
| 8 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | 1480 (?) | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

THESE BEARINGS ARE SELF-ALIGNING FOR [illegible] IN EITHER DIRECTION.

MATERIAL: [illegible]
[illegible] 4130 [illegible] MIL-[illegible], [illegible] MIL-[illegible], 52100 [illegible]

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

DIMENSIONS TO BE MET AFTER PLATING

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

REMOVE BURRS AND SHARP EDGES

INTERNAL CLEARANCE: RADIAL [illegible], AXIAL [illegible]

LUBRICANT IDENTIFICATION: ADD APPROPRIATE [illegible] LETTER TO INDICATE TYPE OF LUBRICANT
A = MIL-G-[illegible] B = MIL-G-[illegible]
D = MIL-G-[illegible] [illegible] = MIL-G-[illegible]

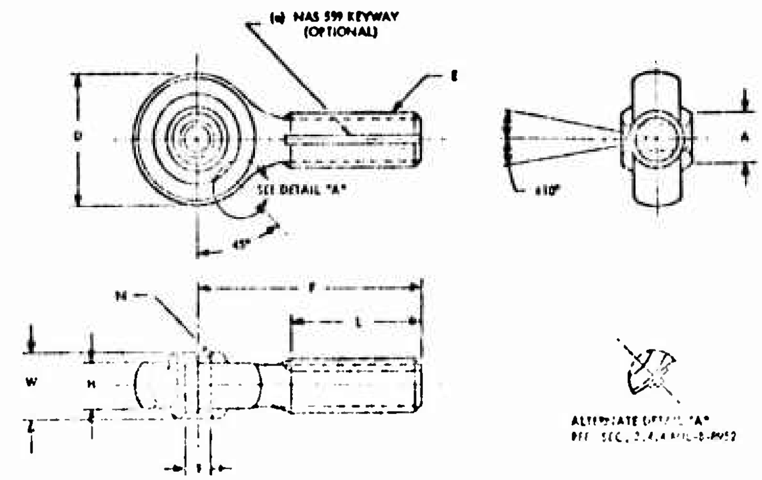
(a) ADD [illegible] LETTER [illegible] WITH NAS 559 KEYWAY IF REQUIRED.
ADD [illegible] LETTER [illegible] WHERE LEFT HAND THREAD IS REQUIRED.
ADD [illegible] LETTER [illegible] WHEN LUBRICATION [illegible] REQUIRED.

EXAMPLE OF PART NUMBER: MS21221-4AKL - BEARING, ROD END, ROLLER, SELF ALIGNING, EXTERNAL THREAD, .250 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).

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 RADIAL | LIMIT LOAD RATING AXIAL | DYNAMIC RADIAL LOAD RATING | WT LB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | .43 | .2500 | [illegible] | 3/8-24 | 1.22 | .36 | 1.6[illegible] | .015 | .500 | 250[illegible] | [illegible] | 2250 | .1[illegible] |
| 5 | .56 | .3125 | 1.3[illegible] | 7/16-20 | 1.91 | .34 | .8[illegible] | | .593 | 3650 | 315 | [illegible] | .13 |
| 6 | .66 | .3750 | 1.6[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-7493, 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 4/, IN ACCORDANCE WITH ANSI B46.1-1962

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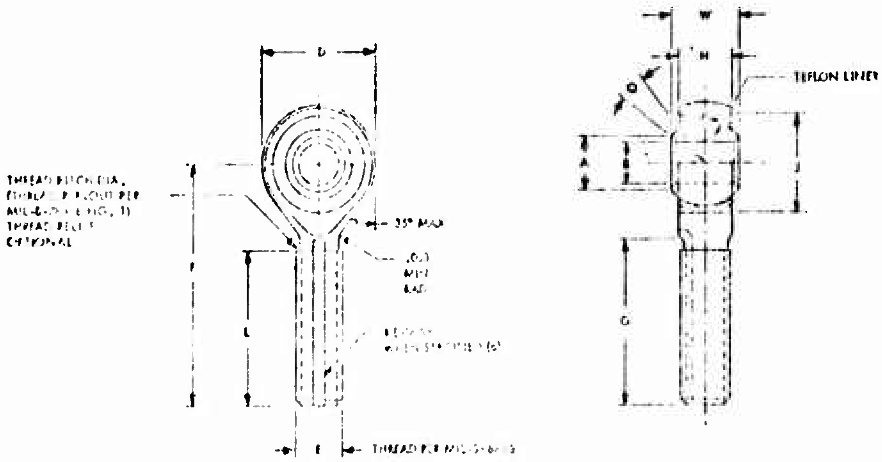
SUB-NOTE 7(8) (Sheet 1 of 2 Sheets) External Thread TFE-Lined Plain Bearing Rod Ends (MS21242)




| [illegible] | 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] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .625 | 15 |
| 4 | [illegible] | | | | | | | | | | |
| 5 | .3125 | [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] | 7/16-20 | [illegible] | .562 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 8 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | .61 | [illegible] | [illegible] | 5 |
| 10 | [illegible] | [illegible] | [illegible] | 5/8-18 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 12 |
| 12 | [illegible] | [illegible] | [illegible] | 3/4-16 | [illegible] | [illegible] | [illegible] | .85 | [illegible] | [illegible] | 11 |
| 14 | [illegible] | [illegible] | [illegible] | 7/8-14 | [illegible] | [illegible] | .765 | [illegible] | [illegible] | [illegible] | 6 |
| 16 | 1.0000 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 2.424 | [illegible] | 12 |

(*) WHEN SPECIFIED, KEYWAY SHALL BE IN ACCORDANCE WITH NAS 559 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] | 1000 | .072 | .5 | 6 |
| 4 | 3,420 | 4,840 | [illegible] | 1000 | | | |
| 5 | 3,590 | [illegible] | [illegible] (d) | 1100 | .087 | 1 | 10 |
| 6 | 5,150 | [illegible] | [illegible] | 1600 | .136 | | |
| 7 | 6,190 | 12,000 | [illegible] | 1850 | .183 | | |
| 8 | 8,370 | [illegible] | [illegible] (d) | 2040 | .278 | | |
| 10 | 13,700 | [illegible] | [illegible] | 2400 | .424 | | |
| 12 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | |
| 14 | [illegible] | 34,500 | [illegible] | [illegible] | .563 | 2 | 16 |
| 16 | 25,600 | [illegible] | [illegible] | 4345 | 2.545 | | |

(c) BASED ON BOLT BENDING FATIGUE STRENGTH [illegible] PSI
(d) SHANK LIMITATION

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

PLATING: ALLOY STEEL, CADMIUM PLATING QQ-P-416, TYPE I, CLASS 2
HARDNESS:
ROD END BODY: 17-4 [illegible]
[illegible]
PASSIVATION: [illegible] STEEL, QQ-P-35, TYPE II OR III
SURFACE FINISH: [illegible]
[illegible] SURFACES, RHR 125 MAX
HEAT TREATMENT: [illegible] 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: 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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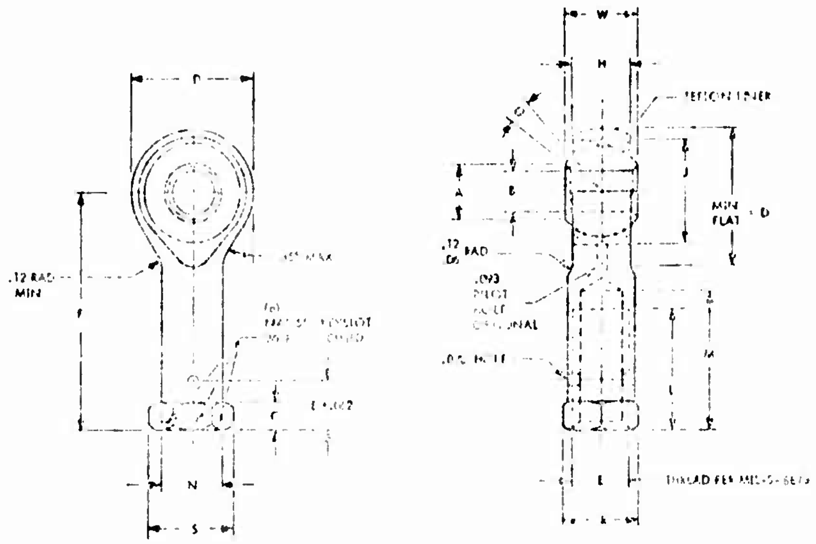
SUB-NOTE 7(9) (Sheet 1 of 2 Sheets) Internal Thread TFE-Lined Plain Bearing Rod Ends (MS21243)




| DASH NO. | B +.0000 -.0005 | D DIA. +.010 | L COMPLETE THREAD MIN. | E THREAD SIZE UNJF-3B | F +.010 | N? SHANK DIA. +.010 | W BALL WIDTH +.000 -.002 | H BODY WIDTH +.005? | A? MIN. | J MIN. | M MAX. | C? +.010 -.062? | K? +.002 -.010 | G° MIN. | S REF ACROSS CORNERS CIR. DIA. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | .1900 | .808 | .750 | 5/16-24 | 1.3[illegible] | .422 | .437 | .337 | | .6250 | .875 | .108 | .437 | 15 | .500 |
| 4 | .2500 | | | | 1.4[illegible] | | | | | | | | | | |
| 5 | .3125 | .900 | .875 | 3/8-24 | 1.[illegible] | [illegible] | | .327 | [illegible] | [illegible] | 1.000 | .250 | .500 | 14 | [illegible] |
| 6 | .3750 | 1.[illegible] | 1.000 | | [illegible] | .547 | .510 | .415 | .47 | [illegible] | 1.[illegible] | | [illegible] | 8 | [illegible] |
| 7 | .4375 | 1.1[illegible] | 1.12[illegible] | [illegible] | 2.[illegible] | [illegible] | [illegible] | .452 | .54 | [illegible] | 1.[illegible] | | [illegible] | [illegible] | [illegible] |
| 8 | .5000 | 1.[illegible] | 1.[illegible] | [illegible] | 2.[illegible] | .735 | .[illegible] | [illegible] | .61 | 1.[illegible] | 1.[illegible] | | [illegible] | [illegible] | [illegible] |
| 10 | .6250 | 1.[illegible] | 1.375 | [illegible] | 2.[illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 1.[illegible] | 1.500 | [illegible] | .875 | [illegible] | 1.0[illegible] |
| 12 | .7500 | 1.775 | 1.625 | 3/4-16 | [illegible] | [illegible] | .675 | [illegible] | [illegible] | 1.3[illegible] | 1.[illegible] | | 1.000 | [illegible] | 1.160 |
| 14 | .8750 | 2.[illegible] | 1.[illegible] | 7/8-14 | 3.[illegible] | 1.[illegible] | [illegible] | .765 | 1.00 | 1.6[illegible] | 2.062 | .500 | 1.[illegible] | 6 | 1.[illegible] |
| 16 | 1.0000 | 2.775 | 2.125 | 1-1/4-12 | 4.125 | 1.[illegible] | 1.375 | 1.015 | 1.27 | 2.1250 | 2.312 | .5[illegible] | 1.7[illegible] | 12 | 2.[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 (c) | 1000 | [illegible] | .5 | 6 |
| 4 | 3,470 | 4,[illegible] | 2,3[illegible] | 1000 | .064 | | |
| 5 | 3,590 | 7,1[illegible] | 3,02[illegible] | 1100 | .102 | 1 | 10 |
| 6 | [illegible],120 | 8,55[illegible] | 3,5[illegible] | [illegible] | .161 | | |
| 7 | [illegible],130 | 1[illegible] | 4,3[illegible] | 1850 | .212 | | |
| 8 | 8,370 | 1[illegible] | [illegible] | 2[illegible] | .325 | | |
| 10 | 1[illegible] | [illegible] | [illegible] | [illegible] | .4[illegible] | | |
| 12 | 13,20[illegible] | [illegible] | 1[illegible] | [illegible] | [illegible] | | |
| 14 | 1[illegible] | 34,5[illegible] | [illegible] | [illegible] | .9[illegible] | 2 | 16 |
| 16 | [illegible] | [illegible] | [illegible] | [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-S-5[illegible] 4[illegible]
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, $R_c$ 32-44
4340, $R_c$ 3[illegible]-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 (last) — ADD L FOR LEFT HAND THREAD WHEN SPECIFIED
- X — KEYWAY (CODE K) WHEN SPECIFIED
- XX — BORE DIAMETER CODE IN MULTIPLES OF 1/16 INCH
- X (first) — 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

$\theta$ = 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

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

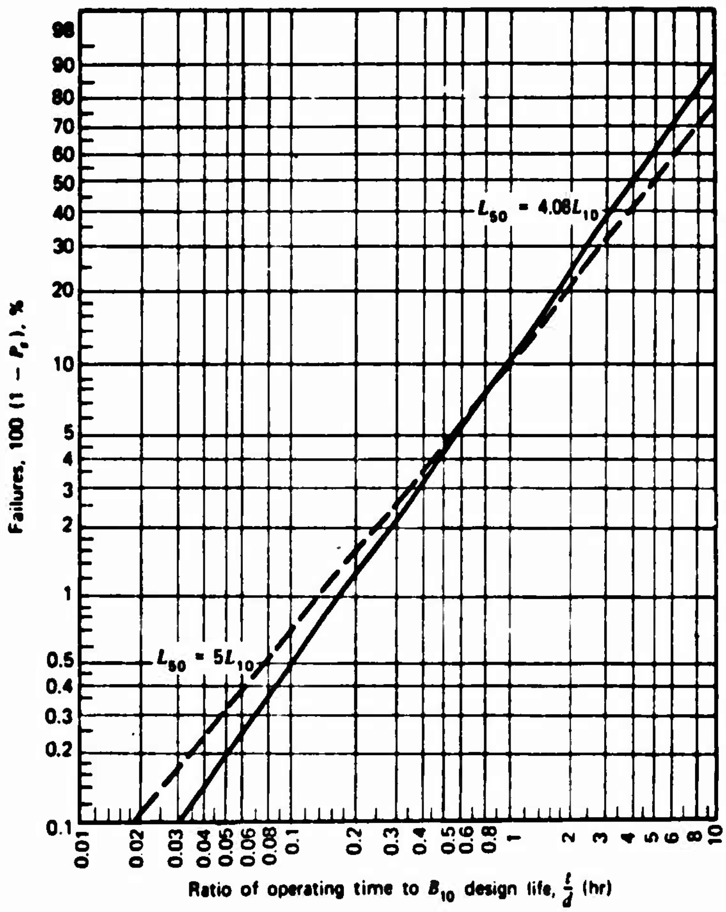


**Fig. 1** Weibull plot of operating life of bearings. From E. Schube (4)

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

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

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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 = 4.08$d$ | $t/d$ for median life = 5$d$ |
| 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,

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

For a ratio of median to rating life of 5, and Ps = 0.50 and 0.10, $\theta$ 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,

$$\frac{Re}{C} = \frac{1.893}{0.333} \left(Ln \frac{1}{Ps}\right)^{0.285} \qquad (6)$$

for roller bearings

$$\frac{Re}{C} = \frac{1.780}{0.3} \left(Ln \frac{1}{Ps}\right)^{0.257} \qquad (7)$$

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

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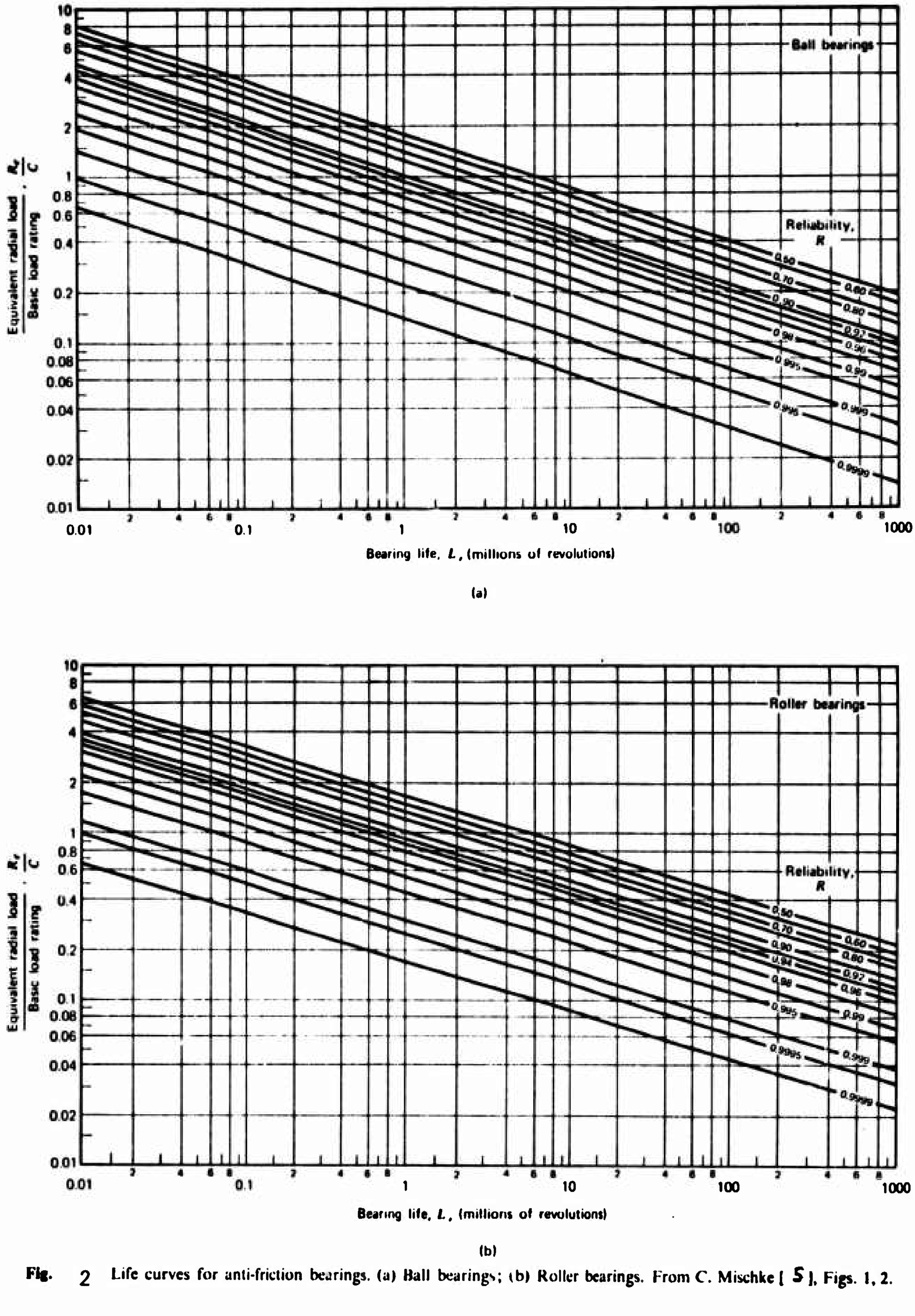


Fig. 2 Life curves for anti-friction bearings. (a) Ball bearings; (b) Roller bearings. From C. Mischke [5], Figs. 1, 2.

## Bibliography


1. Carl C. Osgood, Fatigue Design, Wiley-Interscience, 1970

2. The Bardon Corporation, Engineering Catalogue 6-3, Danbury, Conn. 1962

3. J. Lieblein and M. Zelen, "Statistical Investigation of the Fatigue Life of Deep Groove Ball Bearings", J. Res. Natl Bur Std. (U. S.) Vol 57, No. 5 Research Paper 2719, November 1956

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

5. C. Mischke, "Bearing Reliability and Capacity", Machine Design, 139-40, September 30, 1965

6. T. A. Hams, "Predicting Bearing Reliability", Machine Design, 129-32, January 3, 1963

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.

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 inadvertent 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

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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