INCH-POUND

MIL-B-81793D
15 March 1993
SUPERSEDING
MIL-B-81793C (IN PART)
25 September 1987
(See 6.6.)

MILITARY SPECIFICATION

BEARINGS, BALL, ANNULAR, FOR INSTRUMENTS AND PRECISION ROTATING COMPONENTS

1. SCOPE

1.1 Scope. This specification covers annular ball bearings intended primarily for use in instruments and precision rotating components.

1.2 Classification. Bearings, ball, annular, for instruments and precision rotating components shall be of the following types, as specified:

Bearing, ball, annular, for instruments and precision rotating components, deep groove, unflanged;

Bearing, ball, annular, for instruments and precision rotating components, deep groove, flanged;

Bearing, ball, annular, for instruments and precision rotating components, deep groove, unflanged, inner ring extended;

Bearing, ball, annular, for instruments and precision rotating components, deep groove, flanged, inner ring extended;

Bearing, ball, annular, for instruments and precision rotating components, angular contact, unflanged, non-separable and counterbored outer ring;

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer, Naval Air Engineering Center, Systems Engineering and Standardization Department (Code 53), Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 3110

Bearing, ball, annular, for instruments and precision rotating components, angular contact, flanged, non-separable and counterbored outer ring on flange side;

Bearing, ball, annular, for instruments and precision rotating components, angular contact, unflanged, separable and stepped inner ring (see 6.8.3);

Bearing, ball, annular, for instruments and precision rotating components, angular contact, flanged, separable and stepped inner ring;

Bearing, ball, annular, for instruments and precision rotating components, angular contact, unflanged, non-separable and stepped inner ring.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and Standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

P-D-680	Dry Cleaning and Degreasing Solvent.
QQ-S-763	Steel Bar, Wire, Shape and Forging, Corrosion-resisting.
QQ-S-766	Steel Plate, Sheet and Strip, Corrosion-resisting

MILITARY

MIL-P-197	Packaging Of Anti-Friction Bearings, Associated Parts And Subassemblies.
MIL-L-6085	Lubricating Oil, Instrument, Aircraft, Low Volatility.
MIL-G-23827	Grease, Aircraft and Instrument, Gear and Actuator Screw, NATO Code G-354, Metric.
MIL-S-81087	Silicone fluid, Chlorinated Phenyl Methyl Polysiloxane.
MIL-G-81322	Grease, Aircraft, General Purpose, Wide Temperature Range.
MIL-B-81744	Barrier Coating Solution, Lubricant Migration Deterring.
MIL-L-81846	Lubricating Oil, Instrument, Ball Bearing, High Flash Point.
MIL-G-81937	Grease, Instrument, Ultra Clean, Metric.

MIL-G-83261	Grease, Aircraft, Extreme Pressure, Anti-Wear.

(See Supplement 1 for list of associated specification sheets.)

STANDARDS

FEDERAL

FED-STD-209	Clean Room and Work Station Requirements, Controlled Environment.
FED-STD-791	Lubricants, Liquid Fuel and Related Products, Methods of Testing.

MILITARY

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-129	Marking for Shipment and Storage.
MIL-STD-206	Friction Torque Testing for Instrument Ball Bearings.
MIL-STD-1334	Process for Barrier Coating of Anti-friction Bearings.
MIL-STD-1647	Identification Markings for Domestically Manufactured Miniature and Instrument Ball bearings.
MIL-STD-45662	Calibration Systems Requirements

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Department of Defense Single Stock Point, DODSSP-Customer Service, Standardization Document Order Desk, 700 Robbins Avenue, Bldg 4D, Philadelphia, PA 19111-5094).

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the documents cited in the solicitation.

American National Standards Institute

ANSI/ASME B46.1	Surface Texture (Surface Roughness, Waviness and Lay).
ANSI/ASME B89.3.1	Measurement of Out of Roundness

(Application for copies should be addressed to the American National Standards Institute, 11 West 42nd Street, New York, NY 10036-8002).

American National Standards Institute (ANSI)/Anti-Friction Bearing Manufacturer's Association (AFBMA)

ANSI/AFBMA STD 10	Metal Balls.
ANSI/AFBMA STD 12.2	Instruments Ball Bearings - Inch Design.

ANSI/AFBMA STD 1 Terminology For Anti-Friction Ball And Roller Bearings And Parts.

(Application for copies should be addressed to the Anti-Friction Bearing Manufacturer's Association, Inc., 1101 Connecticut Ave. NW, Suite 700, Washington, DC 20036.)

International Standardization Organization

ISO 3290 Metal Balls.
ISO 1224 Instrument Ball Bearings.

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018.)

American Society for Testing and Materials

ASTM A-313	Specification for Chromium-Nickel Stainless and Heat-Resisting Steel Spring Wire.
ASTM A-380	Practice for Cleaning and Descaling Stainless Steel Parts, Equipment, and Systems.
ASTM A-580	Specification for Stainless and Heat Resisting Steel Wire rods.
ASTM D-2273	Lubricating Oil, Trace Sediment in.
ASTM E-45	Practice for Determining the Inclusion Content of Steel.
ASTM E-140	Standard Hardness Conversion for Metals (Relationship between Brinell Hardness, Vickers Hardness, Rockwell Hardness, Rockwell Superficial Hardness and Knoop Hardness).

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103).

Society of Automotive Engineers

(Aerospace Materials Specification for Flight Vehicle Construction (AMS)

AMS	2303	Aircraft Quality Steel Cleanliness, Martensitic Corrosion-Resistant Steels, Magnetic Particle Inspection Procedure.
AMS	6444	Steel Bars, Forgings, and Mechanical Tubing, 1.45 Cr (0.98-1.10C) (SAE 52100) Premium Aircraft Quality Consumable Electrode Vacuum Melted.

(Application for copies should be addressed to the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.)

2.3 Order of precedence. In the event of a conflict between text of this document and the references cited herein (except for the specification sheets) the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between the requirements of this specification and the specification sheet, the latter shall govern.

3.2 First article. When specified, (see 6.3 and 6.4) a sample shall be subjected to First article inspection in accordance with 4.6.

3.3 Materials.

3.3.1 Ball and ring materials. Balls and rings shall be made of corrosion resistant steel, 440C (UNS S44004), conforming to QQ-S-763 or chromium-alloy steel 52100 (UNS G52986) conforming to AMS 6444 as specified by the applicable specification sheets. (Each specification sheet shall represent a single material).

3.3.1.1 Material cleanliness. 440C corrosion resistant steels used for production of balls and rings furnished under this specification shall have been inspected for relative cleanliness by either the magnetic particle inspection method specified in AMS 2303 or by the Jernkontoret (J-K) microcleanliness standard ASTM-E-45, commonly used by the bearing industry prior to manufacturing into component parts. When the J-K method is used, it shall be in accordance with Method A of ASTM-E-45. The allowable inclusion levels are listed in Table V. Chromium-alloy steel used for the production of bearings shall meet the cleanliness requirements of AMS 6444.

3.3.1.2 Passivation. Passivation shall be accomplished in accordance with ASTM A-380 on all bearing components fabricated from corrosion resistant steel after completion of all machining or metal removing operations and prior to assembly.

3.3.2 Retainer material. When corrosion resisting steel is specified, crown retainers shall be (UNS S41000) and ribbon retainers shall be either (UNS S30200) (UNS S30500) or (UNS S43000) in accordance with QQ-S-766. Configuration shall be as specified by the part number designator in Table II of the specification sheets.

3.3.3 Shield material. Shield material shall be corrosion resistant steel conforming to QQ-S-766.

3.3.4 Snap ring material. Snap ring material shall be corrosion resistant steel conforming to ASTM-A-313, Condition C.

3.3.5 Seal material. Seal materials shall be as specified by the part number designator in Table III of the specification sheets. Materials shall be compatible with and shall be resistant to deterioration due to lubricant, preservative, hydraulic fluid, solvents or other substances and chemicals that can be expected to come into contact with the bearing and shall cause no deterioration of the same. The materials shall not affect or be affected by the lubricants and solvents referred to in this specification. Synthetic rubber seals shall operate from -65°F (-54°C) to 230°F (110°C).

3.4 Design and construction. Bearings shall be of the design, construction and physical dimensions specified on the applicable specification sheet (see 3.1).

3.5 Closures. The number, type and locations of closures shall be as specified by the part number designator in table III of the specification sheets. Normal location for single closures shall be on either side of a symmetrical bearing or the flanged side of a flanged bearing.

3.5.1 Closure attachment. Closures shall be securely attached to the outer ring and shall permit removal and reinstallation using common bearing working tools. Snap ring wires are preferred, but "self-holding" closures are permitted provided they withstand service vibration conditions without becoming detached.

3.6 Visual requirements.

3.6.1 Surface appearance. Cylindrical mounting surfaces, lands and faces of inner and outer rings shall have a smooth finished appearance characteristic of one or more of the following processes: grinding, honing, lapping, polishing or tumbling. The surfaces shall be free of visible tool marks, chatter and waviness, scratches with raised metal, pits, rust or other surface imperfections. Metal retainers, snap rings, and closures shall have a smooth finished appearance characteristic of a tumbling process and shall be free of burrs, dents and folded material. Machined nonmetallic retainers shall be free of delaminations and shall be deburred.

3.6.2 Cracks and fractures. Rings, balls, retainers, snap rings and closures shall be free of cracks and fractures.

3.6.3 Material imperfections. Nonmetallic retainers shall have no material imperfections, such as chipping and pits, in ball contact areas and material imperfections in other areas shall not exceed 0.015 inch major dimension.

3.6.4 Particulate contamination. All exterior surfaces and interior areas of the bearing, shall be free of foreign particles visible using 10X magnification.

3.7 Dimensions.

3.7.1 Boundary dimensions. The boundary dimensions for each specification sheet shall be in accordance with Table I of that specification sheet.

3.7.2 Tolerance class. Tolerance classes for ABEC 5P or 7P shall be in accordance with the tolerance tables of ANSI/AFBMA Standard 12.2. The tolerance classes shall apply to all bearing sizes listed in Table I of the specification sheets.

3.7.3 Roundness. Raceways shall be round within the values specified in Table I of this specification when measured by MRS (minimum radial separation) method. This method consists of constructing two concentric circles, which fully encompass the polar trace of the measured surface and have the least possible radial separation. This radial separation is the measurement of out-of-roundness.

3.7.3.1 Roundness measurement. Roundness of cylindrical mounting surfaces shall be measured without closures installed.

3.7.4 Radial internal clearance. Radial internal clearance (radial play) of deep groove radial bearings shall be as specified by the part number designator in Table IV of the specification sheets.

3.7.5 Contact angle. The contact angle or radial internal clearance of angular contact bearings shall be as specified by the part number designator in Table IV of the specification sheets and reflects the unit of the appropriate method of measurement. The contact angle shall be as defined by ANSI/AFBMA Standard 1. A bearing offered with a singular contact angle shall obtain that value within plus or minus one and one half degrees when measured in accordance with 4.8.5.1

3.8 Performance test. The performance test shall be as specified by the part number designator in Table VI of the specification sheets.

3.8.1 Starting torque. Maximum starting torque, when specified, shall be in accordance with the appropriate values listed in Table III of this specification.

3.9 Ball quality. The minimum quality level of ball geometry and surface roughness for bearings of both ABEC tolerance levels shall be grade 10 for all bearings. The grade levels shall be as specified in ANSI/AFBMA Standard 10/ISO 3290.

3.10 Hardness of balls and rings. Through hardness of rings shall be Rockwell HRC58 to HRC65. Through hardness of balls shall be Rockwell HRC60 to HRC67. Through hardness of individual balls in any bearing shall not vary by greater than four points Rockwell HRC.

3.11 Surface roughness. Surface roughness of raceways shall not exceed two microinches arithmetic average (AA).

Surface roughness of mounting surfaces, cage piloted lands and faces shall not exceed 10 microinches AA. Surface roughness shall be measured in accordance with 4.8.9.

3.12 Dimensional stability. Rings and balls shall withstand temperature changes and exposures under test conditions of 4.8.10 with changes in diameter not exceeding the larger of the following:

Rings 0.000100 inch per inch or 0.000025 inch
Balls 0.000100 inch per inch or 0.000005 inch

3.13 Lubrication.

3.13.1 Lubricant. The lubricant shall conform to the specification specified by the part number designator in Table VII of the specification sheets. The lubricant shall be free of contamination (see 4.8.11.2).

3.13.2 Lubricant amount. The amount of lubricant required shall be as specified by the part number in Table VIII of the specification sheets.

3.13.3 Barrier coating. Barrier coating shall be applied to bearings when specified by the part number designator and Table VII of the specification sheets. The barrier coating shall be applied in accordance with MIL-STD-1334. The material used shall conform to MIL-B-81744.

3.13.3.1 Barrier coating facilities. The facilities used for the application of barrier coating shall conform to the requirements of MIL-STD-1334.

3.14 Marking of barrier coated bearings. Marking of barrier coated bearings shall be in accordance with MIL-STD-1334.

3.15 Marking for identification. Bearings shall be marked in accordance with MIL-STD-1647.

3.16 Calibration. Bearings shall be supplied in classified lots according to bore and outside diameter size in steps of 0.00005 or 0.00010 inch when specified by the part number designator in Table V of the specification sheets. For classification purposes, bore size shall be the smallest single bore measurement and OD shall be the largest single OD measurement.

3.17 Workmanship. The ball bearings, including all parts, shall be constructed and finished in a manner to insure compliance with the requirements of this specification. Particular attention shall be paid to marking of assemblies and freedom of parts from burrs and sharp edges.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or

purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the government to accept defective material (see 6.4).

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. First article inspection (see 4.6).
b. Quality conformance inspection (see 4.7).

4.3 Inspection area cleanliness. Inspection areas shall meet the cleanliness requirements of FED-STD-209 for class 10,000 area.

4.4 Measurement standards calibration. Measurement standards shall have calibrations in accordance with MIL-STD-45662.

4.5 Measurement temperature. Dimensional measurement made at other than the standard calibration temperature shall be corrected for temperature effects.

4.6 First article inspection. First article inspection shall be performed on sample bearings of the type and quantity specified by the contracting officer. The bearings shall be subjected to the tests specified in Table VI. Group I and Group II tests shall be performed on the entire sample. Two bearings shall be selected at random from the first article sample and subjected to Group III tests, and two other bearings from the same first article sample for Group IV tests (see 6.3 and 6.4).

4.6.1 First article approval. The sample bearings shall be submitted to a test facility designated by the government in the procurement document. The acquiring activity shall notify the bearing manufacturer of either acceptance or rejection of the first article sample upon completion of the testing and evaluation of the first article sample.

4.7 Quality conformance sample. A lot shall consist of all bearings of a particular identification number submitted for delivery at the same time. From each lot of assembled bearings, the Government quality assurance representative shall select a random sample in accordance with MIL-STD-105.

4.7.1 Quality conformance inspection. The sample shall be subjected to the applicable tests specified in Table VII.

4.7.2 Acceptance criteria. The lot shall be accepted or rejected in accordance with Acceptable Quality Levels (AQL's) for designated categories of defects shown in Table VIII. Defects observed in each category shall apply to that category only and defects shall be noncumulative.

4.8 Methods of inspection.

4.8.1 Material inspections. Material inspection methods shall be in accordance with the material specification.

4.8.2 Passivation tests. Passivation tests of corrosion resistant components shall be conducted in accordance with the Copper Sulfate Test of ASTM-380. Each component shall be examined under 10X magnification for evidence of copper deposit. The presence of copper deposit indicates failure.

4.8.3 Visual inspections. Inspection for conformance to the requirements of 3.6.1, 3.6.2, 3.6.3 and 3.6.4 shall be made using a 10X binocular microscope. All other visual inspections shall be made without magnification.

4.8.4 Dimensional inspections.

4.8.4.1 Boundary dimensions inspection. The bearing dimensions required in 3.7.1 and respective tolerance class required in 3.7.2 shall be measured in accordance with ANSI/AFBMA Standard 12.2 and ISO 1224.

4.8.4.2 Roundness measurements. Roundness measurements specifying MRS method microinch values (see paragraph 3.7.3) shall be made on equipment meeting ANSI Standard B89.3.1. Such equipment shall include means to provide a permanent recording on either strip or polar chart-type recorders.

4.8.5 Radial internal clearance. Radial internal clearance shall be measured with closures removed and the bearing lubricated with a thin film of oil. Gage pressure shall be the minimum required to overcome friction and weight of moving parts and to obtain repeatable readings. Radial internal clearance shall be the average of three measurements taken with each measurement utilizing a different position of the outer race. The measurements shall be made by comparison with a bearing of known radial play or by the method described in ANSI/AFBMA Standards 12.2 and ISO 1224.

4.8.5.1 Contact angle.(see 6.7.2) When the part number designator in Table IV of the specification sheets for angular contact bearings specifies a contact angle, the bearing shall be mounted in such a manner that no radial distortion is caused by an interference fit. The test fixture shall be set up to impart a net thrust not to exceed two pounds. The inner race or the outer race of the bearing shall be rotated at a constant speed while the speed of the retainer (rolling element pitch diameter) is determined. The number of revolutions of

the retainer shall be counted when either the inner or the outer race is rotated twenty full times. Diametric values shall be determined and recorded for use in the following applicable formulas:

ROTATING INNER RACE

$$\beta = \cos^{-1}\left[\frac{E}{D}\left[1 - \frac{2Ne}{Ni}\right]\right]$$

ROTATING OUTER RACE

$$\beta = \cos^{-1}\left[\frac{E}{D}\left[\frac{2Ne}{Ni} - 1\right]\right]$$

Ne = rpm of pitch circle
Ni = rpm of rotating inner race
No = rpm of rotating outer race
E = pitch diameter
β = contact angle
d = ball diameter

4.8.6 Torque tests.

4.8.6.1 Pretest condition of bearings. The bearings shall be prepared for the torque tests as follows: Bearings shall be degaussed and cleaned thoroughly with solvents filtered with a 0.5 micron or better filter; The bearings shall then be lubricated with MIL-L-81846 or MIL-L-6085 in accordance with Table II, after which the bearings shall be rotated slowly for a minimum of five full revolutions in both directions to distribute the oil evenly.

4.8.6.2 Performance test. Performance test values shall be determined in accordance with MIL-STD-206.

4.8.6.3 Starting torque test. Starting torque test method shall be in accordance with MIL-STD-206.

4.8.7 Ball quality inspections. Ball diameter measurements shall be based on comparative measurements with master balls. The measurements of master balls and balls being tested shall be made at the same temperature and with the same gage pressure. If the master balls are of a different material than the balls being tested, readings shall be referred to zero gage pressure and a temperature of 68°F (20°C). Five measurements of the ball diameter in random orientations shall be made on each ball of the bearing. Ball diameter shall be the average of the five measurements. Conformance to the ball quality requirements specified in ANSI/AFBMA Standard 10 shall be verified by 4.8.7.1 and 4.8.7.2.

4.8.7.1 Diameter variations per ball. Five measurements of the diameter shall be made in random orientations of each ball in the bearing. The differences between the maximum diameter measured and the minimum diameter measured on each ball is the maximum diameter variation of that ball.

4.8.7.2 Ball diameter variation per bearing. Five measurements of the diameter shall be made in random orientations of each ball in the bearing. The average diameter of each ball shall be computed by averaging the five measurements of that ball. The difference between the average diameter of the largest ball and the average diameter of the smallest ball in a bearing is the ball diameter variation of the bearing.

4.8.8 Hardness tests. The bearings selected for this test shall not be the same bearings used for the dimensional stability test. If, because of limited size of surface or for other valid reasons, Rockwell C scale measurements are not feasible, other methods of measuring hardness may be used, provided correlation with the Rockwell C scale measurement values is established. When lighter loads are used, conversion to Rockwell C shall be through the use of charts in ASTM E-140. Hardness tests shall be made on flat surfaces.

4.8.9 Surface roughness tests. Measurements from less than one to 1,000 microinches shall be made with equipment meeting the requirements of ANSI/ASME B46.1. Such equipment shall allow measurements on most surfaces including fine finished or soft materials. The equipment shall include means to provide permanent strip or polar chart-type recordings. Minimum cut-off wavelength shall be determined by dividing width of surface to be measured by 10 and selecting next lowest preferred cut-off wavelength either 0.001, 0.003, 0.01 or 0.03 inches. In deep groove raceways, the width of the surface is the distance from the bottom of the race to either land corner.

4.8.10 Dimensional stability tests. The dimensional stability of the rings and balls of two bearings shall be demonstrated by the following tests: The rings and balls shall be subjected to a temperature of -80°F (-62°C) for 25 hours. Immediately following, the parts shall be subjected to a temperature of 302°F (150°C) for a total of 100 hours. Diameters shall be measured at 68°F (20°C) and compared to values recorded before temperature cycling.

4.8.11 Lubricant inspections.

4.8.11.1 Lubricant. Conformity to a lubricant specification shall be verified by analysis with an infrared spectrometer.

4.8.11.2 Lubricant contamination tests. All tests shall be performed in a FED-STD-209, Class 100 environment. Sample bearings shall be tested for lubricant contamination by the following procedure: When required by contract, the bearing supplier shall take three random samples from the lubricating fixture or container or lubricant if a fixture is not used, at the time bearings are lubricated. Samples of grease shall be prepared and read for dirt count in accordance with

FED-STD-791, Method 3005. Samples of oil shall be prepared and read for dirt count in accordance with FED-STD-791, Method 3004 or ASTM D-2273. The bearings supplier shall maintain the sample and inspection report for examination by the Government's representative and shall certify that the sample was taken from the lubricant used to lubricate the bearings.

4.8.11.3 Barrier coat inspection. Barrier coated bearings shall be inspected in accordance with MIL-STD-1334.

4.8.12 Calibration inspection. Bore and OD measurements of 4.8.4.1 shall be used to verify conformance to calibration requirements. Individual measurements as specified in 3.16 shall be used rather than average values.

4.8.13 Inspection of packaging. The sampling and inspection of the preservation, packing and container marking shall be in accordance with the requirements of MIL-P-197.

5. PREPARATION FOR DELIVERY

5.1 General. The cleaning, drying, packaging, packing and marking of bearings procured to this specification shall be in accordance with the various requirements of MIL-P-197. Where MIL-P-197 options are listed, the contract or purchase order shall cite the definite method.

5.1.1 Preservation and packaging. If level A for packaging is specified, the contract or purchase order shall cite the appropriate method or symbol in accordance with MIL-P-197, method IA-8. Preservation shall be levels A, or C as specified (see 6.2).

5.1.2 Packing. Bearings shall be packed in accordance with MIL-P-197 levels A, or C as specified (see 6.2).

6. NOTES

6.1 Intended use. Ball bearings defined by this specification are intended for use in critical components of instrument systems. Such components range from air circulating blowers and drive motors through precision gear trains, gyro gimbals and pick-offs to rate integrating spin-motors.

6.2 Acquisition requirements. Procurement documents must specify the following:

a. Title, number, and date of the specification.
b. Quantity and part identifying number (PIN) of the bearing required.
c. Levels of packaging (see 5.1.1) and packing (see 5.1.2) required.
d. The laboratory that will conduct tests (see 4.6.1).
e. Ring, ball, retainer and closure materials.
f. Number, type and location of closures.
g. Boundary dimensions.
h. Bearing precision level (ABEC tolerances).
i. Radial internal clearance or contact angle.
j. Type and amount of lubricant.
k. Barrier coating requirements.
l. Performance tests required.

6.2.1 Envelop dimension size availability. The listing of a particular envelop dimension size of a bearing in a specification sheet does not guarantee availability from every manufacturer. Shields or seals, for instance, may not be available on the thinner widths of a particular bore and O.D. Recommend verification of availability from industry sources prior to assignment of PIN.

6.2.2 Test facilities. A test facility should be designated by the acquiring activity when first article testing is required.

6.3 First article. When first article inspection is required, the bearings should be tested and should be a first article sample (see 3.2). The first article should consist of the samples specified in 4.6. The contracting officer should include specific instructions in acquisition documents regarding examinations, tests and approval of first article.

6.3.1 First article provision. When first article samples are required, the manufacture of bearings on the contract should not commence until the samples submitted are pronounced satisfactory by the acquiring activity. The submission of further first article samples on subsequent contracts may be waived at the discretion of the acquiring activity. Approval of first article samples or the waiving of first article tests does not eliminate the requirements of quality conformance inspection.

6.3.2 First article information. It should be understood that the bearings supplied under contract should be identical to the corresponding first article sample in material design, construction, quality, workmanship and method of manufacture. Deviation from the standards of first article sample should be made only by the acquiring activity. Evidence of unauthorized change should constitute cause for rejection.

6.4 Consideration of data requirements. The following data requirements should be considered when this specification is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to insure that only essential data are requested/provided that the DID's are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DOD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

Reference Paragraph	DID Number	DID Title	Suggested Tailoring
4.6	DI-NDTI-80809	Test/Inspection Reports	Use Contractor Format
4.1.1	DI-MDTI-80809	Test/Inspection Reports	Paragraph 10.2.7

The above DID's were those cleared as of the date of this specification. The current issue of DOD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD form 1423.

6.5 Subject term (key word) listing.

ABEC 5P
ABEC 7P
Angle, contact
Angular contact
Barrier coating
Bearing, instrument Bearing, precision
Calibration (classification)
Counterbored outer ring
Non-separable
Passivation
Radial, deep groove
Ring, inner, extended
Separable
Stepped inner ring
Torque, starting
Void, bearing

6.6 Inch-pound specification. This document supersedes only the inch-pound bearings specified by MIL-B-81793C. See MIL-B-913 for coverage of the metric bearings specified by MIL-B-81793C.

6.7 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to previous issues due to the extensiveness of the changes. A cross reference of revision D Part or Identifying Number (PIN) to revision C PIN's was not developed because of the extensive changes.

6.8 Definitions.

6.8.1 Bearing void. The volume between the inner and outer rings minus the volume of the balls and retainer.

6.8.2 Contact Angle. Angular contact bearings are characterized by a relieved (counterbored outer ring or stepped inner ring) surface which permits inclusion of a greater number of balls. This enables the bearing to sustain a thrust load in addition to increased radial capacity. Some applications require only that the unloaded angular contact bearing be manufactured with a specific radial clearance range and no measurement is made of the obtained contact angle. Other applications require that the contact angle be confined to a narrow (3 degree total) range which is accurately measured.

6.8.3 Stepped inner ring. The inner ring of a groove ball bearing with one shoulder completely or partially removed.

6.9 Clean grease. Normal components of clean grease may appear as particulate contamination when viewed under 10X magnification. Recommend that greased bearing surface inspections be compared with pictures or samples of the same grease obtained from a clean room.

6.10 Part number. The part number is developed by selecting a characteristic from each of the tables in a specification sheet.

EXAMPLE: M81793/XX - XX X X X X X X X

TABLE I. SURFACE ROUNDNESS.

PRECISION LEVEL (ABEC)	RACEWAYS (MICROINCHES)
5	50
7	40

TABLE II. STANDARD LUBRICANT QUANTITIES.

Standard Oil Quantities - Drops #26 BD needle

Standard Grease Quantities (mm)^3 Based on 25% ± 3% Fill

1/ Ball Diam	Number of Balls																																					
	5					6					7					8					9					10					11					12				
	0	G				0	G				0	G				0	G				0	G				0	G				0	G				0	G			
		A	B	C	D		A	B	C	D		A	B	C	D		A	B	C	D		A	B	C	D		A	B	C	D		A	B	C	D		A	B	C	D
.025	*	**	**	**	**	*	**	**	**	**	*	**	**	**	**	*	**	**	**	4	*	**	**	4	6	1	**	4	6	7	1	**	5	7	9	1	4	6	9	12
1/32	*	**	**	**	**	*	**	**	**	4	*	**	**	4	5	1	**	4	6	7	1	**	5	8	10	1	6	7	10	13	1	5	9	13	16	1	7	11	16	20
1 mm	*	**	**	**	4	1	**	4	5	6	1	**	5	7	9	1	4	7	10	13	1	6	10	14	17	1	8	13	18	23	2	10	16	22	29	2	12	20	29	36
1/16	1	4	7	10	13	2	7	11	16	20	2	10	16	23	30	2	14	23	32	41	2	19	31	43	56	2	24	40	56	72	3	31	51	71	92	3	38	63	89	114
3/32	2	12	20	27	35	3	19	31	43	56	3	27	45	64	82	3	38	63	89	116	3	51	85	119	153	3	66	111	115	199	4	84	140	197	253	4	105	175	244	314
1/8	3	24	40	56	72	3	38	63	89	116	3	56	93	130	168	3	78	130	182	234	3	104	175	244	314	3	136	227	318	409	4	173	288	404	519	4	215	358	502	645
9/64	3	32	54	75	97	4	51	85	119	153	4	75	125	175	225	4	105	175	244	316	4	141	234	328	421	4	183	305	427	549	4	232	387	542	697	4	289	481	674	865
5/32	3	42	70	98	126	4	66	111	155	199	4	98	163	228	293	4	136	227	318	409	4	183	305	427	549	4	238	397	556	714	4	302	504	705	907	4	376	626	877	1127
3/16	4	66	111	155	199	4	105	175	244	314	4	156	257	359	462	4	215	358	502	645	4	289	481	674	866	4	376	626	877	1127	5	477	795	1112	1430	5	593	988	1383	1778
7/32	4	98	163	228	293	4	154	257	359	462	4	226	377	528	679	4	316	527	738	948	5	424	707	990	1273	5	552	920	1289	1657	5	701	1168	1635	2103	5	871	1452	2033	2614

* Oil: Lubricate bearing with one drop of 50/50 mixture by volume of oil and solvent (P-D-680, Type I) and allow solvent to evaporate. (The properties of the oil shall not change after evaporation of the solvent). Minimum quantity for Gimbal Bearings (1 Drop). Minimum quantity for Spin Axis Bearings (3 Drops).

1/ Except for 1 mm, all ball diam sizes are inch units and reflect unit of measure of ball sizes supplied with metric instrument bearings.

** Grease: All items so marked do not indicate a percentage of fill. Bearings of this type shall be grease plated to yield the desired results for the required application.

Grease Quantity Codings:

Code	% Fill
A	15
B	25
C	35
D	45

Grease: Use 80% of Code B grease figures for machined non-metallic cages.

Basis for calculations of Code B (25%) grease

Vol = 0.04 (nd) 2.5 (mm)^3
n = number of balls
d = diameter of balls
mm = millimeters

Round off calculated volumes to nearest whole number.

Volume to Weight Conversion.
Volume in cubic millimeters x specific gravity of required grease = weight in milligrams.

TABLE III. STARTING TORQUE LIMITS

Bearing Size (millimeters)		Load (grams)	Maximum Starting Torque (milligram-millimeters) 1/		
Bore Dia.	Outside Dia.		Radial Internal Clearance (Micrometers)		
d	D		2 to 7	7 to 12	12 to 20
1.5	5	75	1800	1500	1400
2.0	5	75	1800	1500	1400
2.0	6	75	1800	1500	1400
2.5	6	75	1800	1500	1400
2.5	7	75	1800	1500	1400
3.0	7	75	1800	1500	1400
3.0	10	400	5000	4500	4200
4.0	9	400	5000	4500	4200
4.0	13	400	6500	5500	5000
4.0	16	400	7500	6500	6000
5.0	11	400	6500	5500	5000
5.0	16	400	7500	6500	6000
5.0	19	400	8000	7000	6500
6.0	13	400	6000	5200	4800
6.0	19	400	8000	7000	6500
7.0	14	400	6000	5200	4800
7.0	19	400	8100	7100	6600
7.0	22	400	11000	9500	9000
8.0	19	400	10600	9100	8600
8.0	22	400	11000	11000	11000
8.0	24	400	11000	9500	9000
9.0	20	400	10800	9300	8800
9.0	26	400	11000	9500	9000
10.0	26	400	11200	9800	8800
10.0	30	400	14000	12000	10111

1/ Values in metric units in accordance with standard industry test instrument calibration.

TABLE V. MICROCLEANLINESS "J-K" RATINGS 440C STEEL AND INCLUSION TYPES.

INCLUSION TYPES							
"A" Sulfide		"B" Alumina		"C" Silicate		"D" Globular Type Oxides	
*1 T	*2 H	T	H	T	H	T	H
2.0	2.0	2.5	2.0	2.5	2.0	2.0	2.0

*1 "T" Thin
*2 "H" Heavy

TABLE VI. FIRST ARTICLE INSPECTION.

Inspection	Requirement Paragraph	Test Paragraph
GROUP I		
Design and construction	3.4	4.8.3
Retainer material	3.3.2	4.8.3
Closures	3.5	4.8.3
Closure attachment	3.5.1	4.8.3
Surface appearance	3.6.1	4.8.3
Cracks & fractures	3.6.2	4.8.3
Material imperfections	3.6.3	4.8.3
Particulate contaminations	3.6.4	4.8.3
Workmanship	3.17	4.8.3
Barrier coating	3.13.3	4.8.11.3
Marking for identification	3.15	4.8.3
GROUP II		
Boundary dimensions	3.7.1	4.8.4.1
Radial internal clearance	3.7.4	4.8.5
Contact angle	3.7.5	4.8.5.1
Performance test	3.8	4.8.6.2
Starting torque	3.8.1	4.8.6.3
Calibration	3.16	4.8.12
GROUP III		
Passivation	3.3.1.2	4.8.2
Roundness	3.7.3	4.8.4.2
Ball quality	3.9	4.8.7, 4.8.7.1, 4.8.7.2
Hardness of balls & rings	3.10	4.8.8
Surface roughness	3.11	4.8.9
Dimensional stability	3.12	4.8.10
Lubricant	3.13.1	4.8.11.1
Lubricant cleanliness	3.13.1	4.8.11.2
GROUP IV		
Ball and ring material	3.3.1	4.8.1
Material cleanliness	3.3.1.1	4.8.1
Shield material	3.3.3	4.8.1
Snap ring material	3.3.4	4.8.1
Seal material	3.3.5	4.8.1

TABLE VII. QUALITY CONFORMANCE INSPECTION.

Inspection	Requirement Paragraph	Test Paragraph
GROUP A		
Design and construction	3.4	4.8.3
Retainer material	3.3.2	4.8.3
Closures	3.5	4.8.3
Closure attachment	3.5.1	4.8.3
Surface appearance	3.6.1	4.8.3
Cracks & fractures	3.6.2	4.8.3
Material imperfections	3.6.3	4.8.3
Particulate contaminations	3.6.4	4.8.3
Workmanship	3.17	4.8.3
Barrier coating	3.13.3	4.8.11.3
Marking for identification	3.15	4.8.3
GROUP B		
Boundary dimensions	3.7.1	4.8.4.1
Roundness	3.7.3	4.8.4.2
Radial internal clearance	3.7.4	4.8.5
Contact angle	3.7.5	4.8.5.1
Performance test	3.8	4.8.6.2
Starting torque	3.8.1	4.8.6.3
Surface roughness	3.11	4.8.9
Calibration	3.16	4.8.12
GROUP C		
Passivation	3.3.1.2	4.8.2
Ball quality	3.9	4.8.7, 4.8.7.1, 4.8.7.2
Hardness of balls & rings	3.10	4.8.8
Dimensional stability	3.12	4.8.10
Lubricant	3.13.1	4.8.11.1
Lubricant cleanliness	3.13.1	4.8.11.2
GROUP D		
Ball and ring material	3.3.1	4.8.1
Material cleanliness	3.3.1.1	4.8.1
Shield material	3.3.3	4.8.1
Snap ring material	3.3.4	4.8.1
Seal material	3.3.5	4.8.1

TABLE VIII. CLASSIFICATION OF DEFECTS.

Category	AQL	Description of Defect	Requirement
Critical	0.65	Incorrect material	3.3.1 3.3.2 3.3.3
		Incorrect design and construction	3.4
		Incorrect retainer type	3.3.2
		Incorrect number, type or location of closures	3.5
		Closures not securely attached	3.5.1
		Cracks or fractures in any components	3.6.2
		Barrier coat on raceways, retainers, or ring lands	3.13.3
Major	1.0	Passivation	3.3.1.2
		Burrs, dents or folded material on closures	3.6.1
		Delamination or burring of non-metallic retainers	3.6.1
		Material break out of non-metallic retainers	3.6.3
		Particulate contamination	3.6.4
		Boundary dimensions	
		Outer ring outside diameter (OD)	3.7.1
		Outer ring OD out-of-round	3.7.2
		Outer ring OD taper	3.7.2
		Outer ring radial runout	3.7.2
		Outer ring width variation	3.7.2
		Outer ring OD runout with reference face	3.7.2
		Outer ring corner radii	3.7.1
		Outer ring OD/flange face undercut	3.7.2
		Inner ring bore diameter	3.7.1
		Inner ring bore out-of-round	3.7.2
		Inner ring radial runout	3.7.2
		Inner ring width variation	3.7.2
		Inner ring bore taper	3.7.2
		Inner ring bore runout with reference face	3.7.2
		Inner ring corner radii	3.7.1
		Radial internal clearance or contact angle	3.7.4 or 3.7.5
		Starting torque	3.8.1
		Ball quality	3.9
		Hardness of balls and rings	3.10
		Surface roughness of raceways	3.11
		Incorrect lubricant	3.13.1
		Barrier coating missing from required surface	3.13.3
		Calibration	3.16

TABLE VII. CLASSIFICATION OF DEFECTS. (Cont'd)

Category	AQL	Description of Defect	Requirement
Minor	2.5	Snap rings not easily removable	3.5.1
		Surfaces do not meet visual requirements	3.6.1 through 3.6.4
		Boundary dimensions	
		Outer ring width	3.7.1
		Outer ring flange width	3.7.1
		Outer ring flange OD	3.7.1
		Inner ring width	3.7.1
		Outer ring OD roundness	3.7.2 and 3.7.3
		Outer ring raceway roundness	3.7.2 and 3.7.3
		Inner ring bore roundness	3.7.2 and 3.7.3
		Inner ring raceway roundness	3.7.2 and 3.7.3
		Outer ring raceway runout to reference side	3.7.2
		Inner ring raceway runout to reference side	3.7.2
		Surface roughness of mounting surface, levels and surfaces	3.11
		Marking for identification	3.15

Custodians:
Army - AT
Navy - AS
Air Force - 99

Review activities:
Navy - SH
DLA - IS

User activities:
Navy - MC
Air Force - 84

Preparing activity:
Navy - AS

Agent:
DLA-IS

(Project 3110-0780)

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