INCH-POUND

MIL-DTL-17901C(SH)
10 May 2005

SUPERSEDING
MIL-B-17901B(SH)
AMENDMENT 3
12 December 1990

DETAIL SPECIFICATION

# BEARING COMPONENTS, BONDED SYNTHETIC RUBBER, WATER LUBRICATED

This specification is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

## 1. SCOPE

1.1 Scope. This specification covers stave shaped and cylindrical shaped bearings that have synthetic rubber facings.

1.2 Classification. Bearings are of the following classes, as specified (see 6.2):

1.2.1 Classes.

(Note: Class I replaced with class III).

Class II - Cylindrical bearing, with cylindrical shaped metal backing and internally molded rubber stave forms.

Class III - Stave bearing, nonmetallic backed.

Class IV - Cylindrical bearings, with cylindrical shaped nonmetallic backing and internally molded rubber stave forms.

Class V - Partial-arc bearing consisting of nonmetallic half cylinders with internally bonded rubber.

## 2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

FEDERAL SPECIFICATIONS

QQ-B-639 - Brass, Naval: Flat Products (Plate, Bar, Sheet, and Strip)

Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Sea Systems Command, ATTN: SEA 05Q, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to commandstandards@navsea.navy.mil, with the subject line "Document Comment". Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil

FEDERAL STANDARDS

FED-STD-791 - Lubricants, Liquid Fuels, and Related Products; Methods of Testing

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-P-18324 - Plastic Material, Laminated Phenolic, For Bearings (Water or Grease Lubrication)

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ or http://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation contract.

NAVSEA DRAWING

NAVSHIPS 803-1385664 - Bearings Stern Tube and Strut

(Copies of this document are available from Naval Inventory Control Point, 700 Robbins Avenue, Attn: Code 0862 (Cash Sales), Philadelphia, PA 19111, or www.nll.navsup.navy.mil.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

B74.12 - Specifications for the Size of Abrasive Grain – Grinding Wheels, Polishing and General Industrial Uses (DoD adopted)

(Copies of this document are available from the American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036 or online at www.ansi.org.)

ASTM INTERNATIONAL

B21 - Standard Specification for Naval Brass Rod, Bar, and Shapes (DoD adopted)

B584 - Standard Specification for Copper Alloy Sand Castings for General Applications (DoD adopted)

D256 - Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics (DoD adopted)

D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension (DoD adopted)

D471 - Standard Test Method for Rubber Property - Effect of Liquids (DoD adopted)

D570 - Standard Test Method for Water Absorption of Plastics (DoD adopted)

D638 - Standard Test Method for Tensile Properties of Plastics

D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D1141 - Standard Practice for the Preparation of Substitute Ocean Water (DoD adopted)

D2240 - Standard Test Method for Rubber Property - Durometer Hardness (DoD adopted)

D3183 - Standard Practice for Rubber - Preparation of Pieces for Test from Products (DoD adopted)

(Copies of these documents are available from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, or online at www.astm.org.)

INTERNATIONAL STANDARDS ORGANIZATION (ISO)

ISO 2230 - Rubber Products – Guidelines for Storage

(Copies of this document are available from ISO, 1, rue de Varembé, CH-1211 Geneva 20, Switzerland, or online at www.iso.org.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, 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 Qualification. The bearings furnished under this specification shall be products that are manufactured by a manufacturer authorized by the qualifying activity for listing on the applicable qualified manufacturers list before contract award (see 4.2 and 6.3).

3.2 Bearing material and identification. The following information shall be stamped on each bearing as follows:

a. Class II: Manufacturer identification, date of manufacture, size (outside diameter and inside diameter). The letters shall be at least $^{1}/_{10}$ inch in height; stamped, etched, or engraved; and readily visible to the unaided eye. The markings shall not interfere with the installation or performance of the bearing. Flanged bearings are marked on the end of the flange; sleeved bearings are marked on the outside diameter.

b. Class III: Manufacturer identification, use by month and year (i.e., 5-99), cross section size, and batch number, also special information such as "$^{1}/_{16}$ oversize" (for example: "RCN010A112 $^{1}/_{16}$ oversize"). The letters shall be at least ⅜ inch in height and readily visible to the unaided eye. Starting near one end of the stave the above information shall be stamped at 2-foot intervals along the back of the stave. The markings shall be on the back and not interfere with the installation or performance of the bearing.

c. Class IV: Manufacturer identification, date of manufacture, size (outside diameter and inside diameter). The letters shall be at least $^{1}/_{10}$ inch in height; permanent ink, stamped, etched, or engraved; and readily visible to the unaided eye. The markings shall not interfere with the installation or performance of the bearing. Sleeved bearings are marked on the outside diameter.

d. Class V: Manufacturer identification, date of manufacture, outside diameter, inside diameter, length, unique serial number with –1 or –2 for each half of a matched set. All information shall be permanent ink or engraved into the back of the bearing and shall be a minimum of ½ inch in height. The markings shall not interfere with the installation or performance of the bearing.

3.2.1 Physical requirements for bearing facing material. The facing material shall be a synthetic rubber compound and shall conform to the physical requirements in Table I.

TABLE I. Physical requirements for bearing facing material.

| Property | Units of measurement | Test in accordance with | Class II | Class III | Class IV | Class V |
|---|---|---|---|---|---|---|
| Tensile strength before aging | $LB/IN^2$ | Method A of ASTM D412 | 1500 min | 1500 min | 1500 min | 1500 min |
| Elongation before aging | Percent | Method A of ASTM D412 | 150 min | 150 min | 150 min | 150 min |
| Hardness | Instantaneous Shore A | ASTM D2240, Type A | 65 min<br>75 max | 80 min<br>90 MAX | 65 min<br>75 max | 80 min<br>90 max |
| Tensile strength after aging | $LB/IN^2$ | Method A of ASTM D412 | 1/ | 1/ | 1/ | 1/ |
| Elongation after aging | Percent | Method A of ASTM D412 | 1/ | 1/ | 1/ | 1/ |
| Surface finish | Microinches Ra | 4.5.2.1 | 64 max | 64 max | 64 max | 64 max |
| Volume change | Percent increase in volume | 4.6.4 | +5%, -0% | +5%, -0% | +5%, -0% | +5%, -0% |

1/ After being subjected to the oven aging test as specified in 4.6.2.1 the rubber material shall not vary more than 25 percent from the initial tensile strength and elongation.

3.2.2 Metal parts for class II bearings. Metal parts for class II bearings shall be casting or tubing. Casting and tubing shall be in accordance with the chemical requirements of UNS C85700, C90300, or C92200 according to ASTM B271, B505, or B584 (static, centrifugal, or continuous casting), or C46400 (ASTM B21 or QQ-B-639).

3.2.3 Nonmetallic backing for class III bearing staves, class IV cylindrical bearings, and class V partial-arc bearings. Non-metallic backing for class III bearing staves, class IV cylindrical bearings, and class V partial-arc bearings shall meet the physical requirements in accordance with Table II.

TABLE II. Physical requirements for nonmetallic backing.
(class III, class IV, and class V bearings only)

| Property | Units of measurement | Class III required test value | Class IV required test value | Class V required test value | Test in accordance with | Remarks |
|---|---|---|---|---|---|---|
| Hardness | Shore D | 64 min<br>85 max | 70 min<br>100 max | 70 min<br>100 max | ASTM D2240 | Sample size per Table VI |
| Tensile strength | $LB/IN^2$ | 3900 min | 24,000 min | 15,000 min in hoop direction<br>2500 min in axial direction1/ | ASTM D638 | ---- |
| Yield | $LB/IN^2$ | 2600 min | ---- | ---- | ASTM D638 | ---- |
| Flexural modules | Secant modules measured at a max 1 percent strain $LB/IN^2$ | 45,000 at 73 °F min | ---- | 1900000 min in hoop direction<br>500000 min in axial direction2/ | ASTM D790 | ---- |

TABLE II. Physical requirements for nonmetallic backing - Continued.
(class III, class IV, and class V bearings only)

| Property | Units of measurement | Class III required test value | Class IV required test value | Class V required test value | Test in accordance with | Remarks |
|---|---|---|---|---|---|---|
| Impact resistance | FT-LB/IN | 0.8 min | ---- | ---- | ASTM D256 | 10 Samples tested with Method "A" and A 45-degree notch |
| Water absorption | Percent of specimen volume | 0.2 Percent max | 1.0 Percent max gain | 0.2 Percent max gain | ASTM D570 | Immersed 24 hours at a water temperature of 75 ± 5 °F |
| Oil absorption | Percent of specimen volume | 1.0 Percent max | 1.0 Percent max gain | 1.0 Percent max gain | 4.6.4.1 and 4.6.4.3 | ---- |

1/ Ultimate tensile strength is derived from the flexural modulus results.

2/ The specimens shall be curved. The hoop and axial specimens shall have a span to depth ratio of 16:1. See 4.4.6.b.

3.2.4 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible, provided that the material meets or exceeds the operations maintenance requirements, and promotes economically advantageous life cycle costs.

3.3 General requirements. The class, type, size, dimensions and dimensional tolerances shall be as specified (see 6.2). (Type is a subdivision of class that is flanged, unflanged, optional design type I, II, or III as identified in Drawing 803-1385664. Size refers to basic dimensions that determine bearing size that is shaft sleeve diameter, bearing length.)

3.3.1 Manufacturing of bearings. Unless otherwise specified (see 6.2), stern tube and strut bearings shall be manufactured and fabricated in accordance with Drawing 803-1385664, except class V. Class V bearing drawings are to unique to each application, there is no standard drawing.

3.4 Bond life. The adhesive, which bonds the rubber facing to the bearing backing, shall maintain the bond for the life of the bearing and shall not show signs of separation along the edges. Bearing test specimens when subjected to pull tests shall meet the requirements in accordance with 3.4.1 through 3.4.5, except for class V bearings that shall meet the requirements of paragraph 3.4.6. Test specimens shall not be subjected to more than one type of aging per specimen.

3.4.1 Adhesion before aging. The adhesion of the rubber facing material to the backing for each strip shall have a minimum value not less than 20.0 pounds when tested in accordance with 4.6.5.

3.4.2 Adhesion after oven aging. The adhesion of the rubber facing material to the backing for each strip shall have a minimum value not less than 20.0 pounds when tested after being subjected to warm circulating air for 96 hours in accordance with 4.6.5.1 and tested in accordance with 4.6.5.

3.4.3 Adhesion after oil immersion. The adhesion of the rubber facing material to the backing for each strip after oil immersion for 46 hours in accordance with 4.6.5.2 shall have a minimum value not less than 20.0 pounds when tested in accordance with 4.6.5.

3.4.4 Adhesion after seawater immersion. The adhesion of the rubber facing material to the backing for each strip shall be tested after immersion in seawater for 45 days and shall have a minimum value not less than 20.0 pounds when prepared in accordance with 4.6.5.3 and tested in accordance with 4.6.5.

3.4.5 Adhesion after thermal cycling. The adhesion of the rubber facing material to the backing for each strip, after thermal cycling in accordance with 4.6.5.4 shall have a minimum value not less than 20.0 pounds when tested in accordance with 4.6.5.

3.4.6 Adhesion requirements for class V bearings. The following criteria shall be used to determine the acceptance of adhesive bond for class V bearings when tested in accordance with 4.6.5.

a. A minimum time-average value of 20 pounds or greater for a test strip is acceptable.

b. If any test strip yields a time-average value less than 20 pounds but greater than 16 pounds, then all test strip values for the part (up to three values) shall be averaged. The adhesion test results shall be considered acceptable if the calculated average of the test values for the part is 20 pounds or greater. At any time during an individual pull, any value of zero shall be considered to have failed the specification requirements, except for rubber breakage.

c. If any test strip yields a time-average test value less than 16 pounds, the specimen shall be considered to have failed the specification requirements.

3.5 Delamination. Rubber material shall show no evidence of separation into distinct layers of laminations when prepared and tested in accordance with 4.6.3.

3.6 Volume change.

3.6.1 Volume change after water immersion. When immersed in water, the volume of the rubber facing specimen and non-metallic backing specimen shall not increase more than 5 percent when tested in accordance with 4.6.4.1 and 4.6.4.2. No shrinkage shall be permitted.

3.6.2 Volume change after oil immersion. When immersed in oil as specified in 4.6.4.3, the volume of the rubber facing specimen and non-metallic specimen shall not increase more than 5 percent when tested in accordance with 4.6.4.1. No shrinkage shall be permitted.

3.7 Performance. The rubber material shall pass the performance test for wear, friction, and vibration characteristics in accordance with 4.6.6.

3.8 Interchangeability. Bearings of the same class, type, and size shall be interchangeable both physically and functionally. If the design is symmetric, they shall be reversible. (Flanged bearings are not symmetric.)

3.9 Storage. Storage requirements shall be as specified (see 6.2). For shelf-life guidance, see 6.5. ISO 2230 shall be used as guidance for storage requirements.

## 4. VERIFICATION

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

a. Qualification inspection (see 4.2).

b. Conformance inspection (see 4.3).

4.2 Qualification. Bearings shall pass initial qualification inspection and tests in accordance with 4.2.1, 4.2.2, 4.2.3, 4.2.4, 4.6.6 and Tables III and IV, except class II, class IV, and class V bearings do not require friction testing. Selection of sample bearings and the preparation of test specimens shall be in accordance with 4.4.2, 4.4.3, 4.6.6.1.1, and 4.6.6.2.1, as applicable. Once qualified, any changes to bearing stave manufacturing processes or materials or procedures require re-qualification. The manufacturing process, procedure, and materials (including inspections and test methodology) used for qualification test articles shall be used for all bearing production runs. Bearings that have been qualified require re-qualification at 5-year intervals. Re-qualification test shall consist of the same tests

above. Action to maintain approval of the material shall be taken on the basis of the test results. If re-qualification test results are not received before the expiration of five years from the date of the qualification or prior re-qualification test approval, such approval will be withdrawn, and the product removed from the Qualified Products List.

4.2.1 Visual, dimensional, and hardness inspection. A visual, dimensional, and hardness inspection of the bearings selected in accordance with 4.4.2 or 4.4.3, as applicable, shall be performed in accordance with 4.5.1, 4.5.2, and 4.6.1.

4.2.2 Backing of nonmetallic staves/bearing testing – (classes III, IV, and V only). The backing of nonmetallic-backed staves/bearings shall be subjected to qualification testing. The material shall be as specified in 3.2.3, when tested in accordance with Table III.

TABLE III. Summary of qualification testing for backing of nonmetallic bearings and staves.

| Property | Test in accordance with | Remarks | Requirements | No. of test specimens |
|---|---|---|---|---|
| Hardness | ASTM D2240 | | See Table II | See Table VI |
| Tensile strength | ASTM D638 | | See Table II | 3 |
| Yield | ASTM D638 | | See Table II | 3 |
| Flexural modulus | ASTM D790 | | See Table II | 5 |
| Impact resistance | ASTM D256 | 10 Samples tested with Method "A" and a 45-degree notch | See Table II | 10 |
| Water absorption | ASTM D570 | Immersed 24 hours at 75 ± 5 °F | See Table II | 3 |
| Oil absorption | 4.6.4.1 and 4.6.4.3 | | See Table II | 3 |

4.2.3 Synthetic rubber facing material. The synthetic rubber facing material shall be subjected to the tensile, elongation, delamination, and volume change tests in accordance with Table IV.

4.2.4 Bearing adhesion test specimens. Bearing adhesion test strips shall be subjected to the adhesion bond tests in accordance with Table IV. The minimum force required to strip the rubber facing from the backing at the interface bond shall meet the requirements in accordance with Table IV. Class V bearing qualification only requires before aging adhesion testing; aging testing of class V shall be performed and reported, however, there are no minimum requirements.

TABLE IV. Summary of qualification test information (class II, III, IV, and V bearings).

| Tests to determine | Aging details class II, III, IV, V | Aging time | No. specimens per test class III | No. specimens per test class II and IV | No. specimens per test class V | Reqts. para. | Unit of measurements | Test para. |
|---|---|---|---|---|---|---|---|---|
| Tensile and elongation [1/] | | | | | | | | |
| (a) Before aging | 4.6.2 | N/A | 3 | 3 | 3 | 3.2.1 | Tensile – $LB/IN^2$ | 4.6.2 |
| (b) After oven aging | 4.6.2.1 | 96 HOURS | 3 | 3 | 3 | 3.2.1 | Elongation – percent | 4.6.2.1 |

TABLE IV. Summary of qualification test information (class II, III, IV, and V bearings) - Continued.

| Tests to determine | Aging details class II, III, IV, V | Aging time | No. specimens per test class III | No. specimens per test class II and IV | No. specimens per test class V | Reqts. para. | Unit of measurements | Test para. |
|---|---|---|---|---|---|---|---|---|
| Delamination | | | 3 | 3 | 3 | 3.5 | No separation into layers | 4.6.3 |
| Volume change | | | | | | | | |
| (a) After water immersion | 4.6.4.2 | 1 WK | 3 | 3 | 3 | 3.6.1 | Percent increase in volume | 4.6.4, 4.6.4.1, 4.6.4.2 |
| (b) After oil immersion | 4.6.4.3 | 46 HOURS | 3 | 3 | 3 | 3.6.2 | | 4.6.4.1, 4.6.4.3 |
| Adhesion pull force | | | | | | (min. 20.0 LBS) | | |
| (a) Before aging | 4.6.5 | N/A | 3 | 2 | 3 [2/] | 3.4.1 | | |
| (b) After oven aging | 4.6.5.1 | 96 HOURS | 3 | 2 | 3 [3/] | 3.4.2 | | |
| (c) After oil immersion | 4.6.5.2 | 46 HOURS | 3 | 2 | 3 [3/] | 3.4.3 | LB/HALF IN | 4.6.5 |
| (d) After seawater immersion | 4.6.5.3 | 45 DAYS | 3 | 2 | 3 [3/] | 3.4.4 | | |
| (e) After thermal cycling | 4.6.5.4 | 30 CYCLES | 3 | 2 | 3 [3/] | 3.4.5 | | |

[1/] A tensile and elongation test may be performed on the same specimen.

[2/] Adhesion requirements for class V are listed in paragraph 3.4.6.

[3/] Accelerated aging adhesion testing shall be performed and reported for class V, however, there are no minimum requirements.

Rejection Criteria - Bearing and test specimens shall meet the requirements indicated; failure to do so shall be cause to deny qualification.

4.3 Conformance inspection. Every bearing/stave lot shall pass a conformance inspection selected in accordance with 4.4.4 (class III), 4.4.5 (class II and IV) and 4.4.6 (class V):

a. For stave bearings (class III) the inspection shall consist of visual inspection (see 4.5.1), a dimensional inspection (see 4.5.2), and a hardness test (see 4.6.1) and an adhesion bond test in accordance with 4.6.5, except aging of the specimens is not required. See Table V.

b. For cylindrical bearings (class II and IV) the inspection shall consist of a visual inspection (see 4.5.1), a dimensional inspection (see 4.5.2), a hardness test (see 4.6.1), and adhesion bond test in accordance with 4.6.5 (class IV only), except aging of the specimens is not required. No adhesion bond test is required for class II. See Table V.

c. For partial-arc bearings (class V) the inspection shall consist of a flexural modulus inspection (see Table II), visual inspection (see 4.5.1), a dimensional inspection (4.5.2) and a hardness inspection (4.6.1) of each part (e.g., a bearing half shell) in the as- manufactured condition, except aging of the specimens is not required. Adhesion tests are required in accordance with 4.6.5 for each part.

TABLE V. Summary of conformance testing for staves and bearings (class II, III, IV, and V).

| Property | Testing paragraph | Remarks | Requirements paragraph | No. of test specimens |
|---|---|---|---|---|
| Visual inspection | 4.5.1 | | 4.5.1 | 3 |
| Dimensional inspection | 4.5.2 | | 4.5.2 | 3 |
| Hardness | 4.6.1/ ASTM D2240 | | See Table II | 3 |
| Adhesion | 4.6.5 | No aging of classes III, IV, and V; No adhesion of class II | 3.4.1 | See Table IV |
| Flexural modulus | 4.4.6/ ASTM D790 | Class V only | See Table II | 5 |

4.4 Selection of sample bearings and preparation of test specimens.

4.4.1 Statistical selection of samples. Whenever a visual, and dimensional, and hardness examination of a lot of bearings/staves is required, the sample shall be obtained by statistical sampling. Bearings/staves shall be selected from each lot in accordance with Table VI. The bearings shall be visually inspected (see 4.5.1), dimensionally inspected (see 4.5.2), and hardness tested (see 4.6.1) to verify compliance with this specification.

TABLE VI. Sampling for visual, dimensional, and hardness testing.

| Lot size number of bearings | Sample size number to be inspected |
|---|---|
| 15 and under | 7 |
| 16 to 40 | 10 |
| 41 to 110 | 15 |
| 111 to 300 | 25 |
| 301 to 500 | 35 |
| 501 to 800 | 50 |
| 801 to 1300 | 75 |
| 1301 and over | 110 |

NOTE: Unless otherwise specified (see 6.2), any bearing/stave in the sample containing one or more visual, dimensional, or hardness defect shall be rejected and 100% inspection of all bearings/staves for that particular test is mandated.

4.4.2 Selection of sample bearings and preparation of test specimens for qualification testing - stave shaped bearings only (class III). The bearings used for qualification shall be between sizes 4 through 10 with a length of 36 inches or longer, except for performance test bearings that are size 1. The selection of sample stave bearings for visual, dimensional, and hardness tests and the preparation of test specimens shall include the following:

a. Samples for visual, dimensional, and hardness tests. From a production run of 40 or more staves, select a random sample in accordance with 4.4.1. The visual, dimensional, and hardness tests shall be performed on these selected staves in the as manufactured condition (prior to cutting stave specimens) in accordance with 4.5.1, 4.5.2 and 4.6.1, respectively. Unless otherwise specified (see 6.2), any bearing/stave in the sample containing one or more visual, dimensional, or hardness defect shall be rejected and 100% inspection of all bearings/staves for that particular test is mandated.

b. Samples and specimens for tensile strength and elongation tests. The rubber specimens for tensile and elongation testing shall be obtained from the facing material of three sample staves. Select three sample staves from those selected in 4.4.2.a and cut into 6-inch (+0.5, -0 inches) lengths, marking each piece taken from the first stave with the number 1, each piece taken from the second stave with the number 2, and each piece taken from the third stave with the number 3. Select one 6-inch (+0.5, -0 inches) stave section from each stave and identify on the rubber for use in the before aging test. Select a second set, one from each stave, and identify them on the rubber for use in the after aging test. The rubber for the tension and elongation test shall be sliced from the surface of each of these staves by means of a fine toothed band saw and buffed to a thickness of not less than 0.060 inch or more than 0.120 inch in accordance with ASTM D412. Use the backing material for testing in accordance with 3.2.3. The remaining 6-inch pieces shall be used in subsequent tests.

c. Samples and specimens for delamination tests. The rubber specimens for delamination testing shall be obtained from the 6-inch (+0.5, -0 inches) stave lengths cut as in b above. Select three stave pieces, one from each stave, and remove the rubber from the backing at the interface bond. Cut specimens 3 inches by 1 inch (+/-$^{1}/_{16}$ inch) by the thickness of the rubber facing from the three separate staves pieces.

d. Samples and specimens volume change tests. The rubber specimens for the volume change testing shall be obtained from the 6-inch (+0.5, -0 inches) stave lengths cut as in b above. Select one 6-inch stave section from each of the three staves and identify on the rubber for use in the water immersion test. Select a second set of three from each of the staves and identify on the rubber for use in the oil immersion test. Cut one specimen, 2 inches by 1 inch (+/-$^{1}/_{16}$ inch) with a thickness not to exceed $^{1}/_{16}$ inch, from the surface of each of the six samples above. These samples are now ready for aging by oil and water immersion.

e. Samples and specimens for adhesion bond tests. For class III staves, obtain one stave from each slab from which adhesion test specimens may be cut. The rubber facing of these staves shall be buffed to a uniform thickness of ¼ inch (+/-$^{1}/_{16}$ inch) (see ASTM D3183 for buffing procedures). Cut each stave into three 6-inch (-0.0 inches) lengths, marking the first stave specimen with the number 4, the second stave specimen with the number 5, the third stave specimen with the number 6, then the first stave specimen from the second stave with the number 7, etc. The test specimens required for each type of test shall be from different staves. The stave side angle profile of the test specimens shall not be removed or modified. The test specimens for adhesion pull testing shall have the rubber facing divided into three longitudinal strips by means of saw cuts perpendicular to the rubber face. The cuts shall go completely through the rubber and to a depth of approximately $^{1}/_{16}$ inch into the backing. A cut shall be made ½ inch (+/-$^{1}/_{32}$ inch) from each longitudinal edge of stave facing. Also, two longitudinal cuts equally spaced about the centerline a distance of ½ inch (+/-$^{1}/_{32}$ inch) apart measured along the bond interface shall be made. The rubber facing between the center and edge strips should be removed from the backing at the bond. This leaves a ½-inch center strip and two ½-inch wide edge strips. For adhesion testing, these three strips will be pull tested individually. (See Figure 1 for a cross section view of a test specimen.) The test specimens are now ready for the type of aging required by the particular tests (see 4.6.5).

4.4.3 Selection of sample bearings and preparation of test specimens for qualification testing - cylindrical shaped bearings (class II, IV, and V only). The cylindrical bearings used for qualification tests shall have an inside diameter (I.D.) of 6 inches or greater and shall be 18 inches or greater in length. The selection of sample cylindrical bearings for visual, dimensional, and hardness inspection and the preparation of test specimens shall include the following:

a. Samples for visual, dimensional and hardness tests. From a production run of 8 to 15 bearings for class II and IV, and a production run of 1 or more for class V, select a random sample in accordance with 4.4.1. The

visual, dimensional, and hardness tests shall be performed on all of these selected bearings in the as-manufactured condition (prior to cutting into specimens) in accordance with 4.5.1, 4.5.2 and 4.6.1 respectively. Unless otherwise specified (see 6.2), any bearing/stave in the sample containing one or more visual, dimensional, or hardness defect shall be rejected and 100% inspection of all bearings/staves for that particular test is mandated. After successful completion of visual, dimensional, and hardness inspection, a single bearing shall be selected from the sample bearings to be used for supplying all required tests specimens. The bearing shall be cut into circumferential segments as shown on Figure 2. Each segment shall be cut into 6-inch (+0.5, -0 inches) lengths. Longitudinal cuts shall be made along the length of the cylindrical bearings that cut completely through the rubber and backing separating the bearing into a number of longitudinal segments. The plane of the saw shall pass through the axial centerline of the bearing and through the center of molded grooves that exist between the simulated stave shapes that run the length of the bearings (see Figure 3). For class V, test specimens shall be taken from prolongations removed from the as-manufactured part. A total of 25 test specimens for class II and IV and 30 for class V shall be required for all of the tests.

b. Test specimens for tensile, elongation and hardness tests. Select six segments as prepared in 4.4.3.a and buff facings flat (see ASTM D3183 for buffing procedures). Measure the hardness of the segments at this time in accordance with 4.6.1. The rubber for tension and elongation tests shall be sliced from the surface of each of these segments by means of a fine tooth band saw) and buffed to a thickness of not less than 0.060 inch or more than 0.120 inch in accordance with ASTM D412 (or D3183).

c. Test specimens for delamination tests. Select three segments as prepared in 4.4.3a. The rubber for delamination testing shall be obtained by removing the rubber facing from the backing at the interface bond. From each of the pieces cut a test specimen 3 inches by 1 inch (+/-$^{1}/_{16}$ inch) by the thickness of the rubber.

d. Specimens for volume change tests. The rubber specimens for the volume change test shall be obtained from the facing material of six bearing segments by removing the rubber facing from the backing. Buff the rubber of each segment to a flat surface. Cut one specimen 2 inches by 1 inch (+/-$^{1}/_{16}$ inch) with a thickness not to exceed $^{1}/_{16}$ inch from the surface of the segments. These specimens are now ready for aging (see 4.6.4.2 and 4.6.4.3).

e. Specimens for adhesion bond testing. Select 10 test specimens for adhesion pull testing for classes II and IV and 15 for class V and buff facings to ¼-inch (+/-$^{1}/_{16}$-inch) thickness (see ASTM D3183 for buffing procedure). They shall each have two longitudinal cuts in the facing, equally spaced about the centerline, ½ (+/-$^{1}/_{32}$ inch) inch apart. The cuts shall go completely into through the rubber facing to a depth of approximately $^{1}/_{16}$ inch into the backing. The rubber on each side of the center strip shall be removed from the backing at the bond. This leaves one ½-inch center strip per test specimen. The test specimens are now ready for the type of aging required by the particular tests specified in 4.6.5.

4.4.4 Selection of samples and preparation of test specimens for conformance inspection – stave bearings only (class III). Selection of samples and preparation of the test specimens for conformance inspection (class III) shall include following:

a. Sample stave bearings shall be statistically selected from each lot in accordance with Table VI. A visual, dimensional, and hardness inspection shall be performed on each bearing of the statistical sample (in the as-manufactured condition) in accordance with 4.5.1, 4.5.2, and 4.6.1, respectively. This portion of the conformance inspection shall be successfully passed before proceeding with the preparation of test specimens for adhesion bond testing. Unless otherwise specified (see 6.2), any bearing/stave in the sample containing one or more visual, dimensional, or hardness defect shall be rejected and 100% inspection of all bearings/staves for that particular test is mandated.

b. If the statistical sample passes the above inspection, select a sample stave specimen from each slab for class III staves. Buff the rubber facing of the stave specimen to a thickness of ¼ inch (+/-$^{1}/_{16}$ inch). See ASTM D3183 for buffing procedures. Cut one 6-inch (-0.0 inches) long specimen from one end of each slab or stave to use in making the test specimens.

The rubber facing of the 6-inch stave specimen shall be divided into strips by means of longitudinal cuts that go completely through the rubber and to a depth of $^{1}/_{16}$ inch into the backing. A cut shall be made ½ inch (+/-$^{1}/_{32}$ inch) from each longitudinal edge of the stave facing and two longitudinal cuts shall also be made equally spaced about the center line a distance of ½ inch (+/-$^{1}/_{32}$ inch) apart. This leaves a ½-inch wide center strip and two ½-inch edge strips. The rubber facing between the center and edge strips shall be removed from the backing at the interface bond. For adhesion testing, these three strips will be pull tested individually. (See Figure 1 for a cross section view of a test specimen.) The test specimens are now ready for adhesion bond test in accordance with 4.6.5, except

accelerated aging of the specimens is not required. The stave side angle profile of the test specimens shall not be removed or modified.

4.4.5 Selection of samples for conformance inspection - cylindrical bearings only (class II and IV). Sample cylindrical bearings shall be selected from each lot in accordance with Table VI. The conformance inspection shall be performed on these bearings in the as-manufactured condition. Conformance inspection of cylindrical bearing, class II, does not require adhesion pull testing due to superior bonding record. Therefore, there is no need to cut any of the bearings into test specimens.

a. For class IV bearing, select three bearings for adhesion pull testing, cut the bearings along each water groove to create the test specimens. Buff facings of each specimen to ¼-inch (+/-$^{1}/_{16}$-inch) thickness (see ASTM D3183 for buffing procedure). They shall each have two longitudinal cuts in the facing, equally spaced about the centerline, ½ (+/-$^{1}/_{32}$) inch apart. The cuts shall go completely into through the rubber facing to a depth of approximately $^{1}/_{16}$ inch into the backing. The rubber on each side of the center strip shall be removed from the backing at the bond. This leaves one ½-inch center strip per test specimen. The test specimens are now ready for adhesion bond test in accordance with 4.6.5, except accelerated aging of the specimens is not required.

b. A visual, dimensional, and hardness inspection shall be performed on each bearing of the statistical sample in accordance with 4.5.1, 4.5.2, and 4.6.1, respectively. This completes the conformance requirements for class II and IV bearings. Unless otherwise specified (see 6.2), any bearing/stave in the sample containing one or more visual, dimensional, or hardness defect shall be rejected and 100% inspection of all bearings/staves for that particular test is mandated.

4.4.6 Selection of samples and preparation of test specimens for conformance inspection – partial-arc bearings (class V) only. Selection of samples and preparation of the test specimens for conformance inspection (class V) shall be as follows:

a. A visual, dimensional, and hardness inspection shall be performed on each part (in the as-manufactured condition) in accordance with 4.5.1, 4.5.2, and 4.6.1, respectively. This portion of the conformance inspection shall be successfully passed before proceeding with the preparation of test specimens for adhesion bond testing. In cases of rejection, the manufacturer shall isolate the cause of the defects and produce another part for inspection in which the cause of the previous defect is eliminated.

b. Specimens for adhesive bond testing. Test specimens shall be taken from prolongations removed from the as-manufactured bearing. At least test strips are required for each bearing. The use of a single specimen with three individual test strips may be used or three specimens each with one test strip may be used. The strips shall be machine cut to provide one test strip ½ inch wide by a minimum of 6 inches long. For specimens with three test strips, a space of ¼ inch minimum shall be provided between each strip to prevent inadvertent damage to the adjacent bond during testing resulting in a loss in recorded pull force. The general test strip configuration shall be as represented by Figure 3 except that the test strip will have a radius equal to that of the prolongation from which it is taken, the specimen shall be machined or cut down to the adhesive so that only the ½ inch wide rubber strip is subjected to the adhesive bond pull test. No aging of specimen is required.

c. Specimens for flexural modulus testing. Preparation of specimens shall be in accordance with ASTM D790 per Table II of this specification, except as follows. Test specimens shall be taken from prolongations cut from the production material. The specimens may be curved in lieu of flat, having the same radius as the production material. The length of the test specimen (i.e., span-to-depth ratio) shall be as recommended by ASTM D790. However, if prolongations of sufficient length to provide the recommended span-to-depth ratio cannot be obtained from the production material due to tooling limitations (e.g., insufficient mandrel length), then shorter specimens may be tested. In no case shall the span-to-depth ratio of test specimens be less than 8 to 1.

4.4.7 Sampling for performance test. When specified (see 6.2), a bearing assembly or test specimen, or both shall be selected and subjected to the tests specified in 4.6.6.

4.5 Inspection.

4.5.1 Visual inspection. Sample bearings shall be visually inspected in a strong light for separation at the interface between the surface rubber face and the backing material. If separation exists, the sample is to be considered to have failed the visual inspection. Defects such as roughness, holes, cuts, gouges, bubbles, large dimples, molding imperfections or tears in the rubber facing material that would indicate a bearing of poor workmanship, handling, or quality shall also be cause for rejection of the sample. Defects, except bubbles, less than

0.015-inch diameter and 0.005-inch depth shall be disregarded provided they cover less than 1% of the total surface area, and small dimples less than 0.250-inch diameter and 0.005-inch depth are acceptable provided they cover less than 1% of the total surface area with no more than one dimple in any square inch. No bubbles or imbedded contaminants are acceptable in the rubber facing material regardless of size. Any surface blemish, other than bubbles or imbedded contaminants, which falls with the surface finish requirements of section 4.5.2.1, shall not be cause for rejection. The Government inspector shall be the final arbitrator on site in questions of suitability.

4.5.2 Dimensional inspection. Sample bearings for class II, class III, and class IV shall be dimensionally inspected for conformance to the requirements as specified in Drawing 803-1385664. Class V bearings shall dimensionally conform to the requirements as specified (see 6.2). As a minimum, the following dimensions shall be measured and recorded for each sample at an ambient air temperature of 72+/-3 °F:

a. For class III - the stave width (using across pins method, Johnson gage thread pitch diameter and functional size method or Go, No-Go gages), total thickness, wear rubber thickness, length, side angle, side angle backing radius or chamfer, and bearing face surface finish.

b. For class II and IV - the bore, outside diameter, flange dimensions, length, and bearing face surface finish.

c. For class V, each part (e.g., a bearing half shell) shall be dimensionally inspected for conformance with all dimensions, feature controls and surface finish requirements as specified by the purchase order and changes thereto.

4.5.2.1 Procedure for measuring bearing face surface finish. Surface finish of the rubber facing shall be measured using a light contact stylus with maximum stylus force of 1.0 milli-Newton (mN) (0.225 X $10^{-3}$ pound force). The measuring equipment shall be Talysurf 10 or equal and shall have a 90 degree, four sided, pyramid, diamond stylus with a tip width of 0.0001 inch (0.0025 mm). Other surface finish measuring equipment is acceptable provided they have been calibrated with a Talysurf 10 at a range of finishes that include 64 microinches Ra. The equipment shall be calibrated with a roughness standard just prior to and following measurements. A cutoff or roughness sampling length of 0.030 inch (0.80 mm) shall be used. For class III, three measurements each shall be taken along the length of the rubber and perpendicular to it, and each measurement shall be 64 microinches Ra or less. For class II and IV bearings, the surface finish on the rubber face shall be measured lengthwise on at least three land areas. For class V bearings, the surface finish on the rubber face shall be measured lengthwise on at least three areas. Each measurement should be 64 microinches or less.

4.6 Tests. Unless otherwise indicated in the test, tests shall be conducted on test specimens after a conditioning period of 4 hours minimum at a room temperature of 75+/-5 °F. Sample preparation may be undertaken without regard to this time interval.

4.6.1 Hardness test of rubber facing and nonmetallic backing. The hardness of the bearing face and backing shall be measured in accordance with ASTM D2240. Type A durometer shall be used for the bearing face. Type D durometer shall be used for the backing of class III, IV, and V bearings.

4.6.2 Tension and elongation tests. Tension and elongation tests shall be conducted on straight type test specimens of rubber facing material in accordance with method A of ASTM D412. Tests shall be conducted on both aged and unaged specimens (as applicable, for class II, III, IV, or V test specimens).

4.6.2.1 After oven aging for tension and elongation tests. Test specimens of the rubber facing shall be subjected to circulating air at a temperature of 158+/-2 °F for 96 hours. Tension and elongation tests shall be performed on the straight type specimens in accordance with method A of ASTM D412 not less than 20 hours or more than 48 hours after removal from the 158 °F environment.

4.6.3 Delamination test of rubber facing. The rubber facing material shall be tested for evidence of delamination. Specimens cut in accordance with 4.4.2.c and 4.4.3.c shall be immersed in methyl ethyl ketone at a temperature of 75+/-5 °F for 22+/-¼ hours. After immersion, the specimens shall be examined visually in strong light for evidence of separation into layers by attempting to separate the layers by hand.

4.6.4 Volume change test for rubber facing and non-metallic backing. The volume change of the rubber facing and non-metallic backing shall be measured after the immersing of a test specimen in water and after immersing another test specimen in oil.

4.6.4.1 Procedure for determining volume change. The volume of each test specimen shall be measured by the water displacement method, in which the specimen is accurately weighed to the nearest milligram (mg) in air ($W_1$) and in distilled water ($W_2$) at room temperature. When weighing in water, care shall be taken that the specimen is free from adhering air bubbles, and, if necessary, it may first be wetted by dipping into 95 percent ethyl alcohol and then thoroughly rinsed with distilled water. After weighing, the specimen shall be blotted dry with filter paper, completely immersed in 100 milliliters (mL) of oil (FED-STD-791: IRM 903 oil as specified in ASTM D471), and conditioned for 46+/-¼ hours at a room temperature of 75+/-5 °F. At the termination of the immersion period, the specimen shall be removed from the oil, dipped in 95 percent ethyl alcohol, blotted lightly with filter paper, and placed in a tared weighing bottle and weighed ($W_3$). The specimen shall then be removed from the bottle and weighed in distilled water ($W_4$) in immediate consecutive procedure to determine the displacement after test. The final weighing shall be completed within 3 minutes after removal from the oil.

The increase in volume shall be calculated as follows:

$$\text{Percentage increase in volume} = \frac{(W_3-W_4)-(W_1-W_2)}{(W_1-W_2)} \times 100$$

4.6.4.2 Aging by water immersion. Specimens scheduled for volume change testing shall be immersed for a period of 1 week in distilled water. Except immersion time and the immersion liquid (distilled water), the procedure for determining volume change shall be as specified in 4.6.4.1.

4.6.4.3 Aging by oil immersion. Aging of the rubber facing and non-metallic backing for volume change testing after oil immersion shall be as follows:

Specimens for volume change tests shall be conditioned for 46+/-¼ hours at a room temperature of 75+/-5 °F in a petroleum base oil with the following properties as specified in FED-STD-791: (IRM 903 oil as specified in ASTM D471 meets the requirement of this test fluid.)

a. Viscosity, Saybolt Universal: 155+/-5 seconds (measured at 100 °F).

b. Aniline point: 157+/-1 °F.

c. Flash point: 330+/-5 °F.

4.6.5 Adhesion tests. The bond strength between the rubber face and the backing material shall be determined by measuring the force required to pull, the test strips from the backing at right angles to the interface surface. The testing machine shall be power driven with a device for continuously recording graphically (minimum of 3 reading per second), the force in pounds required to strip the rubber from the backing. The recorder shall be accurate within plus or minus 2 percent of the actual pull force. The load cell rating shall be between 100 and 250 lbs with an accuracy of plus or minus 2 percent of the range, or better. The moving grip of the machine shall travel at the rate of 2 inches per minute. The fixture that holds the test specimen shall be capable of being moved, either manually or automatically, so that pull force is always at 90 degrees to the backing. If the rubber interface is curved, the specimen shall be free to rotate parallel to the long axis of the specimen to insure that the pull is at right angles to the curvature. Test specimens shall be in accordance with 4.4.2.e, 4.4.3.e, or 4.4.4.b, as applicable. Before the load is applied the rubber shall be stripped from the backing at one end for a distance of approximately 1 inch using a sharp knife. This tab is then placed in the grip and a load applied at the rate of 2 inches per minute until either separation is complete or 5 inches of bond adhesion has been tested. The autographic recorder or computer display printout shall be used to show graphically the adhesion values over the full length of the test specimen. The graphic results of each pull strip shall be included with the qualification testing reports. The minimum pull force required to separate the bond shall be recorded. The minimum value shall be taken from the graphic results and shall be the lowest readings from when the graph reaches its initial peak until the end of the test specimen. The minimum value of each strip is required to meet the requirements of section 3.4, except when cutting the wear rubber or retensioning of the pull strip as discussed below.

a. If the rubber face material begins to tear instead of separating at the bond interface, a sharp knife shall be used to encourage separation at the bond line by cutting back to the bond interface. The pull force may momentarily drop below the minimum while cutting back to the bond interface or retensioning of the pull strip. These locations shall be noted on the autographic recorder data. This momentary drop shall be excluded from the minimum requirement but shall be noted on the graph.

b. If the strip persists in tearing instead of separating from the backing, the minimum load at which tearing occurs shall be reported with notation to that type of failure. If the tear strength of the rubber face material is less than the specified minimum adhesive strength, the sample shall be considered to have failed the specification requirements.

4.6.5.1 Oven aging. Test specimens for adhesion testing shall be subjected to circulating air at a temperature of 158+/-2 °F for 96 hours. Following oven aging, specimens shall be subjected to adhesion bond tests.

4.6.5.2 Oil immersion aging. Test specimens for adhesion testing shall be immersed in a petroleum base oil for a period of 46+/-¼ hours at room temperature of 75+/-5 °F (ASTM IRM 903 oil meets these requirements):

a. Viscosity, Saybolt Universal: 155+/-5 seconds (measured at 100 °F).

b. Aniline point: 157+/-1 °F.

c. Flash point: 330+/-5 °F.

Following oil immersion aging, specimens shall be subjected to adhesion bond test.

4.6.5.3 Seawater immersion aging. Test specimens for adhesion testing shall be immersed in substitute seawater for 45 days at a room temperature of 75+/-5 °F. The substitute seawater shall be in accordance with ASTM D1141 (without heavy metals). Following seawater immersion aging, specimens shall be subjected to adhesion bond tests.

4.6.5.4 Thermal cycle aging. Test specimens for adhesion testing shall be thermally cycled by placing specimens at 32 to 35 °F for a period of 8+/-½ hours, removing and allowing to naturally return to a room temperature of 75+/-5 °F for 16+/-½ hours. This cycle shall be repeated until 30 cycles have been completed. Five cycles shall be completed per week with specimens being maintained at room temperature over the weekends, unless automated thermal cycling equipment is used that can continually perform cycling until the required 30 cycles are completed. Following thermal cycle aging, specimens shall be subjected to adhesion bond tests.

4.6.6 Performance tests. A bearing assembly or test specimen, or both, shall be subjected to performance tests for wear and static and dynamic friction coefficients, as described herein to determine acceptability of bearing materials and design. For class III bearings, both wear and friction coefficient tests shall be performed. For class II, IV and V, only wear tests shall be conducted. Test specimens and bearing components shall represent the following:

a. The material composition to be qualified by that particular manufacturer, except class V, which is per contract.

b. The dimensions and design specified in Drawing 803-1385664.

c. The surface finish as specified in Table I.

Samples for these tests shall be representative of the product to be furnished to the Government under this specification. Tests shall be performed at a location as specified (see 6.2). If the bearing fails any or part of any performance test or examination associated with the performance tests, it shall be rejected.

4.6.6.1 Wear test. Three test specimens shall be prepared in accordance with 4.6.6.1.1. Each test specimen shall be identified by permanent markings on the back face. A journal, made in accordance with Figure 4, shall be used to measure wear of the subject bearing material and journal. The same journal shall be used for the three specimen tests. The thickness in the wearing direction shall be measured to the nearest 0.001 inch for each specimen before testing. The diameter of the journal shall also be measured to the nearest 0.001 inch. Each specimen shall be positioned so it contacts the journal in the center (widthwise). The journal speed, lubricant, lubricant flow rate, and abrasive delivery rate are specified in MIL-P-18324. The specimen contact load is 1.76 lbf. The abrasive and lubricant shall be evenly distributed across the specimen width. The abrasive shall be commercially available brown fused aluminum oxide abrasive grain, grit number 54 per Table 2 of ANSI B74.12. The grit shall be discarded after one pass through the sample contact area of the journal. The lubricant, specified in MIL-P-18324, shall be maintained at 75+/-5 °F. The length of the test for each specimen is 10 hours +/- 10 minutes. The journal diameter shall be measured in the area of heaviest wear to the nearest 0.001 inch following each specimen test. The minimum thickness of each specimen shall be measured to the nearest 0.001 inch. The wear shall be calculated by subtracting the final from the initial measurement.

4.6.6.1.1 Preparation of wear test specimens. Wear test specimens shall be cut from actual bearings and prepared as follows:

a. Class III - Wear samples shall be cut from the No. 1 size stave bearings furnished for the friction tests. Three specimens, each being 1 inch by 1 inch (+/-⅛ inch), by the thickness of the stave, shall be cut from the central portion of a randomly selected stave. The flat bearing surface shall be used to evaluate the wear characteristics and shall be representative of the bearings normally furnished to the Government.

b. Class II and IV - Three specimens, each being 1 inch by 1 inch (+/-⅛ inch) shall be cut from the central portion of a fully molded bearing providing at least ¼-inch thickness of rubber bearing surface to establish wear behavior. The rubber surface shall be machined flat and be representative of bearings normally furnished to the Government.

c. Class V - Three specimens, each being 1 inch by 1 inch (+/-⅛ inch) shall be cut from the prolongation of the bearing providing at least ¼-inch thickness of rubber bearing surface to establish wear behavior. The rubber surface shall be machined flat and be representative of bearings normally furnished to the Government.

4.6.6.1.2 Wear test requirements. The average specimen wear shall be computed from the three samples tested. The total journal wear shall be determined from the original diameter. The average bearing specimen wear shall not exceed 0.100 inch. The total journal wear shall not exceed 0.030 inch.

4.6.6.2 Friction tests (class II only). Tests shall be performed at speeds ranging from 5 to 400 revolutions per minute (rpm). Compensation for the tare torque of the support bearings and seal shall be made. A 6¾-inch diameter journal made of 70-30 copper-nickel shall be used for the friction test. The surface finish of the journal shall be less than 32 microinches Ra. The bearing shall be immersed in clean tap water at 70+/-5 °F prior to the friction test and during all subsequent static and dynamic tests. Initial start up runs shall be performed at 60 rpm on the stave assembly by increasing the Projected Area Loading (PAL = applied bearing radial load/(bearing length X journal diameter)) of the bearing in 10-LB/IN$^2$ increments until a PAL of 40 LB/IN$^2$ is reached. The rate of load application depends upon the frictional behavior of the bearing and the limitations of the drive system. Load shall be applied at a rate such that the torque will not exceed 500 inch-pounds (in-lb). If the 40-LB/IN$^2$ test loading cannot be reached in an 8-hour period during break-in due to high friction and torque loads exceeding 500 in-lb, the subject bearing shall be considered failed and no further tests shall be conducted. Once the 60 rpm, 40 LB/IN$^2$ loading condition has been reached, the shaft shall be continuously operated under those conditions for 25 hours. Torque shall be periodically recorded during the 25-hour break-in. Following break-in, the load shall be removed, drive motor shut down, and shafting freed up to determine and record zero drift of torque measuring instrumentation. The test shall be immediately restarted and the speed of the journal increased to 400 rpm, after which a PAL of 40 LB/IN$^2$ shall be applied. The torque and load values are observed and recorded for one minute after reaching 400 rpm and 40 LB/IN$^2$ and again after 15 minutes of running. The median values of torque and load for the one-minute intervals are determined. The median values after 15 minutes at speed and load are used to calculate friction. The shaft shall again be stopped and zero drift measured and recorded. This procedure shall be repeated for the following speeds – 250, 100, 60, 40, 30, 20, 10, and 5 rpm. Tare torque and zero corrections shall be applied to measured torque values. Tare torque accounts for friction in the machine seals and bearings; zero correction accounts for drift in the torque measuring instrumentation. During the entire test, the machine shall operate smoothly and there shall be no evidence of stick-slip vibration at any speed in the test range. Friction coefficients for the dynamic conditions of 400, 250, 100, 60, 40, 30, 20, 10 and 5 rpm shall be calculated based upon the formula:

$$T_{bearing} = fPR$$

where;

$T_{bearing}$ = corrected bearing torque in IN-LB.

f = friction coefficient.

P = normal applied bearing radial load in pounds.

R = journal radius in inches.

Following dynamic friction tests, static friction values shall be determined by applying 40 LB/IN$^2$ load to the journal at rest. Torque shall be applied to the input shaft of the tester. Torque shall be recorded graphically, using

data acquisition software, a strip chart recorder, or other similar data retention means, during torque build-up and breakaway. Load shall be applied for a length of time of 3 hours before torque is applied to rotate the shaft. The test shall be performed three times and the average of those three values of torque determined. The corresponding average static friction coefficient shall be calculated using the formula above.

4.7.6.2.1 Friction test specimens. No. 1 size bearing staves in accordance with Drawing 803-1385664 shall be cut into 15 pieces of 5¾-inch length (+/-1/16 inch) and furnished for friction and wear tests. Samples shall be measured to check for conformance to Drawing 803-1385664. Twelve staves shall be installed in a bearing housing conforming to Drawing 803-1385664 for a 6¾-inch outside diameter (O.D.) shaft sleeve. The I.D. of the bearing assembly shall be measured to the nearest 0.001 inch.

4.6.6.2.2 Friction test requirements. The dynamic friction coefficients after 15 minutes of operation, under the various speed conditions, shall not exceed the following values:

a. Dynamic friction coefficients

| Speed | Maximum acceptable friction coefficient |
|---|---|
| 400 | 0.020 |
| 250 | 0.020 |
| 100 | 0.020 |
| 60 | 0.020 |
| 40 | 0.030 |
| 30 | 0.040 |
| 20 | 0.090 |
| 10 | 0.160 |
| 5 | 0.250 |

If one or more values exceed the maximum allowable values, a second test shall be conducted on the unloaded half of the bearing. The entire procedure for break-in and dynamic testing, as described in 4.6.6.2, shall be repeated for this test. If one or more dynamic friction coefficient values again exceed the maximum allowable values listed above, the bearing will be considered to have failed the dynamic test requirements.

b. Static friction coefficient. The average static friction coefficient shall not exceed 0.8.

## 5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

## 6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The bearings herein specified are intended for use in supporting the rotating propulsion shafts for surface ships and submarines.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of the specification.

b. Class required (see 1.2).

c. Product identification and marking requirements (see 3.2).

d. Type; size; optional design type I, II, or III; dimensions; tolerances; and special requirements required for machining or standard drawings as applicable (see 3.3).

e. If stern tube and strut bearings are to be manufactured other than as specified in Drawing 803-1385664 (see 3.3.1).

f. Storage and shelf-life requirements (see 3.9 and 6.5).

g. Quantity of bearing components.

i. Class V dimensional bearing requirements (see 4.5.2).

j. Criteria for allowing defective bearings and level/number of defects allowed (see Table VI, 4.4.2.a, 4.4.3.a, 4.4.4.a, and 4.4.5.b).

k. Requirements for sampling for performance tests (see 4.4.7).

l. Location of performance tests (see 4.6.6).

m. Levels of preservation, packaging, and packing, required (see 5.1).

n. Certification requirement wherein the contractor states that the materials and processes, used in the production of the shipment bearings, have not changed since the most recent qualification.

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL No. 17901 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to the qualification of products may be obtained by writing Commander, Naval Sea Systems Command, ATTN: SEA O5Q, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or email to commandstandards@navsea.navy.mil, with the subject line "QPL Comment". Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil.

6.4 Definitions.

6.4.1 Batch. Staves or bearings cured from the same production run are considered a batch.

6.4.2 Batch number. Unique number assigned to each batch by the manufacturer.

6.4.3 Bearing. Total assembly of rubber bonded bearing component(s).

6.4.4 Bearing installation. Installation of bearings or staves into the ship's strut barrel or stern tube.

6.4.5 Bubbles. High spots on the wear rubber surface that typically indicate an area of non-bonding to its backing.

6.4.6 Cure date. Month and year when the rubber is cured by heat and pressure.

6.4.7 Dimples. Low spots on the wear rubber surface.

6.4.8 Life of bearing. Bearings are to maintain their integrity and function for the entire in-service time that is prescribed by their wear amount. The service life no longer applies once an interruption of water flow occurs due to foreign matter clogging or entering the bearing or due to lack of ship's service stern tube bearing water flow during shaft rotation.

6.4.9 Lot. A lot is a single batch used to fulfill a contract order or multiple batches provided bearings from each batch are included in each of the conformance testing requirements.

6.4.10 Shelf life. The maximum allowable time between the cure date and installation of the bearing.

6.4.11 Slab. A two-ply sheet of bearing material consisting of synthetic rubber bonded to a non-metallic backing. A slab may be used as feedstock to produce class III stave bearings.

6.4.12 Stave. Wear rubber surface bonded to a non-metallic backing that seats into a bearing housing or shell.

6.5 Shelf life. This specification covers items where shelf life is a consideration. Specific shelf-life requirements should be specified in the contract or purchase order. The shelf-life codes are contained in the Federal Logistics Information System Total Item Record. Additive information for shelf-life management may be obtained from DoD 4140.27-M, Shelf-Life Management Manual, or the designated shelf-life Points of Contact (POC). The POC should be contacted in the following order: (1) the Inventory Control Points (ICPs), and (2) the DoD Service and Agency administrators for the DoD Shelf-Life Program. Appropriate POCs for the DoD Shelf-Life Program can be contacted through the DoD Shelf-Life Management website: http://www.shelflife.hq.dla.mil/.

6.6 Subject term (key word) listing.

Bearing

Partial Arc

Propulsion

Rubber

Shaft

Stave

Strut

Water

Waterborne

6.7 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to extent of the changes.

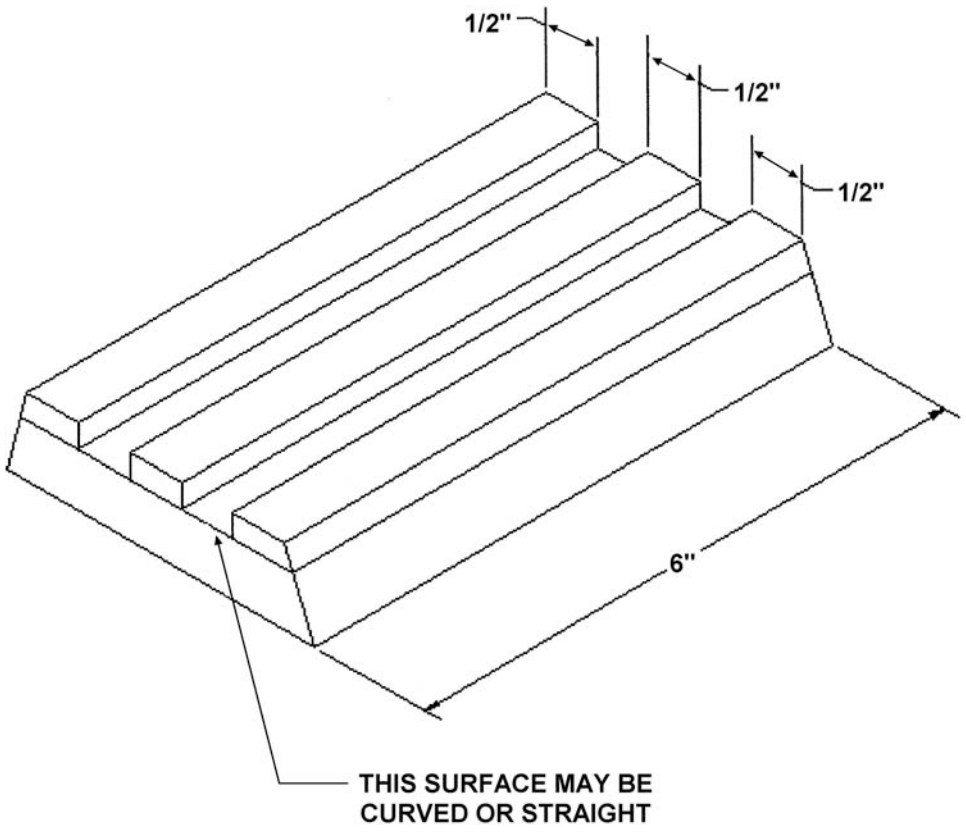


FIGURE 1. Test specimen for adhesion testing class III stave bearing.

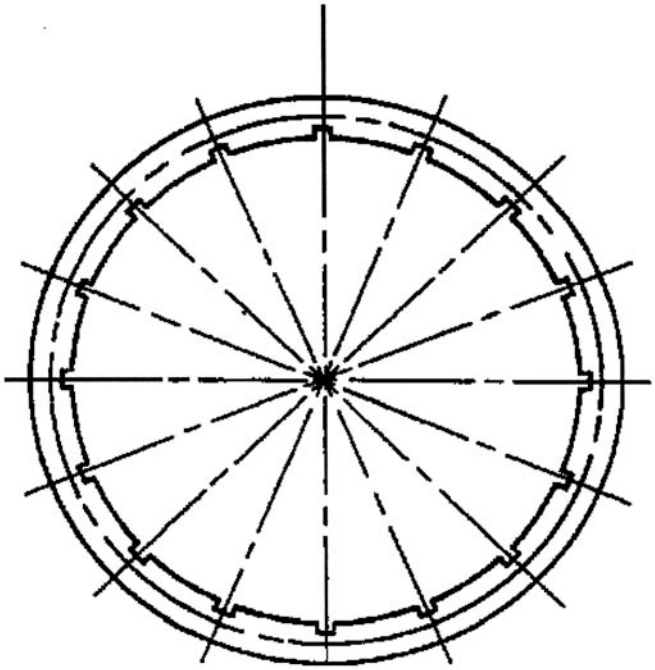

FIGURE 2. End view of class II and class IV cylindrical bearing showing location of saw cuts.

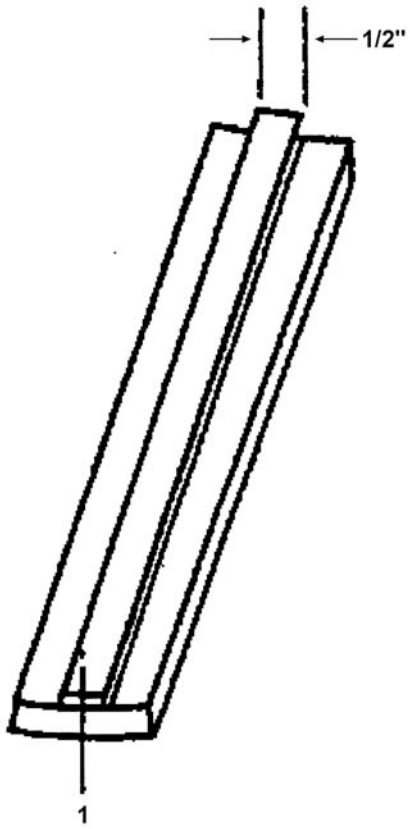


FIGURE 3. Test specimen for adhesion testing class II and IV cylindrical bearing and class V partial-arc bearing.

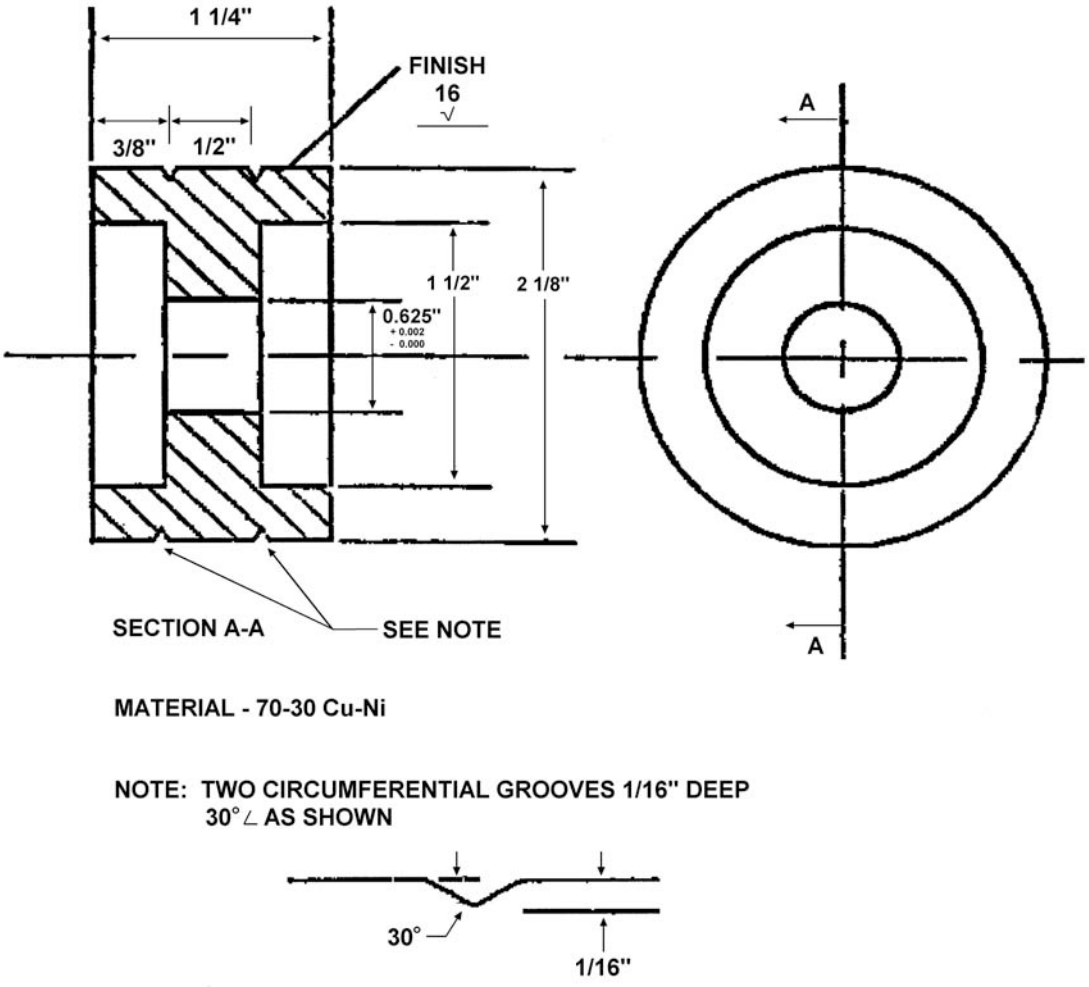


FIGURE 4. Journal for measuring wear.

Custodians:
Navy - SH
Air Force - 99

Preparing Activity:
Navy - SH
(Project 3130-0001-000)

Review Activity:
Air Force - 11

NOTE: The activities listed above were interested in this document as of the date of the document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at http://assist.daps.dla.mil.