NOTE: DOD-STD-2183 has been redesignated as a Test Method Standard. The cover page has been changed for Administrative reasons. There are no other changes to this Document.

DOD-STD-2183 (SH)
5 MARCH 1985
SUPERSEDING
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17 MARCH 1961

DEPARTMENT OF DEFENSE
TEST METHOD

BOND TESTING, BABBITT-LINED BEARINGS

AMSC N/A FSC 3120

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND

Washington, DC 20362-5101

Bond Testing, Babbitt-Lined Bearings.

DOD-STD-2183(SH)

1. This Military Standard 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.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

1. This standard is intended to be used to provide requirements for bond testing and to define the quality of bond required for steel and bronze backed babbitt-lined bearings frequently used in shipboard machinery, such as turbines, gears, pumps, fans, lineshaft, journal and thrust bearings.

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FIGURES

TABLE

APPENDIX

1. SCOPE

1.1 Scope. This standard provides the requirements for destructive and nondestructive metallurgical bond testing of babbitt-lined bearings.

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

SPECIFICATIONS

FEDERAL

QQ-T-390 - Tin Alloy Ingots and Castings and Lead Alloy Ingots and Castings (Antifriction Metal) for Bearing Applications.

STANDARDS

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-271 - Nondestructive Testing Requirements for Metals.
MIL-STD-45662 - Calibration Systems Requirements.

(Copies of specifications and standards required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following document forms a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

B 23 - White Metal Bearing Alloys.

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

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. DEFINITIONS

Not applicable.

4. GENERAL REQUIREMENTS

4.1 Material. The antifriction material to which the bond testing specified herein applies shall be grade 2 or 3 babbitt meeting the requirements of QQ-T-390 or ASTM B 23. The babbitt and shell or backing material shall be the same as the production or repair bearings (i.e., steel or brass/bronze) required to meet this standard.

4.2 Design. The bearing design shall be either journal or thrust and shall have a plain cylindrical, tilting pad, flat washer or tapered land configuration.

4.3 Bond extent. The extent of the bonded area determined ultrasonically as specified in 5.4.1 shall be as specified therein.

4.4 Bond strength. The minimum mean bond strength, when measured as specified in 5.4.2, shall be as specified therein for the respective material.

4.4.1 Bond strength determination. The results of the ultrasonic inspection shall be used to select areas for bond strength determination. Chalmers test samples shall be taken in areas shown as unbonded or of questionable bond.

4.5 Bond ductility. Bond ductility shall be evaluated both from inspection of the Chalmers test samples after completion of that test as specified in 5.4.2 and by means of a chisel test as specified in 5.4.3 (a brittle bond will part at the babbitt-backing material interface while a ductile bond will part in the babbitt some distance from the interface).

4.5.1 Evaluation of bond ductility. Some evidence of a brittle bond from the inspection of a Chalmers test specimen is permissible within the limits specified in 5.4.2. The bond shall be ductile over the entire bond area when evaluated by the chisel test as specified in 5.4.3.

4.6 Quality assurance provisions. The contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the contractor may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examination and tests shall be kept complete and available to the Government as specified in the contract or order. The Government reserves the right to perform any of the inspections set forth in this standard where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

5. DETAILED REQUIREMENTS

5.1 Test equipment and inspection facilities. Test and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the required inspection shall be established and maintained by the babbitting activity. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-STD-45662.

5.2 Material inspections. Material composition inspections shall consist of certification (see appendix) supported by verifying data that the materials used in fabricating the babbitt-lined bearings are in accordance with the applicable referenced specifications prior to such fabrication.

5.3 Sampling for tests. Sampling for tests shall be in accordance with MIL-STD-105, except as modified in 5.3.1. Backing material of sample bearing shall have the same composition, wall thickness and radius of curvature as the shells of the bearings being supplied. Backing material of sample bearing shall be cleaned and prepared for babbitting together with the shells of bearings to be supplied and by exactly the same method. Babbitt from the same heat shall be used for both the sample bearing and the bearings to be supplied. The babbitt thickness cast in the sample bearing shall be at least as great as that cast in the bearings to be supplied and allow the minimum babbitt thickness after finishing the surface to be not less than 4 millimeters (mm) (0.150 inch). The sample bearings shall have the same length as the bearings being supplied for journal bearings up to 100 mm (4 inches) in diameter. For larger journal bearings, the length of the sample bearing shall be limited to 100 mm (4 inches) or 20 percent of the bearing inside diameter whichever is larger. Journal bearing samples shall consist of two half shells. Thrust bearing samples shall consist of flat plates whose inside and outside diameters are equal to those of the tapered land bearings or plain thrust washers being supplied. For tilting pad thrust bearings, sample bearings shall have the same babbitt surface dimensions as a single thrust shoe of the bearings being supplied.

5.3.1 Sample bearings. Lots of new journal bearings and new thrust bearings shall be sampled in accordance with table I. Samples from the first lot of new bearings shipped from a specific manufacturer in each calendar year shall be tested by the test methods of 5.4.1, 5.4.2, and 5.4.3. Records of these tests shall be maintained by the manufacturer to serve as a reference for inspection of subsequent shipments. Subsequent shipments in the same calendar year may be tested by nondestructive testing (NDT) only by the method of 5.4.1. New journal bearings larger than 200 mm (8 inches) in diameter may have the ultrasonic test (see 5.4.1) conducted on a bearing to be supplied, and the destructive tests (see 5.4.2 and 5.4.3) conducted on a separately cast sample. The separately cast sample does not need to be finish machined, but the babbitt thickness shall be sufficient to allow for a finished thickness of not less than 4 mm (0.150 inches). Alternatively for such large journal bearings, the destructive tests may be conducted on a sample which is cast and machined as an integral part of a bearing to be supplied and then cut from one end to achieve the correct length in the bearing to be supplied. The babbitt in the sample shall be sufficiently great to allow a finished thickness of at least 4 mm (0.150 inches) and the sample shall be long enough to provide the area required for the eight specimen locations specified in 5.4.2 and the four edge cuts specified in 5.4.3.

TABLE I. Sampling for tests.

Number of bearings in lot	Number of samples required
1-49	1
50-99	2
100-299	3
300-399	4
400 and over	5

5.3.2 Rebabbitted bearings. Rebabbitted bearings shipped by a babbitting activity which has conducted the necessary tests in accordance with 5.4.1, 5.4.2, and 5.4.3, on a shipment or lot of new bearings in that calendar year and has a record of the test data may test the rebabbitted bearings in accordance with the method of 5.4.1 only. If destructive test data is not on file, it shall be obtained on a sample cast together with the rebabbitted bearing.

5.4 Tests. The tests for bond are as follows:

(a) Ultrasonic test (see 5.4.1) for bond extent measurement.
(b) Chalmers test (see 5.4.2) for bond strength measurement and bond ductility evaluation.
(c) Chisel test (see 5.4.3) for bond ductility evaluation.

These tests shall be performed in the order given. The test of 5.4.1 shall be made over the entire babbitt surface and the acceptance criteria of 5.4.1.3 shall be applied. The chalmers bond tests of 5.4.2 shall be applied at eight locations on the sample bearing. The eight locations shall be selected after a review of the findings of 5.4.1. The acceptance criteria of 5.4.2.4 shall be applied. Chisel tests (see 5.4.3) shall be applied at four locations selected to avoid the holes made by the chalmers bond tests. The acceptance criteria of 5.4.3.1 shall be applied to the results of the chisel tests.

5.4.1 Ultrasonic bond extent measurement. The extent of the bond between the babbitt and the backing metal of the sample bearings shall be determined by the use of ultrasonic methods. Personnel and procedure qualifications shall be in accordance with MIL-STD-271. A detailed written ultrasonic inspection procedure and test report shall be prepared (see appendix).

5.4.1.1 Equipment. A pulse-echo "A" scan instrument shall be used. The transducer shall be a single or dual element and produce a compression wave of 4 to 10 megahertz. The transducer shall have a diameter to suit the bearing without loss of contact. The transducer may be equipped with delays having a curvature which matches that of the bearing being inspected to maintain adequate contact. A couplant shall be used and may be either oil, glycerine, water, or a synthetic couplant with suitable coupling properties.

5.4.1.1.1 Demonstration of instrument suitability. Suitability of the equipment shall be demonstrated by the use of a reference block, such as the ones shown on figure 1. The unbonded areas in the reference block shall be as shown on figure 1, but the babbitt and backing material thicknesses may be other than as shown in order to more closely represent the babbitt and shell thicknesses of the sample bearing to be tested, or the block may incorporate

stepped regions with different babbitt thicknesses. Each unbonded area of the reference block is made by painting the area of the backing material with colloidal graphite in water followed by baking at 120°C (250°F) before babbitting.

5.4.1.1.2 Calibration standard for unbond. The standard used to calibrate the ultrasonic instrument for detection of unbonded areas shall be a strip of clean babbitt without backing material. The strip of babbitt shall have the same thickness as the babbitt in the sample bearing to be inspected, within plus or minus 20 percent or plus or minus 1.5 mm (1/16 inch), whichever is smaller. For thrust bearing or thrust shoe inspections, the strip of babbitt shall be flat. For journal bearing inspection, the strip of babbitt shall have a curvature with a radius equal to the radius of curvature of the bearing to be inspected within plus or minus 10 percent and the transducer shall be equipped with the delay used for the bearing inspection.

5.4.1.2 Bond examination. Prior to each sample bearing inspection, the suitability of the equipment (see 5.4.1.1) shall be demonstrated with a reference block (see 5.4.1.1.1) by mapping the bonded and unbonded areas of the block by using the patterns of pulse reflection. Typical patterns are shown on figures 2 and 3. After demonstrating the suitability of the equipment by verifying that the detected areas of bond and unbond match the known such areas in the block, the same equipment shall be used to test the sample bearing. The calibration standard (see 5.4.1.1.2) that is within plus or minus 1.5 mm (1/16 inch) of the babbitt thickness in the sample bearing shall be used to establish the cathode ray tube (CRT) presentation of unbond for the sample bearing. After establishing the unbond signal on the standard, the surface of the babbitt to be tested shall be scanned using a continuous scanning pattern with successive transducer passes. Each successive pass shall overlap the previous pass by at least 20 percent of the transducer diameter. Unbond areas on the face of the bearing shall be mapped. The equipment calibration made prior to the inspection shall be checked using the calibration standard at least once per 8 hour shift and at completion of testing. If a check shows the amplitude of the IF pulse (see figure 2) at the same equipment settings to have changed by 20 percent or more from its amplitude during the preinspection calibration, all mapping conducted since the previous satisfactory calibration check shall be redone.

5.4.1.3 Bond acceptance criteria. Bearings shall be divided into three zones designated Zone A, Zone B, and Zone C (see figure 4) as follows:

(a) Zone A, for journal bearings, is defined as the periphery whose width is 10 percent of bearing length. (A total of 20 percent when both ends are taken into account.) Zone A for thrust shoes is defined as the 10 percent peripheral area of each shoe based on the nominal thrust shoe outside diameter (od), not to exceed 25 mm (1 inch) in width. (For example, a thrust shoe with an od of 150 mm (6 inches) will have a Zone A width of 15 mm (0.6 inch)).

(b) Zone B for journal bearings is defined as all babbitt areas located over anchoring dovetail grooves or in areas recessed below the nominal bearing bore such as oil pockets, channels, feed or drain grooves, or configurations for producing hydrodynamic loading such as oil dams. Also, all areas located

in the nominally unloaded half of unidirectionally loaded bearings (such as line-shaft bearings). Zone B for thrust shoes is defined as all babbitt areas over anchoring grooves or holes in the shoes or pads.

(c) Zone C is all the area not in Zones A or B.

5.4.1.3.1 Requirements for Zone A. Requirements for Zone A shall be as follows:

(a) Total unbonded area shall not exceed 15 percent of the area of Zone A.
(b) No individual area of unbond shall have a major dimension greater than 12.5 mm (0.5 inch).
(c) Adjacent individual areas of unbond of any size must be farther than 50 mm (2 inches) apart.

5.4.1.3.2 Requirements for Zone C. Requirements for Zone C shall be as follows:

(a) Total unbonded area shall not exceed 15 percent of the total babbitted area of the bearing.
(b) No individual area of unbond shall be larger than 3 percent of the total babbitted area of the bearing or 650 square mm (1 square inch) whichever is smaller.

5.4.1.3.3 Exclusions for Zone B. Zone B is excluded from ultrasonic inspection.

5.4.1.3.4 Bearing acceptance. Sample bearing and the lot which it represents shall be rejected unless it meets all the requirements of 5.4.1.3.1 and 5.4.1.3.2.

5.4.2 Chalmers bond test. The strength of the bond between the babbitt and backing material shall be determined by the chalmers method in which an annular area of bond is isolated and forced off the bearing shell as shown on figure 5. This method is applicable to babbitt thicknesses greater than 4 mm (0.15 inch).

5.4.2.1 Specimen location selection. The chalmers bond test shall be made after the ultrasonic bond extent has been determined. Eight locations on the sample bearings shall be selected, equally spaced, four in Zone A and four in Zone C. If unbonded or doubtful areas have been mapped in accordance with 5.4.1.2 in either Zone A or C, bond tests shall be located to include or be within the suspect areas. Investigation of suspicious areas shall take precedence over the requirement for equal spacing of test locations.

5.4.2.2 Specimen preparation and test. The annular area of bond is isolated by drilling through the babbitt with a trepanning drill (od = d_3, inside diameter (id) = d_2 = 9 mm (0.350 inch)) and drilling a coaxial hole in the backing material with a flat-ended drill (od = d_1 = 6 mm (0.250 inch)). The holes shall be concentric within 0.05 mm (0.002 inch). The babbitt plug is then forced off the backing material. The rod used to force the plug off shall be at least 0.05 mm (0.002 inch) less in diameter than d_1. The force in kilograms required to push the plug from the shell is measured by electric strain gauge, mechanical, pneumatic, or hydraulic piston force measuring systems.

The rate of load application shall be 9 mm (0.350 inch) per minute. The bond strength is calculated by dividing this force by the area of the annulus between the hole in the babbitt and the hole in the backing material as follows:

$$S = 4F/(\pi(d_2^2 - d_1^2))$$

Where: S = bond strength, megapascals
F = rupture force, newtons
d_2 = id of trepanning drill, mm
d_1 = od of flat-end drill, mm

In the event that a babbitt plug falls off during the preparation of the eight specimens, it shall be included in the computation of average bond strength, with a value of zero as the bond strength of that specimen. The average value of the eight specimens shall be computed.

5.4.2.3 Specimen post-test examination. Babbitt plugs forced off in the Chalmers test shall be examined and rated as exhibiting either a brittle or ductile bond. Bonds showing presence of backing machining marks shall be rated as brittle bonds.

5.4.2.4 Acceptance criteria. The sample bearing shall meet both of the following acceptance criteria:

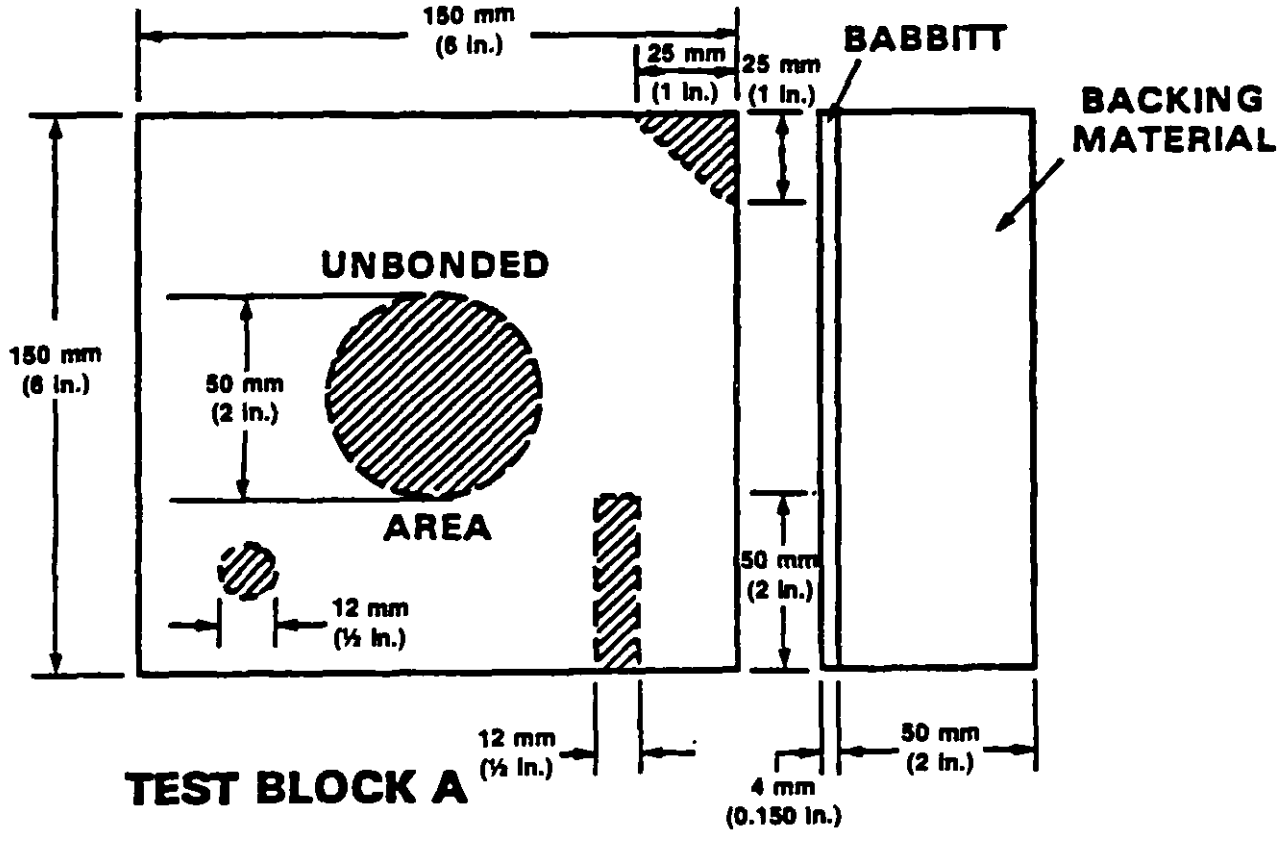
(a) The average bond strength as determined by 5.4.2.2 exceeds 55 megapascals (8,000 pounds per square inch) for steel-backed and 35 megapascals (5,000 pounds per square inch) for bronze-backed sample bearings.
(b) Not more than two of the eight babbitt plugs exhibit brittle bonds when examined and rated in accordance with 5.4.2.3.

5.4.3 Chisel test. Following the successful completion of the tests of 5.4.1 and 5.4.2, a chisel test shall be applied to the sample to check for the presence of a brittle bond. A machinist cold chisel, 13 to 19 mm (1/2 to 3/4 inch) wide with a 30 to 60 degree included angle cutting edge, shall be placed with the cutting edge parallel to the bond line and slightly above the bond line. Repeated hammer blows shall then be applied to the chisel to peel back the babbitt bonded onto the base metal. The angle of the chisel shall be adjusted to carry it to the bond line without actually cutting into the backing material. Cuts shall be extended to the center of the bearing surface. Cuts shall be placed to avoid going through chalmer bond test trepanned areas. Four cuts, one from each edge of the bearing surface, shall be made.

5.4.3.1 Chisel test acceptance criteria. The bond shall be deemed acceptable if separation is above the bond line and if the ribbon of babbitt is not more than 13 mm (1/2 inch) greater in width than the width of the chisel, in all of the four test areas.

5.5 Rejection. The failure of any sample to pass the tests specified in 5.4 shall cause the lot represented thereby to be rejected.

Preparing activity:
Navy - SH
(Project 3120-N637)



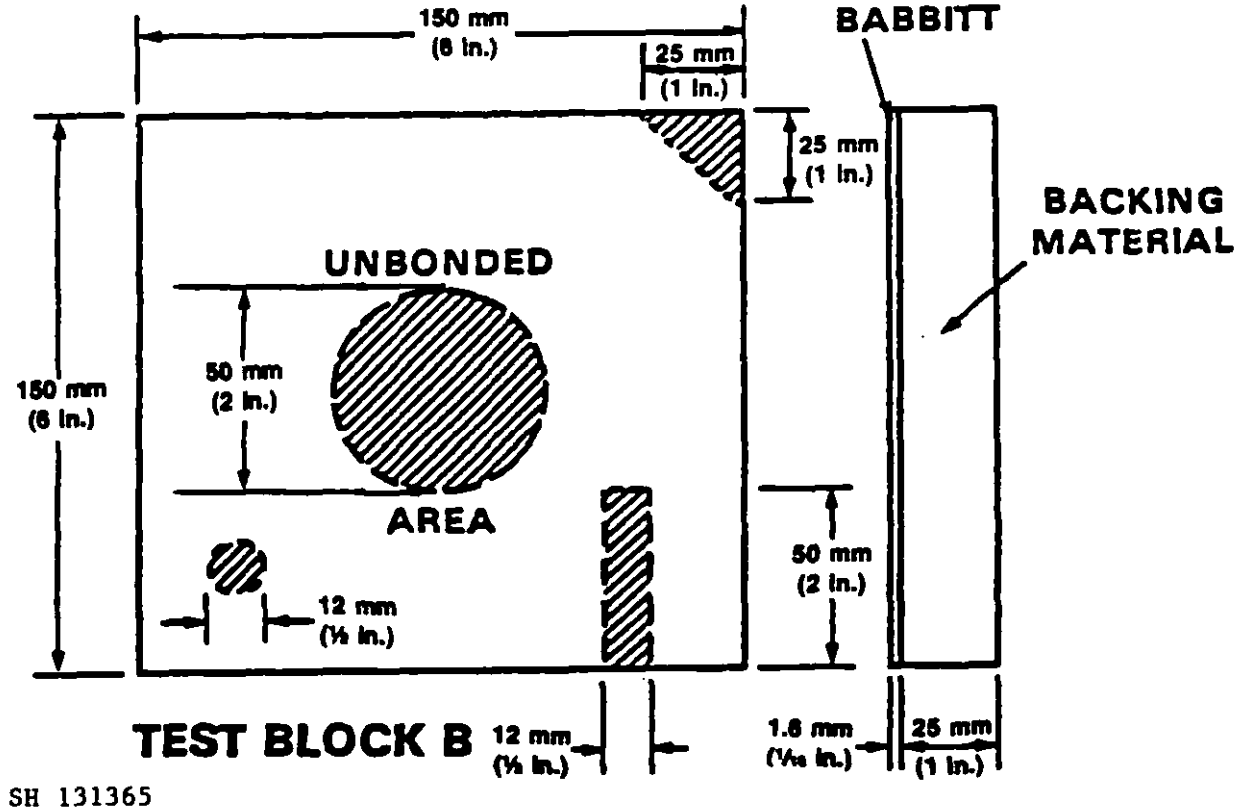


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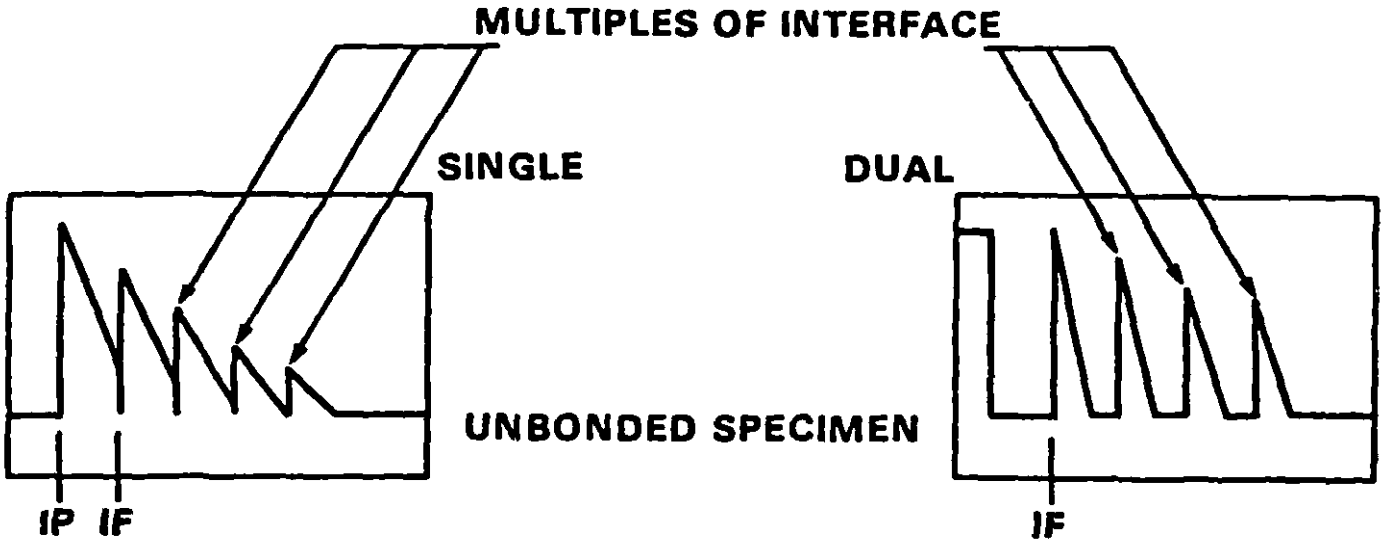
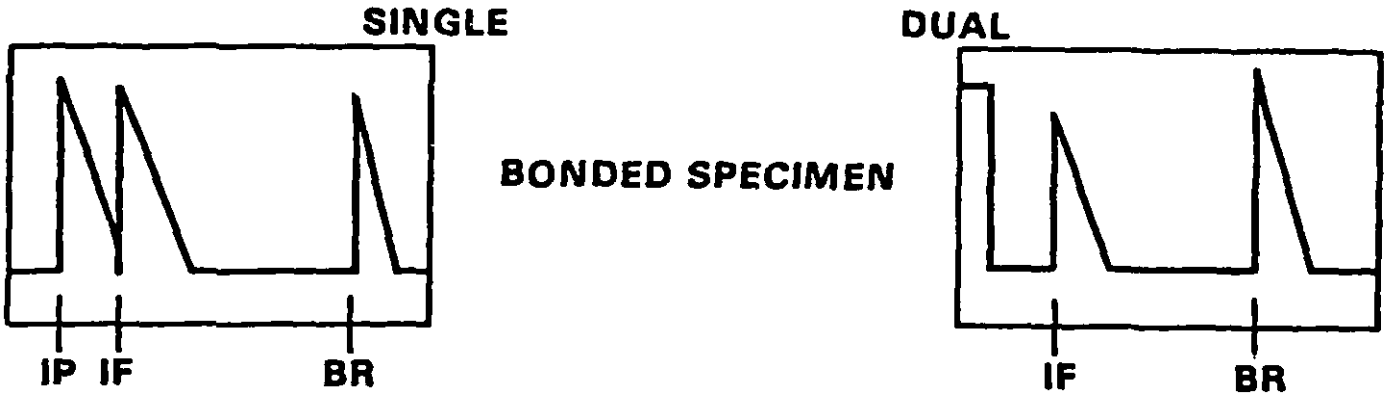
FIGURE 1. Reference test blocks.



SH 131363

FIGURE 2. Patterns of pulse sonic reflections of unbonded specimen.



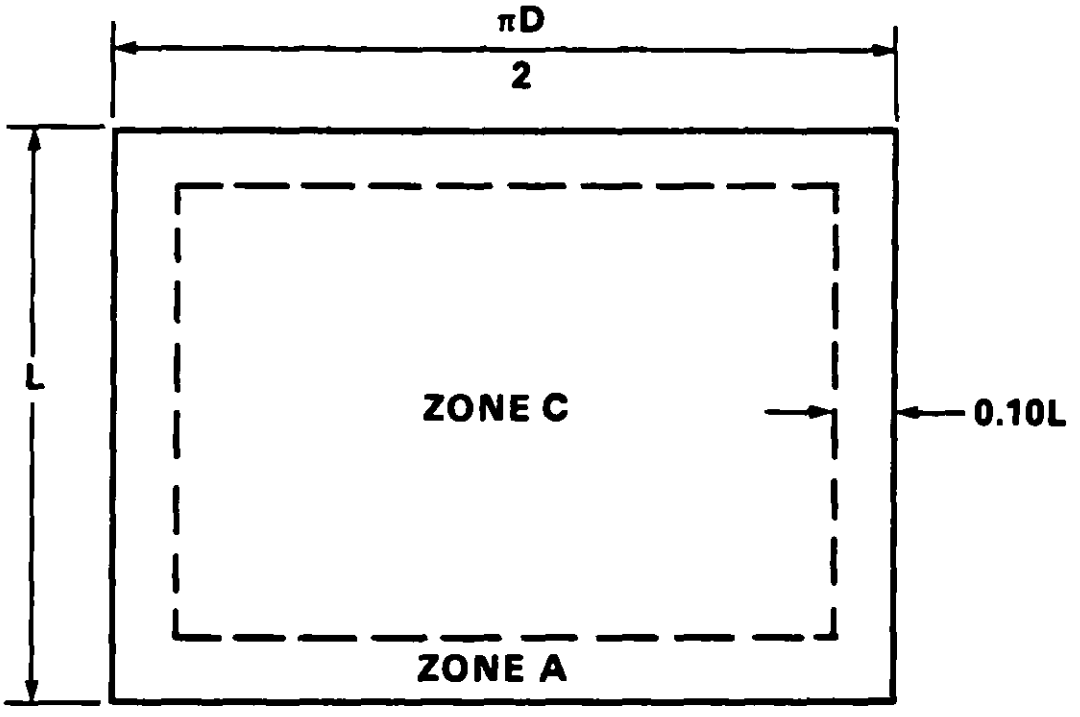
IP=INITIAL PULSE

IF=INTERFACE (BETWEEN BABBITT AND BEARING)

BR=BACK REFLECTION (FROM BACK SURFACE OF BEARING ONLY WHEN SURFACES ARE PARALLEL)

SH 131364

FIGURE 3. Patterns of pulse sonic reflections of bonded specimen.



JOURNAL BEARING

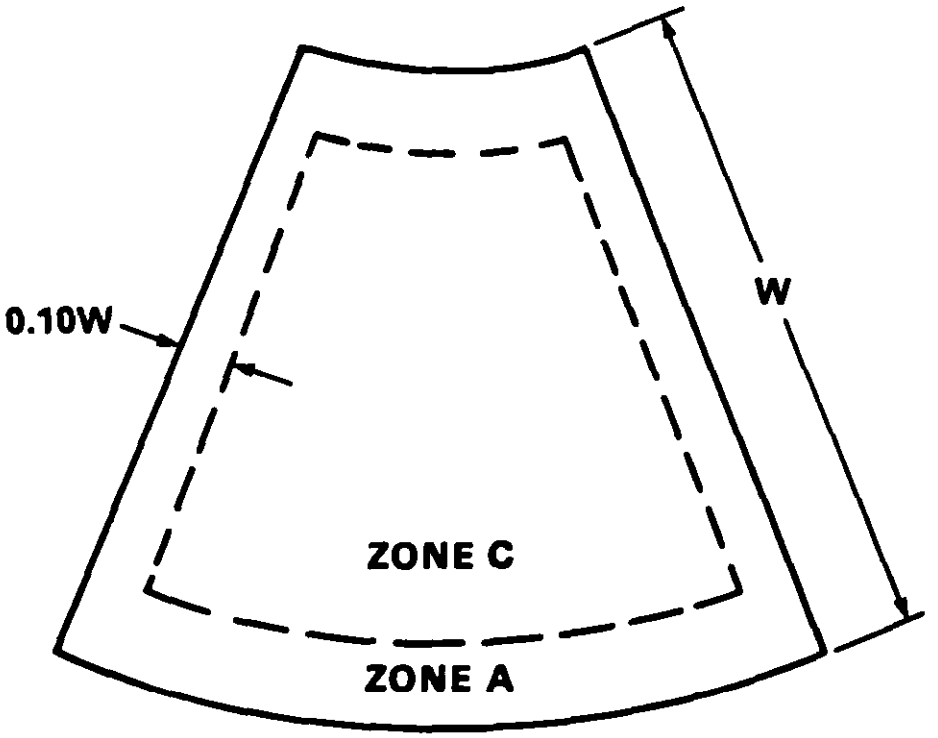


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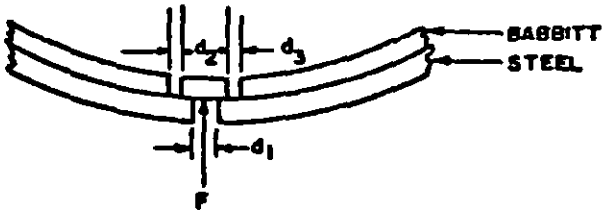
FIGURE 4. Zones A and C of sample bearing surface.



SH 131367

FIGURE 5. Chalmers bond test method.

APPENDIX

10. DATA REQUIREMENTS

10.1 Data requirements. When this standard is used in an acquisition which incorporates a DD Form 1423, Contract Data Requirements List (CDRL), the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved CDRL incorporated into the contract. When the provisions of FAR 52.227-7031 are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this standard is cited in the following paragraphs.

Paragraph no.	Data requirement title	Applicable DID no.	Option
5.2	Certification data/report	UDI-A-23264	----
5.4.1	Procedures, test	UDI-T-23732	----
5.4.1	Reports, manufacturer's test	UDI-T-23797	----

(Data item descriptions related to this standard will be approved and listed as such in DoD 5000.19L., Vol. II, AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

10.2 The data requirements of 10.1 and any task in sections 4 or 5 of this standard required to be performed to meet a data requirement may be waived by the contracting/acquisition activity upon certification by the offeror that identical data were submitted by the offeror and accepted by the Government under a previous contract for identical item acquired to this standard. This does not apply to specific data which may be required for each contract regardless of whether an identical item has been supplied previously (for example, test reports).

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER
DOD-STD-2183(SH)

2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION

b. ADDRESS *(Street, City, State, ZIP Code)*

4. TYPE OF ORGANIZATION *(Mark one)*

- ☐ VENDOR
- ☐ USER
- ☐ MANUFACTURER
- ☐ OTHER *(Specify)*: _____

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional

b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional

c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional

8. DATE OF SUBMISSION *(YYMMDD)*

DD FORM 82 MAR 1426 PREVIOUS EDITION IS OBSOLETE.

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