Designation: E238 – 17a

Standard Test Method for Pin-Type Bearing Test of Metallic Materials[1]

This standard is issued under the fixed designation E238; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers a pin-type bearing test of metallic materials to determine bearing yield strength and bearing strength.

NOTE 1—The presence of incidental lubricants on the bearing surfaces may significantly lower the value of bearing yield strength obtained by this method.

1.2 *Units*—The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E4 Practices for Force Verification of Testing Machines
E6 Terminology Relating to Methods of Mechanical Testing
E83 Practice for Verification and Classification of Extensometer Systems
B769 Test Method for Shear Testing of Aluminum Alloys
B831 Test Method for Shear Testing of Thin Aluminum Alloy Products

3. Terminology

3.1 *Definitions:*

3.1.1 *bearing area*—the product of the pin diameter and specimen thickness.

3.1.2 *bearing stress*—the force per unit of bearing area.

3.1.3 *bearing strain*—the ratio of the bearing deformation of the bearing hole, in the direction of the applied force, to the pin diameter.

3.1.4 *bearing yield strength*—the bearing stress at which a material exhibits a specified limiting deviation from the proportionality of bearing stress to bearing strain.

3.1.5 *bearing strength*—the maximum bearing stress which a material is capable of sustaining.

3.1.6 *edge distance*—the distance from the edge of a bearing specimen to the center of the hole in the direction of applied force (Fig. 1).

3.1.7 *edge distance ratio*—the ratio of the edge distance to the pin diameter.

3.1.8 For definitions of other terms see Terminology E6.

4. Significance and Use

4.1 The data obtained from the bearing test are the bearing ultimate and yield strength. The data provide a measure of the load-carrying capacity of a material edge loaded with a close-fitting cylindrical pin through a hole located a specific distance from the specimen edge.

4.2 Bearing properties are useful in the comparison of materials and design of structures under conditions where the pin is not restricted.

5. Apparatus

5.1 *Testing Machines*—Machines used for bearing testing shall conform to the requirements of Practices E4.

5.2 *Gripping Devices*—Various types of gripping devices may be used to transmit the measured load applied by the testing machine to the test specimens. Any grips considered to apply the load axially for tension testing, such as pin connections or wedge grips, are satisfactory for use in bearing testing.

5.3 *Pin*—The bearing load is generally applied to the specimen through a close-fitting cylindrical pin. The pin shall be harder and stronger than the material being tested. Restraint

[1] This test method is under the jurisdiction of ASTM Committee E28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.04 on Uniaxial Testing.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

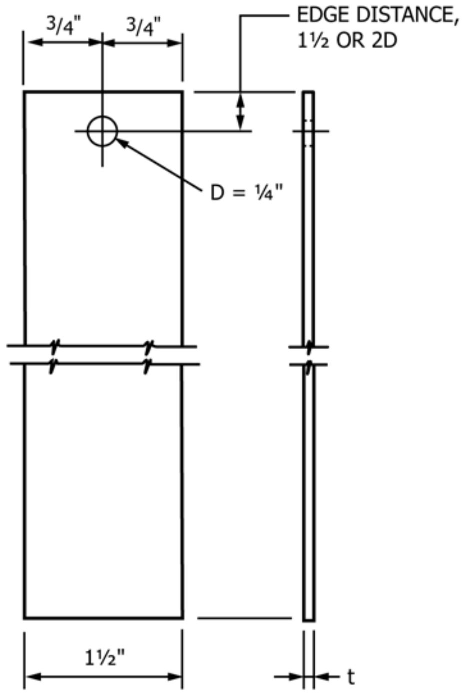

FIG. 1 Bearing Test Specimen

TABLE 1 Characteristics of Pin for Various Materials Tested

Material Tested	Material	Rockwell Hardness	Surface Roughness, μ in. (μm) (avg)
Aluminum alloys	hardened steel	C60 to 64	4 to 8 (0.1 to 0.2 μm)
Beryllium alloys	hardened steel	C60 to 64	4 to 8 (0.1 to 0.2 μm)
Copper alloys	hardened steel	C60 to 64	4 to 8 (0.1 to 0.2μ m)
Magnesium alloys	hardened steel	C60 to 64	4 to 8 (0.1 to 0.2 μm)
Zinc alloys	hardened steel	C60 to 64	4 to 8 (0.1 to 0.2μ m)

of movement of the specimen where it is in contact with the pin has a considerable effect upon the hole deformation obtained as a function of the load applied. Close control of surface conditions on both the specimen and pin is needed to assure reproducible results. The pins used should be uniform in diameter, hardness, and surface roughness. Pin materials, hardness, and surface roughness as shown in Table 1 are recommended for testing the materials listed. The pin should be checked carefully after each test to ensure that no metallic residue adheres to it and that it is both straight and undeformed. If there is any question regarding its quality it should be replaced.

5.4 *Pin Support*—The jig supporting the pin should position the pin concentric with the hole in the specimen. It should not restrain the thickening of the specimen as the load from the pin deforms the hole. Bending of the pin should be kept to a minimum by having the jig support the pin close to the specimen. Fig. 2 and Fig. 3 show examples of the types of jig that have been used and are considered satisfactory.

5.5 *Extensometers*—Extensometers used for measuring the bearing deformation shall comply with the requirements for Class B-2 or better as described in Practice E83. The bearing deformation measurement shall be made in a manner to obtain the axial bearing deformation with a minimum of other deformations being included such as the bending of the pin and tensile strain in the specimen. Fig. 2 shows an adaptation of a Templin extensometer system to record bearing deformation. Fig. 3 illustrates a mechanism that can be used to transfer the bearing deformation so it can be measured with the same extensometers used for tension testing. A method of measuring bearing deformation featuring two linear differential transformers is shown in Fig. 4.

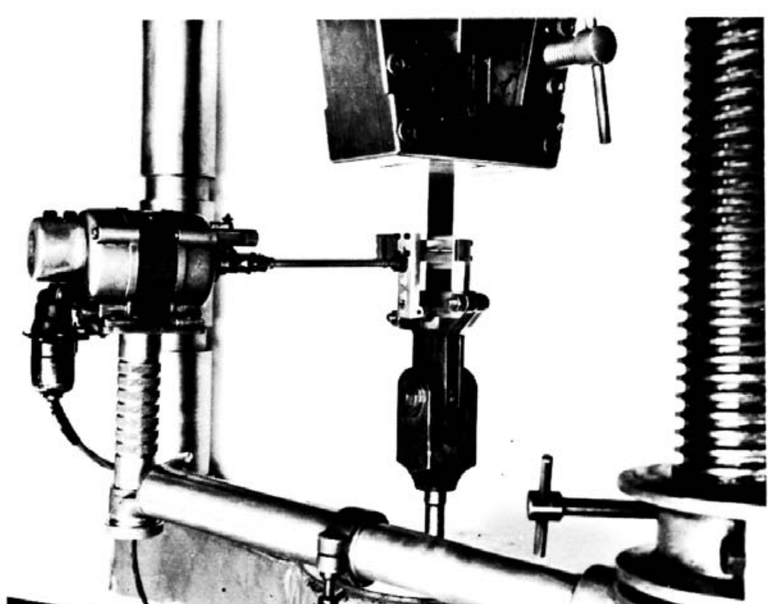

FIG. 2 Bearing Test Fixture Used on Aluminum Sheet

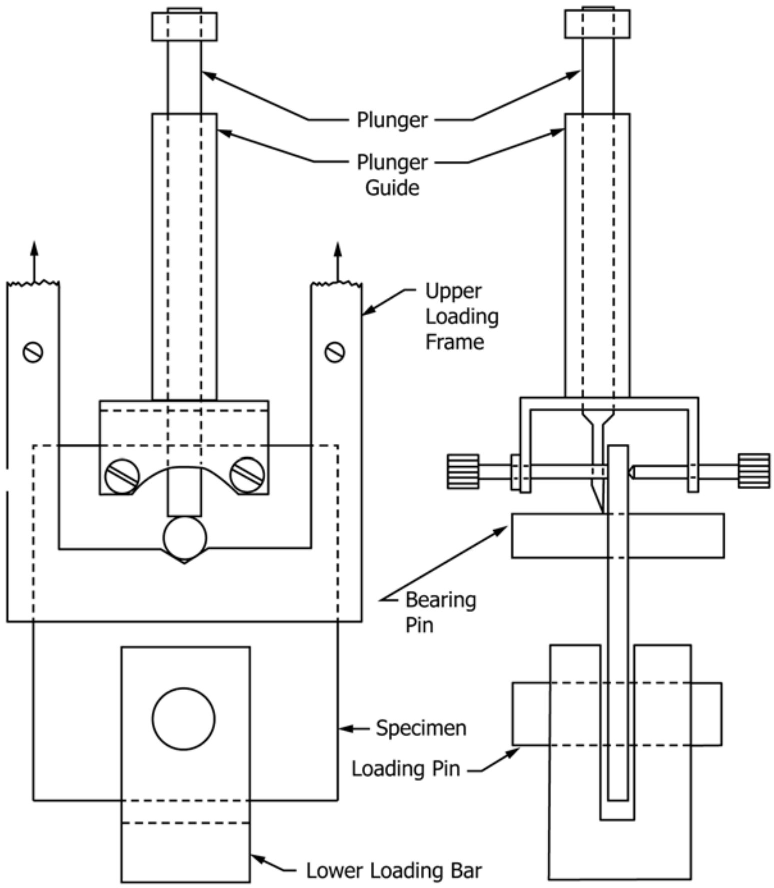

FIG. 3 Schematic Drawing of Bearing Deformation Transfer Device

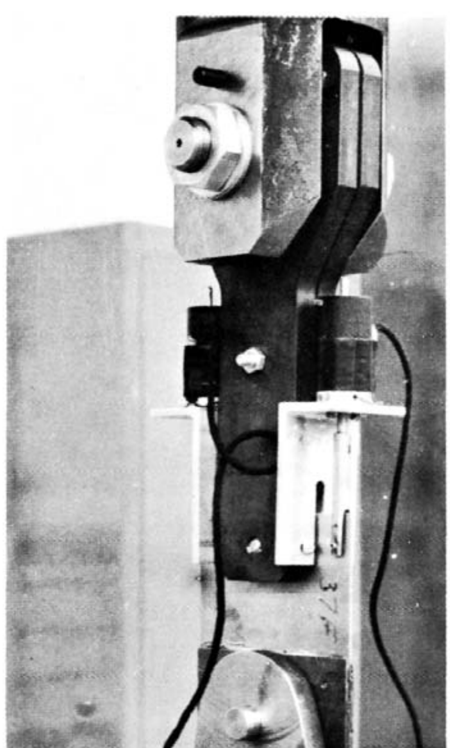

FIG. 4 Autographic Measurement of Bearing Deformation

6. Test Specimens

6.1 *Specimen Geometry*—The specimen shall be a flat sheet type, with the full thickness of the product being used if possible. If the specimen is too thick in relation to the pin diameter, the pin is likely to bend considerably or break before the bearing strength is obtained. If a specimen is too thin, buckling may occur. A ratio of pin diameter to specimen thickness of from 2 to 4 has been used to avoid both conditions. The hole should have approximately the same diameter as for the intended use. For example, if the bearing test results are being used to obtain data for a riveted part, a hole 3⁄16 in. or 1⁄4 in. (5 or 6 mm) in diameter would be suitable, while for a bolted assembly, a larger hole might be desirable. A difference in test results may be obtained with holes of different diameters. The width of the specimen shall be 4 to 8 times the diameter of the hole. A wider specimen encourages the intended shear-out failure mode. The edge distance ratio shall be specified and the edge distance held within a tolerance of ±2 %. Edge distance ratios of 1.50 and 2.00 are commonly used (see Fig. 1). A close fit between the specimen and pin is required, since a loose fit will tend to give lower results. The diameter of the hole shall not exceed the pin diameter by more than 0.001 in. (0.02 mm). The free length between the point of loading and the center of the test pin hole shall be greater than 1.5 times the specimen width. The total length of the test specimen is not critical and may depend on the method used to grip the specimen. Fig. 1 shows a bearing test specimen commonly used.

6.1.1 *Specimen orientation*—The measured bearing properties can depend on the specimen orientation and the direction in which the load is applied relative to the grain flow in the product from which the specimen is extracted. The specimen orientation and the loading direction shall be identified by a two-letter code as illustrated in Fig. 5. The first letter designates the normal to the expected shear plane. The second letter designates the direction of force application. This orientation code is identical to that used for cylindrical and flat shear specimens in Test Methods B769 and B831.

6.1.2 The orientation codes for rectangular shaped products are indicated in Fig. 5a. The product axes are in the longitudinal (L), transverse (T), and short (S) directions. These are suitable for sheet, plate, extrusions, forgings, and other shapes having a rectangle form. The most commonly used specimen orientations are T-L and L-T for thin products. Fig. 5b shows the orientation codes for cylindrical product forms such as rod, tube, and pipe, where the product axes are in the longitudinal (L), radial (R), and circumferential (C) directions.

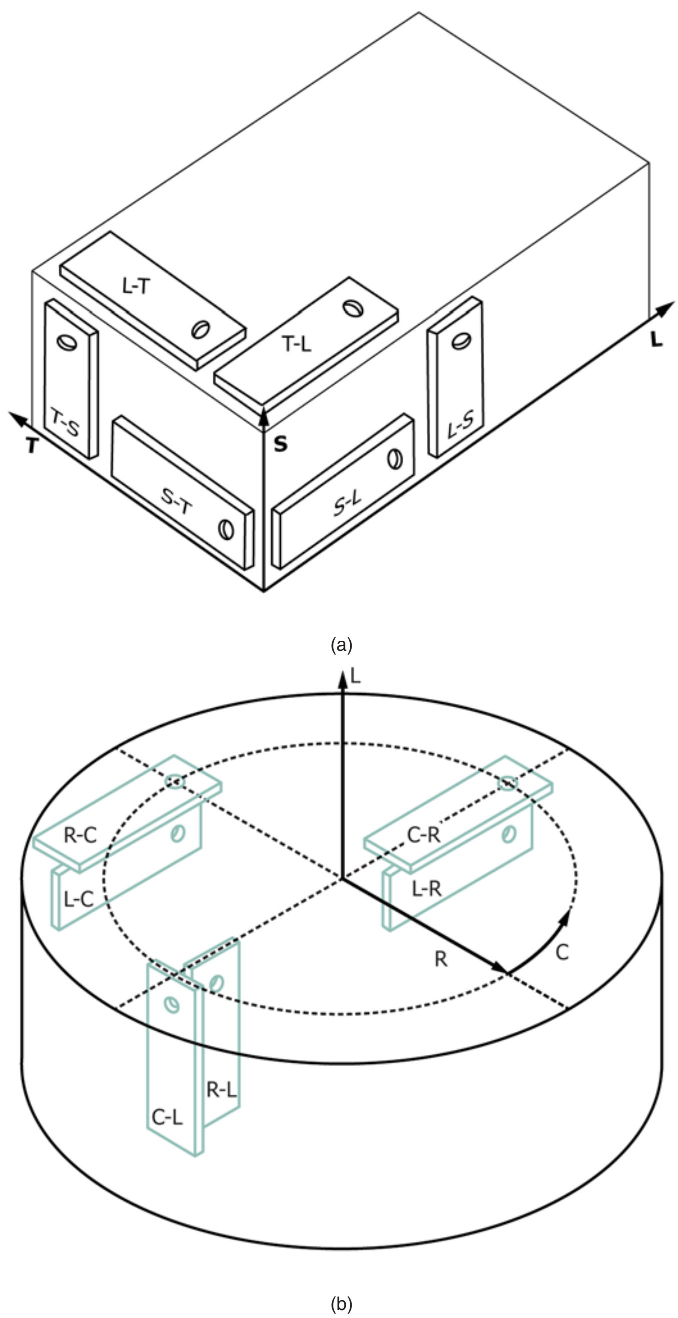

FIG. 5 Pin Bearing Specimen Orientation Codes for Specimens Taken from (a) Rectangular Shapes and (b) cylindrical shapes.

6.2 *Specimen Preparation*—A flat specimen with a hole normal to the face shall be used. A smooth, round hole with a minimum of cold work on the surface must be obtained. The finished hole is generally bored, reamed, or ground as a final operation to obtain the desired degree of roundness. Any burr on the periphery of the hole is indicative of a cold-worked surface on the hole and should be avoided. Removal of the burr will not eliminate the cold work.

7. Procedure

7.1 *Measurement of Specimens*—Measure the actual thickness of the specimen and the pin diameter, preferably reading to at least the nearest 0.5 % of the dimension measured, and in any case to at least the nearest 0.001 in. (0.02 mm). Calculate the stress on the basis of the measured dimensions. Measure the edge distance to the nearest 0.01 in. (0.2 mm).

7.2 *Cleaning*—Clean the specimen, pin, and adjacent areas of the jig of all foreign matter and contamination, especially lubricants, prior to assembly. Keep in that condition until the test is completed. It has been found that oil from human fingers touching the pin significantly lowers the results of the test. A handle on the pin has been found to help in keeping fingers from touching the test area of the pin. Recommended methods of cleaning are given in the Appendix X1.[3] The cleaners recommended for the materials given in the Appendix X1 are generally satisfactory for cleaning the pin and fixtures, too.

7.3 *Testing*—Load the specimen and obtain simultaneous readings of the load and bearing deformation. Any convenient method of load application and system of strain recording may be used. Autographic strain recording equipment can be readily adapted to measure bearing deformation (see Figs. 1-6).

7.4 Conduct the tests at a controlled rate of straining or loading. The recommended rate for metallic materials is 0.05 bearing strain per minute. If a testing speed other than a strain rate of 0.05/min is used, report this fact.

8. Determination of Bearing Yield Strength

8.1 Determine the bearing yield strength from a graph of the bearing load versus bearing deformation. Fig. 6 is an illustration of such a graph. Calculate the yield strength from the load at an offset from the initial straight-line portion of the graph equal to 2 % of the pin diameter. Calculate the stress by dividing the load by the bearing area.

9. Determination of Bearing Strength

9.1 Calculate the bearing strength by dividing the maximum load carried by the specimen by the bearing area.

10. Determination of Fracture Mode

10.1 Determine the fracture mode of the specimen according to Fig. 7 and the descriptions of the depicted fracture modes.

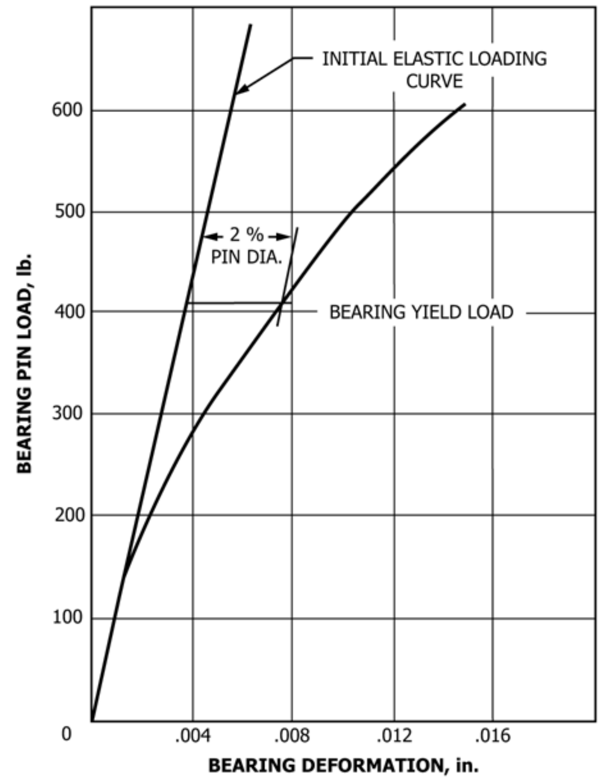

FIG. 6 An Autographic Bearing Load Versus Bearing Deformation Curve on AZ31A-H24 Sheet at Room Temperature

10.1.1 *Crushing (C):* Deformation to the test pin hole without fracture

10.1.2 *End Splitting (E):* : A single fracture in the loading direction directly above the center of the test pin hole

10.1.3 *Shear or Shearout (S):* Fracture in or within 20 degrees of the loading direction of the cross section directly above the test pin hole

10.1.4 *Net-Tension (T or NT):* Fracture through the specimen transverse to the loading direction

10.1.5 *Diagonal Tearing (D):* Tearing fracture toward the corners of the specimen at an angle approximately 20-70 degrees to the loading direction

10.1.6 *Multimodal Failure:* If a specimen exhibits multiple modes of failure, and it cannot be determined which is primary, multiple codes may be assigned, as appropriate.

11. Report

11.1 The report shall include the following:

11.1.1 Material tested and direction of test,

11.1.2 Hole diameter, width, and thickness of specimen.

11.1.3 Edge distance ratio,

11.1.4 Temperature of testing (if other than at room temperature),

11.1.5 Bearing yield strength,

11.1.6 Bearing strength,

11.1.7 Description of fracture according to Fig. 7 and Section 10,

11.1.8 Cleaning procedure, and

11.1.9 Speed of testing.

[3] Stickley, G. W., and Moore, A. A., "*Effects of Lubrication and Pin Surface on Bearing Strengths of Aluminum and Magnesium Alloys*," MTRSA, *Materials Research & Standards* Vol 2, No. 9, pp.747, September 1962.

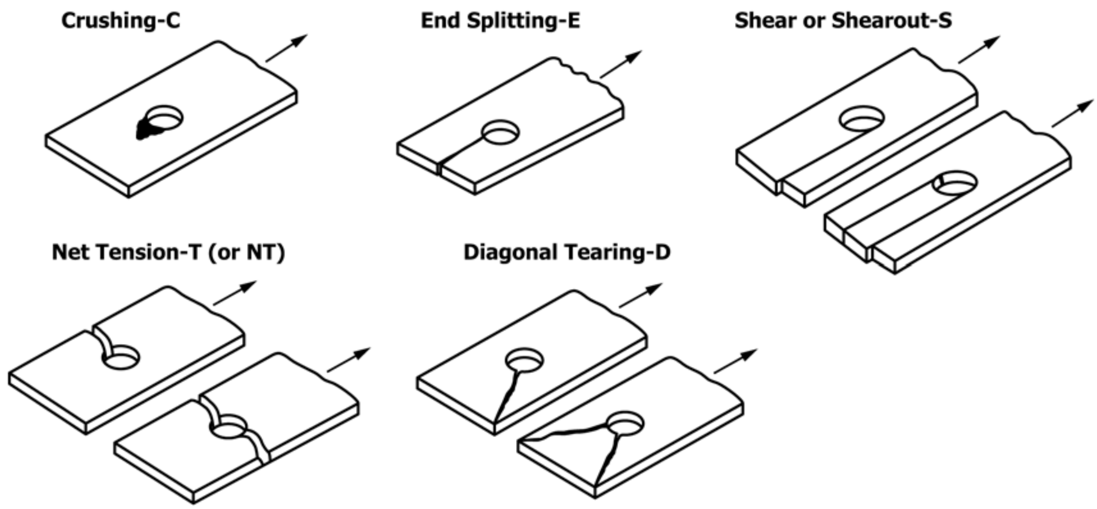

FIG. 7 Bearing Test Specimen Fracture Modes and Corresponding Descriptions of Failure

12. Precision and Bias

12.1 Because of the limited number of users it is difficult to secure information on precision or bias. Committee E28 would welcome participants in an interlaboratory study to develop such information on this method.

13. Keywords

13.1 bearing strength; bearing test; bearing yield strength; metallic materials; pin-type

APPENDIX

(Nonmandatory Information)

X1. RECOMMENDED METHODS OF CLEANING

X1.1 Recommended methods of cleaning the bearing test specimen, pin, and support assembly to get uniform test results are given in this Appendix. They are not intended to be exclusive but have been found adequate for the materials indicated.

X1.1.1 *Aluminum Alloys*—Ultrasonic cleaning in a suitable solvent such as acetone.

X1.1.2 *Magnesium Alloys*—Chemical cleaning with a cleaner such as one consisting of 60 g of NaOH plus 10 g of $Na_3 PO_4 \cdot 12H_2 O$/L of water at 180 to 200°F.

SUMMARY OF CHANGES

Committee E28 has identified the location of selected changes to this standard since the last issue (E238–17) that may impact the use of this standard. (Approved April 1, 2017)

(1) Added Section 10 and Fig. 7 with standard bearing fracture modes, identifications, and descriptions to be used for reporting.

Committee E28 has identified the location of selected changes to this standard since the last issue (E238–12) that may impact the use of this standard. (Approved February 1, 2017)

(1) Minor revisions in 6.1 to clarify that the specimen free length is measured from the centerline of the hole.

(2) Added specimen orientation codes for cylindrical products in 6.1.1 – 6.1.2 and Fig. 5b and revised text for clarity.