



Designation: B593 – 21

Standard Test Method for Bending Fatigue Testing for Copper-Alloy Spring Materials¹

This standard is issued under the fixed designation B593; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method establishes the requirements for the determination of the reversed or repeated bending fatigue properties of copper alloy flat sheet or strip of spring materials by fixed cantilever, constant deflection (that is, constant amplitude of displacement)-type testing machines. This method is limited to flat sheet or strip ranging in thickness from 0.005 in. to 0.062 in. (0.13 mm to 1.57 mm), to a fatigue life range of 10^5 to 10^8 cycles, and to conditions where no significant change in stress-strain relations occurs during the test.

NOTE 1—This implies that the load-deflection characteristics of the material do not change as a function of the number of cycles within the precision of measurement. There is no significant cyclic hardening or softening.

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 The following safety hazard caveat pertains only to the test method(s) described in this test method.

1.3.1 *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, health, and environmental 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.*

¹ This test method is under the jurisdiction of ASTM Committee B05 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.06 on Methods of Test.

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2. Referenced Documents

2.1 *ASTM Standards*:²

B846 Terminology for Copper and Copper Alloys

E468 Practice for Presentation of Constant Amplitude Fatigue Test Results for Metallic Materials

E1823 Terminology Relating to Fatigue and Fracture Testing

2.2 *Other ASTM Document*:³

ASTM STP 91A A Guide for Fatigue Testing and the Statistical Analysis of Fatigue Data

3. Terminology

3.1 For definition of terms relating to this test method, refer to Terminology **E1823** and Practice **E468**.

3.2 For definitions of terms related to copper and copper alloys, refer to Terminology **B846**.

4. Summary of Test Method

4.1 A prepared test specimen of a specific wrought copper alloy flat sheet or strip of spring material is mounted into a fixed cantilever, constant-deflection type fatigue testing machine. The specimen is held at one end, acting as a cantilever beam, and cycled by flexure followed by reverse flexure until complete failure. The number of cycles to failure is recorded as a measure of fatigue life.

5. Significance and Use

5.1 The bending fatigue test described in this test method provides information on the ability of a copper alloy flat sheet and strip of spring material to resist the development of cracks or general mechanical deterioration as a result of a relatively large number of cycles (generally in the range 10^5 to 10^8) under conditions of constant displacement.

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.

³ For referenced ASTM documents, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org.

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

5.2 This test method is primarily a research and development tool which may be used to determine the effect of variations in materials on fatigue strength and also to provide data for use in selecting copper alloy spring materials for service under conditions of repeated strain cycling.

5.3 The results are suitable for direct application in design only when all design factors such as loading, geometry of part, frequency of straining, and environmental conditions are known. The test method is generally unsuitable for an inspection test or a quality control test due to the amount of time and effort required to collect the data.

6. Apparatus

6.1 *Testing Machine*—The fatigue testing machine is a fixed-cantilever, constant-deflection type machine. In this machine (Fig. 1) the test specimen shall be held as a cantilever beam in a clamp at one end and deflected by a concentrated load applied near the other end of the apex of the tapered section (Fig. 2). Either the clamp or the loading member may be adjusted so that the deflection of the free end of the cantilever is either completely reversed (mean displacement equal to zero) or greater in one direction of bending (mean displacement not equal to zero).

6.2 A suitable counter and monitoring circuit is required to provide a direct readout of the number of cycles to complete failure (that is, separation into two pieces).

7. Test Specimen

7.1 The test specimen shall be of the fixed-cantilever type. Examples of specimens that are typically used are shown in Fig. 2.

7.2 It is important, therefore, that care be exercised in the preparation of test specimens, particularly in minimizing effects such as work hardening or induced stress. Conventional milling, blanking, or photochemical machining can be used to ensure good workmanship. Improperly prepared test specimens cause unsatisfactory test results.

7.2.1 Milled specimens are best machined by cross milling a stack, approximately 0.75 in. (19.05 mm) thick, including back-up plates, for which 0.12 in. (3.05 mm) thick brass sheet stock may be used.

7.2.1.1 It is necessary to ensure that any cutting or machining operation required to either rough cut the test specimen from the blank, or to machine it to size does not appreciably alter the metallurgical structure or properties of the material. All cuts taken in machining should be such as to minimize work hardening of the test specimen.

7.2.1.2 In selecting cutting speeds and feed rates, due regard should be paid to the test specimen material, and for finishing cuts, to the quality of the surface finish required.

NOTE 2—It is not practicable to recommend a single procedure for feeds, speeds, and depth of cut, since this will vary with the material tested. The procedure used, however, should be noted in reporting test results, since differences in procedure may produce variability in test results among different laboratories.

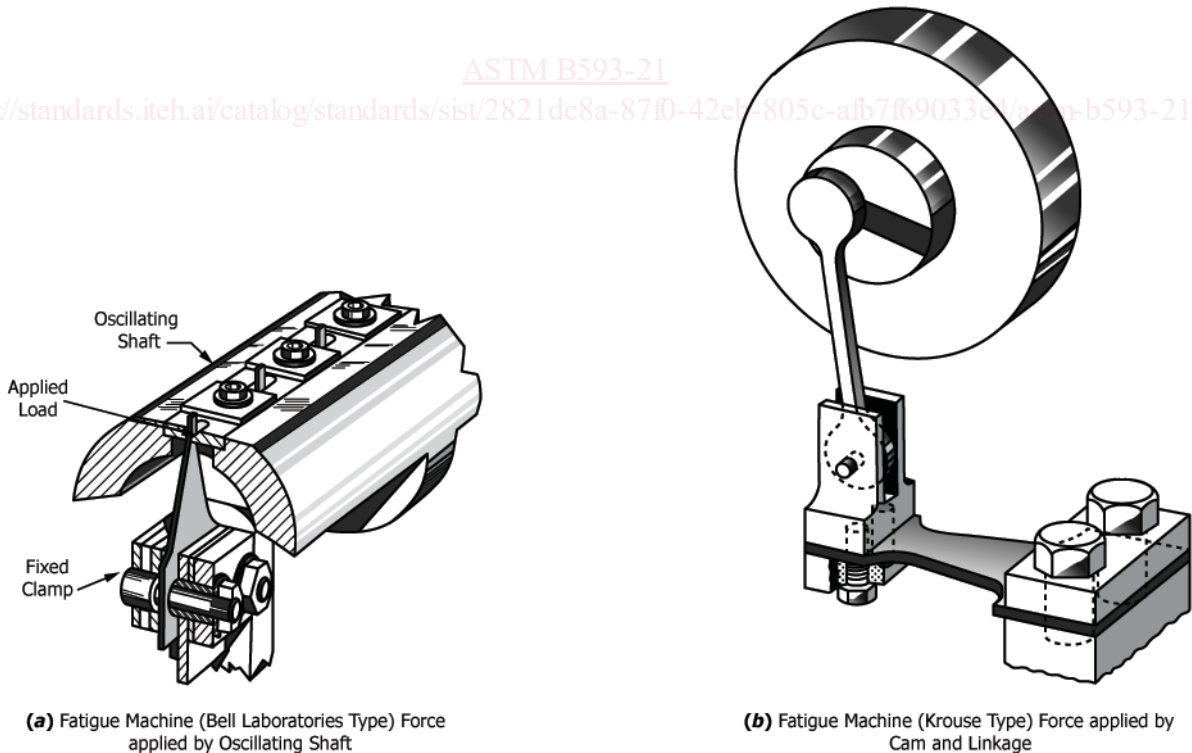
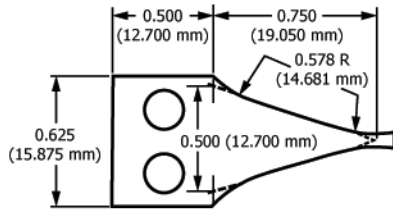
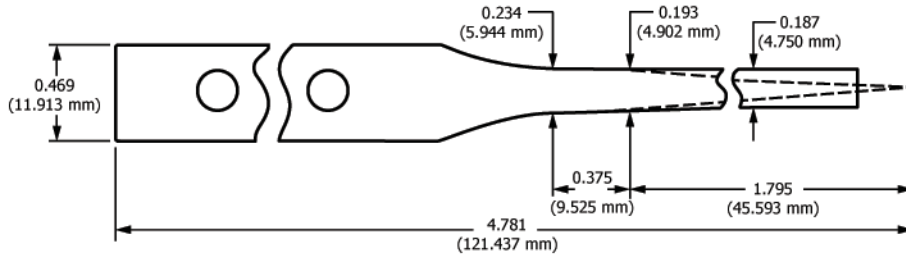


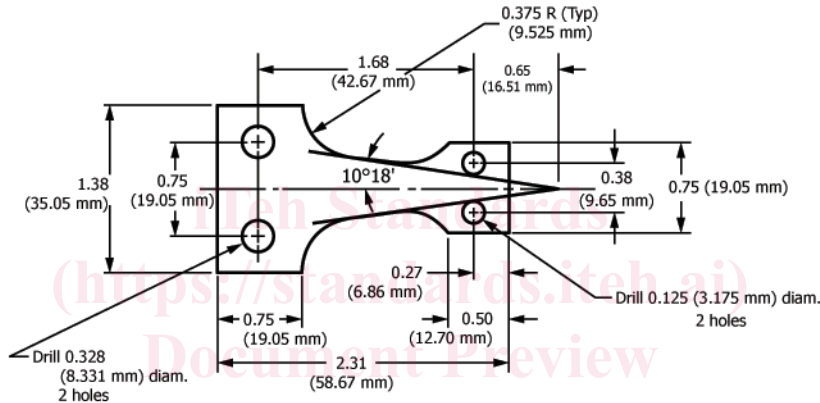
FIG. 1 Fatigue Machines



(a) Sheet or Strip Fatigue Test Specimen (oscillating shaft type) for Thickness Ranging from 0.005 in. to 0.015 in. (0.127 mm to 0.381 mm)



(b) Sheet or Strip Fatigue Test Specimen (oscillating shaft type) for Thickness Ranging from 0.015 in. to 0.062 in. (0.381 mm to 1.575 mm)



(c) Sheet or Strip Fatigue Test Specimen (cam and linkage type) for Thickness Ranging from 0.008 in. to 0.031 in. (0.203 mm to 0.787 mm)

(Gage length is increased for thicker material)

NOTE 1—All dimensions are in inches: in. \times 25.4 = mm.

FIG. 2 Sheet or Strip Fatigue Test Specimens

7.2.2 Photochemical machined specimens are best prepared with a suitable etchant such as ferric chloride or cupric chloride. As with machining, process parameters will vary with the material tested. The procedure should be noted in reporting test results. Etching time should be carefully controlled to avoid the formation of an edge burr from insufficient dwell time or the formation of an undercut from excessive dwell time. The proper etching time will depend on the material and its thickness. Test specimens less than 0.005 in. (0.13 mm) thick are best produced by photochemical machining.

7.3 The test specimen surface shall be in the as-received condition. The edges shall not be roughed or smoothed, since this tends to give an apparent higher fatigue strength.⁴ Burrs, however, may be removed by light stoning.

⁴ George, R. G., and Mantle, J. B., "The Effect of Edge Preparation on the Fatigue Life of Flat-Plate Specimens," *Materials Research and Standards*, MTRSA, Am. Soc. Testing Mats., December 1962, p. 1000.

7.4 Test specimens from material that is used in a thermally treated condition, such as precipitation hardened or stress relieved, shall be treated in a manner reflecting the way the material will be used. The procedure used should be noted in reporting test results.

8. Calculation of Stress

8.1 The maximum bending stress is calculated by using the simple beam equation:

$$S = 6PL/bd^2 \quad (1)$$

where:

S = desired bending stress, lb/in.²;

P = applied load at the connecting pin (apex of triangle), lb;

L = distance between the connecting pin and the point of stress, in.;

b = specimen width at length L from point of load application, in.; and

d = specimen thickness, in.