Designation: B593 − 96 (Reapproved 2014)ε1

# Standard Test Method for Bending Fatigue Testing for Copper-Alloy Spring Materials[1]

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.*

ε[1] NOTE—Editorial changes were made in Sections 1.1, 1.2, 3.1 and 3.2 in September 2014.

## 1. Scope*

1.1 This test method establishes procedures for the determination of the reversed or repeated bending fatigue properties of copper alloy flat-sheet or strip-spring materials by fixed cantilever, constant deflection (that is, constant amplitude of displacement)-type testing machines. This method is limited to flat stock ranging in thickness from 0.005 to 0.062 in. (0.13 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. Values given in parentheses are mathematical conversions to SI units which are provided for information only and are not considered standard.

1.3 The following safety hazard caveat pertains only to the test methods(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 and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

B846 Terminology for Copper and Copper Alloys

B950 Guide for Editorial Procedures and Form of Product Specifications for Copper and Copper Alloys

E206 Definitions of Terms Relating to Fatigue Testing and the Statistical Analysis of Fatigue Data; Replaced by E 1150 (Withdrawn 1988)[3]

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

2.2 *Other ASTM Documents:*[4]

ASTM STP 91-A

## 3. Terminology

3.1 For definition of terms relating to this test method, refer to Definitions E206 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-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-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.

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

[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.

Current edition approved Sept. 1, 2014. Published September 2014. Originally approved in 1973. Last previous edition approved in 2009 as B593 – 96 (2009)ε1. DOI: 10.1520/B0593-96R14E01.

[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] The last approved version of this historical standard is referenced on www.astm.org.

[4] 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**

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 machining, to assure good workmanship. Improperly prepared test specimens cause unsatisfactory test results.

7.2.1 The specimens are best prepared by cross milling a stack, approximately 0.75 in. (19 mm) thick, including back-up plates, for which 0.12-in. (3-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.

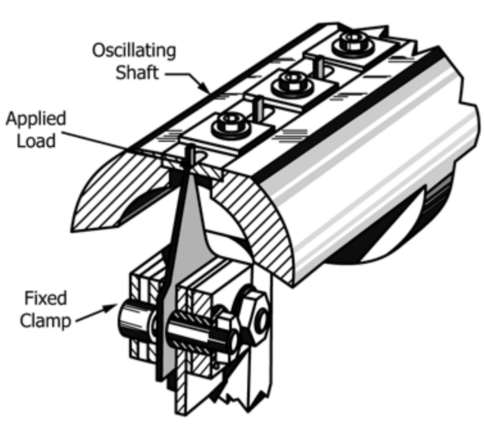
7.2.1.2 In selecting cutting speeds and feed rates, due regard should be paid to the test-specimen material, and for finishing cuts, to the quality of the surface finish required.

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.

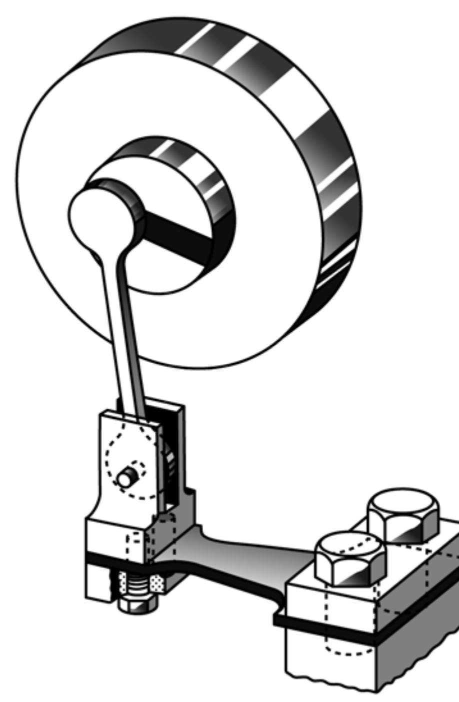
7.3 The test specimen surface shall be in the as-received condition. The edges shall not be roughed or smoothed, since this tends to give an apparent higher fatigue strength.[5] Burrs, however, may be removed by light stoning.

7.4 Test specimens from material that is used in a thermally treated condition, such as precipitation hardened or stress

[5] 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.




***(a)*** Fatigue Machine (Bell Laboratories Type) Force Applied by Oscillating Shaft



***(b)*** Fatigue Machine (Krouse Type) Force Applied by Cam and Linkage

**FIG. 1 Fatigue Machines**