Designation: E2948 – 22

Standard Test Method for Conducting Rotating Bending Fatigue Tests of Solid Round Fine Wire[1]

This standard is issued under the fixed designation E2948; 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 is intended as a procedure for the performance of rotating bending fatigue tests of solid round fine wire to obtain the fatigue strength of metallic materials at a specified life in the fatigue regime where the strains (stresses) are predominately and nominally linear elastic. This test method is limited to the fatigue testing of small diameter solid round wire subjected to a constant amplitude periodic strain (stress). The methodology can be useful in assessing the effects of internal material structure, such as inclusions, in melt technique and cold work processing studies. However, there is a caveat. The strain, due to the radial strain gradient imposed by the test methodology, is a maximum at the surface and zero at the centerline. Thus the test method may not seek out the "weakest link," largest inclusions, that govern uniaxial high cycle fatigue life where the strain is uniform across the cross section and where fatigue damage initiates at a subsurface location (**1-5**).[2] Also, pre-strain, which can influence fatigue life, is not included in this test method.

NOTE 1—The following documents, although not specifically mentioned, are considered sufficiently important to be listed in this test method:
ASTM STP 566 Handbook of Fatigue Testing
ASTM STP 588 Manual on Statistical Planning and Analysis for Fatigue Experiments
ASTM STP 731 Tables for Estimating Median Fatigue Limits (**6-8**)

1.2 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 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:*[3]

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

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

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

F562 Specification for Wrought 35Cobalt-35Nickel-20Chromium-10Molybdenum Alloy for Surgical Implant Applications (UNS R30035)

E739 Practice for Statistical Analysis of Linear or Linearized Stress-Life (***S-N***) and Strain-Life (ε-***N***) Fatigue Data

E1823 Terminology Relating to Fatigue and Fracture Testing

2.2 *ANSI Standard:*[4]

ANSI B4.1 Standard Limits and Fits

3. Terminology

3.1 *Definitions:*

3.1.1 Terms used in this practice shall be as defined in Terminology E1823.

4. Summary of Test Method

4.1 This test methodology describes a means to characterize the fatigue response of small diameter solid round wire using a rotating bending test. Small diameter wire, to be consistent with Specification F562 definition of "fine wire", is less than or equal to a diameter of 0.063 in. (1.60 mm). The wire is subjected to a constant-amplitude bending strain (stress) while it rotates at a fixed speed. This creates a fully reversed, R = (minimum strain (stress)/ maximum strain (stress))= –1, bending strain at any point on the circumference of the wire. The number of revolutions or cycles is counted until a failure

[1] This test method is under the jurisdiction of ASTM Committee E08 on Fatigue and Fracture and is the direct responsibility of Subcommittee E08.05 on Cyclic Deformation and Fatigue Crack Formation.

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[2] The boldface numbers in parentheses refer to a list of references at the end of this standard.

[3] 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.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

(fracture into two or more distinct pieces) is detected. Surface effects due to environmental factors (for example corrosion or cavitation) can be extremely important in assessing fatigue performance. Such effects can be assessed in a myriad of environments (air, phosphate buffered saline (PBS), NaCl, O_2, N_2, varying humidity, etc.) using the protocol outlined in the standard.

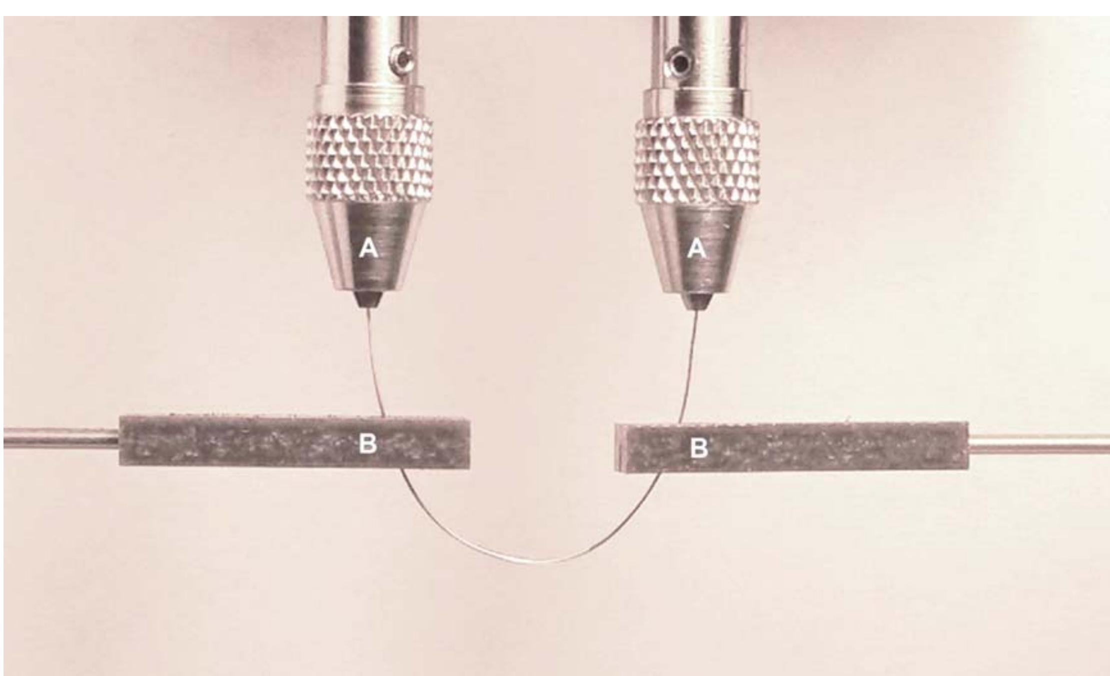
5. Significance and Use

5.1 A method for obtaining fatigue strain (stress) at a specific life is of interest to the wire manufacturer, designer and consumer. The method is useful in production control, material acceptance and determination of the fatigue strain (stress) of the wire at a specific fatigue life, that is, fatigue strength. Rotating bending fatigue testing of small diameter solid round wire is possible by looping a specimen of predetermined length through an arc of 90° to 180°. The bending strain (stress) is determined from the geometry of the loop thusly formed. The methodology is capable of high frequency testing provided the temperature of the test article is constant and there is no adiabatic heating of the wire. A constant temperature can be maintained by immersing the specimen in a constant temperature fluid bath or test media. This makes it practical to quickly test a sufficient number of specimens to provide a statistical frequency distribution or survival probability distribution of fatigue life at a given strain (stress). Fatigue life information is useful to ascertain wire in-service durability and to assess, for example, the effects of melt practice and cold work processing.

6. Methods

6.1 Non-guided or guided rotating bending tests, or both are included in this test method. Typical test frequency ranges from 1 to 37 000 cycles per minute. Test frequency should be selected carefully since it can influence the rate at which fatigue damage accumulates. In the guided rotating bending test, the guiding mandrel maintains the test specimen geometry and is recommended for test specimens under high bending strain (stress); test specimens that exhibit strain (stress)-induced phase transformations; test specimens with asymmetrical tension and compression behavior; test specimens with a non-central neutral axis and test specimens exhibiting excessive vibration during high speed tests (**9, 10**).

6.1.1 *Non-guided rotating bending fatigue test*—The ends of the precut wire are attached to two driven, parallel, counter-rotating, shafts such as illustrated in Fig. 1. Or, in an alternate method, one end of the wire (precut to a precise length) is attached to a driven shaft and the other end is inserted into a restraining bushing, Fig. 2. The wire end is free to rotate within the bushing. A cumulative cycle counter records each revolution of the wire as a fatigue cycle. Cumulative cycles can also be determined from the time to fracture at a constant rotation rate. The specimen is rotated in the arc geometry until a failure occurs (herein defined as complete separation or fracture of the wire) tripping the failure sensor, see Fig. 1 and Fig. 2, and terminating the test. Spacing between the rotating shafts and the specimen length determine the bending strain (stress) through the radius of curvature thereby making the bending



A) Dual driven collets: Both wire ends are held in driven collets. An environmental chamber may be placed on the platform and tests can be performed in a temperature controlled liquid medium. Loss of electrical continuity from one collet through the wire to the other collet indicates wire fracture and test termination. B) Wire supports: The wire passes through slits in the supports to maintain in-plane motion of the wire during the test. The supports should be placed such that they do not impose any additional force or torque on the wire. Preferred placement for the supports is just off the apex of the wire loop perpendicular to a tangent to the loop. The support material should be a low friction material and support placement should be chosen to minimize friction.

FIG. 1 Non-Guided Rotating Bending Apparatus with Counter-Rotating Shafts