Designation: E2948 – 16a

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.

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

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[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.

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(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.

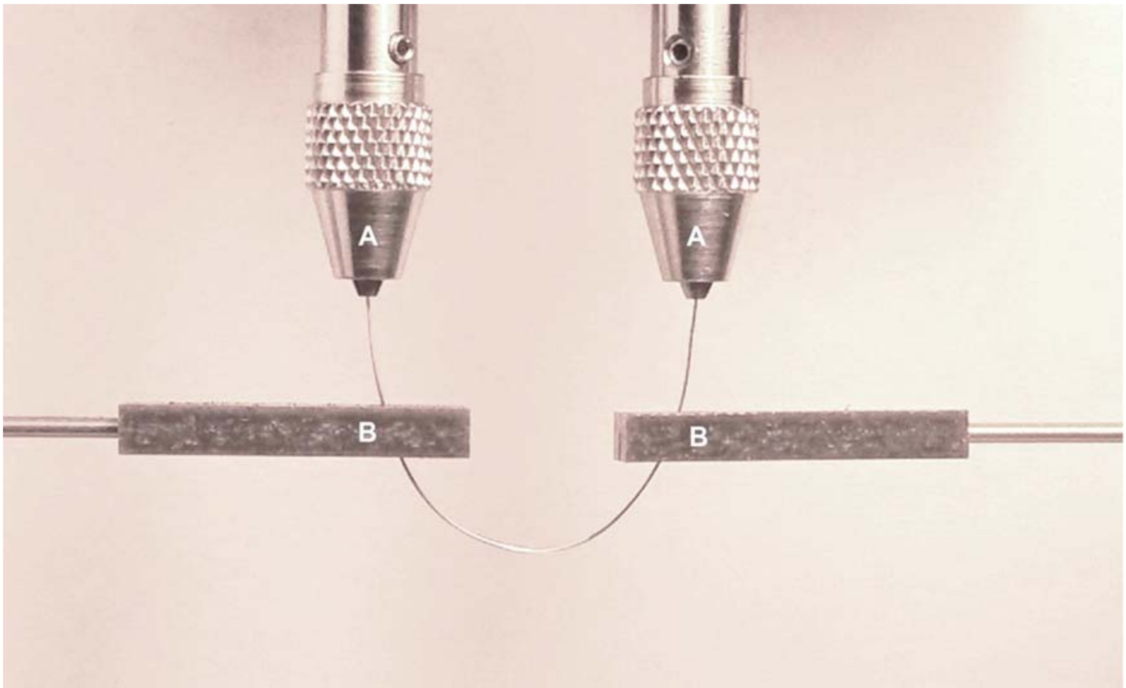
5. Significance and Use

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

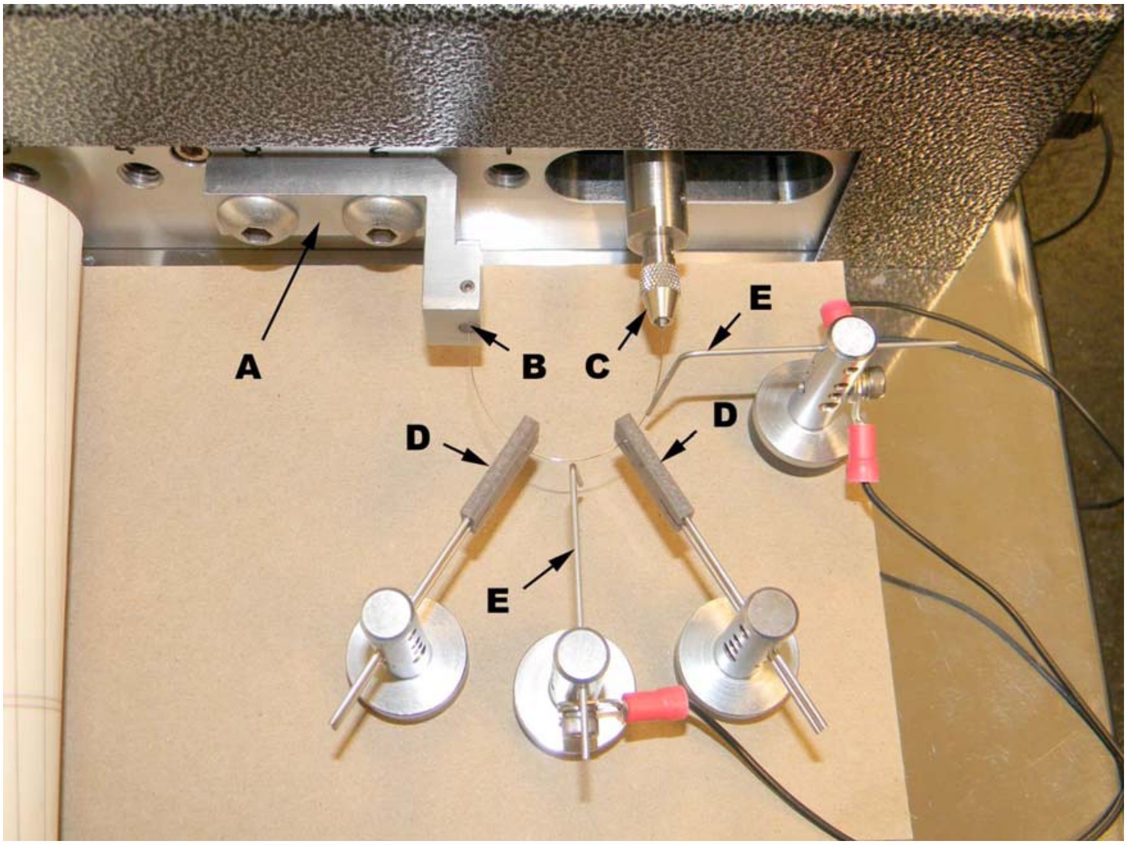
6.1 Non-guided or guided rotating bending tests, or both are included in this test method. Typical test frequency ranges from 1 to 37 000 cycles per minute. Test frequency should be selected carefully since it can influence the rate at which fatigue damage accumulates. In the guided rotating bending 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



A) L-bracket: Contains support bushing and allows for adjustment of driven collet to bushing spacing. B) Bushing: In this apparatus, there is a single driven collet. The wire is free to rotate in the bushing. Clearance between the wire and inside diameter of the bushing is important in order to minimize the tendency of the wire to "fly out" of the bushing. Too great a clearance and the wire may not remain in place and too small a clearance may prevent rotation. C) Collet: The spacing of a single driven collet to bushing fixes the strain amplitude. D) Wire supports: The wire passes through small slits in the supports so that it can be held in-plane during the test. Preferred placement for the supports is just off the apex of the wire loop perpendicular to a tangent to the loop. A test setup with a collet to bushing spacing (that is, center distance as defined in X1.1) greater than 4-5 inches (10.2-12.7 cm) would benefit from an extra set of supports (not shown) to help minimize possible wire out-of-plane oscillation. E) Break detector: When the wire fractures, contact will be made with one of the strategically placed break detectors. The break detector is a corrosion resistant metal wire, electrically connected such that when contact is made with the metal test specimen the test is terminated and the instrument motor and timer/cycle counter stop. It is recommended to place one break detector near the apex of the wire loop and a second detector between the support and the collet. Detectors should be placed within 5 – 10 mm of the rotating wire. Adequate detector to wire clearance is necessary to prevent premature shut down.

FIG. 2 Non-Guided Rotary Bending Apparatus with Bushing and Rotating Shaft

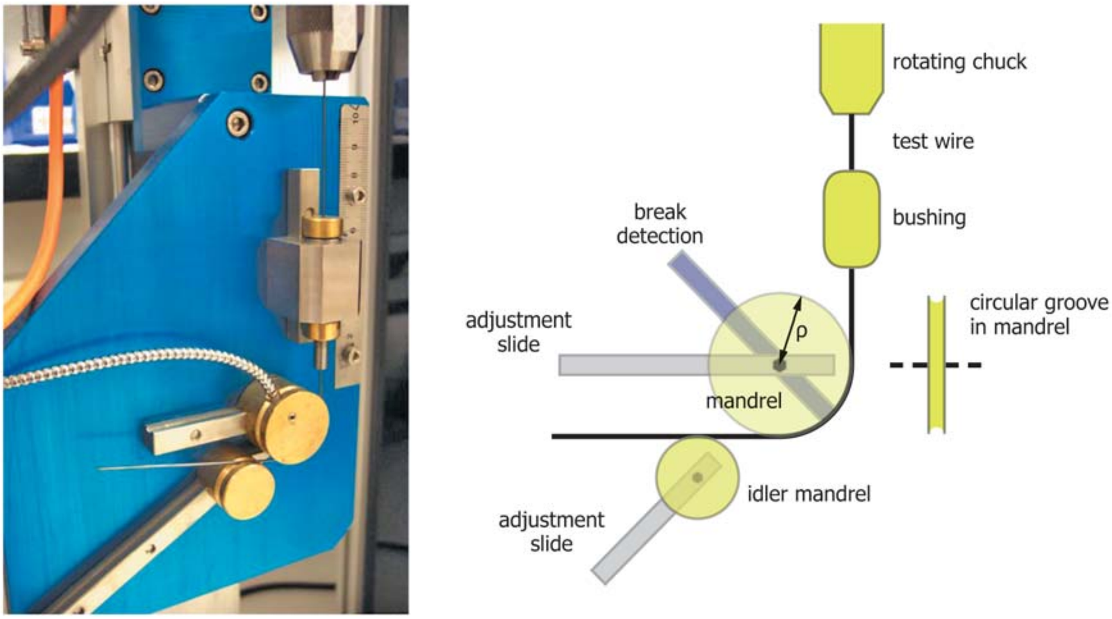
strain (stress) readily adjustable. It is necessary to maintain the shaft spacing and specimen length relations of X1.1 for a valid test. These relations ensure a zero bending moment at the collets (or collet and bushing) and an axial stress that is negligible compared to the maximum bending stress at the midpoint of the specimen.

6.1.2 *Guided rotating bending fatigue test*—One end of the precut test wire is attached to a driven shaft, Fig. 3. The wire passes through a bushing to help reduce vibration and ensure more consistent results. The test wire is then bent around a mandrel (or in a machined groove) of a low friction material with a fixed radius of curvature. The mandrel radius determines the outer-fiber strain (stress). The other end of the wire is supported by an idler mandrel in which the wire freely spins. A cumulative cycle counter records each revolution of the wire as a fatigue cycle. The specimen rotates while bent around the mandrel until a failure occurs (herein defined as complete separation or fracture of the wire) tripping the failure sensor and terminating the test.

6.2 *Fracture detection*—Multiple forms of fracture detection devices are available. In one method a corrosion resistant metal wire is connected electrically such that when contact is made with the fractured metal test specimen the test is terminated and the instrument motor and timer/cycle counter stop. Fracture detection by sensing electrical continuity between the collets should be limited to less than 1 mA mm^{-2}. Other possible fracture detection devices are fiber optic or laser sensors that are triggered by the fracture of the test specimen.

7. Test Procedure

7.1 *Non-guided rotating bending fatigue test*—The specimen free length and the collet-to-collet or collet-to-bushing shaft spacing are determined from the desired fatigue strain or subsequent nominal elastic stress amplitude, the wire diameter and the modulus of elasticity of the material under test. See X1.1 for strain and nominal elastic stress calculations. A cast, or curvature of the wire, is commonly associated with cold-drawn wire. The wire should be straightened only by hand



The wire specimen is bent around a mandrel with a fixed radius, ρ. The optical break detector shown senses a closed or open (failed specimen) optical path through the mandrel and specimen.

FIG. 3 Guided Rotating Bending Fatigue Apparatus

without the use of any mechanical straightening operation to prevent any possible changes in material properties. However, if the desired service state includes mechanical or thermal-mechanical straightening then mechanical or thermal-mechanical straightening is acceptable. The wire is assumed to be in a zero residual stress state. If this is not the case, an assessment of the residual stress state and its influence on the results should be made and reported with the test results. It should then be cut-to-length and the collet-to-collet or collet-to-bushing shaft center distance adjusted and set according to the calculations in X1.1. Clamp the wire in the collet, inserting the other end in the proper collet or bushing location, and locate the supports and fractured wire sensors. Be cautious at this point in the test set-up so as not to kink or unduly bend the wire. It is critical that the supports cause the wire to remain in a single vertical or horizontal plane throughout the test. Out-of-plane displacement or oscillation of the specimen should be less than 5 mm. Low friction materials, such as polyoxymethylene or polytetrafluoroethylene, are recommended for the support material. Metallic supports such as bronze, with or without lubrication, are not recommended because of higher friction coefficients and possible corrosion interaction. Placement of wire supports just off the apex of the wire loop will minimize oscillation. Multiple supports may be used for large collet-to-collet or collet-to-bushing spacing. Friction between the specimen and support may cause fracture under the support. In this case the test result is considered invalid. If the wire is held by a pin-vise collet, cautiously clamp the wire so as not to impart distortion or wire breakage at the collet. Carefully set the wire to wire-support clearance and the wire to bushing clearance. Clearances should be set to conform to an ANSI Standard RC8 Loose Running Fit (ANSI B4.1). In the case of the wire supports, too little clearance will hinder rotation resulting in a frictional torque on the wire and invalid test result. In the case of the bushing, too great a clearance may lead to the wire jumping out of the bushing during the test or too little a clearance may lead to a frictional torque on the wire and invalid test result. Rotate the collet by hand to ensure the specimen is properly aligned in the collet(s) and supports to prevent excessive vibration or out-of-plane skew or oscillation. When using an environmental bath, the test specimen should be positioned with bath-in-place and allowed to equilibrate to the bath temperature. The amount of time required for equilibration will depend on the mass of the specimen as well as the volume, temperature, and medium of the bath. Start the test and wait for the specimen to fracture or to reach a predetermined number of cycles. If the point of fracture does not occur at the center of the loop (the point of maximum strain (stress), that is, minimum radius of curvature), see X1.2 for a fracture strain (stress) correction factor that may be used based on the location of the fracture.

7.1.1 An alternate geometric method to determine the nominal elastic strain is to take an image of the curved specimen while in the machine's collets and curve fit the minimum radius of curvature using one of three methods; *(1)* an enlargement and computer software; *(2)* templates with known radii of curvature matched by overlay on the image or; *(3)* an osculating circle fit to the image. Calibration of length in the enlarged image is necessary. These methodologies provide the strain from the radius of curvature. It is important to report the method used and to be consistent in this methodology to reduce within laboratory and between laboratory errors.

7.2 *Guided rotating bending fatigue test*—The fatigue strain amplitude is related directly to the diameter of the tested wire and the radius of curvature of the mandrel, shown in Fig. 3, around which the wire is bent. See X1.3 for the strain amplitude calculation. Testing at a specific strain amplitude for a given wire diameter requires a mandrel with a specific radius. As such, a series of mandrels can be produced for a test plan with several strain levels. Polymeric mandrels, that is, polyoxymethylene, polytetrafluoroethylene, are recommended to minimize friction and possible surface wear of the wires. Metallic guides such as bronze, with or without lubrication, are not recommended because of higher friction coefficients and possible corrosion interaction. A circular groove in the mandrel is also recommended to accommodate and guide the wire. The wire is clamped in the collet, bent around the mandrel and supported by an idler mandrel to guide the wire and maintain the radius of curvature. A bushing that permits the wire to spin freely is often used between the collet and the mandrel to guide the wire and prevent excessive vibration. It is critical that the bushing and idler mandrel support the wire in a single vertical or horizontal plane. If a specimen fractures in the bushing or under the idler mandrel the test result is invalid. When using an environmental bath, the test specimen should be positioned such that the mandrels are immersed in the bath and are allowed to equilibrate to the bath temperature. The amount of time needed for equilibration will depend on the mass of the specimen and mandrels, as well as the volume, temperature, and media of the bath. The test shall be run until specimen fracture or a predetermined number of cycles.

8. Report

8.1 Report the following information:

8.1.1 The fatigue test specimens, procedures, and results should be reported in accordance with Practices E468 and E739.

8.1.2 The procedure should be reported as guided or non-guided along with the method used to determine the minimum radius of curvature.

8.1.3 The use of this practice is limited to metallic specimens tested in a suitable environment, generally but not limited to atmospheric air at room temperature. Since however, the environment can greatly influence the test results, the environmental conditions, that is, temperature, relative humidity, as well as the medium, should be periodically recorded during the test and reported.

8.1.4 The rotation speed and time or cycles to failure should be reported for each specimen. Fatigue life variability can be reported as a frequency distribution or a probability of survival distribution as shown in Fig. 4. A graphical representation of stress–life data from rotating bending fatigue tests of wire is shown in Fig. 5. Results are generally plotted as strain-life or stress-life on log-log or semi-log coordinates. Strain-life data is consistent with the boundary conditions of the test method. Stress-life data is useful in stress-based design methods but be aware that nominal elastic equations are typically employed to calculate the stress. The difference in these two representations of the data is a constant factor of the modulus of elasticity. If test conditions are not nominally elastic (maximum strain

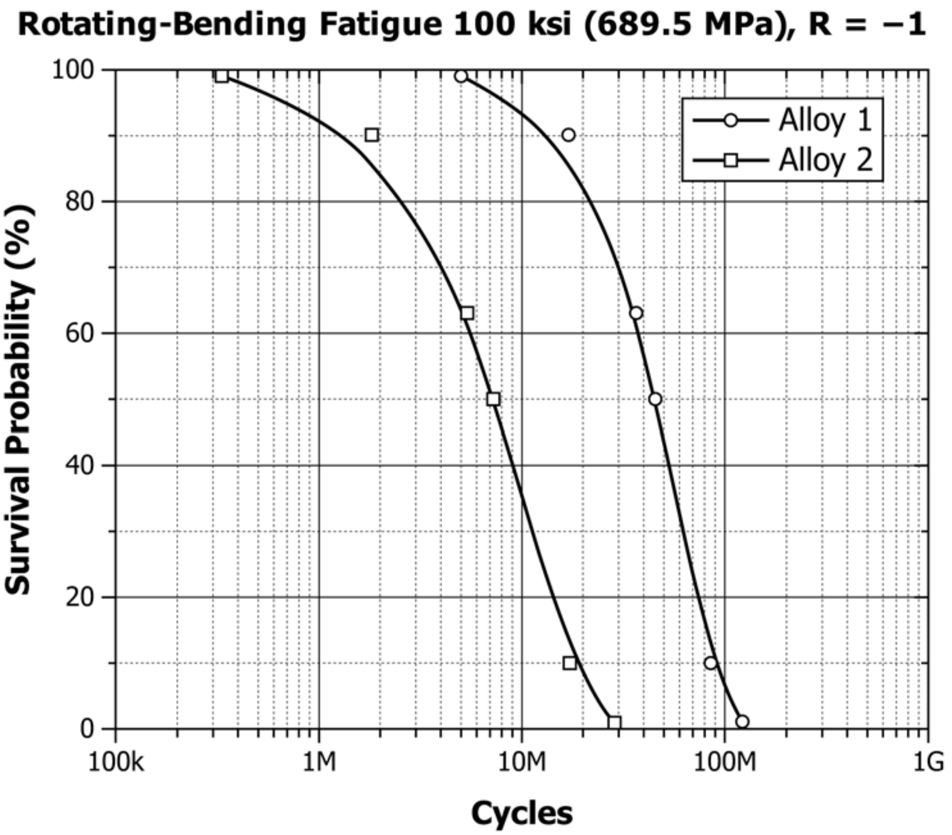


FIG. 4 Typical Survival Probability Graph of Fatigue Data for Alloy 1 and Alloy 2

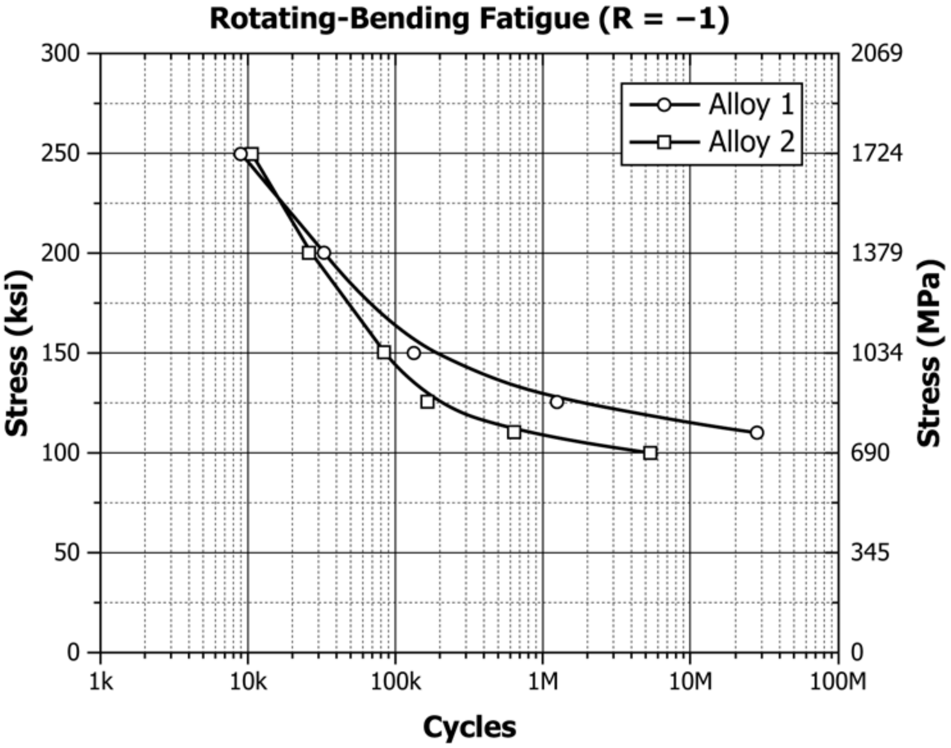


FIG. 5 Typical Stress-Life Diagram for Alloy 1 and Alloy 2.

greater than the cyclic yield strain), the data should be represented only as strain-life.

NOTE 2—Strain is the controlled variable during this testing procedure and is strictly geometry dependent. There may be inelastic strain present in the test article. If the test results are reported as "stress" by using the modulus of elasticity as a multiplying factor on strain, the result is a "computed stress" and as such is not the actual stress experienced by the test article.

8.1.5 When noticeable yielding occurs in the fatigue tests of specimens, the permanent deformation of tested specimens (for example, percent change in cross-section area of test section) should be reported. In this case the test is not valid since nominal elastic behavior is required for a valid test.

8.1.6 A brief description of the fracture characteristics (brittle or ductile); results of post-test metallography or scanning electron microscopy, or both; identification of fatigue initiation mechanism (surface initiation or sub-surface initiation); and the relative degree of trans-granular and inter-granular cracking would be highly beneficial.

9. Precision and Bias

9.1 The precision of this test method is based on an interlaboratory study of ASTM E2948, Standard Test Method for Conducting Rotating Bending Fatigue Tests of Solid Round Fine Wire, conducted in 2015. Ten volunteer laboratories conducted tests on two different materials, each supplied from a single lot of material from a single manufacturer, at three different strain amplitude levels. Every "test result" represents an individual determination. Each laboratory was requested to submit ten replicate test results, from a single operator, for each material and strain level. ASTM Practice E691 was followed for the design and analysis of the resulting data; the details are given in ASTM Research Report RR:E08-1012.[5]

9.1.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would, in the normal and correct operation of the test method, exceed the repeatability limit one instance in 20.

9.1.1.1 Repeatability limit can be interpreted as maximum difference between two results, obtained under repeatability conditions, which is acceptable due to random causes under normal and correct operation of the test method.

9.1.1.2 Repeatability limits are listed in the Table 1 below.

9.1.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the normal and correct operation of the test method, exceed the reproducibility limit one instance in 20.

9.1.2.1 Reproducibility limit can be interpreted as maximum difference between two results, obtained under reproducibility conditions, which is acceptable due to random causes under normal and correct operation of the test method.

9.1.2.2 Reproducibility limits are listed in the Table 1.

9.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

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[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:E08-1012. Contact ASTM Customer Service at service@astm.org.

TABLE 1 Repeatability and Reproducibility Limits (cyles)

Material and Strain Amplitude	Average[A]	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	$\bar{x}$	s_r	s_R	r	R
A	21 000	2 000	5 800	5 600	16 000
B	40 000	8 300	14 000	23 000	40 000
C	100 000	24 000	49 000	68 000	140 000
D	12 000	1 800	3 500	4 900	9 900
E	16 000	2 600	5 500	7 300	15 000
F	25 000	6 900	8 800	19 000	25 000

[A] The average of the laboratories' calculated averages.

TABLE 2 Materials and Strain Amplitudes

Material and Strain Amplitude	Alloy	Strain Amplitude %
A	35N LT	± 0.70
B	35N LT	± 0.60
C	35N LT	± 0.50
D	Nitinol	± 1.00
E	Nitinol	± 0.90
F	Nitinol	± 0.80

9.1.4 Any judgment in accordance with statements 9.1.1 and 9.1.2 would have an approximate 95% probability of being correct.

9.1.5 The precision information in Table 1 is specific to Standard E2948 Standard Test Method for Conducting Rotating Bending Fatigue Tests of Solid Round Fine Wire, for the two materials and three strain levels listed in 9.3.

9.2 *Bias*—This test method has no bias because strain-governed fatigue properties of materials are defined in accordance with this methodology.

9.3 The precision statement was determined through statistical examination of 600 results, from ten laboratories, on two materials and three strain levels. These six combinations of material and strain level are described in Table 2.

9.4 To judge the equivalency of two test results, it is recommended to choose the material closest in characteristics to the material in Table 2.

10. Keywords

10.1 fatigue; rotating bending; wire

APPENDIX

X1. CALCULATIONS AND CORRECTION FACTOR

X1.1 Calculations for Non-Guided Rotating Bending Fatigue Testing

X1.1.1 The following relationships can be derived from the equations of equilibrium for the elastic deflection of a Bernoulli-Euler beam with second order curvature terms included (**11**).

The normal force on the wire at the collet or bushing entry is P and the moment is zero. It is necessary to maintain the shaft spacing and specimen length relations for a valid test. These relations ensure a zero bending moment at the collets (or collet and bushing) and an axial stress that is negligible, 15 d/C % (typically less than 1%) of the maximum bending stress at the midpoint of the specimen. Values stated are in a consistent system of units (such as SI or inch-pound-second). The tolerance on the center distance, C, is 0.1% of the nominal C for a tolerance of 0.1% of the nominal fatigue strain (stress). The geometry and terms for non-guided rotating bending fatigue are shown in Fig. X1.1.

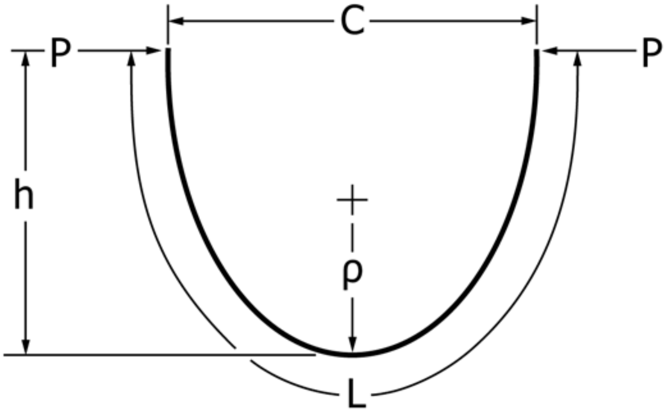

FIG. X1.1 Non-Guided Rotating Bending Fatigue Definition of Terms

E = modulus of elasticity: published or measured
σ = stress: alternating nominally elastic stress ($R = -1$)
d = diameter: wire diameter
C = center distance: $C = 1.198\ [Ed / \sigma]$
ρ_{min} = minimum bending radius: $\rho_{min} = 0.417\ C$
h = height: $h = 0.835\ C$
P = bushing force: $P = 0.141\ [Ed^4 / C^2]$
L = wire length outside of collets (or collet and bushing): $L = 2.19\ C$
TL = total length: TL = collet depth + bushing depth + L
ε_a = strain (bending): $\varepsilon_a = [(d/2)/\rho_{min}] \times 100\%$

X1.2 Correction for Non-Central Failure Location for Non-guided Rotating Bending Fatigue Test

X1.2.1 When fracture does occur for the specimen geometry described in X1.1 and the fracture is not at the minimum radius of curvature (the point of maximum strain (stress)). The strain (stress) at the fracture location can be calculated from the equations of equilibrium for the elastic deflection of a Bernoulli-Euler beam with second order curvature terms included **(11)**. The relationship of the bending strain (stress) at any point on the wire as a percent of the maximum strain (stress) at the minimum radius of curvature is found in Table X1.1. The fracture location measured from the midpoint of L (were L is the free length of the specimen as defined in X1.1) and expressed as a percent of L, "length (%)" in Table X1.1, can be calculated as follows. Determine the percent difference in free length, "length (%)", as the difference in length of the two pieces (as measured from the fracture point to the point of contact with the collet or bushing) divided by two times the specimen length L (the free length of the specimen between grips as shown in Fig. X1.1) times 100 percent; [difference in length/2L] × 100% = "length (%)". For a "length (%)" of up to 10%, the strain (stress) "correction factor (%)" corresponding to the fracture location is found in Table X1.1. Determine the strain (stress) at the fracture location as the initial strain (stress) at the apex of the loop multiplied by the "correction factor (%)".

X1.3 Calculations for guided rotating bending fatigue testing

X1.3.1 Values stated are in a consistent system of units (such as SI or inch-pound-second).

ρ = radius of mandrel
d = diameter: wire diameter
ε_a = strain (bending): $\varepsilon_a = [(d/2)/\rho] \times 100\%$

TABLE X1.1 Strain (Stress) Correction Factor Table

length (%)	correction factor (%)	length (%)	correction factor (%)	length (%)	correction factor (%)
0.1	100.0	4.1	98.8	7.1	96.5
to		4.2	98.7	7.2	96.5
0.4	100.0	4.3	98.7	7.3	96.4
0.5	99.9	4.4	98.6	7.4	96.3
to		4.5	98.5	7.5	96.2
1.0	99.9	4.6	98.5	7.6	96.1
1.1	99.8	4.7	98.5	7.7	96.0
to		4.8	98.4	7.8	95.9
1.6	99.8	4.9	98.4	7.9	95.7
1.7	99.7	5.0	98.3	8.0	95.6[†]
to		5.1	98.2	8.1	95.5
2.1	99.7	5.2	98.1	8.2	95.4
2.2	99.6	5.3	98.0	8.3	95.3
to		5.4	97.9	8.4	95.1
2.5	99.6	5.5	97.9	8.5	95.0
2.6	99.5	5.6	97.8	8.6	94.9
2.7	99.4	5.7	97.7	8.7	94.8
2.8	99.4	5.8	97.6	8.8	94.7
2.9	99.4	5.9	97.5	8.9	94.6
3.0	99.3	6.0	97.5	9.0	94.4
3.1	99.3	6.1	97.4	9.1	94.3
3.2	99.2	6.2	97.3	9.2	94.2
3.3	99.2	6.3	97.2	9.3	94.1
3.4	99.1	6.4	97.1	9.4	94.0
3.5	99.1	6.5	97.0	9.5	93.9
3.6	99.0	6.6	97.0	9.6	93.8
3.7	99.0	6.7	96.9	9.7	93.6
3.8	98.9	6.8	96.8	9.8	93.5
3.9	98.9	6.9	96.7	9.9	93.4
4.0	98.8	7.0	96.6	10.0	93.3

[†] Editorially corrected in July 2016.

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