



Standard Practice for Strain-Controlled Axial-Torsional Fatigue Testing with Thin-Walled Tubular Specimens¹

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1. Scope

1.1 The standard deals with strain-controlled, axial, torsional, and combined in- and out-of-phase axial torsional fatigue testing with thin-walled, circular cross-section, tubular specimens at isothermal, ambient and elevated temperatures. This standard is limited to symmetric, completely-reversed strains (zero mean strains) and axial and torsional waveforms with the same frequency in combined axial-torsional fatigue testing. This standard is also limited to thin-walled tubular specimens (machined from homogeneous materials) and does not cover testing of either large-scale components or structural elements.

1.2 *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:

- E 3 Practice for Preparation of Metallographic Specimens²
- E 4 Practices for Force Verification of Testing Machines²
- E 6 Terminology Relating to Methods of Mechanical Testing²
- E 8 Test Methods for Tension Testing of Metallic Materials²
- E 9 Test Methods of Compression Testing of Metallic Materials at Room Temperature²
- E 83 Practice for Verification and Classification of Extensometers²
- E 111 Test Method for Young's Modulus, Tangent Modulus, and Chord Modulus²
- E 112 Test Methods for Determining Average Grain Size²
- E 143 Test Method for Shear Modulus at Room Temperature²
- E 209 Practice for Compression Tests of Metallic Materials at Elevated Temperatures with Conventional or Rapid Heating Rates or Strain Rates²
- E 467 Practice for Verification of Constant Amplitude Dy-

namic Forces in an Axial Fatigue Testing System²

E 606 Practice for Strain-Controlled Fatigue Testing²

E 1012 Practice for Verification of Specimen Alignment under Tensile Loading²

E 1417 Practice for Liquid Penetrant Examination³

E 1444 Practice for Magnetic Particle Examination³

E 1823 Terminology Relating to Fatigue and Fracture Testing²

3. Terminology

3.1 Definitions:

3.1.1 *axial strain*—refers to engineering axial strain, ϵ , and is defined as change in length divided by the original length ($\Delta L_g/L_g$).

3.1.2 *shear strain*—refers to engineering shear strain, γ , resulting from the application of a torsional moment to a cylindrical specimen. Such a torsional shear strain is simple shear and is defined similar to axial strain with the exception that the shearing displacement, ΔL_s is perpendicular to rather than parallel to the gage length, L_g , that is, $\gamma = \Delta L_s/L_g$ (see Fig. 1).

NOTE 1— γ is related to the angles of twist, θ and Ψ as follows:

$\gamma = \tan \Psi$, where Ψ is the angle of twist along the gage length of the cylindrical specimen. For small angles $\tan \Psi$ approaches Ψ and γ approaches Ψ .

$\gamma = (d/2)\theta/L_g$, where θ expressed in radians is the angle of twist between the planes defining the gage length of the cylindrical specimen and d is the diameter of the cylindrical specimen.

NOTE 2— ΔL_s is measurable directly as displacement using specially calibrated torsional extensometers or as the arc length $\Delta L_s = (d/2)\theta$, where θ is measured directly with a rotary variable differential transformer.

3.1.2.1 *Discussion*—The shear strain varies linearly through the thin wall of the specimen, with the smallest and largest values occurring at the inner and outer diameters of the specimen, respectively. The value of shear strain on the outer surface, inner surface, and mean diameter of the specimen shall be reported. The shear strain determined at the outer diameter of the tubular specimen is recommended for strain-controlled torsional tests, since cracks typically initiate at the outer surfaces.

3.1.3 *biaxial strain amplitude ratio*—in an axial-torsional fatigue test, the biaxial strain amplitude ratio, λ is defined as

¹ This practice 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 *Annual Book of ASTM Standards*, Vol 03.01.

³ *Annual Book of ASTM Standards*, Vol 03.03.