



Standard Practice for Strain Controlled Thermomechanical Fatigue Testing¹

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1. Scope

1.1 This practice covers the determination of thermomechanical fatigue (TMF) properties of materials under uniaxially loaded strain-controlled conditions. A “thermomechanical” fatigue cycle is here defined as a condition where uniform temperature and strain fields over the specimen gage section are *simultaneously varied and independently controlled*. This practice is intended to address TMF testing performed in support of such activities as materials research and development, mechanical design, process and quality control, product performance, and failure analysis. While this practice is specific to strain-controlled testing, many sections will provide useful information for force-controlled or stress-controlled TMF testing.

1.2 This practice allows for any maximum and minimum values of temperature and mechanical strain, and temperature-mechanical strain phasing, with the restriction being that such parameters remain cyclically constant throughout the duration of the test. No restrictions are placed on environmental factors such as pressure, humidity, environmental medium, and others, provided that they are controlled throughout the test, do not cause loss of or change in specimen dimensions in time, and are detailed in the data report.

1.3 The use of this practice is limited to specimens and does not cover testing of full-scale components, structures, or consumer products.

2. Referenced Documents

2.1 ASTM Standards:²

- E 3 Methods of Preparation of Metallographic Specimens
- E 4 Practices for Force Verification of Testing Machines
- E 83 Practice for Verification and Classification of Extensometers
- E 111 Test Method for Young’s Modulus, Tangent Modulus, and Chord Modulus

- E 112 Test Method for Young’s Modulus, Tangent Modulus, and Chord Modulus
- E 220 Method for Calibration of Thermocouples by Comparison Techniques
- E 467 Practice for Verification of Constant Amplitude Dynamic Loads or Displacements in an Axial Load Fatigue Testing System
- E 606 Practice for Strain Controlled Fatigue Testing
- E 739 Practice for Statistical Analysis of Linear or Linearized Stress-Life (S-N) and Strain-Life (ε-N) Fatigue Data
- E 1012 Practice for Verification of Specimens Alignment Under Tensile Loading
- E 1823 Terminology Relating to Fatigue and Fracture Testing

3. Terminology

3.1 The definitions in this practice are in accordance with definitions given in Terminology E 1823 unless otherwise stated.

3.2 Additional definitions are as follows:

3.2.1 *stress*, σ —stress is defined herein to be the engineering stress, which is the ratio of force, P , to specimen original cross sectional area, A :

$$\sigma = P/A \quad (1)$$

The area, A , is that measured in an unloaded condition at room temperature. See 7.2 for temperature state implications.

3.2.2 *coefficient of thermal expansion*, α —the fractional change in free expansion strain for a unit change in temperature, as measured on the test specimen.

3.2.3 *total strain*, ϵ_t —the strain component measured on the test specimen, and is the sum of the thermal strain and the mechanical strain.

3.2.4 *thermal strain*, ϵ_{th} —the strain component resulting from a change in temperature under free expansion conditions (as measured on the test specimen).

$$\epsilon_{th} = \sigma \cdot \Delta T \quad (2)$$

3.2.5 *mechanical strain*, ϵ_m —the strain component resulting when the free expansion thermal strain (as measured on the test specimen) is subtracted from the total strain.

$$\epsilon_m = \epsilon_t - \epsilon_{th} \quad (3)$$

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 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.

