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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.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *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.*

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. Referenced Documents

2.1 ASTM Standards:²

- E3 Guide for Preparation of Metallographic Specimens
- E4 Practices for Force Verification of Testing Machines
- E83 Practice for Verification and Classification of Extensometer Systems
- E111 Test Method for Young’s Modulus, Tangent Modulus, and Chord Modulus
- E112 Test Methods for Determining Average Grain Size
- E220 Test Method for Calibration of Thermocouples By Comparison Techniques
- E337 Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures)
- E467 Practice for Verification of Constant Amplitude Dynamic Forces in an Axial Fatigue Testing System
- E606 Test Method for Strain-Controlled Fatigue Testing
- E1012 Practice for Verification of Testing Frame and Specimen Alignment Under Tensile and Compressive Axial Force Application
- E1823 Terminology Relating to Fatigue and Fracture Testing

3. Terminology

3.1 The definitions in this practice are in accordance with definitions given in Terminology E1823 unless otherwise stated.

3.2 Definitions:

3.2.1 Additional definitions are as follows:

3.2.2 *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.

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

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.