



Standard Guide for Evaluating Mechanical Properties of Metal Materials Made via Additive Manufacturing Processes¹

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1. Scope

1.1 This standard serves as a guide to existing standards or variations of existing standards that may be applicable to determine specific mechanical properties of materials made with an additive manufacturing process.

1.2 As noted in many of these referenced standards, there are several factors that may influence the reported properties, including material, material anisotropy, method of material preparation, porosity, method of specimen preparation, testing environment, specimen alignment and gripping, testing speed, and testing temperature. These factors should be recorded, to the extent that they are known, according to Practice F2971 and the guidelines of the referenced standards.

1.3 The following standards are not referred to directly in the guide but also have information that may be useful in the testing of metal test specimens made via additive manufacturing: A370, A1058, B211, B348, B557, B565, B724, B769, E3, E6, E7, E290, E467, E468, E837, E915, E1049, E1823, E1942.

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

1.5 *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:²

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A1058 Test Methods for Mechanical Testing of Steel Products—Metric

¹ This test method is under the jurisdiction of ASTM Committee F42 on Additive Manufacturing Technologies and is the direct responsibility of Subcommittee F42.01 on Test Methods.

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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.

- B211 Specification for Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire
- B348 Specification for Titanium and Titanium Alloy Bars and Billets
- B557 Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products
- B565 Test Method for Shear Testing of Aluminum and Aluminum-Alloy Rivets and Cold-Heading Wire and Rods
- B645 Practice for Linear-Elastic Plane-Strain Fracture Toughness Testing of Aluminum Alloys
- B646 Practice for Fracture Toughness Testing of Aluminum Alloys
- B647 Test Method for Indentation Hardness of Aluminum Alloys by Means of a Webster Hardness Gage
- B648 Test Method for Indentation Hardness of Aluminum Alloys by Means of a Barcol Impressor
- B724 Test Method for Indentation Hardness of Aluminum Alloys by Means of a Newage, Portable, Non-Caliper-Type Instrument (Withdrawn 2013)³
- B769 Test Method for Shear Testing of Aluminum Alloys
- B909 Guide for Plane Strain Fracture Toughness Testing of Non-Stress Relieved Aluminum Products
- E3 Guide for Preparation of Metallographic Specimens
- E6 Terminology Relating to Methods of Mechanical Testing
- E7 Terminology Relating to Metallography
- E8/E8M Test Methods for Tension Testing of Metallic Materials
- E9 Test Methods of Compression Testing of Metallic Materials at Room Temperature
- E10 Test Method for Brinell Hardness of Metallic Materials
- E18 Test Methods for Rockwell Hardness of Metallic Materials
- E21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials
- E23 Test Methods for Notched Bar Impact Testing of Metallic Materials
- E111 Test Method for Young's Modulus, Tangent Modulus, and Chord Modulus

³ The last approved version of this historical standard is referenced on www.astm.org.

- E132** Test Method for Poisson's Ratio at Room Temperature
- E140** Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness
- E143** Test Method for Shear Modulus at Room Temperature
- E209** Practice for Compression Tests of Metallic Materials at Elevated Temperatures with Conventional or Rapid Heating Rates and Strain Rates
- E238** Test Method for Pin-Type Bearing Test of Metallic Materials
- E290** Test Methods for Bend Testing of Material for Ductility
- E292** Test Methods for Conducting Time-for-Rupture Notch Tension Tests of Materials
- E384** Test Method for Knoop and Vickers Hardness of Materials
- E399** Test Method for Linear-Elastic Plane-Strain Fracture Toughness K_{Ic} of Metallic Materials
- E448** Practice for Scleroscope Hardness Testing of Metallic Materials
- E466** Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials
- E467** Practice for Verification of Constant Amplitude Dynamic Forces in an Axial Fatigue Testing System
- E468** Practice for Presentation of Constant Amplitude Fatigue Test Results for Metallic Materials
- E606** Test Method for Strain-Controlled Fatigue Testing
- E647** Test Method for Measurement of Fatigue Crack Growth Rates
- E740** Practice for Fracture Testing with Surface-Crack Tension Specimens
- E837** Test Method for Determining Residual Stresses by the Hole-Drilling Strain-Gage Method
- E915** Test Method for Verifying the Alignment of X-Ray Diffraction Instrumentation for Residual Stress Measurement
- E1049** Practices for Cycle Counting in Fatigue Analysis
- E1221** Test Method for Determining Plane-Strain Crack-Arrest Fracture Toughness, K_{Ia} , of Ferritic Steels
- E1290** Test Method for Crack-Tip Opening Displacement (CTOD) Fracture Toughness Measurement (Withdrawn 2013)³
- E1304** Test Method for Plane-Strain (Chevron-Notch) Fracture Toughness of Metallic Materials
- E1450** Test Method for Tension Testing of Structural Alloys in Liquid Helium
- E1457** Test Method for Measurement of Creep Crack Growth Times and Rates in Metals
- E1681** Test Method for Determining Threshold Stress Intensity Factor for Environment-Assisted Cracking of Metallic Materials
- E1820** Test Method for Measurement of Fracture Toughness
- E1823** Terminology Relating to Fatigue and Fracture Testing
- E1875** Test Method for Dynamic Young's Modulus, Shear Modulus, and Poisson's Ratio by Sonic Resonance
- E1876** Test Method for Dynamic Young's Modulus, Shear Modulus, and Poisson's Ratio by Impulse Excitation of Vibration
- E1942** Guide for Evaluating Data Acquisition Systems Used in Cyclic Fatigue and Fracture Mechanics Testing
- E2368** Practice for Strain Controlled Thermomechanical Fatigue Testing
- E2472** Test Method for Determination of Resistance to Stable Crack Extension under Low-Constraint Conditions
- E2714** Test Method for Creep-Fatigue Testing
- E2760** Test Method for Creep-Fatigue Crack Growth Testing
- E2789** Guide for Fretting Fatigue Testing
- F2971** Practice for Reporting Data for Test Specimens Prepared by Additive Manufacturing
- F2792** Terminology for Additive Manufacturing Technologies
- ISO/ASTM 52921** Terminology for Additive Manufacturing—Coordinate Systems and Test Methodologies
- 2.2 *ISO Standards*:⁴
- EN ISO 148-1** Metallic materials—Charpy pendulum impact test—Part 1: Test method
- ISO 148-3** Metallic materials—Charpy pendulum impact test—Part 3: Preparation and characterization of Charpy V-notch test pieces for indirect verification of pendulum impact machines
- ISO 377** Steel and steel products—Location and preparation of samples and test pieces for mechanical testing
- ISO 1099** Metallic materials—Fatigue testing—Axial force-controlled method
- ISO 1143** Metallic materials—Rotating bar bending fatigue testing
- ISO 1352** Metallic materials—Torque-controlled fatigue testing
- EN ISO 4545-1** Metallic materials—Knoop hardness test—Part 1: Test method
- ISO/DIS 5173** Destructive tests on welds in metallic materials—Bend tests
- EN ISO 6506-1** Metallic materials—Brinell hardness test—Part 1: Test method
- EN ISO 6507-1** Metallic materials—Vickers hardness test—Part 1: Test method
- EN ISO 6508** Metallic materials—Rockwell hardness test—Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)
- ISO 6892-1** Metallic materials—Tensile testing—Part 1: Method of test at room temperature
- ISO 6892-2** Metallic materials—Tensile testing—Part 2: Method of test at elevated temperature
- EN ISO 7438** Metallic materials—Bend test
- ISO 11531** Metallic materials—Earing test
- ISO 12106** Metallic materials—Fatigue testing—Axial-strain-controlled method
- ISO 12108** Metallic materials—Fatigue testing—Fatigue crack growth method

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