



Designation: E9 – 09 (Reapproved 2018)

Standard Test Methods of Compression Testing of Metallic Materials at Room Temperature¹

This standard is issued under the fixed designation E9; 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 approval. A superscript symbol (n) indicates an editorial change since the last revision or approval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 These test methods cover the apparatus, specimens, and procedure for axial-load compression testing of metallic materials at room temperature (**Note 1**). For additional requirements pertaining to cemented carbides, see **Annex A.1**.

Note 1—For compression tests at elevated temperatures, see Practice E209.

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.

1.3 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, health, and environmental health practices and determine the applicability of regulatory limitations prior to use.

1.4 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.

2. Referenced Documents

2.1 ASTM Standards:²

- E1557 Test Methods for Tension Testing: Wrought and Cast Aluminum- and Magnesium-Alloy Products
- E84 Practices for Force Verification of Testing Machines
- E6 Terminology Relating to Methods of Mechanical Testing

- E83 Practice for Verification and Classification of Extensometer Systems
- E111 Test Method for Young's Modulus, Tangent Modulus, and Chord Modulus
- E171/E171M Practice for Conditioning and Testing Flexible Barrier Packaging
- E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
- E209 Practice for Compression Tests of Metallic Materials at Elevated Temperatures with Conventional or Rapid Heating Rates and Strain Rates
- E251 Test Methods for Performance Characteristics of Metallic Bonded Resistance Strain Gages
- E991 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 **Definitions:** The definitions of terms relating to compression testing and room temperature in Terminology E6 and Practice E171/E171M, respectively, shall apply to these test methods.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 **backling**—In addition to compressive failure by crushing of the material, compressive failure may occur by (1) elastic instability over the length of a column specimen due to nonuniformity of loading, (2) inelastic instability over the length of a column specimen, (3) a local instability, either elastic or inelastic, over a small portion of the gage length, or (4) a twisting or torsional failure in which cross sections rotate over each other about the longitudinal specimen axis. These types of failures are all termed **backling**.

3.2.2 **column**—a compression member that is axially loaded and that may fail by backling.

3.2.3 **radius of gyration**—the square root of the ratio of the moment of inertia of the cross section about the centroidal axis to the cross-sectional area:

$$r = [I/A]^{1/2} \quad (1)$$

where:

r = radius of gyration,

¹These test methods are under the jurisdiction of ASTM Committee E21 on Mechanical Testing and are the direct responsibility of Subcommittee E21.04 on Uniaxial Testing.

Current edition approved Jan. 8, 2018. Published January 2018. Originally published in 1924. Last previous edition approved in 2009 as E9-09. DOI: 10.1520/E0909-2018.

²For 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 release information, refer to the standard's Document Summary page on the ASTM website.

Astm E9

**Chee Kai Chua, Chee How Wong, Wai
Yee Yeong**

Astm E9:

Precision Metal Additive Manufacturing Richard Leach, Simone Carmignato, 2020-09-21 Additive manufacturing AM is a fast growing sector with the ability to evoke a revolution in manufacturing due to its almost unlimited design freedom and its capability to produce personalised parts locally and with efficient material use AM companies however still face technological challenges such as limited precision due to shrinkage built in stresses and limited process stability and robustness Moreover often post processing is needed due to high roughness and remaining porosity Qualified trained personnel are also in short supply In recent years there have been dramatic improvements in AM design methods process control post processing material properties and material range However if AM is going to gain a significant market share it must be developed into a true precision manufacturing method The production of precision parts relies on three principles Production is robust i.e. all sensitive parameters can be controlled Production is predictable for example the shrinkage that occurs is acceptable because it can be predicted and compensated in the design Parts are measurable as without metrology accuracy repeatability and quality assurance cannot be known AM of metals is inherently a high energy process with many sensitive and inter related process parameters making it susceptible to thermal distortions defects and process drift The complete modelling of these processes is beyond current computational power and novel methods are needed to practicably predict performance and inform design In addition metal AM produces highly textured surfaces and complex surface features that stretch the limits of contemporary metrology With so many factors to consider there is a significant shortage of background material on how to inject precision into AM processes Shortage in such material is an important barrier for a wider uptake of advanced manufacturing technologies and a comprehensive book is thus needed This book aims to inform the reader how to improve the precision of metal AM processes by tackling the three principles of robustness predictability and metrology and by developing computer aided engineering methods that empower rather than limit AM design Richard Leach is a professor in metrology at the University of Nottingham and heads up the Manufacturing Metrology Team Prior to this position he was at the National Physical Laboratory from 1990 to 2014 His primary love is instrument building from concept to final installation and his current interests are the dimensional measurement of precision and additive manufactured structures His research themes include the measurement of surface topography the development of methods for measuring 3D structures the development of methods for controlling large surfaces to high resolution in industrial applications and the traceability of X ray computed tomography He is a leader of several professional societies and a visiting professor at Loughborough University and the Harbin Institute of Technology Simone Carmignato is a professor in manufacturing engineering at the University of Padua His main research activities are in the areas of precision manufacturing dimensional metrology and industrial computed tomography He is the author of books and hundreds of scientific papers and he is an active member of leading technical and scientific societies He has been chairman organiser and keynote speaker for several international

conferences and received national and international awards including the Taylor Medal from CIRP the International Academy for Production Engineering

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MMPDS-09 ,2014 MMPDS 09 supersedes MMPDS 08 and prior editions of the MMPDS as well as all editions of MIL HDBK 5 Metallic materials and elements for aerospace vehicle structures handbook that was maintained by the U S Air Force The last edition MIL HDBK 5J was cancelled by the U S Air Force in March 2006 This document contains design information on the mechanical and physical properties of metallic materials and joints commonly used in aircraft and aerospace vehicle structures All information contained in this Handbook has been reviewed and approved using a standardized process The development and ongoing maintenance process involves certifying agencies including the FAA DoD and NASA and major material suppliers and material users worldwide P i

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authored by pioneers of industrial aerospace material technologies This book has a well planned layout in 4 parts The first part deals with primary metal and material processing including nano manufacturing The second part deals with materials characterization and testing methodologies and technologies The third part addresses structural design Finally several advanced material technologies are covered in the fourth part Some key advanced topics such as Structural Design by ASIP Damage Mechanics Based Life Prediction and Extension and Principles of Structural Health Monitoring are dealt with at equal length as the traditional aerospace materials technology topics This book will be useful to students researchers and professionals working in the domain of aerospace materials

Standards, Quality Control, and Measurement Sciences in 3D Printing and Additive Manufacturing Chee Kai Chua, Chee How Wong, Wai Yee Yeong, 2017-06-03 Standards Quality Control and Measurement Sciences in 3D Printing and Additive Manufacturing addresses the critical elements of the standards and measurement sciences in 3D printing to help readers design and create safe reliable products of high quality With 3D printing revolutionizing the process of manufacturing in a wide range of products the book takes key features into account such as design and fabrication and the current state and future potentials and opportunities in the field In addition the book provides an in depth analysis on the importance of standards and measurement sciences With self test exercises at the end of each chapter readers can improve their ability to take up challenges and become proficient in a number of topics related to 3D printing including software usage materials specification and benchmarking Helps the reader understand the quality framework tailored for 3D printing processes Explains data format and process control in 3D printing Provides an overview of different materials and characterization methods Covers benchmarking and metrology for 3D printing

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