

ASME Y14.46-2022

Product Definition for Additive Manufacturing

**Engineering Product Definition and
Related Documentation Practices**

AN AMERICAN NATIONAL STANDARD



The American Society of
Mechanical Engineers

ASME Y14.46-2022

Product Definition for Additive Manufacturing

**Engineering Product Definition and
Related Documentation Practices**

AN AMERICAN NATIONAL STANDARD



**The American Society of
Mechanical Engineers**

Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: June 8, 2022

This Standard will be revised when the Society approves the issuance of a new edition.

Periodically certain actions of the ASME Y14 Committee may be published as Cases. Cases are published on the ASME website under the Y14 Committee Page at <http://go.asme.org/Y14committee> as they are issued.

Errata to codes and standards may be posted on the ASME website under the Committee Pages to provide corrections to incorrectly published items, or to correct typographical or grammatical errors in codes and standards. Such errata shall be used on the date posted.

The Y14 Committee Page can be found at <http://go.asme.org/Y14committee>. There is an option available to automatically receive an e-mail notification when errata are posted to a particular code or standard. This option can be found on the appropriate Committee Page after selecting "Errata" in the "Publication Information" section.

ASME is the registered trademark of The American Society of Mechanical Engineers.

This code or standard was developed under procedures accredited as meeting the criteria for American National Standards. The standards committee that approved the code or standard was balanced to ensure that individuals from competent and concerned interests had an opportunity to participate. The proposed code or standard was made available for public review and comment, which provided an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

ASME does not "approve," "rate," or "endorse" any item, construction, proprietary device, or activity. ASME does not take any position with respect to the validity of any patent rights asserted in connection with any items mentioned in this document, and does not undertake to insure anyone utilizing a standard against liability for infringement of any applicable letters patent, nor does ASME assume any such liability. Users of a code or standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Participation by federal agency representatives or persons affiliated with industry is not to be interpreted as government or industry endorsement of this code or standard.

ASME accepts responsibility only for those interpretations of this document issued in accordance with the established ASME procedures and policies, which preclude the issuance of interpretations by individuals.

No part of this document may be reproduced in any form,
in an electronic retrieval system or otherwise,
without the prior written permission of the publisher.

The American Society of Mechanical Engineers
Two Park Avenue, New York, NY 10016-5990

Copyright © 2022 by
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
All rights reserved

CONTENTS

Foreword	vi
Committee Roster	vi
Correspondence With the Y14 Committee	vii
1 General	1
1.1 Scope	1
1.2 ASME Y14 Series Conventions	1
1.3 Dimensioning and Tolerancing	2
1.4 Examples	2
1.5 References	3
2 Definitions	3
3 Supplemental Geometry	5
3.1 Coordinate System Identification	5
3.2 Unit Vector Identification	5
3.3 Surface Identification	5
4 Product and Process Definition	9
4.1 Geometry Characteristics	9
4.2 Design Characteristics	9
4.3 Process-Related Characteristics	10
5 Product Definition Data Sets	27
5.1 General	27
5.2 Product Definition Data Set Types	27
5.3 PDDS Type Contents	27
5.4 Model Schema and Organization	27
Nonmandatory Appendices	
A Example AM Notes	31
B Defining Transition Regions	32
C Reference Documents to Test for Conformance	36
D Complex Geometry and Forward Work	38
Figures	
3-1 Single Coordinate System Related to the Model	6
3-2 Multiple Coordinate Systems	7
3-3 Unit Vector Indicating Build Direction	7
3-4 Unit Vector Indicating Gravity Direction	8
3-5 A Surface Representing a Build Surface	8
4-1 Example of a Theoretical Supplemental Surface Used on a Rectangular Lattice Cuboid	12
4-2 Example of a Nonplanar Theoretical Supplemental Surface	13

4-3	Example of a Tolerance Zone	13
4-4	Bounded Surface Region to Indicate Internal and External Surfaces	14
4-5	Bounded Volume Region Indicator (VOL1) With a Profile of a Surface Tolerance	15
4-6	Bounded Volume Regions Represented by Several Bounded Volume Region Indicators in a Part	15
4-7	Bounded Surface Region Indicator Coupled With a Feature Control Frame	16
4-8	Examples of Unit Cell Geometries and Lattice Structures	16
4-9	VOL Local Notes That Describe Material Gradient Allocations Shown in Table 4-1	17
4-10	Build Direction Indicated Using the Direction Unit Vector	18
4-11	Multiple Build Directions	18
4-12	Planar Build Surface and a Nonplanar Build Surface	19
4-13	Coordinate Systems Are Used to Locate Parts Within a Build Volume	19
4-14	Four Separate Parts Nested Inside One Another on a Build Surface	20
4-15	Free Zone Description With an Offset Dimension	20
4-16	Free Zone Bounding Box Description	21
4-17	Layer Thickness Specification	21
4-18	Specification of a Track Path With Three Contours	22
4-19	Specification of a Track Path Using a Follow Boundary (FB) Modifier	22
4-20	Specification of Track Paths on Different Layers	23
4-21	Examples of Infill and Unit Volumes	23
4-22	Example Where Support Structure Location Is Not Specified	24
4-23	Example Where Bounded Surface Region 1 (SURF1) Is Annotated to Indicate a Structure Exclusion Area (SEA)	24
4-24	Example Where SURF1 Is Annotated to Indicate a Structure Limiting Area (SLA) of 20%	25
4-25	Example Where SURF1 Is Annotated to Indicate a Structure Required Area (SRA)	25
4-26	Indication of Geometry Created Inside the Part to Specify Support Structure	26
4-27	Local Notes Identifying Test Coupons	26
B-1	Material Transition Specification Between Bounded Volume Regions With Lattice Fill	33
B-2	Part With Material Transition Region (Heterogeneous Material Indicator) and Specification of Tolerance	34
B-3	Acceptable Void Fractions for MAT1 and MAT2	34
B-4	Allowable Material Fraction for MAT1 and MAT2	35
D-1	Complex Geometries Generated From Topology Optimization	39
D-2	Wrench Produced as a Single Build With Three Parts	40

Tables

4-1	Material Gradient Values Used in Figure 4-9	17
5-1	Required and Optional Data Sets for AM Products	27
5-2	Required and Optional Elements Within the AM Design PDDS	28
5-3	Required and Optional Elements Within the AM Build PDDS	28
5-4	Required and Optional Elements Within the AM Processed PDDS	29
5-5	Required and Optional Elements Within the End Product PDDS	29
5-6	Examples of AM Use Cases Using the Codes in ASME Y14.47 to Show the Level of Content in an AM Data Set Type	29
5-7	Examples of Metadata for Model-Based Definition (MBD) Data	30
C-1	Select Reference Documents	37

FOREWORD

The Charter of the ASME Y14.46 Subcommittee was approved by the ASME Y14 Standards Committee on October 10, 2014, with the task to develop requirements in geometric dimensioning and tolerancing for additive manufacturing (AM). The goal of the Subcommittee was to create a broadly accepted standard that incorporates, expands, or refines international practices and symbology to enable AM product definition data to be created, interpreted, and consumed on a global basis. The Y14.46 Subcommittee has brought together subject matter experts (SMEs) who have generously volunteered a significant amount of time and resources to this effort over the last 5 years.

The Subcommittee approved the ASME Y14.46 Draft Standard for Trial Use on June 19, 2017. The Subcommittee welcomed comments and/or proposals for revisions to the Draft Standard, as submitted through the provided forms and additional balloting process. Since the initial release of the Draft Standard for Trial Use, the Subcommittee has received important feedback from the additive manufacturing and product definition communities. The Subcommittee has incorporated the feedback into this document to make it a released Standard.

Some appendices are introduced in this Standard because the Subcommittee is aware of the need to address these topics. Work to enhance these appendices is ongoing, and feedback from the public is welcome (see [Correspondence With the Y14 Committee](#)). The following appendices are identified as “forward work”:

- (a) [Nonmandatory Appendix C](#), Reference Documents to Test for Conformance
- (b) [Nonmandatory Appendix D](#), Complex Geometry and Forward Work

This Standard has been created and edited to be distributed in the pdf format. It was approved as an American National Standard by the American National Standards Institute on May 19, 2022.

ASME Y14 COMMITTEE

Engineering Product Definition and Related Documentation Practices

(The following is the roster of the Committee at the time of approval of this Standard.)

STANDARDS COMMITTEE OFFICERS

J. B. Hoskins, *Chair*
J. D. Meadows, *Vice Chair*
F. Constantino, *Secretary*

STANDARDS COMMITTEE PERSONNEL

A. R. Anderson , Dimensional Dynamics, LLC	W. A. Kaba , Spirit AeroSystems, Inc.
T. Bowers , Lockheed Martin Co.	A. Krulikowski , Krulikowski Consulting, LLC
J. Burleigh , Unaffiliated	S. Lege , U.S. Army
W. Cockrell , Raytheon Technologies	E. F. McCarthy , E. F. McCarthy Consulting, Inc.
F. Constantino , The American Society of Mechanical Engineers	P. J. McCuiston , AltMac DMS
D. O. Coon , Applied Geometrics, Inc.	J. D. Meadows , James D. Meadows and Associates, Inc.
R. Courson , SAE International	M. E. Meloro , Northrop Grumman Corp.
K. Dobert , Siemens PLM Software	J. Michalowicz , Stryker Corp.
P. Drake , MechSigma Consulting, Inc.	J. I. Miller , Technical Consultants, Inc.
B. Fischer , TDP360, LLC	H. W. Oake , U.S. Air Force (University of Dayton Research Institute)
S. Hauger , Deere and Co.	K. F. Wierandt , Consultant
J. B. Hoskins , The Boeing Co.	B. A. Wilson , Consultant
J. Houck , Woodward, Inc.	E. Zwettler , Sigmetrix
R. Jensen , Hexagon Manufacturing Intelligence	J. Scheibel , <i>Alternate</i> , The Boeing Co.

SUBCOMMITTEE 46 — PRODUCT DEFINITION FOR ADDITIVE MANUFACTURING

J. Gardner , <i>Chair</i> , Lockheed Martin Co.	G. Nair , Lloyd's Register
D. Wallace , <i>Vice Chair</i> , Texas A&M University	S. K. Ramasamy , Apple
G. Ameta , Siemens Technology	B. Roberts , The Boeing Co.
L. Bergquist , Tec-Ease, Inc.	J. Schmelzle , Naval Air Systems Command
C. Brown , Honeywell FM&T	M. J. Shaw , Rolls Royce Co.
W. Cockrell , Raytheon Technologies	J. Sykes , Profile Services
A. Frey , U.S. Army	M. Toye , General Electric
J. Herron , Action Engineering	W. Weiss , IBW — Ingenieurbuero Wolfgang Weiss
K. Losoncy , Orbital ATK Space Systems Group	P. Witherell , National Institute of Standards and Technology
J. Michalowicz , Stryker Corp.	J. V. Van Horn , <i>Alternate</i> , The Boeing Co.

Y14.46 SUPPORT GROUP

Y. B. Dama, Geometric America, Inc.

B. Fischer, TDP360, LLC

S. Hauger, Deere and Co.

E. R. Henry, JT3

P. Hojnacki, Deere and Co.

P. Huang, Office of Naval Research

E. Kline, Naval Air Systems Command

Y. Lin, University of Missouri

R. Lipman, National Institute of Standards and Technology

B. Lucht, National Nuclear Security Administration, Kansas City

L. Maggiano, Mitutoyo America Co.

E. Morse, University of North Carolina, Charlotte

B. Nielsen, The Boeing Co.

M. Nielsen, Tech Azul

H. W. Oakes, U.S. Air Force (University of Dayton Research Institute)

B. Romero, Raytheon Technologies

C. Sahay, University of Hartford

A. Schmidt, Woodward, Inc.

J. Shah, Ohio State University

H. Taylor, HDT-GDT, LLC

M. Taylor, Raytheon Technologies

T. T. Taylor, Siemens Power Generation

H. Tran, Sandia National Laboratories

L. C. Webster, The MITRE Corp.

O. Wu, DS Solidworks

E. Zwettler, Sigmetrix

CORRESPONDENCE WITH THE Y14 COMMITTEE

General. ASME Standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by proposing revisions or a case and attending Committee meetings. Correspondence should be addressed to:

Secretary, Y14 Standards Committee
The American Society of Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990
<http://go.asme.org/Inquiry>

Proposing Revisions. Revisions are made periodically to the Standard to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

Proposing a Case. Cases may be issued to provide alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee web page.

Requests for Cases shall provide a Statement of Need and Background information. The request should identify the Standard and the paragraph, figure, or table number(s), and be written as a Question and Reply in the same format as existing Cases. Requests for Cases should also indicate the applicable edition(s) of the Standard to which the proposed Case applies.

Attending Committee Meetings. The Y14 Standards Committee regularly holds meetings and/or telephone conferences that are open to the public. Persons wishing to attend any meeting and/or telephone conference should contact the Secretary of the Y14 Standards Committee. Future Committee meeting dates and locations can be found on the Committee Page at <http://go.asme.org/Y14committee>.

PRODUCT DEFINITION FOR ADDITIVE MANUFACTURING

1 GENERAL

1.1 Scope

This Standard covers the definitions of terms and features unique to additive manufacturing (AM) technologies with recommendations for their uniform specification in product definition data and in related documents. Unless otherwise specified, any reference to features, parts, or processes shall be interpreted as applying to parts or assemblies manufactured using an AM process. Additively manufactured parts or assemblies are referred to as “parts” throughout the Standard. The Standard extends to capturing relevant AM detail from design, manufacturing, and quality engineering.

1.2 ASME Y14 Series Conventions

The conventions in [paras. 1.2.1 through 1.2.12](#) are used in this and other ASME Y14 standards.

1.2.1 Mandatory, Recommended, Guidance, and Optional Words

- (a) The word “shall” establishes a requirement.
- (b) The word “will” establishes a declaration of purpose on the part of the design activity.
- (c) The word “should” establishes a recommended practice.
- (d) The word “may” establishes an allowed practice.
- (e) The words “typical,” “example,” “for reference,” and the Latin abbreviation “e.g.” indicate suggestions given for guidance only.
- (f) The word “or” used in conjunction with a requirement or a recommended practice indicates that there are two or more options for complying with the stated requirement or practice.
- (g) The phrase “unless otherwise specified” or the abbreviation “UOS” shall be used to indicate a default requirement. The phrase is used when the default is a generally applied requirement and an exception may be provided by another document or requirement.

1.2.2 Cross-Reference of Standards. Cross-reference of standards in text with or without a date following the standard designator shall be interpreted as follows:

- (a) Reference to other ASME Y14 standards in the text without a date following the standard designator indicates that the edition of the standard identified in the References section ([para. 1.5](#)) shall be used to meet the requirement.
- (b) Reference to other ASME Y14 standards in the text with a date following the standard designator indicates that only that edition of the standard shall be used to meet the requirement.

1.2.3 Invocation of Referenced Standards. The following examples define the invocation of a standard when specified in [para. 1.5](#) and referenced in the text of this Standard:

- (a) When a referenced standard is cited in the text with no limitations to a specific subject or paragraphs of the standard, the entire standard is invoked. For example, “Dimensioning and tolerancing shall be in accordance with ASME Y14.5” is invoking the complete standard because the subject of the standard is dimensioning and tolerancing and no specific subject or paragraphs within the standard are invoked.
- (b) When a referenced standard is cited in the text with limitations to a specific subject or paragraphs of the standard, only the paragraphs on that subject are invoked. For example, “Assign part or identifying numbers in accordance with ASME Y14.10” is invoking only the paragraphs on part or identifying numbers because the subject of the standard is engineering drawing practices and part or identifying numbers is a specific subject within the standard.
- (c) When a referenced standard is cited in the text without an invoking statement such as “in accordance with,” the standard is invoked for guidance only. For example, “For gaging principles, see ASME Y14.43” is only for guidance and no portion of the standard is invoked.

1.2.4 Definitions. [Section 2](#) provides definitions specific to this Standard. For definitions of words used in but not defined in this Standard, see Merriam-Webster’s Unabridged Dictionary at <https://www.merriam-webster.com/>.