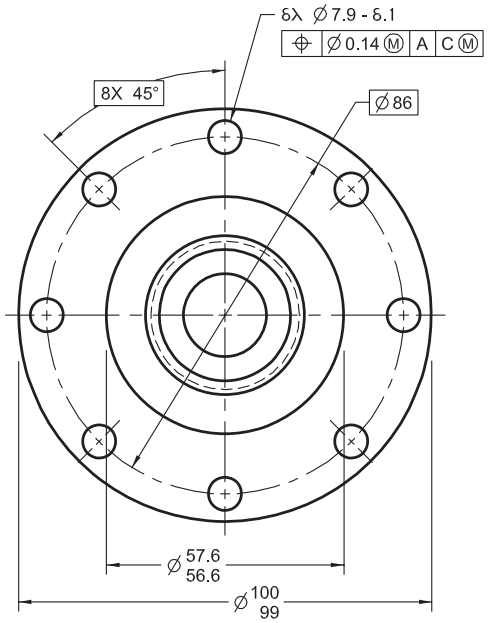
ASME Y14.5-2018
(Revision of ASME Y14.5-2009)

Dimensioning and Tolerancing

Engineering Product Definition and Related Documentation Practices



AN INTERNATIONAL STANDARD

The American Society of Mechanical Engineers

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ASME Y14.5, Dimensioning and Tolerancing, was adopted on 9 February 2009 for use by the Department of Defense (DoD). Proposed changes by DoD activities must be submitted to the DoD Adopting Activity: Commander, U.S. Army Research, Development and Engineering Center (ARDEC), ATTN: AMSRD-AAR-QES-E, Picatinny Arsenal, NJ 07806-5000. Copies of this document may be purchased from The American Society of Mechanical Engineers (ASME), 150 Clove Road, 6th Floor, Little Falls, NJ 07424-2139; http://www.asme.org.

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AN INTERNATIONAL STANDARD

The American Society of Mechanical Engineers

Two Park Avenue • New York, NY • 10016 USA

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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.

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

CONTENTS

FOREWORD

This issue is a revision of ASME Y14.5-2009, Dimensioning and Tolerancing. The objectives for this revision are to correct any inconsistencies in the previous edition, to determine actions based on deferred comments from the review of the previous edition's draft, to include model-based applications in many of the example figures, and to address proposals submitted by the public or members of the Subcommittee. Based on guidance from the Y14 Committee, the material formerly in Section 1 has been reorganized into Sections 1 through 4, and the subsequent Sections have been renumbered.

Because of the widespread use of computer-aided design (CAD) and the industry transition toward reduced use of orthographic views for product definition, model views were added in many figures throughout the Standard. This is in part to ensure that this Standard is applicable to the use of dimensions and tolerances in models and model-based drawings. The methods of application in model views are currently defined in ASME Y14.41, but the meanings of the tolerances are defined in this Standard.

The Foreword of ASME Y14.5-2009 pointed out the increasing importance for design to more precisely state functional requirements through the use of geometric dimensioning and tolerancing (GD&T), and not to rely on the less definitive method of directly applied limit dimensions for form, orientation, location, and profile of part features. This 2018 revision emphasizes the use of profile for location tolerances applied to surfaces; the use of plus and minus tolerances has been moved to an Appendix that is likely to be removed in the next revision.

With a focus on making the transition from the previous edition to this edition simple, no reversals of tolerancing concepts have been made. However, two past practices, use of concentricity and use of symmetry symbols, are no longer supported. Both have been eliminated because other characteristics provide more direct control of features and establish requirements that have a well-defined meaning. Deletion of the symbols does not leave industry without a means to control coaxial or symmetrical features, but it does eliminate the confusion that surrounds these symbols and their misapplication.

Text and figure edits were made to improve readability and clarify content. Changes in sentence structure, organization of content, and method of illustration are not an indication of technical changes.

Work on this issue began at a meeting in Sarasota, Florida, in April 2009. Numerous deferred comments from the public review for the previous revision, as well as new proposals for revision and improvement from the Subcommittee and interested parties in the user community, were evaluated at subsequent semiannual meetings. The first draft entered the review process after it was completed in August 2015. Additional technical improvements and numerous editorial changes were made based on the comments received.

A Nonmandatory Appendix provides information about many of the updates in this edition of this Standard. One of the updates is an explicit statement that unless otherwise specified by drawing/model note or reference to a separate document, the as-designed dimension value does not establish a functional or manufacturing target. In addition, the term "true geometric counterpart" has replaced the term "theoretical datum feature simulator." The use of the "true geometric counterpart" term is limited to datums.

This Standard is available for public review on a continuing basis. This provides an opportunity for additional public-review input from industry, academia, regulatory agencies, and the public-at-large.

This revision was approved as an American National Standard on August 13, 2018.

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.)

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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 requesting interpretations, 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.

Section 1
Scope

1.1 INTRODUCTION

This Standard establishes symbols, rules, definitions, requirements, defaults, and recommended practices for stating and interpreting dimensioning, tolerancing, and related requirements for use on engineering drawings, models defined in digital data files, and related documents. For a mathematical explanation of many of the principles in this Standard, see ASME Y14.5.1M. Additional uniform practices for applying dimensions, tolerances, and related requirements in digital data sets are defined in ASME Y14.41. Practices unique to architectural and civil engineering and welding symbology are not included in this Standard.

1.2 GENERAL

Sections 1 through 4 establish related references, definitions, fundamental rules, and practices for general dimensioning. For tolerancing practices, see Sections 5 through 12. Additional information about tolerancing is in Mandatory Appendix I and Nonmandatory Appendices A through D.

1.3 REFERENCE TO THIS STANDARD

When engineering documentation is based on this Standard, this fact shall be noted on the documentation or in a referenced separate document. References to this Standard shall include the designation of ASME Y14.5-2018.

1.4 ASME Y14 SERIES CONVENTIONS

The conventions in paras. 1.4.1 through 1.4.10 are used in this and other ASME Y14 standards.

1.4.1 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” (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.

1.4.2 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 issue of the standard identified in the References section (Section 2) 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 issue of the standard shall be used to meet the requirement.

1.4.3 Invocation of Referenced Standards

The following examples define the invocation of a standard when specified in the References section (Section 2) 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 paragraph(s) 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 paragraph(s) within the standard are invoked.

(b) When a referenced standard is cited in the text with limitations to a specific subject or paragraph(s) of the standard, only the paragraph(s) on that subject are invoked. For example, “Assign part or identifying numbers in accordance with ASME Y14.100” is only invoking the paragraph(s) 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 for guidance only. For example, "For gaging principles, see ASME Y14.43" is only for guidance and no portion of the standard is invoked.

1.4.4 Parentheses Following a Definition

When a definition is followed by a standard referenced in parentheses, the standard referenced in parentheses is the source for the definition.

1.4.5 Notes

Notes depicted in this Standard in **ALL UPPERCASE** letters are intended to reflect actual drawing or model entries. Notes depicted in initial uppercase or lowercase letters are to be considered supporting data to the contents of this Standard and are not intended for literal entry on drawings. A statement requiring the addition of a note with the qualifier "such as" is a requirement to add a note, and the content of the text is allowed to vary to suit the application.

1.4.6 Acronyms and Abbreviations

Acronyms and abbreviations are spelled out the first time used in this Standard, followed by the acronym or abbreviation in parentheses. The acronym is used thereafter throughout the text.

1.4.7 Units

The International System of Units (SI) is featured in this Standard. It should be understood that U.S. Customary units could equally have been used without prejudice to the principles established. UOS, the unit for all dimension values in this Standard is the millimeter.

1.4.8 Figures

The figures in this Standard are intended only as illustrations to aid the user in understanding the practices described in the text. In some cases, figures show a level of detail as needed for emphasis. In other cases, figures are incomplete by intent so as to illustrate a concept or facet thereof. The absence of figure(s) has no bearing on the applicability of the stated requirements or practice. To comply with the requirements of this Standard, actual data sets shall meet the content requirements set forth in the text. To assist the user of this Standard, a list of the paragraph(s) that refer to an illustration appears in the lower right-hand corner of each figure. This list may not be all-inclusive. The absence of a paragraph reference is not a reason to assume inapplicability. Some figures are illustrations of models in a three-dimensional environment. The absence of dimensioning and tolerancing annotations in a view may indicate that the product definition is defined in three dimensions. Dimensions that locate or orient and are not shown are considered basic and shall be queried to determine the intended requirement. When the letter "h" is used in figures for letter heights or for symbol proportions, select the applicable letter height in accordance with ASME Y14.2. Multiview drawings contained within figures are third angle projection.

1.4.9 Precedence of Standards

The following are ASME Y14 Standards that are basic engineering drawing standards:

ASME Y14.1, Decimal Inch Drawing Sheet Size and Format
ASME Y14.1M, Metric Drawing Sheet Size and Format
ASME Y14.2, Line Conventions and Lettering
ASME Y14.3, Orthographic and Pictorial Views
ASME Y14.5, Dimensioning and Tolerancing
ASME Y14.24, Types and Applications of Engineering Drawings
ASME Y14.34, Associated Lists
ASME Y14.35, Revision of Engineering Drawings and Associated Documents
ASME Y14.36, Surface Texture Symbols
ASME Y14.38, Abbreviations and Acronyms for Use on Drawings and Related Documents
ASME Y14.41, Digital Product Definition Data Practices
ASME Y14.100, Engineering Drawing Practices

All other ASME Y14 standards are considered specialty types of standards and contain additional requirements or make exceptions to the basic standards as required to support a process or type of drawing.

1.4.10 Use of an ASME Y14 Case

Where engineering documentation is based on an ASME Y14 Case, this fact shall be noted on the documentation or in a referenced separate document.

1.5 DRAWINGS WITHOUT REFERENCE TO A STANDARD

When a drawing is produced without a reference to a standard (company, regional, national, or international) or contractually imposed documents, the drawing shall be interpreted in accordance with ASME PDS-1.1–2013.

1.6 REFERENCE TO GAGING

This document is not intended as a gaging standard. Any reference to gaging is included for explanatory purposes only. For gaging principles, see ASME Y14.43, Dimensioning and Tolerancing Principles for Gages and Fixtures.

1.7 SYMBOLS

Adoption of symbols indicating dimensional requirements, as shown in Nonmandatory Appendix C, does not preclude the use of equivalent terms or abbreviations where symbology is considered inappropriate.

Section 2
References

2.1 INTRODUCTION

The following revisions of American National Standards form a part of this Standard to the extent specified herein. A more recent revision may be used provided there is no conflict with the text of this Standard. In the event of a conflict between the text of this Standard and the references cited herein, the text of this Standard shall take precedence.

2.2 CITED STANDARDS

ANSI B4.2-1978 (R2009), Preferred Metric Limits and Fits
ANSI B89.3.1-1972 (R2003), Measurement of Out-of-Roundness
ASME B1.1-2003 (R2008), Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.13M-2005 (R2015), Metric Screw Threads: M Profile
ASME B5.10-1994 (R2013), Machine Tapers — Self Holding and Steep Taper Series
ASME B46.1-2009, Surface Texture, Surface Roughness, Waviness, and Lay
ASME B89.6.2-1973 (R2017), Temperature and Humidity Environment for Dimensional Measurement
ASME B94.6-1984 (R2014), Knurling
ASME B94.11M-1993, Twist Drills
ASME PDS-1.1–2013, Dimensioning, Tolerancing, Surface Texture, and Metrology Standards — Rules for Drawings With Incomplete Reference to Applicable Drawing Standard
ASME Y14.1-2012, Decimal Inch Drawing Sheet Size and Format
ASME Y14.1M-2012, Metric Drawing Sheet Size and Format
ASME Y14.2-2014, Line Conventions and Lettering
ASME Y14.5.1M-1994 (R2012), Mathematical Definition of Dimensioning and Tolerancing Principles
ASME Y14.6-2001 (R2013), Screw Thread Representation
ASME Y14.8-2009 (R2014), Castings, Forgings, and Molded Parts
ASME Y14.36-2018, Surface Texture Symbols
ASME Y14.41-2012, Digital Product Definition Data Practices
ASME Y14.43-2011, Dimensioning and Tolerancing Principles for Gages and Fixtures
USAS B4.1-1967 (R2004), Preferred Limits and Fits for Cylindrical Parts
Publisher: The American Society of Mechanical Engineers (ASME), Two Park Avenue, New York, NY 10016-5990 (www.asme.org)

IEEE/ASTM SI 10-2016, American National Standard for Use of the International System of Units (SI): The Modern Metric System[1]
Publisher: Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Lane, Piscataway, NJ 08854 (www.ieee.org)

2.3 ADDITIONAL SOURCES (NOT CITED)

ASME B1.2-1983 (R2017), Gages and Gaging for Unified Inch Screw Threads; Errata May 1992
ASME B89.1.5-1998 (R2014), Measurement of Plain External Diameters for Use as Master Discs
ASME Y14.3M-2012, Orthographic and Pictorial Views
ASME Y14.38-2007 (R2013), Abbreviations and Acronyms for Use on Drawings and Related Documents
ASME Y14.100-2017, Engineering Drawing Practices
Publisher: The American Society of Mechanical Engineers (ASME), Two Park Avenue, New York, NY 10016-5990 (www.asme.org)

[1] IEEE/ASTM standards are also available from the American Society for Testing and Materials (ASTM International), 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 (www.astm.org).

Section 3
Definitions

3.1 ANGULARITY

angularity: the condition of a line element, surface, feature's center plane, tangent plane, or feature's axis at an implied or specified basic angle of any value from one or more datum planes or datum axes.

3.2 BOUNDARY, INNER (IB)

boundary, inner: a worst-case boundary generated by the collective effects of the smallest feature of size (MMC for an internal feature of size, LMC for an external feature of size) and the applicable geometric tolerance. See Figures 5-14 through 5-19.

3.3 BOUNDARY, LEAST MATERIAL (LMB)

boundary, least material: the worst-case boundary that exists on or inside the material of a feature(s) and is defined by the combined effects of size and geometric tolerances.

3.4 BOUNDARY, MAXIMUM MATERIAL (MMB)

boundary, maximum material: the worst-case boundary that exists on or outside the material of a feature(s) and is defined by the combined effects of size and geometric tolerances.

3.5 BOUNDARY, OUTER (OB)

boundary, outer: a worst-case boundary generated by the collective effects of the largest feature of size (LMC for an internal feature of size, MMC for an external feature of size) and the applicable geometric tolerance. See Figures 5-10 and 5-14 through 5-19.

3.6 CIRCULARITY (ROUNDNESS)

circularity (roundness): the condition of a surface in which

(a) for a feature other than a sphere, all points of each circumferential line created by the surface intersected by any plane perpendicular to the axis or spine (curved line) are equidistant from that axis or spine.

(b) for a sphere, all points of the surface intersected by any plane passing through a common center are equidistant from that center.

3.7 COAXIALITY

coaxiality: the condition in which the axis of the unrelated actual mating envelope (AME) or axis of the unrelated minimum material envelope, as applicable, of one or more surfaces of revolution is coincident with a datum axis or another feature axis.

3.8 COMPLEX FEATURE

complex feature: a single surface of compound curvature or a collection of features.

3.9 CONSTRAINT

constraint: a limit to one or more degrees of freedom.

3.10 CONTINUOUS FEATURE

continuous feature: two or more interrupted features designated with a "CF" symbol, indicating they are to be considered as a single feature. See Figure 11-23.

3.11 CONTINUOUS FEATURE OF SIZE

continuous feature of size: two or more regular features of size or an interrupted regular feature of size that is designated with a "CF" symbol, indicating they are to be considered as a single regular feature of size. See Figure 5-11.

3.12 COPLANARITY

coplanarity: the condition of two or more surfaces having all elements in one plane.

3.13 CYLINDRICITY

cylindricity: the condition of a surface of revolution in which all points of the surface are equidistant from a common axis.

3.14 DATUM

datum: a theoretically exact point, axis, line, plane, or combination thereof derived from the true geometric counterpart.

3.15 DATUM AXIS

datum axis: the axis of a true geometric counterpart.

3.16 DATUM CENTER PLANE

datum center plane: the center plane of a true geometric counterpart.

3.17 DATUM FEATURE

datum feature: a feature that is identified with either a datum feature symbol or a datum target symbol(s).

3.18 DATUM FEATURE SIMULATOR

datum feature simulator: the physical boundary used to establish a simulated datum from a specified datum feature.

NOTE: For example, a gage, a fixture element, and digital data (such as machine tables, surface plates, a mandrel, or a mathematical simulation) are not true planes, but are of sufficient quality that the planes derived from them are used to establish simulated datums. Datum feature simulators are used as the physical embodiment of the true geometric counterparts during manufacturing and inspection. See ASME Y14.43.

3.19 DATUM REFERENCE FRAME

datum reference frame: three mutually perpendicular datum planes and three mutually perpendicular axes at the intersections of those planes. See Figure 7-1.

3.20 DATUM, SIMULATED

datum, simulated: a point, axis, line, or plane (or combination thereof) derived from a datum feature simulator. See subsection 7.6 and Figure 7-7.

3.21 DATUM TARGET

datum target: the designated points, lines, or areas that are used in establishing a datum.

3.22 DERIVED MEDIAN LINE

derived median line: an imperfect (abstract) line formed by the center points of all cross sections of the feature. These cross sections are normal (perpendicular) to the axis of the unrelated AME. See Figure 3-1.

3.23 DERIVED MEDIAN PLANE

derived median plane: an imperfect (abstract) plane formed by the center points of all line segments bounded by the feature. These line segments are normal (perpendicular) to the center plane of the unrelated AME.

3.24 DIAMETER, AVERAGE

diameter, average: the average of several diametric measurements across a circular or cylindrical feature.

3.25 DIMENSION

dimension: a numerical value(s) or mathematical expression in appropriate units of measure used to define the shape, size, orientation, or location of a part feature or between part features.

3.26 DIMENSION, BASIC

dimension, basic: a theoretically exact dimension.

NOTE: A basic dimension is indicated by one of the methods shown in Figures 6-11 and 10-1.

3.27 DIMENSION, DIRECTLY TOLERANCED

dimension, directly toleranced: a dimension with an associated plus/minus tolerance or limit dimension values.

NOTE: Where a plus/minus general tolerance is applied to a dimension, the dimension is considered a directly toleranced dimension.

3.28 DIMENSION, REFERENCE

dimension, reference: dimensional information, usually without a tolerance, that is used for reference purposes only. A reference dimension is a repeat of a dimension or is derived from other values shown on the drawing or on related drawings. It is considered auxiliary information and does not govern production or inspection operations. See Figures 4-17 and 4-18. Where a basic dimension is repeated on a drawing, it is not identified as reference. For information on how to indicate a reference dimension, see para. 4.4.6.

3.29 ENVELOPE, ACTUAL MATING (AME)

envelope, actual mating: a similar perfect feature(s) counterpart of smallest size that can be contracted about an external feature(s) or of largest size that can be expanded within an internal feature(s) so that it coincides with the surface(s) at the highest points. This envelope is on or outside the material. There are two types of AMEs, as described below.

(a) related AME: a similar perfect feature(s) counterpart expanded within an internal feature(s) or contracted about an external feature(s) while constrained in orientation, in location, or in both orientation and location to the applicable datum(s). See Figure 3-1.

(b) unrelated AME: a similar perfect feature(s) counterpart expanded within an internal feature(s) or contracted about an external feature(s), and not constrained to any datum(s). See Figure 3-1.

3.30 ENVELOPE, ACTUAL MINIMUM MATERIAL

envelope, actual minimum material: a similar perfect feature(s) counterpart of largest size that can be expanded within an external feature(s) or of smallest size that can be

contracted about an internal feature(s) so that it coincides with the surface(s) at the lowest points. This envelope is on or within the material. There are two types of actual minimum material envelopes, as described below.

(a) related actual minimum material envelope: a similar perfect feature(s) counterpart contracted about an internal feature(s) or expanded within an external feature(s) while constrained in orientation, in location, or in both orientation and location to the applicable datum(s). See Figure 3-2.

(b) unrelated actual minimum material envelope: a similar perfect feature(s) counterpart contracted about an internal feature(s) or expanded within an external feature(s), and not constrained to any datum reference frame. See Figure 3-2.

3.31 FEATURE

feature: a physical portion of a part (such as a surface, pin outside diameter, hole, or slot) or its representation on drawings, models, or digital data files.

3.32 FEATURE AXIS

feature axis: the axis of the unrelated AME of a feature.

3.33 FEATURE, CENTER PLANE OF

feature, center plane of: the center plane of the unrelated AME of a feature.

3.34 FEATURE CONTROL FRAME

feature control frame: a rectangle divided into compartments containing the geometric characteristic symbol followed by the tolerance value or description, modifiers, and any applicable datum feature references. See Figures 6-24 through 6-29.

3.35 FEATURE OF SIZE

feature of size: a general term that is used in this Standard to refer to instances in which both a regular and an irregular feature of size apply.

3.35.1 Irregular Feature of Size

irregular feature of size: there are two types of irregular features of size, as follows:

(a) a directly toleranced feature or collection of features that may contain or be contained by an unrelated AME that is a sphere, cylinder, or pair of parallel planes. See Figure 7-41.

(b) a directly toleranced feature or collection of features that may contain or be contained by an unrelated AME other than a sphere, cylinder, or pair of parallel planes. See Figures 7-40 and 11-29.

3.35.2 Regular Feature of Size

regular feature of size: one cylindrical surface, a spherical surface, a circular element, or a set of two opposed parallel line elements or opposed parallel surfaces associated with a single directly toleranced dimension. See subsection 5.2 and para. 5.8.1(e).

3.36 FEATURE-RELATING TOLERANCE ZONE FRAMEWORK (FRTZF)

feature-relating tolerance zone framework: the tolerance zone framework that controls the basic relationship between the features in a pattern with that framework constrained in rotational degrees of freedom relative to any referenced datum features.

3.37 FLATNESS

flatness: the condition of a surface or derived median plane having all elements in one plane.

3.38 FREE STATE

free state: the condition in which no externally introduced forces other than gravity are applied to a part.

3.39 INTERRUPTION

interruption: a gap or gaps in a feature that divide it into two or more features (e.g., a slot or a groove).

3.40 LEAST MATERIAL CONDITION (LMC)

least material condition: the condition in which a feature of size contains the least amount of material within the stated limits of size, e.g., maximum hole diameter or minimum shaft diameter.

3.41 MAXIMUM MATERIAL CONDITION (MMC)

maximum material condition: the condition in which a feature of size contains the maximum amount of material within the stated limits of size, e.g., minimum hole diameter or maximum shaft diameter.

3.42 NONUNIFORM TOLERANCE ZONE

nonuniform tolerance zone: an MMB and an LMB, where at least one boundary is a specified shape that is not a uniform offset from true profile.

3.43 PARALLELISM

parallelism: the condition of a line element, surface, tangent plane, feature's center plane, or feature's axis at an implied or specified basic 0° (parallel) angle relative to one or more datum planes or datum axes.

3.44 PATTERN

pattern: two or more features to which a position or profile geometric tolerance is applied and that are grouped by one of the following methods: *n*X, *n* COAXIAL HOLES, ALL AROUND, ALL OVER, between A and B (A ↔ B), from A to B (A → B), *n* SURFACES, simultaneous requirements, or INDICATED, where *n* in these examples represents a number.

3.45 PATTERN-LOCATING TOLERANCE ZONE FRAMEWORK (PLTZF)

pattern-locating tolerance zone framework: the tolerance zone framework that controls the basic relationship between the features in a pattern with that framework constrained in translational and rotational degrees of freedom relative to the referenced datum features.

3.46 PERPENDICULARITY

perpendicularity: the condition of a line element, surface, tangent plane, feature's center plane, or feature's axis at an implied or specified basic 90° (perpendicular) angle relative to one or more datum planes or datum axes.

3.47 PLANE, TANGENT

plane, tangent: a plane that contacts the high point or points of the specified surface.

3.48 POSITION

position: the location of one or more features of size relative to one another or to one or more datums.

3.49 PROFILE

profile: an outline of a surface, a shape made up of one or more features, or a two-dimensional element of one or more features.

3.50 REGARDLESS OF FEATURE SIZE (RFS)

regardless of feature size: a condition in which a geometric tolerance applies at any increment of size of the unrelated AME of the feature of size.

3.51 REGARDLESS OF MATERIAL BOUNDARY (RMB)

regardless of material boundary: a condition in which a movable or variable true geometric counterpart progresses from MMB toward LMB until it makes maximum allowable contact with the extremities of a datum feature(s) to establish a datum.

3.52 REPRESENTED LINE ELEMENT

represented line element: a supplemental geometry line or curve segment indicating the orientation of a direction-dependent tolerance. (ASME Y14.41)

3.53 RESTRAINED

restrained: the condition in which externally induced forces in addition to gravity are applied to a part.

3.54 RESULTANT CONDITION

resultant condition: the single worst-case boundary generated by the collective effects of a feature of size's specified MMC or LMC, the geometric tolerance for that material condition, the size tolerance, and the additional geometric tolerance derived from the feature's departure from its specified material condition. See Figures 5-14, 5-15, 5-17, and 5-18.

3.55 RUNOUT

runout: a general term that applies to both circular and total runout.

3.55.1 Circular Runout

circular runout: the condition in which each circular element of a surface is at zero variation relative to a datum axis or axis of rotation established from the datum reference frame.

3.55.2 Total Runout

total runout: the condition in which all elements of a surface or tangent plane are at zero variation relative to a datum axis or axis of rotation established from the datum reference frame.

3.56 SIMULTANEOUS REQUIREMENT

simultaneous requirement: the condition in which two or more geometric tolerances apply as a single pattern or part requirement. See subsection 7.19.

3.57 SIZE, ACTUAL LOCAL

size, actual local: the actual value of any individual distance at any cross section of a feature of size. See Figure 3-1.

3.58 SIZE, LIMITS OF

size, limits of: the specified maximum and minimum sizes. See subsection 5.5.

3.59 SIZE, NOMINAL

size, nominal: the designation used for purposes of general identification. (USAS B4.1)

3.60 STATISTICAL TOLERANCING

statistical tolerancing: the assigning of tolerances to related components of an assembly on the basis of sound statistics (e.g., the assembly tolerance is equal to the square root of the sum of the squares of the individual tolerances).

3.61 STRAIGHTNESS

straightness: the condition in which an element of a surface, or a derived median line, is a straight line.

3.62 TOLERANCE

tolerance: the total amount a dimension or feature is permitted to vary. The tolerance is the difference between the maximum and minimum limits.

3.63 TOLERANCE, BILATERAL

tolerance, bilateral: a tolerance in which variation is permitted in both directions from the specified dimension or true profile.

3.63.1 Tolerance, Equal Bilateral

tolerance, equal bilateral: a tolerance in which variation is permitted equally in both directions from the specified dimension or true profile.

3.63.2 Tolerance, Unequal Bilateral

tolerance, unequal bilateral: a tolerance that permits unequal amounts of variation in both directions from the specified dimension or true profile.

3.64 TOLERANCE, GEOMETRIC

tolerance, geometric: a tolerance indicated using a geometric characteristic symbol. See Figure 6-1 for a list of the geometric characteristic symbols.

3.65 TOLERANCE, UNILATERAL

tolerance, unilateral: a tolerance in which variation is permitted in one direction from the specified dimension or true profile.

3.66 TRUE GEOMETRIC COUNTERPART

true geometric counterpart: the theoretically perfect boundary used to establish a datum from a specified datum feature.

NOTE: This term is only applicable to datums.

3.67 TRUE POSITION

true position: the theoretically exact location of a feature of size, as established by basic dimensions.

3.68 TRUE PROFILE

true profile: the profile defined by basic radii, basic angular dimensions, basic coordinate dimensions, basic dimension of size, undimensioned drawings, formulas, or mathematical data, including design models.

3.69 UNIFORM TOLERANCE ZONE

uniform tolerance zone: a constant distance between two boundaries equally or unequally disposed about the true profile or entirely disposed on one side of the true profile.

3.70 VIRTUAL CONDITION (VC)

virtual condition: a constant boundary generated by the collective effects of a considered feature of size's specified MMC or LMC and the geometric tolerance for that material condition. See Figures 5-14, 5-15, 5-17, and 5-18.

Figure 3-1 Related and Unrelated AME

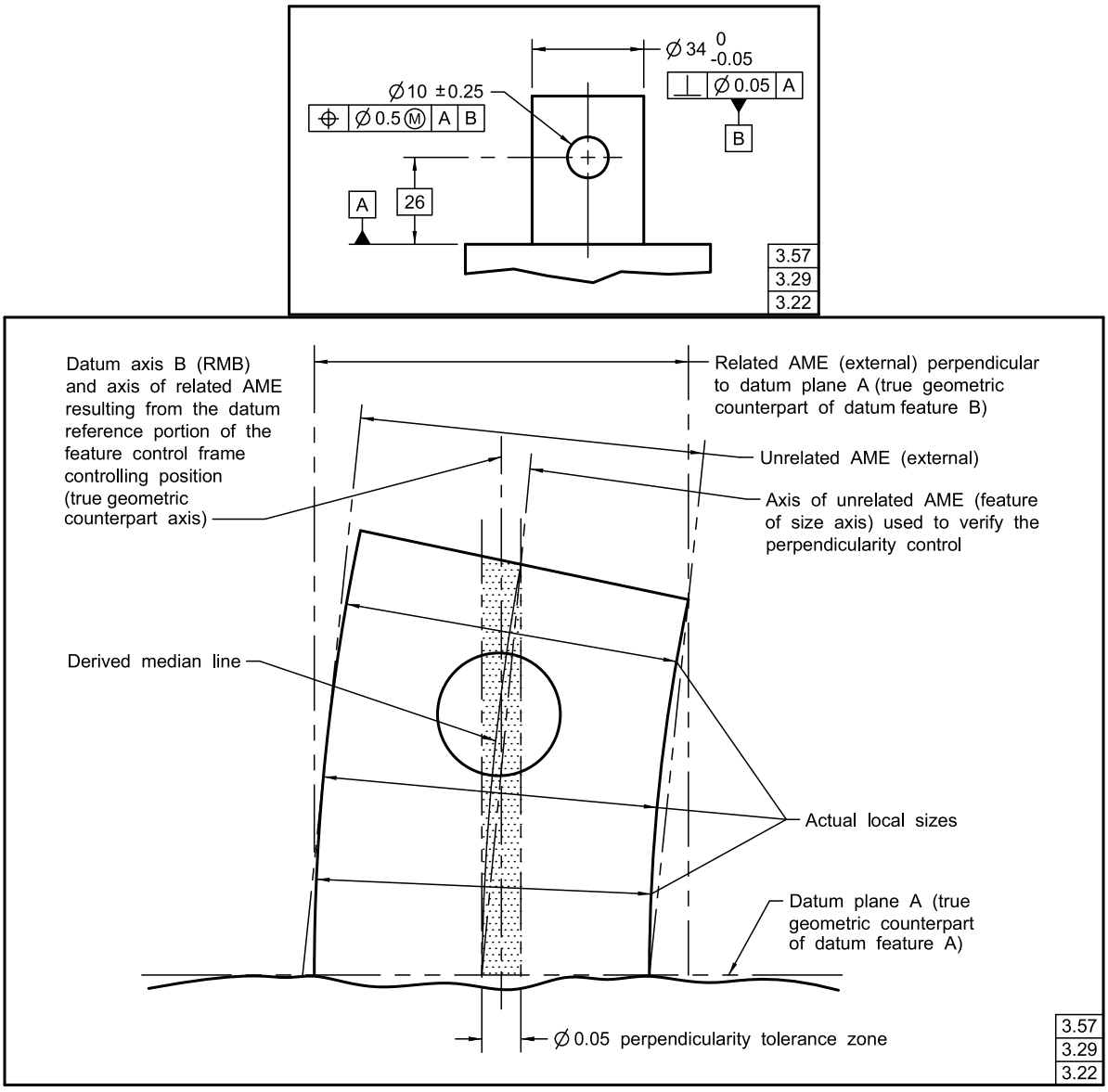
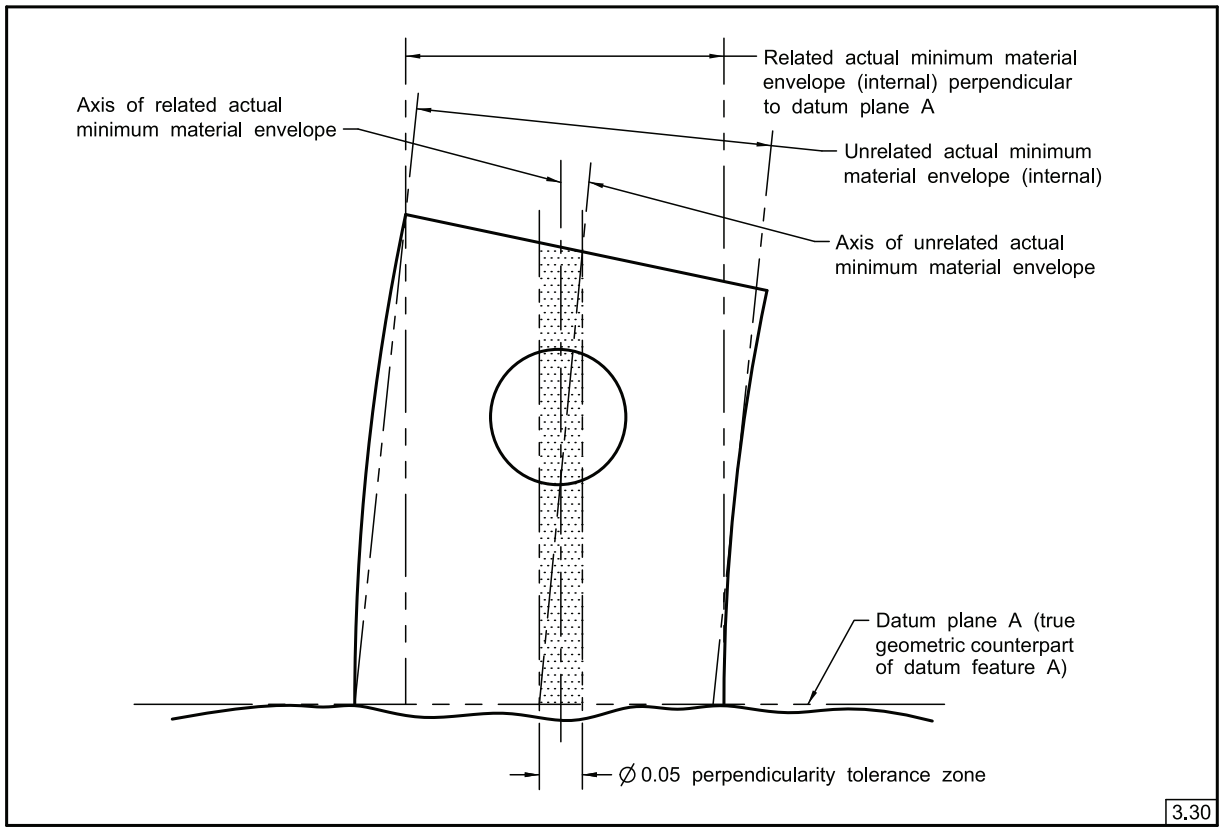


Figure 3-2 Related and Unrelated Actual Minimum Material Envelope From Figure 3-1



Section 4
Fundamental Rules, Tolerancing Defaults, and Dimensioning Practices

4.1 FUNDAMENTAL RULES

Dimensioning and tolerancing shall clearly define engineering intent and shall conform to the following:

(a) Each feature shall be toleranced. Tolerances may be applied directly to size dimensions. Tolerances shall be applied using feature control frames when feature definition is basic. Tolerances may also be indicated by a note or located in a supplementary block of the drawing format. See ASME Y14.1 and ASME Y14.1M. Those dimensions specifically identified as reference, maximum, minimum, or stock (commercial stock size) do not require the application of a tolerance.

(b) Dimensioning and tolerancing shall be complete so there is full understanding of the characteristics of each feature. Values may be expressed in an engineering drawing or in a CAD product definition data set. See ASME Y14.41. Neither scaling (measuring directly from an engineering drawing graphics sheet) nor assumption of a distance or size is permitted, except in undimensioned drawings, such as loft, printed wiring, templates, and master layouts prepared on stable material, provided the necessary control dimensions are specified. Model data shall be queried when dimensions are not displayed on the model.

(c) Each necessary dimension of an end product shall be shown or defined by model data. No more dimensions than those necessary for complete definition shall be given. The use of reference dimensions on a drawing should be minimized.

(d) Dimensions shall be selected and arranged to suit the function and mating relationship of a part and shall not be subject to more than one interpretation.

(e) The drawing should define a part without specifying manufacturing methods. Thus, only the diameter of a hole is given without indicating whether it is to be drilled, reamed, punched, or made by another operation. However, in those instances where manufacturing, processing, quality assurance, or environmental information is essential to the definition of engineering requirements, the information shall be specified on the drawing or in a document referenced on the drawing.

(f) Nonmandatory processing dimensions shall be identified by an appropriate note, such as **NONMANDATORY (MFG DATA)**. Examples of nonmandatory data are processing dimensions that provide for finish allowance, shrink allowance, and other requirements, provided the final dimensions are given on the drawing.

(g) Dimensions should be arranged to provide required information for optimum readability.

(h) Dimensions in orthographic views should be shown in true profile views and refer to visible outlines. When dimensions are shown in models, the dimensions shall be applied in a manner that shows the true value.

(i) Wires, cables, sheets, rods, and other materials manufactured to gage or code numbers shall be specified by linear dimensions indicating the diameter or thickness. Gage or code numbers may be shown in parentheses following the dimension.

(j) An implied 90° angle shall apply where center lines and lines depicting features are shown on orthographic views at right angles and no angle is specified. For information on applicable tolerances for implied 90° angles, see para. 5.1.1.3.

(k) An implied 90° basic angle shall apply where center lines of features or surfaces shown at right angles on an orthographic view are located or defined by basic dimensions and no angle is specified. For information on applicable tolerances for implied 90° basic angles, see para. 5.1.1.4.

(l) A zero basic dimension shall apply where axes, center planes, or surfaces are shown coincident on orthographic views and geometric tolerances establish the relationship between the features. On CAD models, the distance is basic when queried model distances are zero and geometric tolerances establish the relationship between the features. For information on applicable tolerances for zero basic dimensions, see para. 5.1.1.4.

(m) UOS, all dimensions and tolerances are applicable at 20°C (68°F) in accordance with ASME B89.6.2. Compensation may be made for measurements made at other temperatures.

(n) UOS, all dimensions and tolerances apply in a free state condition. For exceptions to this rule, see subsection 7.20.

(o) UOS, all tolerances and datum features apply for full depth, length, and width of the feature.

(p) Dimensions and tolerances apply only at the drawing level where they are specified. A dimension specified for a given feature on one level of drawing (e.g., a detail