ASME Y14.45-2021

Measurement Data Reporting

Engineering Product Definition and Related Documentation Practices

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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The American Society of Mechanical Engineers
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FOREWORD

This is the first edition of ASME Y14.45, Measurement Data Reporting. The objective of this Standard is to provide industry with standardized content for dimensional measurement data for size and geometric tolerances defined in ASME Y14.5.

This Standard provides three measurement data reporting methods: method A for attribute data, method B for variable data, and method C for additional informative data. The user may choose from these methods to communicate the requirements for the type of data needed. The user shall specify the required reporting methods in a dimensional measurement plan or other suitable document.

Example data reports are included, but use of the report format or acronyms shown is not mandatory. Example methods of numbering tolerances using characteristic identifiers are provided, but these particular methods are not mandatory.

This Standard provides

(a) definitions of measured values for each type of tolerance defined in ASME Y14.5, with exceptions stated

(b) information regarding what measurement data to report, and thus inherently what to measure for each type of tolerance

(c) requirements for additional feature location information for position and profile tolerances

(d) reporting practices needed to address the resolved geometry method and the surface method of tolerances specified at maximum material condition or least material condition

This Standard does not provide information on how to measure a part.

This edition was approved by the American National Standards Institute as an American National Standard on July 6, 2021.

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Engineering Product Definition and Related Documentation Practices

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Secretary, Y14 Standards Committee
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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.

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Section 1
General

1.1 SCOPE

This Standard establishes uniform practices for reporting attribute or variable measurement data for the dimensioning and tolerancing specifications defined in ASME Y14.5-2018 and actual values defined in ASME Y14.5.1-2019. This Standard may be used with previous versions of ASME Y14.5 where they do not conflict with ASME Y14.5-2018. Measurement data used in support of product acceptance, manufacturing process evaluation, design development, and other uses is addressed. All reporting requirements are independent of the measurement process or equipment used to gather the data.

1.2 STRUCTURE OF THE STANDARD

Sections 1 through 3 include the scope, references, and definitions. Section 4 includes general information on measurement data and measurement data reporting methods. Sections 5 through 10 include specific information on measurement data reporting methods for geometric dimensioning and tolerancing. Section 11 includes measurement data reporting practices for geometric dimensioning and tolerancing applied to patterns of features. Section 12 includes measurement data reporting practices for geometric dimensioning and tolerancing applied to features that are not orthogonal to the datum reference frame. Mandatory Appendix I explains why basic dimensions shall not have characteristic identifiers applied. Nonmandatory Appendix A includes examples of method C data.

In this Standard, the term "actual" is not subject to measurement uncertainty, whereas the term "measured" indicates data that is subject to measurement uncertainty.

1.3 ASME Y14 SERIES CONVENTIONS

The conventions in paras 1.3.1 through 1.3.9 are used in this and other ASME Y14 standards.

1.3.1 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.

1.3.2 Cross-Reference of Standards

Cross-references to other ASME Y14 standards shall be interpreted as follows:

(a) If an in-text cross-reference does not cite the edition year, the edition cited in Section 2 applies to the requirement.

(b) If an in-text cross-reference cites the edition year, only that edition applies to the requirement.

1.3.3 Invocation of Referenced Standards

The following examples define the invocation of a standard when the standard is specified in 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 paragraphs on that subject are invoked. For example, "Assign part or identifying numbers in accordance with ASME Y14.100" is invoking only 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 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.

1.3.4 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.

1.3.5 Notes

Notes depicted in this Standard in ALL UPPERCASE letters are intended to reflect actual drawing 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 note is allowed to vary to suit the application.

1.3.6 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 or abbreviation is used thereafter.

1.3.7 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.

1.3.8 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 paragraphs 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 list 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. Multiview drawings contained within figures are third angle projection.

1.3.9 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 in Product Definition and Related Documents
ASME Y14.41, Digital Product Definition Data Practices
ASME Y14.45, Measurement Data Reporting
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 REFERENCE TO THIS STANDARD

When measurement data will be reported according to the requirements of this Standard, the note "MEASUREMENT DATA REPORTING IN ACCORDANCE WITH ASME Y14.45-2021" shall be included in product definition data, such as a drawing or model, or in a document such as a contract, purchase order, or dimensional measurement plan. The ASME Y14.45 reporting methods used in the measurement data reports shall also be specified. See subsection 4.5 for information on reporting methods.

1.5 DIMENSIONING AND TOLERANCING

Dimensioning and tolerancing specifications in this Standard are in accordance with ASME Y14.5, ASME Y14.8, and ASME Y14.41 and may be augmented with the methods for measurement data reporting defined in this Standard. These methods include the use of *X*, *Y*, and *Z* coordinate axes to represent a datum reference frame and the use of characteristic identifiers.

1.6 SPECIFICATIONS NOT ADDRESSED BY THIS STANDARD

This Standard does not address all specifications provided by ASME Y14.5 and other ASME Y14 standards. Specifications not addressed include, but are not limited to, surface texture specifications, gear specifications, chamfers, countersinks, directly toleranced angles, radius and controlled radius specifications, and position boundary applied to irregular features of size. Refer to ASME B46.1 for surface texture specifications and associated measurement data reporting practices. Refer to American Gear Manufacturers Association (AGMA) standards for gear specifications and associated measurement data reporting practices.

Section 2
References

2.1 INTRODUCTION

The following revisions of American National Standards form a part of this Standard to the extent specified herein or would be useful to a reader of this Standard. 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 REFERENCES

ANSI B89.3.1-1972 (R2003), Measurement of Out-of-Roundness

ASME B46.1-2009, Surface Texture (Surface Roughness, Waviness, and Lay)

ASME B89.7.2-2014, Dimensional Measurement Planning

ASME B89.7.3.1-2001, Guidelines for Decision Rules: Considering Measurement Uncertainty in Determining Conformance to Specifications

ASME B89.7.3.2-2007, Guidelines for the Evaluation of Dimensional Measurement Uncertainty

ASME B89.7.3.3-2002 (R2017), Guidelines for Assessing the Reliability of Dimensional Measurement Uncertainty Statements

ASME B89.7.4.1-2005, Measurement Uncertainty and Conformance Testing: Risk Analysis

ASME Y14.5-2018, Dimensioning and Tolerancing

ASME Y14.5.1-2019, Mathematical Definition of Dimensioning and Tolerancing Principles

ASME Y14.8-2009 (R2019), Castings, Forgings, and Molded Parts

ASME Y14.41-2019, Digital Product Definition Data Practices

ASME Y14.43-2011, Dimensioning and Tolerancing Principles for Gages and Fixtures

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)

ASTM E29-13(2019), Standard Practice for Using Significant Digits in Test Data to Determine Conformance With Specifications

ASTM E2282-14(2019), Standard Guide for Defining the Test Result of a Test Method

Publisher: American Society for Testing and Materials (ASTM International), 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 (www.astm.org)

SAE AS9102B-2014, Aerospace First Article Inspection Requirement

Publisher: SAE International, 400 Commonwealth Drive, Warrendale, PA 15096 (www.sae.org)

Section 3
Definitions

3.1 ACTUAL LOCAL SIZE

actual local size: the actual value of any individual distance at any cross section of a feature of size. (ASME Y14.5)

3.2 ACTUAL MATING ENVELOPE (AME)

actual mating envelope (AME): 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).

(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).

(ASME Y14.5)

3.3 ACTUAL MINIMUM MATERIAL ENVELOPE

actual minimum material envelope: 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).

(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.

(ASME Y14.5)

3.4 ACTUAL VALUE

actual value: a unique numerical value representing a geometric characteristic associated with one or more actual features.

NOTE: Example characteristics are flatness, perpendicularity, position, actual mating envelope, and actual local size.

(ASME Y14.5.1)

3.5 ADDITIONAL TOLERANCE

additional tolerance: tolerance that is added to the specified tolerance when the specified tolerance is applied at maximum material condition (MMC) or least material condition (LMC), based on the departure of the unrelated measured mating envelope size from the MMC size limit, or the departure of the unrelated measured minimum material envelope size from the LMC size limit, as applicable. The sum of the specified tolerance and the additional tolerance is the total tolerance to which the measured feature axis, measured feature center plane, measured feature center point, measured derived median line, or measured derived median plane must conform. Additional tolerance is often called bonus tolerance.

3.6 CHARACTERISTIC IDENTIFIER

characteristic identifier: a unique numeric or alphanumeric label that is associated with a tolerance or specification range.

3.7 CONTROLLED FEATURE COMPONENT

controlled feature component: the element of the feature or related entity that must be on or within a specified tolerance zone in order to achieve conformance. Examples include a surface, an axis, a derived median line, a center plane, or a tangent plane of a surface.

3.8 FITTING

fitting: the process of finding a relationship between perfect geometric entities and the imperfect geometry of measurement data from an as-produced feature or collection of features, possibly subject to constraints in orientation, in location, or in both orientation and location.

Fitting may be accomplished physically or by mathematical representations. See also para 3.27.

3.9 LEAST MATERIAL CONDITION (LMC)

least material condition (LMC): 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. (ASME Y14.5)

3.10 LOCATION COMPONENTS

location components: method C data for a position tolerance that provides the information about the location of a measured feature center point, measured feature axis, or measured feature center plane. Location components are expressed as (X, Y, Z), (X, Y), (Y, Z), (Z, X), or (X), (Y), or (Z) values, or as ($\Delta X, \Delta Y, \Delta Z$), ($\Delta X, \Delta Y$), ($\Delta Y, \Delta Z$), ($\Delta Z, \Delta X$), or ($\Delta X$), ($\Delta Y$), or ($\Delta Z$) values relative to a datum reference frame or reporting coordinate system. Where applicable, location components may be expressed as polar or spherical coordinates.

3.11 LOCATION-CONSTRAINED MEASURED MATING ENVELOPE

location-constrained measured mating envelope: a similar perfect feature(s) counterpart expanded within an internal feature(s) or contracted about an externalfea ture(s), until it coincides with the measured surface(s) at the highest points, while constrained in location to the applicable datum reference frame or reporting coordinate system and subject to measurement uncertainty. This envelope is on or outside the material.

3.12 LOCATION-CONSTRAINED MEASURED MINIMUM MATERIAL ENVELOPE

location-constrained measured minimum material envelope: a similar perfect feature(s) counterpart expanded within an external feature(s) or contracted about an internal feature(s), until it coincides with the measured surface(s) at the lowest points, while constrained in location to the applicable datum reference frame or reporting coordinate system and subject to measurement uncertainty. This envelope is on or within the material.

3.13 MAXIMUM MATERIAL CONDITION (MMC)

maximum material condition (MMC): 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. (ASME Y14.5)

3.14 MEASURED DERIVED MEDIAN LINE

measured derived median line: a line with imperfect form that is established by the collection of the center points of all measured local cross section sizes or measured minimum material local cross section sizes as applicable.

3.15 MEASURED DERIVED MEDIAN PLANE

measured derived median plane: a plane with imperfect form that is established by the center points of all measured local line segment sizes or measured minimum material local line segment sizes as applicable.

3.16 MEASURED FEATURE AXIS

measured feature axis: the axis of the cylindrical feature's unrelated measured mating envelope regardless of feature size or if maximum material condition is specified, or unrelated measured minimum material envelope when least material condition is specified.

3.17 MEASURED FEATURE CENTER PLANE

measured feature center plane: the center plane of the width feature's unrelated measured mating envelope regardless of feature size or if maximum material condition is specified, or unrelated measured minimum material envelope when least material condition is specified.

3.18 MEASURED FEATURE CENTER POINT

measured feature center point: the center point of the spherical feature's unrelated measured mating envelope regardless of feature size or if maximum material condition is specified, or unrelated measured minimum material envelope when least material condition is specified.

3.19 MEASURED LOCAL CROSS SECTION SIZE

measured local cross section size: the size (diameter) of a perfect-form circular boundary that is fit to a cross section of a surface of revolution. The cross section is normal (perpendicular) to the axis of the unrelated measured mating envelope. The perfect-form circular boundary is fit to the feature's high points, so the boundary is on or outside of the material. For an internal feature the measured local cross section size is the diameter of a maximum inscribed circle. For an external feature the measured local cross section size is the diameter of a minimum circumscribed circle. The value is subject to measurement uncertainty.

NOTE: ASME Y14.5 specifies that a derived median line is formed from the center points of all cross sections of a feature, and those cross sections are normal to the axis of the unrelated actual mating envelope. For derived median line straightness specified at maximum material condition using the resolved geometry method, additional tolerance values shall be determined for each cross section of the feature. The additional tolerance values shall be based on size values that are relevant for the applied material condition modifier and the particular cross sections of the feature from which the center point was found. The orientation of the cross sections used to determine additional tolerance values shall be the same as the orientation of the cross sections used to derive the median line. Measured local cross section size is defined in this Standard to provide the relevant size for additional tolerance calculations at each cross section. See para. 6.2.4.

3.20 MEASURED LOCAL LINE SEGMENT SIZE

measured local line segment size: the size (length) of a line segment that is normal to the center plane of the unrelated measured mating envelope and that has length based on the local width (from surface to surface) of the measured width feature. The value is subject to measurement uncertainty.

NOTE: ASME Y14.5 specifies that a derived median plane is formed from the center points of all line segments bounded by a width feature, and those line segments are normal to the center plane of the unrelated actual mating envelope. For derived median plane flatness specified at maximum material condition using the resolved geometry method, additional tolerance values must be determined for each location on the feature. The additional tolerance values must be based on size values that are relevant for the applied material condition modifier and the particular location of the feature from which the center point was found. The locations and associated orientations used to determine additional tolerance must be the same as the locations and associated orientations used to derive the median plane. Measured local line segment size is defined in this Standard to provide the relevant size for additional tolerance calculations at each location. See para. 6.3.4.

3.21 MEASURED LOCAL SIZE

measured local size: the measured value of any individual distance at any cross section of a feature of size. Measured local size is similar to actual local size but is subject to measurement uncertainty.

3.22 MEASURED MINIMUM MATERIAL LOCAL CROSS SECTION SIZE

measured minimum material local cross section size: the size (diameter) of a perfect-form circular boundary that is fit to a cross section of a surface of revolution. The cross section is normal (perpendicular) to the axis of the unrelated measured minimum material envelope. The perfect-form circular boundary is fit to the feature's low points, so the boundary is on or in the material. For an internal feature the measured minimum material local cross section size is the diameter of a minimum circumscribed circle. For an external feature the measured minimum material local cross section size is the diameter of a maximum inscribed circle. The value is subject to measurement uncertainty.

NOTE: ASME Y14.5 specifies that a derived median line is formed from the center points of all cross sections of a feature, and those cross sections are normal to the axis of the unrelated actual mating envelope. For derived median line straightness specified at least material condition using the resolved geometry method, additional tolerance values must be determined for each cross section of the feature. The additional tolerance values must be based on size values that are relevant for the applied material condition modifier and the particular cross sections of the feature from which the center point was found. The orientation of the cross sections used to determine additional tolerance values must be the same as the orientation of the cross sections used to derive the median line. Measured minimum material local cross section size is defined in this Standard to provide the relevant size for additional tolerance calculations at each cross section. See para. 6.2.6.

3.23 MEASURED MINIMUM MATERIAL LOCAL LINE SEGMENT SIZE

measured minimum material local line segment size: the size (length) of a line segment that is normal to the center plane of the unrelated measured minimum material envelope and that has length based on the local width (from surface to surface) of the measured width feature. The value is subject to measurement uncertainty.

NOTE: ASME Y14.5 specifies that a derived median plane is formed from the center points of all line segments bounded by a width feature, and those line segments are normal to the center plane of the unrelated actual mating envelope. For derived median plane flatness specified at least material condition using the resolved geometry method, additional tolerance values must be determined for each location on the feature. The additional tolerance values must be based on size values that are relevant for the applied material condition modifier and the particular location of the feature from which the center point was found. The locations and associated orientations used to determine additional tolerance must be the same as the locations and associated orientations used to derive the median plane. Measured minimum material local line segment size is defined in this Standard to provide the relevant size for additional tolerance calculations at each location. See para. 6.3.6.

3.24 MEASURED SURFACE

measured surface: a collection of all measured points of a feature that separates it from another feature or from free space.

3.25 MEASURED VALUE

measured value: a unique numeric value subject to measurement uncertainty that is an estimate of an actual value (ASME Y14.5.1-2019).

3.26 MEASURED ZONE

measured zone: the minimum volume or area with the same shape as the considered feature's tolerance zone that is just large enough to contain the controlled feature component (surface, axis, derived median line, etc.). The measured zone is constrained relative to a datum reference frame or reporting coordinate system the same as the considered feature's tolerance zone, if applicable. The measured zone will be equal or smaller in size than the tolerance zone for a conforming feature or larger in size than the tolerance zone for a nonconforming feature.

3.27 OPTIMIZATION

optimization: the process of minimizing the size of a measured zone by using fitting methods and any available degrees of freedom such that it is just large enough to contain controlled feature components. This may be done for an individual feature component or for a pattern of feature components.

3.28 ORIENTATION-CONSTRAINED MEASURED MATING ENVELOPE

orientation-constrained measured mating envelope: a similar perfect feature(s) counterpart expanded within an internal feature(s) or contracted about an external feature(s), until it coincides with the measured surface(s) at the highest points, while constrained in orientation to the applicable datum reference frame or reporting coordinate system and subject to measurement uncertainty. This envelope is on or outside the material.

3.29 ORIENTATION-CONSTRAINED MEASURED MINIMUM MATERIAL ENVELOPE

orientation-constrained measured minimum material envelope: a similar perfect feature(s) counterpart expanded within an external feature(s) or contracted about an internal feature(s), until it coincides with the measured surface(s) at the lowest points, while constrained in orientation to the applicable datum reference frame or reporting coordinate system and subject to measurement uncertainty. This envelope is on or within the material.

3.30 REGARDLESS OF FEATURE SIZE (RFS)

regardless of feature size (RFS): a condition in which a geometric tolerance applies at any increment of size of the unrelated actual mating envelope of the feature of size. (ASME Y14.5)

3.31 REPORTED VALUE

reported value: a measured value, or a calculated value that is based on a measured value, that shall be reported as method B or method C data.

3.32 REPORTING COORDINATE SYSTEM

reporting coordinate system: a set of coordinate axes relative to which data is reported. A reporting coordinate system may be a simulated datum reference frame that is specified by a feature control frame. It may also be a coordinate system that has been rotated, translated, or both rotated and translated using basic dimensions relative to the specified simulated datum reference frame. A reporting coordinate system may be used to enable reporting of location components for position tolerances. A reporting coordinate system may also be constrained only by measurement data for considered features.

3.33 RESOLVED GEOMETRY

resolved geometry: for a regular feature of size, it is the center point of a sphere, the axis of a cylinder, or the center plane of a width (ASME Y14.5.1). In this Standard resolved geometry also includes the derived median line of any feature that is a surface of revolution and the derived median plane of any feature that has a plane of symmetry.

3.34 RESOLVED GEOMETRY METHOD

resolved geometry method: a method of determining conformance where the resolved geometry is compared to the tolerance zone.

NOTE: ASME Y14.5 uses the less-inclusive term "axis method" instead of "resolved geometry method."

3.35 SURFACE DEVIATION

surface deviation: method C data for a profile tolerance, expressed as a distance normal to and relative to the true profile. Each surface deviation is expressed as a positive value for the direction that adds material or a negative value for the direction that removes material.

3.36 SURFACE METHOD

surface method: a method of determining conformance where the surface is compared to the virtual condition.

3.37 UNRELATED MEASURED MATING ENVELOPE

unrelated measured mating envelope: 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 measured surface(s) at the highest points. This envelope is not constrained to any datum reference frame or reporting coordinate system. This envelope is on or outside the material and is subject to measurement uncertainty.

3.38 UNRELATED MEASURED MATING ENVELOPE SIZE

unrelated measured mating envelope size: the diameter, spherical diameter, or width of an unrelated measured mating envelope.

3.39 UNRELATED MEASURED MINIMUM MATERIAL ENVELOPE

unrelated measured minimum material envelope: 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 measured surface(s) at the lowest points. This envelope is not constrained to any datum reference frame or reporting coordinate system. This envelope is on or within the material and is subject to measurement uncertainty.

3.40 UNRELATED MEASURED MINIMUM MATERIAL ENVELOPE SIZE

unrelated measured minimum material envelope size: the diameter, spherical diameter, or width of an unrelated measured minimum material envelope.

3.41 VIRTUAL CONDITION (VC)

virtual condition (VC): the 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. (ASME Y14.5)

Section 4
Measurement Data for Dimensioning and Tolerancing

4.1 GENERAL

This Section describes general requirements and methods for measurement data reporting.

4.2 UNCERTAINTY OF REPORTED MEASUREMENT DATA AND ASSOCIATED TERMINOLOGY

ASME Y14.5.1 defines the actual value for a given geometric characteristic. Examples of actual values include a position actual value, flatness actual value, and circular runout actual value. Due to measurement uncertainty, actual values can never be known. The value found from measurement is a measured value that is an estimate of an actual value. The determination of conformance to a tolerance specification requires the consideration of measurement uncertainty, which is not addressed in this Standard. In this Standard, measured values, or measured zones, or conformance to a tolerance specification is subject to measurement uncertainty as addressed in ASME B89.7.2, ASME B89.7.3.1, ASME B89.7.3.2, ASME B89.7.3.3, and ASME B89.7.4.1.

4.3 SIGNIFICANT DIGITS FOR REPORTED MEASUREMENT DATA

Users of this Standard shall determine the number of significant digits required for reported measured values. The following documents may provide guidance:

(a) a company document (e.g., a general document or specific dimensional measurement plan, such as that described in ASME B89.7.2)

(b) ASTM E29-13

(c) ASTM E2282-14

The user shall specify the standard or source used to determine the number of significant digits for reported values and measured values in a document such as a contract, purchase order, dimensional measurement plan, or product definition data set such as a drawing or three-dimensional computer-aided design (3D CAD) model.

4.4 CHARACTERISTIC IDENTIFIER

Characteristic identifiers are used to associate data in a measurement report with dimensioning and tolerancing specifications defined in a product definition data set, such as a drawing or 3D CAD model. Characteristic identifiers are used to set the order in which measurement data is presented in a report unless another type of data sorting is specified. Characteristic identifiers do not mandate the order in which data is gathered. Characteristic identifiers may be enclosed within a graphical symbol.

For measurement data reporting purposes, characteristic identifiers shall be applied to directly toleranced dimensions and geometric tolerances. They shall not be applied to basic dimensions (see Mandatory Appendix I) or to reference dimensions.

See Sections 5 through 12 for examples of characteristic identifier applications.

4.5 MEASUREMENT DATA REPORTING METHODS

This Standard describes three methods for reporting measurement data: method A, method B, and method C. Each reporting method provides a specific type of data. The user of this Standard shall specify the required reporting methods on a drawing, purchase order, model, digital product definition data set, dimensional measurement plan, or other document, as applicable. The reporting methods required do not affect the number or type of sample locations, the number of measurement data points collected, or any other aspect of the measurement process.

The user of this Standard shall use method A data or method B data to determine whether the measurement result (the pass/fail result from a functional gauge or the measured value) conforms to a specification (see subsection 4.2 for related measurement uncertainty considerations). Method C data is any data in addition to method A or method B data that provides process or design information (e.g., location components for features with a position tolerance applied or surface deviations for features with profile of a surface or profile of a line applied). Method C data shall be specified when process information or design evaluation information is needed.

4.5.1 Method A

Method A provides attribute data (e.g., pass/fail, accept/reject) that is sufficient for determination of whether the measurement result conforms to the tolerance specification.

NOTE: Method A attribute data can be derived from variable data or can result from the use of functional gauging (see ASME Y14.43) or other testing.

4.5.2 Method B

Method B provides variable data for a measured value of a tolerance specification. The method B reported value is the particular measured value, or a value calculated based on a measured value, that is used to determine conformance to the tolerance specification.

NOTE: All examples in this Standard include, at a minimum, method B data.

4.5.3 Method C

Method C provides variable, graphic, or other measured values as additional information characterizing size, form, orientation, or location of the measured feature. The method C reported values shall be determined as specified in a suitable document, such as a dimensional measurement plan.

4.5.3.1 Method C for Position Tolerances. Unless otherwise specified, method C data for position tolerances shall include location components. See subsection 8.2.

4.5.3.2 Method C for Profile Tolerances. Unless otherwise specified, method C data for profile tolerances shall include surface deviations. See paras. 9.2.2 and 9.3.2.

4.6 DEVIATIONS FROM THE REQUIREMENTS OF THIS STANDARD

The organization ordering or requesting measurement data shall specify in a suitable document or product definition data set any deviation from the requirements of this Standard.

4.7 ASME Y14.45 DATA REPORT FORMAT

The data report format used for the examples in this Standard was derived from that shown in SAE AS9102B. The SAE AS9102B report format has been modified to better suit the measurement data reporting needs for geometric tolerances. See Figure 4-1. The report format shown is not mandatory. Model-based and digital methods may also be used.

4.8 ACRONYMS AND ABBREVIATIONS FOR CHARACTERISTIC TYPE

The following acronyms and abbreviations may be used in the "Characteristic Type" column of the method B data reporting examples in this Standard:

(a) Size Tolerances
MMC = maximum material condition
LMC = least material condition

(b) Form Tolerances
CIR = circularity
CYL = cylindricity
FLA = flatness
STR = straightness

(c) Orientation Tolerances
ANG = angularity
PAR = parallelism
PER = perpendicularity

(d) Position Tolerances
POS = position
CPO = composite position (lower segments)

(e) Profile Tolerances
PRS = profile of a surface
PRL = profile of a line
CPS = composite profile of a surface
CPL = composite profile of a line

(f) Runout Tolerances
CRN = circular runout
TRN = total runout

Figure 4-1 ASME Y14.45 Data Report Format

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:		Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: This data report format has been derived from that in SAE AS9102B.

Section 5
Measurement Data Reporting for Size Tolerances

5.1 GENERAL

This Section establishes requirements for method B data reporting for size tolerances. A size specification for a regular feature of size defines two requirements: the MMC size limit and LMC size limit. Method B reporting for size tolerances shall include two reported values to address both limits of size.

5.2 METHOD B DATA FOR SIZE TOLERANCES

Method B measurement data for size tolerances includes cases for which there is perfect form required at MMC, perfect form required at LMC, or no perfect-form boundary at either size limit.

5.3 WHERE PERFECT FORM AT MMC APPLIES

When the requirement for perfect form at MMC applies, a size specification for a regular feature of size defines two requirements, the MMC size limit and the LMC size limit, as follows:

(a) The surface or surfaces of the feature shall not extend beyond a boundary of perfect form at MMC.

(b) The actual local sizes of the feature shall not violate the LMC limit of size.

To address these requirements, method B data shall include reported values for the unrelated measured mating envelope size and the measured local size as defined in paras. 5.3.1 and 5.3.2, with each value separately identified in the report. See Figures 5-1 and 5-2.

5.3.1 Unrelated Measured Mating Envelope Size

The measured value is the diameter of the unrelated measured mating envelope for a cylindrical feature, or the width of the unrelated measured mating envelope for a width feature, or the spherical diameter of the unrelated measured mating envelope for a spherical feature. The method B reported value is the measured value. The method B reported value is used to determine conformance to the perfect-form boundary at the MMC size limit.

5.3.2 Measured Local Size

For each measured location on the regular feature of size, the local size measured value is the individual distance or diameter as defined in ASME Y14.5. The method B reported value is the largest measured value for an internal feature of size, such as a slot or a cylindrical hole, or the smallest measured value for an external feature, such as a tab or a cylindrical pin. The method B reported value is used to determine conformance to the LMC size limit.

5.4 WHERE PERFECT FORM AT LMC APPLIES

When the requirement for perfect form at LMC applies, a size specification for a regular feature of size defines two requirements, the LMC size limit and the MMC size limit, as follows:

(a) The surface or surfaces of the feature shall not extend beyond a boundary of perfect form at LMC.

(b) The actual local sizes of the feature shall not violate the MMC limit of size.

To address these requirements, method B data shall include reported values of the unrelated measured minimum material envelope size and the measured local size as defined in paras. 5.4.1 and 5.4.2, with each value separately identified in the report. See Figures 5-3 and 5-4.

5.4.1 Unrelated Measured Minimum Material Envelope Size

The measured value is the diameter of the unrelated measured minimum material envelope for a cylindrical feature, or the width of the unrelated measured minimum material envelope for a width feature, or the spherical diameter of the unrelated measured minimum material envelope for a spherical feature. The method B reported value is the measured value. The method B reported value is used to determine conformance to the perfect-form boundary at the LMC size limit.

5.4.2 Measured Local Size

For each measured location on the regular feature of size, the local size measured value is the individual distance or diameter as defined in ASME Y14.5. The method B reported value is the smallest measured value for an internal feature of size, such as a slot or a cylindrical hole, or the largest measured value for an external feature, such as a tab or a cylindrical pin. The method B reported value is used to determine conformance to the MMC size limit.

5.5 SIZE WHEN PERFECT FORM IS NOT REQUIRED AT EITHER MMC OR LMC

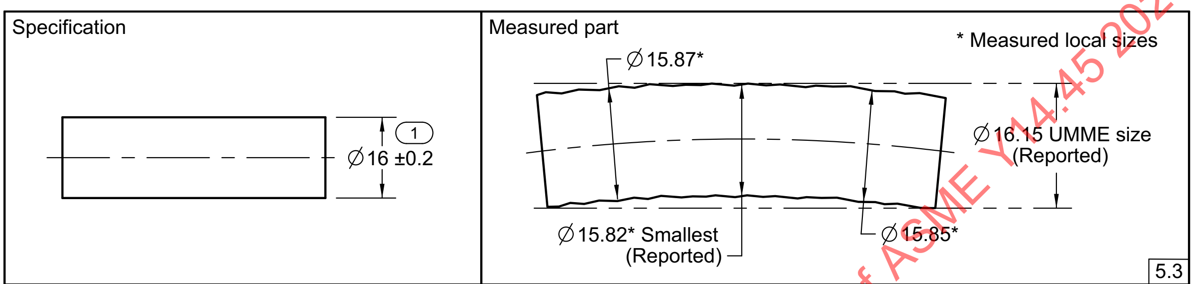
When the requirement for perfect form at MMC or LMC does not apply, a size specification for a regular feature of size defines two requirements, the LMC size limit and the MMC size limit, as follows:

(a) The actual local sizes of the feature shall not violate the LMC limit of size.

(b) The actual local sizes of the feature shall not violate the MMC limit of size.

To address these requirements, method B data shall include two measured values as defined in paras. 5.3.2 and 5.4.2, with each value separately identified in the report. See Figures 5-5 and 5-6.

Figure 5-1 Size When Perfect Form at MMC Applies



GENERAL NOTE: UMME = unrelated measured mating envelope.

Figure 5-2 Example Measurement Data Report for Figure 5-1

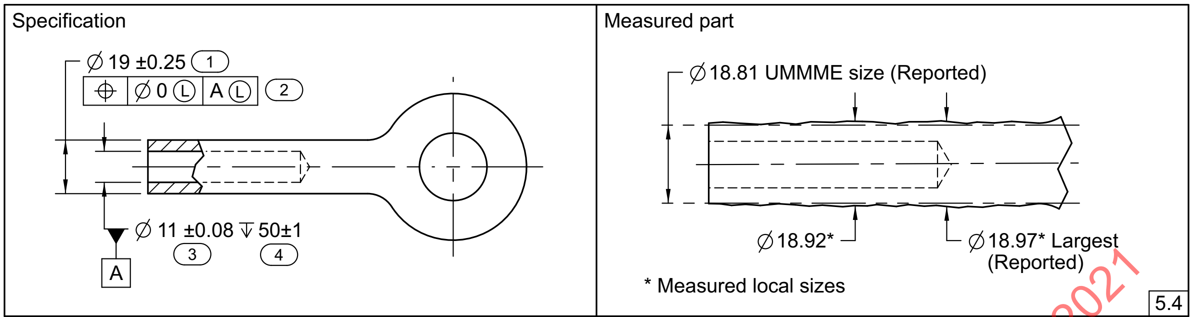
ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:			Drawing Revision:	3D CAD Model #:				3D CAD Model Revision:
Part Name:						Part Serial #:	Inspection Plan #:				Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	MMC	B			Ø16±0.2	16.20	16.15	Y			UMME size
1	LMC	B			Ø16±0.2	15.80	15.82	Y			Smallest measured local size

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: UMME = unrelated measured mating envelope.

Figure 5-3 Size When Perfect Form at LMC Applies



GENERAL NOTE: UMMME = unrelated measured minimum material envelope.

Figure 5-4 Example Measurement Data Report for Figure 5-3

ASME Y14.45 Single Part Data Report Example											
Part #:		Drawing #:			Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	LMC	B			Ø19±0.25	18.75	18.81	Y			UMMME size
1	MMC	B			Ø19±0.25	19.25	18.97	Y			Largest measured local size

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: UMMME = unrelated measured minimum material envelope.

Figure 5-5 Size Where Perfect Form Is Not Required at Either MMC or LMC

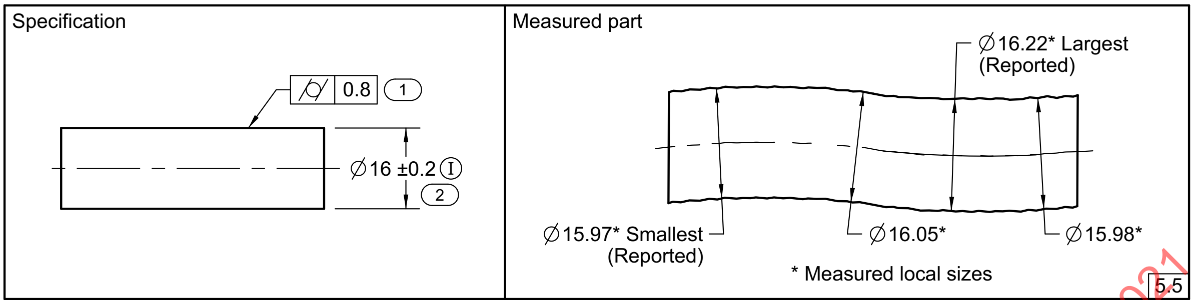


Figure 5-6 Example Measurement Data Report for Figure 5-5

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:			Drawing Revision:	3D CAD Model #:				3D CAD Model Revision:
Part Name:						Part Serial #:	Inspection Plan #:				Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
2	MMC	B			Ø16±0.2	16.20	16.22	N		47-028	Largest measured local size
2	LMC	B			Ø16±0.2	15.80	15.97	Y			Smallest measured local size

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Section 6
Measurement Data Reporting for Form Tolerances

6.1 GENERAL

This Section establishes requirements for method B data reporting for form tolerances, including straightness, flatness, circularity, and cylindricity.

6.2 METHOD B DATA FOR STRAIGHTNESS TOLERANCES

Method B measurement data for straightness tolerances includes straightness of line elements and straightness of a derived median line at RFS, MMC, or LMC. When applied at RFS, straightness tolerances shall be evaluated by the resolved geometry method only. When applied at MMC or LMC, straightness tolerances may be evaluated by either the resolved geometry method or the surface method.

6.2.1 Straightness of Line Elements

For each measured line element on the feature, the measured value is the width of a two-parallel-line measured zone that is just large enough to contain the measured line element. The method B reported value for the feature is the largest of the straightness measured values. See Figures 6-1 and 6-2.

6.2.2 Straightness of a Derived Median Line at RFS

The measured value is the diameter of the cylindrical measured zone that is just large enough to contain the measured derived median line of the feature. The method B reported value is the measured value. See Figures 6-3 and 6-4.

6.2.3 Straightness of a Derived Median Line at MMC or LMC

Derived median line straightness at MMC or LMC may be evaluated by the resolved geometry method or the surface method. The measurement data report shall state whether each reported value is based on the resolved geometry method or the surface method.

6.2.3.1 Resolved Geometry Method. When the resolved geometry method is used, the straightness tolerance zone is a set of circles that is normal to and centered on a common straight line. The diameter of each circle is the specified straightness tolerance plus the additional tolerance that is calculated for each cross section. The sum of the two is called the local straightness total tolerance (TT) value. When straightness at MMC is specified, the additional tolerance for each cross section is the difference between the MMC size limit and the measured local cross section size. When straightness at LMC is specified, the additional tolerance for each cross section is the difference between the LMC size limit and the measured minimum material local cross section size. The measured derived median line shall be within the tolerance zone. See paras. 6.2.4 and 6.2.6.

6.2.3.2 Surface Method. When the surface method is used, the specified size and the straightness tolerances are combined to impose a VC boundary that the surface of the feature may not violate. See paras. 6.2.5 and 6.2.7.

There are two situations for which the surface method cannot be used.

(a) The surface method cannot be used if a straightness tolerance at MMC or LMC has a tolerance value that is large enough to make the VC negative. If this situation is encountered, it shall be noted in the measurement data report and the resolved geometry method shall be used.

(b) The surface method cannot be used if a straightness tolerance at MMC or LMC has a limit to the additional tolerance value followed by "MAX" in the feature control frame. If this situation is encountered, it shall be noted in the measurement data report and the resolved geometry method shall be used.

6.2.4 Straightness of a Derived Median Line at MMC, Resolved Geometry Method

There is a circular measured zone for each measured cross section of the feature. The circular measured zones are normal to and centered on a common straight line that is parallel to the feature axis but is not constrained in location. The measured value for each cross section is the diameter of the circular measured zone that is just large enough to contain the center point of the measured local cross section size. The location of the set of circular measured zones shall be optimized relative to the center points of the measured local cross section sizes such that the method B reported value is minimized.

The method B reported value is the measured value found to be closest to its local straightness TT zone boundary for a conforming measured center point or farthest from its local straightness TT zone boundary for a nonconforming measured center point.

The diameter of the local straightness TT zone boundary at each cross section is the sum of the specified tolerance, T, and the additional tolerance for the particular cross section. The additional tolerance at each cross section for derived median line straightness at MMC is calculated as follows:

(a) For an internal feature

$$\text{additional tolerance} = \text{measured local cross section size} - \text{MMC size limit}$$

(b) For an external feature

$$\text{additional tolerance} = \text{MMC size limit} - \text{measured local cross section size}$$

A local straightness TT is calculated for each cross section as follows:

$$\text{local straightness TT} = T + \text{additional tolerance}$$

After all local straightness measured values and all corresponding local straightness TT values have been found, the values are compared to determine the method B reported value for the feature. See Figures 6-5 and 6-6.

6.2.5 Straightness of a Derived Median Line at MMC, Surface Method

The measured value is the diameter of the unrelated measured mating envelope. A comparison between the unrelated measured mating envelope size and VC size is used to determine conformance to the straightness tolerance specification.

(a) For an internal feature to conform to the straightness tolerance specification, the unrelated measured mating envelope size shall not be smaller than the VC size. The specified tolerance, T, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{VC size} - \text{UMME size})$$

(b) For an external feature to conform to the straightness tolerance specification, the unrelated measured mating envelope size shall not be larger than the VC size. The specified tolerance, T, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{UMME size} - \text{VC size})$$

See Figures 6-7 and 6-8.

NOTES:
(1) In the equations above, UMME = unrelated measured mating envelope.
(2) A reported value that is less than or equal to T, including a negative value, is conforming.
(3) The portion of the method B reported value that is from measurement data is the unrelated measured mating envelope size. The other elements of the method B reported value are from the tolerance specification.

6.2.6 Straightness of a Derived Median Line at LMC, Resolved Geometry Method

There is a circular measured zone for each measured cross section of the feature. The circular measured zones are normal to and centered on a common straight line that is parallel to the measured feature axis but is not constrained in location. The measured value for each cross section is the diameter of the circular measured zone that is just large enough to contain the center point of the measured minimum material local cross section size. The location of the set of circular measured zones shall be optimized relative to the center points of the measured local cross section sizes such that the method B reported value is minimized.

The method B reported value is the straightness measured value found to be closest to its local straightness TT zone boundary for a conforming measured center point or farthest from its local straightness TT zone boundary for a nonconforming measured center point.

The diameter of the local straightness TT zone boundary at each cross section is the sum of the specified tolerance, T, and the additional tolerance for the particular cross section. The additional tolerance at each cross section for derived median line straightness at LMC is calculated as follows:

(a) For an internal feature

$$\text{additional tolerance} = \text{LMC size limit} - \text{measured minimum material local cross section size}$$

(b) For an external feature

$$\text{additional tolerance} = \text{measured minimum material local cross section size} - \text{LMC size limit}$$

A local straightness TT is calculated for each cross section as follows:

$$\text{local straightness TT} = T + \text{additional tolerance}$$

After all minimum material local straightness measured values and all corresponding local straightness TT values have been found, the values are compared to determine the method B reported value for the feature. See Figures 6-9 and 6-10.

6.2.7 Straightness of Derived Median Line at LMC, Surface Method

The measured value is the diameter of the unrelated measured minimum material envelope. A comparison between the unrelated measured minimum material envelope size and VC size is used to determine conformance to the straightness tolerance specification.

(a) For an internal feature to conform to the straightness tolerance specification, the unrelated measured minimum material envelope size shall not be larger than the VC size. The specified tolerance, *T*, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{UMMME size} - \text{VC size})$$

(b) For an external feature to conform to the specification, the unrelated measured minimum material envelope size shall not be smaller than the feature's VC size. The specified tolerance, *T*, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{VC size} - \text{UMMME size})$$

See Figures 6-11 and 6-12.

NOTES:
(1) In the equations above, UMMME = unrelated measured minimum material envelope.
(2) A reported value that is less than or equal to *T*, including a negative value, is conforming.
(3) The portion of the method B reported value that is from measurement data is the unrelated measured minimum material envelope size. The other elements of the method B reported value are from the tolerance specification.

6.3 METHOD B DATA FOR FLATNESS TOLERANCES

Method B measurement data for flatness tolerances includes flatness of a surface and flatness of a derived median plane at RFS, MMC, and LMC. When flatness is applied at RFS, it shall be evaluated by the resolved geometry method only. When flatness is applied at MMC or LMC, it may be evaluated by either the resolved geometry method or the surface method.

6.3.1 Flatness of a Surface

The flatness measured value is the width of the two-parallel-plane measured zone that is just large enough to contain the measured surface. The method B reported value is the measured value. See Figures 6-13 and 6-14.

6.3.2 Flatness of a Derived Median Plane at RFS

The flatness measured value is the width of the two-parallel-plane measured zone that is just large enough to contain the measured derived median plane of the feature. The method B reported value is the measured value. See Figures 6-15 and 6-16.

6.3.3 Flatness of a Derived Median Plane at MMC or LMC

Derived median plane flatness at MMC or LMC may be evaluated by the resolved geometry method or the surface method. The measurement data report shall state whether each reported value is based on the resolved geometry method or the surface method.

6.3.3.1 Resolved Geometry Method. When the resolved geometry method is used, the flatness tolerance zone is a set of linear distances that are normal to and centered on a common flat plane. The length of each linear distance is the specified flatness tolerance plus the additional tolerance that is calculated for each location. This sum is called the local flatness TT value. When flatness at MMC is specified, the additional tolerance for each location is the difference between the MMC size limit and the measured local line segment size. When flatness at LMC is specified, the additional tolerance for each location is the difference between the LMC size limit and the measured minimum material local line segment size. The measured derived median plane shall be within the tolerance zone. See paras. 6.3.4 and 6.3.6.

6.3.3.2 Surface Method. When the surface method is used, the specified size and the flatness tolerances are combined to impose a VC boundary on the surfaces of the feature that the measured surfaces may not violate. See paras. 6.3.5 and 6.3.7.

There are two situations for which the surface method cannot be used.

(a) The surface method cannot be used if a flatness tolerance at MMC or LMC has a tolerance value that is large enough to make the VC negative. If this situation is encountered, it shall be noted in the measurement data report and the resolved geometry method shall be used.

(b) The surface method cannot be used if a flatness tolerance at MMC or LMC has a limit to the additional tolerance value followed by "MAX" in the feature control frame. If this situation is encountered, it shall be noted in the measurement data report and the resolved geometry method shall be used.

6.3.4 Flatness of a Derived Median Plane at MMC, Resolved Geometry Method

There is a linear measured zone for each measured location on the feature. The linear measured zones are normal to and centered on a common flat plane that is parallel to the feature center plane but is not constrained in location. The flatness measured value for each location is the length of the linear measured zone that is just large enough to contain the center point of the measured local line segment size. The location of the set of linear measured zones shall be optimized relative to the center points of the measured local line segment sizes such that the method B reported value is minimized.

The method B reported value for the feature is the flatness measured value found to be closest to its local flatness TT zone boundary for a conforming measured center point or farthest from its local flatness TT zone boundary for a nonconforming measured center point.

The length of the local flatness TT zone boundary at each location is the sum of the specified tolerance, T, and the additional tolerance for the particular location. The additional tolerance at each location for derived median plane flatness at MMC is calculated as follows:

(a) For an internal feature

$$\text{additional tolerance} = \text{measured local line segment size} - \text{MMC size limit}$$

(b) For an external feature

$$\text{additional tolerance} = \text{MMC size limit} - \text{measured local line segment size}$$

A local flatness TT is calculated for each location as follows:

$$\text{local flatness TT} = T + \text{additional tolerance}$$

After all local flatness measured values and all corresponding local flatness TT values have been found, the values are compared to determine the method B reported value for the feature. See Figures 6-17 and 6-18.

6.3.5 Flatness of a Derived Median Plane at MMC, Surface Method

The measured value is the width of the unrelated measured mating envelope. A comparison between the unrelated measured mating envelope size and VC size is used to verify conformance to the flatness tolerance specification.

(a) For an internal feature to conform to the flatness tolerance specification, the unrelated measured mating envelope size shall not be smaller than the feature's VC size. The specified tolerance, T, is used as a basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{VC size} - \text{UMME size})$$

(b) For an external feature to conform to the specification, the unrelated measured mating envelope size shall not be larger than the feature's VC size. The specified tolerance, T, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{UMME size} - \text{VC size})$$

See Figures 6-19 and 6-20.

NOTES:
(1) In the equations above, UMME = unrelated measured mating envelope.
(2) A reported value that is less than or equal to T, including a negative value, is conforming.
(3) The portion of the method B reported value that is from measurement data is the unrelated measured mating envelope size. The other elements of the method B reported value are from the tolerance specification.

6.3.6 Flatness of a Derived Median Plane at LMC, Resolved Geometry Method

There is a linear measured zone for each measured location on the feature. The linear measured zones are normal to and centered on a common flat plane that is parallel to the feature center plane but is not constrained in location. The flatness measured value for each location is the length of the linear measured zone that is just large enough to contain the center point of the measured local line segment size. The location of the set of linear measured zones shall be optimized relative to the center points of the measured local line segment sizes such that the method B reported value is minimized.

The method B reported value for the feature is the flatness measured value found to be closest to its local flatness TT zone boundary for a conforming measured center point or farthest from its local flatness TT zone boundary for a nonconforming measured center point.

The length of the local flatness TT zone boundary at each location is the sum of the specified tolerance, T, and the additional tolerance for the particular location. The additional tolerance at each location for derived median plane flatness at LMC is calculated as follows:

(a) For an internal feature

$$\text{additional tolerance} = \text{LMC size limit} - \text{measured minimum material local line segment size}$$

(b) For an external feature

$$\text{additional tolerance} = \text{measured minimum material local line segment size} - \text{LMC size limit}$$

A local flatness TT is calculated for each location as follows:

$$\text{local flatness TT} = T + \text{additional tolerance}$$

After all local flatness measured values and all corresponding local flatness TT values have been found, the values are compared to determine the method B reported value for the feature.

See Figures 6-21 and 6-22.

6.3.7 Flatness of a Derived Median Plane at LMC, Surface Method

The measured value is the width of the unrelated measured minimum material envelope. A comparison between the unrelated measured minimum material envelope size and VC size is used to verify that conformance to the flatness requirement has been met.

(a) For an internal feature to conform to the flatness tolerance specification, the unrelated measured minimum material envelope size shall not be larger than the feature's VC size. The specified tolerance, *T*, is used as a basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{UMMME size} - \text{VC size})$$

(b) For an external feature to conform to the flatness tolerance specification, the unrelated measured minimum material envelope size shall not be smaller than the feature's VC size. The specified tolerance, *T*, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{VC size} - \text{UMMME size})$$

See Figures 6-23 and 6-24.

NOTES:
(1) In the equations above, UMMME = unrelated measured minimum material envelope.
(2) A reported value that is less than or equal to *T*, including a negative value, is conforming.
(3) The portion of the method B reported value that is from measurement data is the unrelated measured minimum material envelope size. The other elements of the method B reported value are from the tolerance specification.

6.4 METHOD B DATA FOR CIRCULARITY TOLERANCES

For each measured cross section of the feature, the measured value is the radial separation distance of the two-concentric-circle measured zone that is just large enough to contain the measured circular element. The method B reported value for the feature is the largest of the circularity measured values. See Figures 6-25 and 6-26.

NOTE: For various circularity assessment methods, see ANSI B89.3.1.

6.5 METHOD B DATA FOR CYLINDRICITY TOLERANCES

The cylindricity measured value is the radial separation distance of the two-concentric-cylinder measured zone that is just large enough to contain the measured surface of the feature. The method B reported value is the measured value. See Figures 6-27 and 6-28.

Figure 6-1 Straightness of Line Elements

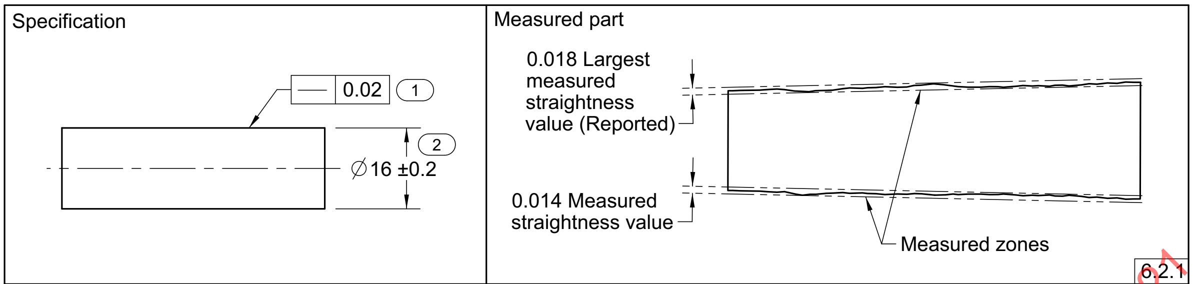


Figure 6-2 Example Data Report for Figure 6-1

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:		Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	STR	B			— 0.02	0.02	0.018	Y			Reported straightness value

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 6-3 Straightness of a Derived Median Line at RFS

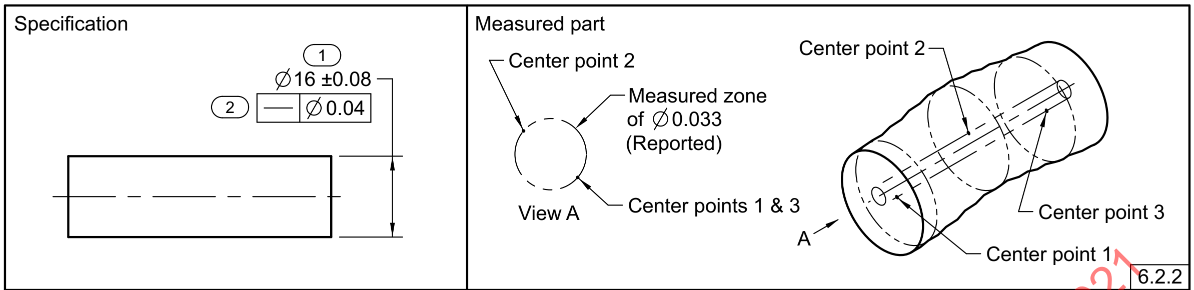


Figure 6-4 Example Data Report for Figure 6-3

ASME Y14.45 Single Part Data Report Example											
Part #:		Drawing #:			Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
2	STR	B			Straightness | Dia 0.04	0.04	0.033	Y			Reported straightness value of the derived median line

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 6-5 Straightness of a Derived Median Line at MMC, Resolved Geometry Method

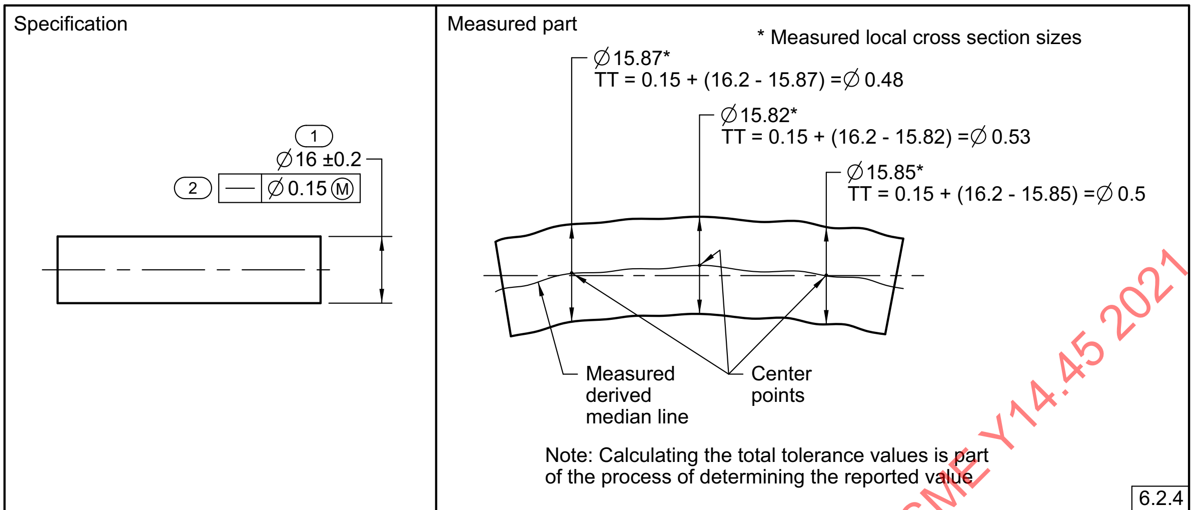


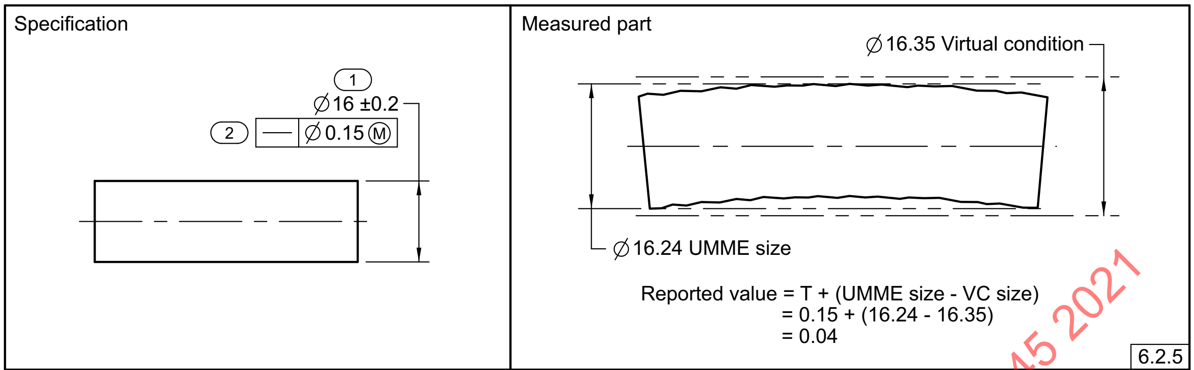
Figure 6-6 Example Data Report for Figure 6-5

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:		Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
2	STR	B			— ⌀0.15Ⓜ	0.53	0.46	Y			Resolved geometry method

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 6-7 Straightness of a Derived Median Line at MMC, Surface Method



GENERAL NOTE: UMME = unrelated measured mating envelope.

Figure 6-8 Example Data Report for Figure 6-7

ASME Y14.45 Single Part Data Report Example											
Part #:		Drawing #:			Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	LMC	B			Ø16±0.2	15.80	15.89	Y			Smallest measured local size
1	MMC	B			Ø16±0.2	16.20	15.93	Y			Largest measured local size
2	STR	B			— ⌀0.15Ⓜ	0.15	0.04	Y			Surface method; UMME size = 16.24

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: UMME = unrelated measured mating envelope.

Figure 6-9 Straightness of a Derived Median Line at LMC, Resolved Geometry Method

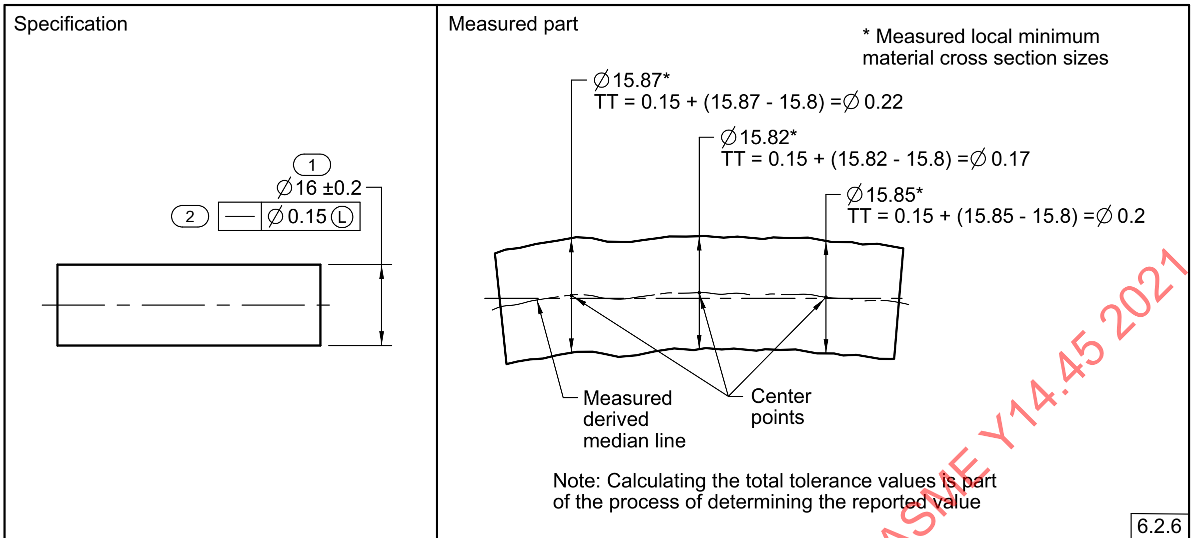


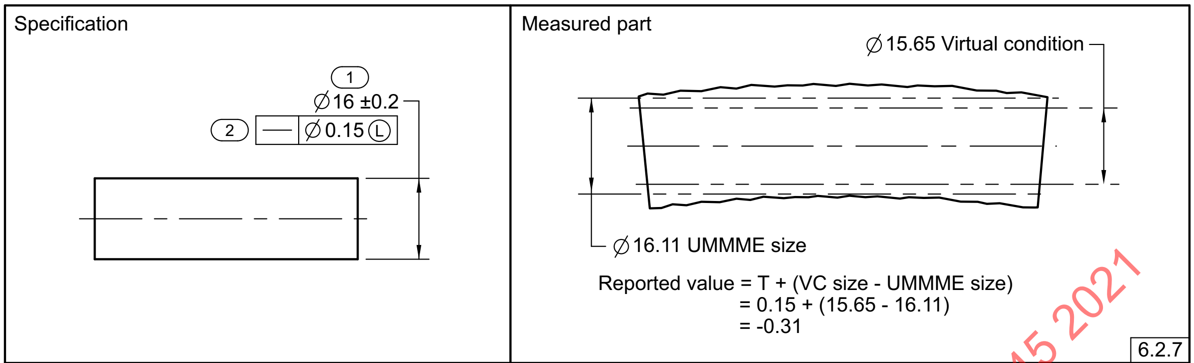
Figure 6-10 Example Data Report for Figure 6-9

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:			Drawing Revision:	3D CAD Model #:				3D CAD Model Revision:
Part Name:						Part Serial #:	Inspection Plan #:				Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
2	STR	B			— ∅0.15Ⓛ	0.16	0.15	Y			Resolved geometry method

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 6-11 Straightness of a Derived Median Line at LMC, Surface Method



GENERAL NOTE: UMMME = unrelated measured minimum material envelope.

Figure 6-12 Example Data Report for Figure 6-11

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:		Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
2	STR	B			— ∅0.15Ⓛ	0.15	−0.31	Y			Surface method, UMMME size = 16.11

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: UMMME = unrelated measured minimum material envelope.

Figure 6-13 Flatness of a Surface

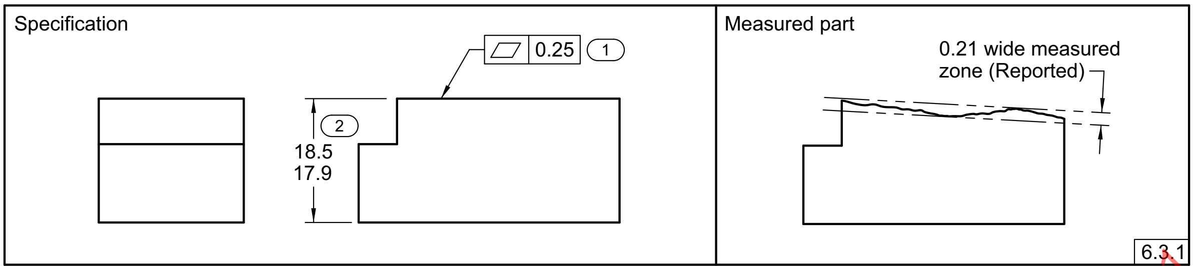


Figure 6-14 Example Data Report for Figure 6-13

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:			Drawing Revision:	3D CAD Model #:				3D CAD Model Revision:
Part Name:						Part Serial #:	Inspection Plan #:				Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	FLA	B			⏥ 0.25	0.25	0.21	Y			

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 6-15 Flatness of a Derived Median Plane at RFS

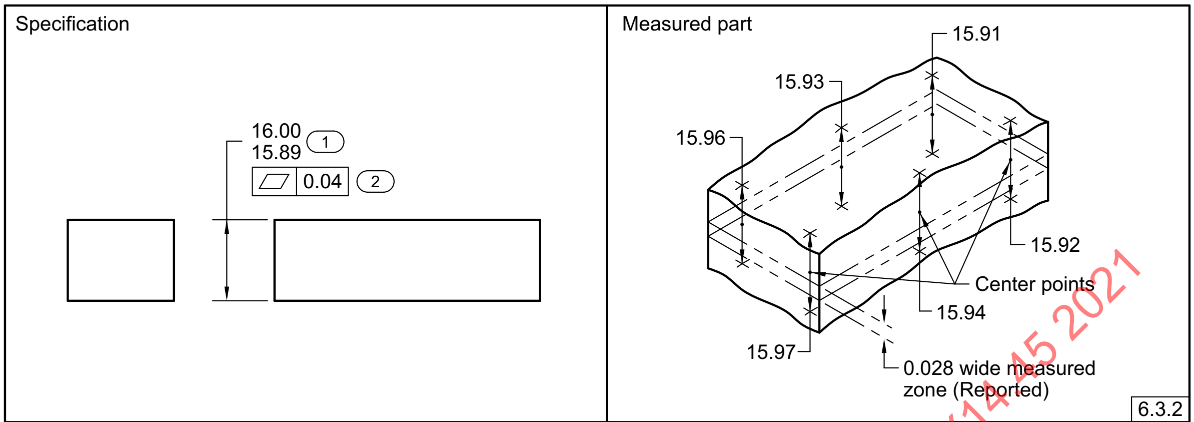


Figure 6-16 Example Data Report for Figure 6-15

ASME Y14.45 Single Part Data Report Example											
Part #:		Drawing #:			Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
2	FLA	B			Flatness | 0.04	0.04	0.028	Y			

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 6-17 Flatness at MMC, Resolved Geometry Method

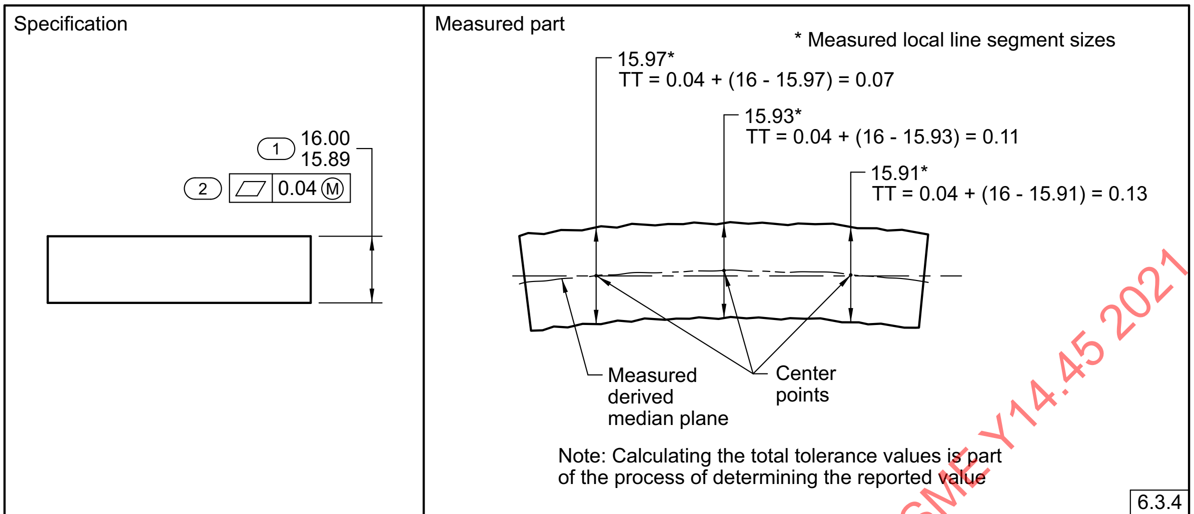


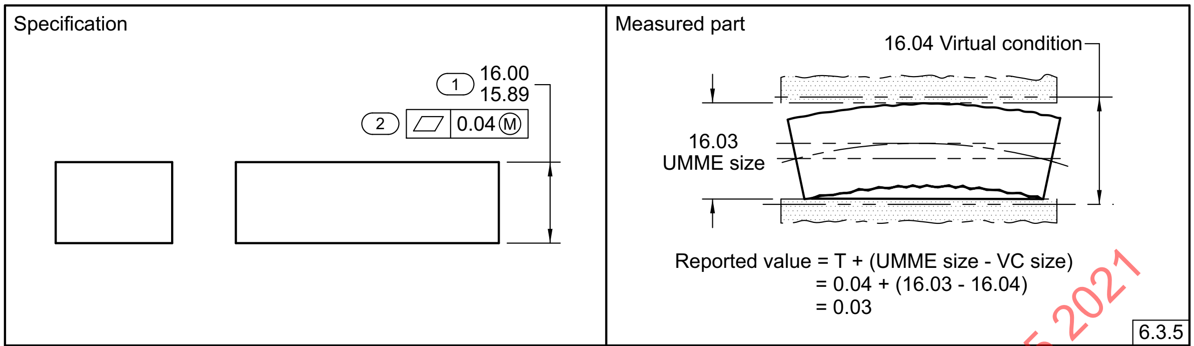
Figure 6-18 Example Data Report for Figure 6-17

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:		Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
2	FLA	B			⏥ 0.04 Ⓜ	0.13	0.11	Y			Resolved geometry method

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 6-19 Flatness of a Derived Median Plane at MMC, Surface Method



GENERAL NOTE: UMME = unrelated measured mating envelope.

Figure 6-20 Example Data Report for Figure 6-19

ASME Y14.45 Single Part Data Report Example											
Part #:		Drawing #:			Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	MMC	B			15.89–16.00	16.00	15.97	Y			Largest measured local size
1	LMC	B			15.89–16.00	15.89	15.93	Y			Smallest measured local size
2	FLA	B			⏥ 0.04 Ⓜ	0.04	0.03	Y			Surface method, UMME size = 16.03

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: UMME = unrelated measured mating envelope.

Figure 6-21 Flatness of a Derived Median Plane at LMC, Resolved Geometry Method

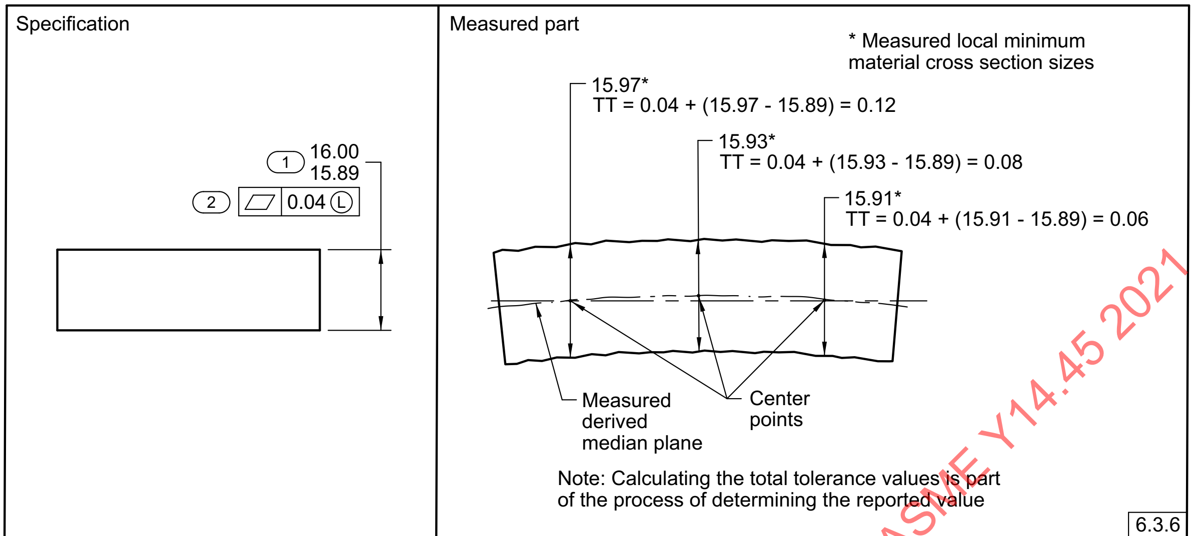


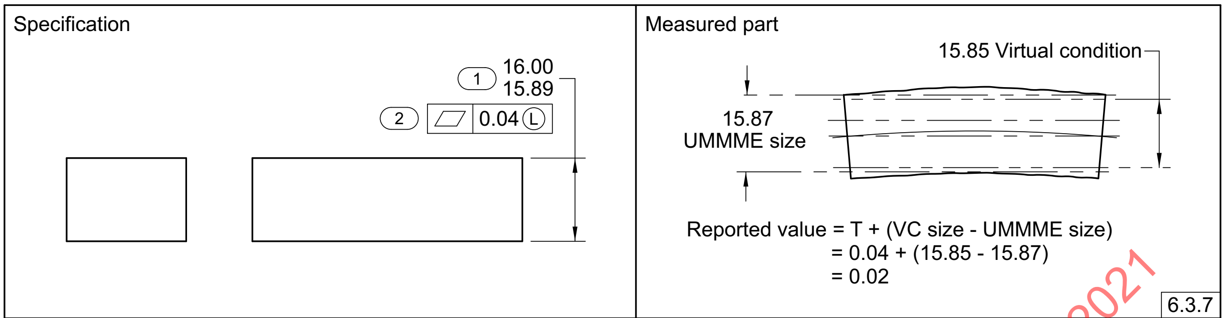
Figure 6-22 Example Data Report for Figure 6-21

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:		Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
2	FLA	B			⏥ 0.04 Ⓛ	0.12	0.07	Y			Resolved geometry method

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 6-23 Flatness at LMC, Surface Method



GENERAL NOTE: UMMME = unrelated measured minimum material envelope.

Figure 6-24 Example Data Report for Figure 6-23

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:			Drawing Revision:	3D CAD Model #:				3D CAD Model Revision:
Part Name:						Part Serial #:	Inspection Plan #:				Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	MMC	B			15.89–16.00	16.00	15.97	Y			Largest measured local size
1	LMC	B			15.89–16.00	15.89	15.91	Y			Smallest measured local size
2	FLA	B			⏥ 0.04 Ⓛ	0.04	0.02	Y			Surface method, UMMME size = 15.87

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: UMMME = unrelated measured minimum material envelope.

Figure 6-25 Circularity

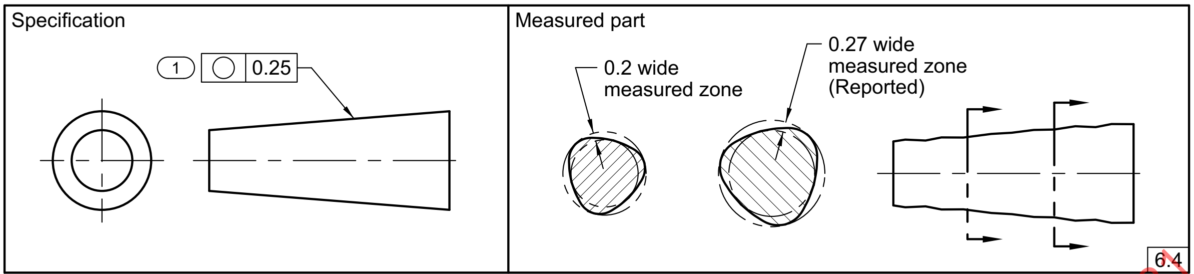


Figure 6-26 Example Data Report for Figure 6-25

ASME Y14.45 Single Part Data Report Example											
Part #:			**Drawing #:**		**Drawing Revision:**	**3D CAD Model #:**					**3D CAD Model Revision:**
Part Name:					**Part Serial #:**	**Inspection Plan #:**					**Report #:**
Characteristic Identifier	**Characteristic Type**	***ASME Y14.45 Method**	**Reference Location**	**Characteristic Designator**	**Specification**	****Calculated Acceptance Limit(s)**	**Reported Value**	**Accept (Y or N)**	**Tooling/Equipment**	**Nonconformance #**	**Comments**
1	CIR	B			○ 0.25	0.25	0.27	N		04-093	Measured value from worst location sampled

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 6-27 Cylindricity

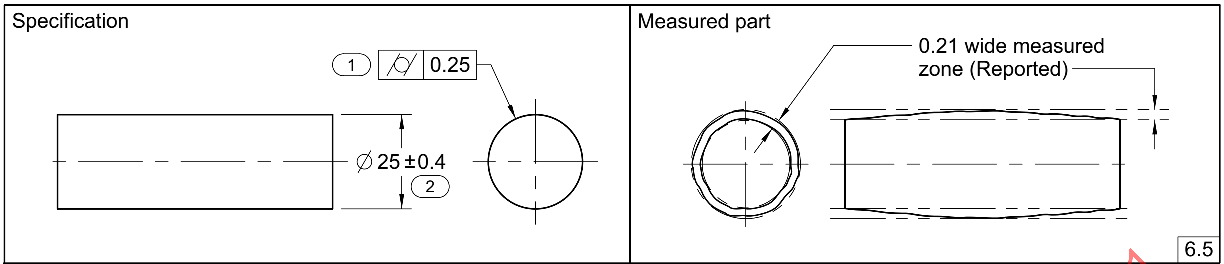


Figure 6-28 Example Data Report for Figure 6-27

ASME Y14.45 Single Part Data Report Example											
Part #:		Drawing #:			Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	CYL	B			⌭ 0.25	0.25	0.21	Y			

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Section 7
Measurement Data Reporting for Orientation Tolerances

7.1 GENERAL

This Section establishes requirements for method B data reporting for orientation tolerances, including perpendicularity, parallelism, and angularity.

7.2 METHOD B DATA FOR ORIENTATION TOLERANCES

Method B measurement data for orientation tolerances includes angularity, parallelism, and perpendicularity. Any of these tolerances can be applied to a planar surface, a planar surface with the tangent plane modifier applied, linear surface elements, or either the axis or the center plane of a feature of size. When an orientation tolerance is applied to an axis or center plane, the default is for the tolerance to be applied at RFS, or an MMC or LMC modifier can be applied instead. Orientation tolerances at MMC or LMC can be evaluated using either the resolved geometry method or the surface method.

7.2.1 Orientation of a Planar Surface

The measured value is the width of the two-parallel-plane orientation-constrained measured zone that is just large enough to contain the measured surface of the feature. The method B reported value is the measured value. See Figures 7-1 and 7-2.

7.2.2 Orientation of a Planar Surface With a Tangent Plane Modifier

The measured value is the width of the two-parallel-plane orientation-constrained measured zone that is just large enough to contain the measured tangent plane of the feature. The method B reported value is the measured value. See Figures 7-3 and 7-4.

7.2.3 Orientation of Linear Surface Elements

For each measured linear element of the feature, the measured value is the width of the two-parallel-line orientation-constrained measured zone that is just large enough to contain the measured linear surface element on the feature. The method B reported value for the feature is the largest of the orientation measured values. See Figures 7-5 and 7-6.

7.2.4 Orientation of a Feature of Size

Orientation tolerances of a feature of size can be applied at RFS, MMC, or LMC. When applied at RFS, orientation tolerances shall be evaluated by the resolved geometry method only. When applied at MMC or LMC, orientation tolerances may be evaluated by the resolved geometry method or the surface method.

7.2.4.1 Orientation of a Feature of Size at RFS. The measured value is the diameter or width of the cylindrical or two-parallel-plane, respectively, orientation-constrained measured zone that is just large enough to contain the axis or center plane of the feature's unrelated measured mating envelope. The method B reported value is the measured value. See Figures 7-7 and 7-8.

NOTE: If a projected tolerance zone is specified, the reporting practices remain the same, even though the tolerance zone is projected outside the feature.

7.2.4.2 Orientation of a Feature of Size at MMC or LMC. Orientation at MMC or LMC may be evaluated by the resolved geometry method or the surface method. The measurement data report shall state whether each reported value is for the resolved geometry method or the surface method.

7.2.4.2.1 Resolved Geometry Method. When the resolved geometry method is used, the axis or the center plane of the unrelated measured mating envelope for an orientation tolerance specified at MMC, or the axis or the center plane of the unrelated measured minimum material envelope for an orientation tolerance specified at LMC, must be within the tolerance zone. The orientation tolerance zone may be increased in size based on the applicable additional tolerance that is calculated by taking the difference between the MMC size limit and the unrelated measured mating envelope size for an orientation tolerance specified at MMC, or the difference between the LMC size limit and the unrelated measured minimum material envelope size for an orientation tolerance specified at LMC. See paras. 7.2.4.2.3 and 7.2.4.2.5.

7.2.4.2.2 Surface Method. When the surface method is used, the specified size and orientation tolerances are combined to impose a VC boundary that the measured surface shall not violate. See paras. 7.2.4.2.4 and 7.2.4.2.6.

There are two situations for which the surface method cannot be used.

(a) The surface method cannot be used if an orientation tolerance at MMC or LMC has a tolerance value that is large enough to make the VC negative. If this situation is encountered, it shall be noted in the measurement data report and the resolved geometry method shall be used.

(b) The surface method cannot be used if an orientation tolerance at MMC or LMC has a limit to the additional tolerance value followed by "MAX" in the feature control frame. If this situation is encountered, it shall be noted in the measurement data report and the resolved geometry method shall be used.

7.2.4.2.3 Orientation of a Feature of Size at MMC, Resolved Geometry Method. The measured value is the diameter or width of the cylindrical or two-parallel-plane orientation-constrained measured zone that is just large enough to contain the axis or center plane of the feature's unrelated measured mating envelope. The method B reported value is the measured value.

To determine conformance to the orientation tolerance specification, the reported value is compared to the orientation TT value, which is the sum of the specified orientation tolerance, *T*, and the calculated additional tolerance. The additional tolerance is calculated as follows:

(a) For an internal feature

$$\text{additional tolerance} = \text{UMME size} - \text{MMC size limit}$$

(b) For an external feature

$$\text{additional tolerance} = \text{MMC size limit} - \text{UMME size}$$

See Figures 7-9 and 7-10.

NOTE: In the equations above, UMME = unrelated measured mating envelope.

7.2.4.2.4 Orientation of a Feature of Size at MMC, Surface Method. The measured value is the orientation-constrained measured mating envelope size of the feature of size. A comparison between the orientation-constrained measured mating envelope size and VC size is used to determine conformance to the orientation tolerance.

(a) For an internal feature to conform to the orientation tolerance specification, the orientation-constrained measured mating envelope size shall not be smaller than the feature's VC size. The specified tolerance, *T*, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{VC size} - \text{OCMME size})$$

(b) For an external feature to conform to the orientation tolerance specification, the orientation-constrained measured mating envelope size shall not be larger than the feature's VC size. The specified tolerance, *T*, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{OCMME size} - \text{VC size})$$

See Figures 7-11 and 7-12.

NOTES:
(1) In the equations above, OCMME = orientation-constrained measured mating envelope.
(2) A reported value that is less than or equal to *T*, including a negative value, is conforming.
(3) The portion of the method B reported value that is from measurement data is the orientation-constrained measured mating envelope size. The other elements of the method B reported value are from the orientation tolerance specification.

7.2.4.2.5 Orientation of a Feature of Size at LMC, Resolved Geometry Method. The measured value is the diameter or width of the cylindrical or two-parallel-plane orientation-constrained measured zone that is just large enough to contain the axis or center plane of the feature's unrelated measured minimum material envelope. The method B reported value is the measured value.

To determine conformance to the orientation tolerance specification, the reported value is compared to the orientation TT value, which is the sum of the specified orientation tolerance, *T*, and the calculated additional tolerance. The additional tolerance is calculated as follows:

(a) For an internal feature

$$\text{additional tolerance} = \text{LMC size limit} - \text{UMMME size}$$

(b) For an external feature

$$\text{additional tolerance} = \text{UMMME size} - \text{LMC size limit}$$

See Figures 7-13 and 7-14.

NOTE: In the equations above, UMMME = unrelated measured minimum material envelope.

7.2.4.2.6 Orientation of a Feature of Size at LMC, Surface Method. The measured value is the orientation-constrained measured minimum material envelope size of the feature of size. A comparison between the orientation-constrained measured minimum material envelope size and VC size is used to determine conformance to the orientation tolerance specification.

(a) For an internal feature to conform to the orientation tolerance specification, the orientation-constrained measured minimum material envelope size shall not be larger than the feature's VC size. The specified tolerance, *T*, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{OCMMME size} - \text{VC size})$$

(b) For an external feature to conform to the orientation tolerance specification, the orientation-constrained measured minimum material envelope size shall not be

smaller than the feature's VC size. The specified tolerance, T, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{VC size} - \text{OCMMME size})$$

See Figures 7-15 and 7-16.

NOTES:
(1) In the equations above, OCMMME = orientation-constrained measured minimum material envelope.
(2) A reported value that is less than or equal to T, including a negative value, is conforming.
(3) The portion of the method B reported value that is from measurement data is the orientation-constrained measured minimum material envelope size. The other elements of the method B reported value are from the orientation tolerance specification.

Figure 7-1 Perpendicularity for a Planar Surface

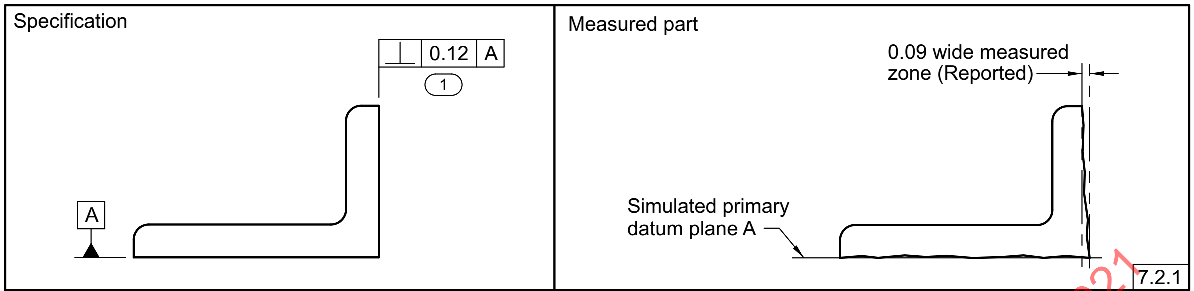


Figure 7-2 Example Data Report for Figure 7-1

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:		Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	PER	B			⊥ 0.12 A	0.12	0.09	Y			

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 7-3 Perpendicularity With a Tangent Plane Modifier for a Planar Surface

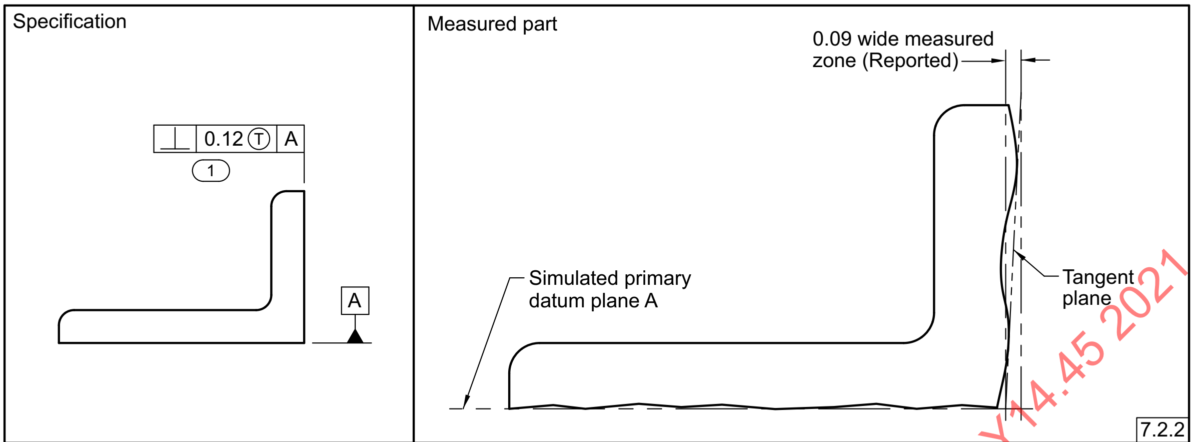


Figure 7-4 Example Data Report for Figure 7-3

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:			Drawing Revision:	3D CAD Model #:				3D CAD Model Revision:
Part Name:						Part Serial #:	Inspection Plan #:				Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	PER	B			⊥ 0.12 A	0.12	0.09	Y			Perpendicularity of the measured feature's tangent plane

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 7-5 Perpendicularity of Linear Surface Elements

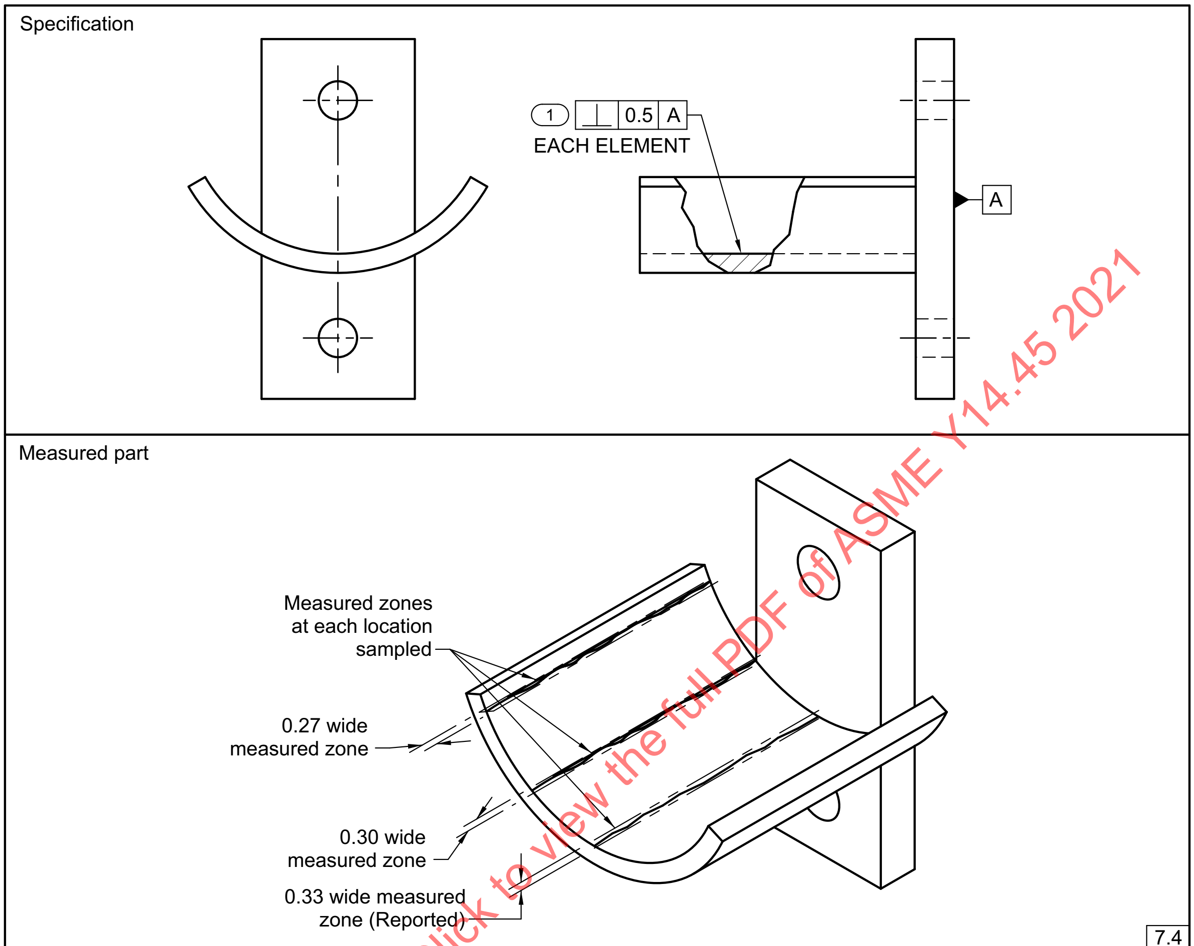


Figure 7-6 Example Data Report for Figure 7-5

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:			Drawing Revision:	3D CAD Model #:				3D CAD Model Revision:
Part Name:						Part Serial #:	Inspection Plan #:				Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	PER	B			⊥ | 0.5 | A	0.50	0.33	Y			Largest measured orientation value from all sampled locations

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document: Method A is attribute (pass/fail) data. Method B is variable data such as a size, profile, or position value. Method C is variable data to provide additional information, such as profile surface deviations or position location components.
**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 7-7 Angularity of the Axis of a Hole at RFS

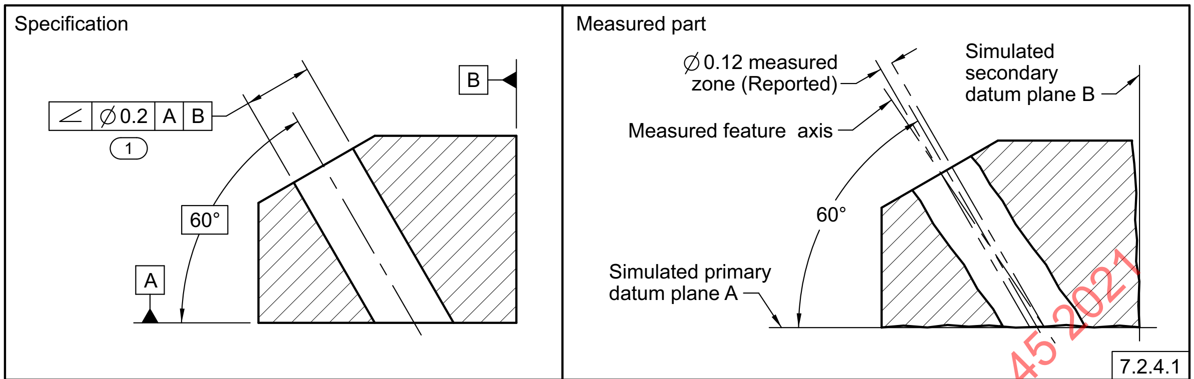


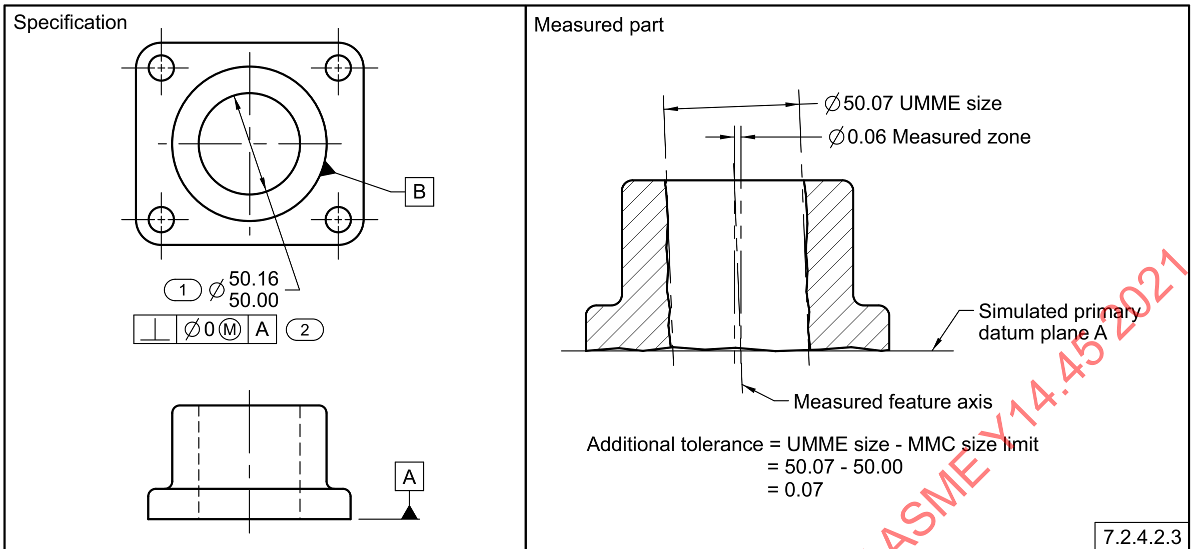
Figure 7-8 Example Data Report for Figure 7-7

ASME Y14.45 Single Part Data Report Example											
Part #:		Drawing #:			Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	ANG	B			Angularity | Dia 0.2 | A | B |	0.20	0.12	Y			

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 7-9 Perpendicularity at MMC Applied to the Axis of a Hole, Resolved Geometry Method



GENERAL NOTE: UMME = unrelated measured mating envelope.

Figure 7-10 Example Data Report for Figure 7-9

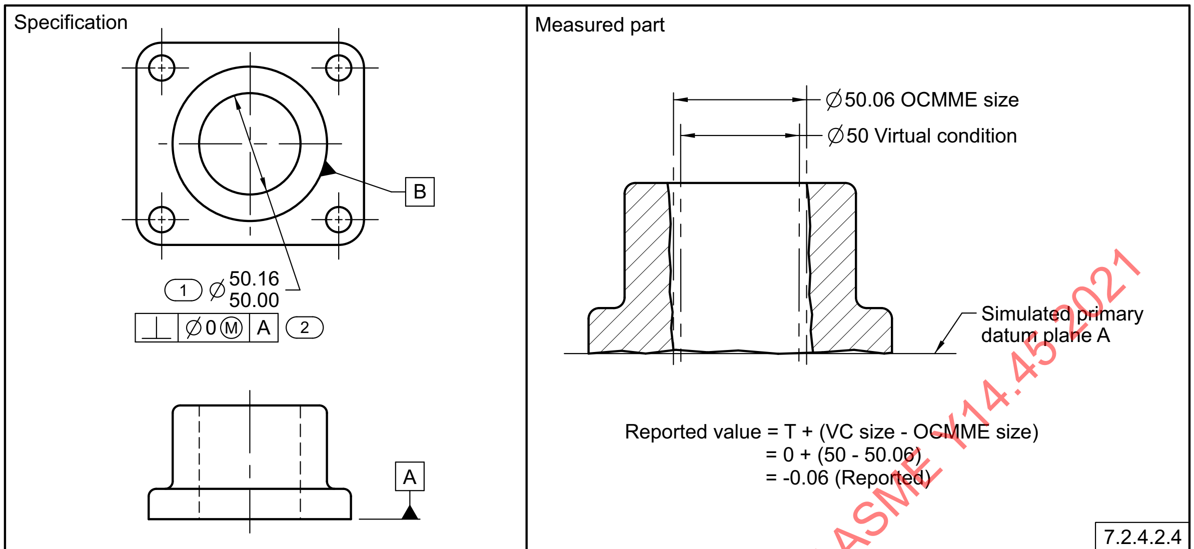
ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:			Drawing Revision:	3D CAD Model #:				3D CAD Model Revision:
Part Name:						Part Serial #:	Inspection Plan #:				Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	MMC	B			Ø50.08±0.08	50.000	50.070	Y			UMME size
1	LMC	B			Ø50.08±0.08	50.160	50.074	Y			Largest measured local size
2	PER	B			⊥ | ∅0Ⓜ | A	0.070	0.060	Y			Resolved geometry method

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: UMME = unrelated measured mating envelope.

Figure 7-11 Perpendicularity at MMC Applied to the Axis of a Hole, Surface Method



GENERAL NOTE: OCMME = orientation-constrained measured mating envelope.

Figure 7-12 Example Data Report for Figure 7-11

ASME Y14.45 Single Part Data Report Example

Part #:	Drawing #:	Drawing Revision:	3D CAD Model #:	3D CAD Model Revision:
Part Name:		Part Serial #:	Inspection Plan #:	Report #:

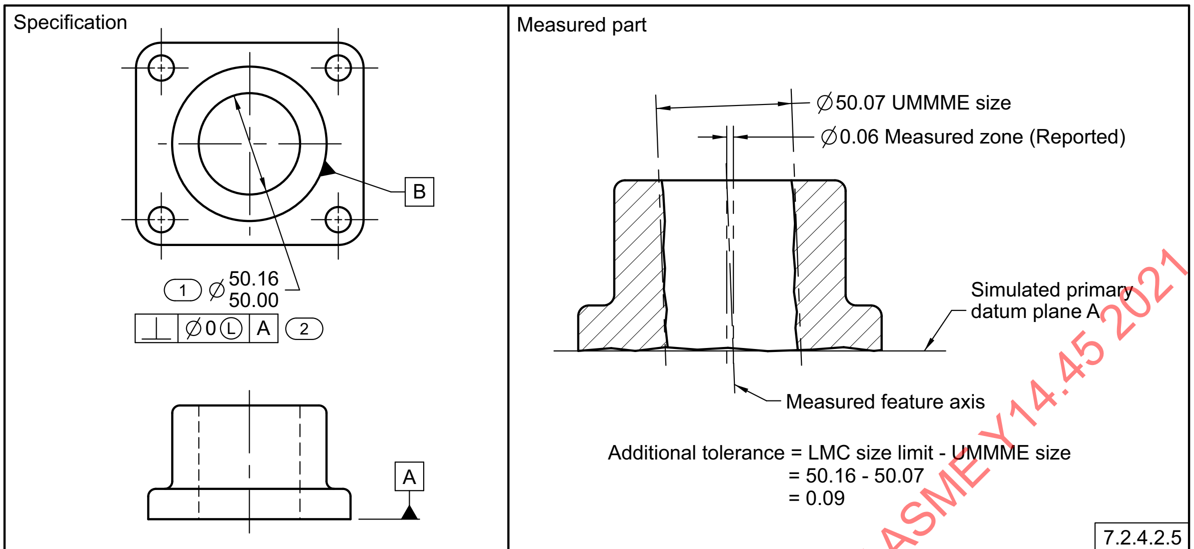
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	MMC	B			Ø50.08±0.08	50.000	50.070	Y			UMME size
1	LMC	B			Ø50.08±0.08	50.160	50.074	Y			Largest measured local size
2	PER	B			⊥ Ø0Ⓜ A	0.000	–0.060	Y			Surface method, OCMME size = 50.06

* ASME Y14.4, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: OCMME = orientation-constrained measured mating envelope; UMME = unrelated measured mating envelope.

Figure 7-13 Perpendicularity at LMC Applied to the Axis of a Hole, Resolved Geometry Method



GENERAL NOTE: UMMME = unrelated measured minimum material envelope.

Figure 7-14 Example Data Report for Figure 7-13

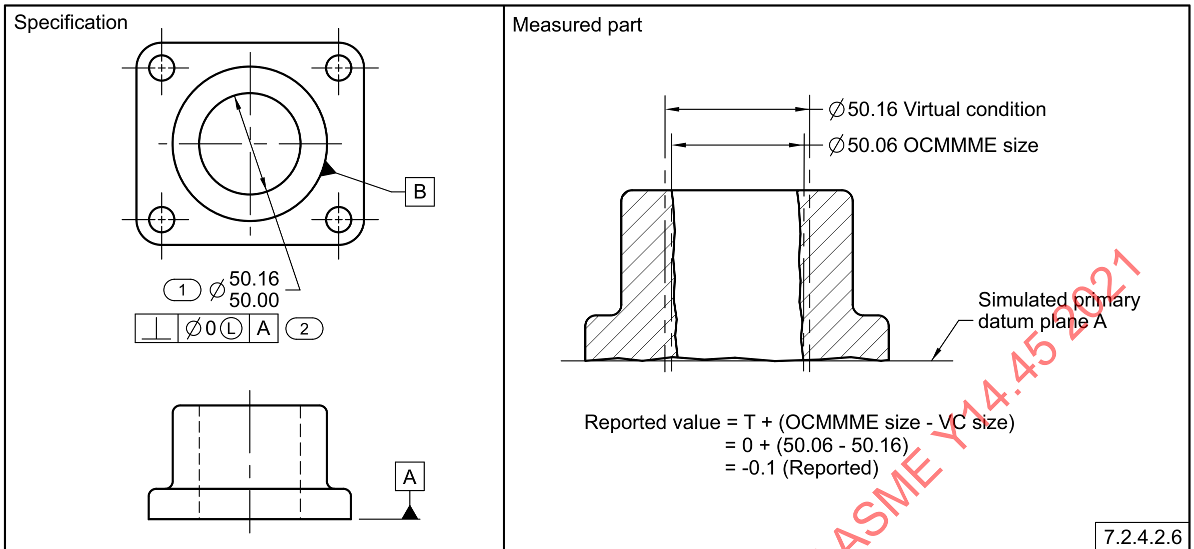
ASME Y14.45 Single Part Data Report Example											
Part #:		Drawing #:			Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	LMC	B			Ø50.08±0.08	50.16	50.070	Y			UMMME size
1	MMC	B			Ø50.08±0.08	50.00	50.044	Y			Smallest measured local size
2	PER	B			⊥ Ø0 Ⓛ A	0.09	0.06	Y			Resolved geometry method

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: UMMME = unrelated measured minimum material envelope.

Figure 7-15 Perpendicularity at LMC Applied to the Axis of a Hole, Surface Method



GENERAL NOTE: OCMMME = orientation-constrained measured minimum material envelope.

Figure 7-16 Example Data Report for Figure 7-15

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:			Drawing Revision:	3D CAD Model #:				3D CAD Model Revision:
Part Name:						Part Serial #:	Inspection Plan #:				Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	LMC	B			Ø50.08±0.08	50.160	50.070	Y			UMMME size
1	MMC	B			Ø50.08±0.08	50.000	50.054	Y			Smallest measured local size
2	PER	B			Perpendicularity | Dia 0 (L) | A |	0.000	−0.100	Y			Surface method, OCMMME size = 50.06

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: OCMMME = orientation-constrained measured minimum material envelope; UMMME = unrelated measured minimum material envelope.

Section 8
Measurement Data Reporting for Position Tolerances

8.1 GENERAL

This Section establishes requirements for method B data reporting for position tolerances. It also defines method C location components for position tolerances and provides examples that include method C location components in measurement data reports.

8.2 METHOD C LOCATION COMPONENTS FOR POSITION

Method C location components for position provide information to quantify the location and orientation of the measured feature axis, measured feature center plane, or measured feature center point. The axes for each relevant datum reference frame or reporting coordinate system shall be specified when location components are reported. See ASME Y14.5 for methods to represent datum reference frame axes on a drawing or ASME Y14.41 for methods to represent a datum reference frame using a model coordinate system.

Location components shall be reported as either of the following:

(a) X, Y, and Z distances from the datum reference frame or from the reporting coordinate system origin

(b) deviations from true position, using coordinate directions from the datum reference frame or from a reporting coordinate system (generally termed delta X, delta Y, and delta Z or ΔX, ΔY, and ΔZ).

For a spherical feature of size, the location component(s) of the measured center point shall be reported. See Figure 8-6.

For a cylindrical feature of size, the location component(s) of two points on the measured feature axis that have sufficient separation shall be reported. See Figures 8-2, 8-8, 8-10, 8-12, and 8-16.

For a width feature of size, the location component(s) of three points on the measured center plane that have sufficient separation shall be reported. See Figure 8-4.

For features that do not have sufficient length or depth (i.e., features that may be considered two dimensional), method C location components may consist of data from one point for an axis or two points for a center plane.

8.3 METHOD B DATA FOR POSITION TOLERANCES

Method B measurement data for position tolerances includes tolerances applied to the center point, axis, or center plane of a feature of size. The default is for the position tolerance to be applied at RFS, or an MMC or LMC modifier can be applied instead. Position tolerances at MMC or LMC can be evaluated using the resolved geometry method or the surface method.

8.3.1 Position at RFS

Position tolerances at RFS control the axis, center plane, or center point of the unrelated measured mating envelope of a feature of size. Position tolerance zone shapes may be a cylinder, two parallel planes, a sphere, a cone, a wedge, or two concentric partial cylinders.

NOTES:
(1) This Standard currently does not include requirements for method B data reporting for position tolerances that define conical and wedge-shaped tolerance zones.
(2) If a projected tolerance zone is specified, the reporting practices remain the same, even though the tolerance zone is projected outside the feature.

8.3.1.1 Position at RFS Defining a Cylindrical Tolerance Zone. The position measured value is the diameter of a cylindrical location-constrained measured zone that is just large enough to contain the axis of the feature's unrelated measured mating envelope. The method B reported value is the measured value. See Figures 8-1 and 8-2.

8.3.1.2 Position at RFS Defining a Two-Parallel-Plane Tolerance Zone. The measured value is the width of the two-parallel-plane location-constrained measured zone that is just large enough to contain the center plane, axis, or center point of the feature's unrelated measured mating envelope. The method B reported value is the measured value. See Figures 8-3 and 8-4.

8.3.1.3 Position at RFS Defining a Spherical Tolerance Zone. The measured value is the diameter of a spherical location-constrained measured zone that is just large enough to contain the center point of the feature's unrelated measured mating envelope. The method B reported value is the measured value. See Figures 8-5 and 8-6.

8.3.1.4 Bidirectional Position at RFS, Rectangular Coordinate Method. Bidirectional position at RFS applied in perpendicular directions to control the axis of a feature of size results in two distinct two-parallel-plane tolerance zones, as defined in para. 8.3.1.2. If the two tolerance zones have been defined in the same datum reference frame (i.e., the tolerance zones are subject to simultaneous requirements), the measured feature axis must be within both tolerance zones; therefore, it must be within the intersection of the two two-parallel-plane tolerance zones.

For this type of control there are two measured values. Each measured value is the width of the two-parallel-plane location-constrained measured zone that is just large enough to contain the axis of the feature's unrelated measured mating envelope. The two method B reported values are the two measured values. See Figures 8-7 and 8-8.

8.3.1.5 Polar Coordinate Position at RFS. Position at RFS applied in a polar coordinate system [using a lateral direction tolerance and a radial (polar) direction tolerance] to control the axis of a feature of size results in two distinct tolerance zones. One tolerance zone, as defined in para. 8.3.1.2, is bounded by two parallel planes. The other tolerance zone is bounded by two concentric partial cylinders. If the two tolerance zones have been defined in the same datum reference frame (i.e., they are subject to simultaneous requirements), the measured feature axis must be within both tolerance zones; therefore, it must be within the intersection of the two-parallel-plane tolerance zone and the two-concentric-partial-cylinder-boundary tolerance zone.

For this type of control, there are two measured values. The lateral direction measured value is the width of the two-parallel-plane location-constrained measured zone that is just large enough to contain the axis of the feature's unrelated measured mating envelope. The radial direction measured value is the width of the two-concentric-partial-cylinder location-constrained measured zone that is just large enough to contain the axis of the feature's unrelated measured mating envelope. The two method B reported values are the two measured values. See Figures 8-9 and 8-10.

8.3.2 Position Tolerances at MMC or LMC

Position tolerances at MMC or LMC may be evaluated by the resolved geometry method or the surface method. The data report shall state whether each reported value is for the resolved geometry method or the surface method.

8.3.2.1 Resolved Geometry Method. When the resolved geometry method is used, the position tolerance controls the axis, center plane, or center point of the unrelated measured mating envelope for a position tolerance specified at MMC or the axis, center plane, or center point of the unrelated measured minimum material envelope for a position tolerance specified at LMC. Position tolerance zones are cylinders, two parallel planes, spheres, cones, wedges, or two concentric partial cylinders.

The position tolerance zone may be increased in size based on the applicable additional tolerance that is calculated by taking either the difference between the MMC size limit and the unrelated measured mating envelope size for a position tolerance specified at MMC or the difference between the LMC size limit and the unrelated measured minimum material envelope size for a position tolerance specified at LMC. See paras. 8.3.2.3 and 8.3.2.5.

8.3.2.2 Surface Method. When the surface method is used, the specified size and location tolerances are combined to impose a VC boundary that the measured surface shall not violate. See paras. 8.3.2.4 and 8.3.2.6.

There are two situations for which the surface method cannot be used.

(a) The surface method cannot be used if a position tolerance at MMC or LMC has a tolerance value that is large enough to make the VC negative. If this situation is encountered, it shall be noted in the measurement data report and the resolved geometry method shall be used.

(b) The surface method cannot be used if a position tolerance at MMC or LMC has a limit to the additional tolerance value followed by "MAX" in the feature control frame. If this situation is encountered, it shall be noted in the measurement data report and the resolved geometry method shall be used.

8.3.2.3 Position at MMC, Resolved Geometry Method. The position measured value is the diameter or width of the cylindrical, spherical, or two-parallel-plane location-constrained measured zone that is just large enough to contain the axis, center plane, or center point of the feature's unrelated measured mating envelope. The method B reported value is the measured value.

To determine conformance to the position tolerance specification, the reported value is compared to the position TT value, which is the sum of the specified position tolerance, T, and the calculated additional tolerance. The additional tolerance is calculated as follows:

(a) For an internal feature

$$\text{additional tolerance} = \text{UMME size} - \text{MMC size limit}$$

(b) For an external feature

$$\text{additional tolerance} = \text{MMC size limit} - \text{UMME size}$$

See Figures 8-11 and 8-12.

NOTE: In the equations above, UMME = unrelated measured mating envelope.

8.3.2.4 Position at MMC, Surface Method. The position measured value is the size of the location-constrained measured mating envelope of the feature of size. A comparison between the location-constrained measured mating envelope size and the VC size is used to determine conformance to the position tolerance.

(a) For an internal feature to conform to the position tolerance specification, the location-constrained measured mating envelope size shall not be smaller than the feature's VC size. The specified tolerance, T, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{VC size} - \text{LCMME size})$$

(b) For an external feature to conform to the position tolerance specification, the location-constrained measured mating envelope size shall not be larger than the feature's VC size. The specified tolerance, T, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{LCMME size} - \text{VC size})$$

See Figures 8-13 and 8-14.

NOTES:

(1) In the equations above, LCMME = location-constrained measured mating envelope.

(2) A reported value that is less than or equal to T, including a negative value, is conforming.

(3) The portion of the reported value that is from measurement data is the location-constrained measured mating envelope size. The other elements of the reported value are from the tolerance specification.

8.3.2.5 Position at LMC, Resolved Geometry Method. The position measured value is the size of the cylindrical, spherical, or two-parallel-plane location-constrained measured zone that is just large enough to contain the axis, center plane, or center point of the feature's unrelated measured minimum material envelope. The method B reported value is the measured value.

To determine conformance to the position tolerance specification, the reported value is compared to the position TT value, which is the sum of the specified position tolerance, T, and the calculated additional tolerance. The additional tolerance is calculated as follows:

(a) For an internal feature

$$\text{additional tolerance} = \text{LMC size limit} - \text{UMMME size}$$

(b) For an external feature

$$\text{additional tolerance} = \text{UMMME size} - \text{LMC size limit}$$

See Figures 8-15 and 8-16.

NOTE: In the equations above, UMMME = unrelated measured minimum material envelope.

8.3.2.6 Position at LMC, Surface Method. The measured value is the size of the location-constrained measured minimum material envelope of the feature of size. A comparison between the location-constrained measured minimum material envelope size and the VC size is used to determine conformance to the position tolerance specification.

(a) For an internal feature to conform to the position tolerance specification, the location-constrained measured minimum material envelope size shall not be larger than the feature's VC size. The specified tolerance, T, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{LCMMME size} - \text{VC size})$$

(b) For an external feature to conform to the position tolerance specification, the location-constrained measured minimum material envelope size shall not be smaller than the feature's VC size. The specified tolerance, T, is used as the basis of the method B reported value calculation:

$$\text{reported value} = T + (\text{VC size} - \text{LCMMME size})$$

See Figures 8-17 and 8-18.

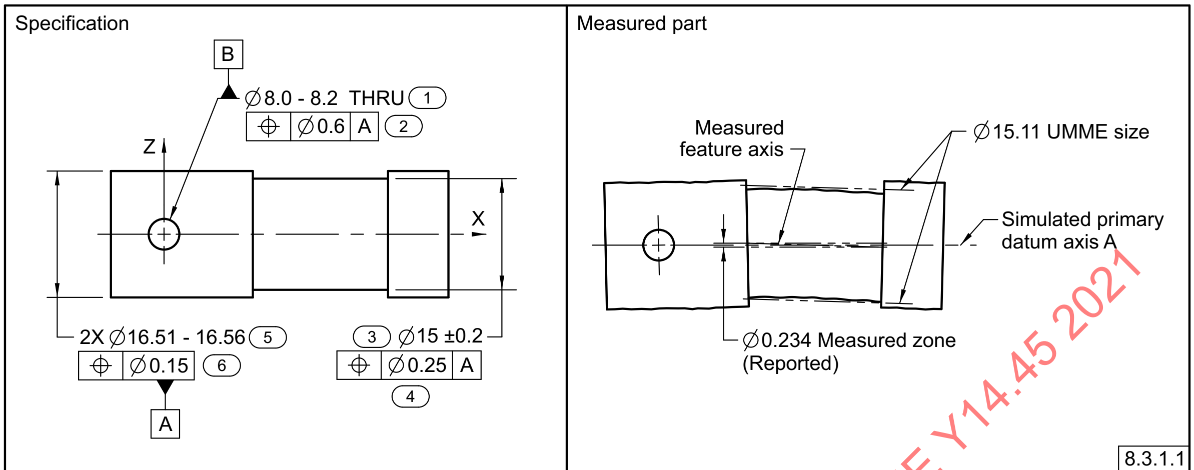
NOTES:

(1) In the equations above, LCMMME = location-constrained measured minimum material envelope.

(2) A reported value that is less than or equal to T, including a negative value, is conforming.

(3) The portion of the reported value that is from measurement data is the location-constrained measured minimum material envelope size. The other elements of the reported value are from the tolerance specification.

Figure 8-1 Position at RFS Defining a Cylindrical Tolerance Zone



GENERAL NOTE: UMME = unrelated measured mating envelope.

Figure 8-2 Example Data Report for Figure 8-1

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:		Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
4	POS	B			Position | Ø0.25 | A	0.250	0.234	Y			
4.01Y		C			Location component for position		−0.040				Y location at X = 15, datum feature B used to stop rotation
4.01Z		C			Location component for position		0.110				Z location at X = 15, datum feature B used to stop rotation
4.02Y		C			Location component for position		0.050				Y location at X = 30, datum feature B used to stop rotation
4.02Z		C			Location component for position		−0.020				Z location at X = 30, datum feature B used to stop rotation

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: The position measured value is calculated for each end of the feature axis. The larger of the two values is the method B reported value for the feature. For this example, the two calculations are as follows:

$$4.01 \text{ position measured value} = 2\sqrt{(-0.04)^2 + 0.11^2} = 0.234$$

$$4.02 \text{ position measured value} = 2\sqrt{0.05^2 + (-0.02)^2} = 0.108$$

The first calculation provides the method B reported value for the feature, since it is larger than the value calculated for the other end of the feature axis.

Figure 8-3 Position at RFS Defining a Two-Parallel-Plane Tolerance Zone

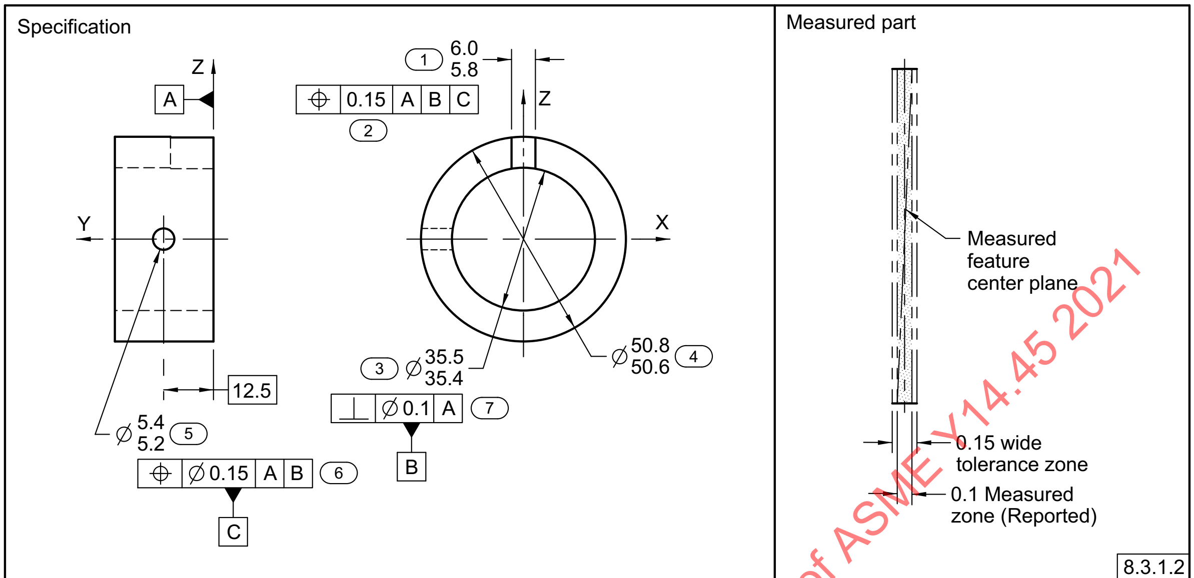


Figure 8-4 Example Data Report for Figure 8-3

ASME Y14.45 Single Part Data Report Example											
Part #:		Drawing #:			Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
2	POS	B			Position 0.15 A B C	0.150	0.100	Y			
2.01X		C			Location component for position		0.050				at Y = −1.0, Z = 24.5
2.02X		C			Location component for position		0.030				at Y = −12.5, Z = 21.25
2.03X		C			Location component for position		−0.015				at Y = −1.0, Z = 18

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: A position measured value is calculated for each location component on the feature center plane. The largest of the three values is the method B reported value for the feature. For this example, the three calculations are as follows:

$$2.01\ \text{position measured value} = 2|0.050| = 0.100$$

$$2.02\ \text{position measured value} = 2|0.03| = 0.060$$

$$2.03\ \text{position measured value} = 2|-0.015| = 0.030$$

Position measured value 2.01 provides the method B reported value for the feature, since it is the largest of the three calculated measured values.

Figure 8-5 Position at RFS Defining a Spherical Tolerance Zone

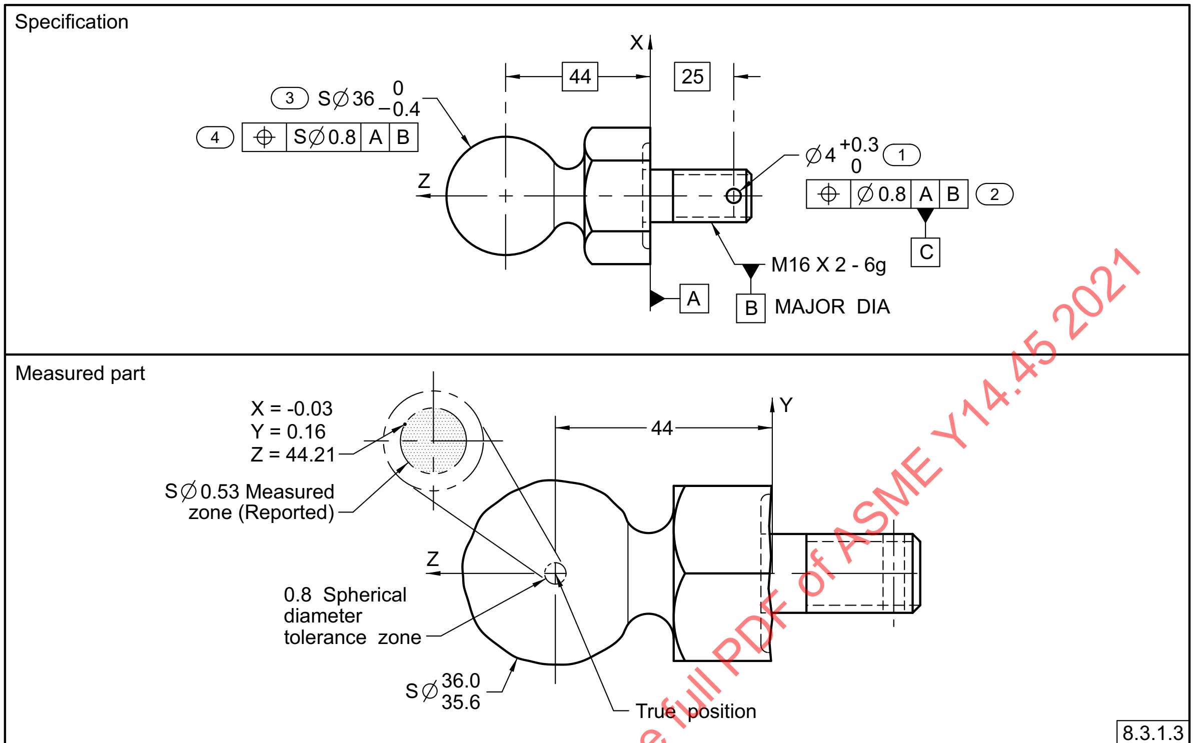


Figure 8-6 Example Data Report for Figure 8-5

ASME Y14.45 Single Part Data Report Example											
Part #:		Drawing #:			Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
4	POS	B			Position | SØ0.8 | A | B	0.80	0.53	Y			
4.01X		C			Location component for position		−0.03				Using datum feature C to stop rotation
4.01Y		C			Location component for position		0.16				Using datum feature C to stop rotation
4.01Z		C			Location component for position		44.21				Using datum feature C to stop rotation

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: The method B reported value for this example is calculated as follows:

$$\text{reported value} = 2\sqrt{(-0.03)^2 + 0.16^2 + (44 - 44.21)^2} = 0.53$$

Figure 8-7 Bidirectional Position at RFS Applied to the Axis of Cylindrical Features

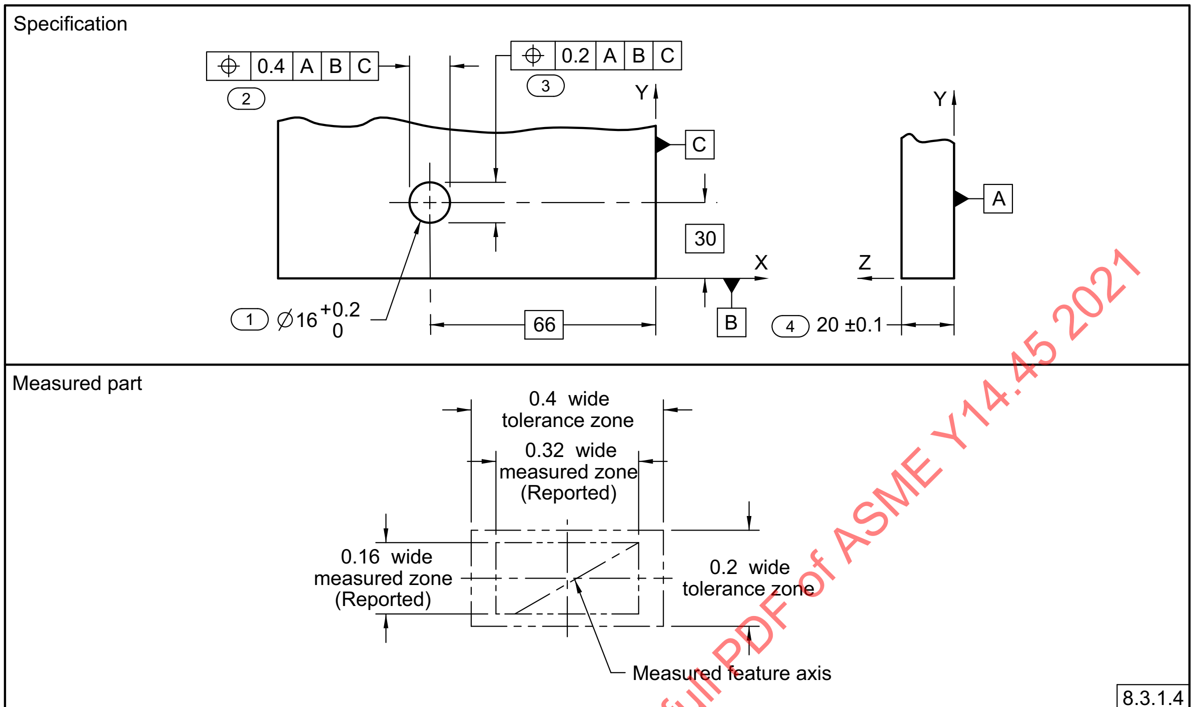


Figure 8-8 Example Data Report for Figure 8-7

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:		Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
2	POS	B			⌖ 0.4 A B C	0.40	0.32	Y			Measured position value
2.01X		C			Location component for position		−66.09				X location at Z = 0
2.02X		C			Location component for position		−65.84				X location at Z = 20
3	POS	B			⌖ 0.2 A B C	0.20	0.16	Y			Measured position value
3.01Y		C			Location component for position		29.92				Y location at Z = 0
3.02Y		C			Location component for position		30.08				Y location at Z = 20

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE:
A position measured value for each of the two position tolerances is calculated at both ends of the measured feature axis. For each of the two position tolerances, the larger of the two values is the method B reported value for the feature. For this example, the two calculations for tolerance 2 are as follows:

$$2.01 \text{ position measured value} = 2\left|-66 - (-66.09)\right| = 0.18$$

$$2.02 \text{ position measured value} = 2\left|-66 - (-65.84)\right| = 0.32$$

The second calculation for this tolerance provides the method B reported value for the feature, since it is larger than the value calculated for the other end of the measured feature axis.
For this example, the two calculations for tolerance 3 are as follows:

$$3.01 \text{ position measured value} = 2|30 - 29.92| = 0.16$$

$$3.02 \text{ position measured value} = 2|30 - 30.08| = 0.16$$

Either calculation for this tolerance provides the method B reported value for the feature, since they are the same.

Figure 8-9 Polar Coordinate Position at RFS Applied to the Axis of a Cylindrical Feature

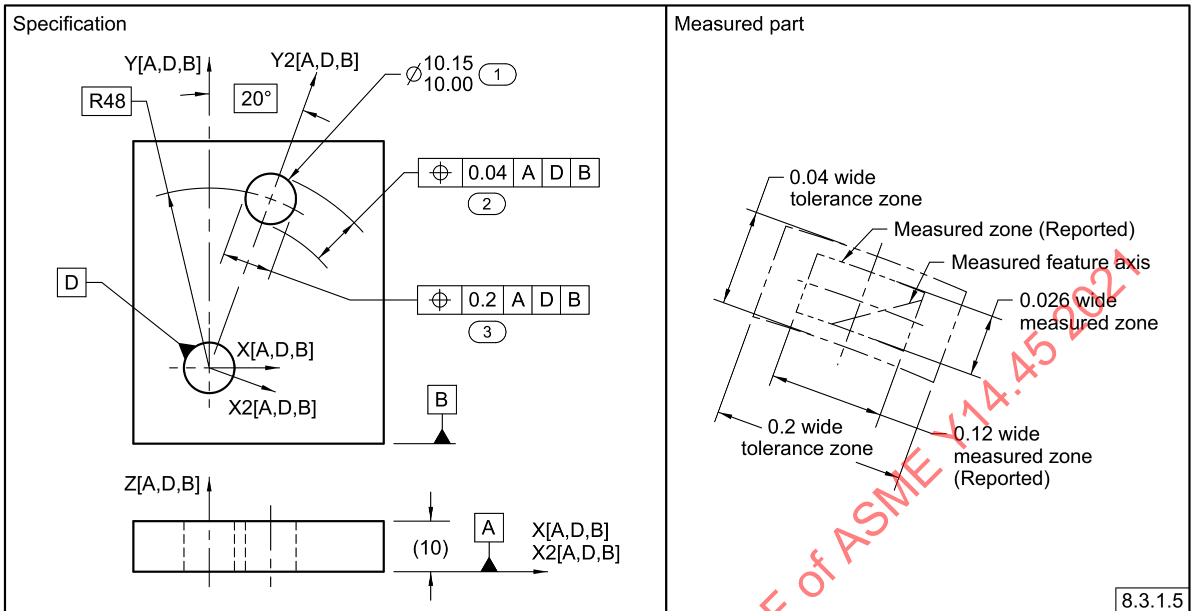


Figure 8-10 Example Data Report for Figure 8-9

ASME Y14.45 Single Part Data Report Example												
Part #:		Drawing #:			Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:	
Part Name:					Part Serial #:	Inspection Plan #:					Report #:	
Characteristic Identifier	**Characteristic Type**	***ASME Y14.45 Method**	**Reference Location**	**Characteristic Designator**	**Specification**	****Calculated Acceptance Limit(s)**	**Reported Value**	**Accept (Y or N)**	**Tooling/Equipment**	**Nonconformance #**	**Comments**	
2	POS	B			⌖ 0.04 A D B	0.04	0.026	Y			Measured radial direction position value	
2.01R		C			Location component for position		48.009				Radial location at Z = 0	
2.02R		C			Location component for position		47.987				Radial location at Z = 10	
3	POS	B			⌖ 0.2 A D B	0.20	0.012	Y			Measured lateral direction position value	
3.01X2		C			Location component for position		0.06				X2 location at Z = 0	
3.02X2		C			Location component for position		−0.02				X2 location at Z = 10	

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: The measured value for each of the two position tolerances is calculated at both ends of the measured feature axis. For each of the two position tolerances, the larger of the two values is the method B reported value for the feature. For this example, the two calculations for tolerance 3 are as follows:

$$3.01\ \text{position measured value} = 2|48 - 48.009| = 0.018$$

$$3.02\ \text{position measured value} = 2|48 - 47.987| = 0.026$$

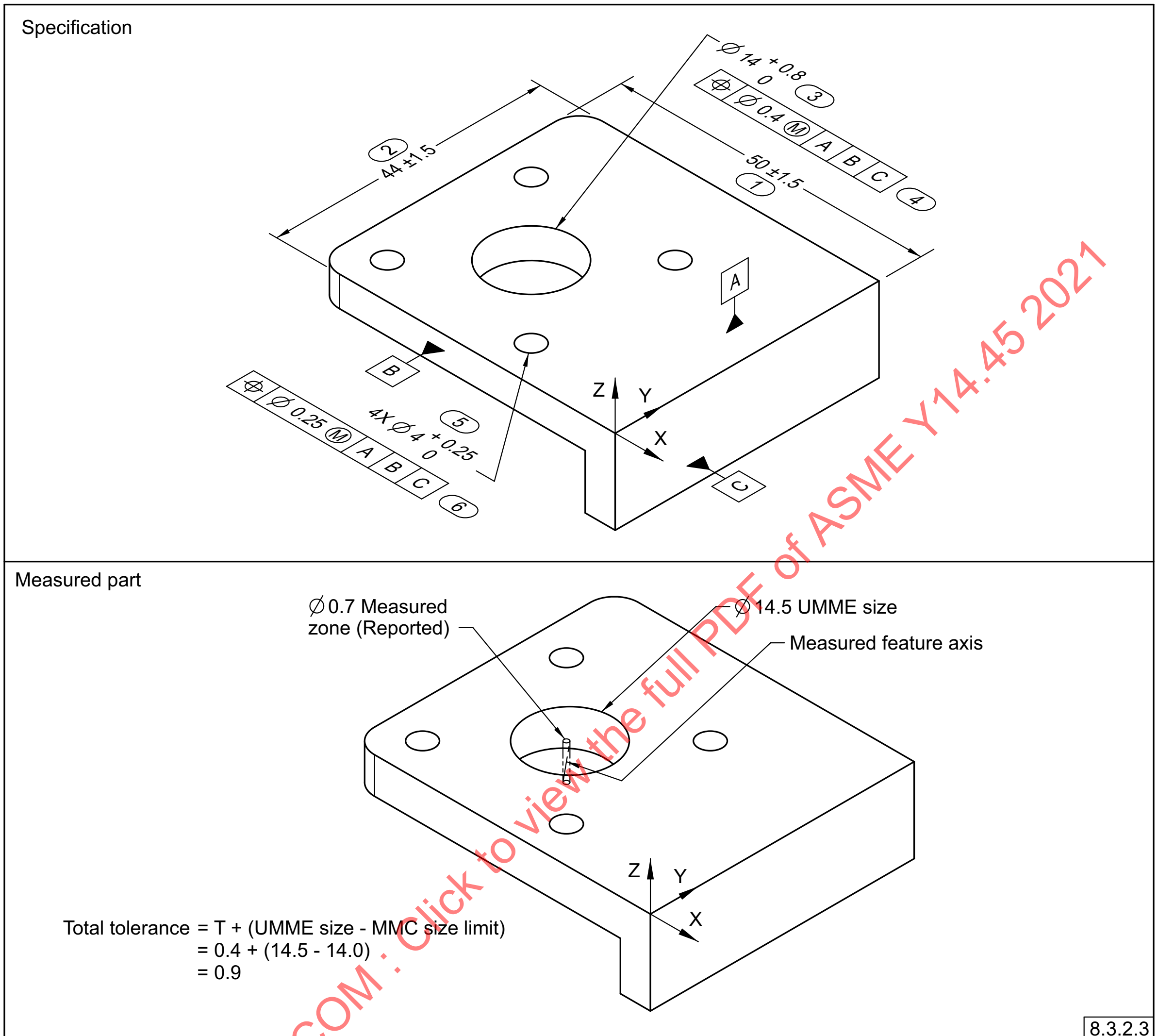
The second calculation for this tolerance provides the method B reported value for the feature, since it is larger than the value calculated for the other end of the measured feature axis. The two calculations for tolerance 4 are as follows:

$$4.01\ \text{position measured value} = 2|0.06| = 0.12$$

$$4.02\ \text{position measured value} = 2\,|-0.02| = 0.04$$

The first calculation for this tolerance provides the method B reported value for the feature, since it is larger than the measured value calculated for the other end of the measured feature axis.

Figure 8-11 Position at MMC Applied to the Axis of a Cylindrical Feature, Resolved Geometry Method



GENERAL NOTE: UMME = unrelated measured mating envelope.

Figure 8-12 Example Data Report for Figure 8-11

ASME Y14.45 Single Part Data Report Example												
Part #:			Drawing #:		Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:	
Part Name:					Part Serial #:	Inspection Plan #:					Report #:	
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments	
3	MMC	B			Ø14 $^{+0.8}_{0}$	14.00	14.5	Y			UMME size	
3	LMC	B			Ø14 $^{+0.8}_{0}$	14.80	14.63	Y			Largest measured local size	
4	POS	B			Position Ø0.4 (M) A B C	0.90	0.70	Y			Resolved geometry method	
4.01X		C			Location component for position		−32.05				X location at Z = 0	
4.01Y		C			Location component for position		17.98				Y location at Z = 0	
4.02X		C			Location component for position		−31.73				X location at Z = −5	
4.02Y		C			Location component for position		18.22				Y location at Z = −5	

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTES:

(a) UMME = unrelated measured mating envelope.

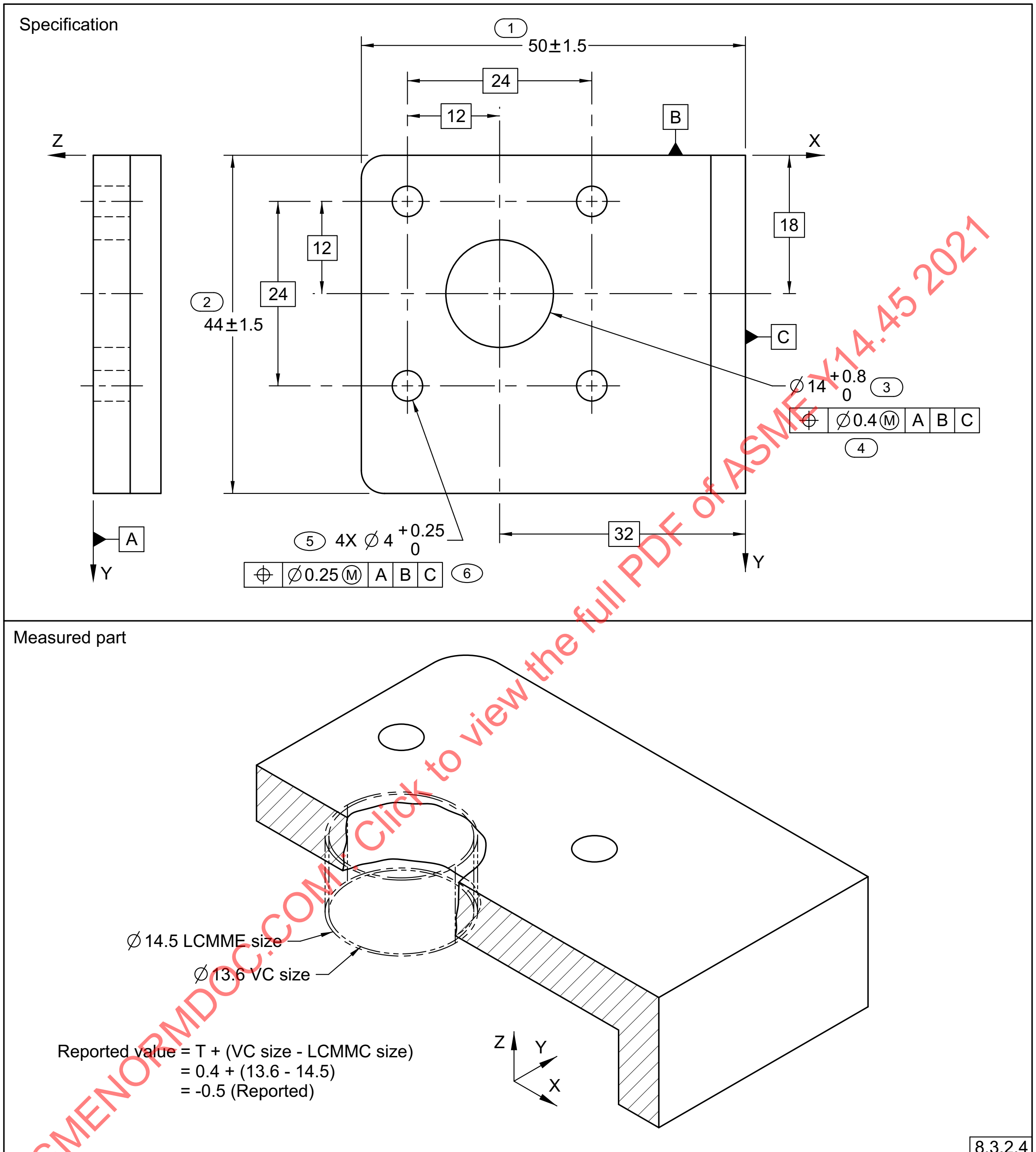
(b) A position measured value for each end of the measured feature axis for this example is calculated as follows:

$$4.01\ \text{position measured value} = 2\sqrt{[-32-(-32.05)]^2+(18-17.98)^2} = 0.11$$

$$4.02\ \text{position measured value} = 2\sqrt{[-32-(-31.73)]^2+(18-18.22)^2} = 0.70$$

The larger of the two measured values is the method B reported value for the feature.

Figure 8-13 Position at MMC Applied to the Axis of a Cylinder, Surface Method



GENERAL NOTE: LCMME = location-constrained measured mating envelope.

Figure 8-14 Example Data Report for Figure 8-13

ASME Y14.45 Single Part Data Report Example

Part #:	**Drawing #:**	**Drawing Revision:**	**3D CAD Model #:**	**3D CAD Model Revision:**
Part Name:		**Part Serial #:**	**Inspection Plan #:**	**Report #:**

Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
4	POS	B			Position Ø0.4 (M) A B C	0.40	−0.50	Y			Surface method, LCMME size = 14.5

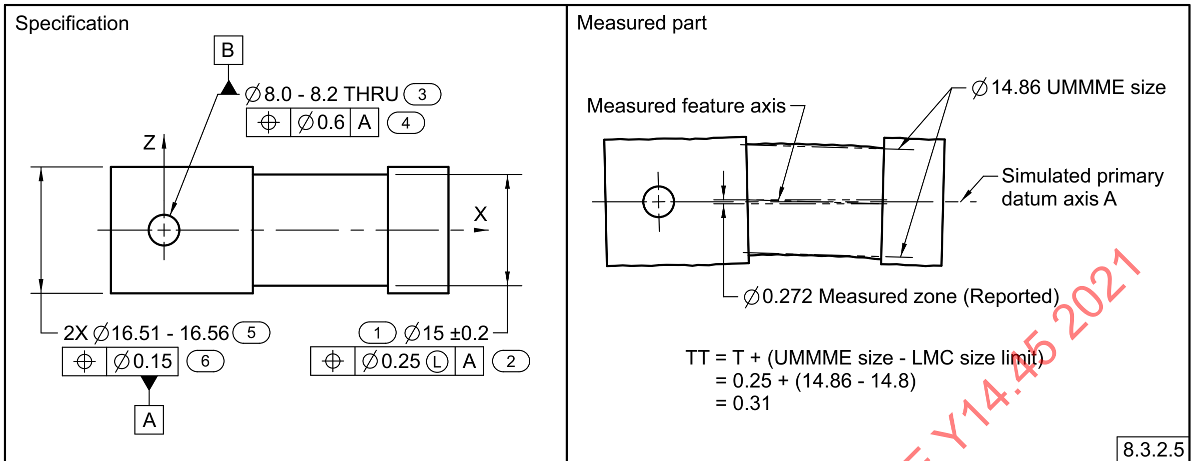
* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTES:
(a) LCMME = location-constrained measured mating envelope.
(b) The method B reported value for this example is calculated as follows:

$$\text{reported value} = T + (\text{VC} - \text{LCMME}) = 0.4 + (13.6 - 14.5) = -0.5$$

Figure 8-15 Position at LMC Applied to the Axis of a Cylinder, Resolved Geometry Method



GENERAL NOTE: UMMME = unrelated measured minimum material envelope.

Figure 8-16 Example Data Report for Figure 8-15

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:		Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	**Characteristic Type**	***ASME Y14.45 Method**	**Reference Location**	**Characteristic Designator**	**Specification**	****Calculated Acceptance Limit(s)**	**Reported Value**	**Accept (Y or N)**	**Tooling/Equipment**	**Nonconformance #**	**Comments**
2	POS	B			⌖ | ⌀0.25Ⓛ | A	0.31	0.272	Y			Measured position value, resolved geometry method
2.01Z		C			Location component for position		0.040				Z location at X = 15, using datum feature B to stop rotation
2.01Y		C			Location component for position		−0.090				Y location at X = 15, using datum feature B to stop rotation
2.02Z		C			Location component for position		−0.080				Z location at X = 30, using datum feature B to stop rotation
2.02Y		C			Location component for position		−0.110				Y location at X = 30, using datum feature B to stop rotation

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

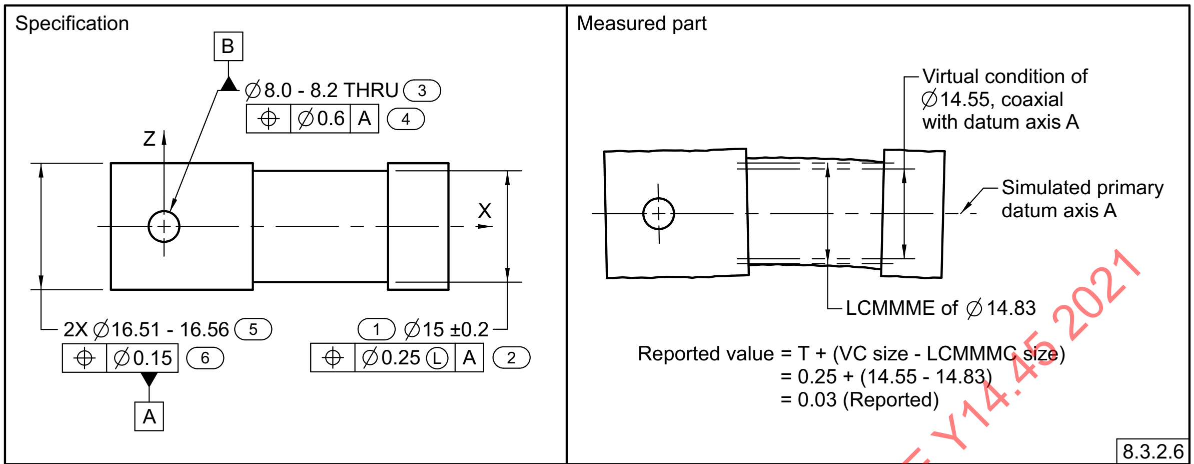
GENERAL NOTE: A position measured value for each end of the measured feature axis for this example is calculated as follows:

$$2.01\ \text{position measured value} = 2\sqrt{0.04^2 + (-0.09)^2} = 0.197$$

$$2.02\ \text{position measured value} = 2\sqrt{(-0.08)^2 + (-0.11)^2} = 0.272$$

The larger of the two measured values is the method B reported value for the feature.

Figure 8-17 Position at LMC Applied to the Axis of a Cylinder, Surface Method



GENERAL NOTE: LCMMME = location-constrained measured minimum material envelope.

Figure 8-18 Example Data Report for Figure 8-17

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:			Drawing Revision:	3D CAD Model #:				3D CAD Model Revision:
Part Name:						Part Serial #:	Inspection Plan #:				Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
2	POS	B			Position Ø0.25 (L) A B	0.25	−0.030	Y			Surface method, LCMMME size = 14.830

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTES:
(a) LCMMME = location-constrained measured minimum material envelope.
(b) The method B reported value for this example is calculated as follows:

$$\text{reported value} = T + (\text{VC} - \text{LCMMME}) = 0.25 + (14.550 - 14.830) = -0.030$$

Section 9
Measurement Data Reporting for Profile Tolerances

9.1 GENERAL

This Section establishes requirements for method B data reporting for profile tolerances, including profile of a line and profile of a surface. It also defines method C surface deviations for profile tolerances and provides example measurement data reports that include method C surface deviations.

9.2 PROFILE OF A LINE DATA

Paragraphs 9.2.1 and 9.2.2 define the requirements for reporting method B data and method C surface deviations for profile of a line tolerances.

9.2.1 Method B Data for Profile of a Line Tolerances

For each measured cross section of the feature, the measured value is the distance between the boundaries of the measured zone that is just large enough to contain all the measured points on the cross section of the feature.

Each measured zone is established by optimizing the relationship between all measured points along a given cross section and the measured zone boundaries using any degrees of freedom available. The thickness of the measured zone is then adjusted such that it is just large enough to contain all the measured points. The measured zone thickness is adjusted by offsetting from both tolerance zone boundaries equally. The offset distance and direction are defined as a single value that applies to both measured zone boundaries, called the growth parameter, g. The sign of g is positive if the measured zone boundary is moved outside the associated tolerance zone boundary (nonconforming condition) or negative if the measured zone boundary is moved inside the associated tolerance zone boundary (conforming condition). The signed value for g is then multiplied by 2 to get the total change in measured zone thickness, relative to the tolerance zone thickness. The measured value is equal to the tolerance value, T, plus the total change in measured zone thickness, $2g$, so the profile of a line measured value = $T + 2g$. This measured value is calculated for each measured cross section. The method B reported value for the feature is the largest method B profile of a line measured value found from the measured cross sections.

9.2.2 Method C Surface Deviations for Profile of a Line Tolerances

Method C surface deviations for profile of a line tolerances are gathered for each measured cross section of the measured feature. The surface deviation values are used to determine the profile measured value for each cross section, based on the high or low extreme surface deviation value that will yield the largest profile measured value. These surface deviation values will be closest to a tolerance zone boundary for a conforming cross section or farthest from a tolerance zone boundary for a nonconforming cross section. When more material than true profile exists at a measured location, the surface deviation shall be a positive value. When less material than true profile exists at a measured location, the surface deviation shall be a negative value.

NOTE: The location of each surface deviation value should be indicated in some manner. For example, the (X, Y, Z) coordinates of surface deviation values for each measured point may be included in a comment cell of the measurement data report. The (X, Y, Z) coordinates represent the location of the measured point relative to the datum reference frame or a reporting coordinate system. If this practice is used, the axes for each relevant datum reference frame or reporting coordinate system shall be included on a drawing or 3D CAD model.

9.3 PROFILE OF A SURFACE DATA

Paragraphs 9.3.1 and 9.3.2 define method B data and method C surface deviation reporting for profile of a surface tolerances.

9.3.1 Method B Data for Profile of a Surface Tolerances

The measured value is the distance between the boundaries of the measured zone that is just large enough to contain all the measured points of the feature.

The measured zone is established by optimizing the relationship between all measured points on the feature and the measured zone boundaries using any degrees of freedom available. The thickness of the measured zone is then adjusted such that it is just large enough to contain all of the measured points. The measured zone thickness is adjusted by offsetting both measured zone boundaries equally relative to the tolerance zone boundaries. The offset distance and direction are defined as a single value, called the growth parameter, g, that applies to both measured zone boundaries. The sign of g is positive if the measured zone boundary is moved outside the associated tolerance zone boundary (nonconforming condition) or negative if the measured zone boundary is moved inside the associated tolerance zone boundary (conforming condition). The signed value for g is then multiplied by 2 to get the total change in measured zone thickness relative to the tolerance zone thickness. The method B profile of a surface measured value is equal to the specified tolerance value, T, plus the total change in zone thickness, $2g$, so the method B profile of a surface measured value = $T + 2g$. The method B reported value is the measured value.

See Figures 9-1 through 9-4.

NOTE: This Section defines reporting methods for uniform profile of a surface. Nonuniform profile of a surface can be reported using method A or method C, but no method B measured value exists for nonuniform profile of a surface.

9.3.2 Method C Surface Deviations for Profile of a Surface

Method C surface deviations for profile of a surface tolerances are gathered for the measured feature. The surface deviation values are used to determine the profile measured value for the feature, based on the high or low extreme surface deviation values that will yield the largest measured value. This surface deviation value will be closest to a tolerance zone boundary for a conforming cross section or farthest from a tolerance zone boundary for a nonconforming cross section. See note in para. 9.2.2.

9.4 PROFILE OF A LINE OR PROFILE OF A SURFACE DATA WHEN THE DYNAMIC TOLERANCE ZONE MODIFIER IS SPECIFIED

The measured value is the distance between the boundaries of the measured zone that is just large enough to contain all the measured points of the feature. This distance is the difference between the largest surface deviation and the smallest surface deviation. The method B reported value is the measured value:

$$\text{reported value} = \text{LSD} - \text{SSD}$$

NOTES:

(1) The measured surface deviations may be all positive, all negative, or a mixture of positive and negative. Within the set of deviations, one will be largest (most positive) and one will be smallest (most negative). Those two deviation values are used to calculate the measured value.

(2) In the equation above, LSD = largest surface deviation, and SSD = smallest surface deviation.

See Figures 9-5 and 9-6.

Figure 9-1 Profile of a Surface, Equal Bilateral Tolerance Zone

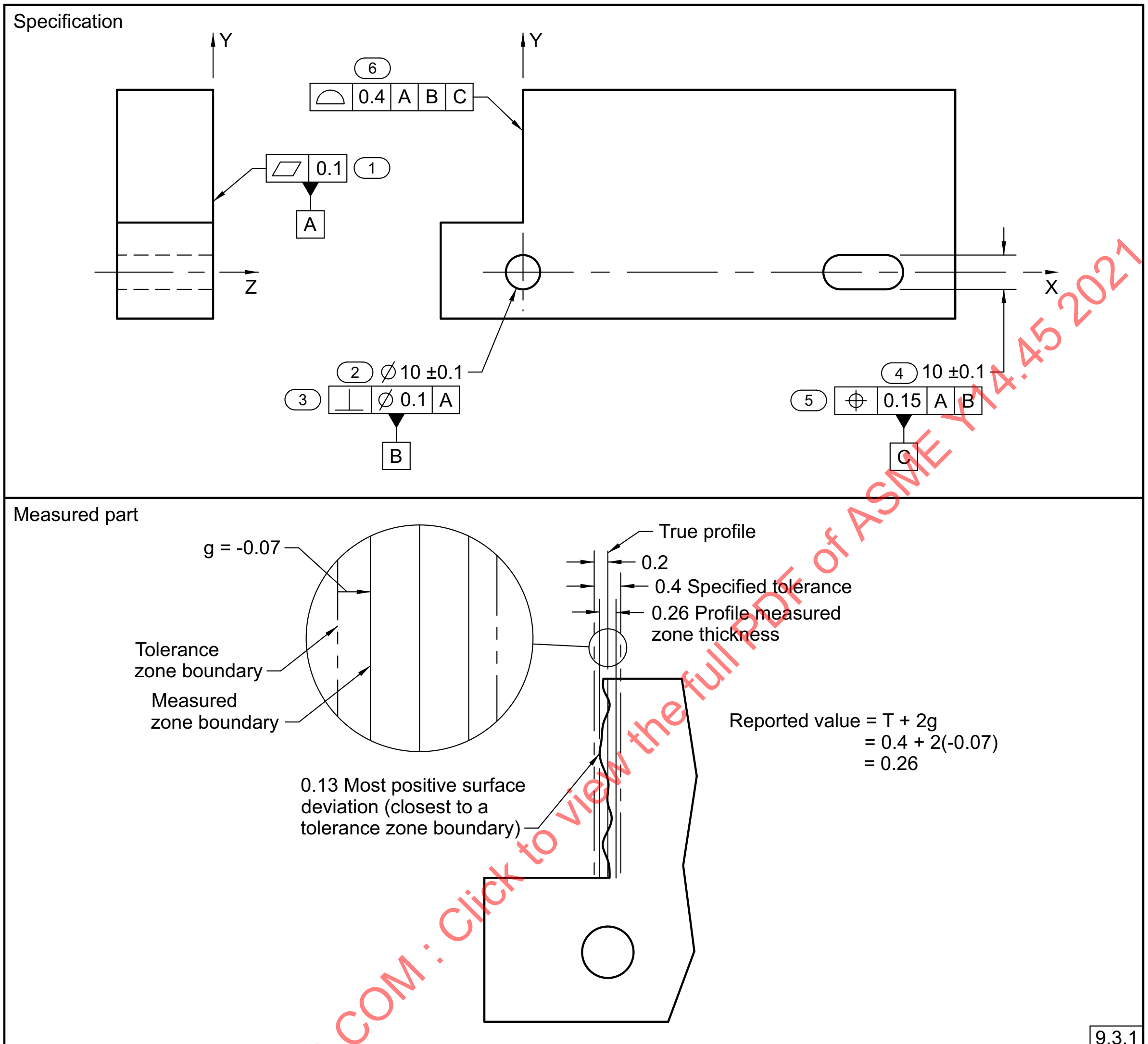


Figure 9-2 Example Data Report for Figure 9-1

ASME Y14.45 Single Part Data Report Example											
Part #:			**Drawing #:**		**Drawing Revision:**	**3D CAD Model #:**					**3D CAD Model Revision:**
Part Name:					**Part Serial #:**	**Inspection Plan #:**					**Report #:**
Characteristic Identifier	**Characteristic Type**	***ASME Y14.45 Method**	**Reference Location**	**Characteristic Designator**	**Specification**	****Calculated Acceptance Limit(s)**	**Reported Value**	**Accept (Y or N)**	**Tooling/Equipment**	**Nonconformance #**	**Comments**
6	PRS	B			⌓ 0.4 A B C	0.4	0.26	Y			
6.01		C			Surface deviation for profile		0.05				(X,Y,Z) is (−0.05, 20.00, −25.00); g = −0.15; measured profile value = 0.4 + 2(−0.15) = 0.1
6.02		C			Surface deviation for profile		0.06				(X,Y,Z) is (−0.06, 20.00, −5.00); g = −0.14; measured profile value = 0.4 + 2(−0.14) = 0.12
6.03		C			Surface deviation for profile		−0.06				(X,Y,Z) is (0.06, 27.50, −15.00); g = −0.14; measured profile value = 0.4 + 2(−0.14) = 0.12
6.04		C			Surface deviation for profile		0.03				(X,Y,Z) is (-0.03, 35.00, -25.00); g = −0.17; measured profile value = 0.4 + 2(−0.17) = 0.06
6.05		C			Surface deviation for profile		0.04				(X,Y,Z) is (-0.04, 35.00, -5.00); g = −0.16; measured profile value = 0.4 + 2(−0.16) = 0.08
6.06		C			Surface deviation for profile		0.13				(X,Y,Z) is (−0.13, 42.50, −15.00); surface deviation that is closest to a tolerance zone boundary; g = − 0.07; measured profile value = reported value = 0.4 + 2(−0.07) = 0.26
6.07		C			Surface deviation for profile		0.02				(X,Y,Z) is (−0.02, 50.00, −25.00); g = −0.18; measured profile value = 0.4 + 2(−0.18) = 0.04
6.08		C			Surface deviation for profile		0.01				(X,Y,Z) is (−0.01, 50.00, −5.00); g = −0.19; measured profile value = 0.4 + 2(−0.19) = 0.02

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 9-3 Profile of a Surface, Unequal Tolerance Zone

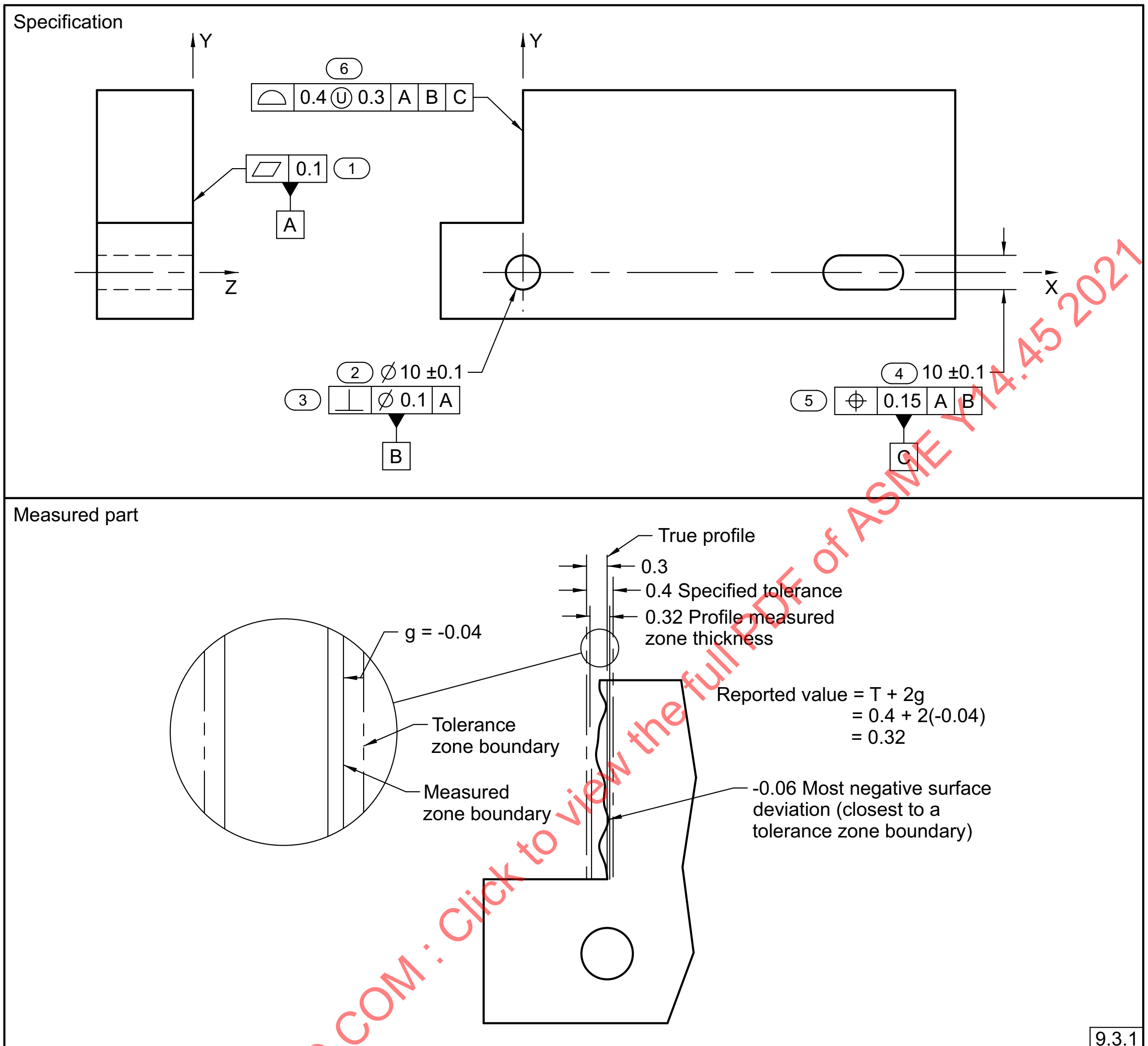


Figure 9-4 Example Data Report for Figure 9-3

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:		Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
6	PRS	B			|Profile|0.4 (U) 0.3|A|B|C|	0.4	0.32	Y			
6.01		C			Surface deviation for profile		0.05				(X,Y,Z) is (−0.05, 20.00, −25.00); g = −0.15; measured profile value = 0.4 + 2(−0.15) = 0.1
6.02		C			Surface deviation for profile		0.06				(X,Y,Z) is (−0.06, 20.00, −5.00); g = −0.16; measured profile value = 0.4 + 2(−0.16) = 0.08
6.03		C			Surface deviation for profile		−0.06				(X,Y,Z) is (0.06, 27.50, −15.00); surface deviation that is closest to a tolerance zone boundary; g = −0.04; measured profile value = reported value = 0.4 + 2(−0.04) = 0.32
6.04		C			Surface deviation for profile		0.03				(X,Y,Z) is (−0.03, 35.00, −25.00); g = −0.13; measured profile value = 0.4 + 2(−0.13) = 0.14
6.05		C			Surface deviation for profile		0.04				(X,Y,Z) is (−0.04, 35.00, −5.00); g = −0.14; measured profile value = 0.4 + 2(−0.14) = 0.12
6.06		C			Surface deviation for profile		0.13				(X,Y,Z) is (−0.13, 42.50, −15.00); g =−0.17; measured profile value = 0.4 + 2(−0.17) = 0.06
6.07		C			Surface deviation for profile		0.02				(X,Y,Z) is (−0.02, 50.00, −25.00); g = −0.12; measured profile value = 0.4 + 2(−0.12) = 0.16
6.08		C			Surface deviation for profile		0.01				(X,Y,Z) is (−0.01, 50.00, −5.00); g = −0.11; measured profile value = 0.4 + 2(−0.11) = 0.18

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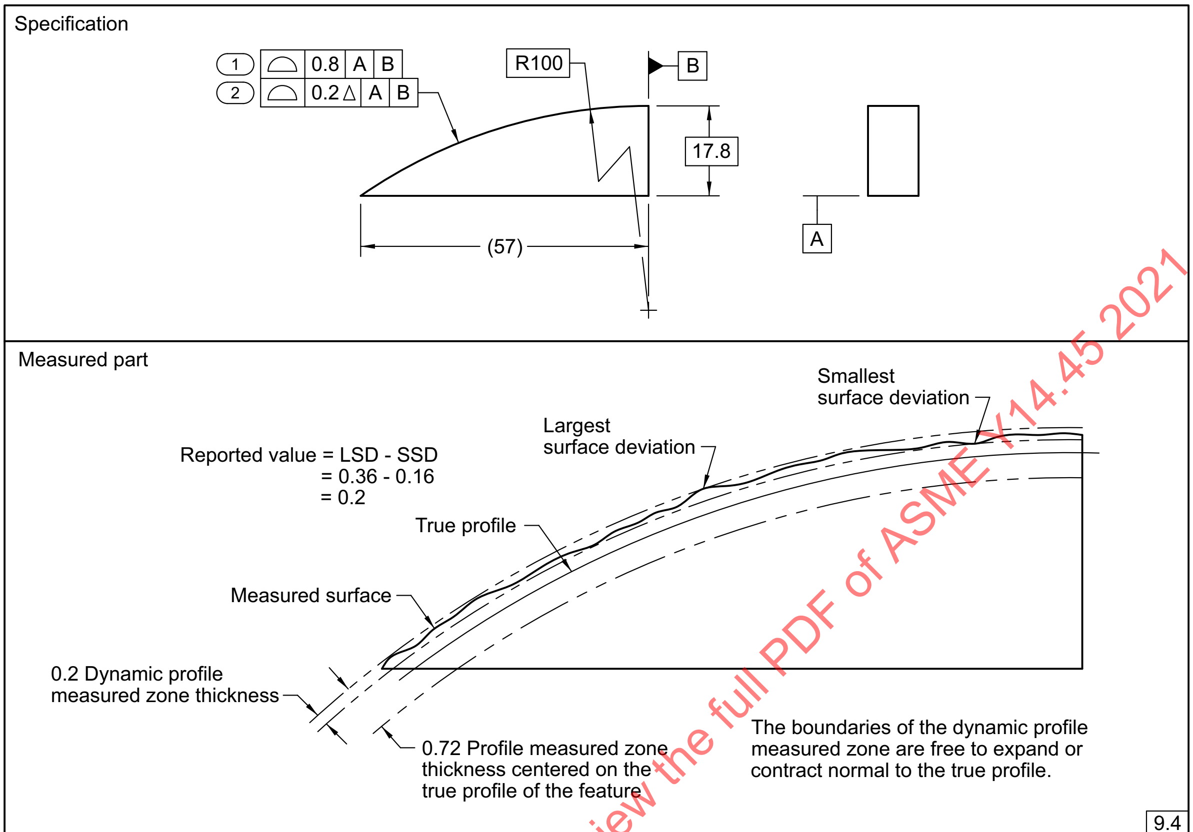
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

Figure 9-5 Dynamic Profile



GENERAL NOTE: LSD = largest surface deviation; SSD = smallest surface deviation.

Figure 9-6 Example Data Report for Figure 9-5

ASME Y14.45 Single Part Data Report Example

Part #:	**Drawing #:**	**Drawing Revision:**	**3D CAD Model #:**	**3D CAD Model Revision:**
Part Name:		**Part Serial #:**	**Inspection Plan #:**	**Report #:**

Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
1	PRS	B			Surface profile 0.8 A B	0.8	0.72	Y			
1.01		C			Surface deviation for profile		0.36				Surface deviation that is closest to a tolerance zone boundary; g = −0.04; reported value = 0.8 + 2(−0.04) = 0.72
1.02		C			Surface deviation for profile		0.31				See measurement plan for location of point
1.03		C			Surface deviation for profile		0.33				See measurement plan for location of point
1.04		C			Surface deviation for profile		0.25				See measurement plan for location of point
1.05		C			Surface deviation for profile		0.16				See measurement plan for location of point
2	PRS	B			Surface profile 0.2 dynamic A B	0.2	0.2	Y			LSD − SSD = reported profile value = 0.36 − 0.16 = 0.2

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.

GENERAL NOTE: LSD = largest surface deviation; SSD = smallest surface deviation.

Section 10
Measurement Data Reporting for Runout Tolerances

10.1 GENERAL

This Section establishes requirements for method B data reporting for circular runout and total runout tolerances.

10.2 CIRCULAR RUNOUT

For each measured circular element of the feature, the measured value is the size of the measured zone that is just large enough to contain the measured circular element of the feature. The size of the measured zone is one of the following:

(a) the distance, measured normal to the feature's true geometry, between two circular boundaries that are centered on the datum axis and lie in one plane or in two planes that are normal to the datum axis for a surface of revolution feature.

(b) the distance, measured parallel to the datum axis, between two circular boundaries that are of the same diameter. The two circular boundaries are centered on the datum axis, lie in planes that are normal to the datum axis, and are axially separated for a planar surface that is perpendicular to the datum axis.

The method B reported value is the largest measured value. See Figures 10-1 and 10-2.

10.3 TOTAL RUNOUT

The measured value is the size of the measured zone that is just large enough to contain the surface of the measured surface of revolution feature. The size of the measured zone is the distance between two boundaries, which are cylinders that are coaxial with the datum axis for cylindrical features or two parallel planes that are perpendicular to the datum axis for planar features. The method B reported value is the measured value. See Figures 10-3 and 10-4.

Figure 10-1 Circular Runout

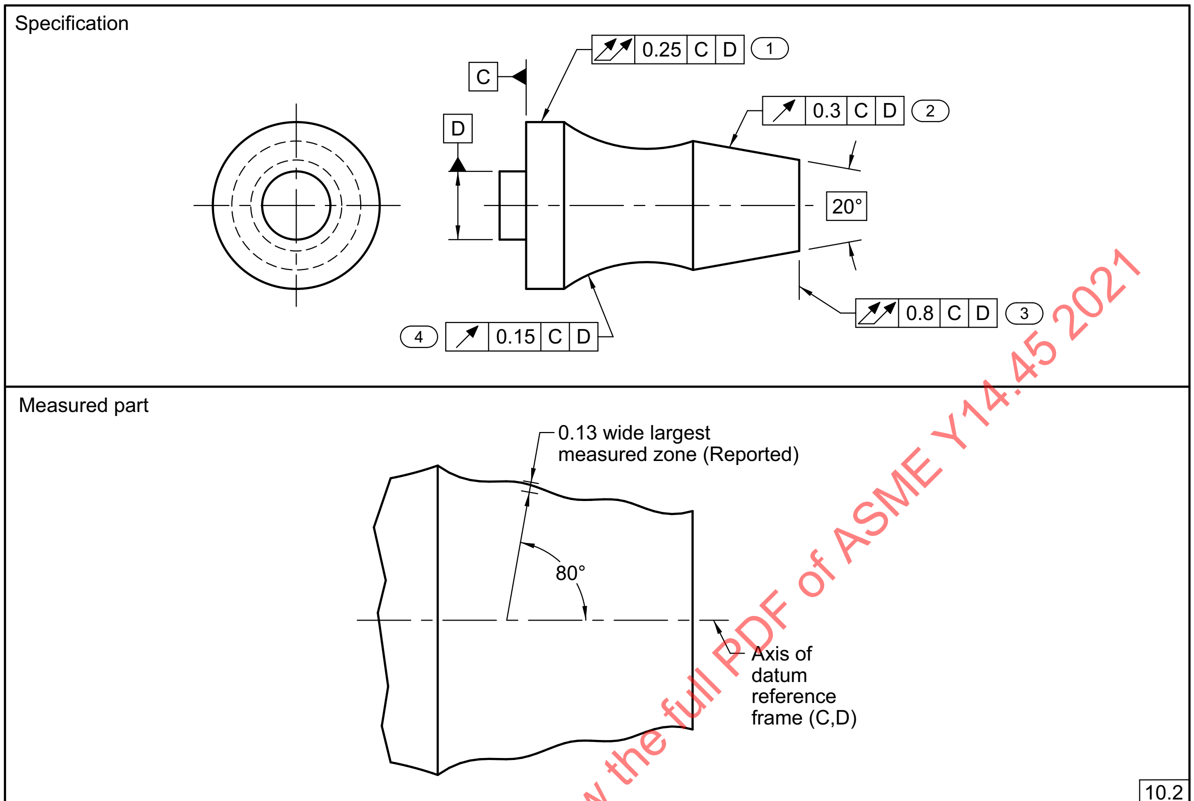


Figure 10-2 Example Data Report for Figure 10-1

ASME Y14.45 Single Part Data Report Example											
Part #:			Drawing #:		Drawing Revision:	3D CAD Model #:					3D CAD Model Revision:
Part Name:					Part Serial #:	Inspection Plan #:					Report #:
Characteristic Identifier	Characteristic Type	*ASME Y14.45 Method	Reference Location	Characteristic Designator	Specification	**Calculated Acceptance Limit(s)	Reported Value	Accept (Y or N)	Tooling/Equipment	Nonconformance #	Comments
2	CRN	B			↗ 0.3 | C | D	0.30	0.13	Y			Largest full indicator movement (FIM) from all sampled locations

* ASME Y14.45, Measurement Data Reporting, includes methods A, B, and C as data categories that may be specified on a measurement plan or other document:
Method A is attribute (pass/fail) data.
Method B is variable data such as a size, profile, or position value.
Method C is variable data to provide additional information, such as profile surface deviations or position location components.

**Calculated acceptance limit(s) may include guard banding and/or bonus tolerance considerations.