ASME Y14.5.2-2017
(Revision of ASME Y14.5.2-2000)

Certification of Geometric Dimensioning and Tolerancing Professionals

Engineering Product Definition and Related Documentation Practices

The American Society of Mechanical Engineers

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(Revision of ASME Y14.5.2-2000)

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The American Society of Mechanical Engineers
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FOREWORD

The American Society of Mechanical Engineers (ASME), recognizing the needs and benefits associated with standard qualifications for professionals using the ASME Y14.5 Standard, established the Y14.5.2 Subcommittee on Certification in October 1988. The Subcommittee was instructed to develop a standard that could be used as the basis of an ASME Program for Certification of Geometric Dimensioning and Tolerancing Professionals (GDTP). This program provides the means to ensure proficiency in the understanding and application of the geometric dimensioning and tolerancing principles expressed in ASME Y14.5. Those principles form an essential element of engineering language.

This is a voluntary standard that sets forth the qualifications for two levels of certification. The first level, Technologist GDTP, provides a measure of an individual's ability to understand drawings that have been prepared using the language of geometric dimensioning and tolerancing, as defined in the ASME Y14.5 Standard. The second level, Senior GDTP, provides the additional measure of an individual's ability to select and apply geometric controls to drawings.

Primary changes to this revision are higher percentages of questions per section to increase the application's emphasis on geometric dimensioning and tolerancing and to revise the criteria for passing the examination.

The original Standard was approved by the Board on Standardization on April 26, 1995. This revised Standard was approved by the Board on Standardization on May 18, 2017.

IN MEMORIAM: In memory of Don Day for his significant contributions to the development of this Standard and to the geometric dimensioning and tolerancing community.

ASME Y14 COMMITTEE
Engineering Product Definition and Related Documentation Practices

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

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

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

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

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

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

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

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

CERTIFICATION OF GEOMETRIC DIMENSIONING AND TOLERANCING PROFESSIONALS

1 INTRODUCTION

1.1 Scope

This Standard establishes certification requirements for a geometric dimensioning and tolerancing professional (GDTP). Certification shall be based on either ASME Y14.5M-1994 or ASME Y14.5-2009, its appendices, and the application of its principles and concepts.

1.2 Purpose

This Standard provides requirements and qualifications to be used in certifying a GDTP. These requirements and qualifications recognize the knowledge, training, and experience necessary to understand, apply, and teach the principles as set forth in ASME Y14.5M-1994 or ASME Y14.5-2009. A GDTP may be employed as, but is not limited to

(a) design engineer
(b) production or manufacturing engineer
(c) process engineer
(d) quality engineer
(e) tool or gage engineer
(f) engineering manager
(g) user or programmer of CAD, CAM, CAE, or other software
(h) drafter
(i) checker
(j) engineering consultant
(k) educator
(l) inspector
(m) contract engineer
(n) project engineer
(o) technical specialist

2 CERTIFICATION LEVELS AND QUALIFICATIONS

2.1 Certification Levels

There shall be two levels of GDTP certification:
(a) Technologist
(b) Senior

Certification indicates that the individual has demonstrated competence in the areas described in para. 2.1.1, 2.1.2, 2.1.3, or 2.1.4.

2.1.1 Technologist Level (ASME Y14.5M-1994 Examination). Certification indicates that the individual has demonstrated an understanding of the meaning of the symbols, modifiers, and relationships of geometric dimensioning and tolerancing (GD&T) as applied to engineering drawings and related documentation that conform to ASME Y14.5M-1994.

2.1.2 Technologist Level (ASME Y14.5-2009 Examination). Certification indicates that the individual has demonstrated competencies in reading and interpreting an engineering drawing that conforms to ASME Y14.5-2009. These include, but are not limited to, the following:

(a) understanding the rules, definitions, principles, and meanings of the symbols and modifiers of GD&T as applied to engineering drawings and related documentation
(b) understanding the functions and relationships of part features and geometric controls
(c) performing calculations associated with GD&T derived from the drawing and related documentation
(d) understanding that the application of GD&T has implications for manufacturing, quality control, and verification processes associated with engineering drawings and related documentation
(e) applying the principles of GD&T to the establishment of functional gaging activities

2.1.3 Senior Level (ASME Y14.5M-1994 Examination). Certification indicates that the individual has demonstrated competencies in application of the rules and principles required to generate an engineering drawing that conforms to ASME Y14.5M-1994. These include, but are not limited to, the following:

(a) understanding the meaning of the symbols, modifiers, and relationships of GD&T as applied to engineering drawings and related documentation that conform to ASME Y14.5M-1994
(b) making the proper selection, with consideration for the function and relationship of part features, of geometric controls to document the product design intent
(c) applying the appropriate geometric control symbols, modifiers, and datum references to the engineering drawings and related documentation
(d) applying the principles of GD&T to the operations of manufacturing, quality control, and verification processes associated with engineering drawings and related documentation
(e) applying the principles of GD&T to the establishment of functional gaging activities

2.1.4 Senior Level (ASME Y14.5-2009 Examination). Certification indicates that the individual has demonstrated competencies in the application of the rules and principles required to generate an engineering

drawing that conforms to ASME Y14.5-2009. These include, but are not limited to, the following:

(a) understanding the rules, definitions, principles, and meanings of the symbols and modifiers of GD&T as applied to engineering drawings and related documentation

(b) making the proper selection with consideration for the function and relationship of part features and geometric controls, to document the product design intent

(c) performing calculations associated with GD&T to determine the geometric requirements

(d) applying the appropriate geometric control symbols, modifiers, and datum references to the engineering drawings and related documentation

(e) applying the principles of GD&T to the operations of manufacturing, quality control, and verification processes associated with engineering drawings and related documentation

(f) applying the principles of GD&T to the establishment of functional gaging activities

2.2 Qualifications

2.2.1 Technologist GDTP. The requirement for certification for a Technologist GDTP is to successfully pass the Technologist GDTP examination.

2.2.2 Senior GDTP. The requirements for certification for a Senior GDTP are as follows:

(a) 5 yr of documented experience in the field of GD&T in the recognized use of the system in both application and understanding.

(b) successfully passing the Senior GDTP examination. An individual is not required to be a certified Technologist GDTP to qualify for taking the Senior GDTP examination.

2.2.3 Equivalencies. Note that ASME Y14.5-2009 is not equivalent to ASME Y14.5M-1994. Successfully passing the ASME Y14.5-2009 examination does not confer certification to ASME Y14.5M-1994. Successfully passing the ASME Y14.5M-1994 examination does not confer certification to ASME Y14.5-2009.

3 TEST REQUIREMENTS (EXAMINATION)

3.1 Technologist Level Examination

The Technologist level examination is a maximum of 4 hr in duration, consisting of 150 questions. The examination is a closed-book, multiple-choice, written examination evaluating the applicant's knowledge of GD&T principles, concepts, and practices in accordance with ASME Y14.5M-1994 or ASME Y14.5-2009. The topics for ASME Y14.5M-1994 certification are defined in Mandatory Appendix A, and those for ASME Y14.5-2009 certification are defined in Mandatory Appendix C. The approximate distribution of questions is as follows:

(a) ASME Y14.5M-1994 Examination

(1) 10% on scope, definitions, and general dimensioning

(2) 10% on general tolerancing and related principles, and former practices included in ASME Y14.5M-1994, Appendix D

(3) 5% on symbology

(4) 15% on datum referencing

(5) 30% on tolerances of location

(6) 30% on tolerances of form, profile, orientation, and runout

For the ASME Y14.5M-1994 examination, a candidate must achieve an overall grade of at least 75% and score at least 50% in each of the preceding categories.

(b) ASME Y14.5-2009 Examination

(1) 10% on scope

(2) 10% on general dimensioning

(3) 5% on symbology

(4) 20% on datum referencing

(5) 5% on form

(6) 5% on orientation

(7) 25% on location

(8) 15% on profile

(9) 5% on runout

For the ASME Y14.5-2009 examination, a candidate must achieve an overall grade of at least 78% and score at least 50% in each of the preceding categories.

3.2 Senior Level Examination

The Senior level examination is a maximum of 6 hr in duration, consisting of 150 questions. The examination is a closed-book, multiple-choice, written examination. The Senior level examination emphasizes knowledge, selection, and application of the dimensioning and tolerancing principles, concepts, and practices contained in ASME Y14.5M-1994 or ASME Y14.5-2009, including appendices. The topics for ASME Y14.5M-1994 certification are defined in Mandatory Appendix B, and those for ASME Y14.5-2009 certification are defined in Mandatory Appendix D. The approximate distribution of questions is as follows:

(a) ASME Y14.5M-1994 Examination

(1) 10% on topics from the Technologist level body of knowledge (see Mandatory Appendix A)

(2) 20% on datum selection

(3) 40% on geometric tolerancing and related principles, tolerance calculation, and ASME Y14.5M-1994 Appendices

(4) 15% on application of modifiers in feature control frames

(5) 15% on composite tolerancing

For the ASME Y14.5M-1994 examination, a candidate must achieve an overall grade of at least 80% and score at least 50% in each of the preceding categories.

(b) ASME Y14.5-2009 Examination

(1) 10% on scope, general dimensioning, symbology
(2) 30% on datum referencing
(3) 5% on form
(4) 5% on orientation
(5) 25% on location
(6) 20% on profile
(7) 5% on runout

For the ASME Y14.5-2009 examination, a candidate must achieve an overall grade of at least 78% and score at least 50% in each of the preceding categories.

4 CERTIFICATION PROCESS

4.1 Application

Each applicant for certification shall submit an application and include the required fees. The completed application shall contain sufficient information to allow verification of the applicant's experience or education in accordance with the requirements of para. 2.2. Applications for certification can be obtained from ASME.

4.2 Certification

A certificate will be issued to an applicant meeting the qualifications noted in para. 2.2 of this Standard.

The certificate will identify the specific edition of ASME Y14.5 on which the certification is based and will expire 3 yr from the date of issuance.

4.3 Recertification

Certification to ASME Y14.5M-1994 or ASME Y14.5-2009 may be renewed without examination upon verification of involvement with GD&T for at least 24 of the previous 36 months.

A verifiable record, such as a letter from the employer or a client, or other evidence of participation, shall be provided to ASME.

MANDATORY APPENDIX A
TECHNOLOGIST LEVEL BODY OF KNOWLEDGE FOR THE ASME Y14.5M-1994 EXAMINATION

This Appendix provides the body of knowledge upon which the Technologist level examination for certification to ASME Y14.5M-1994 is based. This Appendix is referenced in para. 3.1 of this Standard.

A-1 SCOPE, DEFINITIONS, AND GENERAL DIMENSIONING

(a) general
- *(1)* what ASME Y14.5M-1994 covers
- *(2)* reference to this Standard
- *(3)* reference to gaging

(b) definitions
- *(1)* datum
- *(2)* datum feature
- *(3)* datum target
- *(4)* dimension
- *(5)* basic dimension
- *(6)* reference dimension
- *(7)* feature
- *(8)* feature of size
- *(9)* full indicator movement (FIM)
- *(10)* least material condition (LMC)
- *(11)* maximum material condition (MMC)
- *(12)* regardless of feature size (RFS)
- *(13)* actual size
- *(14)* limits of size
- *(15)* tolerance
- *(16)* bilateral tolerance
- *(17)* geometric tolerance
- *(18)* unilateral tolerance
- *(19)* true position
- *(20)* virtual condition

(c) fundamental rules
- *(1)* dimensioning
- *(2)* implied 90-deg angle
- *(3)* basic 90-deg angle

(d) units of measurement
- *(1)* identification of linear units
- *(2)* angular units

(e) types of dimensioning
- *(1)* millimeter dimensioning
- *(2)* decimal-inch dimensioning

(f) application of dimensions
- *(1)* dimension lines
- *(2)* extension (projection) lines
- *(3)* limited length or area indication
- *(4)* leaders (leader lines)
- *(5)* reading direction
- *(6)* reference dimensions
- *(7)* overall dimensions
- *(8)* dimensioning within the outline of a view

(g) dimensioning features
- *(1)* diameters
- *(2)* radii
- *(3)* chords, arcs, and angles
- *(4)* rounded ends
- *(5)* rounded corners
- *(6)* outlines consisting of arcs
- *(7)* irregular outlines
- *(8)* symmetrical outlines
- *(9)* round holes
- *(10)* slotted holes
- *(11)* counterbored holes
- *(12)* countersunk and counterdrilled holes
- *(13)* spotfaces
- *(14)* chamfers
- *(15)* keyseats
- *(16)* rods and tubing details

(h) location of features
- *(1)* rectangular coordinate dimensioning
- *(2)* rectangular coordinate dimensioning without dimension lines
- *(3)* tabular dimensioning
- *(4)* polar coordinate dimensioning
- *(5)* repetitive features or dimensions
- *(6)* use of “X” to indicate “BY” or “NUMBER OF PLACES”

A-2 GENERAL TOLERANCING AND RELATED PRINCIPLES, AND FORMER PRACTICES

(a) application of tolerances
- *(1)* directly applied tolerances
- *(2)* geometric tolerances
- *(3)* application by note
- *(4)* specified in reference documents
- *(5)* general tolerance block

(b) tolerance expression
- *(1)* metric tolerances

(2) inch tolerances
(3) angle tolerances
(c) interpretation of limits
(d) plated and coated parts
(e) single limits
(f) tolerance accumulation
(1) chain dimension
(2) baseline dimensioning
(3) direct dimensioning
(g) limits of size
(1) individual feature of size (Rule 1)
(2) exceptions to Rule 1
(h) relationship between features
(i) applicability of RFS, MMC, LMC
(1) effect of RFS
(2) effect of MMC
(3) effect of LMC
(4) effect of zero tolerance at MMC and LMC
(j) geometric tolerance application to screw threads
(1) default feature
(2) specified feature
(k) geometric tolerance application to gears and splines
(l) virtual/resultant condition
(1) LMC
(2) MMC
(m) datum features at virtual condition
(n) angular surfaces
(1) parallel planes
(2) nonparallel planes
(o) conical tapers
(p) flat tapers
(q) radii
(1) radius (R)
(2) controlled radius (CR)
(r) statistical tolerancing identification
(s) former practices (ASME Y14.5M-1994, Appendix D)
(1) general
(2) definition for feature of size
(3) applicability of RFS, MMC, and LMC
(4) tangent radii
(5) datum feature symbol
(6) projected tolerance zone

A-3 SYMBOLOGY

(a) geometric characteristic symbols
(1) straightness
(2) flatness
(3) circularity
(4) cylindricity
(5) profile of line
(6) profile of surface
(7) angularity
(8) perpendicularity
(9) parallelism
(10) position
(11) concentricity
(12) symmetry
(13) circular runout
(14) total runout
(b) datum feature symbol
(1) datum identifying letters
(2) method of relating symbol frame to datum feature
(c) datum target symbol
(1) indicating size of target area
(2) indicating targets on hidden side of view
(d) basic dimension symbols
(e) material condition symbols
(1) maximum material condition
(2) least material condition
(3) restrictions on use of symbols
(f) projected tolerance zone symbol: use and restrictions
(g) diameter and radius
(h) reference symbol
(i) arc length symbol
(j) statistical tolerance symbol
(k) between symbol
(l) counterbore or spotface symbol
(m) countersink symbol
(n) depth symbol
(o) square symbol
(p) dimension origin symbol
(q) taper and slope symbol
(r) all-around symbol
(s) free state symbol
(t) tangent plane symbol
(u) geometric tolerance symbols
(1) feature control frame
(2) feature control frame incorporating one datum reference
(3) composite feature control frame
(4) two single-segment feature control frames
(5) combined feature control frame and datum feature symbol
(6) feature control frame with a projected tolerance zone
(v) tolerance zone identification

A-4 DATUM REFERENCING

(a) definitions
(1) datum simulator
(2) datum reference frame
(b) immobilization of part
(1) purpose — measurable relationships
(2) true geometric counterparts
(3) application
(4) datum reference frame
(c) datum feature identification
(d) datum feature controls
(e) datum feature order of precedence

(f) establishing datums from datum features
(1) datum features not subject to size variations
(2) datum features subject to size variations
(3) multiple datum features
(4) pattern of features
(5) screw threads, gears, and splines
(6) partial surface as datum features
(7) mathematically defined surface
(8) multiple datum reference frames
(9) simultaneous versus separate requirements
(10) simultaneous requirements and composite feature control
(g) datum targets
(1) purpose/applications
(2) datum target symbol
(3) datum target points
(4) datum target lines
(5) datum target areas
(6) datum target dimensions
(7) datum planes established by datum targets
(8) methods of establishing a primary datum axis
(9) equalizing datums
(10) datums established from complex or irregular surfaces

A-5 TOLERANCES OF LOCATION

(a) general
(1) types of location tolerances
(2) relationships controlled
(b) position tolerancing
(1) features applicable to
(2) basic dimensions
(3) use of feature control frame
(4) application to baseline and chain dimensioning
(5) effect of material condition
(-a) RFS (implied)
(-b) MMC
(-c) LMC
(6) zero positional tolerancing at MMC
(7) multiple patterns of features located by basic dimensions relative to common datums
(8) simultaneous requirements — RFS
(9) simultaneous requirements — MMC
(c) feature pattern location
(1) definitions
(-a) feature — relating tolerance zone framework (FRTZF)
(-b) pattern — locating tolerance zone framework (PLTZF)
(2) composite positional tolerancing
(3) projected tolerance zone
(4) nonparallel holes
(5) counterbored holes
(6) closer control at one end of a feature
(d) bidirectional positional tolerancing of features
(e) noncircular features
(f) coaxiality controls
(1) definition
(2) position tolerance control
(g) concentricity
(1) definition
(2) differences between coaxiality controls and concentricity
(h) positional tolerancing for symmetrical relationships
(i) symmetry tolerancing
(1) definition
(2) material condition basis
(j) spherical features

A-6 TOLERANCES OF FORM, PROFILE, ORIENTATION, AND RUNOUT

(a) form tolerance
(1) straightness
(2) flatness
(3) circularity
(4) cylindricity
(b) orientation
(1) angularity
(2) parallelism
(3) perpendicularity
(c) profile
(1) profile of a line
(2) profile of a surface
(d) runout
(1) circular
(2) total

MANDATORY APPENDIX B
SENIOR LEVEL BODY OF KNOWLEDGE FOR THE ASME Y14.5M-1994 EXAMINATION

This Appendix provides the body of knowledge upon which the Senior level examination for certification to ASME Y14.5M-1994 is based. This Appendix is referenced by para. 3.2 of this Standard.

B-1 TOPICS FROM THE TECHNOLOGIST LEVEL BODY OF KNOWLEDGE

See Mandatory Appendix A.

B-2 DATUM SELECTION

(a) immobilization of part
(1) purpose — measurable relationships
(2) true geometric counterparts
(-a) a plane
(-b) maximum material condition (MMC) boundary
(-c) least material condition (LMC) boundary
(-d) virtual condition boundary
(-e) actual mating envelope
(-f) mathematically defined contour
(b) application
(1) measurement origin
(2) examples of simulated datums
(3) surface extremities establish datums
(c) datum reference frame
(1) purpose
(-a) relate features
(-b) restrict motion of part
(2) multiple datum reference frames
(-a) functional requirements
(-b) requires different datum simulation methods
(d) datum feature selection criteria
(e) datum feature symbol placement
(f) datum feature controls
(1) to account for datum feature variations
(2) datum targets used alternatively
(g) selection of datum feature order of precedence
(1) design requirements
(2) functional requirements
(3) process requirements
(4) verification requirements/principles
(h) establishing datums from datum features
(1) datum features not subject to size variations
(-a) unstable
(-b) restrained
(2) datum features subject to size variations
(-a) diameters and widths
(-b) datum features regardless of feature size (RFS)
(-1) primary datum feature — diameters or width RFS
(-2) secondary datum feature — diameter or width RFS
(-3) tertiary datum feature — diameter or width RFS
(-c) datum features at MMC
(-1) size of a primary or single datum feature
(-2) size of a secondary or tertiary datum feature
(-d) datum features at LMC
(-e) effects of datum precedence and material condition
(-1) cylindrical feature at RFS primary
(-2) cylindrical feature at MMC secondary
(3) multiple datum features
(-a) simulation of a single datum plane (coplanar)
(-b) single axis of two coaxial features
(4) pattern of features
(5) screw threads, gears, and splines
(6) partial surface as datum features
(7) mathematically defined surface
(8) multiple datum reference frames
(9) simultaneous versus separate requirements
(10) simultaneous requirements and composite feature control
(i) datum targets
(1) purpose/applications
(2) datum target area dimensions
(3) datum planes established by datum targets
(-a) primary, secondary, and tertiary datums
(-b) stepped surfaces
(4) methods of establishing a primary datum axis
(5) secondary datum axis
(6) equalizing datums
(7) datums established from complex or irregular surfaces

B-3 GEOMETRIC TOLERANCING AND RELATED PRINCIPLES; TOLERANCE CALCULATION AND APPENDICES

(a) general need for expressing tolerances
(b) application
(1) means of expressing tolerances
(2) controlling features of size
(3) controlling other features
(c) direct tolerancing methods
(1) general
(-a) limit dimensioning
(-b) plus-and-minus tolerancing
(2) metric limits and fits
(3) limits and tolerance symbols
(4) tolerance symbols and limits
(5) millimeter tolerancing
(-a) unilateral tolerancing
(-b) bilateral tolerancing
(-c) limit dimensioning
(-d) with basic dimensions
(6) inch tolerances
(-a) unilateral tolerancing
(-b) bilateral tolerancing
(-c) limit dimensioning
(-d) with basic dimensions
(7) angle tolerances
(8) plated or coated parts
(9) single limits
(10) tolerance accumulation
(-a) chain dimensioning
(-b) baseline dimensioning
(-c) direct dimensioning
(11) dimensional limits related to an origin
(d) limits of size
(1) individual feature of size (Rule 1)
(-a) when form control does not apply
(-b) indicating that perfect form at MMC not required
(2) relationship between individual features
(-a) no relationship unless otherwise specified
(-b) zero tolerance of orientation
(-c) zero tolerance of position
(-d) control with general note
(-e) relate dimensions to a datum reference framework with a general note
(e) applicability of RFS, MMC, and LMC
(1) appropriate applications
(2) all applicable geometric tolerances (Rule 2)
(3) alternate practice for position control
(4) effect of RFS
(5) effect of MMC
(6) effect of zero tolerance at MMC
(7) effect of LMC
(8) effect of zero tolerance at LMC
(f) screw threads
(1) feature
(2) modifier
(g) gears and splines
(h) virtual/resultant condition
(1) determining the appropriateness of MMC and LMC
(2) virtual condition determination
(3) resultant condition determination
(4) datum features at virtual condition
(5) calculating inner and outer locus
(i) angular surfaces
(j) conical tapers
(k) flat tapers
(l) radius
(m) statistical tolerancing
(1) application to assemblies
(2) identification
(n) tolerances of location
(1) utilization of modifiers
(-a) effects of RFS (implied)
(-b) effects of MMC
(-c) effects of LMC
(2) displacement allowed by datum features at MMC
(3) calculating positional tolerance
(4) zero positional tolerance at MMC
(5) simultaneous requirements
(6) separate requirements
(7) projected tolerance zone
(8) nonparallel holes
(9) counterbored holes
(10) closer control at one end of a feature
(11) bidirectional positional tolerancing
(12) noncircular features
(13) coaxial controls
(14) concentricity
(15) symmetry
(o) form
(1) straightness
(-a) surface
(-b) axis
(-c) center plane
(-d) applied on a unit basis
(2) flatness
(-a) surface
(-b) applied on a unit basis
(3) circularity
(4) cylindricity
(p) profile
(1) profile of a line
(2) profile of a surface
(3) coplanarity
(4) for plane surfaces
(5) on conical features
(q) orientation tolerances
(1) angularity
(-a) of a surface

(-b) applied to features of size
(2) parallelism
(-a) of a surface
(-b) applied to features of size
(3) perpendicularity
(-a) of a surface
(-b) applied to features of size
(r) runout tolerances
(1) circular
(2) total
(s) ASME Y14.5M-1994 Appendices
(1) Appendix A, Principal Changes and Improvements
(-a) figures
(-b) scope, definitions, and general dimensioning
(-c) general tolerancing and related principles
(-d) symbology
(-e) datum referencing
(-f) tolerances of location
(-g) tolerances of form, profile, orientation, and runout
(-h) principal changes and improvements
(-i) formulas for positional tolerancing
(-j) form, proportion, and comparison of symbols
(-k) former practices
(-l) decision diagrams for geometric control
(2) Appendix B, Formulas for Positional Tolerancing
(-a) general
(-b) formula symbols
(-c) floating fastener case
(-d) fixed fastener case
(-e) provision for out-of-squareness when projected tolerance zone is not used
(-f) coaxial features
(-g) limits and fits
(3) Appendix C, Form, Proportion, and Comparison of Symbols
(-a) general
(-b) form and proportion
(-c) comparison
(4) Appendix D, Former Practices
(-a) general
(-b) definition for feature of size
(-c) applicability of RFS, MMC, and LMC
(-d) tangent radii
(-e) datum feature symbol
(-f) projected tolerance zone
(5) Appendix E, Decision Diagrams for Geometric Control
(-a) purpose
(-b) functional requirements
(-c) reference to standard
(-d) geometric controls
(-e) choosing other controls
(-f) use of modifiers
(-g) datums
(-1) datum modifiers
(-2) multiple datums

B-4 APPLICATION OF MODIFIERS IN FEATURE CONTROL FRAMES

(a) types of modifiers
(1) RFS
(2) MMC
(3) LMC
(b) application
(1) to the toleranced feature
(2) to datums
(3) when applicable
(-a) to geometric tolerances
(-b) to datums
(4) zero tolerance at MMC
(5) results of datum features modified
(-a) RFS (implied)
(-b) MMC
(-c) LMC
(6) results of pattern of features modified
(-a) RFS (implied)
(-b) MMC
(-c) LMC
(7) simultaneous requirements

B-5 COMPOSITE TOLERANCING

(a) location of a pattern of features
(1) location of a pattern of features
(2) interrelationship of individual features within a pattern
(3) multiple patterns of features; separate requirements
(b) composite profile tolerancing
(c) part verification methods
(1) functional gaging
(2) graphical analysis
(3) mathematical analysis
(d) application of composite positional tolerancing versus two single-segment tolerancing