ASME Y14.41-2012
[Revision of ASME Y14.41-2003 (R2008)]

Digital Product Definition Data Practices

Engineering Drawing and Related Documentation Practices

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

ADOPTION NOTICE

ASME Y14.41, Product Definition Data Practices — Digital, was adopted on 7 July 2003 for use by the Department of Defense, (DoD). Proposed changes by DoD activities must be submitted to the DoD Adopting Activity: Commander, U.S. Army ARDEC, ATTN: RDAR-QES-E, Picatinny Arsenal, NJ 07806-5000. Copies of this document may be purchased from The American Society of Mechanical Engineers (ASME), 22 Law Drive, PO Box 2900, Fairfield, NJ 07007-2900; http://www.asme.org.

Custodians:
Army — AR
Navy — SA
Air Force — 16

Adopting Activity:
Army — AR
(Project DRPR-2011-001)

Review Activities:
Army — CR, MI, PT, TE, TM
Navy — AS, CG, CH, EC, MC, NP, TD
Air Force — 13, 99
OSD — SE
NGA — MP
NSA — NS
Civil agency:
DLA — DH, IS

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at http://assist.daps.dla.mil.

AMSC N/A

FSC DRPR

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

ASME Y14.41-2012
[Revision of ASME Y14.41-2003 (R2008)]

Digital Product Definition Data Practices

Engineering Drawing and Related Documentation Practices

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

Three Park Avenue • New York, NY • 10016 USA

Date of Issuance: May 14, 2012

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

Periodically certain aspects of the ASME Y14 Committee may be published as Cases. Cases are published on the ASME Web site under the Committee Pages at http://cstools.asme.org/ as they are published.

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

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

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

CONTENTS

FOREWORD

The development of this Standard was initiated at the request of industry and the government. A meeting was held to determine the interest in this subject in January 1997 in Wichita, Kansas, hosted by The Boeing Company in their facility. A subsequent meeting was held during the spring ASME meeting in 1997 to enlist membership of those who would be interested in working this project.

The Chairs of the different Y14 standards have been collaborating to improve the coordination of the Y14 standards. To this end, in this revision of ASME Y14.41 material regarding Saved Views is being move to ASME Y14.3. This material is retained in this publication of ASME Y14.41 in Mandatory Appendix I as a baseline until such time as ASME Y14.3 is published. This Appendix will be removed at a later revision of ASME Y14.41. Information on unequally or unilaterally disposed profile tolerances has been removed from this standard since this information is now included in ASME Y14.5-2009.

The material in the standard was reorganized to locate all of the information on a topic together in the text. This allows the reader to find all of the requirements for a functional area in one location.

A definition of data set classifications was developed to describe the combinations of model and drawing graphics sheets that might be required by a customer. This material is being included in ASME Y14.100 as it has broader applicability than is appropriate for ASME Y14.41.

Suggestions for improvement of this Standard are welcome. They should be sent to The American Society of Mechanical Engineers; Attn: Secretary, Y14 Standards Committee; Three Park Avenue; New York, NY 10016-5990.

This edition was approved as an American National Standard on February 17, 2012.

ASME Y14 COMMITTEE
Engineering Drawing and Related Documentation Practices

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

STANDARDS COMMITTEE OFFICERS

F. Bakos, Jr., *Chair*
W. A. Kaba, *Vice Chair*
C. J. Gomez, *Secretary*

STANDARDS COMMITTEE PERSONNEL

A. R. Anderson, Dimensional Dynamics, LLC
F. Bakos, Jr., Consultant
J. V. Burleigh, Consultant
D. E. Day, TEC-EASE, Inc.
K. Dobert, Siemens PLM Software
C. J. Gomez, The American Society of Mechanical Engineers
B. A. Harding, Purdue University
D. H. Honsinger, Consultant
W. A. Kaba, Spirit AeroSystems, Inc.
A. Krulikowski, Effective Training, Inc.
E. F. McCarthy, Raytheon Missile Systems
P. J. McCuistion, Ohio University
J. D. Meadows, James D. Meadows & Associates, Inc.
M. E. Meloro, Northrop Grumman Corp.
H. W. Oakes, U.S. Air Force (Peerless Technology)
N. H. Smith, Spirit AeroSystems, Inc.
M. J. Stahl, Caterpillar, Inc.
N. Stern, U.S. Army
R. G. Wilhelm, University of North Carolina
B. A. Wilson, The Boeing Co.
K. E. Wiegandt, *Contributing Member,* Consultant

SUBCOMMITTEE 41 — DIGITAL PROJECT DEFINITION DATA PRACTICES

N. Smith, *Chair*, Spirit AeroSystems, Inc.
J. I. Miles, *Vice Chair*, Lockheed Martin Aeronautics Co.
L. Irwin, *Secretary,* Siemens PLM Software
J. V. Burleigh, Consultant
B. Davis, Ford Motor Co.
K. Dobert, Siemens PLM Software
G. Follett, Raytheon Co.
A. Hall, Rolls-Royce Corp.
B. Harding, Purdue University
J. Hoskins, The Boeing Co.
S. Hughes, Lockheed Martin Space Systems Co.
C. Markt, Lockheed Martin Space Systems Co.
T. J. Miller, Ford Motor Co.
E. Moore, Rolls-Royce Corp.
M. A. Murphy, General Motors Corp.
G. R. Mussell, CNH America, LLC
H. W. Oakes, U.S. Air Force (Peerless Technology)
M. J. Stahl, Caterpillar, Inc.
H. Taylor, GE Aviation
T. T. Taylor, Siemens Energy, Inc.
J. C. Weers, The Boeing Co.
R. Wheeler, Goodrich Aerostructures
R. Whittenburg, Universal Technical Resource Services

Y14/SC 41 SUPPORT GROUP

N. Bonhomme, Bombardier, Inc.
B. Fischer, Advanced Dimensional Management LLC
G. Flanik, Areva NP, Inc.
P. Huang, U.S. Army Research Laboratory
A. Krulikowski, Effective Training, Inc.
A. Levin, Rose-Hulman Institute of Technology
E. Morse, University of North Carolina — Charlotte
M. Murphy, General Motors Corp.
J. Parisi, BAE Systems
D. Schminke, Rockwell Collins
J. Sykes, Profile Services
N. Weister, Eaton Corp.

CORRESPONDENCE WITH THE Y14 COMMITTEE

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

Secretary, Y14 Standards Committee
The American Society of Mechanical Engineers
Three 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 for the purpose of providing 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, 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 or telephone conferences, which are open to the public. Persons wishing to attend any meeting or telephone conference should contact the Secretary of the Y14 Standards Committee or check our Web site at http://cstools.asme.org/csconnect/CommitteePages.cfm?Committee=C64000000.

INTENTIONALLY LEFT BLANK

DIGITAL PRODUCT DEFINITION DATA PRACTICES

Section 1
General

1.1 SCOPE

This Standard establishes requirements and references documents applicable to the preparation and revision of digital product definition data, hereafter referred to as data sets. This Standard defines exceptions and additional requirements to existing ASME standards for using product definition digital data sets or drawing graphic sheet in digital format, hereafter referred to as drawing graphic sheet. When no exception or additional requirements are stated, existing ASME standards shall apply.

It is essential that this Standard be used in close conjunction with ASME Y14.24, ASME Y14.34, ASME Y14.35M, and ASME Y14.100. In addition, classification codes as defined in ASME Y14.100 may apply for data sets that include a combination of a model and drawing graphics sheet.

1.2 STRUCTURE OF STANDARD

This Standard supports two methods of preparing a data set: model only, and model and drawing graphic sheet. The structure starts with the requirements common to both methods, and then branches to the other sections that have differing requirements for each method. In addition, it provides a guide for the many computer aided design (CAD) software packages to develop better modeling and annotation practices for CAD and engineering disciplines.

1.3 ASME Y14 SERIES CONVENTIONS

The conventions in paras. 1.3.1 through 1.3.10 are guidance used in this and other ASME Y14 Series of standards.

1.3.1 Mandatory, Nonmandatory, Guidance, and Optional Words

(a) The word "shall" establishes a mandatory requirement.

(b) The word "will" establishes an intended, mandatory requirement.

(c) The words "should" and "may" establish a nonmandatory practice.

(d) The words "typical," "example," "for reference," or the Latin abbreviation "e.g." indicate suggestions given for guidance only.

(e) When the text of this Standard has an "or" statement it indicates that there are two or more options on how to comply with the stated requirement.

1.3.2 Cross-Reference of Standards. Cross-reference of standards in text with or without a date following the standard identity is interpreted as follows:

(a) reference to other ASME Y14 Series of standards in the text without a date following the Standard identity indicates the issue of the standard as identified in the References section (section 2) shall be used to meet the requirement

(b) reference to other ASME Y14 Series of standards in the text with a date following the standard identity indicates that only that issue of the standard shall be used to meet the requirement

1.3.3 Invocation of Referenced Standards. The following examples define the invocation of a standard when specified in the References section (section 2) and referenced in the text of this Standard:

(a) When the text states "dimensioning and tolerancing shall be in accordance with ASME Y14.5-2009," with no limitations to a specific subject or area of the Standard, the entire text of ASME Y14.5-2009 is invoked.

(b) When the text states "assign part or identifying numbers in accordance with ASME Y14.100-2004," only the paragraph requirements on Part or Identifying Number assignment in ASME Y14.100-2004 are invoked.

(c) When the text states "for gaging principles see ASME Y14.43," the text provides a cross-reference of where to find guidance for dimensioning and tolerancing for gages and fixtures, and no portion of ASME Y14.43 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 controlling standard 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 text 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 is used thereafter throughout the text.

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 listing of the paragraph(s) that refer to an illustration appears in the lower right-hand corner of each figure. This listing may not be all inclusive. The absence of a listing is not a reason to assume inapplicability. Most figures are illustrations of models in a three-dimensional environment. Figures illustrating drawings in digital format have a border included. When the letter "h" is used in figures for letter heights or for symbol proportions, select the applicable letter height in accordance with ASME Y14.2.

1.3.9 Precedence of Standards. The following are 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, Multiview and Sectional View Drawings
ASME Y14.5, Dimensioning and Tolerancing
ASME Y14.24, Types and Applications of Engineering Drawings
ASME Y14.34, Associated Lists
ASME Y14.35M, Revision of Engineering Drawings and Associated Documents
ASME Y14.36M, Surface Texture Symbols
ASME Y14.38, Abbreviations and Acronyms for Use on Drawings and Related Documents
ASME Y14.41, Digital Product Definition Data Practices
ASME Y14.100, Engineering Drawing Practices

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

1.3.10 Unless Otherwise Specified (UOS). The phrase "unless otherwise specified" or UOS is used to indicate a default requirement. The phrase is used when the default is a generally applied requirement and the exception can be clarified by providing a reference to another document or requirement.

1.4 REFERENCE TO THIS STANDARD

When data sets are based on this Standard, this fact shall be noted in the data set or in a document referenced by the data set. References to this Standard shall state ASME Y14.41-2012.

1.5 SYMBOLS

The use of symbols to indicate dimensional requirements does not preclude the use of equivalent terms or abbreviations in accordance with ASME Y14.38 when symbology is considered inappropriate.

Section 2
References

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

ASME Y14.1-2005, Decimal Inch Drawing Sheet Size and Format

ASME Y14.1M-2005, Metric Drawing Sheet Size and Format

ASME Y14.2-2008, Line Conventions and Lettering

ASME Y14.3-2003, Multiview and Sectional View Drawings

ASME Y14.5-2009, Dimensioning and Tolerancing

ASME Y14.24-1999, Types and Applications of Engineering Drawings

ASME Y14.34-2008, Associated Lists

ASME Y14.35M-1997, Revision of Engineering Drawings and Associated Documents

ASME Y14.38-2007, Abbreviations and Acronyms for Use on Drawings and Related Documents

ASME Y14.100-2004, Engineering Drawing Practices

Publisher: The American Society of Mechanical Engineers (ASME), Three Park Avenue, New York, NY 10016-5990; Order Department: 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900 (www.asme.org)

IEEE/ASTM SI 10, Standard for Use of the International System of Units (SI): The Modern Metric System

Publisher: Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Lane, Piscataway, NJ 08854 (www.ieee.org)

Section 3
Terms and Definitions

The following terms are defined as their use applies in this Standard.

3.1 ANNOTATION

annotation: dimensions, tolerances, notes, text, or symbols visible without any manual or external manipulation.

3.2 ANNOTATION PLANE

annotation plane: a conceptual plane containing annotation that either perpendicularly intersects, or is coincident with one or more surfaces of a feature.

3.3 ASSEMBLY MODEL

assembly model: a model in which the product described is an assembly of two or more items.

3.4 ASSOCIATED ENTITY

associated entity: the portion of a product definition to which annotation pertains.

3.5 ASSOCIATED GROUP

associated group: a user-defined set of related digital elements.

3.6 ASSOCIATIVITY

associativity: the established relationship between digital elements.

3.7 ATTRIBUTE

attribute: a dimension, tolerance, note, text, or symbol required to complete the product definition or feature of the product that is not visible but available upon interrogation of the model.

3.8 COORDINATE SYSTEM

coordinate system: a representation of a Cartesian coordinate system in a product definition data set.

3.9 DATA

data: information represented in a formal manner suitable for communication, interpretation, or processing by human beings or computers.

3.10 DATUM SYSTEM

datum system: a partial or complete datum reference frame.

3.11 DERIVATIVE

derivative: data duplicated or extracted from the original. A copy of a derivative is also a derivative.

3.12 DESIGN MODEL

design model: the portion of the data set that contains model geometry and supplemental geometry.

3.13 DIGITAL ELEMENT

digital element: geometric element, feature, group of features, annotation, associated group, or attribute that exists in a data set.

3.14 DIGITAL ELEMENT IDENTIFIER

digital element identifier: a label or name used to specify a unique digital element.

3.15 DIRECTION-DEPENDENT TOLERANCE

direction-dependent tolerance: a tolerance that invokes a zone of parallel lines or curves.

3.16 DRAWING GRAPHIC SHEET

drawing graphic sheet: the 2D geometric elements and annotations that define an item and the data elements of the sheet format in accordance with ASME Y14.1 or ASME Y14.1M.

3.17 GEOMETRIC ELEMENT

geometric element: a graphic entity used in a data set. For example: point, line, plane, surface, solid, coordinate system, or crosshatching.

3.18 HARD COPY

hard copy: a printed or plotted copy of a displayed image on a medium such as paper or polyester film.

3.19 INSTALLATION MODEL

installation model: a model in which the product described is an installation, showing parts or assemblies and a partial or complete representation of the installation site.

3.20 MANAGEMENT DATA

management data: the data required for the release, control, and storage of product definition data as well as other relevant engineering data.

3.21 MODEL

model: a combination of design model, annotation, and attributes that describes a product.

3.22 MODEL GEOMETRY

model geometry: geometric elements in product definition data that represent an item.

3.23 MODEL VALUE

model value: the numerical value derived by interrogating the model that quantifies the form and spatial relationships of the geometry composing a design model, or assembly of models, to the precision (number of decimal places) of the computer system.

3.24 PRODUCT DEFINITION DATA

product definition data: denotes the totality of data elements required to completely define a product. Product definition data includes geometry, topology, relationships, tolerances, attributes, and features necessary to completely define a component part or an assembly of parts for the purpose of design, analysis, manufacture, test, and inspection. (See ASME Y14.100.)

3.25 PRODUCT DEFINITION DATA SET

product definition data set: a collection of one or more data file(s) that discloses, directly or by reference, by means of graphic or textual presentations, or combinations of both, the physical or functional requirements of an item.

3.26 QUERY

query: a means of interrogating a digital element or the relationship between digital elements.

3.27 REPRESENTED LINE ELEMENT

represented line element: a supplemental geometry line or curve segment indicating the orientation of a direction dependent tolerance.

3.28 RESOLVED DIMENSION

resolved dimension: a model value that is rounded off to the number of decimal places required for the design.

3.29 SAVED VIEW

saved view: a stored and retrievable specific orientation and a magnification factor of a model. (See ASME Y14.3.)

3.30 SPECIAL CHARACTER

special character: entries such as dash (-), slash (/), and asterisk (*) that are not included in the set of capital letters A–Z, lowercase letters a–z, numerals 0–9, and punctuation symbols. (See ASME Y14.100.)

3.31 SUPPLEMENTAL GEOMETRY

supplemental geometry: geometric elements included in product definition data to communicate design requirements but not intended to represent a portion of an item.

Section 4
Data Set Identification and Control

This Section establishes requirements for a data set identification system.

4.1 GENERAL

The current revision of the data and the computer application(s) and version(s) used to develop the data set shall be specified with other management data. See para. 5.3.

NOTE: The identification of the data set, the drawing graphic sheet, the associated lists when used, and the Part or Identifying Number (PIN) for the item being defined may be identical. See Fig. 4-1.

4.1.1 Data Set Identifier

The data set identifier shall be unique and consist of numeric, alpha, or special characters in any combination. Spaces are not permitted between any of the characters of the data set identifier.

(a) Data Set Identifier Length. The length of the data set identifier may be a direct function of the computer system and the operating system. When the PIN is used as the data set identifier, the length shall be compatible with recognized limitations on PIN number length in accordance with ASME Y14.100.

(b) Special Characters. Special characters shall be selected in a manner that does not hinder data set identification or have an adverse effect on the computer system operation such as dash (-), slash (/), or asterisk (*).

(c) Identifier Prefixes and Suffixes. A recognizable prefix or suffix may be included as part of the identifier to associate files and sets of related data.

4.1.2 Drawing Graphic Sheet Identification

Drawing graphic sheet identification shall be assigned in accordance with ASME Y14.100.

4.1.3 Associated List Identification

Associated list identification shall be assigned in accordance with ASME Y14.34.

4.1.4 Part or Identifying Number

The PIN shall be assigned in accordance with ASME Y14.100.

4.2 RELATED DATA

Related data shall be integral to or referenced in the data set. Related data consists of, but is not limited to the following: analytical data, associated lists, test requirements, material specifications, and process and finish requirements in accordance with Fig. 4-1.

4.3 DATA MANAGEMENT

The following paragraphs describe the structure and control requirements for data management.

4.3.1 Management System

A data management system shall provide control and tracking information of the data sets. This system may include work in process, data review status, model checked status, release status, design tool and version, libraries, etc.

4.3.2 Approval

The data set shall be approved in accordance with ASME Y14.100.

4.3.3 Storage and Retention

Data sets shall be controlled and available throughout the life cycle of a product.

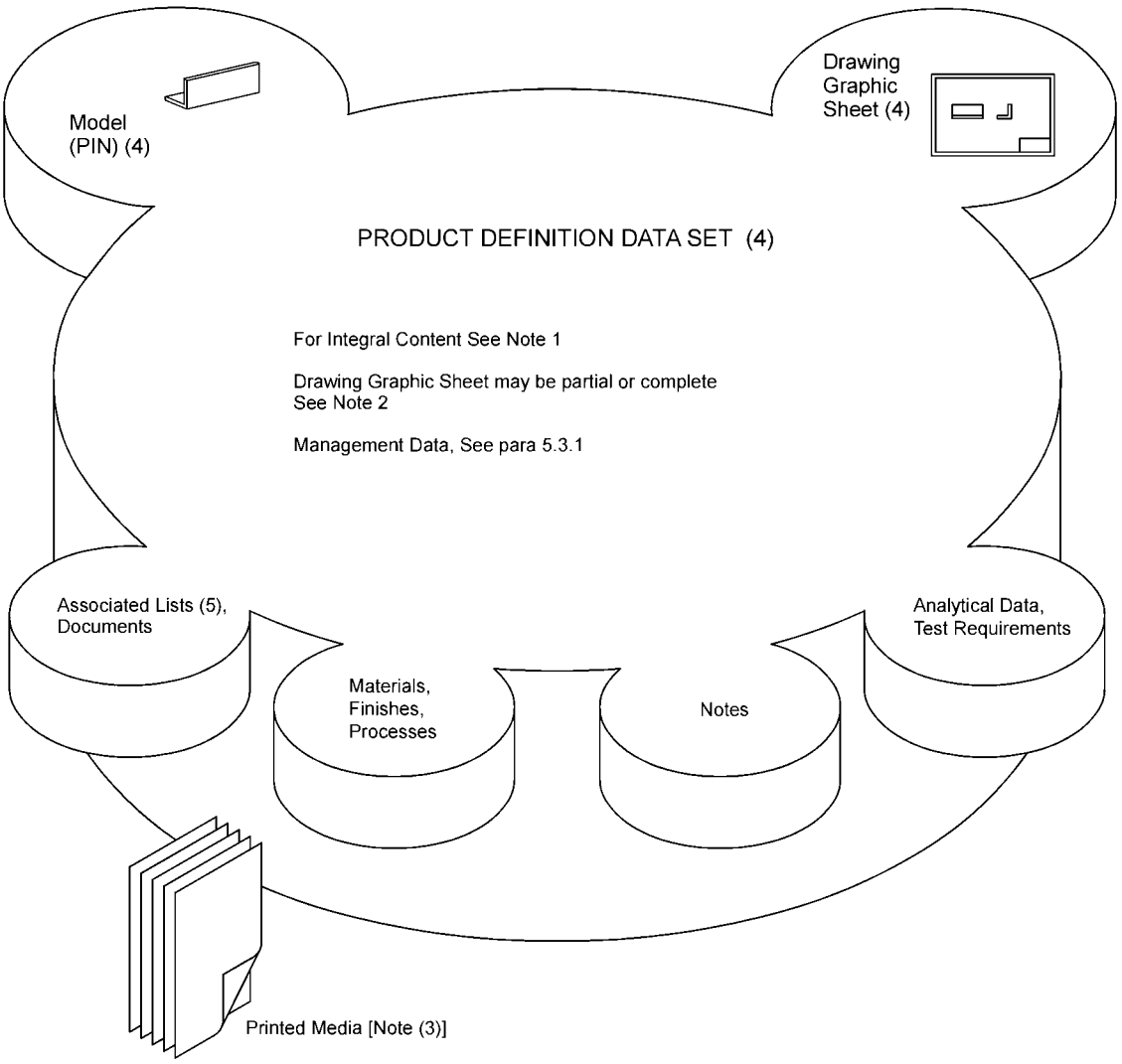
4.3.4 Revision History

The following requirements apply to revision history:

(a) revision history shall be prepared in accordance with ASME Y14.35M

(b) revision history shall be recorded in the data set

Fig. 4-1 Contents of a Product Definition Data Set



NOTES:
(1) Related data, as applicable, required for complete definition may be integral to or referenced in the product definition data set. Data not integral to the product definition data set may be revised independently.
(2) A drawing graphic sheet is not required for Model Only data sets.
(3) Related data may be manually or computer generated.
(4) May have the same PIN.
(5) Shall have the same identity as the dataset identifier.

4.1
4.2

Section 5
Data Set Requirements

This Section establishes the requirements for a data set. The data set shall provide complete product definition; for example, a design model, its annotation, and supporting documentation.

5.1 GENERAL MODEL REQUIREMENTS

The following paragraphs describe general requirements for a model.

5.1.1 Design Model Requirement

A design model is required and shall be in accordance with Section 6.

5.1.2 Associativity

Associativity shall be available, maintainable, and electronically accessible.

5.1.3 Coordinate Systems

A model shall contain one or more coordinate systems. A coordinate system shall be depicted by three mutually perpendicular line segments with its origin located at the intersection of the three axes. Each axis shall be labeled with an uppercase letter indicating the positive direction. Coordinate systems shall be right-handed unless otherwise specified. See Fig. 5-1.

5.1.4 Applications of Supplemental Geometry

When supplemental geometry is used, there shall be a clear distinction between the supplemental geometry and the design model geometry.

(a) Represented Line Element. The following geometric tolerances may use a represented line element to clarify the directionality of a two-dimensional tolerance zone of parallel lines. When a represented line element is used to indicate the direction of a geometric tolerance application, the leader from the feature control frame shall terminate on the represented line element in an arrowhead. See Fig. 12-4.

(1) Straightness applied to the line elements of a planar surface. See Table 12-1 and Fig. 12-4.

(2) Orientation tolerance applied on an Each Element basis. See para. 12.2.2(a) and Fig. 12-9.

(3) Line profile. See para. 12.2.3(e) and Fig. 12-18.

(b) Associativity. The represented line element, the feature control frame, and the controlled feature should be organized as an associated group. See Figs. 12-4, 12-9, and 12-18.

(c) Centerlines and Centerplanes. Display of centerlines or centerplanes for features of size are optional.

(d) Direction of Movement for Movable Datum Targets. Represented line elements are used to indicate the direction of movement for movable datum targets. See para. 11.2.3(b) and Fig. 11-4, illustration (b) or para. 11.3(d) and Fig. 11-11, illustration (b).

(e) Datum Target Areas or Locations. The areas for datum targets may be indicated using supplemental geometry. The "X" for point targets may also be indicated using supplemental geometry. See Fig. 11-4, illustration (b).

5.1.5 Part Features Not Fully Modeled

A simplified representation of part features such as threads, holes, fillets, rounds, and drafts may be shown using partial geometry definition, annotations, attributes, or a combination thereof. See Fig. 7-4.

5.1.6 Assembly Model Completeness

Assembly model completeness shall be in accordance with para. 6.1.2, except part and subassembly models shown in the assembly model need only show sufficient detail to ensure correct identification, orientation, and placement. The assembly model may be shown in an exploded, partially assembled, or completely assembled state. The placement of parts and subassemblies within the assembly may alternatively be defined via annotation, or a combination of annotation and pictorial representation of the model.

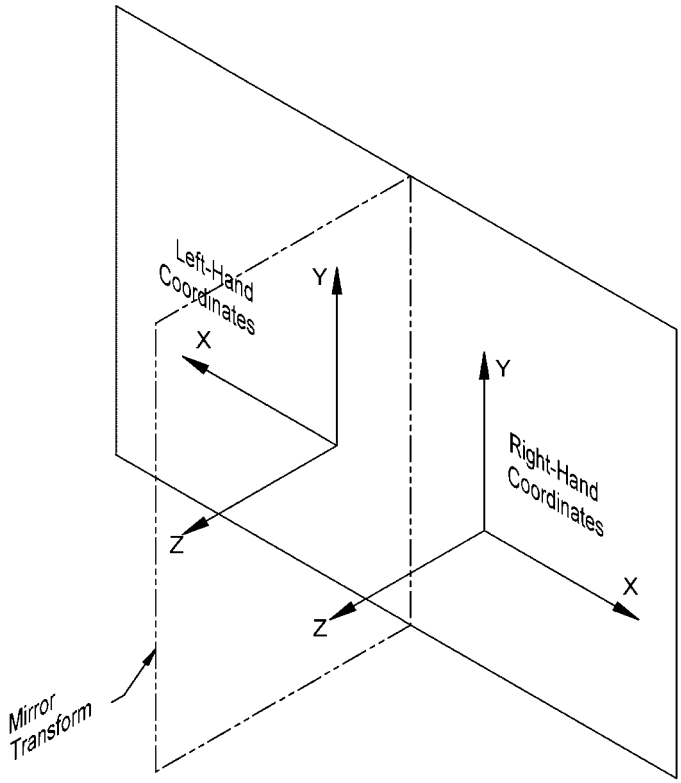
5.1.7 Installation Model Completeness

Installation completeness shall be in accordance with paras. 6.1.2 and 5.1.6 except part and assembly models shown in the installation model need only show sufficient detail to provide installation and space requirements. The maximum envelope for parts and assemblies may be shown using supplemental geometry, annotation, or a combination of both. Location and orientation of parts and assemblies may be shown by geometric definition, annotation, or a combination of both.

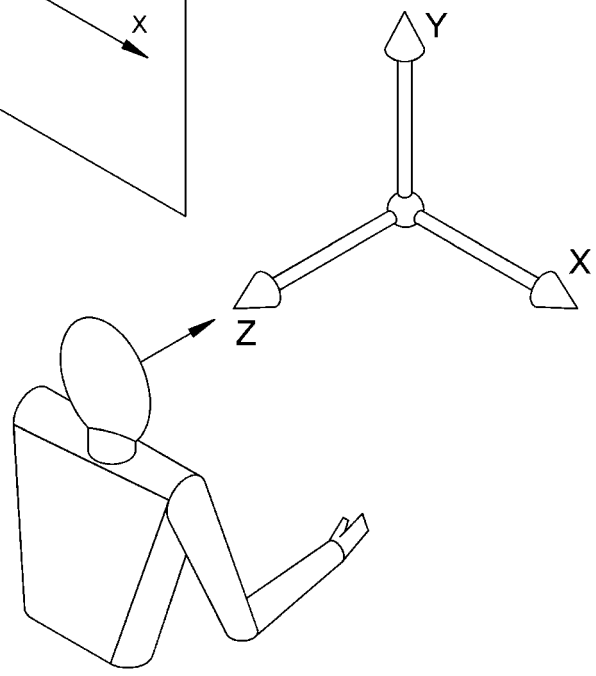
5.2 GENERAL METHOD REQUIREMENTS

The following paragraphs cover the product definition methods listed below. Each different method for specifying product definition is used in support of different industry processes and requirements. The data set is the

Fig. 5-1 Left-Hand and Right-Hand Coordinate Systems



(a) Mirror Image Relationship.



Right-hand Coordinate System:
When observed in the negative Z direction with positive Y ascending, positive X is directed to the right-hand side of the observer.

(b) Recognizing the right-hand system.

5.1.3

original for all of the methods, and any hard copy output is a derivative.

5.2.1 Model Only

The following paragraphs describe requirements when complete product definition is contained in the model.

(a) Product definition data, including but not limited to notes, associated lists, marking requirements, dimensions, and tolerances shall be contained or referenced in the data set.

(b) The following data elements of a drawing graphic sheet format as defined in ASME Y14.1 or ASME Y14.1M are required and shall be contained in the data set:

(1) Design Activity Identification
(2) data set title
(3) data set identifier
(4) approval indicators and approval dates
(5) contract number when required
(6) originator's name and date
(7) CAGE Code when required for identification of the design activity whose data set identifier is used

(c) When working with a model, the first or third angle projection symbol in accordance with ASME Y14.3 is not required.

5.2.2 Model and Drawing Graphic Sheet

The following paragraphs describe requirements when complete product definition is contained in the model and drawing graphic sheet.

(a) A complete definition of a product shall contain a model and a drawing graphic sheet that may contain orthographic views, axonometric views, or a combination thereof. Annotation may be applied to the model, on the drawing graphic sheet, or a combination of both.

NOTE: The development of a drawing graphic sheet that provides a complete product definition is allowed.

(b) Product definition data created or shown in the model and subsequently shown on the drawing graphic sheet shall be in agreement.

(c) Product definition data created and shown on the drawing graphic sheet shall not conflict with product definition data in the model.

(d) The drawing graphic sheet shall contain a border and title block information in accordance with ASME Y14.1 or ASME Y14.1M.

(e) The drawing graphic sheet shall reference all applicable models or design models and data for the product specified.

(f) Minimum drawing graphic sheet hard copy output capability shall be in accordance with ASME Y14.1 or ASME Y14.1M, ASME Y14.2, and ASME Y14.3.

(g) Annotation displayed on the drawing graphic sheet shall be interpretable without the use of query.

(h) When complete product definition is not contained on the drawing graphic sheet, it shall be noted.

(i) When complete product definition is not contained in the model, it shall be noted.

(j) Dimensions, tolerances, datum specifications, and notes on drawing graphic sheets may be shown in true profile views and refer to visible outlines, or appear in axonometric views.

(k) The use of color is acceptable on drawing graphic sheets prepared by digital data files.

5.3 MANAGEMENT DATA

Management data that is not placed on a drawing graphic sheet shall be placed on the model or in the data set.

5.3.1 Management Data in the Data Set

The following management data shall be contained in the data set or on the model as applicable:

(a) application data
(b) approval
(c) data set identification
(d) design activity transfer
(e) revision history for the data set
(f) ASME Y14.41 Note
(g) CAD Maintained Notation
(h) Design Activity Identification
(i) Duplicate Original Notation
(j) item identification
(k) Metric/U.S. Customary Notation
(l) navigation data

5.3.2 Management Data on a Model

Management data placed on a model shall be placed on a management data annotation plane or use a similar method. When displayed, the management data shall not rotate.

5.4 SECURITY MARKING

Security marking shall be placed in the file(s) or in the referenced document(s) to which it applies. The following requirements pertain to models.

5.4.1 Location of Security Marking on Models

Security marking shall be placed on an annotation plane or use a similar method. This information shall be available for display with the model. Reproductions of technical data, or any portions thereof, subject to asserted restrictions, shall also reproduce the asserted restrictions. When displayed, the security markings shall not rotate.

5.4.2 Government, Department of Defense, and Other Federal Agencies Security Marking

Models containing classified information, e.g., secret, confidential, etc.

(a) shall contain the applicable security markings

(b) shall be controlled in accordance with the applicable security level

(c) shall have the applicable security markings constantly displayed for all mediums of viewing

5.4.3 Company Security Marking

Models containing company intellectual property may include notes to this effect. These include, but are not limited to, the following:

Company Proprietary Notes

Competition Sensitive Information

The display and control shall be in accordance with company policy.

5.4.4 Government Notices, Statements, and Legends

Models may require government notices, statements, and legends. Contractual requirements determine which are applicable. These include, but are not limited to

(a) Copyright Notices

(b) Distribution Statements

(c) Export Control Notices

(d) Rights in Data Legends

5.5 VIEWS ON MODELS

See ASME Y14.3 for sections and views.

Section 6
Design Model Requirements

This Section establishes the requirements for a design model.

6.1 GENERAL

Design models represent ideal geometric constructs; that is, perfect dimensionality and shape aspect of the part geometry are assumed. Parts shall be modeled at a specified dimensional condition(s); for example, minimum, maximum, or mean. The dimensional condition(s) shall be specified in one or more notes or in a referenced document.

6.1.1 Geometric Scale, Units, and Precision

The following are the requirements concerning the scale, units, and precision of a design model.

(a) Scale. Design models shall be created at a scale of 1:1.

(b) Units. The units of measure (Metric or U.S. Customary) at which the design model is created shall be specified within the data set.

(c) Precision. The design model precision indicates the numeric accuracy required in the production of the part in order for it to fulfill the design intent. The number of significant digits of the design model shall be specified in the data set. The number of decimal places required for the design cannot exceed the precision of the design model.

6.1.2 Design Model Completeness

The design model shall contain a complete geometric definition of the part.

(a) Design models not fully modeled shall be identified as such (e.g., partially modeled symmetrical part).

(b) Features that are not fully modeled shall be identified as such (e.g., threaded holes that are only shown as holes).

Section 7
Common Requirements for Models and Drawing Graphics Sheets

This Section establishes the common requirements for the application, display management, and query of product definition data in models and drawing graphics sheets. Specific requirements for particular types of product definition data are described in Sections 8 through 12.

7.1 COMMON REQUIREMENTS

The following paragraphs describe requirements common to models and drawing graphics sheets.

7.1.1 Display Management

Display management shall include the ability to enable or disable the display of all annotation, annotation by type, or selected annotation, except as noted in para. 5.4. See Fig. 7-1.

7.1.2 Hard Copy

A hard copy of any given visual display shall be available on demand. When a hard copy is intended to be used as an engineering drawing graphic sheet, it shall meet applicable drawing graphic sheet standards.

7.1.3 Leader Lines

The following paragraphs describe common requirements for leader lines.

(a) Leader lines directed to represented line elements shall terminate with an arrowhead. See Fig. 12-18.

(b) When an indicated element is a surface, the leader shall terminate with a dot within the bounds of the surface. Leader lines may terminate on the rim or edge of a feature of size when doing so provides a clearer understanding of the intention of the annotation. See Fig. 7-2.

7.2 MODEL REQUIREMENTS

The following paragraphs describe requirements for annotation applied to a design model. These are general requirements that apply to all types of annotation. Specific requirements for particular types of annotation are addressed in Sections 8 through 12. See Fig. 7-2 for a diagram showing the relationship between annotation and model geometry.

7.2.1 Associativity

The following are general requirements for defining an associative relationship between digital elements.

(a) Selection of Associated Entities. Annotation may be associated to a feature, a group of features, or a portion of an applicable feature. For an example of the associated features for a dimension, see Fig. 7-3.

(b) Associated Groups. Annotation, model geometry, and supplemental geometry may be placed into associated groups to indicate their relationships. For example

(1) supplemental geometry used to define location, orientation, or further clarify the application of annotation to a model.

(2) a coordinate system for datum symbols and datum targets.

(3) other annotation. This could include qualifying notes and size limit callouts.

(c) Associativity Agreement. The associated entities, annotation, and attributes shall be in agreement with each other.

(d) Continuous Feature. When features are designated as CONTINUOUS FEATURE or the continuous feature symbol is used, the appropriate features should be designated as the associated objects for the accompanying GD&T. Extension lines between the features shall not be used on models.

7.2.2 Attributes

Attributes are used to capture additional information that is not shown using geometry or in the model annotation. Attributes shall be available on demand. Attributes may be presented using text description, forms, or other techniques. See Fig. 7-4 for an example of how the attributes of a hole could be represented. Applications of attributes include, but are not limited to, coatings, knurling, threaded holes, and pins.

7.2.3 Annotation Planes

The following describe the requirements for annotation planes and their use.

(a) Annotation in Annotation Planes. All annotation shall be specified in one or more annotation planes.

(b) Annotation Plane Orientation. The orientation of the annotation plane shall be maintained relative to the model geometry as the model is manipulated in 3D. For example, as the geometry is rotated the text rotates

correspondingly. See Fig. 7-5. When CAD software does not support maintenance of annotation plane orientation relative to the model, the model only method shall not be used.

(c) Annotation Reading Direction. To ensure the annotation is being interpreted as intended (for example, the text could be upside down or backwards following rotation of the model), one of the following techniques shall be used:

(1) ensure the reading direction is updated after rotation of a model.

(2) include a means of determining the correct reading direction in each annotation plane applied to a model.

(3) when using saved views, ensure the model is orientated in the intended view direction. For example, this may be accomplished by including a means of determining the correct reading direction in the view.

(d) Use of True Profiles. When tolerancing features, alignment of the annotation plane to the true profile is not required.

(e) Annotation Legibility. Legibility requirements of ASME Y14.2 shall apply when the annotation is viewed perpendicular to the annotation plane.

(f) Overlapping Annotation in an Annotation Plane. Annotation in any given annotation plane shall not overlap other annotation in the same annotation plane when the model is viewed perpendicular to the annotation plane.

(g) Annotation Over the Design Model. Annotation text within any given annotation plane shall not be placed over the design model when the model is viewed perpendicular to the annotation plane.

7.2.4 Leader and Extension Lines

Requirements for leader lines in models are described as follows:

(a) Extension Lines. Visible gaps between extension (projection) lines and geometry are not required on models.

(b) Leader Lines

(1) A solid leader line shall be used to indicate all datum targets in a design model.

(2) Leader lines shall be directed to an associated entity. See para. 7.2.1(c).

7.2.5 Direction-Dependent Tolerances

When a direction-dependent tolerance (e.g., straightness) is applied to a design model, the direction shall be explicitly defined as described in either (a) or (b) as follows:

(a) Supplemental geometry is added to the model geometry to show the direction of application. The model geometry to which the tolerance applies shall be defined as the associated geometry for the annotation. See Figs. 12-4, 12-9, and 12-18, and para. 5.1.4(a).

(b) Direction-dependent tolerances may use a coordinate system vector to define the direction of application. The coordinate system vector, associated feature, and tolerance shall be organized as an associated group. See Figs. 12-5, 12-10, and 12-19.

7.2.6 Indicating Limited Application of a Tolerance

Limited length, area, and location indicators may consist of, but are not limited to, supplemental geometry and associative annotation. When supplemental geometry is used, it shall be located on the model geometry. See Figs. 11-3 and 12-16.

7.2.7 Query

The ability to query the model shall be available. A notation stating the requirement for query of the model or associated data shall be added to the drawing graphic sheet or in the general notes. The model shall contain information needed to enable the following types of queries.

(a) Obtaining Model Values. Model values shall be obtainable from the model.

(b) Annotation To/From Model Geometry. The ability to traverse the relationship between model geometry and annotation, in either order, shall be available within the model. This includes

(1) Graphic Display of Associated Entities. The associated entities for a piece of annotation shall be highlighted, or otherwise distinguished from other entities on the display, on demand. See Fig. 7-3 and Fig. 11-10, illustrations (b) through (f).

(2) Graphic Display of Associated Annotation. All annotations associated with selected geometry or features shall be highlighted, or otherwise distinguished from other entities, on demand. See Fig. 7-6 and Fig. 12-3, illustration (c).

(c) Digital Element Identifiers. Digital element identifiers shall be obtainable from the model. See Fig. 7-7.

(d) Model Geometry and Features

(1) Features shall be identifiable by selecting a geometric element of the feature.

(2) All geometric elements in an associated group shall be identifiable by selecting any geometric element within the group.

(3) All features in an associated group shall be identifiable by selecting one of the features.

(e) Feature Control Frames, Datum Feature Symbols, and Datum Targets

(1) Upon selection of a feature control frame, the datum feature symbols and datum target symbols that correspond to the datum references shall be highlighted or otherwise distinguished from other entities on the display. See Fig. 7-8.

(2) Upon selection of a datum target symbol or a datum feature symbol, other datum target symbols and datum feature symbols that have the same datum letter

shall be highlighted or otherwise distinguished from other entities on the display. See Fig. 7-9.

(3) Upon selection of a feature control frame, the portion of the corresponding coordinate system representing the partial or complete datum reference frame referenced in the feature control frame shall be highlighted or otherwise distinguished from other entities on the display. See Fig. 7-10, illustration (a).

(f) Annotation and Supplemental Geometry. Upon selection of annotation, the supplemental geometry used in the definition of the annotation shall be highlighted or otherwise distinguished from other entities on the display. See Fig. 7-10, illustration (b).

(g) Associated Groups. Upon selection of one of the digital elements in an associated group, the members of the associated group shall be highlighted or otherwise distinguished from other entities on the display.

7.3 DRAWING GRAPHIC SHEET REQUIREMENTS

See ASME Y14.3 for sections and views. Specific requirements for particular types of annotation are addressed in Sections 8 through 12. The relationship between a model and a drawing graphic sheet is illustrated in Figs. 7-11 and 7-12.

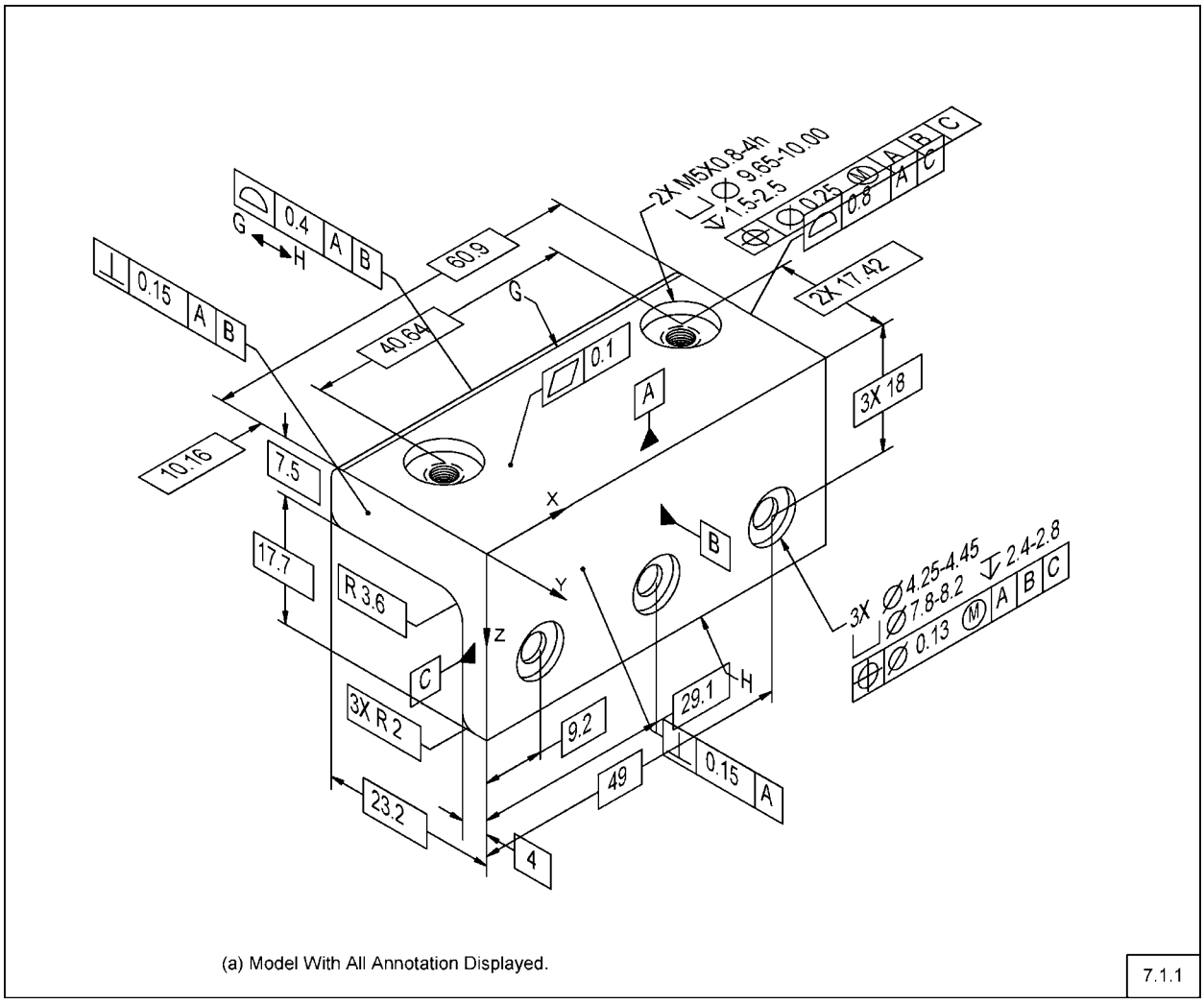
7.3.1 Annotation in Axonometric Views

(a) The orientation of the annotation shall be parallel to, normal to, or coincident with the surface to which it applies.

(b) Annotation shall not overlap other annotation.

(c) Annotation shall not overlap the part.

Fig. 7-1 Display Management



(a) Model With All Annotation Displayed.

7.1.1

Fig. 7-1 Display Management (Cont'd)

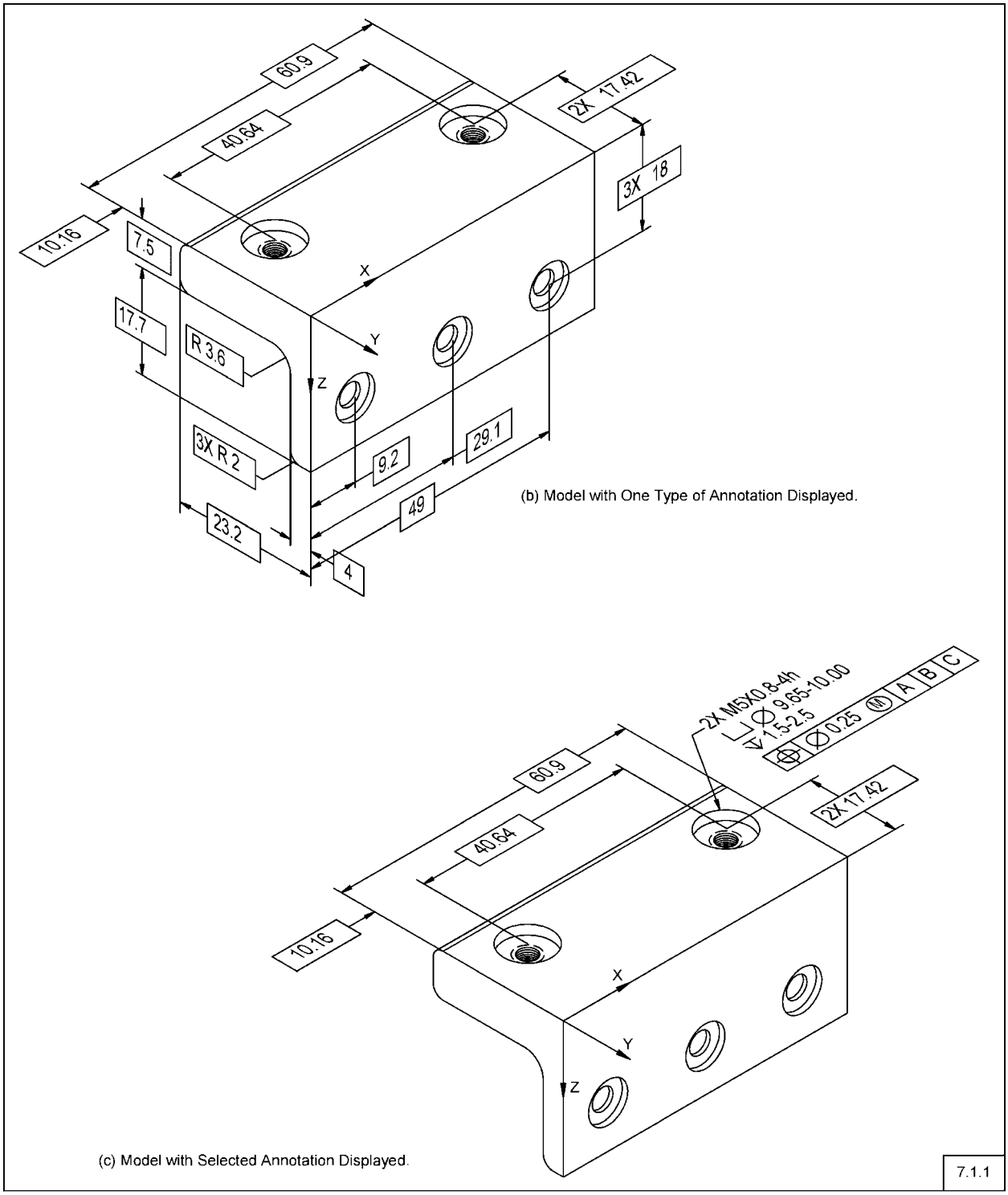


Fig. 7-2 Annotation and Model Geometry Relationship

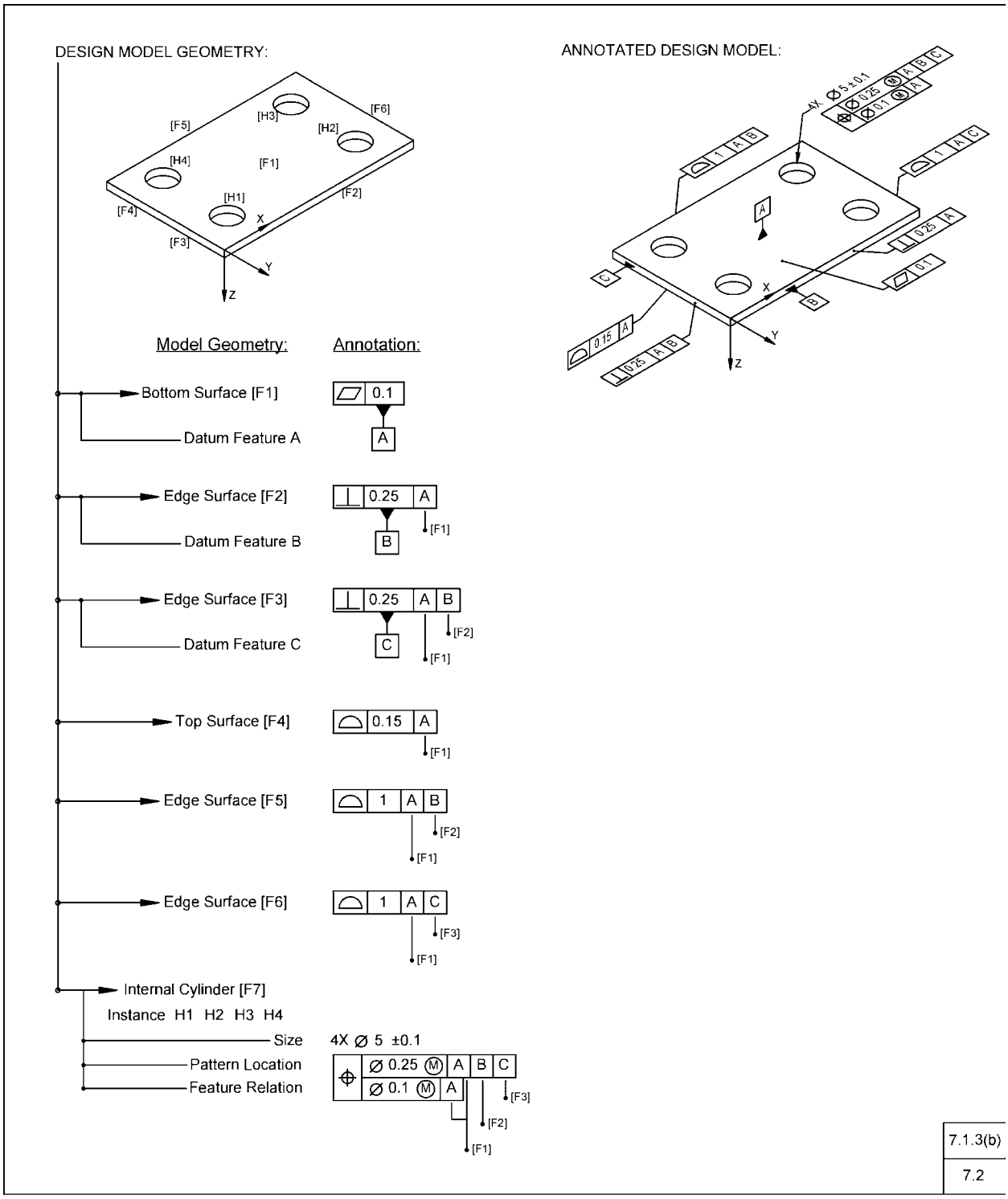


Fig. 7-3 Tolerance Query Associativity

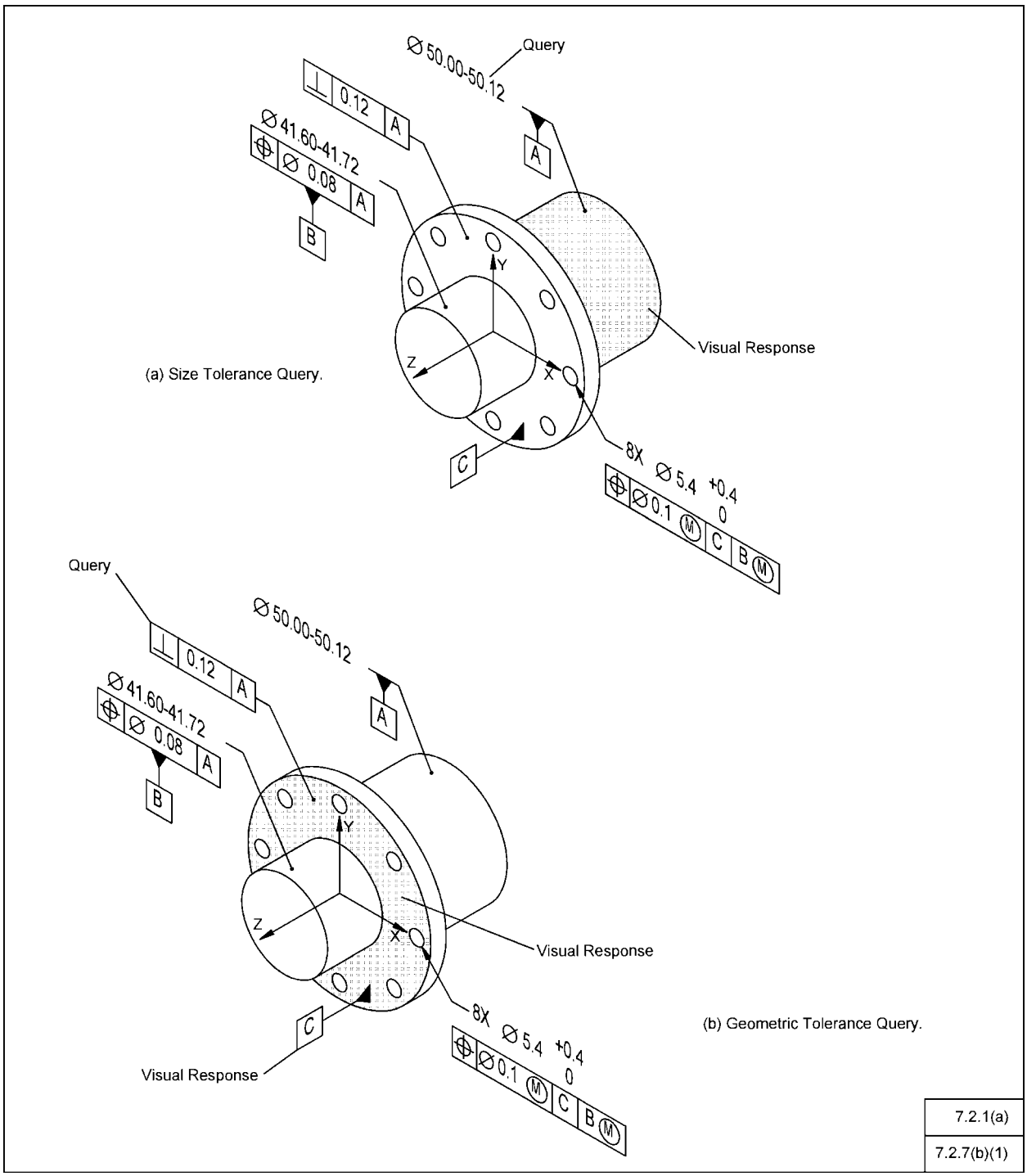
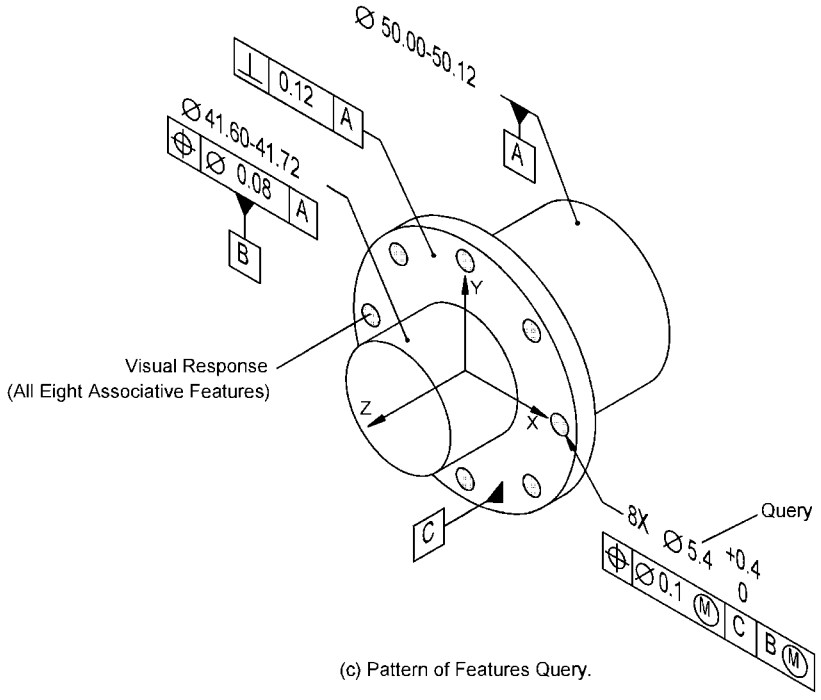


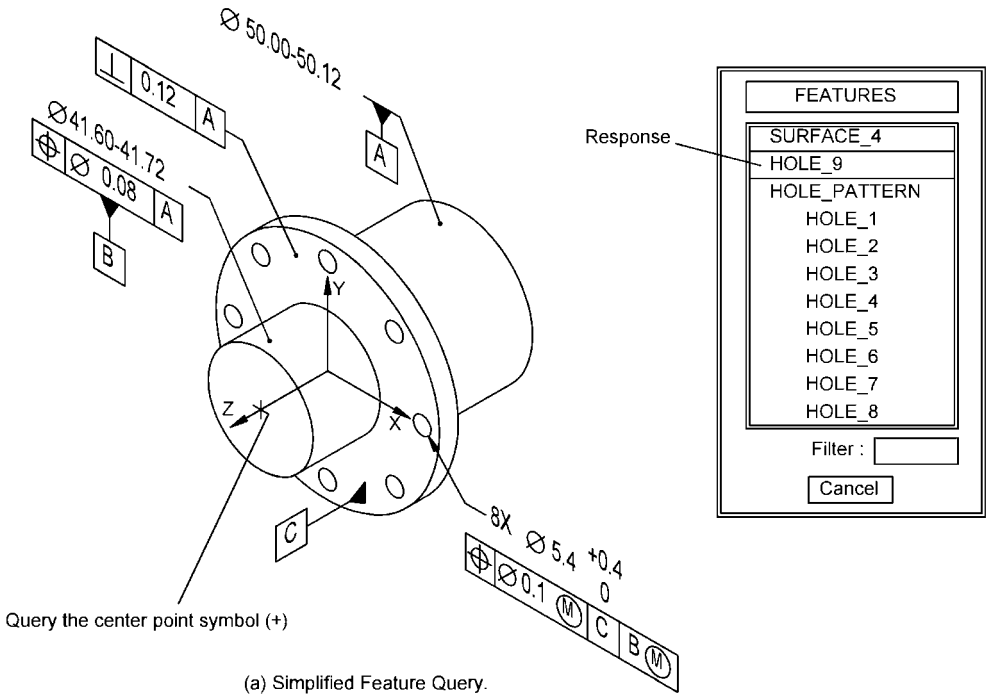
Fig. 7-3 Tolerance Query Associativity (Cont'd)



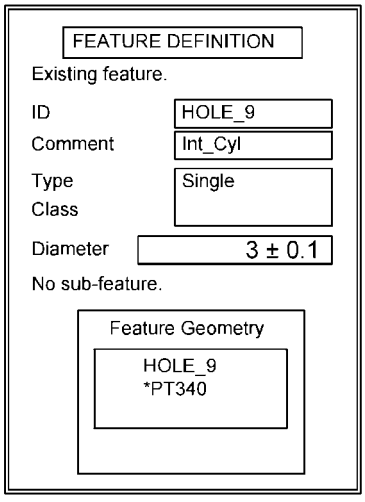
(c) Pattern of Features Query.

7.2.1(a)
7.2.7(b)(1)

Fig. 7-4 Simplified Feature Representation and Attributes



(a) Simplified Feature Query.



(b) Feature Attributes.

5.1.5
7.2.2

Fig. 7-5 Annotation Planes Relative to Model Geometry

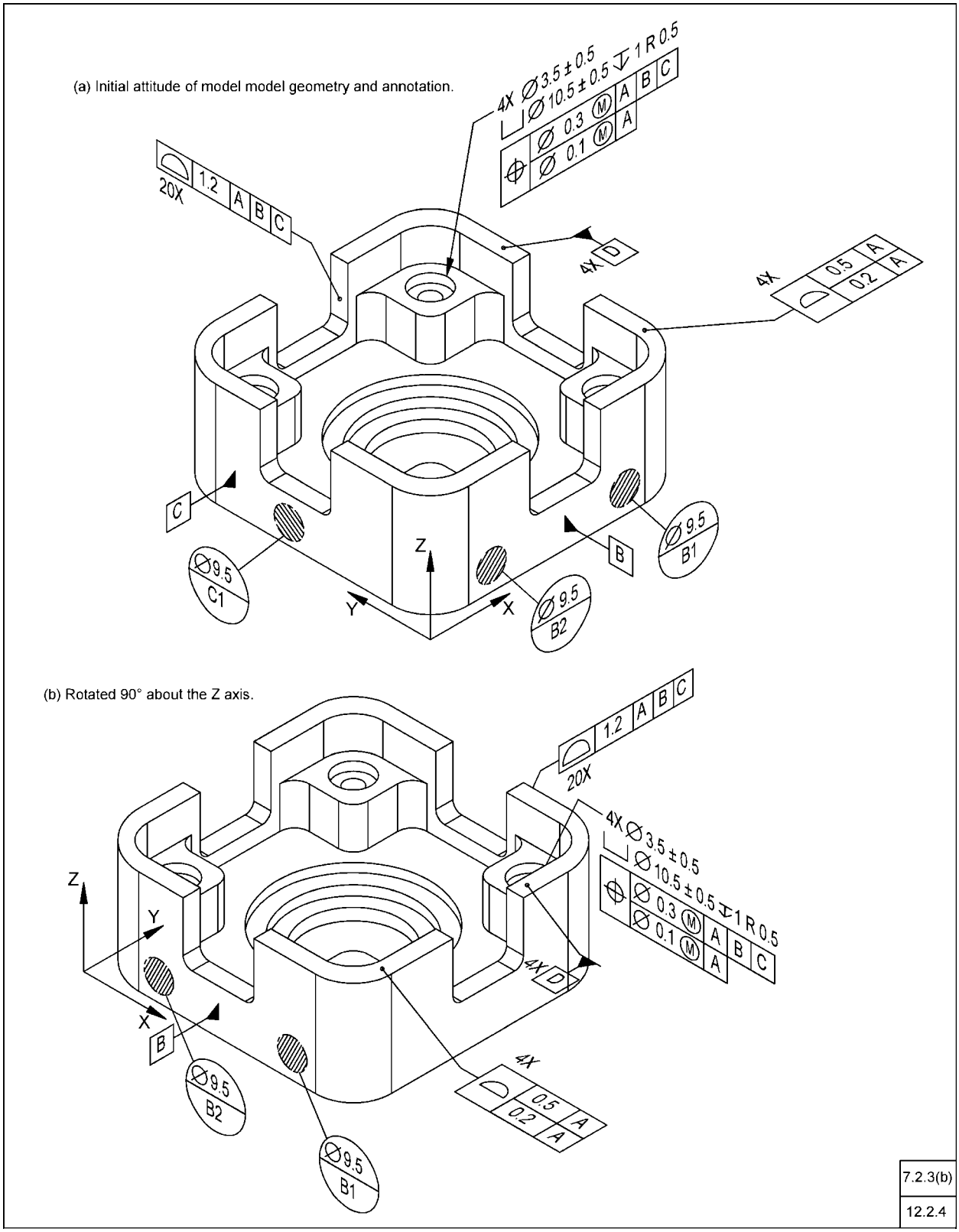


Fig. 7-6 Graphic Display of Associated Annotation

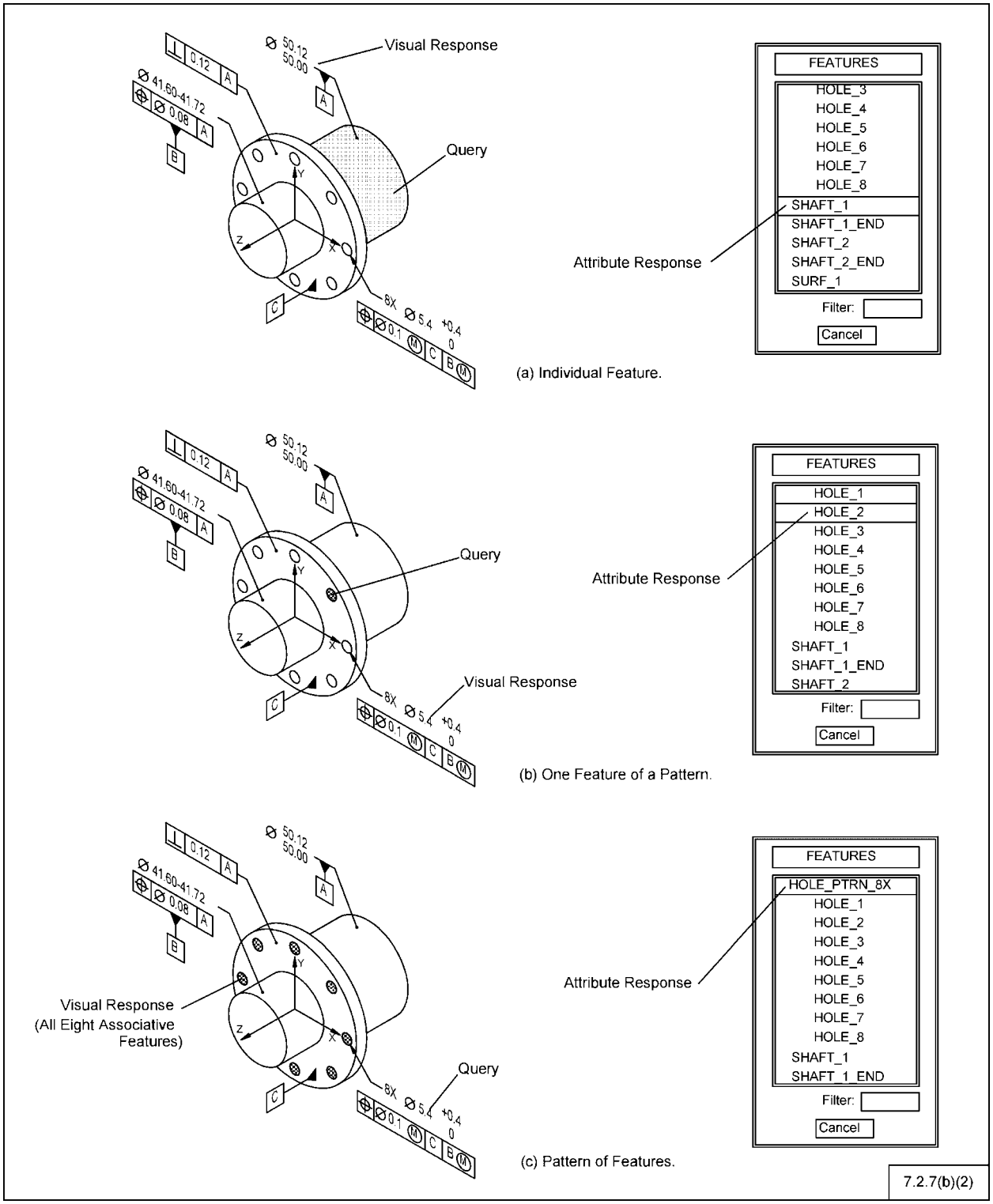


Fig. 7-7 Listing of Digital Element Identifiers

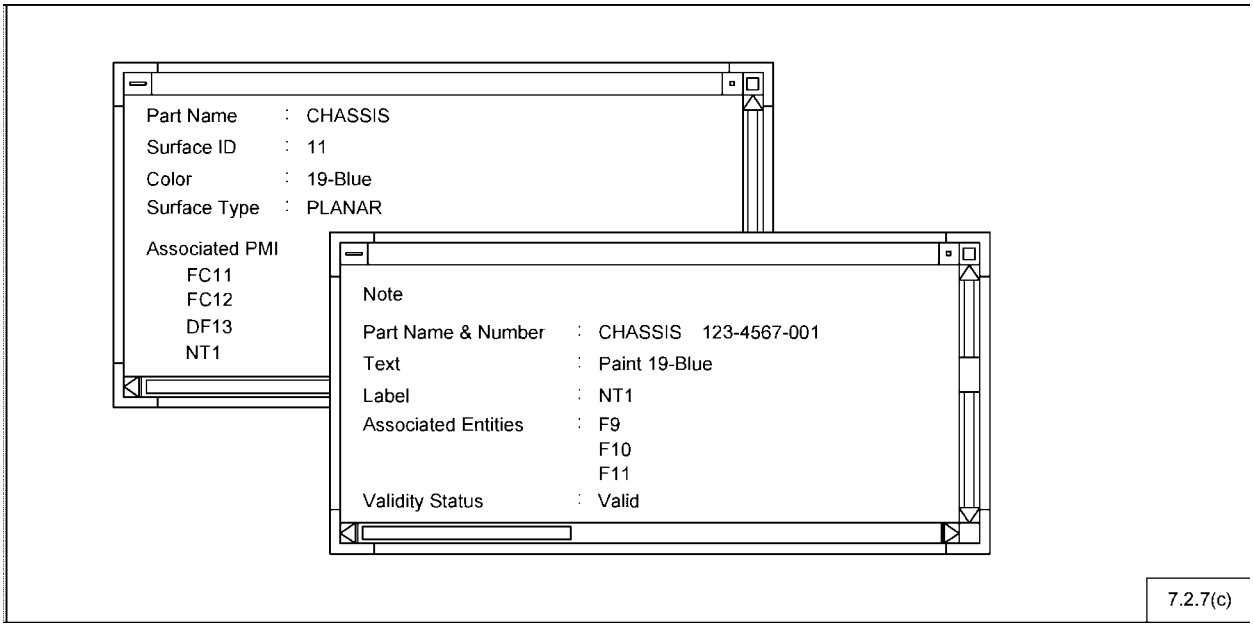


Fig. 7-8 Queries for Datum Feature Symbols and Datum Target Symbols

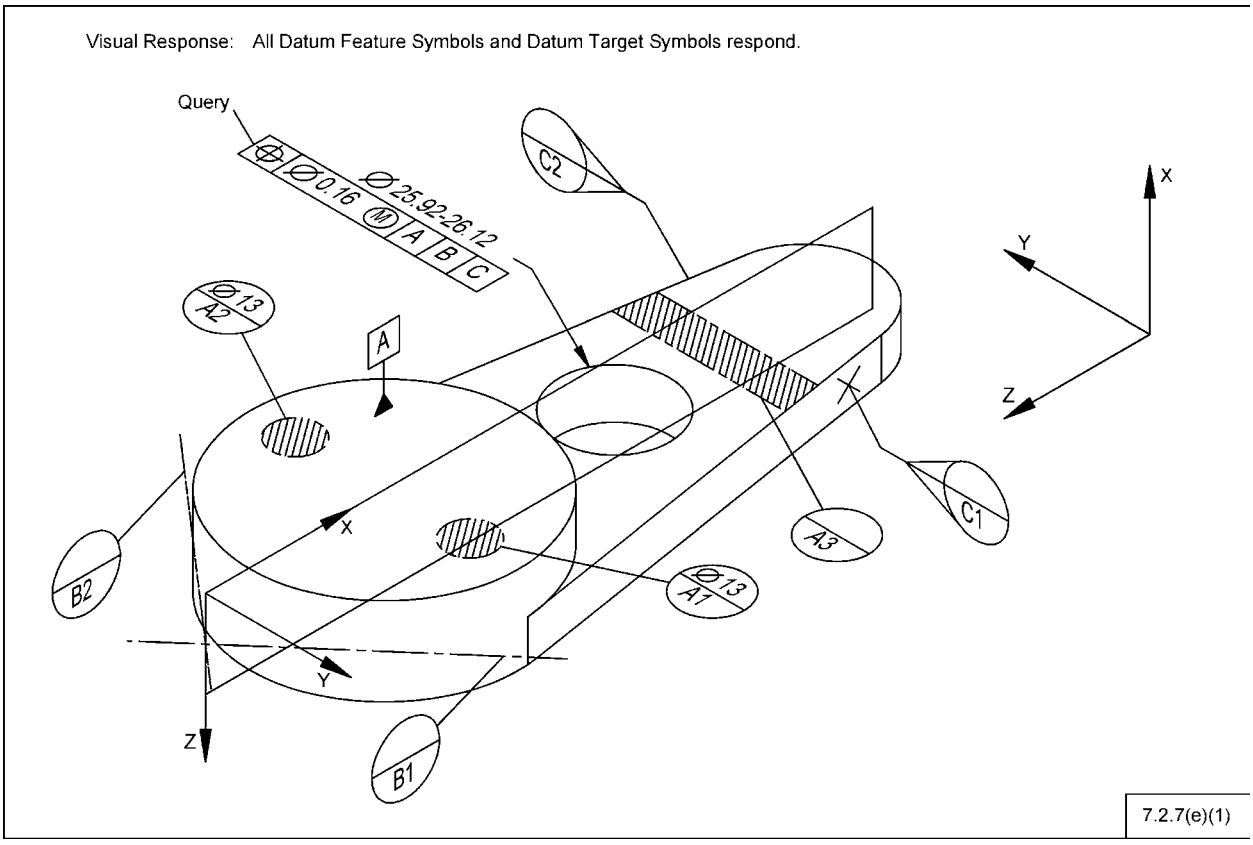
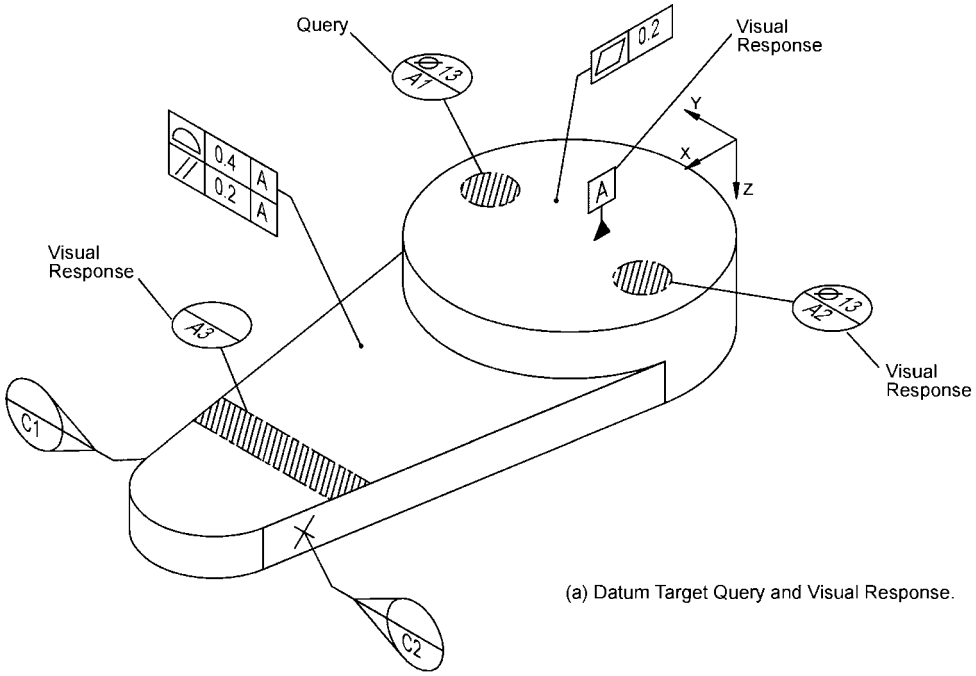
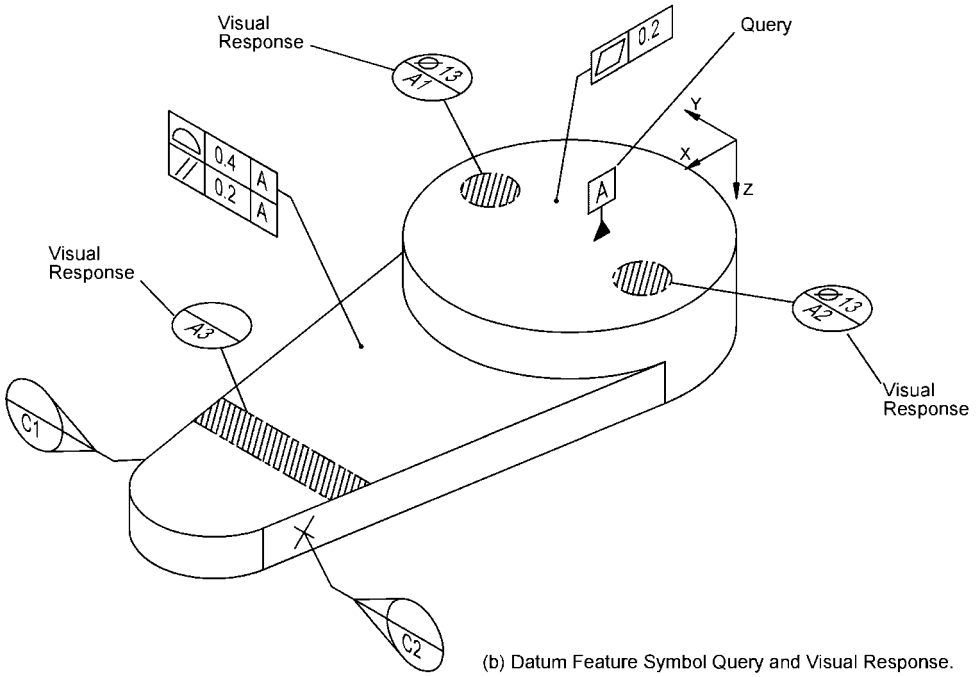


Fig. 7-9 Queries for Datum Targets



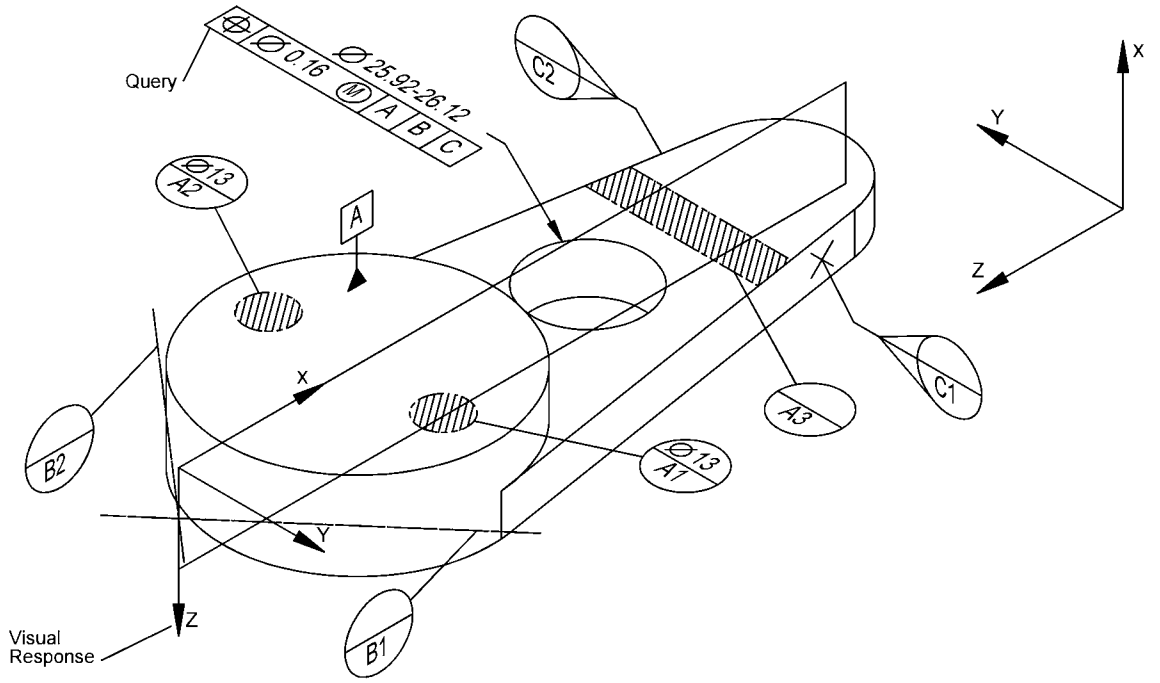
(a) Datum Target Query and Visual Response.



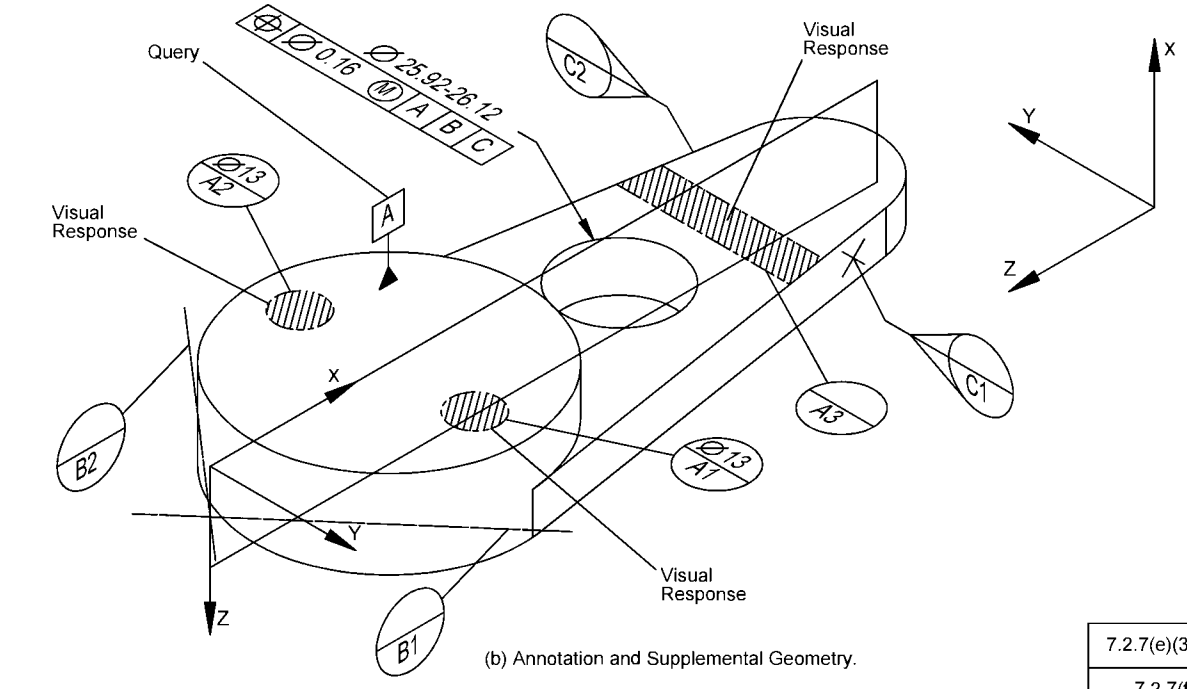
(b) Datum Feature Symbol Query and Visual Response.

7.2.7(e)(2)

Fig. 7-10 Queries for Coordinates and Supplemental Geometry



(a) Feature Control Frame and Corresponding Coordinate System.



(b) Annotation and Supplemental Geometry.

7.2.7(e)(3)

7.2.7(f)

Fig. 7-11 Annotated Model

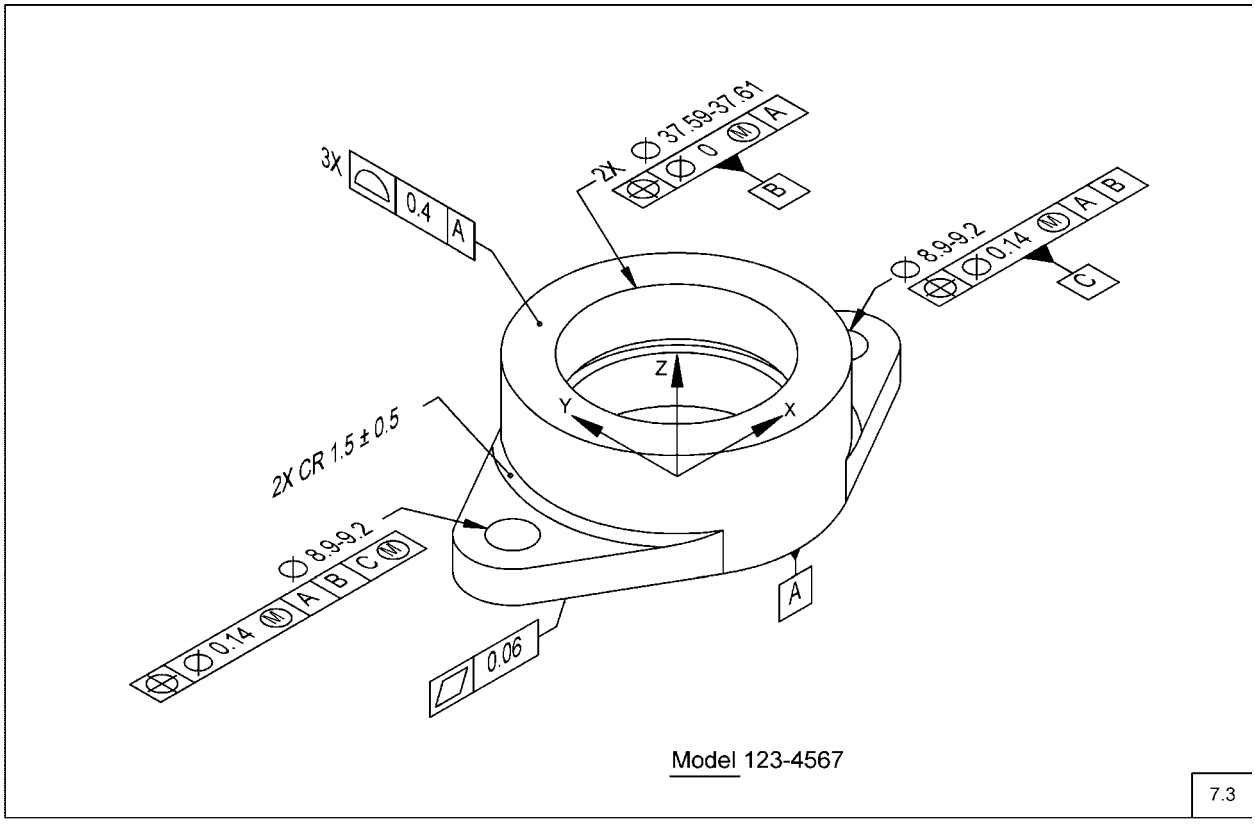
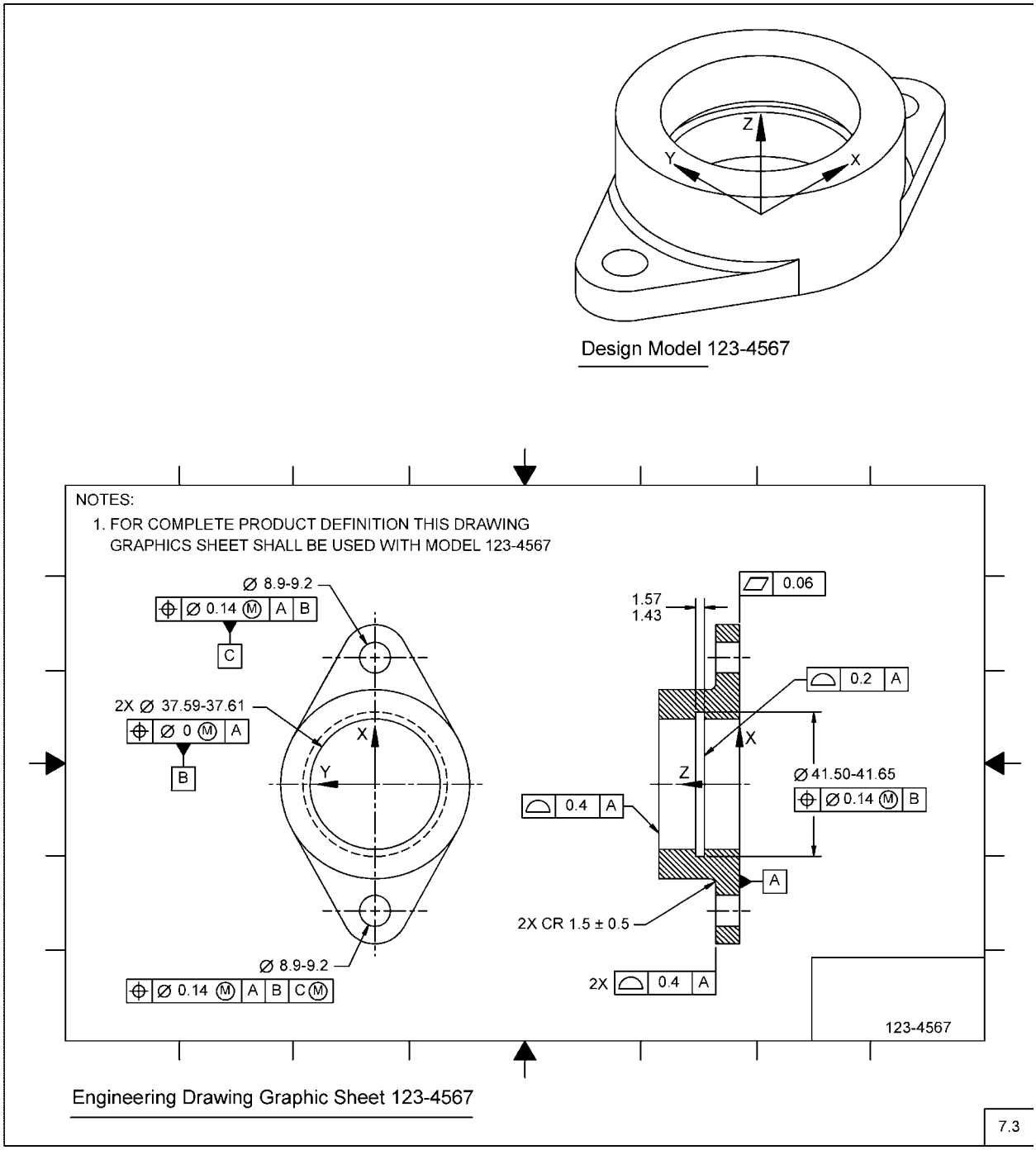


Fig. 7-12 Design Model and Drawing Graphic Sheet



Section 8
Notes and Special Notations

This Section establishes requirements for the application of notes and special notations used with a model, a drawing graphic sheet, or a combination of both.

8.1 COMMON REQUIREMENTS

There are no common requirements for notes and special notations.

8.2 MODEL REQUIREMENTS

The following paragraphs describe requirements for models.

8.2.1 Notes Area Annotation Plane

When general notes, flag notes, and special notations are placed in a model, they shall be placed on a single annotation plane or use a similar method. When displayed, these notes shall not rotate.

8.2.2 General Notes

General notes do not require associativity. General notes may include default tolerance(s) for the entire model.

8.2.3 Local Notes

Local notes shall be associated to the applicable digital elements in the model.

8.2.4 Flag Notes

When a flag note is placed in a model, the following shall apply:

(a) The flag note symbol, note number, and text shall be placed on the notes area annotation plane.

(b) The flag note symbol, note number, and text shall be associated to the digital elements to which it applies.

(c) The flag note symbol and note number shall be shown adjacent to the applicable digital elements in the model.

(d) The flag note symbol and note number shown adjacent to the digital elements in the model shall rotate with the model.

8.2.5 Special Notations

When special notations, as defined in ASME Y14.100, are placed in a model, the following shall apply:

(a) When the special notations are applicable to the entire model, the notation shall be placed on the notes area annotation plane.

(b) When the special notations are applicable only to a portion of a model, the special notations symbol and its associated text shall be placed on the notes area annotation plane in accordance with para. 8.2.1. The special notations symbol shall be shown adjacent to the applicable digital elements in the model. The special notation symbol shall be associated to the digital elements to which it applies.

8.3 DRAWING GRAPHIC SHEET REQUIREMENTS

The following paragraph describes requirements for drawing graphic sheets.

8.3.1 Local Notes in Axonometric Views

Local notes shall have a leader line(s) that clearly indicates the feature(s) that is related to the note. For leader line terminators, see para. 7.1.3.

Section 9
Model Values and Dimensions

This Section establishes the requirements for model value query, and resolved, basic, size, and limit dimensions in a data set. Direct tolerancing methods, as defined in ASME Y14.5, should only be used to define the size of a feature. See paras. 9.2.2 and Section 10. Geometric tolerancing is the preferred method. This Section also contains the common requirements for associativity and dimensions on a model or drawing graphic sheet. Linear, radial, and angular dimensions are addressed in Section 10.

9.1 COMMON REQUIREMENTS

All model values and resolved dimensions shall be obtained from the model. The following paragraphs address requirements for model values and resolved dimensions. Model values are obtained for one of the following purposes:

(a) to determine the location and orientation of surfaces

(b) to determine the distance or angle between two surfaces

(c) to determine the position (basic location and orientation) of features of size

(d) to determine the feature relation (the basic hole-to-hole spacing and orientation) dimensions within a pattern of features of size

(e) to determine the contour of surface geometry

(f) to determine the size value for a feature of size or a pattern of features of size

Model value queries (a) through (d) shall always be conducted in relation to the absolute or a user-defined coordinate system of the design model. For queries (e) and (f), direct interrogation of the model surface or feature of size is usually conducted.

9.1.1 Resolved Dimensions

Dimensions displayed on a model are resolved dimensions. Resolved dimensions derived from model values are considered the same as dimensions specified per ASME Y14.5. For examples of resolving model values to displayed dimensions, see Table 9-1. The requirements for resolved dimensions follow.

(a) To obtain a resolved dimension, a model value shall be rounded to the number of decimal places required for the design.

(b) All resolved dimensions shall be absolute values in accordance with ASME Y14.5.

(c) Rounding shall be in accordance with IEEE/ASTM SI 10.

(d) Resolved Dimension Preservation and Association. A direct and permanent association to the originating model value shall be established and maintained for every resolved dimension.

(e) Utilization of Model or Resolved Dimensions. The use of model values or resolved dimensions for analyses and other processes shall be defined in appropriate documentation.

9.2 MODEL REQUIREMENTS

Requirements for attaching and displaying basic and size dimensions on a model are defined in the following paragraphs. Linear, radial, and angular dimensions are addressed in Section 10. Dimensions and tolerances may be shown to internal features without the use of a section. See Fig. 10-4, illustration (c).

9.2.1 Basic Dimensions

Queried model values shall be interpreted as basic dimensions unless superseded by a toleranced dimension or defined as a reference dimension. Values queried from the model for any feature(s) without a direct tolerance relationship, or datum target specification(s) assigned, shall be reference dimensions.

(a) Basic Dimensions. Querying of the model for the profile, location, and orientation of a feature shall occur within the appropriate coordinate system. See paras. 9.1 and 11.2.1(a).

(b) Displaying Basic Dimensions. The display of basic dimensions may be necessary in defining some model relationships. This is applicable to the location of datum targets, an inclined datum feature, and features that may appear to be 90 deg but the actual model geometry angle is other than 90 deg. Displayed basic dimensions shall be enclosed in a box in accordance with ASME Y14.5.

(c) Placement. Basic dimensions should be placed in annotation planes that are parallel with one of the planes of the absolute or a user-defined coordinate system. An example of an exception is the 3× 6.35 basic dimension shown in Fig. 9-1.

(d) Attachment to Surface Features. Basic dimensions defining surface curvature or extent, such as fillets, rounds, or chamfers, shall be directed to the feature surface by a leader. See Fig. 9-1.

(e) Attachment With Dimension and Extension Lines. Basic dimensions defining linear distance or angular

relation are shown using dimension and extension lines. See Fig. 9-1.

(f) Implied Angle. There are no 90-deg implied angles in a model. All angular values shall be queried from the model. Exceptions to this are the coordinate system(s) and planes associated with a datum reference frame(s) and orthographic views.

NOTE: The use of a rectangular coordinate tabulation chart for basic dimensions can reduce or eliminate the need for dimension and extension lines. See ASME Y14.5 for examples.

9.2.2 Size Dimensions

A displayed feature of size dimension shall always include a tolerance.

(a) Size Dimension and Model Agreement. A size dimension shall agree with the queried model value for the same feature when the model value is rounded to the same number of decimal places. This agreement shall meet one of the following requirements, depending on the tolerance expression used.

(1) Bilateral or Unilateral Tolerance. The displayed size dimension shall equal the resolved model value.

(2) Limit Dimensions. The resolved model value shall equal one of the limit dimensions, or a value within the displayed range of limits.

(3) Limit Dimensions With Plus/Plus or Minus/Minus Tolerances. The resolved model value shall not be within the displayed range of limits.

(b) Placement and Attachment. The placement and attachment methods for size dimensions are as follows:

(1) Spherical Surface. The size dimension and leader shall be placed on an annotation plane containing the feature centerpoint.

(2) Cylindrical Surface. The size dimension and leader shall be placed on an annotation plane perpendicular to the feature axis or containing the feature axis.

(3) Set of Two Opposed, Parallel Surfaces (a Width). The size dimension, dimension line, and extension lines shall be placed on an annotation plane perpendicular to or containing the feature centerplane. The extension lines shall clearly indicate the surfaces comprising the width. See Fig. 9-2 for examples.

(c) Use of the Term TRUE. The term TRUE, when used with a dimension, shall not be used on models.

9.3 DRAWING GRAPHIC SHEET REQUIREMENTS

Basic dimensions not displayed on a drawing graphic sheet shall be obtained by querying of the model.

9.3.1 Presentation of Dimensions in Axonometric Views

Requirements for dimensions on axonometric views of a drawing graphic sheet are defined in the following paragraphs.

(a) Displayed Dimensions. Dimensions shown in an axonometric view shall be true, and the use of the term TRUE is not required.

(b) Displayed Basic Dimensions. Basic dimensions shall be enclosed in a box in accordance with ASME Y14.5.

(c) Dimension Leader Lines. Leader lines shall be used to relate a dimension to a cylindrical feature. The leader line shall be directed to the intersection of the cylindrical feature and a surface. Leader lines shall terminate with an arrowhead.

Fig. 9-1 Placement and Attachment of Basic Dimensions

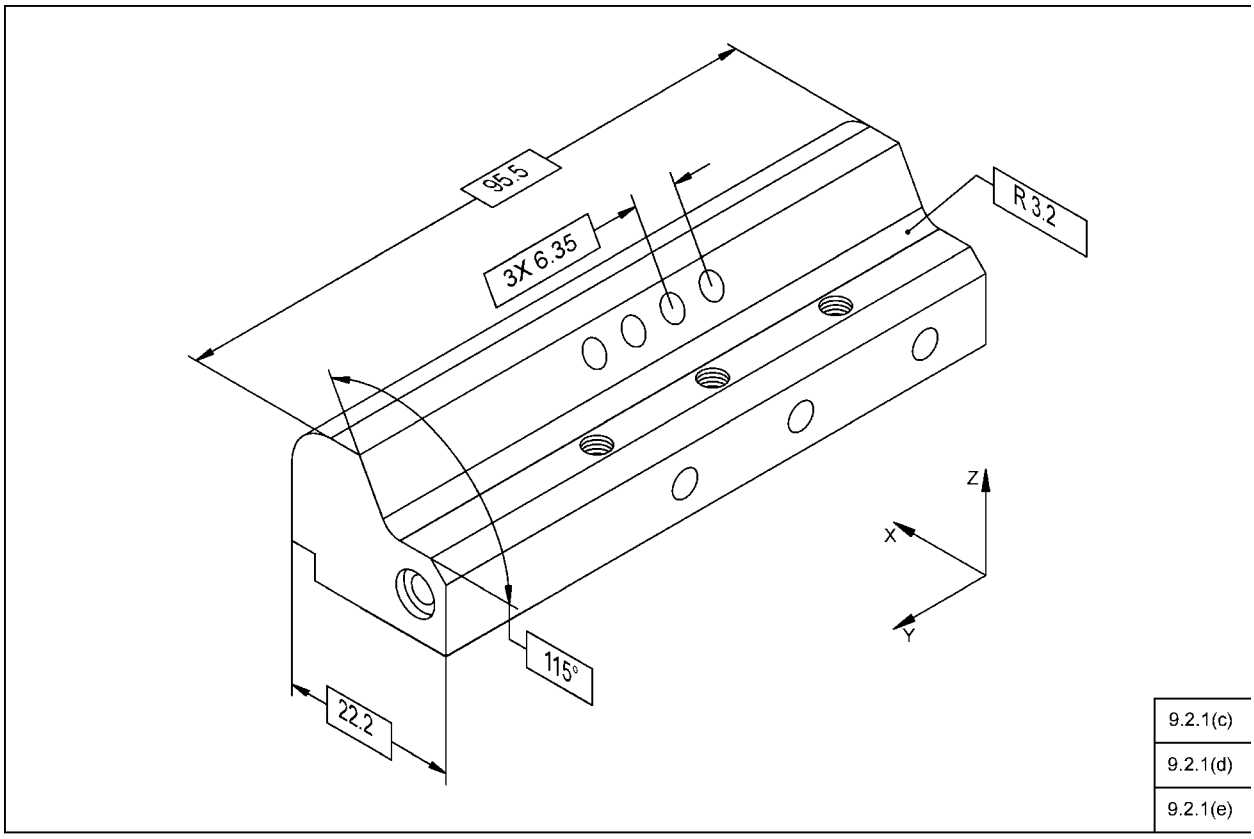


Fig. 9-2 Placement and Attachment of Size Dimensions

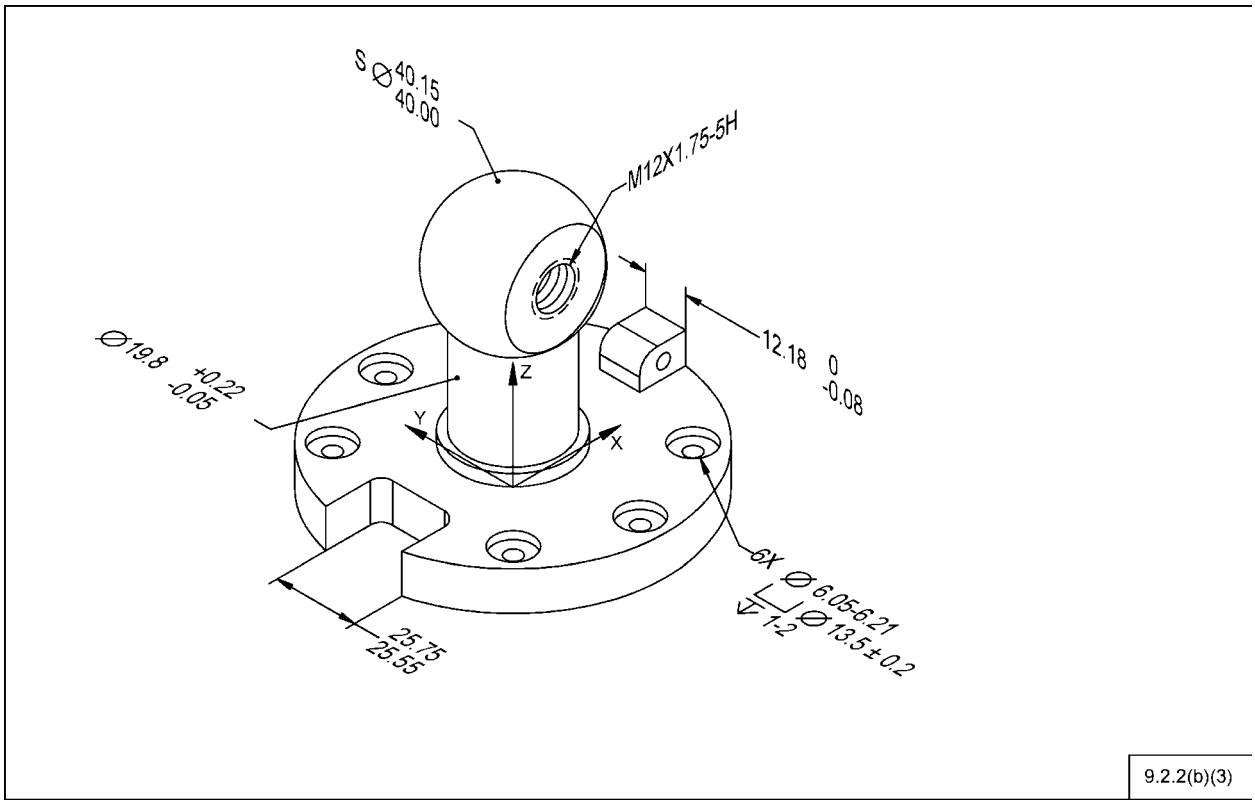
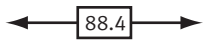
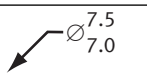
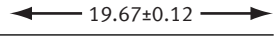
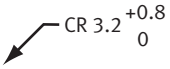
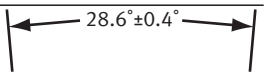
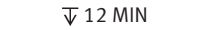
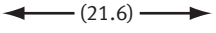


Table 9-1 Resolved Dimension Examples

ASME Y14.5	ASME Y14.41 Model Value [Note (3)]	ASME Y14.41 Resolved Dimension	Application Example
Basic [Note (1)]	88.4100000...	88.4	
Size [Note (2)]	7.0000000...	7.0	
Linear	19.6666666...	19.67	
Radial	3.1500000...	3.2	
Angular	28.5918273...	28.6	
Single Limit [Note (1)]	12.0000000	12	
Reference [Note (1)]	21.6018043	21.6	

NOTES:
(1) Linear, radial, angular, diametral, or spherical diameter.
(2) Linear, diametral, or spherical diameter.
(3) The values shown are examples. Actual values will reflect the defined precision of the model and the rounding requirements of each particular application.

Section 10
Plus and Minus Tolerances

This Section establishes the placement, attachment, and display requirements for plus and minus tolerances in a data set.

10.1 COMMON REQUIREMENTS

One or more general notes defining plus and minus tolerances may be specified.

10.2 MODEL REQUIREMENTS

Table 10-1 lists general applications for plus and minus tolerance of linear, radial, and angular dimensions. The attachment method generally used is shown.

NOTE: The features listed in Table 10-1 do not comprise an exhaustive list, and define requirements that are applicable to similar and other valid applications. The omission of a particular application is not cause to consider the application invalid.

10.2.1 Chamfers

Attachment for 90-deg surface intersections with an equally disposed chamfer is indicated in Table 10-1. Oblique surface intersections, unequally disposed extents, or chamfers defined using a linear and angular dimension require the use of dimension and extension lines. See Fig. 10-1, illustrations (d) and (e). The value shall be located and oriented in a manner that is clear.

10.2.2 Depth Specification

When a feature depth is governed by a remaining thickness tolerance, the feature tolerance and the remaining thickness requirement should be an associated group. See Fig. 10-4, illustration (c).

10.3 DRAWING GRAPHIC SHEET REQUIREMENTS

Use existing drawing standards for plus and minus tolerances. See para. 1.1.

Table 10-1 Plus and Minus Tolerance Applications

General Applications	Attachment Technique: Size Callout	Attachment Technique: Directed Leader	Attachment Technique: Extension Lines	Paragraph	Figure
Fillets, Rounds, Chamfers	. . .	●	. . .	10.2.1	10-1
Reliefs, Step Surfaces	. . .	. . .	●	. . .	10-2
Countersinks	●	. . .	. . .	. . .	10-3(a)
Oblique Surfaces	. . .	. . .	●	. . .	10-3(b)
Entry Depth and Spotface	●	. . .	. . .	10.2.2	10-4(a)(b)
Remaining Thickness	. . .	. . .	●	10.2.2	10-4(c)
Notches, Flats, and Pin Height	. . .	. . .	●	. . .	10-5

Fig. 10-1 Attachment Techniques: Fillets, Rounds, and Chamfers

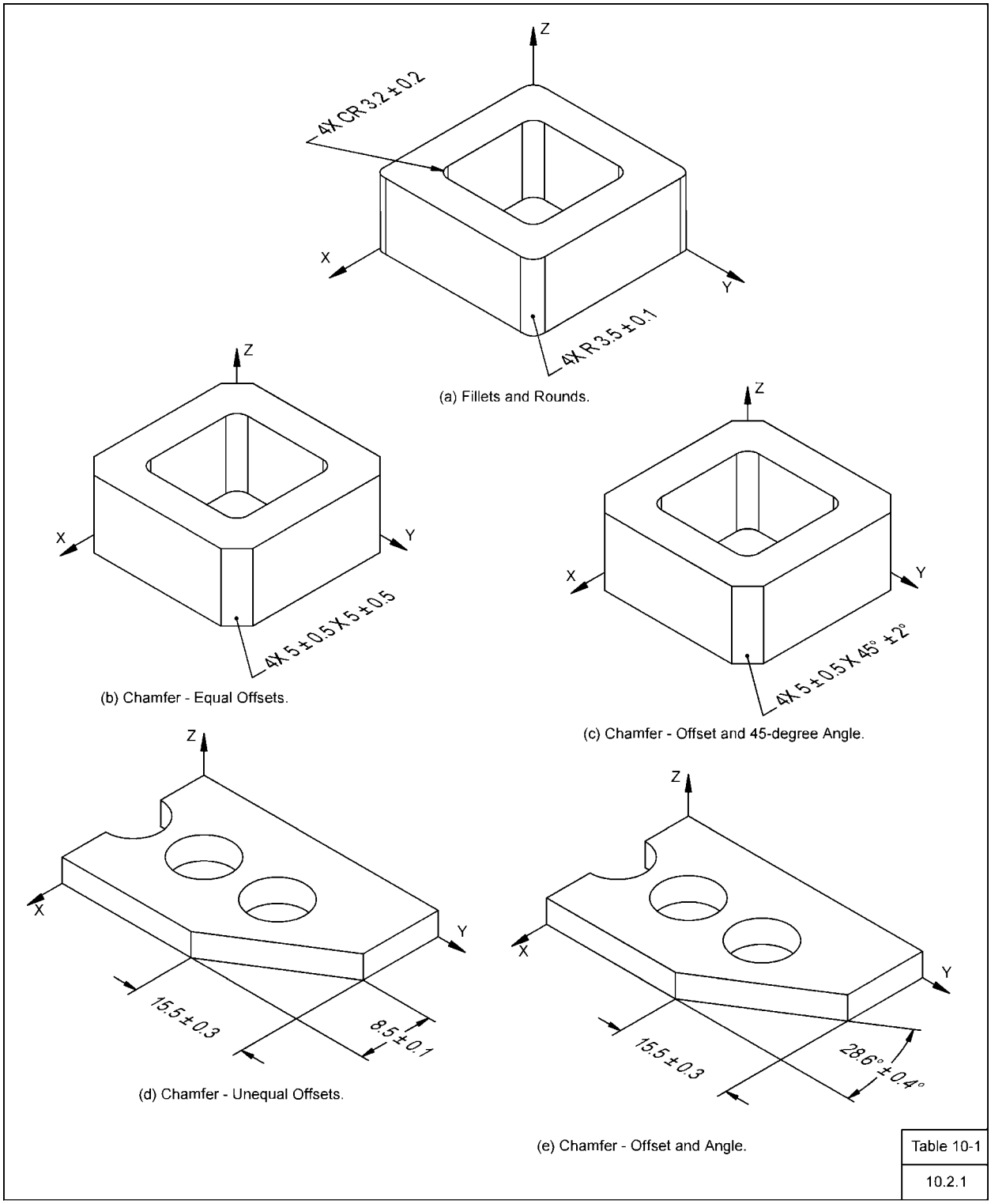


Fig. 10-2 Attachment Techniques: Reliefs and Step Surfaces

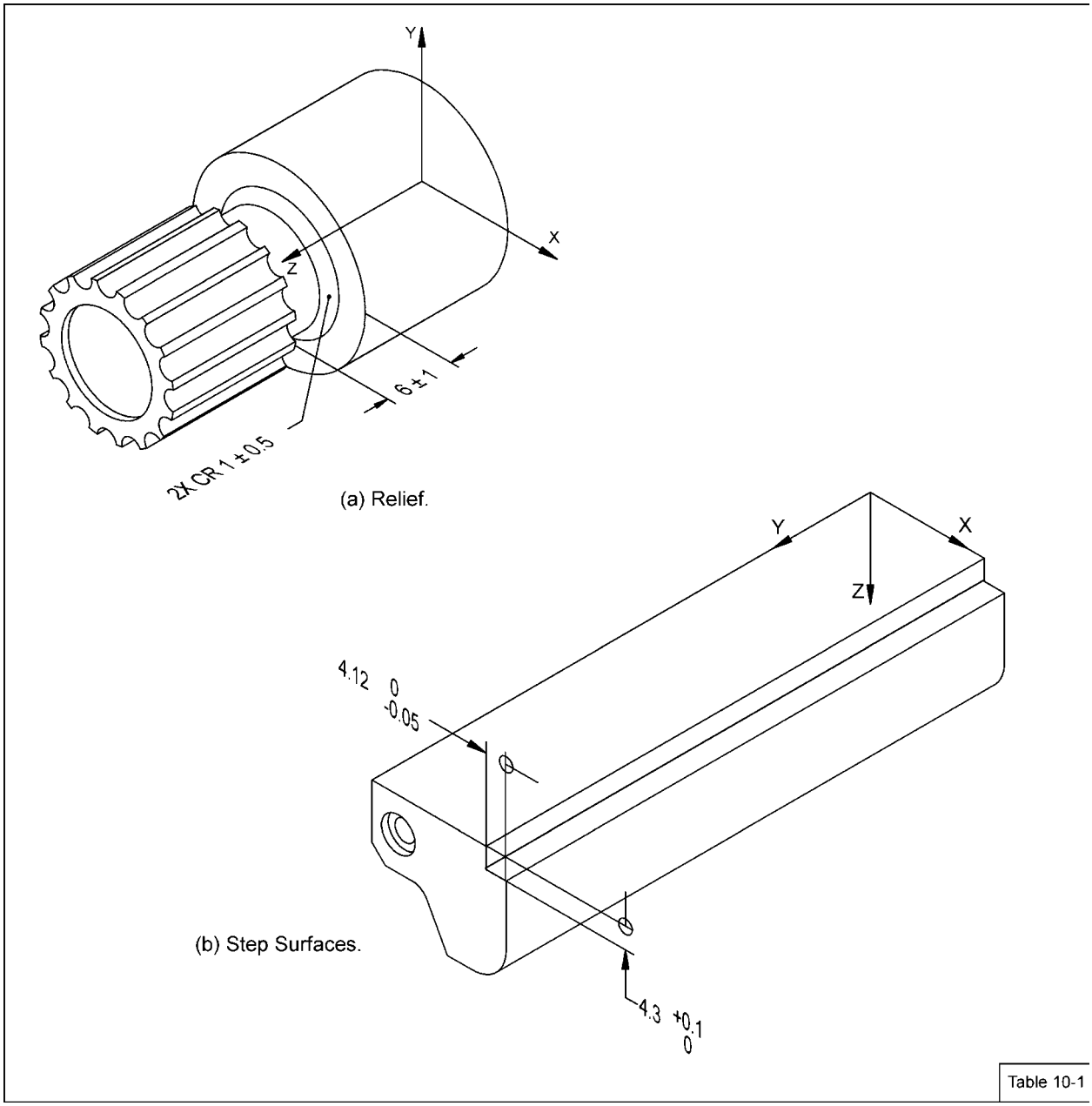


Fig. 10-3 Attachment Techniques: Countersinks and Oblique Surfaces

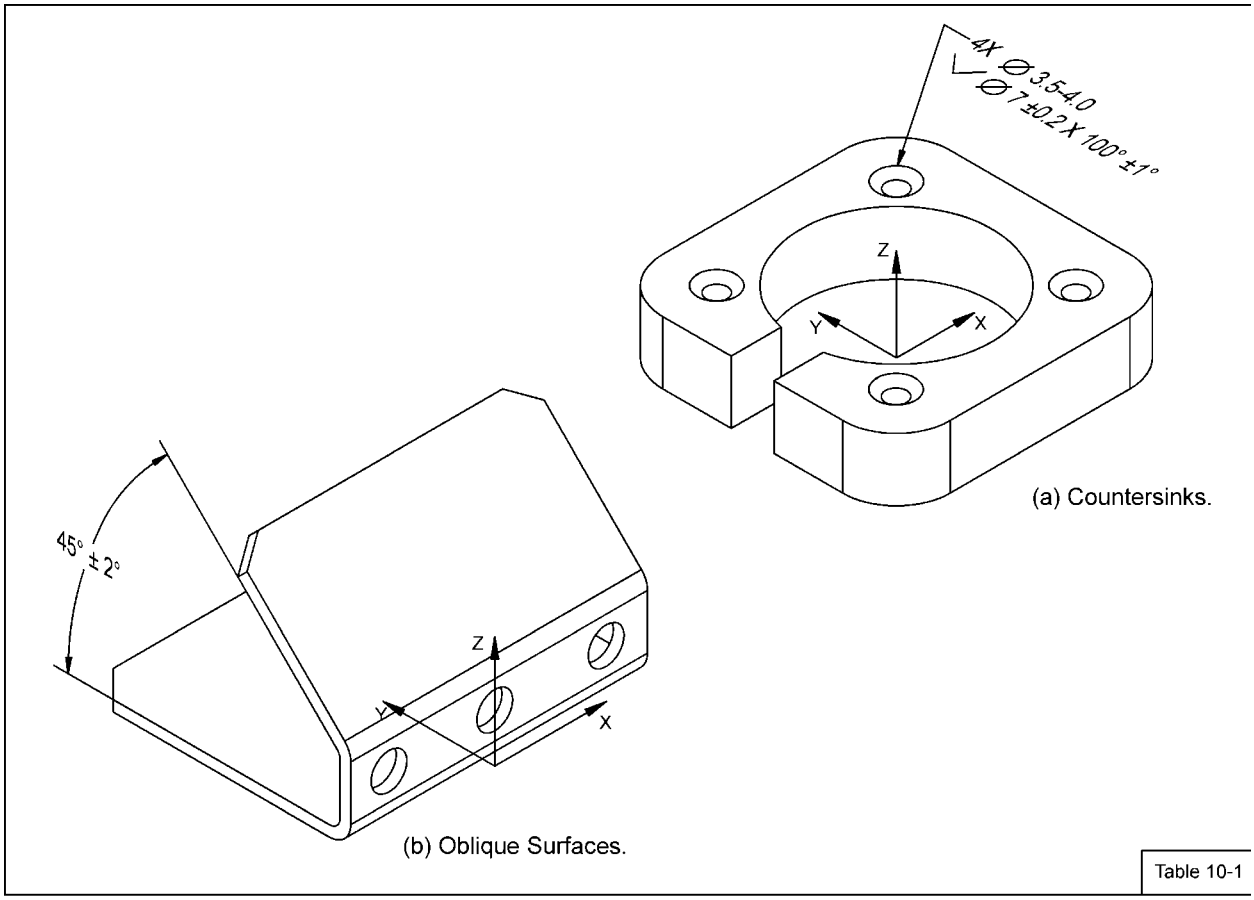


Fig. 10-4 Attachment Techniques: Depth, Spotface, Remaining Thickness

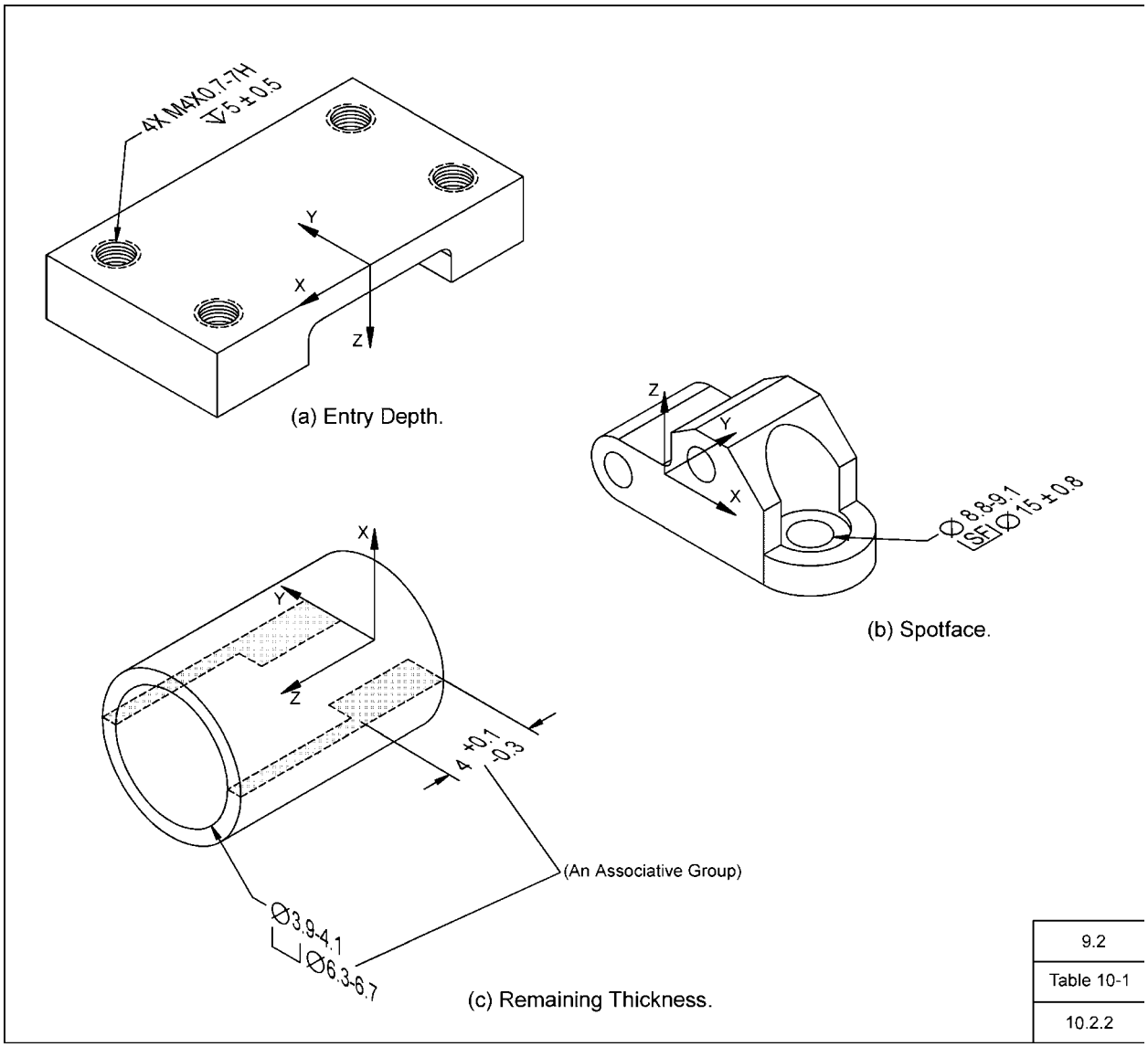
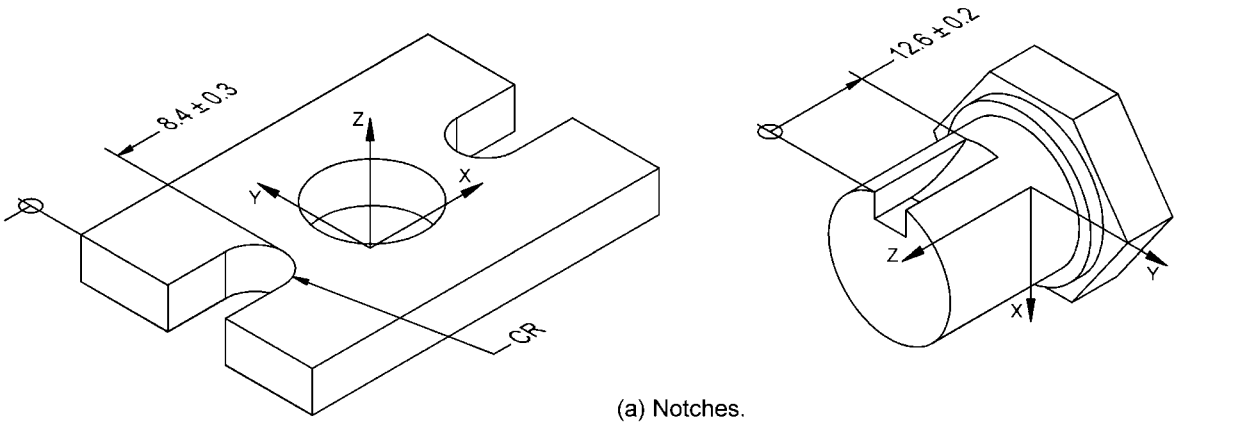
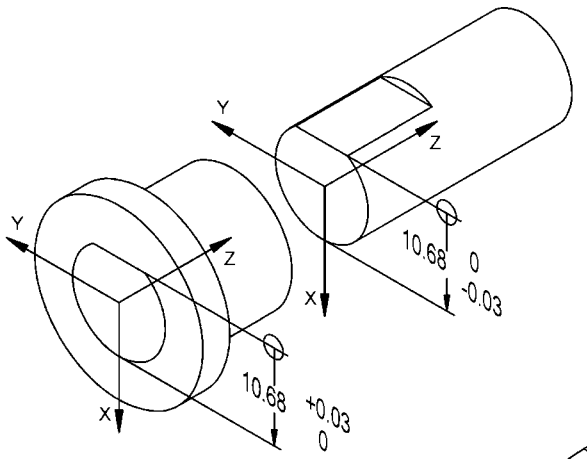


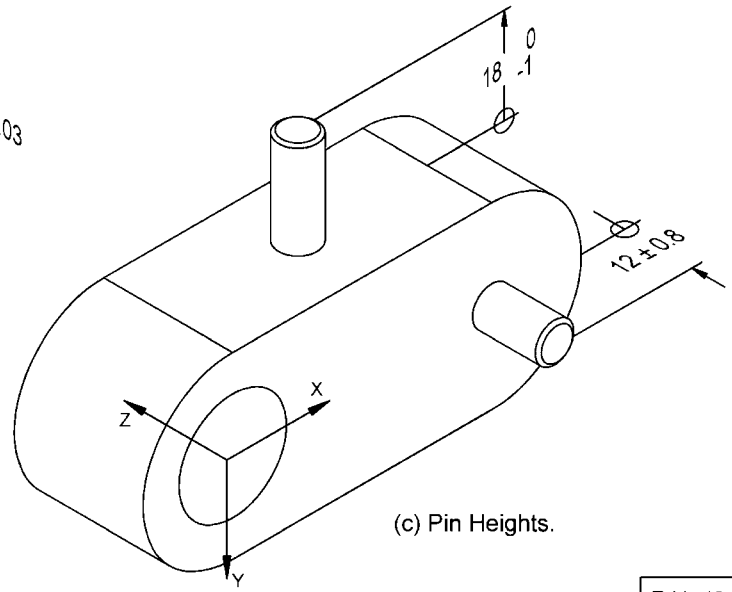
Fig. 10-5 Attachment Techniques: Notches, Flats, and Pin Heights



(a) Notches.



(b) Flats on Cylinders.



(c) Pin Heights.

Table 10-1

Section 11
Datum Applications

This Section establishes practices for organizing, attaching, and displaying datum feature symbols, datum targets, and related information associated with models. Requirements and recommendations for correlating datum features to the coordinate axes of the model space are given.

11.1 COMMON REQUIREMENTS

There are no exceptions or additions to existing standards that are common for datum applications. See para. 1.2.

11.2 MODEL REQUIREMENTS

The following paragraphs describe requirements applicable to models.

11.2.1 Datum Reference Frames and Coordinate Systems

The following requirements apply to the relationship between the datum reference frames on the model and the coordinate systems.

(a) Datum Reference Frame and Coordinate System Correspondence. Each datum reference frame shall be associated to a corresponding coordinate system.

(b) Datum Reference Frame and Coordinate System Associativity. A definite visual association between any datum reference frame and the corresponding coordinate system shall be preserved throughout navigation and interrogation of the presented design data.

(c) Multiple Datum Reference Frame and Coordinate Systems Relationship. When more than one datum reference frame is imposed upon a model, each distinguished datum reference frame-to-coordinate system relationship shall be clearly presented and maintained. See Fig. 11-1, illustrations (a), (b), and (c) for an example of multiple datum reference frames and coordinate systems organized in a single design presentation.

(d) Datums Established From Complex or Irregular Surfaces. A coordinate system shall be used to indicate the orientation of a datum reference frame that has been defined from complex or irregular surfaces.

(e) Labeling of Datum Reference Frames. When a datum reference frame is labeled, the label shall take the form of "DRF_XXX" where the datum letters of the datum reference frame are used in place of "XXX".

(1) When used, a customized datum reference frame in accordance with ASME Y14.5 shall be labeled.

(2) When a datum reference frame is not a customized datum referenced frame, labeling is optional. See Fig. 11-1, illustrations (a), (b), and (c).

11.2.2 Identification of Datum Features

The following paragraphs describe requirements for identification of datum features and attachment or placement of datum feature symbols on models.

(a) Identification of Datum Features. Figure 11-2 demonstrates symbol attachment methods for identifying the datum features. The datum feature symbol should be attached to the surface representing the datum feature. Single extension lines of feature outlines should not be used for attachment of datum feature symbols. Particular requirements and the preferred methods governing each of the four fundamental datum feature types are given in the following paragraphs.

(1) Identification of a Planar Surface Datum Feature. The datum feature symbol is placed on an annotation plane perpendicular to the surface with the leader attached, terminating in a triangle. See datum A in Fig. 11-2, illustration (a).

(2) Identification of a Spherical Surface Datum Feature. The datum feature symbol is attached as shown to the size limits imposed upon the feature. See datum F in Fig. 11-2, illustration (a).

(3) Identification of a Cylindrical Surface Datum Feature. The datum feature symbol is attached as shown to the size limits imposed upon the feature. See datum B and datum G in Fig. 11-2, illustration (a).

(4) Identification of a Set of Two Opposed, Parallel Planes (a Width). The datum feature symbol and the dimension and extension lines are placed on an annotation plane perpendicular to the width centerplane. The size limits shall be organized and displayed similarly as shown. See datum C and datum E in Fig. 11-2, illustration (a).

(5) Identification of Limited Area Application. When the surface containing a datum feature also contains an area of limited application of a geometric tolerance, the limited area of application is represented on the model geometry using supplemental geometry. See Fig. 11-3. The use of a chain line to indicate limited area of application, as described in ASME Y14.5, is not recommended.

(6) The datum feature symbol may also be placed on the horizontal portion of a leader line that is directed

to the appropriate surface. See Figs. 11-5, 12-27, and 12-28.

(b) Query of Datum Features and Design Data. A query of any datum feature shall permit access to all relevant information for the datum feature. This includes the datum feature symbol, the size limits (if applicable), any applied geometric tolerance, and the relevant coordinate system.

11.2.3 Datum Target Identification and Attachment

The following paragraphs describe the requirements for attaching, associating, and displaying datum targets on models.

(a) V-Type Equalizers. When the design requires the use of V-type equalizers, the display presentation method of Fig. 11-4, illustration (a), is created. The V-type equalizers are represented by supplemental geometry tangent to the cylindrical datum feature, and the leader of a datum target symbol is attached.

(b) Movable Datum Targets. When a datum target does not have a fixed location, the target may be represented as supplemental geometry. The movable target symbol of ASME Y14.5 shall be attached. See Fig. 11-4, illustration (b). The direction of movement shall be indicated by the addition of a represented line element to the model geometry to indicate the direction of movement. The represented line element shall be placed on the outside of the material. The line element is placed at the point of contact for a datum target point, along the line for a datum target line or within the area for a datum target area. The movement is along the represented line element. See Fig. 11-4, illustration (b).

(c) Establishing Datum Axis Targets on a Single Interior Cylindrical Surface. A primary datum axis in Fig. 11-5 is established by two sets of three equally spaced target points.

(d) Establishing Datum Axis Targets on Two Exterior Cylindrical Surfaces. The primary datum axis in Fig. 11-6, illustration (a), is established by targets on two cylindrical datum features. The target for datum A is a cylindrical area, and the targets for datum B are three equally spaced points.

(e) Establishing a Circular Datum Target Line on a Cylindrical Surface. When the designated target for a cylindrical datum feature is a circular line, the display and attachment method shown in Fig. 11-6, illustration (b), is employed, using supplemental geometry to represent the circular datum target line.

(f) Distinguishing Datum Target Areas. Datum target areas shall be shown using shading or crosshatching. See Fig. 11-4.

11.2.4 Multiple Features Establishing a Datum

When two or more features are combined to establish a datum, associativity shall be established in the design presentation. For several common instances, the following display and associativity requirements apply. A phantom line connecting the features, as depicted in ASME Y14.5, shall not be used.

(a) A Pattern of Features Establishing a Datum Axis. When a pattern of features of size is used to establish a datum axis, the involved features and any applied tolerance for these features shall be organized as an associated group. See Fig. 11-7.

(b) Two Coaxial Cylinders Establishing a Single Datum Axis. When two coaxial and cylindrical datum features are used to establish a single, common datum axis, the involved features and any applied tolerance for these features shall be organized as an associated group. See Fig. 11-8.

(c) Coplanar Surfaces Establishing a Datum Plane. When two or more coplanar surface features are used to establish a datum plane, the involved model surfaces and any applied tolerance for these surfaces shall be organized as an associated group. See Fig. 11-9. When an intervening feature separates the surfaces being toleranced, the profile tolerance shall be attached to one of the surfaces but not both. See Fig. 11-10.

11.3 DRAWING GRAPHIC SHEET REQUIREMENTS

Datum features in axonometric views shall be indicated as follows:

(a) Datum Reference Frame and Coordinate System Correspondence. The corresponding coordinate system shall be displayed in each axonometric view in which a datum reference frame is cited.

(b) Identification of Datum Features in Axonometric Views. The following paragraphs describe requirements for identification of datum features in axonometric views:

(1) The datum feature symbol should be attached to the model geometry surface representing the datum feature. A single extension line of a feature outline should not be used for attachment of datum feature symbols in an axonometric view.

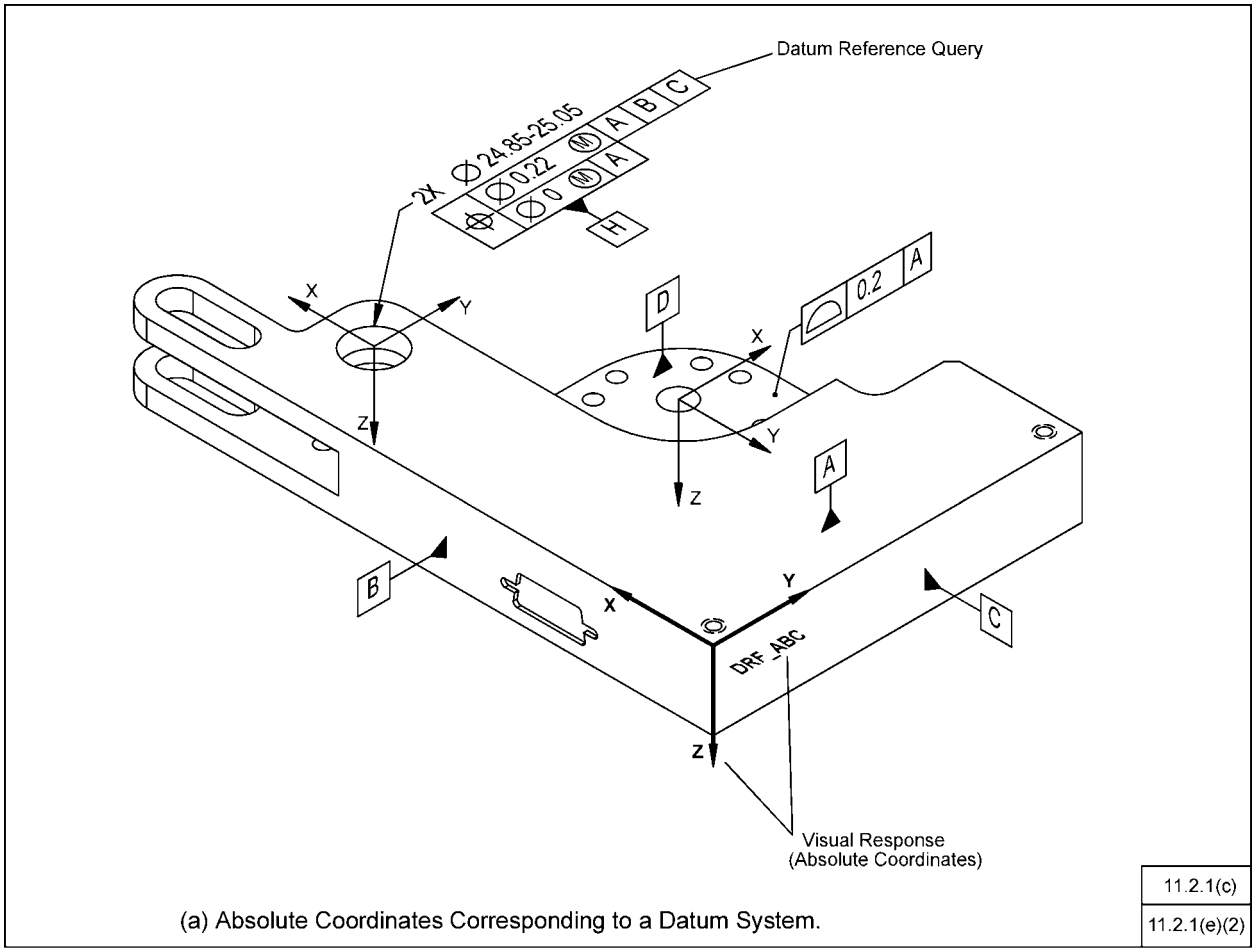
(2) Datum feature symbols may be attached to the dimension for features of size when the feature is used to define a datum. See Fig. 11-2.

(c) V-Type Equalizers Using Axonometric Views. When the design requires the use of V-type equalizers, the display presentation method of Fig. 11-11, illustration (a), is created. The V-type equalizers are represented by supplemental geometry tangent to the cylindrical datum feature, and the leader of a datum target symbol is attached.

(d) Movable Datum Targets Using Axonometric Views. When a datum target does not have a fixed location, the target may be represented as supplemental geometry. The movable target symbol of ASME Y14.5 shall be attached. See Fig. 11-11, illustration (b). The direction

of movement shall be indicated by the addition of a represented line element to the model geometry to indicate the direction of movement. The represented line element shall be placed on the outside of the material. The line element is placed at the point of contact for a datum target point, along the line for a datum target line, or within the area for a datum target area. The movement is along the represented line element. See Fig. 11-11, illustration (b).

Fig. 11-1 Datum System and Coordinates Relationship



(a) Absolute Coordinates Corresponding to a Datum System.

Fig. 11-1 Datum System and Coordinates Relationship (Cont'd)

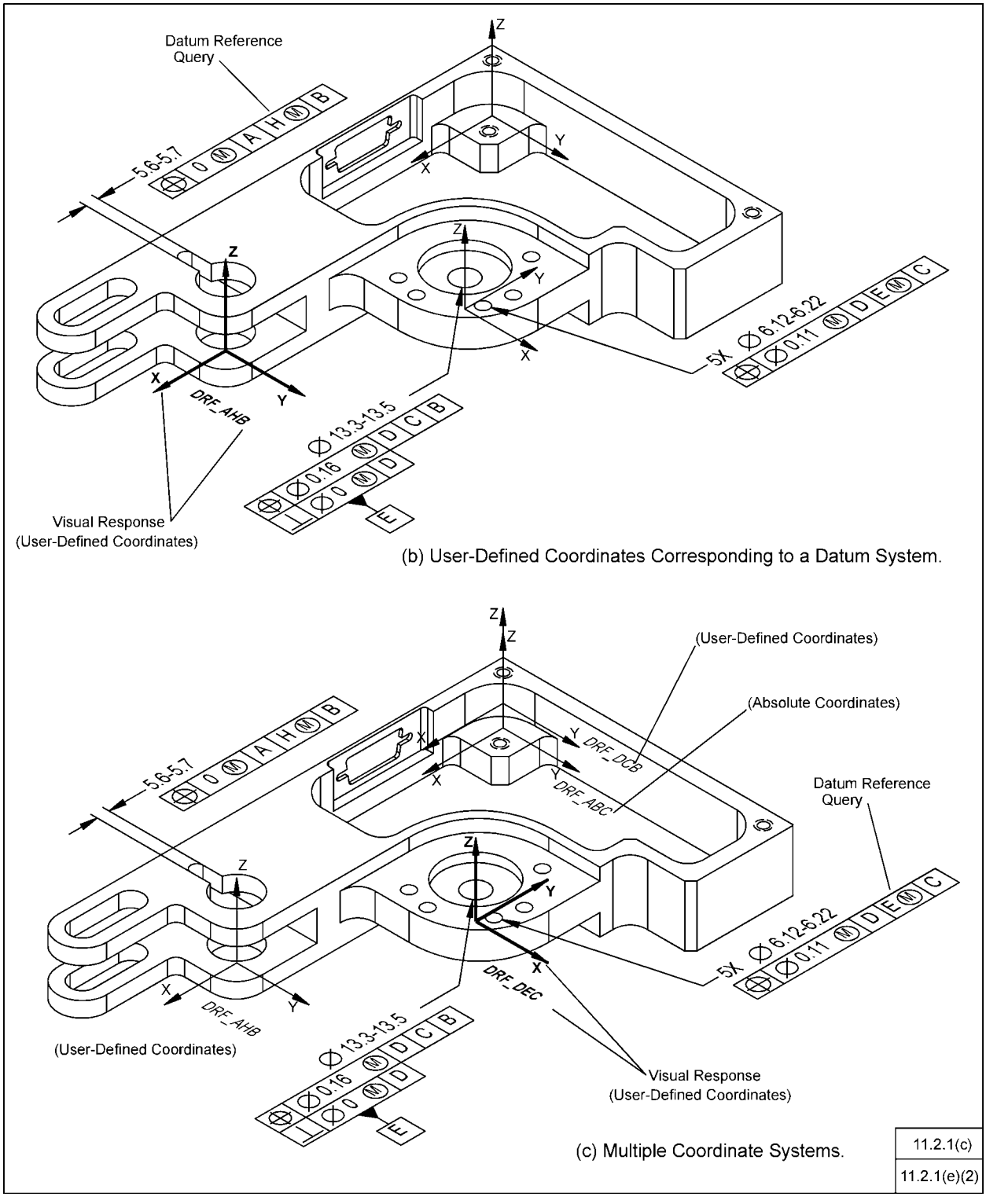
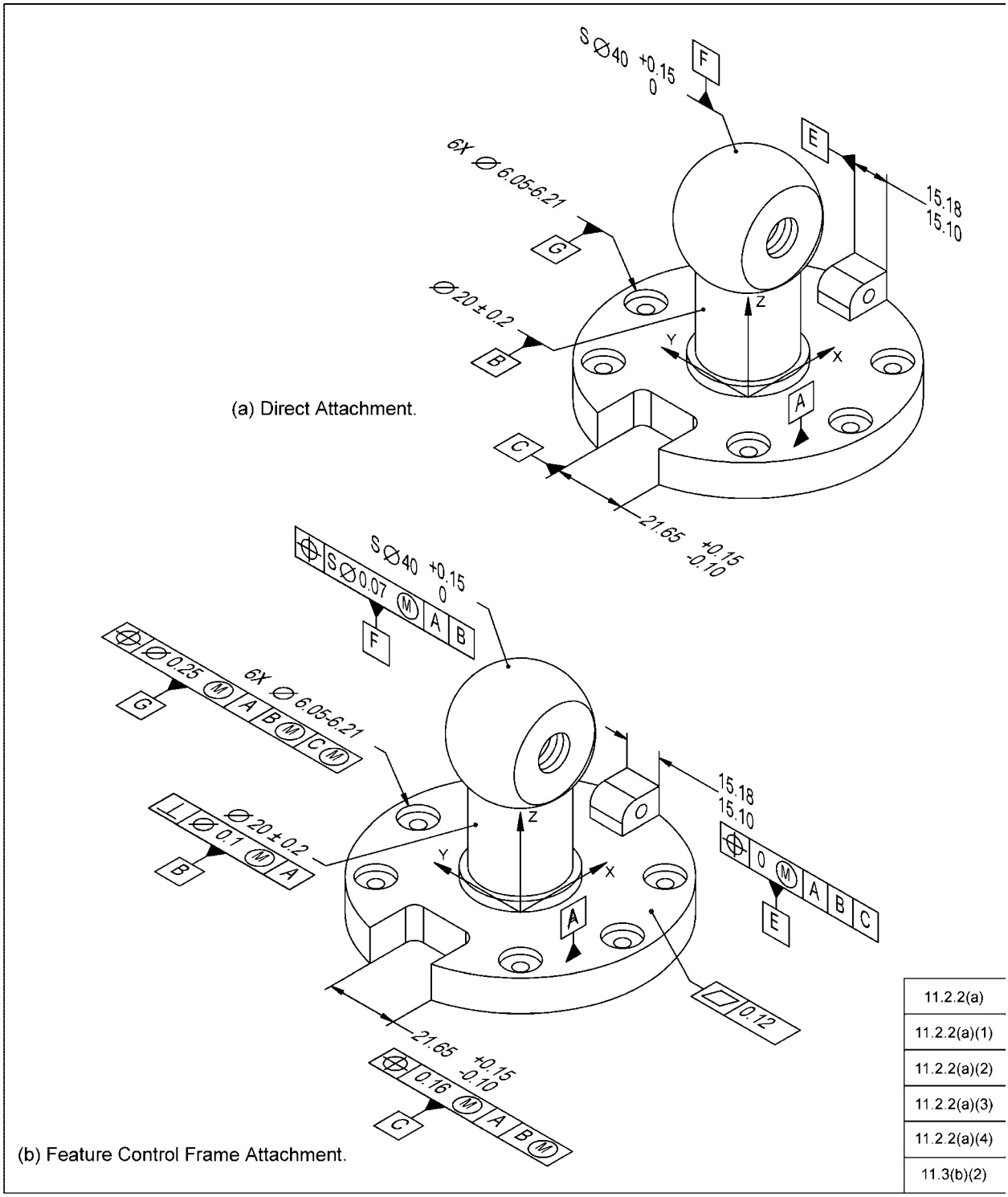
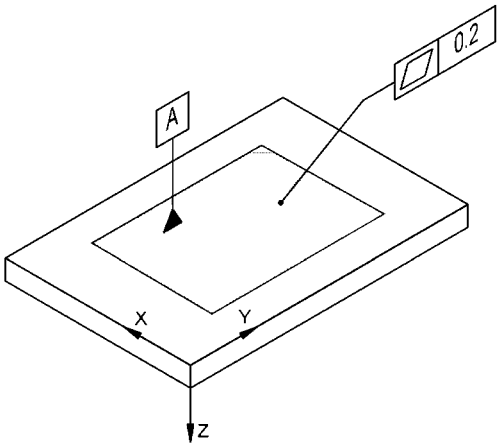


Fig. 11-2 Datum Feature Symbol Attachments



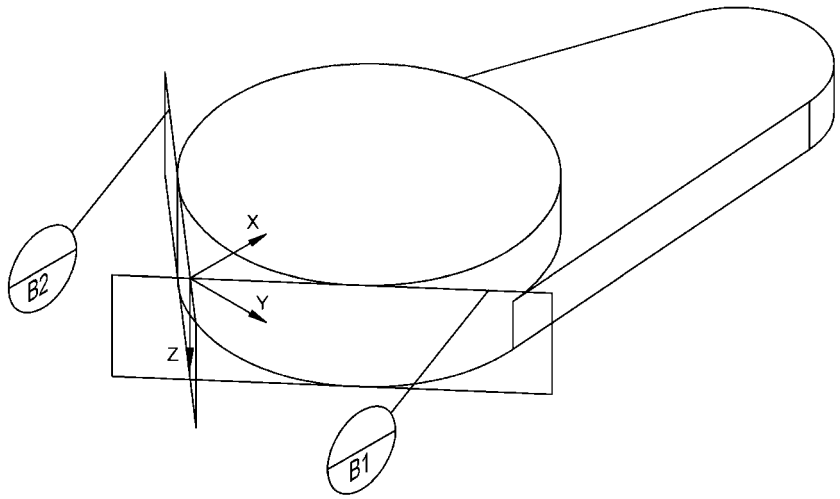
11.2.2(a)
11.2.2(a)(1)
11.2.2(a)(2)
11.2.2(a)(3)
11.2.2(a)(4)
11.3(b)(2)

Fig. 11-3 Partial Surface as a Datum Feature

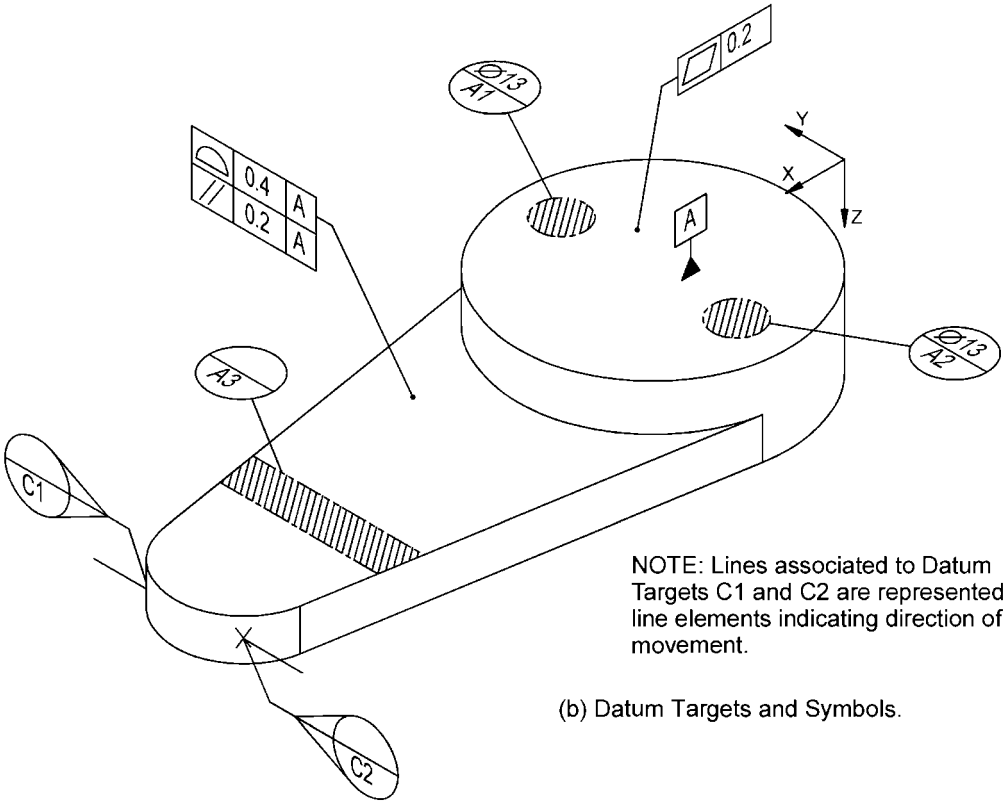


7.2.6
11.2.2(a)(5)
12.2.1(a)
Table 12-1

Fig. 11-4 Datum Targets and Symbols Attachment



(a) V-type Equalizer - Datum Target Planes.



NOTE: Lines associated to Datum Targets C1 and C2 are represented line elements indicating direction of movement.

(b) Datum Targets and Symbols.

5.1.4(d)
5.1.4(e)
11.2.3(a)
11.2.3(b)
11.2.3(f)

Fig. 11-5 Equalizing Target Points Establish a Datum Axis on an Internal Cylindrical Surface

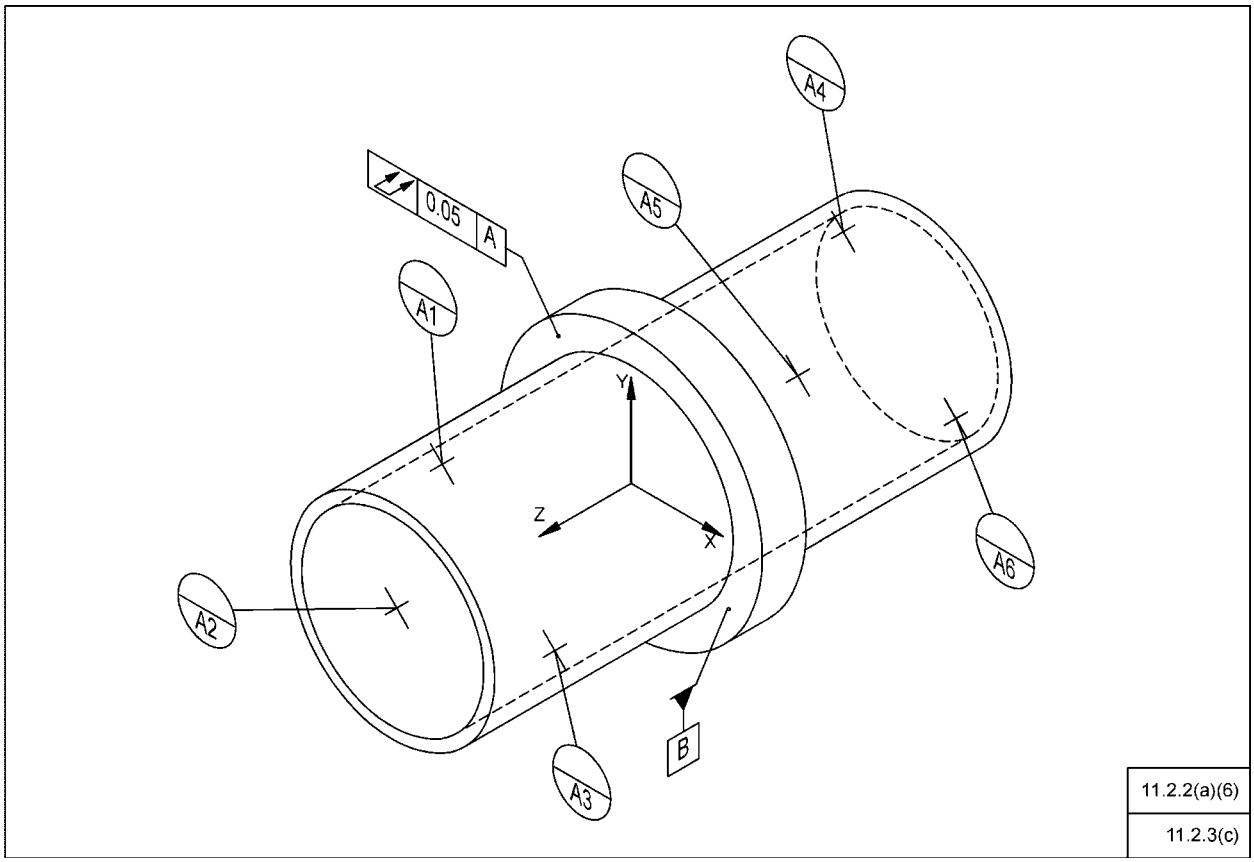
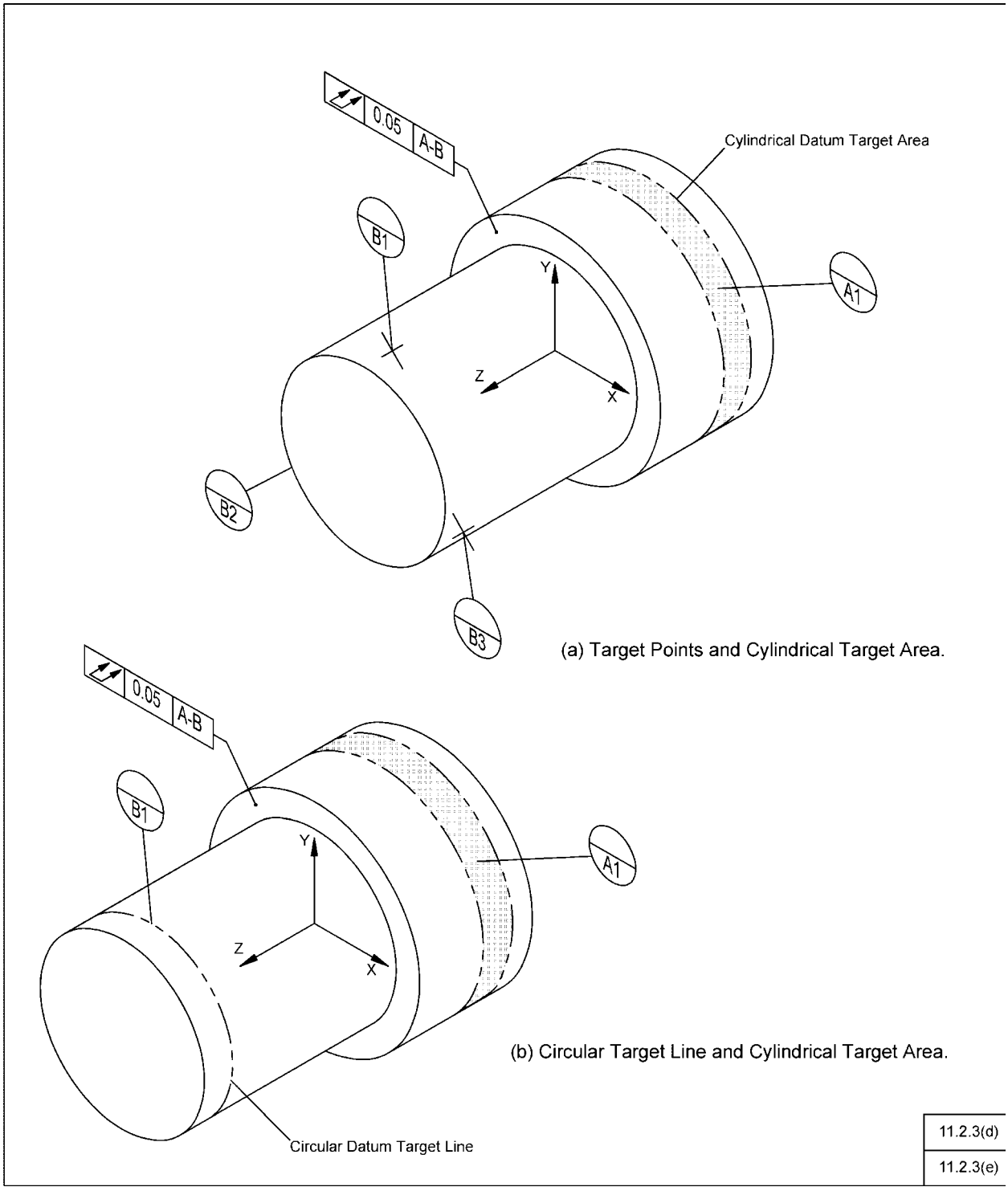


Fig. 11-6 Two Cylindrical Features Establish a Datum Axis



11.2.3(d)
11.2.3(e)

Fig. 11-7 Pattern of Features Establish a Datum Axis

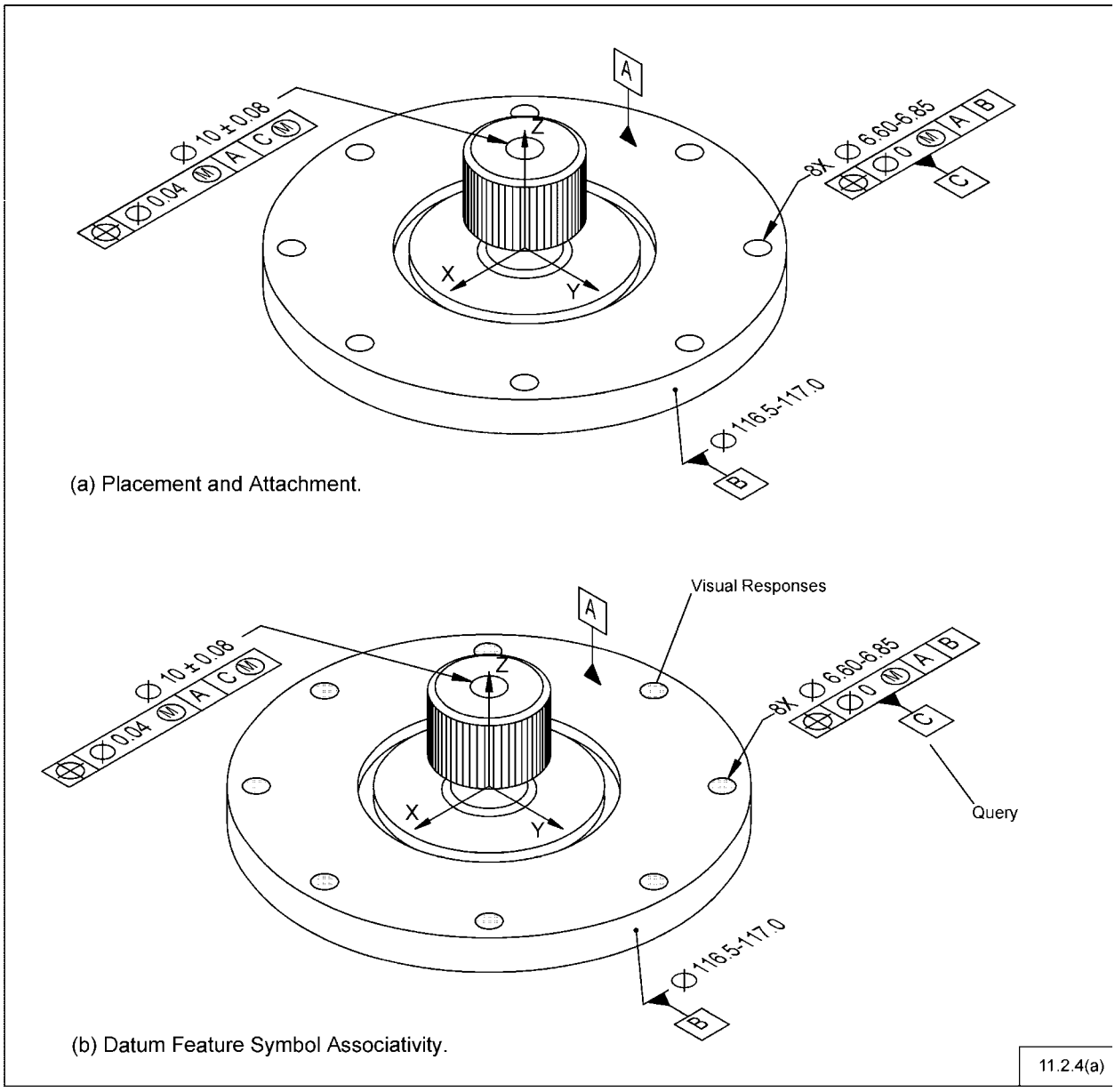


Fig. 11-8 Two Coaxial Features Establish a Datum Axis

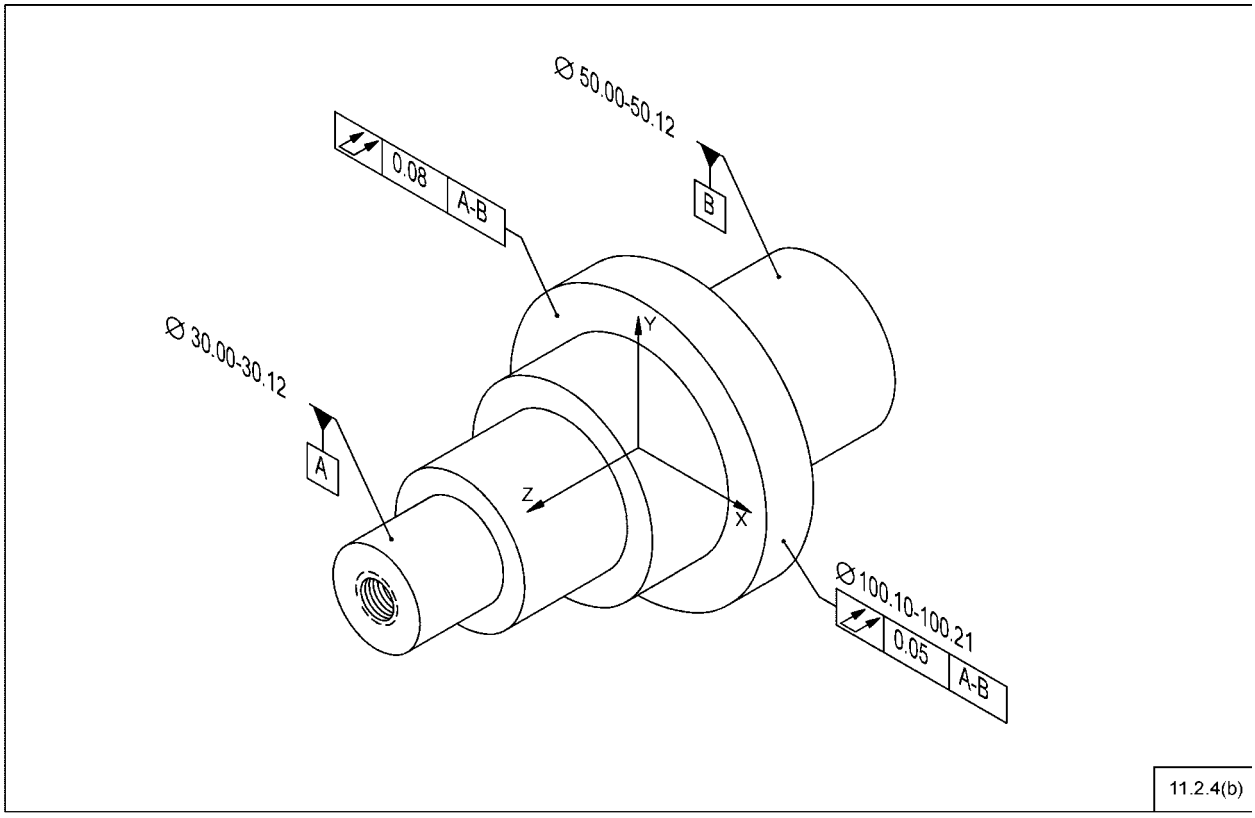


Fig. 11-9 Coplanar Surfaces Establish a Datum Plane

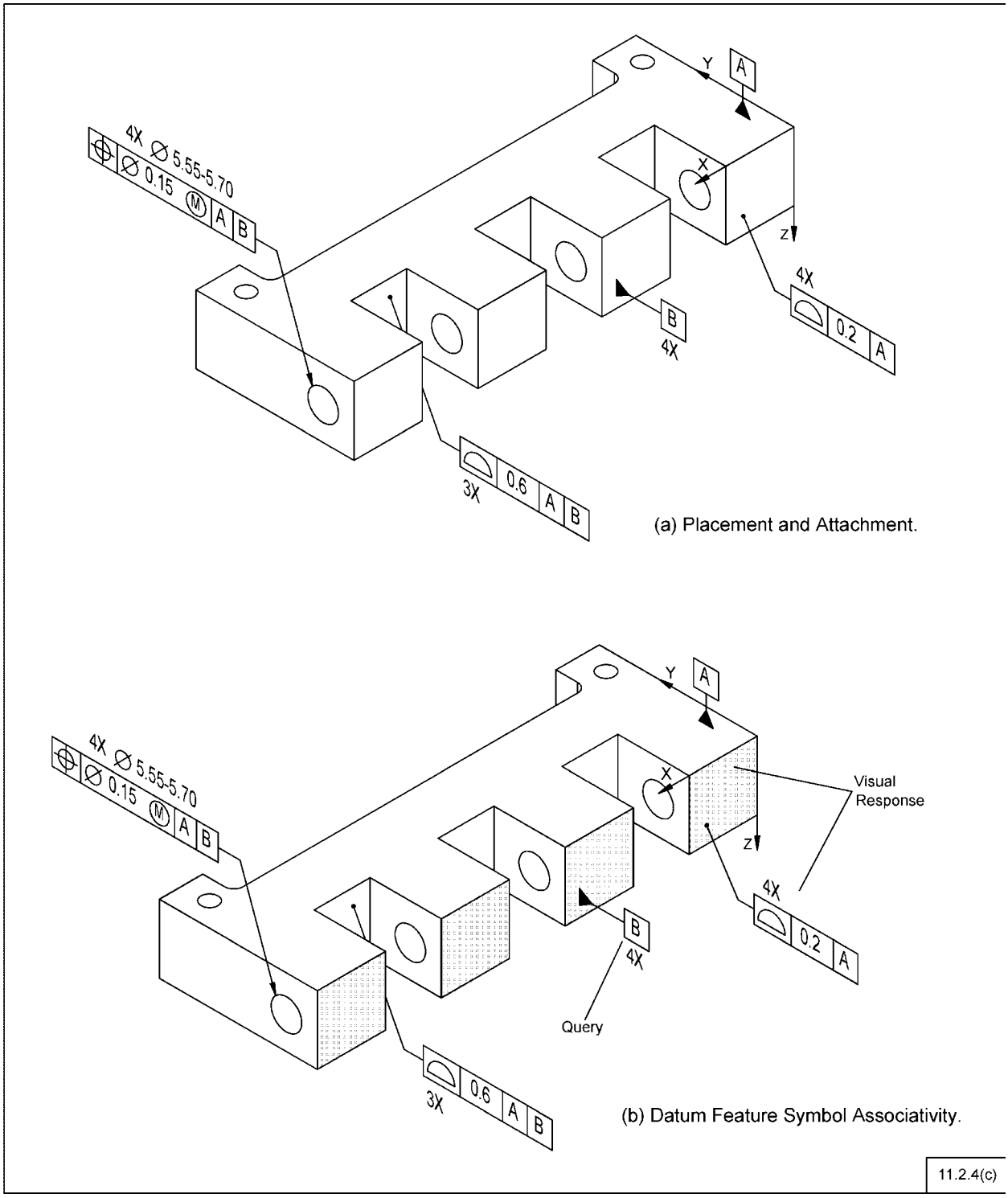


Fig. 11-10 Separated Surfaces Establish a Datum Plane

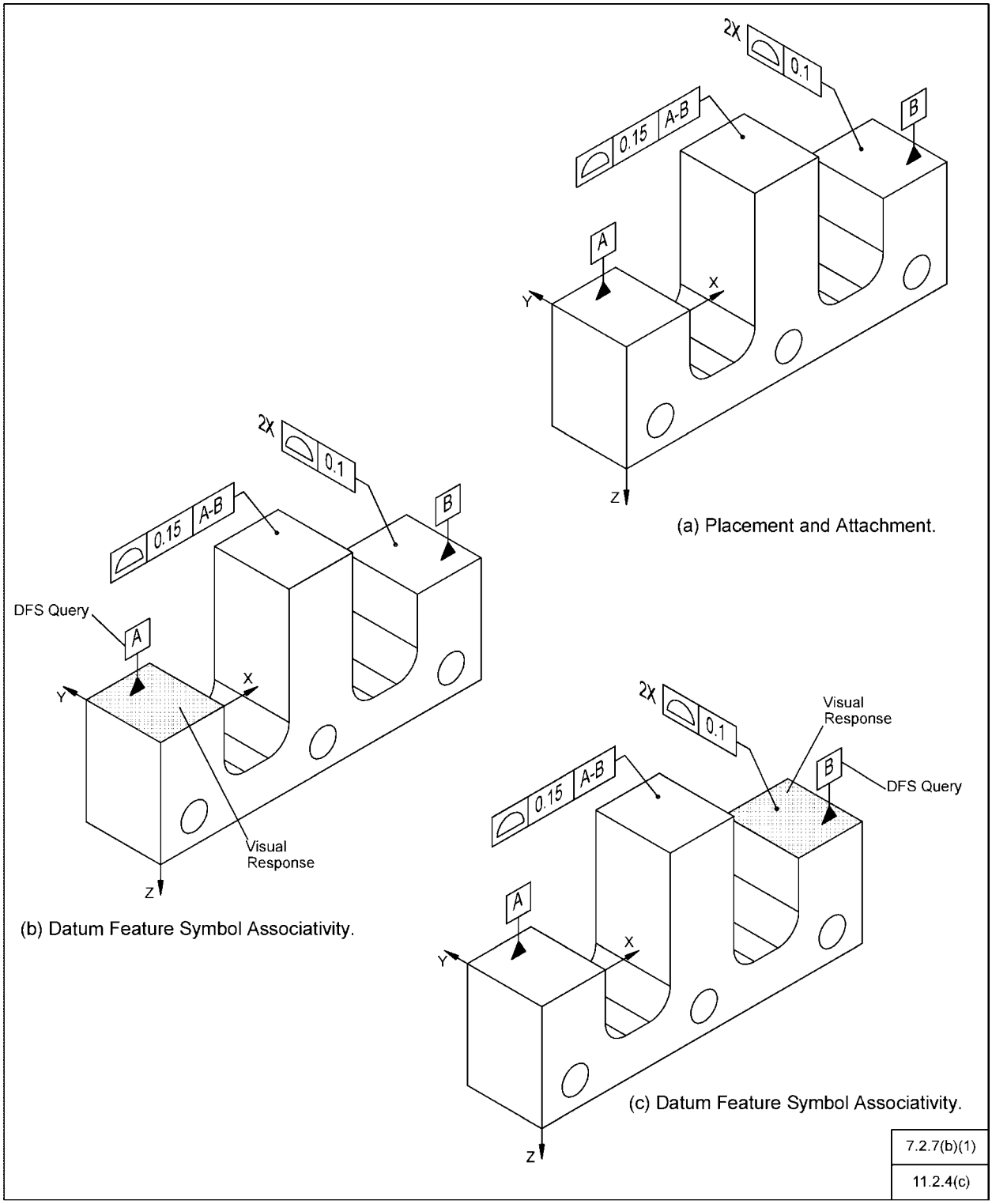


Fig. 11-10 Separated Surfaces Establish a Datum Plane (Cont'd)

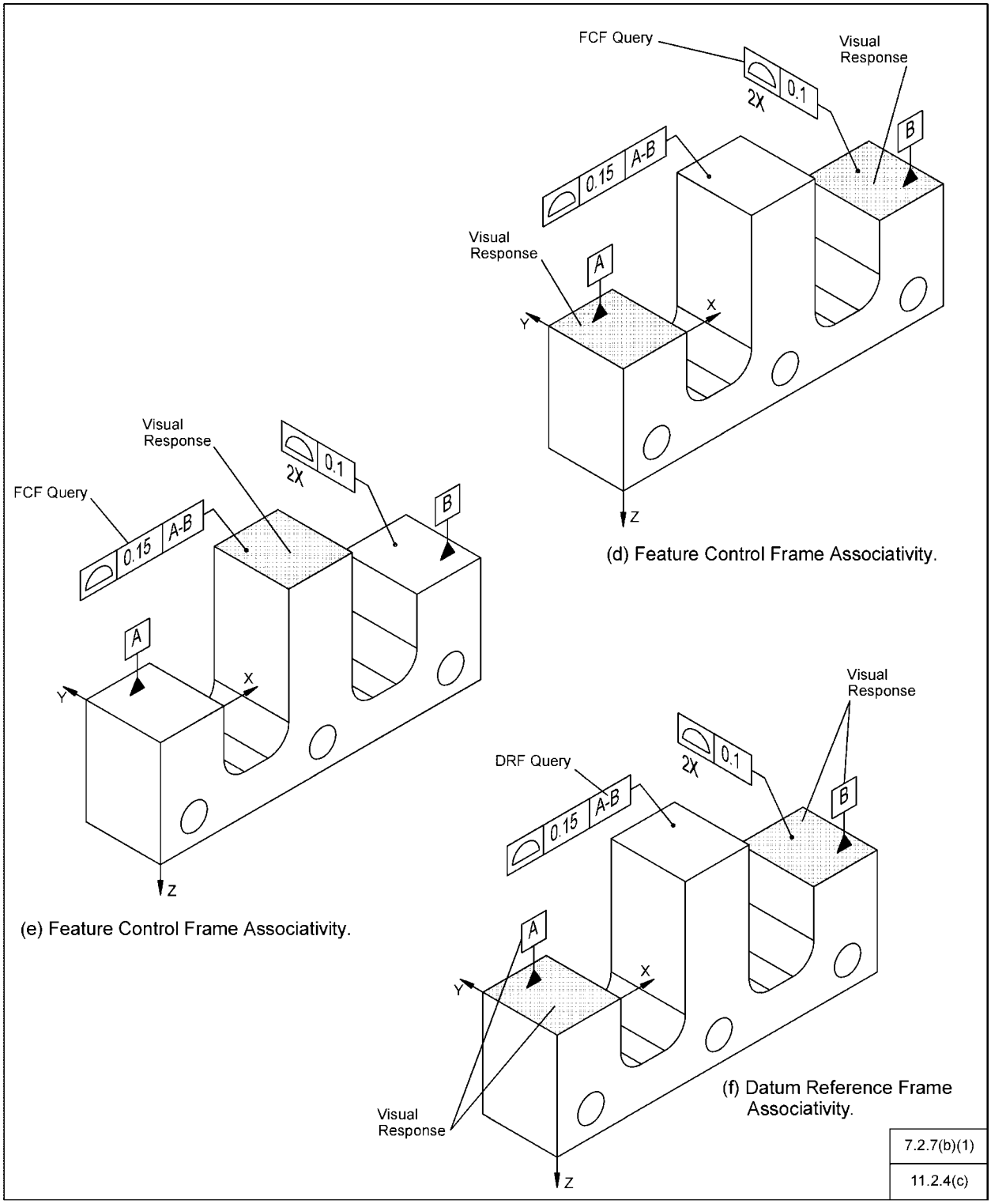
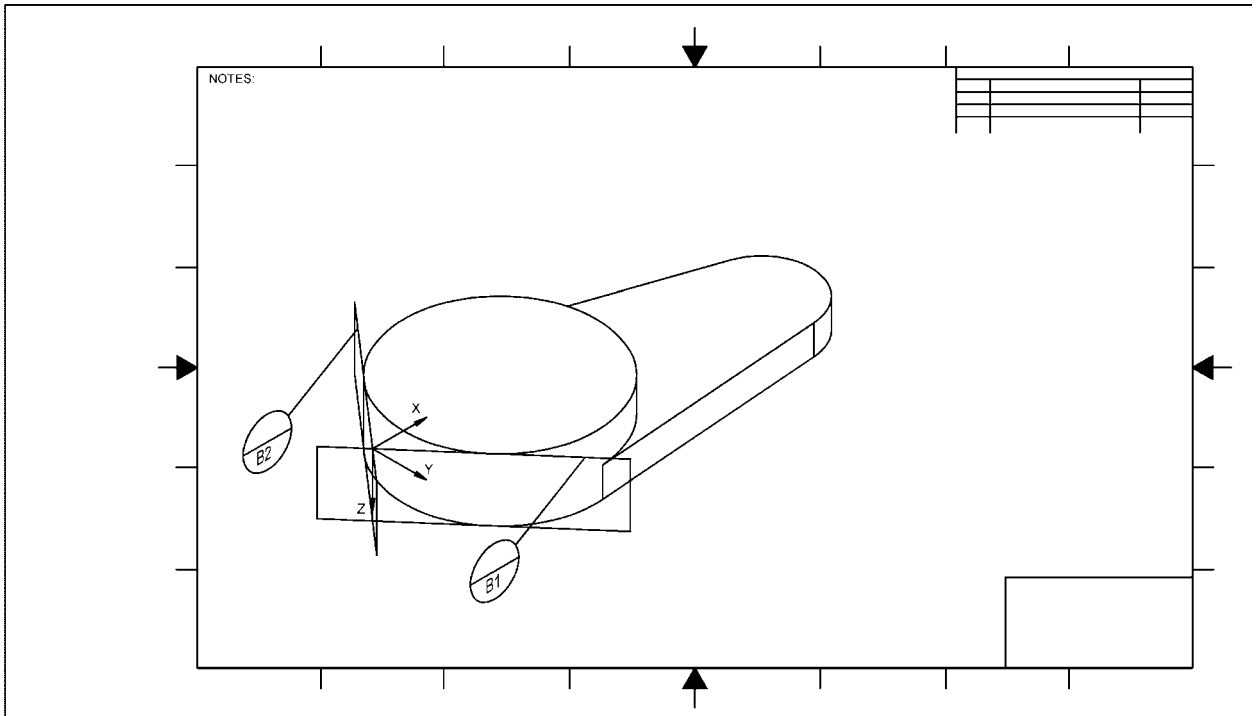
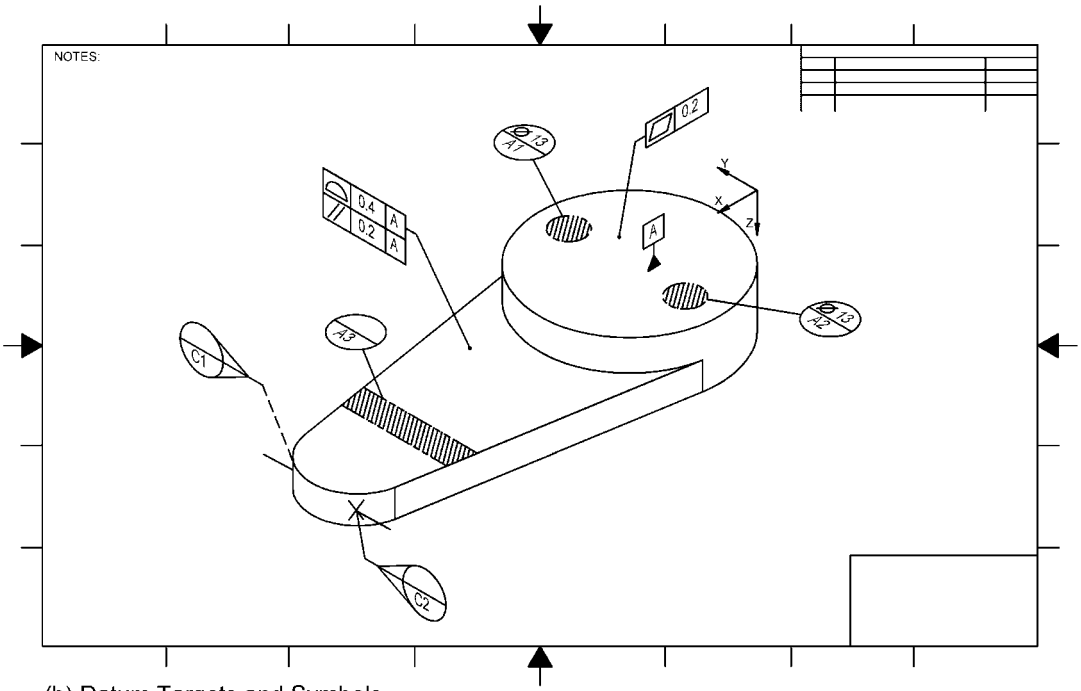


Fig. 11-11 Datum Targets and Symbols in an Axonometric View



(a) V-Type Equalizers and Symbols.



(b) Datum Targets and Symbols.

5.1.4(d)
11.3(c)
11.3(d)

Section 12
Geometric Tolerances

This Section establishes the placement, attachment, and display requirements for geometric tolerances.

12.1 COMMON REQUIREMENTS

A general note defining a geometric tolerance may be specified. More than one tolerance may be specified.

12.2 MODEL REQUIREMENTS

The following paragraphs address the placement, attachment, and display requirements for geometric tolerances.

12.2.1 Form Tolerances

The feature control frame shall be placed on an annotation plane parallel to, perpendicular to, or coincident with the surface to which it applies. See Fig. 12-1. Table 12-1 lists the form tolerances with the type of attachment method used when a single form tolerance is applied.

(a) Flatness, Limited Area Application. A limited area of application shall be represented on the model geometry using supplemental geometry. The leader directed from the flatness feature control frame shall be attached within the represented area. See Fig. 11-3.

(b) Circularity Applied to a Sphere, Cylinder, Cone, or a Surface of Revolution. The feature control frame shall be placed on an annotation plane perpendicular to the feature axis, or containing the centerpoint of a sphere. See Fig. 12-2.

(c) Straightness Applied to the Line Elements of a Cylindrical or Conical Surface. The feature control frame shall be placed on an annotation plane containing the axis of the feature surface. See Fig. 12-6.

12.2.2 Orientation Tolerances

The orientation feature control frame shall be placed on an annotation plane parallel or perpendicular to the referenced primary datum. Table 12-2 lists the orientation tolerances with the attachment method used when an orientation tolerance is directly applied.

(a) Each Element Directed by Line Element. When using multiple datum references, the orientation feature control frame and the EACH ELEMENT qualifier shall be placed on an annotation plane containing the represented line element indicating the direction of application. See Fig. 12-9.

(b) Each Element Directed by Ordinate Axis. The orientation feature control frame and the EACH ELEMENT qualifier shall be placed on an annotation plane parallel and perpendicular with the absolute coordinate system or an established user-defined coordinate system. See Fig. 12-10.

(c) Orienting an Axis Within a Parallel Planes Tolerance Zone. The orientation feature control frame shall be attached to the diametral size and any other geometric tolerance requirement. The orientation of the extension lines defines the orientation of the tolerance zone. See Fig. 12-13.

12.2.3 Profile Tolerances

When an individual profile requirement is specified, it shall be attached using a directed leader. Table 12-3 lists individual profile applications.

(a) Conical Surface or a Surface of Revolution. The feature control frame shall be placed on an annotation plane perpendicular to or containing the feature axis. See Fig. 12-14, illustration (b).

(b) Multiple or Coplanar Surfaces. When a profile tolerance applies to multiple surfaces, the features shall be combined into an associated group. The feature control frame shall be placed on an annotation plane parallel or perpendicular to the referenced primary datum. See Fig. 12-15.

(c) Between Basis. When the associated geometry is not sufficient to indicate the application, labeled supplemental geometry may be added to indicate the boundary of application. The between symbol may be used to clarify the requirement. See Fig. 12-16.

(d) All-Around Application. When the all-around symbol is used, query shall be used to identify the controlled surfaces. See Fig. 12-17.

(e) Profile of a Line Directed by Line Element. The feature control frame shall be placed on an annotation plane containing the represented line element, parallel and perpendicular to the absolute coordinate system or an established user-defined coordinate system. See Fig. 12-18.

(f) Profile of a Line Directed by Ordinate Axis. The feature control frame shall be placed on an annotation plane parallel and perpendicular to the absolute coordinate system or an established user-defined coordinate system. See Fig. 12-19.

(g) All-Over Application. When the all-over symbol is used, all of the appropriate portions of the model should

be designated as associated objects for the profile tolerance.

12.2.4 Location Tolerances

The location feature control frame shall be placed on an annotation plane parallel or perpendicular to the referenced primary datum or on an annotation plane that is perpendicular to or contains the feature axis or centerplane of the toleranced feature. See Fig. 7-5.

Table 12-4 identifies location tolerance applications and the attachment method used.

(a) Positioning Feature Patterns Individually to Individual Datum Features. Each individual pattern of features and the required individual datum feature shall be collected as an associated group. A coordinate system representing each individual datum system shall be established. See Fig. 12-20.

(b) Projected Tolerance Zones. The leader for a position or orientation tolerance applied with a projected tolerance zone shall be directed to the surface from which the tolerance zone projects and terminate with an arrowhead. The feature control frame shall contain the projected tolerance zone symbol and the required projection value. The use of a chain line to indicate projected tolerance, as described in ASME Y14.5, is not recommended. See Fig. 12-21.

(c) Closer Control at One End of a Feature. The size dimension and both feature control frames shall be collected as an associated group. For a conical tolerance zone, the leaders for the positional tolerances shall be directed to the surface to which it applies. See Fig. 12-22.

(d) Bi-Directional Positional Tolerancing for Polar and Rectangular Coordinates. The callouts specifying the bi-directional requirements shall be placed on the same annotation plane as the size specification for the feature. See Fig. 12-24.

12.2.5 Runout Tolerances

Table 12-5 lists runout applications and the attachment method generally used. Applications of circular runout to a spherical, conical, or revolved surface are also listed.

(a) Attachment Methods for Runout Tolerances. The use of multiple leader lines should be avoided when assigning runout tolerances. When the same runout control with the same tolerance value and datum reference(s) is applied to multiple features, one of the following methods may be used:

(1) Create a single runout feature control frame for all identically controlled surfaces, and associate it to all applicable model surfaces. A note indicating the number of surfaces to which the tolerance applies may be included for additional associative emphasis. See Fig. 12-27, illustrations (a) and (b).

(2) Define the geometric tolerance in a general note.

(3) Create and attach a separate runout feature control frame to each of the toleranced surfaces. See Fig. 12-27, illustration (c).

(b) Circular Runout Applied to a Spherical or Conical Surface, or a Surface of a Revolution. The circular runout feature control frame shall be placed on an annotation plane perpendicular to the conical or revolved surface axis, or containing the centerpoint of a sphere. See Fig. 12-29.

12.3 DRAWING GRAPHIC SHEET REQUIREMENTS

When using orthographic views, geometric tolerances shall be specified in accordance with ASME Y14.5 unless otherwise specified. When axonometric views are used, the following paragraphs provide exceptions and additional requirements.

12.3.1 Requirements Applicable to all Geometric Tolerances

(a) Toleranced Features on Axonometric Views. A portion of the toleranced feature shall be visible in the view in which the tolerance is applied.

(b) Feature Control Frame Applied to a Feature of Size. When a geometric tolerance is applied to a feature of size, the feature control frame shall be placed below the size dimension. See Fig. 12-30, illustration (a).

(c) Feature Control Frame Applied to a Feature. The leader line shall terminate on the surface with a dot. See Fig. 12-30, illustration (b).

12.3.2 Form Tolerances

The requirements described in para. 12.3.1 apply unless otherwise specified. Table 12-1 lists the form tolerances with the type of attachment method used when a single form tolerance is applied.

(a) Flatness, Limited Area Application Using Axonometric Views. A limited area of application shall be represented using supplemental geometry. The leader directed from the flatness feature control frame shall be attached within the represented area. See Fig. 12-31.

(b) Straightness Applied to Line Elements of a Cylindrical or Conical Surface Using Axonometric Views. The feature control frame shall be directed to the surface with a leader line. The direction of application is parallel to the axis of the feature. See Fig. 12-32, illustration (a).

12.3.3 Orientation Tolerances

The requirements described in para. 12.3.1 apply unless otherwise specified. Table 12-2 lists the orientation tolerances with the attachment method used when an orientation tolerance is directly applied.

(a) Specifying Each Element Using Axonometric Views. The orientation feature control frame and the notation EACH ELEMENT shall be directed to the represented line element indicating the direction of application. See Fig. 12-32, illustration (b).

(b) Orienting an Axis With a Parallel Planes Tolerance Zone Using Axonometric Views. The orientation feature

control frame shall be attached to the diametral size and any other geometric tolerance requirement. The orientation of the extension lines defines the orientation of the tolerance zone. See Fig. 12-33.

12.3.4 Profile Tolerances

The requirements described in para. 12.3.1 apply unless otherwise specified. Table 12-3 lists individual profile applications.

(a) Profile of a surface may be applied to a feature that is not displayed in a profile view.

(b) When an individual profile requirement is specified, it shall be attached using a directed leader.

(c) Profile of a surface applied to multiple surfaces. The tolerance shall be specified using one of the following:

(1) the feature control frame shall be directed to all of the toleranced features using one or more leader lines.

(2) a qualifying note such as 2× INDICATED K shall accompany the feature control frame and the appropriate features shall be identified. See Fig. 12-34.

(3) the between symbol shall be placed beneath the feature control frame. The features shall be identified with two lines to indicate the limits of the area of application. The lines shall be labeled and referred to with the between symbol. See Fig. 12-35.

(d) Profile of a Surface Using the All-Around Symbol. When the all-around symbol is used with a profile of a surface, it shall be shown in an orthographic view that contains the true profile of the toleranced features.

(e) Profile of a Line Using Axonometric Views. When a line profile callout is required, it shall be applied to a represented line element showing the direction of application.

(f) General Application of Surface Profile. When a surface profile callout is required, it shall be applied using a directed leader.

12.3.5 Position Tolerances

Table 12-4 identifies position tolerance applications and the attachment method used.

(a) The requirements described in para. 12.3.1 apply unless otherwise specified.

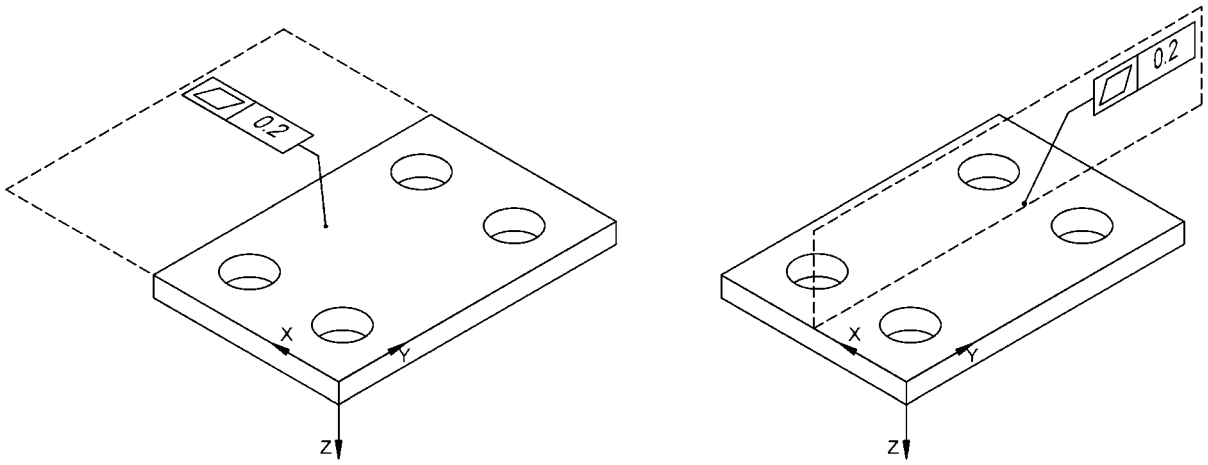
(b) When a boundary control for a noncylindrical feature is required, the applicable geometric tolerances shall be shown in an orthographic view that contains the true profile of the toleranced feature.

12.3.6 Runout Tolerances on a Drawing Graphic Sheet

Runout tolerances shall be applied as described in para. 12.3.1. Table 12-5 lists runout applications and the attachment method generally used.

Fig. 12-1 General Application of Geometric Tolerances – Coincident or Perpendicular Annotation Plane

NOTE: The annotation planes shown here as dashed lines are for clarification only, and are not part of an actual presentation.



(a) Coincident Annotation Plane.

(b) Perpendicular Annotation Plane.

Table 12-1
12.2.1

Table 12-1 Form Tolerances

	Condition	Attachment Technique: Size Callout	Attachment Technique: Directed Leader	Paragraph	Figure
⏥	Planar Surface	...	●	12.2.1	12-1
	Limited Area	...	●	12.2.1(a)	11-3
⌾	Sphere	●	...	12-2.1(b)	12-2(a)
	Sphere	...	●	12-2.1(b)	12-2(b)
	Cylinder	●	...	12.2.1(b)	12-2(c)
	Cylinder	...	●	12-2.1(b)	12-2(d)
	Conical Surface	...	●	12-2.1(b)	12-2(e)
	Surface of Revolution	...	●	12-2.1(b)	12-2(f)
⌭	Cylinder	●	...	...	12-3(a)
	Cylinder	...	●	...	12-3(b)
⏤	Planar Surface	...	●	...	12-4
	Planar Surface	...	●	...	12-5
⏤	Cylindrical or Conical Surface	...	●	12.2.1(c)	12-6
⏤	Median Line	●	...	...	12-7(a)
⏥	Median Plane	●	...	...	12-7(b)

Fig. 12-2 Circularity – Sphere, Conical, or Revolved Surface

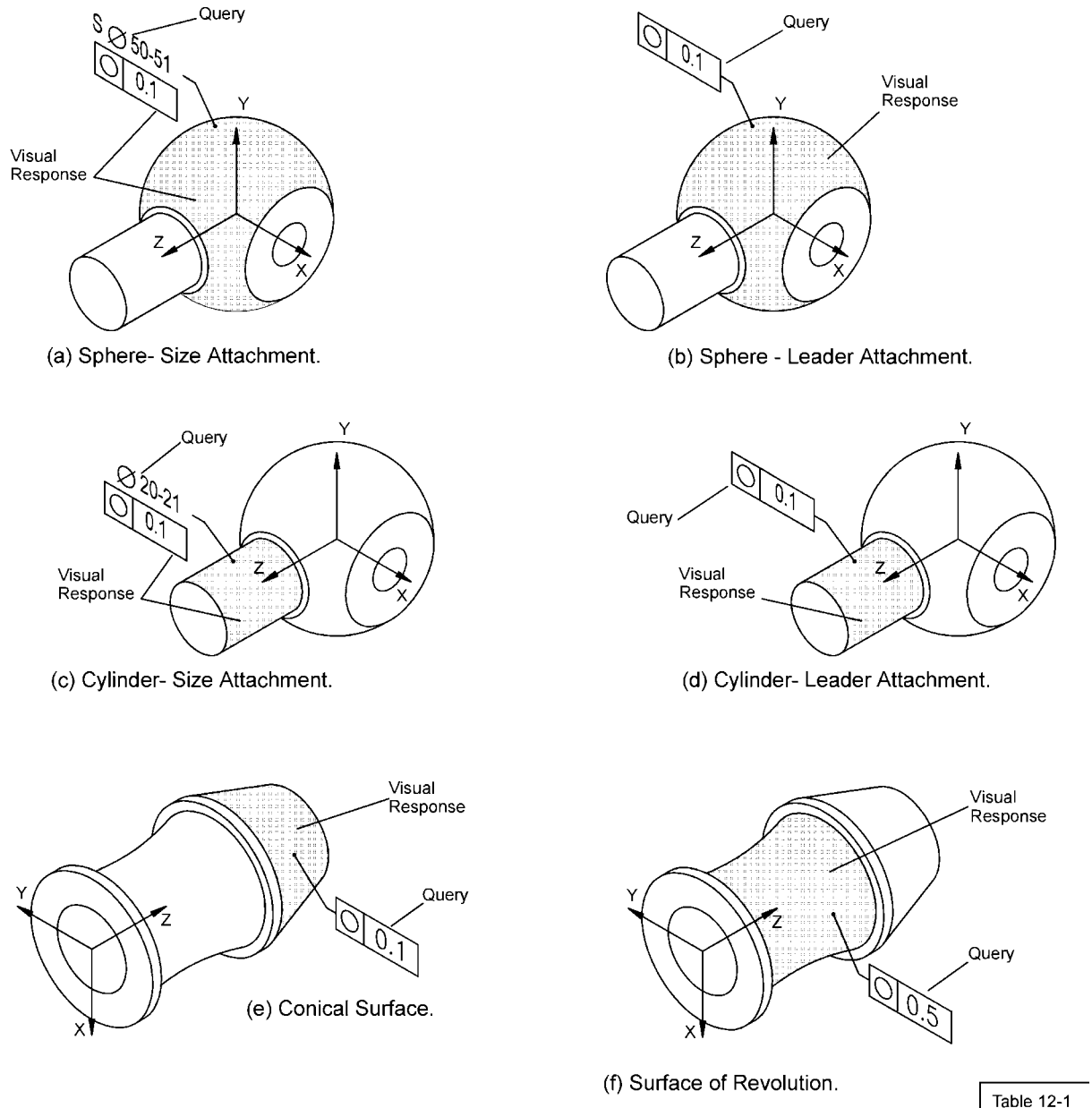


Table 12-1
12.2.1(b)

Fig. 12-3 Cylindricity

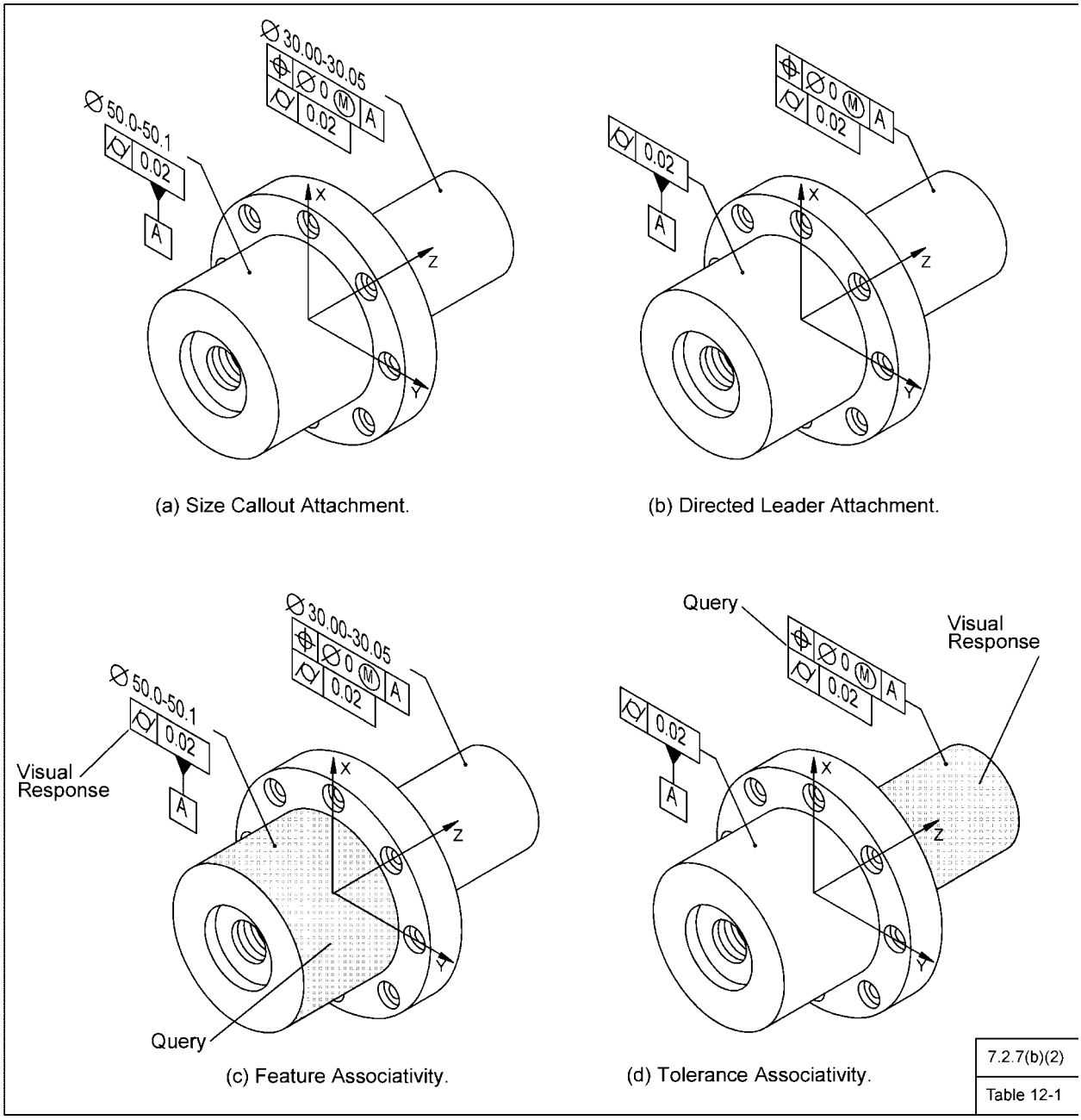


Fig. 12-4 Straightness – Directed by Line Element

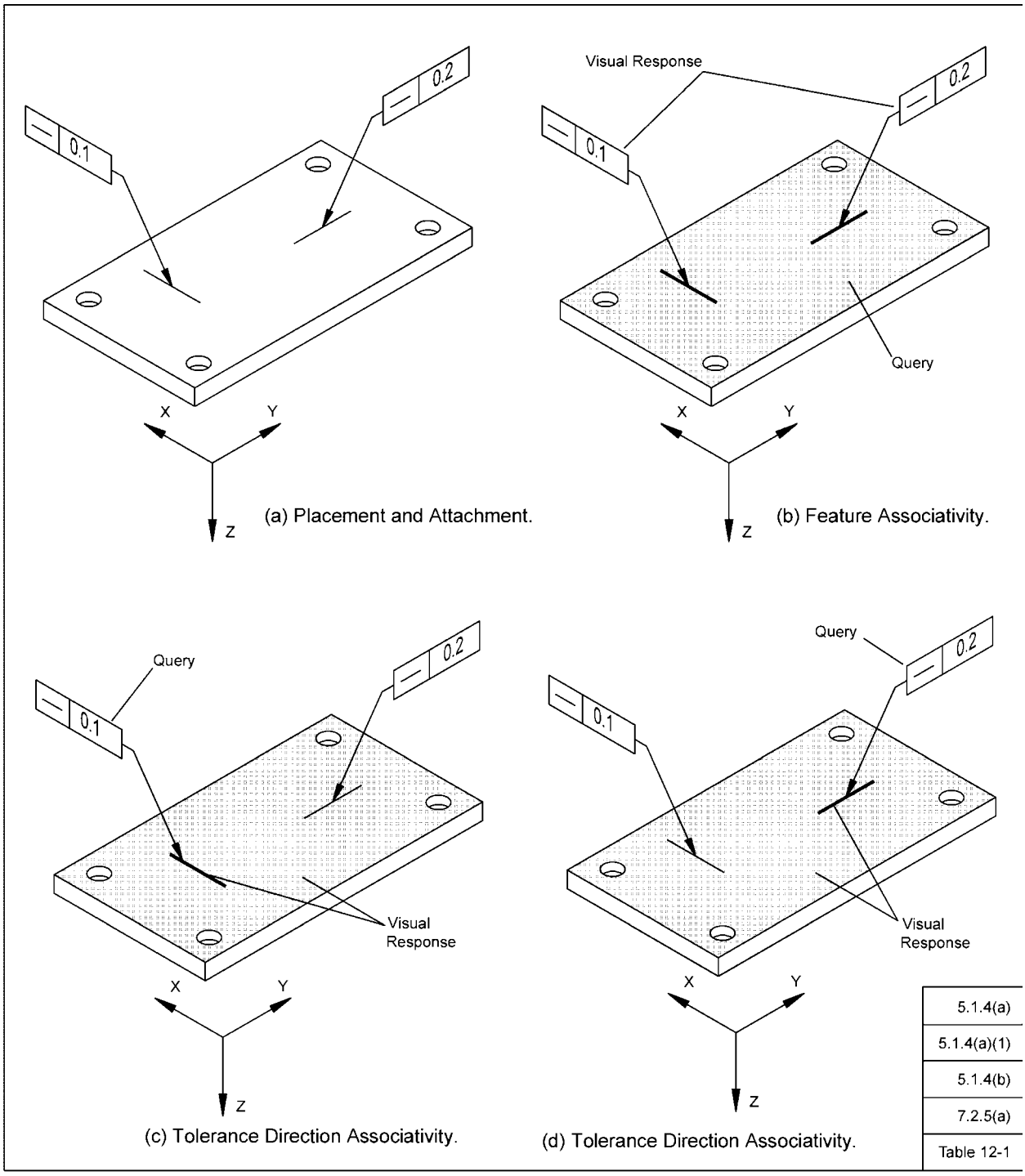


Fig. 12-5 Straightness – Directed by Ordinate Axis

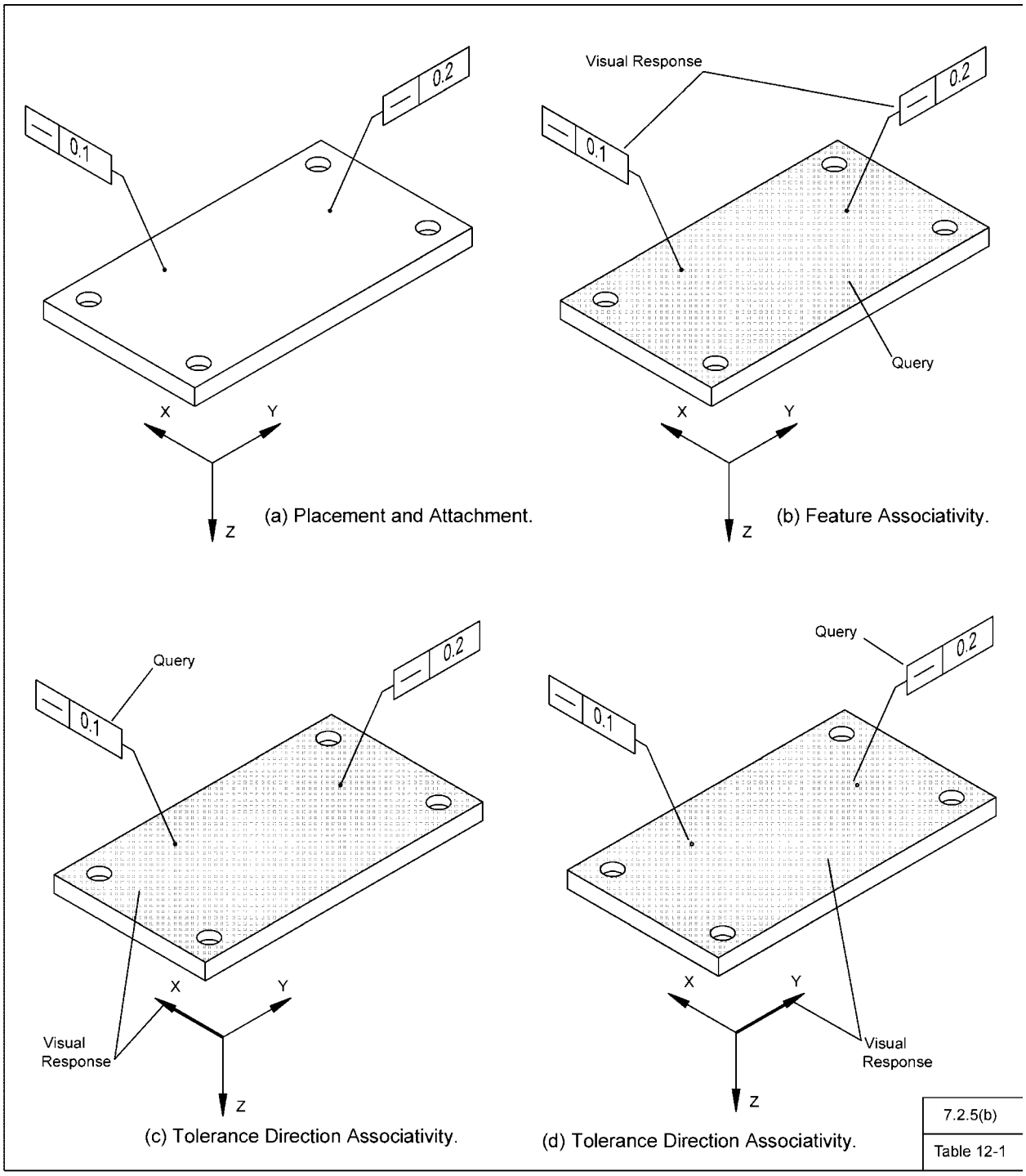


Fig. 12-6 Straightness – Cylindrical or Conical Surface

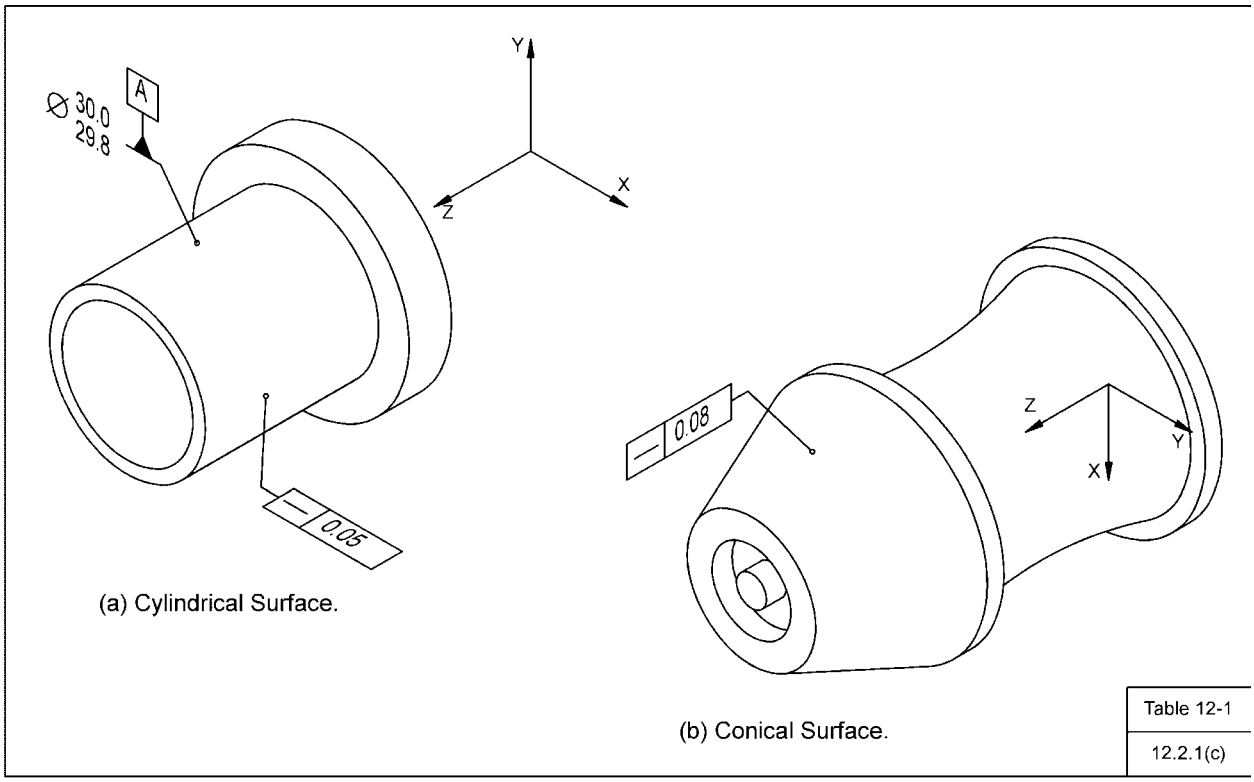


Fig. 12-7 Straightness – Median Line and Flatness: Median Plane

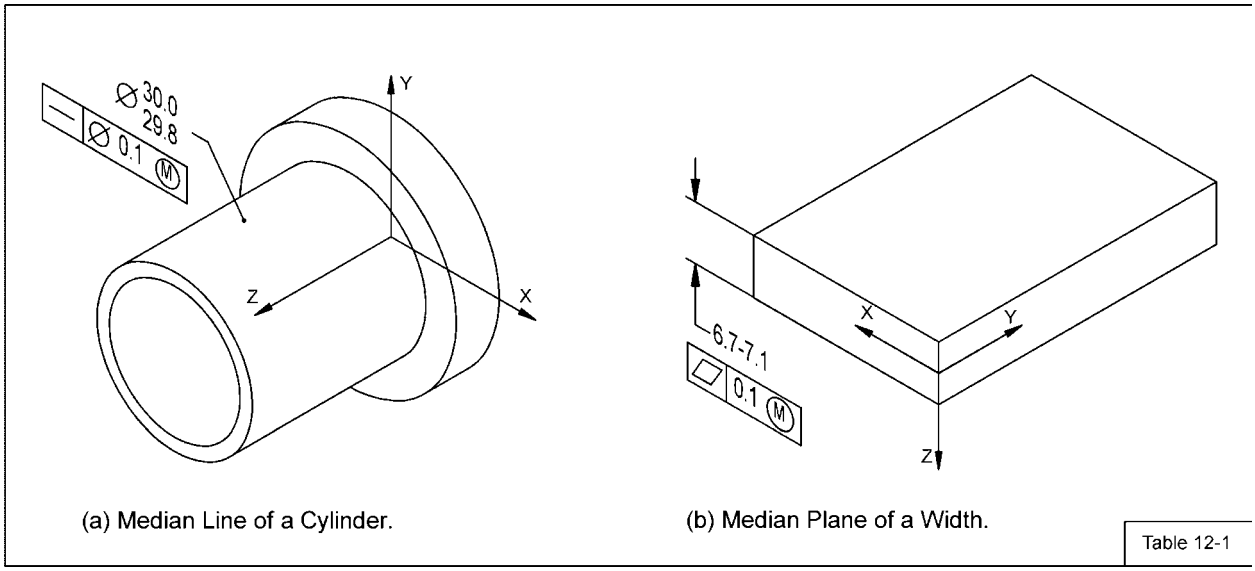


Table 12-2 Orientation Tolerances

Condition [Note (1)]	Attachment Technique: Size Callout	Attachment Technique: Directed Leader	Extension Lines	Paragraph	Figure
Planar Surface	...	●	...	...	12-8
Each Element	...	●	...	12.2.2(a)	12-9
Each Element	...	●	...	12.2.2(b)	12-10
Inclined Surface	...	●	...	...	12-11
Cylinder	●	...	...	...	12-12(a)
Cylinder	...	●	...	...	12-12(b)
Width (Set of Opposed, Parallel Surfaces)	●	...	...	...	12-12(c)
Width (Set of Opposed, Parallel Surfaces)	...	...	●	...	12-12(d)
Axis — Within a Parallel Planes Tolerance Zone	●	...	...	12.2.2(c)	12-13(a)
Axis — Within a Parallel Planes Tolerance Zone	...	...	●	12.2.2(c)	12-13(b)

NOTE:
(1) All three symbols are shown when perpendicularity, parallelism, and angularity equally apply.

Fig. 12-8 Orientation – Planar Surfaces

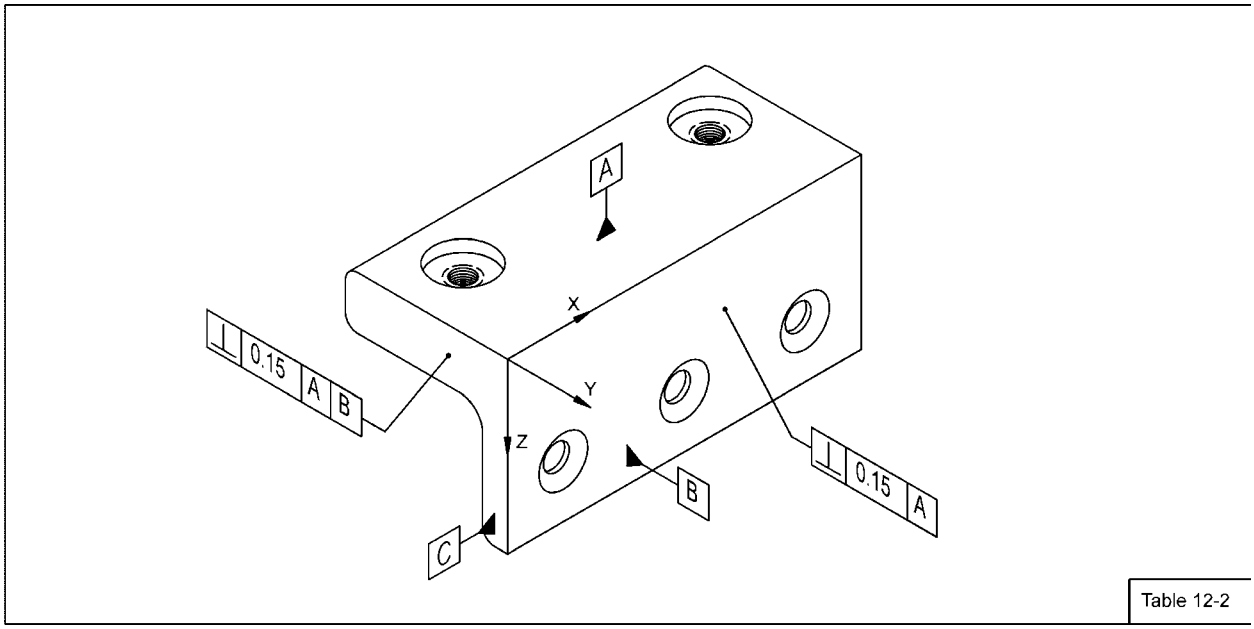
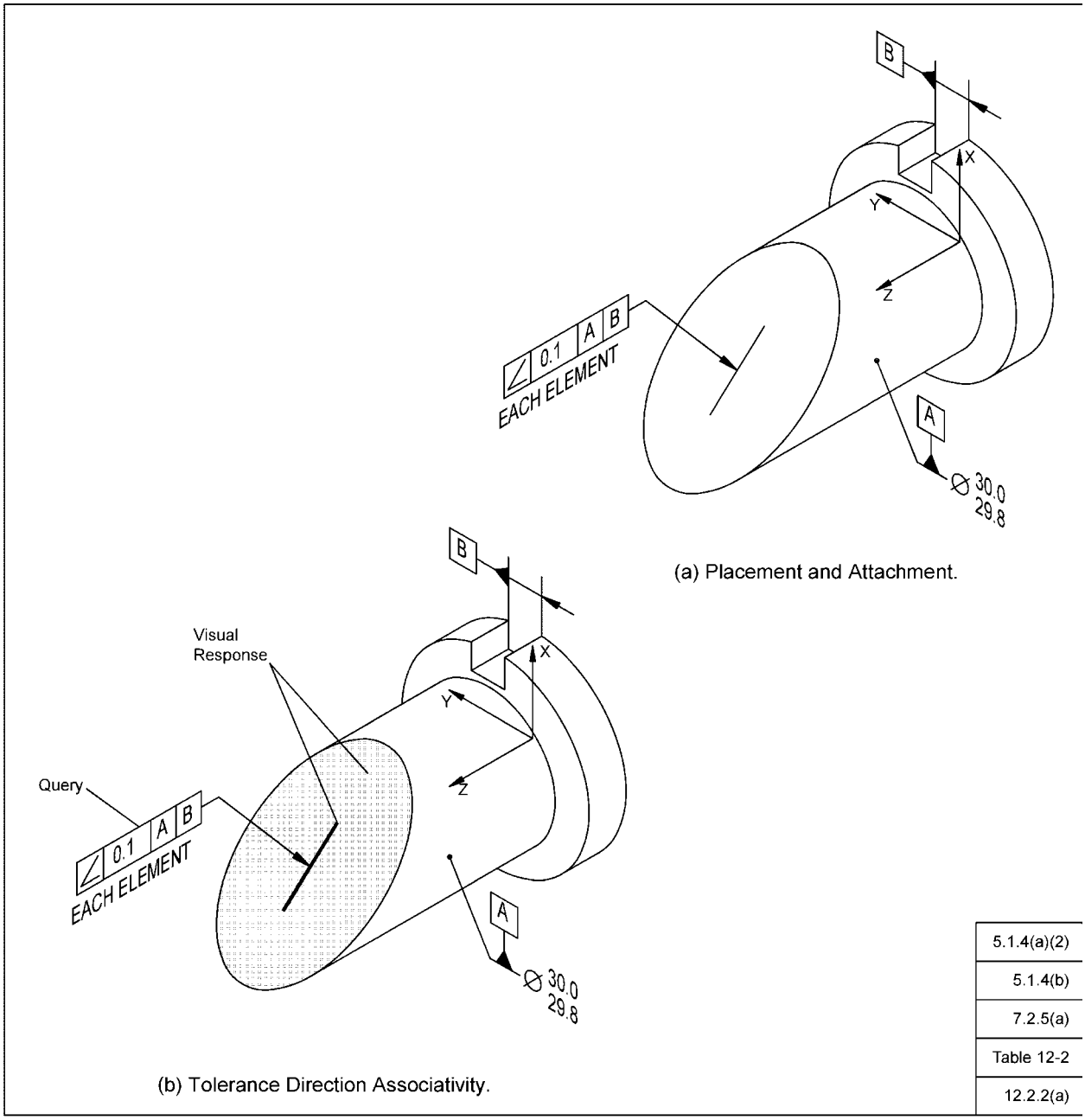


Fig. 12-9 Each Element Orientation – Directed by Line Element



5.1.4(a)(2)
5.1.4(b)
7.2.5(a)
Table 12-2
12.2.2(a)

Fig. 12-10 Each Element Orientation – Directed by Ordinate Axis

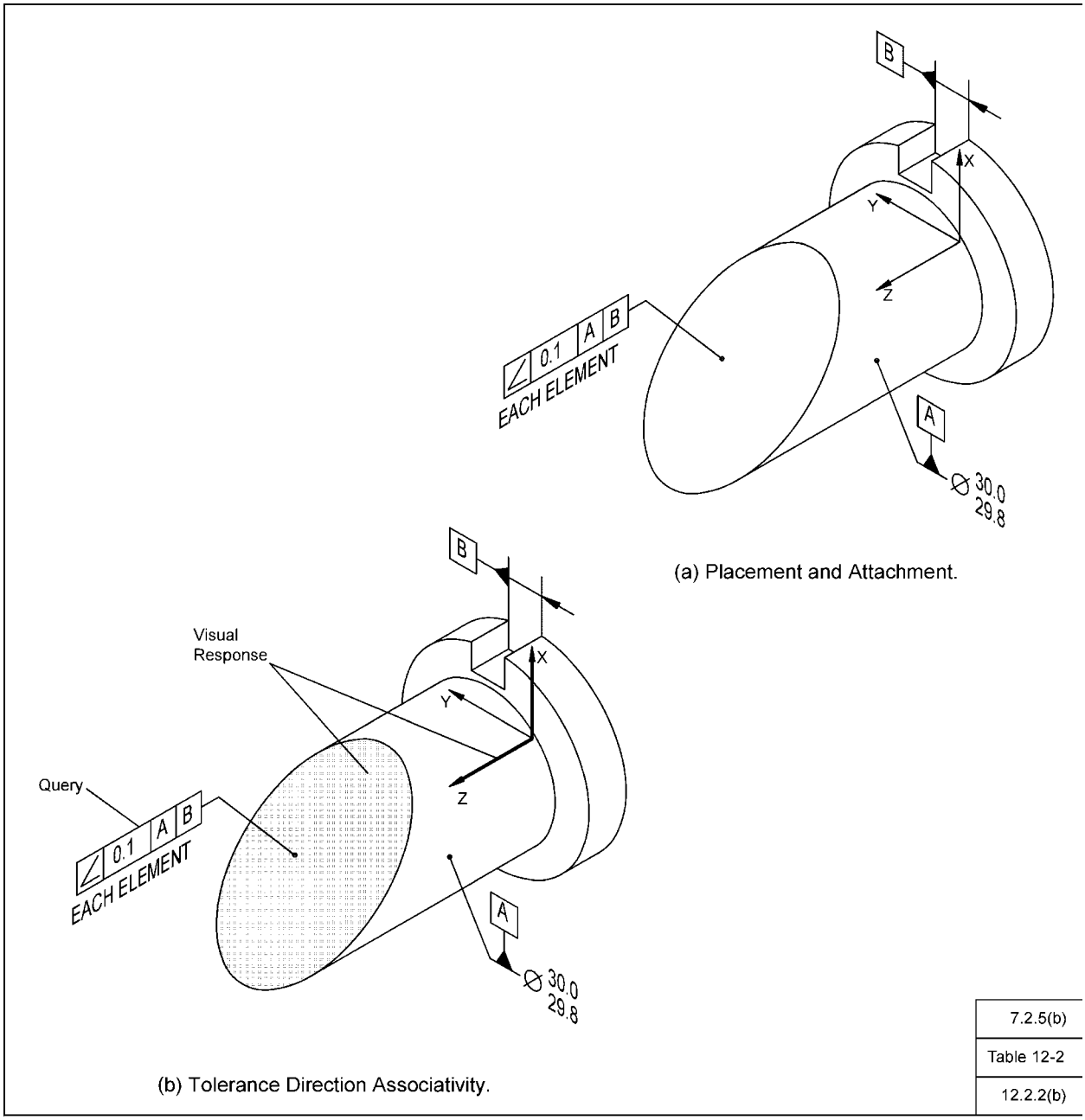


Fig. 12-11 Orientation – Inclined Surface

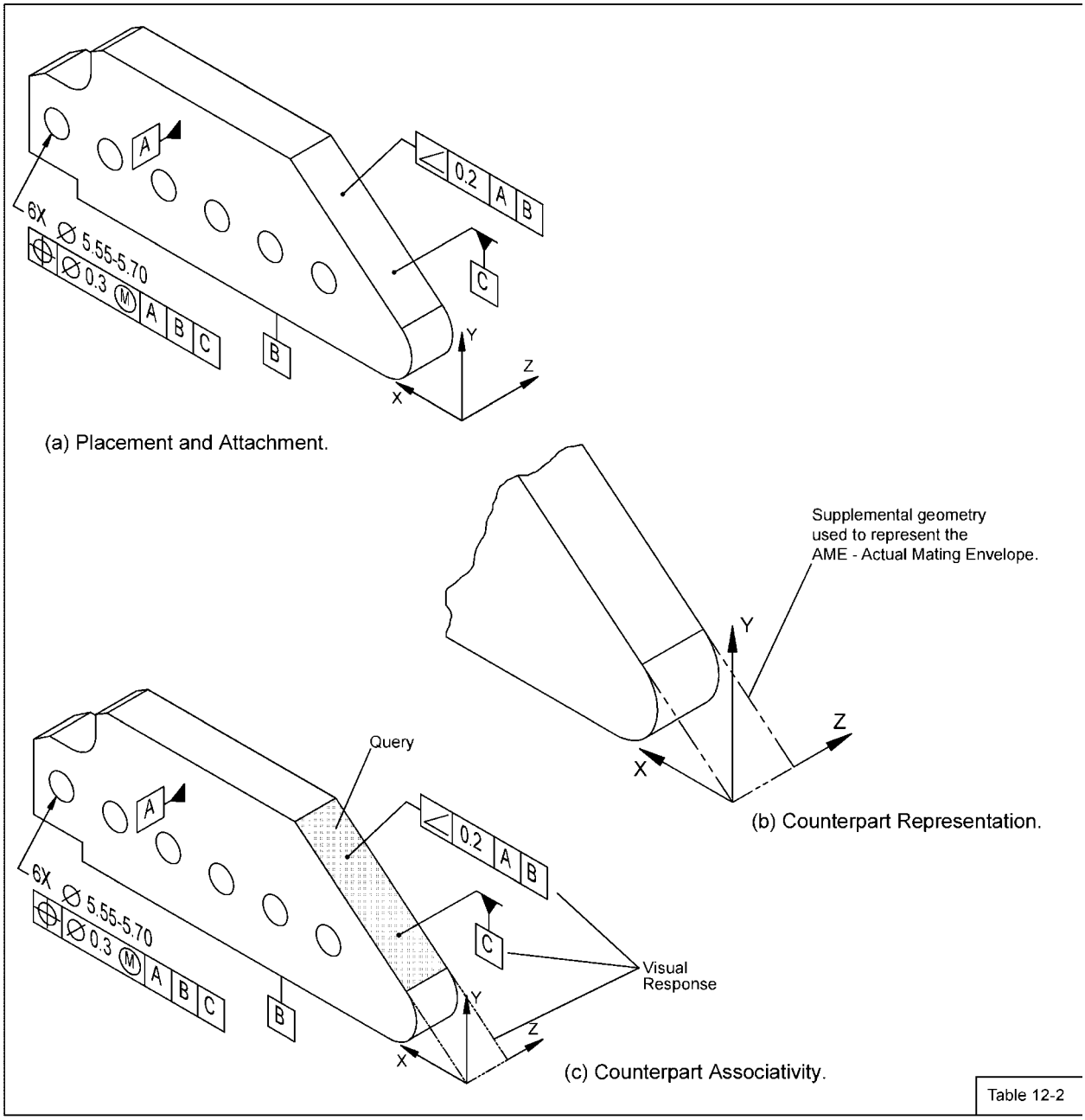


Fig. 12-12 Orientation – Cylinder or a Set of Opposed, Parallel Surfaces

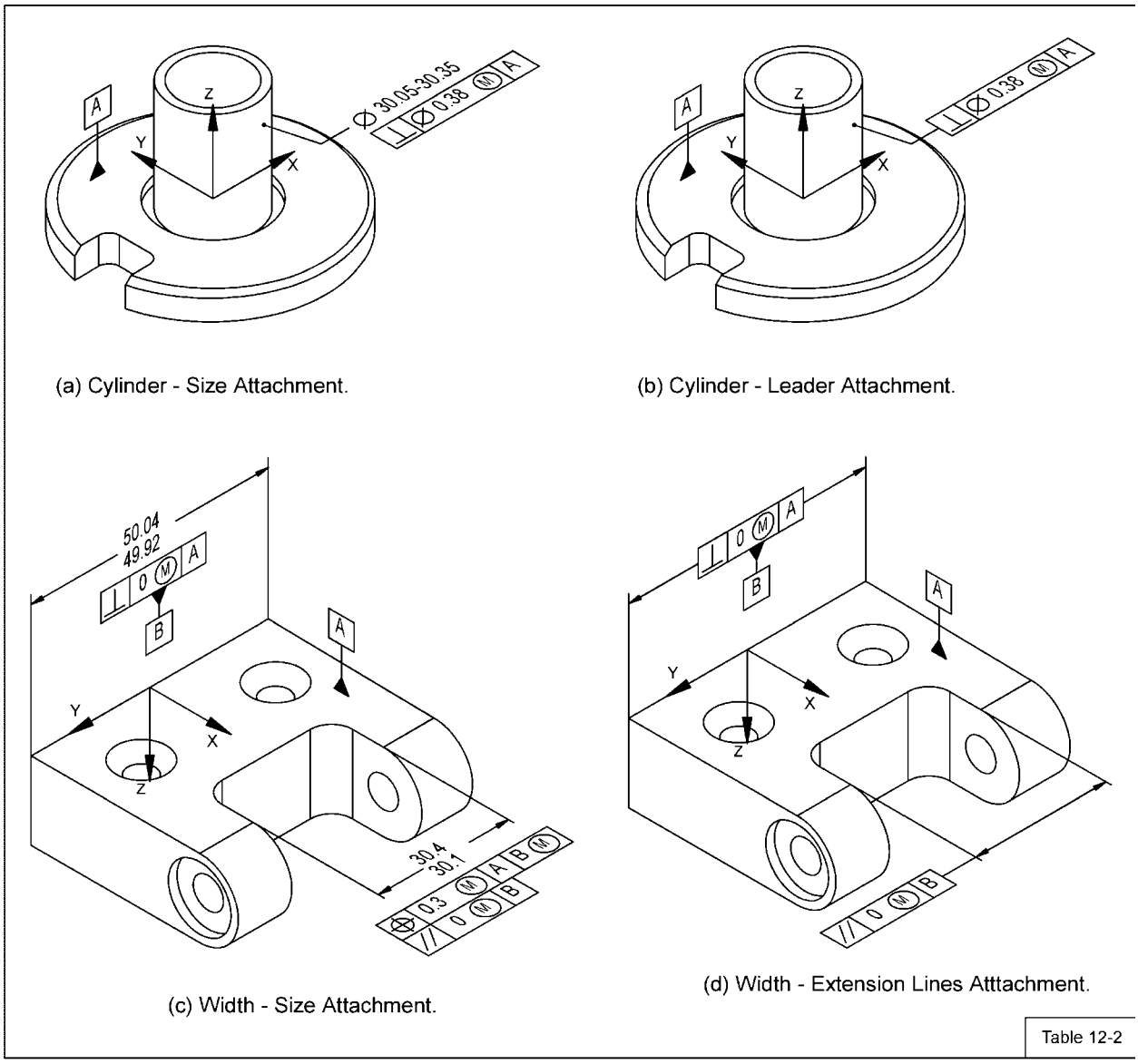
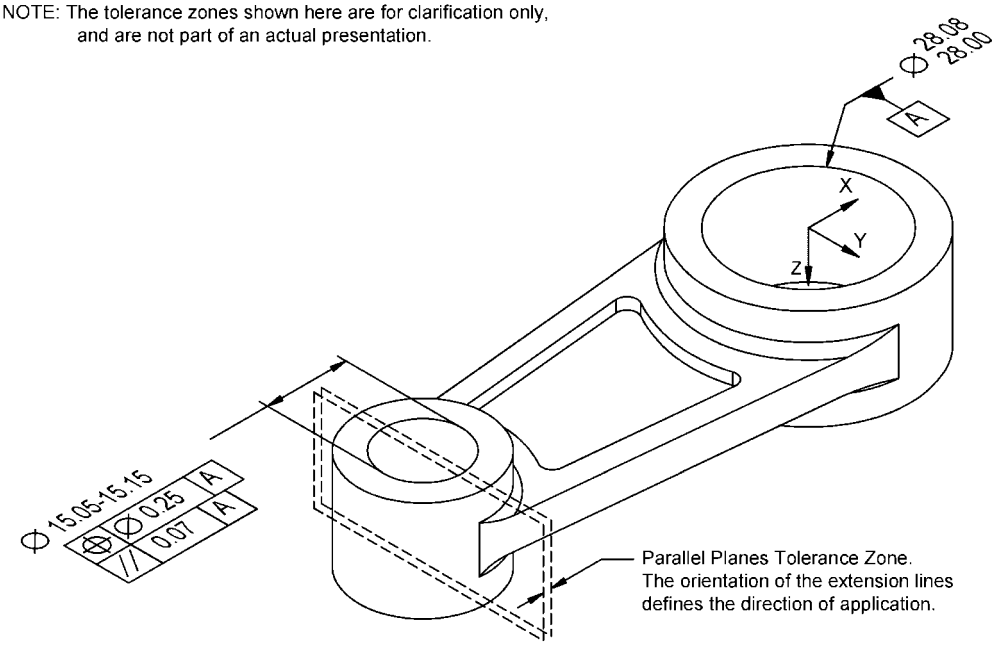
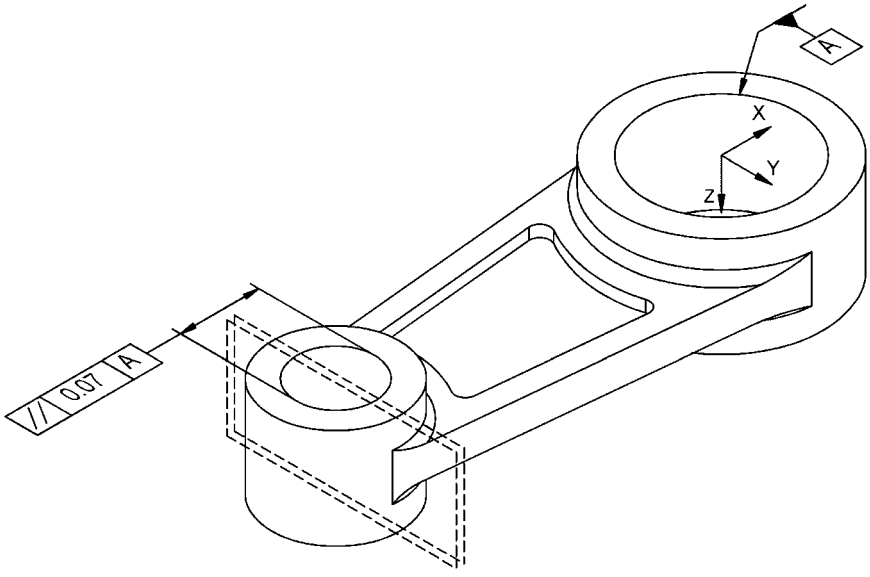


Fig. 12-13 Orientation of an Axis With a Parallel Planes Tolerance Zone

NOTE: The tolerance zones shown here are for clarification only, and are not part of an actual presentation.



(a) Size Callout Attachment.



(b) Extension Lines Attachment.

Table 12-2
12.2.2(c)

Table 12-3 Profile Tolerances

Condition	Attachment Technique, Directed Leader	Paragraph	Figure
Planar Surface	●	. . .	12-14(a)
Conical or Revolved Surface	●	12.2.3(a)	12-14(b)
Multiple or Coplanar Surfaces	●	12.2.3(b)	12-15
Between Basis	●	12.2.3(c)	12-16
All-Around Basis	●	12.2.3(d)	12-17
Line Elements	●	12.2.3(e)	12-18
Line Elements	●	12.2.3(f)	12-19
All-Over Basis	●	12.2.3(g)	. . .

Fig. 12-14 Profile – Planar, Conical, or Revolved Surface

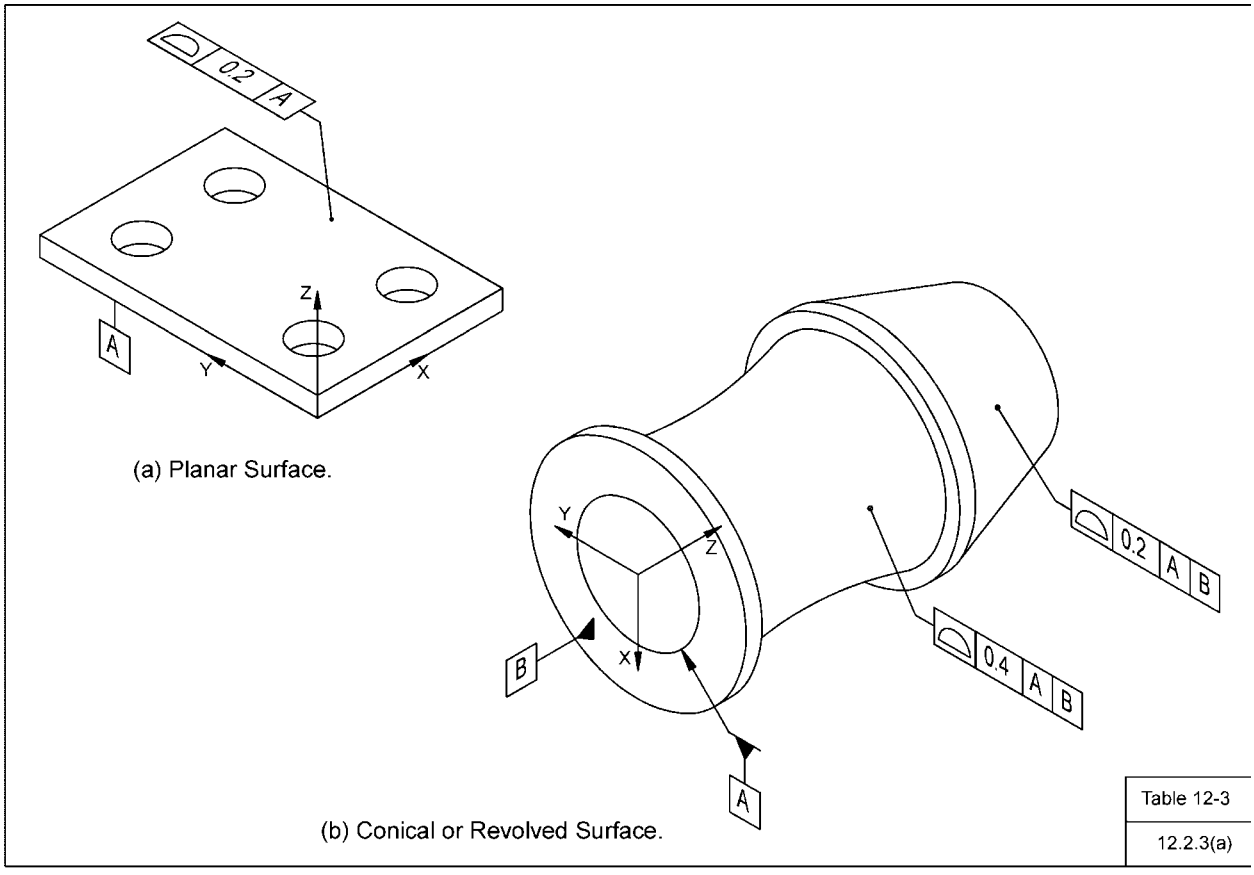


Fig. 12-15 Profile – Multiple or Coplanar Surfaces

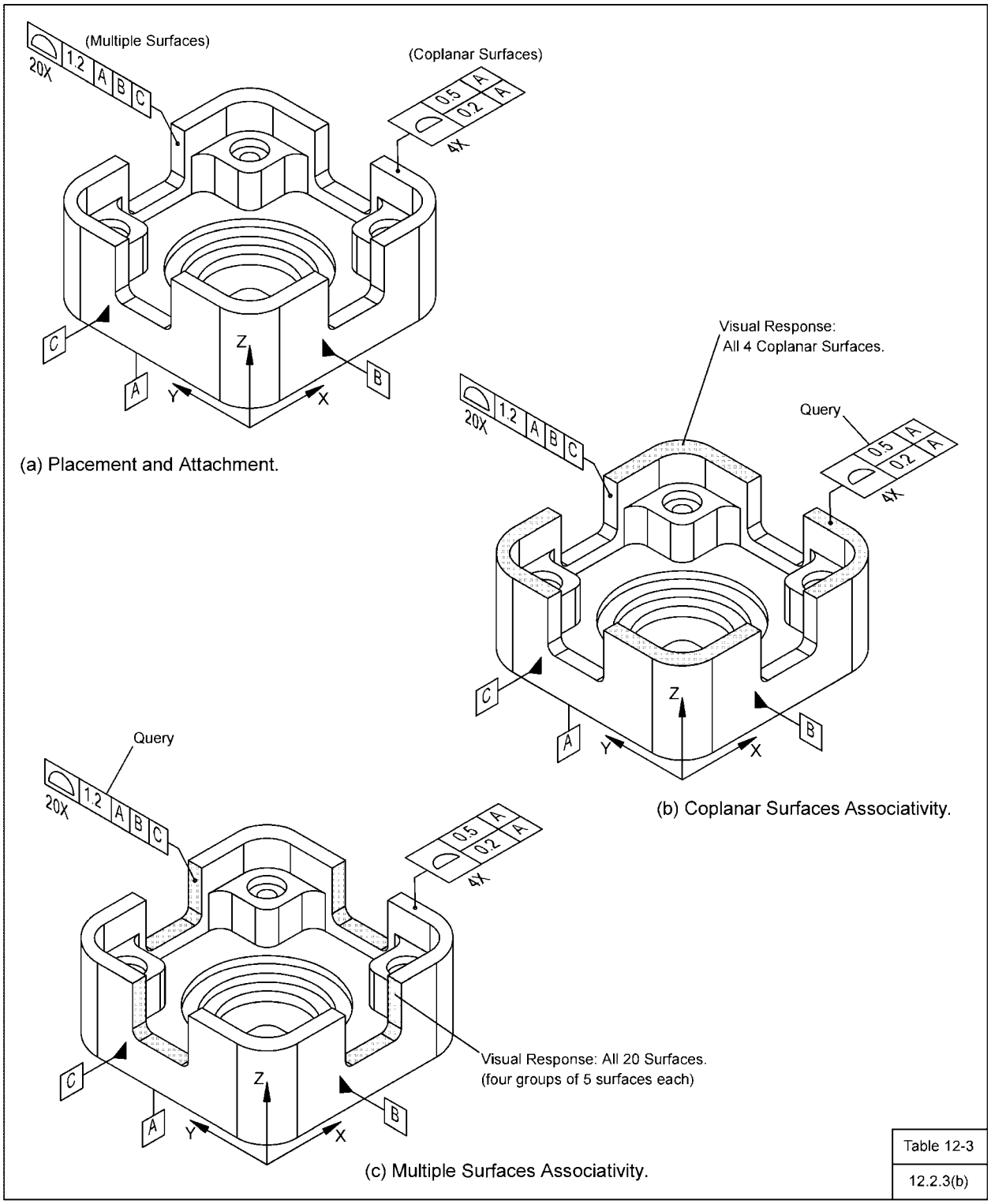
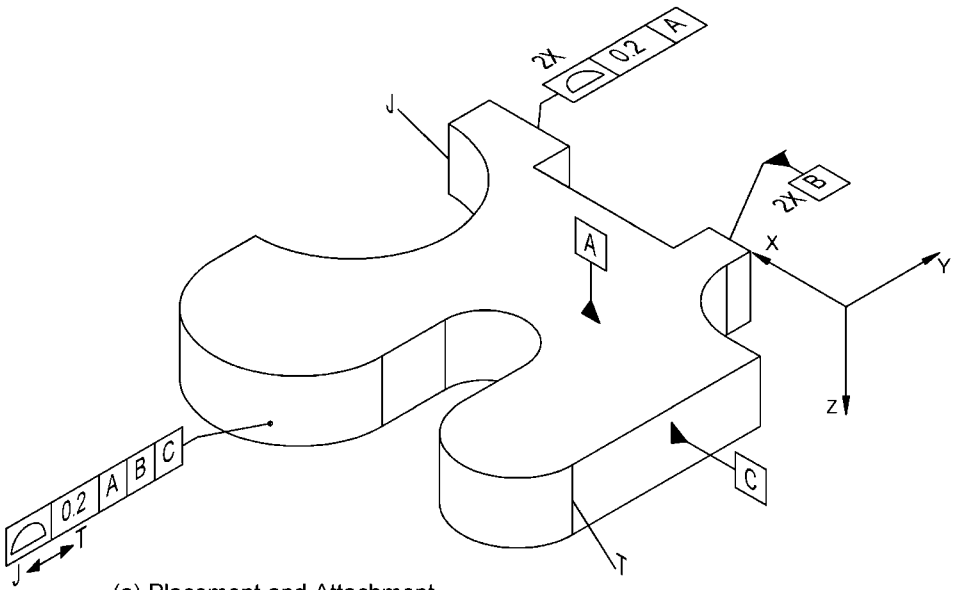
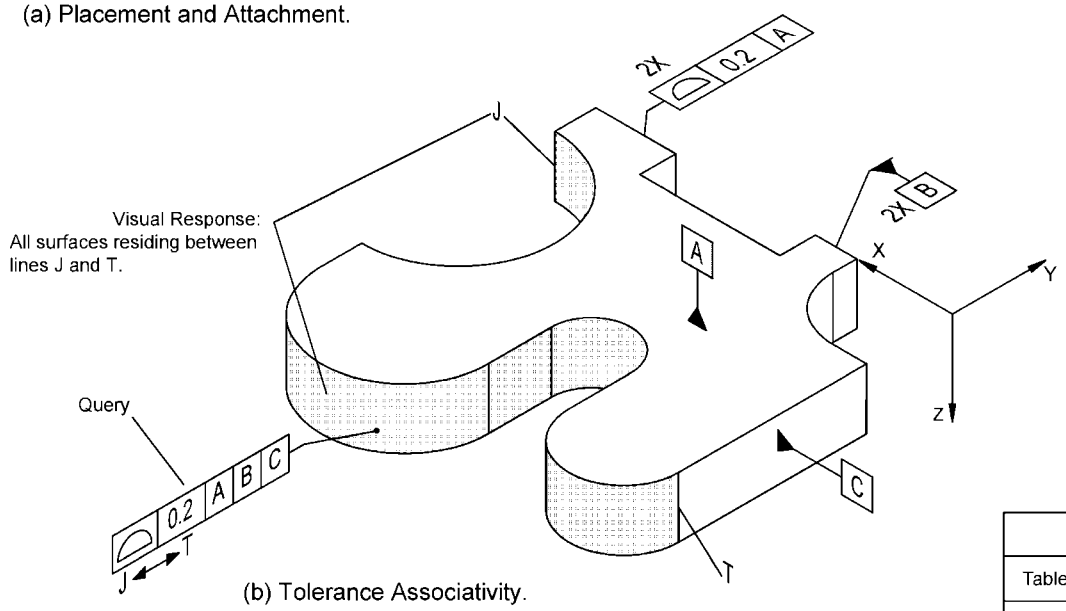


Fig. 12-16 Profile – Between Basis



(a) Placement and Attachment.



(b) Tolerance Associativity.

7.2.6
Table 12-3
12.2.3(c)

Fig. 12-17 Profile – All-Around Applications

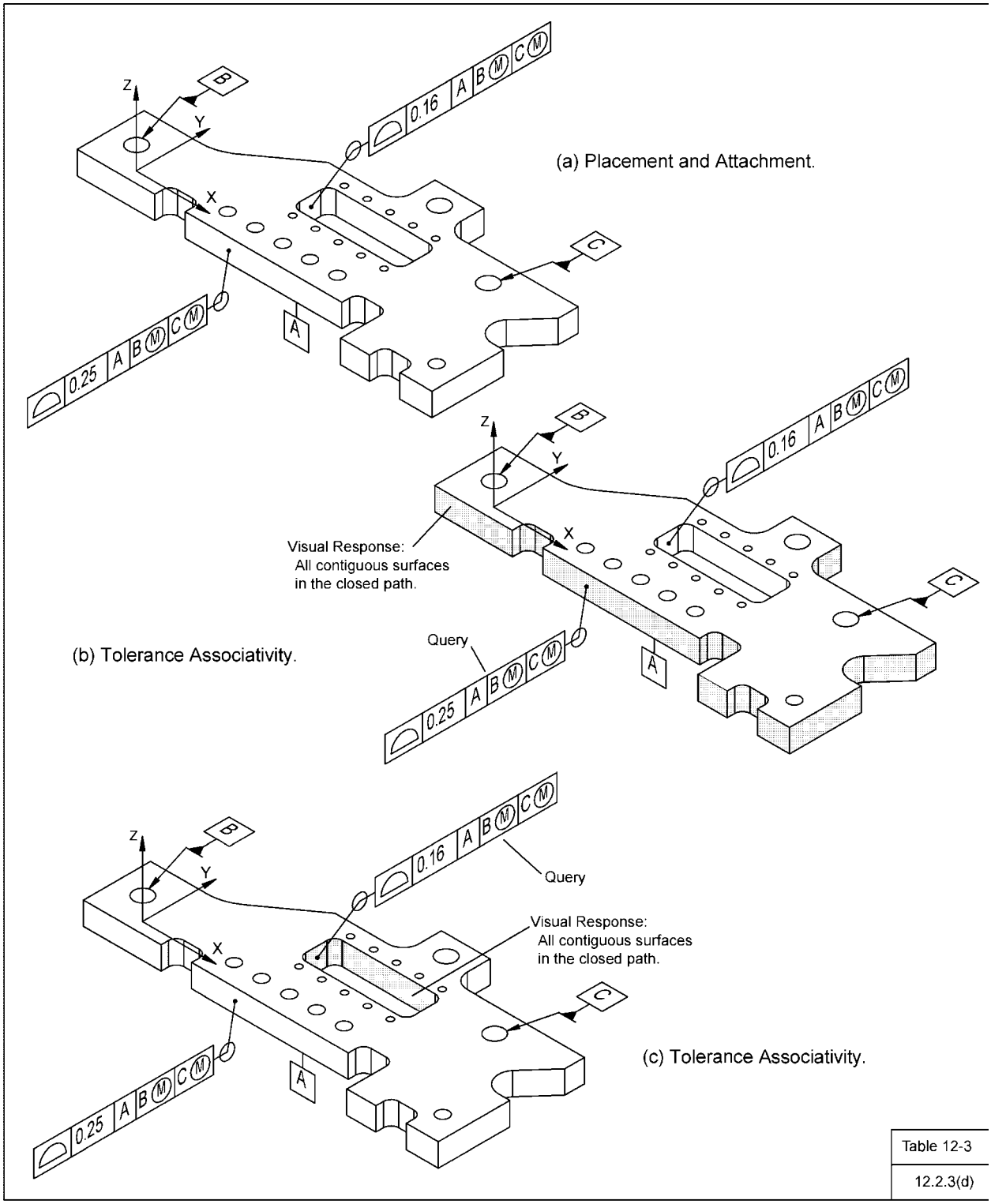
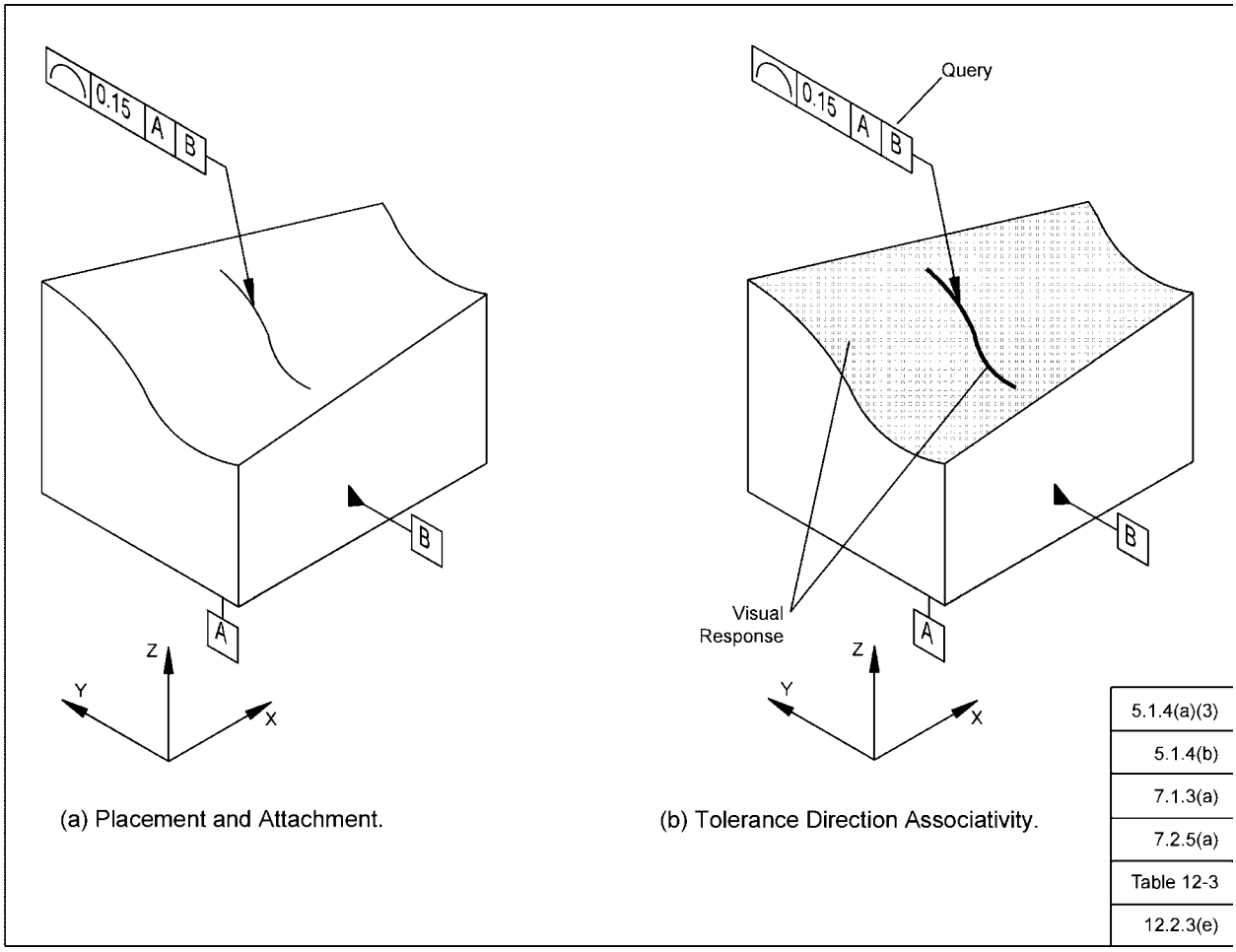


Fig. 12-18 Line Profile – Directed by Line Element



(a) Placement and Attachment.

(b) Tolerance Direction Associativity.

5.1.4(a)(3)
5.1.4(b)
7.1.3(a)
7.2.5(a)
Table 12-3
12.2.3(e)

Fig. 12-19 Line Profile – Directed by Ordinate Axis

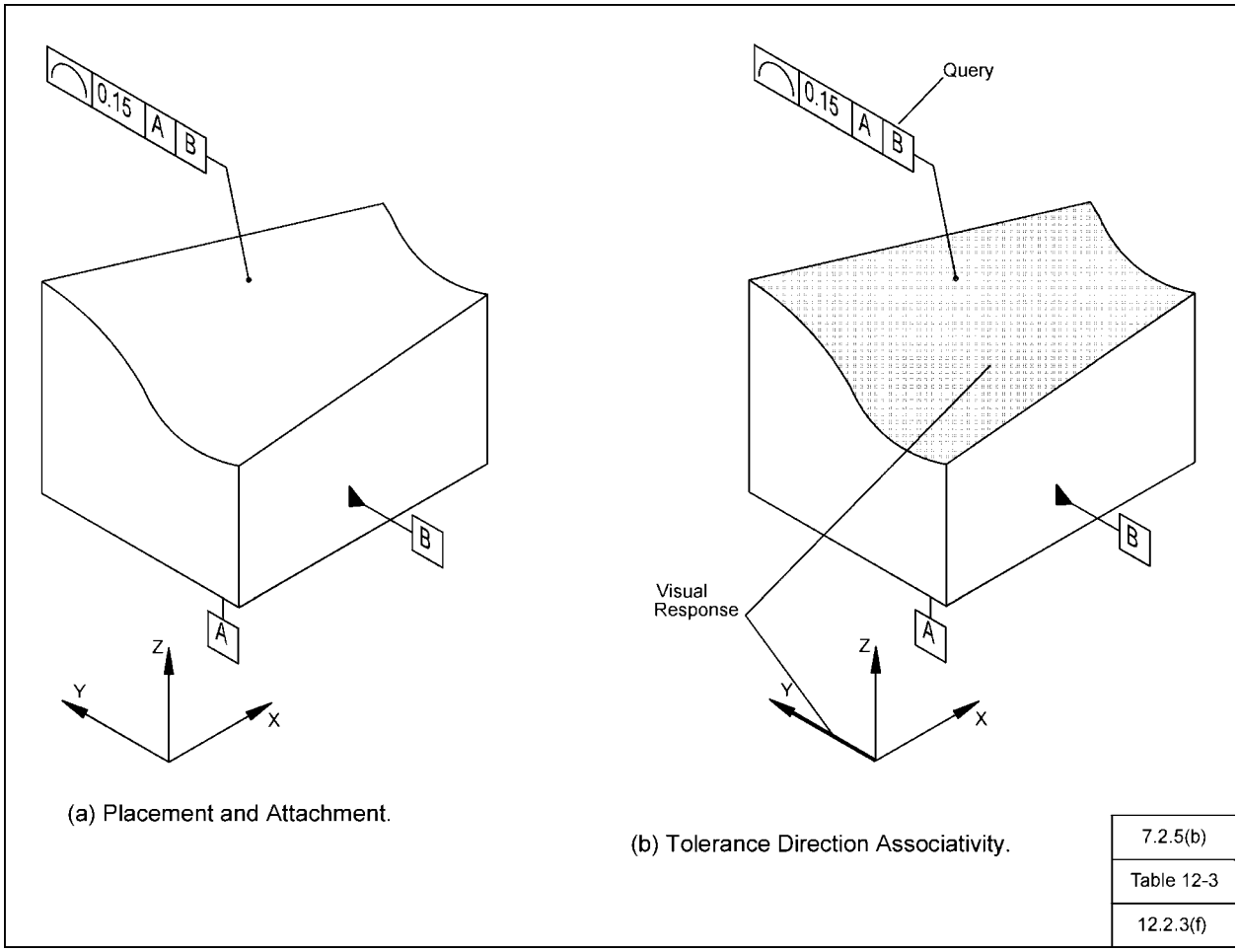


Table 12-4 Location Tolerances

	Condition	Attachment Technique: Size Callout	Attachment Technique: Directed Leader	Attachment Technique: Extension Lines	Paragraph	Figure
	Individually, to an Individual Datum	●	...	...	12.2.4(a)	12-20(a)
	Individually, to an Individual Datum	...	●	...	12.2.4(a)	12-20(b)
	Projected Tolerance Zone	●	...	...	12-2.4(b)	12-21(a)
	Projected Tolerance Zone	...	●	...	12-2.4(b)	12-21(b)
	Extremities of Long Holes	●	●	...	12.2.4(c)	12-22
	Elongated Holes (Slots) Boundary Basis	●	...	...	...	12-23(a)
	Elongated Holes (Slots) Boundary Basis	...	●	...	...	12-23(b)
	Elongated Holes (Slots) Boundary Basis	...	...	●	...	12-23(c)
	Bi-Directional, Polar, or Rectangular Coordinates	...	...	●	12.2.4(d)	12-24
	Profile and Boundary Position	...	●	...	...	12-25
	Derived Median Line	●	...	...	...	12-26(a)
	Derived Median Line	...	●	...	...	12-26(b)
	Derived Median Plane	●	...	...	...	12-26(c)
	Derived Median Plane	...	...	●	...	12-26(d)

Fig. 12-20 Position – Individual Patterns of Features

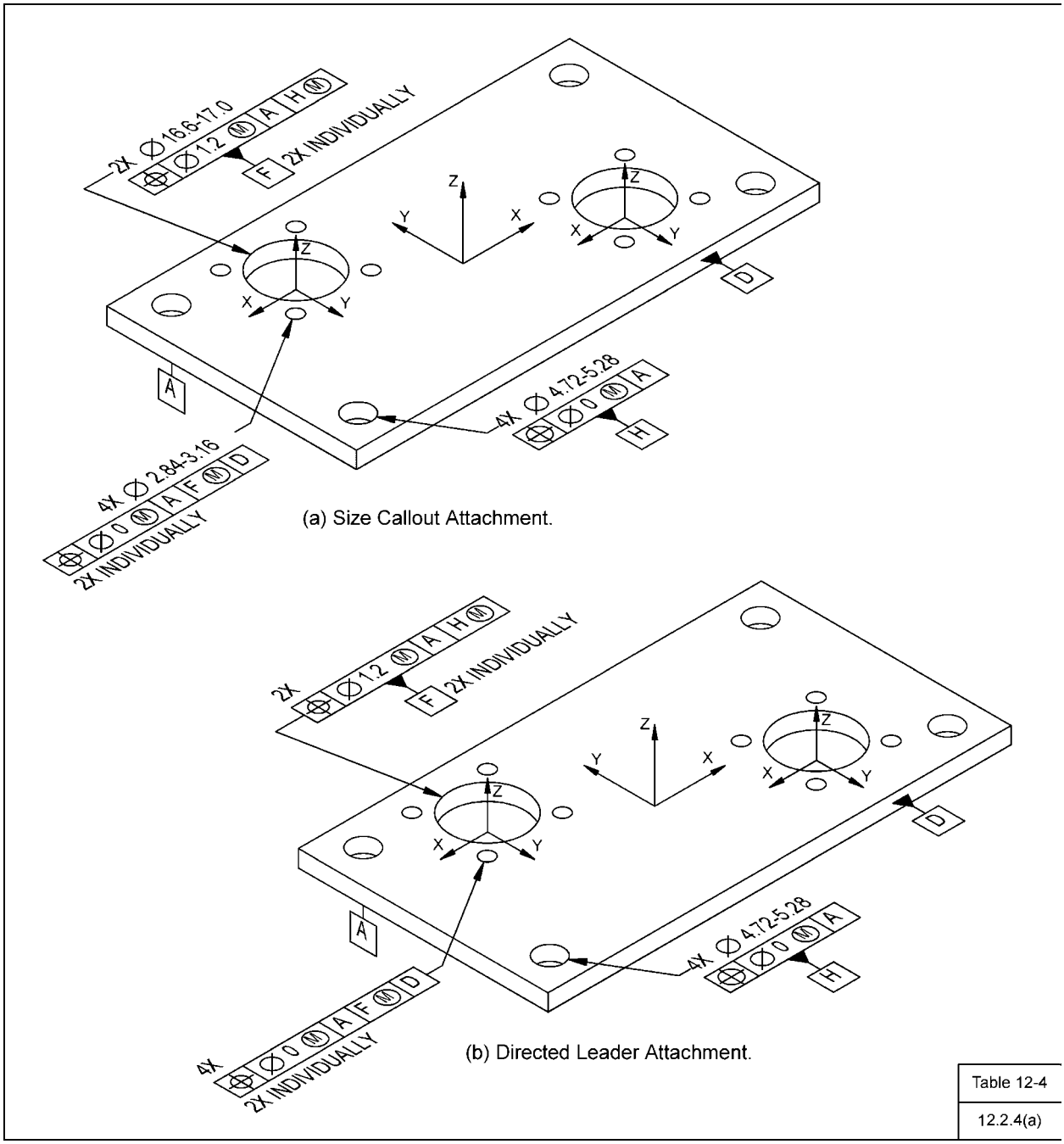
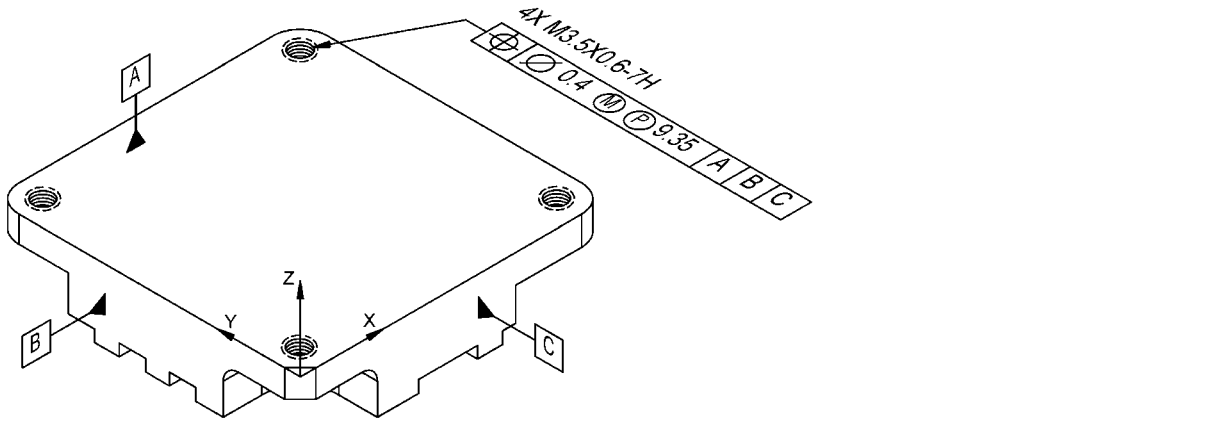
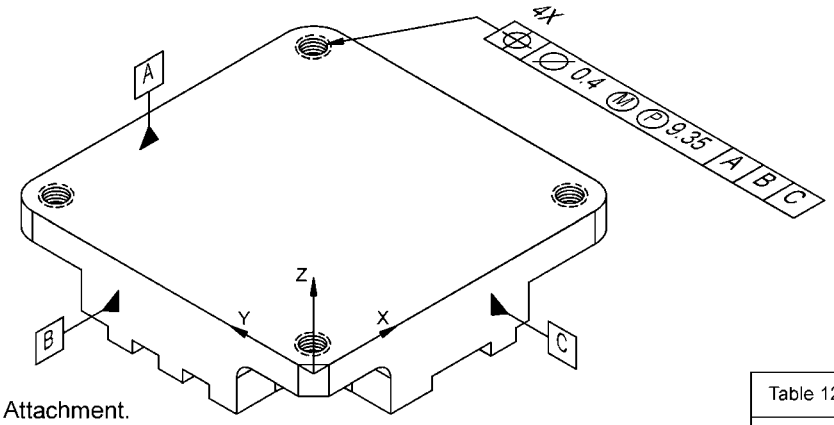


Table 12-4
12.2.4(a)

Fig. 12-21 Position – Projected Tolerance Zones



(a) Size Callout Attachment.



(b) Directed Leader Attachment.

Table 12-4
12.2.4(b)

Fig. 12-22 Position – Extremities of Long Holes

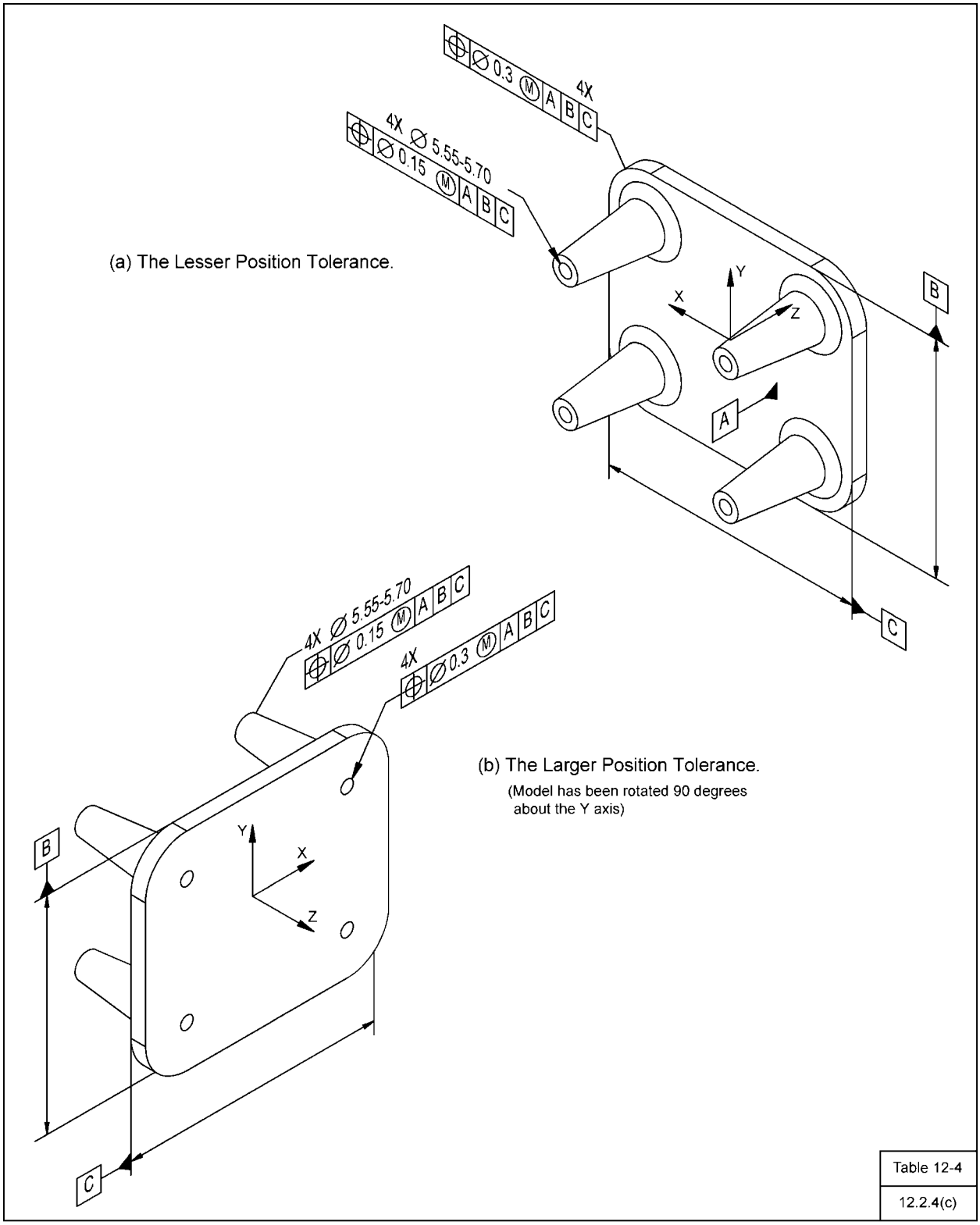


Fig. 12-23 Position – Elongated Holes (Slots)

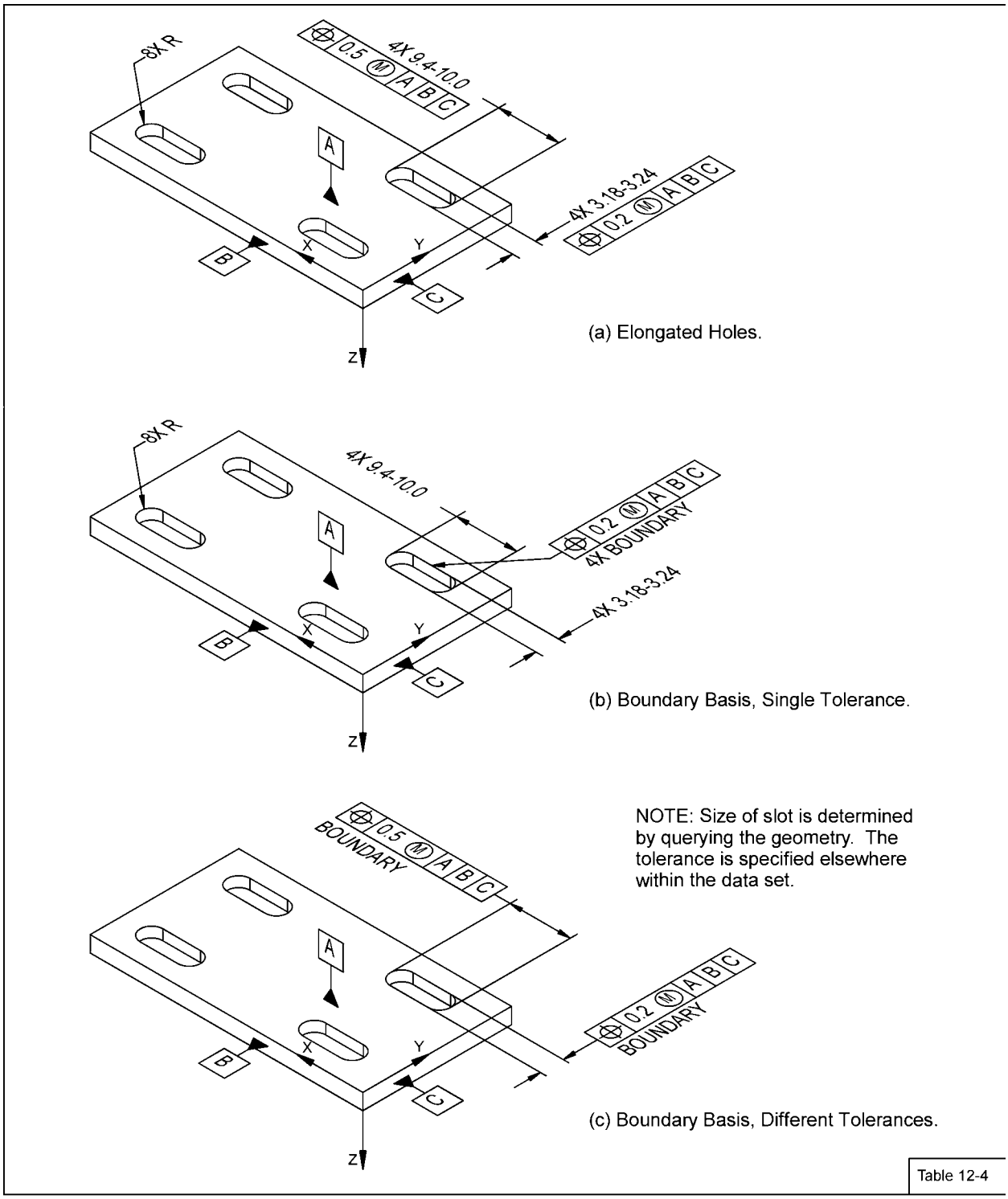


Fig. 12-24 Bi-directional Position – Polar or Rectangular

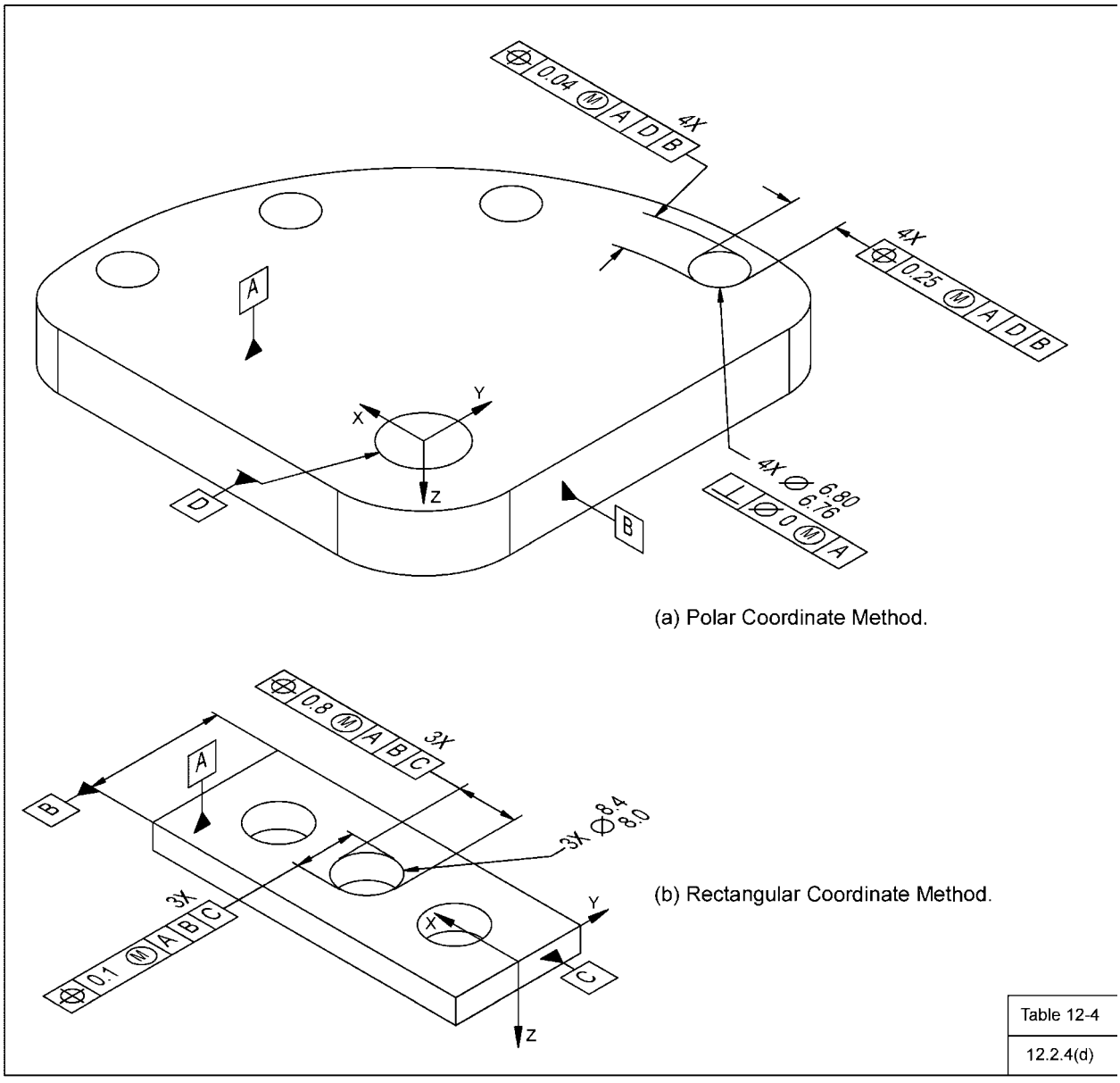


Table 12-4

12.2.4(d)

Fig. 12-25 Position – Combined With Profile

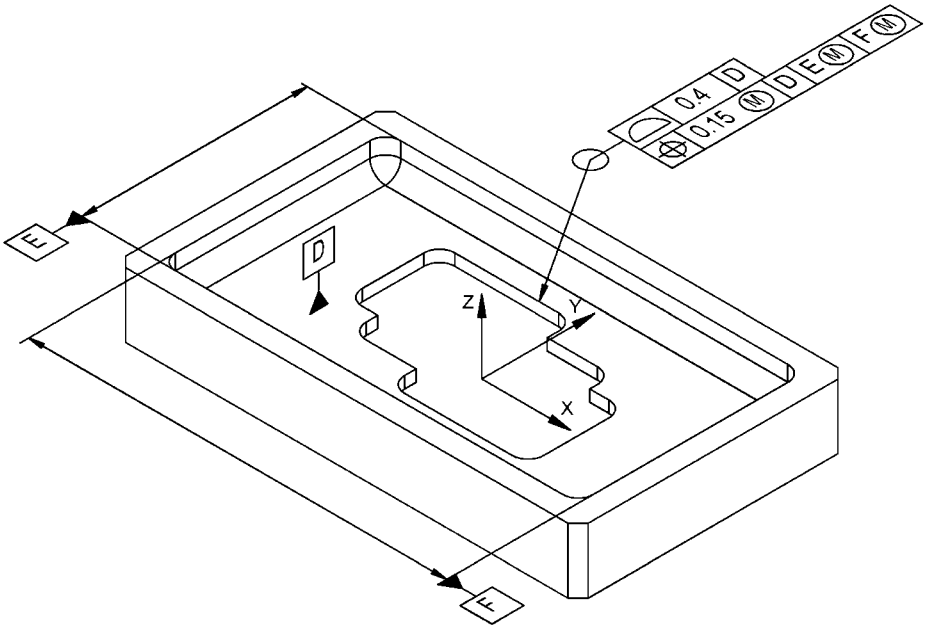


Table 12-4

Fig. 12-26 Concentricity and Symmetry

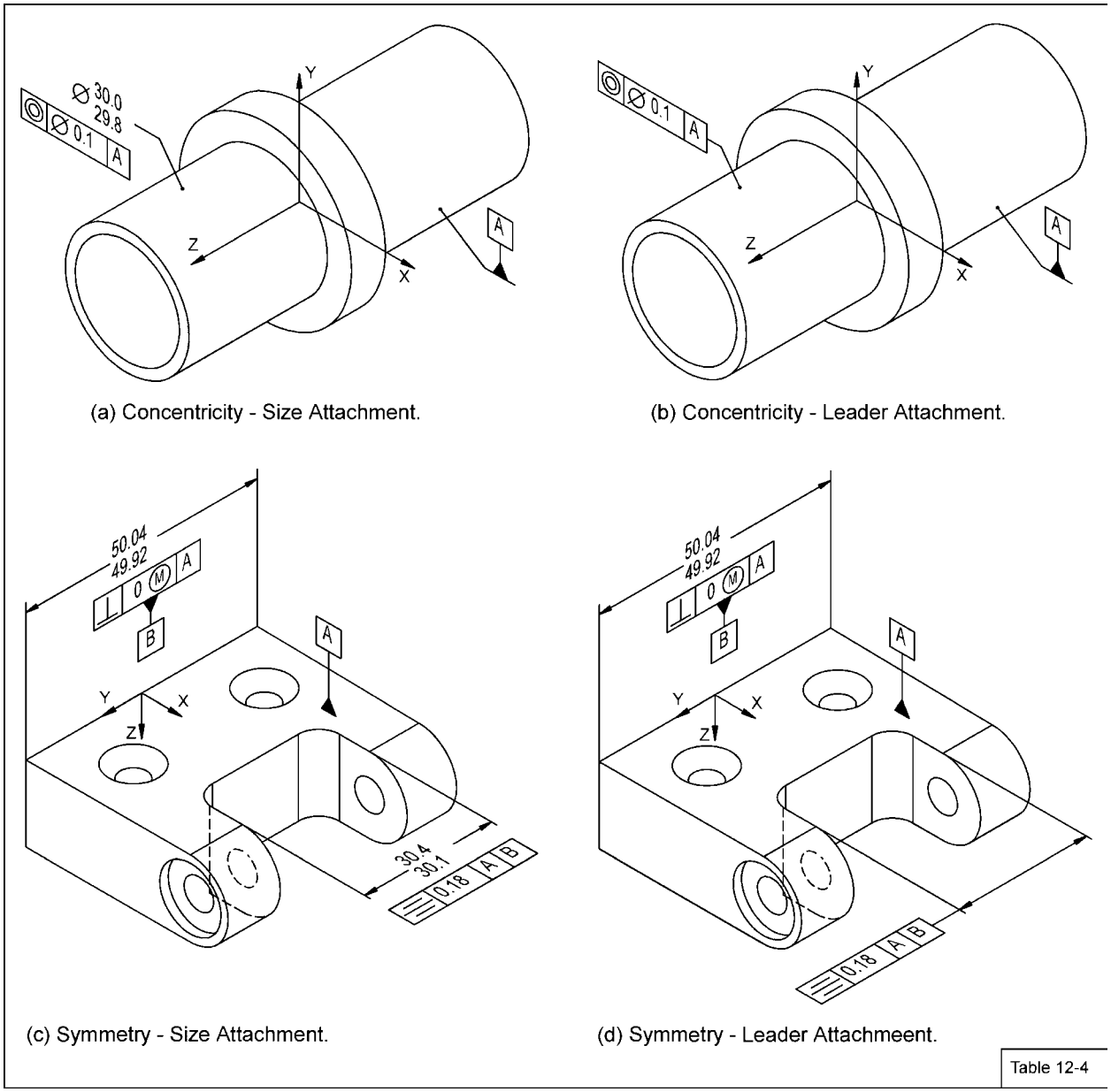
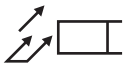
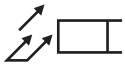
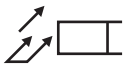


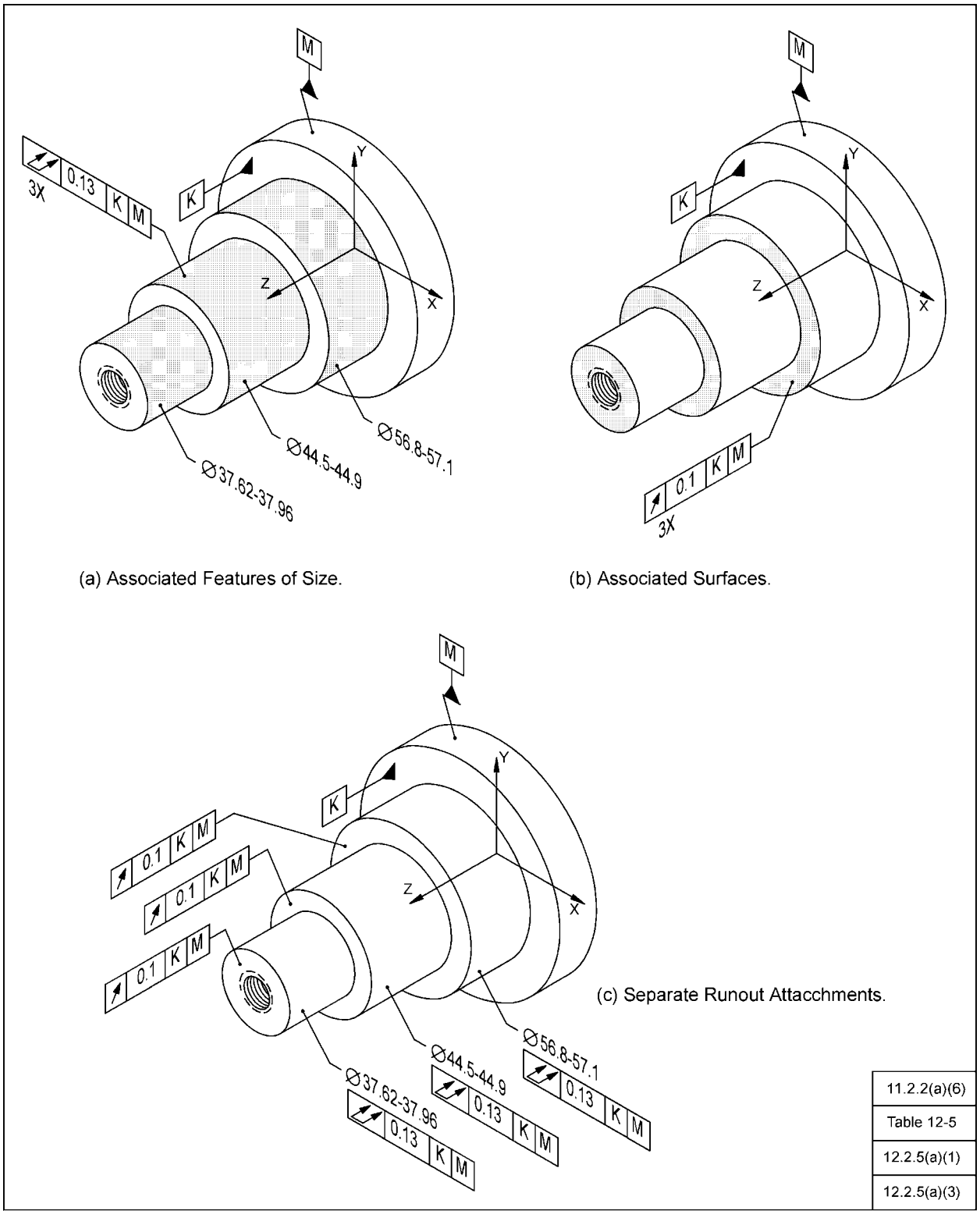
Table 12-4

Table 12-5 Runout Tolerances

	Condition [Note (1)]	Attachment Technique: Size Callout	Attachment Technique: Directed Leader	Paragraph	Figure
	Associativity	●	●	12.2.5(a)(1) 12.2.5(a)(3)	12-27
	Surface, Perpendicular to a Datum Axis	. . .	●	. . .	12-28(a)
	Cylindrical Surface	●	. . .	. . .	12-28(b)
	Cylindrical Surface	. . .	●	. . .	12.28(c)
	Spherical Surface	●	. . .	12.2.5(b)	12-29(a)
	Spherical Surface	. . .	●	12.2.5(b)	12.29(b)
	Conical or Revolved Surface	. . .	●	12.2.5(b)	12-29(c)

NOTE:
(1) Both symbols are shown when circular and total runout equally apply.

Fig. 12-27 Runout – Attachments and Associativity



11.2.2(a)(6)
Table 12-5
12.2.5(a)(1)
12.2.5(a)(3)

Fig. 12-28 Runout – Perpendicular and Cylindrical Surfaces

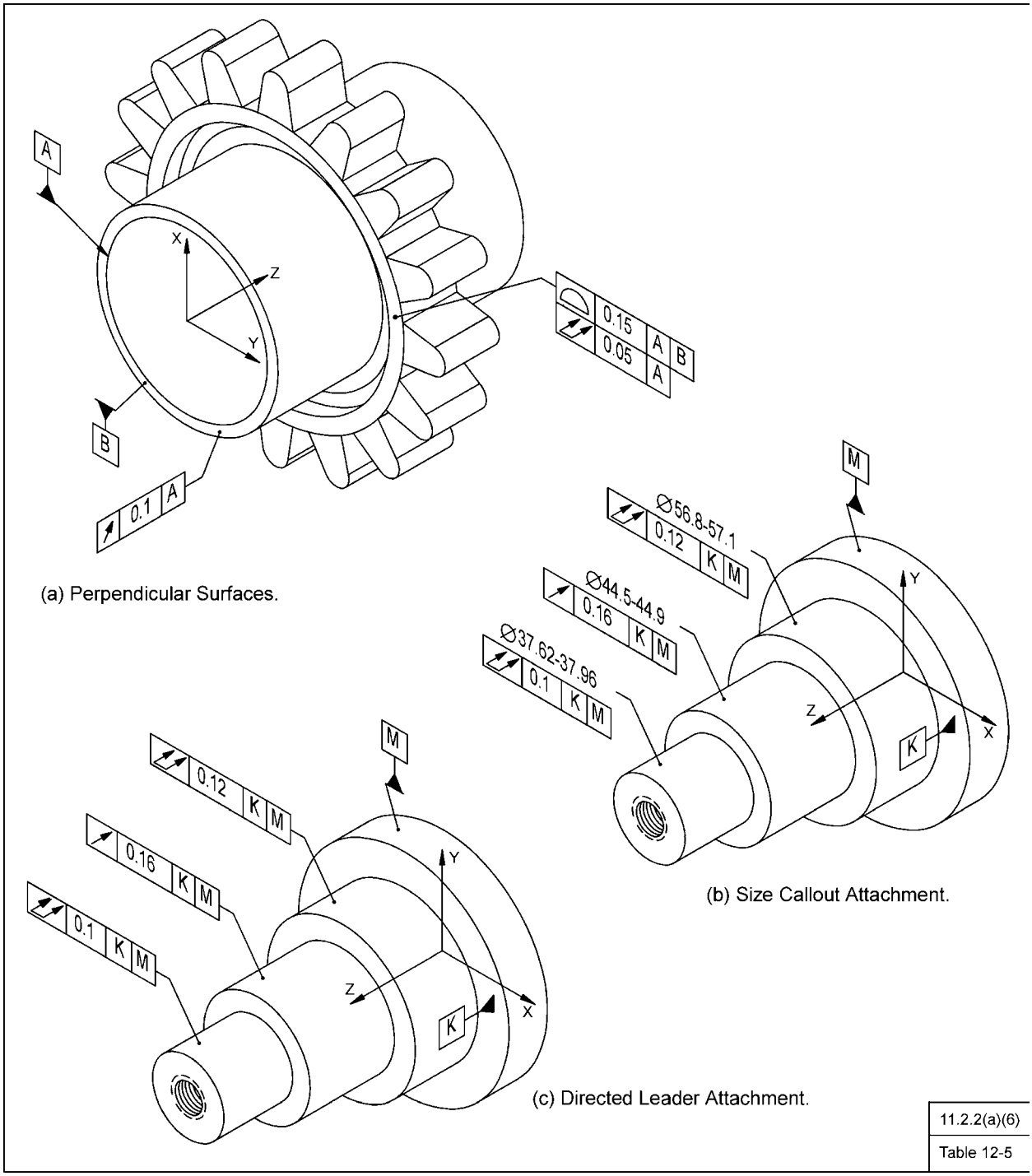


Fig. 12-29 Runout – Spherical, Conical, and Revolved Surfaces

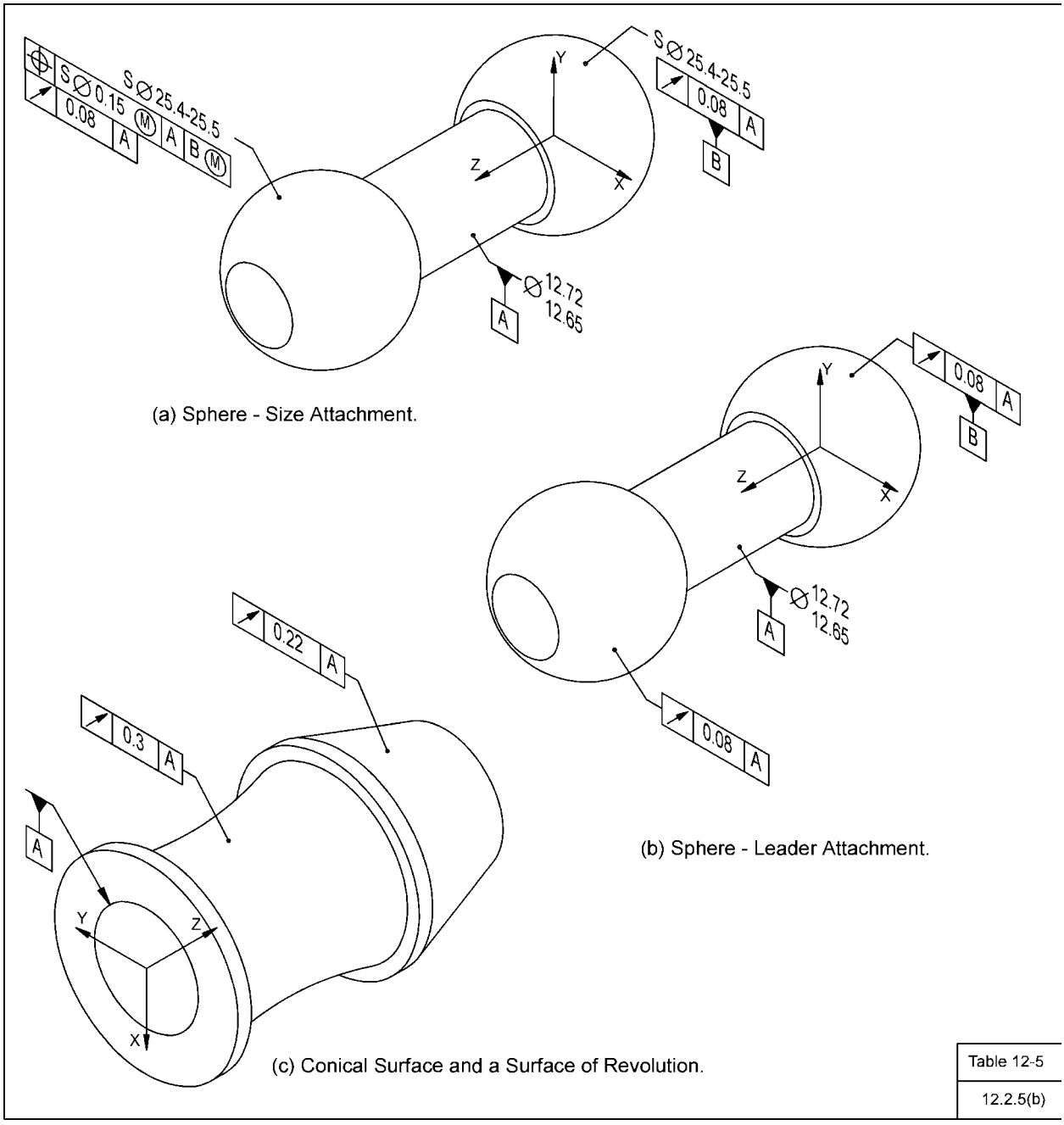
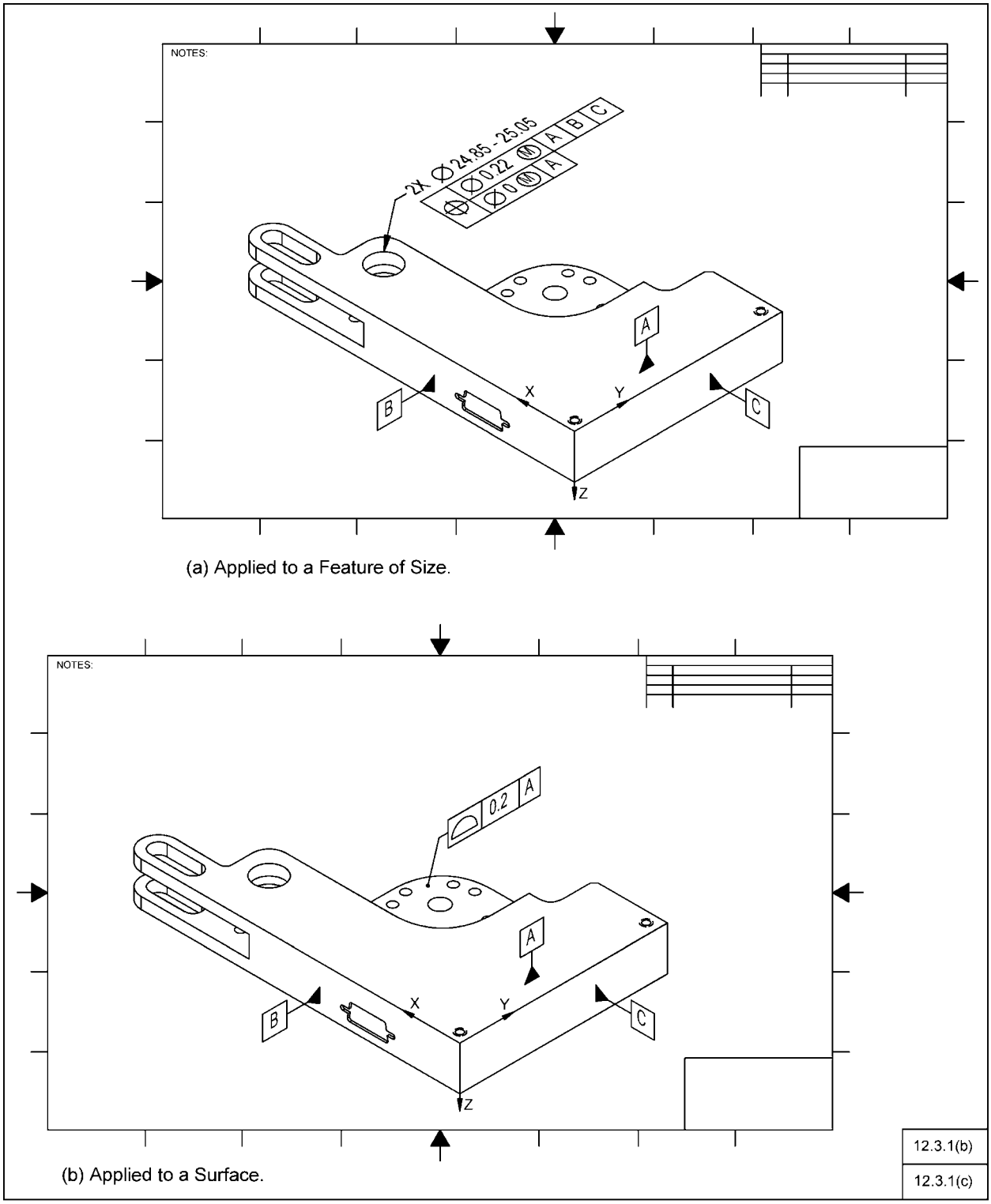


Table 12-5
12.2.5(b)

Fig. 12-30 Axonometric Views – Feature Control Frames



(a) Applied to a Feature of Size.

(b) Applied to a Surface.

Fig. 12-31 Axonometric Views – Limited Area Application

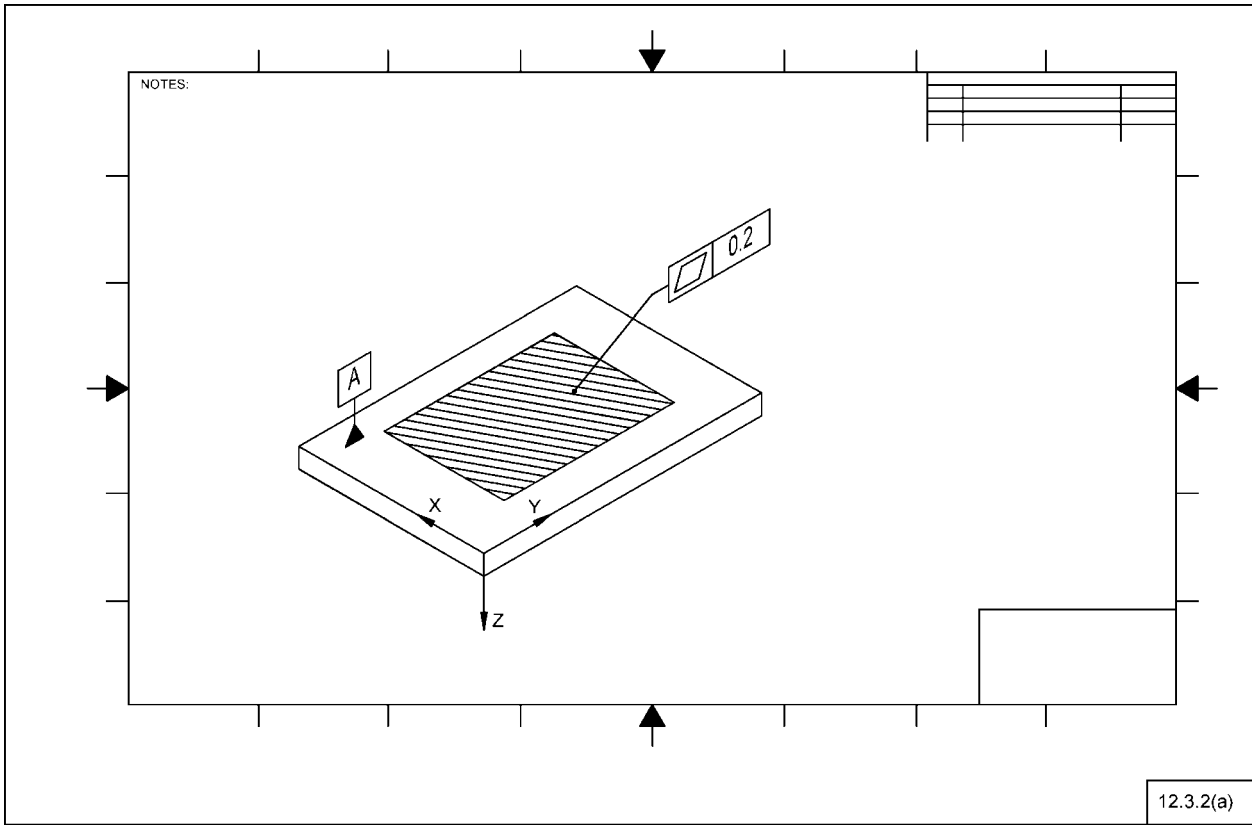


Fig. 12-32 Axonometric Views – Straightness, Each Element Applications

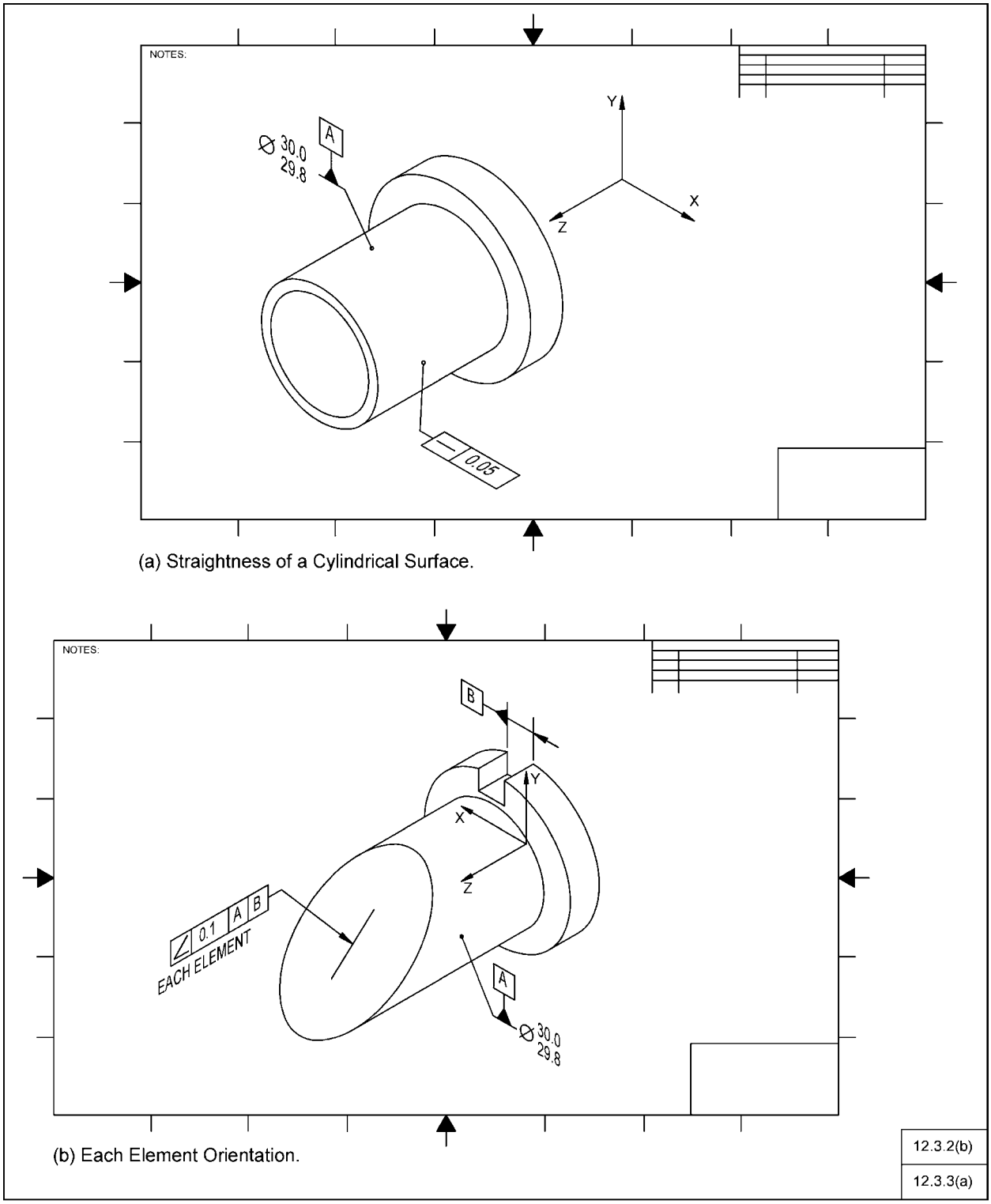


Fig. 12-33 Axonometric Views – Parallel Planes Tolerance Zone

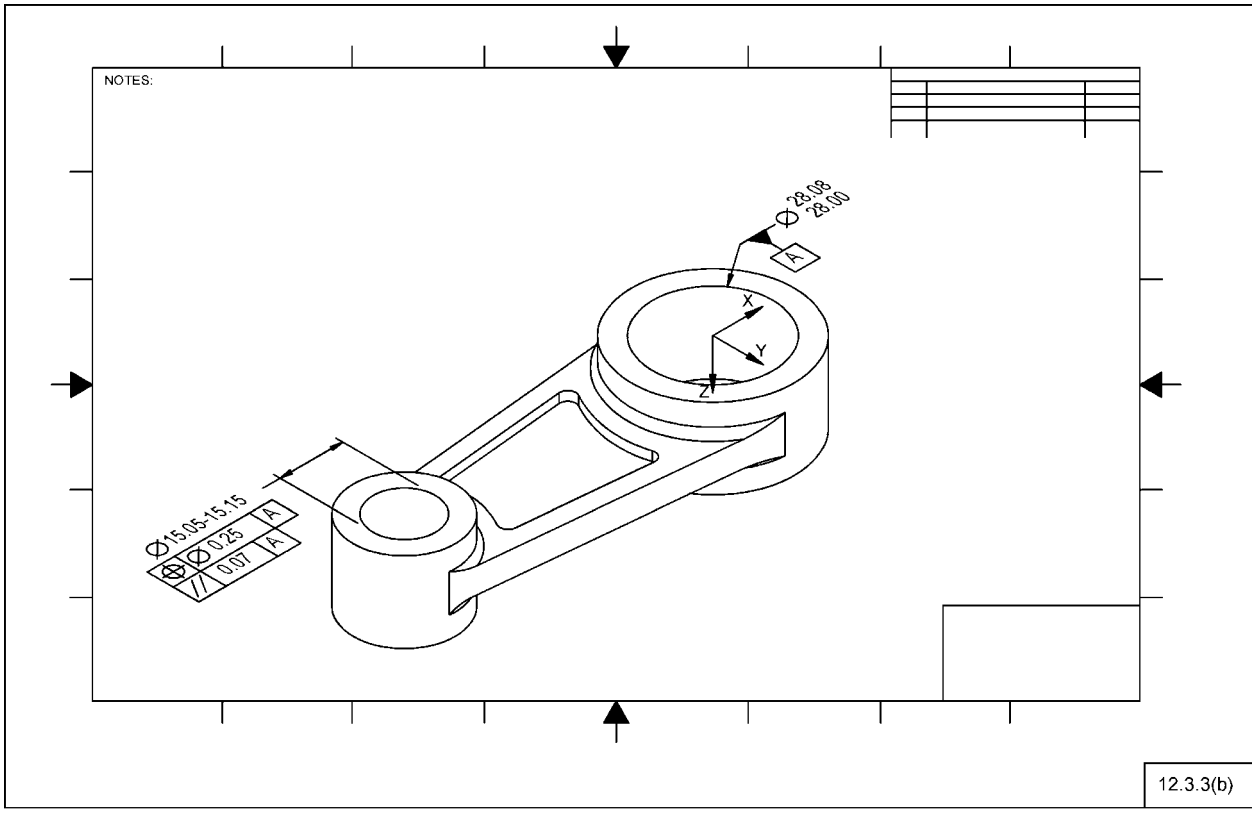


Fig. 12-34 Axonometric Views – Multiple Surfaces

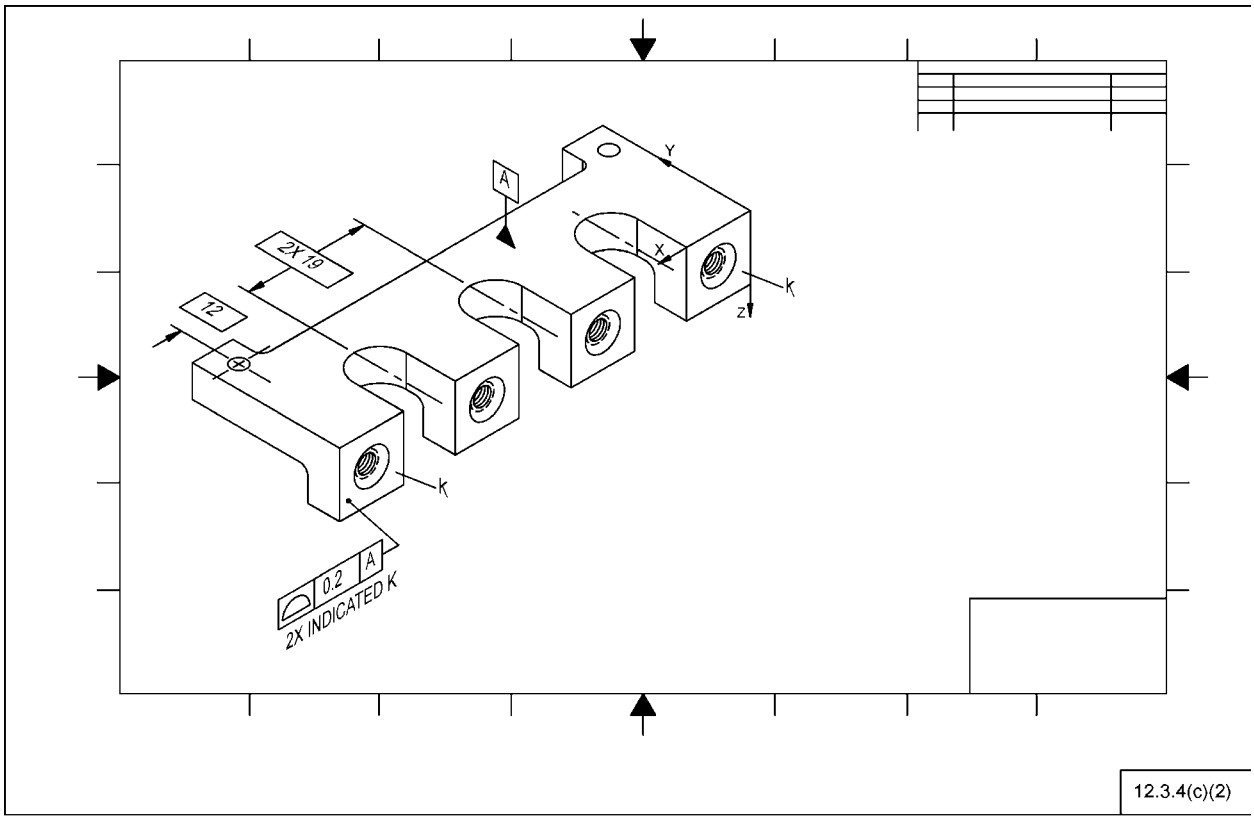
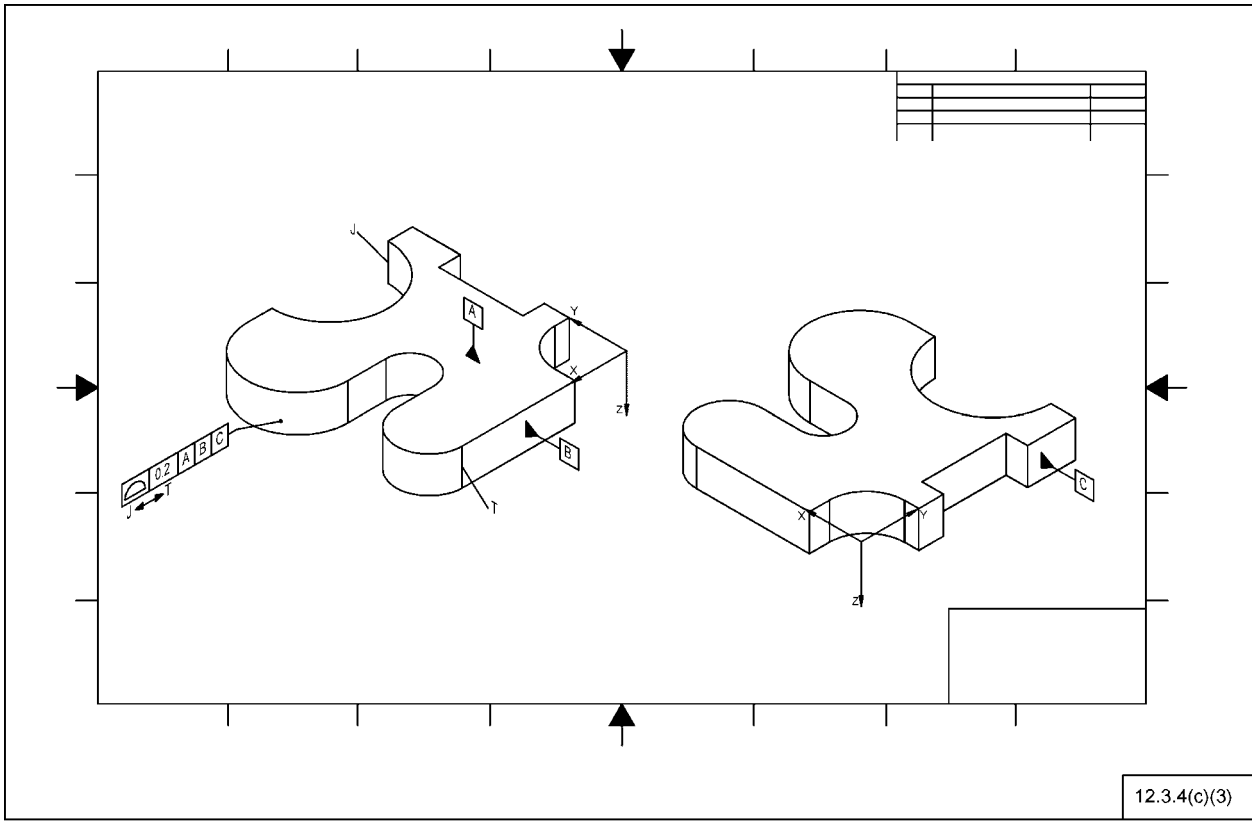


Fig. 12-35 Axonometric Views – Between Basis



INTENTIONALLY LEFT BLANK

MANDATORY APPENDIX I

The following material is being moved to ASME Y14.3 in the next revision. It is listed here for reference. Paragraph numbers shown are those from ASME Y14.41-2003. Any differences in the text reflect that the material was revised prior to its inclusion in ASME Y14.3.

1.9.1 Definitions

saved view: a stored and retrievable specific orientation and a magnification factor of a model.

3.6 Views on Models

See ASME Y14.3 for sections and views. The following paragraphs describe exceptions or additions for views on models.

(a) Saved Views. Saved views of a design model may be defined to facilitate presentation of the model and its annotation.

(1) A saved view shall have an identifier.

(2) A saved view shall be retrievable on demand.

(3) A saved view shall contain a model coordinate system that denotes the direction of the view relative to the model.

(4) A saved view may contain one or more of the following:

(a) annotation plane

(b) a selected set of annotation

(c) a selected set of geometry

(b) Sections. Saved views may be used to retain sections. All sections shall be the same scale as the design model.

(1) Cutting Plane. A representation of a cutting plane shall be used to indicate the location and viewing direction of a section. The edges of the cutting plane shall be solid or phantom lines. A means to identify all cutting planes in a model shall be available. A visible viewing arrow or arrows shall be included to show the direction in which the section is viewed. See Fig. 3-2. To relate the cutting plane to its section view, uppercase letters such as A, B, C, etc., shall be placed near the viewing arrow or arrows and in the same plane as the arrowheads. The corresponding section views are identified as SECTION A, or SECTION A-A when two viewing arrows are used. Section letters should be used in alphabetical order excluding I, O, Q, S, X, Y, and Z. When the alphabet is exhausted, additional sections shall be indicated using double letters in alphabetical order, as in AA, AB, AC, etc., or AA-AA, AB-AB, etc., when two viewing arrows are used.

(2) Depiction of Section Cut. The result of the section cut may be shown either by removing material from the part, see Fig. 3-2(b), or by the display of the curves overlaid on the model that result from intersecting the cutting plane with the part or both, see Fig. 3-2(c).

(3) Offset Sections. Multiple, connected cutting planes shall be used for offset sections. The multiple, connected cutting planes shall be labeled as a single cutting plane. See Fig. 3-3.

(4) Aligned Sections. Aligned sections shall not be used on design models.

(5) Removed Sections. Removed sections shall not be used on design models.

(6) Revolved Sections. Revolved sections shall not be used on design models.

(7) Broken-out Sections. Broken-out sections shall be accomplished as offset sections. See para. 3.6(b)(2).

(8) Foreshortened and Aligned Features. Foreshortened and aligned features shall not be used on design models.

(9) Rotation of Features. Rotation of features shall not be used on design models.

(10) Associativity. Section views shall be derived from the design model. Changes to the design model shall cause the related section views to be updated accordingly.

5.3.1 Orthographic Views. When orthographic views are used, the model coordinate system may be used to indicate view orientation.

5.3.2 Axonometric Views. The following paragraphs describe requirements for axonometric views.

(a) Methods of Projection for Axonometric Views. The model coordinate system showing model orientation shall be included in each axonometric view. See Fig. 5-13(a).

(b) Section Views. Section views may be created from axonometric views. A section view may be orthographic or axonometric.

(1) Cutting Plane. A representation of a cutting plane shall be used to indicate the location and viewing direction of a section. The edges of the cutting plane shall be solid or phantom lines. A visible viewing arrow or arrows shall be included to show the direction in which the section is viewed. See Fig. 5-13. To relate the cutting plane to its section view, upper case letters such as A, B, C, etc., shall be placed near the viewing arrow or arrows. The corresponding section views are identified as SECTION A, or SECTION A-A when two viewing

arrows are used. Section letters should be used in alphabetical order, excluding I, O, Q, S, X, Y, and Z. When the alphabet is exhausted, additional sections shall be indicated using double letters in alphabetical order, as in AA, AB, AC, etc., or AA-AA, AB-AB, etc., when two viewing arrows are used.

(2) Depiction of Section Cut. The result of the section cut may be shown either by removing material from the part [see Fig. 5-13(a), (b)], or by display of the curves overlaid on the view that result from intersecting the cutting plane with the part [see Fig. 5-13(c)].

(3) Rotation of a Section Taken from Axonometric Views. Sections taken from axonometric views may be presented in the same orientation as the parent view or may be rotated. See Fig. 5-13(a).

(4) Offset Sections. The use of a stepped or offset cutting line is supported in axonometric views. The resulting section cut geometry may be shown in its true position on the design model or drawn as if the offsets were in one plane.

(5) Aligned Sections. The use of a cutting plane line containing angular changes is supported in axonometric views. The resulting section may show all features in their true position on the design model or be drawn as if the bent cutting plane and features were rotated into a plane perpendicular to the line of sight of the sectional view.

(6) Foreshortened and Aligned Features. Features may be shown in their actual position, without foreshortening or alignment, when the section is made from a axonometric view.

(7) Rotation of Features. Features may be shown in their actual location when shown in a section view cut from an axonometric view.

Fig. 3-2 Design Model Cutting Plane

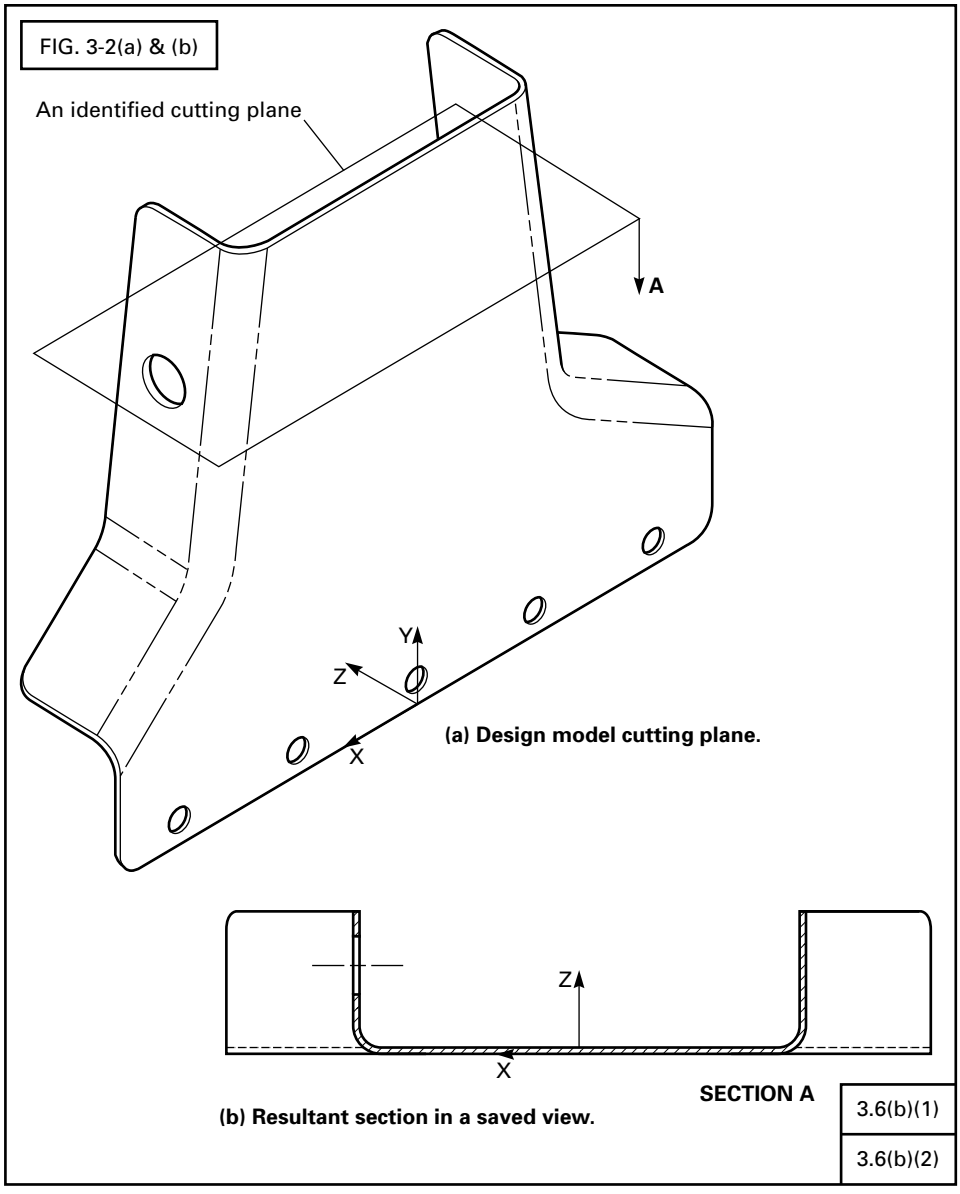


Fig. 3-2 Design Model Cutting Plane (Cont'd)

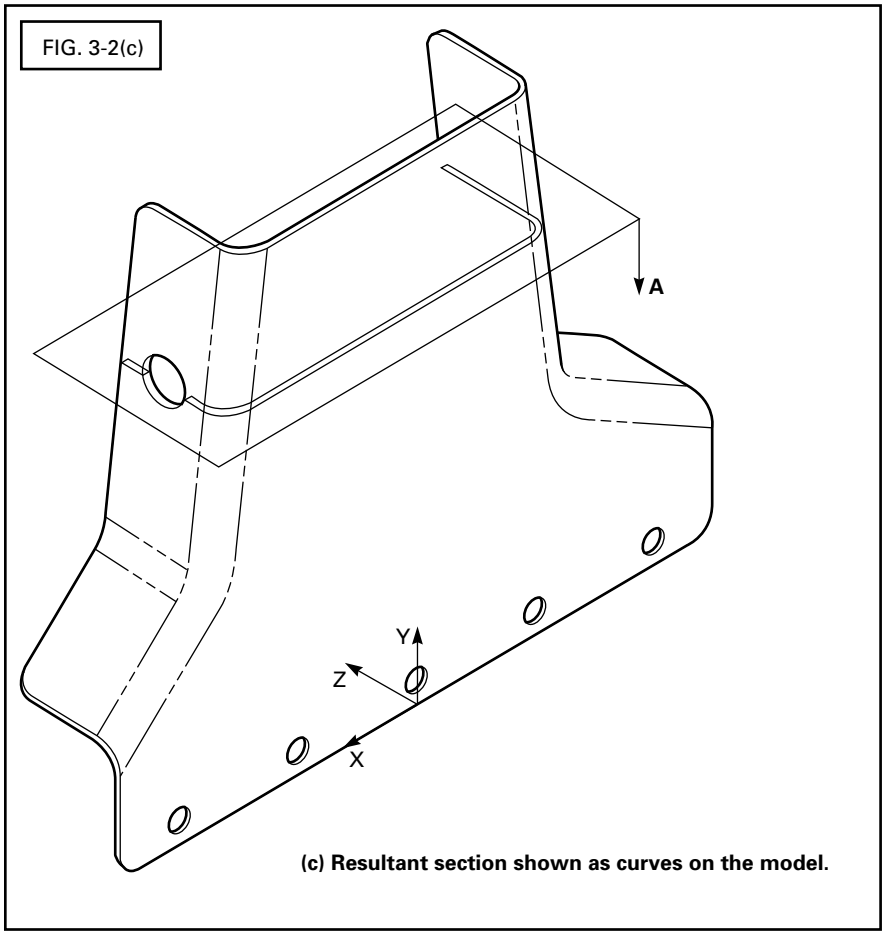


Fig. 3-3 Design Model With Offset Section

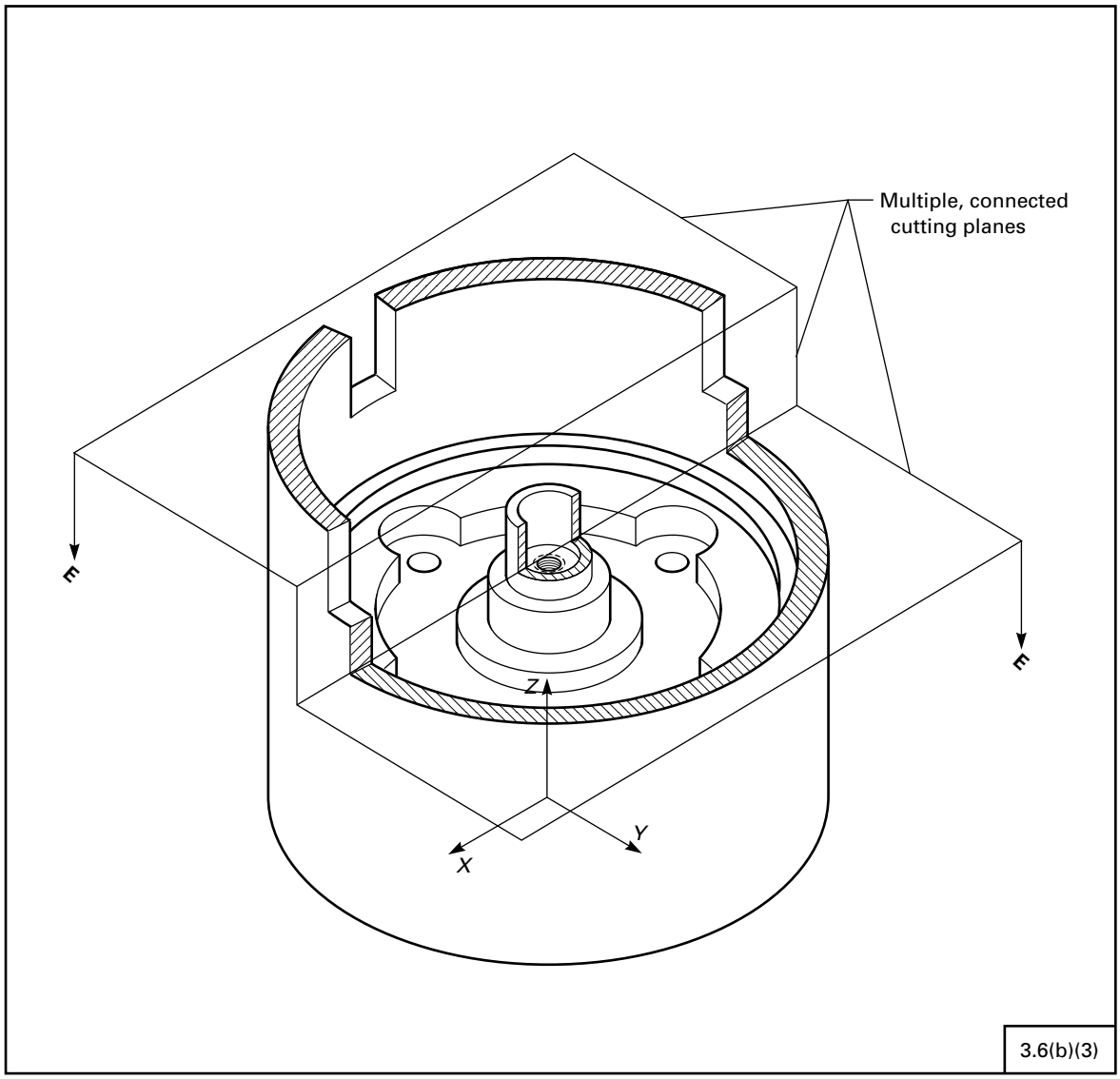
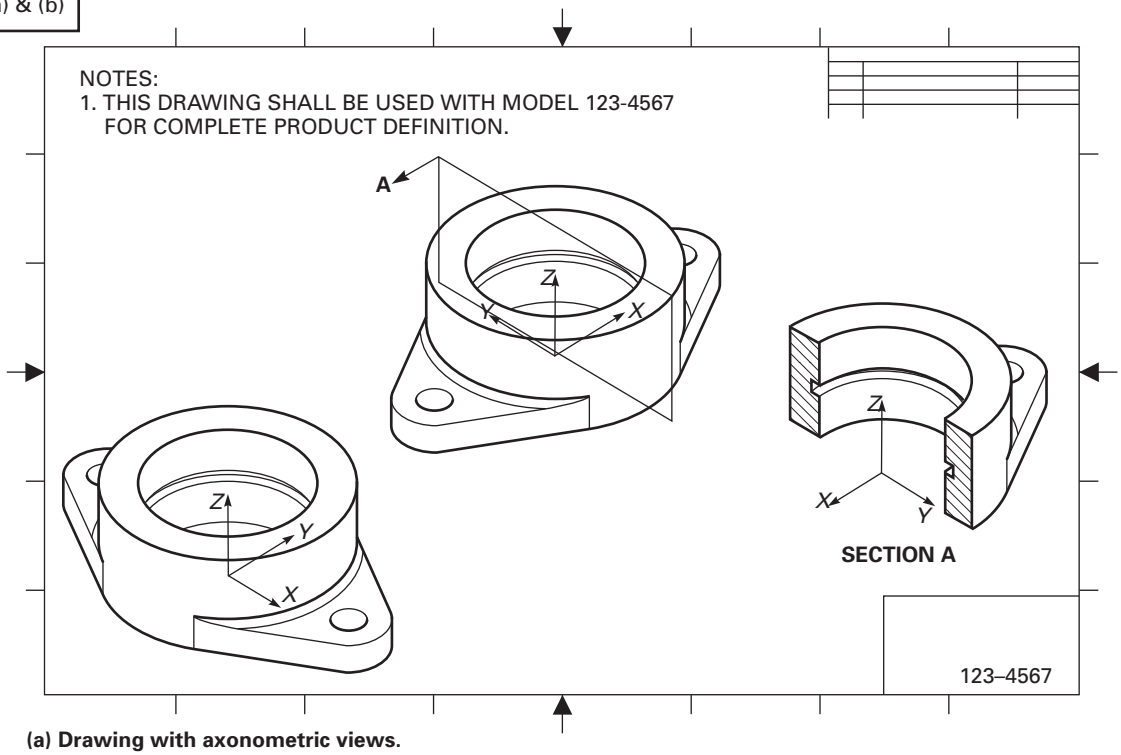
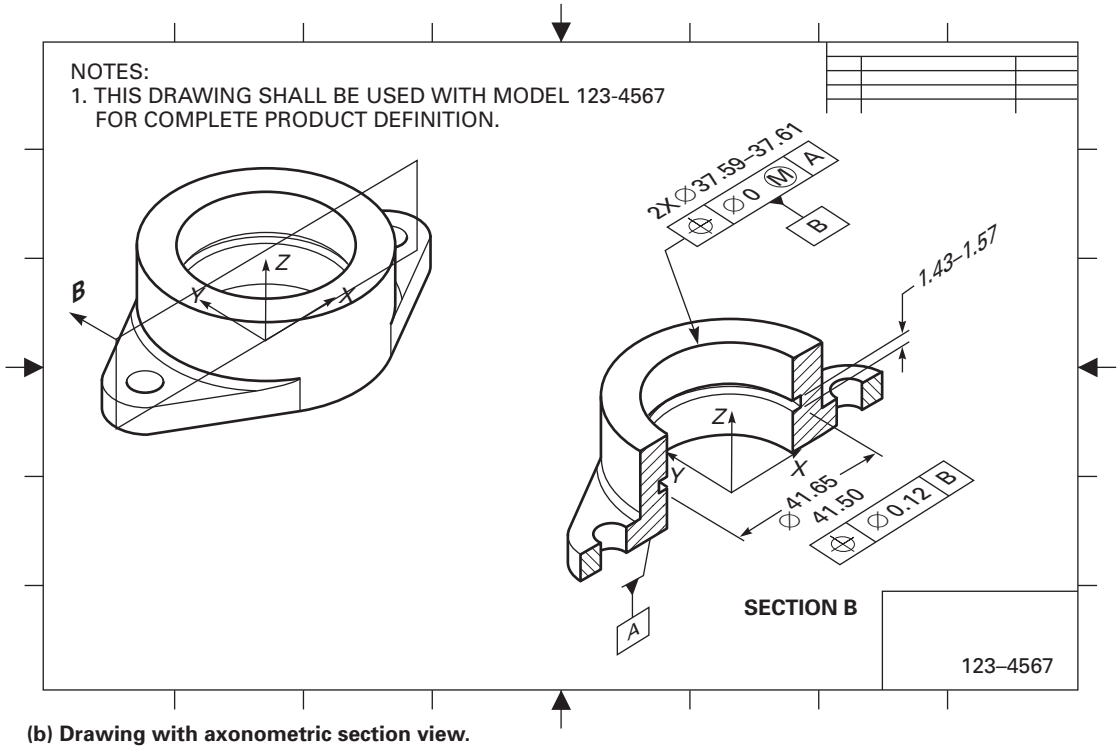


Fig. 5-13 Axonometric Views

FIG. 5-13(a) & (b)



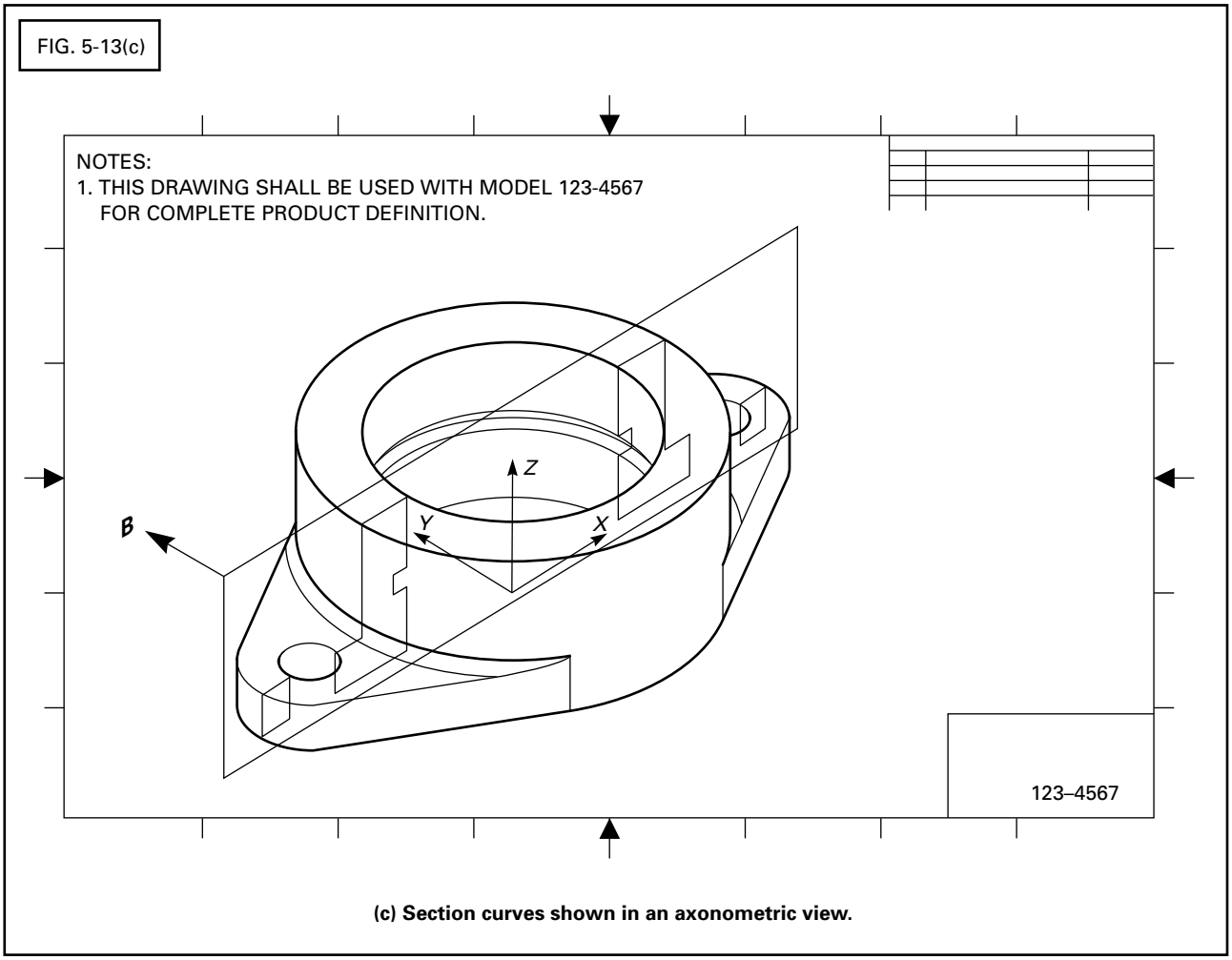
(a) Drawing with axonometric views.



(b) Drawing with axonometric section view.

5.3.2(a)
5.3.2(b)(1)
5.3.2(b)(2)

Fig. 5-13 Axonometric Views (Cont'd)



(c) Section curves shown in an axonometric view.

INTENTIONALLY LEFT BLANK

INTENTIONALLY LEFT BLANK

ASME Y14.41-2012

ISBN 978-0-7918-3407-7

N17112