ASME Y14.3-2012
[Revision of ASME Y14.3-2003 (R2008)
and Consolidation of ASME Y14.4M-1989 (R2009)]

Orthographic and Pictorial Views

Engineering Drawing and Related Documentation Practices

AN AMERICAN NATIONAL STANDARD

The American Society of
Mechanical Engineers

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Two Park Avenue • New York, NY • 10016 USA

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This Standard will be revised when the Society approves the issuance of a new edition. There will be no written interpretations of the requirements of this Standard issued to this edition.

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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.

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

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FOREWORD

This issue is a revision of ASME Y14.3-2003, formerly titled "Multiview and Sectional View Drawings." This revision of ASME Y14.3 was initiated in response to industry and DoD requests that international practices and computer aided design (CAD) capabilities be accommodated. The work on this revision of the standard began in April 2009 in a virtual meeting of the ASME Y14 Subcommittee 3 (SC3). Work moved forward with a focus on adding practices relevant to CAD utilization.

Following the April 2009 meeting, the chairman of SC3, B. A. Wilson, and the chairman of SC4, J. D. Keith, began discussions regarding the possible merge of content from ASME Y14.3 and Y14.4 to locate orthographic and pictorial view requirements in one standard. A new scope and charter of SC3 was drafted to cover the combined content, and it was submitted to the ASME Y14 committee for approval. Approval was given and members of SC4 were combined with SC3. ASME Y14.3 was given a new title of "Orthographic and Pictorial Views."

The first meeting of the combined subcommittees was held in April, 2010. During 2010, the chairman of SC3 began working with N. H. Smith, chairman of SC41, to determine if view-specific content in ASME Y14.41 should be moved into ASME Y14.3. The cooperative efforts between SC3 and SC41 resulted in movement of view-specific content from ASME Y14.41 into ASME Y14.3.

ASME Y14.3 now includes requirements for orthographic and pictorial views, whether product definition is accomplished by 2D drawing only, model only, or both. Generally, view requirements are applicable regardless of means of creation, but there are some specific requirements limited in applicability based on view creation method.

This revision of ASME Y14.3 continues a transition to standardize view requirements that are compatible with CAD capabilities and common industry practices. The inclusion of CAD specific requirements was initiated in the development of ASME Y14.3-2003 as well as in the development of ASME Y14.41-2003. It is expected that in the future, the requirements in ASME Y14.3 will continue to move towards one set of requirements that are consistent regardless of view creation method. At this time, there are practices that are limited to constructed views or to model-based views. It is anticipated that future revisions of this Standard will continue to expand coverage of view requirements for CAD-created views with the constructed view conventions potentially being removed when there is no longer a need for them.

Significant revisions include the following:

(a) reorganizing to include and advance the content of ASME Y14.3-2003, ASME Y14.4-1989(R2004), and applicable paragraphs and figures from ASME Y14.41-2012

(b) making view requirements based on CAD practices and capabilities more prevalent throughout the standard

(c) noting as such, requirements applicable to only constructed views , and excluding from constructed view practices, the newer practices when applicable only to CAD-created views

In this Standard, anything identified as a requirement is mandatory. Compliance with requirements is not optional except where more than one method is provided in which case one of the options shall be used. Actions, drawing elements, or other items identified as practices are typical but are not required, except where those practices are expressed as requirements or specified as practices to be used.

The successful revision of this Standard is attributed to the commitment of the committee members and the support of their sponsoring companies. The commitment of their time and contributed expertise are gratefully acknowledged. J.D. Keith, former chairman of ASME Y14 SC4, worked alongside with the SC3 chairman to keep the work on schedule and ensure that it was technically correct. N.H. Smith, chairman of ASME Y14 SC41, worked closely with the SC3 chairman to transition technical content from ASME Y14.41 to ASME Y14.3. L.F. Irwin served as a technical liaison between SC3 and SC41 to ensure the technical intent of the Y14.41 material was correctly merged into Y14.3. R.H. Settle created the figures for this and the previous edition of ASME Y14.3. J.B. Burleigh, R.G. Campbell, R.R. Cruz, J.I. Miles, and A. Watts served as section leaders, each of whom worked to develop the first draft of one or more of the Sections.

It is our intention for future revisions of this Standard to continue moving us forward towards defining common practices that are applicable regardless of view creation methods. Interested parties are invited to contact ASME for involvement in future development efforts.

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

This Standard was approved as an American National Standard on November 30, 2012.

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Engineering Drawing and Related Documentation Practices

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

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

Secretary, Y14 Standards Committee
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http://go.asme.org/Inquiry

Proposing Revisions. Revisions are made periodically to the Standard to incorporate changes which 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.

ORTHOGRAPHIC AND PICTORIAL VIEWS

1 GENERAL

1.1 Scope

This Standard establishes the requirements for creating orthographic, and pictorial views on engineering drawing graphic sheets and in models. View requirements are generally the same regardless of how they are created. Specific requirements that are applicable only to constructed or to saved views are defined throughout the standard.

The topics covered include the multiview system of drawing, selection, and arrangement of orthographic views, auxiliary views, section views, details, pictorial views, conventional representation of features with some practices applicable only to constructed views, practices applicable to saved views on drawing graphic sheets, and practices applicable only to saved views in models.

The methods for constructing orthographic and pictorial views are beyond the scope of this Standard. Space geometry and space analysis and applications are included in the appendices for informational purposes.

1.2 ASME Y14 Series Conventions

The following conventions in paras. 1.2.1 through 1.2.10 are used in this and other ASME Y14 series of standards.

1.2.1 Mandatory, Nonmandatory, Guidance, and Optional Words

(a) The words "shall" and "will" establish a mandatory requirement.

(b) The words "should" and "may" establish a recommended practice.

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

(d) The word "or" used in conjunction with a mandatory requirement or a recommended practice indicates that there are two or more options for complying with the stated requirement or practice.

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

(a) Reference to other ASME Y14 series of standards in the text without a date following the standard identity indicates that the issue of the standard as identified in the references section 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.

1.2.3 Invocation of Referenced Standards. The following examples define the invocation of a standard when specified in the references section and referenced in the text of this Standard:

(a) When a referenced standard is cited in the text with no limitations to a specific subject or paragraphs(s) of the standard, the entire standard is invoked. For example, "dimensioning and tolerancing shall be in accordance with ASME Y14.5" is invoking the complete standard because the subject of the standard is dimensioning and tolerancing and no specific subject or paragraph(s) within the standard are invoked.

(b) When a referenced standard is cited in the text with limitations to a specific subject or paragraph(s) of the standard, only the paragraph(s) on that subject is invoked. For example, "assign part or identifying numbers in accordance with ASME Y14.100" is only invoking the paragraph(s) on Part or Identifying Numbers because the subject of the standard is engineering drawing practices and part and identifying numbers is a specific subject within the standard.

(c) When a referenced standard is cited in the text without an invoking statement, such as "in accordance with," the standard is for guidance only. For example, "for gaging principles see ASME Y14.43" is only for guidance, and no portion of the standard is invoked.

1.2.4 Parentheses Following a Definition. When a definition is followed by a standard referenced in parentheses, the standard referenced in parentheses is the source for the definition.

1.2.5 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.

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

1.2.7 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.

1.2.8 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.

1.2.9 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	Orthographic and Pictorial Views
ASME Y14.5	Dimensioning and Tolerancing
ASME Y14.24	Types and Applications of Engineering Drawings
ASME Y14.34	Associated Lists
ASME Y14.35M	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.

1.2.10 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 exception may be provided by another document or requirement.

1.3 Symbols for Surface Texture and Welding

Symbols for surface texture, welds, and other requirements shall reflect their respective standards. See Fig. C-5-1.

2 REFERENCES

The following revisions of American National Standards form a part of this Standard to the extent specified herein except when a different revision is specified in the text. When no specific date is noted in the text, the following revisions apply but 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 Y14.1M-2005, Metric Drawing Sheet Size and Format
ASME Y14.1-2005, Drawing Sheet Size and Format
ASME Y14.2-2008, Line Conventions and Lettering
ASME Y14.5-2009, Dimensioning and Tolerancing
ASME Y14.6-2001, Screw Thread Representation
ASME Y14.8-2009, Castings and Forgings
ASME Y14.41-2012, Digital Product Definition Data Practices

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

ISO 128-30, Technical drawings — General principles of presentation — Part 30: Basic conventions for views.

Publisher: International Organization for Standardization (ISO) Central Secretariat 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Genève 20, Switzerland/Suisse (www.iso.org)

3 TERMS AND DEFINITIONS

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

3.1 Adjacent Views

adjacent views: two adjoining orthographic views aligned by projectors.

3.2 Constructed View

constructed view: a view that is created by hand or with computer software without being dependent on a model.

3.3 Design Model

design model: the portion of the data set that contains model geometry and supplemental geometry (see ASME Y14.41).

3.4 Drawing View

drawing view: orthographic or pictorial views shown on a drawing graphic sheet. A drawing view may be constructed or it may be a saved view generated from a model.

3.5 Model

model: a combination of design model, annotation, and attributes that describes a product (see ASME Y14.41).

3.6 Projector

projector: a line either theoretical or real, extending between a point on an object to a viewing plane or extending between points on adjacent views.

3.7 Related Views

related views: two views that are adjacent to the same intermediate view.

3.8 Saved View

saved view: a stored and retrievable specific orientation and a magnification factor of a model or design model and may be a view within a model or a view generated from the model and placed in a drawing graphic sheet.

3.9 Section View

section view: a view where material is removed to show internal features.

3.10 Supplemental Geometry

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

3.11 True Geometry View

true geometry view: a view that shows the actual shape description whether parallel or not parallel to the viewing plane; when it is a *section view*, it shows the actual shape cut by the cutting plane and background features.

3.12 True Shape View

true shape view: when the viewed shape is parallel to the viewing plane.

4 PICTORIAL VIEW CREATION

This Section provides requirements for pictorial views used in a drawing graphic sheet when those views are constructed or generated from the models or design models defined by ASME Y14.41. Alternatively, pictorial view requirements are explained in terms related to drawing (view construction) practices such as projection lines and viewing planes. Unless otherwise specified, the resulting view requirements apply equally to constructed views and views generated from models and design models.

4.1 Pictorial Views

A pictorial view is the figure outlined upon the viewing plane by lines of projection extending from an object when that object may be at angles other than parallel to the viewing plane. The projection lines may be perpendicular to the viewing plane, or may, as in the case of perspective views, emanate from a viewing point. Constructed pictorial views generally do not show the true shape of all features.

A pictorial view is created using one of the projection systems specifically delineated in this Standard. This includes the selection of the method of projection and the appropriate specification of parameters to link to an associated CAD model to enable reproduction of the view when requested.

Pictorial view requirements contained in this Standard apply equally to constructed views and saved views in drawing graphic sheets unless exception is stated. See para. 4.2.4. In general, constructed views include the use of drawing conventions that may not be true geometry. Conversely, saved views generally contain true shape and true size geometry.

4.2 Types of Pictorial Views

There are three basic types of pictorial views: axonometric, oblique, and perspective. These three differ in the fundamental system of projection, that is, the spatial relationship between the object, the point of sight, the plane of projection, and the projectors or lines of sight, which create the pictorial view on the plane. Figure 4-1 shows the projection of each type of pictorial view: axonometric in illustration (a), oblique in illustration (b), and perspective in illustration (c). These examples are third angle projections in that the plane of projection is placed between the object and the observer. The views depict width, height, and depth. Figure 4-1 also shows a front view in each case for comparison, and illustrates that the axonometric projection is a special case of orthographic projection.

4.2.1 Axonometric Projection. An axonometric projection is one in which the projectors are perpendicular to the plane of projection and parallel to each other. The principle surfaces and edges of a cube or other rectangular object are all inclined to the plane of projection. The angles between the principle edges or axes of the object shall not measure 90 deg on the viewing plane. The relationship between the three angles shall be such that the apparent mutual perpendicularity of the axes on the object is maintained. See Figs. 4-2 through 4-5. The view direction should be one that gives the most information about the object unless other considerations, such as natural position or relation to other objects, take precedence. It should be noted that an axonometric projection can be obtained by constructing a secondary auxiliary view in which the desired line of sight appears as a point, or by revolving the object into the desired position and drawing a front view or other principal view. Axonometric projection methods are divided into isometric, dimetric, and trimetric projections.

4.2.1.1 Isometric Projection. An isometric projection is an axonometric projection in which the three axes of the object make equal angles with the plane of projection. Taken two at a time, the three axes make three equal angles of 120 deg on the view (see Fig. 4-2). Linear dimensions along or parallel to any one of the three axes are to scale in the viewing plane. Linear dimensions, not along or parallel to an axis, and angular dimensions are not to scale in the viewing plane and cannot be directly measured in the viewing plane. Height is measured vertically in Fig. 4-2. Typical orientation of an isometric view places two of the axes at 30-deg angles with the horizontal.

4.2.1.2 Dimetric Projection. A dimetric projection is an axonometric projection in which two axes of the object make equal angles with the plane of projection and the third axis makes a different angle with the plane of projection. Two of the angles between the axes are equal; the third angle is unequal. See Fig. 4-3. A dimetric view may be constructed by orienting the object relative to the viewing plane such that one scale is used along or parallel to the two equally inclined axes and a different scale along or parallel to the third axis. Linear dimensions, not along or parallel to an axis, and angular dimensions are not to scale in the viewing plane and cannot be directly measured in the viewing plane. Height is measured vertically in Fig. 4-3. Width and depth are measured at 15-deg angles with the horizontal. These two equal angles shall be greater than 0 deg and less than 45 deg, but not equal to 30 deg because 30 deg is a special case used for isometric views. Other positions of the axes may be used provided the proper angles between the axes are maintained.

4.2.1.3 Trimetric Projection. A trimetric projection is an axonometric projection in which all three axes of the object make unequal angles with the plane of projection. The axes make three different angles with each other in the view. See Fig. 4-4. A trimetric view may be constructed by using three different scales along or parallel to the three axes in the viewing plane. Linear dimensions, not along or parallel to an axis, and angular dimensions are not to scale and cannot be directly measured in the viewing plane. Height is measured vertically in Fig. 4-4. Width is measured at 15 deg with the horizontal. Depth is measured at 30 deg with the horizontal. These two unequal angles shall each be greater than 0 deg and their sum shall be less than 90 deg. Other positions of the axes may be used, provided the proper angles between the axes are maintained relative to the true geometry.

4.2.1.4 Choice of Axonometric Axes. Axes orientation should be chosen so as to provide as accurate a description of the object as possible. The appearance of distortion on a large flat surface may be decreased by increasing the angle which that surface makes with the plane of projection. The true outline of a more important surface may be shown more clearly by decreasing the angle which that surface makes with the plane. In Fig. 4-5, illustration (a) would be preferable to illustration (b) when the horizontal features are to be shown with less foreshortening. Illustration (b) would be preferable to illustration (a) when more detail is to be shown on the vertical features.

4.2.2 Oblique Projection. An oblique projection is one in which parallel projectors, or lines of sight, make an angle other than 90 deg with the plane of projection. Oblique views are typically constructed, but the following requirements for the resulting view would apply equally to any generated oblique view unless otherwise specified. A common practice is to position a principal surface of the object parallel to the plane of projection so that it and surfaces parallel to it show their true shape. Two of the principal edges or axes of the object are parallel to the plane of projection and make a 90-deg angle in the view. The receding axis may extend in any direction in the view not parallel to or at right angles with either one of the first two. See Figs. 4-6 and 4-7. Oblique projections are divided into cavalier, cabinet, and general oblique projections. They differ only in the comparative scales of the two frontal axes and the receding axis.

4.2.2.1 Cavalier Oblique Projection. A cavalier projection is an oblique projection on which the projectors are at an angle greater than 0 deg and less than 90 deg with the plane of projection. See Fig. 4-6, illustration (a) and Fig. 4-7, illustration (a). A cavalier view is constructed by measuring dimensions along or parallel to any one of the three axes full size or to the same scale. Other linear dimensions parallel to the plane of projection are also measured full size or to scale. An angular dimension in a surface parallel to the plane is measured full size. Other linear and angular dimensions are not to scale and are not used. Height and width are measured vertically and horizontally in Fig. 4-6, illustration (a). Depth is measured parallel to the receding axis. The depth angle shall be greater than 0 deg and less than 90 deg. Other positions of the axes may be used provided the proper angles between the axes are maintained.

4.2.2.2 Cabinet Oblique Projection. A cabinet projection is an oblique projection in which the projectors make an angle with the plane of projection, which reduces distance along or parallel to the receding axis to one half of that for cavalier projection. See Fig. 4-6, illustration (b). A cabinet view is constructed by using a scale for the receding axis that is one-half the scale for the other two axes. Other dimensions are measured in the same manner as on the cavalier view. Width and height are measured horizontally and vertically in Fig. 4-6, illustration (b). Depth is measured parallel to the receding axis. The depth angle shall be greater than 0 deg and less than 90 deg. Other positions of the axes may be used, provided the proper angles between the axes are maintained.

4.2.2.3 General Oblique Projection. A general oblique projection has a different receding axis scale than a cavalier or cabinet oblique projection. The scale for the receding axis cannot equal one-half the scale for the other two axes and cannot be equal to them. See Fig. 4-7, illustration (b).

4.2.2.4 Choice of Type of Oblique Projection. The appearance of distortion in an oblique view may be decreased by reducing the scale on the receding axis. Oblique views are commonly used for objects which have a series of circles, curves, or irregular outlines in the same or parallel plane surfaces. The object is positioned with these planes parallel to the plane of projection so that the circles and outlines project in true shape. Cylindrical and conical objects should usually be drawn with their major axis (center line) on the receding axis to reduce distortion and facilitate documentation. See Fig. 4-7.

4.2.3 Perspective Projection. A perspective projection is one in which the projectors are not parallel and converge from points on the object to the point of sight located at a finite distance from the plane of projection. Any set of parallel edges or lines on the object converge, when extended, to a single vanishing point. Perspective views are divided into one-point, two-point, and three-point projections.

4.2.3.1 One-Point Perspective Projection. A one-point perspective projection is one in which the object is positioned with two of the principle axes of the object parallel to the plane of projection. The third axis is perpendicular to the plane. Width and height are shown horizontally and vertically in Fig. 4-8. Horizontal edges or lines that are parallel to the depth axis converge, when extended, to one vanishing point on the view horizon.

4.2.3.2 Two-Point Perspective Projection. A two-point perspective projection is one in which the object is positioned with one of the principle axes (usually the vertical axis) parallel to the plane of projection. The other two axes are inclined to the plane. Height is shown vertically in Fig. 4-9. Horizontal edges or lines which are parallel to the depth axis converge, when extended, to one vanishing point on the view horizon. Horizontal edges or lines which are parallel to the width axis converge, when extended, to a second vanishing point on the view horizon.

4.2.3.3 Three-Point Perspective Projection. A three-point perspective projection is one in which the object is positioned with all three of the principle axes inclined to the plane of projection. See Fig. 4-10. Each set of edges or lines parallel to an axis converges, when extended, to one of three vanishing points for the view.

4.2.3.4 Location of Plane of Projection and Point of Sight. A common practice associated with constructed views is to locate the plane of projection to pass through the front face of a rectangular object in a one-point perspective, the front edge of the object in a two-point perspective, and the front corner of the object in a three-point perspective. Dimensions within the plane of projection may then be measured full size or to scale. The point of sight should be located so that the cone of projectors, which has its apex at the point of sight and includes the whole object, has an angle at the apex not greater than 30 deg. See Fig. 4-11. A larger angle adds to distortion in the perspective view. Best results are obtained when the point of sight is located centrally in front of the object and is high enough to show the top surfaces of the object.

4.2.4 Pictorial Views Generated From Models or Design Models. Pictorial views generated from models or design models are direct representations of the geometry. When supplemental geometry is included for any purpose as part of a model, the model geometry that represents the product shall be clearly delineated from any supplemental geometry. See ASME Y14.41. Any automatically generated view that meets the criteria for the types of pictorial views described in this Standard may be used.

4.3 Dimensioning and Tolerancing of Pictorial Views

Unless otherwise specified in the drawing graphic sheet or model, dimensions applied to pictorial views shall be in accordance with ASME Y14.5, ASME Y14.41, and other applicable ASME standards.

NOTE: Determination of relationships between pictorial views can be difficult to achieve and thus it shall be decided whether the application of dimensions in pictorial views provide the needed clarity. When in doubt, dimension orthographic views or interrogate the model to establish the dimensional requirements.

4.4 Shading of Pictorial Views and Line Widths

Pictorial views may be shaded to enhance viewing ease when shading does not negatively impact legibility. Lines of variable width may be used to improve the visualization quality of the view and vary the emphasis on individual details.

4.5 Pictorial View Coordinate System

There is no default requirement for a standard arrangement of pictorial views. The coordinate system showing model orientation shall be included in each axonometric view and may be shown in all pictorial view types. See Fig. 4-12.

Fig. 4-1 Kinds of Projection

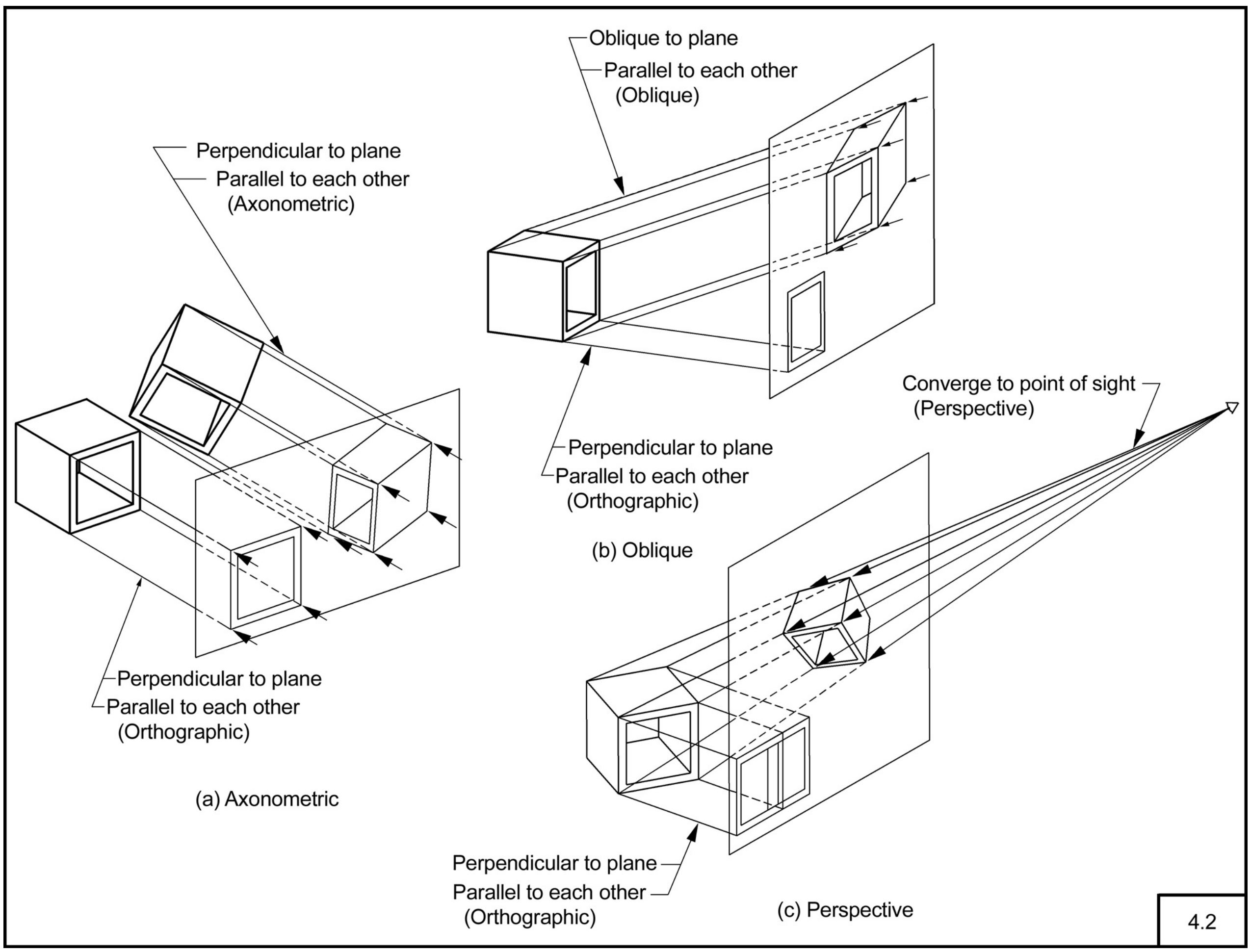


Fig. 4-2 Isometric Projection

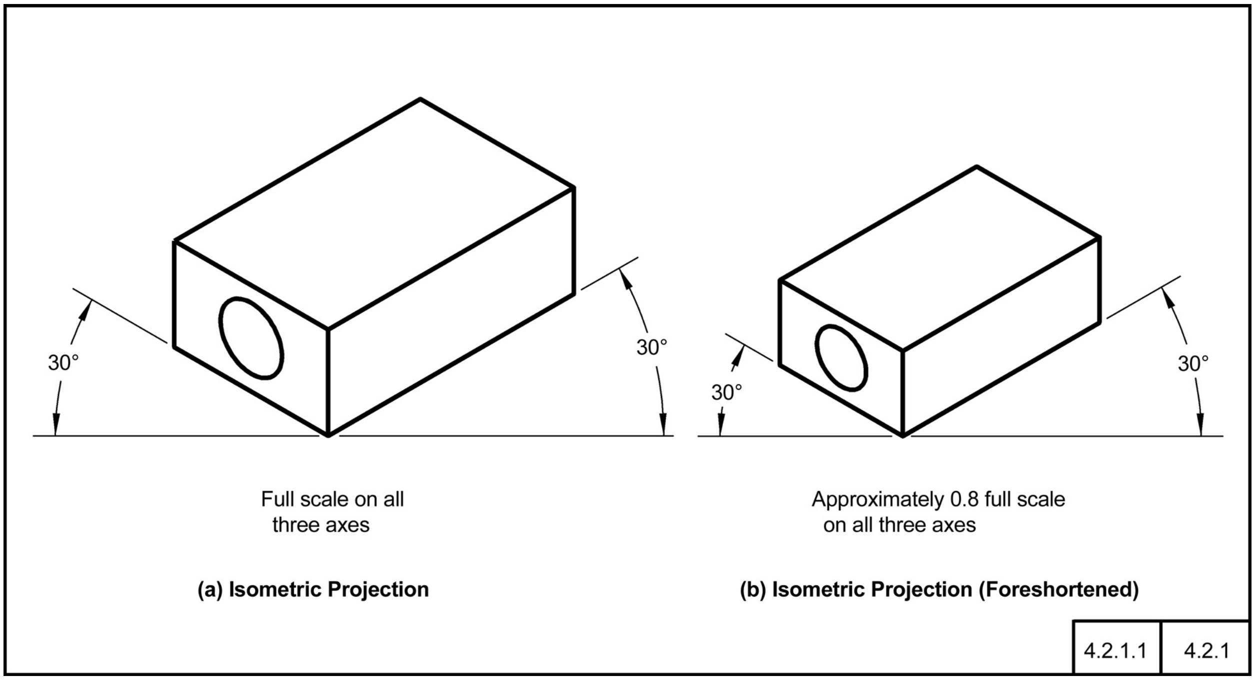


Fig. 4-3 Dimetric Projection

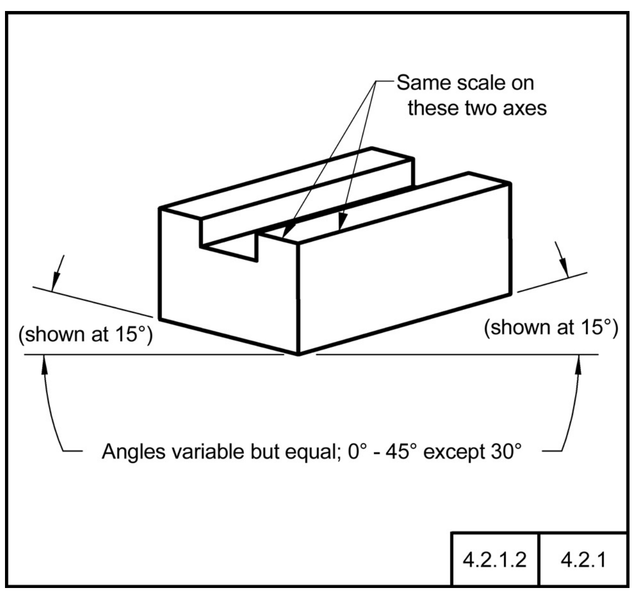


Fig. 4-4 Trimetric Projection

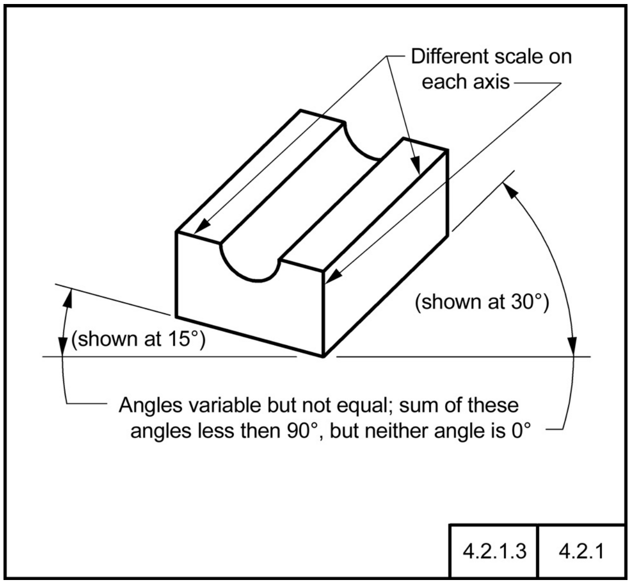
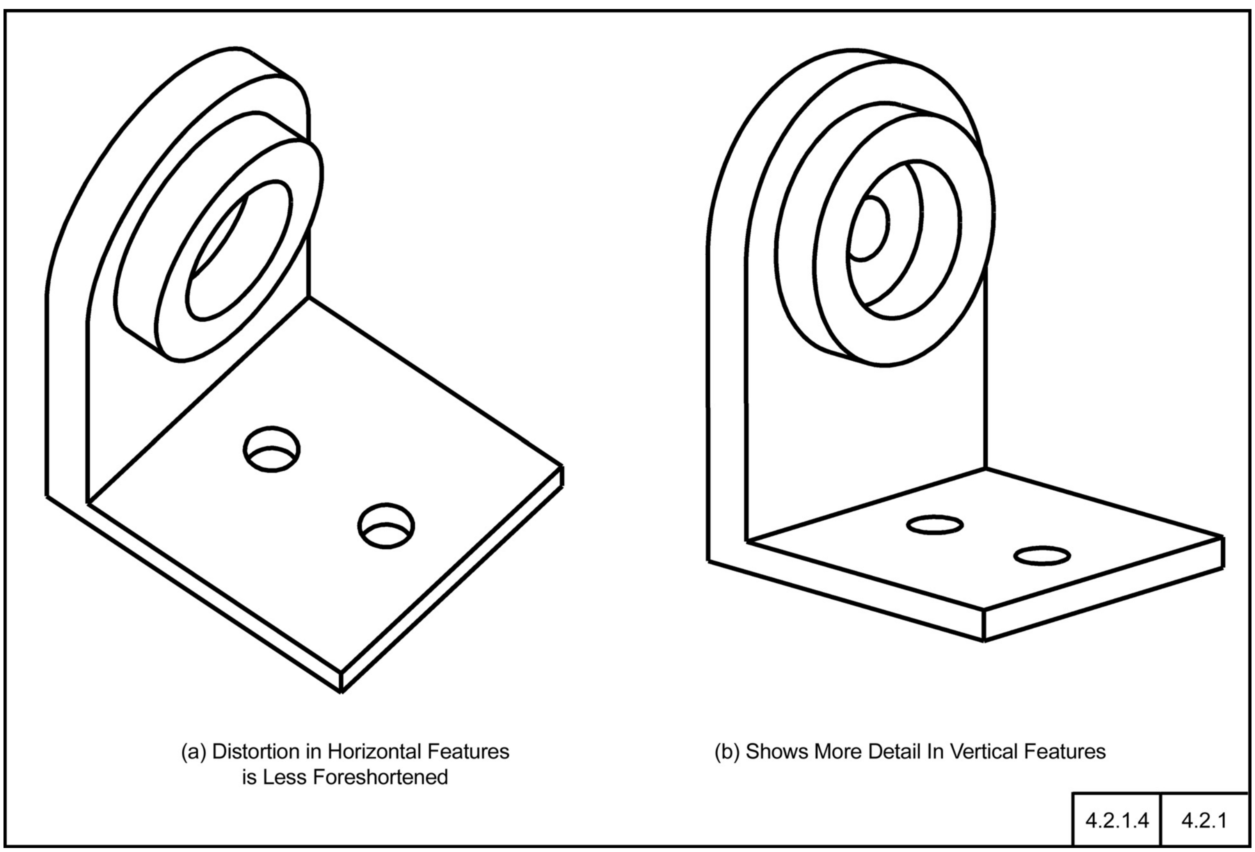


Fig. 4-5 Choice of Axonometric View



(a) Distortion in Horizontal Features is Less Foreshortened

(b) Shows More Detail In Vertical Features

Fig. 4-6 Oblique Projection

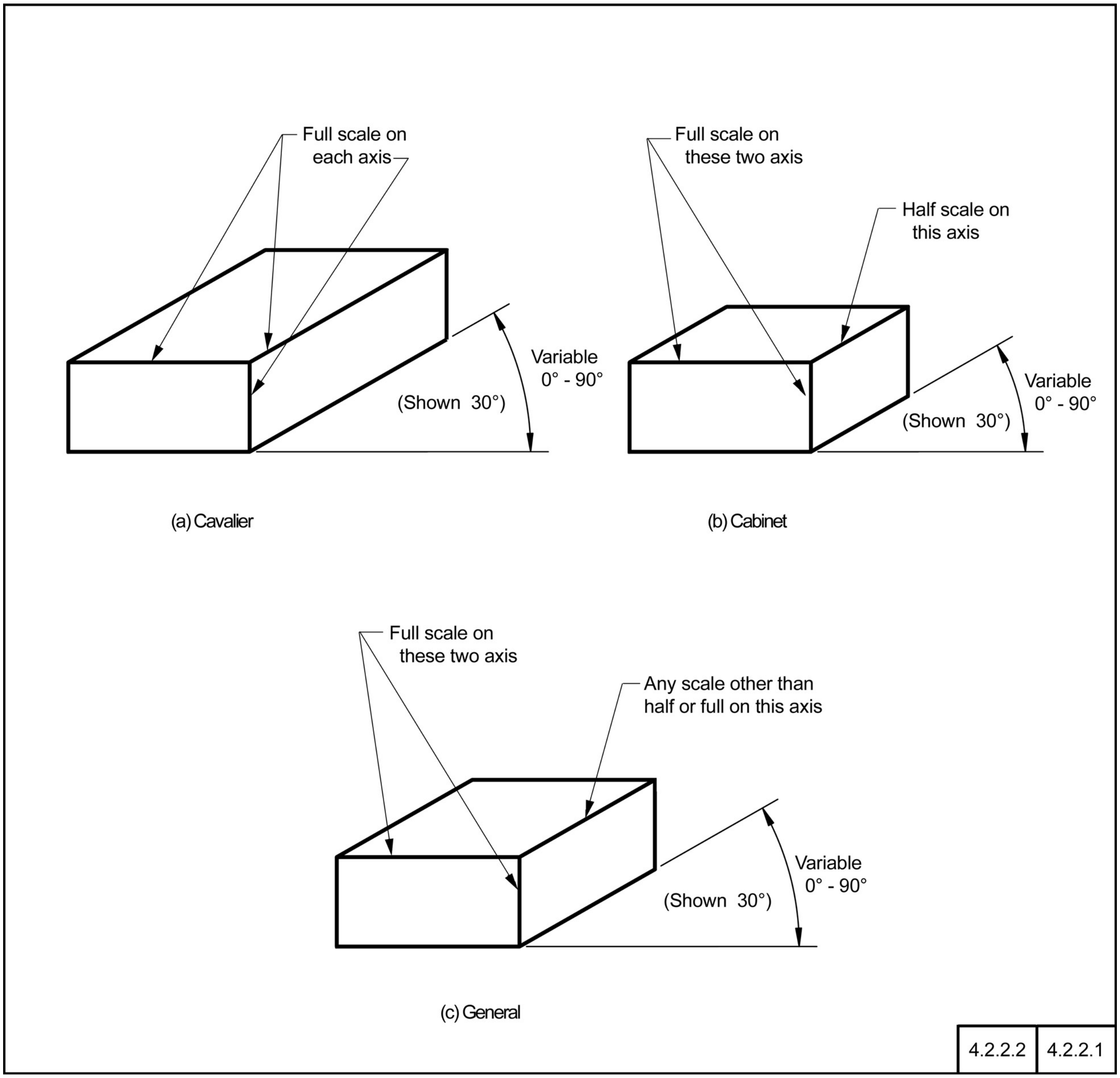


Fig. 4-7 Oblique Projections and Effect of Foreshortening

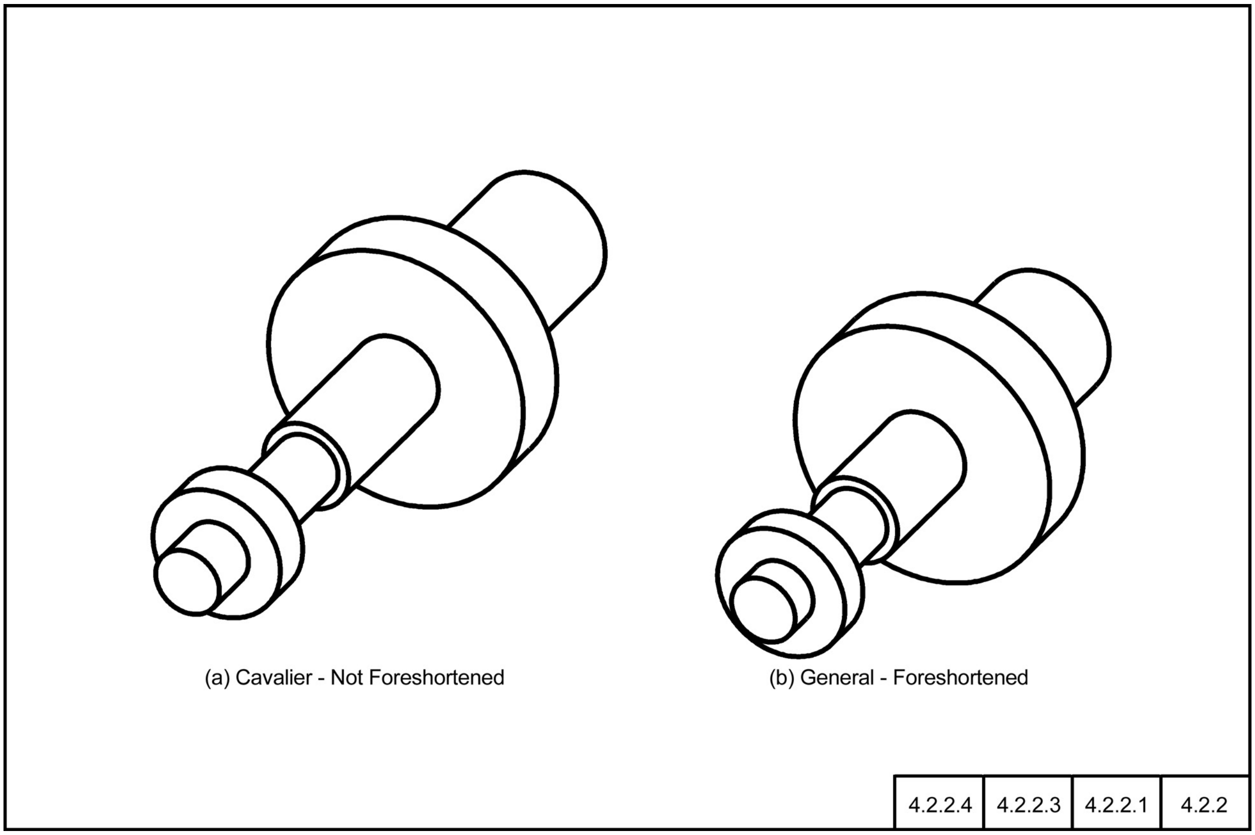


Fig. 4-8 One-Point Perspective

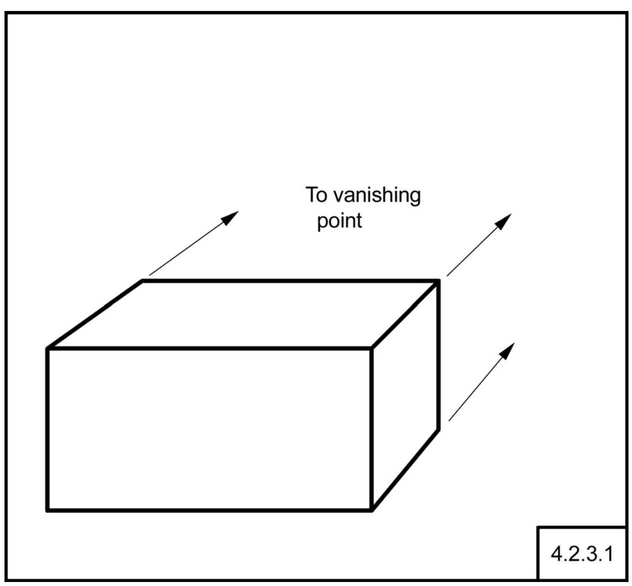


Fig. 4-9 Two-Point Perspective

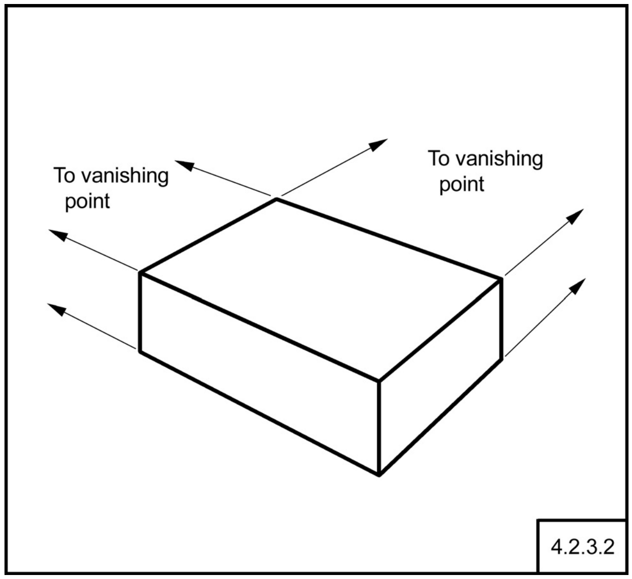


Fig. 4-10 Three-Point Perspective

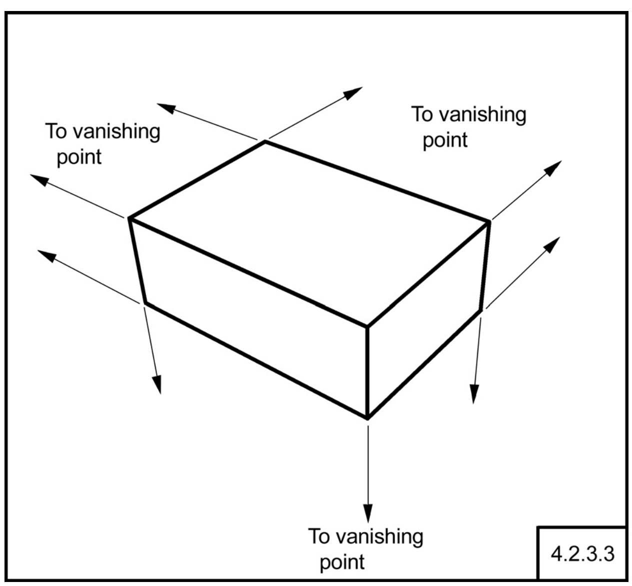


Fig. 4-11 Location of Point of Sight in Perspective

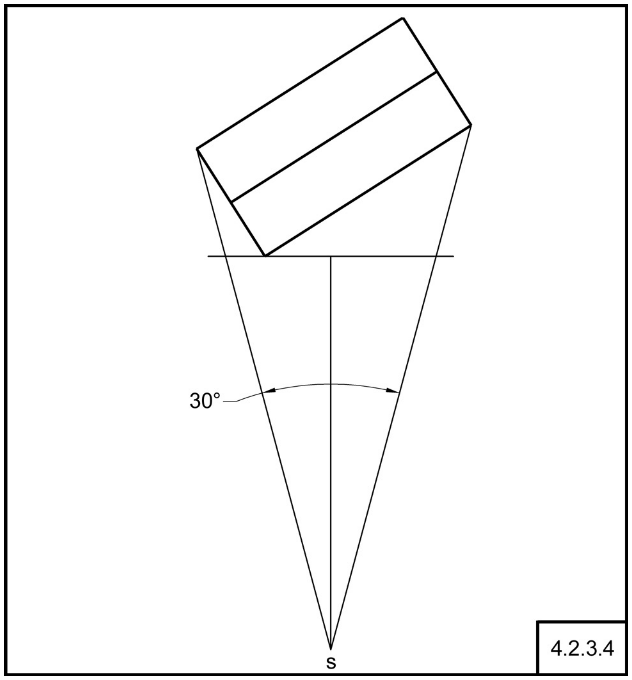
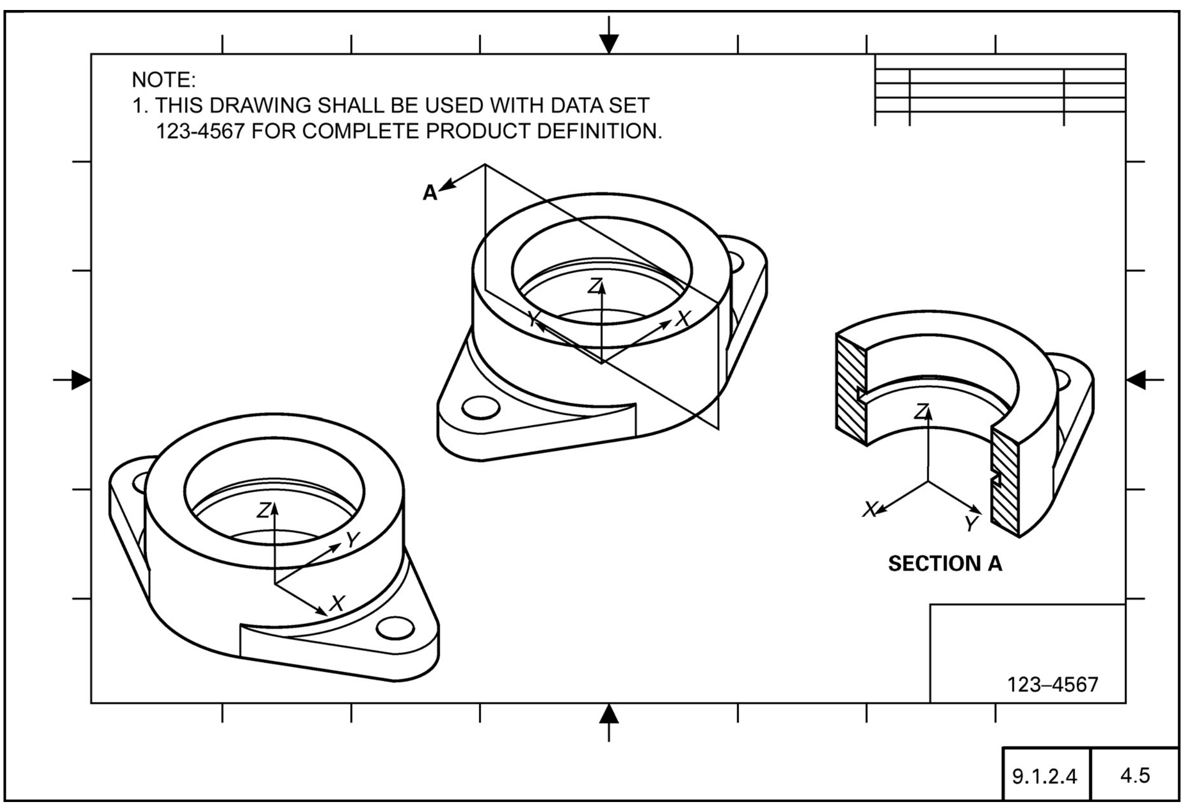


Fig. 4-12 Pictorial View Coordinate System



5 ORTHOGRAPHIC VIEW CREATION

5.1 Orthographic Projection

Orthographic projection is a system of drawing composed of images of an object formed by projectors from the object perpendicular to desired planes of projection.

5.2 Orthographic View

An orthographic view is the figure outlined upon the projection plane by means of the system of orthographic projection. Orthographic views may be constructed, or they may be saved views that are automatically generated from models or design models. Orthographic view requirements apply equally to constructed and automatically generated views unless exception is stated. Such a view shows the true shape view of a surface parallel to the projection plane (surface ABCD with hole in Fig. 5-1). When a surface is not parallel to the plane, the view of the surface will be foreshortened (surface BCEF in Fig. 5-1). Surfaces ABCD and BCEF are seen in an orthographic view that is a true geometry view.

5.3 Projection Systems

The two internationally recognized systems of projection are third-angle projection and first-angle projection. Unless otherwise stated, this Standard uses the third-angle projection system in its illustrations.

5.3.1 Third-Angle Projection. Third-angle projection is the formation of an image or view upon a plane of projection placed between the object and the observer. Third-angle projection is the accepted method used in the United States. See Fig. 5-2.

5.3.2 First-Angle Projection. First-angle projection places the object between the observer and the plane of projection. This method of projection used in some countries is herein described in consideration of the need to interchange engineering product definition in international commerce. See Fig. 5-3.

5.4 Orthographic View Relationships

Note that the orthographic views of the object have the same geometry in both the first- and third-angle projections, but the placement of the views with respect to one another is different. The visibility of lines is always taken from the observer's point of view. See Figs. 5-4 and 5-5.

5.4.1 Alternate Practice, Reference Arrow Method. When it is desired to achieve compliance with ISO practices, this Standard allows for an alternate practice reference arrows and view letters to be used for all views. These practices are in agreement with ISO 128-30. View identification for the reference arrow method does not include the word VIEW, and the identifying letter is placed above the view. Reference arrows may be shown with constructed or automatically generated pictorial views and orthographic views. When the reference arrow method is used, it shall be used for all views within the drawing. See Fig. 5-6. Reference arrow proportions are defined in Fig. 5-7, relative to the letter height of "other characters" as defined in ASME Y14.2. When modeling in 3D without drawing graphic sheets, the reference arrow method is not used on saved views.

5.5 Projection Symbols

The projection symbols shown in Figs. 5-2 through 5-5 are internationally recognized. They may be used in drawing graphic sheets to be interchanged internationally to identify the projection method used in preparing the document. See Fig. 5-8 for proportional sizes relative to the letter height of "other characters" as defined in ASME Y14.2 and allowable orientations.

Fig. 5-1 Orthographic Projections to Form Orthographic Views

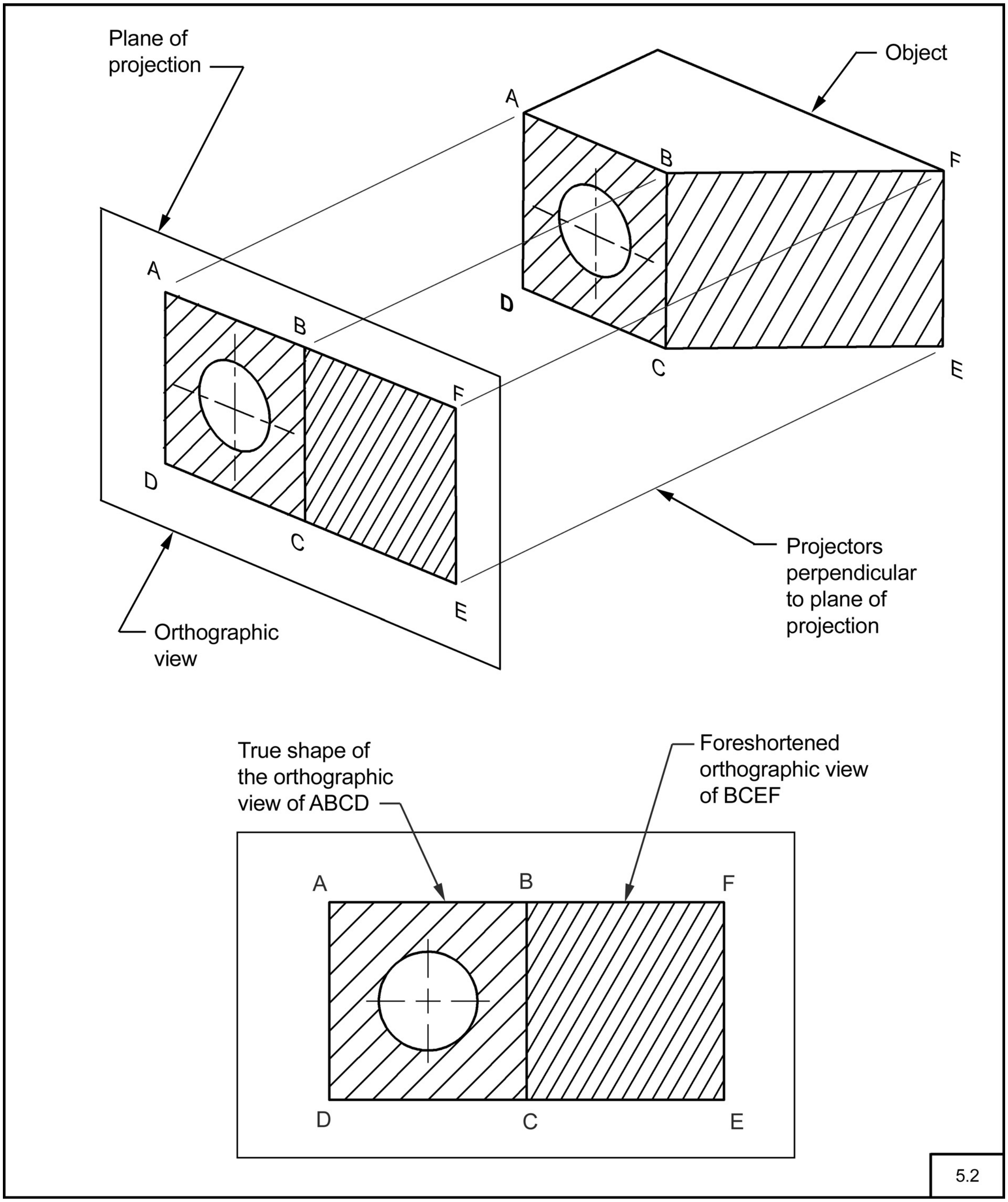


Fig. 5-2 Space and Orthographic Arrangement of Views (Third-Angle Projection)

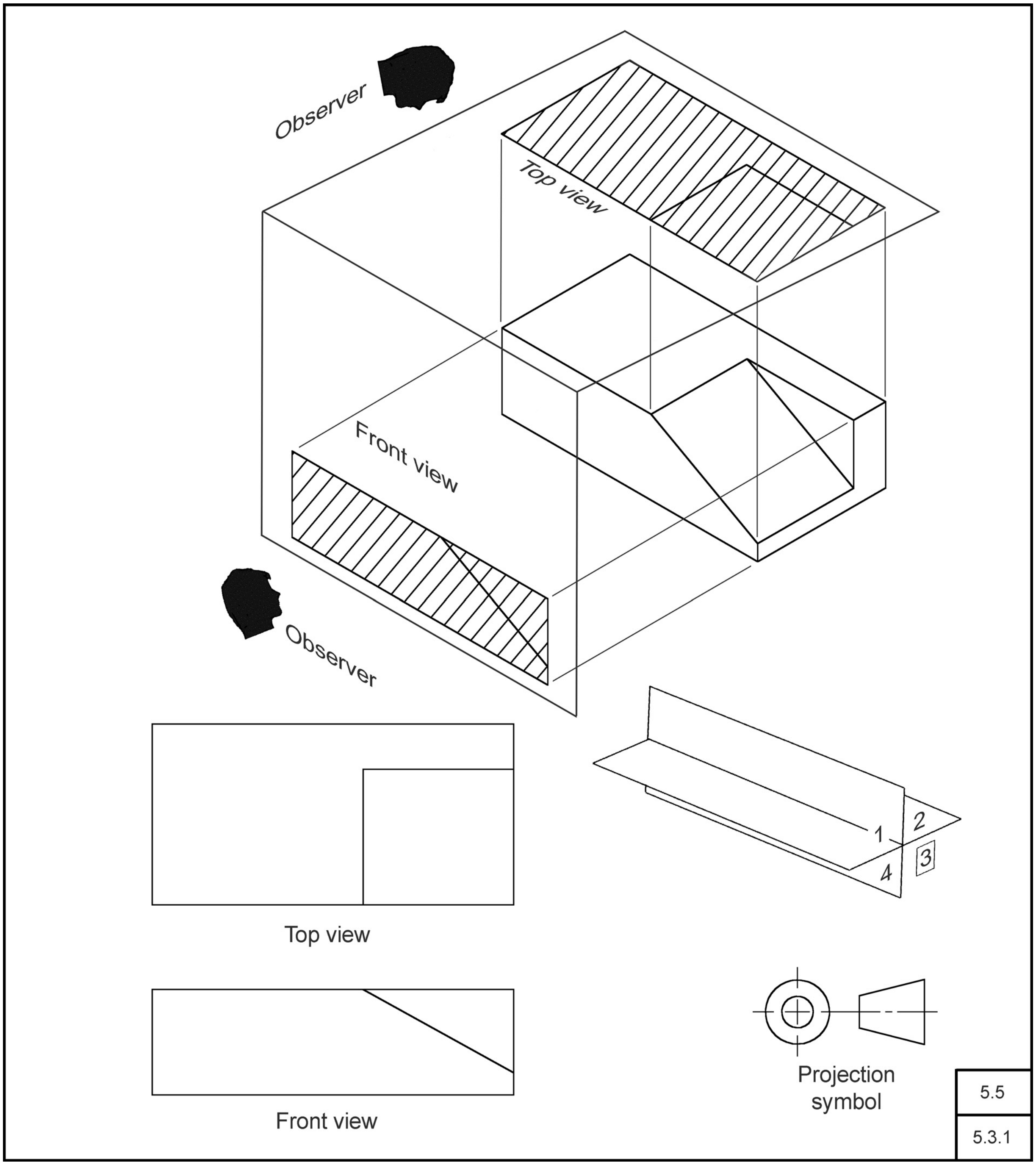


Fig. 5-3 Space and Orthographic Arrangement of Views (First-Angle Projection)

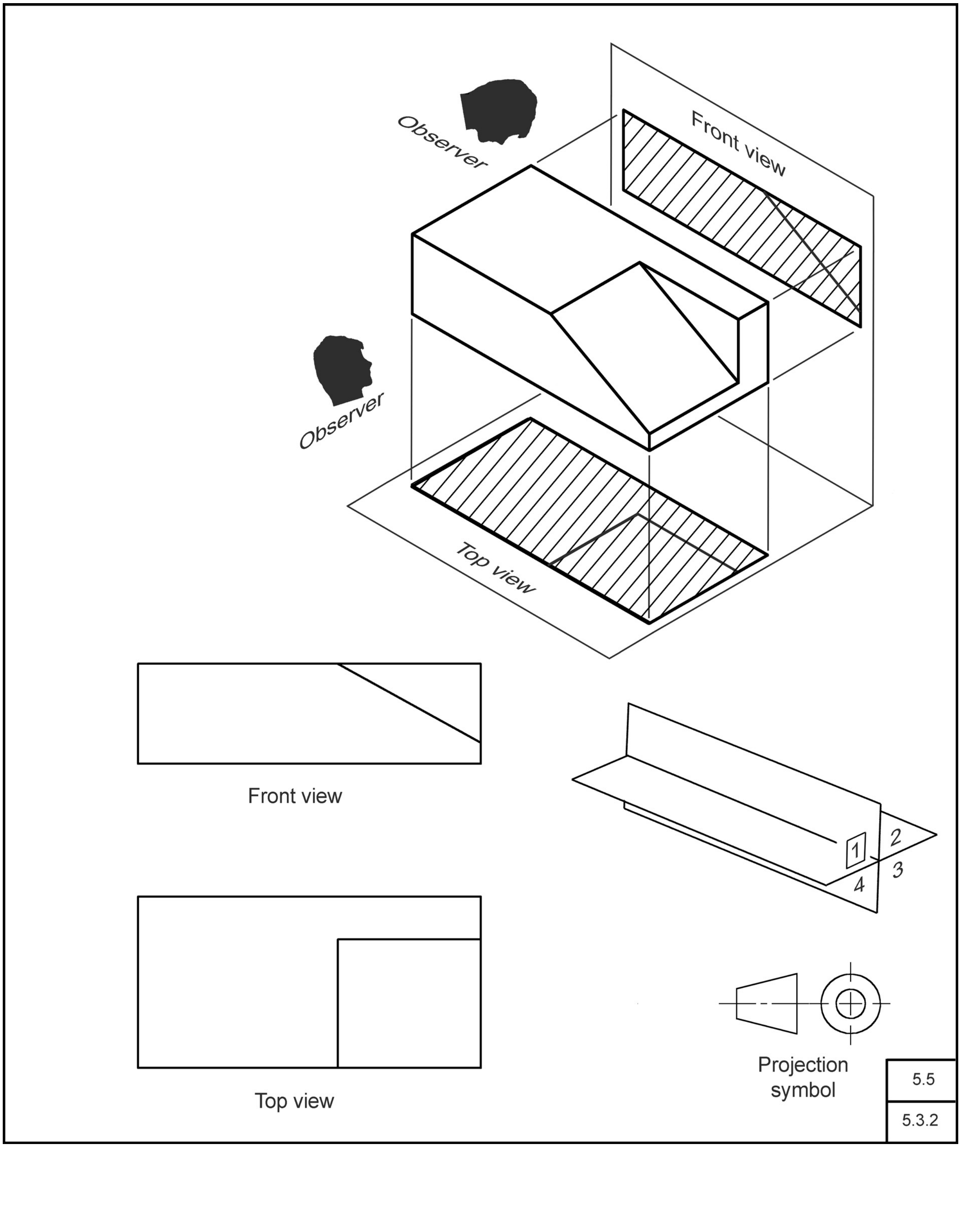


Fig. 5-4 Third-Angle Projection Standard Arrangement of the Six Principal Orthographic Views

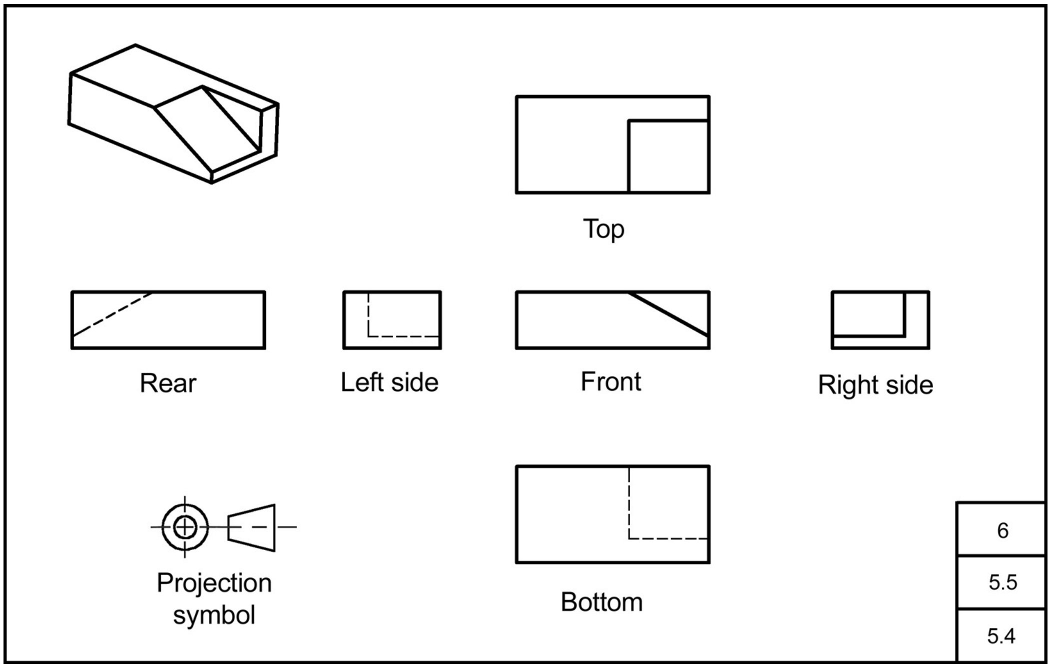


Fig. 5-5 First-Angle Projection Standard Arrangement of the Six Principal Orthographic Views

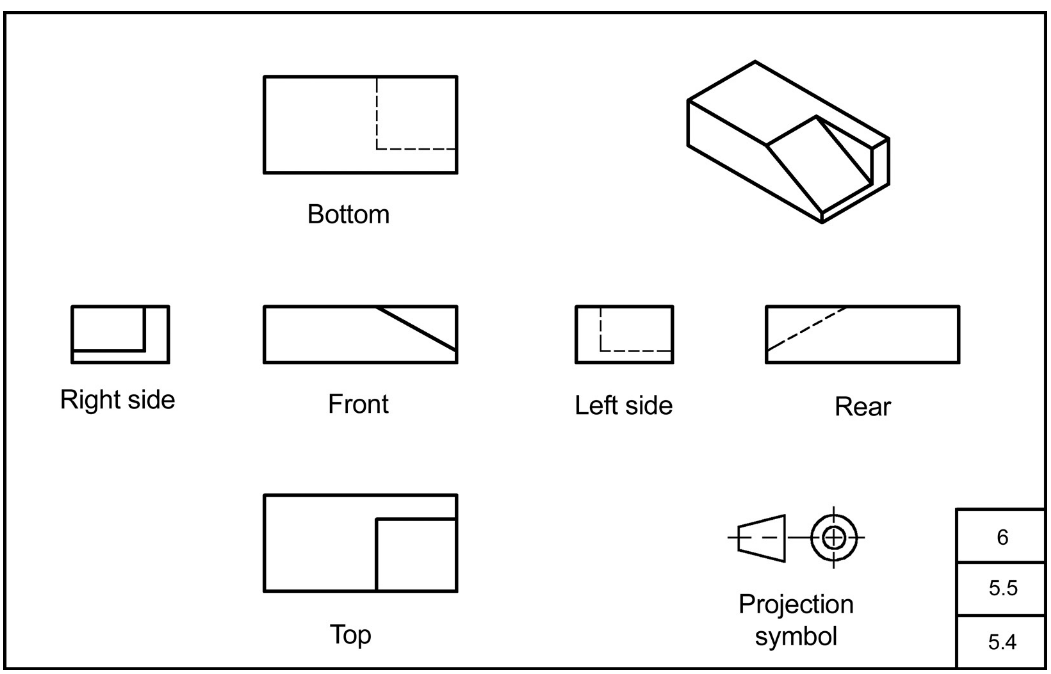


Fig. 5-6 Arrow Method — Principal Views

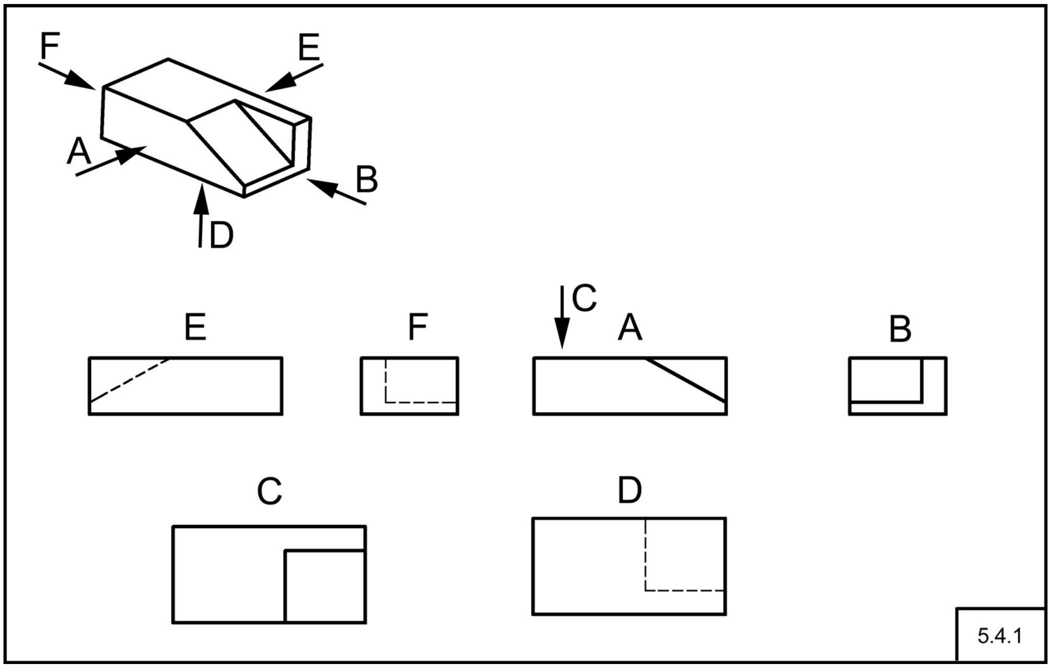


Fig. 5-7 Arrow Proportions

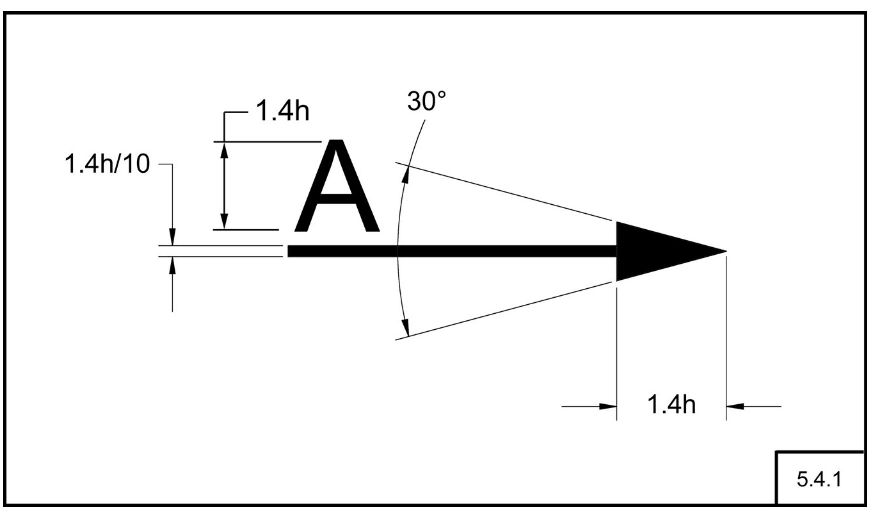
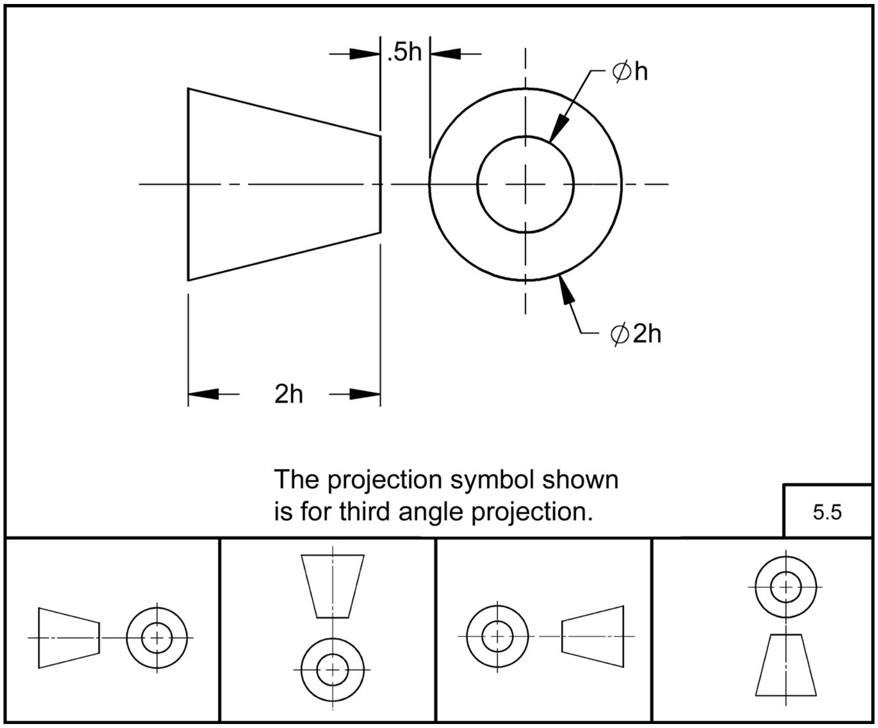
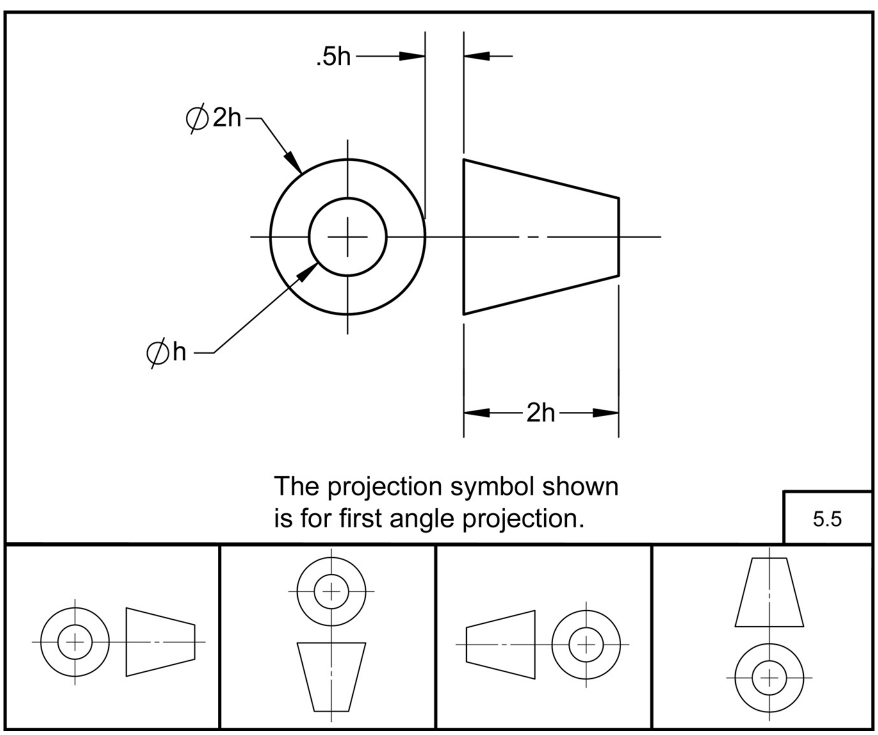


Fig. 5-8 Projection Symbol





6 PRINCIPAL ORTHOGRAPHIC VIEWS

There are six principal orthographic views, commonly referred to as: top, front, bottom, right side, left side, and rear. The standard arrangement of all principal views in third-angle orthographic projection is shown in Fig. 5-4. The standard arrangement of all principal views in first-angle projection is shown in Fig. 5-5. The terms "top," "front," "bottom," "right side," "left side," and "rear" shall themselves not be used for naming views.

6.1 Placement and Orientation of Views

The standard arrangement of orthographic views or alternate positions may be used to conserve space. Orthographic views, unless removed as described below, shall be properly oriented to one another based on orthographic projection and whether first- or third-angle projection is used. For example, right- or left-side view might be placed adjacent to and in alignment with the top view. The rear view is sometimes placed in alignment with and to the right of the right-side view. The coordinate system may be used to indicate view orientation, and to establish the relationships between views. When complex features need to be related in the drawing, and pictorial views are inadequate, orthographic views, saved views in the model, or a design model shall be used.

6.2 Removed Orthographic Views

Under certain conditions, it may be impractical to place an orthographic view in its normal aligned position in a drawing graphic sheet. In this instance, viewing indicators are used to indicate from where the view was taken, and the view is removed to another location on the field of the drawing graphic sheet. See Fig. 6-1. Removed views are preferably shown on the same sheet from where the view is taken. The removed view is identified using the view letters. The removed view may be drawn at the same scale as the view from which it is taken, or it may be drawn at a noted scale. It is also permissible to use a combination of numbers and letters for removed view identification as explained in paras. 6.3 and 6.3.1.

When the views are generated from a model or design model based on ASME Y14.41 and there are exceptions in that standard to the principles addressed in this Standard, requirements from ASME Y14.41 take precedence. Among the requirements in ASME Y14.41 is the specification that a coordinate system may be used to indicate view orientation for orthographic views.

6.3 Identifying Removed Orthographic Views

To relate the viewing plane or cutting plane to its removed orthographic view, uppercase letters such as A, B, C, etc., are placed near each arrowhead. The corresponding removed views are identified as VIEW A-A, VIEW B-B, VIEW C-C, etc. When using conventional practice, the view identification shall appear below the view.

When using view letters, they should be used in alphabetical order, and the letters I, O, Q, S, X, and Z shall not be used. When the alphabet is exhausted, additional views shall be identified by double letters in alphabetical order, as in AA-AA, AB-AB, AC-AC, etc. Only one set of alpha characters shall be used per drawing for naming views of all types without repeating the same letters on more than one view. Example, for a drawing consisting of three named views of either the same or different types (a section view, a removed view, and a detail view) the views would be named SECTION A-A, VIEW B-B, and DETAIL C. See para. 9.2 for view identification in saved views.

6.3.1 Removed Orthographic Views Alternate Practice. When using the reference arrow method, a single reference arrow and identifier are used. See Fig. 6-2.

6.4 Rotated Orthographic Views

Due to the large size of depicted items and limitations on the height or width of the drawing graphic sheet-format, an orthographic view may be rotated within the boundaries of a drawing graphic sheet rather than maintain the orientation and split the view over two or more sheets. The angle expressed in degrees and direction of rotation shall be placed beneath the view title. See Fig. 6-3.

6.4.1 Rotated Orthographic Views Alternate Practice. When using the reference arrow method, the direction of rotation is indicated by an arc and arrow. The angle of rotation in degrees is noted adjacent to the arc. See Fig. 6-4. Arc and arrow proportions are shown in Fig. 6-5. The view letter is placed to the left, and the angle expressed in degrees is placed to the right of the arc. Character sizes are in accordance with ASME Y14.2.

6.5 Cross-Referencing of Views

Cross-reference zoning may be used to indicate the location of an indicated view, and to reference a view back to the viewing location. When views are located on different sheets, the sheet number as well as the zone of the cross-reference location shall be indicated. See Fig. 6-6. One method of cross-referencing is shown in the figure. Other methods of cross-referencing may be used. View identification letters shall not be repeated on more than one view. Only one set of alpha characters shall be used per drawing for naming views of all types without repeating the same letters on more than one view. For example, for a drawing consisting of three named views of either the same or different types (a section view, a removed view, and a detail view) the views would be named SECTION A-A, VIEW B-B, and DETAIL C.

Fig. 6-1 Removed View

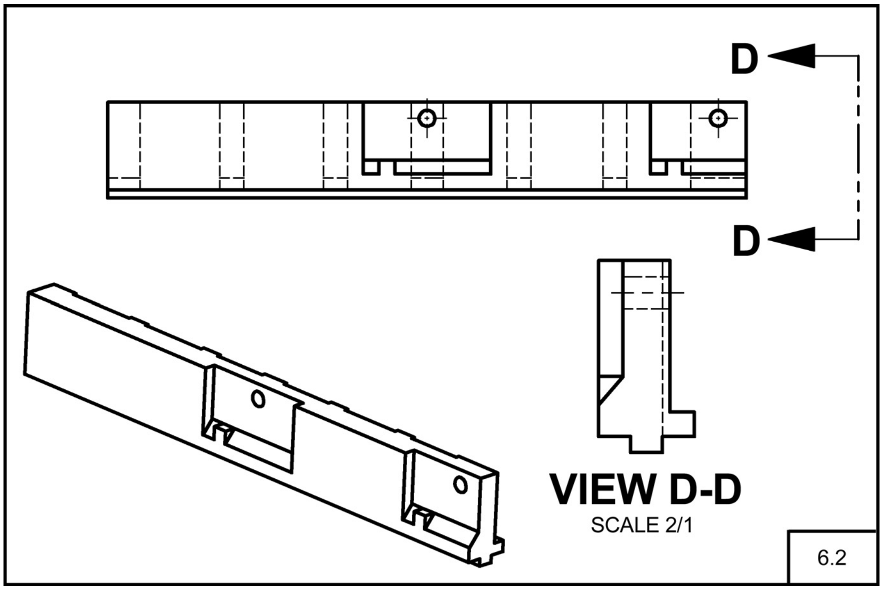


Fig. 6-2 Arrow Method — Removed View

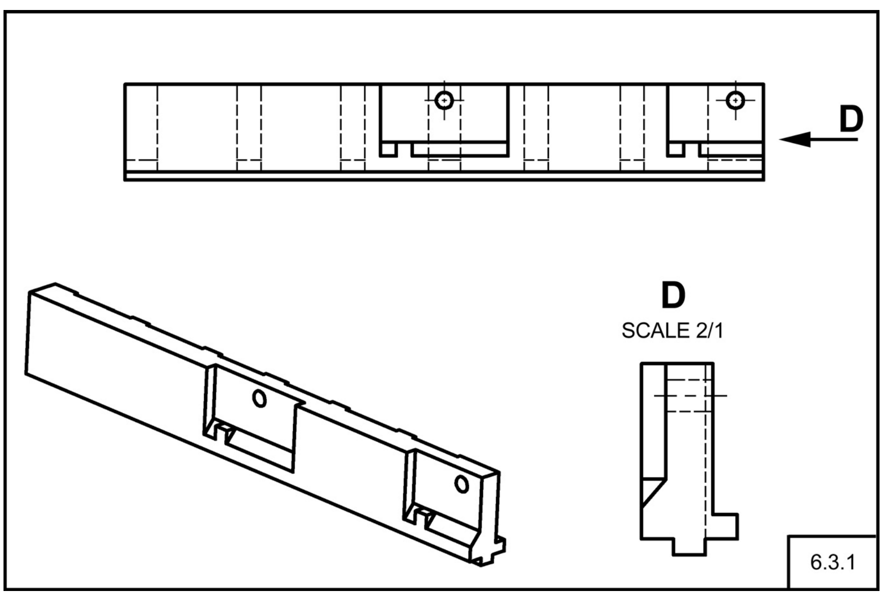


Fig. 6-3 Rotated View

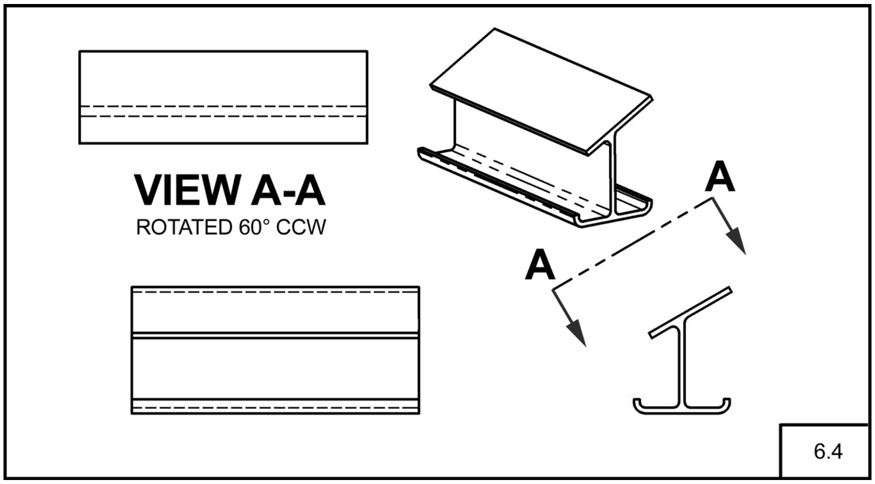


Fig. 6-4 Arrow Method — Rotated View

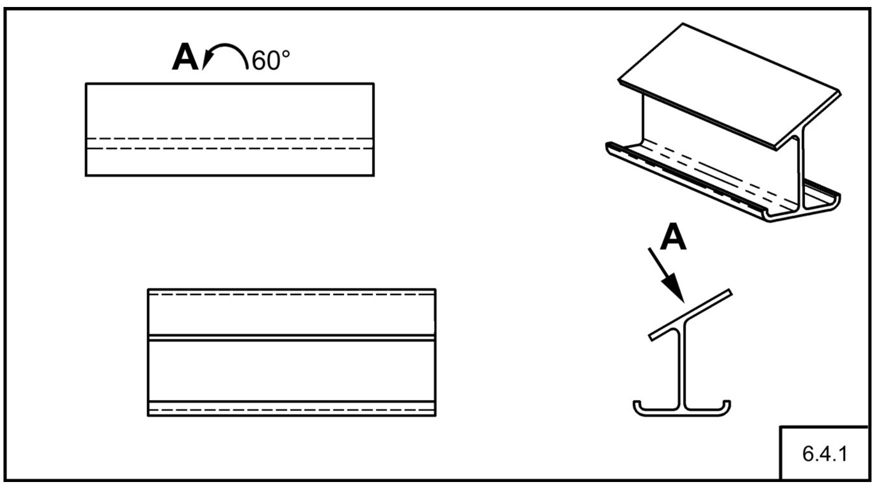


Fig. 6-5 Rotation Arrow

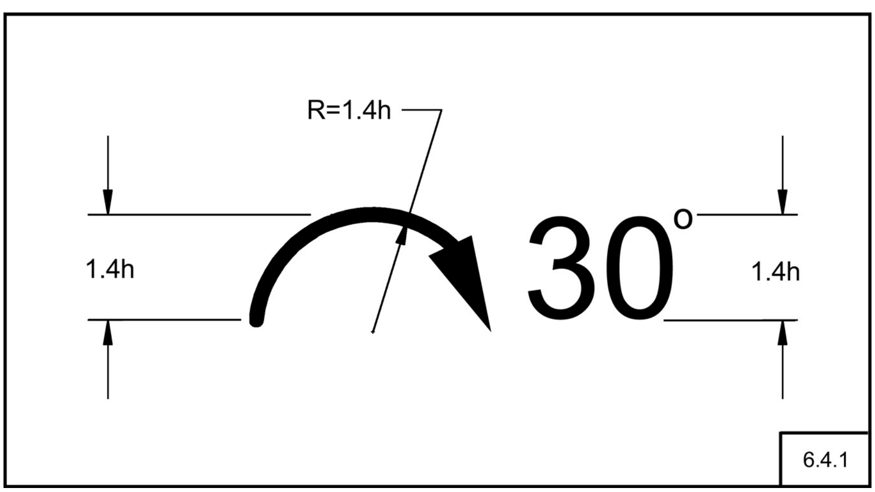
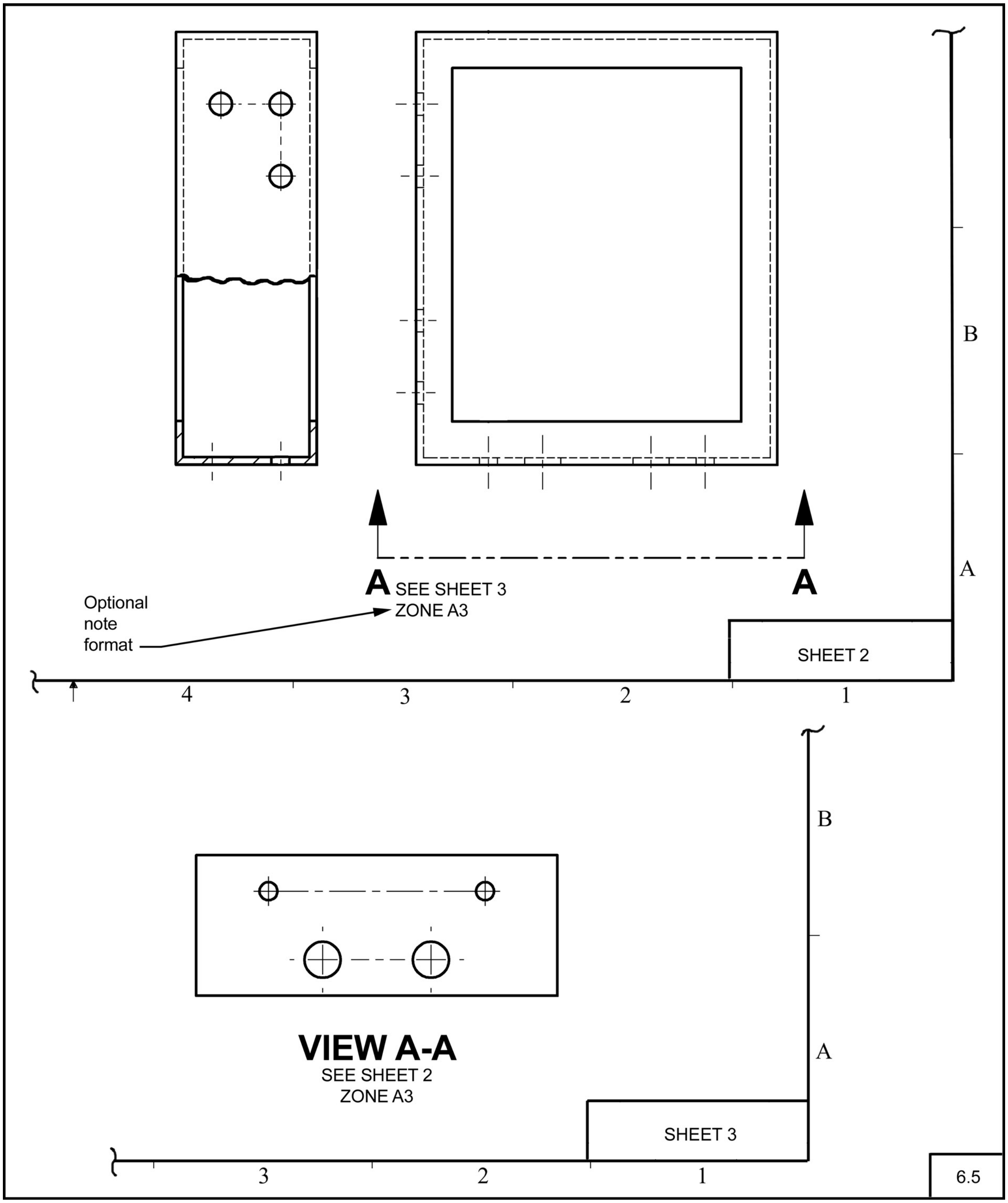


Fig. 6-6 Removed View When Multiple Drawing Graphic Sheets Are Used



7 DRAWINGS WITH ORTHOGRAPHIC VIEWS

7.1 Purpose of Drawings With Orthographic Views

Orthographic multiview drawings represent the shape of an object using two or more orthographic views. These views, together with necessary notes and dimensions, are sufficient for the part to be fabricated without further information concerning its shape. Consideration should be given to the choice and number of views that will completely define the true shape of the part.

7.2 Choice of Orthographic Views

The front or primary view of the part is generally shown in a natural or assembled position. The minimum number of views necessary to describe the part is shown. Views are selected to show the fewest hidden lines and yet convey maximum clarity.

7.3 Necessary Views

The number of views required to describe a part is controlled by the complexity of the part. Simple parts may require only a short word description. Others may require one or two views. Three or more views may be required for complete product definition and to permit dimensioning of visible outlines in their true shape as required by ASME Y14.5.

7.4 Drawings With One View

Two adjacent orthographic views are normally considered the minimum requirement to describe a three-dimensional object. However, the third dimension of some objects (washers, shafts, bushings, spacers, etc.) may be specified by a note and the drawing reduced to a single view. See Fig. 7-1.

7.5 Drawings With Two Views

Many items may be adequately described by showing only two orthographic views. These views shall be aligned in any standard position that will clearly illustrate the object. See Fig. 7-2.

7.6 Drawings With Three Views

The majority of multiview drawings consist of front, top, and side views arranged in their standard positions. Any three adjacent views that best suit the shape of the part may be employed. See Figs. 7-3 and 7-4.

A partial third view may be used when the missing portion of the incomplete view is adequately described in other views. See Figs. 7-5 and 7-6. This practice is typically limited to constructed views and may not be feasible in views generated from models.

7.7 Auxiliary Views

Auxiliary views are used in orthographic projections to show true shape and relationship of features that are not parallel to any of the principal planes of projection. See Figs. 7-5 through 7-8. Projection lines, when shown in the figures, are not typically part of the drawing.

7.7.1 Primary Auxiliary Views. A primary auxiliary view is one that is adjacent to and aligned with a principal view. Primary auxiliary views are identified as front, side, or top adjacent auxiliary views to indicate the principal view with which it is aligned. See Fig. 7-8.

7.7.2 Secondary Auxiliary Views. A secondary auxiliary view is one that is adjacent to and aligned with a primary auxiliary view or with another secondary auxiliary view. See Fig. 7-8.

7.7.3 Alignment of Auxiliary Views. Auxiliary views are aligned with the views from which they are projected. A center line or projection line may continue between the adjacent views to indicate the alignment. See Figs. 7-5 through 7-8. Alignment is not required in the case of a removed view or when using the reference arrow method.

7.8 Partial Views

Partial auxiliary views or partial principal views may show only pertinent features not described by true projection in the principal or other views. They are used in lieu of complete views to simplify both construction and interpretation of the drawing. See Figs. 7-5 through 7-8.

7.9 Details

In areas where clarification is necessary or to better illustrate a complex configuration, a detail is shown on the drawing graphic sheet to show small features at an increased scale and provide additional information. See Fig. 7-9. Details when used in saved views may be at an increased magnification but the geometry scale is the same as the model.

Figure 7-9 shows a detail. It also shows additional information since the fastening device is included. View and zone referencing as described in paras. 6.2 and 6.5 may be used. The scale of the detail shall be noted.

7.10 Related Parts

When the relationship between mating parts is important, the relative position of the detailed part to the related part may be shown in constructed views by using phantom lines to outline the related part. Notes may be added to indicate the functional relationship of these parts. See Fig. 7-10.

Fig. 7-1 Drawings With One View

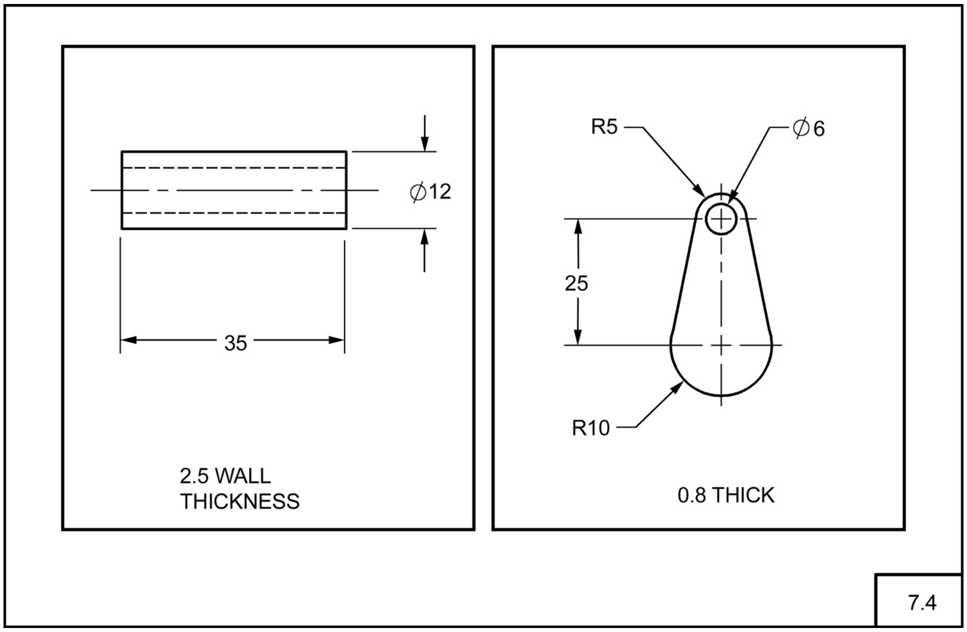


Fig. 7-2 Drawings With Two Views

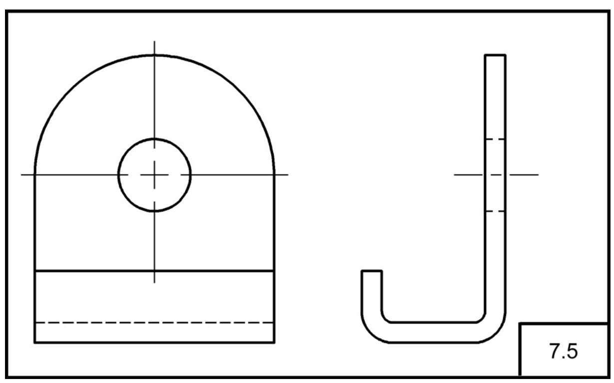


Fig. 7-3 Drawing With Three Orthographic Views

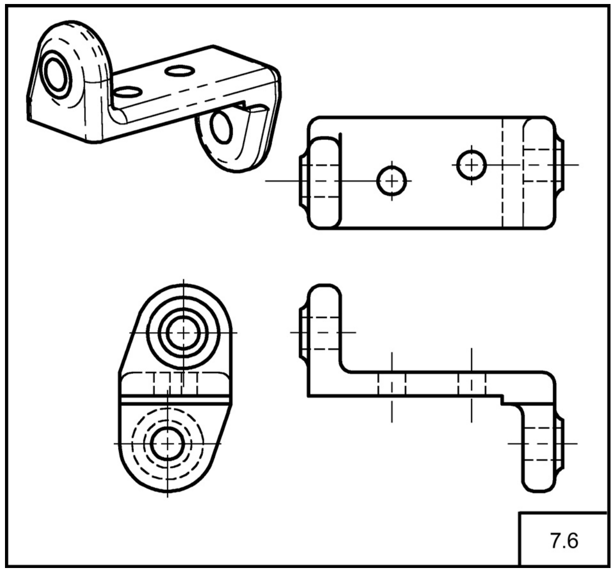


Fig. 7-4 Drawing With Three Orthographic Views of a Stamping

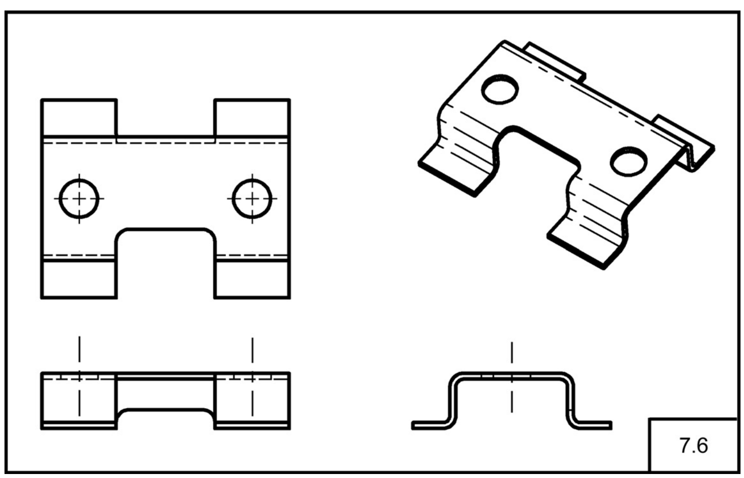


Fig. 7-5 Front View and Partial Auxiliary Views

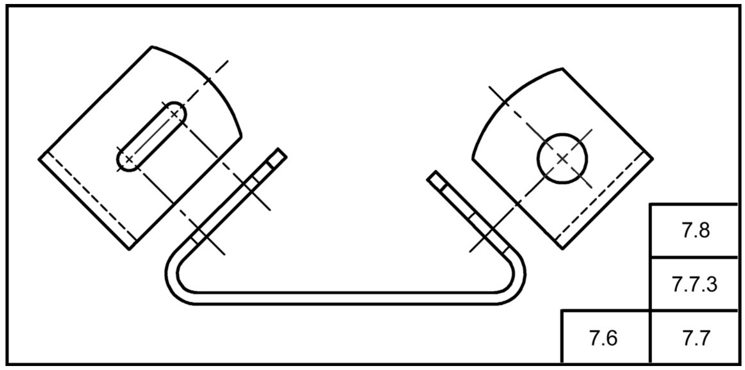


Fig. 7-6 Partial Auxiliary View

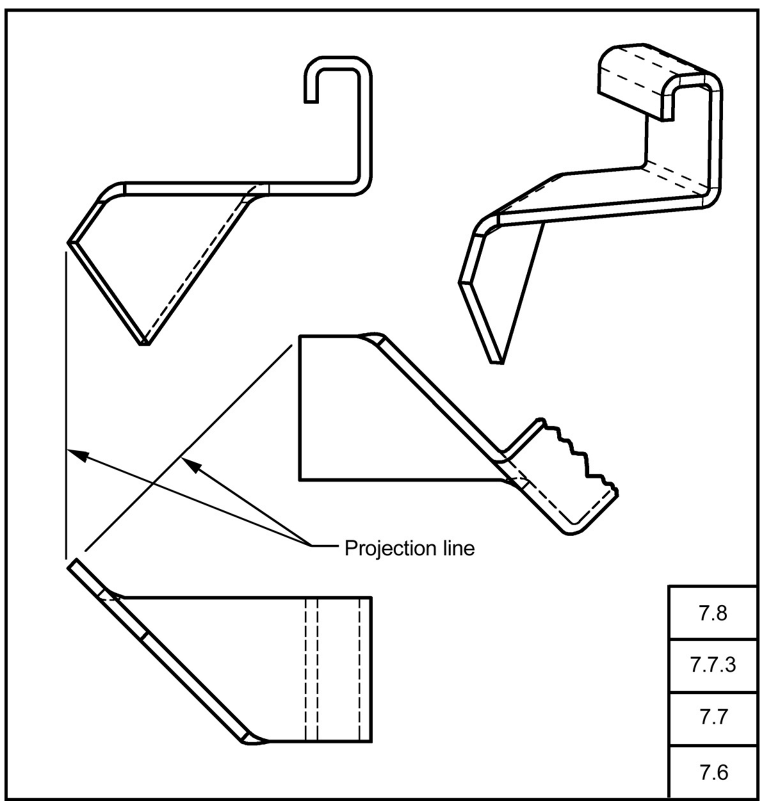


Fig. 7-7 Partial Auxiliary, Partial Front, and Right-Side Views

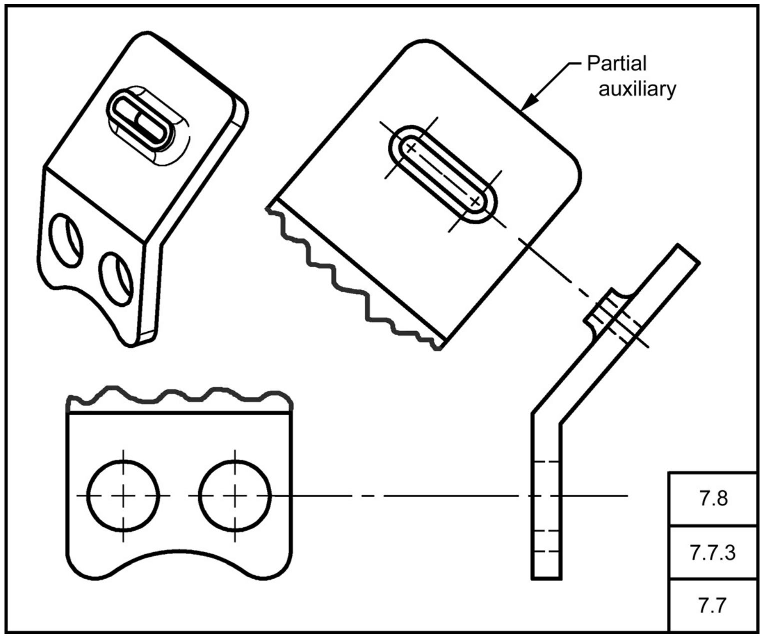


Fig. 7-8 Partial Primary and Secondary Auxiliary Views

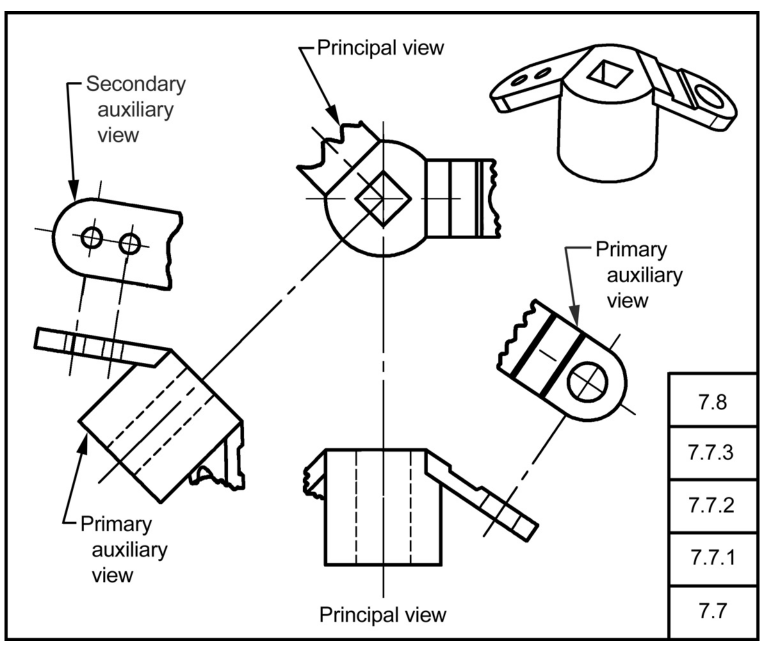


Fig. 7-9 Detail

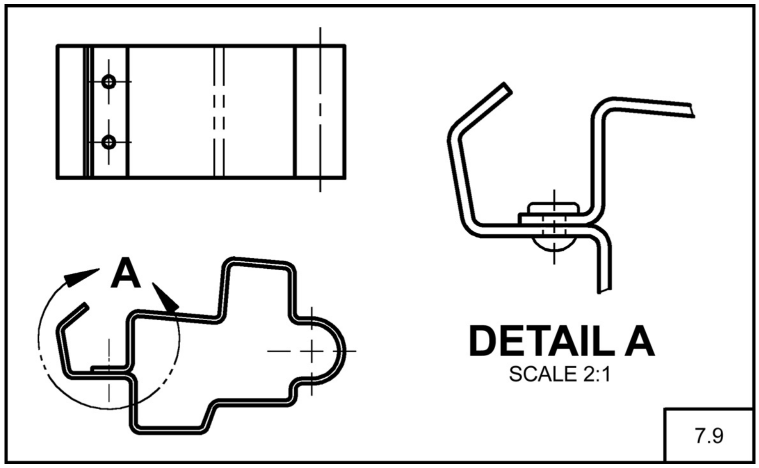
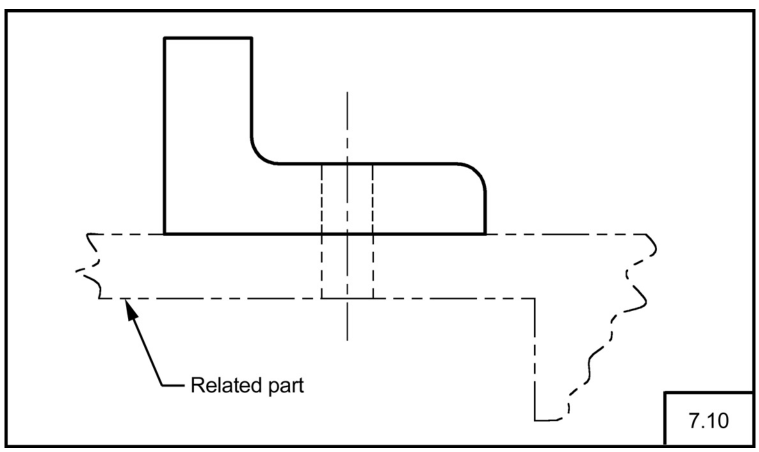


Fig. 7-10 Phantom Lines for Related Parts



8 SECTION VIEWS IN ORTHOGRAPHIC PROJECTION

8.1 Principles

8.1.1 Section Views. Section views, also called sections, are used to clarify interior construction that cannot be clearly described by hidden lines in exterior views. A section view is obtained by passing an imaginary cutting plane through the object perpendicular to the direction of sight. The portion of the object between the cutting plane and the observer is assumed to be removed, but removal of the material is not always required in models. Section lining is optional. See ASME Y14.2. When section lining is used, the exposed cut surfaces of the object are indicated by the section lining. See Fig. 8-1. The graphic depiction of the cut surface may be the true geometric view, or for constructed views, it may be modified according to conventions defined in this Standard. CAD practices usually result in a true geometry section, while manual practices often rely on conventional representations. See Section 10. Unless otherwise specified, section views are at the same scale as the views from which the section is projected.

8.1.2 Section View Location Placement. Section view placement is applicable to drawing graphic sheets and not to views in models when no drawing graphic sheets are created. A section view should appear on the same drawing graphic sheet with the cutting plane view and be projected from and perpendicular to the cutting plane in conformity with the standard arrangement of views. This will result in the section view being placed behind the cutting plane in a properly projected position. When space does not permit placement in the standard position, a removed or rotated section may be used. Views shall be oriented according to the cutting plane orientation, unless clearly noted as described in paras. 6.4 and 8.8.

8.1.3 Cross-Referencing of Sections. Cross-reference zoning may be used on drawing graphic sheets to indicate the location of an indicated section, and to reference a section back to the viewing location. When sections are located on different sheets, the sheet number and zone of the cross-reference location shall be indicated. See Fig. 8-2. Sections shall be oriented according to the cutting plane orientation, unless clearly noted otherwise. The sheet number and zone cross-reference may be in any format, provided that it is easily understood.

8.2 Cutting Plane

8.2.1 Cutting Plane Location. The location of the cutting plane is shown by a cutting plane line that represents the edge view of the cutting plane. The cutting plane may be omitted when its location is obvious, as shown in Figs. 8-3 and 8-4.

8.2.2 Identifying Sections. To relate the cutting plane to its section view, uppercase letters such as A, B, C, etc., are placed near each arrowhead. Placement near one arrowhead is permitted when cutting planes are continuous between arrowheads and clarity is achieved. The corresponding section views are identified as SECTION A-A, SECTION B-B, SECTION C-C, etc. Section letters should be used in alphabetical order, and the letters I, O, Q, S, X, and Z shall not be used.When the alphabet is exhausted, additional sections should be indicated by double letters in alphabetical order, as in AA-AA, AB-AB, AC-AC, etc. Only one set of alpha characters shall be used per drawing for naming views of all types without repeating the same letters on more than one view.

EXAMPLE: For a drawing consisting of three named views of either the same or different types (a section view, a removed view, and a detail view) the views would be named SECTION A-A, VIEW B-B, and DETAIL C.

See Fig. 8-5. It is also permissible to use a combination of numbers and letters for section view identification.

8.2.3 Section View Arrangement. When two or more sections appear on the same drawing graphic sheet, they should be arranged in positions determined by the relative locations of the cutting planes to the extent made possible by view geometry and drawing graphic sheet size. See Fig. 8-5.

8.2.4 Reference Arrow Method for Identifying Sections. Arrowheads are pointed toward the cutting plane line when using the reference arrow method. The arrowhead points in the viewing direction. The view letters are placed at the ends of the cutting plane. The section view identification letters are placed above the view. The reference arrow method is not used in models. See Fig. 8-6.

8.2.5 Showing Cutting Planes. The cutting plane line on a drawing graphic sheet shall be shown when the cutting plane is bent, offset, or when the resulting section is asymmetrical. See Fig. 8-7. The cutting plane should be shown through an exterior view and not through a section view.

8.3 Section Lining

When section lining is used, a uniformly patterned appearance should be evident. In most cases, only the general purpose section lining (uniformly spaced lines) is used. See Fig. 8-1.

8.4 Full Sections

When the cutting plane extends straight through the object, usually on the center line of symmetry, a full section is obtained as in Fig. 8-8. In this figure, the representation of the cutting plane is not shown as its location is obvious. In orthographic views, the portion of the object between the observer and the cutting plane is assumed to be removed, exposing the cut surface and visible background lines of the remaining portion.

8.5 Half Sections

The view of a symmetrical object or one very nearly symmetrical that represents both the interior and exterior features by showing one-half in section and the other half as an external view is known as a half section. See Fig. 8-9 for a half-sectioned assembly.

This half section is obtained by passing two cutting planes, at right angles to each other, through the object so that the intersection line of the two cutting planes is coincident with the axis of symmetry of the object. Thus, one-fourth of the object is considered removed and the interior exposed to view. Cutting-plane lines, arrows, and section letters may be omitted when cutting planes are coincident with the center lines. A center line shall be used in constructed views to divide the sectioned half from the unsectioned half of a half-section view.

8.6 Lines Behind the Cutting Plane

8.6.1 Visible Lines. Visible lines behind the cutting plane are generally shown. Selected lines may be omitted from constructed views when greater clarity is gained, as shown in spokes A and B in Fig. 8-10. It is also permissible to display only the elements cut by the cutting plane.

8.6.2 Hidden Lines. Hidden lines behind the cutting plane are generally not shown. See Fig. 8-11. Hidden lines may be shown when greater clarity is gained.

8.7 Offset and Aligned Sections

8.7.1 Offset Sections. In order to include features not located in a straight line, the cutting plane may be stepped or offset (generally at right angles) to pass through these features. Such a section is called an offset section.

Constructed offset section views are drawn as if the offsets were in one plane, and the offsets are not indicated in any manner in the section views. See Fig. 8-12. The offsets may be shown in generated views.

8.7.2 Aligned Sections. When the features lend themselves to an angular change in the direction of the cutting plane (less than 90 deg), the section view is drawn in a constructed view as if the bent cutting plane and features were rotated into a plane perpendicular to the line of sight of the section view.

Such sections are called aligned sections, whether the features are rotated into the cutting plane or the cutting plane is bent to pass through them. See Fig. 8-13. Rotation of cut features onto a single viewing plane is not required for views on drawing graphic sheets created from models. Rotation of cut features onto a single viewing plane is not permitted for saved views from models.

8.8 Removed Sections

A removed section is not in direct orthographic projection from the view containing the cutting-plane line, but displaced from its normal projection position.

(a) The removed section may be drawn at the same scale as the view from which it is taken, or when a constructed view is used; it may be drawn at a noted scale. See Fig. 8-14.

(b) Removed sections that are symmetrical may be placed on center lines extended from the imaginary cutting planes. See Fig. 8-15.

(c) Removed sections on a drawing graphic sheet are preferably shown on the same drawing graphic sheet from which the section has been taken. When it is not practical to place the removed section on the same drawing graphic sheet as the cutting plane, cross-referencing of removed section views shall be effected in the same manner as for removed views. See paras. 6.2 and 6.5.

8.9 Revolved Sections

When a cutting plane is passed perpendicular to the axis of an elongated symmetrical feature, such as a spoke, beam, or arm, and then revolved in place through 90 deg into the plane of the view, a revolved section is obtained. Visible lines on each side of the revolved section may be removed and break lines used. No cutting plane is indicated. See Fig. 8-16.

8.10 Broken-Out Sections

When it is necessary to show only a portion of the object in section on a constructed view, the section area is limited by a break line, and the section is called a broken-out section. No cutting plane is indicated. See Fig. 8-17.

8.11 Auxiliary Sections

A section view appearing in other than a principal view is called an auxiliary section. Rules for cutting planes and sectioning are the same as for other section views. See Fig. 8-18.

Fig. 8-1 Section Lining

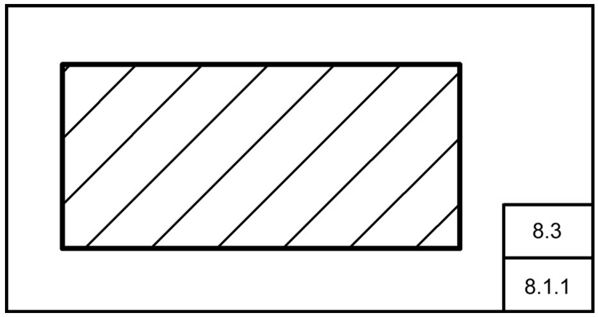


Fig. 8-2 Zone Referencing for Removed Sections

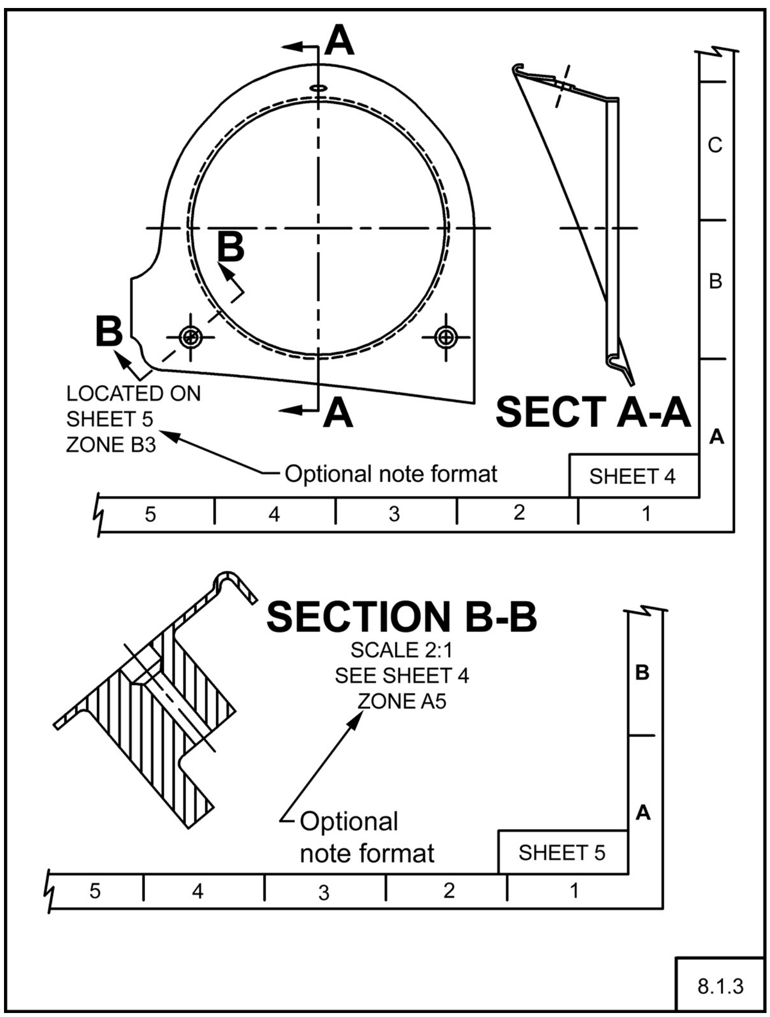


Fig. 8-3 Full Section, Cutting Plane Omitted

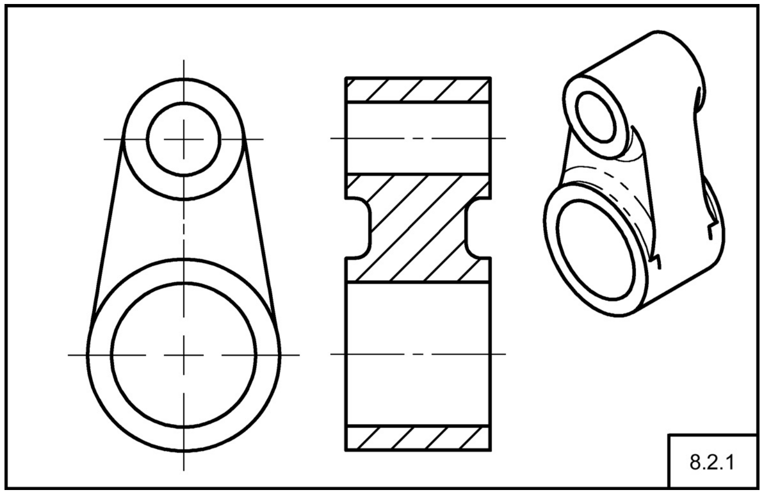


Fig. 8-4 Half Section, Cutting Plane Omitted

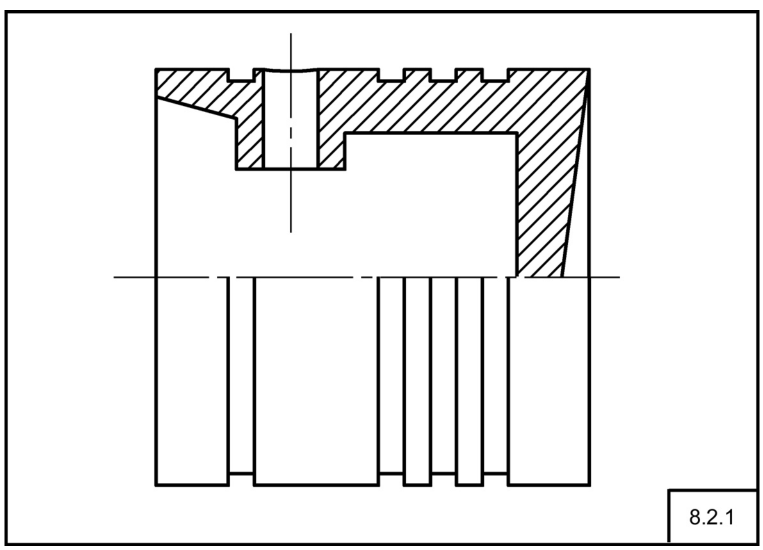


Fig. 8-5 Identifying Sections

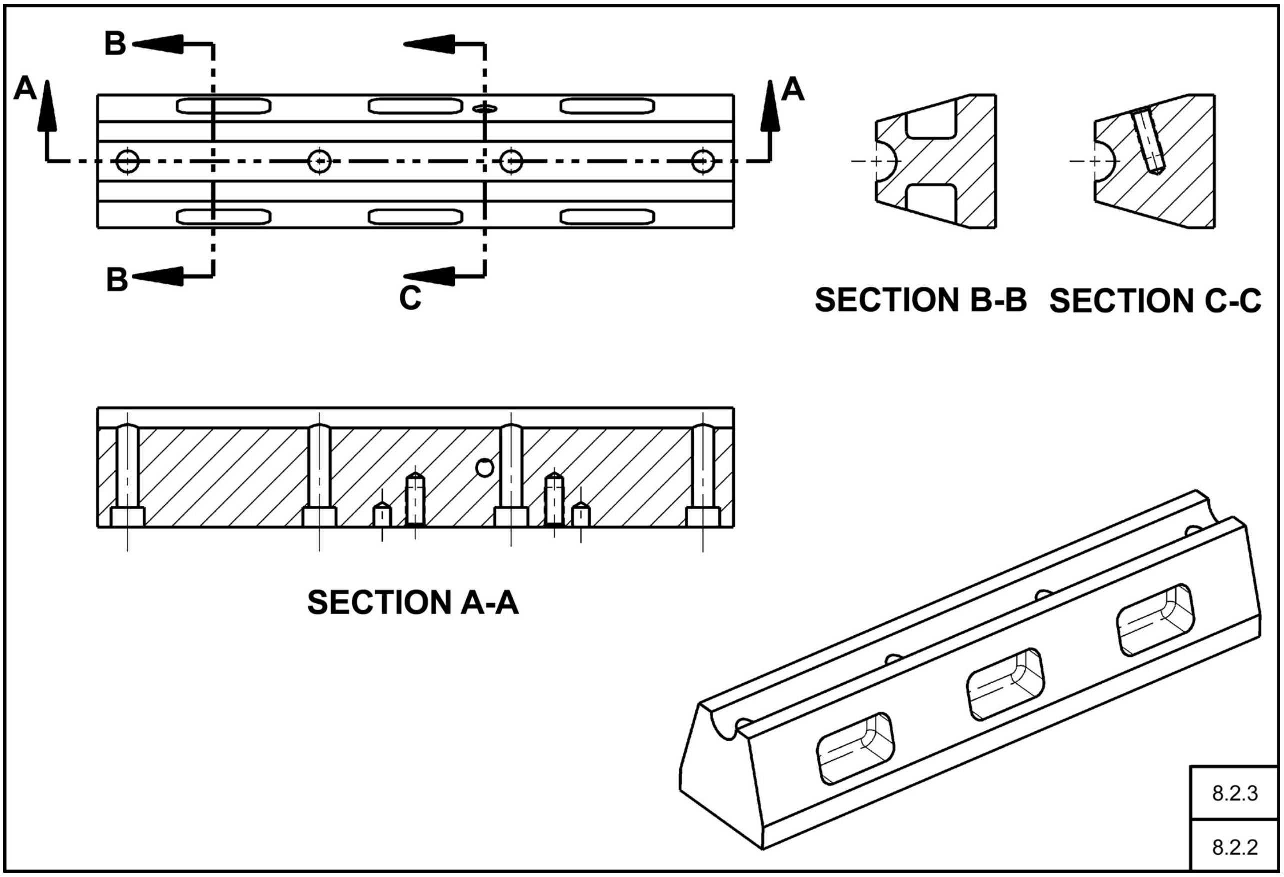


Fig. 8-6 Arrow Method — Identifying Sections

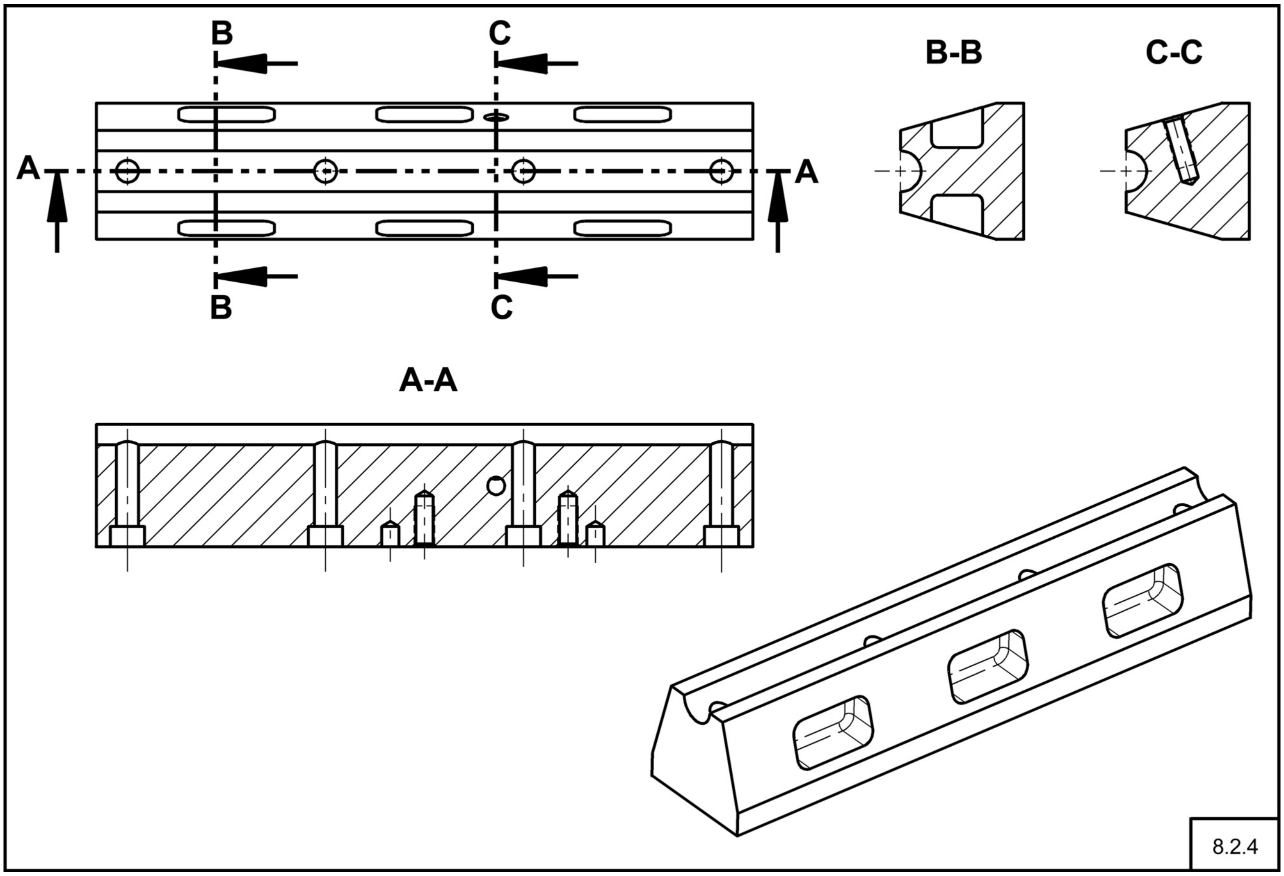


Fig. 8-7 Bent and Offset Cutting Planes

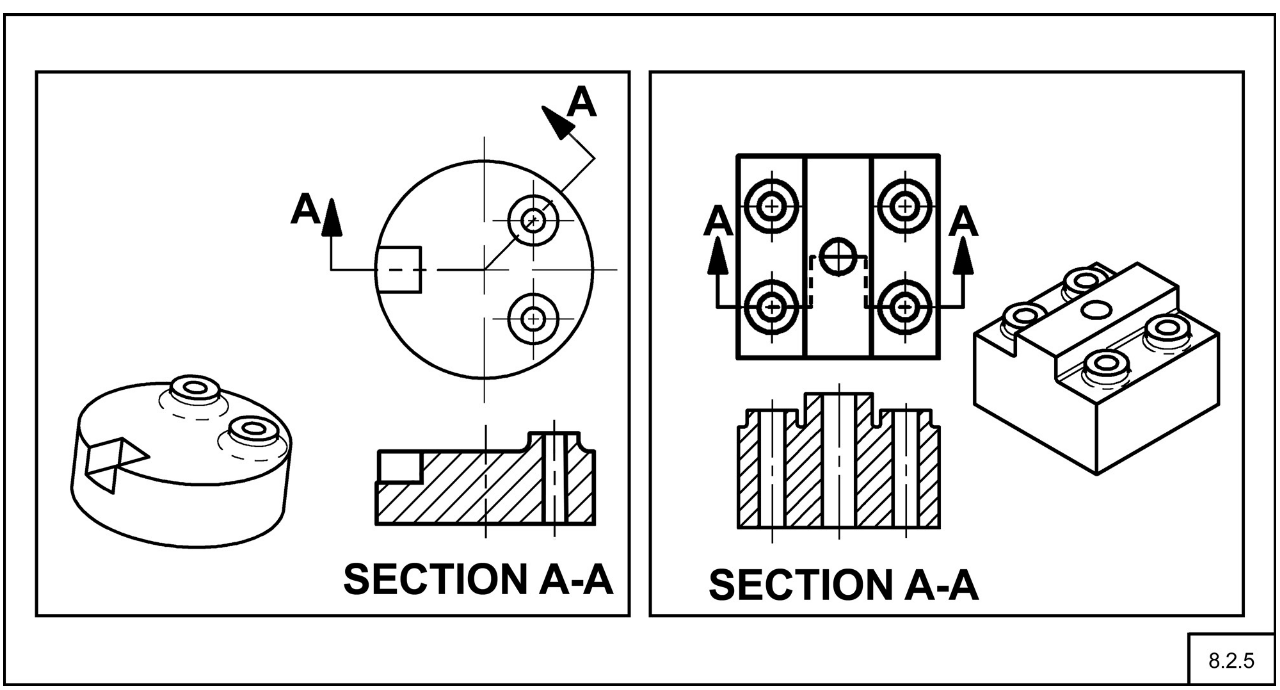


Fig. 8-8 Full Section

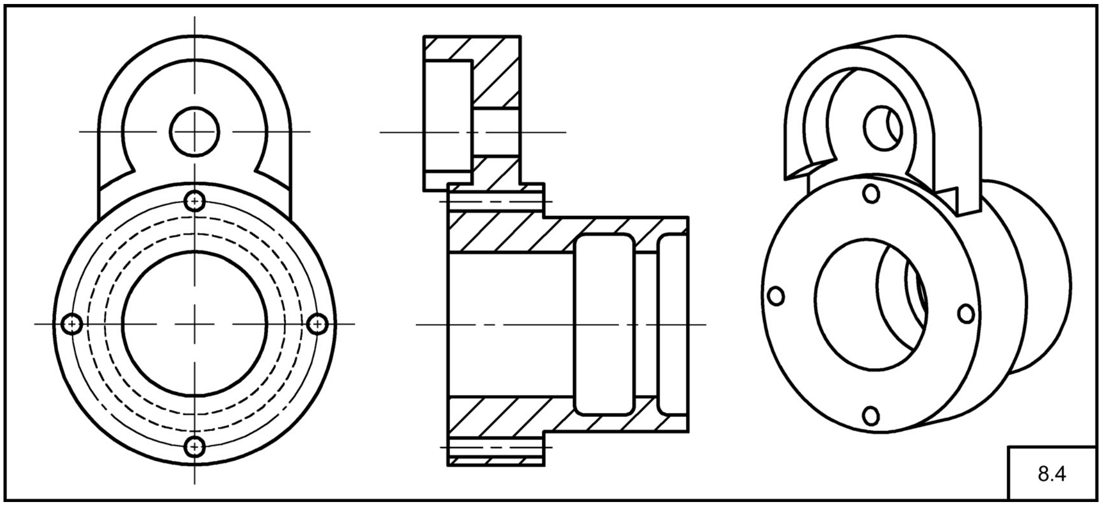


Fig. 8-9 Half Section, Assembly

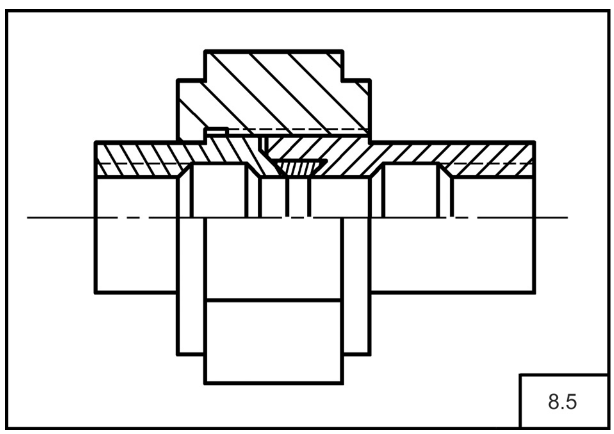


Fig. 8-10 Omission of Visible Lines

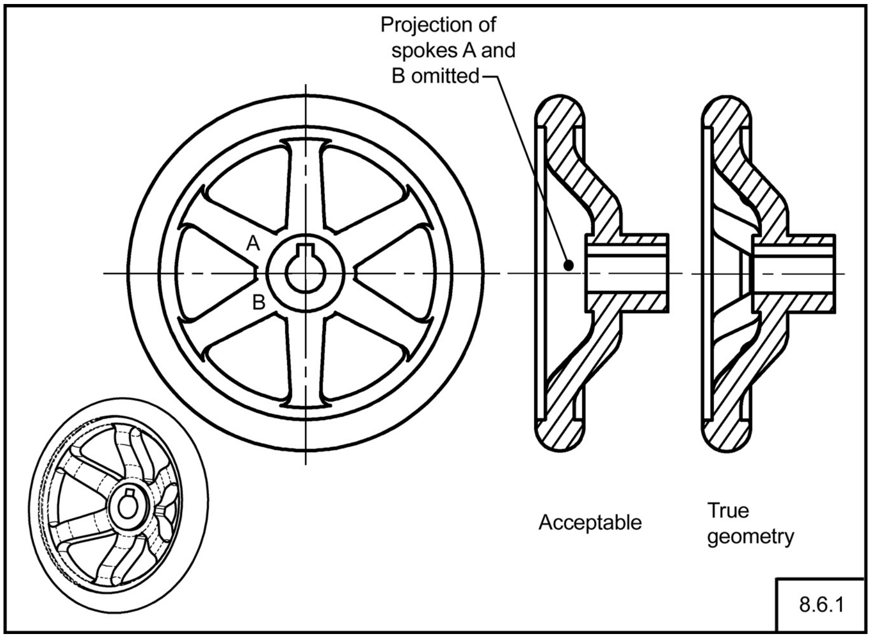


Fig. 8-11 Omission of Hidden Lines

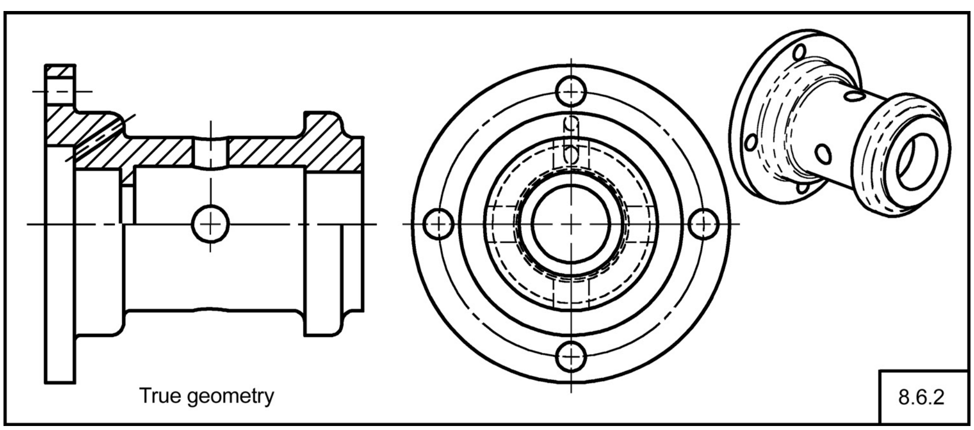


Fig. 8-12 Constructed Offset Section View

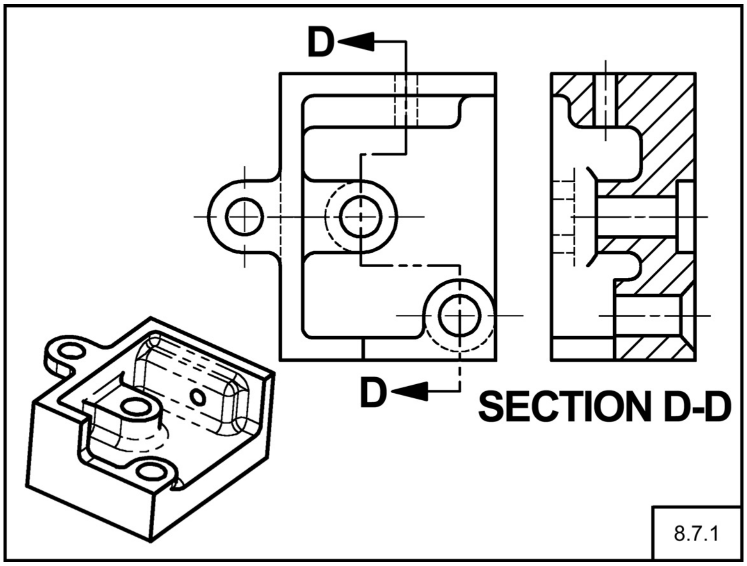


Fig. 8-13 Aligned Section

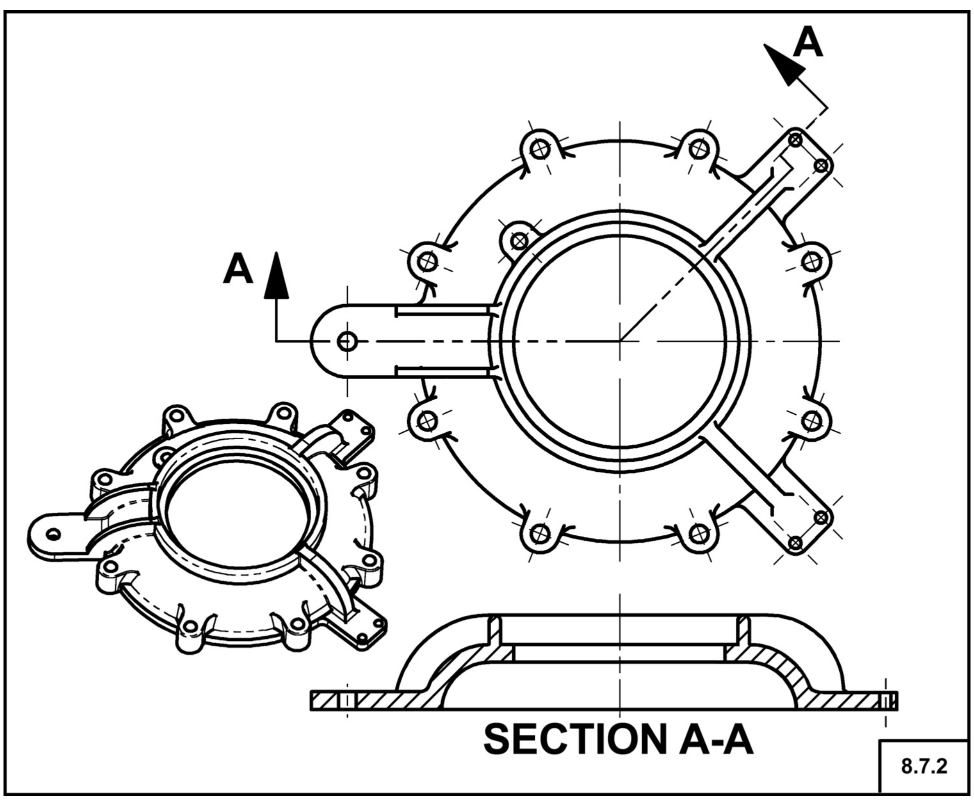


Fig. 8-14 Removed Section

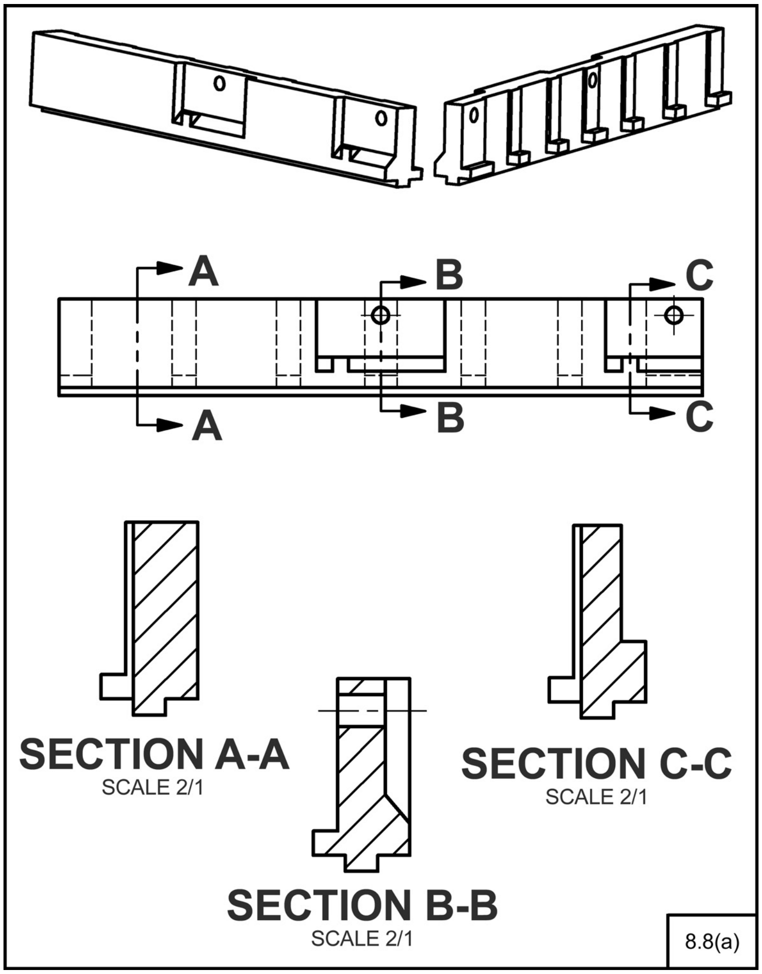


Fig. 8-15 Removed Sections on Center Lines

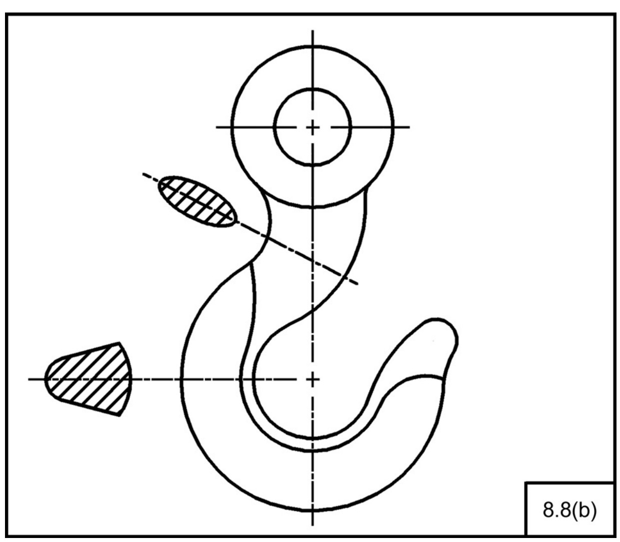


Fig. 8-16 Revolved Sections

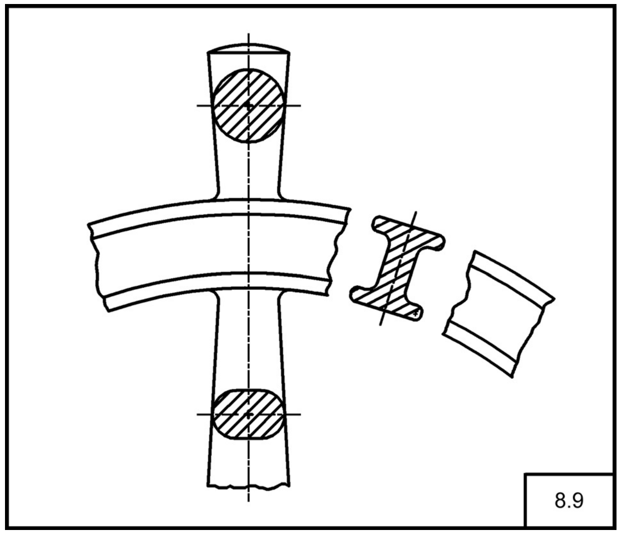


Fig. 8-17 Broken-Out Sections

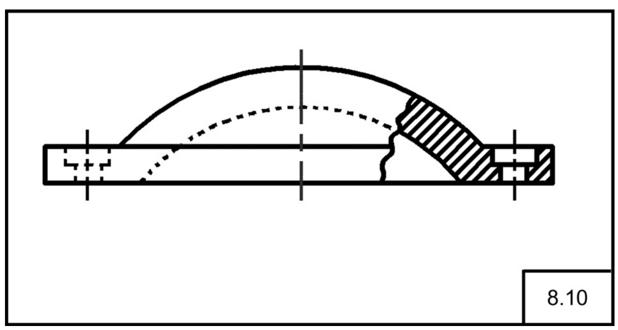
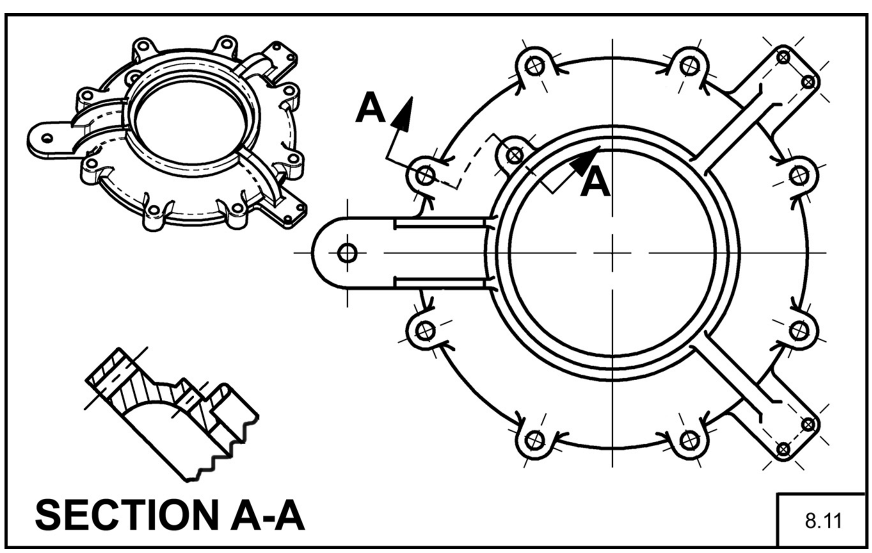


Fig. 8-18 Auxiliary Sections



9 SAVED VIEWS

Previous Sections of this Standard define the general requirements for sections and views, and those requirements apply to saved views unless otherwise specified either where the requirement is first defined or in this Section. The following paragraphs describe requirements and exceptions or additions for saved views in models.

To facilitate presentation of a design model and its annotation, views depicting different orientations of the model may be defined and saved in the digital data set. See Fig. 9-1. These saved views may be used on drawing graphic sheets that are part of the digital data set. Drawing graphic sheets containing saved views may fully define the product definition, or be used in conjunction with the model or design model to fully define the product. The relationship between a model and a drawing graphic sheet is illustrated in Fig. 9-2.

Figure 9-1 shows a screen image of a model. Saved views of the model may be created to facilitate users quickly returning to specific viewpoints.

Figure 9-2, illustration (b) shows a drawing graphic sheet that is created from a model that is shown in Fig. 9-2, illustration (a). The drawing is part of the digital data set. The views placed in the drawing graphic sheet are saved views. Saved views placed in a drawing graphic sheet may include edits but shall not alter the product definition from the geometry defined by the design model.

9.1 Requirements for Saved Views on Models

9.1.1 Data Set Requirements. Saved views in data sets are part of the model and shall be in compliance with the following:

(a) A saved view shall have an identifier.

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

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

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

(1) annotation plane

(2) a selected set of annotation

(3) a selected set of geometry

9.1.2 Section Views. Saved views may be used to retain sections.

9.1.2.1 Additional Section View Requirements. In addition to previously defined section view requirements, the following are applicable to saved section views:

(a) All sections shall be the same scale as the design model.

(b) *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. Additional guidance for models is contained in ASME Y14.41.

9.1.2.2 Exceptions to Section View Requirements. The types of section views and view requirements established in other Sections of this Standard may be used on saved views except as follows:

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

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

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

(d) *Broken-Out Sections.* Broken-out sections shall be accomplished as offset sections.

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

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

(g) *Multiple, Connected Cutting Planes.* Multiple, connected cutting planes shall be used for offset sections in models. See Fig. 9-3.

9.1.2.3 Depiction of Cutting Plane in a Model. A representation of a cutting plane shall be used in a model 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 single visible viewing arrow, or two arrows, shall be included to show the direction in which the section is viewed. See Figs. 9-3 and 9-4. To relate the cutting plane to its section view, uppercase letters such as A, B, C, etc., shall be placed near the viewing arrow(s). The corresponding section views are identified as, for example, SECTION A when one viewing arrow is used, or SECTION A-A when two viewing arrows are used. Section letters should be used in alphabetical order, and the letters I, O, Q, S, X, and Z shall not be used. When the alphabet is exhausted, additional sections shall be indicated using double letters in alphabetical order, as in AA, AB, AC, etc., when one viewing arrow is used, or AA-AA, AB-AB, AC-AC, etc., when two viewing arrows are used. Only one set of alpha characters shall be used per drawing for naming views of all types without repeating the same letters on more than one view. For example, for a drawing consisting of three named views of either the same or different types (a section view, a removed view, and a detail view) the views would be named SECTION A-A, VIEW B-B, and DETAIL C.

9.1.2.4 Depiction of Section Cut. The result of the section cut may be shown either by removing material from the part, as shown in Figs. 4-12, 9-3, and 9-4, or by display of the curves overlaid on the model or view that result from intersecting the cutting plane with the part. See Figs. 9-5 and 9-7.

9.2 Drawing Graphic Sheet Requirements for Saved Views

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

9.2.2 Axonometric Views. When axonometric views are used, the coordinate system shall be used to indicate view orientation. See Fig. 9-6.

9.2.3 Section Views. Section views may be created from orthographic and axonometric views. A resulting section view may be orthographic or axonometric.

9.2.3.1 Depiction of Cutting Plane. Cutting plane and section view identification shall be as defined in para. 9.1.2.3.

9.2.3.2 Depiction of Section Cut. Requirements from para. 9.1.2.4 apply for axonometric views on drawing graphic sheets. See Fig. 9-7.

9.2.3.3 Offset Sections. In drawing graphic sheets, the use of a stepped or offset cutting plane line is supported in axonometric views. The resulting section cut geometry in an axonometric view may be shown in its true position on the model or in an orthographic view; it may be drawn as if the offsets were in one plane.

9.2.3.4 Rotation of a Section Taken From Axonometric Views. Sections taken from axonometric views in drawing graphic sheets may be presented in the same orientation as the parent view or may be rotated. See Figs. 9-6 and 9-8.

9.2.3.5 Aligned Sections. The use of a cutting plane line containing angular changes is supported in axonometric views but not in views generated to show true geometry. 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 section view.

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

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

Fig. 9-1 Model

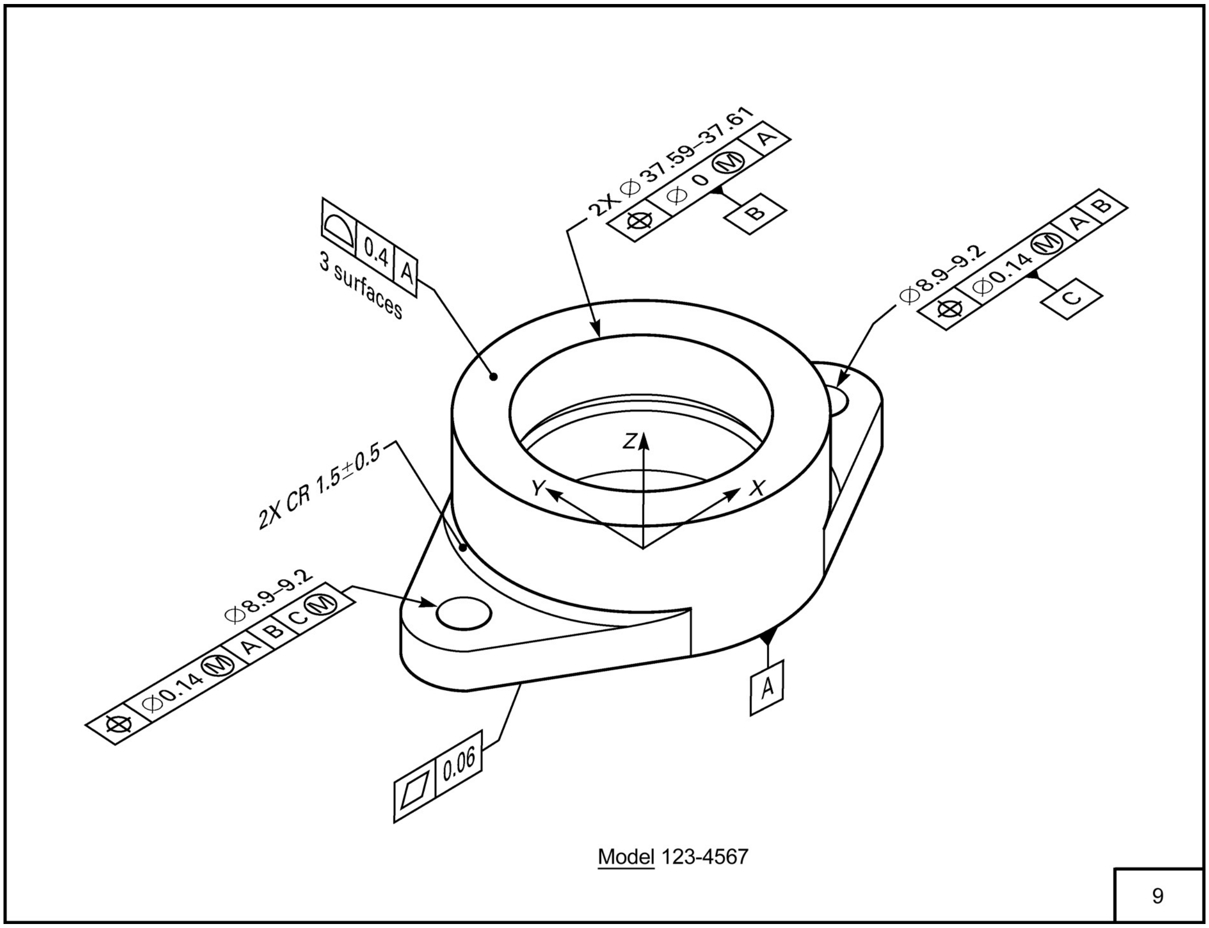

2X ⌀ 37.59–37.61
⌀ 0 Ⓜ A
B
0.4 A
3 surfaces
⌀8.9–9.2
⌀0.14 Ⓜ A B
C
Z
Y
X
2X CR 1.5±0.5
⌀8.9–9.2
⌀0.14 Ⓜ A B C Ⓜ
A
0.06
Model 123-4567
9

Fig. 9-2 Model and Drawing Graphic Sheet

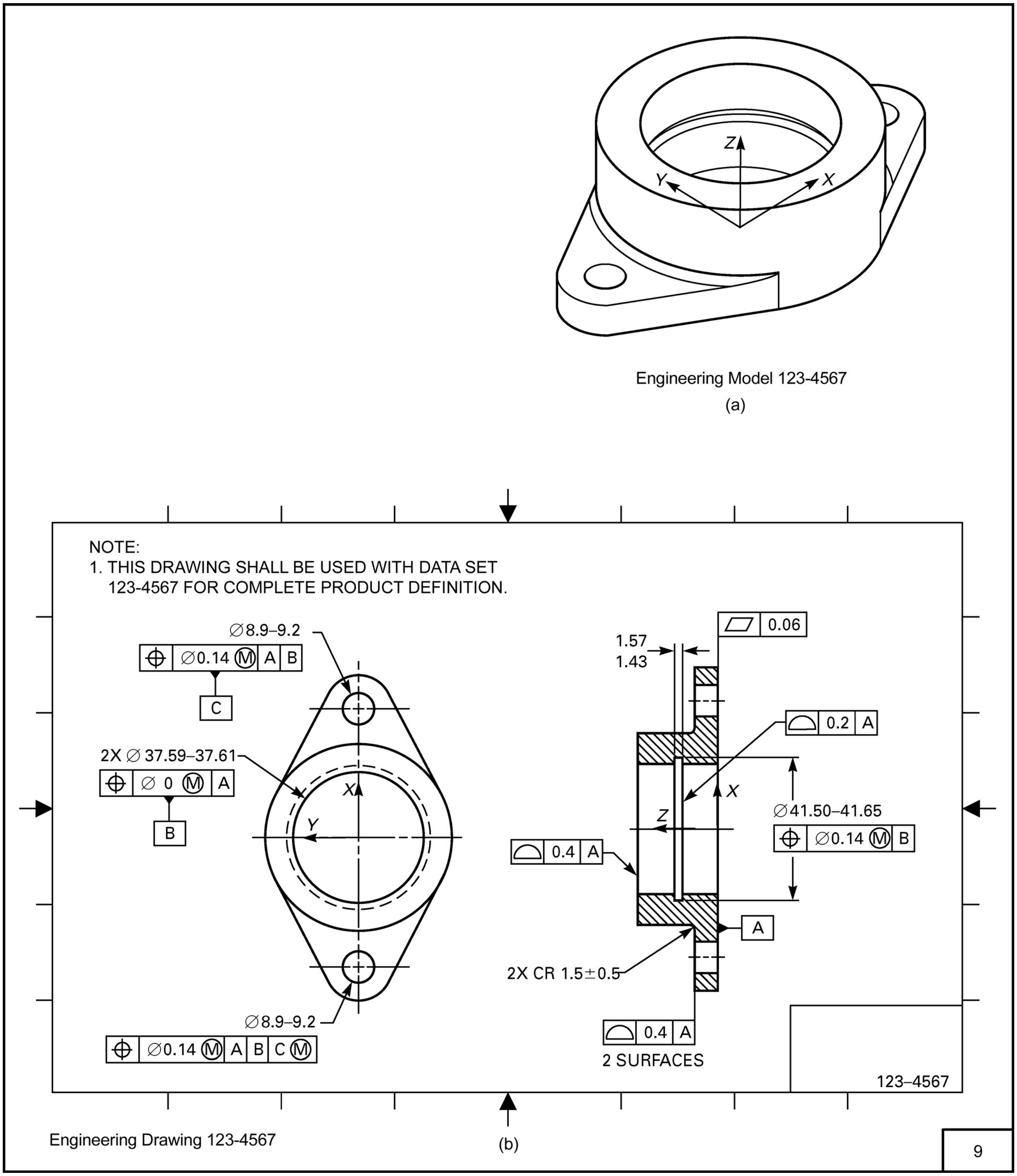


Fig. 9-3 Design Model With Offset Section

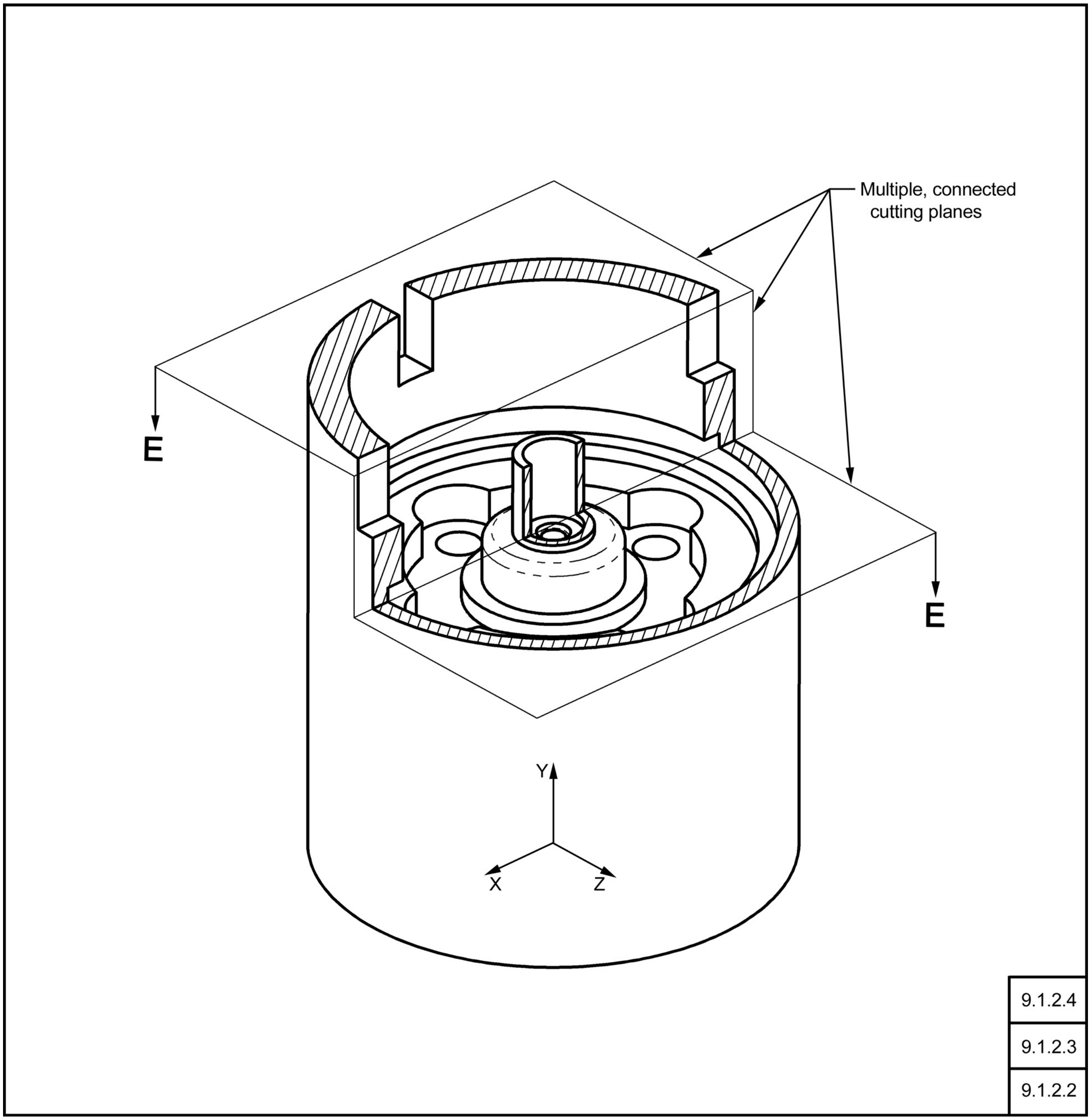
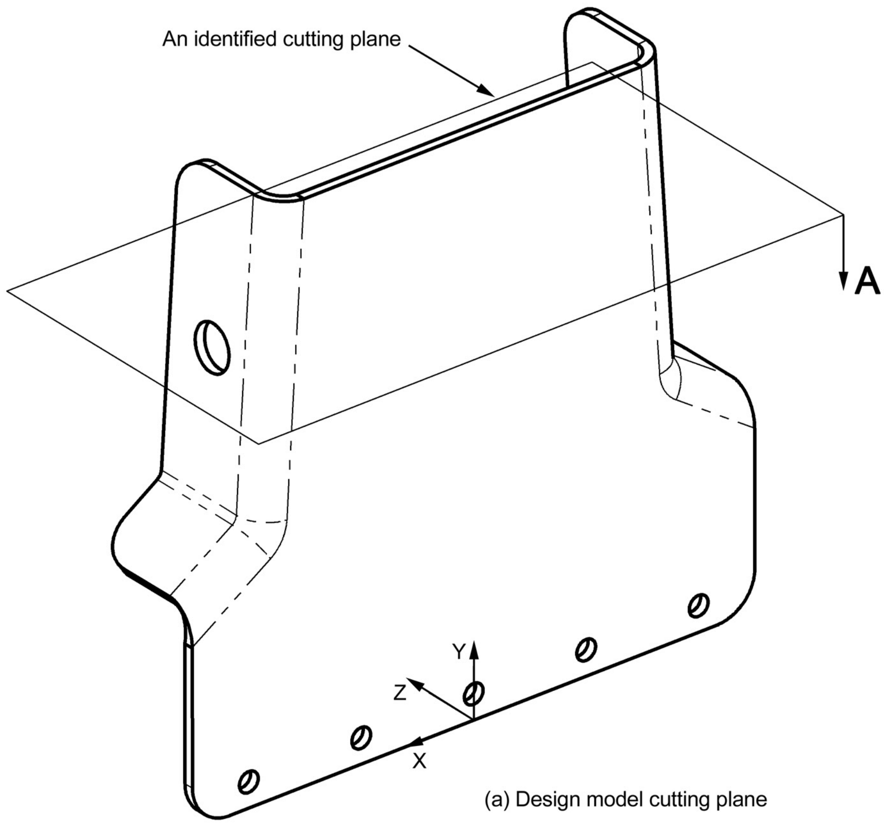
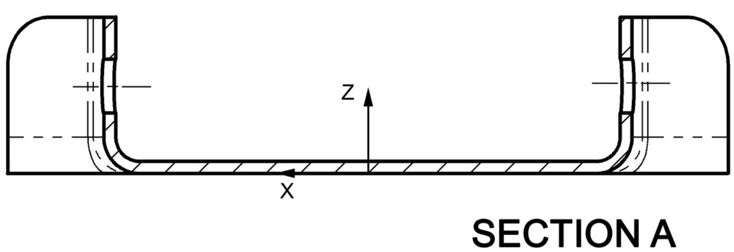


Fig. 9-4 Design Model Cutting Plane



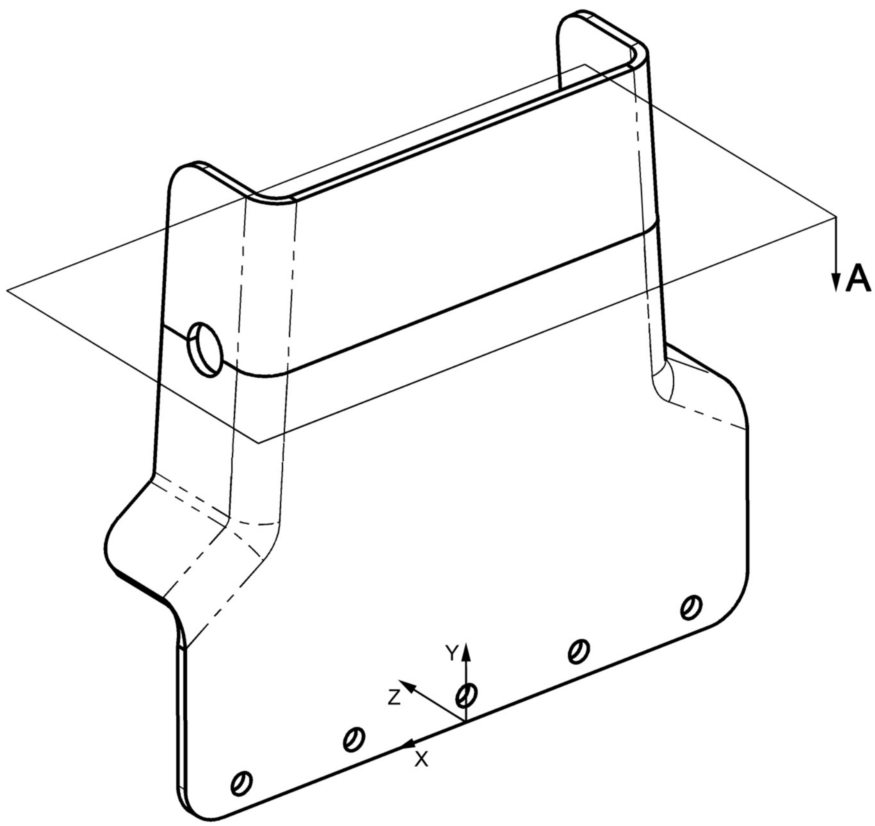
(a) Design model cutting plane



(b) Resultant section in a saved view

9.1.2.4	9.1.2.3

Fig. 9-5 Design Model With Cutting-Plane Intersection Lines Shown



Resultant section shown as curves in the model

9.1.2.4

Fig. 9-6 Axonometric Views, Coordinate System Shown, Section View Rotated

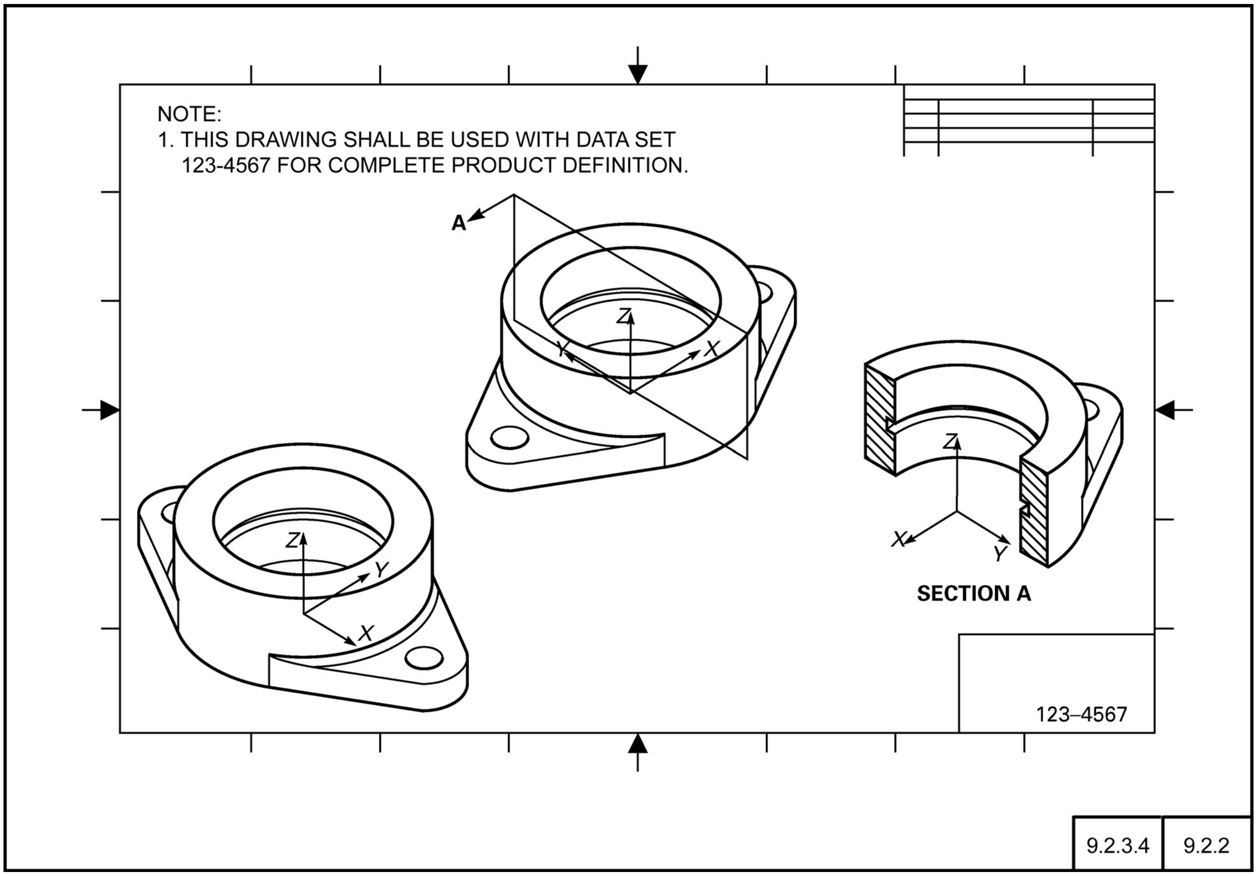


Fig. 9-7 Drawing Graphic Sheet, Cutting-Plane Intersection Lines Shown

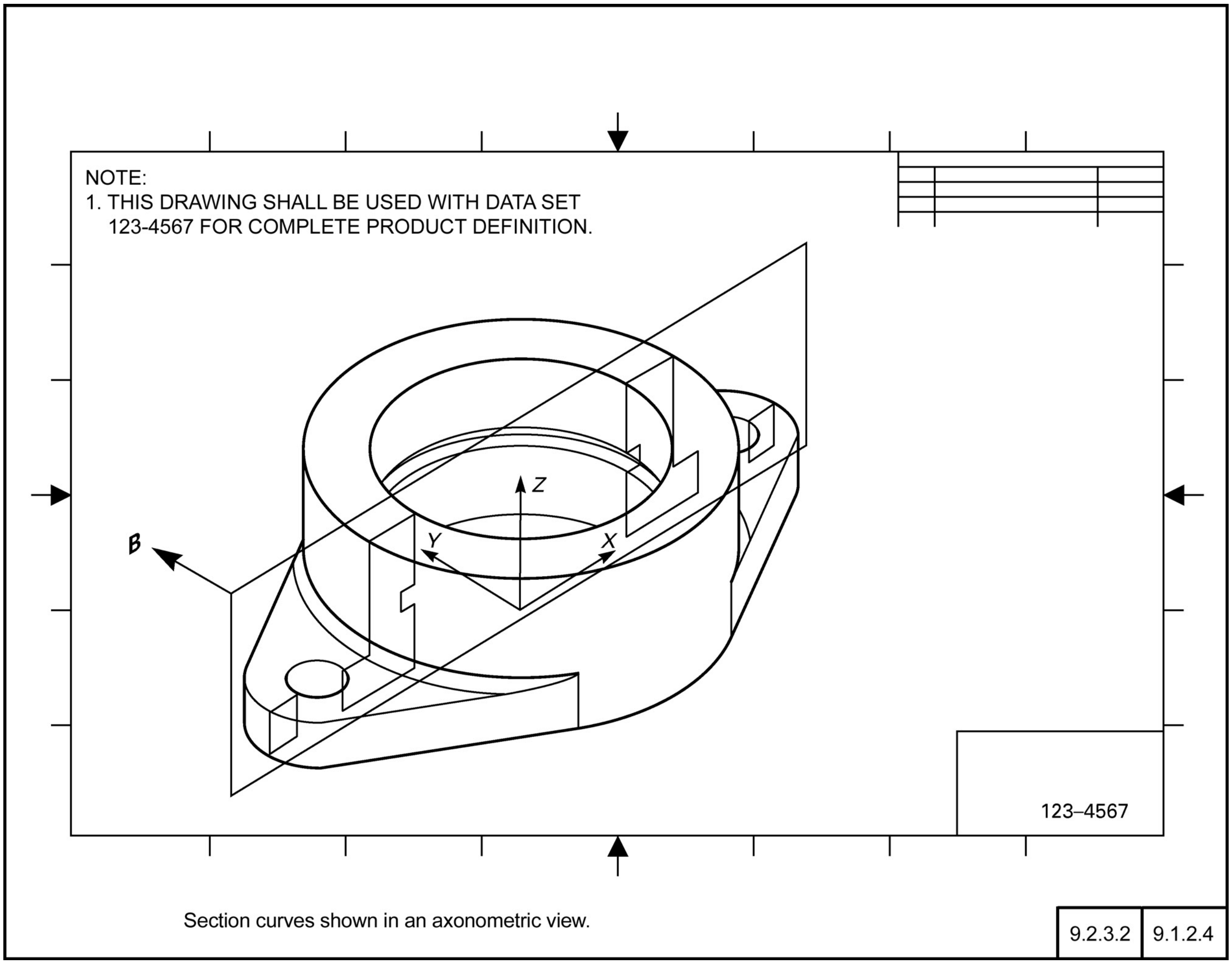
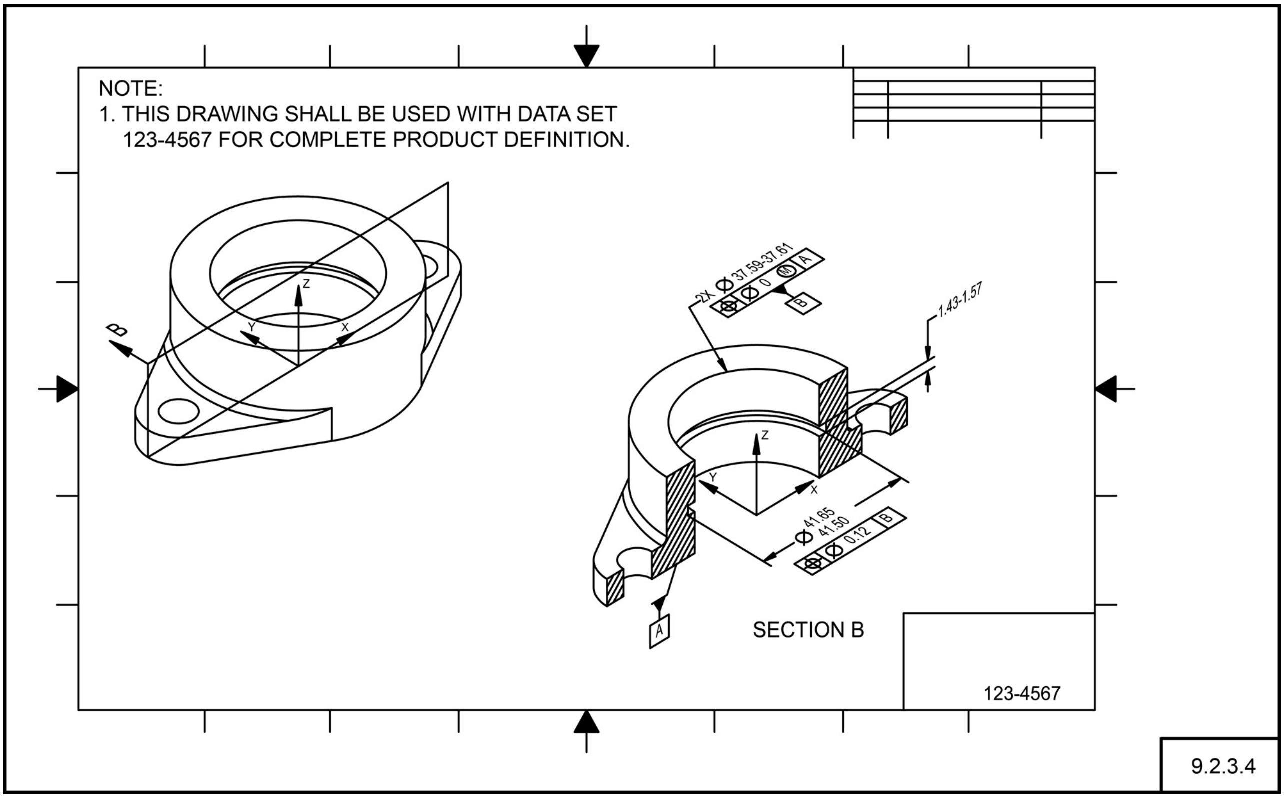


Fig. 9-8 Section View in the Same Orientation as the View Containing the Cutting Plane



10 CONVENTIONAL REPRESENTATION

10.1 General

Conventional representation enhances view creation economy and clarity by using simplified representations of an object. While it does contain deviations from true orthographic projection, it consists of abbreviated delineations that are generally recognized and accepted as standard basic drawing practice. Conventional representation as defined by this Standard is only used when true geometry representation is not required.

10.2 Conventional Representation Applied to Exterior Orthographic and Pictorial Views

Individual details may be shown in numerous ways on orthographic views and those conventions differ from some of the conventions used for pictorial views. The conventions given in paras. 10.2.1 through 10.2.9 are noted as to applicability when the convention is limited to either orthographic or pictorial views. The object of the conventions is to present the details in universal and easily understood methods. The conventions are not applicable to models except when specifically indicated as applicable.

10.2.1 Orders of Precedence Between Lines. Line conventions and lettering shall be in accordance with ASME Y14.2. Visible lines take precedence over hidden lines and center lines. Hidden lines take precedence over center lines. Cutting plane lines take precedence over center lines when locating a cutting plane. See Fig. 10-1.

10.2.2 Hidden Lines. Hidden lines should be omitted on pictorial views except where necessary to describe the shape of the object or to add clarity to the view. See Fig. 10-2.

10.2.3 Rotation of Features and Elements to Show True Shapes. Features and elements, such as arms, ribs, lugs, or other similar features, or portions of the object at angular positions are preferably aligned or rotated to show the true shape and proportion of these elements when shown in orthographic views. See Fig. 10-3.

10.2.4 Simplified Representation of Small Details. When the true projection of an intersection is small, the true lines of intersection may be disregarded in orthographic views. See Fig. 10-4.

10.2.5 Conventional Representation of Large Details. When the true projection of an intersection is large, lines of intersection may be approximated or projected true in orthographic views, as shown in Fig. 10-5.

10.2.6 Representation of Fillets and Rounds. When sharp intersection lines of two surfaces are removed by fillets or rounds, the abrupt changes in surface directions are represented in orthographic views by a phantom line at the approximate intersection of the surfaces. See Fig. 10-6.

10.2.7 Depictions of Fillets, Rounds, and Runouts. Examples of fillets, rounds, and runouts for tangent and intersecting surfaces in orthographic views are shown in Fig. 10-7. Fillets and rounds may be defined by a note and omitted from the geometric representation.

Fillets and rounds may be shown in pictorial views as highlights as shown in Fig. 10-8, illustration (a). The representation of fillets and rounds by straight or curved lines, as shown in Fig. 10-8, illustrations (b) and (c), is an accepted alternate practice.

10.2.8 Conventional Representations of Breaks. Examples of conventional representations of breaks, used to shorten an orthographic view of elongated features, are shown in Fig. 10-9.

Break lines, when used to shorten the length of a detail or assembly in pictorial views, shall reveal the characteristic shape of the cross section in each case. See Fig. 10-10.

10.2.9 Thread Representation. True geometry representation of threads is not required in pictorial views. See ASME Y14.6.

10.3 Conventional Representation Applied to Sections

Conventions used for orthographic and pictorial section views are generally the same. Conventions applicable to only one view type are indicated in the following explanations. Exceptions for views generated from models are given in Section 9.

10.3.1 Sectioning Thin Elements in Orthographic Views. When the cutting plane passes along the length of a thin rib, lug, or other relatively thin element, the outline of the feature is drawn without section lines to aid in the interpretation of thickness variations of part features. See section views in Figs. 10-11 and 10-12. True geometry representation permits section lining of the entire area of a feature. This may require additional section views to provide adequate part description. See Fig. 10-13.

10.3.2 Sectioning Regular Features. Normal section lining procedures apply when the cutting plane cuts across, or is perpendicular to, such elements as ribs, lugs, bolts, and spokes. See Fig. 10-14.

10.3.3 Arrangement. The object shall be positioned in a section pictorial view so that the cutting plane does not appear edgewise. See Figs. 10-15 and 10-16.

10.3.4 Section Lining for a Pictorial View Half Section. Section lining shall be drawn in a pictorial half section view so that the lines would appear to coincide when the cut surfaces were to be folded together about the center line of the object. See Fig. 10-15, illustration (a).

10.3.5 Nonsectioned Items in the Cutting Plane: Sectioning Assembled Items in Orthographic Views. When the cutting plane lies along the longitudinal axis of items such as shafts, bolts, nuts, rods, rivets, keys, pins, screws, ball or roller bearings, gear teeth, and spokes, these parts are not sectioned except when internal construction is shown. See Fig. 10-17.

10.3.6 Conventional Section Lining of View in Orthographic Views. When the cutting plane is perpendicular, or cuts across the items in para. 10.3.5, the section view is section-lined in the usual manner.

10.4 Foreshortened and Aligned Features in Section and Exterior Views

10.4.1 Rotation of Inclined Elements. When the true projection of a part results in foreshortening or in unnecessary drafting time, or both, inclined elements such as lugs, ribs, spokes, arms, or similar elements are rotated into a plane perpendicular to the line of sight of the section view, or omitted. The elements are not section lined. See Fig. 10-18. True geometry representation may include section lining in the cut features and shows the true projection of all elements.

10.4.2 Rotation of Features. Holes, slots, and other such features spaced around a bolt circle or cylindrical flange are rotated to their true distance from the center axis. See Figs. 10-19 and 10-20. True geometry representation shows the features in their true projection.

10.5 Intersections

10.5.1 Intersections in Orthographic Views. Conventional representation of intersections permit economy in manual drawing graphic sheet preparation, but it can increase preparation time when using CAD methods. True geometry representation is permitted. Conventional representation and true geometry representation shall not both be applied to any one of the following feature types within one document, including CAD generated documents.

10.5.1.1 Simplified Representation of Small Details. When a section is cut through an intersection in which the true projection of the intersection is small, the true line of intersection may be disregarded. See Fig. 10-21, illustrations (a) and (c).

10.5.1.2 Conventional Representation of Large Details. Larger intersections are projected true as shown in Fig. 10-21, illustration (b), or approximated by arcs as shown in Fig. 10-21, illustration (d).

10.5.2 Intersections In Pictorial View Sections. Intersections of surfaces are shown in constructed pictorial views as a line or by shading. See Fig. 10-22.

Fig. 10-1 Line Precedence

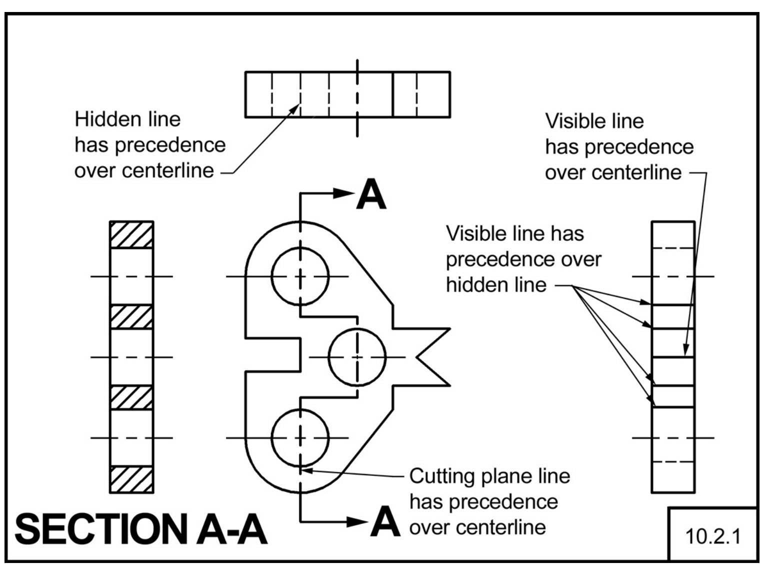


Fig. 10-2 Use of Hidden Lines in Pictorial

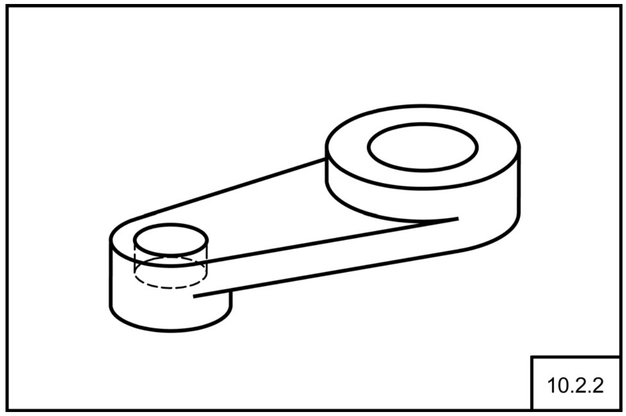


Fig. 10-3 Rotated Features to Show True Shape

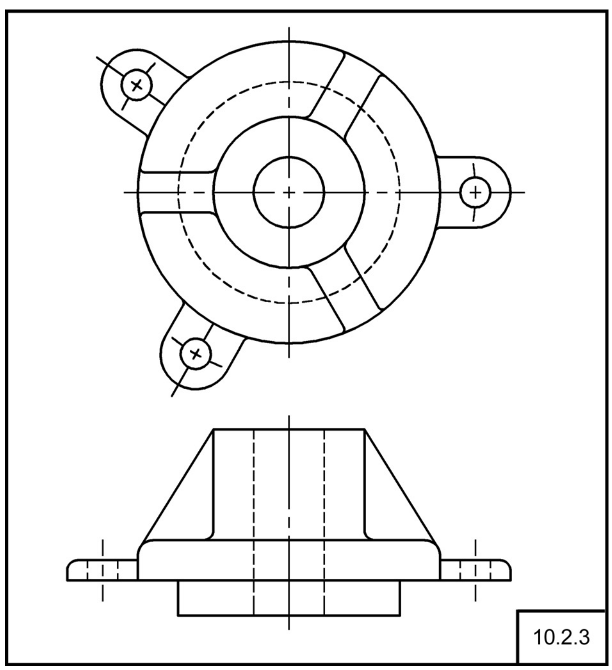


Fig. 10-4 Small Intersections

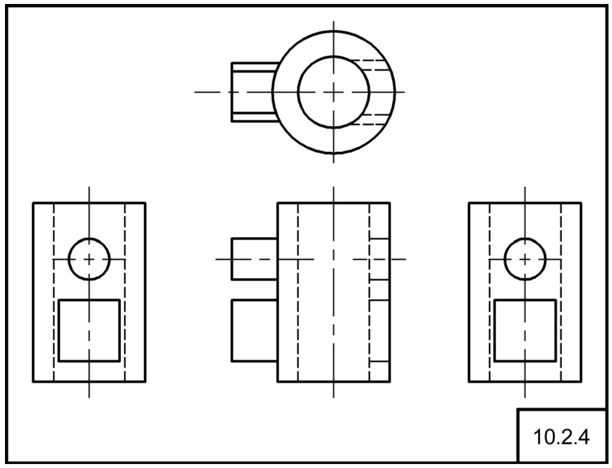


Fig. 10-5 Large Intersections

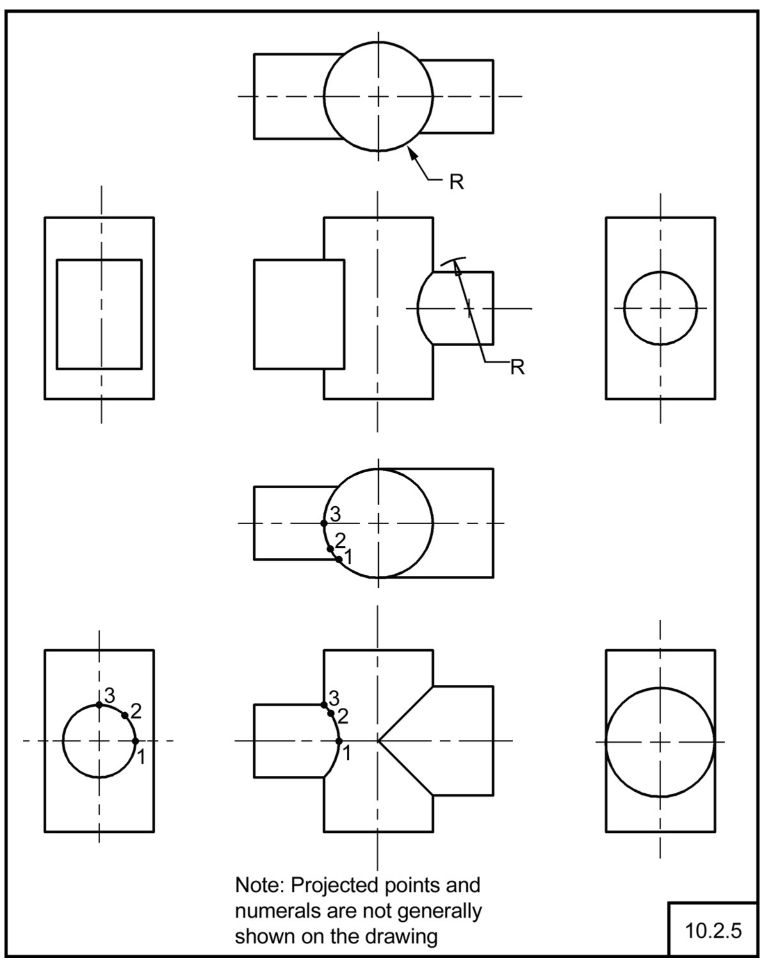


Fig. 10-6 Conventional Representation, Filleted and Rounded Corners

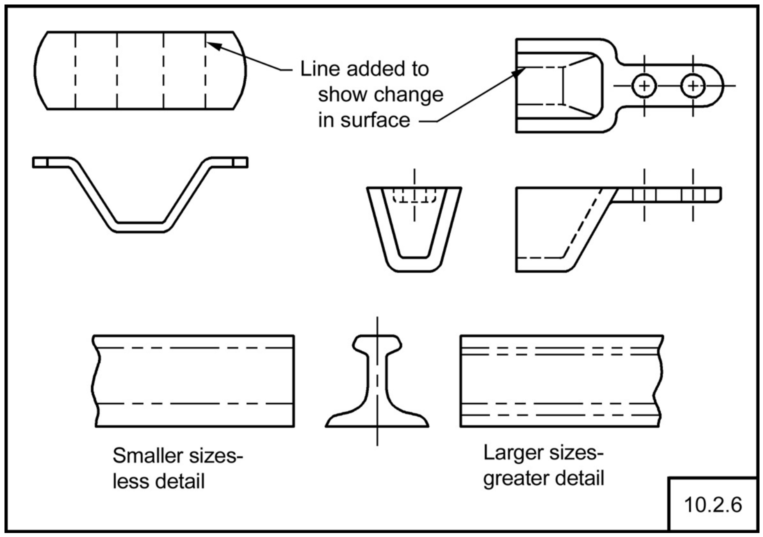


Fig. 10-7 Conventional Representations, Fillets, Rounds, and Runouts

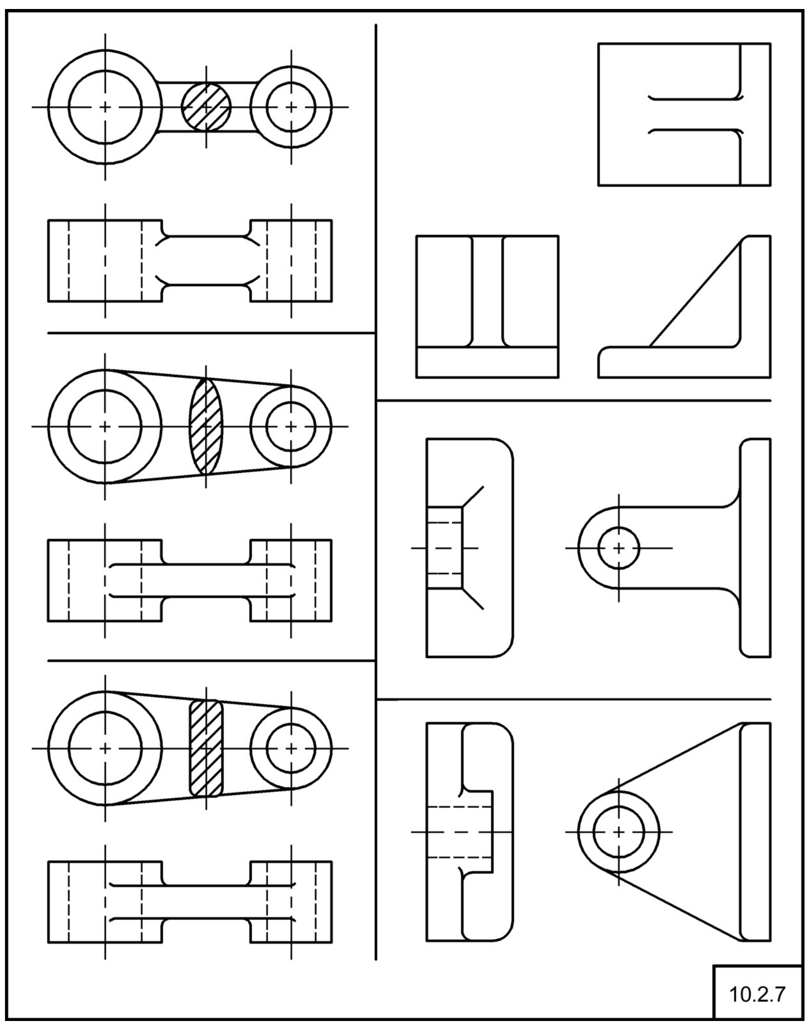


Fig. 10-8 Fillets and Rounds

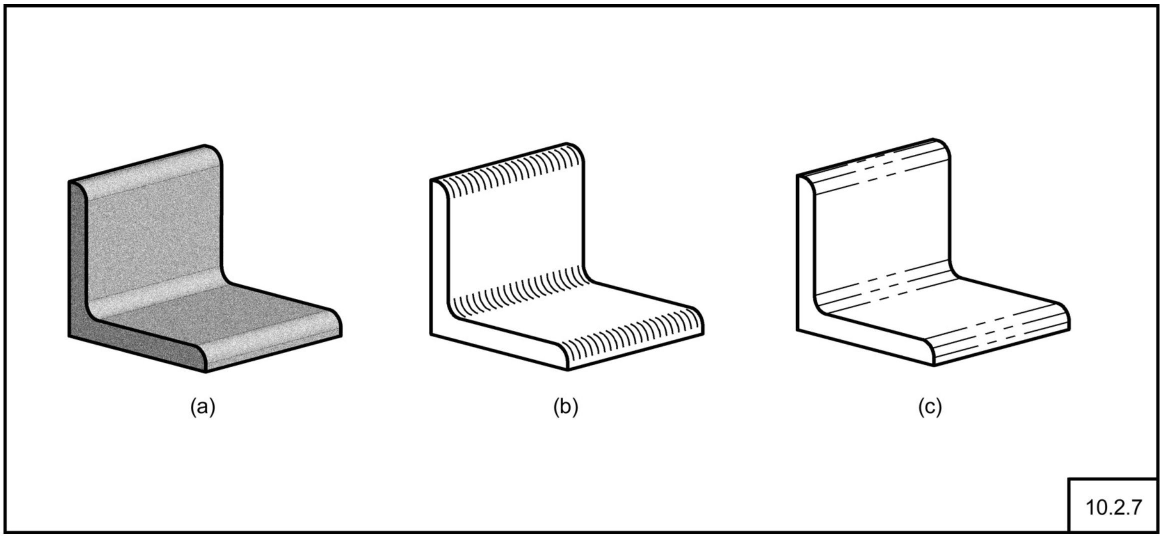


Fig. 10-9 Conventional Representation, Breaks in Elongated Features

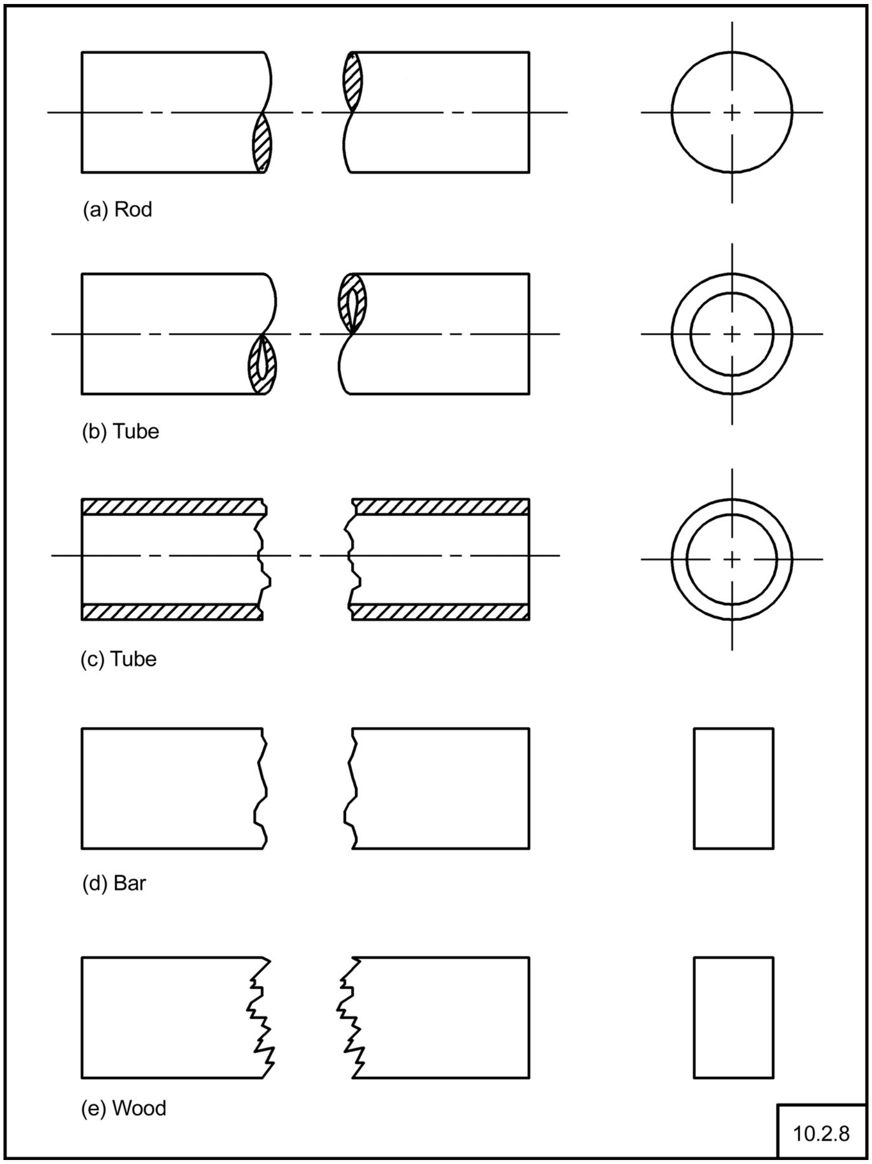


Fig. 10-10 Break Lines

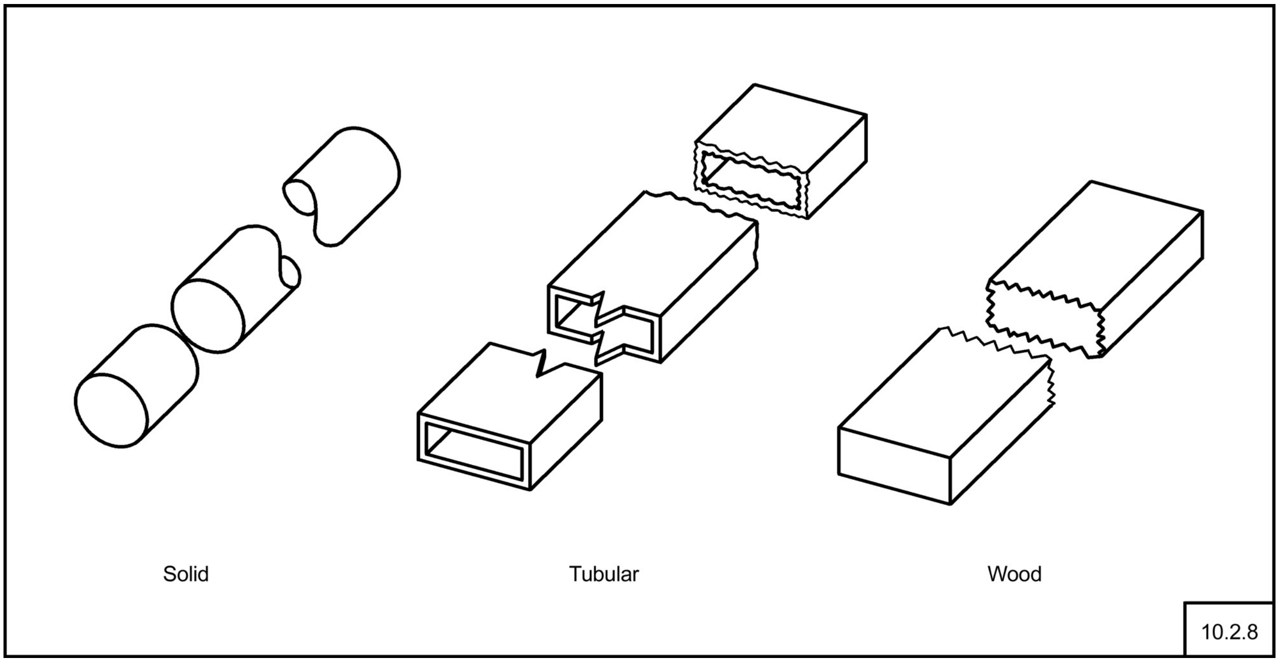


Fig. 10-11 Section Through Ribs

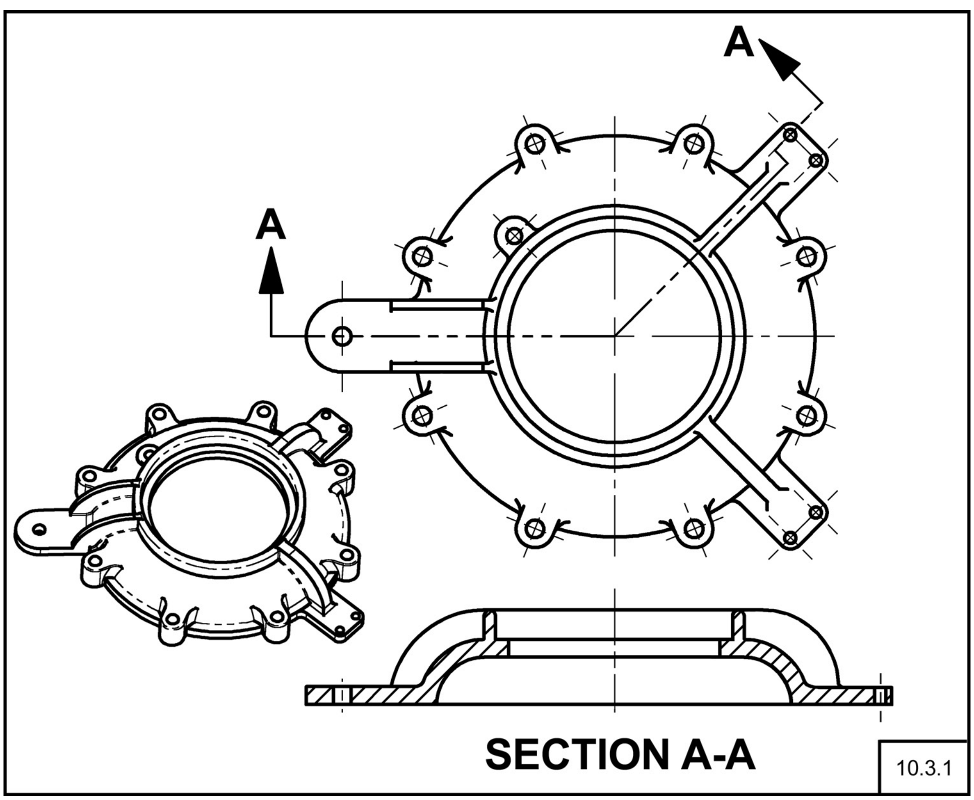


Fig. 10-12 Conventional Representation of Ribs

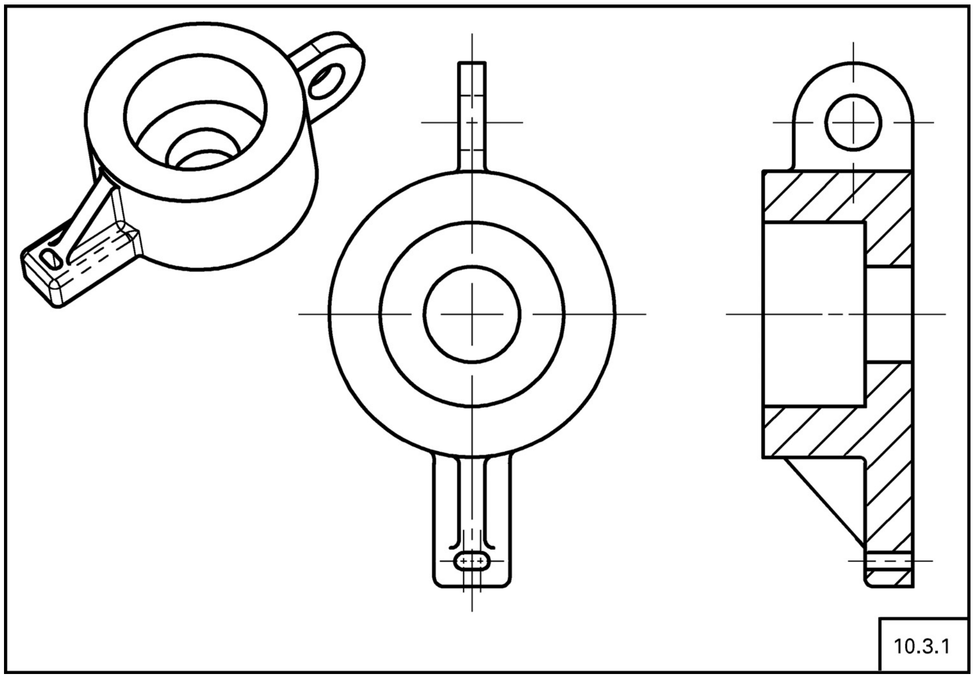


Fig. 10-13 True Geometry Through Ribs

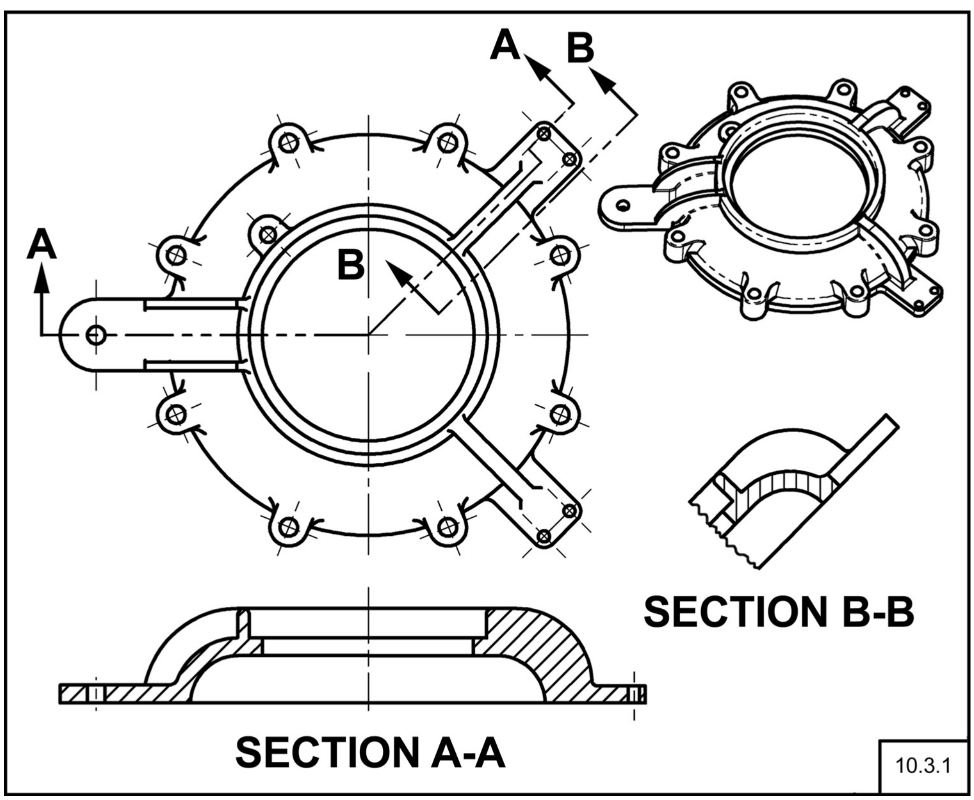


Fig. 10-14 Section Across Ribs

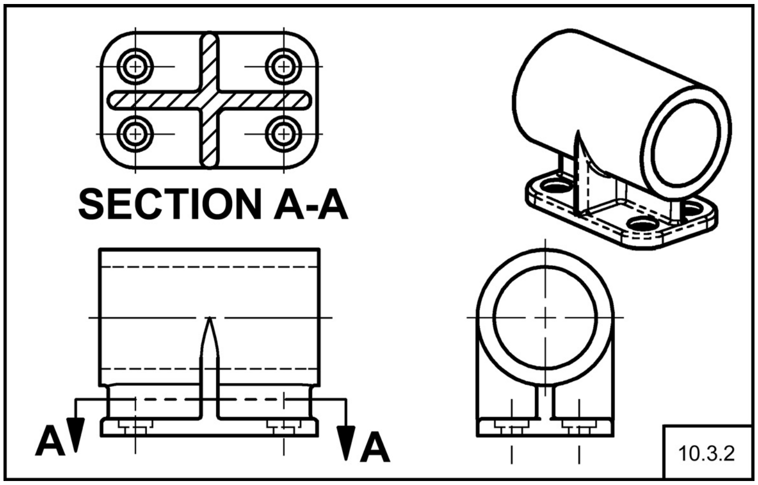


Fig. 10-15 Section Views and Section Lining

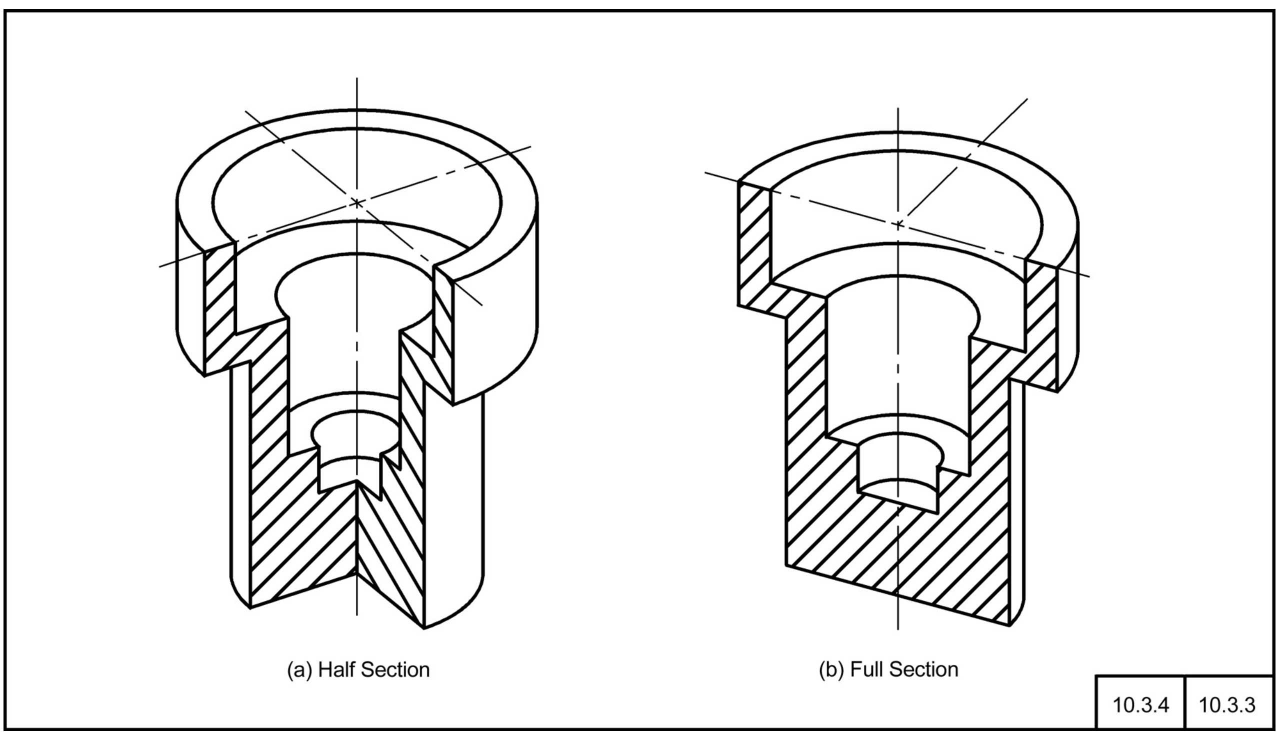


Fig. 10-16 Section Through Assembly

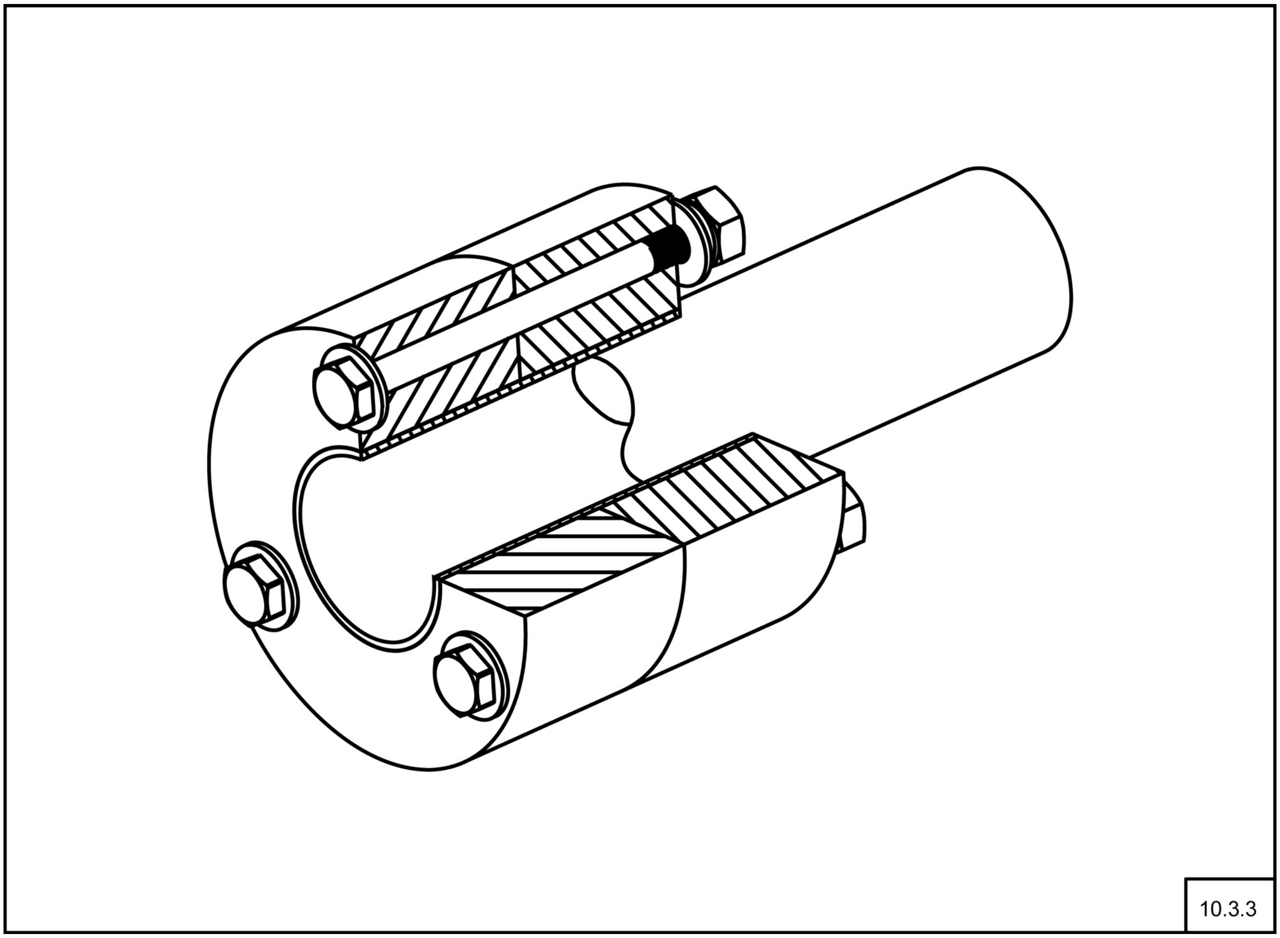


Fig. 10-17 Section Through Shafts, Keys, Bolts, Nuts, and Like Items

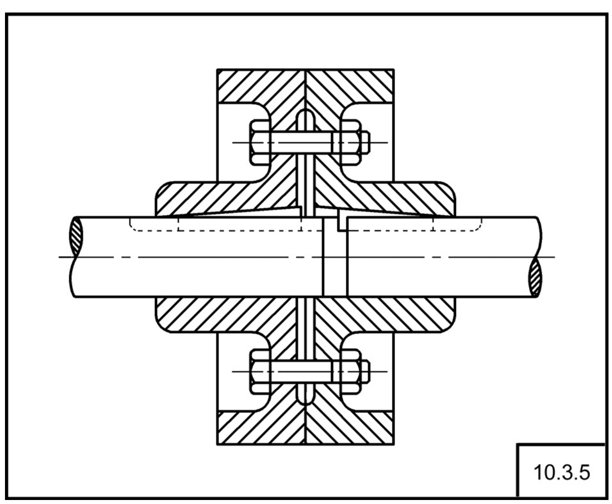


Fig. 10-18 Spokes in Section

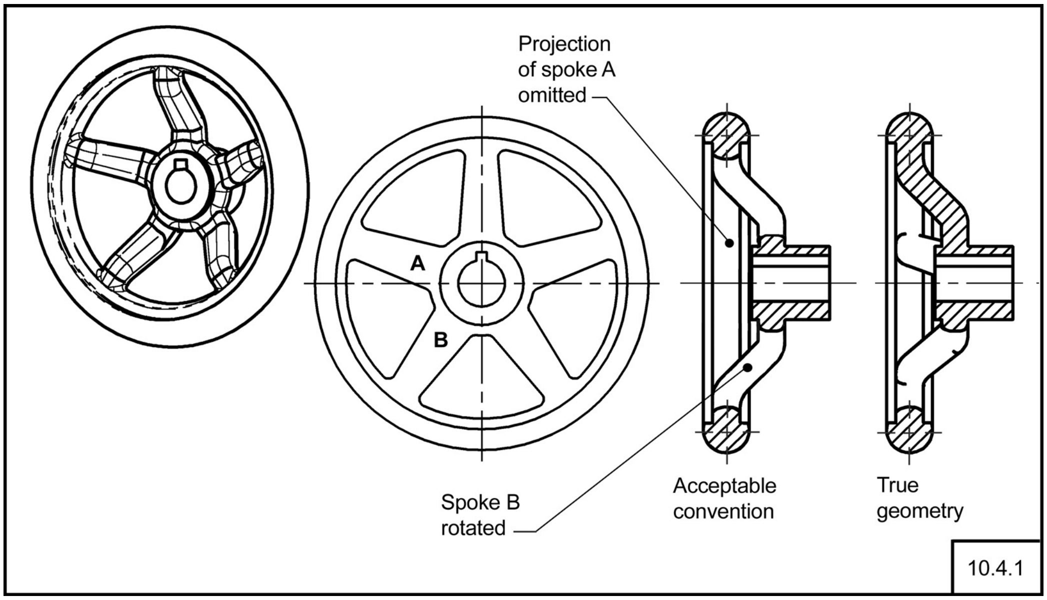


Fig. 10-19 Rotated Features

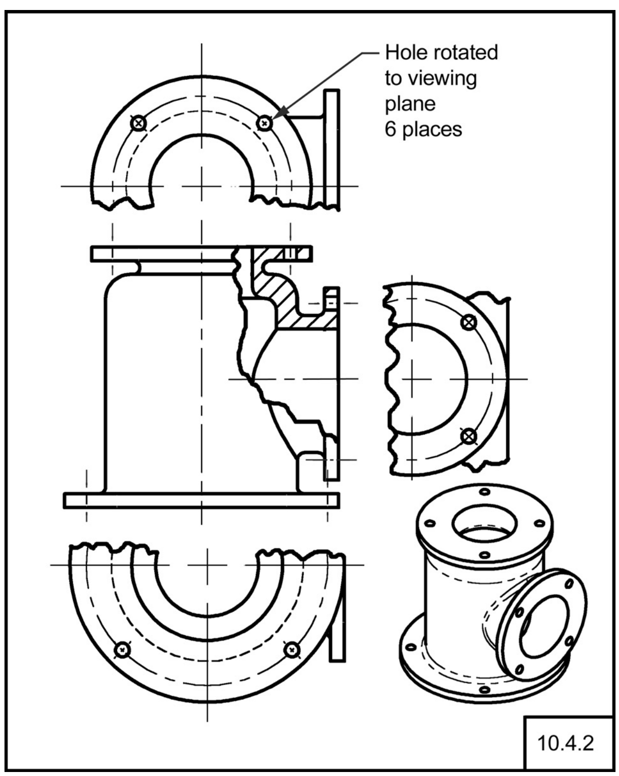


Fig. 10-20 Conventional Representation of Rotated Features

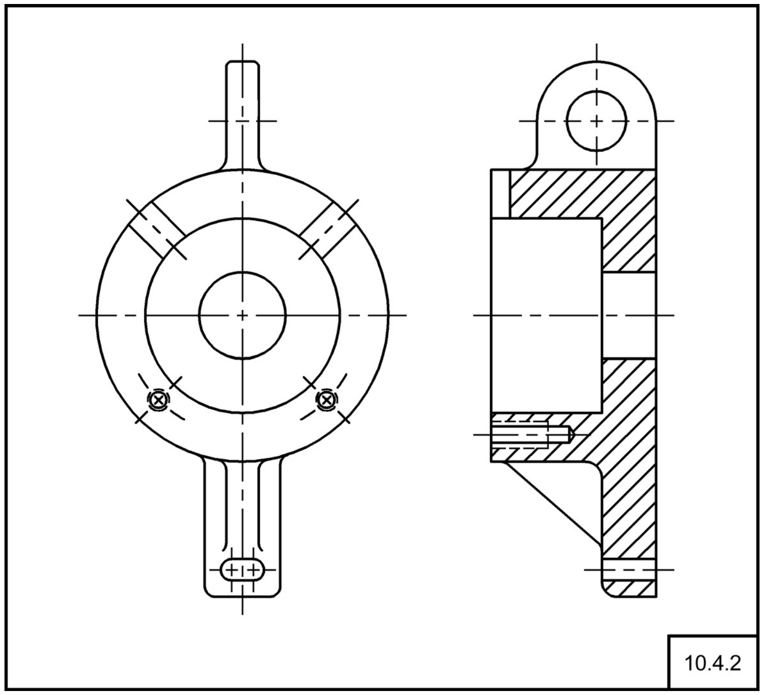


Fig. 10-21 Intersections in Section

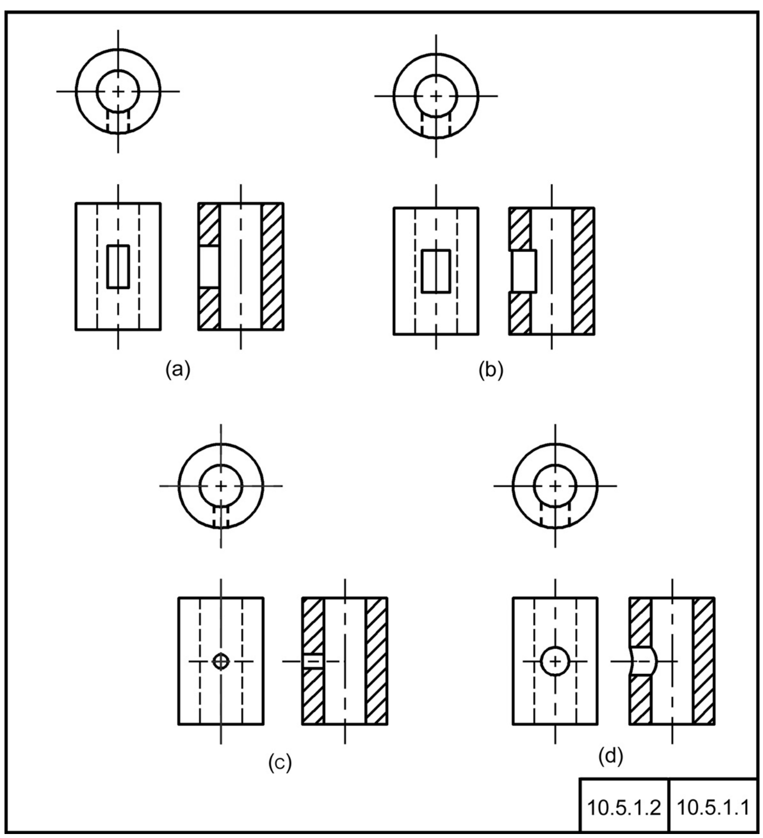
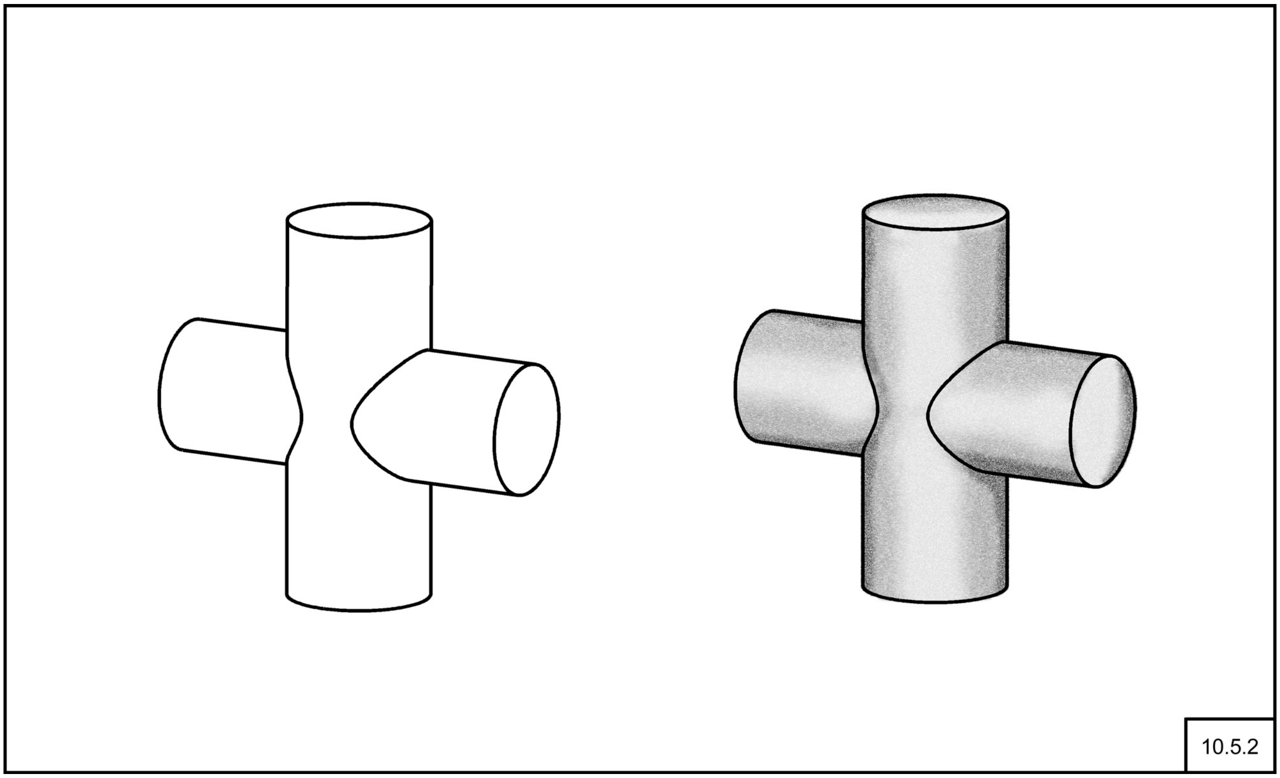


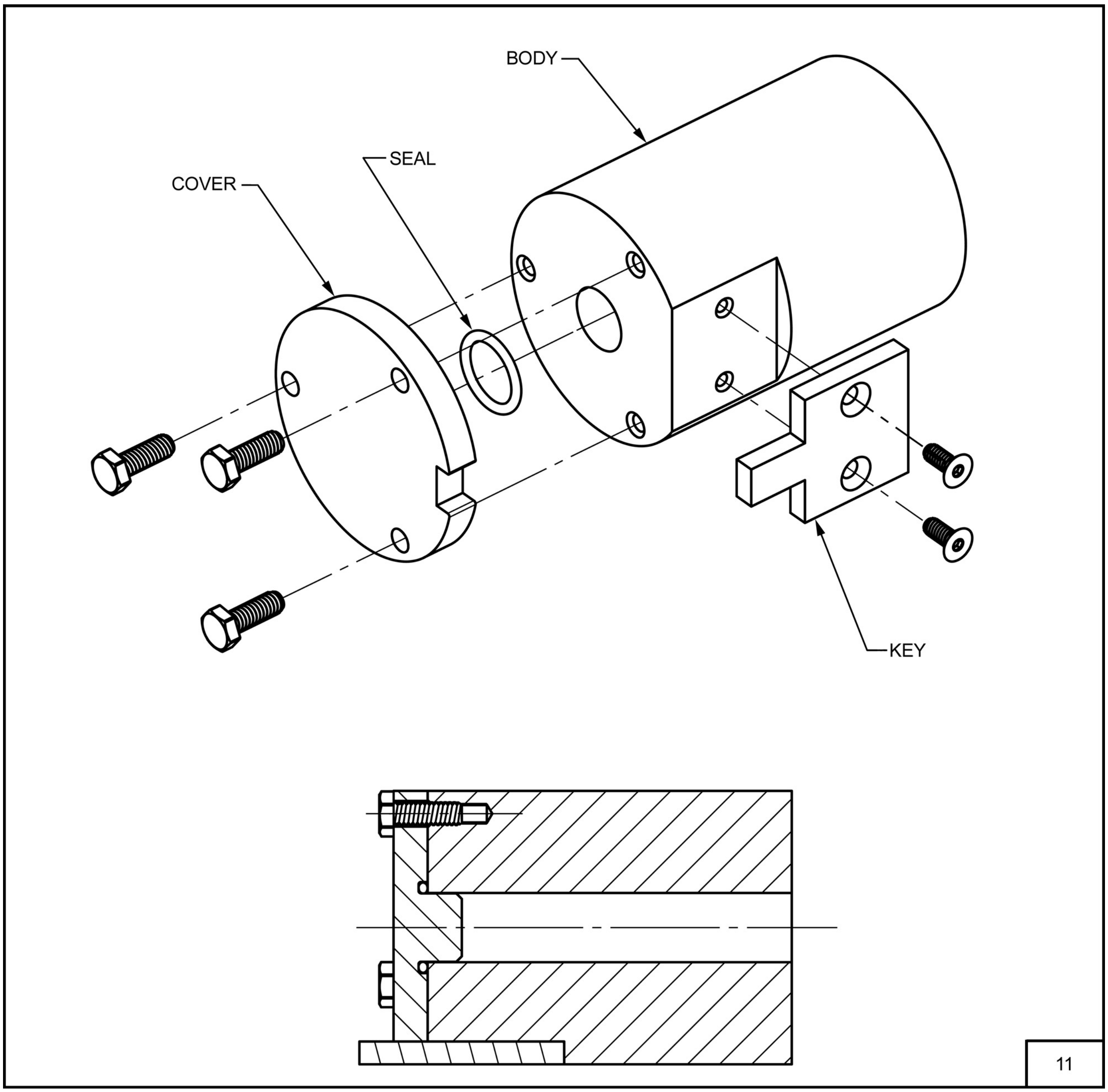
Fig. 10-22 Intersections



11 EXPLODED PICTORIAL ASSEMBLY VIEWS

An exploded pictorial assembly view shows the parts of an assembly separated but in proper position and alignment for reassembly. Exploded views are used extensively in service manuals and as aids in assembling or erecting machines or structures. Any type of pictorial view may be used for this purpose. Figure 11-1 is an example of a dimetric pictorial view exploded for use in assembling or ordering parts.

Fig. 11-1 Comparison of Standard Section With Exploded Assembly



12 PICTORIAL VIEWS AS ILLUSTRATIONS

Illustrations as defined in this Standard shall not be used for engineering product definition of detail parts. Illustrations for installations are not recommended, but may be used when clarity is provided by pictorial views. Illustrations may be, but are not limited to, any of the view types in the scope of this Standard. Illustrations are used for applications such as catalogs, consumer assembly instructions, parts manuals, and art. Nonmandatory Appendix C includes guidelines that may be applied to illustrations.

NONMANDATORY APPENDIX A
SPACE GEOMETRY

A-1 DEFINITION

Space geometry is the science of graphically solving problems involving space distances and relationships. (Space geometry is also referred to as descriptive geometry or engineering geometry.) The most popular and practical method of solution is that in which the principal views are supplemented by auxiliary views. Four basic types of views are used.

(a) the true-length view of a line
(b) the point view of a line
(c) the edge view of a plane
(d) the true view of a plane

A-2 REFERENCE LINES AND NOTATION

A-2.1 Reference Lines

A phantom line, used as a reference line between adjacent views, is

(a) an edge view of a plane of projection
(b) the intersection line of adjacent projection planes (a folding line or hinge line), or
(c) an artificial device employed as an aid in construction

NOTE: It is helpful when visualizing space relationships to think of each reference line as representing a 90-deg bend between the adjacent projection planes, or, in other words, a change in the observer's direction of viewing by 90 deg when going from one view to the adjacent view. The line may be labeled with letters or numerals as desired.

A-2.2 Construction of Auxiliary Views

In the construction of auxiliary views, the consistent and accurate transfer of distances from one related view to another is facilitated by the use of the reference lines. Several reference lines are shown in Fig. A-2-1. A height dimension such as *X*, measured from the reference line, shall be the same in both the front view and the related top-adjacent view. Similarly, distance *Y* shall be the same in all views that are adjacent to the front view. Any side-adjacent view shall show the same width dimension, *W*, as that shown in the front view. Distance, *Z*, illustrates the correct measurement of an auxiliary-adjacent view.

A-2.3 Identification of Views

The letters T, F, and S shown in the appendix figures, beside the reference lines and as subscripts for points, signify top, front, and side views, respectively, from which the auxiliary views are developed. The numbers 1, 2, 3, and 4 in the appendix figures signify the auxiliary views projected from the top, front, or side views or from other auxiliary views.

A-2.4 Symmetrical Items

For symmetrical items, the reference line is on an axis of symmetry. See Fig. A-2-2.

A-3 TRUE LENGTH VIEW OF A LINE

A-3.1 True Length of a Line Segment

The true length (TL) of a line segment is the actual straight-line distance between its two endpoints. The projection of a line will be in true length when in the adjacent view, the subject line is parallel to the reference line between the views. A line that is in true length in a principal view is called a principal line (lines AB in the top view and CD in the front view of Fig. A-3-1).

A-3.2 Oblique Lines

An oblique line (line BC in Fig. A-3-1) is not in true length in any principal view. Its true length is found in a primary auxiliary view, such as view 1 or 2 in Fig. A-3-1, when the reference line is parallel to the line in the given views.

A-4 POINT VIEW OF A LINE

A view with the direction of sight parallel to a straight line in space provides a point view of the line. See Fig. A-3-1. A point view of a line is adjacent to a true length view, and the reference line is perpendicular to the true length projection of the line. The point view appears in a secondary auxiliary view as if the line is in true length in a primary auxiliary view. See line B_1C_1 and point B_3C_3 in Fig. A-3-1.

A-5 EDGE VIEW OF A PLANE

(a) A view with the direction of sight parallel to a plane in space gives the observer a straight line or edge view of the plane. An edge view is obtained whenever any line on the plane appears as a point.

(b) When any line of the plane is in true length in one view (line A_TB_T or assumed line A_FE_F in Fig. A-5-1), then a point view of that true-length line will also show the plane as an edge (view 1 or 3 in Fig. A-5-1).

A-6 TRUE VIEW OF A PLANE

A true view is the direction of sight perpendicular to a plane. See Fig. A-5-1, views 2 and 4. A true view of a plane is adjacent to an edge view, and the reference line is parallel to the edge view.

Fig. A-2-1 Standard Use of Reference Lines Between Views

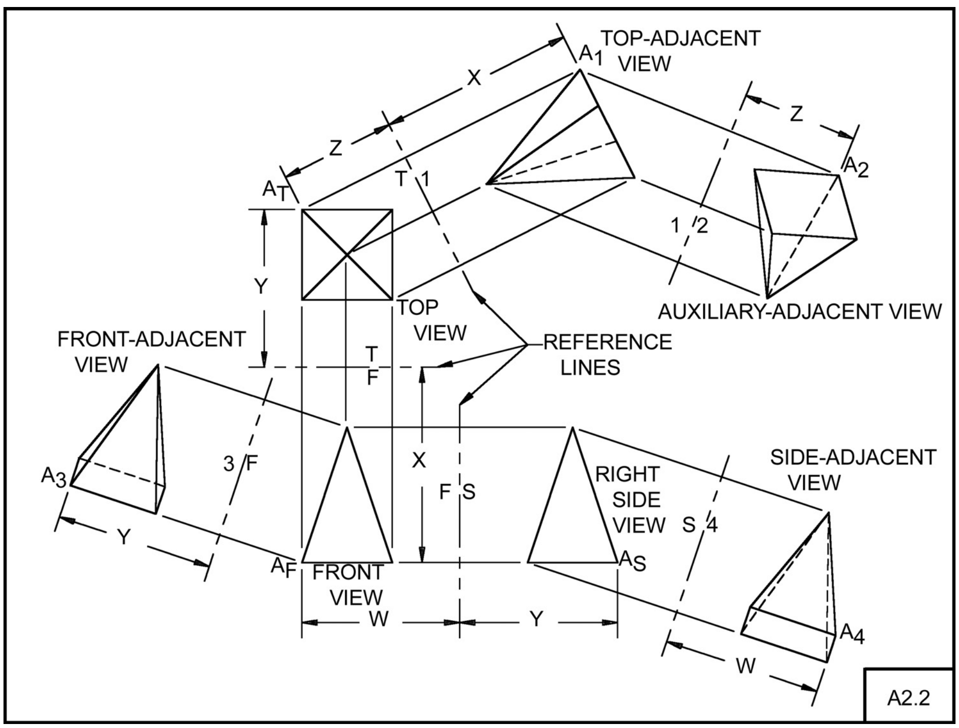


Fig. A-2-2 Symmetrically Placed Reference Line

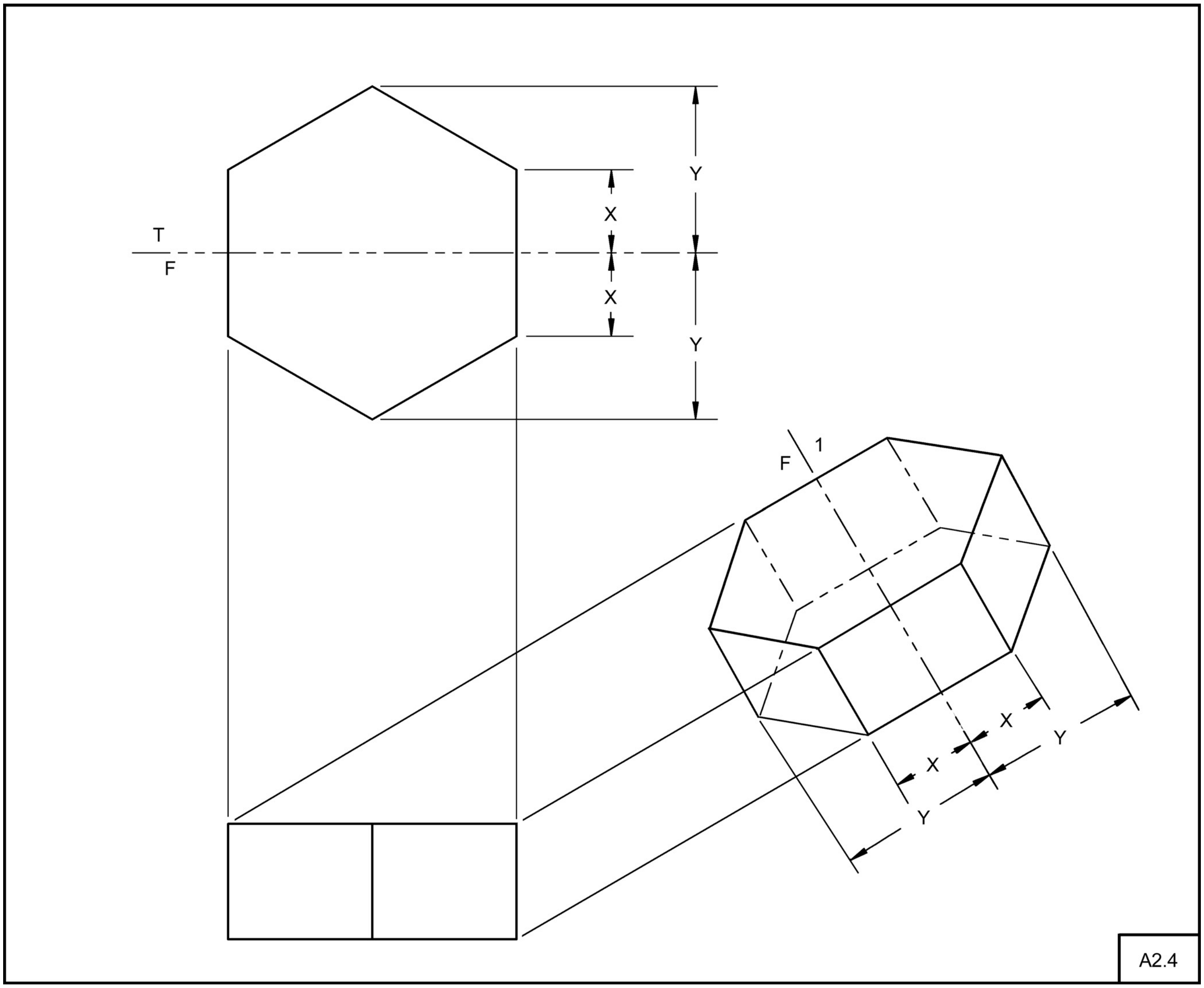


Fig. A-3-1 True Lengths and Point Views of Lines

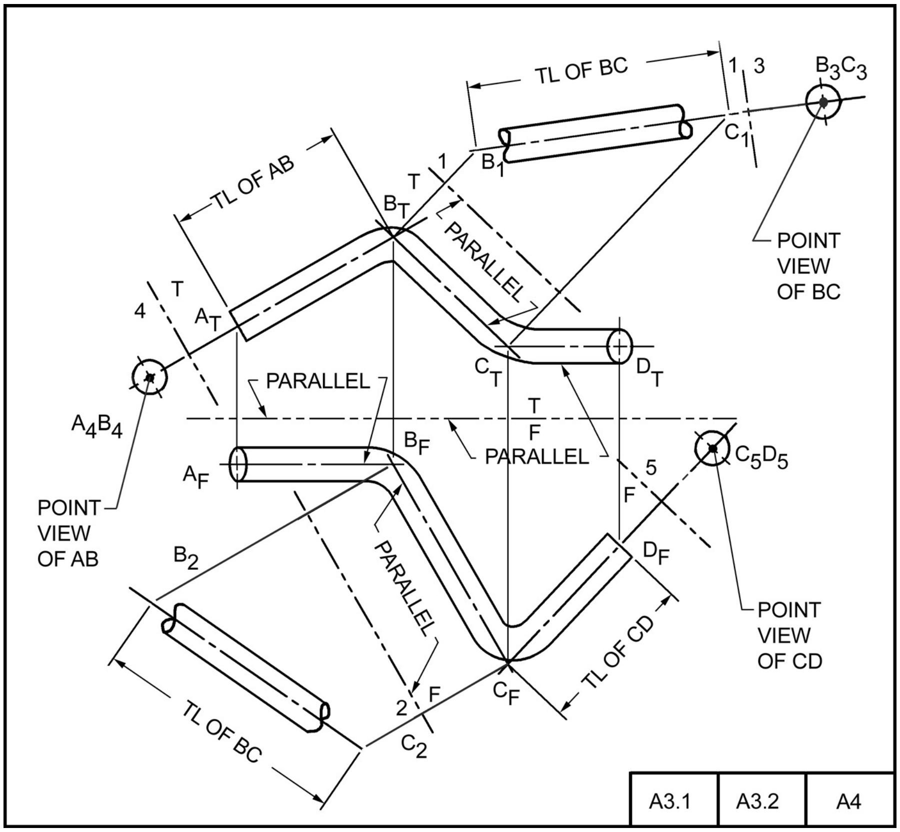
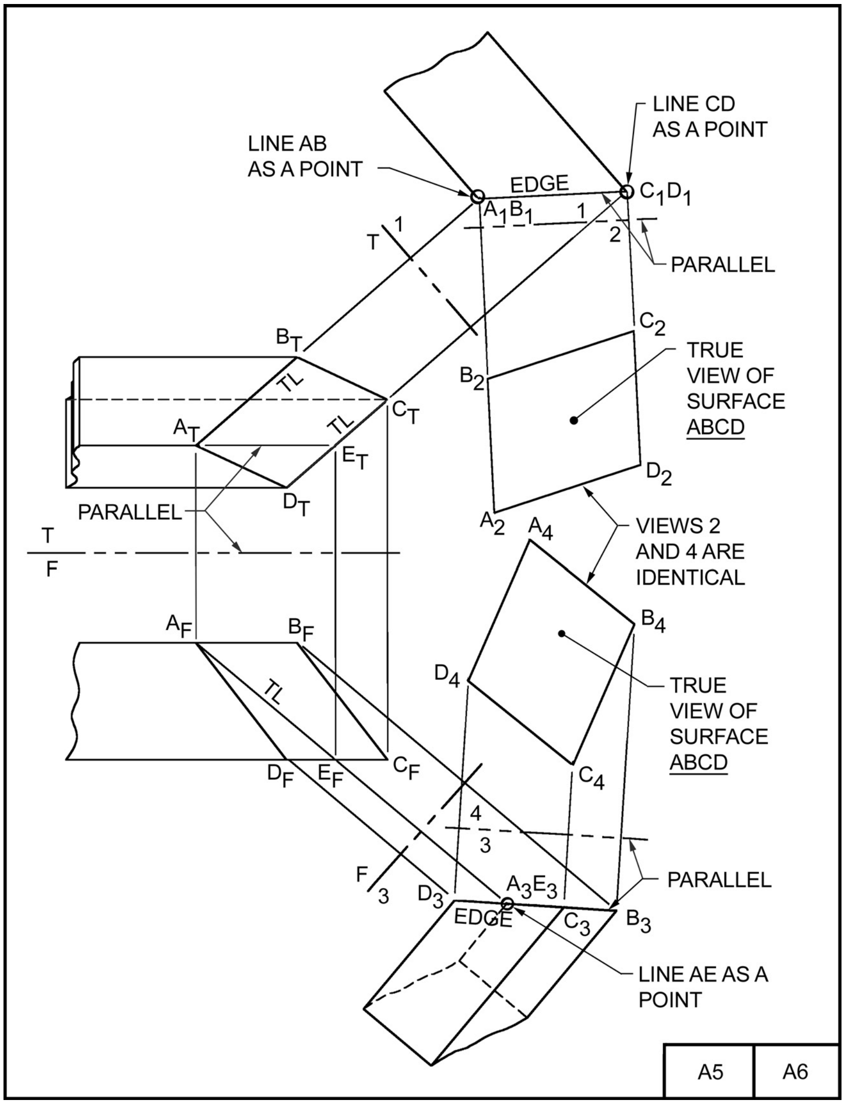


Fig. A-5-1 Edge and True Size Views of a Plane Surface



NONMANDATORY APPENDIX B
SPACE ANALYSIS AND APPLICATIONS

B-1 GENERAL

To make a space analysis, it is usually helpful to simplify the problem by reducing it in terms of points, lines, and planes. A pipe can be considered in terms of its center line, or a plane surface can be treated by using only three points, a point and a line, or two lines that lie on the plane surface.

B-2 CLEARANCE BETWEEN A POINT AND A LINE

B-2.1 Point Method

In a view of the point and line which shows the line as a point, the clearance between the line and point will be in true length. View 2 of Fig. B-2-1 shows the clearance between oblique line AB and point C.

B-2.2 Plane Method

By an alternative method, the point and line can be treated as a plane, and in the true view of the plane, the perpendicular distance from the point to the line is the clearance. See Fig. B-2-2.

B-3 CLEARANCE BETWEEN TWO LINES

In a view of the two lines which shows one of the lines as a point, the clearance between the two lines will be in true length as the perpendicular distance from the point to the line. View 2 of Fig. B-3-1 shows the clearance between oblique lines AB and CD.

B-4 CLEARANCE BETWEEN A POINT AND A PLANE

In a view of the point and plane that shows the plane as an edge, the clearance will be in true length as a perpendicular distance from the point to the edge. View 1 of Fig. B-4-1 shows the clearance between plane ABC and point X.

B-5 POINT OF INTERSECTION OF A LINE AND A PLANE

(a) When a vertical plane, that is an edge in the top view, is passed through the given line, the line of intersection of this plane with the given plane, as observed in the front view, will intersect the given line at the piercing point. In Fig. B-5-1, line MN is the line of intersection between the given plane, ABC, and the vertical plane passing through the given line, XY. Line MN intersects line XY at the piercing point, P. It is equally effective to pass a plane appearing as an edge in the front view through the given line.

(b) *Alternative Method*. A view of the line and plane showing the plane as an edge can be used to locate the point of intersection of the line and plane.

(c) The planes in Figs. B-5-1, B-5-2, and B-5-3 are considered opaque with a corresponding visibility of lines in each instance.

B-6 LINE OF INTERSECTION OF TWO PLANES

(a) When the points are determined when two lines on one plane pierce another plane, a line connecting the piercing points will be the line of intersection of the two planes. Figure B-5-2 shows the line of intersection, PR, of planes ABC and DEFG as if plane ABC were extended in area. PS is the segment of the line of intersection common to the bounded planes.

(b) *Alternative Method*. A view of two planes showing one of the planes as an edge will locate the line of intersection. Figure B-5-3 shows the line of intersection PR of planes ABC and DEFG through this method.

B-7 ANGLE BETWEEN TWO INTERSECTING LINES

Two intersecting lines form a plane whose true view is found by the method of A6. The angle between the two lines will be shown in the true view. In Fig. B-7-1, the true size of the angle ABC is found at B_2.

B-8 ANGLE BETWEEN A LINE AND A PLANE

A view in which the plane appears as an edge and the line appears true-length will show the true angle between the line and plane. Any view adjacent to a true view of a plane will show the plane as an edge. This principle is employed in Fig. B-8-1 where reference line 2-3 is drawn parallel to X_2Y_2 to obtain a true-length view of XY and an edge view of plane ABC in view 3.

B-9 ANGLE BETWEEN TWO PLANES

The line of intersection between two planes is first identified or found by the method of para. B-6. A view of the two planes with the line of intersection appearing as a point will show the required angle. Both planes will appear as edges in this view. View 2 of Fig. B-9-1 shows the angle between planes M and N.

Fig. B-2-1 Clearance Between a Point and a Line (Point Method)

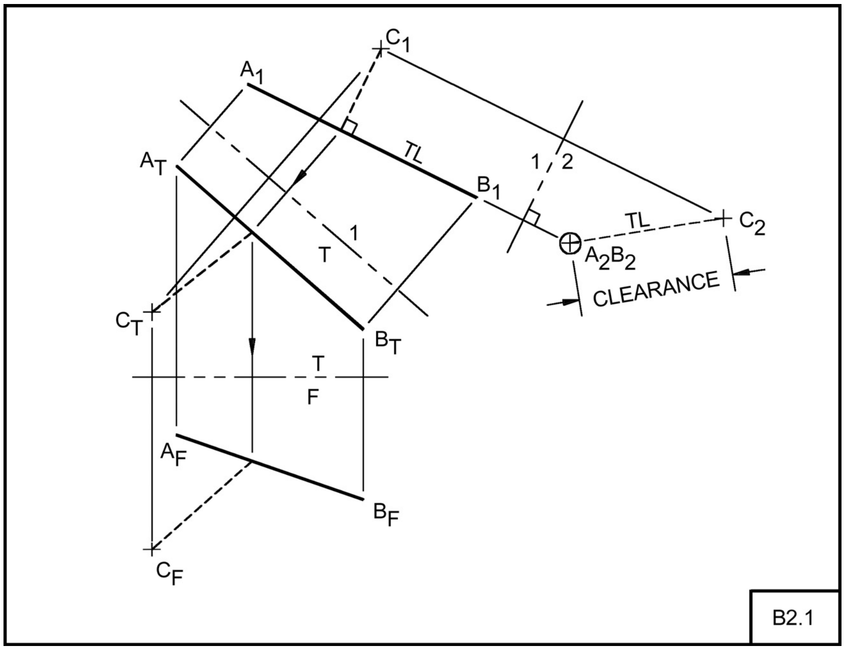


Fig. B-2-2 Clearance Between a Point and a Line (Plane Method)

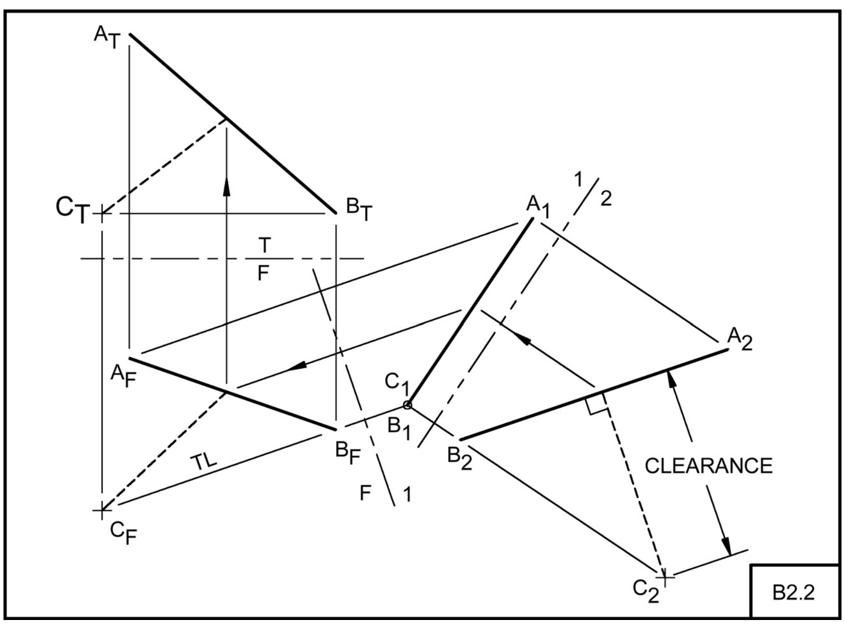


Fig. B-3-1 Clearance Between Two Oblique Lines

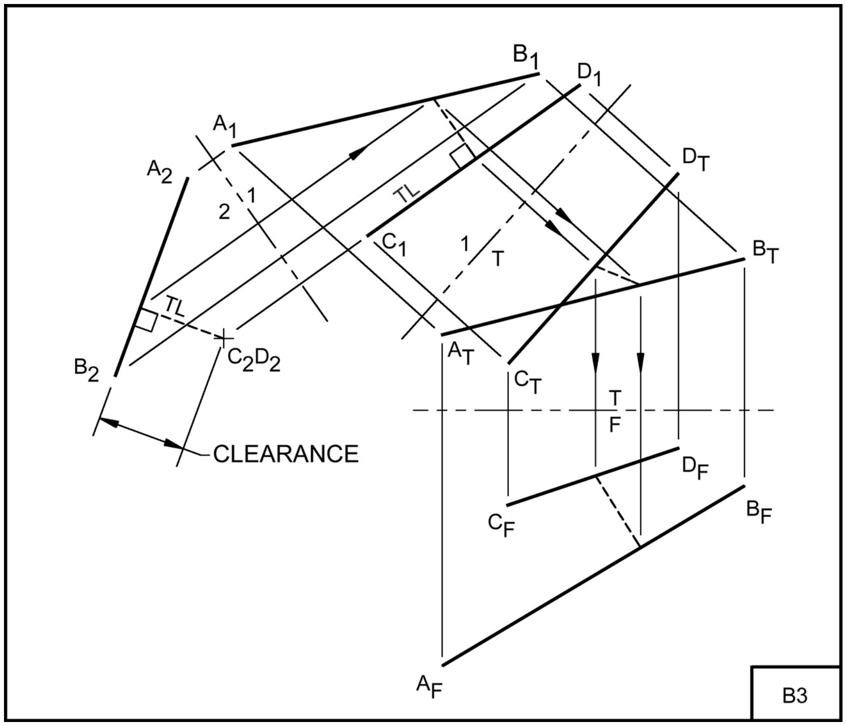


Fig. B-4-1 Clearance Between a Point and a Plane

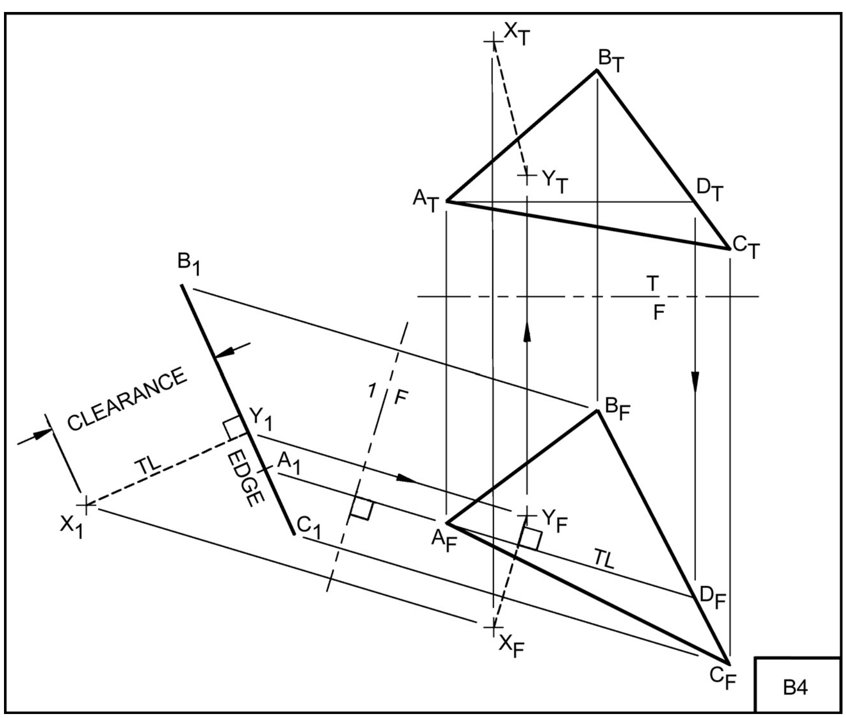


Fig. B-5-1 Intersection of a Line and a Plane (Piercing Point)

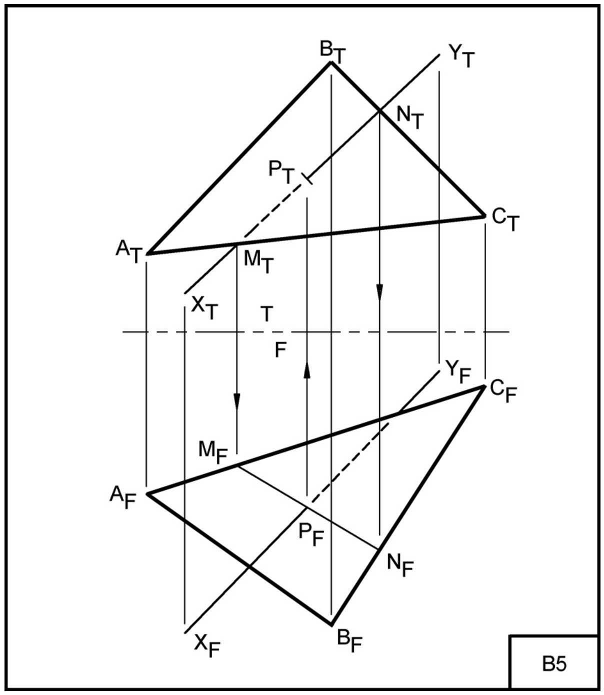


Fig. B-5-2 Intersection of Two Planes

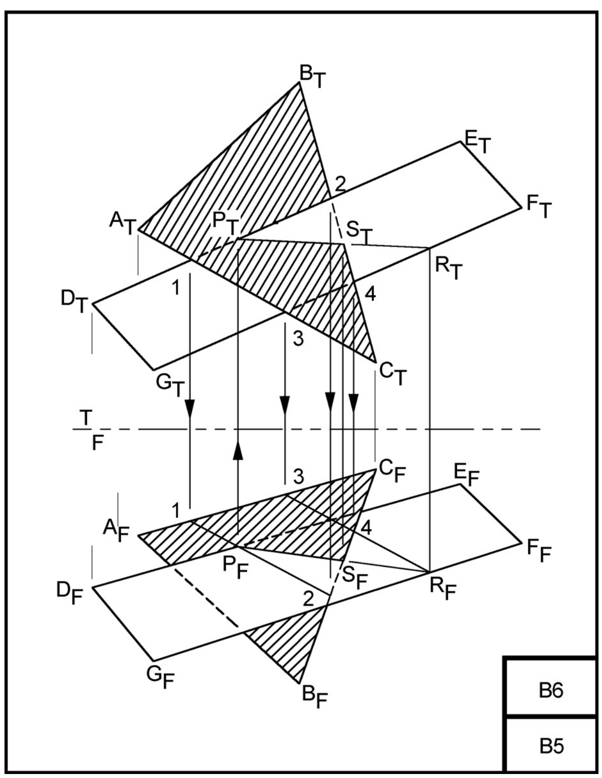


Fig. B-5-3 Intersection of Two Planes (Alternate Method)

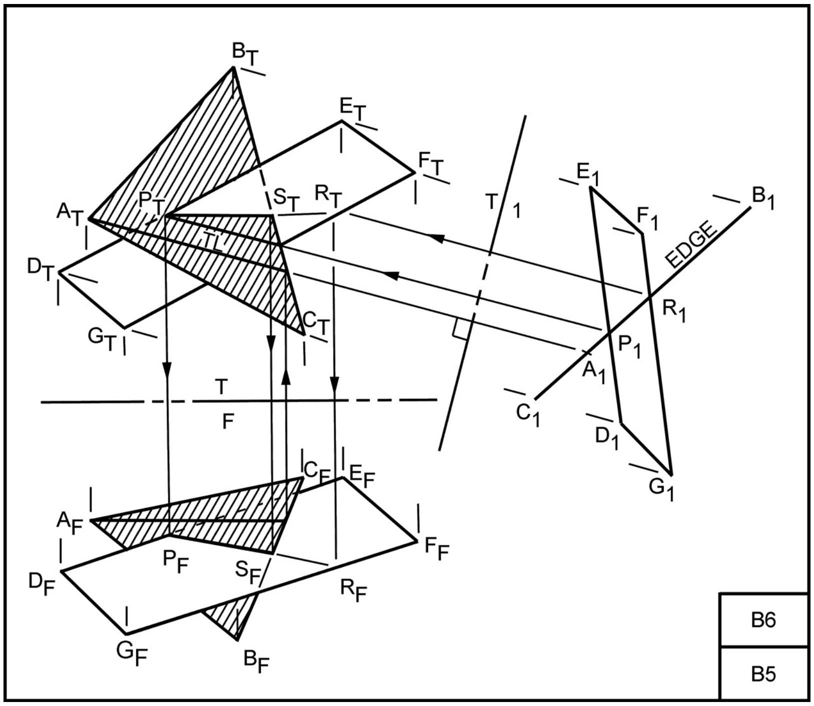


Fig. B-7-1 Angle Between Two Intersecting Lines

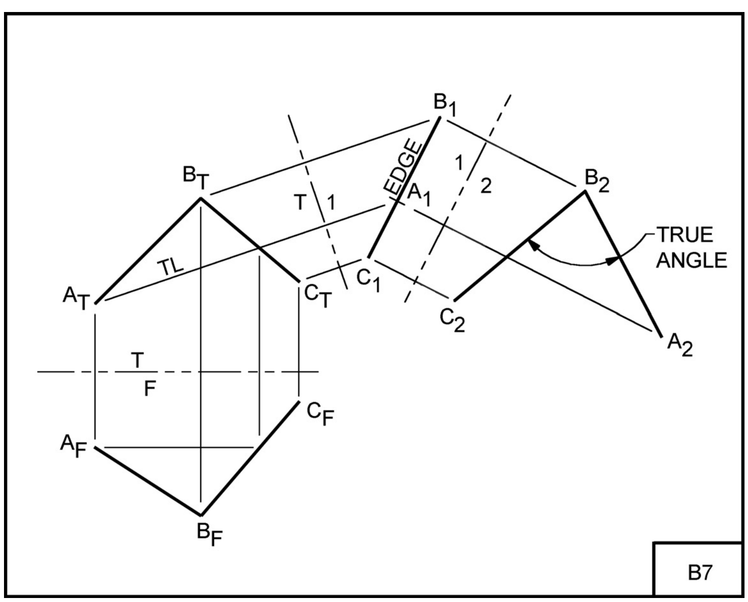


Fig. B-8-1 Angle Between a Line and a Plane

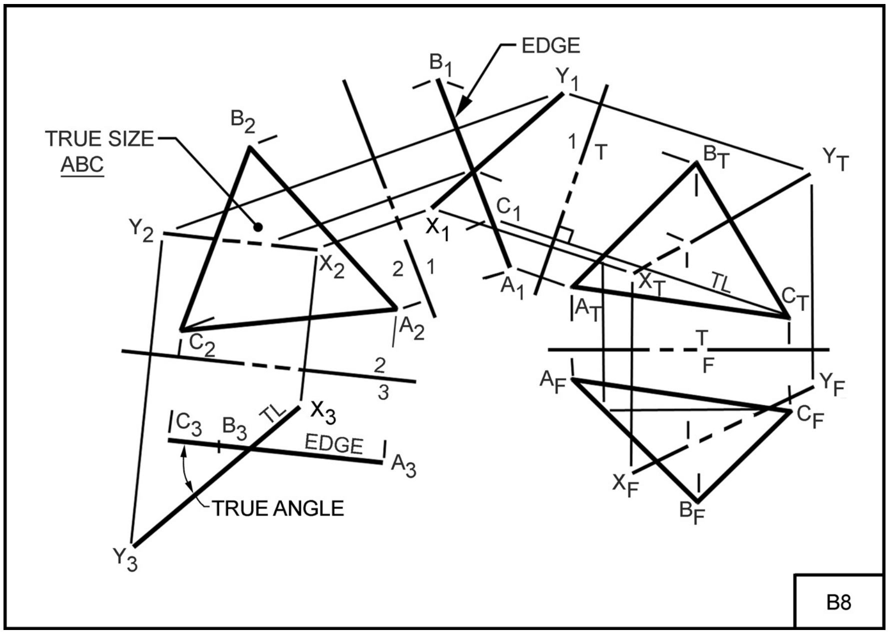
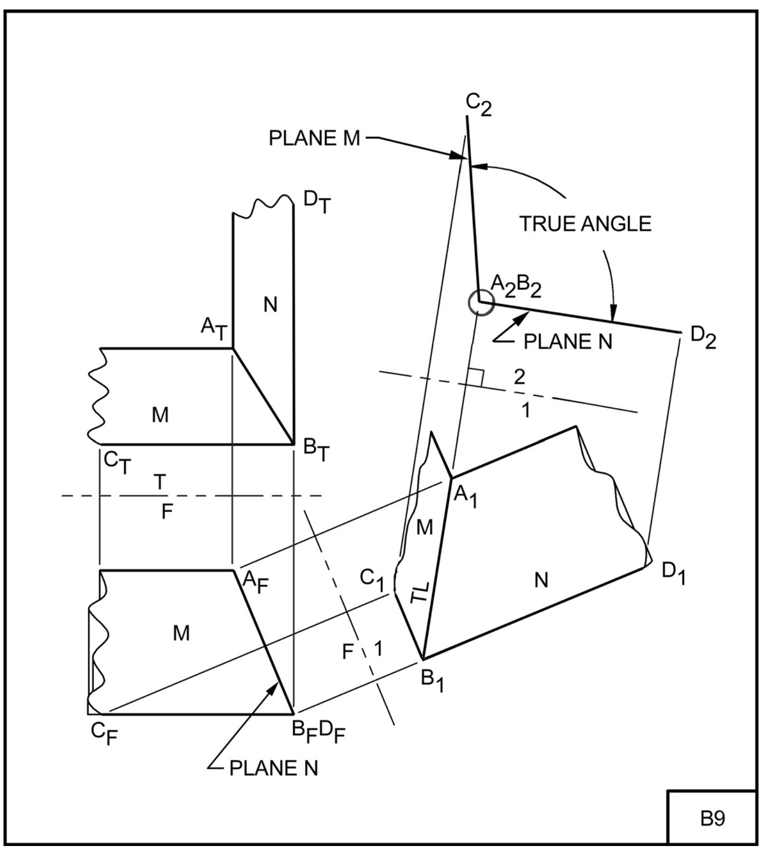


Fig. B-9-1 Angle Between Two Planes



NONMANDATORY APPENDIX C
ILLUSTRATIONS

C-1 GENERAL

This Appendix includes explanation of some of the practices used when creating illustrations. These practices are not mandatory and are not applicable to views created for product definition.

C-2 THREAD REPRESENTATION

Threads shall be represented in a pictorial drawing by a series of ellipses or circles uniformly spaced along the center line of the thread. Shading may be used in addition to the lines. See Fig. C-2-1. Threads are equally spaced, but the distance between adjacent threads does not have to equal the actual pitch.

C-3 SHADING

Shading may be used on pictorial drawings. The type of shading depends on the purpose of the drawing and method of reproduction. See Fig. C-3-1.

C-3.1 Shading of Engineering Drawings

It is recommended that pictorial views on engineering drawings not be shaded. Object lines of varying widths may be used to improve the visualization quality of the drawing and vary the emphasis on individual details.

C-4 SHADING ON ILLUSTRATIONS

Shading may be used on illustrations. The type of shading depends on the purpose of the illustration and method of reproduction. See Fig. C-3-1.

C-4.1 Shading of Catalog Illustrations

Some form of overall shading is recommended for catalog illustrations. Air brush rendering and commercially available shading media may be used for this purpose. See Fig. C-4-1.

C-5 DIMENSIONING AND TOLERANCING

Dimensioning and tolerancing shall be in accordance with ASME Y14.5. Dimensions and tolerances on illustrations may digress from practices of ASME Y14.5 and Y14.41 when desired for artistic or other purposes.

C-5.1 Plane of Dimension Lines

The dimension lines, extension lines, and the lines being dimensioned should lie on the same plane.

C-5.2 Dimensions and Notes

For manually created illustrations, it is recommended that all dimensions and notes be unidirectional, read from the bottom of the drawing up, and located outside the view whenever possible. See Fig. C-5-1.

C-6 PHANTOM DRAWINGS

A phantom drawing is a pictorial drawing which shows the outer shell or covering and, at the same time, the interior part of an assembly. The outer parts or the covering material are shaded in light tones and the interior parts are shaded in darker tones. See Fig. C-6-1.

C-7 PHOTOGRAPHIC DRAWINGS

Pictorial illustrations for single parts and for exploded views may be prepared by photography. Photographs and line details may be combined into a single drawing. See Fig. C-7-1.

Fig. C-2-1 Representation of Threads

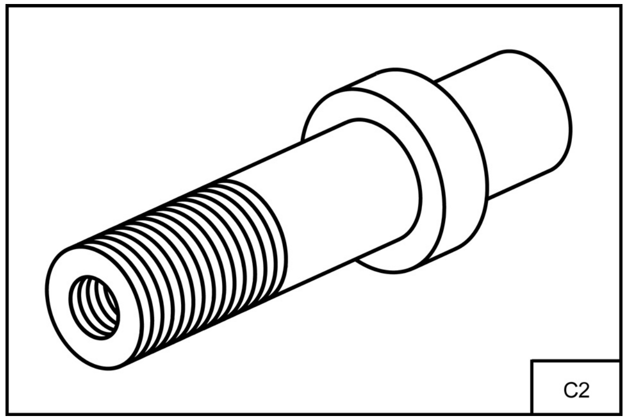


Fig. C-3-1 Shading of Pictorial Drawings

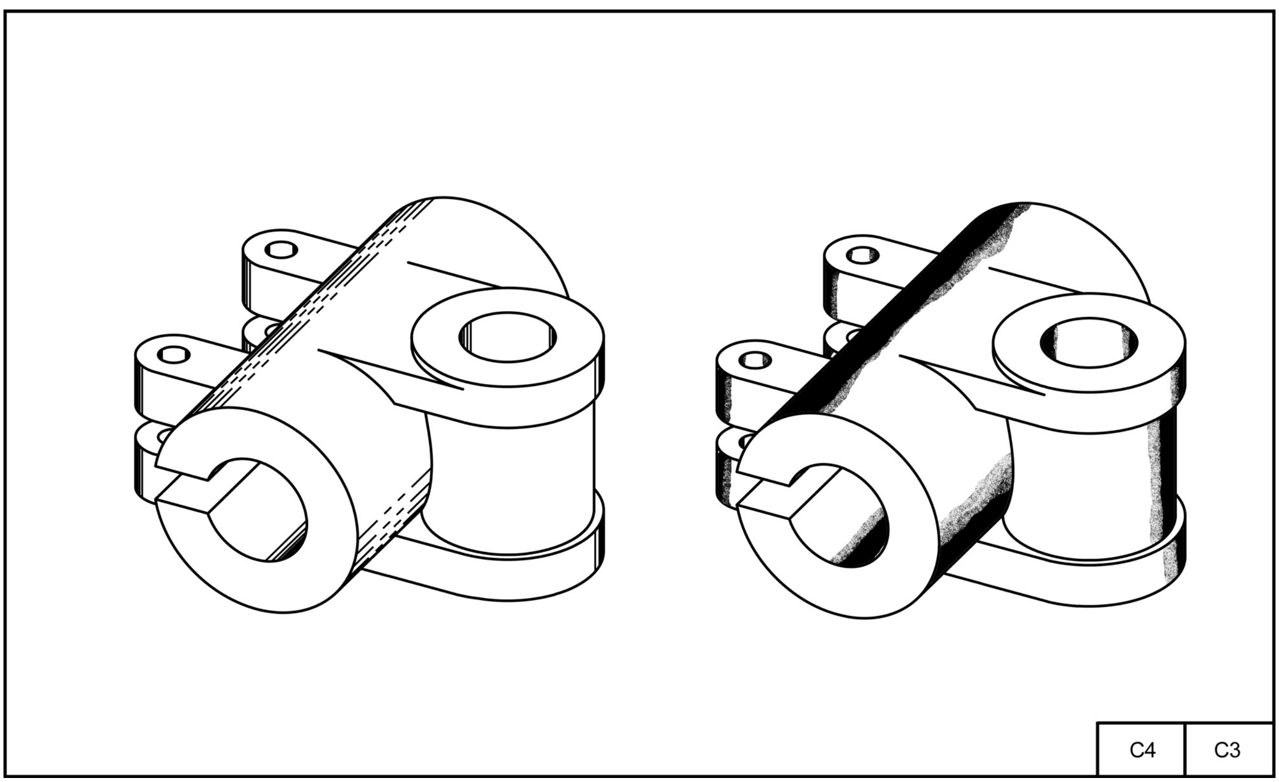


Fig. C-4-1 Shading of Catalog Illustrations

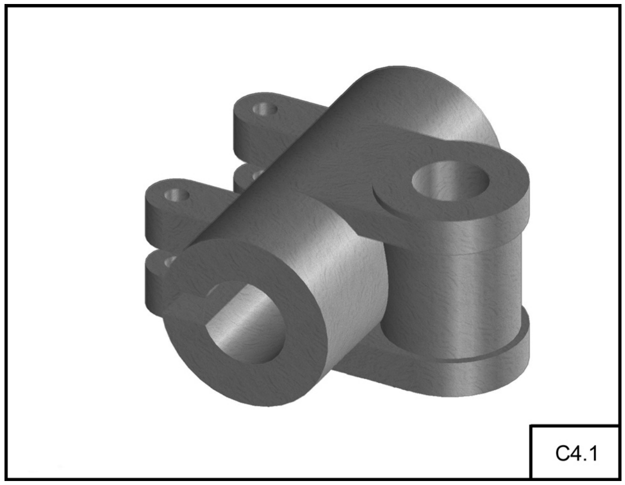


Fig. C-5-1 Unidirectional Dimensions and Notes

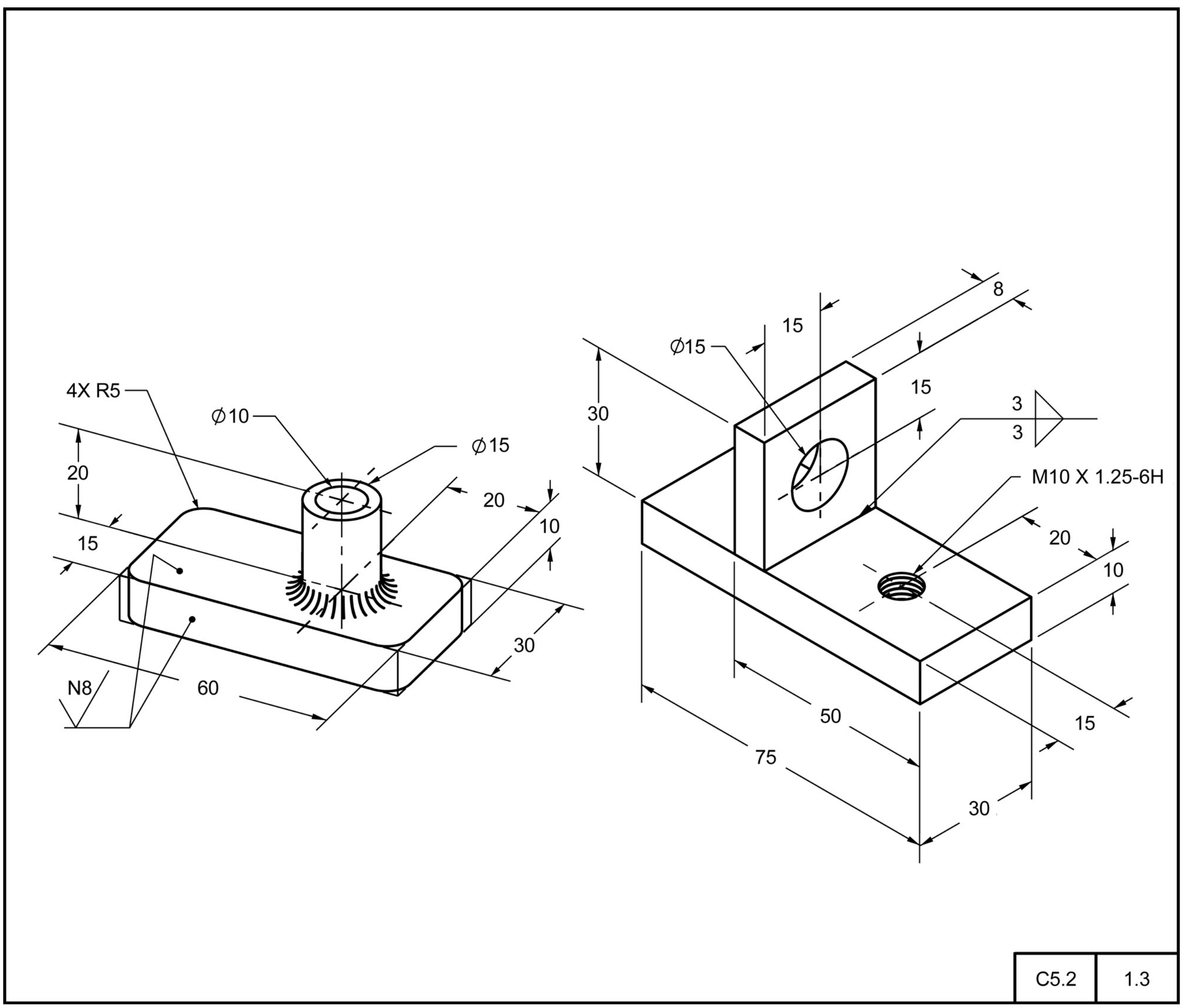


Fig. C-6-1 Phantom Drawings

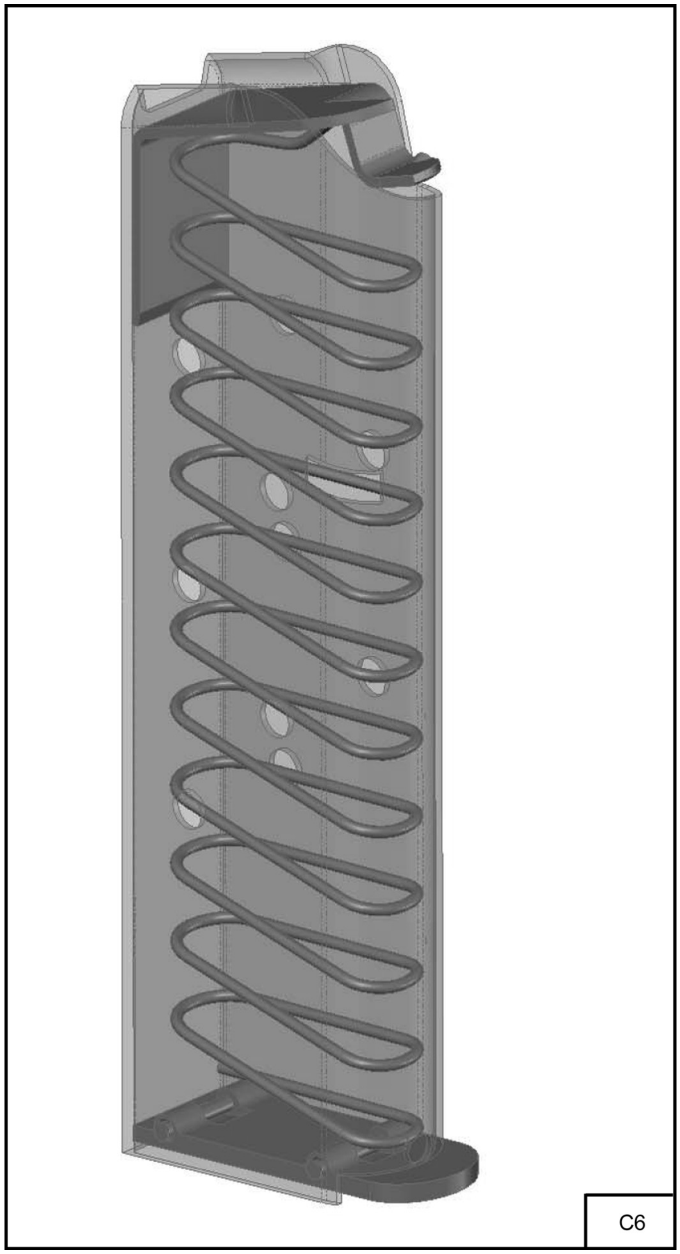
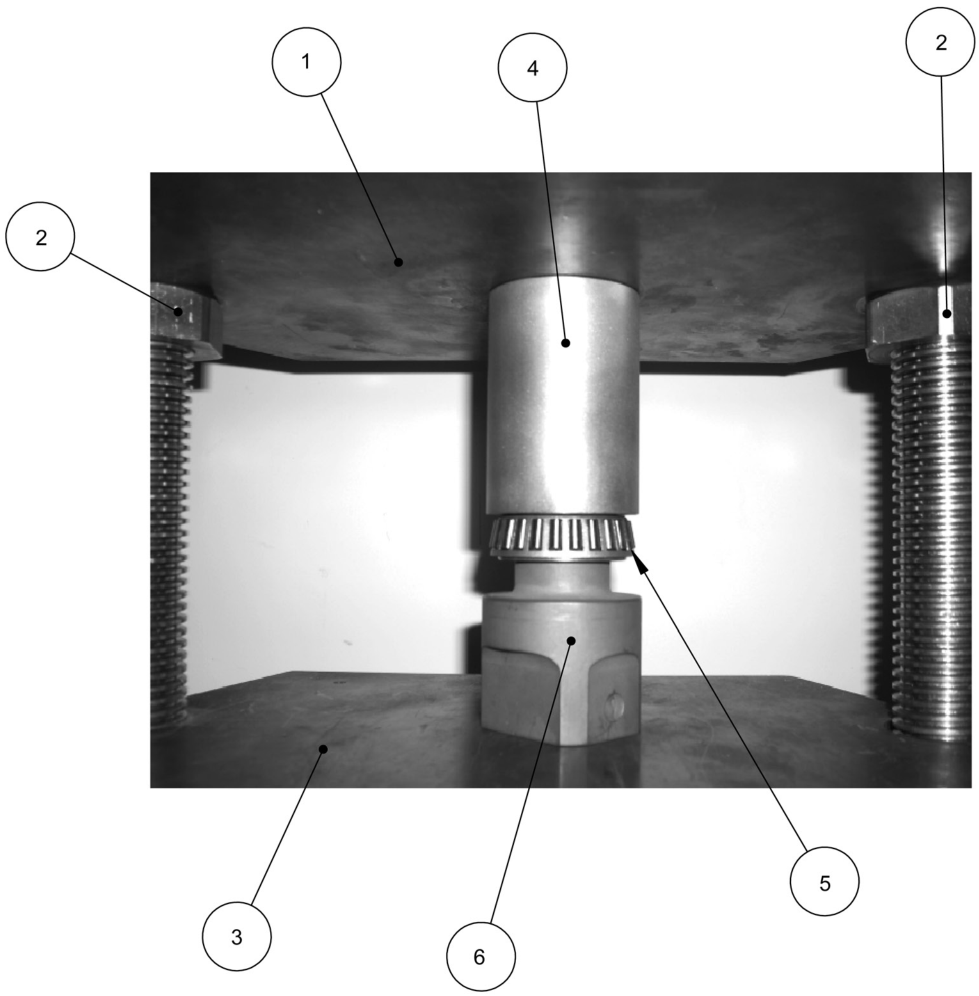


Fig. C-7-1 Photographic Drawings



PARTS LIST

1. UPPER PLATE
2. STANDOFF
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4. UPPER BEARING PLATE
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