ASME Y14.37-2012

Composite Part Drawings

Engineering Drawing and Related Documentation Practices

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

Three 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.

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

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

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

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FOREWORD

This Standard establishes engineering practices for the definition of Composite Parts and together with related documentation practices in the Y14 Series will enable full composite part definition.

When this Standard is specified as a requirement, its defined requirements are assumed to be consistent with the needs of the user. Therefore, each user provides appropriate application consistent with the environment in which it is applied. Those who use this Standard as a requirement for contractual purposes should keep the following facts in mind:

(a) This Standard should be tailored to meet any specific needs. All users shall take careful note of the necessity of tailoring this Standard and the contents. The extent of tailoring will in large part be governed by drawing ownership and the logistics intent.

(b) It is not the intent of this Standard to prevent individual organizations from designing specific drawing practices that meet their individual needs, but rather to provide common engineering delineation standards to aid the increasing interchange of drawing among industry, government, and other users.

It is well recognized that individual companies have many detailed requirements for their specific method of operation. Consequently, the minimum requirements set forth in this Standard will provide them flexibility in implementation.

The successful creation and release of this Standard is attributed to the subcommittee members and their respective companies.

Suggestions for improvement of this Standard are welcome. They should be sent to the American Society of Mechanical Engineers; Attn: Secretary, Y14 Standards Committee; Three Park Avenue; New York, NY 10016-5900.

This Standard was approved as an American National Standard on April 10, 2012.

ASME Y14 COMMITTEE
Engineering Drawing and Related Documentation Practices

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

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

Secretary, Y14 Standards Committee
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Three Park Avenue
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Proposing Revisions. Revisions are made periodically to the Standard to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published periodically.

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

Proposing a Case. Cases may be issued 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.

COMPOSITE PART DRAWINGS

1 SCOPE

This Standard establishes the definition of composite parts that are not covered within the existing ASME Y14 Series of standards. This Standard defines exceptions and additional requirements to existing ASME standards for defining composite parts. Composite parts as addressed by this Standard are inseparable assemblies of composite materials that may include noncomposite material(s). When no exception or additional requirements are stated, existing ASME standards shall apply.

1.1 ASME Y14 Series Conventions

The conventions in paras. 1.1.1 through 1.1.10 are guidance used in this and other ASME Y14 Series of standards.

1.1.1 Mandatory, Nonmandatory, Guidance, and Optional Words

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

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

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

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

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

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

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

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

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

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

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

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

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

1.1.5 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.

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

1.1.7 Units. U.S. Customary units are featured in this Standard. It should be understood that International System of Units (SI) could equally have been used without prejudice to the principles established.

1.1.8 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. The absence of a listing is not a reason to assume inapplicability. 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.

1.1.9 Precedence of Standards. The following are Y14 Standards that are basic engineering drawing standards:

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

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

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

2 REFERENCES

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

ASME Y14.5-2009, Dimensioning and Tolerancing
ASME Y14.34-2008, Associated Lists
ASME Y14.35M-1997 (R2008), Revision of Engineering Drawings and Associated Documents
ASME Y14.41-2003 (R2008), Digital Product Definition Data Practices
ASME Y14.100-2004 (R2009), Engineering Drawing Practices
Publisher: The American Society of Mechanical Engineers (ASME), Three Park Avenue, New York, NY 10016-5990; Order Department: 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900 (www.asme.org)

MIL-HDBK-17, Composite Materials Handbook
Publisher: Department of Defense Single Stock Point (DODSSP), 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094. Copies are available on-line at http://assist.daps.dla.mil/quicksearch/.

3 DEFINITIONS

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

3.1 Adhesive

adhesive: a substance capable of holding two materials together by surface attachment (MIL-HDBK-17).

3.2 Annotation

annotation: dimensions, tolerances, notes, text, or symbols visible without any manual or external manipulation (ASME Y14.41).

3.3 Band

band: the width of the collection of tows or prepreg tape that a machine can lay down on the work surface.

3.4 Bond

bond: the adhesion of one surface to another, with or without the use of an adhesive as a bonding agent (MIL-HDBK-17).

3.5 Braid Angle

braid angle: the acute angle measured from the axis of braiding (MIL-HDBK-17).

3.6 Braid, Biaxial

braid, biaxial: braided fabric with two-yarn systems, one running in the +0 direction, the other in the −0 direction as measured from the axis of braiding (MIL-HDBK-17).

3.7 Braid, Triaxial

braid, triaxial: a biaxial braided fabric with laid-in yarns running in the bias of braiding (MIL-HDBK-17).

3.8 Braiding

braiding: a textile process where two or more strands, yarns, or tapes are intertwined in the bias direction to form an integrated structure (MIL-HDBK-17).

3.9 Cocured

cocured: simultaneously cured and bonded to another prepared surface.

3.10 Composite Material

composite material: a material made by imbedding load carrying fibers within an essentially homogeneous resin matrix.

3.11 Composite Part

composite part: an inseparable assembly of composite material(s) that may include noncomposite material(s). See Fig. 3-1, illustrations (a) and (b).

3.12 Core

core: an internal item of a sandwich construction to which the sandwich faces or skins are attached.

3.13 Core Ribbon Direction

core ribbon direction: an indicator that shows the direction of maximum shear strength and rigidity along the continuous webs of material.

3.14 Cure

cure: to change the properties of a thermosetting resin irreversibly by chemical reaction. Cure may be accomplished by addition of curing agents, with or without catalyst, and with or without heat and pressure (MIL-HDBK-17).

3.15 EOP

EOP: end of part.

3.16 EOPM

EOPM: edge of ply material.

3.17 Helical (Helix) Ply

helical (helix) ply: two windings, one for each of the plus/minus orientations.

3.18 Laminate

laminate: the product resulting from the uncured buildup of two or more ply levels of material. See Fig. 3-2.

3.19 Ply

ply: one discrete piece of manufactured material such as fabric, tape, adhesive film, etc. See Fig. 3-2.

3.20 Ply Drop-Off

ply drop-off: when the edge of ply material (EOPM) does not correspond with the end of part (EOP) and ends inside the EOP.

3.21 Ply Identification

ply identification: a temporary identification that is not a part or identifying number in accordance with ASME Y14.100.

3.22 Ply Level

ply level: the relative position from the tool surface of one or more discrete materials or plies in a laminate. See Fig. 3-2.

3.23 Ply Orientation

ply orientation: the direction of the reinforcing fiber within a laminate that may be at any angle but are normally 0 deg, 90 deg, +45 deg, or −45 deg relative to a fixed reference direction on the part as indicated by a ply orientation symbol.

3.24 Ply Stackup View

ply stackup view: a view representing the ply level relationship of each ply and other items within the laminate.

3.25 Ply Table

ply table: a table annotating the plies and items that are applicable to a composite part. See Fig. 9-1.

3.26 Preform

preform: an assembly of dry fabric and fibers that has been prepared for one of several different wet resin injection processes. A preform may be stitched or stabilized in some other way to hold its shape. A commingled preform may contain thermoplastic fibers and may be consolidated by elevated temperature and pressure without resin injection.

3.27 Roving

roving: a number of strands, tows, or ends collected into a parallel bundle with little or no twist. In spun yarn production, an intermediate state between sliver and yarn.

3.28 Sequence

sequence: denotes a sub-bond configuration (grouping of plies) for design definition/clarity. It may also be used, when specified, to define the manufacturing process (i.e., to tie groups of plies to specific tooling or process methodologies).

3.29 Tool Side

tool side: the surface of the item adjacent to the tool surface.

3.30 Tool Side View

tool side view: a viewing direction looking through the part towards the tool surface.

3.31 Tow

tow: an untwisted bundle of continuous filaments. Commonly used in referring to man-made fibers, particularly carbon and graphite fibers, in the composites industry (MIL-HDBK-17).

4 PART IDENTIFICATION

Assign a Part or Identifying Number (PIN) in accordance with ASME Y14.100. A PIN is not required for individual plies. For ply identification, see para. 7.1.

Fig. 3-1 Ply Definition

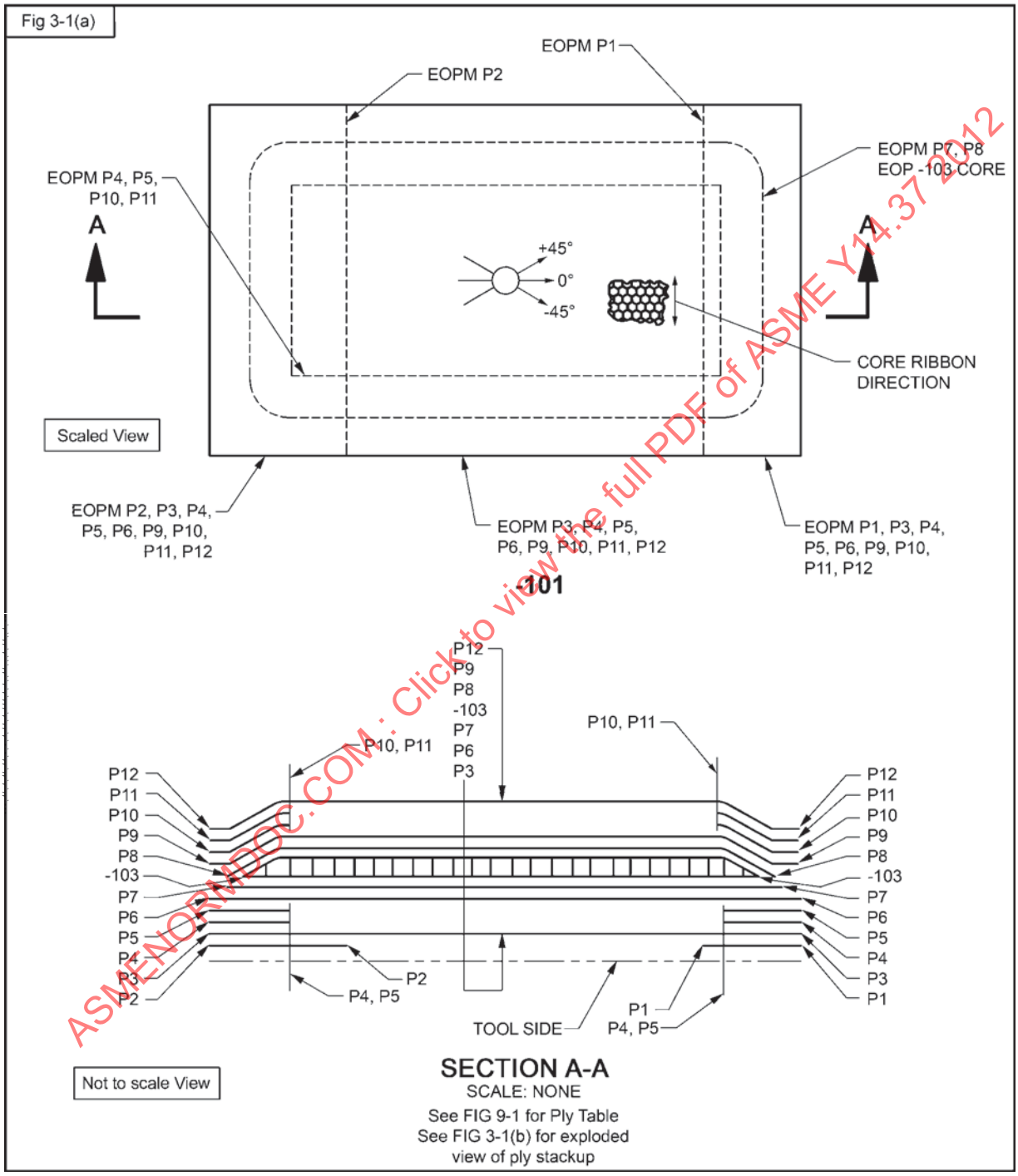


Fig. 3-1 Ply Definition (Cont'd)

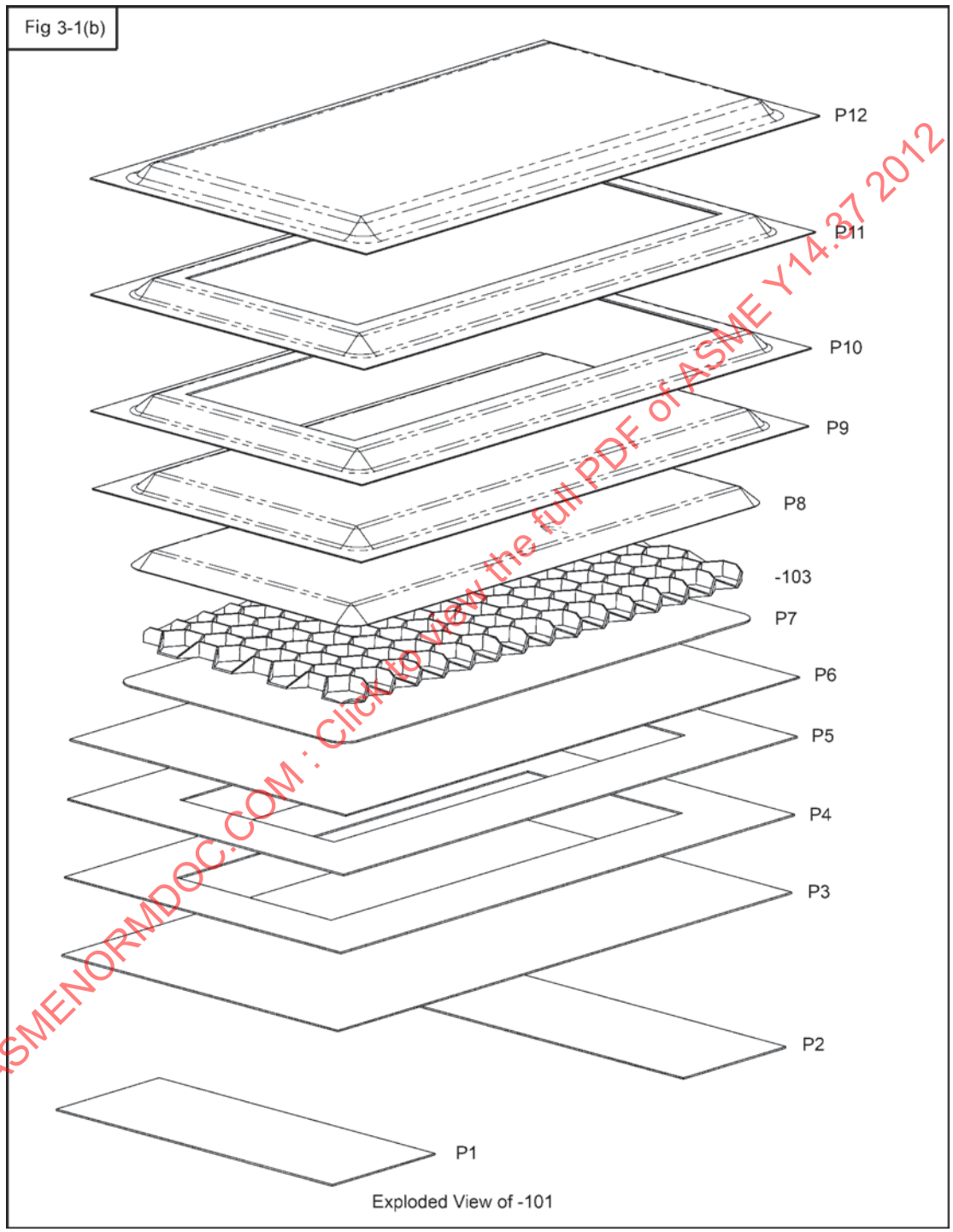
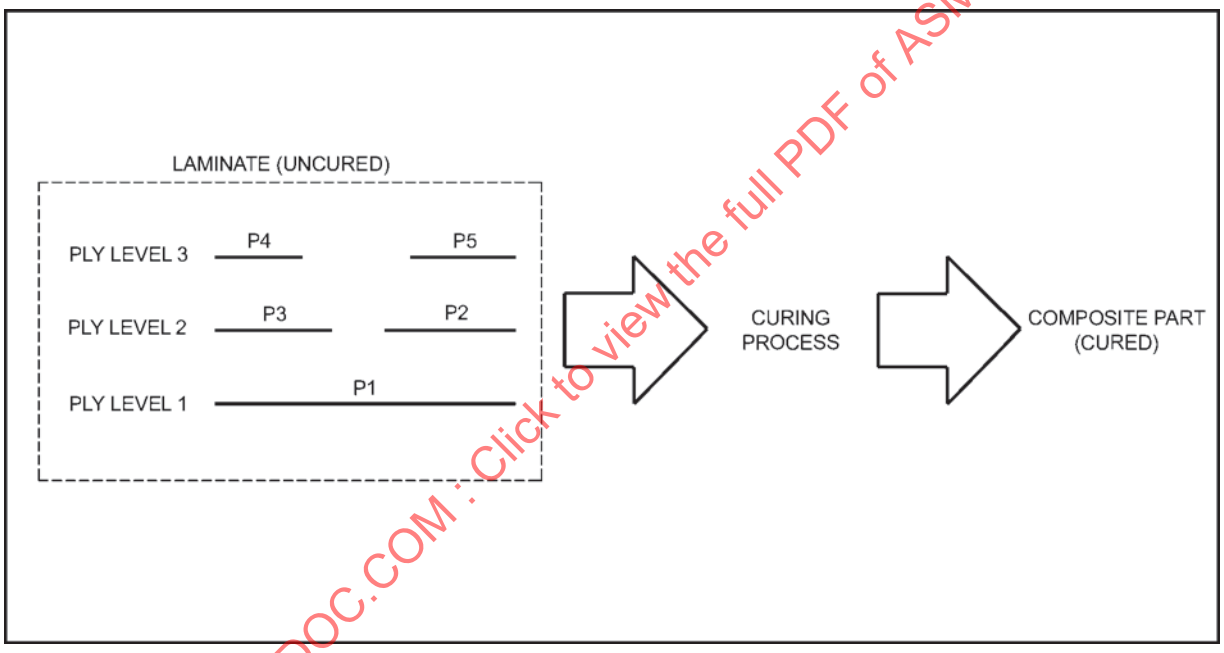


Fig. 3-2 Composite Part Process



5 PARTS LIST REQUIREMENTS

Prepare parts list in accordance with ASME Y14.34. Material for each ply of the part may be specified in the NOTES column by reference to the ply table such as SEE PLY TABLE.

6 COMPOSITE PART DEFINITION REQUIREMENTS

Composite part definition shall contain all data required to define a part as follows:

(a) Provide a tool side view.

(b) Complete surface definition(s).

(c) Show the part in the finished condition including variations due to ply drop-off, core shape, etc. See Fig. 3-1.

(d) Ply orientation symbol(s). See para. 7.3.

(e) Dimensioning and tolerancing in accordance with ASME Y14.5 and ASME Y14.41.

(f) Complete ply definition including internal cutouts and perimeters of each ply. See Fig. 3-1.

(g) Supplementary views and ply stackup views as required.

(h) Annotations.

(i) Ply table.

(j) Identify tool side(s) on each part.

(k) Where used, identify the honeycomb core ribbon direction on the tool side view. See Fig. 3-1.

(l) Manufacturing process specification.

NOTE: Composite parts are highly dependent on the manufacturing process utilized. Process parameters such as cure and post cure cycles, splices and darts, orientation deviation, temperature ramp rate, thermal soak cycles, vacuum pressure, material conditioning, and manufacturing environment can all have significant impact on the end product performance. Because verification of end products can yield incomplete information as to proper fabrication, a process specification should be used to define and control the manufacturing variables.

7 PLY DEFINITION REQUIREMENTS

7.1 Ply Identification

Each ply shall be identified with a separate ply identifier regardless of configuration or orientation. See para. 3.21.

7.2 Ply Size and Location

The definition of each ply shape shall include clear indications of the edges of each ply within the laminate. Ply location within the laminate shall be shown. See Fig. 3-1. Developed ply flat patterns are optional for design definitions.

7.3 Ply Orientation Symbol

The ply orientation symbol is used to indicate the ply orientation. See para. 3.23. The requirements for ply orientation symbols are as follows:

(a) Place the symbol in the tool side view.

(b) Show the zero axis and orientation of the symbol, either positive, negative, or both. See Fig. 7-1.

(c) Show the allowable orientation tolerance deviation of the plies from the ply orientation symbol directly or by reference. No tolerance is applied to the ply orientation symbol vectors.

(d) When more than one ply orientation symbol is required, identify each to differentiate the ply orientation symbols. See Fig. 7-2.

7.4 Ply Level

Each ply level encompasses all the plies and items laid in the same layer of the laminate prior to being covered either fully or partially by another ply or item. The entire list of ply levels per part shall be in ascending order in the ply table. Ply level is frequently identified by terms such as layup step level or ply layer.

8 PLY STACKUP VIEWS

The requirements for ply stackup views are as follows:

(a) The view has no scale and shall be so noted.

(b) Each ply and item shown shall be identified individually or in a callout listed in the order they are stacked in the laminate.

(c) Solid lines shall be used to depict each ply.

(d) The tool side(s) of the ply stackup shall be labeled.

(e) Other items shall be depicted within the ply stackup view through representation of the geometric shape.

See Fig. 3-1.

9 PLY TABLE

A ply table contains information about plies and items within a composite part. See Fig. 9-1. The requirements for a ply table are as follows:

(a) part number with optional part nomenclature

(b) ply level

(c) ply/item

(1) ply identifier

(2) identification number of embedded item(s)

(d) orientation

(e) ply orientation symbol identifier when more than one symbol is used (see Fig. 9-2)

(f) material

(g) optional fields may be included; for example: sequence, splice control, revision letter, ply thickness, notes, etc.

Fig. 7-1 Ply Orientation Symbols

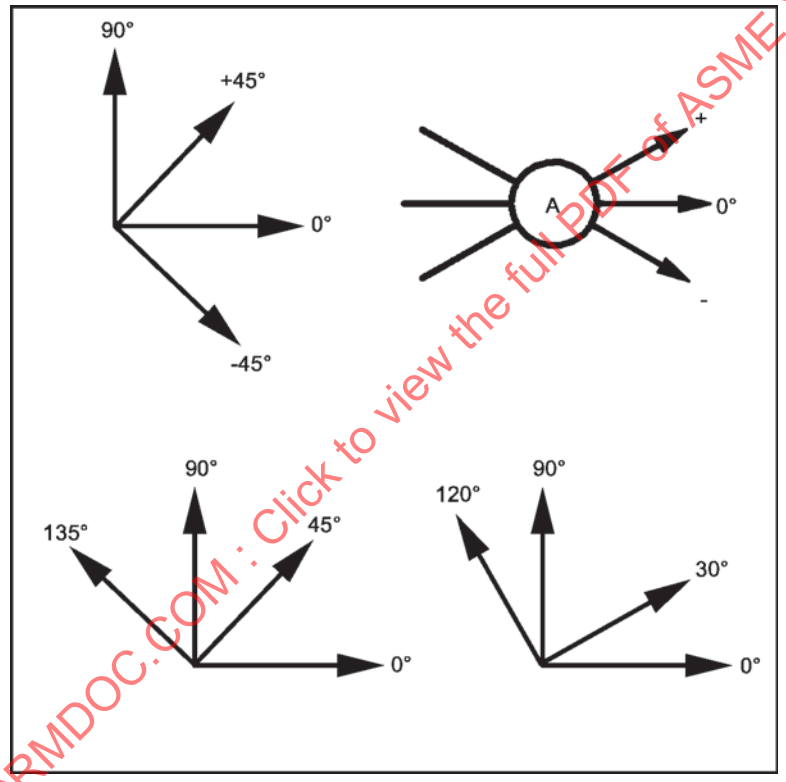


Fig. 7-2 Multiple Ply Orientation Symbol

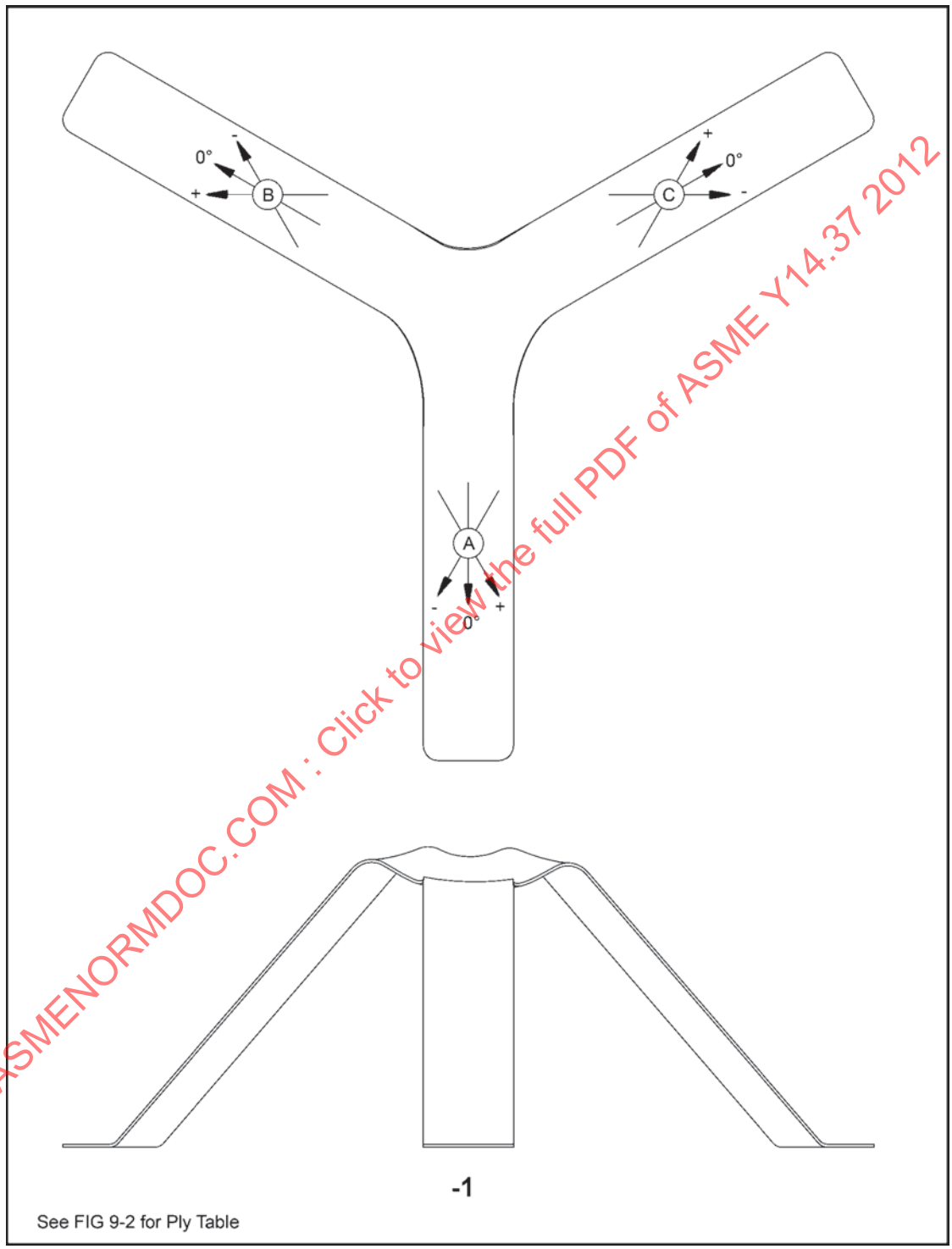


Fig. 9-1 Typical Ply Table

-101 BOND ASSEMBLY			
PLY LEVEL	PLY / ITEM	ORIENTATION	MATERIAL
1	P1	0°	10745
1	P2	0°	10745
2	P3	0°	10721
3	P4	45°	10721
4	P5	0°	10721
5	P6	45°	10721
6	P7	-45°	10679
7	-103 CORE		
8	P8	-45°	10679
9	P9	45°	10721
10	P10	0°	10721
11	P11	45°	10721
12	P12	0°	10721

Fig. 9-2 Ply Table — Multiple Orientation Symbol

-1 BOND ASSEMBLY				
PLY LEVEL	PLY / ITEM	ORIENTATION	PLY ORIENTATION SYMBOL	MATERIAL
1	P1	0°	A	10721
2	P2	+45°	A	10721
3	P3	-45°	A	10721
4	P4	90°	A	10721
5	P5	0°	B	10721
6	P6	+45°	B	10721
7	P7	-45°	B	10721
8	P8	90°	B	10721
9	P9	0°	C	10721
10	P10	+45°	C	10721
11	P11	-45°	C	10721
12	P12	90°	C	10721

10 OPPOSITE PARTS

10.1 Opposite Parts Categories

Opposite parts are divided into two categories.

(a) Opposite shape with identical ply orientation. Ply orientation symbol is not mirrored. See Fig. 10-1.

(b) Opposite shape with opposite ply orientation. Ply orientation symbol is mirrored. See Fig. 10-2.

10.2 Detailing of Opposite Parts

Preferred presentation of symmetrically opposite parts is by separate views or drawings. When separate views or drawings are not used and the symmetrically opposite parts are presented in the same view, use one of the following methods with SHOWN and OPPOSITE nomenclature applied.

(a) For identical ply orientations, enter each PIN in a ply table(s) and itemize the plies for both parts. Add a note such as USE THE SAME PLY ORIENTATION SYMBOL FOR THE SHOWN AND OPPOSITE PARTS. DO NOT MIRROR THE PLY ORIENTATION SYMBOL. See Fig. 10-3. It is optional to use the ply orientation symbol in the ply table in place of the note. See Fig. 10-1.

(b) For opposite ply orientations, the ply orientation symbol is mirrored and each PIN is entered in a ply table(s) to itemize the plies for both parts. Add a note such as THE PLY ORIENTATION SYMBOL IS MIRRORED FOR THE OPPOSITE PART. It is optional to use the ply orientation symbol in the ply table in place of the note. See Figs. 10-2 and 10-4.

11 REVISIONS

Revisions shall be prepared in accordance with ASME Y14.35M.

12 MANUFACTURING PROCESS REQUIREMENTS

This section defines exceptions and additional requirements that are specific to a manufacturing process. Where no exceptions or additional requirements are stated, the requirements in sections 4 through 11 shall apply.

12.1 Braiding

The braiding process creates a preform or final shape. The requirements for a braided preform are as follows:

(a) Part or Identifying Number
(b) braid configuration, e.g., biaxial or triaxial
(c) braid angle
(d) number of preform layers
(e) tension

12.2 Compression Molding

Identify specific areas or zones of the mold when different size or length of fibers is required.

12.3 Fiber and Tape Placement

Allowable gaps and overlaps between tows and bands shall be defined.

12.4 Filament Winding

The ply orientation symbol shall be oriented with zero degrees in relation to the tool axis of rotation. When the part is defined to the outside mold line (OML) surface, an inside mold line (IML) surface shall also be generated for fiber winding on the tool surface. Extend the IML surface beyond the part definition as required. Allowable gaps and overlaps between tows and bands shall be defined. See Fig. 12-1. In addition to the ply table requirements in section 9, each ply level of the ply table shall specify

(a) either hoop or helical pattern
(b) material, such as adhesive or other pertinent method of material application such as hand layup for nonwound materials
(c) band width
(d) number of tows per band
(e) tension per tow

12.5 Multistage Bonding

Multistage bonded assemblies may be defined with individual precured parts in separate ply tables. See Fig. 12-2 and Fig. 12-3, illustration (a). When a single ply table defines a multistage bonded assembly, a sequence may be indicated in the ply table to define individual ply groupings. See Fig. 12-3, illustration (b). When the shape of the assembly is complex, individual ply tables and ply stackup views may be provided in addition to the bonded assembly view and ply table. See Fig. 12-4.

12.6 Pultrusion

The ply orientation symbol shall be oriented with zero degrees in relation to the longitudinal direction of the tool. Show a constant cross section of the part with the location of each roll and drop-off. See Fig. 12-5. Section views shall be created for each material roll used in the part. See Fig. 12-6, illustrations (a) and (b). Material roll section views shall contain the following:

(a) location of material rolls
(b) location of drop-offs
(c) definition of splices
(d) ply table and any additional data about the plies within the roll noted in the corresponding table

Fig. 10-1 Same Ply Orientation Symbol

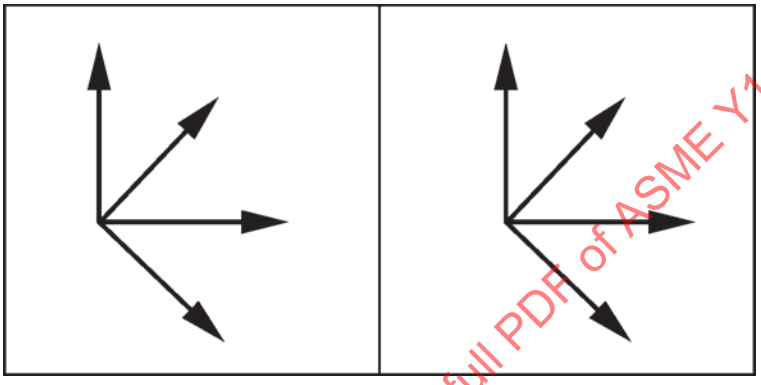


Fig. 10-2 Opposite Ply Orientation Symbol

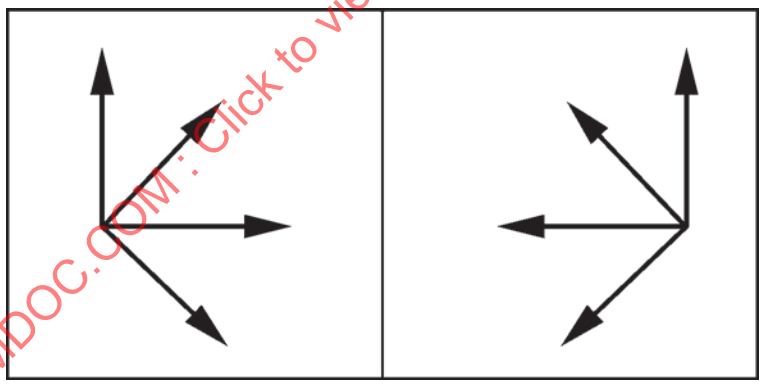


Fig. 10-3 Opposite Shape With Identical Ply Orientation in Same View

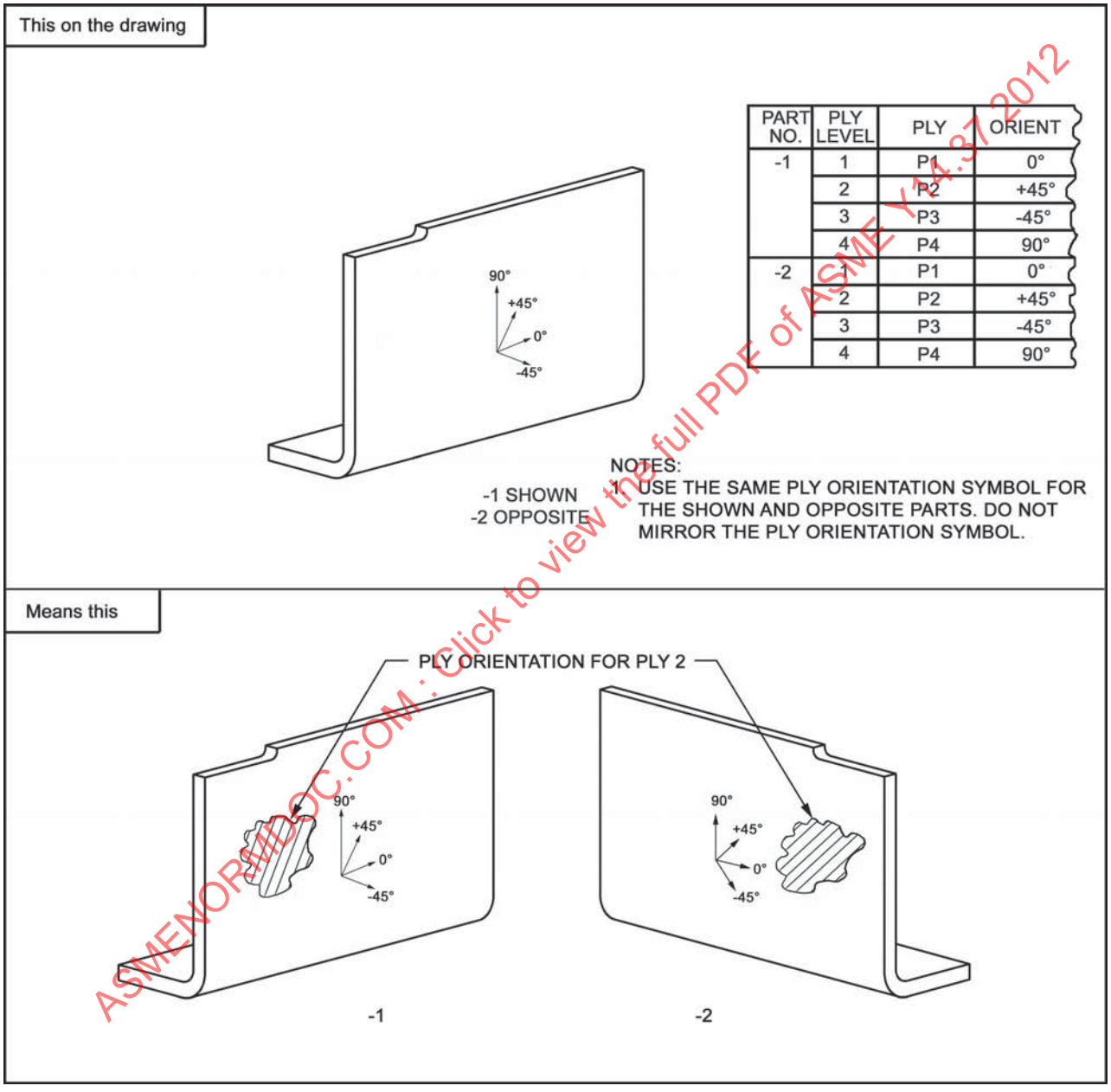


Fig. 10-4 Opposite Shape With Opposite Ply Orientation in Same View

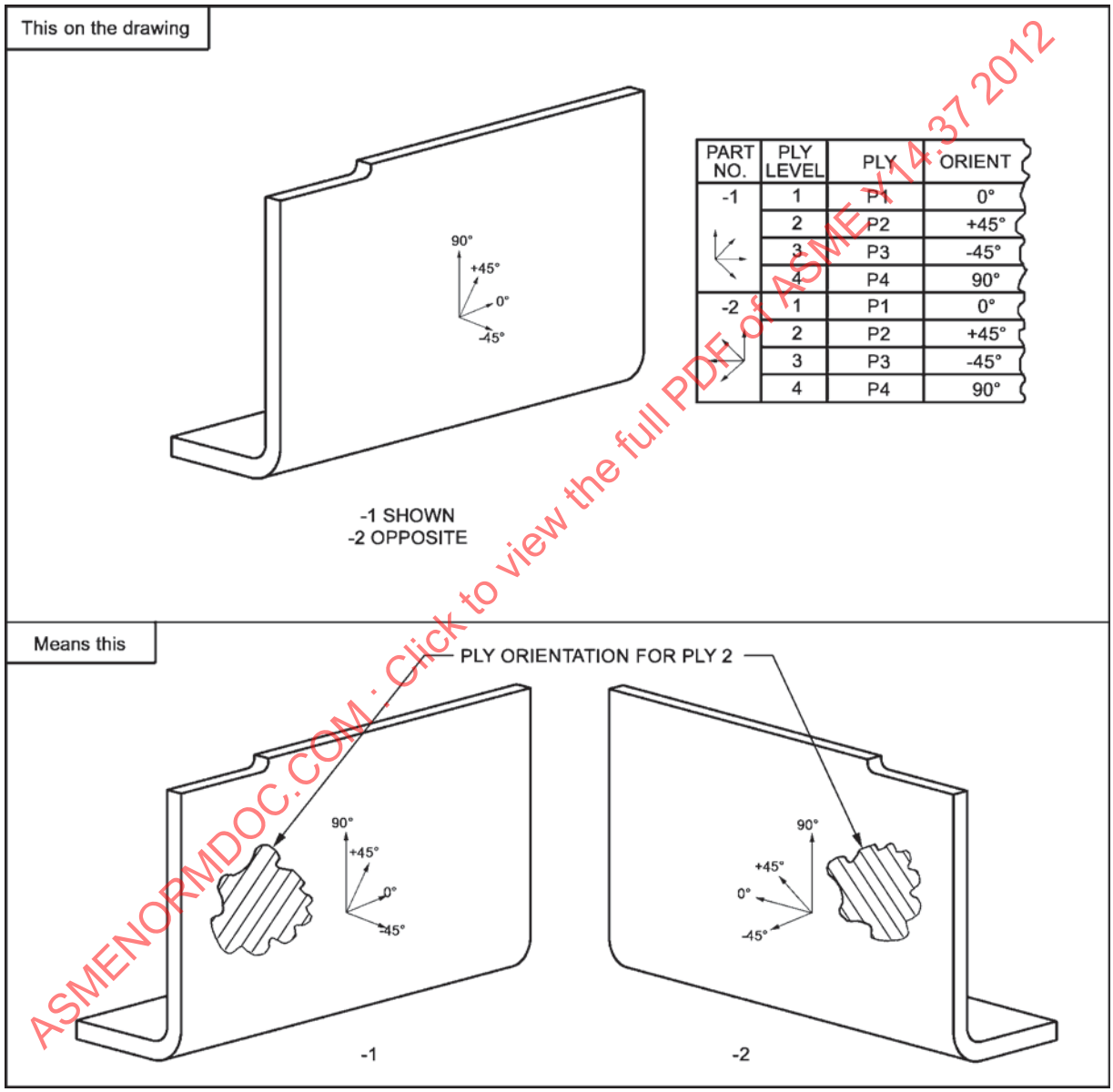
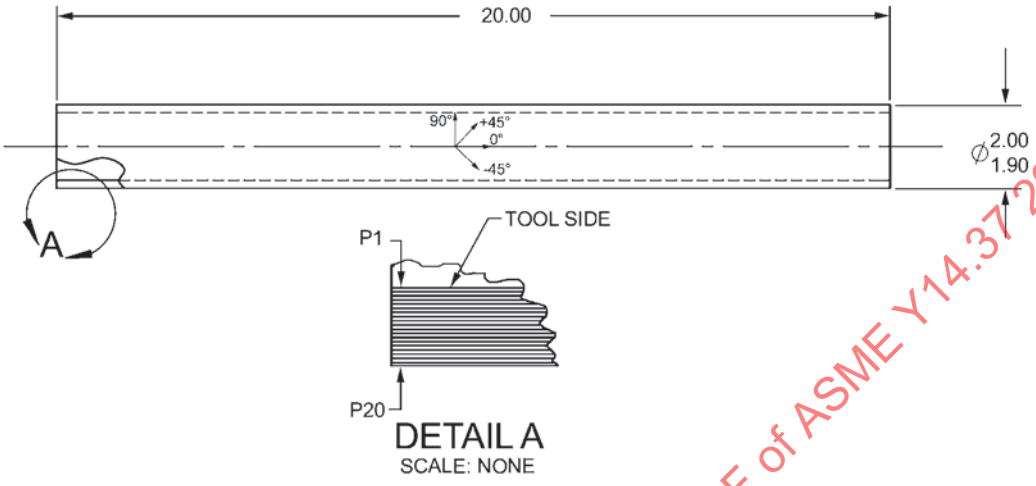
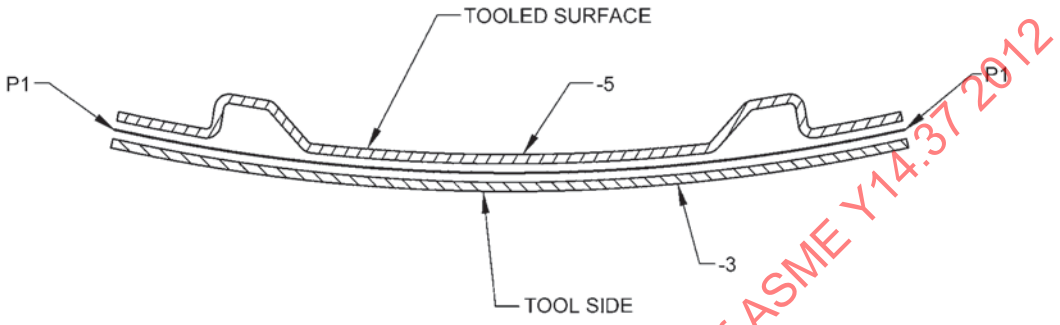


Fig. 12-1 Filament Winding Part



PLY NO.	TYPE OF PLY	PLY ANGLE	BAND WIDTH INCHES	NO. OF TOW PER BAND	TENSION PER TOW LB
1	FILM ADH	--	--	--	--
2	HELIX	+45°	.25	3	2.0
3	HELIX	-45°	.25	3	2.0
4	HOOP	90°	.30	3	2.0
5	HOOP	90°	.30	3	2.0
6	HOOP	90°	.30	3	2.0
7	HOOP	90°	.30	3	2.0
8	HOOP	90°	.30	3	2.0
9	HOOP	90°	.30	3	2.0
10	HOOP	90°	.30	3	2.0
11	HOOP	90°	.30	3	2.0
12	HOOP	90°	.30	3	2.0
13	HOOP	90°	.30	3	2.0
14	HOOP	90°	.30	3	2.0
15	HOOP	90°	.30	3	2.0
16	HOOP	90°	.30	3	2.0
17	HELIX	+45°	.25	3	2.0
18	HELIX	-45°	.25	3	2.0
19	HELIX	+45°	.25	3	2.0
20	HELIX	-45°	.25	3	2.0

Fig. 12-2 Multistage Bonding — Precured Method



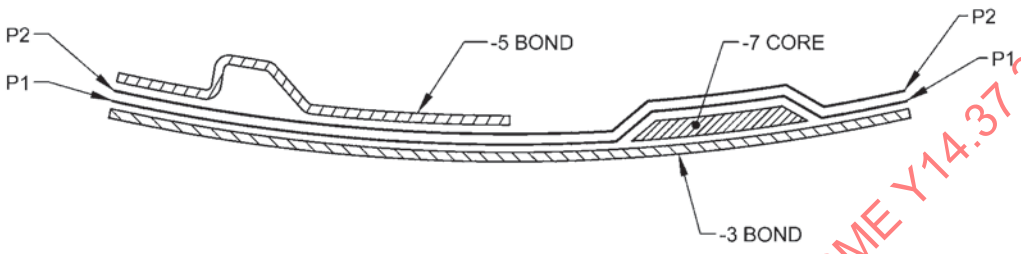
-1 BOND ASSY			
PLY LEVEL	PLY/ITEM	ORIENTATION	MATERIAL
1	-3		-3 BOND
2		OPT	10005
3	-5		-5 BOND

-3 BOND ASSY			
PLY LEVEL	PLY/ITEM	ORIENTATION	MATERIAL
1	P1	0°	10721
2	P2	45°	10721
3	P3	45°	10721
4	P4	0°	10721
5	P5	OPT	PEEL PLY

-5 BOND ASSY			
PLY LEVEL	PLY/ITEM	ORIENTATION	MATERIAL
1	P1	OPT	10745
1	P2	OPT	10745
2	P3	0°	10721
3	P4	45°	10721
4	P5	45°	10721
5	P6	0°	10721
6	P7	OPT	PEEL PLY

Fig. 12-3 Multistage Bonding — Precured With Additional Layup Method

Fig 12-3(a)



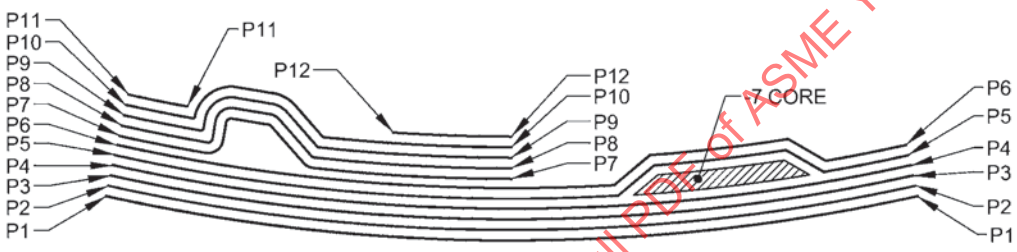
-1 BOND ASSY				
SEQUENCE	PLY LEVEL	PLY/ITEM	ORIENTATION	MATERIAL
A	1	-3		-3 BOND
A	2	-7		-7 CORE
A	3	P1	0°	10721
A	4	P2	45°	10721
B	5	-5		-5 BOND

-3 BOND ASSY			
PLY LEVEL	PLY/ITEM	ORIENTATION	MATERIAL
1	P1	0°	10721
2	P2	45°	10721
3	P3	45°	10721
4	P4	0°	10721
5	P5	OPT	PEEL PLY

-5 BOND ASSY			
PLY LEVEL	PLY/ITEM	ORIENTATION	MATERIAL
1	P1	OPT	10745
1	P2	OPT	10745
2	P3	0°	10721
3	P4	45°	10721
4	P5	45°	10721
5	P6	0°	10721
6	P7	OPT	PEEL PLY

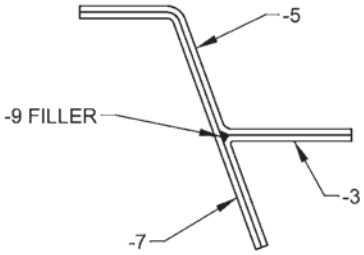
Fig. 12-3 Multistage Bonding — Precured With Additional Layup Method (Cont'd)

Fig 12-3(b)

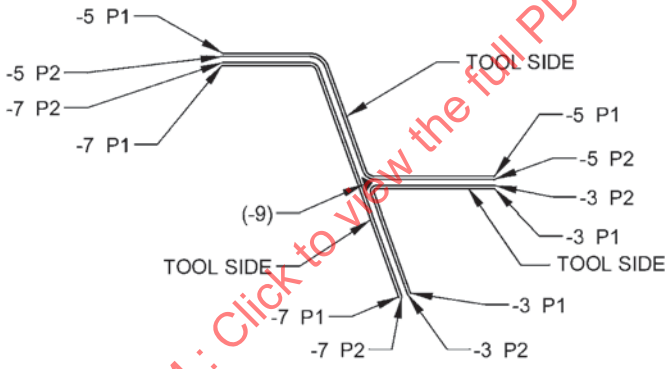


-1 BOND ASSY				
SEQUENCE	PLY LEVEL	PLY/ITEM	ORIENTATION	MATERIAL
A	1	P1	0°	10721
A	2	P2	45°	10721
A	3	P3	45°	10721
A	4	P4	0°	10721
B	5	-7		-7 CORE
B	6	P5	0°	10721
B	7	P6	45°	10721
C	8	P7	0°	10721
C	9	P8	45°	10721
C	10	P9	45°	10721
C	11	P10	0°	10721
C	12	P11	OPT	10745
C	12	P12	OPT	10745

Fig. 12-4 Multistage Bonding — Layup Method



-1 BOND ASSY			
PLY LEVEL	PLY/ITEM	ORIENTATION	MATERIAL
1	-3		-3 BOND
2	-5		-5 BOND
3	-9		
4	-7		-7 BOND



-3 BOND ASSY			
PLY LEVEL	PLY/ITEM	ORIENTATION	MATERIAL
1	P1	0°	10721
2	P2	45°	10721

-5 BOND ASSY			
PLY LEVEL	PLY/ITEM	ORIENTATION	MATERIAL
1	P1	0°	10721
2	P2	45°	10721

-7 BOND ASSY			
PLY LEVEL	PLY/ITEM	ORIENTATION	MATERIAL
1	P1	0°	10721
2	P2	45°	10721