ASME Y14.37-2019

(Revision of ASME Y14.37-2012)

Product Definition for Composite Parts

Engineering Product Definition and Related Documentation Practices

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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ASME Y14.37, Product Definition for Composite Parts, was adopted on 27 April 2012 for use by the Department of Defense (DoD). Proposed changes by DoD activities must be submitted to the DoD Adopting Activity: Commander, U.S. Army Research, Development and Engineering Center (ARDEC), ATTN: RDAR-QES-E, Picatinny Arsenal, NJ 07806-5000. Copies of this document may be purchased from The American Society of Mechanical Engineers (ASME), 150 Clove Road, 6th Floor, Little Falls, NJ 07424-2139; http://www.asme.org.

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AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers
Two Park Avenue • New York, NY • 10016 USA

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The next edition of this Standard is scheduled for publication in 2024.

Periodically certain aspects of the ASME Y14 Committee may be published as Cases. Cases are published on the ASME website under the Y14 Committee Page at http://go.asme.org/Y14committee as they are issued.

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

The Y14 Committee Page can be found at http://go.asme.org/Y14committee. There is an option available to automatically receive an e-mail notification when errata are posted to a particular code or standard. This option can be found on the appropriate Committee Page after selecting "Errata" in the "Publication Information" section.

The American Society of Mechanical Engineers
Two 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 may be tailored via contractual agreement or documented business requirements to meet any specific needs. All users shall take careful note of the potential impacts of tailoring this Standard and provide downstream users of the product definition a map of the changes and relationship to this Standard.

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

(c) 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.

Between 2012 and 2017, the Y14.37 Subcommittee worked diligently to address the requirements for composite product definition in a model-based enterprise, including harmonization with ISO 10303 for the definition of ply orientation transformation types used to query the ply orientation at a specific *seed point* location. Requirements specific to composite Limited Length or Area Indicators (LLAIs) were also added.

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

This Standard is available for public review on a continuing basis. This provides an opportunity for additional public review input from industry, academia, regulatory agencies, and the public-at-large.

This Standard was approved as an American National Standard on March 22, 2019.

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Engineering Product Definition and Related Documentation Practices

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

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

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

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

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

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

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

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PRODUCT DEFINITION FOR COMPOSITE PARTS

1 SCOPE

This Standard establishes the requirements for composite product definition that are not covered within the existing ASME Y14 Series of standards.

1.1 ASME Y14 Series Conventions

The conventions in paras. 1.1 through 1.10 are used in this and other ASME Y14 standards.

1.2 Mandatory, Nonmandatory, Guidance, and Optional Words

(a) The word "shall" establishes a requirement.
(b) The word "will" establishes a declaration of purpose on the part of the design activity.
(c) The word "should" establishes a recommended practice.
(d) The word "may" establishes an allowed practice.
(e) The words "typical," "example," "for reference," or the Latin abbreviation "e.g." indicate suggestions given for guidance only.
(f) The word "or" used in conjunction with a requirement or a recommended practice indicates that there are two or more options for complying with the stated requirement or practice.
(g) The phrase "unless otherwise specified" or UOS shall be used to indicate a default requirement. The phrase is used when the default is a generally applied requirement and an exception may be provided by another document or requirement.

1.3 Cross-Reference of Standards

Cross-reference of standards in text with or without a date following the standard designator shall be interpreted as follows:
(a) Reference to other ASME Y14 standards in the text without a date following the standard designator indicates that the issue of the standard identified in the References section (section 2) shall be used to meet the requirement.
(b) Reference to other ASME Y14 standards in the text with a date following the standard designator indicates that only that issue of the standard shall be used to meet the requirement.

1.4 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 a referenced standard is cited in the text with no limitations to a specific subject or paragraph(s) of the standard, the entire standard is invoked. For example, "Dimensioning and tolerancing shall be in accordance with ASME Y14.5" is invoking the complete standard because the subject of the standard is dimensioning and tolerancing and no specific subject or paragraph(s) within the standard are invoked.
(b) When a referenced standard is cited in the text with limitations to a specific subject or paragraph(s) of the standard, only the paragraph(s) on that subject is invoked. For example, "Assign part or identifying numbers in accordance with ASME Y14.100" is invoking only the paragraph(s) on part or identifying numbers because the subject of the standard is engineering drawing practices and part or identifying numbers is a specific subject within the standard.
(c) When a referenced standard is cited in the text without an invoking statement such as "in accordance with," the standard is invoked for guidance only. For example, "For gaging principles, see ASME Y14.43" is only for guidance and no portion of the standard is invoked.

1.5 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.

1.6 Notes

Notes depicted in this Standard in **ALL UPPERCASE** letters are intended to reflect actual data set 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 in data set. A statement requiring the addition of a note with the qualifier "such as" is a requirement to add a note, and the content of the note is allowed to vary to suit the application.

1.7 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.

1.8 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.

1.9 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. Some figures are illustrations of models in a three-dimensional environment. The absence of dimensioning and tolerancing annotations in a view may indicate that the product definition is defined in three dimensions. Dimensions that locate or orient and are not shown are considered basic and shall be queried to determine the intended requirement. 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. Multiview drawings contained within figures are third-angle projection.

1.10 Precedence of Standards

The following are ASME Y14 standards that are basic engineering product definition standards:

ASME Y14.1, Decimal Inch Drawing Sheet Size and Format
ASME Y14.1M, Metric Drawing Sheet Size and Format
ASME Y14.2, Line Conventions and Lettering
ASME Y14.3, Orthographic and Pictorial Views
ASME Y14.5, Dimensioning and Tolerancing
ASME Y14.24, Types and Applications of Engineering Drawings
ASME Y14.34, Associated Lists
ASME Y14.35, Revision of Engineering Drawings and Associated Documents
ASME Y14.36, Surface Texture Symbols
ASME Y14.38, Abbreviations and Acronyms for Use 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.

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 Y14.2-2014, Line Conventions and Lettering
ASME Y14.5-2018, Dimensioning and Tolerancing

ASME Y14.34-2013 (R2018), Associated Lists
ASME Y14.35-2014, Revision of Engineering Drawings and Associated Documents
ASME Y14.41-2012, Digital Product Definition Data Practices
ASME Y14.100-2017, Engineering Drawing Practices
Publisher: The American Society of Mechanical Engineers (ASME), Two Park Avenue, New York, NY 10016-5990 (www.asme.org)

ASTM D6193, Standard Practice for Stitches and Seams
Publisher: American Society for Testing and Materials (ASTM International), 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 (www.astm.org)

CMH-17, Composite Materials Handbook
Publisher: SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001 (www.sae.org)

3 TERMS AND 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 (CMH-17).

3.2 Annotated Model

annotated model: a combination of model, annotation, and attributes that describe a product (ASME Y14.41).

3.3 Annotation

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

3.4 Attribute

attribute: a dimension, tolerance, note, text, or symbol required to complete the product definition or feature of the product that is not visible but available upon interrogation of the annotated model (ASME Y14.41).

3.5 Band

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

3.6 Bond

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

3.7 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 (CMH-17).

3.8 Braid, Triaxial

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

3.9 Braid Angle

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

3.10 Braiding

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

3.11 Composite Material

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

3.12 Composite Part

composite part: an inseparable assembly of composite material(s) that may include non-composite material(s). See Figures 3-1 through 3-3.

3.13 Core

core: a component used to separate structural laminates (e.g., face sheets, skins, sandwich faces) that are bonded to it.

3.14 Core Ribbon Direction

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

3.15 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 (CMH-17).

3.16 End Item

end item: an item, such as an individual part or assembly, in its final or completed state (ASME Y14.24).

3.17 Fabric, Nonwoven

fabric, nonwoven: textile structure produced by bonding or interlocking of fibers, or both, accomplished by mechanical, chemical, thermal, or solvent means, and combinations thereof (CMH-17).

3.18 Fabric, Woven

fabric, woven: a generic material construction consisting of interlaced yarn or fibers, usually a planar structure. Specifically, cloth woven in an established weave pattern from advanced fiber yarns and used as the fibrous constituent in an advanced composite ply.

3.19 Fiber Orientation Array

fiber orientation array: an array of discrete locations on the laminate reference surface used to define the primary (e.g., 0°) and/or secondary (e.g., 90°) fiber orientation directions.

3.20 Filament Winding

filament winding: a reinforced-plastics process that employs a series of continuous, resin-impregnated fibers applied to a mandrel in a predetermined geometrical relationship under controlled tension.

3.21 Helical (Helix) Ply

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

3.22 Hoop Ply

hoop ply: a ply laid on a spinning form where the desired ply orientation angle is perpendicular to the axis of rotation within the specified ply angle tolerance (e.g., in automated layup such as tape laying, fiber placement, or filament winding).

3.23 Item

item: a nonspecific term used to denote any unit or product, including materials, parts, assemblies, equipment, accessories, and computer software (ASME Y14.100).

3.24 Laminate

laminate: the product resulting from the uncured buildup of two or more ply levels of material. See Figure 3-4.

3.25 Laminate Layup Direction

laminate layup direction: a vector direction in the model indicating the side of the laminate reference surface that the laminate grows from. The vector direction indicates the side of the laminate reference surface coinciding with the geometric location of the solid representing the end item.

3.26 Laminate Reference Surface

laminate reference surface: the representative surface in the model defining the start of the laminate (e.g., the first ply or item in the stackup).

NOTE: This is usually the same as the tool side surface.

3.27 Model

model: the portion of the dataset that contains model geometry and supplemental geometry (ASME Y14.41).

3.28 Part

part: one item, or two or more items joined together, that is not normally subject to disassembly without destruction or impairment of designed use [e.g., transistor, composition resistor, screw, transformer, and gear (ASME Y14.100)].

3.29 Ply

ply: one discrete piece of manufactured material (e.g., fabric, tape, adhesive film). See Figure 3-2.

3.30 Ply Drop-Off

ply drop-off: any terminating edge of a ply that does not correspond with the edge of the part.

3.31 Ply Identification

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

3.32 Ply Level

ply level: the relative position from the tool surface of one or more discrete materials or plies in a *laminate*. See Figure 3-4.

3.33 Ply Orientation

ply orientation: angular direction of the reinforcing fiber within a laminate relative to a coordinate system (e.g., ply orientation symbol, rosette, or axis).

3.34 Ply Orientation Symbol

ply orientation symbol: graphical presentation of the ply orientation coordinate system or rosette.

3.35 Ply Stackup Schematic

ply stackup schematic: a graphical diagram presentation of the ply level relationship of each ply and other items within the laminate and the relative location of ply drop-offs. See Figure 3-2.

3.36 Ply Table

ply table: a graphical presentation of ply and item data elements applicable to a composite part using annotation in a table format. See Figure 3-5.

3.37 Preform

preform: an assembly of dry fabric and fibers prepared for one of several wet resin injection processes.

3.38 Prepreg

prepreg: ready to mold or cure material in sheet form that may be tow, tape, cloth, or mat impregnated with resin (CHM-17).

3.39 Presentation State

presentation state: a retrievable collection, or set, of model display elements arranged for formal display to the viewer (e.g., saved views, viewing orientation, assembly component configurations including selective display of components, section views, detail views, broken-out views, exploded condition, and geometry display methods including appearance).

3.40 Rosette

rosette: a ply orientation coordinate system with an associated ply orientation transformation type.

3.41 Seed Point

seed point: a reference point at which the ply orientation direction is determined by the associated ply orientation, ply orientation coordinate system, and the ply orientation transformation type. (i.e., the origin of the ply orientation symbol or locally transferred ply orientation symbol).

3.42 Sequence

sequence: denotes a sub-bond configuration (e.g., grouping of plies) for design definition and clarity. Also used to define the manufacturing process (e.g., tie groups of plies to specific tooling or process methodologies).

3.43 Tape

tape: A material with fibers all in one direction, usually a prepreg.

3.44 Tool Side Surface

tool side surface: the surface of the part adjacent to the tool surface. See Figure 3-2.

3.45 Tool Side View

tool side view: a view of the ply definitions with a viewing direction looking through the part towards the tool side surface. See Figures 3-1 and 3-2.

3.46 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 (CMH-17).

3.47 Vector Product

vector product: in mathematics and vector algebra, the vector product (or cross product) is a binary operation on two vectors in three-dimensional space. Given two linearly independent vectors a and b, the vector product is a vector that is perpendicular to both a and b and therefore normal to the plane containing them.

Figure 3-1 Ply Definition

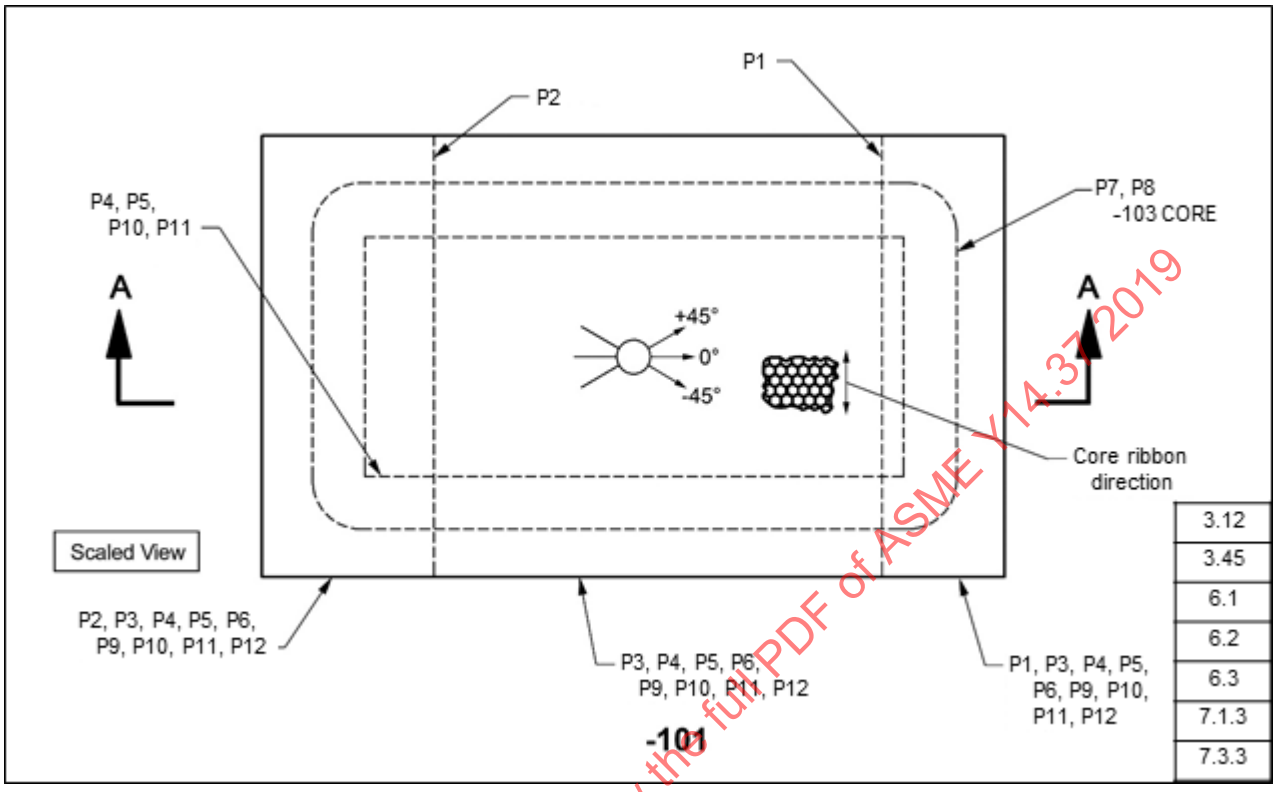


Figure 3-2 Ply Stackup Schematic (Figure 3-1, Section A-A)

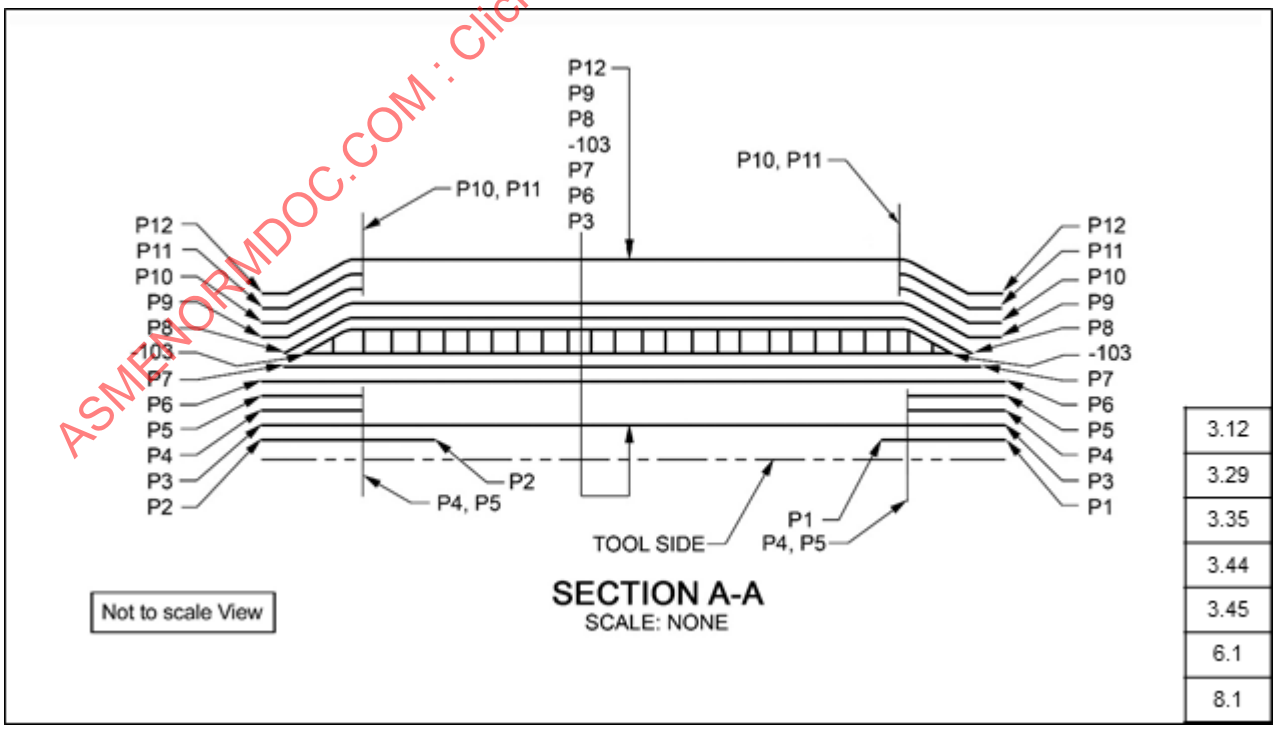
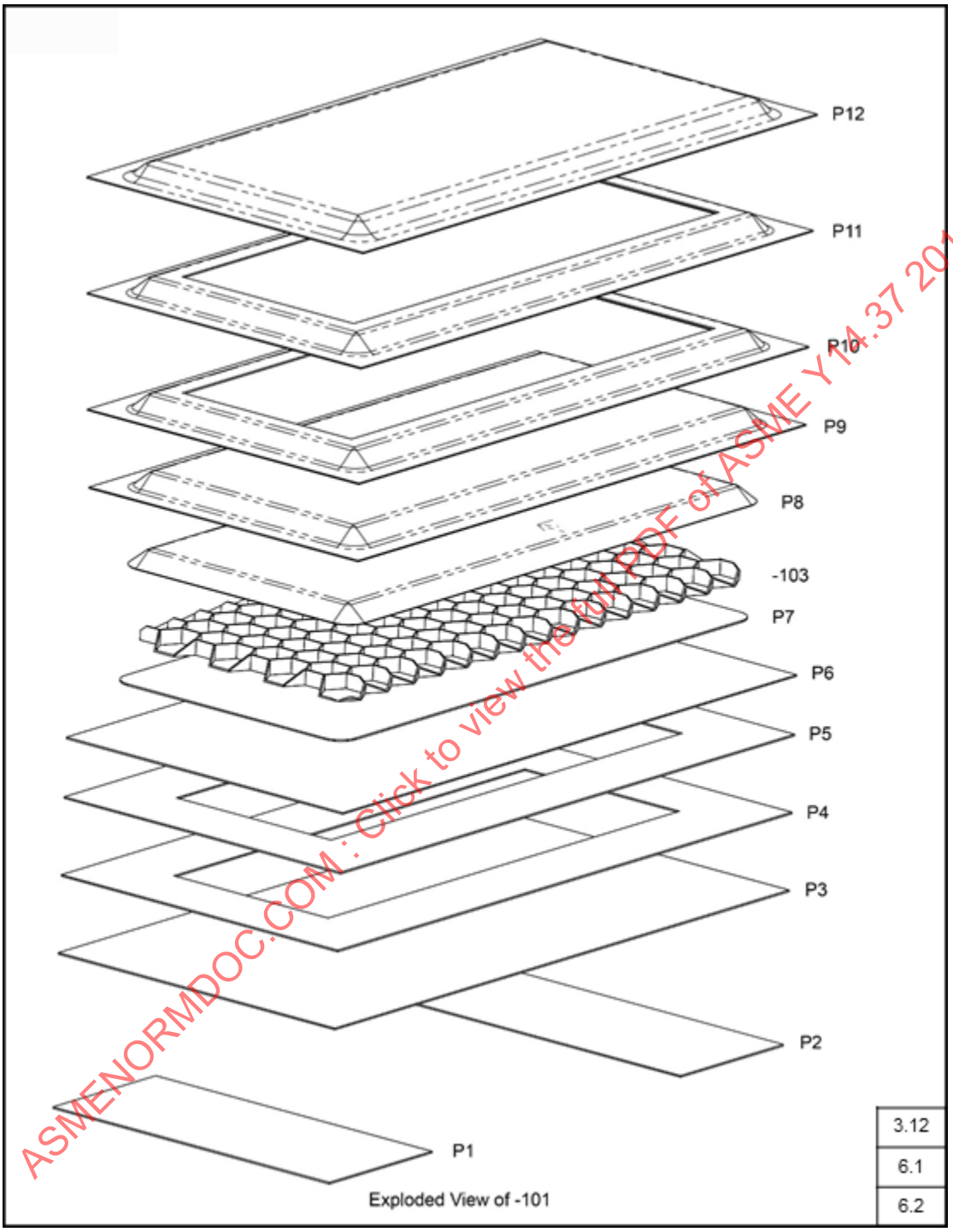


Figure 3-3 Exploded View of -101 From Figure 3-1



GENERAL NOTE: Figure is used to clarify the physical structure of a composite part and is not intended to imply detailed requirements for representation of ply data.

Figure 3-4 Composite Part Process

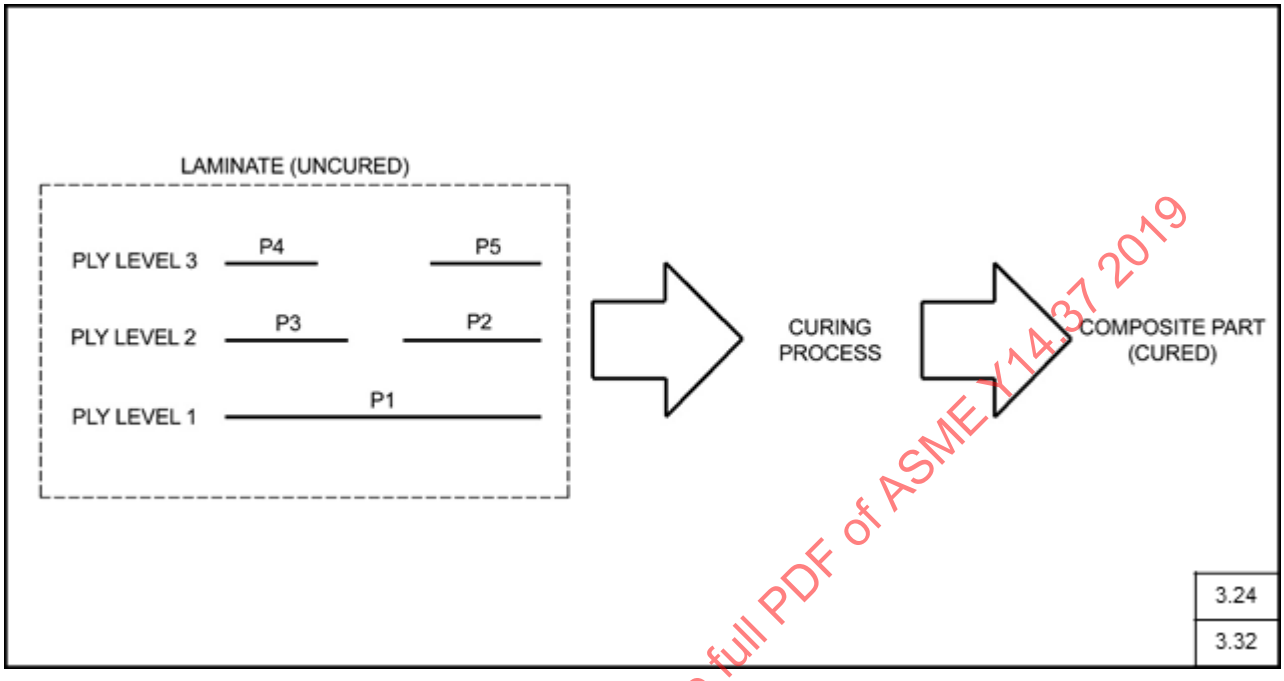


Figure 3-5 Ply Table For -101 From Figure 3-1

-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

3.36
7.1.3
9.1
9.3

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.

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

ASME Y14.41 requirements for product definition apply. In context of this Standard the term "model" shall be generically used to refer to a model or annotated model (as defined by ASME Y14.41). In addition, the following requirements apply to composite part definition:

(a) Composite product definition shall use one of the following classification codes from ASME Y14.100: 1, 2, 3, or 5.

(b) Model requirements apply only to classification codes 3 and 5 (ASME Y14.100), unless otherwise specified.

(c) For classification codes 2 and 3 per ASME Y14.100, composite product definition created or shown in the model and subsequently shown on the drawing graphic sheet shall not conflict.

6.1 Common Requirements

Composite product definition data set requirements shall include

(a) all data necessary to completely define the part.

(b) identification of the tool side surface(s).

(c) complete surface definition(s) to define the envelope of the part, including dimensioning and tolerancing.

(d) a part representation in the end item condition including variations due to ply drop-off, core shape, etc. See Figure 3-1.

(e) ply orientation symbol(s) per para. 6.1.1.

(f) ply orientation determination at a local seed point per para. 6.1.2.

(g) complete ply definition per section 7. See Figures 3-1 and 3-2.

(h) supplementary views and ply stackup schematic(s) as required. See section 8 for ply stackup schematic requirements. See Figures 3-2 and 3-3.

(i) annotation, attributes, or both, as defined in this Standard to provide complete and unambiguous definition of the part.

(j) identification of the honeycomb core ribbon direction. See Figure 3-1.

(k) identification of the intended manufacturing process (e.g., hand layup, automated fiber or tape placement, pultrusion, resin infusion, compression molding, filament, braiding, co-cured, co-bonded) per section 12.

(l) ply table data elements, attributes, or both per section 9.

(m) limited length or area indicators as required to complete composite product definition. See para. 6.4.

6.1.1 Ply Orientation Symbol. See Nonmandatory Appendix A for recommended dimensions and proportions. The requirements for a ply orientation symbol are as follows:

(a) The origin of the ply orientation symbol shall be defined by the intersection of the 0° axis and the orientation vectors of the symbol and shall be coincident with the origin of the associated ply orientation coordinate system.

(b) The 0° axis and orientation vectors, either positive, negative, or both, shall be presented. See Figure 7-1.

(c) For parts defined using classification code 2, 3, and 5 per Y14.100, the 0° axis and orientation vectors shall be aligned to a coordinate system, such that the 0° axis is aligned to the *X* direction vector of the coordinate system and the 90° axis is aligned to the *Y* direction vector of the coordinate system.

(d) When more than one ply orientation is required, annotations or attributes shall be used to differentiate the ply orientation symbols. See Figure 7-2.

(e) Each ply orientation symbol should have an associated ply orientation transformation type. See para. 6.1.2.

6.1.2 Ply Orientation Query at Local Seed Point. Unless otherwise noted below, the queried direction of the reinforcing fibers at a local seed point (i.e., any location inside an edge of ply) shall be determined by the specified ply orientation of the ply and application of the ply orientation transformation type (see paras. 6.1.2.1 through 6.1.2.5) associated to the ply orientation symbol associated to the ply.

If a ply orientation transformation type is not specified in the dataset, the following requirements apply:

(a) The fiber orientation of the ply shall be applicable only within the plane of the ply orientation symbol defined by the 0° axis and orientation vectors. Any queried ply orientation value at a location outside of the applicable plane shall be reference only.

(b) If the ply orientation symbol is not located in a planar region of the part, the ply orientation symbol associated to the ply shall be located inside the edge of the ply and the fiber orientation specified by the ply shall be applicable only at the origin of the ply orientation symbol. Any queried ply orientation value at any other location of the part surface shall be reference only.

6.1.2.1 Ply Orientation Transformation Type 1: Standard (Cartesian) Orientation. This transformation type is suitable for most geometries. See Figure 6-1.

For part geometries with complex curvatures, other rosette types or multiple rosettes may be required to define the ply orientation requirements for the part. For example, part geometries where one or more surface features are at or near 90° to others (e.g., flanges or other bend geometry). Additionally, an engineering allowance may be made for local fiber deviations. See para. 6.4(b).

Ply orientation transformation type 1 requirements for the associated local ply orientation coordinate system are as follows:

(a) The local *Z* orientation shall be a vector normal to the ply surface at the local seed point.

(b) The local *Y* orientation shall be computed using the vector product of the local *Z* orientation vector and the *X* orientation vector of the rosette coordinate system.

(c) The local *X* orientation shall be computed using the vector product of the local *Y* orientation vector and the local *Z* orientation vector at the local seed point.

(d) The local fiber orientation of the ply at the local seed point shall be determined by adding the assigned ply orientation angle (para. 3.33) as a rotation angle around the local *Z* vector in the direction from the local *X* orientation vector to the local *Y* orientation vector. See Figure 6-1.

6.1.2.2 Ply Orientation Transformation Type 2: Orientation Guided by Curve. This transformation type is suitable for curved or tubular geometry where it is desired for the primary fiber orientation to follow the path of the curve or tube. See Figures 6-2 and 6-3.

Ply orientation transformation type 2 requirements for the associated local ply orientation coordinate system are as follows:

(a) The guide curve shall be identified using annotation, an attribute, or both.

(b) The guide curve shall be represented using supplemental geometry.

(c) The guide curve shall be associated to the ply orientation symbol.

(d) The local *Z* direction shall be a vector normal to the ply surface at the local seed point.

(e) The local *Y* orientation vector shall be computed by the vector product of the local *Z* orientation vector and a reference *X* direction vector.

(f) The reference *X* direction vector shall be tangent to the guide curve at a point computed by projection of the local seed point to the guide curve, in the direction orientation specified by the rosette *X* direction.

(g) The local *X* orientation vector shall be computed by the vector product of the local *Y* orientation vector and the local *Z* orientation vector.

(h) The local fiber orientation of the ply at the local seed point shall be determined by adding the assigned ply orientation angle (para. 3.33) as a rotation angle around the local *Z* vector in the direction from the local *X* orientation vector toward the local *Y* orientation vector.

(i) An angle attribute may be identified to the guide curve to specify a fiber orientation other than 0° as the tangent direction. The primary direction *(X)* is then computed creating a vector at the specified angle from the tangent to the guide curve, following the same rotational direction going from *X* toward *Y*, around the *Z* axis (See Figure 6-3).

Ply orientation transformation type 2.1: orientation guided by multiple curves. See para. 6.1.2.4.

6.1.2.3 Ply Orientation Transformation Type 3: Polar (Radial). This transformation type is suitable for generally spherical geometry. The primary fiber orientation direction is always set in the direction of translation, or radial from the center of the part. See Figure 6-4.

Ply orientation transformation type 3 requirements for the associated local ply orientation coordinate system are as follows:

(a) The rosette origin and the *Z* vector shall define the center of rotation of the ply orientation coordinate system.

(b) The local *Z* direction shall be a vector normal to the ply surface at the local seed point.

(c) The local *X* orientation direction shall point outward in the radial direction and shall be defined as a vector tangent to the surface at the local seed point.

(d) The local *Y* orientation is the resulting vector product of the local *Z* direction and the local *X* orientation direction.

NOTE: Type 2 could be used to accomplish the same transformation results, by specifying a 90° guide curve (see Figure 6-3).

6.1.2.4 Ply Orientation Transformation Type 4: Fiber Orientation Array. This transformation type provides refined control across the entire laminate reference surface. See Figure 6-5. The following requirements apply:

(a) The fiber angles shall be defined only at the discrete locations in the array.

(b) A suitable interpolation scheme shall be used if the ply orientations need to be queried in-between locations.

(c) The array may be comprise one of the following:

(1) rosettes

(2) guide curves

(3) points and vectors

6.1.2.5 Ply Orientation Transformation Type 5: User Defined. User-defined transformations shall be defined in the data set directly or by reference to associated documentation to define the transformation. The organization shall maintain the definition of the user-defined transformation.

6.2 Model Requirements

In addition to common requirements in para. 6.1, the following requirements apply:

(a) The model or annotated model shall contain a representation of the end item.

(b) The tool side surface shall be identified using annotation or an attribute.

(c) Every ply shall be presented at least once in one or more saved views or presentation states, which should be created looking through the part to the tool side surface (i.e., as if the viewer is looking at the part on the tool from above). An equivalent methodology clearly depicting the part and ply arrangement, such as detail views, section views, broken-out sections, or other methods may be used.

(d) A saved view shall be defined presenting all ply geometry.

(e) The laminate layup direction shall be represented using supplemental geometry.

(f) The laminate layup direction shall be defined as an attribute.

NOTE: The laminate layup direction is typically the surface normal direction of the laminate reference surface but may be the inverse direction.

(g) The ply table data should be presented in table form as annotation or available in table form by query. The ply table may be attached as a supplemental document to the data set.

(h) Core ribbon direction, when presented in the model shall use supplemental geometry and be included in at least one presentation state. See Figure A-2 for recommended size and form of the core ribbon direction geometry.

(i) Core ribbon direction shall be defined as an attribute.

(j) A ply stackup schematic is optional in the model if one or both of the following is true:

(1) Each ply is represented at its nominal location in space relative to other plies in the laminate (e.g., using a surface, bounded volume, or solid representation for each ply). See para. 7.2.3.

(2) An exploded presentation of the laminate is provided.

(k) If an exploded presentation of the laminate is provided, a presentation state shall be provided for the exploded presentation. See Figure 3-3.

6.2.1 Ply Orientation Symbol. The model requirements for a ply orientation symbol are as follows:

(a) Each ply orientation symbol shall be represented in the model using supplemental geometry (e.g., coordinate system, axes, wireframe, planes, vectors, surfaces, solids, or volumes).

(b) The supplemental geometry shall be grouped together.

(c) The supplemental geometry shall be annotated to clearly identify the primary orientation vectors (e.g., 0°, +45°, −45°, 90°).

(d) If applicable, the ply orientation transformation (para. 6.1.2) type shall be associated to the ply orientation symbol by an attribute.

(e) Each ply orientation symbol shall be shown in at least one presentation state.

6.2.2 Ply Orientation Transformation Type. No model specific requirements apply to the ply orientation transformation type.

6.3 Drawing Graphic Sheet Requirements

In addition to the common requirements specified in para. 6.1, the drawing graphic sheet shall contain as a minimum the following:

(a) a tool side view per para. 3.45: see Figure 3-1. In lieu of a tool side view, an equivalent methodology clearly depicting the part, such as breakout views, section cuts, or other methods may be used.

(b) one or more ply stackup schematics (para. 3.35) as needed to present each ply at least once, relative ply drop-off locations, and an indication of the tool side surface. See section 8 for ply stackup schematic requirements.

(c) a ply table per para. 3.36: see section 9 for ply table requirements. For ASME Y14.100 classification codes 2 and 3, the ply table on the drawing graphic sheet shall be in agreement with the ply definition attributes defined in the model.

(d) the core ribbon direction when presented on the drawing graphic sheet shall be identified on the tool side view using a core ribbon direction symbol (see Figure 3-1). See Figure A-2 for recommended size and form of the core ribbon direction symbol.

6.3.1 Ply Orientation Symbol. In addition to the requirements in para. 6.1.1, the following requirement applies:

(a) The ply orientation symbol shall be depicted in the tool side view.

6.3.2 Ply Orientation Transformation Type. No drawing graphic sheet specific requirements apply to the ply orientation transformation type.

6.4 Limited Length or Area Indicators (LLAIs) for Composite Product Definition

An LLAI may be used to define a specific region of the part with unique characteristics or requirements. The common requirements for a composite LLAI is as follows:

(a) Each composite LLAI shall have an identifier.

(b) Each LLAI shall have a specified type (see para. 6.4.1). The type may be specified via attribute, naming, notes, annotation, native CAD feature specific to the LLAI type, or other similar method.

(c) Each LLAI shall have a geometric representation defining a region or area of the part. The geometric representation shall use supplemental geometry or bounded region. The supplemental geometry shall be grouped together.

(d) Each LLAI shall have appropriate requirements associated to it via attributes, notes, annotations, GD&T, or associated documents (see para. 6.4.1).

(e) Each LLAI shall specify the specific entity or entities to which it applies [e.g., part(s), ply table(s), ply level(s), ply(s), core(s), or material(s)].

(f) Each LLAI shall be shown in at least one saved view or presentation state.

6.4.1 Composite LLAI Types. The following list of LLAI types represents commonly used composite product definition elements. Absence of a specific LLAI type should not be considered as noncompliance to this Standard.

Recommended minimum specifications and attributes per LLAI type are as follows:

(a) Overlap Splice Area. Specify the overlap direction, overlap width, stagger distance between splices, and number of ply levels between repeated splice locations.

(b) Butt Splice Area. Specify the minimum gap, maximum gap, stagger distance between splices, and number of ply levels between repeated splice locations.

(c) No Splice Area. Specify local areas of the part, specific ply levels, orientations, and/or materials that may not be spliced.

(d) Fiber Orientation Angle Tolerance Deviation Area. Specify the allowed angular deviation (e.g., ±10°).

(e) Surface Porosity Allowance Area. Specify the allowed void size, density, and spacing between voids.

(f) Ply Drop-Off Stay Out Area (e.g., Faying Area, Interface Area). Specify flatness, surface roughness, or other specific surface profile tolerance requirements.

(g) Surface Preparation Area (e.g., Secondary Bonding, Electrical Grounding, Sacrificial Machining). Specify surface preparation processes and attributes required to meet secondary bonding, electrical conductivity, or mating condition requirements.

(h) Potting Area (Volume, Bounded Region). Specify potting material, processing, and fabrication tolerances.

(i) Darting Area. Define dart shape, locations, and types. Define any regions where darting is not allowed.

(j) Perforation Area. Specify hole size, shape, and pattern.

(k) Ply Wrinkle Allowance Area. Specify allowed amplitude and magnitude of ply wrinkles (e.g., height and length)

(l) Stitching Area. Specify thread material, seam type, stitch type, and stitch density per ASTM D6193.

(m) Strategy Point. For hand layup, specify location point to begin ply draping and smoothing. Specify smoothing/draping methodology. For automated layup, specify initial course start points for each ply level. Points may be stored in a dedicated LLAI or as part of the ply definition.

(n) Guide Curve. For automated layup, specify initial fiber orientation path.

(o) Edge Sealing. Specify sealing requirements for exposed trim edges.

(p) Core Sample (ISO 10303-242 "Point Zone"). Specify ply count, ply materials, thickness, laminate code, or local ply table stackup at a specified point location.

(q) User Defined. For composite LLAI types not defined in this Standard, define complete definition and specifications as needed.

Figure 6-1 Type 1 Rosette

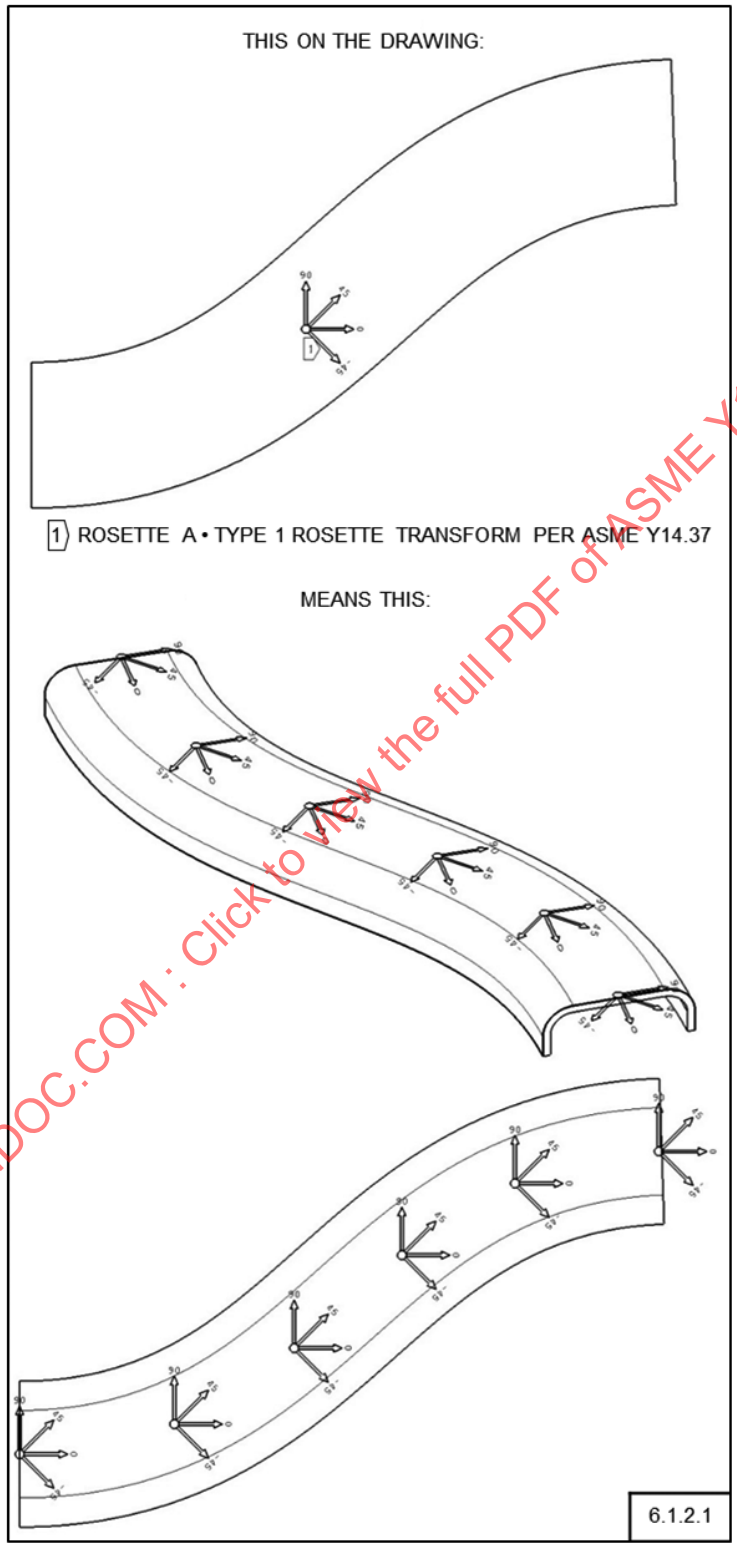


Figure 6-2 Type 2 Rosette With 0° Guide Curve

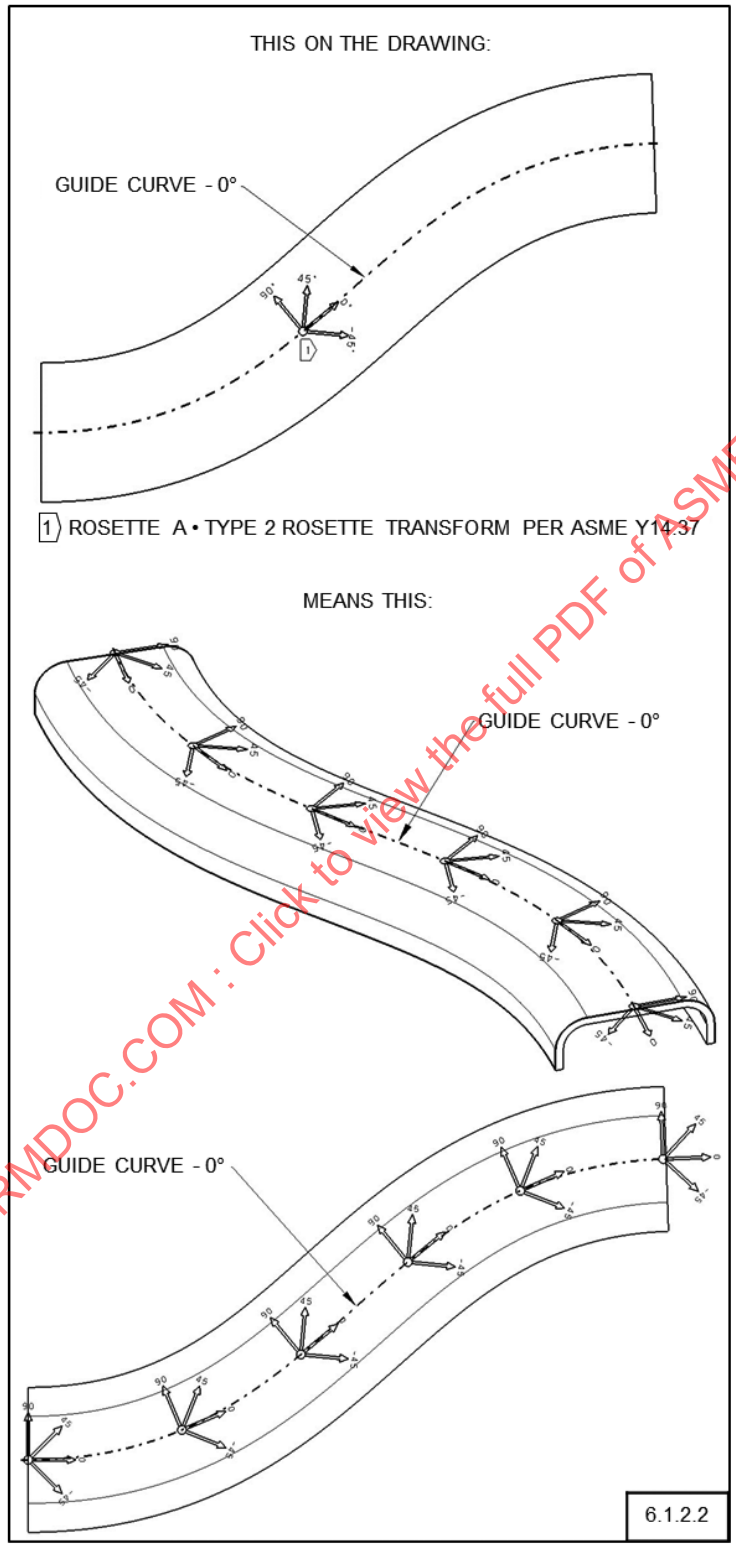


Figure 6-3 Type 2 Rosette With 90° Guide Curve

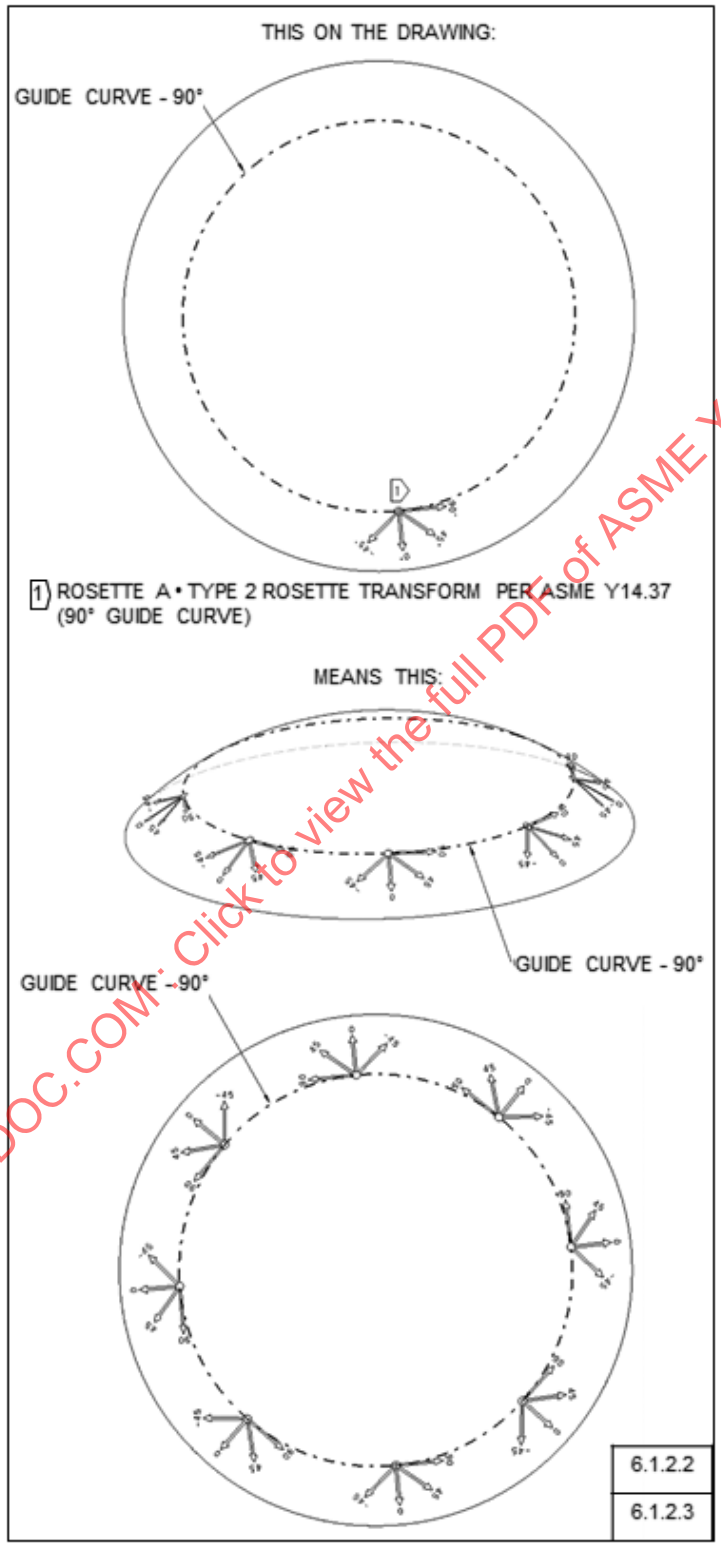


Figure 6-4 Type 3 Polar Rosette

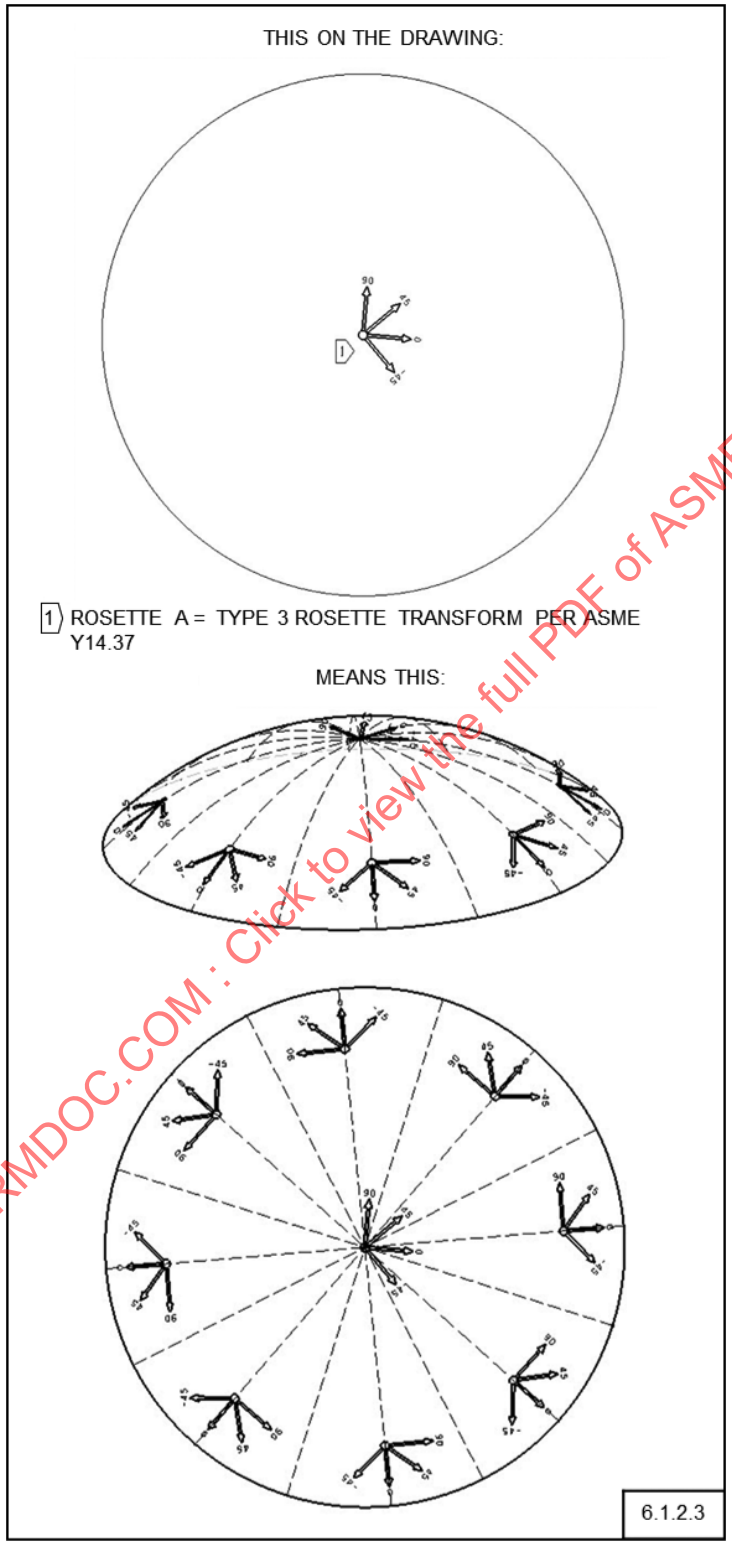
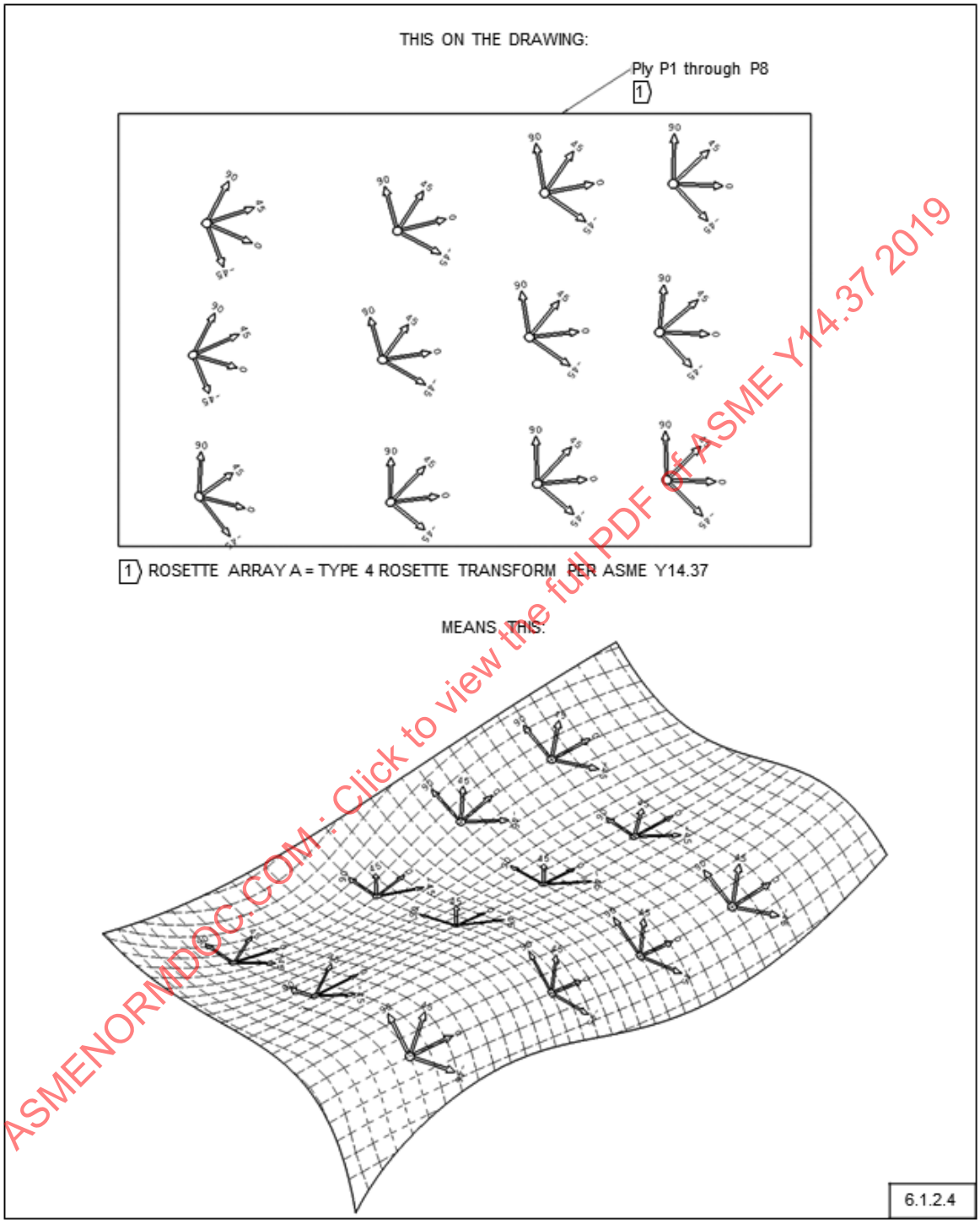


Figure 6-5 Type 4 Rosette Array



7 PLY DEFINITION REQUIREMENTS

7.1 Common Requirements

Ply definition requirements shall include the following:
(a) ply level (see para. 7.1.1)
(b) ply/item identification (see para. 7.1.2)
(c) ply representation [(geometry, size, and location) see para. 7.1.3]
(d) ply orientation (see para. 7.1.4)
(e) material (see para. 7.1.5)
(f) user-defined attribute(s) included by the terms of a contract or business requirement

7.1.1 Ply Level. The requirements for ply level are as follows:
(a) 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.
(b) The entire list of ply levels per part shall be in ascending order.

7.1.2 Ply/Item Identification. The requirements for ply/item identification are as follows:
(a) Each ply shall be identified uniquely within a part with a separate ply identification regardless of configuration or orientation. See para. 3.31.
(b) An embedded item included in the laminate shall be identified with the item identifier.

7.1.3 Ply Representation (Geometry, Size, and Location). The requirements for ply representation are as follows:
(a) The definition of each ply shape shall include clear indications of the edges of each ply within the laminate, including internal cutouts and outside perimeter.
(b) Ply location within the laminate shall be specified via the ply level. See Figures 3-1 through 3-5.
(c) Developed ply flat patterns may be included in the data set. Use of flat patterns may be defined by the terms of a contract or business requirement.

7.1.4 Ply Orientation

7.1.4.1 Ply Orientation for Materials Without Reinforcing Fibers. For materials without reinforcing fibers (e.g., adhesive films or surfacing films), each ply shall have a ply orientation such as “optional”, “none”, “—”, or “NA” (not applicable) specified.

7.1.4.2 Ply Orientation for Materials With Reinforcing Fibers. For materials with reinforcing fiber, the requirements for ply orientation are as follows:
(a) Each ply shall have a ply orientation defined.
(b) Ply orientation values shall be defined between −180° to +180°. If control of the ply orientation is not required, a ply orientation such as “optional” or “none” may be specified.
(c) The allowable ply orientation angle tolerance shall be defined in relation to the ply orientation symbol. No tolerance shall be applied to the ply orientation vectors.
(d) Each ply shall be associated with a ply orientation symbol.
(e) For tape plies, ply orientation refers to the fiber direction.
(f) For woven fabric plies, ply orientation refers to the warp direction.

7.1.4.3 Ply Orientation for Items. For embedded items (e.g., cores, precured parts, inserts, metallic parts), the requirement for ply orientation are as follows:
(a) Items without a required orientation (e.g., items with isotropic material properties) should have an orientation specified such as “optional”, “none”, “—“, or “NA”; or the orientation may be unspecified.
(b) Items with a required orientation (e.g., core with ribbon direction or metallic parts with grain direction) should have an orientation specified. See requirements in para. 7.1.4.2.

7.1.5 Ply Material. The requirement for ply material is that each ply shall have a material identified.

7.2 Model Requirements

In addition to common requirements in para. 7.1, the requirements in paras. 7.2.1 through 7.2.5 apply.

7.2.1 Ply Level. The model requirement for ply level is that each ply shall have an associated ply level attribute.

7.2.2 Ply/Item Identification. The model requirements for ply/item identification are as follows:

(a) Each ply shall have an associated identification attribute.
(b) Each item in the stackup shall have an associated identification attribute.

7.2.3 Ply Representation (Size, Location, and Geometry). The model requirements for ply size and location are as follows:
(a) Ply size and location shall be defined by its geometry and associated data.
(b) Ply geometry shall be represented using one or more of the following methods:
(1) solid or volumetric (bounded volume region) representation of the nominal ply shape positioned in its relative nominal position within the laminate.
(2) surfaces with a variable offset from the laminate reference surface representing the local thickness applicable to the ply level.
(3) supplemental geometry on the laminate reference surface representing the edge of the ply. At least one ply stackup schematic shall be presented to clearly define the laminate stackup. See section 8.

7.2.4 Ply Orientation. The model requirement for ply orientation is for each ply to have an orientation attribute associated with a ply orientation symbol.

7.2.5 Ply Material. The model requirements for ply material are as follows:
(a) Each ply shall have an associated material attribute.
(b) The material shall be represented in the ply attributes using one of the following methods:
(1) Dynamically link material specification to the ply.
(2) Embed a static derivative of the material specification as a user-defined attribute associated to the ply.

7.3 Drawing Graphic Sheet Requirements

In addition to common requirements in para. 7.1, the requirements in paras. 7.3.1 through 7.3.5 apply.

7.3.1 Ply Level. The two-dimensional (2D) drawing graphic sheet requirement for ply level is as follows:
(a) Ply level on a drawing graphic sheet shall be defined via the ply table (section 9) and on at least one ply stackup schematic (section 8).

7.3.2 Ply/Item Identification. The 2D drawing graphic sheet requirements for ply/item identification are as follows:
(a) All plies and items for the part shall be defined in the ply table view.
(b) Where identified in additional views, it is not necessary to append the ply/item identifiers with “ref.”

7.3.3 Ply Representation (Geometry, Size, and Location). The 2D drawing graphic sheet requirement for ply size and location is as follows:
(a) Edges of the plies shall be specified using one or more text with arrow leaders pointing to the edges with the ply identification. See Figure 3-1.

7.3.4 Ply Orientation. The 2D drawing graphic sheet requirements for ply orientation are as follows:
(a) The ply orientation shall be defined in the ply table view.
(b) The ply orientation shall be associated to the ply orientation symbol presented in the ply table, tool side view, or both.
(c) The ply orientation symbol shall be presented in the tool side view.
(d) The zero degree axis and orientation of the ply orientation symbol, either positive or negative, or both, shall be presented. See Figure 7-1.
(e) The allowable orientation tolerance deviation of the plies from the ply orientation symbol shall be presented directly or by reference. No tolerance shall be applied to the ply orientation symbol vectors.
(f) Each ply orientation symbol shall be identified to differentiate them from each other when more than one ply orientation symbol is required. See Figures 7-2 and 9-1.

7.3.5 Ply Material. The 2D drawing graphic sheet requirement for material is as follows:
(a) Each ply shall have a material identified via the ply table directly or by flag note to associated documentation.

Figure 7-1 Example Ply Orientation Symbols

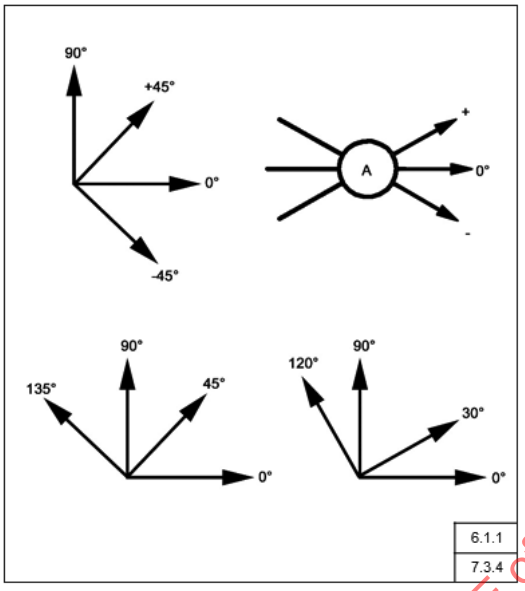
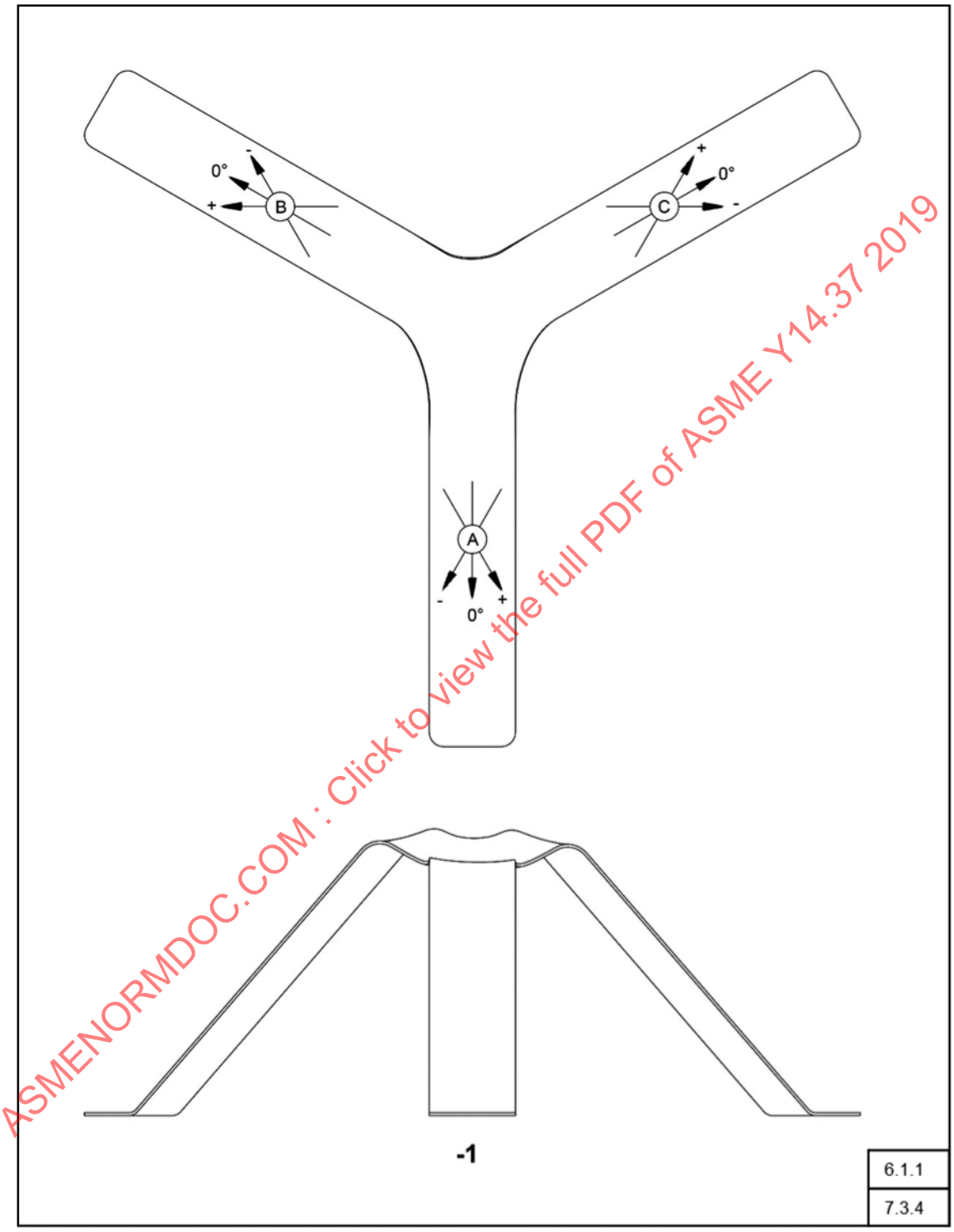


Figure 7-2 Multiple Ply Orientation Symbols



GENERAL NOTE: See Figure 9-1 for ply table with multiple orientation symbols.

8 PLY STACKUP SCHEMATIC

8.1 Common Requirements

The requirements for a ply stackup schematic are as follows:

(a) A ply stackup schematic 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) Other items shall be depicted within the ply stackup schematic through representation of the geometric shape. See Figure 3-2.

(d) One or more ply stackup schematics shall be provided, as required to present every ply or item in the laminate at least once. See Figures 3-2 and 12-4.

(e) The tool side surface(s) of the laminate(s) shall be labeled.

8.2 Model Requirements

The model requirements for a ply stackup schematic are as follows:

(a) Each ply stackup schematic shall be shown in at least one presentation state.

(b) Each ply or item presented in the schematic shall be represented with supplemental geometry. For example; wireframe, surface, shaded bounded areas, or bounded areas with section lining per ASME Y14.3 or other fill pattern.

8.3 Drawing Graphic Sheet Requirements

The drawing graphic sheet requirements for a ply stackup schematic are as follows:

(a) Each ply or item presented in the ply stackup schematic shall be represented with solid lines or bounded areas with fill patterns (e.g., section lining per ASME Y14.3).

(b) Each ply stackup schematic shall have an associated drawing view.

(c) Section views and section view callouts shall be defined per ASME Y14.3 to indicate the region of the part represented by the ply stackup schematic.

9 PLY TABLE

9.1 Common Requirements

The ply data elements listed in paras. 9.1.1 and 9.1.2 shall be able to be presented in a table format upon query of the data set (see Figure 3-5).

9.1.1 Required Ply Table Data Elements

(a) part identifier with optional part nomenclature
(b) ply level
(c) ply/item
  (1) ply identification
  (2) identification number of embedded item(s)
(d) ply orientation
(e) material

9.1.2 Additional Ply Table Data Elements. The following fields for any additional information shall be added as required to adequately define the configuration:

(a) ply orientation symbol identifier: when more than one ply orientation symbol identifier is used in the part, the associated ply orientation symbol for each ply/item in the ply table shall be identified. See Figure 9-2.

(b) user-defined fields (e.g., sequence/kit, splice control, revision letter, ply thickness, notes).

9.2 Model Requirements

A ply table is optional for a model. If a ply table is used, the requirements are as follows:

(a) The information presented in the ply table shall not conflict with the model ply definition attributes defined per para. 7.2. See Figure 9-1 for an example.

(b) Each ply table shall be shown in at least one presentation state.

9.3 Drawing Graphic Sheet Requirements

The drawing graphic sheet requirements for a ply table are as follows:

(a) A separate drawing view shall be created for each ply table on the drawing graphic sheet. See Figure 3-5.

(b) For classification codes 2 and 3 per ASME Y14.100, the ply data elements presented on the ply table on the drawing graphic sheet shall not conflict with the ply data elements defined in the model.

Figure 9-1 Ply Table in an Annotated Model

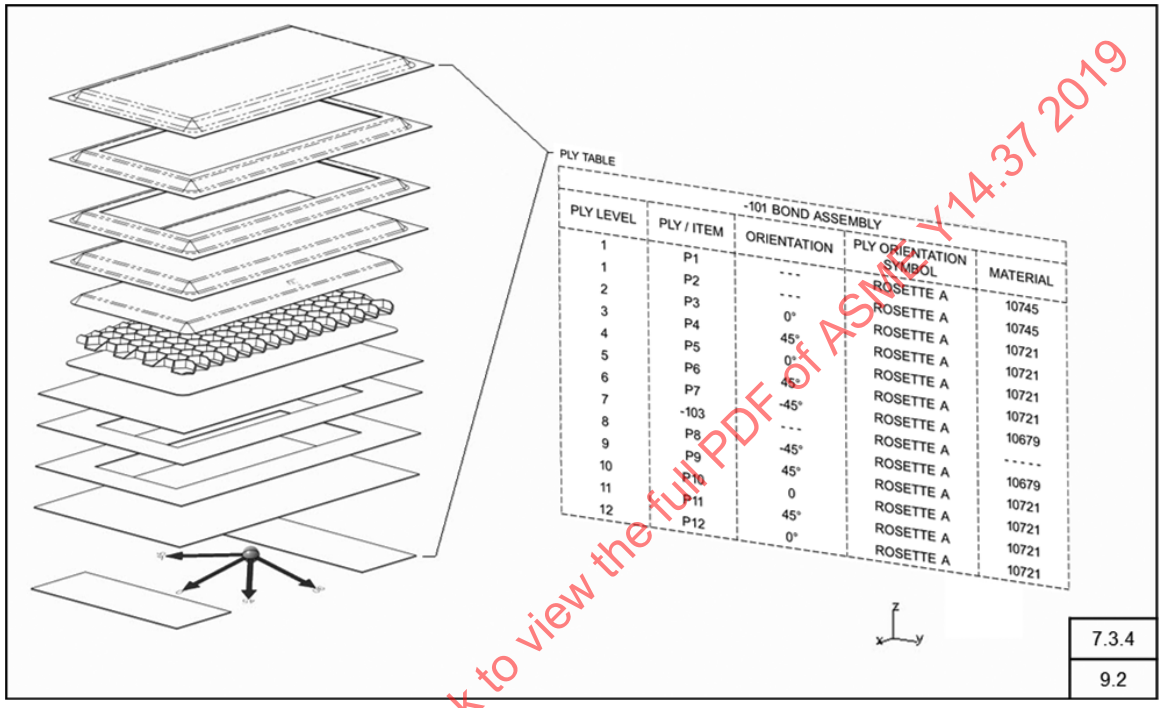


Figure 9-2 Ply Table With Multiple Orientation Symbols

-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

9.1.2

10 OPPOSITE PARTS

10.1 Common Requirements

The requirements for opposite parts are as follows:

(a) An opposite composite part shall be geometrically symmetrical, including ply geometry, ply level, ply orientation, and end item trim.

(b) If the parts are not completely symmetrical, both parts shall be completely defined.

(c) The relationship between the parts shall be defined in the datasets and associated administrative data.

(d) The opposite part may be defined by reference to the prime part via notation such as **#PART 1# IS AN EXACT OPPOSITE OF #PART 2#. THE PART AUTHORITY DEFINITION RESIDES IN #PART 1# AND IS APPLICABLE TO THE PRIME AND OPPOSITE PARTS.**

10.2 Model Requirements

Model requirements for opposite parts are as follows:

(a) A dataset for both prime and opposite parts shall be provided.

(b) Complete ply definition and solid part representation shall be provided in the opposite part.

10.3 Drawing Graphic Sheet Requirements

Drawing graphic sheet requirements for opposite parts are as follows:

(a) Presentation of symmetrically opposite parts should be separate definition in separate drawing graphic sheets or views.

(b) The SHOWN and OPPOSITE nomenclature method shall be used when separate definitions are not used and the symmetrically opposite parts are presented in the same view. See Figures 10-1 and 10-2.

(c) For opposite parts, the ply orientation symbol shall be mirrored and each PIN shall be entered in a ply table to itemize the plies for both parts. A note specifying that the ply orientation symbol is mirrored for the opposite part shall be used. For example **THE PLY ORIENTATION SYMBOL IS MIRRORED FOR THE OPPOSITE PART.**

(d) The ply orientation symbol may be used in the ply table in place of the note. See Figures 10-1 and 10-2.

Figure 10-1 Opposite Ply Orientation Symbol

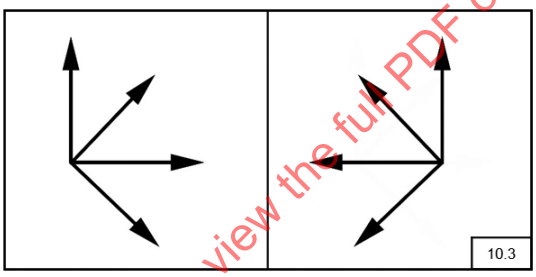
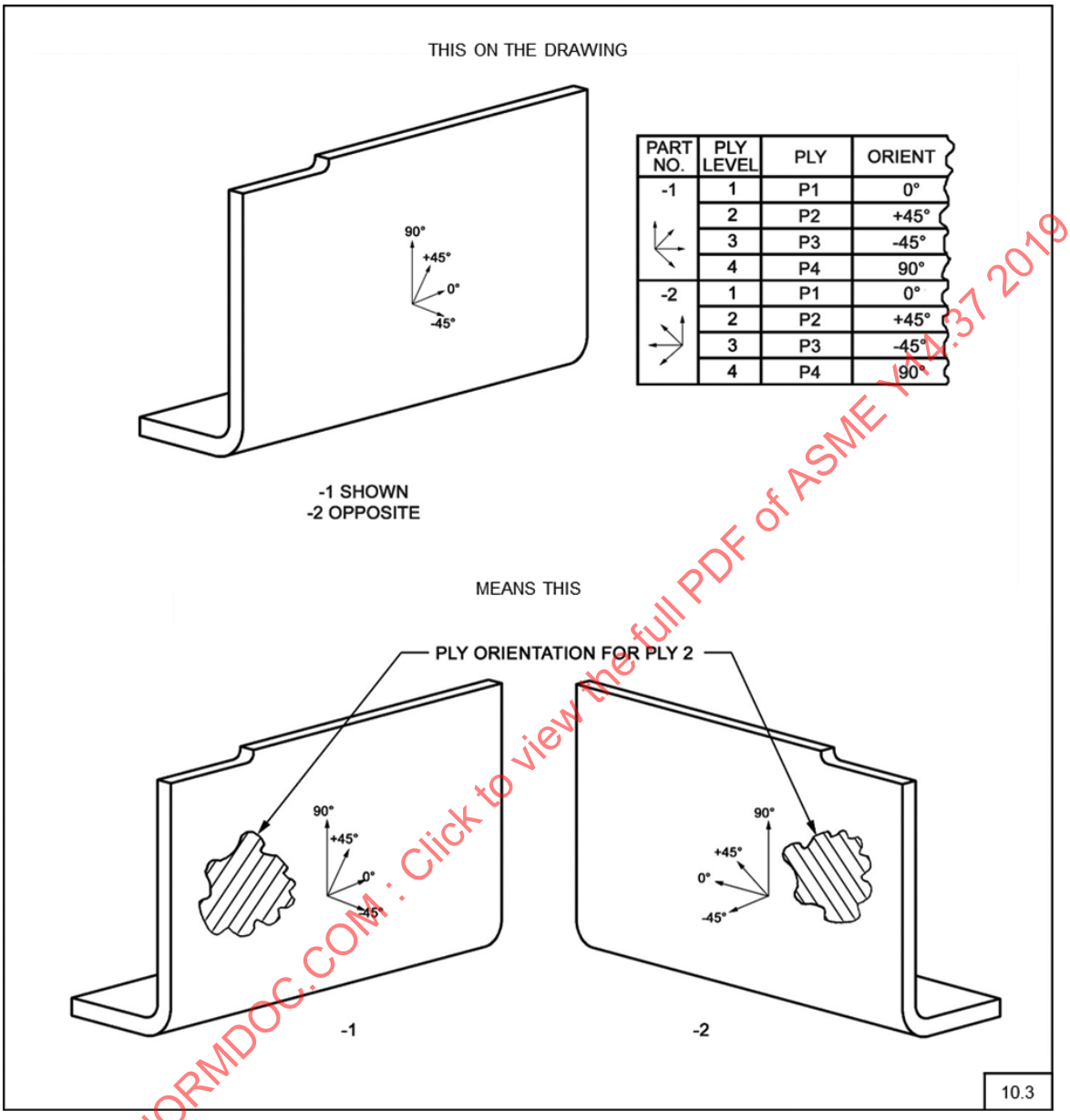


Figure 10-2 Opposite Part in Same View



11 REVISIONS

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

12 MANUFACTURING PROCESS REQUIREMENTS

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, the following applies:

(a) The process parameters shall be defined directly (i.e., as annotations, attributes, or both) in the annotated model, drawing graphic sheet, associated list, or by reference to an associated process specification.

(b) The intended manufacturing process shall be identified in the product definition data set.

Paragraphs 12.1 through 12.6 define exceptions and additional requirements that are specific to a manufacturing process. Unless otherwise stated, the requirements in sections 4 through 11 shall apply.

12.1 Braiding

The braiding process creates a preform or final shape. One or more preforms are then placed in layers in a mold, resin infused, and cured. Preforms may be stitched (or stabilized in some other way) to hold their shape or positional relationship to other preforms. A commingled preform may contain thermoplastic fibers and may be consolidated by elevated temperature and pressure without resin injection.

The requirements for braided parts are as follows:

(a) The number of ply levels shall define the number of preform layers or number of layers in the final shape.

(b) Stitching shall be represented with supplemental geometry and per ASTM D6193. See para. 6.4.1(l).

(c) Stabilization methods, other than stitching, shall be defined directly or by reference to associated documentation using supplemental geometry, annotation, flag notes, attributes, or combination thereof.

12.1.1 Ply Definition Requirements for Braided Parts. In addition to ply definition requirements in section 7, each ply level (i.e., preform or layer) shall define

(a) the braid configuration (e.g., biaxial or triaxial)

(b) the braid angle

(c) tension

12.1.2 Model Requirements. The following shall be defined as attributes or material attributes in the model directly or by reference to associated documents:

(a) the braid configuration for each ply level

(b) the braid angle for each ply level

(c) tension for each ply level

12.1.3 Ply Table for Braiding. In addition to ply table requirements in section 9, paras. 12.1.1(a) through 12.1.1(c) shall be specified for each ply level in the ply table or by reference to associated documents.

12.2 Compression Molding

Specific areas or zones of the mold shall be identified when different size or length of fibers is required.

12.3 Fiber and Tape Placement

(a) Allowable gaps and overlaps between tows and bands shall be defined.

(b) Ply geometry shall be defined such that minimum course length is accounted for in the design, or the ply geometry shall be defined without accommodations for minimum course length and a note similar to the following shall be provided: **PLY DEFINITIONS DO NOT ACCOUNT FOR MINIMUM COURSE LENGTH FOR FIBER PLACEMENT \ AUTOMATED TAPE LAYING MACHINE OPERATIONS. MANUFACTURING MAY ADJUST PLY DEFINITIONS AS NEEDED TO ADD MATERIAL.**

12.4 Filament Winding

(a) The ply orientation symbol shall be oriented with 0° in relation to the tool axis of rotation.

(b) 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. The IML surface shall extend beyond the edge of the part as required.

(c) Allowable gaps and overlaps between tows and bands shall be defined. See Figure 12-1.

12.4.1 Ply Table for Filament Winding. In addition to the ply table requirements in section 9, each ply level of the ply table shall specify

(a) either hoop ply or helical ply

(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

(a) Multistage bonded assemblies may be defined with individual precured parts in separate ply tables. See Figures 12-2 and 12-3, illustration (a).

(b) When a single ply table defines a multistage bonded assembly, a sequence may be indicated in the ply table to define individual groupings of plies. See Figure 12-3, illustration (b).

(c) When the shape of the assembly is complex, individual ply tables and ply stackup schematics may be provided in addition to the bonded assembly view and ply table. See Figure 12-4.

12.6 Pultrusion

(a) The ply orientation symbol shall be oriented with 0° in relation to the longitudinal direction of the tool.

(b) A constant cross section of the part shall be presented with the location of each roll and drop-off. See Figure 12-5.

12.6.1 Material Roll Section Views — Pultrusion. Material roll section views shall contain the following:

(a) section views for each material roll used in the part [see Figure 12-6, illustrations (a) and (b)]

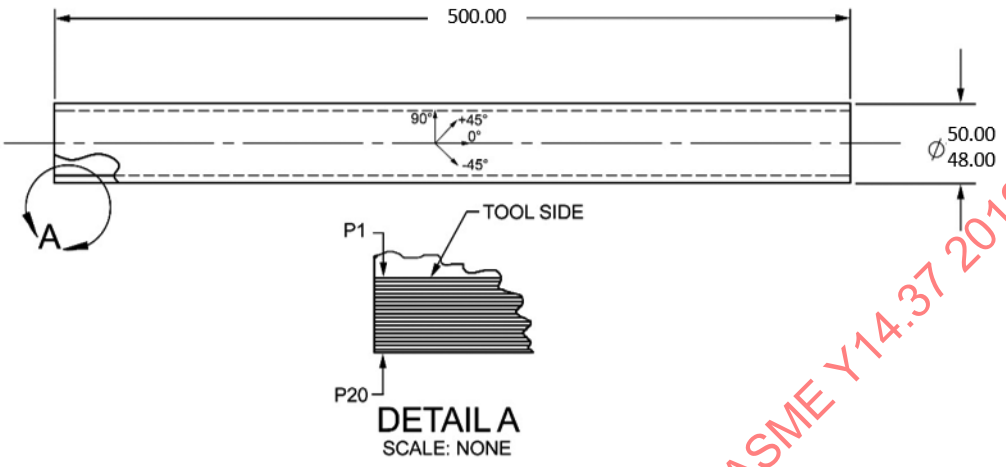
(b) location of material rolls

(c) location of drop-offs

(d) definition of splices

(e) ply table and any additional data about the plies within the roll noted in the corresponding table

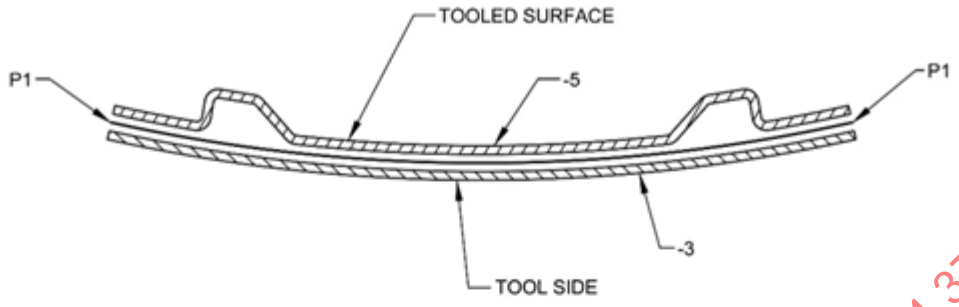
Figure 12-1 Filament Winding Part



-1204							
PLY LEVEL	PLY/ITEM	TYPE OF PLY	ORIENTATION	MATERIAL	BAND WIDTH mm	NO. OF TOW PER BAND	TENSION PER TOW N
1	P1	FILM ADH	---	10745	---	---	---
2	P2	HELIX	+45°	10721	6.5	3	9
3	P3	HELIX	-45°	10721	6.5	3	9
4	P4	HOOP	90°	10721	7.5	3	9
5	P5	HOOP	90°	10721	7.5	3	9
6	P6	HOOP	90°	10721	7.5	3	9
7	P7	HOOP	90°	10721	7.5	3	9
8	P8	HOOP	90°	10721	7.5	3	9
9	P9	HOOP	90°	10721	7.5	3	9
10	P10	HOOP	90°	10721	7.5	3	9
11	P11	HOOP	90°	10721	7.5	3	9
12	P12	HOOP	90°	10721	7.5	3	9
13	P13	HOOP	90°	10721	7.5	3	9
14	P14	HOOP	90°	10721	7.5	3	9
15	P15	HOOP	90°	10721	7.5	3	9
16	P16	HOOP	90°	10721	7.5	3	9
17	P17	HELIX	+45°	10721	6.5	3	9
18	P18	HELIX	-45°	10721	6.5	3	9
19	P19	HELIX	+45°	10721	6.5	3	9
20	P20	HELIX	-45°	10721	6.5	3	9

12.4

Figure 12-2 Multistage Bonding — Precured Method



-1 BOND ASSY			
PLY LEVEL	PLY/ITEM	ORIENTATION	MATERIAL
1	-3		-3 BOND
2	P1	OPTIONAL	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	OPTIONAL	PEEL PLY

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

12.5