Designation: D 6507 – 00

Standard Practice for Fiber Reinforcement Orientation Codes for Composite Materials[1]

This standard is issued under the fixed designation D 6507; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice establishes orientation codes for continuous-fiber-reinforced composite materials. Orientation codes are explicitly provided for two-dimensional laminates and braids. The laminate code may also be used for filament-wound materials. A method is included for presenting subscript information in computerized formats that do not permit subscript notation.

2. Referenced Documents

2.1 *ASTM Standards:*

D 3878 Terminology of High-Modulus Reinforcing Fibers and Their Composites[2]

E 1309 Guide for Identification of Composite Materials in Computerized Material Property Databases[2]

2.2 *Other Documents:*

MIL-HDBK-17-2D, *Polymer Matrix Composites*, Vol 2 Materials Properties, Section 1.6.1[3]

ISO 1268-1 *Fibre-reinforced plastics—Methods of producing test plates—Part 1: General Conditions*, Annex Stacking Designation Systems[4]

3. Terminology

3.1 *Definitions*—Definitions in accordance with Terminology D 3878 shall be used where applicable.

4. Significance and Use

4.1 The purpose of a laminate orientation code is to provide a simple, easily understood method of describing the lay-up of a laminate. The laminate orientation code is based largely on a combination of industry practice and the codes used in the *NASA/DOD Advanced Composites Design Guide*,[5] MIL-HDBK-17, and ISO 1268-1.

4.2 The braiding orientation code provides similar information for a two-dimensional braid, based largely on *Standard Test Methods for Textile Composites*.[6]

5. Reference System

5.1 A reference plane and direction are selected before writing the orientation code. The reference plane is selected as the bottom or top layer for the laminate orientation code. For laminates symmetric about their midplane, the orientation code using the top layer as the reference plane is identical to the orientation code using the bottom layer as the reference plane; selection of the reference plane effectively determines the positive *z*- or three-axis of the laminate. The reference direction (0°) is somewhat arbitrarily selected for convenience and relevance to the application. Often, a dominant fiber direction is defined to be 0°. An example in which relevance to testing determines the reference direction is in-plane shear specimens in which the loading direction is selected as 0°.

[1] This practice is under the jurisdiction of ASTM Committee D-30 on Composite Materials and is the direct responsibility of Subcommittee D30.01 on Editorial/Reference Standards.

Current edition approved Feb. 10, 2000. Published April 2000.

[2] *Annual Book of ASTM Standards*, Vol 15.03.

[3] Available from DOD Single Stock Point, 700 Robbins Ave., Building 4D, Philadelphia, PA 19111-5094, http://www.dodssp.daps.mil/

[4] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[5] *NASA/DOD Advanced Composites Design Guide*, Vol 4, Section 4.0.5, Air Force Wright Aeronautical Laboratories, Day, OH, prepared by Rockwell International Corp., 1983 (distribution limited).

[6] Masters, J. E., and Portanova, M. A., *Standard Test Methods for Textile Composites*, NASA CR-4751, NASA Langley Research Center, 1996.

6. Laminate Orientation (Lay-up) Code

6.1 The following information and the examples in Fig. 1 describe the laminate orientation code. Ply directions and number of layers are indicated using the laminate orientation code as follows:

$$[\theta_1 m_1 b_1 / \theta_2 m_2 b_2 \ldots]_{nsb} \text{ notes} \quad (1)$$

where:

θ_1, θ_2 = ply orientations (degrees) of the laminate stacking sequence (see 6.1.2),

m_1, m_2 = number of plies at each particular orientation θ_1, θ_2, . . . (not used for a single ply) (see 6.1.3),

b_1, b_2 = material type and form, or both, (if required) at each particular orientation θ_1, θ_2, . . . (see 6.1.5),

n = number of repetitions of the bracketed group of plies (see 6.1.4),

s = indication of geometric symmetry (see 6.1.6), and

b = indicator of material type and form, or both, (if required) for an abbreviated group of plies.

All subscripts are lowercase with the exception of 'T' for total (see 6.1.6).

6.1.1 Laminae are listed in order from the reference plane to the opposite side of the laminate. Square brackets are used to indicate the beginning and the end of the code.

6.1.2 The orientation of each lamina with respect to the reference direction is indicated by the angle between the principal fiber direction of that lamina and the reference direction. When indicating the lay-up of a weave, the angle is measured between the warp direction and the reference direction. Positive angles are measured counter-clockwise from the reference direction when looking toward the lay-up surface (right-hand rule). A consistent range of angles is used with all angles in the range $90 \geq \theta > -90$. Orientations of successive laminae with different values are separated by a virgule (/). Pairs of plies of equal and opposite angle may be indicated by plus-minus ($\pm$) and minus-plus ($\mp$) symbols, where the top of the symbol indicates the direction of the first ply. For example, [+45/–45/–45/+45] is the same as [$\pm$ 45/$\mp$45].

6.1.3 Ply symbols for two or more adjacent laminae with the same orientation and material system can be condensed by writing the common angle (and material form, if necessary)

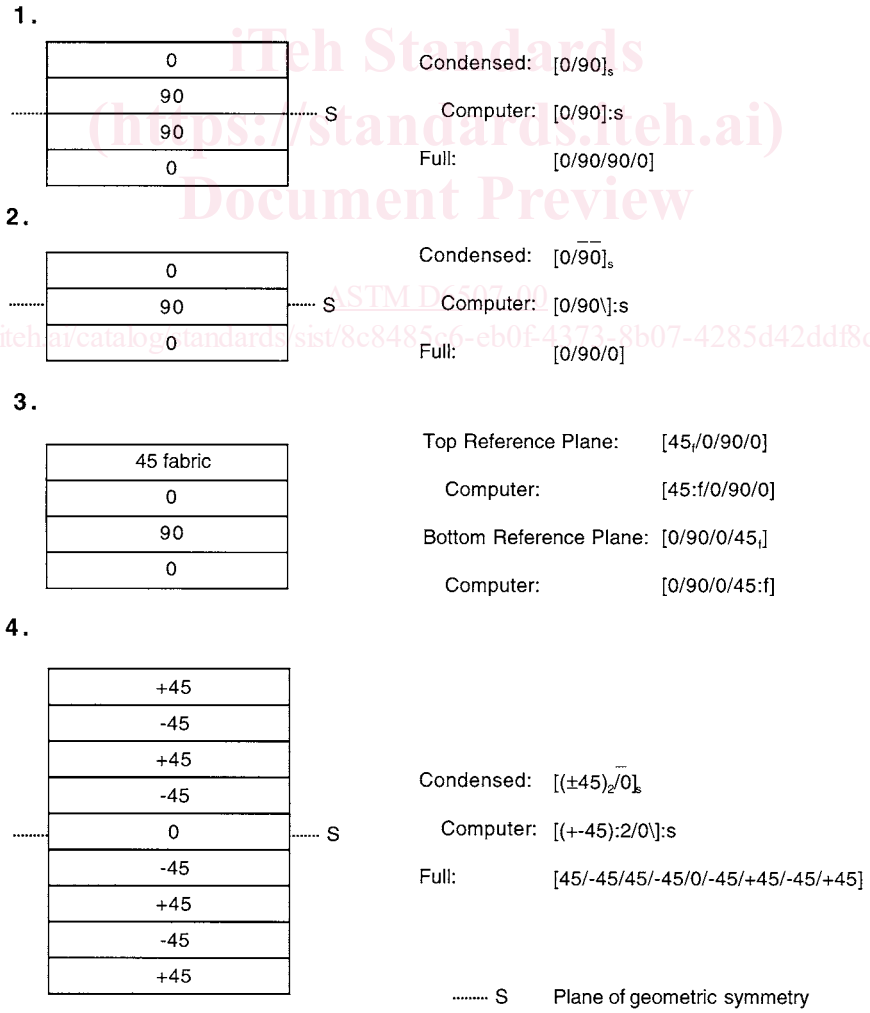

FIG. 1 Examples of Laminate Orientation Code