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Standard Terminology for Composite Materials[1]

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This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 These definitions cover generic terms, including terms of commercial importance, that appear in one or more standards on composites containing high-modulus (greater than 20-GPa (3×10^6 psi)) fibers.

1.2 The definitions cover, in most cases, special meanings used in the composites industry. No attempt has been made to include common meanings of the same terms as used outside the composites industry.

1.3 Definitions included have, in general, been approved as standard.

2. Referenced Documents

2.1 *ASTM Standards:*
D 123 Terminology Relating to Textiles[2]
2.2 *Military Standard:*
MIL-HDBK-17[3]

3. Terminology

3.1 *Definitions:*

±45° laminate—a balanced symmetric laminate composed of only +45° plies and −45° plies.

angleply laminate—any balanced laminate consisting of plus and minus theta plies where theta is an acute angle with respect to a reference direction.

balanced laminate—any laminate that contains one ply of minus theta orientation with respect to the laminate principal axis for every identical ply with a plus theta orientation.

braided fabric—see *braided fabric* under **fabric.**

bundle—a general term for a collection of essentially parallel filaments.

carbon fiber precursor—a material from which carbon fiber is made by pyrolysis. Polyacrylonitrile, rayon or pitch fibers are commonly used precursors.

catenary:

filament catenary—the difference in length of the filaments in a specified length of tow, end, or strand as a result of unequal tension; the tendency of some filaments in a taut horizontal tow, end, or strand to sag lower than others.

roving catenary—the difference in length of the ends, tows, or strands in a specified length of roving as a result of unequal tension; the tendency of some ends, tows, or strands in a taut horizontal roving to sag lower than others.

composite:

composite material—a substance consisting of two or more materials, insoluble in one another, which are combined to form a useful engineering material possessing certain properties not possessed by the constituents.

DISCUSSION—a composite material is inherently inhomogeneous on a microscopic scale but can often be assumed to be homogeneous on a macroscopic scale for certain engineering applications. The constituents of a composite retain their identities: they do not dissolve or otherwise merge completely into each other, although they act in concert.

discontinuous fiber-reinforced composite—any composite material consisting of a matrix reinforced by discontinuous fibers. The fibers may be whiskers or chopped fibers.

fabric-reinforced composite—any composite material consisting of a matrix reinforced by fabric (woven, knitted, or braided assemblages of fibers).

fiber-reinforced composite—any composite material consisting of a matrix reinforced by continuous or discontinuous fibers.

filamentary composite—a composite material reinforced with continuous fibers.

unidirectional fiber-reinforced composite—any fiber-reinforced composite with all fibers aligned in a single direction.

crossply laminate—a laminate composed of only 0 and 90° plies. This is not necessarily symmetric.

damage, *n—in structures and structural materials,* an anomaly or imperfection in a material or structure.

DISCUSSION—This is a generic usage of the term covering all anomalies and imperfections ranging from the material level to the overall structural level. Specific terms that are used include defects and flaws. For example, in common (aircraft) industry usage, that which occurs in the basic acquired material as produced is referred to as a defect; that which occurs due to manufacturing processes is referred to

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[2] *Annual Book of ASTM Standards*, Vol 07.01.

[3] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111–5094.

as a flaw; and only that which occurs due to in-service usage is specifically referred to as damage.

damage resistance, *n—in structures and structural mechanics,* a measure of the relationship between the force, energy, or other parameter(s) associated with an event or sequence of events and the resulting damage size and type.

DISCUSSION—Damage resistance increases as the force, energy, or other parameter increases for a given size or type of damage. Conversely, damage resistance increases as damage decreases, for a given applied force, energy, or other parameter. Damage resistance and damage tolerance are often confused. A material or structure with high damage resistance will incur less physical damage from a given event. Materials or structures with high damage tolerance may incur varying levels of physical damage but will have high amounts of remaining functionality. A damage-resistant material or structure may, or may not, be considered damage tolerant.

debond—a deliberate separation of a bonded joint or interface, usually for repair or rework purposes.

delamination—separation of plies in a laminate. This may be local or may cover a large area in the laminate.

disbond—an area within a bonded interface between two adherents in which an adhesive or cohesive failure has occurred. It may occur at any time during the life of the structure and may arise from a wide variety of causes. It is sometimes used to describe an area of separation between two laminae in the finished laminate (the term "delamination" is preferred).

discontinuous fiber—a polycrystalline or amorphous fiber that is discontinuous within the sample or component or that has one or both ends inside of the stress field under consideration. The minimum diameter of a discontinuous fiber is not limited, but the maximum diameter may not exceed 0.25 mm (0.010 in.).

end, *n—in fibrous composites,* a general term for a continuous, ordered assembly of essentially parallel, collimated filaments, with or without twist.

DISCUSSION—This term covers tow, strand, sliver, yarn, and roving. The relationship between fiber form terms is shown in Table X1.1.

fabric—a planar textile (Synonym: cdth)

braided fabric, n—a cloth constructed by a braiding process.

knitted fabric, n—a cloth constructed by a knitting process.

nonwoven fabric, n—a cloth constructed by bonding or interlocking, or both (but not interlacing) fiber by any combination of mechanical, chemical, thermal, or solvent means.

plied yarn, n—a yarn formed by twisting together two or more single yarns in one operation.

DISCUSSION—Plying, which is done in the opposite direction from the twist of each of the simple yarns, serves to counter the tendency of simple yarns to untwist.

woven fabric, n—a cloth constructed by a weaving process.

fiber, *n*—one or more filaments in an ordered assemblage.

DISCUSSION—There are a number of general and specific terms that define specific types of fiber forms. The relationship between fiber form terms is shown in Table 1.

fiber content—the amount of fiber present in a composite expressed either as percent by weight or percent by volume. This is sometimes stated as a fraction, that is, fiber volume fraction.

TABLE 1 Fiber Forms

	Continuous Filaments		Discontinuous Filaments	
Twist	Twisted	Little or No Twist	Twisted	Little or No Twist
Tow,[A]	*[B]	P[C]	—[D]	—
strand, sliver				
Single yarn	P	*	P	—
Plied yarn	P	—	P	—
Roving[E]	*	P	—	—
end	(generic term that can be applied to any of the above)			
Chopped fiber	—	—	—	P
Whisker	—	—	(single crystal)	

[A] Small filament count.
[B] *—Secondary/alternate definition.
[C] P—primary/preferred definition.
[D] —not applicable.
[E] Large filament count.

fiber volume fraction—see **fiber content.**

filament, *n*—a fibrous form of matter with an aspect ratio >10 and an effective diameter <1 mm. (See also **monofilament.**)

DISCUSSION—Filaments may be essentially continuous (aspect ratio on the order of 10^5 or larger) or discontinuous. Whiskers are the special case of single crystal discontinuous filaments.

filament count—number of filaments in the cross section of a fiber bundle.

fill, *n—in a woven fabric,* the yarn running from selvage to selvage at right angles to the warp. **MIL-HDBK-17**

filler—in composite materials, a primarily inert solid constituent added to the matrix to modify the composite properties or to lower cost.

float, *n—in woven fabric,* the portion of a warp (or fill) yarn that extends unbound over two ro more fill (or warp) yarns. **D 123**

gel time, *n—in thermosetting polymers,* the period of time from a predetermined starting point to the onset of gelation as determined by a specific test method.

hybrid—(for composite materials) containing at least two distinct types of matrix or reinforcement. Each matrix or reinforcement type can be distinct because of its a) physical or mechanical properties, or both, b) material form, or c) chemical composition.

interlaminar—describing objects (for example, voids), events (for example, fracture), or fields (for example, stress) between the laminae of a laminate.

intralaminar—describing objects (for example, voids), events (for example, fracture), or fields (for example, stress) within the laminae of a laminate.

knit—a textile process that interlocks, in a specific pattern loop of yarn by means of needles or wires.

knitted fabric—See *knitted fabric* under **fabric.**

lamina—a subunit of a laminate consisting of one or more