**COMPOSITES TERMS GLOSSARY**

**A**

**abrasion:** The wearing away of a portion of the surface by either natural (rain, wind, etc.), mechanical (misfit, etc.), or manmade (oversanding, etc.) means; penetrates only the surface finish.

**abrasion resistance:** Ability of a plastic to withstand damage caused by mechanical action such as rubbing, scraping, etc.

**absorption:** The penetration into the mass of one substance by another. The process whereby energy is dissipated within a specimen placed in a field of radiant energy. The capillary or cellular attraction of adherent surfaces to draw off the liquid adhesive film into the substrate.

**accelerated test:** A test procedure in which conditions are increased in magnitude to reduce the time required to obtain a result. To reproduce in a short time the deteriorating effect obtained under normal service conditions.

**acrylic plastic:** An inexpensive thermoplastic for use at moderate temperatures.

**accelerator:** A material that when mixed with a catalyst or resin, will speed up the chemical reaction between the catalyst and the resin (either in polymerizing of resins or vulcanization of rubbers), Also called promoter.

**activation:** The (usually) chemical process of making a surface more receptive to bonding, to a coating, or an encapsulating material.

**addition:** A polymerization reaction in which no by-products are formed.

**additives:** Ingredients mixed into resin to improve properties

**adherent:** A body that is held to another body, usually by an adhesive. A detail or part prepared for bonding.

**adhesion:** The state in which two surfaces are held together at an interface by mechanical or chemical forces or both.

**adhesive:** A substance capable of holding two materials together by surface attachment. Adhesive can be in solid, liquid film, or paste form.

**adhesive failure:** A rupture of adhesive bond caused by a separation at the adhesive/adherent interface.
**adhesive film:** A synthetic resin adhesive, with or without carrier fabric, usually of the thermosetting type, in the form of a thin film of resin. Applied under heat and pressure between the two adherents.

**adhesive joint:** The location at which two adherents or substrates are held together with a layer of adhesive. The general area of contact for a bonded structure.

**adhesive strength:** Strength of the bond between an adhesive, and an adherent.

**absorption:** The adhesion of the molecules of gasses dissolved substances, or liquids in more or less concentrated form, to the surfaces of solids or liquids with which they are in contact. A concentration of a substance at a surface or interface of another substance.

**advanced composites:** Composite materials applicable to aerospace construction and made by imbedding high-strength, high-modulus fibers within an essentially homogeneous matrix.

**advanced filaments:** Continuous filaments made from high-strength, high-modulus materials for use as constituents of advanced composites.

**aging:** The effect on materials of exposure to an environment for an interval of time. 2. The process of exposing materials to an environment for an interval of time.

**air-bubble void:** Air entrapment within and between the plies of reinforcement or within a bond line of encapsulated area: localized, non-interconnected, and spherical in shape.

**alloy:** In plastics, a blend of polymers or copolymers with other polymers or elastomers under selected conditions; for example, styrene-acrylonitrile. Also called polymer blend. In metals, a substance having metallic properties and being composed of two or more chemical elements of which at least one is a metal.

**alternating stress:** A stress varying between two maximum values which are equal but with opposite signs, according to a law determined in terms of the time.

**ambient conditions:** The surrounding environmental conditions such as pressure, temperature, or relative humidity.

**amorphous plastic (amorphous phase):** A plastic that has no crystalline component. There is no order or pattern to the distribution of the molecules.

**amorphous polymer:** A polymer or plastic of which the molecular chains are arranged randomly with no long-term order.

**anaerobic adhesive:** An adhesive that cures only in the absence of air after being confined between assembled parts.

**anelasticity:** A characteristic exhibited by certain materials in which strain is a function of both stress and time, such that while no permanent deformations are involved, a finite time is required to establish equilibrium between stress and strain in both the loading and unloading directions.

**angle-ply laminate:** A laminate having fibers of adjacent plies oriented at alternating angles to the longitudinal direction.
**anisotropic material:** A material which has different properties in different directions. A unidirectional fiber composite, for instance, is much stronger and stiffer along the fibers (in the longitudinal direction) than across them (in the transverse direction).

**annealing:** In plastics, heating to a temperature at which the molecules have significant mobility, permitting them to reorient to a configuration having less residual stress.

**antioxidant:** A substance that, when added in small quantities to the resin during mixing, prevents its oxidative degradation and contributes to the maintenance or its properties.

**aramid:** A type of highly oriented polymer used as reinforcing fibers in composites. The best known aramid fiber is Kevlar by Dupont.

**areal weight:** The weight of fiber per unit area (width x length) of a tape or fabric.

**A-stage:** An early stage in the polymerization reaction of certain thermosetting resins (especially phenolic) in which the material, after application to the reinforcement, is still soluble in certain liquids and is fusible.

**attenuation:** The diminution of vibrations or energy over time or distance. The process of making thin and slender, as applied to the formation of fiber from molten glass.

**autoclave:** A closed vessel capable of being heated under pressure using an inert gas (CO₂ or N₃) to transfer the heat and pressure to a laminate component in order to consolidate and cure.

**automatic press:** A hydraulic press for compression and molding or an injection machine that operates continuously, being controlled mechanically, electrically, hydraulically, or by a combination of any of these methods.

**autoclave molding:** The process by which a layup in a mold or tool is cured or consolidated in an autoclave, rather than by some other means.

**axial strain:** The linear strain in a plane parallel to the longitudinal axis of the spectrum.

**axial winding:** In filament winding, a winding with the filaments parallel to the long axis of the mandrel. The would fiber tows are said to be at a 0° helix angle.

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**b-basis:** The “B” mechanical property value is the value above which at least 90 percent of the population of values is expected to fall, with a confidence of 95 percent.

**b-stage:** An intermediate stage in the reaction of a resin; that is, partial cure. In most thermoset prepeg, the resin has been cured to the b-stage.
**back pressure**: Resistance of a material, because of its viscosity, to continued flow when the mold is closing.

**bagging**: Applying an impermeable layer of film over an uncured part and sealing the edges so that a vacuum can be drawn.

**bag molding**: A molding technique in which the composite material is placed in a rigid mold and covered with a flexible bag, with pressure applied by a fluid or gas to flatten the composite against the mold.

**balanced construction**: 1) In fabric, equal parts of warp and fill yarn. 2) In composite layups, equal numbers of plies at opposite angles to the 0° direction, e.g. +/-45°, so that tensile loads cause only tensile strains, compressive loads cause only compressive strains, etc.

**balanced design**: In filament-wound reinforced plastics, a winding pattern so designed that the stresses in all filaments are equal.

**balanced laminate**: A composite laminate in which all laminae at angles other than 0° and 90° occur only in +/-pairs (not necessarily adjacent) and are symmetrical around the centerline.

**barrier coat**: An exterior coating applied to a composite wound structure to provide protection.

**barrier strength**: (See also bearing stress). When a composite laminate is overlapped and joined with a fastener, the tensile load that can be applied before the holes in the composite elongate beyond a specified maximum.

**batch**: In general, a quantity of material formed during the same process or in one continuous process and having identical characteristics throughout. Also called a lot.

**bearing area**: The diameter of the hole times the thickness of the material. The cross-section area of the bearing load member on the sample.

**bearing strength**: The maximum bearing stress that can be sustained. Also, the bearing stress at that point on the stress-strain curve where the tangent is equal to the bearing stress divided by n% of the bearing hole diameter.

**bearing stress**: If the edges of two composite laminates are joined using a fastener, and then tension is applied, the bearing stress is the stress on the fastener.

**bias fabric**: A fabric which contains fibers oriented at an angle, such as +/-45°, to its length.

**biaxial load**: A loading condition in which a laminate is stressed in two different directions in its plane. See also uniaxial load.

**biaxial winding**: A type of filament winding in which the helical band is laid in sequence, side by side, with no crossover of the fibers.

**bidirectional laminate**: A reinforced plastic laminate in which the fibers are oriented in more than one direction in the plane of the laminate.
**binder:** 1) The resin or cementing constituent (of a plastic compound) that holds the other components together. 2) The agent applied to fiber mat or preforms to bond the fibers before laminating or molding.

**bismaleimide:** A type of thermoset that cures by an addition reaction, avoiding formation of volatiles, and has temperature capabilities between those of epoxy and polyimide.

**bladder:** An elastomeric lining for the containment of hydroproof or hydroburst pressurization medium in filament-wound structures.

**blanket:** Fiber or fabric plies that have been laid up in complete assembly and placed on or in the mold all at one time (Flexible bag process). Also, the form of bag in which the edges are sealed against the mold.

**bleeder cloth:** Material, such as fiberglass, used in the manufacture of composite parts to allow the escape of excess gas and resin during cure. The bleeder cloth is removed after the curing process and is not part of the final composite.

**bleed out:** In filament winding, the excess liquid resin that migrates to the surface of the winding before cure.

**blister:** Defect on the surface of a molded part caused by gases trapped within the part during curing.

**bond:** The adhesion of one surface to another, with or without the use of an adhesive as a bonding agent.

**bond strength:** As measured by load/bond area, the stress required to separate a layer of material from that to which it is bonded.

**boron fiber:** A fiber usually of a tungsten-filament core with boron vapor deposited on it to impart strength and stiffness. Boron fibers are heavier than carbon or graphite fibers and are more expensive.

**braiding:** Weaving fibers into a tubular shape.

**breather:** A loosely woven cloth placed inside the vacuum bag over a layup. The breather allows the vacuum to be applied uniformly over the laminate so that air and volatiles can escape from it.

**broad goods:** Fibers woven into fabrics that may or may not be impregnated with resin, usually furnished in rolls.

**buckling (composite):** A mode of failure generally characterized by an unstable lateral material deflection due to compressive action on the structural element involved.

**bulk density:** The density of a molding material in loose form (granular, nodular, and so forth), expressed as a ratio of weight to volume.

**bulk factor:** The ratio of the volume of a raw molding compound or powdered plastic to the volume of the finished solid piece produced therefrom. The ratio of the density of the solid plastic object to the apparent or bulk density of the loose molding powder.

**bulk modulus:** The ratio of the hydrostatic pressure to the volume strain.
**burst strength (bursting strength):** Measure of the ability of a material to withstand internal hydrostatic or gas dynamic pressure without rupture. Hydraulic pressure required to burst a vessel of given thickness.

**butt joint:** A joint in which parts are jointed with no overlap. See also lap joint.

**c-scan:** A non-destructive inspection method for detecting delaminations and voids in composite laminates using ultrasonics. The part must be placed in a tank of water and scanned in transmission to produce a picture of the damage. C-scan results are easier to interpret than a-scan signals, but c-scan is usually limited to flat or mildly curved parts which will fit into the tank. See also a-scan, NDI.

**c-stage:** The final step in the cure of a thermoset resin, results in irreversible hardening and insolubility.

**carbon:** A more ordered form of carbon. Diamond is the densest crystalline form of carbon.

**carbon-carbon:** A composite material consisting of carbon or graphic fibers in a carbon or graphite matrix.

**carbon fiber:** An important reinforcing fiber known for its light weight, high strength, and high stiffness that is produced by pyrolysis of an organic precursor fiber in an inert atmosphere at temperatures above 1800°F. If the fibers are then graphitized above 3000°F, they are called graphite fibers.

**catalyst:** A substance used in small quantities to promote or control the curing of a compound without being consumed in the reaction.

**catastrophic failures:** Totally unpredictable failures of a mechanical, thermal, or electrical nature.

**caul plates:** Smooth plates free of surface defects used during the curing process on the mold face to provide a controlled surface on the finished laminate.

**cell:** In honeycomb core, a cell is a single unit, usually of a hexagonal shape.

**ceramic:** A rigid frequently brittle material made from clay and other inorganic, nonmetallic substances and fabricated into articles by sintering, that is, cold molding followed fusion of the part at high temperature.

**C-glass:** A glass with a soda-lime-borosilicate composition that is used for its chemical stability in corrosive environments.

**charring:** The heating of a composite in air to reduce the polymer matrix to ash, allowing the fiber content to be determined by weight.

**chemical vapor deposition (CVI):** A process in which desired reinforcement material is deposited from vapor phase onto a continuous core, boron on tungsten for example. See also boron fiber.

**circuit:** One complete traverse of the fiber feed mechanism filament-winding machine.

**circumferential winding:** A type of filament winding in which the filaments are perpendicular to the axis.
**Clamping pressure:** In injection molding and transfer molding, the pressure that is applied to the mold to keep it closed in opposition to the fluid pressure of the compressed molding material.

**Closure:** The complete coverage of a mandrel with one layer (two plies) of fiber. When the last tape circuit that completes mandrel coverage lays down adjacent to the first without gaps or overlaps, the wind pattern is said to have “closed.”

**Co-consolidation:** A processing step where two or more thermoplastic preformed parts are joined by being placed against each other in a fixture or tool and heated under pressure to melt the matrix resin.

**Co-curing:** The act of curing a composite laminate and simultaneously bonding it to some other prepared surface (such as stiffeners), or curing together an inner and outer tube of similar or dissimilar fiber-resin combination after each has been wound or wrapped separately.

**Coefficient of thermal expansion:** A material’s fractional change in length or volume for a given unit change of temperature.

**Cohesion:** The propensity of a single substance to adhere to itself. The internal attraction of molecular particles toward each other. The ability to resist partition of itself. The force holding a single substance together.

**Cohesive failure:** Failure of an adhesive joint occurring primarily in the adhesive layer.

**Cohesive strength:** Intrinsic strength of an adhesive.

**Cold flow:** The distortion that takes place in materials under continuous load at temperatures within the working range of the material without a phase or chemical change.

**Cold-setting adhesive:** A synthetic resin adhesive capable of hardening at normal room temperature in the presence of a hardener.

**Collimated:** Rendered parallel, as filaments in a tow or tows during the pre-pregging process.

**Commingled yarn:** A hybrid yarn made with two types of materials intermingled in a single yarn; for example, thermoplastic filaments intermingled with carbon filaments to form a single yarn.

**Compaction:** The application of a temporary vacuum bag and vacuum to remove trapped air and compact the lay-up.

**Compatibility:** The ability of two or more substances combined with one another to form a homogeneous composition of useful plastic properties: for examples the suitability of a sizing or finish for use with certain general resin types. Nonreactivity or negligible reactivity between materials in contact.

**Composite:** A material created from a fiber (or reinforcement) and an appropriate matrix material in order to maximize performance properties. The constituents do not dissolve or merge completely but retain their identities as they act in concert. The matrix acts as a load transfer medium between fibers.
**Composite Class**: A major subdivision of fibrous composite materials in which a class is defined by the geometric characteristic of the fiber arrangement. Examples of composite classes are filamentary laminates (q.v.), random chopped-fiber composites, and woven fabric.

**Composite Material**: A combination of two or more materials (reinforcing elements, fillers, and composites matrix binder), differing in form or composition on a macroscale. The constituents retain their identities; that is, they do not dissolve or merge completely into one another although they act in concert. Normally, the components can be physically identified and exhibit and interface between one another.

**Compound**: The intimate admixture of a polymer with other ingredients, such as fillers, softeners, plasticizers, reinforcement, catalysts, pigments, or dyes. A thermoset compound usually contains all the ingredients necessary for the finished product, while a thermoplastic compound may require subsequent addition of pigments, blowing agents etc.

**Compression Molding**: Introducing a material into an open mold closing the mold, and applying heat to make a part.

**Compressive Strength**: 1) The ability of a material to resist a force that tends to crush or buckle. 2) The maximum compressive load sustained by a specimen divided by the original cross-sectional area of the specimen.

**Compressive Stress**: The normal stress caused by forces directed toward the plane on which they act.

**Computer Aided Design (CAD)**: The use of a computer to develop the design of a product to be manufactured. The use of a computer to develop the design and necessary NC programs for use by the manufacturing equipment which will produce a product.

**Condensation**: A polymerization reaction in which simple byproducts (for example, water or alcohol) are formed.

**Conditioning**: Subjecting a material to a prescribed environmental and/or stress history before testing.

**Conductivity**: Reciprocal of volume resistivity. The electrical or thermal conductance of a unit cube of any material (conductivity per unit volume).

**Consolidation**: A process that fuses each ply together by tacking and flowing the matrix between plies. Usually involves heat and pressure.

**Contact Adhesive**: An adhesive that is apparently dry to the touch and which will adhere to itself simultaneously upon contact. This adhesive is applied to both adherents and allowed to dry, but it develops a bond when the adherents are brought together without sustained pressure.

**Contact Molding**: A molding technique in which reinforcement and resin are placed in a mold with cure taking place at room temperature with a catalyst/promoter system or in a healed oven, no additional pressure is used.

**Continuous Filament**: An individual, small-diameter reinforcement that is flexible and indefinite in length.
**continuous filament yarn:** Yarn formed by combining two or more continuous filaments into a single continuous strand with or without twisting.

**continuous roving:** Parallel filaments coated with a sizing, gathered together into single or multiple strands. It may be used to provide continuous reinforcement in woven roving, winding, pultrusion, prepregs, or high strength molding compounds, or it may be used chopped.

**copolymer:** A long-chain molecule formed by the reaction of two or more dissimilar monomers.

**core:** 1) The central component of a sandwich construction to which the sandwich faces or skins are attached. 2) Part of a complex mold that forms undercut parts. See also sandwich construction.

**core corrosion:** Oxidation or other chemical or electrolytic attack that adversely affects the core.

**core crush:** A collapse, distortion, or compression of the core.

**core splicing:** The joining of segments of a core by bonding, or by overlapping each segment and then driving them together.

**corrosion resistance:** The ability of a material to withstand damage by contact with ambient natural factors or those of a particular artificially created atmosphere, without degradation or change in properties. For metals, this damage could be pitting or rusting; for organic materials, it could be crazing.

**coupling agent:** Any chemical substance designed to react with both the reinforcement and matrix phases of a composite material to form or promote a stronger bond at the interface.

**coupon:** Usually, a specimen for a specific test, as a tensile coupon.

**cowoven fabric:** A reinforcement fabric woven with two different types of fibers in separate yarns; for example, thermoplastic fibers woven side by side with carbon fibers.

**crack:** An actual separation of material, visible on opposite surfaces of the part, and extending through the thickness. A fracture.

**crazing:** The development of a multitude of very fine cracks in a polymer.

**crack growth:** Rate of propagation of a crack through a material due to a static or dynamic applied load.

**creep:** The irreversible dimensional change in a material under mechanical load overtime.

**crimp:** A fiber’s waviness.

**critical length:** The minimum length of fiber required for complete transfer of stress from the adjacent matrix material.

**creel:** A device for holding the required number of roving balls (spools) or supply packages in desired position for unwinding onto the next processing step, that is, weaving, braiding, or filament winding.
Critical longitudinal stress: Applied to the longitudinal stress necessary to cause internal slippage and separation of a spun yarn. The stress necessary to overcome the interfiber friction developed as a result of twist.

Critical strain: The strain at the yield point.

cross laminated: Material laminated so that some of the layers are oriented at various angles to the other layers with respect to the laminate grain. A cross-ply laminate has plies oriented only at 0°/90°.

crossply: Any filamentary laminate which is not uniaxial.

crystallinity: In polymers, a microstructure in which the linear molecular chains are arranged in an orderly fashion. Branched or network polymers are not crystalline. Even linear polymers are not entirely crystalline, but have pockets of order within their bulk. They are, therefore, said to be “semi-crystalline.”

cure: To change the physical properties of a thermoset resin irreversibly by chemical reaction via heat and catalysts, alone or in combination, with or without pressure.

cure cycle: The time/temperature/pressure cycle used to cure a thermosetting resin system or prepreg.

cure stress: A residual internal stress produced during the cure cycle of composites containing reinforcements and/or resins with different thermal coefficients of expansion.

cure temperature: The temperature at which a material attains final cure.

curing agent: A catalytic or reactive agent that brings about a cross-linking reaction when it is added to a resin.

cycle: One full sequence in a molding operation, from a point in the process to the same point in the next sequence.

Dam: Boundary support or ridge used to prevent excessive edge bleeding or resin runout of a laminate and to prevent crowning of the bag during cure.

damage tolerance: The ability of a structure to withstand damage, as by impact, and still perform acceptably.

debond: An unplanned nonadhered or unbonded region in an assembly.

debulking: Compacting of a thick laminate under moderate heat and pressure and/or vacuum to remove most of the air or volatiles, to ensure seating on the tool, and to prevent wrinkles.

deformation: The change in size and/or shape of a material caused by some (usually mechanical) force.

degradation: A deleterious change in the chemical structure, physical properties, or appearance of a plastic.

degree of polymerization: Number of structural units, or mers, in the average polymer molecule in a sample measure of molecular weight.
**delamination**: The separation of a laminated plastic material between plies.

**dent**: A concave depression which does not rupture plies or debond the composite structure.

**deposition**: The process of applying a material to a base by means of vacuum, electrical chemical, screening, or vapor methods, often with the assistance of a temperature and pressure container.

**D-glass**: A high boron Content glass made especially for laminates requiring a precisely controlled dielectric constant.

**design allowables**: The measured strengths and strains-to-failure of a material reduced by some safety factors. These reduced properties are used in designing parts to be made from a material.

**disbond**: 1) An area within a bonded interface between two adherents in which an adhesion failure or separation has occurred. 2) Colloquially, an area of separation between two laminae in finished laminate (in this case, the term delamination is normally preferred). See also debond.

**doily**: In filament winding, the planar reinforcement applied to a local area between windings to provide extra strength in an area where a cut-out is to be made, for example, port openings. Usually placed at the knuckle joints of cylinder to dome.

**dome**: In filament winding, the portion of a cylindrical container that forms the spherical or elliptical shell ends of the container.

**draft angle**: A mandrel’s taper or angle for ease of part removal.

**draw**: To shape plastic by stretching or deforming through dies.

**dry laminate**: A laminate containing insufficient resin for complete bonding of the reinforcement.

**dry layup**: Construction of a laminate by the layering of preimpregnated reinforcement (partly cured resin) in a female mold or on a male mold, usually followed by bag molding or autoclave molding.

**ductility**: The amount of plastic strain that a material can withstand before fracture. Also, the ability of a material to deform plastically before fracturing.

**dwell**: A pause in the application of pressure or temperature mold, made just before it is completely closed to allow the escape of gas from the molding material. In filament winding, the time that the traverse mechanism is stationary while the mandrel continues to rotate to the appropriate point for the traverse to begin a new pass. In a standard autoclave cure cycle, an intermediate step in which the resin matrix is held at a temperature below the cure temperature for a specified period of time sufficient to produce a desired degree of staging. Used primarily to control resin flow.

**E**

**e-glass**: “Electrical glass”; the borosilicate glass most often used for the glass fibers in conventional reinforced plastics.
**elastic deformation**: The part of the total strain in a stressed body that disappears upon removal of the stress.

**elasticity**: That property of materials by virtue of which they recover their original size and shape instantaneously after the load which caused the change in size and shape is removed.

**elastomer**: A polymer having elastic properties.

**environment**: The aggregate of all conditions (such as contamination, temperature humidity, radiation, magnetic and electric fields, shock and vibration) that externally influence the performance of an item.

**environmental stress cracking (ESC)**: The susceptibility of a thermoplastic resin to crack or craze when in the presence of surface active agents or other environments.

**epoxy plastic**: A polymerizable thermoset polymer containing one or more epoxide groups and curable by reaction with amines, alcohols, phenols, carboxylic acids, acid anhydrides, and mercaptans. An important matrix resin in composites and structural adhesive.

**fabricating (fabrication)**: The manufacture of products from molded parts, rods, tubes, sheeting, extrusions, or other forms by appropriate operations, such as punching, cutting, drilling, and tapping. Fabrication includes fastening parts together or to other parts by mechanical devices, adhesives, heat sealing, welding, or other means.

**fabric fill face**: That side of the woven fabric where the greatest number of the yarns are perpendicular to the selvage.

**fabric prepreg batch**: Prepreg containing fabric from one fabric batch, impregnated with one batch of resin in one continuous operation.

**fatigue**: Damage caused by repeated loading of a material.

**fatigue life**: The number of cycles of deformation required to bring about failure of the test specimen under a given set of oscillating conditions (stresses or strains).

**fatigue limit**: The stress level below which a material can be stressed cyclically for an infinite number of times without failure.

**faying surface**: The surfaces of materials in contact with each other and joined or about to be joined together.

**felt**: A fibrous material made up of interlocked fibers by mechanical or chemical action, moisture, or heat. Made from fibers such as asbestos, cotton, glass, etc.

**fiber**: A single homogeneous strand of material, essentially one-dimensional, used as a principal constituent in composites because of its high axial strength and modulus.

**fiber count**: The number of fibers per unit width of ply preset in a specified section of a composite.
**fiberglass:** An individual filament made by drawing molten glass. A continuous filament is a glass fiber of great or indefinite length. A staple fiber is a glass fiber of relatively short length, generally less than 430 mm (17in) the length related to the forming or spinning process used.

**fiber orientation:** The fiber alignment in a non-woven or a mat laminate in which most of the fibers are in the same direction, thereby affording higher strength in that direction.

**fiber wash:** Splaying out of woven or nonwoven fibers from the general reinforcement direction. Fiber wash Occurs when fibers are carried along with bleeding resin during the cure cycle or consolidation.

**filaments:** Individual fibers of indefinite length used in yarn, or roving.

**filamentary composites:** A major form of advanced composites in which the fiber constituent consists of continuous filaments. Filamentary composites are defined here as composite materials composed of laminae in which the continuous filaments are in nonwoven, parallel, uniaxial arrays. Individual uniaxial laminae are combined into specifically oriented multiaxial laminates for application to specific envelopes of strength and stiffness requirements.

**filament weaving:** A process for fabricating a composite structure in which continuous reinforcements (filament, wire, yarn, tape, or other), either previously impregnated with a matrix material or impregnated during the winding are placed over a rotating and removable form or mandrel in a prescribed way to meet certain stress conditions. Generally the shape is a surface of revolution and may or may not include end closures. When the required number of layers is applied, the wound form is cured and the mandrel removed.

**fill:** Yarn oriented at right angles to the length of a woven fabric. See also warp, weft.

**filler:** A second material added to a basic material to alter its physical, mechanical, thermal, or electrical properties. Sometimes used specifically to mean particulate additives.

**fillet:** A rounded filling or adhesive that fills the corner or angle where two adherents are joined.

**film adhesive:** A synthetic resin adhesive, usually of the thermosetting type, in the form of a thin, dry film of resin with or without a paper or glass carrier.

**finish:** A mixture of materials for treating glass or other fibers. It contains a coupling agent to improve the bond of resin to the fiber, and usually abrasion, as well as a binder to promote strand integrity. With graphite or other filaments, it may perform any or all of the above functions.

**flame resistance:** Ability of a material to extinguish flame once the source of heat is removed.

**flash:** Excess resin which forms at the parting line of a mold or die, or which is extruded from a closed mold.

**flow:** 1) the movement of resin under pressure, allowing it to fill all parts of a mold. 2) The gradual but continuous distortion of a material under continued load, usually at high temperatures; also called creep.

**fluted core:** An integrally woven reinforcement material consisting of ribs between two skins in a unitized sandwich construction.
fracture: A rupture of a laminate because of external or internal forces, with or without complete separation.

free wall: The portion of a honeycomb cell wall that is not connected to another cell.

fungus resistance: The ability of a material to resist attack by fungi, especially in conditions promoting fungic growth.

gap: In filament winding the space between successive windings which are usually intended to lay next to each other. Separations between fibers within a filament winding band. The distance between adjacent plies in a lay-up of unidirectional tape materials.

gel: 1) The initial jellylike solid phase that develops during the cure of a thermoset resin. 2) A semisolid system consisting of a network of solid aggregates in which liquid is held.

gel coat: A quick setting resin applied to the surface of a mold and gelled before layup. The gel coat becomes an integral part of the finished laminate, and is usually used to improve surface appearance and bonding.

glass: An inorganic product of fusion that has cooled to a rigid condition without crystallizing. Glass is typically hard and relatively brittle, and has a conchoidal fracture.

glass, percent by volume: The product of the specific gravity of a laminate and the percent glass by weight, divided by the specific gravity of the glass.

glass stress: In a filament wound part, usually a pressure vessel, the stress calculated using the load and the cross-sectional area of the reinforcement only.

glass transition: The temperature range above which a thermoset or an amorphous thermoplastic is too “leathery” or “rubbery” to be a useful structural material. Most plastics and composites have continuous service temperatures below the glass transition.

graphite: The crystalline allotrope of carbon.

graphite fiber: A fiber made from a precursor by oxidation, carbonization and graphitization process. See also carbon fiber.

hand lay-up: The process of placing (and working) successive plies of reinforcing material or resin-impregnated reinforcement in position on a mold by hand.

handling life: The out-of-refrigeration time over which a thermoset prepreg retains its handle-ability.
**hardener:** A substance or mixture added to a plastic composition to promote or control the curing action by taking part in it.

**hardness:** The resistance to surface indentation usually measured by the depth of penetration (or arbitrary units related to the depth of penetration) of a blunt point under a given load using a particular instrument according to a prescribed procedure.

**harness satin:** Weaving pattern producing a satin appearance. “Eight-harness” means the warp tow crosses over seven fill tows and under the eighth (repeatedly). See also warp, fill.

**heat-activated adhesive:** A dry adhesive that is rendered tacky or fluid by application of heat, or heat and pressure, to the assembly.

**heat resistance:** The property or ability of plastics and elastomers to resist the deteriorating effects of elevated temperatures.

**heat sealing:** A method of joining plastic films by simultaneous application of heat and pressure to areas in contact.

**heatsink:** A material for the absorption or transfer of heat away from a critical element or part. Bulk graphite is often used as a heat sink.

**heat treating:** Term used to cover annealing, hardening, tempering, etc.

**heterogeneous:** 1) Consisting of dissimilar constituents separately identifiable. 2) Consisting of regions of unlike properties separated by internal boundaries. Note that not all nonhomogeneous materials are not necessarily heterogeneous. Fiber-reinforced composites are heterogeneous.

**homogeneous:** Having uniform composition throughout. Having no internal physical boundaries. Having properties that are constant at every point, that is, constant with respect to spatial coordinates (but not necessarily with respect to directional coordinates).

**honeycomb:** Manufactured product of resin-impregnated sheet material (paper, glass fabric, and so on) or metal foil, formed into cells usually of a hexagonal shape. Used as a core material in sandwich construction. See also sandwich constructions.

**hot head tape layer:** A computer controlled automated tape placement process for thermoplastic prepregs utilizing a gantry mounted hot shoe to partially consolidate each consecutive ply in a programmed orientation and laminate size.

**hotmelt adhesive:** An adhesive that is applied in a molten state and forms a bond after cooling to a solid state. A bonding agent that achieves a solid state and resultant strength by cooling, as contrasted with other adhesives, which achieve the solid state through evaporation of solvents or chemical cure. A thermoplastic resin that functions as an adhesive when melted between substrates and cooled.

**hot-setting adhesive:** An adhesive that requires a temperature at or above 100°C (212°F) to set.
**hybrid:** 1) A composite laminate consisting of laminae of two or more composite material systems. 2) A combination of two or more different fibers, such as carbon and glass or carbon and aramid, into a structure. Tapes, fabrics, and other forms may be combined; usually only the fibers differ.

**impact damage:** Damage from foreign object (other than ballistic).

**impact strength:** A material’s ability to withstand shock loading as measured by the energy absorbed in an impact test.

**impregnate:** In reinforced plastics, to saturate the reinforcement with a resin.

**inclusion:** A physical and mechanical discontinuity occurring within a material or part, usually consisting of solid encapsulated foreign material. Inclusions are often capable of transmitting some structural stresses and energy fields, but in a noticeable different degree from the parent material. See also voids.

**infrared:** Part of the electromagnetic spectrum between the visible light range and the radar range. Radiant heat is in this range, and infrared heaters are frequently used in the thermoforming and curing of plastics and composites. Infrared analysis is used for identification of polymer constituents.

**initial strain:** The strain produced in a specimen by giving loading conditions before creep occurs.

**initial (instantaneous) stress:** The stress produced by force in a specimen before stress relaxation occurs.

**injection molding:** Method of forming a plastic to the desired shape by forcing the heat-softened plastic into a relatively cool female or matched metal mold under pressure.

**insulation resistance:** The electrical resistance between two conductors or systems of conductors separated by only insulating material. The ratio of the applied voltage to the total current between two electrodes in contact with a specified insulator. The electrical resistance of an insulating material to a direct voltage.

**insulator:** A material of such low electrical conductivity that the flow of current through it can usually be neglected. Similarly, a material of low thermal conductivity, such as that used to insulate structural shells.

**integral composite structure:** Composite structure in which several structural elements, which would conventionally be assembled together by bonding or mechanical fasteners after separate fabrication, are instead laid up and cured as a single, complex, continuous structure, for example spars, ribs and one stiffened cover of a wing box fabricated as a single integral part. The term is sometimes applied more loosely to any composite structure not assembled by mechanical fasteners. All or some parts of the assembly may be co-cured.

**integrally heated tool:** A tool that is self-heating, through use of electrical heaters such as cal rods. Most hydroclave tooling is integrally heated. Some autoclave tooling is integrally heated to compensate for thick sections, to provide high heat-up rates, or to permit processing a higher temperature than is otherwise possible with the autoclave. A laminate may be cured or consolidated in a pressure vessel rather than an autoclave, and in less time, if an integrally heated tool is used.
interface: The boundary or surface between two different, physically distinguishable media. On fibers, the contact area between fibers and sizing or finish. In a laminate, the contact area between the reinforcement and the laminating resin.

interference fits: A joint or mating of two parts in which the male part has an external dimension larger than the dimension of the mating female part. Distension of the female by the male creates a stress, which supplies the bonding force for the joint.

interlaminar shear: Shearing force tending to produce a relative displacement between two laminae in a laminate along the plane of their interface.

interply hybrid: A composite in which adjacent laminae are composed of different materials.

intralaminar: Descriptive term pertaining to an object (voids, etc.), event (fracture, etc.), or potential field (temperature gradient, etc.) existing entirely within a single lamina without reference to any adjacent laminae.

irreversible: Not capable of redissolving or remelting. Chemical reactions that proceed in a single direction and are not capable of reversal (as applied to thermosetting resins) are said to be irreversible.

isotropic: Having uniform properties in all directions. Metals and unreinforced plastics are usually isotropic.

joggle: The projecting or retreating surface of a formed part, or the section of a tool that forms a joggle.

Kevlar: Dupont’s trade name for aramid fibers. See also aramid.

K factor: The coefficient of thermal conductivity. The amount of heat that passes through a unit cube of material in a given time when the difference in temperature of two opposite faces is 1°.

knitted fabrics: Fabrics produced by interlooping chains of yarn.

lamina: A single ply or layer in a laminate made up of a series of layers (organic composite). A flat or curved surface containing unidirectional fibers or woven fibers embedded in a matrix (metal matrix composite).

laminate ply: One layer of laminated product.

lap joint: A joint made by bonding overlapped portions of two adherents. See also butt joint.

layup: The placement of layers of reinforcement in a mold.

liquid crystal polymer: A newer thermoplastic polymer that is melt processable and develops high orientation in molding with resultant tensile strength and high-temperature capability that is notably improved. First
commercial availability was as an aromatic polyester with or without fiber reinforcement.

**liquid shim:** If preconsolidated composite parts are to be there may be regions where the two parts do not butt up against each other perfectly. In such a case, a thermoset resin is introduced into the gap and cured in place. This resin is a liquid shim.

**longitudinal:** 1) Along the length of material. 2) In the zero-degree direction.

**macro:** In relation to composites, denotes the gross properties of a composite as a structural element but does not consider the individual properties or identity of the constituents.

**mandrel:** A male mold used in the production of a part by layup or filament winding.

**matched metal molding:** A reinforced plastics manufacturing process in which matching male and female metal molds are used (similar to compression molding) to form the part with time, pressure, and heat.

**matrix:** The essentially homogeneous resin or polymer material in which the fiber system of a composite is imbedded. Both thermoplastic and thermoset resins may be used, as well as metals and ceramics.

**mechanical adhesion:** Adhesion between surfaces in which the adhesive holds the parts together by interlocking action.

**mechanical properties:** The properties of a material such as compressive and tensile strengths, and modulus, that are associated with elastic and inelastic reaction when force is applied. The individual relationship between stress and strain.

**mesophase:** An intermediate phase in the formation of carbon from a pitch precursor. This is a liquid crystal phase in the formation of microspheres, which upon prolonged heating above 400°C (750°F) coalesce, solidify, and form regions of extended order. Heating to above 2000°C (3630°F) leads to the formation of graphite structure.

**microcracks:** Small cracks formed in composites when thermal stresses locally exceed the strength of the matrix. Since most microcracks do not penetrate the reinforcing fibers, microcracks in a cross-plied tape laminate or in a laminate made from cloth prepreg are usually, but not always, limited to the thickness of a single ply.

**microstructure:** A structure with heterogeneities that can be seen through a microscope.

**modulus:** A measure of the stiffness of a material defined as the ratio of stress to strain in the range of elastic deformation. A high modulus indicates a stiff material.
**modulus of elasticity**:: The ratio of the stress or load applied to the strain or deformation produced in a material that is elastically deformed. If a tensile strength of 13.8 MPa (2.0 ksi) results in an elongation of 1 %, the modulus of elasticity is 13.8 MPa (2.0 ksi) divided by 0.01, or 1380 MPa (2.0 ksi). Also called Young’s modulus.

**modulus of resilience**:: The energy that can be absorbed per unit volume without creating a permanent distortion. Calculated by integrating the stress-strain curve from zero to the elastic limit and dividing by the original volume of the specimen.

**modulus of rigidity**:: The ratio of stress to strain within the elastic region for shear or torsional stress. Also called shear modulus or torsional modulus.

**modulus of rupture, in bending**:: The maximum tensile or compressive stress value (whichever caused failure) in the extreme fiber of a beam loaded to failure in bending.

**modulus of rupture in torsion**:: The maximum shear stress in the extreme fiber of a member of circular cross section loaded to failure in torsion.

**Mohs hardness**:: A measure of the scratch resistance of a material. The higher the number, the greater the scratch resistance (No. 10 being termed diamond).

**moisture absorption**:: The pickup of water vapor from air by a material. It relates only to vapor withdrawn from the air by a material and must be distinguished from water absorption which is the gain in weight due to the take-up of water by immersion.

**moisture content**:: The amount of moisture in a material determined under prescribed condition and expressed as a percentage of the mass of the moist specimen, that is, the mass of the dry substance plus the moisture present.

**mold**:: The cavity or matrix into or on which the plastic composition is placed and from which it takes form. To shape plastic parts of finished articles by heat and pressure. The assembly of all the parts that function collectively in the molding process.

**molding cycle**:: The period of time required for the complete sequence of operations on a molding press to produce one set of moldings. The operations necessary to produce a set of moldings without reference to the total time taken.

**molding powder or compound**:: Plastic material in varying stages of pellets of granulation, and consisting of resin, filler, pigments, reinforcements, plasticizers, and other ingredients, ready for use in the molding operation.

**molding pressure**:: The pressure applied to the ram of an injection machine or compression or transfer press to force the softened plastic to fill the mold cavities completely.

**mold-release agent**:: A lubricant, liquid, or powder (often silicone oils and waxes), used to prevent sticking of molded articles in the cavity.
mold shrinkage: The immediate shrinkage that a molded part undergoes when it is removed from a mold and cooled to room temperature. The difference in dimensions, expressed in inches per inch, between a molding and the mold cavity in which it was molded (at normal-temperature measurement). The incremental difference between the dimensions of the molding and the mold from which it was made, expressed as a percentage of the mold dimensions.

morphology: The overall form of a polymer structure, that is, crystallinity, branching, molecular weight, etc.

neat resin: A polymer with no second phase reinforcement; an unfilled polymer.

necking: The localized reduction in cross section that may occur in a material under tensile stress.

nesting: In reinforced plastics, the placing of plies of fabric so that the yarns of one ply lie in the valleys between the yarns of the adjacent ply (nested cloth).

netting analysis: The analysis of filament wound structures that assumes the stresses induced in the structure are carried entirely by the filaments, and the strength of the resin is neglected, and that assumes also that the filaments possess no bending or shearing stiffness, and carry only the axial tensile loads.

nominal stress: The stress at a point calculated as force per area on the net cross section without taking into consideration the effect on stress of geometric discontinuities, such as holes, grooves, fillets, and so forth. The calculation is made by simple elastic theory.

nominal value: A value assigned for the purpose of a convenient designation. A nominal value exists in name only. It is often an average number with a tolerance so as to fit together with adjacent parts.

nondestructive evaluation (NDE): 1) Broadly considered synonymous with nondestructive inspection (NDI). 2) More specifically, the analysis of NDI findings to determine acceptable for its function.

nondestructive inspection (NDI): A process or procedure, such as ultrasonic or radiographic inspection for determining the quality or characteristics of a material, part, or assembly without permanently altering the subject or its properties. Used to find internal anomalies in a structure without degrading its properties.

nondestructive testing (NDT): Broadly considered synonymous with nondestructive inspection (NDI).

notch factor: Ratio of the resilience determined on a plain specimen to the resilience determined on a notched specimen.

nylon: The generic name for all synthetic polyamides.

nylon plastics: Plastics based on a resin composed principally of a long-chain synthetic polymeric amide that has recurring amide groups as an integral part of the main polymer chain. Numerical designations (nylon 6, nylon 66, and so on) refer to the monomeric amides of which they are made. Characterized by great
toughness and elasticity.

offset modulus: The ratio of the offset yield stress to the extension at the offset point.

open-cell foam: Foamed or cellular material with cells that are generally interconnected. Closed cell refers to cells that are not interconnected.

orange peel: An uneven surface somewhat resembling that of an orange peel; said of injection moldings that have unintentionally ragged surfaces.

orientation: The alignment of the crystalline structure in polymeric materials in order to produce a highly aligned structure. Orientation can be accomplished by cold drawing or stretching in fabrication. See also fiber orientation.

orthotropic: Having three mutually perpendicular planes of elastic symmetry. A balanced symmetric composite laminate is orthotropic.

out time: The time a prepreg is exposed to ambient temperature, namely, the total amount of time the prepreg is out of the freezer. The primary effects of out time are to decrease the drape and tack of the prepreg while also allowing it to absorb moisture from the air.

oven dry: The condition of a material that has been heated under prescribed conditions of temperature and humidity until there is no further significant change in its mass.

oxidation: 1) In carbon/graphite fiber processing, the step of reacting the precursor polymer (rayon, PAN, or pitch) with oxygen, resulting in stabilization of the structure for the hot stretching operation. 2) In general usage, oxidation is any chemical reaction in which electrons are transferred.

parallel laminate: A laminate of woven fabric in which the plies are aligned in the same position as originally aligned in the fabric roll. A series of flat or curved cloth-resin layers stacked uniformly on top of each other.

particulate composite: Material consisting of one or more constituents suspended in a matrix of another material. These particles are either metallic or nonmetallic.

peel ply: Layer of material applied to a prepreg layup surface that is removed from the cured laminate prior to bonding operations and leaves a clear resin-rich surface ready for bonding.

peel strength: Adhesive bond strength, as in pounds per inch of width, obtained by a stress applied in a peeling mode.

pegging: The joining of two pieces of core by splicing them together with a third piece of core.
**penetration:** A surface discontinuity which penetrates one skin and core or both skins and core, and whose width is the same order of magnitude as its length, i.e. hole, ballistic damage.

**permeability:** 1) The passage or diffusion (or rate of passage) of a gas, vapor, liquid, or solid through a barrier without physically or chemically affecting it. 2) The ability of a barrier to pass a gas or other substance through it.

**Ph:** The measure of the acidity or alkalinity of a substance, neutrality being at pH 7. Acid solutions are less than 7; alkaline solutions are more than 7.

**phenolic (phenolic resin):** A thermosetting resin produced by the condensation of an aromatic alcohol with an aldehyde, particularly of phenol with formaldehyde. Used in high-temperature applications with various fillers and reinforcements.

**phenylsilane resins:** Thermosetting copolymers of silicone and phenolic resins. Furnished in solution form.

**physical catalyst:** Radiant energy capable of promoting or modifying a chemical reaction.

**pin holes:** Small cavities that penetrate the surface of a cured part.

**pit:** A small, regular or irregular crater in the surface of a plastic, usually of a width approximately the same order of magnitude as its depth.

**pitch:** A high molecular weight material left as a residue from the destructive distillation of coal and petroleum products. Pitches are used as base materials for the manufacture of a certain high-modulus carbon fibers and as matrix precursors for carbon-carbon composites.

**plastic:** A material that contains as an essential ingredients an organic polymer of large molecular weight, hardeners, fillers, reinforcements etc; is solid in its finished state, and at some stage in its manufacture or its processing into finished articles, can be shaped by flow. Made of plastic. A plastic may be either thermoplastic or thermoset.

**plastic deformation:** Change in dimensions of an object under load that is not recovered when the load is removed, as opposed to elastic deformation.

**plastic flow:** Deformation under the action of a sustained hot or cold force. Flow of semisolids in the molding of plastics.

**plastic memory:** The tendency of a thermoplastic material that has been stretched while hot to return to its unstretched shape upon being reheated.

**ply:** 1) A single layer of a composite laminate. 2) A sheet of prepreg ready for inclusion in a laminate.

**PMR polyimides:** A novel class of high temperature resistant polymers. PMR represents *in situ* polymerization of monomer reactants.

**polyacrylonitrile (pan):** a polymer used as a base material in the manufacture of certain carbon fibers.
**polyamide**: A thermoplastic polymer in which the structural units are linked by amide or thio-amide groupings (repeated nitrogen and hydrogen groupings). Many polyamides are fiber forming.

**polyamideimide**: A polymer containing both amide (nylon) and imide (as in polyimide) groups; properties combine the benefits and disadvantages of both.

**polyarylsulfone (PAS)**: A high temperature resistant thermoplastic (Tg=275°C, or 527°F). The term is also occasionally used to describe the family of resins which includes polysulfone and polyethersulfone.

**polycarbonate resin**: A transparent thermoplastic polymer with the highest impact resistance of any transparent plastic.

**polyether etherketone (peek)**: A linear semi-crystalline thermoplastic. A composite with a peek matrix may have a continuous-use temperature as high as 250°C (480°F).

**polyetherimide**: An amorphous polymer with good thermal properties for a thermoplastic. Reported T_g of 215°C (419°F) and continuous-use temperature of about 170°C (338°F).

**polyimide (PI)**: A polymer produced by reacting an aromatic dianhydride with an aromatic diamine. It is a highly heat-resistant resin, > 315°C (600°F). Similar to a polyamide, differing only in the number of hydrogen molecules contained in the groupings. Suitable for use as a binder or adhesive. May be either thermoplastic or thermoset.

**polymer**: A substance in which each molecule contains a large number of atoms bonded to each other in a long chain or a three-dimensional network of short chains bonded to each other. The main chain may be branched, that is, may have short chains attached along its length.

**polymerization**: A chemical reaction in which the molecules of a monomer are linked together to form large molecules whose molecular weight is a multiple of that of the original substance. When two or more monomers are involved, the process is called copolymerization.

**polymethyl methacrylate**: A thermoplastic polymer synthesized from methyl methacrylate. It is a transparent solid with exceptional optical properties: available in the form of sheets, granules, solutions, and emulsions. Used as facing material in certain composite constructions.

**polyphenylene sulfide (PPS)**: A high temperature thermoplastic useful primarily as a molding compound. Optimum properties depend on slightly cross-linking the resin. Known for chemical resistance.

**polypropylene**: A tough, lightweight, thermoplastic made by the polymerization of high-purity propylene gas in the presence of an organometallic catalyst at relatively low pressures and temperatures.

**polysulfide**: A synthetic polymer which is elastomeric in nature, resistant to light, oil, and solvents and impermeable to gases.
**polysulfone**: A high temperature resistant thermoplastic polymer with the sulfone linkage, with a Tg of 190°C (375°F).

**polyurethane**: A thermosetting resin prepared by the reaction of diisocyanates with polyols, polyamides, alkyd polymers, and polyether polymers.

**porosity**: The presence of trapped pockets of air, gas, or vacuum within a solid material. Usually expressed as a percentage of the total nonsolid volume to the total volume (solid plus nonsolid) of a unit quantity of material.

**postcure**: An additional step after the main curing cycle of a thermoset composite. This step is exposure to a yet higher temperature, sometimes at atmospheric pressure, in order to increase the glass transition temperature.

**postforming**: The forming, bending, or shaping of a fully consolidated thermoplastic laminate that has been heated to make it flexible. On cooling, the formed laminate retains the contours and shape of the mold over which it has been formed.

**precure**: The full or partial setting of a synthetic resin or adhesive in a joint before the clamping operation is complete or before pressure is applied.

**preform**: A preshaped fibrous reinforcement formed by distribution of chopped fibers of cloth by air, water flotation, or vacuum over the surface of a perforated screen to the approximate contour and thickness desired in the finished part. Also, a preshaped fibrous reinforcement of mat or cloth formed to the desired shape on a mandrel or mock-up before being placed in a mold press.

**preheating**: The heating of a compound before molding or casting to facilitate the operation or reduce the molding cycle.

**preimpregnation**: The practice of mixing resin and reinforcement and effecting partial cure before use or shipment to the user. See also prepreg.

**preplied tape**: Tape received from the manufacturer with two or more plies laid into specific orientation.

**preply**: A composite material lamina in the raw-material stage, ready to be fabricated into a finished laminate. The lamina is usually combined with other raw laminae before fabrication. A preply includes a fiber system that is placed in position relative to all or part of the required matrix material to constitute the finished lamina. An organic matrix preply is called a prepreg. Metal matrix preplies include green tape, flame-sprayed tape, and consolidated monolayers.

**prepreg**: A combination of mat, fabric, nonwoven material, or roving impregnated with resin or other matrix material.

**press clave**: A simulated autoclave made by using the platens of a press to seal the ends of an open chamber, providing both the force required to prevent loss of the pressurizing medium and the heat required to cure the laminate inside.
**pressure bag molding:** A process for molding reinforced plastics in which a tailored, flexible bag is placed over the contact lay-up on the mold, sealed, and clamped in place. Fluid pressure, usually provided by compressed air or water, is placed against the bag, and the part is cured.

**pressure intensifier:** A layer of flexible material (usually a high temperature rubber) used to ensure the application of sufficient uniform pressure to a location, such as a radius, in a lay-up being cured.

**pressure-sensitive adhesive:** A viscoelastic material that, in solvent-free from, remains permanently tacky. Such material will adhere instantaneously to most solid surfaces with the application of very light pressure.

**primary structure:** In an aircraft, a structure which is essential to safety and carries primary loads, e.g., a wing.

**processing window:** The range of processing conditions, such as stock (melt) temperature, pressure, shear rate, and so on, within which a particular grade of plastic can be fabricated with optimum or acceptable properties by a particular fabricating process, such as extrusion, injection molding, sheet molding, and so forth. The processing window for a particular plastic can vary significantly with design of the part and the mold, with the fabricating machinery used, and with the severity of the end-use conditions.

**pultrusion:** A continuous process for manufacturing composites that have a constant cross-sectional shape. The process consists of pulling a fiber-reinforcing material through a resin impregnation bath and through a shaping die, where the resin is subsequently cured. Prepreg tows may be pultruded; for prepreg, the resin bath is not used.

**puncture:** A break in the skin that may or may not extend through inner and outer skin.

**Quadrax biaxial tape:** Unidirectional thermoplastic prepreg tape ribbons interlaced in fabric weaves that have the benefits of fabric formability and the strength of unidirectional tapes in both longitudinal and transverse directions.

**quasi-isotropic:** A laminate laid up symmetrically with an equal number of plies at each 0°, 45°, and 90° angle. The properties in the plane of such a laminate will be nearly the same in all directions.

**random pattern:** A winding with no fixed pattern. If a large number of circuits is required for the pattern to repeat, a random pattern is approached. A winding in which the filaments do not lie in an even pattern.

**reaction injection molding (RAM):** A process for molding polyurethane, epoxy, and other liquid chemical systems. Mixing of two to four components in the proper chemical ratio is accomplished by a high-pressure impingement-type mixing head, from which the mixed material is delivered into the mold at low pressure, where it reacts (cures).

**reinforced plastics:** Molded, formed, filament-wound, tape-wrapped, or shaped plastic parts consisting of resins to which reinforcing fibers, mats, fabrics, etc., have been added before the forming operation to provide some strength properties greatly superior to those of the base resin.
**relaxation time:** The time required for a stress under a sustained constant strain to diminish by a stated fraction of its initial value.

**release agent:** A material that is applied in a thin film to the surface of a mold to keep the resin from bonding to the mold. Also called parting agent.

**release film:** An impermeable layer of film that does not bond to the resin being cured.

**residual strain:** The strain associated with residual stress.

**residual stress:** The stress existing in a body at rest, in equilibrium, at uniform temperature, and not subjected to external forces. Often caused by the forming and curing process.

**resin:** A solid or pseudosolid organic material, usually of high molecular weight, that exhibits a tendency to flow when subjected to stress. It usually has a softening or melting range, and fractures conchoidally. Most resins are polymers. In reinforced plastics, the material used to bind together the reinforcement material; the matrix.

**resin content:** The amount of resin in a laminate expressed as either a percentage total weight or total volume.

**resin-rich area:** Localized area filled with resin and lacking reinforcing material.

**resin-starved area:** Localized area of insufficient resin, usually identified by low gloss, dry spots, or fiber showing on the surface.

**resin system:** A mixture of resin and ingredients such as catalyst, initiator, dluents, etc., required for the intended processing and final product.

**resin-transfer molding (RTM):** A molding process in which catalyzed thermoset is transferred under moderate pressure into an enclosed mold into which the fiber reinforcement has been placed; cure normally is accomplished without external heat. RTM combines relatively low tooling and equipment costs with the ability to mold large structural parts. In general, thermoplastics are too viscous to be used in RTM.

**reverse impact test:** A test in which one side of a sheet of a material is struck by a pendulum or falling object and the reverse side is inspected for damage.

**room-temperature curling adhesive:** An adhesive that sets (to handling strength) within an hour at temperatures from 20 to 30°C (68 to 86° F) and later reaches full strength without heating.

**room-temperature vulcanizing (RTV):** Vulcanization or curing at room temperature by chemical reaction; usually applies to silicones and other rubbers.

**s-glass:** Structural glass; used as fiber reinforcement, designed to provide very high tensile strength.
**sandwich constructions**: Panels composed of a lightweight core material, such as honeycomb or foamed plastic, to which two relatively thin, composite faces or skins are adhered. Sandwich construction is stronger in bending than the composite skins by themselves.

**satin**: A type of finish having a satin or velvety appearance, specified for plastics or composites.

**S-basis**: The S-basis property allowable is the minimum value specified by the appropriate federal, military, Society of Automotive Engineers, American Society for Testing and Materials, or other recognized and approved specifications for the material.

**scarf joint**: A joint made by cutting away complementary angular segments on two adherents and bonding the adherents with the cut areas fitted together. See also lap joint.

**scrim**: A low-cost reinforcing fabric made from continuous filament yarn in an open-mesh construction. Used in the processing of tape or other B-stage material to facilitate handling. Also used as a carrier for structural film adhesives.

**secondary bonding**: The joining together, by the process of adhesive bonding, of two or more already cured or consolidated composite parts, during which the only chemical or thermal reaction occurring is the curing of the adhesive itself.

**secondary structure**: In aircraft and aerospace applications, a structure that is not critical to flight safety. See also primary structure.

**self-extinguishing resin**: A resin formulation that will burn in the presence of a flame but will extinguish itself within a specified time after the flame is removed.

**semicrystalline**: In plastics, exhibiting localized crystallinity. See also crystallinity.

**shear modulus**: The ratio of shearing stress to shearing strain within the range of elastic behavior of a material.

**shear strain**: The tangent of the angular change, caused by a force between two lines originally perpendicular to each other through a point in a body. Also called angular strain.

**shear strength**: The maximum shear stress that a material is capable of sustaining before failure. Shear strength is calculated from the maximum load during a shear or torsion test and is based on the original cross-sectional area of the specimen.

**shear stress**: The component of stress tangent to the plane on which the forces act.

**sheet molding compound (SMC)**: A composite of fibers, usually a polyester resin, and pigments, fillers, and other additives that have been compounded and processed into sheet from to facilitate handling in the molding operation.
shelf life: The length of time a material, substance, product, or reagent can be stored under specified environmental conditions and continue to meet all applicable specification requirements and/or remain suitable for its intended function.

shrinkage: The relative change in dimension from the length measured on the mold when it is cold to the length of the molded object 24 hours after it has been taken out of the mold.

silicon carbide: Reinforcement, in whisker, particulate, and fine or large fiber, that has application as metal matrix reinforcement because of its high strength and modulus, density equal to that of aluminum, and comparatively low cost. If the whisker or particle form is used, the composite is isotropic and easily machined.

silicone plastics: Plastics based on resins in which the main polymer chain consists of alternating silicon and oxygen atoms, with carbon-containing side groups. Derived from silica (sand) and methyl chlorides and furnished in different molecular weights, including liquids, solid resins, and elastomers.

slurry preforming: Method of preparing reinforced plastic preforms by wet processing techniques similar to those used in the pulp molding industry. For example, glass fibers suspended in water are passed through a screen that passes the water but retains the fibers in the form of a mat.

solvation: The process of swelling, gelling, or dissolving a resin by a solvent or plasticizer.

splice: The joining of two ends of glass fiber yarn or strand usually by means of an air-drying adhesive.

sprayed metal molds: Molds made by spraying molten metal onto a master until a shell of predetermined thickness is achieved. The shell is then removed and backed up with plaster, cement, casting resin, or other suitable material. Used primarily as a mold in the sheet forming process.

spray up: Technique in which a spray gun is used as an application tool. In reinforced plastics, for example, fibrous glass and resin can be simultaneously deposited in a mold. In essence, roving is fed through a chopper and ejected into a resin stream that is directed at the mold by either of two spray systems. In foamed plastics, fast-reacting urethane foams or epoxy foams are fed in liquid streams to the gun and sprayed on the surface. On contact, the liquid starts to foam.

stabilization: In carbon fiber forming, the process used to render the carbon fiber precursor infusible prior to carbonization.

stacking sequence: A description of a laminate that details the ply orientations and their sequence in the laminate.

staging: Heating a premixed resin system, such as in a prepreg, until the chemical reaction (curing) starts, but stopping the reaction before the gel point is reached. Staging is often used to reduce resin flow in subsequent press molding operations.

starved area: An area in a plastic part that has an insufficient amount of resin to wet out the reinforcement completely. This condition may be due to improper wetting, impregnation or resin flow; excessive molding pressure; or improper bleeder cloth thickness.
**static fatigue:** Failure of a part under Continued static load. Analogous to creep rupture failure in metals testing, but often the result of aging accelerated by stress.

**static stress:** A stress in which the force is Constant or slowly increasing with time, for example, test of failure without shock.

**stiffness:** A measure of modulus. The relationship of load and deformation. The ratio between the applied stress and resulting strain. A term often used when the relationship of stress to strain does not conform to the definition of Young’s modulus.

**storage life:** The amount of time a thermoset prepreg can be stored and remain suitable for use.

**strain:** Elastic deformation due to stress. Measured as the change in length per unit of length in a given direction, and expressed in percentage or mm/mm (in/in.).

**strain gage:** Device to measure strain in a stressed material based on the change in electrical resistance of the gage.

**strand:** 1) A single fiber or filament. 2) An ordered assemblage of long fibers to be used as a unit, e.g., a tow.

**strand count:** The number of strands in a plied yarn. The number of strands in a roving.

**stress:** The internal force that resists change in size or shape, expressed in force per unit area.

**stress corrosion:** Preferential attack of areas under stress in a corrosive environment where such an environment alone would not have caused corrosion.

**stress cracking:** The failure of a material by cracking or crazing some time after it has been placed under load. Time-to-failure may range from minutes to years. Causes include mold-in-stresses postfabrication shrinkage or warpage, and hostile environment.

**stress-strain curve:** Simultaneous readings of load and deformation converted to stress and strain, plotted as ordinates and abscissae, respectively, to obtain a stress-strain diagram.

**structural adhesive:** Adhesive used for transferring required loads between load-bearing adherents exposed.

**structural bond:** A bond that joins basic load-bearing parts of an assembly. The load may be either static or dynamic.

**superform:** A patented double metallic diaphragm process utilizing the unique superplastic deformation properties of the aluminum cauls to form and consolidate thermoplastic composite parts.

**superplastic forming (SPF):** A strain rate sensitive metal forming process that uses characteristics of materials exhibiting high elongation-to-failure.

**surface activation:** The (usually) chemical process of making a surface more receptive to bonding to a coating or an encapsulating material.
**symmetrical laminate:** A composite laminate in which the sequence of plies below the laminate midplane is a mirror image of the stacking sequence above the midplane.

**syntactic foams:** Composites made by mixing hollow microspheres of glass, epoxy, phenolic, etc, into fluid resins (with additives and curing agents) to form a moldable, curable lightweight, fluid mass; as opposed to foamed plastic, in which the cells are formed by gas bubbles released in the liquid plastic by either chemical or mechanical action.

**tabs:** Extra lengths of composite or other material at the ends of a tensile specimen to promote failure away from the grips.

**tack:** 1) Stickiness of an adhesive or of a fiber-reinforced resin prepreg material. 2) To locally join thermoplastic plies during layup by spot welding in order to maintain orientation and hold the laminate together for handling and transfer operations before consolidation.

**tape:** Unidirectional prepreg fabricated in widths up to 305 mm (12 in.) for carbon and 75 mm (3 in.) for boron. Woven broad goods carbon and glass tapes up to 1250 to 1500 mm (50 or 60 in.) wide are available commercially.

**tape laying:** A fabrication process in which prepreg tape is laid side by side or overlapped to form a structure.

**template:** A pattern used as a guide for cutting and laying plies.

**tensile strength:** Stress caused by the different expansion in different directions of plies in a laminate at different orientations. The maximum stress sustained by a plastic specimen before it fails in a tension test.

**thermal conductivity:** The quantity of heat conducted per unit time through unit area of a slab of unit thickness having unit temperature difference between its faces.

**thermal endurance:** The time at a selected temperature for a material or system of materials to deteriorate to some predetermined level of electrical, mechanical, or chemical performance under prescribed conditions of test.

**thermal expansion molding:** A process in which elastometric tooling details are constrained within a rigid frame to generate consolidation pressure by thermal expansion during the curing cycle of the autoclave molding process.

**thermal stress:** Stress caused by the different expansion in different directions of plies in a laminate at different orientations.

**thermal stress cracking:** Crazing and cracking of some thermoplastic resins, resulting from overexposure to elevated temperatures See also microcracks.

**thermocouple:** A device which Uses a circuit of two wires of dissimilar metals or alloys, the two junctions of which are at different temperatures. A net electromotive force (emf) occurs as a result of this temperature
difference. The minute electromotive force, or current, is sufficient to drive a galvanometer or potentiometer. The emf is proportional to the difference in temperature between the two junctions.

**thermoforming:** Forming a thermoplastic material after heating it to the point where it is soft enough to be formed without cracking or breaking reinforcing fibers.

**thermoplastic:** A plastic material that is capable of being repeatedly softened by application of heat and repeatedly hardened by cooling. Softening and hardening are reversible for a thermoplastic.

**thermoset:** A plastic material that is capable of being cured by heat or catalyst into an infusible and insoluble material. Once cured, a thermoset cannot be returned to the uncured state. Thus, hardening is irreversible for a thermoset.

**thermosetting polyesters:** A class of resins produced by dissolving unsaturated, generally linear, alkyd resins in a vinyl type active monomer such as styrene, methyl styrene, or diallyl phthalate. Cure is effected through vinyl polymerization using peroxide catalysts and promoters of heat to accelerate the reaction. The two important commercial types are (1) liquid resins that are cross-linked with styrene and used either as impregnants for glass or carbon fiber reinforcements in laminates, filament-wound structures, and other build-up constructions, or as binders for chopped-fiber reinforcements in molding compounds such as sheet molding compound (SMC), bulk molding compound (BMC), and thick molding compound (TMC); and (2) liquid or solid resins cross-linked with other esters in chopped-fiber and minralfilled molding compounds for example, alkyd and diallyl phthalate.

**thread count:** The number of yarns (threads) per inch in either the lengthwise (warp) or crosswise (fill or weft) direction of woven fabrics.

**tolerance:** The guaranteed maximum deviation from the specified nominal value of a component characteristic at standard or stated environmental conditions.

**tool side:** The side of the part that is cured against the tool (mold or mandrel).

**toughness:** A property of a material for absorbing work. The actual work per unit volume or unit mass of material that is required to rupture it. Toughness is proportional to the area under the load-elongation curve from the origin to the breaking point.

**tow:** An untwisted bundle of continuous filaments. Commonly used in referring to man-made fibers, particularly carbon and graphite, but also glass and aramid. A tow designated as 140K has 140,000 filaments.

**tracer:** A fiber, tow, or yarn or a different material added to a prepreg for verifying fiber alignment and, in the case of woven material, for distinguishing warp fibers from fill fibers.

**transfer molding:** Method of molding thermosetting materials in which the plastic is first softened by heat and pressure in a transfer chamber and then forced by high pressure through suitable sprues, runners, and gates into the closed mold for final shaping and curing.
transition temperature: The temperature at which the properties of a material change. Depending on the material, the transition change may or may not be reversible.

transverse: 1) Perpendicular to longitudinal 2) In a unidirectional composite or prepreg tape, in the material plane and perpendicular to the fibers.

true strain: The natural logarithm of the ratio of gage length at the moment of observation to the original gage length for a body subjected to an axial force.

true stress: The stress along the axis calculated on the actual cross section at the time of observation instead of the original cross sectional area. Applicable to tension and compression testing.

ultimate tensile strength: The ultimate or final (highest) stress sustained by a specimen in a tension test. Rupture and ultimate stress may or may not be the same.

ultrasonic testing: A nondestructive test applied to materials for the purpose of locating internal flaws or structural discontinuities by the use of high-frequency sound waves.

ultrasonic welding: A method of joining thermoplastic composites utilizing vibrations at a fixed frequency into a properly designed set of parts. The rapid agitation of the joint area under pressure creates frictional heat, melting the plastic in a fraction of a second.

ultraviolet (UV): Zone of invisible radiations beyond the violet end of the spectrum of visible radiations. Since UV wavelengths are shorter than visible wavelengths, their photons have more energy, enough to initiate some chemical reactions and to degrade most plastics, particularly aramids.

unbound area: An area within a bonded interface between two adherents in which the intended bonding action failed to take place, or where two layers or prepreg in a cured component do not adhere to each other. Also used to denote specific areas deliberately prevented from bonding in order to simulate a defective bond, such as in the generation of quality standards specimens.

undercure: A condition of the molded article resulting from the allowance of too little time and/or temperature or pressure for adequate hardening of the molding.

uniaxial load: A load on a material in only one direction See also biaxial load.

unidirectional laminate: A reinforced plastic laminate in which substantially all of the fibers are oriented in the same direction.

urethane plastics: Plastics based on resins made by condensation of organic isocyanates with compounds or resins that contain hydroxyl groups. The resin is furnished as two component liquid monomers or prepolymer that are mixed in the field immediately before application A great variety of materials are available depending upon the monomers used in the prepolymer, polyis, and the type of diisocyanate employed. Extremely
abrasion and impact resistant.

**unsymmetric laminate:** A laminate having an arbitrary stacking sequence without midplane symmetry.

**vacuum bag:** The plastic or rubber layer used to cover the part so that a vacuum can be drawn.

**vacuum bag molding:** A process in which a sheet of flexible transparent material plus bleeder cloth and release film are placed under the lay-up on the mold and sealed at the edges. A vacuum is applied between the sheet and the lay-up. The entrapped air is mechanically worked out of the lay-up and removed by the vacuum, and the part is cured with temperature, pressure, and time.

**vacuum bag:** The plastic or rubber layer used to cover the part so that a vacuum can be drawn.

**vacuum hot pressing (VHP):** An experimental forming method developed at CDC. In this process the prepreg layup is placed in a vacuum bag and heated. The assembly is then removed from the oven and placed in a mold. The mold is closed in a hot press and formed under pressure. This process is expected to have two major advantages over conventional press forming in which no vacuum is applied: The part should be fully consolidated after pressing with no further processing, and more complex parts should be formable.

**vent:** A small hole or shallow channel in a mold that allows air or gas to exit as the molding material enters.

**vent cloth:** A layer or layers of open-weave cloth used to provide a path for vacuum to “reach” the area over a laminate being cured, such that volatiles and air can be removed. Also causes the pressure differential that results in application of pressure to the part being cured. Also called breather cloth.

**venting:** In autoclave curing of a part or assembly, turning off the vacuum source and venting the vacuum bag to the atmosphere. The pressure on the part is then the difference between pressure in the clave and atmospheric pressure.

**vinyl esters:** A class of thermosetting resins containing esters of acrylic and/or methacrylic acids, many of which have been made from epoxy resin. Cure is accomplished as with unsaturated polyesters by copolymerization with other vinyl monomers, such as styrene.

**virgin filament:** An individual filament that has not been in contact with any other fiber or any other hard material.

**viscoelasticity:** A property involving a combination of elastic and viscous behavior in the application of which a material is considered to combine the features of a perfectly elastic solid and perfect fluid. Phenomenon of time-dependent, in addition to elastic, deformation (or recovery) in response to load.

**viscosity:** The tendency of a material to resist flow.

**void contact:** Volume percentage of voids, usually less than 1% in a properly cured or consolidated composite. The experimental determination is indirect, that is, is calculated from the measured density of a cured laminate and the “theoretical” density of the starting material.
voids: Pockets of entrapped gas that have been cured into a laminate.

volatiles: Materials in a sizing or a resin formulation that can be vaporized at room or slightly elevated temperature.

W


water absorption: Ratio of the weight of water absorbed by a material to the weight of the dry material.

water jet: Water emitted from a nozzle under high pressure (70 to 410 MPa, or 10 to 60 ksi or higher). Useful for cutting composites.

weeping: Slow leakage manifested by the appearance of water on a surface.

wet lay-up: A method of making a reinforced product by applying the resin system as a liquid when the reinforcement is put in place. In prepreg layup, the resin and fiber are already together.

wet-out: The condition of an impregnated roving or yarn in which substantially all voids between the sized strands and filaments are filled with resin.

wetting: The spreading, and sometimes absorption, of a fluid on or into a surface such as the surface of a fiber.

whisker: A short single crystal fiber or filament used as a in a matrix. Whisker diameters range from 1 to 25 urn (40 to 980 uin.), with aspect ratios between 100 and 15,000 There are usually ceramic materials.

work hardening: Increase in resistance to further deformation with continuing distortion. Hardening and strengthening of a metal or alloy caused by the strain energy absorbed from prior deformation.

working life: The period of time during which a liquid resin or adhesive, after mixing with catalyst, solvent, or other compounding ingredients, remains usable.

wrinkle: A surface imperfection in laminated plastics that has the appearance of a crease or fold in one or more outer sheets of the paper, fabric, or other base, which has been pressed in. Also occurs in vacuum bag molding when the bag is improperly place, causing a crease.

X

x-axis: In composite laminates, an axis in the plane of the laminate which is used as the 0° reference for designating the angle of a lamina.

xy-plane: In composite laminates, the reference plane parallel to the plane of the laminate.
yarn: An assemblage of twisted filaments, fibers, or strands, either natural or manufactured, to form a continuous length that is suitable for use in weaving or interweaving into textile materials.

y-axis: In composite laminates, the axis is the plane of the laminate that is perpendicular to the x-axis. Usually the “width axis,” X being the axis of length and Z of thickness.

z-axis: In composite laminates, the reference axis normal to the plane of the laminate. Axis through the thickness of the laminate.

zero bleed: A laminate fabrication procedure that does not allow loss of resin during cure. Also describes prepreg made with the amount of resin desired in the final part, such that no resin has to be removed during cure.