

FiberSystems

521 Kiser Street
Dayton, OH 45404-1641
Tel: 937-222-9000
Fax: 937-222-9020

Technical Bulletin

Glossary of FRP Industry Terms

This glossary is a compilation of technical terms often used in the design, construction, and maintenance of industrial fiberglass reinforced plastic (FRP) equipment.

Accelerator - A material which, when mixed with a catalyzed resin, will speed up the chemical reaction between the catalyst and the resin. Also known as "promoter".

Acoustic Emission (AE) - In composites, a sound generated by defects within the laminate, such as plastic deformation, crack initiation, or crack growth.

Acoustic Emission Monitoring - A non-destructive test (NDT) method by which the location and severity of active flaws are determined by monitoring the acoustic emissions from the defects. A particularly useful NDT technique to determine structural adequacy of FRP tanks and vessels.

Barcol Hardness - A hardness value obtained by measuring the resistance to penetration of a sharp steel point under a spring load. The instrument, called a Barcol Impressor, gives a direct reading on a 0-100 scale. The hardness value is often used as a measure of the degree of cure of the plastic.

Bi-Directional Laminate - A reinforced plastic laminate with the fibers oriented in various directions in the plane of the laminate: a cross laminate. See also Unidirectional Laminate.

Binder - The agent applied to glass mat or performs to bond the fibers prior to laminating or molding.

Bisphenol A Fumarate - A condensation product formed by reaction of two (bis) molecules of phenol with acetone (A) used as a component in one type of traditional corrosion resistant FRP resin.

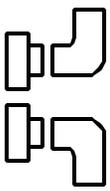
Blister - An undesirable rounded elevation of the surface of a plastic, whose boundaries may be more or less sharply defined. The blister may contain process fluid.

Bond Strength - The amount of adhesion between bonded surfaces; a measure of the stress required to separate a layer of material from the base to which it is bonded. See also Peel Strength.

Benzoyl Peroxide/Dimethylaniline (BPO/DMA) - A resin catalyst system that provides improved corrosion resistance in some chemical environments that are reactive to the Cobalt in the more commonly used MEKP/CoNap catalyst system.

Bromine - A fire retardant (halogen) which is used to reduce or eliminate a resin's tendency to burn. Often used in conjunction with chemicals such as antimony trioxide and pentoxide to achieve a maximum Class 1 fire retardancy rating and often used in ducting systems.

Butt Wrap Joint A secondary laminate wrapped around two or more components in an edge-to-edge configuration used to join them together.



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Catalyst - A substance which changes the rate of a chemical reaction without itself undergoing permanent change in its composition; a substance which markedly speeds up the cure of a compound when added in minor quantity compared to the amounts of primary reactants (hardener, initiator or curing agent).

Composite - An homogenous material created by the synthetic assembly of two or more materials (selected reinforcing elements and compatible matrix resin) to obtain specific characteristics and properties.

Contact Molding - A process for molding reinforced plastics in which reinforcement materials, such as mat and woven roving saturated with resin, are applied to a mold. The cure is either at room temperature using a catalyst-promoter system or by heat in an oven with no additional pressure.

Corrosion Liner - See Liner.

Creep - The change in dimension of a plastic under load over a period of time, not including the initial elastic deformation.

Crosslink - The formation of a three-dimensional polymer by means of inter-chain reactions resulting in changes in physical properties.

Cure - To change the properties of a resin by chemical reaction, which may be condensation or addition -- usually accomplished by the action of either heat or catalyst or both, and with or without pressure.

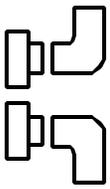
Dead Load - Permanent, unchanging loads on the FRP structure caused by walkways, platforms or similar permanent fixtures.

Delamination - To split a laminated plastic material along the plane of its layers. Physical separation or loss of bond between laminate plies.

Dew Point - That temperature at which the weight of steam associated with a certain weight of dry air is adequate to saturate that weight of air. When air at less than 100% relative humidity is cooled to the temperature at which it becomes saturated, the air has reached the minimum temperature to which it can be cooled without precipitation of the moisture (dew).

Discontinuity Stress - Additional stress produced where abrupt changes in geometry, materials and/or loading occur in an FRP laminate.

Differential Scanning Calorimetry (DSC) - DSC is used to determine the glass transition temperature and the degree of cure of an FRP laminate by measuring the heat flow into and out of a sample as the material which is heated at a constant heating rate under a nitrogen purged atmosphere. The degree of cure may be determined by repeated heating of a sample beyond the glass transition temperature. If the laminate was undercured, the glass transition temperature will continue to increase.



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"E" Glass - A borosilicate glass; the type most used for glass fibers for reinforced plastics; suitable for electrical laminates because of its high resistivity.

ECR Glass - A corrosion-grade glass exhibiting corrosion resistant properties superior to "E" glass. Superior resistance to acids and alkalis is obtained through the application of special treatments and sizings to "E" fibers.

Elastic Deformations - That part of the total strain in a stressed body which disappears upon removal of the stress; opposed to plastic deformation.

Elongation - Deformation caused by stretching; the fractional increase in length of a material stressed in tension. When expressed as a percentage of the original gage length, it is called percentage elongation.

Epoxy Plastics - Plastics based on resins made by the reaction of epoxides or oxiranes with other materials such as amines, alcohols, phenols, carboxylic acids, acid anhydrides and unsaturated compounds.

Exotherm - The liberation or evolution of heat during the curing of a plastic product.

Fiberglass Reinforced Plastic (FRP) - A general term covering any type of plastic reinforced cloth, mat, strands or any other form of fibrous glass.

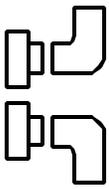
Filament Winding - A process for fabrication of a composite structure in which continuous reinforcements, either previously impregnated with a matrix material or impregnated during the winding, are placed over a rotating and removable form or mandrel in a previously prescribed way to meet certain stress conditions.

Filler - A relatively inert material added to a plastic mixture to reduce cost, to modify mechanical properties, to provide thixotropy, to serve as a base for color effects or to improve the surface texture.

First Crack Strength - The strain or stress level present at the onset of significant laminate damage. The laminate damage is the result of resin microcracking, debonding of fibers in the resin matrix and, occasionally, of local failure of fibers.

Finite Element Analysis (FEA) - A method of analysis used in situations that are difficult to model by standard engineering techniques. The finite element method operates on the assumption that any continuous function over a global domain can be approximated by a series of functions operating over a finite number of small sub-domains. The series of functions are piecewise, continuous and will approach the exact solution as the number of sub-domains approaches infinity.

FRP - See Fiber Reinforced Plastic.



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Gelation (Gel) Time - That interval of time in connection with the use of synthetic thermosetting resins, extending from the introduction of a catalyst into a liquid adhesive system until the interval of gel formation.

Glass Reinforcement - An inorganic product of fusion in the form of a filament which has cooled to a rigid condition without crystallizing. Glass filaments are combined, cut, woven or matted into many types of reinforcements.

Halogenated Resin - A resin combined with chlorine or bromine to increase fire retardancy. See also Bromine.

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.

Heat Distortion Temperature (HDT) - The temperature at which a standard test bar deflects under a stated load.

Helix Angle - The angle at which continuous filaments are placed relative to the longitudinal mandrel axis in the filament winding process.

Hoop Stress - The circumferential stress in a material of cylindrical form subjected to internal or external pressure.

Hydrostatic Load - Loading produced by a fluid head.

Hydrotest - A test in which static fluid head is used to produce test loads.

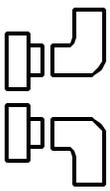
Ignition Loss - The difference in weight before and after burning; as with glass, the burning off of the binder or size. Used to determine the amount and types of glass reinforcement present.

Inhibitor - A substance which retards a chemical reaction; used in certain types of monomers and resins to prolong storage life.

Isotropic Laminate - One in which the strength properties are equal in all directions, such as contact-molded laminates or metals.

Knuckle - The transition area between a vessel shell and bottom, dome or ends.

Laminate - To unite sheets of material by bonding material usually with pressure and heat. A product made by bonding.



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Lamination Theory - An analytical procedure in which composite physical properties are predicted from an examination of the properties and interaction of the individual plies that comprise the laminate.

Liner (Corrosion Liner) - The continuous, usually flexible reinforced resin barrier on the inside surface of the FRP laminate used to protect the laminate from chemical attack or to prevent leakage under stress.

Live Load - Pressure, vacuum, thermal or other variable loads that may be applied to a structure.

Mandrel - The mold around which resin-impregnated glass is wound or placed by hand to form pipes, tubes, vessels or irregularly shaped components. See also Filament Winding.

Mat - A fibrous material consisting of randomly-oriented chopped or swirled filaments loosely held together with a binder.

Matrix - The resin in which the glass reinforcements are distributed.

Modulus Of Elasticity - The ratio of the stress or load applied to the strain or deformation produced in a material that is elastically deformed.

Monomer - A simple molecule which is capable of reacting with like or unlike molecules to form a polymer; the smallest repeating structure of a polymer.

Orthotropic - Having three mutually perpendicular planes of elastic symmetry; usually with differing properties, typically filament-wound laminates.

Peel Strength - Bond strength, in pounds per inch of width, obtained by peeling the layer. See Bond Strength.

Percentage Elongation - See Elongation.

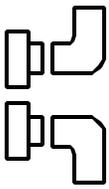
Permeability - The passage or diffusion of a gas, vapor, liquid or solid through a barrier without physically or chemically affecting it.

Penetrant - Process fluids that have penetrated the FRP liner or structural wall.

pH - A measure of the acidity or alkalinity of a process fluid.

Plastic Deformation - Change in dimensions of an object under load that is not recovered when the load is removed; opposed to elastic deformation.

Ply - An individual layer of reinforcement within a total laminate comprised of several such layers.



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PM (Preventive Maintenance) - An ongoing inspection program with thorough documentation and evaluation that provides a knowledgeable basis for determination for appropriate maintenance or timely replacement of individual pieces of equipment.

Poisson's Ratio - When a material is stretched, its cross-sectional area changes as well as its length. Poisson's Ratio is the constant relating these changes in dimensions, and is defined as the ratio of the change in width per unit width to the change in length per unit length.

Polyester - Thermosetting resins, produced by dissolving unsaturated, generally linear, alkyd resins in a vinyl-type active monomer such as styrene, methyl styrene and diallyl phthalate. The resins are usually furnished in solution form, but powdered solids are also available.

Polymer - A high molecular weight organic compound, natural or synthetic, whose structure can be represented by a repeated small unit. Some polymers are elastomers while others are plastics. When two or more monomers are involved, the product is called a co-polymer.

Post-Cure - Additional elevated temperature cure, usually without pressure, to improve final properties and/or complete the cure. In certain resins, complete cure and ultimate mechanical properties are attained only by exposure of the cured resin to higher temperatures than those of curing.

Principle Directions - The directions in which the principle tensile, compressive and shear stresses are located in combined stress analysis. There are three principle directions which are mutually perpendicular.

Promoter - A chemical, itself a weak catalyst. See Accelerator.

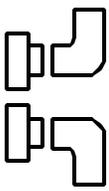
Reagents - A substance used in a chemical reaction to produce other substances.

Roving (filament winding) - The term "roving" is used to designate a collection of bundles of continuous filaments either as untwisted strands or as twisted yarns. Glass rovings are predominantly used in filament winding.

Safety factor - The ratio of ultimate stress to allowable stress, or some similar ratio of units expressing this intent.

Shear - An action or stress resulting from applied forces which causes or tends to cause two contiguous parts of a body to slide relative to each other in a direction parallel to their plane of contact. In interlaminar shear, the plane of contact is composed of resin only.

Size - A treatment consisting of starch, gelatin, oil, wax or other suitable ingredient which is applied to fibers at the time of formation to protect the surface and aid the process of handling and fabrication, or to control the



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fiber characteristics. The treatment contains ingredients which provide surface lubricity and binding action but, unlike a finish, contains no coupling agent.

Steady State - Stable operating or other load conditions that do not change with time.

Stiffness - The relationship of load and deformation; a term often used when the relationship of stress to strain does not conform to the definition of Young's modulus. See also Modulus Of Elasticity.

Strain - The elongation per unit length of a material.

Stress Corrosion - Preferential attack of areas under stress in a corrosive environment, where this factor alone would not have caused corrosion.

Stress Relaxation - Stress relaxation occurs when the stresses in the structure decrease while the deformation is held constant. Under this condition, the FRP laminate will assume a permanently deformed shape after mechanical and thermal loads are removed.

Structural Laminates - That portion of a total laminate that is designed to take the imposed equipment loads. Normally does not include the sacrificial portion of the corrosion barrier or liner.

Survival - A term used to describe a safety factor between 1.0 and 2.0. Equipment may be designed for "survival" when subjected to infrequent or unlikely upset conditions of short duration.

Synthetic Fiber - Fiber made of materials other than glass, such as polyester.

Thermal Gradient - The change in temperature through the FRP laminate from the interior to the exterior of the equipment. The change in temperature per unit of wall thickness.

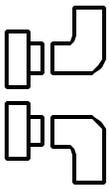
Thermoplastic - Capable of being repeatedly softened by increase of temperature and hardened by decrease in temperature.

Thermoset - A plastic which, when cured by application of heat or chemical means, changes into a substantially infusible and insoluble material.

Thixotropic - Concerning materials that are "gel-like" at rest but that are fluid when agitated. Materials having high static shear strength and low dynamic shear strength at the same time.

Transient Loads - Temporary loads of limited duration.

Transverse Crack - A crack occurring in the resin matrix at right angles to the direction of the reinforcements.



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Ultimate Tensile Strength - The ultimate or final stress sustained by a laminate under tension loading; the stress at the moment of rupture.

Unidirectional Laminate - A reinforced plastic laminate in which substantially all of the fibers are oriented in the same direction.

Veil - An ultra thin mat often composed of organic fibers as well as of glass fibers; used primarily in corrosion barriers.

Warp - The yarn running lengthwise in a woven fabric.

Weft - The transverse threads or fibers in a woven fabric; those fibers running perpendicular to the warp.

Weeping - A slow passage of process fluid through an FRP laminate that can occur when a leak path is established by extensive cracking.

Woven Roving - A heavy glass fiber fabric made by the weaving of roving and used as the primary structural material in the laminate.

Yield Point - The first stress in a material, less than the maximum attainable stress, at which an increase in strain occurs without an increase in stress.