



Fiberglass Pipe Glossary

Accelerator	A chemical compound which, when mixed with a hardener or resin, will speed up the chemical reaction between hardener and resin.
Adapter	A fitting used to join together two pieces of pipe or a pipe and a fitting which have different joining systems.
Aggregate	A siliceous sand.
Aliphatic Amine (cured epoxy)	Aliphatic amines are curing or hardening agents for thermoset resins (epoxies). They will cure at room temperature and so are often used in adhesives and in some winding operations. These epoxies are serviceable up to about 93 °C (200 °F).
Anhydride (cured epoxy)	Anhydrides are commonly used curing agents for fiberglass reinforced epoxy pipe. These epoxies are generally serviceable up to 82 °C (180 °F).
Aromatic Amine (Cured Epoxy)	Aromatic Amines are used as epoxy curing agents for high temperature service. These epoxies generally have a service temperature up to 121 °C (250 °F).
Bell	The female end of a pipe or fitting (also called socket).
Bisphenol-A	One of the major ingredients used to make an epoxy resin, Bisphenol-A epoxy resin.
Box	The female end of a threaded pipe or fitting.
Burst Pressure	(see weep pressure).
Burst Strength	The circumferential stress (hoop stress) at burst pressure.
Bushing	A fitting used to join two different sizes of pipe together.

Catalyst	(see hardener).
Centrifugal Casting	A process used to manufacture pipes by applying resin and reinforcements to the inside of a mold that is rotated and heated.
Coating	A resin layer, with or without filler or reinforcement, or both, applied to the exterior surface of the pipe or fitting.
Collapse	Failure caused as a result of application of a uniform force around the entire circumference of a pipe. This force is caused by either vacuum inside the pipe or by external pressure. The mode of failure is stability related and occurs as flattening of the pipe or by compressive (shear) failure of the pipe wall.
Collapse Pressure (ultimate collapse)	The ultimate external pressure a pipe can withstand.
Collar	(see coupling).
Compression	The force that occurs when opposing loads are applied to a material, thus crushing or attempting to crush it. In pipe, compressive forces can develop in the pipe's circumference by external pressure and along the pipe's axis by longitudinal loads such as thermal expansion in a fixed-end pipe line.
Concentric Reducer	A fitting used to join two different pipe sizes together while maintaining the same centerline in both pipes.
Coupling	A fitting used to joint two pieces of pipe together in a straight line. It may feature threaded, adhesive bonded, or mechanical joining systems, but will always have female ends.
Creep	Deformation or strain that occurs over time when a material is subjected to constant stress. Creep is usually measured by mm/mm (inch/inch) per unit of time.
Cure	The process of hardening of a thermosetting resin (by cross-linking of the molecular structure), under the influence of heat and/or curing agents.
Cure Stages	Terms given to denote the degree to which a resin has crosslinked. In order of increasing degrees of crosslinking, the following terms are commonly used: A-Stage, B-Stage, C-Stage.
Curing Agent	(see hardener).
Curing Time	The time taken for a resin to cure to its full extent.
Cut & Mitered Fittings	Fittings manufactured by cutting, assembling, and bonding pipe sections into a desired configuration. The assembled product is then overwrapped with resin-impregnated roving mat or cloth to provide required strength.

Cyclic Pressure Rating (of fiberglass pipe)	The pressure rating obtained as the result of performing tests in accordance with ASTM D2992 procedure "A". This method rates pipe on the basis of 150 million cycles. This is an extremely conservative rating for pipes but is very useful for comparing one manufacturer's products to another.
Differential Scanning Calorimetry	A sophisticated process for measuring the degree of cure of a thermoset resin by heating a small sample. The DSC test gives a "glass transition temperature" (T _g), which is the approximate temperature at which the resin loses its crystalline structure and becomes soft. Sometimes the heat deflection is used to estimate this factor.
Drift Diameter	A measure of a pipe's internal diameter, including both ovality and longitudinal warpage, over a given length of pipe.
Eccentric Reducer	A fitting used to join two different pipe sizes together while maintaining the same bottom of pipe elevation.
Elastic Limit	The theoretical point to which a material may be stressed without permanent or irreversible structural changes. This implies that the material will repeatedly return to its original shape. In reality, there is no true elastic limit for composites. (See also proportional limit).
Elastic Modulus	The rate of change in strain (elongation) as stress (pressure) changes within the elastic range of a material. The elastic modulus of a material is defined as the slope of its stress-strain curve in the elastic deformation region.
Epoxy Resin	Epoxy is a thermosetting epoxide polymer that cures (polymerizes and crosslinks) when mixed with a catalyzing agent or hardener. Most common epoxy are produced from a reaction between epichlorohydrin and bisphenol-A.
Failure Mechanisms	Any effect which will cause leakage of fluid from any part of a piping system. These include: weep, burst, porosity, rupture, parting of end connections (thread shear), thread leakage, buckling, bending, torque, chemical degradation, heat softening, vacuum, collapse, impact, physical abuse, abrasion, leak of adhesive bond, shear of adhesive bond etc.
Fatigue	Permanent structural damage in a material subjected to fluctuating stress and strain.
Fiberglass Pipe	A tubular product containing glassfiber reinforcements embedded in or surrounded by cured thermosetting resin. The composite structure may contain aggregate thixotropic agents and pigments or dyes. Thermoplastic or thermosetting liners or coatings may be included.
Filament Winding	A manufacturing method for pipe and fittings by winding resin-impregnated continuous strands around a mandrel to achieve high reinforcement concentration and precise filament orientation.
Fillers	Materials added to a resin which do not affect the cure of the resin itself, but may influence the resin's physical and mechanical properties. Generally used to increase wall thickness at low cost.

Fitting Types	The method of manufacturing of particular fittings, i.e. molded, cut and mitered, filament wound.
Flexibilizer	(see plasticize).
Friction Loss	Friction loss refers to that portion of pressure lost by fluids while moving through a pipe. Various equations (Fanning, Darcy, Reynolds, Hazen-Williams, Manning, Etc.) can be used to estimate these friction losses and the accompanying decrease in pressure through a given length of pipe.
Gel Time	The time it takes for a resin to begin to harden.
Hand Lay-Up	Any number of methods for forming resin and fiberglass into finished pipeproducts by manual procedures. Hand lay-up products generally have poor physical properties since fibers cannot be oriented for maximum performance. These procedures include overwrapped techniques, contact molding, hand molding, etc.
Hardener (Catalyst, Curing Agent)	A chemical compound which initiates polymerisation of a resin (also called catalyst or curing agent).
Hoop Stress	(see bursting strength)
Integral Joint	Joining method where the female end connection is manufactured as an integral part of a pipe. A length of pipe with integral joints will have one male end and one female end. This eliminates the need for couplings or collars.
Joint	The term joint generally refer to the actual joining mechanism (i.e., adhesive bonded - Quick-Lock & Taper/Taper, threaded, flanged, mechanical - Key-Lock, etc). It is sometimes used to describe an individual length of pipe.
Liner	A generic term referring to the type of interior surface in pipe. Generally, liners are resin-rich regions of .001 to .1 inch thickness. They may include fibrous material such as veil or mat. Liners are generally used to add extra corrosion resistance for severe service or to provide a leak resistant barrier to a non-congruent wall which will not hold pressure without a liner, i.e. an innertube effect. Liners may be applied prior to, during, or after manufacture of the pipe wall, depending on the type of process used.
Matrix	The resin material used to bind reinforcements and fillers together. This material may be either thermoplastic or thermoset and dictates to a large degree the temperature and chemical service conditions allowable for a pipe or fitting.
Minimum Bending Radius	The farthest deflection of the centerline allowable in a pipe before damage occurs. The radius refers to an imaginary circle of which the pipe length or pipe segment would be an arc.
Modulus of Elasticity	(see elastic modulus).
Molded Fittings	Fittings formed by compressing resin, chopped fibers, and other ingredients under heat and pressure in a mold.

Molding	Many of several manufacturing methods where resin and reinforcing materials are shaped into final products by use of pressure or compression in a mold or other fixtures.
Nominal Measurements (ID, OD, Wall Thickness)	The average inside diameter (ID), outside diameter (OD), etc. of a piece of pipe or fitting.
Pin	The male end of a threaded pipe that fits into the female end (box) of another pipe or a fitting.
Pipe Stiffness	A measure of the force required to deflect the diameter of a given length of pipe. Stiffness relates to: pipe deflection, ring bending, stiffness factor, parallel plate loading, external loading, tangential stress, crush or collapse strength.
Plasticize (Flexibilize)	To make a cured resin softer or more rubber-like with additives. Plasticizing additives can be used to improve low temperature properties of a composite. Measured by Durometer, Barcol or hardness numbers.
Poisson's Effect (Ratio)	The property of a material that causes a change in its dimensions due to force applied perpendicular to the plane of the dimension change. Expressed as the ratio of lateral strain to load direction strain.
Polyester resin	Any of a large family of resins that are normally cured by crosslinking with styrene. The physical and chemical properties of polyester resins vary greatly. Polyester has poor corrosion resistance and so is primarily used in non-critical applications such as automobiles, boats, bathtubs, etc.
Pressure Rating	The maximum anticipated long-term operating pressure a manufacturer recommends for a given product. Also referred to as working pressure, pressure class, or design pressure.
Promotor	(see accelerator).
Proportional (elastic) Limit	The greatest stress a material can sustain for a short time without causing permanent deformation. Defined by the point at which the stress-strain curve deviates from linearity. For composite materials, this point is often called the Apparent Elastic Limit since it is an arbitrary approximation on a non-linear stress-strain diagram (see stress-strain diagram).
Reinforced Plastic Mortar Pipe (RPMP)	A fiberglass pipe with aggregate.
Reinforced Thermosetting Resin pipe (RTRP)	A fiberglass pipe without aggregate.
Reinforced Wall Thickness	The total wall thickness minus the thickness of the liner and minus the thickness of the exterior coating.

Reinforcement	<p>Usually consisting of fibers (glass, carbon or synthetic material) the reinforcement is the major source of strength and stiffness in a composite.</p> <p>The types of fiber used has a major role, as does the fiber diameter, the type of sizing used, and the fiber's ability for positive interaction with the resin.</p> <p>Terms relating to the physical form of the reinforcement include:</p> <p><u>Chopped Fiber</u></p> <ul style="list-style-type: none"> - Continuous fiberglass that is chopped to about 3,2 - 50 mm (1/8 - 2 inch) lengths. <p><u>Filament</u></p> <ul style="list-style-type: none"> - A single individual fiber of glass (e.g., a monofilament). <p><u>Mat</u></p> <ul style="list-style-type: none"> - Coarse fabric sheets made from chopped or continuous strands randomly placed and held together by resin binders. <p><u>Milled Fibers</u></p> <ul style="list-style-type: none"> - Glassfibers usually ground or milled to 0,8 - 3,2 mm (1/32 - 1/8 inch) lengths. <p><u>Roving</u></p> <ul style="list-style-type: none"> - A collection of one or more strands coated with a finish or coupling agent to improve compatibility with resins. <p><u>Strand</u></p> <ul style="list-style-type: none"> - A group of filaments collected into a bundle (contains hundreds of thousands of filaments). <p><u>Veil (surface mat)</u></p> <ul style="list-style-type: none"> - A porous fabric mat made from filaments to provide a resin-rich liner. <p><u>Yarn</u></p> <ul style="list-style-type: none"> - Fiberglass filaments twisted together to form textile-type fibers. <p><u>Yield</u></p> <ul style="list-style-type: none"> - The number of yards of material made from one pound of the product.
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Resin (Polymer)	The main component of a thermoset material.
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Service Design Factor	The hydrostatic design basis stress (HDBS) is multiplied with the service (design) factor to obtain the hydrostatic design stress (HDS). The HDS is used in wall thickness calculation (according ASME B31.3). The service (design) factor shall not exceed 0,5 when using the static HDBS or 1,0 when using the cyclic HDBS.
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Socket	(see bell).
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Static Pressure Rating (of Fiberglass Pipe)	The recommended constant pressure (without significant changes) at which a pipe can be operated in continuous duty and still maintain a long service life. Determined by conducting tests in accordance with ASTM 2992, procedure B.
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Strain	The deformation of materials caused by stress induced by applied forces. Measured by mm/mm (inch/inch) or percent of elongation.
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Stress	The amount of force per unit of area. Measured in Newton per square meter (pound per square inch -psi). This should not be confused with hydraulic pressure measured by barg or bara (psig or psia), which can induce stress but is not stress by itself.
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Stress-Strain Diagram	A graph of unit stress versus the corresponding unit strain. As the load increases, elongation or deformation of the material also increases.
Support Spacing	The recommended maximum distance between pipe supports to prevent excessive sagging or bending.
Surge Pressure	(see water hammer).
Tensile Rating	The maximum anticipated long-term operating axial load (weight) a manufacturer recommends for tubing products.
Tensile Force	Forces applied to a body tending to pull or rip the material apart. Hydrostatic pressure within a closed pipe loads the walls in both circumferential (hoop) and axial (longitudinal) tension.
Thermal Conductivity	The rate at which a material (pipe) transmits heat from an area of high temperature to an area of lower temperature. Fiberglass pipe is generally considered to have low thermal conductivity.
Thermal Expansion	The increase in dimensions of a material (pipe) due to the application of heat. The coefficient of thermal expansion is positive as temperature increases and negative as it decreases.
Thermoplastic	<p>A polymeric material which can be softened by heat for molding or extruding into various shapes. It can then be hardened by cooling, which restores the initial material rigidity and mechanical properties. This process may be reproduced without affecting properties of the resin.</p> <p>Typical thermoplastics used in producing pipe include:</p> <ul style="list-style-type: none"> - Polyvinyl chloride (PVC) - Polyethylene (PE) - High density polyethylene (HDPE) - Chlorinated PVC - Acrylonitrile-butadiene-styrene (ABS) - Polypropylene (PP) - High density polypropylene (HDPP) <p>Although reinforcing fibers can be added to these materials, thermoplastics are generally not reinforced resins.</p>
Thermoset	<p>A polymer resin generally cured by heat or chemical additives. Upon setting, a thermoset becomes substantially infusible (cannot be remelted) and insoluble. Thermosetting resins used in the manufacture of pipe often incorporate reinforcing fibers. Typical thermosets include:</p> <p><u>Epoxies</u></p> <p><i>Anhydride cured:</i></p> <ul style="list-style-type: none"> - Aliphatic polyanhydrides - Cycloaliphatic anhydrides - Aromatic anhydrides <p><i>Amine cured:</i></p> <ul style="list-style-type: none"> - Aromatic amines - Aliphatic polyamines - Aliphatic poly alkylene amines - Cycloaliphatic amines

Thermoset c'tnd	<p><u>Vinylesters</u></p> <ul style="list-style-type: none"> - Bisphenphenol-A methacrylates - Bisphenphenol-F methacrylates <p><u>Unstaured Polyesters (seldom used)</u></p> <ul style="list-style-type: none"> - Orthophtalic polyester - Isophtalic polyester - Bisphenol-A fumerate polyesters
Thrust Forces	Often used to refer to the forces developed by changes in direction of a moving column of fluid, but also covers the axial or longitudinal end loads at fittings, valves, etc., due to hydraulic pressure alone.
Torque	A term often used interchangeably with torsion to indicate a twisting force in a pipe or fitting. Torque is measured by the amount of force applied to rotate an object around its axis. Torque is expressed in Newton meters (Nm) or (ft lb).
Ultimate Burst Pressure	(see weep pressure).
Ultimate Collapse Pressure	(see collapse pressure).
Vinyl Ester Resin	A premium resin system with excellent corrosion resistance widely used on filament wound pipe because of its versatility. Vinyl ester resin is generally serviceable up to a temperature of 93 °C (200 °F).
Water Hammer	Water hammer is a pressure surge or pressure wave resulting when a fluid in motion is forced to stop or change direction suddenly.
Weep Pressure	The ultimate pressure a pipe can withstand for a short time before leaking. This pressure is obtained from ASTM D-1599 test procedures. Though often referred to as Ultimate Burst pressure, this term is misleading in that it implies a sudden rupture of the pipe wall, which seldom (if ever) happens. Rather, a pipe which has reached weep pressure will merely begin to leak through the pipe wall.

References

1. *Fiberglass pipe handbook, SPI composites institute (January 1990).*
2. *Fiberglass pipe design AWWA M45, American water works association (1996).*



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