Fiberglass Reinforced Plastics and Resin Information

Fiberglass Reinforced Plastic (FRP)

ACO is a leading manufacturer of fiberglass products. ACO uses fiberglass to manufacture a variety of products for the construction and waste water industries. FRP is produced from glass fibers laminated together using a thermosetting resin system.

Resins

There are a variety of resins available, which help determine the properties of the finished product. Chemical resistance data can be found on pages 4-7.

Commonly used resins for construction products include:

Orthophthalic Polyester

Orthophthalic polyester resins are widely used. They offer a combination of economy and good physical properties and are an excellent option for "dirty water" and non-corrosive applications.

Isophthalic Polyester

Isophthalic resins are a premium grade, general purpose polyester resin suitable for use in a wide range of conventional FRP applications. They are high molecular weight thermosetting resins, formulated specifically for their corrosion resistance and physical properties.

Vinyl Ester

Standard vinyl ester resins offer excellent resistance to acids, alkalis, and oxidizing chemicals. They also provide good toughness and fatigue resistance. Vinyl ester resins are premium quality thermosetting products used in a wide range of corrosion resistant FRP applications by all conventional fabricating techniques.

Premium Vinyl Ester

A higher grade vinyl ester resin combines corrosion resistance with superior retention of physical properties at high temperatures, superior oxidation resistance, and resistance to mixtures of chemicals, including solvents.

Ideally suited for fabricating corrosion and heat resistant products used in particularly corrosive environments, where combinations of acids, halogenated organics, caustics and solvents are present.

Glass Fiber Reinforcement

Reinforcements are an integral part of any fiberglass product. Usually made from glass, they come in a variety of 'structures.' Typical reinforcements include:

- Veils - thin layers of material, used to create a resin-rich corrosion barrier
- Chopped or continuous strand mats
- Woven rovings - mats made from woven bundles of thin glass strands

Laminate construction (resin and layers of reinforcement) is determined by the intended use of the finished product.

Other materials such as carbon fiber may be used in highly specialized applications.

Performance Benefits

- Outstanding resistance to corrosion by many different chemicals, at room and elevated temperatures
- High impact resistance
- High fatigue resistance
- High strength to weight ratio
- Excellent electrical and thermal insulation properties
- Temperature resistance
- Class 1 flame spread available
- Low maintenance
- Repair friendly
- Custom sizes and shapes easily fabricated

Typical Physical Properties of Fiberglass

1. Tensile strength - 12,500 psi
2. Hardness - (Bacol) 35
3. Flexural yield strength - 27,600 psi
4. Modulus of Elasticity - 1.02 psi x 10^6
5. Expansion coefficient - 12 µin/in per ˚F
6. Thermal conductivity - 1.5 BTU - in./hr. - ft^2 - ˚F

Additives

Fiberglass material can be tailored to meet particular project requirements. Additives are used to increase a specific performance of the finished product. These include:

Abrasion Resistant Gel Coat

Abrasion resistant gel coating is used in projects where abrasive particles are present, which can wear through standard fiberglass. This process increases the Barcol hardness to 55, compared to 30-40 for standard fiberglass. Ceramic or tungsten carbide powder can also be added to increase abrasion resistance.

Special Fire-Retardant Resin

Some applications and regulatory bodies require building materials to be fire retardant, such that they should not act as fuel and increase or prolong a fire. Additives can be mixed with the resin to give a 'NFPA Class 1 Flame Spread' rating.

Commonly required around petrochemical plants and areas where large volumes of flammable liquids are present.

Ultra-violet (U.V.) Light Inhibitor

This additive limits the amount of damage caused by sun exposure.

Manufacturing Processes

The process of combining resins, glass fiber reinforcements and additives can be achieved through a number of techniques. The process used depends upon product size, type and anticipated usage.

Filament Winding

Filament winding is an open molding rotary process used to fabricate structures with a consistent thickness and resin-to-glass ratio. While filament winding is used for the structural portion, the corrosion barrier is fabricated using either hand lay-up or spray-up.

A mandrel, used as a mold, is positioned either horizontally or vertically and turned with a motor. As the mandrel turns, the laminate layers (veils, mats, rovings, etc.) are saturated with catalyzed resin and wound onto the mandrel. The angle at which the glass is wound directly relates to the physical strength of the piece.

Hand Lay-up

Hand lay-up can be used to produce the corrosion barrier or the entire part. It is typically used for low volume parts.

Laminate structure is saturated with catalyzed resin and applied, by hand, to a mold. A metal roller removes air bubbles that may affect laminate performance.

Spray-Up

Spray-up can be used to produce the corrosion barrier or the entire part. It is typically used for high volume parts.

Spray-up is an open molding process in which a spray gun is used to apply a mixture of catalyzed resin and chopped glass to the mold. A metal roller removes any trapped air. Additional resin and glass are applied to reach the desired thickness.

Pultrusion

The pultrusion process produces parts with a constant cross-section. It utilizes glass, resin, filler, pigments, and release agent. The pultrusion process is ideal for producing high volumes of a continuous shape.

A combination of veils, mats and rovings pass through a resin bath before being pulled through a heated metal die to form the desired shape.

Closed Molding

Closed molding uses matching male and female molds. It is ideal for both low and high volume applications.

The laminate components are placed into the mold prior to closing. Catalyzed resin is pumped into the mold. Hydraulic presses, or vacuum seals, are used to clamp the two halves of the mold. The part is removed from the mold after curing.

Chemical Resistance

The following chart lists chemical reagents and the highest known temperature at which products made with the listed resins either had given good service, or on which field or laboratory testing had indicated good expected service life.

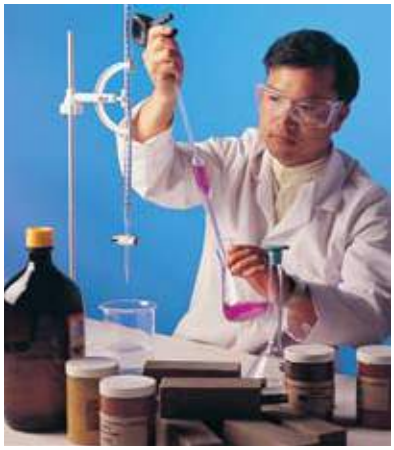
If exposure is intermittent or is to fumes or spills only, it is possible to get good service at temperatures considerably higher than those shown.

For information on any chemicals not listed in the chart, please contact ACO.

Material coupons are available for final determination of chemical resistance.

In assessing a resin for a particular environment, factors other than maximum service temperature to consider include:

- Amount and type of impurities in the chemical and/or environment
- Contact time of chemicals to product
- Compatibility of other product components, frames, grates, outlet pipes, etc.



Legend

~ — No data available
✗ — Not recommended
? — May be suitable. Call for further information.

	Isophthalic Polyester		*Vinyl Ester*		*Premium Vinyl Ester*	
Reagent	*% Concentration*	*Max. Temp (°F)*	*% Concentration*	*Max. Temp (°F)*	*% Concentration*	*Max. Temp. (°F)*
Acetic Acid	10	160	10	210	10	210
Acetic Acid	50	140	50	180	50	180
Acetone	100	✗	100	✗	100	✗
Alcohol (Ethyl)	100	80	95	80	95	100
Aluminium Chloride	All	170	All	210	All	250
Aluminium Sulfate	All	170	All	210	All	250
Ammonia [1]	Gas	90	Gas	100	Gas	100
Ammonium Chloride	All	170	All	210	All	210
Ammonium Hydroxide [2]	All	✗	5	180	5	180
Ammonium Hydroxide [2]	~	~	10	150	10	150
Ammonium Nitrate	60	160	All	210	All	250
Ammonium Phosphate	All	160	All	210	All	210
Ammonium Sulfate	All	170	All	210	All	250
Ammonium Sulfide	All	✗	Sat'd	120	Sat'd	120
Amyl Chloride	All	✗	100	120	100	120
Aniline	100	✗	100	✗	100	70
Barium Chloride	All	170	All	210	All	210
Barium Hydroxide	All	✗	All	150	All	150
Barium Sulfate	All	170	All	210	All	250
Barium Sulfide	Sat'd	✗	All	180	All	180
Beer	~	110	~	120	~	~
Beet Sugar Liquor	All	120	~	180	~	~
Benzene [3]	100	✗	100	✗	100	100
Benzoic Acid	All	170	Sat'd	210	Sat'd	210
Bleach (Chlorine Dioxide Wet) [4]	All	✗	Sat'd	200	Sat'd	200
Boric Acid	All	170	All	210	All	210
Bromine Liquid	100	✗	100	✗	100	✗
Butane	~	~	100	122	100	122

Reagent	Isophthalic Polyester		Vinyl Ester		Premium Vinyl Ester	
	% Concentration	Max. Temp (°F)	% Concentration	Max. Temp (°F)	% Concentration	Max. Temp. (°F)
Calcium Carbonate	All	160	All	180	All	180
Calcium Chloride	All	170	All	210	All	250
Calcium Hydroxide [2]	15	120	15	180	15	150
Calcium Hypochlorite	All	✗	All	180	All	150
Calcium Sulfate	All	170	All	210	All	250
Cane Sugar Liquors	All	110	All	180	~	~
Carbonic Acid	All	150	~	~	~	~
Carbon Disulfide	All	✗	100	✗	100	✗
Carbon Dioxide	~	180	~	210	~	350
Carbon Monoxide [4]	~	180	~	210	~	400
Carbon Tetrachloride	100	✗	100	150	100	180
Chlorine (Dry Gas) [5]	~	14	100	210	100	250
Chlorine (Wet Gas) [5]	All	✗	100	210	100	250
Chloroacetic Acid [4]	25	90	25	120	25	120
Chlorobenzene	100	✗	100	✗	100	100
Chloroform	100	✗	100	✗	100	✗
Chromic Acid	5	80	10	150	10	150
Chromic Acid	20	✗	20	120	20	150
Citric Acid	All	160	All	210	All	210
Copper Chloride	All	170	All	210	All	250
Copper Cyanide	All	120	All	210	All	210
Copper Nitrate	All	150	All	210	All	210
Copper Sulfate	All	170	All	210	All	250
Cottonseed Oil	~	100	~	210	~	210
Cresol	All	✗	~	~	~	~
Cyclohexanone	100	✗	~	~	~	~
Cyclohexane	All	120	100	120	100	150
Diethylamine	100	✗	100	✗	100	?
Dimethyl Acetamide	70	~	100	✗	100	?
Distilled Water	~	150	100	180	100	180
Ethyl Acetate	100	✗	100	✗	100	80
Ethylene Chloride	100	✗	100	✗	100	80
Ethylene Glycol	All	170	All	210	All	210
Fatty acids	All	170	All	210	All	250
Ferric Sulfate	All	170	All	210	All	210
Fluorine Gas [2]	~	~	~	80	~	80
Formaldehyde [6]	40	90	All	150	All	150
Formic Acid	10	120	10	180	10	180
Freon 12	~	~	~	80	~	100
Furfural	All	✗	100	✗	100	✗
Gasoline (Refined)	All	?	100	120	100	150
Glucose	All	120	100	210	100	250
Glycerine	All	170	100	210	100	210
Hydrobromic Acid	25	120	18	180	18	180
Hydrochloric Acid [7]	~	~	10	230	10	180
Hydrocyanic Acid	10	75	All	210	All	210
Hydrogen Peroxide [4, 8]	50	120	30	150	30	150
Hydrogen Peroxide	5	✗	50	✗	50	✗

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Reagent	Isophthalic Polyester		Vinyl Ester		Premium Vinyl Ester	
	% Concentration	Max. Temp (°F)	% Concentration	Max. Temp (°F)	% Concentration	Max. Temp. (°F)
Hypochlorous Acid [4]	10	100	~	~	~	~
Iodine Vapor	100	~	100	150	100	180
Kerosene	100	120	100	180	100	180
Lactic Acid	All	160	All	210	All	210
Linseed Oil	All	160	100	210	100	230
Magnesium Chloride	All	170	All	210	All	250
Magnesium Sulfate	All	150	All	210	All	250
Maleic Acid	All	140	100	210	100	250
Methylene Chloride	All	✗	100	✗	100	✗
Methyl Ethyl Ketone [3, 4]	100	✗	100	✗	100	70
Milk	All	140	100	210	~	~
Mineral Oils	100	170	100	210	100	250
Nickel Chloride	All	160	All	210	All	210
Nickel Sulfate	All	170	All	210	All	210
Oleic Acid	All	170	All	210	All	200
Oleum	~	✗	~	✗	~	✗
Oxalic Acid	100	170	Sat'd	120	Sat'd	120
Palmitic Acid 10%	100	160	100	210	100	250
Perchloric Acid	All	✗	10	150	10	150
Perchloric Acid	~	~	30	100	30	100
Phenol	100	✗	5	~	5	120
Phosphorous Trichloride	100	90	~	✗	~	✗
Picric Acid	~	✗	10	✗	10	100
Potassium Carbonate [2]	10	80	10	150	10	150
Potassium Chloride	All	160	All	210	All	210
Potassium Dichromate	All	170	All	210	All	210
Potassium Hydroxide [2, 9]	All	✗	10	150	10	150
Potassium Hydroxide [2, 9]	~	~	45	180	45	180
Potassium Permanganate	All	100	All	210	All	210
Potassium Sulfate	All	170	All	210	All	210
Propane Gas	~	~	100	122	100	122
Propyl Acetate	~	~	100	✗	100	80
Sea Water (Natural)	~	160	~	210	~	210
Silver Nitrate	All	160	All	210	All	210
Silver Sulfate	~	~	~	~	~	?
Sodium Bicarbonate [2]	All	100	10	180	10	180
Sodium Bisulfite	All	170	Sat'd	210	Sat'd	210
Sodium Carbonate [2]	All	✗	10	180	10	180
Sodium Carbonate [2]	~	~	25	180	25	180
Sodium Cyanide	10	120	All	210	All	210
Sodium Ferrocyanide	All	170	All	210	All	210
Sodium Hydroxide [2, 9]	All	✗	10	180	10	150
Sodium Hydroxide [2, 9]	~	~	50	210	50	180
Sodium Hypochlorite [2, 4, 6, 8, 9]	All	✗	10	180	10	150
Sodium Sulfate	All	170	All	210	All	210

Reagent	Isophthalic Polyester		Vinyl Ester		Premium Vinyl Ester	
	% Concentration	Max. Temp (°F)	% Concentration	Max. Temp (°F)	% Concentration	Max. Temp. (°F)
Sodium Sulfide	10	80	All	210	All	210
Sodium Sulfite	All	✗	All	210	All	210
Sodium Thiosulfate	All	120	All	180	All	180
Stannous Chloride	All	170	All	210	All	210
Stearic Acid	100	170	All	210	All	210
Sulfurous Acid	10	✗	10	120	10	120
Sulfur Dioxide (Dry or Wet)	~	170	~	210	~	250
Sulfuric Acid	Fumes	170	Vapor	210	Vapor	350
Sulfuric Acid	25	170	10	210	10	220
Sulfuric Acid	50	150	50	210	50	210
Sulfuric Acid	93	✗	80	100	80	120
Tannic Acid	All	170	All	210	All	210
Tartaric Acid	All	170	All	210	All	210
Toluene	100	✗	100	80	100	120
Trichloroethylene	~	✗	100	✗	100	✗
Triethylamine	All	✗	All	120	All	120
Trisodium Phosphate	Sat'd	✗	All	210	All	250
Turpentine	All	✗	100	150	100	210
Urea	All	140	50	150	50	150
Vinegar	100	150	100	210	100	210
Water (Deionized) [9]	~	150	100	180	100	180
Water (Distilled) [9]	~	150	100	180	100	180
Wines	All	80	~	~	~	~
Xylene	All	✗	100	80	100	120
Zinc Chloride	All	170	70	210	70	250
Zinc Sulfate	All	170	All	210	All	210

1. Probably satisfactory at higher temperatures, but temperature shown is the highest for which information was available.
2. Double synthetic veil should be used in inner layer.
3. If service is marginal, use premium vinyl ester resin.
4. Check with corrosion technical service lab for specific recommendations.
5. Double surfacing veil and 200-mil corrosion liner should be used.
6. Satisfactory up to maximum stable temperature for product.
7. Double surfacing veil.
8. Benzoyl peroxide — DMA cure system recommended to increase service life.
9. Post-cure recommended to increase service life.

ACO product lines

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