Bhavi Plast

FRP & THERMOPLASTIC PROCESS EQUIPMENT · EST. 1977

ENGINEERING GUIDE

Resin and liner selection guide

How to choose the resin system, corrosion barrier and thermoplastic or fluoropolymer liner for FRP and dual-laminate process equipment.

DOCUMENT	REVISION	ISSUED	APPLIES TO
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About this guide

In a fibre-reinforced plastic vessel, the glass carries the load and the resin keeps the chemical out. Most premature failures of FRP equipment trace back not to fabrication, but to a resin, barrier or liner chosen without the full picture of the service.

This guide sets out how Bhavi Plast approaches that choice. It explains how a corrosion-resistant laminate is built, how chemicals attack it, how the main resin families and liner materials compare, and the procedure we follow to select between them. It is written for process, maintenance and project engineers specifying FRP and dual-laminate equipment.

> **Use this guide for orientation, not final selection.** Chemical resistance depends on concentration, temperature, trace components, cleaning regimes and cyclic conditions together. Ratings here are general guidance for typical service. Every Bhavi Plast design is confirmed against the resin or liner manufacturer's published chemical resistance data for the specific duty.

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How a corrosion-resistant laminate is built

A corrosion-resistant FRP laminate is not one material but several layers, each with a different job. The inner layers resist the chemical; the outer layers carry the load. Under BS EN 13121 and ASME RTP-1, the inner corrosion barrier is not counted as load-bearing.

LAYER	TYPICAL CONSTRUCTION	THICKNESS	FUNCTION
Surfacing veil	C-glass or synthetic (polyester, carbon) veil, about 90% resin	0.25 – 0.5 mm	Resin-rich inner skin that meets the chemical first. Synthetic veils are used where glass is attacked.
Inner corrosion layer	Two to three plies of chopped strand mat, 25 – 30% glass	2.0 – 2.5 mm	Second line of defence. Its high resin content slows permeation and stops cracks reaching the structure.
Structural laminate	Chopped strand mat and woven roving, or filament winding, 35 – 70% glass	By design	Carries hydrostatic, pressure, wind, seismic and nozzle loads. Thickness comes from the governing code.
Exterior topcoat	Resin-rich coat with UV absorbers or pigment	0.3 – 0.5 mm	Protects the structure from weather, UV and external spillage.

The surfacing veil and inner layer together form the **corrosion barrier**, typically 2.5 to 3.0 mm thick. In **dual-laminate** construction, a thermoplastic or fluoropolymer liner replaces or backs up the barrier, and the FRP is bonded behind it as the structural shell.

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How chemicals attack FRP

Understanding the mechanism matters, because each one is prevented by a different choice.

MECHANISM	WHAT HAPPENS	TYPICAL CAUSES · HOW IT IS DESIGNED OUT
Permeation and blistering	Small molecules diffuse into the laminate, collect at interfaces and form blisters	Hot water, dilute acids at high temperature · resin-rich barrier, full cure, higher-performance resin
Hydrolysis	Ester linkages in the resin backbone are split, softening the laminate	Strong alkalis, hot water · vinyl ester or bisphenol resins, which have fewer or shielded ester groups
Oxidation	Oxidising agents break the polymer chain; surface chalks and erodes	Hypochlorite, wet chlorine, chlorine dioxide, nitric acid · vinyl ester with a suitable cure system, chlorendic resin, or a fluoropolymer liner
Glass attack	Glass fibres dissolve, removing reinforcement from within	Fluorides and hydrofluoric acid, strong alkalis · synthetic veil in the barrier, or a liner
Solvent swelling	Solvents dissolve into the resin, swelling and weakening it	Aromatic and chlorinated solvents, ketones · novolac vinyl ester, or PVDF / FEP / PFA liner
Stress corrosion of glass	Acid reaches glass through a crack and causes brittle fibre fracture	Over-strained laminates, impact damage · strain limit in design, tougher resin, intact barrier
Thermal degradation	Resin softens or degrades near or above its heat distortion temperature	Process upsets, hot gas inlets · higher-temperature resin, quench, temperature interlock
Abrasion and erosion	Solids wear away the barrier mechanically	Slurries, particulate-laden gas · abrasion-resistant filled barrier, thicker barrier, lower velocity

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Resin systems compared

Properties below are typical values for clear resin castings, given for comparison only. Heat distortion temperature (HDT) is not a service temperature: the maximum safe service temperature is usually well below HDT, and falls further with aggressive chemicals.

RESIN FAMILY	TYPICAL HDT	ELONGATION	STRENGTHS	LIMITATIONS
Isophthalic polyester (ISO)	90 – 120 °C	2 – 3%	Economical; good with water, salts and dilute non-oxidising acids at moderate temperature	Poor with alkalis, oxidisers and solvents; resistance falls quickly with temperature
Bisphenol-A fumarate polyester (BPA)	120 – 135 °C	1.5 – 2.5%	Broader acid and alkali resistance than isophthalic; good hot acid performance	Brittle; limited with solvents and thermal shock
Chlorendic polyester (CHL)	120 – 140 °C	1.5 – 2.5%	Hot, strongly oxidising mineral acids; wet chlorine; inherent fire retardance	Poor with alkalis; brittle; specialist use
Epoxy vinyl ester (VE)	100 – 110 °C	5 – 6%	The industry workhorse: strong acids, alkalis, many oxidising services; tough and crack-resistant	Some solvents and concentrated oxidisers; limits vary strongly by chemical
Vinyl ester FR	105 – 125 °C	4 – 5%	Brominated vinyl ester for fire retardance, with chemical resistance close to standard vinyl ester	Fire performance usually needs a synergist; slightly lower resistance in some services
Super vinyl ester	Grade-dependent	Grade-dependent	High-performance vinyl ester grades formulated for higher temperature and improved resistance, between standard and novolac vinyl esters	Properties vary by supplier grade; select from the specific data sheet
Novolac vinyl ester (NVE)	140 – 165 °C	2.5 – 4%	Highest temperature and solvent resistance of the vinyl esters; hot acid gases and flue gas	Less tough; less tolerant of cyclic loading and thermal shock

> **Why toughness matters.** Many vessels fail not from steady chemical attack but because a crack opens during a temperature swing or pressure cycle and lets the chemical behind the barrier. Resins with higher elongation, such as epoxy vinyl ester, tolerate this far better. That is why a hot inlet zone may use novolac vinyl ester while the rest of the same scrubber uses standard vinyl ester.

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Thermoplastic and fluoropolymer liners

When a chemical would attack even the best resin, or the margin is too thin, a welded thermoplastic or engineering fluoropolymer liner takes over the chemical duty. Liner sheets are supplied with a glass or polyester fabric backing so that the FRP structure can bond to them mechanically.

LINER	TYPICAL MAX. SERVICE*	STRENGTHS	LIMITATIONS
PP / PPH	≈ 90 °C	Broad acid and alkali resistance; economical; easily welded	Not for strong oxidisers, aromatic or chlorinated solvents
PPC, PPC-UV	≈ 80 °C	Copolymer with better impact toughness; UV-stabilised grade for outdoor tanks	Lower temperature limit than homopolymer
HDPE	≈ 60 °C	Alkalis, many acids, effluent and fluoride service	Low temperature limit; not for oxidisers at temperature
PVC / CPVC	≈ 60 / 90 °C	Hypochlorite, chlorine-bearing and acid services; CPVC to higher temperature	Not for aromatics, ketones or esters
PVDF	≈ 140 °C	Strong acids, oxidisers, halogens, hydrofluoric acid; high-purity duty	Strong alkalis at temperature, amines, ketones
ECTFE	≈ 150 °C	Very broad resistance including alkalis and chlorine at temperature; low permeation	Higher cost; specialised welding
FEP / PFA	≈ 200 / 260 °C	Virtually universal chemical resistance; PFA for the highest temperatures	Highest cost; thin sheets; some small-molecule permeation

* Polymer limits under mild conditions. In dual-laminate equipment, the FRP backing laminate and the liner bond usually set the working limit, which is why our standard design temperature range for dual-laminate equipment is 30 – 120 °C.

Points to engineer in every dual-laminate design

- **Bond:** the fabric-backed liner must be fully wetted out and bonded; bond strength is verified on test pieces.
- **Welds:** liner seams are hot-gas or extrusion welded, and every weld is spark tested for pinholes before the FRP is applied.
- **Thermal expansion:** thermoplastics expand several times more than FRP. Design and bonding must keep the liner restrained across the temperature range.
- **Permeation:** some chemicals slowly permeate even an intact liner. For these, liner thickness, venting or a permeation-resistant fluoropolymer is specified.

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Chemical resistance matrix

● Generally recommended ◐ Conditional — concentration, temperature or construction limits apply ○ Not recommended

SERVICE	ISO	BPA	VE	NVE	CHL	PP	PVC / CPVC	HDPE	PVDF	ECTFE	FEP / PFA
	FRP RESIN SYSTEM					THERMOPLASTIC / FLUOROPOLYMER LINER					
Hydrochloric acid, ≤ 37%	◐	●	●	●	●	●	●	●	●	●	●
Sulphuric acid, ≤ 50%	◐	●	●	●	●	●	●	●	●	●	●
Sulphuric acid, 50 – 75%	○	◐	●	●	●	●	●	◐	●	●	●
Sulphuric acid, > 75%	○	○	○	◐	◐	◐	◐	◐	◐	●	●
Nitric acid, ≤ 20%	○	◐	◐	◐	●	◐	●	◐	●	●	●
Nitric acid, > 40%	○	○	○	○	◐	○	◐	○	◐	◐	●
Hydrofluoric acid and fluorides	○	◐*	◐*	◐*	◐*	●	◐	●	●	●	●
Phosphoric acid	◐	●	●	●	●	●	●	●	●	●	●
Chromic acid, plating baths	○	◐	◐	◐	◐	◐	●	◐	●	●	●
Sodium hydroxide, ≤ 50%	○	●*	●*	◐*	○	●	●	●	◐	●	●
Sodium hypochlorite, ≤ 15%	○	◐	◐†	◐†	○	○	●	◐	●	●	●
Wet chlorine gas	○	◐	●	●	●	○	◐	○	●	●	●
Chlorine dioxide	○	○	◐	◐	◐	○	◐	○	●	●	●
Salts, brines, neutral effluent	●	●	●	●	●	●	●	●	●	●	●
Aqueous ammonia, amines	○	◐	●	◐	○	●	◐	●	◐	●	●
Alcohols (methanol, ethanol)	◐	◐	◐	●	◐	●	●	●	●	●	●
Aromatic solvents (toluene, xylene)	○	○	◐	●	◐	○	○	○	●	●	●
Chlorinated solvents	○	○	○	◐	○	○	○	○	◐	◐	●
Ketones and esters (acetone, MEK)	○	○	○	◐	○	◐	○	◐	○	◐	●
Demineralised and ultrapure water	◐	◐	●	●	◐	●	◐	●	●	●	●
Hot wet flue gas, 60 – 180 °C	○	◐	◐	●	◐	○	○	○	◐	◐	●

Ratings indicate typical service from ambient to about 60 °C unless the service states otherwise. * Synthetic (polyester or carbon) veil required in the corrosion barrier. † Requires a cure system suited to oxidising service and close temperature control. A conditional rating always means an engineering review against manufacturer data for the actual concentration and temperature. ISO isophthalic · BPA bisphenol-A fumarate · VE epoxy vinyl ester, including FR and super grades · NVE novolac vinyl ester · CHL chlorendic.

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Special cases

Fluorides attack glass

Hydrofluoric acid, fluorosilicic acid and fluoride salts dissolve glass fibres. A standard glass veil gives fluoride a direct path into the structure. These services need a synthetic veil throughout the barrier, or a PP, HDPE, PVDF, ECTFE or FEP/PFA liner.

Strong alkalis

Caustic soda attacks both polyester resins and glass. Vinyl ester or bisphenol resin with a synthetic veil is the usual choice; PVDF is avoided for hot, concentrated caustic.

Oxidisers

Hypochlorite, chlorine dioxide and wet chlorine attack many resins, and the attack accelerates sharply with temperature. A suitable vinyl ester needs an oxidiser-resistant cure system and a fully cured inner surface. Many such duties are better lined in PVC, CPVC, PVDF or ECTFE.

Temperature and cycling

Chemical resistance falls as temperature rises, often steeply. Design to the worst credible temperature, including upsets and hot cleaning, and prefer tough resins where the equipment cycles.

Abrasion

For slurries and particulate-laden gas, resin choice alone is not enough. An abrasion-resistant barrier filled with silicon carbide or ceramic, a thicker barrier and lower velocities are specified.

Fire retardance and purity

Where fire performance is required, Vinyl ester FR is used, usually with a synergist. For high-purity and ultrapure water service, fully cured vinyl ester, PP or PVDF limits leaching into the product.

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Cure and verification

A correctly selected resin only performs as its data sheet promises if it is fully cured. Our quality plan for corrosion-resistant laminates includes:

CHECK	METHOD	PURPOSE
Hardness	Barcol hardness, ASTM D2583	Confirms the degree of cure of the inner surface and the laminate against the resin manufacturer's values
Surface cure	Acetone sensitivity test	Detects a tacky, under-cured inner surface
Glass content	Resin burn-off, ASTM D2584	Verifies the laminate matches the design schedule

CHECK	METHOD	PURPOSE
Thickness	Ultrasonic or physical measurement	Confirms barrier and structural thickness
Liner integrity	High-voltage spark test of welds and sheet	Finds pinholes before the FRP is applied
Weld quality	Destructive and non-destructive weld tests	Verifies thermoplastic seam strength
Post-cure	Controlled elevated-temperature cure, where specified	Develops full chemical resistance for demanding service

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Our selection procedure

1. **List every chemical** the wetted surface will meet: main component, every trace component, and every cleaning or neutralising chemical.
2. **Define the temperature envelope**: normal, maximum, upset and cleaning temperatures.
3. **Define the concentration range** from weakest to strongest, including any concentration step during filling or dosing.
4. **Identify the mechanism of attack** using section 03, and screen candidate resins and liners with section 06.
5. **Confirm against manufacturer data** for the shortlisted resin or liner at the actual concentration and temperature.
6. **Assess the mechanical duty**: pressure, vacuum, cycling, vibration, thermal shock, abrasion and outdoor exposure.
7. **Specify the construction**: resin grade, veil type, barrier thickness, liner and its thickness, cure system and post-cure, and the verification tests.

> **To get a recommendation from us, send:** the chemical and its concentration range, the normal and maximum temperatures, any trace components and cleaning chemicals, whether the equipment is atmospherically vented, under pressure or subject to vacuum, and whether it stands indoors or outdoors. We will reply with the recommended resin or liner and the reasoning in writing.

This guide provides general technical guidance only and does not constitute a design or warranty for any specific application. Chemical resistance is affected by concentration, temperature, impurities, operating cycles and fabrication quality. Final material selection for any Bhavi Plast equipment is made by our engineering team against the full design basis and the manufacturer's data for the materials used. © Bhavi Plast Pvt Ltd. 603 Dev Corpora, Cadbury Junction, Khopat, Thane (W) 400 601, Maharashtra, India.