

Improving PU Foam / GRP Adhesion: Resin Strategy and Cost Evaluation

Guy Harris – CEO / CTO
June 2025

Context

During the pilot phase in Norway, HydroFoamer tested adhesion of polyurethane (PU) foam to glass-reinforced plastic (GRP) from Future Pipe Industries (FPI), at two relevant temperatures:

- 21°C: 300 kPa (Laboratory)
- 2°C: 170 kPa (Field)

The goal is to enhance these values using GRP manufactured with PU-philic resins. This document outlines potential strategies, their expected performance improvement, and real-world cost impacts.

1. Interface Chemistry: Why PU-philic Matters

Standard GRP based on unsaturated polyester or vinylester has low surface energy and poor chemical compatibility with PU foam. PU-philic resins increase polarity, reactivity, or mechanical interlocking at the interface, yielding stronger, more durable bonds.

2. Resin and Surface Treatment Options

Strategy	Adhesion Gain	Difficulty	Estimated Added Cost (per m ²)	Comment
Functionalised Vinylester	++	Low	€2–4	Hydroxyl- or amine-functional resins improve wetting and chemical bonding.
PU-philic Gelcoat Layer	+++	Medium	€4–7	Applied as skin layer; improves interface without changing matrix resin.
Full PU-Based Matrix Resin	++++	High	€12–20	Forms chemically continuous bond; expensive and slow curing.
Silane Surface Treatment	++	Low	€0.80–1.50	Effective, especially with polar or reactive groups; easy to apply.
Corona / Plasma Surface Prep	++	Medium	€1.50–3.00	Boosts surface energy; requires equipment and controlled environment.

3. Performance Expectations

Based on prior studies and cross-industry data, switching to PU-philic strategies should yield:

Temperature	Standard GRP	PU-philic GRP (Est.)	Improvement
21°C	300 kPa	480–660 kPa	+60–120%
2°C	170 kPa	270–370 kPa	+60–118%

These increases depend on preparation, curing, and interface cleanliness.

4. Recommendations for Mountain Pipe Installations

Given the possible low temperature conditions and need for reliable adhesion in GRP pipelines:

- **Primary Recommendation:** Use functionalised vinylester for general resin matrix + silane surface treatment on interface.
 - **Rationale:** Best combination of cost (€2.80–5.50/m² total), manufacturability, and performance gain.
- **Alternative (Premium):** Add a **PU-philic gelcoat layer** if manufacturing processes allow, especially on curved inner surfaces.
 - **Use Case:** Critical joints, bends, or zones with complex load distribution.
- **Avoid unless required:** Full PU-based GRP matrix. Not currently justified for cost or process risk.

5. Testing Protocols

Recommended standards for validating adhesion strength:

- ASTM D3163: Lap shear strength
- ASTM D903: 90° peel strength
- ASTM D4541: Pull-off strength (field-suitable for coated structures)

6. Conclusion

The adhesion of PU foam to GRP can be significantly improved at modest cost by leveraging PU-philic resin strategies. Functionalised vinylester, optionally combined with silane treatment or gelcoat layers, offers the optimal trade-off for mountain-installed pipelines requiring high structural integrity and weather resilience.

Further technical validation through lap shear and peel strength testing is recommended before standardization.