Gluing plastic with G/flex®

By Tom Pawlak and Jeff Wright

G/flex news

G/flex has been out for a year now and enthusiasm continues to run high within our company and in the field because of the unique properties that G/flex offers. In this issue of *Epoxyworks* we are focusing on the ability of G/flex to bond to plastic and techniques that take advantage of this ability. No doubt articles on the benefits and many uses of G/flex will be a regular feature of future issues of *Epoxyworks*.

One of our goals for G/flex was an ability to bond to a variety of plastics. This was an ambitious goal because plastics historically have been used as mold release surfaces for epoxy, allowing it to release from the plastic when cured. While developing G/flex, we tested adhesion to a number of plastics with a variety of surface prep methods. We discovered that some plastics need only be abraded for good adhesion to take place. Other plastics required additional surface prep involving a flame treatment to form dependable bonds. We discovered that a few plastics, like polypropylene and acrylic and their molecular cousins, are difficult to glue reliably no matter how we prepared the surfaces.

Adhesion testing

Adhesion with G/flex to properly prepared plastics (other than polypropylene and acrylic) varies from about 1,700 to 3,300 psi, depending on the plastic and the surface prep used. We tested these bonds with the Pneumatic Tensile Test Instrument (PATTI).

Plastic	Surface Prep	Tensile Adhesion (psi)
ABS	Sand w/ 80-grit	1,854
	Sand w/ 80-grit + Flame treat	1,813
	Alcohol wipe + Flame treat	3,288
PVC	Sand w/ 80-grit	1,780
	Sand w/ 80-grit + Flame treat	1,813
	Alcohol wipe + Flame treat	2,081
Polyethylene	Sand w/ 80-grit	400
	Sand w/ 80-grit + Flame treat	1,890
	Alcohol wipe + Flame treat	2,312
Polycarbonate	Sand w/ 80-grit	1,870

Figure 1—Effectiveness of different surface preparation techniques on the adhesion of G/flex 655 Epoxy to various plastics

The chart above shows average adhesion achieved by G/flex 655 Epoxy to various plastics with different surface prep. In many cases the adhesion is not enough to exceed the strength of the plastic, but it is considerably better than bonds between plastic and other epoxy formulations. The chart also shows the advantage of flame treating (especially in the case of polyethylene) and the advantage of alcohol wiping over sanding before flame treating.

Joint design

It takes more than good adhesion to make a successful repair. We all know how well epoxy bonds to plywood, but it is common practice to use a scarf joint or butt block instead of a straight butt joint. Plastic joints should be treated much like plywood joints.

Our 002-550 *Fiberglass Boat Repair and Maintenance Manual* discusses the importance of grinding the proper bevel when repairing a hole or major crack in a fiberglass skin. The shallow bevel angle reduces the stress concentration between the repair and the original surface, and increases the amount of surface area for adhesion. Reducing the stress concentration often helps minimize the chance of a peel failure, which is a common way adhesives can fail on plastic surfaces. Testing has demonstrated that the same technique improves bonding strength in plastic panels and reduces the chance of a repair failing in peel.

Bevel and Round the Edges

To repair ⅛" to ¼" plastic, we recommend increasing the surface area along the joint by beveling and rounding the edges to be glued. This strategy is effective for repairing cracks

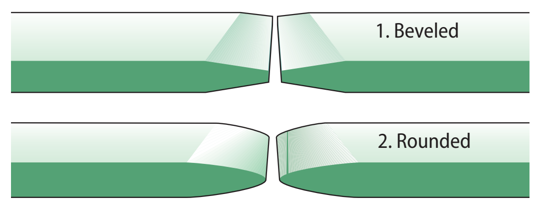

Figure 2—Above, beveling and rounding the edges of the joint increases the bonded surface area and reduces concentration of stress on the joint.

Figure 3—Below, this joint style in an edge-glued, ⅛" thick HDPE strip holds tight when deflected.

and splits in plastic canoes and kayaks. To test G/flex® for this type repair, we simulated splits in the bottom of a thermal formed plastic hull by edge gluing 1/8" thick high-density polyethylene (HDPE) sheets.

By beveling and rounding the edges of the joint with a sharp object, sanding, and flame treating the surface with a propane torch, we effectively glued this plastic together. Figure 3 shows plastic being tested under deflection after repair. The article "Repairing a Royalex™ canoe with G/flex Epoxy" featured in this issue used this same joint style.

Consider Stiffness

The thickness of a material has an exponential effect on stiffness. When repairing small plastic boats, the relatively thin hull helps reduce the stress in the repair because the entire bottom or side will often deflect a significant amount under a small load. Although the plastic hull shell has deflected significantly, the overall stress in the material is low.

A thicker, and stiffer panel can generate much higher stresses as it deflects and put more stress on the edges of the glue joint. Repairing stiffer (thicker) plastic parts requires more attention to the possible cleavage and peeling loads.

Use Fillets

Bonding surface area can be optimized with the use of fillets. Fillets are used to increase the surface area of the joint and reduce the stress concentration. The reduced stress concentration can help deal with off axis loads which can cause the joint to cleave apart. We recently performed a tensile test on polyethylene butt joints by pulling apart samples with and without fillets *(photos right)*. The samples that used fillets required almost 100% more force to pull apart.

Reaching our goal

Our formulating efforts were successful. We had an epoxy that would bond to plastics and we had a strategy for making plastic boat repairs.

As word of G/flex spread, we received lots of calls from canoe and kayak liveries. They had damaged boats made of molded plastic that needed to be repaired quickly because their season was about to begin. The damage ranged from normal wear and tear on the bottoms near the bow and stern, to cracks and splits that appeared randomly on the hulls.

Figure 5—Making a fillet on the test sample billet of polyethylene. Fillets are used to increase the surface area of the joint.

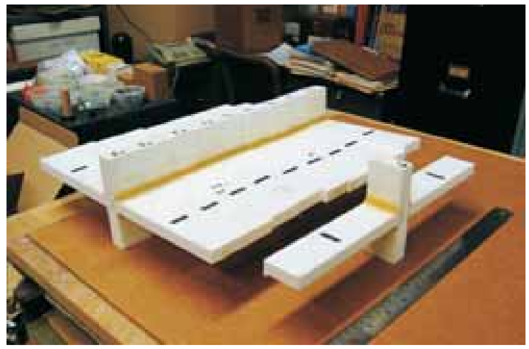

Figure 6—The billet cut into individual, consistently prepared test samples.

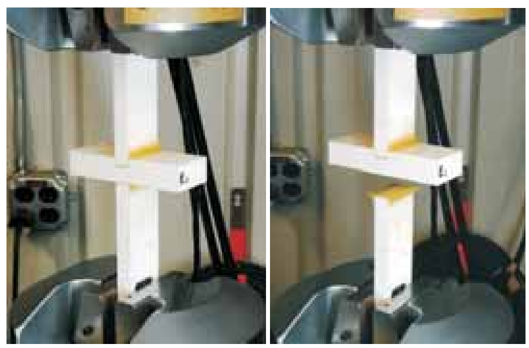

Figure 8—A test sample with a filleted butt joint in the test fixture, before and after failure.

The G/flex Epoxy kits we send them come with an instructional brochure that explains a variety of repair techniques including plastic canoe and kayak repairs and the technique for flame treating *(below)*. The following article demonstrates the effectiveness of those repair techniques on a severely cracked canoe made of ABS plastic. ■

To flame treat a plastic surface, hold a propane torch so the flame just touches the surface and move it across the surface at a rate of 12 or 16 inches per second. Keep the torch moving and overlap the previous pass slightly. When done correctly, the surface will not discolor or burn in any obvious way. This technique oxidizes the surface and improves adhesion. For best adhesion, bond to the surface within 30 minutes of treatment.