Tips for solvent cementing acrylic sheet

by Grant LaFontaine

Acrylic sheet can be easily joined to itself or other plastic surfaces with commercially available solvent cements. The proper cementing of acrylic sheet is a vital step in creating attractive, high-quality displays that exhibit strong, unblemished joints. The following information is given as advice on how to achieve these joints.

Equipment and materials

All cements should be used only in well-ventilated areas with the proper protective equipment as recommended by the manufacturer. Before using any solvent or cement, review the manufacturer's Material Safety Data Sheet (MSDS) for that particular product. Viscous cement can be used on hard-to-reach joints or for parts that do not fit together precisely.

Additional items likely needed for proper cementing include a solvent cement applicator such as a needle-nose plastic container (used in capillary cementing), pins or wire brads, and a dip or soak pan (used in dip or soak cementing). Forms, clamps and weights may also be needed.

General procedures

Follow these basic precautions when working with acrylic solvents: work in a well-ventilated area and do not smoke. Some solvents are highly volatile and may be flammable. Always protect skin from contact with solvent cements.

The ideal temperature for cementing acrylic sheet is between 70° and 75°F. Do not attempt to cement in room temperatures under 60°F or over 100°F. Be sure to follow manufacturer's safety recommendation for equipment and materials used with acrylic sheet.

Preparation

Always prepare the area to be cemented. Edges must be cleanly cut and properly machined. Melted or chipped edges could be the result of using a dull blade during a saw cut. Contact between a chipped or melted edge and the solvent cement may cause crazing (the appearance of tiny cracks in the part). Finish all rough edges with a jointer, shaper or edge finisher. If finishing on these machines is not possible, ensure you have a clean smooth saw-cut edge free of chips and melt. Saw-cut edges can produce acceptable results, although machining marks will sometimes be visible.

Do not polish edges that are to be cemented. Polishing produces a convex edge with rounded corners and results in an unsightly, weak joint. Flame-polished edges will usually craze when contacted with solvent cement.

Crazing can also occur if internal stresses from fabrication are high. To eliminate such stresses, anneal the piece at 180°F (80°C). When annealing, the heating and cooling time, in hours, should each equal the material thickness in millimeters, up to 6mm. For example, a 3mm thick sheet (.118-inches) would be heated for three hours, then cooled gradually for an additional three hours.

For thin sheet, heating time should be at least two hours. It is not necessary to heat any piece for more than six hours. Note that each hour of heating time requires a corresponding hour of cooling time.

Capillary cementing

Capillary cementing, the most popular form of joining acrylic sheet, works because of the ability of a low-viscosity, solvent-type cement to flow into a joint gap by capillary action. Properly done, capillary cementing yields a strong, transparent joint.

Be certain all parts fit together properly. Then use masking tape or a supporting jig to hold them firmly in place.

When solvent cementing acrylic sheet, keep the joint in a horizontal plane. Solvent cement flow can be improved by spacing the two edges with shims. This is usually only necessary with very large pieces. Use .004-inch shims with sheet 1/4-inch or thinner and .008-inch shims with sheet thicker than 1/4-inch. Insert shims every two feet for long edges.

Let the cement soak into the edges 45 to 60 seconds, for sheet thicknesses less than 0.236-inches, before removing the shims. Thicker sheet requires less time. Apply a small amount of pressure, 0.7 to 1.4 lb./sq. in. (50 to 100 gr./sq. cm.), for three minutes until the joint is set. Apply pressure carefully, as the joint area will be soft.

If the cement doesn't flow completely into the joint, tilt the vertical piece very slightly, about 1°, toward the outside. This should allow the solvent to flow freely into the entire joint and tilt the piece back again for a square corner.

The initial bond forms in five to 10 seconds. Wait three hours before subsequent processing. High strength is reached within 24 to 48 hours. Strength of the joint will continue to build over several weeks.

Dip or soak cementing

Pour a moderate amount of solvent cement into a dip or soak pan. Dip the edge of one of the pieces to be joined into the solvent. Only dip the edge. Exposing too much area to the solvent will result in a weak, slow-setting joint.

Thin sheet should remain in the solvent for 20 seconds. Relatively thicker material should remain for 30 seconds. The time varies for different solvents and bond strength requirements.

ACRYLITE® AR OP-2 acrylic sheet from CYRO Industries was cemented for this museum display from the National Archives' "American Originals" exhibit, currently touring the United States.

Remove and hold the sheet at a slight angle to allow excess solvent to drain off. Carefully and quickly place the soaked edge, precisely in place, on the part to be joined. Hold together for 30 seconds without applying pressure. This allows the solvent to work on the surface of the piece that was not dipped.

After 30 seconds, apply slight pressure to squeeze out air bubbles. Too much pressure will squeeze out the cement.

When the pieces are joined, place in a jig or clamp to maintain firm contact for 10 to 30 minutes. Do not allow the parts to move during this critical time.

The initial bond forms in five to 10 seconds. Subsequent processing can be carried out after three hours. A high strength bond is achieved in 24 to 48 hours, with additional strength continuing to build for several weeks.

Viscous cementing

For inaccessible joints or edges that do not fit together well, use viscous cement to join parts that cannot be easily cemented by capillary or soak solvent methods. Viscous cement is thick and will fill small gaps to make strong, transparent joints where solvent cements cannot.

Remove the masking around the joint area. Carefully apply a bead of cement to one side of the joint using a brush, spatula or cement applicator. Gently join the pieces together as in soak cementing.

Viscous cements are commercially available or can be made by dissolving chips of clear acrylic sheet in a small amount of solvent. Let solution stand overnight in a tightly covered container.

Solvent-resistant tape, such as #685 Specialty Tape from the 3M Company, may be applied to protect the area around the joint. Remove it carefully after five minutes while the cement is still wet. Do not touch the parts during the critical first three minutes or the joint will not hold. The part can be moved, carefully, after 10 minutes.

SOLVENT CEMENTING TROUBLE-SHOOTING GUIDE

Problem	Cause	Solution
Bubbles in joint	Uneven surface	Ensure edges are smooth and free of machining marks. Check joint preparation for squareness. Use shims to provide an even gap. Use viscous cement.
Crazing	Stresses in material	Ensure edges are free of chips or melting. Anneal areas near line bends. Allow cement joints to cure for at least 24 hours prior to flame polishing. Use water when sanding edges. Use proper ventilation when cementing to eliminate trapped vapors.
Hazy, white cement joints	Water in the cement Fast evaporation of cement	Replace cement. Reduce evaporation rate by adding glacial acetic acid (1 to 3 percent).
Weak joints	Uneven surface Cement problem	Check edge preparation for squareness. Use viscous cement. Check cement storage methods. Solvent evaporation can change cement properties.
Whitening of joints over time	Mechanical stress on the parts being joined caused by "forcing" them to fit into place.	Ensure edges are square and gaps between pieces are even (use shims and weights, if necessary). Do not force fit pieces.

■ POLYMERIZABLE CEMENT

The following information is given regarding the use of chemically reactive, two-part polymerizable cements, such as Weld-On® 40 by IPS Corporation of Compton, CA, or PS-18 and PS-30 by Caseway Industrial Products, Inc., Fort Myers, FL.

Two component adhesives

Polymerizing adhesives are polymers dissolved in monomers, which cure when a hardener is added. The cure is brought about by a chemical reaction.

Polymerizing adhesives fill better, imposing fewer demands on the fit and accuracy of parts. These adhesives must be used when strength and resistance to environmental conditions are required. Other two-component adhesives like epoxy resins, isocyanates (polyurethane), phenolics and aminoplastics are not suitable for bonding acrylic sheet to itself or other materials because the adhesion is very low.

Equipment and materials

A flat working surface is needed. Cover work area with glass or polyester film. Strong ventilation or vapor removal is necessary, as solvent vapors are heavier than air. The easiest method for applying two-part polymerizable cement is to utilize a cement dispensing gun. These devices automatically mix both cement components, from replaceable cartridges, and permit relatively easy application through an applicator tip. If a dispensing gun is not used, then a weigh scale, mixing containers, a vacuum and applicators are necessary. The weighing scale should have an accuracy of one gram for weighing out the adhesive. Use round beakers made of glass, polyethylene or other materials that are insoluble as a mixing vessel. Glass or polyethylene rods should be used for stirring small amounts.

The vacuum chamber is a small metal, glass or plastic chamber that can hold a beaker of the adhesive under a vacuum pressure of –11 to –12 psi. A vacuum pump, capable of evacuating the vacuum chamber to a vacuum pressure of –11 to –12 psi, is also needed. Disposable syringes for applying the adhesives are required as well.

Jigs and fixtures are used repeatedly as gluing aids in mass production. Parts can be held with clips, clamps, lead weights or vacuum. Sealing of the joints to contain cement can be achieved by using #685 Specialty Tape from the 3M Company. ▶

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Area bonds

Area bonds may be produced either horizontally or vertically. Thin sheets and thick blocks can be bonded horizontally. Blocks can be bonded vertically.

For horizontal bonding, the degassed cement (bubble-free) is poured on the panel approximately one-third the distance from the edge of the part (Figure 1.). The adhesive may be held in at the base with adhesive polyester tape. Any bubbles formed while the adhesive is poured should be removed. Starting from one edge, the top plate is placed in such a way that the adhesive moves evenly between the plates.

With thin sheets, the relatively high viscosity of the adhesive is sufficient to prevent the cement from being squeezed out from the area being bonded by the weight of the cover.

Thick blocks should be separated approximately 0.050-inches from the base by suitable spacers (polyethylene cords).

If bubbles form while the cement is applied, suck them out with fine capillaries while the adhesive is still soft. Bubbles can also be extracted by pricking them with a fine steel wire and then pulling them out at high speed. This technique is most suitable when bonding large areas.

With vertical bonding, space the sheet or blocks with a soft elastic cord so as to create a chamber at the top. The prepared adhesive is then poured into the chamber.

The minimum thickness of the chamber is .060 to .080-in. This allows the cement to flow without causing bubbles.

Vertical bonding has several advantages. An adhesive with bubbles can still be poured because the bubbles will rise to the top. Since the adhesive area is thicker, block with variations in thickness can be bonded. Difficulty in placing the top plate (the horizontal method) is eliminated, and adjoining surfaces may be covered with adhesive polyester film. As the cement sets (still soft), the film can be removed with any remaining cement.

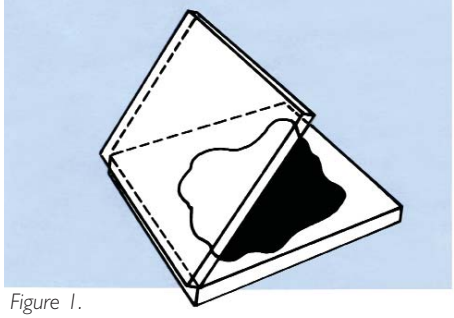

Figure 1. For horizontal bonding, the degassed cement (bubble-free) is poured on the panel approximately one-third the distance from the edge of the part.

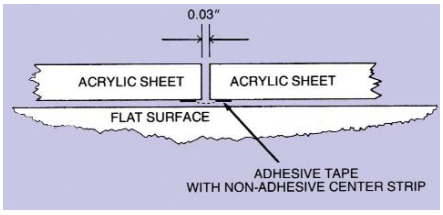

Figure 2. To create butt joints, fix panels to a flat support. Leave gap of at least .030-inches between the panels. Seal the underside and face of the gap using strip adhesive tape with a non-adhesive center strip.

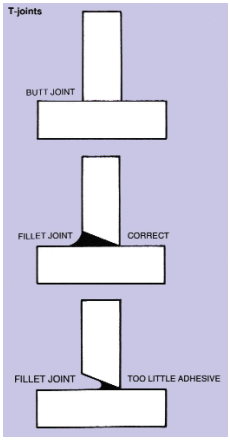

Figure 3. In order to produce a strong, attractive t-joint, the bottom sheet should extend slightly past the edge of the vertical piece to support a full bead of adhesive. After curing, the excess can be machined off and the joint sanded and buffed.

Butt joints

To create butt joints, fix panels to a flat support. Leave gap of at least .030-inches between the panels. Seal the underside and face of the gap using strip adhesive tape with a non-adhesive center strip (Figure 2.). Using a syringe, introduce the two-part cement on the one open side of this joint. Avoid bubbles.

The shape of the bonding gap depends primarily on the thickness of the panels that will be butt jointed. V-butt joints with a 60° aperture angle provide the highest tensile strength, but aperture angles of this size are only practical when the sheets are thin. For thicker sheet, smaller angles are recommended.

The shrinkage of the adhesive during polymerization and heat conditioning is about 15 to 20 percent by volume. To prevent a concave surface, the gap should be sufficiently overfilled with adhesive.

T-joints

Bonding must be done in suitable jigs to ensure that the bonding materials are fixed during bonding and the cure.

When creating T-joints, spacing the bonding gap uniformly is difficult, especially when the adhesive joints of thin materials are long. In addition, there is an adhesive bead on either side of the joint. Solvent cements are better for bonding thin sheets with a blunt edge. A beveled edge is generally useful for two-part polymerizable adhesives because it allows one sheet's edge to be placed directly on top of the other sheet's surface.

In order to produce a strong, attractive joint, the bottom sheet should extend slightly past the edge of the vertical piece to support a full bead of adhesive. After curing, the excess can be machined off and the joint sanded and buffed (Figure 3.).

Finishing the adhesive joint

A bonded part should be heat conditioned (annealed) before finishing the adhesive joint. If not, it could form constrictions when it is later heat conditioned. These constrictions will impair the bond strength. Excess hardened cement or protruding edges can be effectively removed using a stationary router equipped with a carbide tipped bearing flush trim bit.

The finished surfaces can be sanded with fine, wet, abrasive paper or fine steel wool, then polished, to produce higher optical quality bonds.

The amount of adhesive used in the joint should be controlled so that only a little of it projects from the joint after heat conditioning. This helps keep finishing work to a minimum. ■

NOTE: Acrylic sheet is a combustible thermoplastic. Precautions should be taken to protect this material from flames and high heat sources. The information and statements contained herein are not to be taken as warranty or representation for which CYRO Industries assumes legal responsibility nor as permission, inducement or recommendation to practice any patented invention without a license. Users should undertake sufficient verification and testing to determine the suitability for their own particular purpose or application. Be sure to follow the manufacturer's safety recommendations for equipment and materials used with acrylic sheet.

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