

High-Strength Adhesives are Replacing Mechanical Fasteners for Durable, Low-Cost Bonds



Liquid adhesives are replacing mechanical fasteners where high strength and structural integrity are requirements.

With advances in structural adhesive formulations, designers in every industry have many new options for bonding metals, composites, plastics, rubbers, glass, and more where structural integrity and high strength are requirements. Epoxy, acrylic, and urethane liquid adhesives and flexible thin bonding products (like the tape that holds the scuff strips to wing flaps) are replacing mechanical fasteners — rivets, screws, nuts, and bolts, and welding and fusion fastening in transportation, aerospace, electronics, appliance, industrial equipment, architectural, and other applications.

Beyond their high-strength bonding capabilities, structural adhesives offer many performance, production, and styling benefits that can lower overall costs while increasing the value, durability, and desirability of products and applications.

Structural adhesives have a number of advantages.

Compared to rigid fastening techniques, adhesives:

- **Distribute stress across the entire bonded joint** — Adhesives provide stress relief in structural joints compared to fasteners and spot welding. As a result, a designer can specify thinner, lighter materials while meeting strength requirements. Because fastener holes are not needed, structural integrity is maintained and failure-prone stress points are eliminated.
- **Maximize flexibility and fatigue resistance** — Adhesives remain flexible throughout their life creating bonded joints that are up to 20 times more resistant to fatigue than riveted or welded assemblies. Adhesives accommodate different coefficients of expansion between dissimilar substrates to maintain strong bonds during extreme temperature swings, and absorb flexural, vibration, and impact stresses.
- **Bond and seal joints against corrosion** — Continuous contact between mating surfaces keeps contaminants out and resists the effects of harsh environments. Adhesives' strong film barrier prevents galvanic corrosion between dissimilar metals.
- **Provide invisible fastening** — Adhesives allow cleaner styling by eliminating protruding fasteners or joint puckering caused by spot or fusion welding. Assemblies require less machining or finishing to achieve a desired aesthetic appeal.

Bonding, Joining
& Sealing

- **Reduce the weight of fastening material** — The average car is now about 130 lb lighter because adhesives have replaced many mechanical fasteners. In applications such as transportation, aerospace, personal electronics, and some medical equipment, lighter weight is a crucial design concern and cost factor.
- **Increased productivity and reduced costs** — With liquid adhesives, and particularly thin bonding systems, assembly is simpler, quicker, and requires less training, which lowers overall production time and cost.

High-Strength Bonding Adhesives

Three adhesive families generally are considered for structural bonding applications: epoxies, acrylics, and urethanes. While each has excellent properties the best choice can only be made in light of the substrates to be bonded, their operating environment, and production considerations. An allied decision is whether to use liquid adhesives or thin bonding systems, such as PSA tapes or adhesive transfer tapes for a given application. Many times, either method is appropriate. However, usually one method is a better fit to the production process. For example, in situations where immediate handling strength is needed, thin bonding systems offer an advantage. In other cases where the user needs time to position their parts, liquid adhesives are a better solution. At the end of the day, there are multiple ways to create a solution that best fits your process requirements.



Liquid adhesives offer an alternative to mechanical or fusion fastening.

When the user needs time to position parts, liquid adhesives provide a superior solution.

Table 1: Typical Properties of Adhesives

	Methyl Methacrylate	UV Acrylics	Epoxies	Elastomerics	Anaerobic	Cyanoacrylates
Fixture Time	Minutes	Seconds	Minutes to Hours	Hours	Minutes	Seconds
Components	1 or 2	1	1 or 2	1 or 2	1	1
Shear Strength	High	Medium	High	Low	Low	Medium/High
Temperature Resistance (°F)	-65° — 300°	-65° — 300°	-20° — 500°	-40° — 600°	-65° — 300°	Up to 180°
Advantage	High Impact Resistance	Fast Cure	Formulation Versatility	Best Temperature Resistance	Chemical Resistance	Fastest Fixture Time
Disadvantage	Strong Odor	Light Must Reach Adhesive	Long Cure Time	Low Strength	Needs Metal Substrates	Poor High Temperature Resistance

Epoxies

Epoxy resin combines high strength and elevated temperature resistance. Epoxy pastes are available in one-part, heat-curing, and two-part, room-temperature curing formulations. Heat-curing epoxies provide higher shear strength (about 5,000 psi at room temperature) and better high-temperature performance than two-part epoxies. However, advances in two-part systems have begun to level the playing field, producing toughened epoxies with overlap shear strengths of 4,500 psi and excellent peel strength. The two-part systems don't need hot air ovens, UV lamps, or other heat sources, but may require fixtures to hold parts during curing, which can range from a few minutes to a couple of hours.

Epoxy film adhesives can be die-cut, making it easy to bond complex parts. With this approach, adhesive bond thickness is uniform across the joint and produces a better combination of shear and peel strength and resistance to shock and fatigue. However, epoxy film adhesives also require fixturing and heat curing.



Acrylics provide fast curing, high-strength bonds for a range of substrates without surface preparation.

Acrylics

Acrylic adhesives cure faster than epoxies or urethanes and create high-strength bonds with a wide range of substrates, including lightly oiled metals, usually without surface preparation. Maximum shear strength of about 4,200 psi and good peel strength can be achieved depending on the formulation and substrate. Acrylics are available with maximum temperature capabilities of 160°F to greater than 300°F, rivaling the performance of some epoxies.

Acrylics are available as one-part, anaerobic adhesives that cure in the absence of oxygen (long used in thread-locking compounds), one-part light-cure adhesives that set up in seconds to create high-strength bonds, and newer two-part formulations that have improved viscosity and handling characteristics and form strong, flexible bonds for long-term fatigue resistance and durability.

Cyanoacrylates are one-part, acrylic-based adhesives with very fast cure times of a few seconds (although formulations are available with extended cure rates). They bond many plastics, rubber, metal, and other materials producing tensile strengths up to 5,000 psi and are uniquely suited to joining certain problem materials — EPDM rubber gaskets to metal, for example. Others have good resistance to fuels and chemicals over a temperature range of -40°F to 250°F.

Flexible, pressure-sensitive acrylic foam tapes and adhesive transfer tapes offer unique application opportunities because of their high holding strength, excellent resistance to harsh environments, and prevention of bi-metallic corrosion. With fast and easy assembly that eliminates pre-treatment, drilling, screwing, riveting, welding, grinding, refinishing, and cleanup, acrylic tapes save time and money. Die cut peel-and-stick acrylic adhesives precisely fit any shape, size, or profile for quick assembly. Pressure-sensitive acrylic adhesives strongly bond parts instantly so fixtures and long cure times are avoided.

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Urethanes

Polyurethanes are one- and two-part adhesives that are tougher than epoxies because of their combination of strength and flexibility. They are used for bonding dissimilar materials because of their ability to handle expansion and contraction between bonded substrates. While overlap shear of 2,500 psi with good peel strength is obtained, strength decreases with elevated temperatures more rapidly than with epoxies and acrylics. Polyurethane formulations have maximum temperature capabilities from 160°F to 300°F. Applications include bonding large panels that may experience flexing from wind or vibration to repairing conveyor belts and cracked concrete.

High-Strength Applications

Designers are discovering a growing list of applications where adhesives compete effectively with conventional fasteners in terms of strength while offering significant advantages: weight reduction, sleeker styling, faster assembly, and lower overall production costs:

Transportation

Exterior metal panels for truck trailers, ambulances, RVs, and other vehicles are traditionally spot welded or riveted to structural steel or aluminum body supports. Welds may create a rough surface with poor visual appeal while fastener failures lead to rattling and panel flexing. Thin bonding acrylic foam tapes and structural adhesives/sealants are effective alternatives. These products are resilient, damping vibration that can shear weld points, pull out rivets, and initiate cracks. They have high peel strength and resistance to moisture, solvents, and UV light that make them useful for many exterior and interior vehicle applications.



Tapes are used worldwide instead of rivets, screws, or other mechanical fastening systems.

Architectural

Thin foam tapes, adhesive transfer tapes, and adhesives have revolutionized curtain wall design and application for structures ranging from air terminals to skyscrapers. Exterior curtain wall panels are stiffened against wind loads by adhering unseen stiffeners to their inner surfaces. These bonds resist wind loads, daily thermal expansion and contraction, elevated temperatures, and water penetration.

Tapes have been used worldwide instead of rivets, screws, or other mechanical fastening systems to attach aluminum, stainless steel, and composite panels to steel stiffeners. Panels have passed wind load structural tests corresponding to a sustained wind speed of 220 mph and hurricane impact and pressure cycling tests with a building design pressure up to 60 lb/ft².

Industrial

Adhesive tapes for bare or painted metal are increasingly used in metal fabrication instead of fasteners to produce strong and durable cabinets and equipment enclosures. The tape permanently attaches aluminum structural brackets, stiffeners, and channels and bonds metal skin panels to enclosure frames. A flexible, strong adhesive, unlike bolts, screws, or welds, produces no visible signs of stress in assembly components and eliminates the time and unsightly results of welding and drilling.

Medical Device

Many medical devices, including reusable surgical instruments like endoscopes and laproscopes, are assembled using a variety of biocompatible adhesives. These adhesives must be able to tolerate repeated sterilization cycles that may include steam autoclaving, chemical treatment, and radiation.

Thin bonding tape attaches stiffeners to exterior building skin panels to withstand loads, thermal expansion and contraction, and elevated temperatures.

Material Partners

Fabrico has strategic relationships with world-class materials suppliers, such as 3M and Loctite®, to assist its customers in selecting the best material for the intended use and to expedite materials sourcing. Whether adhesive films or liquids, all critical material properties are considered in any Fabrico project, including chemical, thermal, and moisture resistance.

With more than 30 years of materials experience, Fabrico engineers also understand the impact of a material selection on the overall manufacturing process, and design material systems that optimize production efficiency and improve overall cost-effectiveness.



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