Based on an original 3M publication.

The Benefits of Using a Structural Adhesive

Structural adhesives have excellent benefits when used in particular assembly operations needing tough, durable and permanent results instead of traditional mechanical fastening methods or other types of adhesives. They include epoxies (one and two part formulations); acrylics (two-part and two-step formulations); urethanes (two-part formulations); and cyanoacrylates (instant adhesives) with overlap shear strengths in excess of 1000 psi when bonding metal and testing at room temperature.

Structural adhesives –

- Cause no substrate damage (e.g., drill holes, heat distortion)
- Join materials without galvanic corrosion
- Suited for a number of different geometries
- Reduce localized stress points – increased fatigue resistance
- Eliminate refinishing steps; leave no protrusions (better aesthetics)

What makes them different?

With the many characteristics and applications available to you, what determines your decision? Because structural adhesives remain less predictable, processing decisions can affect overall structural adhesive performance.

Structural adhesives, when compared to other adhesives -

- highest load-bearing capability
- environment and chemical resistance
- generally, formulate to100% solids (produce no solvent emissions)
- offer different cure times and properties, temperature and solvent resistant properties (irreversible cure process)
- unlimited depth of cure unlike one-part silicone and polyurethane sealants.

How to choose a structural adhesive

Depending on your situation, you may want to tap a consultant or subject matter expert, however, no matter what--the structural adhesive performance should be validated by testing. When making your selections for testing consider -

End use conditions

- Temperature – hot or cold environment
- Humidity – rain, salt water exposure
- Ultra violet light – exposure to sunlight with possible UV penetration through substrates to adhesive

Chemical resistance needed

- Joint exposure to fluids (motor oil, gasoline, diesel fluid, jet fuel)
- Joint cleaning frequency (weak acids and bases)

- Bond exposure to specialized chemicals
- Continual or only occasional exposure, e.g., in a filtering assembly

Cleanliness and environmental considerations during production and end use -

- Sensitivity of bonded part to outgassing, ionics, corrosion (e.g., electronics, optics applications)
- Adhesive usage, i.e., toxicity levels, such as regulations pertinent to food packaging or medical devices

Mechanical challenges

- Impact and vibration exposure – will the bonded part be subject to high impact or vibrational forces in use?
- Stress type and magnitude – height and types of stresses on bondline

Know your adhesives

Acrylics - provide the highest bonding strength on plastics and may provide good bonds to metals and many oily metals. Commonly have lower vibration/impact resistance than epoxies, therefore lower fatigue resistance and performance at high temperatures.

Cyanoacrylates - provide good shear strength on many plastics and rubbers (primers may be required), rigid, show low peel and impact resistance.

Urethanes – very flexible, however lower strength in general. Good as plastic and rubber bonders and often lower priced than other categories of structural adhesives.

Epoxies - available in the widest range of properties and possess the best properties for use on metals. Includes standard 5-minute rigid epoxies commonly found in hardware stores and can be brittle. Use with applications with moderately low stress and where little impact can be expected.

Flexible epoxies, such as 3M™ Scotch-Weld™ Epoxy Adhesive 2216 have higher peel strengths resulting in better impact performance; a good choice for parts requiring some flex in end use.

Toughened epoxies, such as 3M™ Scotch-Weld™ Epoxy Adhesive DP420 and DP460 incorporate elastomeric regions - absorb impact and provide the highest shear, peel, impact, vibration and fatigue resistance. Good choices for very demanding end-use applications. Generally, epoxies require rigorous cleaning of oils from metal joint surfaces. Exceptions include most one-part heat cure epoxies and formulas like 3M™ Scotch-Weld™ Epoxy Adhesive DP920, which bond to most oily metals.

In general –

If wanting to bond ABS to stainless steel and the part will encounter only moderate environmental stress (e.g. -20°F to 150°F) and little vibration or impact, choose epoxies and acrylics.

If wanting to bond wood to plastic for outdoor use with expectations of significant movement of the substrate due to weather, consider urethanes for their flexibility. Use a flexible epoxy if higher strength is needed.

If bonding a low surface energy plastic (such as HDPE) to itself or to another plastic, consider a specialty acrylic like 3M™ Scotch-Weld™ Structural Plastic Adhesive DP8010.

Handling and processing considerations

Once adhesives have been identified that might meet your end use performance requirements, then consider handling, processing, storage conditions and shelf life.

One-part and two-part epoxies – pros and cons

The curative and base pre-mixed in one-part epoxies eliminates the need to measure and mix, however results in less shelf life (premature aging and cold temperature storage requirements) and requires high temperature curing (around 250°F to 350°F). Although they involve careful handling, dispensing is easy and one-part epoxies generally provide the highest shear strengths on metal and best high temperature and solvent resistance.

Cyanoacrylates offer production convenience, don't require mixing and have a lengthy pot life or open time prior to bonding. However, once bonding takes place, parts cannot be repositioned and they can be odorous and easily bond to skin. Cyanoacrylates also tend to bloom (volatilized monomer that recondenses on parts). Consider 3M™ ScotchWeld™ Low Odor Instant Adhesive LO5 and LO100 if needing low blooming characteristics.

Two-part epoxies, acrylics and urethanes require cure time once the parts have been mixed as well as time to create a bond, aka, set time fixture time, green strength or time to handling strength. Carefully study datasheets and determine the proper parameters for the adhesive. Like cyanoacrylates, these adhesives stabilize at room temperature prior to mixing. Room temperature storage is greatest for two-part epoxies and shortest for urethanes (moisture-sensitive) and acrylates (sometimes temperature-sensitive).

Temperature sensitivity

When considering a two-part adhesive, consider temperature sensitivity in determining cure time. They cure faster in warmer temperatures however have shorter pot lives, open times, and time to handling strengths. Curing occurs slower in cool weather, therefore if using the adhesives in uncontrolled environments, temperature differences need to be considered (i.e. environment vs. standard "room temperature" of 70°-75°F, generally used by manufacturers to report the pot life and time to handling strength). Roughly, when using adhesives outside on a hot day, the open time might be half of what shows on a datasheet. In cool weather cure times might double.

A simple guide would be to estimate that with every 10°C warmer cure environment the adhesive will have half the open time and in 10°C cooler environments, the open time will be doubled.

Adhesives will be *thinner in a warmer environment* (the same thing occurs when a person warms honey or maple syrup) and will *thicken in a cooler environment*. Recommendation for two-part adhesives application maximums - 60°F – 80°F; minimums around 40°F.

Heat can be used to accelerate cure time such as by using radiant heat sources. See datasheets for cure levels and special instructions.

Viscosity

The viscosity range is widest in the two-part epoxy and urethane categories and can range from very thin to heavy pastes. Non-sag adhesives may be created to be shear-thinning to allow them to dispense easier. however not run or sag after dispensing.

Summary

Take time when choosing adhesives. Making the right choice can make all the difference in outcomes. Formulas have complex properties and may act uncharacteristically under certain circumstances. Contact our adhesive experts to help you be as certain as possible. Be sure to test before using even after receiving suggestions.