

5 Structural Adhesives Myths Disproved

Myth #1: Structural Adhesives Don't Hold

Skepticism that structural adhesives can work in applications requiring strong and durable bonds is a common mistake in joint design. Engineers typically have more experience with traditional joining methods like welding, spot welding, screws and rivets. They often rely on these methods without ever considering the advantages of structural adhesives. Changing from a traditional joining method to a structural adhesive can be uncomfortable at first but understanding how structural adhesives work helps build confidence and could help identify performance and cost advantages.

Depending on your circumstance and specifications structural adhesives may outperform traditional joining methods in many applications. Adhesive bonds distribute loads throughout the bond line, eliminating stress concentrations at spot welds, screws or rivets (Figure 1) to improve the joint strength and durability of the part. Structural adhesives also have better aesthetics because they do not require refinishing steps or leave protrusions.

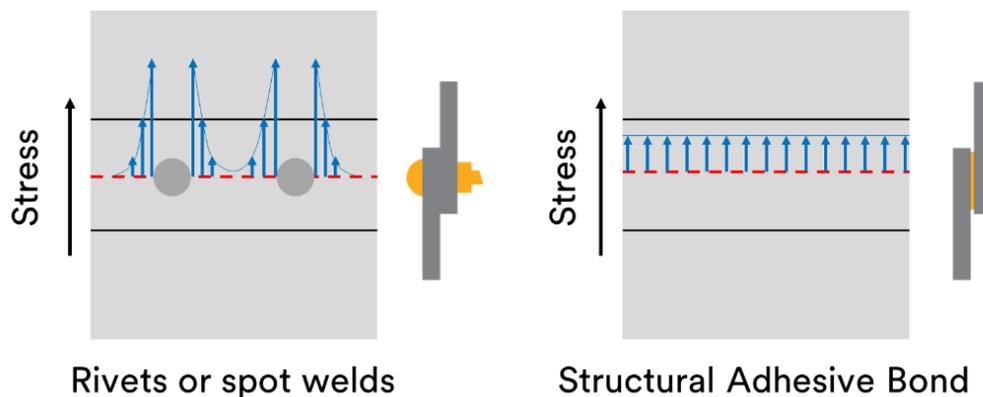


Figure 1. Stress distribution of rivets or spot welds (left) and structural adhesive bonds (right). The red dotted line is the midline of the overlap joint. The blue arrows represent how the stress is being distributed within the bondline. Stress concentrations are created by rivets or spot welds as seen by the ascending blue arrows.

[Structural adhesives](#) are similar in strength when compared to welds, and more than twice as strong as spot welds, bolts and rivets (Figure 2). As a result, structural adhesives are an ideal choice for even the most demanding applications. For example, structural adhesives have been used to bond high performance aerospace components and carbon fiber drive shafts. In one 3M test, a structural adhesive was strong enough to hold 14,550 lbs. suspended in the air over 18 hours ([watch video](#)) through a winter night in Minnesota.

Manufacturers often have the additional option of combining structural adhesives with traditional joining methods. For example, in the transportation industry structural adhesives are often combined with spot welds or rivets.

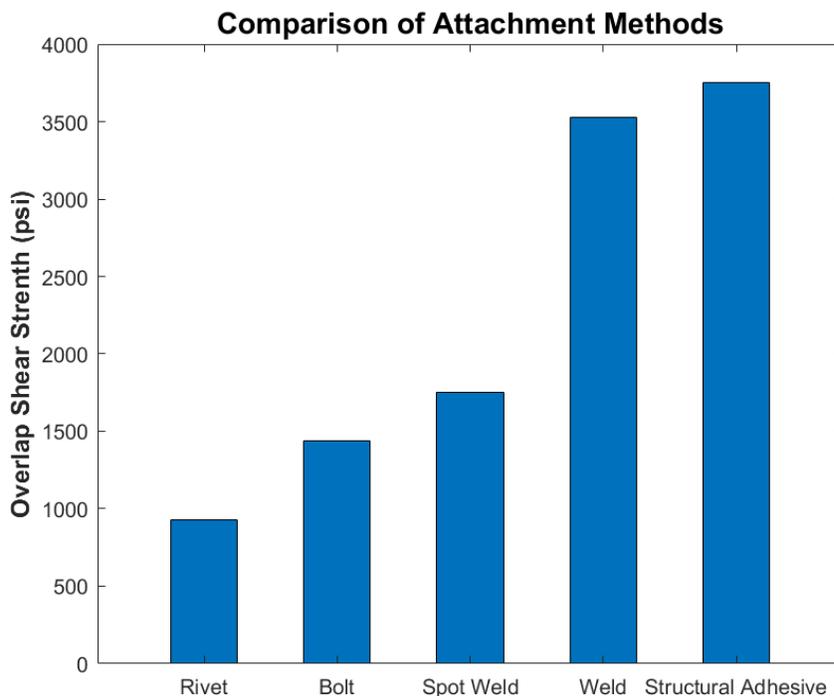


Figure 2. Overlap shear strength of different attachment methods.

Data was collected by 3M, <https://multimedia.3m.com/mws/media/6469940/3ms-tough-stuff-white-paper.pdf>,
<https://multimedia.3m.com/mws/media/10540520/acrylic-adhesives-recent-advancements-white-paper.pdf>

Materials that cannot be effectively joined by traditional methods can be bonded with structural adhesives. Structural adhesives have had a large role in lightweighting because they enable the bonding of thin gauge metals and composite materials. Structural adhesive bonding does not require drilling holes and they do not cause thermal distortions that damage thin gauge metals. Composite materials cannot be welded or effectively drilled into but can be joined by structural adhesives.

Structural adhesives are polymers and have different properties when compared to traditional joining methods. For example, structural adhesives can make flexible bonds, reducing stresses due to part movement and thermal expansion. This makes structural adhesives ideal for joining dissimilar materials including metals, plastics, composites and wood. Structural adhesives can also help to dissipate energy, making them ideal for vibration and impact resistance.

Myth #2: Holding Pieces Together is All That Matters

There's more to bonding and adhesion than just selecting the right product and applying it to your part. It is also a good idea to evaluate the whole process while also considering the operating conditions of the final part. 3M adhesive specialists use a comprehensive evaluation framework to help our customers assess their needs. The process starts by listening to design and materials engineers to understand the requirements of that particular structural adhesive application. Finding out more about each customer's unique process, current goals and challenges helps provide more holistic solutions for customer evaluation. The most common challenges fall into the following categories:

Production Challenges:

- Need to shorten overall cycle time
- Concerns of high scrap or rework rates
- High levels of work in process (WIP)
- Moving to a more automated process to address a shortage of skilled labor

Evaluating your entire production process can help identify process steps where changes could help an adhesive work and perform better. This can also lead to areas where you might reduce time or labor, like the time spent inserting mechanical fasteners or refinishing weld distortions. 3M adhesive specialists can help reduce scrap by testing adhesive alternatives to your substrates and suggesting products or modifying process steps. Rework can also be reduced by selecting adhesives with longer open times that enable repositionability. Production cycles can be shortened, while also reducing WIP, by utilizing fast-cure or heat-cure adhesives that reach handling strength more quickly and enable parts to be moved within the process faster. As engineers look to automate the dispense process, our specialists can offer ideas that could help reduce and reallocate labor by mapping out different automation options.

Labor Challenges:

- High turnover creates demand for standard operating procedures (SOPs) and optimizing processes for consistency
- Process training
- Worker fatigue and injuries

Labor is an important part of the production process and should also be evaluated. Replacing mechanical fasteners with structural adhesives may help reduce worker fatigue related to applying mechanical fasteners (screws, bolts, rivets). Reducing the number of welds in an assembly process can help reduce not only the specialized and expensive labor of welding itself, but also the grinding and refinishing required to make the weld aesthetically pleasing. 3M adhesive experts can help in this evaluation and recommend easy-to-use adhesives and tapes.

Design Challenges:

- Pressure to reduce cost or weight
- Need to create more streamlined designs by removing metal attachments
- Using new difficult-to-bond materials such as LSE plastics
- Assemblies that need to reduce noise and vibration or withstand harsh conditions
- Issues with bond line read-through that occur while using your current adhesive
- Changing or challenging conditions of final end-use of the assembly

Finally, reviewing an assembly and its expected environment helps engineers evaluate the process used to make it. Can a joint be redesigned for greater strength by changing the stress modes, or do you need to bond new materials such as composite substrates or low surface energy (LSE) plastics? 3M adhesive experts can help your design engineering teams evaluate these and other possibilities, including adhesive options that don't run or drip. There are also available product options that help eliminate bond line read-through or reduce noise and vibration. Challenging end-use conditions such as heat, cold, humidity or chemical environments can also be solved with the correct adhesive selection. A review of testing protocols and the ability to perform tests on specific substrates to determine whether a solution may be "over-engineered" is an important step in the overall selection process. 3M can provide on-site testing that will simulate the temperature, humidity and stress levels that a specific assembly will experience.

3M adhesives specialists have worked with and advised customers in nearly every industry, application and location – we can help evaluate and help you improve your unique assembly and application.

- [Watch](#) how 3M structural adhesives helped one customer reduce labor hours by 50%*
- [Watch](#) how 3M adhesives products helped one customer see 5x* faster assembly than competitors
- [Watch](#) how 3M structural adhesives helped one customer increase output from 35% to 98%*

* Results are specific to each unique customer process and adhesive application. Individual results may vary.

Myth #3: “I Tried One so I’ve Tried Them All”

After a failed attempt to use a structural adhesive for an application, the decision to trial another adhesive for either the same application or a different one can be difficult. This can be especially true if design engineers may have historically had success with more traditional methods of attachment (bolting, riveting, welding, etc.). Before giving up on structural adhesives, it is important to investigate why the previous option(s) failed to meet all expectations. Understanding how and why the previous structural adhesive application was unsuccessful can provide insight into attributes that are needed in subsequent adhesive selection.

An assembly created with structural adhesives can fail to meet expectations for several reasons. These reasons can be process-dependent, end use-dependent, or a combination of the two.

Process-dependent issues can include any of the following:

- Surface preparation: cleanliness, surface energy modification, etc.
- Dispensability: viscosity, sag behavior, etc.
- Curing times: open time, time to handling strength, time to full cure.

End-use-dependent topics can include any of the following:

- Mechanical properties: modulus, elongation, etc.
- Adhesion strength to chosen adherends in various stress modes: shear, tensile, impact, etc.
- Environmental resistance: temperature and humidity extremes, solvents or fluids, etc.

Once the failure analysis is complete and it is understood why the previous adhesive failed, it is important to investigate other adhesives that have the newly discovered and required attributes. 3M’s structural adhesive portfolio covers the breadth of differing chemistries and has the depth within each to tailor the attributes of the adhesive to match the needs of the application.

There are three main chemistry families within the 3M structural adhesives portfolio: acrylic-based, epoxy-based and polyurethane-based. Each of these chemistries have generalities that can be applied to adhesives within a specific family.

- Acrylic-based adhesives, for example, will typically cure and build strength at a much faster rate than epoxies or polyurethanes. This rate of strength build provides a convenience advantage when considering the process of creating a joint. The acrylic-

based chemistry can be split into three main sub-categories: methyl methacrylate (MMA), low odor and low surface energy bonders.

- Epoxy adhesives will typically have higher overall strength and superior environmental resistance that are great attributes to have when considering the performance in the end-use state. The epoxy-based chemistry can be split into three main sub-categories: rigid, flexible and toughened.
- Polyurethane-based products are useful when bonding composite-based materials where energy absorption is required. This chemistry class can be split into three main sub-categories: polyurethane reactive (PUR) hot melts, flexible and semi-rigid.

Figure 3 provides a comparison of the main chemistries and their sub-categories against six different product attributes. The product attributes contrast the processing characteristics (x-axis) against the physical characteristics (y-axis) of each structural adhesive family and ranks each attribute within that family as good (red circles), better (yellow circles), or best (green circles).

The processing characteristics are a set of attributes that make using and applying the adhesive more convenient from a production perspective. These attributes are shelf life (SL), rate of strength build (RoSB) and minimal surface preparation required (MSPR). Shelf life is important for understanding how long a product can remain viable at a production facility and how frequently the adhesive would need to be ordered. A longer shelf life associated with a product will be an advantage and score higher on the convenience scale (best). Rate of strength build describes how fast an adhesive will build strength after a bond has been made. Typically, the faster the adhesive can build bond strength the more quickly the resultant part can be moved to the next process step, reducing the work-in-progress (WIP) and increasing production throughput (best). Finally, the amount of surface preparation required for an adhesive to achieve optimal performance plays a vital role in the time associated with the assembly process. Certain adhesive families require extensive surface preparations or treatments (good) to obtain optimal adhesion and final joint performance whereas other adhesive families require very little preparation (best).

The physical characteristics are a set of attributes that provide an indication of how an adhesive will behave when stressed in different ways or exposed to different environmental conditions. These attributes are shear strength (SS), peel strength (PS) and environmental resistance (ER). For the purpose of this graphic, higher strengths and resistances will equate to the best overall performance and rating. The scores provided here are generalities of the product family and are meant to be directional in nature. With that said, adhesives will perform their best and provide the highest strengths when stressed in shear mode and on properly prepared adherends. Peel strengths are a good indicator and proxy for how much energy an adhesive can absorb before failure. Finally, the types of environmental conditions can range from short term (seconds-minutes-hours) to long-term (days-weeks-months) temperature, humidity or solvent/fluid exposures. Higher ER ratings indicate the best chance of surviving the exposure while retaining the original strength of the joint.

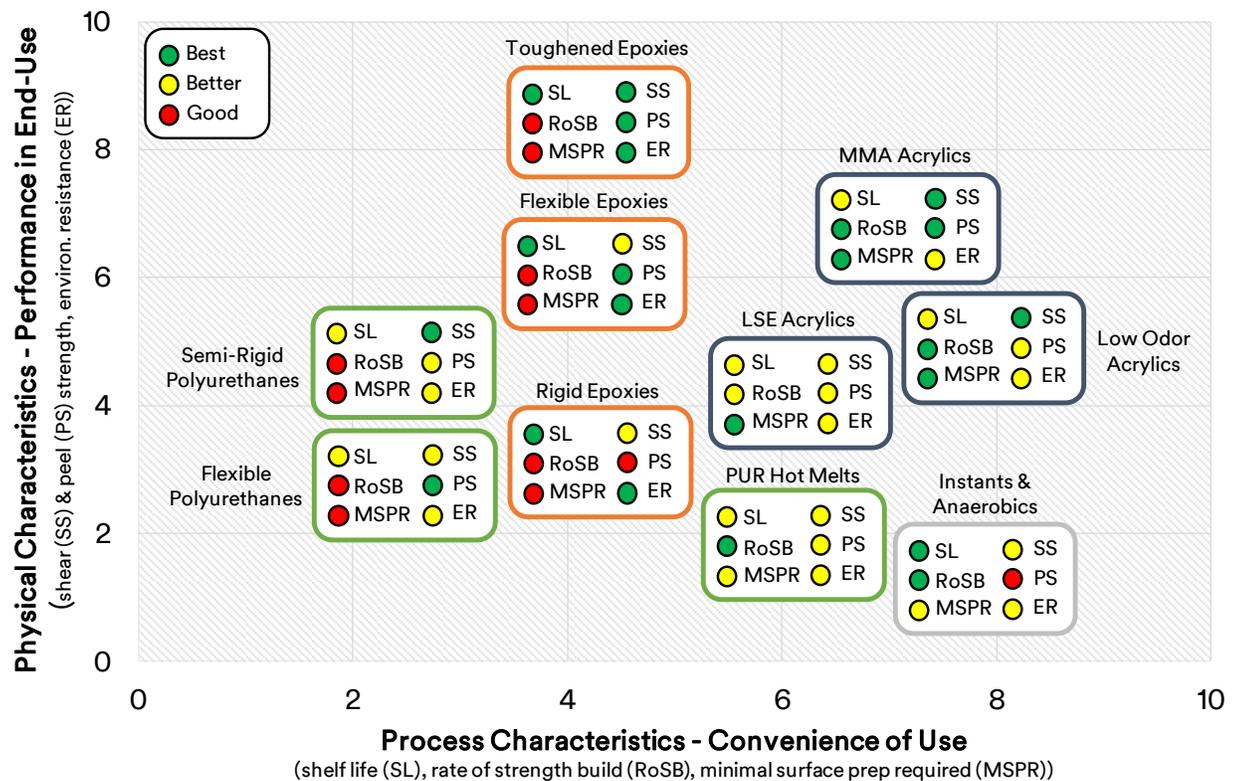


Figure 3. A schematic of the main types of structural adhesives and how they directionally compare to each other when considering both process characteristics and physical characteristics. This chart can help determine which adhesive family to lead with when the application requirements are known and prioritized. Within each sub-category (e.g., toughened epoxy, MMA Acrylic, PUR, etc.) there are different open times not listed here.

The 3M structural adhesives portfolio offers an extensive assortment of options that can span low-to-high modulus, short-to-long open times, self-leveling to non-sag dispensability and much more. Understanding the prioritized requirements of an application is an important first step. This prioritized list should be based on the criticality of the bonded assembly coupled with the production requirements. Systematically thinking through the entire bonding process can help ensure the correct adhesive solution is chosen and the resultant bonding application is a confidence-building success.

Myth #4: All Structural Adhesives are Epoxies

An adhesive, in its most fundamental description, is any material that binds two or more things together for the duration of its useful lifecycle. With innovations in new materials and the breakneck speed at which modern consumer goods are being designed and manufactured, there is a demand for new and better ways to assemble these products.

Adhesives are finding more and more uses in modern day manufacturing for their benefits like lightweighting, sealing, vibration damping, lower susceptibility to corrosion and better aesthetics, to name a few. For these reasons adhesives are

increasingly being used in the automotive, transportation and metal fabrication industries as well as in the manufacture of aircraft, furniture, appliances, medical devices, consumer electronics, general manufacturing and much more.

In the world of adhesives, structural adhesives provide extremely high bond strength and can carry considerable load for the bonded assembly - it is meant to become an integral and permanent part of the assembly. A structural adhesive can produce strength up to several thousand pounds per square inch (psi) in overlap shear, depending on the materials bonded. It can also bond to a wide variety of substrates including metals, plastics, composites, woods, elastomers and, with a unique formulation, even hard-to-bond materials such as polyolefins and silicone elastomers. Structural adhesives are therefore used in many applications where strength and durability are critical.

Structural adhesives are commonly classified according to their base chemistry. Epoxy is perhaps the most-recognized term people associate with structural adhesives. Indeed, many people use this term to generically refer to any adhesive that exhibits high strength, but for clarity, the name epoxy derives from the chemistry. By no means is it the only material that can impart structural strength to assemblies; other common structural adhesive families include acrylics, 1- and 2-part urethanes, cyanoacrylates and anaerobic adhesives. 3M offers a wide selection of products from each of these adhesive categories. Each has its own strengths and limitations. Understanding the capabilities of these adhesives gives you freedom and flexibility to choose the best adhesive to best suit individual bonding applications. Remember, when one adhesive does not quite meet your bonding requirements, look further into the portfolio of structural adhesives. With a wide range of chemistries and properties, one is sure to solve each unique bonding challenge.

3M Structural Adhesives Families

[Epoxy Adhesives](#)

Key Strengths: High bond strength and durability.

Epoxy adhesives are extremely strong and durable in demanding conditions including outdoor weathering and harsh chemical exposures. They are available in two-part room temperature curing or one-part heat curing formulations.

- Highest overall strength under various stresses including shear, peel, tensile and impact
- Best resistance to high temperatures, solvents and harsh environments
- Bonds to a wide variety of materials: bond strength to metals is outstanding, but epoxies also bond many common engineering plastics, composites, woods, glass and ceramics
- Cured adhesive can be soft and flexible, rigid, or extremely tough to suit different applications
- Withstand vibration, impact and fatigue
- Low shrinkage
- Available in the widest variety of open times to suit most applications

- Example Uses:
 - Instrumentation for defense, automotive and oil and gas industries – applications that require rigorous quality and performance in harsh environments
 - Sporting goods – due to high load and high impact over a small bond area
 - Renewable energy, passenger rail car – applications requiring high performance with environmental considerations
- Popular Products:
 - 3M™ Scotch-Weld™ Epoxy Adhesive DP420NS - General purpose, tough and strong, best for bonding metals
 - 3M™ Scotch-Weld™ Epoxy Adhesive DP100 Plus – Flexible, clear, fast curing
 - Plus 38 other 1-part or 2-part products with a wide range of open and cure times to fit your applications

Acrylic Adhesives

Key Strengths: Robustness and fast curing

Acrylic adhesives bond exceptionally well to most plastics including low surface energy (LSE) plastics, difficult-to-bond paints and coatings, and to metals that may be somewhat oily. This versatility enables engineers and manufacturers more design flexibility when it comes to assembly of parts consisting of different materials.

- Exceptional in bonding plastics, including LSE plastics
- Least sensitive to surface preparation
- Least sensitive to off-ratio mixing
- Faster cure rate than epoxy or urethane adhesives
- Toughened formulations with good impact resistance
- May contain spacer beads to maintain consistent bond line
- User-friendly, low odor options available
- Example Uses:
 - Panel-to-frame – bond to a wide range of plastics and metals for processes that don't allow rigorous cleaning
 - Enclosures – potential for process improvement due to speed of cure with a durable bond; also bonding of parts that will go through a powder coat process
 - LSE plastics – the best chemistry to bond to LSE plastics with little to no surface prep
- Popular products:
 - 3M™ Scotch-Weld™ Low Odor Acrylic Adhesive DP8805NS – Low odor, fast curing, strong and tough, bonds many materials
 - 3M™ Scotch-Weld™ Structural Plastic Adhesive DP8010 – Excellent bonder to many engineering plastics plus LSE plastics

- 3M™ Scotch-Weld™ Metal Bonder Acrylic Adhesive DP8407NS – Metal bonder, resists powder coating temperatures, strong and tough
- Plus 14 other products with a range of open times to fit your applications

Urethane Adhesives

Key Strengths: Flexible and strong

Urethane chemistries are ideal for creating strong, flexible bonds between dissimilar materials. Urethanes excel at bonding to composites, wood and concrete as well as a variety of engineering plastics and some metals.

- Better aesthetics without a visible bond line due to low shrinkage
- Bonds provide the strength or flexibility to resist shock, vibration and impact loads
- Variety of open times available to suit process needs
- Example Uses:
 - Composite panel bonding with a class A surface – no read-through of adhesive
 - Glass bonding – adhesive's low modulus allows for fluctuations in temperature
 - Potting applications requiring flexible adhesive
- Popular products:
 - 3M™ Scotch-Weld™ Multi-Material Composite Urethane Adhesive DP6310NS General purpose, bonds especially well to composite materials, good impact strength at high and low temperatures, relatively fast setting
 - 3M™ Scotch-Weld™ Urethane Adhesive DP604NS – Flexible and fast setting, best for bonding plastics
 - Plus 11 other products to fit your applications

PUR Adhesives

Key Strengths: Fast holding power with flexibility

PolyUrethane Reactive (PUR) adhesives are one-part formulations that combine the initial speed of a hot melt adhesive with the strength of a structural adhesive. They bond exceptionally well to wood, glass, ceramics and many plastics including nylon.

- Rapidly reaches handling strength
- Eliminates clamping of parts
- One-part adhesive requires no mixing
- Variety of open times to suit process requirements
- Example Uses:
 - Panel and stiffener bonding for appliances – due to fast cure and ability to gap fill
 - Woodworking – offers improvements over traditional wood glue
 - Electronics – due to fast curing and viscoelasticity
 - Glass and plastics bonding – flexible and elongating, fast cure
- Popular products:
 - 3M™ Scotch-Weld™ PUR Adhesive TS230 – General purpose, bonds well to plastic, wood and glass, longer open time
 - 3M™ Scotch-Weld™ PUR Adhesive EZ250060 – Wood bonder, plasticizer resistant, medium set speed
 - Plus 17 other products with a range of open times to fit your applications

Instant Adhesives

Key Strength: Speed

Instant adhesives, also known as cyanoacrylates, are one-part products that attain handling strength in a matter of seconds. They are excellent for bonding rubber, including LSE elastomers such as EPDM and silicone. They also bond well to common engineering plastics, LSE plastics, metals and wood. They are best suited for small parts assembly.

- One-part formulations requires no mixing
- Reaches handling strength in seconds
- Eliminates clamping of parts
- Excellent bonder of elastomers
- Can bond to LSE plastics and elastomers when used with a primer
- Clear and colorless
- Example Uses:
 - Small plastic and metal parts assembly
 - Rubbers and elastomers such as door seal or rubber soles for orthopedic devices
 - Decorative wood trims
- Popular products:
 - 3M™ Scotch-Weld™ Plastic & Rubber Instant Adhesive PR100 – General purpose, especially for plastics and rubbers
 - Plus 25 other special purpose products with a range of viscosities to fit your applications

Anaerobic Adhesives

Key Strength: Keep nuts and bolts from loosening

Commonly known as threadlockers, Anaerobic adhesives are one-part adhesives that cure in the absence of oxygen; this group also includes gasket makers, pipe sealants and hydraulic/pleumatic sealants. They augment the strength of a threaded metallic joint, preventing loosening due to excessive vibration. Specialized formulations can also be used as retainer adhesives for bonding non-threaded shafts, or as a temporary gasket for flanges.

- Lock and in some cases seal
- One-part adhesive that requires no mixing
- Threadlockers are color coded to easily identify strength rating
- Resist vibration and galvanic corrosion
- Example Uses:
 - Thread locking and in some cases thread sealing
 - Tube-in-tube retaining compound to replace keys, splines or set screws
 - Gaskets
- Popular product:
 - 3M™ Scotch-Weld™ Threadlocker TL42 – medium strength thread locker resists pressure and vibration for long term durability
 - Plus 18 other specialized products with varying strengths to fit your applications

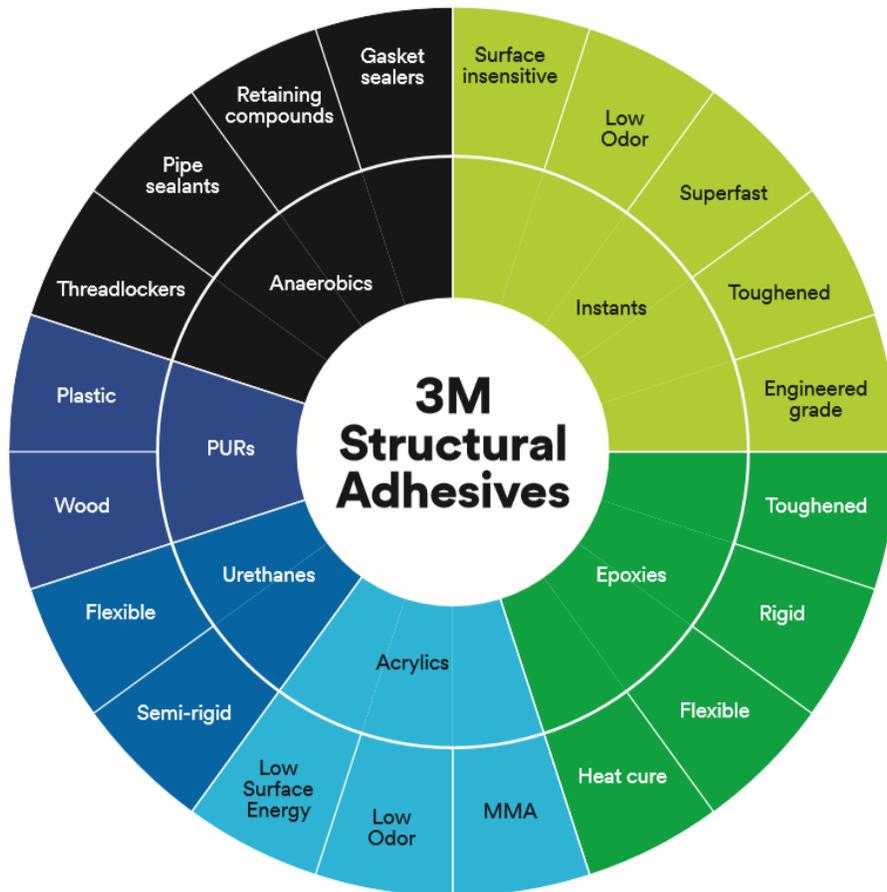


Figure 4. 3M Structural Adhesives grouped by family.

Myth #5: “I’m On My Own to Figure This Out”

One of the most important things to remember is that you are not alone. Just as design engineers are experts on the products they are creating, there are bonding experts who can help you with selecting the right adhesives to make it possible. When you think of 3M, some memorable brands and products come to mind, including 3M™ Post-It™ Notes, 3M™ Command™ Strips and 3M™ Cubitron™ Abrasives. All of these products have one thing in common: they have an adhesive component. Adhesives are core to some of 3M’s most iconic brands because 3M has been designing and innovating in adhesive categories for decades. 3M’s global engineering and development teams have expertise in material science and a 40+ year history in developing 3M™ Scotch-Weld™ Structural Adhesives. 3M engineers invented both the flexible and toughened epoxy product categories. Our people are experts in material and adhesive science who regularly work with multiple bonding product options from tapes to spray, hot melts to structural adhesives.

If cost control and the bottom line are an important part of a design engineer’s overall decision, 3M has global technical and bonding support teams with the knowledge, expertise and local resources to help you bring concepts to life cost-effectively. 3M’s engineers, scientists and inventors share customers’ inquisitive nature and passion to create something newer and better.

In addition to global teams, 3M employs over 45 global application engineers who offer custom testing and reporting for customers of all sizes, industries and locations. They can test the strength performance of multiple adhesives using specific substrates under different heat, humidity and force tests. They can also help design engineers evaluate specific joint designs for better adhesive performance.

Another valuable resource 3M has recently built to help support adhesive customers are three automation-focused labs located in the United States, Germany and China. In these labs, customers and 3M engineers come together to test out adhesive options using different manual and automated equipment ranging from table-top dispense stations to sophisticated screen and jet printing dispensers. 3M also works with customers who need assistance with more sophisticated Finite Element Analysis (FEA) and data modeling. FEA has emerged as a powerful tool for predicting assembly performance and it can be used to compare structural adhesives to traditional joining methods and provide confidence in the joint design.

Finally, online and video-based training services and real-time chat support allow quick and easy access to engineers with answers. Whether you're a design engineer who is new to adhesives or trying a new adhesive category for the first time, 3M has a team of over 75 bonding specialists across the globe who can offer design teams an introduction to using structural adhesives. 3M works with customers of all sizes, from start-ups with a handful of employees to large multi-national manufacturers across a variety of industries. No design challenge is too specific or unique.

If you are interested in working together to address any bonding needs or challenges you have call 1-800-362-3550, email 3mproducts.adhesives.us@mmm.com or visit 3M.com/structuraladhesives to learn more.

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