The seven-product test field included Sika's Sikaflex 291 LOT (top) and (left to right) West Marine 8200, 3M Silicone, BoatLife Life Caulk, 3M Fast Cure 4200, West Marine Multi Caulk, and 3M Fast Cure 5200.

Jack Tar's New Goop

PS *tests some new types of marine adhesives along with the tried and true.*

Putties and caulks originated as tar and tree sap, and probably were first used by Neolithic boatbuilders trying to keep water on the outside of a crudely planked hull.

Today, hulls are tighter, but there's still a need to seal various joints, seams, and fastened hardware. The job now is done with a wide range of improved sealants and adhesives that offer less shrinkage, better elongation characteristics, long-term structural stability, and resistance to chemical deterioration. The majority of these hydrophobic marine gap-fillers tends to fall into four generic chemical categories—silicone, polysulfide, polyurethane, and polyether sealant/adhesives.

For decades, bedding compounds such as Dolfinite were industry favorites and were put into service between two mechanically fastened surfaces. They had no adhesive quality and remained soft and pliable until time, heat, and weathering left them dry and brittle. Modern alternatives go a big step further, melding an adhesive quality with a flexible gap-filling ability that improves the materials' watertight integrity.

This article will look at seven of the most popular products on chandlery shelves that perform the dual role of bonding agent and bedding compound.

WHAT WE TESTED

Practical Sailor rounded up seven readily available marine sealants and adhesives, including products from marine maintenance giant 3M, mega-retailer West Marine, marine cleaning supplies-maker BoatLife, and Sika Corp., which serves the marine, construction, and industrial markets. The test field included four polyurethane-based products, one silicone product, one polysulfide caulk, and one polyether caulk.

Silicone sealants are inorganic polymers that contain silicon. They are inert, non-conductive, UV-tolerant compounds that fit the bill as effective gap-filling sealants and are moderately effective as adhesives.

Silicone sealers in the consumer market use acetic acid as a reaction agent rather than hydrogen chloride. This makes them more user-friendly as they are non-toxic and have an extended working time. Prior to skinning over, silicone is a toothpaste-like gel that transforms into a flexible solid over a 24-hour period. Paint will not adhere to cured silicone, and care should be taken not to contaminate surfaces that are destined to be refinished.

Polysulfides are polymers that comprise alternating chains of sulfur and hydrocarbons. This gives them a natural Gumby-ish quality when they're cured, as they return to their natural shape after being tensioned. Polysulfides have good adhesive quality and can be recognized by their distinct egg-like odor. For decades, they remained the seam-sealers of choice when it came to caulking teak decks.

The chemical company Thiokol, a key player in the aerospace industry, actually chose its name based upon the combination of the Greek words for "sulfur" and "glue." Thiokol's epoxy-modified two-part polysulfide sealers were a favorite among boatbuilders and repairers. Today, single-part polysulfide sealers remain a popular gap-filling compound with a good blend of adhesive quality and weathering resistance.

Polyurethane sealants and adhesives have grown in popularity and are preferred by boatbuilders for projects like sealing hull-to-deck joints and installing through-hulls. The long-chain molecules that crosslink in the curing process include isocyanate resin that reacts with moisture to form a flexible solid.

These highly adhesive polymers offer both excellent surface grip and desirable gap-filling characteristics. There are numerous formulations that lead to products with different cure rates, elongation characteristics, and tensile strength.

CONTINUED ON PAGE 24

Finding the Breaking Point

After selecting seven popular caulking products representative of the four major sealant/adhesive types, we set up a six-step test procedure to compare adhesion, elongation, and the effects of immersion and cure time.

In the first round of tests, we used identical coupons (pieces) cut from a fiberglass (FRP) laminate, and placed identical size dabs of sealant on each test coupon in order to cement them to a base made of the same FRP laminate, mimicking a fiberglass-to-fiberglass seal, one of the best uses of such adhesive/sealants. Prior to the application of caulk, both contact surfaces were sanded with 100-grit paper and wiped clean with Interlux 202 solvent wipe. The coupons were placed sequentially on the FRP base and uniformly pressed until the sealant reached the edge of the coupon. A covering board and weight was placed over the entire seven coupons and left in place for 24 hours. Temperature ranged from 61 to 84 degrees during the curing period. Three weeks after the bonds were made, they were tested to failure.

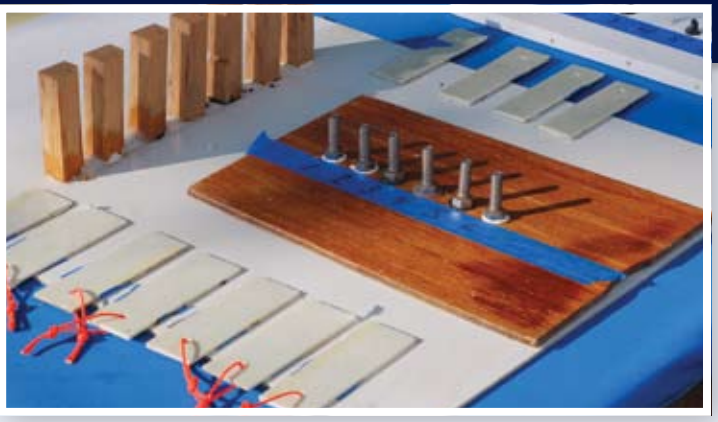
Each fiberglass coupon had a thin line inserted in a hole at the end opposite to the adhesive bond. The length of each coupon, and the position of the line attachment point was consistent on each sample. Tension was applied at this point causing the coupon to create a lever-like shearing effect across the bond. Tension was gradually increased until bond failure occurred. The load at the time of the bond failure was measured with an accurate spring scale; the numbers on the Value Guide reflect the maximum load (in pounds) each held.

In addition to shear stressing the adhesive bonds, we conducted a similar test with wood-to-fiberglass bonds. Three-inch-long oak segments were end-grain bonded to a fiberglass base, and using the same spring-scale pull to destruction process, each of the seven adhesive/sealant products were tested.

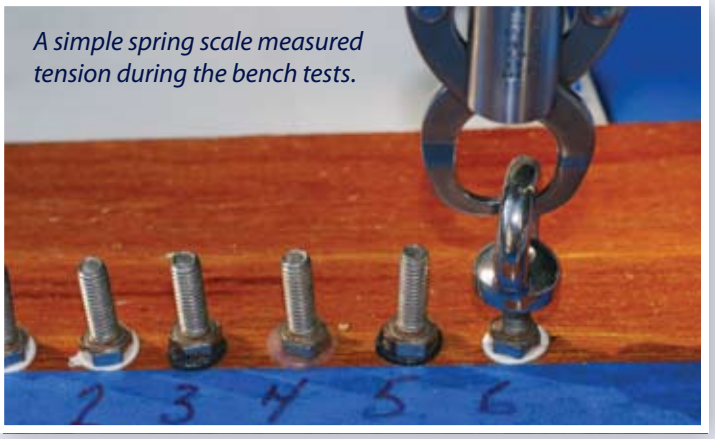
We followed this dissimilar material adhesion evaluation with a tension test of how well stainless and wood could be attached via an adhesive bond. Prior to placing a hex-head cap screw in a dollop of adhesive, we cleaned and degreased each with acetone and provided a rough wooden surface to act as the substrate.

The wood-to-fiberglass, metal-to-wood, and immersion testing followed a similar surface prep and material application process. We also included a Dacron-to-Dacron adhesion test to determine the value of these sealant/adhesives for emergency sail repair. None of the product manufacturers highlighted their adhesive as a sail repair product, but because Dacron-to-Dacron bonding is inhibited by fillers and cloth coatings, it made a good test of an adhesive's tenacity. We did not weight the result of this testing as highly as the others; it was more of an extra-credit assignment.

In order to enhance the validity and reliability of the testing, we repeated each battery of tests five times, dropping the high and low readings and averaging the mid-scores. Comparing these results with the mean, median, and mode of the full trial provided numerical correlation that did not alter the standing of winners and losers—a good indication of test repeatability.



Most adhesives are designed to bond to multiple substrates. To test the variety of possibilities, PS *tested each product's adhesion on FRP-to-FRP, wood-to-FRP, and metal-to-wood joints.*



A simple spring scale measured tension during the bench tests.

The wood-to-fiberglass (above) and Dacron-to-Dacron (below) tests put a zipper-like shear load on the adhesive joint.

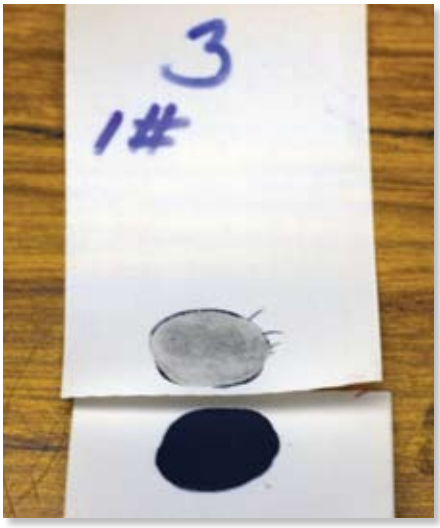
PS VALUE GUIDE	CAULKS & SEALANTS						
MAKER	3M	3M	WEST MARINE	SIKAFLEX	3M	BOATLIFE	WEST MARINE
PRODUCT	5200 Fast Cure	4200 Fast Cure	8200	291 LOT	Silicone	Life-Caulk	Multi-Caulk
PRICE / 10 OUNCES	$22	$20	$9 / 2.8 ounces	$21	$17	$20	$19
TYPE	Polyurethane	Polyurethane	Polyurethane	Polyurethane	Silicone	Polysulfide	Polyether
CURE TIME	1 day	1 day	2-3 days	7 days	1 day	7-10 days	1 day
PAINTABLE	Yes	Yes	Yes	Yes	No	Yes	Yes
USE ON PLASTIC	No	No	No	No	Yes	No	No
TEST RESULTS							
FRP to FRP*	7 pounds	23 pounds	20 pounds	23 pounds	18 pounds	7 pounds	17 pounds
WOOD to FRP*	13 pounds	8 pounds	10 pounds	10 pounds	1 pounds	3 pounds	3 pounds
METAL to WOOD*	4 pounds	22 pounds	29 pounds	21 pounds	14 pounds	16 pounds	25 pounds
DACRON to DACRON*	4 pounds	10 pounds	10 pounds	3 pounds	5 pounds	1 pounds	1 pounds
IMMERSION TEST	Poor	Good	Good	Good	Fair	Poor	Excellent
CLEANUP	Fair	Fair	Fair	Fair	Good	Fair	Fair

✓ Recommended

* The maximum load at the point of failure during tension tests.

CONTINUED FROM PAGE 22

Polyether-based caulks are the newest genre of ultra flexible gap-filling adhesive/sealants, and their cure is dramatically accelerated by a more reactive methyl silyl-enhanced reaction with water vapor that causes polyether products to skin cure faster than silicone and deep cure much quicker than polyurethanes. Their lack of solvents eliminates odor and minimizes shrinkage-based skin stress. They have very favorable stretch capacity and good resistance to ultraviolet rays and weathering.



This Dacron-to-Dacron bond suffered adhesion failure, but its cohesiveness stayed in tact.

BACKGROUND

Practical Sailor has evaluated a range of caulks, adhesives and sealants in past articles, searching for the best teak-deck caulk (September 2006, March 2007, Otober 2008) and the best bedding and sealing products (April 1, 2005 and Nov. 15, 1998). Our tests have revealed that most gap-filling compounds fail at one or both of the interfaces that separate the sealant from the substrate. In other words, the molecular ability of the sealer to remain bonded to itself remains intact, while its ability to adhere to a surface has failed. This is called adhesive failure. Shrinkage, excess movement, moisture intrusion, and other physical factors conspire to break the adhesive bond. Adhesion failure is lessened in situations where the seam filler is held like a gasket between two mechanically fastened surfaces. But in situations such as when a bead of caulk is placed in a right-angle corner—for example, where a toerail meets the deck—the compound's adhesive quality will be stressed, and modified polyurethane products have proven that adhesive strength matters most.

The adhesive quality of polyurethane caulks is superior, and they also remain flexible enough to handle the elongation differentials associated with wood, metal, fiberglass, and other mixed-material junctions. The new addition of polyether products to the fray may challenge polyurethane's stronghold.

Cohesive failure is defined as the inability of an adhesive to resist internal separation; it separates from itself. During cohesive failure, the adhesive sticks to both substrates, but cannot hold them together.

The products in this evaluation were all tested to failure, and testers noted the type of failure each showed. Find out how we pushed the products to their break-in points in "How We Tested" on page 23.

3M 5200 FAST CURE

This modification of 3M's signature high-strength polyurethane adhesive dries in 24 hours and can be used for hardware bedding, hull-to-deck joints or through-hull fittings.

The manufacturer suggests that the impressive adhesive quality of traditional 5200 is retained in the fast-cure version, but our testing indicated that

A Sticky Situation: Handling Adhesives

We prepped the test panels as we would any FRP surface we planned to use a sealant on, cleaning it well to erase any contaminants like wax, oil, or dirt and dust.

Application ease is an important factor when it comes to the caulking and seam-filling process, and some sealant/adhesives behave better than others. Among the most desirable traits is viscosity with the ideal consistency of the paste-like material being one that allows it to be injected into a seam or to be easily spread on a piece of hardware.

Of the products we tested for this article, we found that Sikaflex 291 LOT and 3M's 4200 Fast Cure had the right consistency to make application a user-friendly experience. They were thin enough to penetrate small seams, but stiff enough to form an even bead.

When applying sealants, surface prep follows the painter's mantra of smooth, even, and clean. Any contamination—be it oil, wax, or loose varnish or paint—has the ability to nullify the adhesion of a sealant. The prerequisite to a reliably caulked seam starts with the usual scrape, sand, dust, and wash clean.

Most products like well-prepped gelcoat or an epoxy-primed surface, but in the case of the latter, beware of what's called "amine blush," a residue that forms on the surface of epoxy resins and primers when they cure. Washing the surface before applying an sealant is a simple cure that removes the adhesion-robbing residue.

All of the test products have the near-magic ability to stick to every place they are not welcome, and cosmetic attention to detail during the application process is required. Lightweight throw-away gloves, a roll of paper towels, and a paper bag to dump contaminated wipe-off towels into are a must. Work from the top down whether it's on deck or filling plank seams on the hull. Use masking tape to confine the over-spread and maintain a crisp cut line. All but silicone sealers can be sanded and painted, but the best bet is to achieve a fair, even bead that needs no hiding.

If you're left with a half-used tube of sealant or caulk, try this preservation method suggested to us years ago by former contributor Dick Wilkens: With a piece of plastic (like Saran Wrap) over your finger, push the sealant back into the tube a bit, leave the plastic in place, and replace the tube's cap. The plastic excludes the air that usually lets the sealant harden under the cap. According to Wilkens, this can extend the usable life of the product for years.

the sample we purchased in a local chandlery did not meet this claim. The Fast 5200 did top the scale as an adhesive attaching wood to fiberglass, but its adhesive quality in FRP-to-FRP joints left much to be desired. The same lower-than-anticipated results surfaced during the tension test of a metal to wood bond, and the shear-strength testing of Dacron sailcloth.

The manufacturer says that the material can be softened by some teak cleaners and solvents, and is best not used as a paying compound for teak decks.

Bottom line: Tapped as one of the best adhesives, above and below the waterline, in the 1998 test, 3M's 5200 Fast Cure left us with more questions than answers in regards to its adhesive shortfalls, especially on FRP to FRP joints. However, we do recommend it for wood to fiberglass joints, as it outperformed all others in this area.

3M 4200 FAST CURE

This polyurethane adhesive/sealant is billed as a less tenacious version of fast-cure 5200, and yet in our testing, it outshined its big brother in all but its ability to bond fiberglass to wood. It cures in 24 hours and can be used above and below the waterline.

One of the big surprises of the test was how tight a grip 4200 had when it came to shear testing the FRP coupons. It out-performed all but the Sikaflex 291 LOT (also a modified polyurethane sealant/adhesive). The 4200 also showed good adhesion to metal and sailcloth.

Bottom line: Near across-the-board excellence makes 4200 Fast Cure a useful product to carry on board.

WEST MARINE 8200

A fast-curing polyurethane adhesive/sealant, West Marine's 8200 is suitable for use above and below the waterline. It adheres to glass and metal and resists UV degradation. The 8200 attained earned high scores as a versatile moisture-resistant adhesive.

Packaged in small, fluid-ounce tubes, 8200's fast-cure moisture-accelerated chemistry results in opened tubes hardening quickly. Star brite, which manufactures 8200 for West Marine, recommends using the contents within 24 hours after opening. However, the single-use tubes are convenient to stow in a toolbag and erase the worry of paying more for a larger-volume tube or cartridge, only to have it turn solid before it's used up.

Bottom line: The versatility of this adhesive makes it a good addition to toolkits and paint lockers.

SIKAFLEX 291 LOT

Sikaflex 291's "LOT" designation stands for a "long open time," an indicator that this version of Sika's poly-

PS USER'S GUIDE

CHOOSING THE RIGHT CAULK FOR THE JOB

TO	FIBERGLASS	METAL	WOOD	TEAK	ACRYLIC	LEXAN	MARELON	PLASTIC	RUBBER
FIBERGLASS	U, P, S, E	X, P, E, U	P, X, E	P, E	G, S, E	G, S, E	U, P, X, S, E	S	P, X, S, E
METAL	X, P, E, U	S, U, E	P, X, E	P, E	G, S, E	G, S, E	U, P, X, S, E	S	P, X, S, E
WOOD	P, X, E	P, X, E	P, S, X, E	P, S, E	S, E	S, E	P, X, E	S	P, E
TEAK	P, E	P, E	P, S, E	P, S, E	S, E	S, E	P, S, E	S	P, E
ACRYLIC	G, S, E	G, S, E	S, E	S, E	S, E	S, E	S, E	S	S, E
LEXAN	G, S, E	G, S, E	S, E	S, E	S, E	S, E	S, E	S	S, E
MARELON	U, P, X, S, E	U, P, X, S, E	P, X, E	P, S, E	S, E	S, E	U, P, X, S, E	S	P, E
PLASTIC	S	S	S	S	S	S	S	S	S
RUBBER	P, X, S, E	P, X, S, E	P, E	P, E	S, E	S, E	P, E	S	P, E

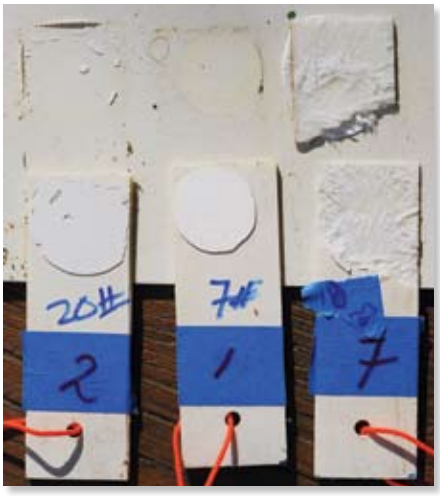
Legend — E: Polyether G: Glazing silicone P: Polysulfide S: Silicone U: Polyurethane X: Polyurethane silicone mix

This table, adapted from marine maintenance guru Don Casey's second edition of "This Old Boat" (McGraw Hill, $50; also available as iPhone app and eBook) offers some guidance as to which type of adhesive/sealant is best for specific bonds.

urethane sealant is slow to skin over and slightly more flexible than the regular, faster-curing 291. This is a well-balanced medium modulus adhesive/sealant that can be used above and below the waterline, and it turned out to be a strong performer in our testing, scoring high on all but the Dacron-to-Dacron fabric adhesion test.

In addition to delivering impressive adhesion numbers, the slow-curing 291 was easy to handle and was thixotropic enough not to sag but viscous enough to be smoothed, wiped, and spread evenly.

Bottom line: Recommended for applications where a slow-cure sealant is needed such as fastening a toerail or rubstrake, or when working in hot, humid conditions. Sikaflex slow-cure also is less likely to harden in the tube between work sessions.



The adhesive quality of Sikaflex 291 LOT was so strong that the resin bond of the FRP panel failed rather than the adhesive.

3M SILICONE

The 3M Silicone is a high-quality, non-conductive, gap-filling adhesive/sealant for use above the waterline. It skins over in five to 10 minutes and cures in 24 hours. Its adhesive ability on fiberglass-to-metal bonds proved better than we expected. In fact, our testers found that silicone's easy to use, quick-dry chemistry make it a good choice for quick fixes or more lasting repairs where maximum adhesive strength is not an absolute necessity.

3M bills its Silicone sealant as a low-strength, easily removable sealant, testers found its shear and tensile strength good on fiberglass and capable of providing a flexible gasket-like seal between two mechanically fastened parts.

Bottom line: When gap-filling is more important than ultimate adhesive strength, 3M silicone is a good option. It can help keep water off electrical connections, and its non-toxic nature makes it a good choice around sinks and countertops.

BOATLIFE

BoatLife's Life-Caulk is a Thiokol synthetic-rubber compound that adheres to wood, fiberglass, and metal. When cured, it provides a desirable blend of flexibility and adhesive strength. A full cure requires seven to 10 days, depending upon the temperature and humidity. Moisture actually accelerates the curing process. When using it on oily wood like teak, it's recommended to apply Life-Caulk Primer first for improved adhesion.

Life-Caulk's relatively poor results in our adhesion tests was a disappointment, but it showed good elongation and cohesiveness, making it a durable bedding compound when mechanically held between two fastened surfaces. We plan to re-test it using the primer for a follow-up evaluation.

Bottom line: Life-Caulk is worth considering for paying deck seams, but our top pick is still Teakdecking Systems caulk, the Best Choice in our 2008 test.

WEST MARINE MULTI-CAULK

Polyether sealants were developed for the building trades, but their good adhesive quality and excellent elongation characteristics led several companies to market marine versions.

In the tension test, West Marine's Polyether Multi-Caulk grabbed onto the metal bolthead like a vice. It also aced our warm-water submersion test, but

Do You Get What You Pay For?

Most of the adhesive/sealant bonds are still intact on our five-year-old test panel.

Always looking for a price-point advantage, *Practical Sailor* scrutinized non-marine caulking products more often seen in bathrooms than in boatyards. Many of these dual-purpose interior/exterior sealants tend to be modified acrylics meant for home use and trending toward latex formulations rather than a polyurethane or polysulfide base.

In general, they lack the adhesive strength of marine sealants and break down in water over time. They shrink as they cure, and when used in a marine environment, they tend to deteriorate more quickly. Acrylics harden and crack when exposed to extreme heat and the sun's ultraviolet rays. In short, the acrylic portion of the non-marine product list is best left to shoreside use.

Silicones offer a more encouraging outcome, and what we looked at were the 100-percent silicone sealants rather the modified silicone products that have become homeowner favorites. Sealants like GE Silicone II and Dow Corning's 795 are a match in quality for marine-grade products but with the latter's cost averaging around $16.50, purchasing and using the non-marine product adds up to less than a 3-percent savings. Off-brand silicone products can be found for considerably less, but the gamble lies in betting that the quality is equivalent.

In our April 1, 2005 and August 2006 reports on waterproof caulks and sealants, testers included several hardware-store brands, including GE Silicone II, Ace Hardware's Clear Sealant, and Elmer's Squeeze and Caulk. After a year, all three performed well in the elasticity and waterproofness tests, but the Elmer's and Ace products proved to have better adhesive quality.

The 2005 test panels are still undergoing exposure testing, and after five years, the GE Silicone, Ace, and Elmer's are still intact; however, the Ace silicone we tested is no longer available. (Look for a full update on how all 23 products in that test are faring in a future issue.)

While these non-marine brands are holding their own after a few years, it's hard to say at this point how they will compare over the long haul to the products designed for the marine environment and onboard applications.

The bottom line is that most boating projects that involve sealants and adhesives are labor-intensive endeavors that consume a relatively small amount of caulk. Saving a few dollars by betting on bargain-priced materials can be a foolish gamble, in our opinion. Ending up with an inadequate caulk that prematurely fails negates the value of all the labor invested in the project.

When it comes to caulking, going with the good stuff typically pays off in the long run.

it fell short in our wood-to-FRP adhesion test and the emergency sail repair simulation.

Made by Star brite for West Marine, this fast-curing polyether product gets a cure boost from moisture. It has much to offer in applications that involve metal and FRP sealing, high flex and expansion rates, plus lots of moisture. It was the standout performer in our "wet test," and its reluctance to release its grip on the Starboard surface resulted in a shearing of the sealant bead rather than the material peeling from the surface.

Bottom line: We liked Multi-Caulk's fast cure and the bond it developed on stainless steel as well as its ability to stay stuck on Starboard.

CONCLUSION

In this round of testing, no one product met our every adhesive need, so we've tapped a few recommended products for specific applications. For example, as much as we liked West Marine's fast curing 8200, 3M's versatile 4200 (fast), and longer open time Sikaflex 291 LOT—all of which are polyurethane products—we recognized their shortcomings. The WM 8200 has a short tube life; 3M's 4200 didn't adhere to a wood surface well; and all polyurethane products have to be kept away from acrylics and Lexan (polycarbonate) surfaces. Otherwise, the 8200, 4200, and Sikaflex 291 LOT are good choices for sealing jobs where adhesion counts—like bedding a through-hull. The 8200, 4200, and Sikaflex all get *PS*'s recommendation.

For projects that involve bedding stainless deck hardware like a stanchion base, we'd use the Sikaflex, but if the hardware is aluminum, any of the three recommended products would work.

Silicone, which won't harm most plastics, can be used to re-bed plastic hatch and port lenses. In this test field, 3M's Silicone stands out as the choice for these projects.

A polysulfide compound such as Life-Caulk remains a good option for filling teak deck seams, but the 2008 top pick Teakdecking Systems' caulk is a bit less expensive.

We were disappointed with the FRP-metal adhesion of the fast-cure 3M 5200, but its wood to fiberglass bonds were impressive. For jobs like bedding a teak handrail to a cabintop, we'd use the 5200 or Sikaflex 291 LOT.

CONTACTS

3M, 888/364-3577
www.3M.com

BOATLIFE,
800/382-9706
www.boatlife.com

SIKA CORP. (SIKAFLEX),
800/548-0496
www.sikaconstruction.com

WEST MARINE,
800/262-8464
www.westmarine.com