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Practical Sailor™

Steering System Saavy

Which type best suits your boat and your ambitions?

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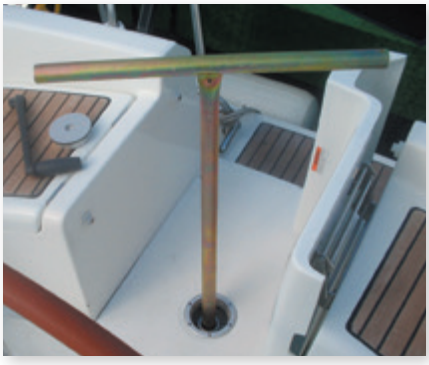

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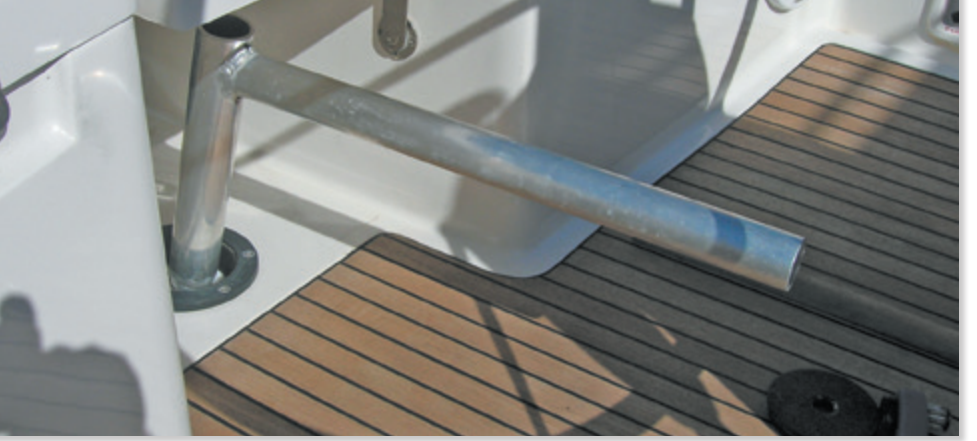

Photo by Darrell Nicholson

Our hunt for emergency tillers in the November 2007 issue turned up several systems that were impractical to use in heavy seas.

Steering Our Way to Safer Passages at Sea

With so many conveniences aboard the modern cruising boat, it's easy to forget that the bare essentials required to get us from here to there are so few—the hull, the rig, the sails, and the rudder. And with the rudder, of course we include the steering system that allows some control.

Unlike the hull, the rig and the sails, the steering system is often out of sight, tirelessly working beneath the cockpit sole or aft in a lazarette. Gears mesh, sheaves turn, cables push or pull, and inevitably they wear or begin to corrode.

Like many maintenance chores below deck on a small vessel, inspecting the steering system often requires us to squeeze into dark corners of the boat, where even if we do fit, the light is poor. Any flaws that might offer a hint of impending disaster can easily go unnoticed.

But inspect it we must. All it takes one corroded cotter pin, one loose screw, one frayed wire to begin the cascade of failures that can lead to disaster. It surprises to me how frequently I find mild steel components in a new boat's steering systems, as if salt air never made its way below deck.

It is easy for the armchair sailor to talk of jury rigging a steering repair, or using sails or drag devices to steer in place of the rudder, but when you are far from safe harbor and near a lee shore or other some hazard, the sense of helplessness can be overwhelming. Sure, you made it through the storm that led to the failure, but what about the next one? Will your disabled boat be able to creep around the next cape or reef?

Losing steering has to be one of the most challenging situations to confront at sea, especially when you are tired. Although the boat is otherwise fit for sea, the inability to set a safe and comfortable course can prompt the most difficult decision. You need only do an internet search under the terms "sailboat abandoned at sea," and you'll find several sad accounts of sailors abandoning an otherwise perfectly good boat that had lost its steering.

Even my own cruising boat, the Atkin ketch *Tosca*—a tiller-steered boat with a barn-door rudder that seemed immune from harm—suffered her own brush with rudderlessness, when a loose set screw in the shaft coupling caused the prop to jam in the rudder when I put the boat in reverse. The incident occurred on the Miami River, so the consequence was merely embarrassing: we put our bowsprit into a bachelor pad (a story for another day). The helplessness I felt when I realized I'd lost all control made me vow it would never happen again.

Hopefully, this month's article by Ralph Naranjo (see page 7), exploring the various types of steering gear—and their various pitfalls—will inspire each of us to take a close look at our own system and make sure we can avoid any failures, as well as be prepared with a plan in case this occurs.

Cover: *A Niagara 42 cuts a fine figure across the Chesapeake. (Photo by Ralph Naranjo)*

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Photos courtesy of Jeff Robinette, by Rod Collins (below)

Reader Jeff Robinette's Lagoon 42 Sonder *sits at Chub Cay Marina in the Berry Islands, Bahamas. The marina, like many favorite spots in the Bahamas, escaped Hurricane Dorian unscathed.*

CARBON FOAM BATTERY?

I saw your article in about Firefly batteries (carbon foam) in the May 2015 issue of *Practical Sailor* "Can Carbon Fiber Batteries Meet the Hype?" I am looking at upgrading the batteries on my relatively new Lagoon 42 catamaran. I was wondering what kind of feedback you have received regarding these batteries or any others.

Jeff Robinette
Lagoon 42, *SV Sonder*
Falls Church, VA

At the time of that article, Firefly had plans to accelerate production in a factory in India, and the idea was that once that occurred carbon foam would be more competitive. According to Bruce Schwab, Vendee Globe veteran and founder of Ocean Planet Energy, the factory in India is open now. Although the company is now able to meet demand—they have plenty of their 450Ah x 4V (three in a series for 450Ah x 12V, or 6 in a series for 450Ah x 24V)—prices are expected to rise soon, although nowhere near those for lithium ion, which has been in the crosshairs of US trade tariffs. Schwab reminded us that carbon foam batteries won't reach full potential under perpetual slow or weak charging sources (such as solar), as we discovered in our extensive follow-up test "Fighting Sulfation in AGM" in *Practical Sailor* May 2015 (originally posted online April 16, 2015). Schwab says the batteries will do better if you routinely give them a hard/fast charge from an alternator and/or shore charger. Ideally, the charge rate should be approximately 46 A for each G31 (.4 C). This brings up an important point that we've emphasized before—when switching to a battery that calls for different charging regimens (set points for tapering charging, etc.), you may have to change or reprogram your charger and other components in the system so as not to harm the batteries or the system itself. Any time you change battery types, you want to make sure your new charging system maximizes battery potential. In addition, we'd not advise mixing-and-matching battery types for your house banks. In any case, if you think your existing batteries do not meet your needs, then we recommend that you examine at the system as a whole — not just the batteries.

The Firefly carbon foam battery is among many that were tested and re-tested during our look at the effects of sulfation on batteries in the December 2017 issue.

KEEL MATERIAL

It would be useful for *Practical Sailor* to list which manufacturers use iron encapsulated in their keel. I am surprised to learn that many old sailboats have iron instead of lead as encapsulated ballast.

Edward Addeo
via *Practical Sailor* Online

Good idea. Our boat reviews (www.practical-sailor.com/topics/sailboat_reviews) typically indicate the keel material, as do the manufacturers. We'll start working on a list. Owners associations are a good source of information for older boats, as are builder specs. However, the specs for older boats (1970s-'80s especially) aren't always accurate, so do your homework. Concrete and low-grade iron scrap found itself into more than a few Taiwan-built vessels from this era. A good surveyor can help determine ballast material, but this

Find More at *PS* Online

About now, the list of off-season, "to-do" projects that wound up as "to-didn't" boat projects might be staring you in the face, begging to be taken care of, once and for all.

If you're looking to upgrade your running rigging hardware this year, we've published a slew of product tests that you'll want to check out in our online archives at *www.practical-sailor.com*.

- We evaluated snatch blocks in the July 2007 issue, looking at blocks from Antal, Garhauer, Harken, Lewmar, Schaefer, and Wichard. In the August 2008 issue, we featured a test update that put a line of blocks from Ronstan in the mix.
- Testers dove into the crowded world of shackles in the July 2014 issue. Now is a good time to inspect old shackles for signs of wear or failure, and to replace any that are questionable.
- If you're upgrading your running rigging to high-tech lines, you'll want to consider replacing your old rope clutches too. In the November 2014 issue, we reviewed a range of new rope clutches engineered to be grippier to handle today's slick, high-tech fiber rope.

Many boat owners who did not remove their running rigging during the off season might find their sheets and halyards need cleaning. Before starting, read our extensive report on washing ropes in the July 2011 issue. It answers those often-asked questions like whether you should use bleach or fabric softener; should they be laundered in a washing machine or bucket? The post "Fast and Easy Rope Cleaning" on our *Inside Practical Sailor* blog offers a short recap of the article as well.

Another boat chore you can cross off your list a little early is cleaning—or clearing—foggy Eisenglass. In the May 2014 issue, we reviewed several products designed to clean or revive aged, clear-vinyl windows.

Ugrading your electrical system? Our five-part series covers marine electrical systems and includes volumes on batteries; electrical system installation (grounding and lightening protection); alternative energy; AC systems; and panels, charging, and monitoring. Check it out at our online bookstore at *www.practical-sailor.com/products*.

can be expensive and sometimes involve some destructive testing. If you have a ballast surprise to share, we'd like to here it. Send it to the editor at practicalsailor@belvoir.com.

MULTI-PURPOSE CORKSCREW

Regarding your article on tools, ("Get Home Sailboat Toolkit," *PS* October 2018), a corkscrew will help fish out broken bits from the water pump impeller. A bicycle spoke has a little hook on the end that can also help fish little things out of holes and in a pinch you can do all the things you used to do with coat hanger wire on that old junk car you used to drive, except it's stainless.

Dave Brezina
Tartan 10, *Ratty*
Montrose, IL

CONSEQUENTIAL DAMAGE COVERAGE

Having been a professional marine insurance broker for 32 years and an avid reader of your magazine for much of that period, I was disappointed to read about consequential damage coverage in your January 2020 issue. While I don't dispute that having such coverage is valuable, to suggest having insurance coverage without this feature is equivalent to 'going bare' is dangerously inaccurate. Until a decade or two ago when BoatUS introduced this feature into their policy, all marine insurance policies excluded losses arising from a consequence of normal wear and tear or gradual deterioration. If there were no value to insurance with such a limitation, the marine insurance market would, of course, never have existed. The author dismisses coverage for hurricane damage as barely worth anything, but this, in fact, is the largest source of financial loss to U.S. boat owners. The author also blithely dismisses any value of coverage for theft, and, regretfully, doesn't even mention common types of losses such as lightning, collision, and groundings as things that are covered whether or not a policy provides consequential

Photo by Ralph Naranjo (top) Drew Frye (ropes)

damage coverage. And even most of the examples cited in the article as consequential damage excluded from coverage by a typical insurance policy are not accurate. Other than the rotten backing plate, none of the other claims should be denied, because they are not the consequence of normal wear and tear or gradual deterioration, and, if they were denied, the boatowner needs a better marine insurance broker acting as an advocate.

Gary Golden
Via *Practical Sailor* Online

Thanks for your letter, you make an excellent point. The main object of the article was to urge sailors to closely check their policies. In going over his own policy and some scenarios with the experts at BoatUS, a major insurer in the U.S., our writer discovered that many incidents described in the article that he thought were covered by insurance might not be covered—or the insurer could not say for certain without seeing an actual claim. Indeed, if you live in an area where hurricanes are a risk, that is a very strong reason to carry insurance. Freezing conditions is often a cause of sinking in the mid-Atlantic states, and we found that some policies do not cover damage due to freezing conditions.

Photo courtesy of BoatUS, by Darrell Nicholson (bottom)

Boats lie beached in the sand at Playa Del Ray Beach in Southern California after a severe storm in September 2004. Insurance is meant to cover these types of events.

BOTTOM PAINT CHOICES

I sail a Hunter 38 in the mid-Chesapeake that currently has a Pettit, non-ablative [hard] bottom paint that needs to have new antifouling paint applied. What suggestions do you have about whether I should continue with this kind or switch to an ablative that I used on a prior boat? I want at least a two-year paint and am also interested in maximizing potential speed of the boat.

John Fillipini
Hunter 38
Tracey's Landing, MD

Our bottom paint testing revealed a few eco-friendly solutions that would help us keep our bottom clean and minimize environmental harm.

The first step is to check with manufacturer for compatibility. If it is compatible, make sure you follow its directions for prep. For guidance on which paint will work best—hard or ablative—check the 2014 report (see "Bottom Paints by Region," *Practical Sailor*, March 2014.) To supplement our report, we recommend you talk with your boatyard owner, local marina operators, and local sailors with long experience in the region. As for speed, we've not tested this, but if you intend to burnish your finish for maximum smoothness, hard "racing" paints are best suited for this approach.

CARING FOR SEACOCKS

Regarding your recent article on seacock maintenance (see "Caring for Seacocks," *Practical Sailor* March 2016). I had a frozen 1½-inch Wilcox Crittenden seacocks on my 1982 Sea Sprite. I also used a torch, sprayed with PB Blaster, but nothing would work. I finally got the nerve to remove it from the boat. Judicious use of a butane torch and leverage got it out with no trouble at all. On the bench, I soaked it in PB Blaster in a plastic bag for a few weeks. That did the trick to break the corrosion, then I used regular valve-lapping compound to true it out. A new thru-hull set in 3M 4000 made it leak-free and easy this season.

Alfred Voskian
Via *Practical Sailor* Online

SAILBOAT SALVAGE YARDS

I am curious as to whether you have ever done an article on sailboat salvage yards. With the number of sailboats being scrapped due to age, storm damage, etc., I would think that there would be a market for used parts such as rigging, winches, electronics, etc. Yet even in my area

(Massachusetts) I have found it difficult to locate anyone that sells the parts I am looking for. As an example, I would like to get a radar pole, and would be happy to get a decent used one for half the $1,000 new price, but can't find one anywhere.

Walter Gotham
1987 Freedom 28, *Nova Vita*
Salem, MA

Check out our April 2011 issue of *Practical Sailor* online (posted March 1). The article "The Treasure Hunting Guide to Used Sailing Gear," offers a detailed guide on shopping at used gear chandleries—what to look for, and what to avoid. Radar poles are often in high demand, but you might be able to get a good deal on one, depending on region. For you, check *www.marineconsignment.com* and *www.massmarineparts.com*. These are websites linked to brick and mortar consignment stores that serve New England sailors.

Fort Lauderdale landmark consignment store Sailorman (above), was one of several featured in our April 2011 issue of Practical Sailor.

CHECK THOSE WELDS

Regarding your recent report on weld inspection (see "Welds on Your Boat Require Special Care," *Practical Sailor*, November 2018). As a welding inspector, I wanted to make a clarification of your destructive DIY weld analysis. It is not uncommon for a fillet weld to fail during this type of test. Under these conditions, being "bent back on itself" is the least favorable direction of force that these type of weld can resist. The main point of the analysis, simple visual examination, is of "how" the weld failed. Also, this is only one of several tests to determine if a weld passes full inspection, per the American Welding Society criteria. As you said, the recreational boating community might require these standards, although any reputable machine shop should have qualified welders. If you are a do-it-yourself welder, then I would recommend you review these or similar standards and learn some their inspection criteria. Another good point is to research the common boat materials and learn about welding alloys and filler material. There are numerous resources on the internet and even your local welding supply shop.

Ray Nic
Via *Practical Sailor*
Online

Many cruising sailors are equipping their nav station with a laptop running free or nearly free open source navigation systems, several of which we reviewed in the June 2007 issue.

Photo by Captain Joan Hildal

CHART DEFENDER

Regarding the blog post on NOAA getting out of the chart printing business, "NOAA Charts Coming to an End," I am more of a traditionalist, and like the paper charts and keeping up with my navigation skills. There are sailors who just cannot afford the new gadgets and some who just don't want them. If NOAA goes this route there needs to be a provision that paper charts can be ordered as needed by sailors of this style.

Don Wray
Cape Dory Typhoon
Eagle Lake, MI

CORRECTIONS

The new HIT solar panels from Solbian (see "Product Update" *PS* November 2019), are semi-flexible, not rigid.

Credit for photos of the Universal diesel in our report on air filters (see *PS* January 2020) belongs to Les Troyer, of the Catalina 36/375 International Association *www.catalina36.org*.

Practical Sailor welcomes reader comments and questions. Send email & reader photography (digital .jpeg 1MB or greater) to *practicalsailor@belvoir.com*; include your name, homeport, boat type, and boat name. Send any broken gear samples to Practical Sailor, 1600 Bayshore Rd., Nokomis, FL 34275

Steady at the Helm

The best steering system depends on preference and boat's complexity.

By Ralph Naranjo

A sailboat's steering system also plays a vital role in safety at sea. The failure of any key component can jeopardize boat handling and turn your, easy-to-steer, well behaved old friend into an unguided missile. When such chaos grabs hold, it's the emergency tiller that can save the day.

In the November 2008 issue of *PS* and in the December 2018 *Inside PS* blog, we raised a few concerns about steering system problems and emergency steering alternatives. This month's close-up look at steering systems focuses on new and traditional ways to link the rudder and the helm, notes the importance of well-engineered hardware and delves into what's going on with emergency steering alternatives. Our focus is on steering system malfunctions, not rudder failures. The latter will be addressed in a future look at vital seaworthy systems.

Dual steering systems have become the norm in boats as small as 35-feet today.

Photos by Ralph Naranjo

BACKGROUND

Tiller steering is about as bulletproof a system as found on any a modern sailboat. There are fewer components, easier access for inspection and certainly lower cost. This "keep it simple" approach has a lot to offer.

Unfortunately, larger boats require longer tillers and unless it's a semi balanced rudder, with ample surface area forward of the rudder stock, there's no power-steering effect. That's what gave rise to the old adage about needing "two men and a boy" to steer some sailboats. Hours spent on such a helm yield more pain than pleasure. The good news is most modern wheel steering systems can ease such a burden. So, despite the simplicity and reliability advantages that tiller steering has to offer, it's rarely found on new cruising boats longer than 30 feet.

Wheel steering isn't the holy grail and one system doesn't fit all boat designs. It has some challenges all its own. One of them is how to link the helm and rudder on sailboats with center cockpits. Quite often, the space between is occupied by an engine room, owner's cabin or both. This results is a maze-like pathway that must be traversed in order to link the wheel and the rudder. The way each designer/builder decides to bridge this gap helps define what system they use and how complicated, smooth spinning and reliable the steering becomes.

There are five generic approaches to turning the helmsperson's rotary motion wheel input into an axial force exerted on the rudder. They are usually referred to as geared, cable/quadrant, drag link, torque tube, or hydraulic steering.

RACK AND PINION

Early on, the bronze geared rack-and-pinion system scored a hit aboard aft cockpit sloops, yawls, schooners, and ketches. This simple rack and pinion design relied on the wheel being placed close to the rudder and keeping the gears in tight alignment throughout the turning arc. This system was revered by some but deemed "hard-mouthed" by many.

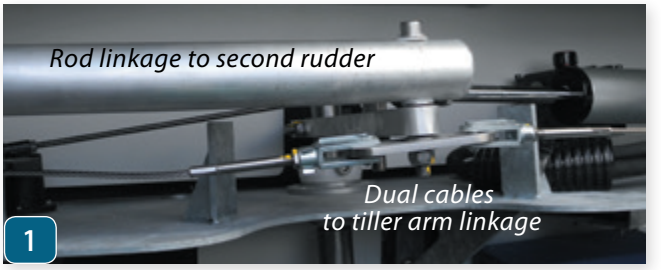
Unfortunately, with age, the gears and shaft support bushings become worn and tight tolerances give way to gear teeth jumping over each other rather than affecting rudder angle changes. The cost of replacing custom

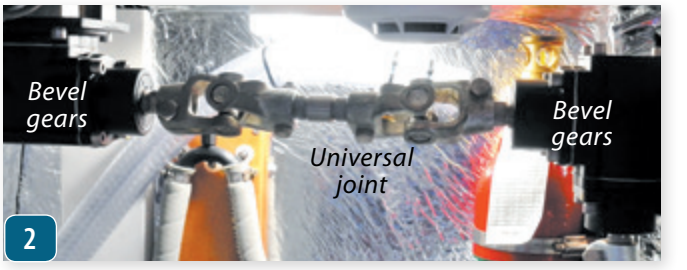
Continued on page 10

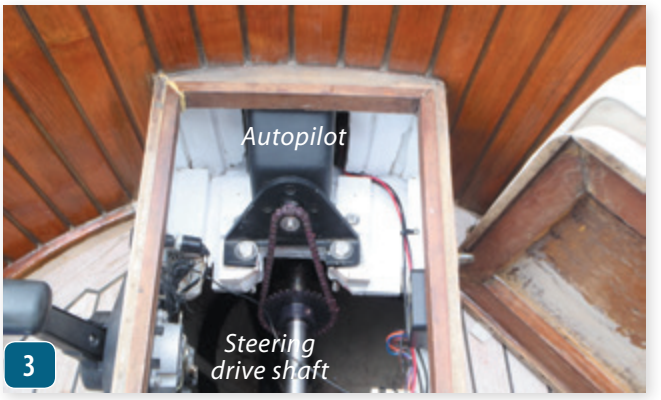
PS VALUE GUIDE **PROS AND CONS OF STEERING TYPES**

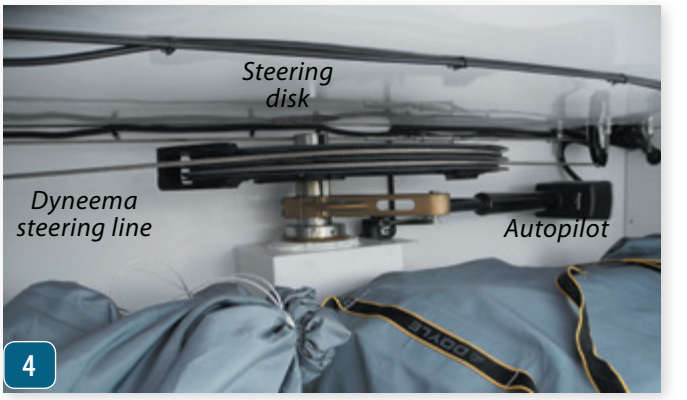
STEERING TYPE	PROS	CONS	COMMENTS
RACK AND PINION	Rugged, proven design	Increased friction, no feedback	Watch for wear, fiction
CABLE QUADRANT	Relatively simple design	Cables and sheave failure potential	Requires routine checks
CABLE IN CONDUIT	Simple installation	Increased friction, corrosion	Twin cable system is far superior
DRAG LINK	Robust system	Bearing corrosion is an issue.	Good compromise for big boats
TORQUE TUBE	Popular on big boats	Bearing corrosion can be an issue	Check for friction, corrosion
HYDRAULIC	Easily routed through boat	No rudder feedback	Robust design, have backup pump
TILLER	Simple, instant feedback	Not suited for big boats	Easy to setup for windvane steering

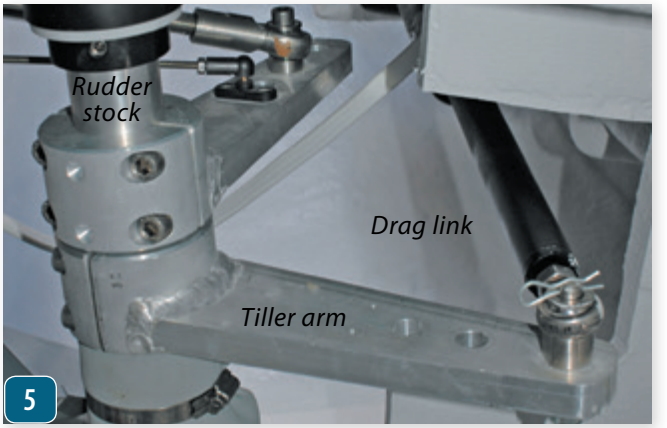
Every steering system has its pros and cons, and the proper application will depend upon how your boat is being used. ***1.*** *Twin rudders require a linkage to transmit steering forces from one rudder to another.* ***2.*** *Universal joints and bevel gears transmit steering forces in torque-tube steering systems.* ***3.*** *A chain drive connects the autopilot to the shaft of a rack-and-pinion steering system.* ***4.*** *A disk-like radial drive delivers cable tension to the rudder stock.* ***5.*** *Increasing the length of the tiller arm on the rudder stock decreases forces, but increases the throw needed to get response.* ***6.*** *Locating the rudder linkage right above the engine can be a problem at sea when you might be need to perform engine service.*

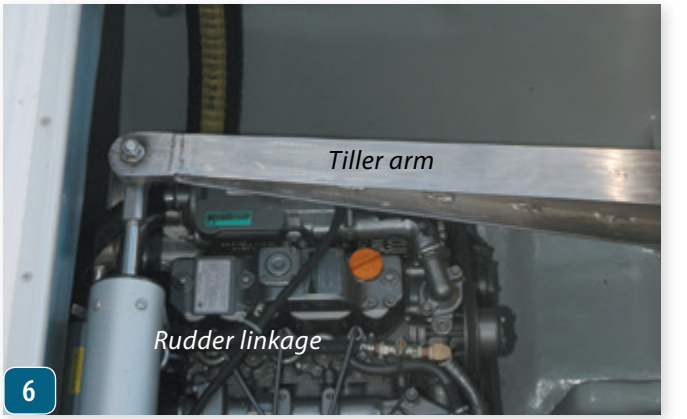












Emergency Steering is Getting a Short Shrift

Photos by Ralph Naranjo

Unfortunately, our recent boat show surveys and sea trials show that many emergency tiller designs are worse than the automotive industry's idea of a spare tire. Those faced with a steering system failure at sea need an easy-to-install, efficient steering alternative. Many approaches to emergency steering have become more of an afterthought rather than a 24/7 ocean usable backup system. Ideally, we want hardware that solidly attaches to the rudder stock, offers enough leverage to easily affect rudder angle changes in all weather conditions, and situates the helmsperson in a safe place with good visibility.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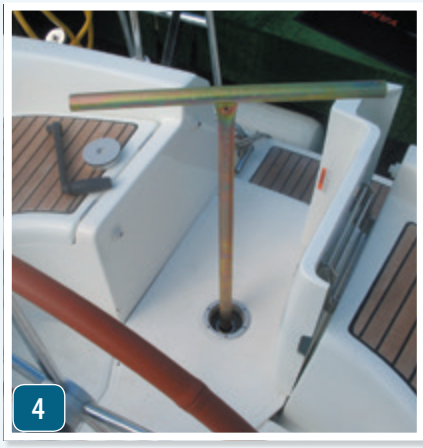
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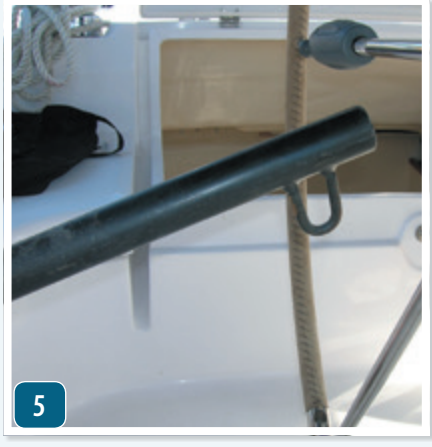
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1. Adding block and tackle emergency steering to a crowded compartment located under the aft cabin berth makes boat handling difficult for a helmsperson who can't see where they are going.

2. The main problem with the "bent pipe" emergency tiller approach is that there's not enough lever length to handle steering loads and all too often there's a poorly fitted connection between pipe and the head of the rudder stock

3. We found ill-fitting, wobbly pipe extensions, weak connections with too little leverage, that in some cases left the helmsperson with little or no visibility at all.

4. Some emergency tillers are so inefficient that the helmsperson, rather than the vessel, are being steered. As wind and wave action increases, course control becomes a losing battle. This wobbly T-fitting is misaligned so that it rubs against the access hole. A T-type emergency tillers can be efficient as long as the person at the helm retains good visibility and some comfort. This setup meets the former criteria.

5. Some emergency tillers provide fittings for two lines to be run to cockpit winches on either side of the boat. This requires two people with winch handles to be available on a 24/7 basis. In many cases, a short emergency tiller is mandated due to cockpit tables, binnacles and running rigging that intrude on a longer tillers swing arc. Connection points for lines to winches can add more steering power but the tiller's connection to the head of the rudder stock must be solid

Dealing with a Broken Idler Pulley on the High Seas

By Ralph Naranjo

Photos by Ralph Naranjo

Wind Shadow, *an Ericson 41 owned by PS contributor Ralph Naranjo suffered a steering failure off the coast of Africa.*

When I started cruising aboard a 26 foot, tiller steered sloop. I learned the value of simplicity. Fewer components meant that there was less to fail and fewer things to fix. Despite all the upsides of doing more with less, I dreamed about a wheel-steered 40 footer and days spent surfing down trade wind seas.

Some years later, my wife and I were headed westward on a family voyage around the world. The 26-foot pocket cruiser had been replaced with a wheel steered, 41-foot sloop that we named *Wind Shadow*. In those days, wheel steering was an add-on option and most boats in the 40 foot range still retained the ability to easily switch from a wheel to a tiller. Fortunately, the tiller had yet to become a vestigial organ.

We learned an important lesson about wheel steering a few days and a few hundred miles northwest of Cape Town, SA. *Wind Shadow* was reaching in 20 knots true under a reefed main, high cut jib and staysail. One moment, all was well and the next the helm spun like a roulette wheel. We gained some directional control by easing and trimming the sheets. It was enough to prevent the boat from rounding up or jibing, but it was clear that sheet steering in a good sized seaway was marginally effective at best.

What saved the day was the ease with which we could transition to tiller steering. In just a few minutes, a four foot, ash tiller was attached to the bronze fitting at top of the rudder stock and things were back under control. Ironically, the pendulum servo self-steering vane favored the tiller, steering the boat more efficiently thanks to the lack of the helm's "flywheel effect".

Ralph Naranjo

The steering failure had been caused by a broken idler pulley bracket, an essential part of the steering system that guides the wire cable on its run from the helm to the quadrant. In this case, a stainless steel axle pin, on which the bronze sheave rotated, had corroded enough to bind itself to the sheave. This caused the pin to rotate in the bracket, wearing the fitting away. More frequent cleaning and lubrication might have prevented the problem and is a good reason why a pre-passage steering system inspection should include a careful look at all of the moving parts.

Thanks to the efficiency of easy access to tiller steering aboard many older wheel steered boats, there was no need for an at sea repair. The full-length tiller fit the proportions of the cockpit and was quickly connected to the head of the rudder stock. The net result was a fully effective back up means of steering—just the opposite of the makeshift, high friction, contrivances we find on all too many sailboats today. On that Atlantic crossing, we sailed over 3,000 miles with the tiller in place. Very few "in the good old days" recollections hold as much validity.

Renowned safety at sea expert and Practical Sailor contributing writer Ralph Naranjo is the author of The Art of Seamanship *and the cruising narrative* Wind Shadow West.

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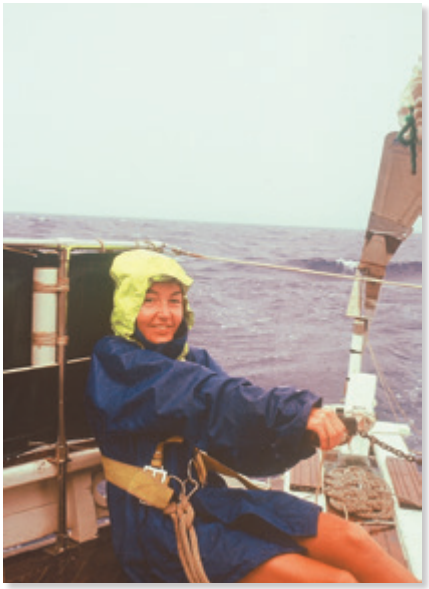
castings can be prohibitive and many builders and boat owners of rack-and-pinion steered boats have switched to other systems.

CABLE/QUADRANT

One of the most popular ways to connect the wheel and rudder is via a set of cables run through sheaves to a chain and sprocket attached to the steering wheel shaft. There are several major advantages to this approach and they include simplicity, excellent feedback and the relative simplicity of DIY repairs. Such systems began to play a dominant role with the advent of fiber reinforced plastic (FRP) boatbuilding. The industry rallied toward this wire rope, "pull/pull" approach to changing rudder angle. It was augmented by the development of flexible, low stretch, 7x19 stainless steel wire. Edson refined the approach, adding better aligned bracket



In gusty winds, a barn door rudder (left) makes for a serious workout compared to a balanced rudder and a big wheel (right).

mounted bronze sheaves, easy to attach at cable turning points. These carefully placed lead pulleys (also called idler blocks), led the wire rope to the port and starboard sides of the quadrant or disk drive. At the opposite end, both lengths of cable attached to a short piece of stainless steel, bicycle-like chain that engaged the wheel shaft sprocket.

In most cases, this hardware was built into the pedestal base directly below the binnacle. The wheel itself is keyed to the shaft and as it turns in one direction or the other, cable tension causes rudder deflection and the boat steers toward where the wheel has been rotated. Inside the pedestal, the chain is swaged, clamped or nicopressed to the wire steering cables.

Bushings support the wheel shaft and a set of carefully aligned blocks at the base of the pedestal redirect the cable run from the vertical into a horizontal plane. This rather simple, yet ingenious solution, fit the bill for decades, especially when helms and rudder stocks were in close proximity. However, the longer the run and the more obstacles in the way, the more cable length and pulleys had to be added and friction, stretch, and chafe increased.

Advocates still say that no other steering system, other than the tiller, offers as much feel. These cable-over-sheaves systems are alive and well, even among performance oriented sailors who have shown a growing interest in using high modulus fiber rope instead of wire. But, many have learned the hard way that although the tensile strength and resistance to elongation of HMPE fibers is very impressive, great care must be taken to eliminate chafe and maintain careful alignment throughout the arc of the rudder's swing.

CABLE IN CONDUIT

Cable steering also has an alternate genre that's seen on both multihulls and monohulls. There are two iterations of this cable-inside-a-conduit approach. The main advantage with this alternative goes to boat builders who can link the helm and the rudder with far fewer labor hours involved in the process. The push/pull version is akin to a throttle or shift cable on steroids. It turns the rotary motion of the wheel into a push or pull axial force that turns the rudder stock. These single cable system systems were first used on outboard motors and incorporated a bidirectional, rack-and-pinion link to the wheel. The appeal of this approach includes an ease of installation, the elimination of the need for turning blocks and the convenience with which a single cable could be snaked around obstacles. Unfortunately, when the cable bends are too tight and it's not secured to the hull's inner skin, the result is increased friction, poor feedback, and when used on larger sailboats with higher steering loads, the frequency of stripped rack-and-pinion gears grows much higher, especially in the push phase of cable motion.

The dual cable-in-conduit alternative tends to eliminate this problem. It combines a chain and cable pedestal with a transition to twin cable-in-conduit runs that snake through the bilge. It replaces the single push/pull cable with a system that handles turning in either direction through cable tension. This type of steering eliminates the push component, the Achilles heel of the single cable system.

DRAG LINK

A drag link steering system uses rigid tubes, rods and levers to affect the push/pull force needed to change rudder angle. The drag link steering system's pedestal supports a wheel connected to a pinion shaft that engages a bronze rack gear. It delivers wheel-induced torque to a vertical tube running down the center of the pedestal. It's connected to a lever located just below the base of the pedestal. The rotary motion actuates the lever and causes movement of the tubular linkage connecting the wheel to another small lever attached to the rudder stock. The geometry of

Practical Sailor tested methods of steering without a rudder in June 2017.

Photos by Drew Frye

this push-pull exchange is very important and components must be carefully aligned. Slight misalignment is handled by the ball joints in the tube end fittings. But the better the alignment, the more efficient the steering will be. It's important to keep the ball joints lubricated (greased) and regularly pump some grease into the zerk fitting at the bottom pedestal bearing.

Drag link steering systems deliver smooth, sensitive steering control. But the pedestal does contain more mechanical linkage and one of the major concerns is making sure that the manufacturer's recommendations about rudder stops are adhered to. If not, when the wheel is intentionally or unintentionally released while going astern, the rudder will slam over to one side or the other and the linkage can be seriously damaged. To a greater or lesser extent, this goes for all wheel steering systems and most manufacturers provide specific details about required rudder stops.

TORQUE TUBE

On one hand, this is the most complex approach to sailboat steering, but on the other, when skillfully installed, it can span half a boat length and still provide smooth efficient helm control. One of the key considerations is that there are lots of dissimilar metals combined in housings, bearings and seals, bevel gears, tubing, universal joints and reduction gears. And despite the fact that the system is installed below deck, ambient conditions in the bilge are moist enough to add some corrosion control concerns.

Like all other steering systems, the torque tube approach, is all about delivering a 180-degree reversible, axial steering force to the rudder. To do so, the wheel and the rudder are connected via a series of universal joints, torque tubes, and specialized bevel gears.

This tube rotation link up between the helm and the rudder requires a set of pillow block bearing supports for each tube, universal joints to interconnect the tubes, and secure anchor points on bulkheads, custom brackets or the hull itself. A reduction gear, placed near the rudder stock, converts tube torque into the axial movement of a short lever linked to the rudder stock. This short lever, is a mini tiller and a small amount of throw (movement) results in a larger amount of rudder deflection.

Unfortunately, with less leverage there's a big uptick in the force need to execute the movement. Not only does the reduction gear create some serious output force, but the base that supports the hardware must be up to task of handling these steering loads. Momentary peaks in rudder surface pressure, induced by sea state, cause loads in the steering system to spike. The bottom line is that the mounting bases and bracketing need to be up to the challenge.

Those with a Whitlock/Lewmar Mamba system can greatly extend the life of the hardware by following the manufacture's maintenance guidelines and keeping seawater away from bevel gear housing and the reduction gear. Also, use a magnet to locate ferrous metal components and regularly spray them with a corrosion protectant such as CRC Heavy Duty Corrosion Inhibitor.

HYDRAULIC SYSTEMS

Powerboaters hold hydraulic steering systems in high regard, partly because of their reliability and partly because rudder feedback is of little desire. Sailors, on the other hand, appreciates the "feel" of the helm and put that feedback to use in the sail trimming process. Consequently, sailors see steering via pumping hydraulic fluid to a piston ram as best suited to an auto pilot rather than a helmsperson.

The upsides of hydraulic steering, however, includes the ease with which a flexible hose can be snaked through the bilge, from the wheel to the rudder. And there's some logic to the idea that what works on a bulldozer is certainly rugged enough to handle things on a sailboat. Leaks and pump/ram problems are usually noticed early when steering begins to get a little spongy. In short, it's a good way to transfer force but numb when it comes to useful feedback.

CONCLUSION

Although there's no perfect wheel steering system, we do like and recommend traditional pull/pull wire cable with traditional sheaves. We also favor meticulously installed drag link and torque tube systems as long as the skipper recognizes the need to carry out periodic maintenance and watch out for corrosion related problems.

Some designers and builders seem to have greater faith in long term system reliability and give too little attention to emergency steering systems. All too often, the manual override for the autopilot is the go-to emergency steering plan. We found that many sailboats with emergency tillers also flunked the emergency steering test. These so called emergency tillers were often ill-fitting, unwilling to stay attached to the head of the rudder stock or were so hard to operate that they made steering in a seaway, all but impossible.

Bent Rudder Remedy

Careful application of force puts an old cat back at sea again.

By Drew Frye

With a careful application of force and robust bracing, it is possible to straighten a rudder. Note that no forces were applied from points off of the boat.

A few years ago while sailing my PDQ catamaran, we struck something hard and bent the rudder so badly that the top of the trailing edge jammed against the hull. Fortunately, could disconnect the rod linking the two rudders, and get home with just one rudder.

While often the rudder and stock are usually removed for straightening, I'd heard tales of simply pulling them back in situ. Certainly, the rudder tube and bearings must be strong enough to bend the rudder without creating a hole in the boat, but it was clear the construction had a considerable safety factor.

A few back-of-the envelope engineering calculations confirmed for me that the straightening load would not be a problem. Certainly the load of careful bending would be gentle compared to the strike that bent it.

RUDDER DESIGN

The second bit of required information is the rudder armature design. While it would be lovely if the stock continued to the bottom, this is not required for sailing strains and thinning of the blade often makes it impossible. Instead, the rudder is typically made with a rigid foam core fitted around a stock stub that extends only partially down the rudder, with welded reinforcements extending down and aft.

In order to keep the leverage point as low as possible on the rudder and minimizing force on the bearings and tube, while protecting the rudder trailing edge and armature, I built a virtual cast for the trailing edge to distribute the straightening pressure along the entire rudder. The cast was built from a pair of 2 by 6 planks, one of which was beveled to match the taper of the rudder trailing edge, bolted together with three 5/16-inch carriage bolts, and then notched to retain the pulling cable. A non-stretch belt secured the cast tightly to the upper rudder, the curved profile of the trailing edge, and some flex in the planks combined to provide even support.

For the PDQ 32, calculations determined the stock would straighten with about 1,350 pounds applied low on the rudder. Fortunately, we had a dynamometer to measure loads.

The front of the tackle was attached to doubled ½-inch polyester double braid rope looped around the hull forward of the keel (always use low-stretch lines for pulling under high load—nylon can whip dangerously if it breaks, and application of force is less accurate). This provided a nice low anchor point. The chain fall was a rated at one ton working load. Because of the poor traction on gravel I could only pull it to 1,000 pounds, so I connected a spinnaker sheet to the chain with a sling and used a winch to save my back. (The turning block is anchored to another rope sling, this one wrapped around the transom).

This arrangement makes it easy to increase the pressure in a very controlled manner, while monitoring the bending progress and the applied force. Note that none of the forces were applied from off the boat, which would result in dragging the boat off of its jackstands.

At about 700 pounds the rudder came clear of the hull, and by 1,320 pounds the trailing edge was about 1-inch clear; calculations had predicted 1,350 pounds. We released the tackle, and it sprung back to 1/2-inch clearance, our target clearance.

I then turned the rudder hard over to each side, inspecting for any evidence of cracking around the stock; the bottom paint was still well adhered and spanned the transition from stock to rudder without a crack. Further inspection of the rudder and keel leading edges revealed nothing; I suppose submerged logs must have a little surface softness about them.

We spent a lot of time on preparation, but once the pulling started, everything went smoothly. I was once told by a rigger (the 100-ton crane and millwright type, not sailboats) that moves should always look easy; if there is straining or tugging involved, something is going to break or someone is going to get hurt. It's all about control.

Not every bent rudder will be so simple to straighten. If the rudder had been bent severely to the side or further back, and driven far into the hull, I would not trust rebending; the rudder could be damaged. With a monohull, having only one rudder, a lot depends on reliable steering. But for minor tweaks, a little pulling can save a pile of boat bucks and weeks or months out of the water.

Photos by Drew Frye

Sail repairs made with polyurethane adhesives did not last beyond the two year mark, but repairs made to Sunbrella survived four years. Testers believe UV was the culprit. A UV-resistant adhesive sealant might last longer, but we have yet to test this.

4 Years Later Sail Repairs Hold Well

We never expected sail tape to endure as long as it did, the trick, it seems, is careful application.

After four long years in the sun, we're finally taking our polyester (Dacron) sail repair samples out of the elements for good. Even glued dodger repairs to tenacious Sunbrella material wouln't be expected to last longer than this. For detail on the earlier portions of this project, see articles *Practical Sailor* November 2017 and June 2018.

CONTACT CEMENT

Contact cement and Ailene's Tacky Glue failed long ago.

Bottom line: Not recommended.

TEAR-AID TYPE A

The tape just plain fell off, and it wasn't even on a sail. We had a patch fall off a Sunbrella dodger just weeks after it was applied.

Bottom line: Not recommended.

POLYURETHANE ADHESIVES

When applied to either polyester or laminate sailcloth, 3M 5200, Loctite PL S40, and Sika 291 failed completely before two years were up, peeling apart under their own weight. This wasn't a big surprise, since we have long known that polyurethanes make poor glazing adhesives unless the surface is properly primed with a UV blocker. The UV transmitted through the glazing, or fabric in this case, and attacks the critical bond area.

However, even after four years, the bonds to Pacific blue Sunbrella remain nearly as strong as the fabric. The difference, of course, is that darker Sunbrella colors block greater than 95 percent of ultraviolet rays (white Sunbrella blocks only 90 percent of UV rays).

Bottom line: Recommended for Sunbrella repair and temporary sail repair. Loctite gets the Budget Buy.

EPOXY

West Systems G-Flex was still strong, although it is a little stiffer than we would like. Dr. Sails from Sailing Technologies began failing after one year in the sun, and we had peeling problems within six months on furling laminate sails, while G-Flex repairs on the same tear remained strong for another 6 months, until the sail failed in multiple places.

Bottom line: G-Flex is Recommended for sail and canvas repair.

CLOTH TAPES

The polyester and nylon repair tapes in this test were Bainbridge brand, but we'd expect similar results with Sail Rite's equivalents (#2353 for polyester and #721 for nylon), based on results in our long-term tests on laminated sails (see *PS* May 2019). The bond of nylon and polyester sail repair tapes just got better with time. However, the thin nylon tape tore easily, as we'd expect from nylon after four years of UV exposure.

The polyester tape was weakened, but if taped on both sides it was stronger than the sail cloth. We've been using these on the boat for decades and have never been disappointed.

Bottom line: Bainbridge Polyester Repair Tape (aka Insignia Cloth) is recommended for working sail repair, and Bainbridge Nylon Repair Tape is recommended for spinnaker repair. These, or their equivalents, belong in every sail repair kit. Apply to both sides and rub down hard.

SAIL RITE LAMINATE REPAIR TAPE

We had some problems with peeling along the edge, which was easily solved by covering the edges with polyester tape. It remained very strong and non-stretch until the sail disintegrated.

Bottom line: Recommended where great strength is required.

APPLICATION TIPS

One interesting note: We bought a second-hand sail (laminate with polyester scrim on both sides), and after a few sails, realized that the scrim was failing a few places, pinholes were appearing a few places, and the UV cover (self-adhesive UV Dacron)

Photo by Drew Frye

PS VALUE GUIDE **TAPES AND ADHESIVES FOR POLYESTER (DACRON) SAIL REPAIR**

MANUFACTURER	MODEL	CONDITION AFTER 4-YEARS	BOND STRENGTH (NEW)	PRICE	QUANTITY	COST PER FOOT REPAIR
			TAPES			
BAINBRIDGE* ✓	Polyester Repair Tape	Good	82 pounds	$5.95	15 feet	14 cents
BAINBRIDGE* ✓	Nylon Repair Tape (Insignia cloth)	Fair	64 pounds	$8.95	3 feet	17 cents
TEAR AID	Type B	Poor	14 pounds	$4.95	1 foot	$ 4.95
			ADHESIVE SEALANTS/GLUES			
3M ✓	5200	Poor	>150 pounds	$16.99	10 oz.	68 cents
LOCTITE ✓	Marine Sealant	Poor	>150 pounds	$12.95	10 oz.	52 cents
LOCTITE $	PL S40	Poor	>150 pounds	$5.85	10 oz.	23 cents
SIKA ✓	Sikaflex 291	Poor	>150 pounds	$13.99	10 oz.	56 cents
WELDWOOD	Contact Cement	Poor	55 pounds	$4.97	89 ml.	34 cents
ALEENE'S	Multi-surface Adhesive	Poor	80 pounds	$3.95	29 ml.	79 cents
			EPOXIES			
WEST SYSTEMS	G 5 Epoxy	Fair	60	$24.50	946 ml.	16 cents
WEST SYSTEMS ✓	G-Flex	Good	>150	$25.99	236 ml	22 cents
SAILING TECH	Dr. Sails	Good	>150	$38.50	25 ml.	$9.24

★ Best Choice ✓ Recommended $ Budget Buy *Based on subsequent tests, we expect Sail Rite equivalents to yield similar results.

From left: **1.** *G-Flex hangs tough on polyester sail cloth and on Sunbrella.* **2.** *Polyester tape, applied to both sides remains stronger than the sailcloth. The bond becomes better with time.* **3.** *Polyurethane failed after one year,due to UV exposure.*

was shot. We reinforced the foot and leach with large, overlapping patches of Insignia Cloth.

We laid the sail flat, applied the patches carefully and rubbed them down well, and they have proven durable and strong. The problem is, because the sailcloth was wrinkled from years of use (characteristic of this type of laminate), and in spite of our efforts to flatten the cloth first, the long reinforcing patches resulted in excessive tightening of the leach and horrible sail shape problems. We wouldn't say the sail was ruined, not for testing purposes, but the change was considerable and we are looking forward to a new sail, just as soon as this trial is over. Be very careful not to alter the shape of the sail when applying large patches.

CONCLUSION

We are done. G-Flex epoxy and polyester (Dacron) tape worked out well on polyester sails, nylon tape for chutes, and polyurethane or G-Flex for Sunbrella. This mirrors decades of field experience.

CONTACTS

3M, www.3m.com

ALEENE'S, www.aleenes.com

BAINBRIDGE, www.bainbridgeint.com

DAP (WELDWOOD), www.dap.com

LOCTITE, www.loctiteproducts.com

SAIL-RITE, www.sail-rite.com

TEAR-AID, www.tear-aid.com

WEST SYSTEM, www.westsystem.com

Photos by Drew Frye

Boaters can greatly reduce their impact on local waters by minimizing the number of times they haul out and repaint their hulls.

Cleaning Up Spring Cleaning

The hidden impacts of boat maintenance are rippling local waters.

By Drew Frye

Spring is boat prep season, which is followed closely by the first cruise of the season. As the author of many articles on marine sanitation and my experience designing industrial waste facilities, I've become known around the marina as the wastewater guy, so when my neighbors have a question about how to dispose of something or why the head isn't working right, they come right to me. Fun.

WHAT CAN GO IN THE HEAD

The traditional rule is that if you didn't eat it, it doesn't belong in the holding tank. That's a good starting point, from which we begin our discussion of safe exceptions, beneficial treatments and why certain things are trouble.

Toilet Paper. Only single-ply toilet paper. Scott makes several good ones; see *PS* reviews in October 2016 and June 2011. Inform guests that ONLY toilet paper may go in the head, and encourage them to use lots of water when needed. Water is the key, since any amount of paper and waste will break down if there is enough water. Do not keep Kleenex in the head compartment, it is orders of magnitude more durable than TP and will not break down in water. Provide zip lock bags in an obvious place for other disposal items.

Acid Cleaners. Periodic acid treatments can reduce scale build-up caused by flushing with hard water (seawater is very high in calcium). Sew Clean (see *PS* August 2017) strikes the best balance between effective scale removal and safety. Vinegar is so weak as to be completely ineffective in any practical treatment regimen. Hydrochloric acid (muriatic acid) is hazardous to work with and damaging to aluminum. A proper annual cleaning should be sufficient.

Toilet Bowl Cleaners. Some will harm the tank culture and make things smelly, some will strip the lube from the pump, and some are safe, in moderation (see *Inside Practical Sailor*, "A Simple Solution for Toilet Bowl Stink").

WHAT CAN'T GO IN THE HEAD

Oils. The only substances—other than non-degradable paper and forbidden solids—that correlated to sludge build up in *PS* testing are vegetable oil and cooking grease. It causes solids to cling to the walls and buildup on the bottom, creating deposits that the gentle agitation of sailing won't break loose. It is barely degradable and slows the beneficial digestion processes by sealing the bacteria in little raincoats—the oil coats the bacteria, blocking the absorption of water soluble foods and enzymes. Metabolism slows down, degradation halts, and the sludge clumps

PS VALUE GUIDE WATER QUALITY STANDARDS

CONTAMINATE	ACUTE	CHRONIC	OUNCES PER 660,000 GALLONS (OLYMPIC SWIMMING POOL)
ARSENIC	69 parts per billion (PPB)	36 PPB	0.19 PPB
COPPER	4.8 PPB	3.1 PPB	0.02 PPB
ZINC	90 PPB	81 PPB	0.42 PPB
OIL AND GREASE	100-1000 PPB	1-10 PPB	0.005 - 0.05 PPB

One ounce of paint (25% Cu) = 75,000,000 gallons of water. If pollutant levels exceed these levels, aquatic life will suffer. For copper, this is about 1/4 of a penny in an olympic swimming pool. Not much in a harbor full of boats. And remember, the boat is not the only source. This includes all sources, many of which we are responsible for indirectly.

together. This is why disposing of cooking oil by restaurants is illegal—it gums up the pipes and interferes with sewage treatment. Instead of flushing oil to lube the head, maintain it properly each spring with synthetic grease, following manufacture instructions.

If there are solids on the tank walls that are preventing you from seeing the liquid level, a cup of an effective degreaser (Simple Green or Oil Eater) followed by a brisk sail is the best treatment. Some suggest adding 10 pounds of ice for some extra scrubbing effect, although it didn't help in our testing—cold doesn't help degreasers work. Don't add it through the head! It will strip the lubrication. Pour it in the pump out and rinse it down.

Bleach, Drain Cleaners, Etc. Bleach is rough on the rubber components of the system, disrupts the natural balance of bacteria in the holding tank, and will never be enough to actually sterilize the tank, since bleach has poor penetration effectiveness. It ends up making the odors worse and decreasing the life expectancy of the hoses and soft parts of the head. Not recommended under any circumstances. If you want to clean the system prior to working on it, flush with lots of clean water, followed by a brief soak in vinegar and one last flush with clean water.

Antiseptic Holding Tank Chemicals. Our reviews of head treatment chemicals (see *PS* February 2012, December 2012) explained that bio-augmenting treatments are most effective. Only portable heads benefit from antiseptic products (*PS* September 2018), but there is still a catch. The chemicals are quite toxic to bacteria and should never be disposed of in a septic tank, where they will upset proper operation. Only a large public treatment works. I've seen smaller treatment works crippled in my consulting work, and many prohibit disposal by chemical toilet service companies.

What about wastes we might generate while cruising, away from shore-side disposal options? Perhaps the head isn't the best place, but it may be the only choice. Because the answer is going to be "no" for many of these, keep a few empty PET (water bottles) and PE (oil and laundry detergent) bottles around for what must be kept.

Oily Bilge Water. Also soapy water from degreasing parts. Store it for on-shore disposal if possible. If not possible, use as little soap as possible (biodegradable) and let it sit overnight, so that the oil can float to the top (save the oil for on-shore disposal) before pouring into holding tank. With only well-emulsified oil remaining, the bacteria should be able to degrade the soap and oil over the next week, until it can be discharged, either well offshore or at a pump-out facility.

Cooking Oil. Keep this in bottles until you return to shore. Even if it were not for the environment, there is damage to the holding tank and clogging of sink lines to consider. Also used oil, of course.

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Many pumpout facilities are actually dumped in municipal wastewater treatment facilities that can be overwhelmed by the addition of treatment chemicals.

Chemicals to be banned for sale or use in California effective 1-1-2022:
- Bronopol (AKA myacide)
- Dowicil (a quaternary amine)
- Formalin (formaldehyde solution in methanol)
- Formaldehyde
- Gluteraldahyde
- Paraformaldahyde (time-release formaldehyde)
- Paradichlorobenzene (moth balls)
- Benzene
- Toluene
- Xylene
- 1,1,1-trichloroethane
- Trichloroethelene (trichlor)
- Perchloroethylene (perc)
- Ethylene glycol (engine antifreeze)

Chemicals from portable toilets (and holding tanks) can impact a wastewater treatment plant's ability treat waste.

What Happens to Your Pumpout Waste?

By Technical Editor Drew Frye

California's decision to ban sale or use of several chemicals found in marine products (above) is of interest to *PS* readers. After a careful review, we generally support this list, and we're adding a few more we've found troublesome.

The California Association of RV Parks and Campgrounds has been working on this since about 2000, in an attempt to solve problems the members were having with ruined septic systems and contaminated ground water. After several failed attempts, a measure was passed in September 2019, with an effective date of 1-1-2022, that bans both the sale and use of holding tank treatments that contain formaldehyde, bronopol, gluteraldahyde, and eleven more chemicals that have proven damaging.

The first seven are anti-bacterials that interfere with septic tank treatment. The next six are solvents, added to clean grease build up from waste lines. They are toxic, difficult to degrade, and are persistent in groundwater. Ethylene glycol is sometimes added as antifreeze and has very high biological oxygen demand, overloading septic systems.

Chemical toilet treatments actually eat up the hoses at this portable toilet waste unloading station.

Perhaps you think you do not discharge into a septic tank. In fact, at some small marina pump-outs you may. And there are other reasons to avoid these chemicals. *Practical Sailor* testing (see *PS* February and December 2012) has shown that the best way to minimize holding tank odors and reduce pump-out issues is to maintain a healthy aerobic bacterial culture in the tank, by providing ventilation, using holding tank treatments that augment nature, and by not poisoning the bugs. These chemicals are also generally rough on elastomers and hoses. They may claim to be safe, but more likely they are doing slow damage to hoses and joker valves, increasing permeation and shortening their lives.

Even large public treatment works often refuse chemical toilet waste based on bad experiences with treatment chemicals inhibiting waste treatment and causing upsets. Generally, marina pumpouts must go to a holding tank and be sent out for treatment, rather than discharged into the sewer. Finally, the solvents will either evaporate and become hazardous air pollutants or pass right through the treatment system. Contrary to labeling claims, most of these are very difficult to degrade.

The private treatment plant above accepts as many as 20 tankers per day of chemical toilet waste that the city refuses. The anti-bacterial agents were causing violations at the public treatment plants.

How am I so certain of this? When I'm not sailing I do engineering consulting work, and a recent project involved operational difficulties at an industrial wastewater plant that was accepting large volumes of chemical toilet waste. The city wised up and stopped accepting this chemical soup. The private plant (above) can treat the waste by the using pretreatments that would be impractical if applied to their entire sewer volume.

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BOATYARD DISPOSAL

What about boatyard wastes? Many products are becoming water-based, but that does NOT mean we can pour them willy-nilly on the ground or in the sewer. In many cases, they are hardly less toxic at all, no matter what the label says.

Recycle. Read the instruction on the recycle collection tank. Recycling processes vary (I worked in the industry for 30 years), so acceptable materials vary, and how they must be separated vary. Oil and fuels can generally go in the used oil tank. Only ethylene glycol and propylene glycol antifreeze go in the antifreeze tank—never alcohol-based winterizing antifreeze, fuel-water mixtures, gasoline-water mixtures, or soapy water.

Since most "virgin" products for sale today contain some recycled component (no matter what they say), we need to work together to avoid recycling materials that will degrade the products made from it. Recycle bins are not waste tanks, they are feedstock tanks. Hopefully there are also oily water and hazardous waste containers with clear instructions. Mixing gasoline with used antifreeze or paint/solvents with used oil will render the entire container hazardous waste, preventing recycling and incurring considerable expense to the marina.

Water-Based Paint. These products tout "easy clean-up" as a benefit, but this claim is misleading at best and dangerously false in many cases. Antifouling paints contain the same copper and zinc as solvent-based paints, and sewer ordinances ban disposal for reasons of toxicity. Brushes cannot be washed out in the sink or on the ground. Rollers and trays must be left to dry and disposed of as solid waste. At best, "easy clean-up" means you can try to wash your arms with soap and water, but given how fast water-based paints dry, this is probably more difficult than with oil-based paint. Better to wear long sleeves.

To quote Interlux AquaOne Product Specification Sheet: "Remainders of AquaOne cannot be disposed of through the municipal waste route or dumped without permit. Disposal of remainders must be arranged for in consultation with the authorities."

Antifouling Powerwash Water. The wastewater from cleaning hulls is far too contaminated for direct discharge. Scrubbing the hull in the water is a more delicate matter, with best practice guidelines that specify that the gentlest means possible should be used and that no paint-plume should be visible (See "Cleaning Your Hull," *Practical Sailor* April 2018). While this may not be state law, it is typically a condition of the marina's operating permit, giving it the effect of a local regulation.

Photos by Drew Frye

In order to meet local, state, and federal guidelines for runoff into adjacent waters, most boatyards are required to trap powerwash runoff to be sent out later for treatment.

Phosphates. Identified as nutrients that contribute to algae blooms and eutrophication, these were voluntarily removed from US laundry detergents in the early 1990s, and 17 states have either partial or complete bans on use in dishwashing detergents. However, we still occasionally suggest a cleaner containing phosphate or TSP for specific cleaning tasks. It is particularly effective before painting, and unlike organic cleaners, it is fully compatible with bleach. Use only the bare minimum, and when possible, guide the run-off and excess onto grassed areas; the plants will take it up as fertilizer, preventing it from reaching surface waters.

AT HOME

Conserve water at home. This isn't just a desert thing. Every drop of water that reaches the sewer adds volume and reduces treatment efficiency. The treatment plant is more effective at lower flow rates.

Reduce Storm Water. Some older cities have districts where sanitary and stormwater sewers are combined. In dry weather or light rains, lift stations transport the waste to the treatment plant. However, when it rains hard, pumping and treatment capacity is overwhelmed and the excess volume, including raw sewage, is discharged to surface waters. These are the sewage overflows that we commonly hear about—they are not accidents, just a consequence of obsolete design.

If you live in an area served by combined sewer outfalls, every drop of rainwater that can be absorbed into the ground rather than discharged to the sewer is a gallon of raw sewage that will not overflow during the next rainstorm. If you can direct your roof and driveway runoff into the grass, it helps. This issue is most serious in freshwater areas, because unlike seawater, there is no salt to deactivate infectious organisms.

This may sound like a lot of work, but if we like to swim, fish, and sail, this is what it takes. I never thought of myself as a particularly "green" individual. I'm a chemical engineer, for heaven's sake. But this is what the math says.

PS *Technical Editor Drew Frye is the author of the book "Rigging Modern Anchors." You can read his blog at www.saildelmarva.com.*

Tech Editor Drew Frye modified his soldering iron with a DIY tip to cut fabric.

Photos by Drew Frye

The Unsung Hero of Canvas Work

Turn your soldering iron into a hot knife.

You can cut cloth, carpet, and rope with scissors or a knife, but the result is a frayed mess, as soon as the item is put to use. There are reasons a sailmaker uses a hot-knife for most cuts and the chandlery bothers with fume control equipment, just so they can cut rope with a ribbon of hot steel. It works.

THE PROCESS

The right temperature is vital. Too hot and the blade wanders all over the place and makes a mess. Too cold and it must be forced, distorting the cut. Practice on a scrap.

SOLDERING IRON CONVERSION

This discussion is based on a 150/230 watt soldering iron with a replaceable tip. The wattage is regulated by how far you pull the trigger. If the blade gets too hot, which will happen cutting single layers of cloth, just take your finger off the trigger for a few seconds now and then, or increase the diameter of the wire used to make the blade. Commercial hot knives are about 90 watts, so they are in the same basic range.

DIY blade. The thinner the wire, the higher the temperature. We've heard copper wire suggested, but it lacks sufficient strength once it gets hot. A mild steel wire, on the other hand, works fine. After experimenting with a number of gauges and wire types, we settled on a 0.13-inch diameter coat hanger as about perfect for our 150/230 watt soldering iron. For a different wattage, just keep the wire cross section proportional to the wattage. It does not need to be exact.

Form the wire as shown in photo #1 (adjacent page), leaving the legs long. Hammer the wire flat, tapering from ~ 1/32-inch on the edge to 1/16-inch along the spine. Smooth the sides and edge with a few strokes from a fine bastard file, creating a dull edge. Trim the legs to length and fit into the soldering iron.

HEAT-RESISTANT WORK SURFACE

Glass is often recommended for a work surface. It does not draw heat from the blade like metal, is smooth, and the melted cloth does not stick. In practice, I nearly always use metal, because it is portable and won't break. The knife still slides smoothly, the cloth does not stick noticeably, and perhaps because of the over-sized soldering iron we use, we never notice the heat loss. We can insert a sheet between layers, protecting the fabric below. Plywood is OK, but it will get a lot of burn marks and add some smoke. Plastic will melt, and concrete is too rough.

Fabric. For fabric, the blade should be shaped something like an ice skate, with enough rocker to turn, but enough flat edge to track straight. It should not be sharp, but thin to an edge to about 1/32-inch thick; this will help it track straight and cut cleanly without excessive melting.

You should not feel the fabric drag against the blade. It should glide easily, the heat doing the work. But keep it moving at a steady pace or the melting will be excessive, the blade will wander, and it will smell as plastic builds up on the blade. Normally there is very little smell when cutting fabric, since the plastic does not build up on the blade.

Carpet. Cut carpet as you would fabric, but with more emphasis on keeping the knife moving. You do NOT need to linger to get good fusion; the thickness of the carpet virtually assures that. Do peel the cut portion away in an arc with your free hand, as though cutting thin metal with tin snips; this results in a smoother cut. It will smell, so work outside.

Rope. A straight blade is best, but the fabric blade will work just fine, particularly when cutting against a surface. For thick ropes, cut from both sides; it will be straighter and smoke less. Unlike the typical chandlery practice, we like to minimize the melted lump and apply a sailmaker's whipping. Eventually a melted end can fray. On ropes over 3/8-inch in diameter, large melted lumps can crack, resulting in painfully sharp edges.

Bungee Cord. This really stinks, a consequence of melting the rubber core, but there is simply no other satisfactory way to cut and seal bungee cord. Whippings don't hold and tape slides right off. A dip might work, but is doesn't restrain the rubber core. For this reason, we melt bungee cord more generously than rope. Attachments are generally interchangeable between hot knife models and soldering guns.

PRODUCT REVIEWS

DIY Blade. Hammered from a length of heavy wire coat hanger, it took us several generations to get it just right, but the result is versatile and durable.

Bottom line: This Budget Buy is enough for even serious DIYs.

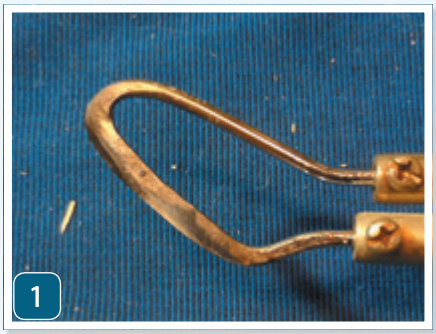
WELLER HOT KNIFE BLADE

Cheap enough, but the straight shape

PS VALUE GUIDE HOT KNIVES

MANUFACTURER	MODEL	POWER	COMMENTS	PRICE
		HEATING ELEMENTS		
ENGEL HSGM ★	Hot Knife	90 watts	Hot knife	$190
ROMECH $	Hot knife	100 watts	Hot knife	$65
WELLER ✓	Dual Heat 9400 PKS	140/140 watts	Soldering iron	$38
		TIPS		
WELLER ✓	RCT Tip	N/A	For cutting rope only	$6.50
DIY TIP ✓	DIY	N/A	Made from heavy wire	Free

★ Best Choice ✓ Recommended $ Budget Buy *Stitched seam and fabric began tearing at 150 pounds.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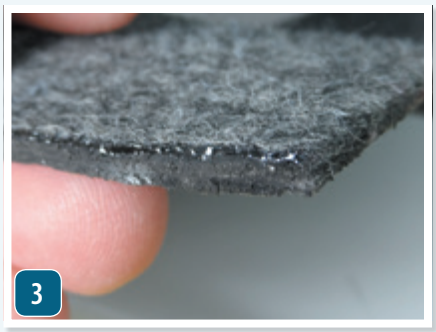
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1. The DIY cutting tip is easy to make .
2. A modified cutting tip cuts thin.
3. This rug has been cut and sealed.
4. RoMech with foam cutting blade.
5. The Weller with DIY tip.

4


5

and angle are all wrong for anything but cutting rope. $6.50.

Bottom line: Make you own.

WELLER SOLDERING IRON, DUAL HEAT 9400 PKS

This is just representative of the soldering gun class suitable for converting to a hot knife. With 100/140 watt capability, this will solder wires up to 8 AWG, and cut carpet, rope, and many layers of fabric with the hot knife attachment. Many brands are suitable and the elements are mostly interchangeable. Price is around $38.

Bottom Line: Recommended for hot knife and general soldering.

ENGLE HSGM HOT KNIFE

This 90-watt unit is the gold standard in hot knives, we've seen this model in most sail and canvas lofts. Perfect temperature control, better balance than a soldering iron, and it will outlive any DIY. Replacement blades and blades for cutting foam etc. are available. The cutting foot is particularly handy, allowing you to cut out windows and work around other fabric. About $190.

Bottom line: Best Choice.

ROMECH HOT KNIFE

A less expensive alternative, and the sailors we talked to were quite satisfied. Often you can find it in a kit that includes a longer blade for cutting foam. 100 watts. Price is $65.

Bottom line: Best Value for the occasional user.

CONCLUSION.

The hot knife one of those tools you didn't realize how much you needed, until you the first time you use it.

CONTACTS

HSGM, www.sailrite.com.

ROMECH, www.aleenes.com

WELLER, www.weller-tools.com

A horizontal-mount cockpit vise can be fitted into a piece of plywood that tucks neatly away when the boat is at sea, (see "A Handy Cockpit Vise is Ready in a Pinch," PS October 2019).

Photos by Drew Frye

Workbenches for Cruising Sailors

Improvising solutions for small sailboats.

So you've got a locker full of tools and materials and the skills to take on anything. But what do you work on? Spill a can of paint, lose a small part, or slam a hammer into the deck and the collateral damage outweighs all of the good you've done. How do you hold a small part firmly while drilling or filing? Although I have the space for an elaborate workroom at home, space and weight are critical on a boat. Though you can haul some work back to the home shop, we need portable solutions for everyday use.

Aboard a boat, a concrete mixing tub can serve multiple uses, rightside up or upside down.

WORKING SURFACES

There are three parts to this problem; on the boat, on the dock, and when the boat is on the hard.

On the Water Few sailors want to dedicate space for a shop, and normally the best place to work is where the project is, so the work surface must be mobile. Food service trays are perfect for painting, fiberglass work, minor bangs, and catching small parts while rebuilding carbs and winches. They are indestructible and compact, and can even be scrubbed off and used to clean fish! A fenderboard can be lashed down across the cockpit. A hole in one end that fits over or around a winch helps stabilize it.

In the Water. For heavy duty job like rebuilding a self-steering windvane or lower unit on an outboard, a concrete mixing tub with a small line tied to holes into corners is the trick. The tray easily supported a couple of lower units and all of the heavy tools used to pull them.

The lines secured the tray from floating away. The tray catches tools and fasteners. For smaller jobs, like adjusting a bobstay, working on a through hull, or replacing zincs, a litter box size tray is enough and can serve double duty as a dishwashing tray or small part tray on deck. Again, drill small holes in the corner and length of light line keep it handy. A type-III PFD eliminates treading water.

At the Dock. When real grinding, cutting, or banging are required, I don't want to do that on the boat, no matter what the bench. I move to the dock and lay down a protective bit of plywood fitted with a few bench stops to secure the work. Underside stops keep it on the dock. I'm sure it could be made fancy, according to the reader's imagination and needs. Keeps the dockmaster from having a cow.

On the Hard Time for some serious work. While a card table or a pair of saw horses and a sheet of plywood can do well, I like the Black and Decker Workmate 450. Very sturdy, clamps well, and covered with a towel, makes a nice general purpose table.

CLAMPING

Work surfaces can incorporate cleats or holes for this purpose, but sometimes more specific clamping measures are required.

Clamp-on vise Unless you have a very sturdy table to clamp this to, with an edge you don't mind scarring, the larger sizes aren't practical. We carried a small clamp-on vice on two boats for 20 years, and I can remember a single job where it was critically useful. A machinists vice must be through bolted to be of much use.

Drill Press Vise Although more limited in terms of what they can hold, drill press vises have the major advantage of being useful without being bolted to anything. For drilling or filing small parts they can often be used without being secured at all.

The disadvantages are that they are shallow, not as good for bending rods and strips, and less versatile when holding odd shapes.

C-Clamps and Vice Grips. The clamps can keep plywood work surfaces in place and prevent larger projects from moving. Vice grips are surprisingly versatile as a minimal vice, even better when a helper is available.

Portable Benches. An elevated work surface that avoids being bent over all day is a blessing for larger projects. Add a clamping function and they can be darn handy for working on rudders, cabinetry, and larger parts.

Beware of leaving many of these in the elements; they have particle board tops, which although plenty strong, will warp if left in the rain. A passing shower is harmless, but don't let it become a habit.

ON THE BOAT

Food Service Tray. Perfect for painting, fiberglass work, minor bangs, and catching small parts. Great for rebuilding carbs, winches, and holding the varnish can. Indestructible and compact. Can also be scrubbed off and used to clean fish! $2.50.

Bottom Line: One of the Best Buys on the boat.

Fender Board. A mandatory accessory for cruisers that go far or more to pilings, they can also be used to lash jerry cans to the stanchions or as a surface to cut and pound on. A good reason to stay simple, with pressure treated lumber or red cedar. About $5-10.

Bottom line: Fender Boards are Recommended for mooring to pilings and for projects.

IN THE WATER

Concrete Mixing Tub. Sized to hold 29 gallons of concrete, these are rugged and can easily support 75 pounds of tools and parts. A dinghy can work, but it's really hard to reach over the side. About $12 at any home improvement center.

Bottom Line: Handy for big in-water jobs.

Dishwashing tray or Litter Box. Good for smaller jobs, like changing a prop or cleaning the bottom. $3-$5.

Bottom Line: Recommended, because you need a dishwashing tray anyway.

ON THE HARD

Workmate 450, Black and Decker. I've gone through three of these, over 30 years of hard use. They aren't industrial grade, and leaving them in the rain or running the clamps in too tight takes a toll. On the other hand, they fold in moments, are quite stable, and with an extra board inserted they make good work tables. The wide clamp holds larger wood working projects, and the bench stops. There is also a lighter duty model—the Workmate 250—but In my mind, if I'm going to lug a bench, I want the 450.

Black and Decker Workmate

Bottom line Recommended for home and boat yard use.

Grizzly Mini-Bench. A baby cousin of the Workmate, I've seen this table top version on a number of boats, including some full-time cruising friends. They found it useful when working on projects, but eventually gave it to a beginning cruiser when their projects were finished. They felt OK about this, since they had been given it by another cruiser who had finished his move-in projects.

Bottom line: We can recommend it as useful, but whether it is worth the space on-board depends on the size of the boat and the work you are doing.

Drill Press Vice, 4-inch. My home shops has a heavy 6-inch machinist's vice, bolted to an even heavier bench, bolted to the wall. I use it to bend thick metal and to hold things while cutting. I use it more often than the drill press vice, but as I think about it, often it is just a matter of convenience and where it is located.

If the job requires precision drilling of small parts, I reach for the drill press vice, even when I'm not using the press; it holds the parts better. Because it lies flat, there is very little leverage and I often use it without securing it down at all.

Bottom line: More useful than a bench vice if you don't have a heavy bench to bolt it to.

The Grizzly workbench, modified with some outdoor carpet on the bottom can be used for a variety of onboard projects. The Black and Decker workmate series benches (below), collapses and can provide a handy platform for boatyard work. Just don't leave it out in the rain.

CONCLUSIONS

My cafeteria tray shows the scars of hundreds of uses. I've banged on fender boards, laid sheets of plywood on the dock, and wedged work against pilings. Precision drilling or working on engine parts might include both the cafeteria tray and my lazarette cover vice. For large project on the hard, my Workmate 450 comes with me. A good work surface and clamps can be just as important as what's in your tool box.

CONTACTS

BLACK AND DECKER, www.blackanddecker.com

GRIZZLY, www.grizzly.com

Photos courtesy of the manufacturer

Practical Sailor®

Twist Your Way Back to Safe Harbor

By Drew Frye

Last month we looked at some get home "kludges" if your rigging fails. Here I'll share some other quick fixes to get you home when things go wrong. All you need is a little twist

PS ADVISOR

THE NO SOLDER TWIST

The outboard charging harness tears apart on your daysailer. Although a sealed crimp connector is the right answer, you didn't have the parts.

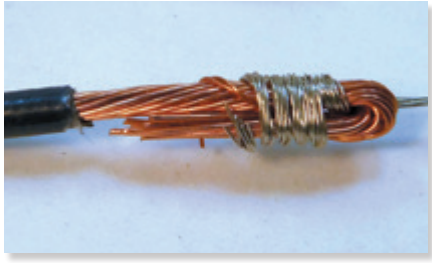
Kludge. Don't just twist the wires together; you might not even make it home. The Western Union Splice is the gold standard for splicing solid wire without a crimp.

Unfortunately, by code, boats only use stranded wire, and the Western Union Splice is weak with stranded wire. It also takes a lot of wire. Instead, bend one of the wires double with a loop at the end, thread the other through the opening and wrap the tail around the double wire at least 3 turns (see image below right).

Tape thoroughly and replace with a crimp when you get home. In previous testing, we referred to this as a half-lineman's splice ("Connecting Small Wires, Part II," *PS* December 2016).

PLUMBING

Stainless clamps are often low grade or have carbon steel parts (see hose clamp report *PS* August 2016). Often they rust on the side you can't see.



Kludge. Your spare clamps should all be the same width, so that they can be chained together to fit all sizes. Alternatively, rigging wire can apply considerable tension if each turn is snugged independently by snubbing after each turn, like a running tugboatman's hitch. Even polyester cord or whipping twine will do. Pulling with vise grips helps.

First, form a tight loop by twisting with pliers around a Phillips screwdriver. Then make as many wraps as possible, in alternating directions every 60 degrees, pulling hard with vice grip and then locking off by bending over sharply through the loop.

CHAFED HOSE

Lots of tape works for a suction leak on a cold water hose, but not if there is significant pressure or if there is heat or petroleum (the adhesive melts away). Instead, cut a slightly oversize piece of rubber from another hose (surely something is too long) and clamp it over the bad spot using a row of metal hose clamps with no gaps between them.

The stiffer the hose, the better this works, and it's best if you catch it before it actually blows. Also very good on pipes. If you're going to keep a sheet of rubber in your kit, 3/16-inch fabric reinforced nitrile is most versatile.

Drew Frye is technical editor of Practical Sailor, he blogs at his website www.sailingdelmarva.com.

Photos by Drew Frye

A few tight wraps is all it to replace a hose clamp or splice a wire