From the Editors of





Marine Sanitation Systems Volume Two

Table of Contents

EDITORS DARRELL NICHOLSON ANN KEY

PUBLISHER TIMOTHY H. COLE

EDITORIAL OFFICES 7820 Holiday Dr. S., Suite 315, Sarasota, FL 34231 practicalsailor@belvoirpubs.com www.practical-sailor.com

Δ	Chapter 1: Sanitation System Plumbing Sanitation Hoses • Hose Installation Notes • Manufacturers' Advice • Y-valves Bench Test • Y-valves Installation Advice • Plumbing Options	Page 3
Δ	Chapter 2: Holding Tank Test Sealand vs. Trionic	Page 14
Δ	Chapter 3: Holding Tank Sensors External Tank Sensors • Internal Tank Sensors • Long-term Test Results	Page 16
Δ	Chapter 4: Controlling Head Odors Waste Vent Filters • Proper Vent Installation • Holding Tank Treatments • Inline Deodorizers	Page 23
▲	Chapter 5: Maintaining A Healthy System	Page 33
¥	Contacts Directory	Page 34



Practical Sailor (ISSN #0161-8059) Marine Sanita-tion Systems e-book is published by Belvoir Pub-lications Inc., 800 Connecticut Ave, Norwalk, CT 06854-1631. Copyright © 2012, Belvoir Publica-tions, Inc. All rights reserved. Reproduction in whole or in part is strictly prohibited.

Contact information, product availability, and product specifications included in this e-book may have changed. We recommend supplementing this report with online research or calls to the manufacturers to ensure that you have the most up-to-date information when purchasing any products.



Sanitation System Plumbing

Sanitation Hoses • Hose Install Notes • Manufacturers' Advice • Y-valves Bench Test • Y-valves Installation Advice • Plumbing Options

We've often fantasized about the invention of some scientific doodad that could make waste disappear with the push of a button or at least transmogrify it into something useful (such as biodiesel or gold doubloons). Until that happy day arrives, sailors will continue to have need of a reliable way to collect and store waste until it can be properly disposed of.

What follows are our bench test results on everything from holding tanks to diverter valves, as well as some tried-andproven tips for controlling head odors and properly maintaining your system.

Sanitation Hoses

There simply is nothing like the smell of the sea. Unfortunately, the smell of a boat with defective sanitation hose is nothing at all like that.

Sanitation hoses are specifically designed to contain odorous gases. They are made of very different materials than the many similar-looking hoses used for fuel, coolant, and tap water— and they are not interchangeable.

In September 2000, *Practical Sailor* reported on our hosepermeation study, which used carbon disulfide as a surrogate for sewage to test for permeation and other signs of deteriora-

tion. SeaLand's OdorSafe Plus hose was the clear winner in that test, but a few synthetic-rubber hoses known to provide good service failed. One, Trident 102, is known to be dependable, and the maker claims there's never been a documented failure with it in over 15 years. Hose maker Shields was similarly surprised with its hose's failure.

Since carbon disulfide is used as a solvent in the production of rubber, was this test somehow unfair or irrelevant? Much as a pure oxygen atmosphere can cause metals to burst into flame that would never burn in atmospheric oxygen, did the use of a single chemical cause failures that were not real?

Practical Sailor repeated the test using diluted chemical in place of sewage and by using vapor only, but the results were similar. We never were able to establish a correlation between the test bench results using synthetic waste and those using real waste in the field.

One year ago, we launched a new round of long-term waste hose testing. This time, we decided to use actual

sewage, the waste of a 20-pound iguana. This article will look at the various hoses and materials we're testing, and the Value Guide offers our preliminary results after one year.

A LOOK AT HOSE MATERIALS

The builder of *PS* tester Drew Frye's catamaran, PDQ Yachts, had the good sense to place the holding tank and all of the sanitation hoses in a bulkhead compartment, sealed off from the rest of the boat. Unfortunately, someone also had the poor sense to use clear vinyl hose for the vent lines, which didn't resist permeation at all, turning yellow and stiff and sticky with a foul surface residue. They also used ordinary reinforced exhaust hose for the sewage and pump-out lines; these didn't fair much better than the clear vinyl.

Over time, a brown residue formed on the surface, and the whole compartment became foul to the point where retrieving the fishing poles stored there became quite an unpleasant task. It seems a reinforced fuel or coolant hose, no matter how well built, simply can't contain the stink of stagnant sewage. Given three to five years, the odors simply go right through the wall (permeate), and the boat becomes unlivable.

In a home, sewage is contained by metal and polyvinyl chloride (PVC) pipes—completely impervious to permeation—but these rigid materials usually are not practical on a boat, given the fitting and flexing challenges a marine installation presents. As it turns out, achieving long-term resistance in a flexible product





is a real challenge.

Instead of nitrile and neoprene—the material of choice for fuel and exhaust hose—boat owners should look at urethane, butyl, EPDM, and PVC hose for sanitation systems.

Why isn't PVC pipe, vinyl tubing, or vinyl hose the best choice? Because PVC pipe is rigid, and vinyl hose is softened by adding plasticizers; on a chemical level, these have the effect of leaving the plastic porous. The softer the formulation, the faster acid gases like hydrogen sulfide and carbon disulfide seep through. Soft vinyl tubing fails in months and is included in this test only as a reference point. The vinyl sanitation hose in the test (SeaLand OdorSafe Plus) is very stiff, contains much lower levels of plasticizers, and contains other polymers that help block odors; a hybrid product of sorts. This is a necessary compromise, aimed at delivering the required permeation resistance with adequate flexibility.

Butyl rubber is known for very low gas permeation rates—it's been used for inner tubes for many years and even today, all tubeless tires use a laminated butyl rubber liner to control air loss—but it doesn't handle oils well at all. Of course, sanitary waste doesn't contain oil, and when used properly, head lubricants are too limited in volume to be an issue. However, disposing of any oil or solvent in the head or placing oils in a head plumbing system in a manner where they will be in the hose or head for any period of time is likely to damage any sanitation hose and elastomers in the head itself.

EPDM is a common choice for steam hoses and is used in highend engine coolant hoses because of its low permeation rates with hot water and glycol (antifreeze). It resists acids and bases well, but has a weakness regarding oil.

Polyurethane has a good combination of chemical resistances and also resists oil. However, air and steam permeation rates are higher than butyl and EPDM, respectively. It is common in hoses used by honey dippers. Whether it resists sewage well, we will see. Wastehose maker Shields has combined this with other polymers into a composite hose, an approach that is common in chemical hoses.

WHAT WE TESTED

We tested flagship sanitation hoses from four of the market's leading manufacturers. The test field included Trident Marine's 101/102 EPDM hose; SeaLand's OdorSafe Plus, a PVC and ac-

Suspending a 1-pound, ball-peen hammer from the end of a hose is a simple but effective test to measure hose stiffness.

rylonitrile butadiene rubber hose; Raritan's butyl rubber Sani/ Flex Odor Shield; and Shields Marine's Poly-X polyurethane sanitation hose.

For comparison, we also tested schedule 40 PVC sanitation pipe and clear vinyl hose made by Trident. PVC pipe was selected as a material known to resist permeation indefinitely, while clear vinyl hose was selected as a material expected to fail and as a product that is occasionally found in marine sanitations systems with universally disappointing results.

HOW WE TESTED

To mimic real-world conditions, we created a series of six miniature holding tanks—5-gallon buckets with lids—containing sanitary waste supplied by a 20-pound, 5-foot iguana. Seawater was used to "flush" the tanks, as the odor problems are known to be more severe with seawater-flushing systems, the result of bacteria reducing sulfate into more odorous chemicals.

These are the same holding tanks we're using for the longterm waste vent filter test (see chapter 3). Testers used 3/4- to 5/8-inch hose fittings, as required by each vent filter design. A 4-inch PVC filling standpipe with valve was used to fill each tank with 1 gallon of sewage every five days (effluent plus seawater). The holding tanks were dumped each time they reached 80-percent capacity.

A hose was attached to the bottom of each holding tank, so that it is continuously filled with sewage. Although having hoses fully submerged in sewage is contrary to the installation advice of every hose maker, they agreed that the method was a sound way to force failure and is something they use in their own testing programs. None of the manufacturers consider their hoses to be permeation "proof" and recognize that permeation will eventually occur, if sewage sits in the hose continuously.

Proper installation of sanitation hose includes sloping all lines toward the holding tank, and proper head operation includes pumping enough water after the sewage to clear the line. We ignored this advice to force failures.

We also tested hose flexibility. Manufacturers give minimum bend radius limitations for hose, but just what the ratings mean is unclear. Different makers rate the allowable radius bends at different temperatures, and it's not always specified whether the number indicates where kinking begins, the farthest it can be pressed, or is simply a "good practice" value.

To determine uniform measurements for radius limitations, we devised two tests, both performed at 65 degrees. (See results in the accompanying Value Guide.) To measure stiffness, we clamped a 1-foot section of the hose being tested to the edge of a workbench, suspended a 1-pound weight from its end, and measured the vertical deflection after 10 seconds. This gave testers an idea of the hose's relative stiffness and workability. To measure bend radius, we took a length of test hose and pressed it until it showed signs of buckling. Some were very difficult to bend to that threshold, most notably the SeaLand OdorSafe. Raritan Sani/Flex, on the other hand, bends easily to its minimum radius

PS VALUE GUIDE SANITATION HOSES PRELIMINARY RESULTS									
MANUFACTURER	RARITAN	SEALAND	SHIELDS	TRIC	DENT	PVC			
NAME	Sani/Flex Odor Shield 🛩	OdorSafe Plus 🖊	Poly-X ★	101/102 \$	Clear vinyl**	Schedule 40**			
PRICE / FOOT*	\$13	\$9.65	\$19.62	\$7.99	\$5.99	45¢			
MATERIAL	Butyl rubber	PVC and acrylonitrile butadiene rubber	Polyurethane	EPDM	PVC	PVC			
ТҮРЕ	Sanitation hose	Sanitation hose	Sanitation hose	Sanitation hose	Potable water hose	Rigid pipe			
SIZE TESTED	1.5-inch ID	1.5-inch ID	1.5-inch ID	1.5-inch ID	1.5-inch ID	1.5-inch ID			
COMMENTS	Can kink if forced because it is so flexible.	Very stiff; smooth surface; easy to clean	Smooth surface; easiest to clean	Distinctive rubber smell; stains easily	Becomes yellow when permeation is severe	Susceptible to freeze damage; not flexible			
		TEST	RESULTS						
PERMEATION @ 6 MONTHS	None	None	None	None	Minor (only present in wipe test)	None			
PERMEATION @ 12 MONTHS	None	None	None	None	Major (noticeable by smell)	None			
STIFFNESS (DEFLECTION @ 65 DEGREES)	4.25 inches	0.21 inches	0.56 inches	1.25 inches	Not measured; limp	0.1 inches			
U-TURN RADIUS (@ 65 DEGREES)	7 inches	20 inches	12 inches	11 inches	Not measured; kinks easily	Not applicable			
★ Best Choice \$ Budget Buy	Recommended		*Prices may vary,	depending on retai	iler. ** Only tested	as reference.			

but would be ruined if pushed hard.

The stiffness values will certainly be less at warmer temperatures—based on our experience working with these in hot weather—but the minimum bend radius will not be much different. The rubber hoses were softened slightly by warmer temperatures and stiffened slightly in cooler temperatures, but temperature seemed to affect the OdorSafe hose the most significantly. It rapidly stiffened below 60 degrees in testing, was not workable at 50 degrees, and was effectively rigid at 40 degrees. Conversely, it softens rapidly with heat, and on a 90-degree day, it would be comparable to a stiffer rubber hose. However, adding heat to gain flexibility is not recommended by the manufacturer; the hose can be weakened and more prone to kinking.

When it comes to waste hoses, there is only one true measure of effectiveness: whether the vent stinks when the head is flushed. However, as much as we might like to have calibrated noses and compared the relative foulness of the products, it wasn't possible. Instead, we sought a quantitative figure for direct comparison by using a hydrogen sulfide monitor (like those used to test sewer gas) to back-up our sniff testing.

At regular intervals, the hoses were tested as follows: Each month, each hose was wrapped in aluminum foil and sealed for one week. The fittings were not in the wrapped section, to avoid any contribution from potential leaks. The hydrogen sulfide detector was inserted under the foil and a reading was taken. This was followed by a sniff test. At the end of the test period, each hose was wiped with a damp cloth and the cloth sniffed. Each hose also was observed for changes in appearance. During this initial test period (one year), none of the sanitation hoses permeated enough sulfide for the gas to be detected or for any odor to be perceived under the wrapping. However, after four to six months, the clear vinyl hose did fail the wipe test.

Testers will continue with the testing for the next several years to determine which product is the best, most durable waste hose for onboard use. We want to emphasize that the ratings and recommendations at this point are only preliminary; look for followup reports in future issues.

SEALAND ODORSAFE PLUS

The lone PVC-based sanitation hose in this test, SeaLand's Odor-Safe Plus, is a well-respected but very stiff hose. In some cases, we had to gently warm the hose (but not so much that it could not be held) and fitting to get it to slide on the barb; this was not required with any other hose. For this reason, the manufacturer sells a special silicon hose lubricant and recommends the use of its special smooth hose adapters in place of traditional barbs.

The hose's smooth finish is easy to clean, and of the hoses we tested, it looks the best for exposed runs. The OdorSafe, which out-performed all others in the previous test using synthetic odor, is performing well at the one-year mark in this test, with no signs of permeation. It is available in $1\frac{1}{2}$ inch only.

Bottom line: The stiff OdorSafe was very hard to fit in our test boat installation (see "Field Test Installation Notes"), but we expect it to excel in permeation resistance. It would be a solid choice for installations where space is not too tight. It's Recommended at one year.



TRIDENT 101/102

The 101/102 from Trident Marine Systems is a premium hose with a proven track record; we have not heard of a single documented case of permeation issues using this hose. The Trident 101/102 rated in the middle of the pack for stiffness, and testers had no difficulty fitting it in our test bench and test boat installations. However, testers did find the white hose significantly prone to picking up dirt and minor staining, but this would only be an issue for the most fastidious plumber.

Testers also noted that it has a very distinctive and slightly acrid "new rubber" smell that lingered for 12 months, but it was only noticeably strong—even in a small compartment—for about a week. Would this bother someone with a sensitive sniffer? We don't think so; it's more like new car smell than something foul.

The 101/102 is available in 1-inch, 1 $\frac{1}{2}$ -inch, and 1 $\frac{7}{8}$ -inch sizes, but only 1 $\frac{1}{2}$ -inch is widely distributed.

Bottom line: Well-known as a dependable product, the Trident 101/102 has held up so far in testing, was easy to install, and can be found at an affordable price. It gets the *PS* Budget Buy pick at the one-year mark.

SHIELDS POLY-X

The Shields Marine Poly-X sanitation hose is another well-respected product, with a perfect track record, but high quality comes at a high price with the Poly-X. It was the most expensive hose we tested, costing nearly twice the price of the other hoses.

On the other hand: It has no odor of any sort, resists dirt and grime, and was the easiest of the test field to clean. Only slightly less stiff than the OdorSafe, the Poly-X was surprisingly not difficult to push onto fittings in our test installations.

It is available in 1-inch and the widely distributed $1\frac{1}{2}$ -inch sizes.

Bottom line: With a good reputation and high marks for in-

When installing waste hose, it's best practice to secure connections with two stainless-steel hose clamps.

stallation and cleaning ease, the Poly-X gets the *PS* Best Choice pick at the one-year point in this long-term test.

RARITAN SANI/FLEX ODOR SHIELD

A very flexible hose, Raritan Engineering's Sani/Flex Odor Shield is much easier to fit than any other tested hose and had the lowest bend radius in this test, making it a good choice for installing in tight spaces. However, do not be tempted to bend it to less than a 4-inch centerline radius, as kinking is surely possible. Cut and insert a PVC fitting for really tight turns. Though some people are concerned that fittings can lead to blockages, that does not seem to be the common experience; the joker valve at the exit of the head is much smaller than the fittings, so anything that can be flushed will pass through the fittings to reach the tank.

Odor Shield is available in 1 or 1¹/₂-inch.

Bottom line: The jury's still out on the durability of the Odor Shield hose, a comparatively new product, but it is worth considering for installations where very flexible hose is a must. It is a Recommended hose after one year of testing.

TRIDENT CLEAR VINYL HOSE

Trident Marine's clear vinyl hose is soft and easy to work with, but it began to permeate within four to six months and in a few test installations (vent plumbing), it often kinked after install, sealing off the vent. Our experience lends us to believe that it will continue to stiffen and permeate very badly, even in vent applications.

We want to be clear that Trident never recommended its clear vinyl hose for application in marine sanitation systems, so its failure should not be interpreted as a criticism of Trident. We knew the clear vinyl would fail, and we included it in the test solely for comparison of various hose types. In fact, every brand of vinyl hose we encountered during this test was yellowed and badly permeated.

We recommend Shields 148 or equivalent white vinyl sanitation hose for vent applications, as they will serve well in this duty and are available in smaller sizes.

Bottom line: Clear, soft vinyl tubing—in any brand—has no place in sanitary waste lines or vent lines.

CONCLUSIONS

So far in this test, no premium sanitation hose has shown signs of permeation, but we are only one year into the long-term testing, and we wouldn't expect failures yet—except with the clear vinyl hose. The clear vinyl hose permeated within a few months; it has no place in marine sanitation applications.

No hose connections leaked during the duration of the test, and none were overly difficult to seat on the hose barbs. In fact, all hoses held drip free under gravity pressure without clamping.

The white vinyl OdorSafe Plus was very stiff and difficult to deal with but should make a solid installation choice for systems installed in spaces that aren't too restricted. Premium synthetic rubber hoses are considerably more flexible, but even within the class, there are significant differences: The Raritan Sani/Flex

The test boat previously had exhaust hose installed in the waste line.

Odor Shield is quite flexible, but the Shields Poly-X and Trident 101/102 hoses are quite stiff. Whether these construction differences have any bearing on permeation and durability is not yet known. We recommend the Raritan for cramped installations that call for very flexible hose.

We were impressed with all of the test products and believe all will contribute to be trouble-free, odor-free installations for some time.

After only a year of testing, we recommend the Trident 101/102 as the budget pick. The easy to install, easy to clean—but pricey— Poly-X gets the nod for Best Choice.

Hose Installation Notes

While model holding-tank testing allows side-by-side comparisons, there's nothing like on-the-boat testing to sort out practical differences. Our test boat, a PDQ 32, had been plumbed with a mix of low-end vinyl sanitation hose and water exhaust hose; the rubber hose was permeated, cracked, and discolored, and the sanitation hose was permeated to the point of having a thin film of sticky goo that had condensed on the external surface. A textbook case of time showing the weaknesses of poor material selection.

Testers re-plumbed the sanitation system using pieces of each hose type reviewed in this article. We'll see how they hold up. Because they are not in identical exposures, the field test won't offer direct apples-to-apples comparisons of permeation resistance. However, we did learn a few things about the hoses' installation differences.

Head to tank: We used Shields Poly-X here because it appeared to be the toughest hose that would make the bends. As with many marine head installations, there is a hose bend leaving the head, and the SeaLand OdorSafe Plus hose had no chance of making the turn. As it was, we put a slight kink in the hose trying to force it into the previous tie-down locations. We ended up working the kink out and moving the tie-downs a few inches. This hose required a bit of pressure to slide on the fittings, but no lubricant was needed, and it sealed up nicely.

Holding tank to vent: We chose fabric-reinforced clear vinyl tubing, so that we could see what was going on. Since this boat is also a test bed for holding tank vent filters, we wanted to be able to monitor overflow behavior and the water trap. The boat had been previously plumbed with the same tubing to the vent, and it was badly yellowed and permeated. Clear vinyl is easy to work with and very flexible, but it's prone to collapse if bent even a little too sharply. In fact, after a few months of testing, the clear vinyl loop collapsed, and we replaced the section with Shields 148 white vinyl sanitation hose, one of very few sanitation hoses commonly available in ³/₄-inch.

Holding tank to Y-valve: We again chose Shields Poly-X. It parallels the fill hose for part of the run, and this insured matching turns.



Y-valve to pump-out: Petroleum tank truck hose was fitted here two years ago and is doing fine, so we left it in place, for comparison. It is most similar in fitting to Shields Poly-X.

Y-valve to discharge pump: We used the Trident 102 here. The bend radius was long enough, and the hose slid on the fittings easily. The liner is soft enough to seal easily. Testers found the 102 to be a very solid hose that is a pleasure to work with.

Discharge pump to seacock: We used the SeaLand OdorSafe Plus here. This section was an easy run so hose stiffness was not an issue. However, we had to heat both ends to get the hose to go over the fittings, and the seacock end was still quite difficult. (Note: SeaLand does not recommend heating hoses.) Although this hose was the most difficult to fit, testers noted that it was probably the best-looking in the test field, so the challenging install may be worth it for use in exposed locations.

GENERAL OBSERVATIONS & TESTER TIPS:

► We can easily see using more than one sanitation hose to plumb a boat, each serving where it fits best. It also seemed clear that the head-to-tank, tank-to Y-valve, and Y-valve-to-pumpout hoses were the most deteriorated.

► Before you buy expensive hose, be certain it will make the required bends. Check out the accompanying Value Guide to get an idea of each hose's stiffness.

► Ambient temperature matters. All of these hoses were much stiffer when the mercury dropped. We wouldn't choose to tackle a hose fitting job when it's colder than 70 degrees. Use a space heater on the boat, if necessary, in the winter.

► Flush a lot of clean water through the hoses first.

► PVC-coated palm gloves are a big help when muscling hose through bulkheads and onto fittings. They are also good for handling yucky old hoses.

► Glycerine is a good lubricant choice when trying to fit hoses. It's compatible with all sanitation hose types and will eventually evaporate, leaving no slippery residue, unlike soap. Do NOT use petroleum compounds on sanitation hose. EPDM and butyl rubber sanitation hoses are very vulnerable to petroleum compounds and will be damaged.

► Do not use silicone caulk to seal hoses. It only makes a mess for the next time hoses are changed, and it increases the probability of leaks. If the hose is leaking, check the barb.

► Use two all stainless-steel hose clamps, 180 degrees apart, to shore up connections.

► Except for white vinyl hoses, all sanitation hoses are wire

reinforced. The cut end of the wire is needle-sharp, so secure it under clamping bands to prevent a puncture-wound hazard. You can cut it off flush, but it's safer to pull it out and secure it.

► Inspect the bulkhead pass-throughs and smooth as needed. You can seal the pass through with caulk to prevent motion and possible chafing.

► Don't cut the new hose to length based upon the old hose. The securing points and fit will change if you switch to a different hose type.

Manufacturers' Advice

Before starting most tests, we like to interview the participating manufacturers. Below is a rundown of some advice we gleaned from the waste hose manufacturers.

► Hose routing: Always slope pipes and hoses toward the holding tank after the initial rise. Any hose will eventually permeate if sewage is left standing in it. If long runs are unavoidable, consider using well-secured Schedule 40 PVC pipe—not DWV (drain-waste-vent) PVC, which has thinner walls.

► **Head operation:** Always flush enough clean water to move all the waste to the holding tank to prevent standing sewage.

► Antifreeze: PVC hoses are not compatible with glycol- or alcohol-based winterizing products. The glycol or alcohol can extract some of the PVC plasticizers, resulting in increased permeability and stiffness. Although the hose will not fail, it may permeate. This does not apply to synthetic rubber hoses.

► Oil: Synthetic rubber hoses made of EPDM or butyl rubber may not tolerate large amounts of mineral or vegetable oil. However, small amounts of oil that may find their way into a head as a result of owner maintenance practices should not be harmful. However, this is one more reason why greasing head pumps with heavy silicone grease at the start of each season is a far better practice than the often-suggested practice of flushing a tablespoon of vegetable oil in the head. In fact, the vegetable oil will only hasten the grease's washout. This incompatibility does not apply to PVC, neoprene, or urethane hoses.

► Wipe test: If you suspect a permeated hose, scrub the hose area clean, wait for several days and then wipe the suspect hose with a damp cloth and sniff the cloth. If it is permeation, the odor will come back soon enough.

► Leaks: Although permeation is a common cause of hose odor, it is by no means the only cause. Slow leaks around fittings and hose clamps, and sewage that was inadequately cleaned up are also frequent causes; inspect the ends before assuming you have a failed hose. A crooked clamp or scored barb often allow leaks that will not be cured by tightening a clamp. It is tempting to cure a leak by using a sealer (polyurethane or silicone caulk), but generally this is temporary and is very bad practice when installing new hose. Instead, fix the problem.

► Hose connections: Barbs vs. smooth adapters. SeaLand, maker of the SeaLand hose brand, is a believer in smooth connections. Properly sized, the company claims, they are easier to use, seal better, and do less damage to the hose. This is particularly true with the stiff PVC hoses, like SeaLand OdorSafe Plus, which fits well enough on barbed fittings but is impossible to remove. For high-pressure applications, some type of contoured or barbed fitting is still generally recommended, though many hose makers now specify rounded profiles. Not all fittings are a good match; if fit seems too loose, check with the hose maker.

► Hose lubrication for installation: A compatible lubricant can be a big help in getting a hose installed correctly. Read the hose specs to be certain the lube is compatible. EPDM, for example, is not compatible with petroleum, so K-Y, glycol, or glycerine are better choices. Soap will work but can leave a non-drying residue that can interfere with a secure fit, particularly when using non-barbed fittings. SeaLand sells a silicone grease for use with its hose.

► Sharp turns: Many sanitation hoses are quite stiff and don't like sharp turns; even if you can bend them to your will, it shortens their life. The manufacturers maintain that it is better to use a PVC elbow fitting as needed than to risk kinking a hose by forcing a turn. The fitting will be larger than the smallest passage in the toilet and should not create a problem.

► Fit the hoses a few inches long: Hose removal often involves destruction of the hose. Providing a few extra inches to play with will simplify future repairs, rather like leaving halyards a few feet too long to allow for wear and cutting off knots.

► Heat: While many authorities suggest using heat to help a stiff PVC hose onto a fitting, SeaLand does not recommend the practice. A company representative explained that the key is moderation; the hose and fitting should be no more than warm to the touch. The problem is that often, customers take heating too far, the hose is weakened, and failures are blamed on the maker. We found heating with hot water was required with the SeaLand OdorSafe Plus hose; it was awkward, but it allowed us to insert the fittings with reasonable effort.

Y-Valves Bench Test

Continuing with our recent evaluations of marine sanitation systems, *Practical Sailor* tested eight marine-grade diverter valves, or Y-valves. Y-valves are a means of controlling the flow of liquid from one source to two different outlets or from two sources to one outlet. On boats, one use is to control waste management. The Y-valve directs toilet waste to either a holding tank or directly overboard through an appropriate seacock.

Many states require that the valve be locked in the holding tank position while sailing lakes or inland waterways. Under federal regulations, no overboard holding-tank discharge is allowed within three miles of shore.

A Y-valve can also be reversed and used in a bilge-pump arrangement to select between two separate bilge areas using only one bilge pump.

WHAT WE TESTED

The test field for this evaluation comprised seven manual diverter valves and one electric valve from seven manufacturers. The Bosworth Co. is a family-owned, Rhode Island company, while Gross Mechanical (Groco brand) is a third-generation maker of marine



The TruDesigns' color-coded O-rings (above left) allow multiple size fittings to be used. The Groco valve (above right) uses large, threaded pipe fittings.

hardware and is head-quartered in Maryland. Jabsco, Forespar, Johnson Pump, and Whale are all worldwide players in the leisure marine market. (Jabsco is now part of Xylem Flow Control, a new spinoff from ITT Industries.) TruDesign, the maker of the only electric diverter valve in this test, is a New Zealand-based manufacturer of marine composite fittings.

HOW WE TESTED

Practical Sailor tested the diverter valves to determine which were the top picks for marine sanitation systems or for installations where a manual or electric pump may be used in conjunction with the valves.

All of the Y-valves tested were new, never used, and dry. Testers mounted them to a piece of lumber for the bench tests. Ambient temperature during testing was about 72 degrees, and there was no wastewater or matter present in the test-bench setup.

To rate how easily each valve's handle turned, we attached a Manley bronze spring scale (calibrated to 50 pounds) to the hole in each handle (designed for locking the handle) and measured the amount of pull needed to release inertia and move the handle. The placement of the holes in the handles was not consistent, with some at the end and a few near the handle center, so some mechanical advantage was lost for those with holes closer to the center. Testers kept this in mind when calculating the ratings.

The ratings listed under "initial handle stiffness" in the Value Guide are the averages of 10 pulls. The "stiffness after some use" ratings are the average pounds of pull required after the handle's seal was loosened up.

Some valve handles were stiffer to turn than others. Several TI manufacturers advise you to keep the valve seals lubricated, recommending silicone grease or even Vaseline, and suggest operating the valve frequently, at least once a month, to prevent the greater from seizing up. Several units loosened up after we did the pressure test.

To test resistance to odor and water leaks, we attached appropriately sized sanitation hose to one outlet port and capped the other end of the hose. To the other outlet port, testers connected a garden hose with 55-pounds per square inch (psi) of water pressure. We worked valve handles back and forth for 30 seconds each and left them in the closed position for two minutes with the water running. We evaluated the smoothness of operation, the feel for a positive stop in both positions, and leaks from the outlets, base, or handle.

Practical Sailor recognizes that a Y-valve in a marine sanitation installation during normal operation would be less than 55 psi (more like 2 to 10 psi) and there—ideally—would be no blocked outlet, but we consider the pressure to be a fair amount for the purpose of our tests. Diverter valves are also used in other systems—sometimes in conjunction with a manual or electric pump—and those installations would see greater pressure than a valve in a waste-disposal setup; also these systems do become clogged.

Unlike seacocks and through-hull valves, there are no industry standards for Y-valves related to pressure. According to Forespar's Bill Hanna, the company shop-tests each of its valves to 45 psi. Similarly, Groco tests its valves to 30 psi, and Forespar also randomly leak-tests its valves to 50 psi but does not move the handle during tests. Whale tests its valves to 17 psi but does so with them in a traditional installation setup.

For this test, *PS* also considered the valves' prices, ease of installation and maintenance, construction quality and materials, and whether they could be easily locked in accordance with some areas' laws. Most units come with holes or feet for mounting the base to a deck or bulkhead and offer handle extensions for allowing the handle to be on the front of a bulkhead for easier access.

BOSWORTH SEA-LECT

The Bosworth Co.'s BM94 Sea-Lect valve was the most simple and compact of our test samples. It was the only one with ports to 1-inch ID hoses, and they are smooth and fixed to 120 degrees. It is also available for 1½-inch hose, NPT tapped ports, and flush mounting.

The body is made of Delrin, and the handle is epoxycoated aluminum. Delrin is an acetal resin that is as strong and hard as a metal but is easily molded and resistant to salt, solvents, and friction. Bosworth offers a whole series of polypropylene and nylon-barbed fittings and adapters for hoses from ½ to 2 inches.

VALUE GUIDE	Y-VALVES FOR MARINE SANITATION SYSTEMS								
MANUFACTURER	BOSWORTH	JABSCO	FORESPAR	GROCO	JOHNSON	WHALE	TRUD	ESIGN	
MODEL NO.	BM94 Sea-Lect 🖊	45490- 1000 ★	90200 (MF852) \$	TWV- 1500 🛩	81-47238- 01 Aqua T	DV5606	1169 (Raritan TD 90314)	EA 015 (Raritan TD 90344)	
PRICE	\$55	\$73	\$69	\$208	\$83	\$78	\$112	\$680	
WARRANTY	5 years	1 year	3 years	1 year	2 years	5 years	1 year	1 year	
MATERIAL	Delrin	Polypropylene	Marelon	Bronze	Polypropylene	Delrin	Nylon	Nylon	
DIMENSIONS (inches)	3.75 x 4.5	4 .63 x 8.5	3.38 x 4	7.5 x 7	4.75 x 8.5	5.5 x 6	4.38 x 10	6.5 x 10	
			1	EST RESULTS					
LEAKS	No leaks	No leaks	No leaks	No leaks	Small leak by handle	Small leak at ports	Leak at ports	Leak at ports	
INITIAL HANDLE STIFFNESS	Good	Good+	Good	Good	Good+	Good+	Good+	NA	
STIFFNESS AFTER SOME USE	Good+	Good+	Good	Good	Good+	Good+	Good+	NA	
★ Best Choice \$ Bud	★ Best Choice \$ Budget Buy ⊬ Recommended								

Although the Bosworth's handle has a hole, there are no corresponding holes in the housing into which you could insert a padlock, so it's unclear how you would lock the valve closed. The handle was well-marked with molded arrows for the flow direction.

Handle operation was stiff at first but became smooth. Bosworth re-designed its valves in 2011 to make them easier to turn and more resistant to the freeze ups that sometimes occur

with Y-valves. The Sea-Lect came with a tube of Dow Corning No. 44 grease and was unique in explaining how to lubricate the inside of the body completely, at least once a year.

Bottom line: The Bosworth Y-valve was trouble-free in testing, has a compact design, and at \$55 (with a five-year warranty), it was the least expensive of the products tested. It gets *PS*'s Recommendation for a valve in this size range.

JABSCO

Jabsco's 45490-1000 has a larger footprint than some other valves because it comes with two curved, 120-degree, 1¹/₂inch discharge ports that can rotate in any direction to make plumbing it easier. It comes with both 1¹/₂- and 1-inch screw-in inlet port adapters.

The body and handle have holes for accommodating a padlock to prevent discharge and comply with discharge regulations. The valve body is made of chemical- and corrosion-resistant polypropylene with stainless-steel bolts, screws, and bright silver, inlaid flow arrows. The ports and diverter shaft have replaceable O-ring seals.

Made in China, the valves came with a well-written four-page instruction sheet. The unit is easy to disassemble for cleaning and lubricating, and testers found operation to be very smooth, with positive stops and no leaks. **Bottom line:** The Jabsco performed well in our tests, and its rotating outlet ports and easy locking arrangement were bonus features. Priced at \$73, it gets the *PS* Best Choice in this test field.

FORESPAR

Forespar, established in 1967, has an extensive line of sailing hardware and marine plumbing parts. The Forespar MF852 (No. 902000) Y-valves we tested are made of Marelon, a proprietary

formulation of polymer composite compounds designed for use in marine plumbing systems and use below the waterline. Marelon is lightweight, easily molded, and resistant to the ravages of saltwater corrosion and electrolysis.

The Forespar Y-valve is available in four sizes with hose barbs from ³/₄ to 1¹/₂ inches. The valve has a small, rounded handle, which enables it to have a small footprint: 3.5 inches wide by 4.5 inches tall.

The smooth handle moves only 120 degrees and includes a hole for a padlock, but there are no corresponding holes in the valve base. The handle movement was quite stiff initially, and under pressure, it was even stiffer until it locked up. According to Forespar Sales Manager Art Bandy, this was likely a result of the high pressure used in testing, which could have forced the valve's internal seals to seat beyond normal use.

A second sample was tested, and it worked better with no leaks and a smoother operation under pressure. It rated in the middle of the pack for ease of turning. We can only assume the difficulty with the first test valve was an anomaly.

> The MF852, which comes with a three-year warranty, is designed for easy maintenance and repair, and repair kits are available.

> **Bottom line:** The Forespar MF852 is compact and costs \$69, a bit less than the top-rated Jabsco. It gets our Budget Buy pick for installs where its small stature is a good fit.

Forespar

GROCO

Groco, founded in 1918, manufactures a line of specialized bronze valves, seacocks, pumps, marine toilets, and holding tanks. The Groco TWV-1500 is a heavy-duty, bronze three-way valve with ports for 1½-inch threaded pipe fittings.

It's important to use the correct pipe threads. Straight ones posirequire a lot of space to bend the hoses, which can be a real problem in a tight space. Be sure to determine which way the hoses will run before mounting the valve. Groco markets a full line of prest threaded fittings that are available from West Marine stores.

The Groco is heavy and compact, but it has only two mounting holes, whereas the other test products had more. The handle mounts on the side and points to the flow direction with the center closed "off." No instructions were included, but none were needed.

The valves are heavy-duty cast bronze with stainless-steel. The coated-stainless handle was initially quite stiff, but after some lubrication and working back and forth, it loosened up adequately.

The handle rotates a full 180 degrees. It does not have any indicators for flow direction, but it's a logical design that's intuitive to use.

Under pressure, the Groco, with its PTEF seats and seals, worked better than any other test product and had no leaks.

Bottom line: Although the \$208 Groco is considerably more expensive than others, the cast-bronze housing is likely to outlast those made of plastic, and with only one bolt for the handle, it has few parts to worry about breaking. It gets the *PS* Recommendation for its bullet-proof design, top-notch performance, and smooth operation. Some things are worth the added expense, and the Groco is one of them.

JOHNSON PUMP

Johnson Pump is a division of Sweden-based SPX Flow Technology, which is a leading manufacturer of marine pumps, marine toilets, and sanitation accessories.

The Johnson Aqua-T Diverter Valve (No. 81-47238-01) came with reducers and a handle extension for flush mounting. The valve looks very similar to the Jabsco we tested, but it came with no instructions.

The operation was smooth, but the handle has no marking to indicate flow direction, and it was a little confusing which position was open or closed.

In bench testing, the Johnson valve leaked under the handle when operated under pressure.

Bottom line: The Johnson valve's leak and lack of flow indicators held it back.

WHALE

Founded in 1810, Whale Water Systems manufactures fresh, gray, bilge, and wastewater pumps, showers, faucets, and accessories. The Whale diverter valve is made of Teflon-coated Delrin acetal composite that is manufactured in Ireland and comes with a five-year warranty.

The Whale DV5606 diverter valve is fairly compact and has smooth 1¹/₂-inch ports at 90-degree angles.



When plumbing hose to smooth ports, be sure to secure it with two hose clamps. The Whale has four mounting flanges

and three holes in the body, but there is no hole in the handle for securing it to the body. It includes stick-on arrows and labels such as "Tank," "Sea," etc., and the handle points to the "open" position.

The unit is compact, its operation is clean and very smooth, but it did leak through the closed port when operated under pressure. We tested a second sample, and it also leaked.

Whale explained that leaks were rare, but in our case, it was likely a result of the high pressure used in testing. The valve is not rated to 55 psi.

"Our testing is carried out with a normal installation of an open head, i.e. an open seacock overboard or open inlet to black waste," Whale Engineering

Manager Richard Bovilli explained. "Typically, the pressure in this installation is only generated by flow of the pump, which is always less than a lift of 13.1 feet or 7 psi (0.4 bar)."

Bottom line: The leaks and lack of permanent flow indicators kept testers from favoring the Whale valve.

TRUDESIGN MANUAL

TruDesign products are made in New Zealand and sold in the U.S. through Raritan Engineering Co. (www.raritaneng.com). We tested the Manual Aquavalve (Model 1169; sold by Raritan as No. 90314).

Made of glass-reinforced nylon composite, the white valve we tested had black lettering identifying it as a "Toilet Diverting Valve" and labeling the three ports as "Inlet," "Overboard," and "Holding Tank." It clearly shows which port is closed and which is open, a feature testers liked.

TruDesign's Aquavalve has holes to secure a padlock in one of two positions and includes three 1½-inch thread to 1½-inch hose nipple adapters (one straight, one 90 degrees, and one 120

degrees). They come with appropriate washers and a plastic wrench, but the threads are not standard PVC pipe threads. Installers must determine which fitting and washer each port should have before screwing in and screwing down the base.

The Aquavalve has a silicone seal, which Raritan said gives less resistance when changing the flow from one port to another. The silicone also will not bind to its housing when unused for extended periods, a common problem among diverter valves with rigid seals.

> When we applied water pressure during bench tests, testers heard a "pop" inside the valve housing, which resulted

in considerable leaking from the closed port. Raritan reported that in seven years of production, there have been no customer complaints of experiences like ours. The company carried out its own test, trying to replicate our problem, and found that it was related to the high pressure in testing.

"The pop sound comes from the silicone seal coming out of its seat and relieving all the pressure



TruDesign

Electric

suddenly—just like a cork from a champagne bottle," Raritan's Kim Shinn explained. The silicone seal can be re-seated by moving the handle back and forth, if the handle does not offer resistance. If there is resistance, Shinn said, then the only safe way to re-seal the valve is to take the unit apart.

Shinn added that although there is no standard for Y-valve pressure ratings, the American Boat and Yacht Council and UL standards related to hull piping specify

that sea valves tolerate 10 psi test during opening and closing. "We tested the Aquavalve with 10 psi applied and opened and closed (the valve) 25 times as per UL 1121 17.3, and there were no leaks. We also applied 45 psi for one minute in the closed position as per 18.1 of UL 1121, and no leak and no pop sound."

Bottom line: The second most expensive (\$112) manual diverter valve tested, the Aquavalve has some great features. However, its strong point—the silicone seal— may also be its Achilles heel in moderate- to high-pressure installations.

TRUDESIGN ELECTRIC

TruDesign's EA015 Electronic Aquavalve (sold by Raritan as No. 90344) uses a similar valve body as the manual valve, but the manual handle was replaced with an electric one, a small remote-control panel (2½ by 3½ by 5/8 inches), and a 15-foot data cable. It can be ordered in either 12- or 24-volt.

The 12-volt Aquavalve requires 3.3 amps to operate and 40 mA in standby. The valve housing and control panel are dust- and jet-spray proof. To insure seal lubrication, the valve automatically cycles between ports at regular intervals (so long as the power is on).

The top of the valve and control panel have colored LEDs to show the position of the valve. The control panel has three pushbuttons, two for the valve positions and one to lock it in place. The electrical hookup was very simple.

Testers experienced the same seal popping and leaking in the electric version as we did with the manual TruDesign. The remote panel flashed all three LEDS showing a "fault," indicating there was a blockage in the valve's rotation. When this happens—or if power is lost—the valve will not operate. To operate manually, you must disassemble the unit to access the rotor, then use parts that came with the unit to fit out the valve for manual operation. This does not void the warranty.

Bottom line: Priced at \$680, the Electronic Aquavalve is overkill for most boats, and we're hesitant to add an electronic device where a manual will serve just fine. This is more designed for boats where the skipper really needs the convenience of diverting the head without going below, in our opinion.

CONCLUSIONS

While only half the test valves passed our high-pressure test, any of them would likely perform well onboard. However, there were a few standouts in the group.

For small boat and other installations where space is a problem, the petite Bosworth is worth considering; it was the most compact and least expensive. But, for just \$15 more, we'd go with the Forespar, which is also very compact and well made. It gets our Budget Buy pick. For those with a little more space, we'd opt for the Jabsco or Groco. The Jabsco was a smooth operator with no leaks; it also has the advantage of rotating outlets and would be the easiest to take apart for cleaning and lubricating. It's the Best Choice. The *PS* Recommended Groco is more pricey, but it worked perfectly and the onepiece bronze housing has definite advantages for minimum service and longevity.

TruDesign Manual

DIVERTIA

Y-valve Installation Advice

All waste plumbing hoses should be kept as short and straight as possible with no dips where waste could collect. The diverter valve should be located for easy access to the selector handle and free of other stored "stuff" that could bump the handle. The handle positions should be clearly marked for no confusion as to tank or overboard. Before mounting, make sure there is enough room for all three hose fittings and hose bends. Use 120- or 90-degree hose fittings where necessary to prevent tight bends in discharge hoses, and make sure to use the correct reinforced hose designed for sanitation systems.

A Y-valve can also be reversed and used in a bilge-pump arrangement to select between two separate bilge areas using only one bilge pump.

In most boats, these valves are used infrequently, so one of the main problems is that they become stiff, hard to operate, and even lock up. The other problem, as with all parts of the onboard sanitation system, is a slight leak either through the hoses or by the housing or handle that could cause odors.

Plumbing Options

Elizabeth Barrett Browning would have a fine time counting the variety of ways to treat waste aboard a sailboat. Let us count the ways. Apart from the "standard" electric toilets that we tested here (either raw-water or freshwater plumbed), there are portable toilets, composting toilets like the Air Head, hold-and-treat systems like Raritan's Lectra San, and vacuum-based systems like Sea-Land's VacuFlush. In addition, there are multiple ways to plumb a holding tank into the system.

Most of the manufacturers in our test this month offer selection and installation guides on their websites, and products designed for specific installation scenarios. Two good resources for do-it-yourselfers contemplating an upgrade are Nigel Calder's "Boatowner's Mechanical and Electrical Manual: How to Maintain, Repair, and Improve Your Boat's Essential Systems," which is available at the *PS* online bookstore, and Peggie Hall's "Get Rid of Boat Odors: A Boat Owner's Guide to Marine Sanitation Systems and Other Sources of Aggravation and Odor."

Follow the installation instructions carefully as to discharge sanitation hose size and wire gauge (no more than 3-percent voltage drop). These units have high start-up demands, so sizing for the smallest acceptable gauge is not wise. The two most common causes of poor performance are lack of water and insufficient power, both of which can lead to clogging.

Raw-water inlets (on those designed for raw water flush) or outlets plumbed directly to through-hulls should have vented loops to prevent water from siphoning back into the head. However, air in the inlet line can hinder pump performance, so a solenoid may be required to close any vented loops in the raw water inlet line during flushing.

1. Most contemporary manual flush systems incorporate a Y-valve that diverts waste to the holding tank or overboard. While a well-designed system will provide years of service, the DIY result is often a pretzel-like series of poorly clamped hoses such as this.

2. Raw-water inlet and outlet lines need anti-siphon vents. The vent must loop above the water-line at all angles of heel.

3. Early holding tank designs had leak-prone outlets at the bottom of the tank and often lacked a deck-level pumpout fitting. Similar systems, with the addition of a deck pumpout, are common today. Ideally, a system should not trap waste in the lines.

4. At the other end of the design spectrum are systems tailored for areas where pumpout facilities are readily available, like this one from Dometic. Instead of a Y-valve, multiple check valves prevent back-siphon.









Holding Tank Test

Sealand vs. Trionic

The undisputed heart of a marine sanitation system continues to be the holding tank. We recently revisited holding tanks, both to smell out any new advances in design and construction, and to see how our past top choices would compare with a new kid on the block.

GETTING TANKED

The tank material of choice continues to be rotationally molded linear polyethylene. Polyethylene is light in weight, doesn't corrode, allows for seamless tank construction, is relatively inexpensive and (if thick enough) won't allow odors to permeate. In short, a good quality polyethylene tank could very well outlast the hull of the boat you're installing it in.

On the construction front, one improvement we did note was placement of the tank fittings, particularly the discharge outlet. Holding tanks we tested in the past had discharge outlets located at the sides near the bottom, in efforts to allow users to drain as much waste as possible when pumping out.

Today, the trend (with better quality tanks anyway) is to use all top-mounted fittings. This placement not only reduces the potential for leaks, but also prevents sewage from sitting in the discharge hose, reducing the chance of hose failure and odor problems due to permeation.

Top-mounted outlet fittings use a ridged PVC pump-out



tube (SeaLand labels theirs a "diptube") that extends to a point just above the bottom of the tank. This design reduces the chance of plugging, while allowing most all of the waste to be pumped out.

WHAT WE TESTED

This test pitted a holding tank from SeaLand with a comparable tank from Trionic Corp.

We chose a current Sealand model that was similar in size and construction, an updated 18-gallon 20 HTS-VRT from SeaLand's Basic Series lineup. Trionic provided us a 20-gallon SP-2020 model from its line of super premium holding tanks.

(While the tanks in our test were rectangular, both Trionic and SeaLand offer a variety of other shapes.)

For this test, SeaLand sent us a tank with the inlet and outlet fittings firmly installed and sealed with pipe sealant, as the maker recommends. Aftermarket tanks are typically shipped with fittings separate.

HOW WE TESTED

Tanks were tested per Code of Federal Regulations 159.109, which states, "Any sewage retention tank that is designed to operate under pressure must be pressurized hydrostatically at a pressure head of 7 feet or to 150 percent of the maximum pressure specified by the manufacturer for operation of the tank, whichever is greater. The tank must hold the water at this pressure for one hour with no evidence of leaking."

To accomplish this, we attached a section of hose to each tank and hydrostatically pressurized them to a head of 7 feet. Once pressurized, each tank was monitored for leaks and deflection. Tanks also were rated on factors such as cost, quality of construction, and features (inspection ports, pressure relief valves, options for additional fittings, etc.).

Preventing threaded fittings from leaking was the hardest part of this test. Teflon tape was used with some success, though nylon fittings in polyethylene tank walls generally make for a tight fit. Still, you'd be surprised how much pressure is created with 7 feet of head.

Once the leaks were minimized and the water level stabilized to the extent possible, we waited the required one hour, and then measured the amount of deflection.

Fittings on the SeaLand tank were clustered at one end, allowing easy access to all fittings through a smaller, single access panel.

SEALAND 20 HTS

The 20 HTS is constructed of 3/8-inch virgin, lowlinear density polyethylene and is ISO/USCG compliant. The 20 HTS comes with a %-inch vent, 3-inch inspection port, 1½-inch inlet, and two 1½-inch discharge outlets (one for connection to a deck mounted discharge fitting, the other for connection to an overboard discharge pump). Testers particularly liked inclusion of the second discharge outlet as standard equipment (and the greater installation versatility it provides). As noted, the inlet and outlet fittings were firmly installed and sealed with pipe sealant.

The 20 HTS comes equipped with a Tank-Saver vacuum relief valve, which protects the tank from implosion damage due to excessive dockside pumpout vacuum levels. The capacity of the 20 HTS was advertised as 18 gallons, however its measurements were strangely a bit larger than those of the 20-gallon Trionic tank.

The SeaLand's total deflection for the top and bottom was a half-inch, while the combined panel deflection for the ends and sides was 1 inch. This was more than the 5/8-inch combined side deflection of the older SeaLand tank and the 1/4-inch deflection for the Trionic. The side deflection was significantly more pronounced on one side than the other.

No leaks were noted. The pipe sealant was so effective that testers were unable to remove the fittings from the tank afterward. According to a SeaLand rep, the fittings are not supposed to un-thread; however, the grommets into which they are mounted can be rotated to orientate the

fittings as needed. The sealing grommets of the Trionic tank feature square shoulders, allowing you to more easily put a wrench to them for adjustment or removing the fittings.

Bottom line: The 20 HT is a good quality tank that comes standard with features we liked, but costs roughly \$60 more than the Trionic (even after factoring in the additional cost for a second discharge outlet for the Trionic tank). It gets a Recommended rating from our testers.

TRIONIC SP-2020

Trionic's Super Premium Holding Tanks are constructed of 3/8-inchthick virgin polyethylene and comply with U.S. Coast Guard requirements. The SP-2020 comes with a 5/8-inch barb vent assembly, 3-inch inspection port, 1½-inch inlet, and a 1½-inch discharge outlet and all fittings, as well as a 1½-inch screw in plug. A second overboard discharge is available as an option, but costs an additional \$30.

All fittings were mounted at the top of the tank. We used Sikaflex 291, the sealant used by Trionic's boatbuilding client.

The SP-2020 also features a vacuum relief valve to prevent tank collapse due to dock pump out stations with high vacuum levels. Testers particularly liked the screw-cap design of the Trionic relief valve, which provided easy access for cleaning.

After one hour at pressure, total panel deflection for the top,

FS	VALUE GUID	E HOLDING TANKS			
MANU	FACTURER	SEALAND	TRIONIC		
MODEL #		20 HTS-VRT 🛩	SP-2020 ★		
NAME		Marine Holding Tank	Super Premium		
PRICE		\$400	\$220		
TYPE		18-gallon, rectangular shape	20-gallon, rectangular shape		
MATE	RIAL	3/8″ virgin polyethylene	3/8" virgin polyethylene		
SIZE (H-W-D in inches)		16.75 x 11.5 x 28.28	12 x 16 x 24		
PRESSURE RELIEF VALVE		Yes	Yes		
NUMBER OF INLETS / SIZE		Two / 1½ inches	One / 1½ inches		
NUMBER OF OUTLETS / SIZE		Two / 1½ inches	One / 1½ inches		
INSPE DIAME	CTION PORTS/ ETER	One/ 3 inches	One / 3 inches		
VENT	SIZE	5/8-inch	5/8-inch		
сомм	ENTS	Includes hose fittings	Removable pressure relief valve		
WARR	ANTY	1 year	1 year		
		TEST RESULTS			
TOP PANEL DEFLECTION		1/2 inch	1/4 inch		
SIDE PANEL DEFLECTION		1 inch	1/4 inch		
LEAK TEST		None	None		
★ Best	Choice 🖊 Recomi	mended			

bottom, and side panels was a miserly 1/8-inch each.

As with the SeaLand tank, there were no leaks with a 7-foot head. **Bottom line:** The SP-2020 not only cost less than the SeaLand 20 HTS, but also had less material deflection and leakage. It received a Best Choice rating from our testers.

CONCLUSION

Both holding tanks were of high quality and would carry out their duties of holding doody well. Although both had minor leaks during our test, we think we could have eventually finessed them to hold 7 feet of head.

That being said, the leaks that did exist were more pronounced with the SeaLand tank, specifically the one at the inspection port this was possibly due to a combination of its larger diameter (as compared to the leaky outlet fitting) and the greater deflection of the top panel where it was located.

Although not conclusive in and of itself, less deflection would seem to indicate greater strength, and while the difference wasn't huge, deflection for the Trionic tank was noticeably less than the SeaLand unit.

Taking the test results and the price difference into consideration, the Trionic SP-2020 adds up to a better value in this holding tank size range.



Tank Sensors

External Tank Sensors • Internal Tank Sensors • Long-term Test Results

Knowing how full your holding tank is can mean more than simply having peace-of-mind. Whether you're starting out on a Sunday daysail or a two-week inland cruise, one of your checklist items should always be "Check the tanks." Unless you are far offshore, realizing the holding tank is full as you attempt to pump the head—or when you pick up the telltale odor from the overflow vent—can be a real problem.

Federal law mandates that all boats with permanent toilets have either an on-board treatment system or a holding tank to store wastewater. Many states with inland lakes and coastal areas have designated them as No Discharge Zones (NDZ) and require that the through-hull and Y-valve for direct discharge ports be sealed to prevent any discharge into the water.

From the freshwater supply to fuel and wastewater, knowing the level of all tanks is a must for comfortable and safe sailing. Several tank-monitor manufacturers now refer to three types of tanks: "fresh" for drinkable water, "gray" for drain water from sinks and showers, and "black" for wastewater holding tanks from toilets. State and federal regulations are changing to address these differences, but not all boats are plumbed with multiple tanks hooked to different through-hulls.

Most older and smaller boats do not have level gauges on any tanks. A captain "just knew" about how full his tanks were or could judge the level by simply thumping the tank with his knuckles. Occasionally, if the tanks had inspection ports, a visual check with a flashlight or inserting a dipstick was sufficient.

Today, there are several options for measuring tank levels,



starting with the simple internal float gauge and progressing to sophisticated ultrasonic capacitance or sonar internal probes.

External Tank Sensors

Packaged kits containing externally mounted tank level sensors with remote reading displays are becoming increasingly popular due to the fact they don't come into contact with the holding tank contents. Probes located inside the tank are more likely to be fouled, corrode, and need cleaning.

External sensors use basic capacitance sensors or the electronic Mirus detector cells that read liquid levels on the other side of plastic, polyethylene, and fiberglass tanks. External tank readers are for wastewater and fresh "sweet" water tanks, not aluminum or metal fuel tanks for diesel or gasoline. All of those we tested should work on standard tanks up to 3/8-inch thick, and all come with a one-year warranty.

When choosing a tank-level indicator, bear in mind that at least one side of the tank must be accessible for mounting the external sensor devices.

For this evaluation, *Practical Sailor* tested five external sensors with their mated display: Raritan Tank Monitor (1510012), Scad Profile Tank Monitor, SensaTank Marine 100, Snake River Acu-Gage Smart Mini, and Snake River Acu-Gage Three-Tank.

HOW WE TESTED

Practical Sailor acquired an unused 3/8-inch-thick polyethylene tank that measured about 12 inches deep x 15 inches wide x 28 inches long, or about 30 gallons, with a 3.5-inch top inspection port, two 1.5-inch fill and drain hose connections on a side and two half-inch vent hose plugs.

We followed manufacturers' directions for each external tank sensor, and attached the four different sensors, display panels, and foil tapes onto the sides of the test tank. One kit came with all necessary cable and plugs, but we cut, stripped, soldered, and taped No.

The fake effluent developed into a smelly, dark liquid after nine months in the test tank.

PS VALUE GU	I D E	EXTERNAL HOLDING TANK SENSORS							
PRODUCT	KIT PRICE / SENSOR PRICE	NO. OF TANKS	DISPLAY DIMENSIONS	SENSOR TYPE	OPERATION	TECH SUPPORT	INSTRUCTIONS	ACCURACY	EASE OF INSTALL
RARITAN TANK MONITOR	\$224 / \$91	4	2.25″ x 4.5″	Capacitance	Fair	Fair	Good	Fair	Good
SCAD SOLO 🔎 PROFILE SERIES	\$141 / \$36	1	2″ x 3.5″	Capacitance	Excellent	Excellent	Fair	Excellent	Good
SENSATANK MARINE 100 mm	\$220 / NA	3	3.5" x 5.5"	Field Effect	Excellent	Good	Good	Excellent	Excellent
SNAKE RIVER ACU-GAGE SMART MINI	\$130 / \$35	1	2″ x 3.5″	Capacitance	Good	Fair	Fair	Good	Good
SNAKE RIVER ACU-GAGE THREE TANK	\$160 / \$35	3	2.75" x 5.25"	Capacitance	Good	Fair	Fair	Fair	Good
Recommended									

18 AWG stranded wires between the sensors, in-line fuses and monitor panels of the others. All were wired to a 12-volt DC battery for power. We filled the tank with water from a garden hose, and then each unit was calibrated and tested per its instruction sheets.

Each kit was evaluated on what it included, quality of workmanship, ease of wiring and installation, how well the instructions were written, relative costs, useful features and functions, and accuracy. We also noted the quality of tech support, website information, and availability through retail distribution.

RARITAN TANK MONITOR

Raritan's tank sensor works on 12-volt DC (other voltages are available). While it can display the liquid levels of four tanks, the kit comes with only two capacitance tank sensor modules. The kit also includes 10 feet of aluminum foil, a 3-amp fuse holder, 12 crimp splice connectors, and a display panel with screws and stick-on labels. These stickers—with universal symbols for "waste," "gray," and "fresh"—can be affixed to the display to identify the four buttons. *PS* testers questioned the durability of these stick-on labels.

The display panel is fairly small, measuring 2.25 inches high by 4.5 inches wide. It has four touch buttons for tank selection, and each has a corresponding hole for calibration. Five

LED lights indicate the tank level: empty, quarter-full, half-full, three-quarters full, and full. Testers found these indicator lights to be dim and hard to see in daylight.

Raritan's instructions are clear and well written—as long as you have a standard size tank. Tanks less than 7.5 inches tall or more than 20 inches tall require adjusting the amount of aluminum foil that is mounted to the side of the tanks.

Calibrating the Raritan is a simple a matter: fill a tank

with water up to where you consider it full, then insert a small flat-head screwdriver into the hole above the selected tank's touchbutton on the display panel, then turn it until all lights are on and then just the full light comes on. Repeat for each tank. The kit includes four small plastic plugs to insert in the holes once calibration is complete.

Bottom line: The Raritan unit provides standard tank mon-

E ½ ½ ½ F Solo Tank Monitor Tank Full © F E E SCAD www.scadtech.com Read

SCAD Solo

itor features with external capacitance sensors. We found its tech support and website to be lacking.

SCAD SOLO

The Scad Solo Profile Series (TM01) holding-tank monitoring kit includes a very small 2-inch-by-3.5-inch display panel, five feet of aluminum sensor foil, and one capacitance external tank sensor module. The display panel has a membrane-covered mechanical switch labeled "Read," five prominent LED lights (that illuminate quite brightly) above each of which are labeled tank status levels (from empty to full) and a "Tank Full" red LED. It also has two tiny buttons (marked "F" and "E") for calibrating functions.

Installation of the Scad Solo got off to a rough start due to its lengthy and unclear instruction manuals: a six-page booklet for the external non-contact fluid level sensor and a 10-page manual for the display panel. That seemed like a lot of reading for what should be a simple installation and hook-up. Upon digesting the instructions, testers found the manuals to be extremely wordy and not explicit enough. In fact, we had to call the manufacturer twice for clarification. Scad immediately e-mailed a new version of the instructions and offered verbal help.

Part of the confusion stems from the fact that Scad offers several versions of the display, and it can be programmed to work with many different types of tank sensor devices. The model we tested is intended for a holding tank. Scad also offers sen-

> sors specifically for water tanks as well as display panels that monitor up to eight tanks (Profile TM02).

In response to *PS* testers' difficulty in translating the instructions, Scad said it is now overhauling the manual to make it shorter and more concise.

What the instructions lacked, the company makes up for in customer service. Technical support is available via

phone seven days a week, 365 days a year. Our initial problems aside, the installation and test-

ing went smoothly. The Scad Solo Profile monitoring panel and external sensor have some unique and interesting features, including the ability to be calibrated for more accurate readings when using oddly shaped tanks that may be custom fitted. It also has the ability to program the characteristics of different types of tank sensors such as several internally mounted devices and the standard float sensors. Third, it allows you to program and set exactly where you want both the "empty" and "full" levels to be on your tank. Fourth, the external tank sensor module has a green LED indicator light that glows when the panel's "Read" button is pushed, to indicate that all wiring is working. Finally, the Solo designed for holding tanks has a large red LED light on the panel, marked "Tank Full," that will



Sensatank

illuminate when the tank is 85 percent full. It reads

the tank level every half-hour, so there may be about a 30-minute delay before the alarm goes off.

The Scad Solo will monitor only one tank, and the kit comes with one sensor and one display panel. To monitor two tanks, Scad suggests installing a rotary switch at the display panel, wiring it to sensors on the tanks and simply switching from one tank to the other as needed.

Bottom line: Our favorite in the single-tank category, the Scad Solo kit was the most accurate, has more programming and calibrating flexibility, and will handle irregular-shaped tanks. We also like the tech support availability.

SENSATANK MARINE 100

The SensaTank Marine 100, made by Material Sciences Corp. and distributed by West Marine, says "Holding Tank Monitor" on the box but will work on freshwater tanks as well. This kit can monitor three tanks and contains three sets of fluid-level external tank sensors.

Each set has four proprietary stick-on "Mirus" field-effect detector cell sensors—one each for full, quarter-, half-, and three-quarters full—all pre-wired to a plug. This plug connects to the interface board presumably located near the tanks. The kit includes 20 feet of CAT-5 type cable and connectors to wire to the remote display panel. The 3.5-by-5.5-inch panel comes with screws and a plug for mounting and connection to 12-volt DC. The kit included an AMP male plug but did not include a female plug, and instructions suggested cutting off the plug to wire up to power. The panel has three field-effect touch-sensor buttons identifying "Tank 1," "Tank 2," and "Tank 3," and an LED lighted bar graph that illuminates progressively to show the level of the selected tank when the corresponding button is pushed.

It comes with a very simple two-page instruction sheet with good diagrams. The installation is fast and straightforward with "plug-and-play" wiring that is obvious and intuitive with little chance of mistakes. No calibration is required. However, it would help if the detector cell sensors were marked: "full, ³/₄, ¹/₂, ¹/₄." (There is no "empty" sensor.) We accidentally stuck the quarterfull sensor near the bottom and the full sensor too close to the top. Once affixed, the sensors are very difficult to move.

Operating the monitor is very simple, and reading the level status is straightforward. Pressing and holding the button for the desired tank will illuminate LEDs behind cutouts that clearly show the liquid level. The SensaTank also has a visual alarm: If the tank liquid level reaches either below the quarter-full sensor or up to the full sensor, the indicator light flashes two times per second.

Bottom line: SensaTank Marine 100, our top choice for the multi-tank monitor kits, comes with all necessary wire, con-

nectors, and equipment, is easy to install, and simple to operate. The LED indicator lights are bright with easy-to-read labels, and the empty and full lights will flash when in alarm condition.

ACU-GAGE SMART MINI

Another single tank monitoring kit, the

Acu-Gage Smart Mini, manufactured by Snake River Electronics (now owned by Diamond Distribution), looks and functions almost identical to the Scad Solo.

The kit comes with a small display panel with stick-on ID stickers ("Fresh," "Grey," "Black," "Waste," and "Diesel") for the single panel button, a holder for fuses and crimp connectors, a Moda capacitance sensor module, and five feet of aluminum sensor tape. The display panel includes five LEDs marked "Empty" through "Full," tiny calibrating buttons, and a larger tank reading button. The 10-page instruction booklet was straightforward and well written—although like the Scad, it too had an incomplete wiring diagram.

While the Acu-Gage and Scad Solo look similar, their electronics and software are different. The Acu-Gage does not have an LED on the sensors, a "Tank Full" alarm/LED, or the ability to program different types of sensor or calibrate for odd-shaped tanks. The Acu-Gage monitors one tank.

Bottom line: The Smart Mini is a no-frills kit that works well and is the least expensive, but it lacks extra features, and current availability through local marine distributors is lacking.

ACU-GAGE THREE TANK

We also tested Snake River's three-tank monitoring kit. It has a larger monitor panel than the Smart Mini, but it calibrates and operates the same. It also has two additional tank push buttons.

Testers noted that accuracy was a bit off during testing, but Snake River suggested that adjusting the tape application slightly will alleviate this.

Bottom line: This Snake River unit functioned without any problems, and it's reasonably priced. We would like to see Snake River improve its tech support and presence in the marine retail market.

CONCLUSION

The quality and workmanship of all the display panels we tested appear to be good or better. The products are small enough to mount just about anywhere, and all draw minimal amperage.

The cost per tank monitored is difficult to determine since we tested both single- and multi-tank sensors. If you need to monitor two or more tanks, a multi-tank display makes sense and may even save you time and money. Each manufacturer represented offers additional tank sensors, and some offer other displays that allow for more tanks to be monitored.

Rating the sensors' accuracy also was difficult, since each of the capacitance foil sensors read the tank water levels a little differently. When the tank was half full (visually measured), only one lit up half, while one showed one-quarter, and the others three-quarters full.

That being said, we decided against choosing a Best Choice and

PS VALUE GUIDE INTERNAL HOLDING TANK-SENSOR KITS											
Manı	ufacturer	BEP MARINE 🖈	DOMETIC	FIREBOY- XINTEX 🛩	GROCO	HART SYSTEMS 🛩	SEALAND	WEMA 💲			
Sensor / Monitor		TS1 / 600-TLM	DTM4	PTS / LLM-1	TLM	Tank Tender	TankWatch 1	SHS-8 / HTG			
Kit p	rice	\$380	\$265	\$143	\$275	\$421	\$80	\$97			
No. o	f tanks	3	1	1	1	2	1	1			
Display (H x W)		2 5/8 x 3.5 in.	3.25 x 3.25 in.	2.25 in. diameter	2.75 x 3.5 in.	6 x 4 in.	1 5/8 x 2 in.	2.5 in. diameter			
Sensor type		Ultrasonic	3 floats	Pneumatic	2 floats	Pneumatic	1 float	1 float			
Displ	ay type	Digital	4 LEDs	5 LEDs	2 LEDs	Needle	1 LED	Needle			
Adde funct	d tion	Alarm	Optional auto shutdown	None	Pump out	Purge	None	None			
4L INGS	Accuracy	Excellent	Good	Good	Good	Excellent	Good	Excellent			
rigin/	Ease of install	Excellent	Fair	Excellent	Good	Good	Excellent	Good			
0 TES1	Instructions	Good	Good	Excellent	Good	Good	Excellent	Excellent			
Accuracy after 9 months		Excellent	Fair	Excellent	Poor	Excellent	Good	Excellent			
🖊 Re	commended \$	Budget Buy 📩 I	✓ Recommended \$ Budget Buy ★ Best Choice								

Budget Buy, and instead recommend the two standouts in this test: the Scad Solo single-tank monitor and the SensaTank 100 multi-tank monitor. The feature-laden Scad was a top performer in accuracy with its main drawback being the instructions that are being revised, and the SensaTank was easy to install, accurate, and had good tech support.

Internal Tank Sensors

Practical Sailor also tested seven pre-packaged kits containing internally mounted tank-level sensors and remote monitor panels. Those that used some form of float sensor were the SeaLand TankWatch 1, Dometic DTM4, Groco TLM Series, and Wema SHS-8. Two test products used air pressure for reading: Fireboy-Xintex PTS and Hart Systems Tank Tender. And one productthe BEP Marine's TS1 sender-used ultrasonic technology to measure tank levels. All should work on standard composite, polyethylene, or aluminum tanks.

Most of the products tested are rated for wastewater holding tanks, fresh, or "sweet" water tanks, and aluminum or metal fuel tanks for diesel. Gasoline tanks require **BEP MArine** different sensors.

The quality and workmanship of all units tested appeared to be Good to Excellent. The sender units were easily mounted on top of our tank, and the monitor panels were small enough to be mounted anywhere. All drew minimal amperage. All instructions were adequate given the complexity of the

ing the probe senders. Float-type level sensors in holding tanks have a bad reputation for fouling and requiring periodic cleaning, and we kept this in mind during testing. Some manufacturers offer different size sensor units, factory adjustments, or programming for different size tanks. Some also offer other gauges or monitor panels for multiple tanks.

The accuracy of any tank level reading is dependent on the

accuracy of the length of probe or calibration needed when order-

If you are considering adding an internal tank sensor to your boat, remember, you must have access to the top of the tank to mount the sensor.

BEP MARINE TS1

products' installation.

BEP Marine takes a different approach to measuring liquid levels with its acoustic "sonar" technology. Its TS1 ultrasonic tank sender can be used on composite, fiberglass, and metal tanks for fresh water, grey, or black water holding tanks, and diesel fuel tanks.

The sensor will operate in any tank up to 6 feet deep and is programmable for odd-shaped (non-rectangular) tanks. It can be programmed to work with a wide variety of gauges and monitoring meters with different output voltages.

Our test sensor was factory programmed for our tank, and we used the corresponding BEP 600-TLM monitor unit for display. Users can also order software and an interface box to connect the sensor to their computer.

The advanced ultrasonic technology is extremely accurate, and the digital screen shows liquid levels three ways: in U.S. gallons, as a percentage, and with a bar graph. This multi-



method data delivery makes reading the display nearly foolproof.

Testers found the instructions to be clear and well written, and the installation was fast and simple. We drilled a 1½-inch opening plus five screw holes on the tank, inserted the sensor and gasket, and tightened the screws. We connected three wires to the monitor and two more for power (ring-eye terminals provided), and we were done.

This is a very sophisticated tank sensor. It can monitor up to three tanks with selectable programming for 14 types of tanks and independently adjustable high-low alarms with visual and audible functions. The display is backlit for easy night viewing.

The BEP device comes with a 15-page instruction manual, and testers found that it pays to read the instructions carefully before starting.

Testers were most impressed with the sophisticated electronics of BEP Marine's ultrasonic tank sensor and digital read-out monitor. We're optimistic that our longterm testing will prove the BEP to be a favorite.

Bottom line: It is moderately priced, well made, easy to install, and gives very accurate continuous readings. If you are into advanced electronics, and want the latest on the market, it's worth your consideration.

DOMETIC DTM4

Dometic's single-tank monitoring kit (an update to its previous SeaLand TankWatch 4) comes with three probe float-switch assemblies, an indicator panel, and the necessary wire harnesses.

The probe cap switch assembly is designed to screw into a standard 3-inch female pipe thread tank opening—like the observation port on many tanks. If your tank doesn't have a 3-inch threaded opening, an optional universal flange kit is available. The cap comes with three float-switch probes that must be cut to appropriate lengths. One operates when liquid is about 2 inches from the tank top to indicate tank full, one in the middle to indicate half-full, and a third to indicate empty.

The kit includes an eight-page instruction manual with detailed assembly and wiring diagrams. Testers found installation a little time-consuming: Our probe kit came with two 22-inchlong probes, inside of which were wires to the pre-assembled wire harness. We needed lengths of 10 inches and 6 inches for our tank, and so followed the instructions to trim the probes to fit.

The plastic indicator panel has symbols indicating the type of tank and four vertical LEDs. There are no switches or openings on the panel. The tank-empty LED stays on, and as the tank fills, the other LEDs illuminate and remain on.

Dometic also offer two- and three-tank monitors that use the same probe float-switch assembly.

Bottom line: The Dometic DTM4 took the most time to install and is moderately priced.

FIREBOY-XINTEX

The Fireboy-Xintex monitoring system came with a new series PTS-10 tank sender and an LLM-1 single-tank display gauge. The PTS uses pneumatic (air pressure) reading technology with no moving parts, encapsulated electronics, and a simple two-

wire hook-up. It can be purchased with either a 1½inch threaded or gasketed screw-mount flange and the plastic tube probe is factory cut and calibrated to the depth of your tank.

> Since we had a threaded opening, installation was fast and easy. The LLM gauges come in either one- or two-tank versions and are labeled either for "fresh water" or "holding

tanks." The round gauge has five LEDs in a semicircle (to indicate tank empty, ¼, ½, ¾, and full). Pressing a button illuminates the appropriate liquid-level LED for three seconds.

Bottom line: The Fireboy has no moving parts to break and an easy-to-read gauge. We feel the PTS-10 is an improvement over the company's older model and a good functioning system for the money. It's Recommended.

HART TANK TENDER

Dometic

DTM4

The Tank Tender by Hart Systems takes a different approach to monitoring tank levels. It uses air pressure direct to an analog gauge, which means there's no need for electrical connections.

The pneumatic gauge displays the level of the tank in inches, either water or diesel fuel (not gasoline). We tested Hart's No. 30-2 PV, which will monitor two tanks up to 30 inches deep and comes with a "purge" switch for a holding tank.

Hart offers several models (that can monitor up to 10 tanks) and has been selling these units to the marine and industrialcommercial markets for more than 25 years.

The kit included a 6-by-4-inch panel with gauge, a tank penetration fitting with 30 inches of rigid 1/8-inch tubing and about 30 feet of 1/8-inch flexible nylon tubing.

Installation was simple: Cut the rigid tubing to fit the tank, drill a hole in the tank top, screw in the top fitting, and run the nylon tubing to the monitor panel. To operate, press the button for the selected tank and slowly pump one or two strokes. The gauge needle show the level of the tank in inches. Accuracy should be within one-quarter inch, or 1 percent, at mid scale.

For holding tanks, first place the switch in the purge position, pump a couple times to blow out any debris at the bottom of the rigid tube, then switch back to get a reading. Since it just reads inches, you need to know how deep your tank is and what constitutes almost full. Testers particularly liked that there is not much that can go wrong with this unit, and it works without power.

Bottom line: Easy to install and use, the Tank Tender is a quality product with proven technology. It is a little pricey, but it will monitor multiple tanks with accuracy and without electricity. We recommend it.

SEALAND TANKWATCH 1

Made by Sealand (Dometic Inc.), the TankWatch 1 is an extremely simple full-tank warning device. The kit includes one short float-type switch assembly, a rubber gasket, an indicator panel, and all necessary screws. The one-page, seven-step instructions are well written with clear diagrams.

To install the sensor, testers drilled a 1¹/₄-inch hole and four screw holes in the top of the tank, inserted the float assembly,



and screwed it down. We then hooked up two wires to the panel and two to 12-volts DC. And that was it.

The 1 5/8-inch by 2 1/2-inch indicator panel is simply a red LED labeled "Tank Full" that will illuminate when liquid is within 2½ inches of the top of the tank. The TankWatch 1 draws only .016 amps when on, and it worked as intended during testing.

Bottom line: If you are on a budget, the no-frills Sealand TankWatch 1 is the cheapest and easy to install, but it offers only a tank-full warning.

GROCO TLM

Groco's TLM series of tank level monitors uses an internal probe with two free-floating mercury micro switches attached to the custom length probe with 2-inch wires. The length of the plastic TLM sender probe must be custom cut for your tank and is on a 1½-inch threaded flange with a female threaded 1½-inch adaptor included.

The small 3¹/₂- by 2³/₄-inch monitor panel has two corresponding LEDs marked "¹/₄" and "³/₄." The float switches work so that the bottom one floats up to indicate one-quarter full and the top one floats up to indicate three-quarters full. One or both will illuminate as the liquid level rises, when the "Show level" switch is pressed.

The kit included four screws and 25 feet of cable with the necessary connectors. The monitor panel comes with a rubber gasket and the switches and LEDs are sealed so that it can be mounted in the head, where it might face occasional splashes from a shower.

The TLM appears rugged and well made and comes with a one-page instruction sheet that is simple and well written.

Bottom line: Groco's TLM-10, with its two free-floating micro-switches, should get around the fouling problem, but the gauge has only two LEDs marked for level indicating, and it was not very accurate during testing.

WEMA SHS-8

The Wema system we evaluated came with an SHS-8 sensor and an HTG monitor. The sensor consists of a float mounted on an 8-inch vertical metal tube encased in a 1½-inch protective metal pipe with a sender and threaded cap. This screws into a 2¼-inch threaded collar that attaches to the tank with a gasket and five screws. All construction is heavy-duty 316 stainless steel. The Wema is specified for only holding tanks.

The HTG is a 2 1/16-inch-wide round gauge with an analog needle that moves from empty to full as the tank is filled. Each device has a concise one-page instruction sheet with good diagrams. Installation and hook-up were easy, and testers found the readings to be accurate.

Bottom line: Of the float- switch type monitors, *PS* preferred the economical Wema. It's not much more than the bargain-basement TankWatch but offers more data. It gets the nod for *PS* Budget Buy.

CONCLUSIONS

Our Best Choice goes to Fireboy-Xintex for its new pneumatic probe with encapsulated micro-processor sender and a simple electronic level gauge.

With good quality, excellent accuracy, and a no-frills analog needle gauge, the Wema SHS-8 gets the Budget Buy.

For those needing a dual-tank monitor, the Hart Tank Tender is Recommended. It is pricey, but its accuracy and no-power appetite lead us to believe it's worth the money.

Long-term Test Results

For these tests, in an attempt to replicate real holding-tank conditions, we half-filled a 16-gallon polyethylene tank with water, then added salt, bananas, rolls of toilet paper, and a couple boxes of instant mashed potatoes. It was a goopy mess.

Testers let the tank, with internal sensors attached, marinate for nine months in the humid, warm Florida weather. When we checked in on the setup, our "fake" holding-tank effluent had grown into a thick, dark, smelly, liquid with an oily, foamy layer on top—just what we were looking for to long-term test the internal probes. But unlike tanks installed on boats kept in the water and used often, our test tank received only occasional "sloshing" over the nine months. However, we were sure to shake things up a bit before re-testing the sensors for this update.

Testers applied power to all kits and observed the readings on the monitors. We then sloshed the lumpy liquid around to simulate the motion of a boat, read the monitors again, and filled the tank with more water to see whether the sensors would indicate the change in liquid level.

HART TANK TENDER

The non-electric Hart Systems Tank Tender uses a pneumatic tube and a needle gauge. We switched the pump to "purge" to remove any debris from the tube, switched back to tank No. 1 and got an accurate reading. It also gave an accurate reading when filled. It was not affected by the goop.

DOMETIC DTM4

Groco

The DTM4 comes with three float switches on three adjustable (by cutting) plastic tubes, representing empty, low, mid-level, and full. These are wired to a monitor with corresponding LEDs. This mid-priced device has been around for some time.

Our test unit failed to register at the mid-full level after we added liquid. Upon inspection after the test, testers noted that the gunk had left a greasy sludge on the sensor's vertical

float slide that may have prevented it from rising. This may not be an issue with freshwater tanks, but could pose a problem if you leave effluent sitting in your holding tank for any length of time. According to Dometic, this is not a common problem and the regular motion of a boat, even when moored, should prevent this from occurring.

GROCO SERIES TLM

Contrary to our expectations, the Groco did not fare very well. The internal mechanism on this unit is two free-floating mercury switches that are attached to a probe with 2-inch wires. The monitor has two LED lights marked "¼" and "¾," which should illuminate when the "Show Level" switch is pushed.

During the check up, only the ¹/₄ LED lit up after sloshing the tank, tapping the monitor, and adding water. *PS* testers speculated that some of the floating debris might have prevented the mercury float switch from closing the contact. However, we discovered the actual problem when we pulled the sensors out of the tank: Some chemical reaction had eaten away the rubber covering on both float switches and was working on the probe tube.

According to Groco, this failure was due to a problem with the coating mixture, and the damage would be covered by the unit's warranty.

SEALAND TANKWATCH 1

Sealand TankWatch takes the inexpensive approach with one float switch at the top of the tank and a simple red LED marked "Tank Full" on the monitor. Since the short probe was not affected by our goop, it worked fine when the tank was absolutely full, but this type of monitor is of limited value to a cruising sailor.

WEMA SHS-8

The Wema kit comprises a float switch mounted on an 8-inch vertical stainless-steel tube, encased in a 1½-inch protective stainless-steel pipe. This Budget Buy pick has a reasonable price, heavy-duty construction with protection for the float and the continuous-read, responsive needle-gauge indicator panel. Again, it gave the correct readings during our checkup test, and the float was not fouled with the goop.

FIREBOY-XINTEX PTS/ LLM

The PTS/ LLM uses pneumatic technology (air pressure) and has no moving parts that can become fouled. It was our Best Choice kit in the initial test because of the new pneumatic probe with encapsulated microprocessor sender and the simple electronic level gauge.

A receiver screwed on the top of the tank is attached to a cutto-length 1-inch plastic tube inserted in the tank. In our test, this tube was not fouled in any way, and the five-LED monitor (marked "E," "¼," "½," "¾," and "F") responded correctly to the various tank levels.

Care should be taken in figuring how high the sender unit

sits on the top of the tank and exactly how deep the air tube should be cut. Tube sender sizes are available from 7 inches to 36 inches in 1-inch intervals. Note that the tube can be cut shorter if necessary and the sender re-calibrated.

BEP MARINE'S TS1

BEP's TS1, tested with the 600-TLM monitor display, had the most unique and sophisticated system of any tank monitor we tested. It uses an acoustic sonar technology to read the amount of liquid in a tank. The ultrasonic technology is extremely accurate, and the digital screen shows liquid levels three ways: in gallons, as a percentage full, and with a bar graph.

In the initial evaluation, *PS* testers were concerned that the sensor was too delicate, too complicated, and being new (released in late 2007), too untested. However, after nine months in the goop and the brutal Florida heat, it fired up and worked flawlessly. There is no way for the "gunk" to foul it up.

Although BEP products are made in New Zealand, the company is part of Marinco Electrical Group, a U.S.-based company with sales and service offices worldwide.

CONCLUSIONS

Practical Sailor does not recommend float-switch level indicators in holding tanks because of the propensity for fouling, especially if the tanks are left standing with solid wastes.

After nine months of testing, the Fireboy-Xintex pneumatic kit, with the single tank indicator and costing just over \$140, is highly recommended. It is simple, has no moving parts, and includes a compact, easy-to-read liquid level display. The Hart Tank Tender is a quality, tried and true product. It's easy to install with a simple thin nylon pneumatic tube that can be run up to 1,000 feet and a precise monitor panel that will display multiple tanks and does not require any power. At more than \$400, it's a little pricey, but we recommend it for those cruising away from home for long periods.

The Wema was the only kit ringing in under \$100. It's accurate and fairly easy to install, so it gets the Budget Buy nod.

The BEP TS1/600-TLM system really intrigued our *PS* testers. At \$380, it is not cheap, but the sonar technology worked flawlessly, was easy to install, and has a host of interesting features and functions. It must be factory programmed for your tanks, but the sender can be used for fuel and can be set up to work with other indicator monitors. The 600 TLM will monitor up to three tanks with selectable labels in English, adjustable high-low level alarms, and is backlit for easy nighttime viewing. It seems reliable and really fits those who love new electronic gadgets. It's the Best Choice.



Controlling Head Odors

Waste Vent Filters • Proper Vent Installation • DIY Pressure Control • Holding Tank Treatments • Inline Deodorizers

While a boat's sailing performance may be of primary importance to the skipper, you can bet that the boat's livability is as important to the rest of the crew. Livability suffers when each flush of the head becomes public knowledge within moments, and a boat that is not livable won't be a part of your family for long. Thus, from a certain point of view, keeping head odor under control may be one of the most important performance factors to the cruising sailor.

Here we take a look at three potential ways to stopping stink on board: the waste vent filter, holding tank treatments, and inline deodorizers.

Waste Vent Filters

On one of *Practical Sailor*'s test boats, a PDQ 32 catamaran, the otherwise meticulous builder made an unforgivable blunder: The holding tank vent is just upwind of the main saloon's air

intake, and all emissions go through the cabin. We tried every common chemical treatment; none was dependably effective. We tried a larger holding tank vent, eventually increasing the vent to a 1-inch diameter, less than 30 inches long, with less than 18 inches of rise. No luck. We installed a home-built vent filter. Finally, success.

This *Practical Sailor* test built upon our learning process, and to be certain no rock was left unturned, we set up six 5-gallon "holding tanks" to test all of our theories. (The tester's wife/first mate wasn't too keen on the testing, but she was happy with the result.)

ODOR CONTROL

When sanitary wastes are allowed to biodegrade in a closed tank, particularly with poor mixing and inadequate oxygen, anaerobic bacteria dominate. Instead of oxidizing the waste completely, they go only part way, producing some extremely malodorous products in the process; organic acids, assorted mercaptans, and hydrogen sulfide gas are chief among these. Detectable and unpleasant at sub-part per million levels, they can make a boat unlivable unless they are eliminated or contained.

Testers measured gas levels inside the test "holding tanks." This test tank has the Big Orange vent filter installed in the line.

The problem isn't unique to boating; controlling mercaptan and other sulfide odors from chemical plants and wastewater treatment plants has been big business ever since neighbors realized they could complain about it, and the environmental movement provided the lever to force action. Some solutions—caustic scrubbing, incineration, and catalytic oxidation—simply aren't practical on a boat. Additionally, they are often odor specific: Caustic scrubbing is effective in removing acid gases such as hydrogen sulfide and CO2 (a useful combination in spacecraft and submarines), but it will miss many other odors, and iron-ore fines react with and absorb sulfide but miss everything else. Perfumes are a patch at best. Formaldehyde—a common ingredient in old-style disinfecting treatments—can stop biological activity, but there is still chemical breakdown, plus it stinks and is listed by the EPA as a suspected human carcinogen.

Maintaining adequate oxygen in the holding tank promotes the growth of aerobic bacteria and is the primary tool of the wastewater industry; aerobic bacteria don't produce sulfides, organic acids, or mercaptans, and they can consume those that are



PS VALUE GUIDE WASTE VENT FILTERS								
MANUFACTURER	DOMETIC 🔎	BIG ORANGE ★	VETUS	HOME BUILT \$				
NAME	SeaLand SaniGard (309310002)	5/8-inch Big Orange	No-Smell (NSF16)	N/A				
MODEL / SIZE	5/8-inch	5/8-inch	5/8-inch	5/8-inch				
PRICE	\$111	\$145	\$120	\$16				
REFILL COST	\$101	\$25	\$16	\$5.75				
MAKER RECOMMENDED REPLACEMENT PERIOD	1-2 years	Annually Annually		2 years				
MATERIAL	PVC	PE	PE and PET	PVC				
DIMENSIONS (W x D x H)	18 x 3.5 x 3 in.	7.5 x 6.5 x 10.75 in.	5.75 x 6 x 6 in.	18 x 3.5 x 3 in.				
HOSE SIZES AVAILABLE	5/8; 3/4; 1; 1 1/2 in.	5/8; 1 1/2 in.	5/8; 3/4; 1; 1 1/2 in.	Any size				
CARBON TYPE	Flat granular bulk	Bulk	Impregnated foam	Bulk				
CARBON CAPACITY	620 milliliters	878 milliliters 323 milliliters		620 milliliters				
	TI	ST RESULTS						
4 MONTHS	Pass	Pass	Failed (after 6 weeks)	Pass				
★ Best Choice \$ Budget Buy ⊭ Recommended								

ate for that purpose. However, the test is not intended to determine whether a vent filter is effective on a marine holding tank or how long it might last in real-world onboard conditions, where thermal breathing is both in and out, and there are long periods of inactivity. (ASTM tests are designed to be fast, not to mirror real-world use.) Carbon tends to self-regenerate in these applications, much like the carbon canister in your car, and useful life expectancies can be quite long.

The primary interaction of carbon with organic vapors is surface absorption, as the ASTM standard tests explore. However, carbon is a complex surface and presents very complex behaviors. In the presence of fresh air, we have catalytic removal of sulfur by this simplified mechanism: $3O2 + 2H2S \Rightarrow$ (SO4)-2 + S + 2H2O.

While this reaction eventually fouls the carbon, it does extend its life many times over. The carbon bed must be sufficient in size, as this is a slow reaction in most carbons, and oxygen is only available in small amounts, provided by

present. Chemical additives and selected bacteria or concentrated enzyme products are also effective, and are used in both large wastewater treatment plants and boat holding tanks. Carbon filters are often fitted to chemical process vents and are used to eliminate waste odors in applications ranging from the space shuttle to household bathroom fans, and have more recently been applied to marine holding tanks. These filters are simple, dependable, and absorb a wide variety of odors. Filters also require thoughtful installation and replacement when expended.

Odor is a complex issue. A great deal of money has been spent by chemical and marine industries on finding solutions, and we can't tackle it all at once. We're going to break this into pieces. *Practical Sailor* is currently investigating vent filters, improved ventilation, and treatment chemicals using a set of identical holding tanks. This article will focus on vent filters and holding tank ventilation. Our report on holding tank treatments was published in the February 2012 issue.

Another source of odor is permeation of the hoses connecting the head to the tank and discharge; many hoses begin to pass odor right through the side after prolonged exposure. We are testing this, too. The vent filter and hose permeation studies are long-term and will be presented in installments, as conclusive data becomes available.

ASTM TESTING

Standard ASTM methods for testing the capacity of carbon in vent filters to absorb odors call for drafting a mixture of hydrogen sulfide and carbon disulfide through a fixed-size bed. This test was developed to compare carbon types used for odor control applications in sewage treatment plants and is approprithermal breathing of the tank, inflow during pump outs, and slow bi-directional flow in the vent hose. The oxygen requirement is easily met, however, as it is much less than that required to support aerobic tank conditions. The standard ASTM methods are not ideal for estimating carbon life when catalytic reactions are present, because the method substitutes nitrogen for air, eliminating oxygen from the process.

Additionally, the carbon does not need to remove sulfide—or any other odor, for that matter—on a continuous flow basis to attain odor control; it need only temporarily absorb and delay the peak load for a few minutes while the toilet is being flushed. If the filter absorbs the sulfide load only temporarily and bleeds it off over a period of hours, noticeable odors are eliminated. Continuous-flow laboratory testing does not measure this "timedelay" influence on surges. In industrial practice, it is not unusual to see carbon beds that have become saturated on a continuousflow basis within weeks continue to serve very well as peak absorbers for many years.

There are limits. Eventually, the carbon becomes fouled by non-volatile reaction products and damaged by acid build up. Additionally, the bed must be large enough for these slower processes to function.

WHAT WE TESTED

Practical Sailor rounded up three popular, commercial waste vents and a home-built system to evaluate. Each test unit contains activated carbon and is intended to be installed in a 5/8-inch diameter vent hose. From marine plumbing manufacturer Dometic, we tested the SeaLand SaniGard vent filter. We also tested

the 5/8-inch filter from Canadian manufacturer Big Orange and the No-smell NSF16 from Vetus, a marine manufacturer based in Maryland.

All makers suggest replacing the vent filter media annually, but user field experience indicates that the service life of a vent filter can vary greatly and averages about two years. According to Big Orange, the company advises users to replace the carbon every year, but achieving a service life of up to three years is not uncommon.

Plan to replace filter media every year or two, but be sure to inspect the vents more frequently to ensure there are no system clogs. The vents will last longer if they are protected from salt water and holding tank overflow.

HOW WE TESTED

To create a real-world test, we assembled a series of miniature holding tanks containing sanitary waste generously supplied by a 20-pound, 5-foot pet iguana named Ziggy. This was supplemented with other sanitary waste as needed. Seawater flush was used because saltwater is known to contribute to odor.

The six tanks—5-gallon polyethylene buckets with tight lids were fitted with 5/8-inch hose vent fittings, as required by each vent filter design. Approximately 1 gallon of waste was added to each bucket every seven days using the same 4-inch PVC pipe with a valve to provide uniform "flushes." The buckets were shaken vigorously after each addition to simulate the movement a holding tank sees underway. The buckets were then left undisturbed for six days. Once the buckets reached 80 percent capacity—about once a month—they were emptied. Clearly our results with iguana poo may not directly correlate with the results you'd get using human waste.

We started testing the tanks, near Chesapeake Bay, in the spring and continued through the summer, with high temperatures over 100 degrees and lows to 50 degrees. Testing will continue through winter and summer 2012. On-board testing is also in progress on the Chesapeake Bay. The test boat is cruised three weeks per year and sailed or over-nighted most weekends year-round.

Although the volume for these tanks would be somewhat less than a real-world holding tank, because the tanks were not in the bilge of a boat, both average summer temperatures and diurnal temperature swings were greater, and thus thermal breathing somewhat greater. We also compared the performance of the vent filter on the test boat; the results were equivalent, indicating a fair and realistic measure of performance.

There is only one true measure of effectiveness: Does the vent stink when the head is flushed? However, as much as we might like to have calibrated noses and compared the relative foulness of the products, it was nice to have an analytical number to compare as well, so we measured gases with a meter at regular intervals.

For testing, about a half-gallon of seawater was added to the 4-inch flush pipe. This was used in place of sanitary waste so that all tanks could be tested at the same time under identical slug filling conditions. The level of hydrogen sulfide in the discharge gas was measured in the vent during this slug filling, and an olfactory observation was made, with noses about 3 inches downwind of the vent. On some trials, this was a bit hard to take. On most of the filter trials, only the faint plastic smell of new vinyl hose was noticeable.

To provide baseline and to evaluate other options, we also equipped three tanks with common venting arrangements.

• 30 inches of 5/8-inch hose. The industry standard and our experimental control.

• 30 inches of 1 1/5-inch hose. Some experts, including Raritan Engineering, recommend that oversize hoses allow enough ventilation to promote aerobic conditions and thus reduce odor to the point where no filter is needed. Incompatibility of filters with the Electro Scan treatment systems made by Raritan may be another reason for this preference. However, we got good results with enhanced ventilation, discussed below.

• Forced air. We pumped 540 ml./minute of air into one holding tank, using a simple aquarium air pump, simulating the Groco Sweet Tank System on a smaller scale. Electrical consumption for these systems is about 2.5 watts, 24 hours per day, or about 5 amp-hours per day. Not much for a boat that is plugged in to shore power or has a substantial solar system, but one more thing to be left running, unattended.

DOMETIC

Fabricated from 12 inches of 2-inch PVC pipe and custom end fittings, the SeaLand SaniGard filter is a simple but effective holder for bulk carbon, which does the work.

The company has studied many carbon types in the lab and claims to use a type that's far more effective than that used in competing filters. Indeed, industry practice confirms that certain types of carbon are better suited to odor removal than others, and the Dometic test data convinced us that the company has done its homework in this field.

The mounting hardware is minimal but functional.

To refill the SaniGard, users must replace the entire cartridge, which costs about 90 percent of the price of a new unit (based on manufacturer's suggested retail price).

Bottom line: The SeaLand SaniGard is expensive and not a bargain to refill, but it uses high-quality carbon. It gets *PS*'s Recommendation.

VETUS

The Vetus No-smell NSF16 filter is unique in this group because it uses a carbon-impregnated filter media instead of bulk carbon. The package and the mounting are sharp, and the media are easily replaced, but the performance was disappointing.

The media contains far less carbon per unit volume than other test products, and the volume of the unit is small. The instructions suggest that this unit was originally designed for fuel vent applications, and it may work better for that.

On a side note, we suggest lubricating the cover with silicone grease, if you ever expect to get it off.

Bottom line: In our opinion, rapid failure removes this filter from serious consideration.

BIG ORANGE

As the name implies, the Big Orange filter was the largest of the test field. Refills are either bulk carbon from the manufacturer (\$25), or you can find your own local bulk carbon source. Changing the carbon is a simple matter of pulling out a drawer, dumping, and refilling; it couldn't be easier.

It is the only unit on the market that includes a vacuum break valve in the design, which is essential to protect the holding tank in the event of filter plugging.

The only shortcoming testers noted was that it was designed to mount on a horizontal edge—the top of the holding tank—and we've found that it is better mounted high on a bulkhead, which the manual suggests; a simple cleat or bracket will solve this.

Bottom line: Top features and lower long-term operating cost make the Big Orange a good choice despite its higher initial price. It's the *PS* Best Choice.

HOME-BUILT FILTER

Similar in size to some commercial vent filters, our DIY vent filter is made from 12 inches of 2-inch PVC pipe. Testers tapped NPTto-garden hose adapters into PVC end caps, but this transition could as easily be accomplished with a collection of bushings available at the local hardware store. The filter used in side-by-side testing was not designed for refill; however, a very similar homebuilt test filter was installed on a test boat, and that unit is refillable. To accomplish this, one end cap is not glued on but rather held in place with a 2-inch, no-hub connector—a simple hose with 2 clamps available in any hardware store. It was mounted in a wooden saddle, but two 2-inch PVC conduit clamps would make a simple, durable, and inexpensive bracket.

Bottom line: If you're at all handy, there's no reason you can't fabricate a durable and economical filter with common tools. This option is the Budget Buy choice.

CONCLUSIONS

If the holding tank vent on your boat is in a particularly sensitive location, vent filters offer complete odor control at a cost competitive with chemical treatment options. As the only vent filter to fail in our test was the carbon-impregnated Vetus, we can only recommend using bulk carbon filters that are refillable; these offer the best long-tern economy.

How long will carbon last? This is a very complex question, not easily resolved with lab test methods or even extended field testing. Simple sulfide generation, breathing, and absorption calculations suggest that the carbon should be saturated in weeks or months, but field testers report life times of up to five years. We will continue our exposure testing until failure, both in test tanks and on-board our test boat, and report back as we learn more.

All the vent filters tested seemed well-built and durable enough to last several seasons in a protected location. All survived a season outdoors and rough handling, but proper installation is a must. A high mounting location and a vacuum break are required, and pressure relief and overflow by-pass plumbing are recommended.

If your vent is in a sensitive location and chemical treatments have not worked for you, give a vent filter a try. (But remember to follow our installation tips.) The result obtained with a vent filter is different from that obtained through ventilation and treatment chemical options. Filters offer perfect odor control with little to no operator attention. Chemical treatments offer more variable control and require regular treatment—skip a dose or leave a partially full holding tank for a few weeks, and things can turn unpleasant. Improved ventilation alone offers substantial improvement and may be enough in most cases, but not complete control for the most sensitive vent placements. Freshwater-flushed systems will have less odor.

Testing will continue for at least one year to accurately project operating life. A minimum two-year life expectancy has been reported by many users, with up to five years achievable with light use and good installation. Because of the combined absorptive and catalytic mechanism, we recommend that boaters who live aboard or have larger holding tanks (more than 40 gallons) use the largest unit (Big Orange) or custom-fabricate one in order to ensure maximum service life.

Proper Vent Installation

The effectiveness of activated carbon comes both from surface activity (a result of activation by partial combustion of coal or woody products) and the vast pore structure formed during this partial combustion. Anything that clogs the pores will dramatically reduce carbon life, potentially ruining it within minutes.

Even fresh water can dramatically reduce the pores' effectiveness, though this loss in capacity is temporary and is recovered with drying. But here's the catch: The filter will not dry unless it is removed from the boat and flushed with dry air for many hours.

Salt water is worse, leaving a residue in the pores that is fatal to carbon efficiency. Thus, it is vitally important that the vent filter is installed so that seawater cannot splash into it, even when heeled, and that sewage splash and overflow are directed away.

Be sure to place the vent filter high or provide a high loop between the through-hull and the vent filter to avoid accidental dousing.

CLOGS ARE BAD NEWS

Clogging a tank vent with sewage—with or without a vent filter—is a serious matter.

The carbon will become plugged and the vacuum formed during pumpout can collapse the tank. Pressure formed while pumping the head can rupture the tank (very rare) or cause eruption of sewage (more common) when the pumpout cap is removed. Ugh.

This also can be avoided with proper installation.

MOUNT VENT HIGH

Vent filter makers Dometic/SeaLand and Big Orange accept mounting the filters directly on the holding tank, though all manufacturers recommend mounting them as high as possible. Some owners will rely on tank gauges or diligent pumpouts to prevent overflows, but we don't think this is enough. A more fail-safe installation is required. Certainly, the holding tank can be pumped before it becomes too full—and this is good practice since overflowed or over-filled tanks can plug a free vent through simple buildup—but just one mistake during the life of a carbon filter will ruin the filter and place the tank at risk. The test system aboard tester Drew Frye's PDQ uses the same type of trap commonly found under household sinks and a home-built vent filter made of PVC. Inset is the filter outlet.

Newer tanks are often fitted with vacuum break

valves, but older tanks are not. The Big Orange filter is equipped with an integral vacuum relief valve, but other filters are not. In any case, vacuum relief valves do not address over-pressure. The over-pressure problem is less prevalent because the volume pumped during a flush is small and pressure has more time to bleed off. That said, pumpout-station geysers are not unheard of.

DIY Pressure Control

We're testing a more robust installation, including a bypass through a water-filled trap. Excess sewage can go through this low-mounted bypass, while holding tank gases are held back. (This same mechanism is found under every household sink and toilet: The P-shaped trap directs sewer gas away from the room and up through a vent in the roof.) As the vent comes out of the holding tank, provide a T, where the gases can either continue up a minimum of 18 inches above the through-hull fitting to the vent filter inlet, or can go through a loop of hose (filled with water). The loop outlet is connected to a second T that is mounted on the through-hull fitting, where the vent filter outlet also exits. The gases go through the filter and only splashed water or sewage can go through the loop.

The filter is mounted high, and gravity keeps it dry. Though in principle, the water could evaporate from the loop, this has proven to take over a year in practice. Antifreeze can be substituted where this is a concern.

Practical Sailor even tested the system with an intentional overflow—no problem. Note: The test boat was factory-fitted with 3/4-inch ID hose, one size up from the industry-standard 5/8-inch; we believe 5/8-inch hose is too small to protect the filter in the case of a full tank overflow, unless the 18-inch elevation is increased. We used clear vinyl tubing so that we could watch the behavior of the system; sanitation hose should be used on the tank side of the system, though soft vinyl hose can be used between the vent filter and the through hull.

Many sailors back flush the vent line at each pumpout to prevent vent plugging. If this is your practice, install a valve at the outside end of the vent filter to protect it from water intrusion during back flushing of the vent line. This valve is only closed during vent back flushing.

Mounting the vent filter in a high location, well above the heeled waterline and the holding tank can be a problem on sailboats, although it's usually easy enough on most multi-hulls and power boats. If proper installation is impossible, you're likely to have trouble with plugged filters and ruined carbon, so reconsider whether a vent filter is the right solution for your boat.



Holding Tank Treatments

No one wants a marine head that brings back memories of portable toilets, yet that's exactly what we think of when holding tank chemicals are mentioned. Some of the chemicals bearing that familiar port-a-potty smell—disinfectants and surfactants mixed with deodorizers—are still being used in holding tanks. However, there's a new generation of holding tank treatments that use enzymes and nutrients for bacteria to reduce odors more naturally, and we found, often more effectively. Some chemicals also claim to help liquefy the waste and prevent clogging. While larger boats can use vent filters and enhanced ventilation to reduce odors, the only practical option for the small-boat owner with a portable toilet is some sort of treatment in a can.

How do disinfectant treatments work? Aqua-Kem, a traditional and popular product in this category, contains formaldehyde, a traditional disinfecting agent. This is not healthy stuff; it's listed by the Environmental Protection Agency (EPA) as a suspected human carcinogen. New buildings are limited by law to 16 parts per billion (ppb) and the Environmental Protection Agency's action level for existing homes is 8 ppb. This amounts to a spill of about 0.0003 grams in a typical 35-foot boat, or about 1/13th of a drop. If enough is used, it will halt all biological activity, but that doesn't mean it will kill all odor; the formaldehyde stinks, and there is still some chemical breakdown, so strong perfumes are loaded in with it, along with a powerful blue dye so that there is no mistaking it for a tall glass of spring water. Unfortunately, the dye also stains everything it touches. In our view, formaldehyde doesn't belong on a boat, much less in a poorly ventilated area, such as the average marine head compartment.

The newer, enzyme-loaded products are known as bio-augmentation treatments, because they augment the natural bio-

PS VALUE GUIDE	VENTILATION WITHOUT CHEMICALS							
MANUFACTURER	1 1/2″ VENT	AQUARIUM AIR PUMP	GROCO					
NAME	1 1/2-inch vent 🛩	Aquarium Air Pump \$	Sweet Tank System					
PRICE	\$100	\$16	\$128					
AIR FLOW RATE	NA	540 ml/minute for 10 gal.	1500 ml/minute for 50 gal.					
COST PER GAL.	3 cents	1 cent	11 cents					
TOTAL ANNUAL COST*	\$9.90	\$3.20	\$31.60					
ТҮРЕ	Enhanced ventilation	Air injection/mixing	Air injection/ mixing					
MATERIAL		Some pump noise, but pump can be installed anywhere in the boat	NA					
NOTES	May require chemical treatment to be effective	Aquarium pump tested as small- scale substitute for Sweet Tank System	Not tested					
LIVE BACTERIA / 5-DAY CULTURE RESULTS	0.2-2 ppm	0.2-2 ppm <0.2 ppm						
	TEST RES	ULTS						
ODOR	3	3	Not tested					
TEST/HYDROGEN SULFIDE	Pass	Pass	Not tested					
CONCLUSIONS	May work best with chemical treatment	A DIY Sweet Tank system	May be best system for live-aboards					
\$ Budget Buy ⊭ Recommended *12 x 25 gal. pumpout								

logical processes. How do bio-augmentation treatments work? Some—such as Odorlos and TST Ultra Concentrate—work primarily by providing nitrate as both a nutrient and as an alternative oxygen source for bacteria. Bacteria convert nitrate to nitrite or nitrogen, liberating oxygen and encouraging aerobic decomposition. If nitrate is present in sufficient amounts, anaerobic and facilitative bacteria (bacteria that can quickly switch from aerobic to anaerobic metabolism, as conditions require) can use it instead of sulfate, which is present in both seawater and waste, as an oxygen source. This greatly reduces the production of sulfide, mercaptan, and organic-acid odors. In very simplified terms, the dominant reactions are these:

- Organics + O2 \rightarrow CO2 + H2O + energy
- Organics + (NO3)- \rightarrow N2 + H2O + energy
- Organics + (SO4)-2 \rightarrow CO2 + H2S + energy
- Organics \rightarrow CO2 + organic acids + CH4 + H2O + energy

TST Ultra Concentrate also includes sodium carbonate (washing soda), presumably to help disperse solids and buffer the pH upward. Decomposing wastes tend to become acid (low pH), aerobic bacteria prefer neutral pH, and hydrogen sulfide is far more volatile in acidic water.

How do enzyme and bacterial culture treatments work? Here we must guess, as the manufactures are tight with information. Presumably these mixtures contain a combination of nutrients, surfactants, aerobic bacteria, and enzymes, though we can only judge the results by measuring sulfide reduction and observing odor. We find claims that any sealed products contain live aerobic bacteria difficult to support, since the bottles will become anaerobic, and effectively, all of the aerobic bacteria will die within a few weeks. There are tricks to extend the life of these bacteria, but, as wastewater treatment experts will tell you, aerobic bacterial samples don't remain viable for very long in a closed bottle. Enzymes can work—they are more stable and do most of what the bacteria would do—but they can't multiply. They also break down in time, and must be added regularly and after each pump-out.

In the end, the complex chemistry and variable nature of the waste create a black box for the user—as well as for any tester. Given the variables that can impact this particular test, the best we could do is measure what we find, and in the case of biologically active treatments, add a little air in order to foster growth.

WHAT WE TESTED

Treatment chemicals were obtained from a number of leading manufacturers. Although not a comprehensive field, it included the main players, many of which, such as Camco, are more familiar among RV aficionados. Other contenders included products from marine toilet makers Thetford and Dometic (under the SeaLand brand), and multina-

tional chemical corporation Yara, the makers of Odorlos. Some smaller niche-players like Unique Distributing, makers of Marine Digest-It, and Nature-Zyme rounded out the field. One entry, VanishOdor, was unable to gain traction in this crowded field, so it pulled its product from the market before our test ended—a shame since it did well in testing. Since it is no longer available, VanishOdor was not included in the final results.

We also tested odor control in two tanks that relied solely on enhanced ventilation to promote the biological processes that combat odor. One tank used an oversized vent; the other was aerated with a fish-bubbler, which functions similarly to the Sweet Tank system offered by one of the oldest names in American marine plumbing: Groco.

HOW WE TESTED

For a real-world test, we created a series of small but realworld holding tanks containing real sanitary waste. The sanitary waste was supplied by the 20-pound iguana, Ziggy. He already poops in a tray of water and we know this mixture to be plenty foul. This was supplemented with additional sanitary waste during the start-up period each spring. Seawater flush was used, as the odor problems associated with seawater are known to be more severe, the result of bacteria-reducing sulfate into more odorous sulfide chemicals. Tank tests were supplemented with field testing aboard a test boat on the Chesapeake Bay. The test apparatus included:

• Six identical holding tanks: 5-gallon buckets with lids.

• 5/8-inch hose vent fittings and 30 inches of vent hose, rising 15 inches above each tank.

• One holding tank with a 5/8-inch vent as a control.

• One holding tank with a 1¹/₂-inch vent and 30 inches of hose to encourage aerobic conditions.

• One tank with an aquarium air pump to simulate the aerating effect of the Groco Sweet Tank System.

• A 4-inch PVC pipe fill-pipe with valve.

• A one-gallon deposit of sewage was added every three days.

• Odor and sulfide were measured after two weeks. Each chemical was tested four times: twice under summer conditions (high 85-100 degrees), and twice in the fall (high 50-65 degrees).

EVALUATING RESULTS

There is only one true measure of effectiveness: whether the vent stinks when the head is flushed. Since calibrating noses presents certain challenges, it's nice to have an analytical number to compare as well. A hydrogen sulfide monitor, of the type used to test sewer gas, was used to back-up our sniff testing. At regular intervals, the vents were tested as follows:

• A ½-gallon of seawater was added to the 4-inch standpipe. This was used in place of sanitary waste addition so that all tanks could be tested at the same time under the same flow conditions.

• The standpipe valve was opened and hydrogen sulfide in the discharge gas was measured at the vent.

• An olfactory observation was made at the same time, about 3 feet downwind of the vent.

• At the end of the test period, the tanks were cleaned and the viscosity of the sludge observed.

BACTERIA CULTURES

Some vendors claim that their product contains live aerobic bacterial cultures that promote the breakdown

of organic matter. Industrial experience indicates that such cultures do not remain viable for more than a few weeks in sealed (anaerobic) containers. To check this, we tested each of these by diluting in distilled water to normal use doses and then culturing on dip slides for 72 hours. Only one product, the now discontinued Vanish Odor, showed culture. None of the products tested were freshness dated, which would be required of a live product.

HYDROGEN SULFIDE LEVELS

We measured hydrogen sulfide (H2S) levels in the

holding tanks—not at the vent—using a Honeywell Gas Alert Quattro meter. The holding tanks with 5/8-inch vents ranged from 79-139 parts per million H2S, while our test boat varied from 60-154 ppm H2S when fitted with a 3/4 –inch vent during the same time period. The vent-filtered holding tanks ranged from 140-350 ppm H2S, while the test boat holding tank fitted with a vent filter ranged from 190-360 ppm. Reduced oxygen levels and methane levels followed similar patterns. This demonstrates reasonable agreement between the five-gallon test holding tanks and the 47-gallon test boat holding tank, suggesting that the modeling is fair.

OBSERVATIONS

Whatever happens with these treatments, it happens in one week, perhaps two weeks in larger tanks. Solids digestion evaluation is difficult to determine, in part because it's too foul to measure quantitatively and also because agitation makes it quite variable; these solids break up quickly if the tank is shaken by the action of sailing in vigorous conditions. Thus, we gave only pass/fail ratings to solids digestion; if we saw lumps, it failed. Marine Digest-It and Nature-zyme, which fared well in the summer, failed this test in the fall.

Treated tanks contained far less hydrogen sulfide than the untreated tanks with equivalent ventilation, an indicator that all of the products did work. All were far better than the poorly ventilated, untreated tanks. Other than residual solids, which eventually could cause pump-out difficulties, the two things testers disliked were strong deodorant smells reminiscent of portable toilets and strong dyes that can cause staining.

Temperature makes a difference. The odor and hydrogen sulfide results reported the accompanying Value Guide were from our summer observations, since this was when odors were strongest and it is when most people sail. For fall and winter sailors and for those in cold-water areas (Maine, Pacific Northwest), the results were quite different. The bio-augmentation chemicals performed poorly in cooler weather. Vented tanks were also less effective, though the difference was less significant. Vent filters remained efficient year round. However, odors decline with temperature and true winter weather odor problems are very rare.

All of the products claiming to contain live bacterial cultures tested negative for bacteria. Control inoculations flourished, however, quickly producing both bacteria and fungus. But, we are not certain this is too important. The enzymatic properties

> of several products seemed capable of quickly reducing holding tank odor, and there is already plenty of bacteria in waste. Sewage treatment plants very seldom add cultured bacteria because of this. Additionally, many of the so-called anaerobic bacteria in waste are actually facilitative bacteria that are capable of either aerobic or anaerobic metabolism and can shift mechanism quickly when circumstances change. This change takes only minutes to hours, explaining why chemicals that add oxygen and enhanced venting can materially affect odor in less than 12 hours, far quicker than an aerobic culture could blossom. In time, as every sewage treatment plant op-

erator learns, the optimum culture will establish itself based upon the governing conditions; the bacteria in the waste and these conditions overwhelm any minor biomass additions. Avoiding the addition of toxic chemicals—formaldehyde and related compounds, and bleach being the most common holding tank offenders—is the key to preserving healthy biomass.

FINDINGS

Holding tanks and waste are surprisingly variable, and this can have a great effect on odors. Like most ocean sailors, we used



seawater flush for our testing. Seawater is known to contribute to odors. Many newer systems use freshwater, and very little of it. Others use several pints per flush. Temperatures vary, and ventilation varies. Clearly, individual tanks will be subject to a number of variables that our test tanks were not. To compensate for this, we tested all the chemicals more than once under different conditions. Those that showed the most merit



Camco Ultra TST

in early testing underwent additional testing. All of the recommended products did well, and we encourage you to try each and see which one works best for your special circumstances.

ODORLOS

Containing nitrate as an active ingredient, this product is quite effective when holding-tank ventilation is provided. The liquid version has a green dye, but it is non-staining. We tested the powder version, which was convenient and without mess and perfumes. Among one of the most effective products in our test, Odorlos is a solid performer, and deserves its large following. We tested the 10-pack powder packet. Although the liquid version is the best-selling form, cruising sailors seem to prefer the powder, as it requires the least storage space.

Bottom line: Odorlos was one of our three recommended products. Pricing is competitive.

CAMCO

Camco is a major player in the world of RVs, and we tested two of its holding tank treatments. Its best-selling holding tank treatment, TST Ultra Concentrate, contains nitrate as an oxygen source and washing soda as a cleaner. It performed very well and was the least expensive of the group. The mild orange perfume was just enough and not overpowering; pine scent and "fresh" scent (as opposed to stale?) are available, but testers didn't like these quite as well. *PS* testers focused on the powder form, as it seems most convenient to cruisers. A liquid is also available and performed the same in testing.

Camco's other product, TST Advanced Enzyme, claims to break down organic matter, but this enzyme formula was too variable in our testing. It had no noticeable perfume.

Bottom line: Camco's TST Ultra Concentrate is our Best Choice, and it is also one of the least expensive products in this test. *PS* does not recommend the TST Advance Enzyme product.

MARINE DIGEST-IT

Unique Manufacturing is a web-based company with its headquarters in Tucson, Ariz. Its range of anti-stain and anti-odor products address everything from wine spills to dog poop to septic tanks. Unique Marine Digest-It is an enzyme product without any dye or perfumes.

According to the maker, the bacteria in Marine Digest-It digests organic solids in the holding tank. The company claims that its product has a longer shelf life than similar products because the active bacteria is in a spore form. Bottom line: The product was inconsistent in our testing. The dip slide test did not yield any bacteria cultures. Not recommended.

NATURE-ZYME

Sold in tablet form, Nature-Zyme is developed by Chicago-based Biowish Technologies. According to the maker, Nature-Zyme is an "all

natural" product that removes odors and liquefies wastes inside vehicle and watercraft holding tanks and will continue to work after wastewater is emptied into dumping stations and finds its way into onsite septic systems at marinas and RV resorts. The maker claims that Nature-Zyme contains dry bacterial spores that, unlike many chemical treatments, will not harm septic systems, and will improve their treatment ability. The product is sold in pouches of 12 tablets, with each tablet treating holding tanks up to 25 gallons and costing about \$1 each.

Bottom line: This convenient product did not control odor as well as others. The maker claimed it contained bacterial spores, but it failed to produce cultures in our test.

DOMETIC MAX CONTROL ADVANCED

Dometic is a major force in the world of marine and RV sanitation, making everything from holding tanks to hoses to heads. Its low-water VacuFlush system has become a standard on many larger yachts. Its advanced formula Max Control did not contain any formaldehyde, but the perfume was quite strong. Its inconsistent odor control and staining blue dye put it near the bottom of the field. SeaLand recently introduced a new environmentally friendly formula, which we will test this summer.

Bottom line: Not recommended, but given SeaLand's expertise in this field, the newer product is worth a shot.

THETFORD AQUA-KEM

Thetford is another big player in the marine sanitation game. Its electric-flush EasyFit toilet earned a Budget Buy rating in our test of marine toilets. Containing powerful dye and powerful perfumes and odors, Thetford's Aqua-Kem also contains formaldehyde, making it a non-starter in our view. Fortunately, Thetford has a very good alternative. A bio-augmentation and

enzyme formula, Thetford Eco-Smart, performed much better and was safer and less messy to use. It is available in economy size bottles, small single-dose bottles, or as a toss-in bubble pack.

Bottom line: Eco-Smart earns a Recommended rating; avoid Aqua-Kem.

CONCLUSIONS

Chemical treatments that relied on disinfection, surfactants, and deodorants were generally better than nothing, and they did a serviceable job of reducing solids. However, none of them controlled odor very well, most were messy, and all left a characteristic portable toilet aroma behind. Even if the waste odor were gone—and it was not—they would be distasteful. We do not recommend this class of products.

Good tank ventilation helps significantly, particularly



in the absence of chemical treatment, though it was not as effective alone as the better treatments. Combined with bio-augmenting chemical treatments, well-ventilated tanks effectively controlled odor. Larger vents make good sense and will reduce odors in boats that are left unattended for weeks at a time. Our bubbler system, intended to model the effect of the Groco Sweet Tank System, offered some improvement over natural ventilation. In a larger tank or one where good ventilation is very difficult to achieve, this offers a viable and robust approach.

Bio-augmentation treatments, particularly the recommended treatments, did a fine job of reducing tank solids and controlling odors. The only challenge, which we were not able to adequately investigate, is that they may not last long enough to work in boats that sit unused for three weeks or longer, which can prevent the exchange of air. One solution is to go sailing more often. Another solution is to increase the vent size so that natural ventilation helps these treatments work optimally.

None of the treatments were effective when the air exchange was overly restricted by a long vent line or a vent filter. The conventional wisdom that a vent line can be no longer than five feet, no smaller than ¾-inch inside diameter, and have a rise no more than 18 inches, has proven sound.

How do chemical treatments, vent filters, and enhanced tank ventilation compare? After many months spent lugging waste and comparing results, we've learned all can work, but that each approach has limitations. Good tank ventilation seems a good place to start, supplemented with chemical treatment as needed. The Sweet Tank System can be the answer when good ventilation is otherwise difficult to achieve or the tank is very heavily loaded. For sensitive vent locations (near cockpits, hatches, ports, etc.), vent filters offer the best odor control if a good installation can be achieved. However, the elevated hydrogen sulfide levels in these tanks may increase permeation risk over the long term. We are currently running some long-term tests of hoses and vent filters. Fortunately, the total costs of all of these odor control approaches, taken over time, are low.

Inline Deodorizers

There's no doubt about it, stinky toilets are the subject of much concern among boat owners, ranking right up there with other such bugaboos as bad-tasting water, mildew in the hanging locker and crud in the fuel tank.

Last time we replumbed a boat, we installed an in-line disinfectant/ deodorizer as part of our plan to achieve a sweetsmelling head. It worked, though we're not sure how much of this success is attributable to the new plumbing and how much to the in-line device. In any case, we think they are beneficial. So much so that we found two others, using all three alternately over the course of the season. Here's how they work, plus a brief description of each.

IN-LINE DISPENSERS

Our first exposure to these devices was a number of years ago, when one of our editors tried the R-Tec Head Treatment System

on his boat. A small (several ounces) bottle installs in the water hose between the pump and bowl. A little bit of the concentrated chemical is injected into the bowl with each pump stroke. At the time, we said it seemed to help minimize odors. Raritan makes a similar product, which includes a 2-liter reservoir, check valve and tubing.

The two systems we used are different in that they are larger than the R-Tec and install in the intake hose before the pump. This assures that the water is treated as early as possible, before the micro-organisms in the water lead to odors, even in the pump.

Each pump stroke brings seawater through the dispenser into the system. The tablet of disinfectant placed in the dispensing chamber slowly dissolves, leaking through small holes into the seawater hose.

The chemicals used in the dispensers have a three-fold job: mask nasty odors, minimize calcium buildup in the lines, and accelerate the breakdown of wastes in the holding tank. Because they are dispensed in small amounts, with each flush, these devices use less chemical over the long haul than the holding tank treatments, which are dumped into the toilet bowl; each time the holding tank is emptied, you must pour in a new bottle.

Both chemicals described below give the water in the bowl a slight blue color, very similar to products sold for home use. When the color begins to fade away, you know it's time to put another tablet in the dispenser.

These are, by the way, a bit messy to handle, and can stain clothing, so be careful taking them out of their plastic wraps.

EARTH SAFE

This unit is made of PVC, which appears to be a modified T fitting with a screw-cap on top to insert the chemical tablet.

As with all three units, the inlet hose is cut and the two ends slipped over the barbed ends of the unit, then fastened tight with hose clamps. Because the logical place to install these units is on the bulkhead behind the toilet, most often the inlet hose will come up from beneath the unit. A slight drawback to the Earth Safe is that no right-angle barbed fittings are supplied; if the lead from the intake seacock doesn't provide for a gentle curve, the hose may kink. Of course, you can add a short piece of hose to the straight barbed fitting, then add your own right-angle fittings. These parts are cheap, but it's an added chore and the installation won't look quite as neat. The Earth Safe unit does have molded feet for screwing to the bulkhead.

The size of the holes through which the chemical leaks into the hose is not adjustable. Fred Prue, who makes the competing Tank-Ette, says that not all water is the same; in some locales, he said, tiny holes may clog. We did not, however, experience this, at least in our New England waters.

The Earth Safe chemical is listed as benzalkonium chloride quaternary ammonium compound, which is a common disinfectant. A four pack of tablets costs about \$20.

They are said to last 30 days for liveaboards, longer for weekenders.

Bottom line: The Earth Safe was the least expensive of the three units tested. As best we could tell, it works as well as the others.

TANK-ETTE

A somewhat more sophisticated, and expensive, unit, the Tank-Ette also is made of what appears to be a Schedule 40 PVC Tfitting, though it is larger than the Earth Safe. Inside is a smaller PVC pipe with two tiny holes that can be rotated inside a sleeve to be partially covered, thereby allowing you to control the amount of chemical dispersed in the flush water. If you rotate it too far, however, you can no longer see the holes through the top-cap and chemical reservoir; then you must take off the end caps, at which point the innards fall out. It isn't difficult to reassemble the apparatus, but the design seems a bit homemade.

Installation of the Tank-Ette is easy, though it uses electrical cable ties to hold the unit to the bulkhead; we much prefer molded feet. Right –angle hose fittings are supplied, however, which in our case simplified the plumbing. It can be installed above or below the waterline; if below, the manufacturer recommends installing a vented loop to prevent siphoning of water into the toilet.

The Tank-Ette comes with a screw-on winterizing/flushing cap that replaces the regular cap and makes fall maintenance quite simple: Close the seacock, run a hose from the flush cap to a bottle of antifreeze, then pump the antifreeze through the system. This protects the pump, which doesn't happen if you winterize by dumping antifreeze into the toilet bowl and pumping through.

The chemical used is chloroxylenol, which one chemist told

us is basically a solvent. Fred Prue, maker of the Tank-Ette, says it has been "tested to the international OECD Method 301 D Standard," is biodegradable and is EPA registered. A pack of six universal "bullets" costs about \$25. Prue designed these to fit the chambers in his competitors' devices. Each bullet should last up to about six weeks of normal use. Prue says his bullets also contain a lubricant to keep the pump valves operating smoothly.

Bottom line: We like the adjustable dispensing feature and the winterizing feature, but not the mounting method. It's a bit of a toss-up with the Earth Safe. Both seem fairly priced, and a bargain if they eliminate your head odors.

CONCLUSION

We think both devices do a good job of helping eliminate head odors. They are easy to install and are not expensive. There is very little to lose by trying any one of these.

As mentioned, earlier tests have shown that the worst odors occur when warm, stagnant sewage lies for a time in PVC sanitation hose. (Buying good quality, heavy, reinforced hose with a smooth bore helps. Other things you can do include frequent flushing, either with a solution of muriatic acid, which may froth violently, or a solution of water and 30% vinegar.) Therefore, it is beneficial if such low spots can be either designed out of the plumbing system, or those sections replaced with rigid PVC pipe. That, plus installing an in-line dispenser, has worked for us.



Maintaining a Healthy System

While permeation of waste gases through flexible sanitation hose is a major source of odors in the head, it is not the only one. Here are some tips to help you target odor control:

HOSE

We believe that replacing flexible white PVC sanitation hose with Shields Poly-X or SeaLand OdorSafe Plus hose will help eliminate odors. But it, too, will eventually fail, albeit after a much longer time. You can prolong the lifespan of sanitation hose by eliminating low spots in the installation where sewage collects. No sewage sitting in the hose, no hose failure. Hence, vigorous flushing of the hose helps, too. This is fine if you're offshore and pumping directly overboard, but if pumping into a holding tank, overflushing fills the tank that much faster.

RIGID PVC

Our tests have proven what we already knew, that rigid PVC pipe contains odors. When re-plumbing the head aboard our 1975 Tartan 44 test boat some years ago, we used rigid PVC as much as possible—between the holding tank and discharge pump and seacock. Of course, you can't connect rigid PVC directly to them, so need to switch to flexible hose, using adapters. This also helps protect the rigid PVC from cracking should it be exposed to forces when the boat is crashing around or twisting slightly.

FRESHWATER FLUSH

Not all head odors emanate from sewage; in fact, considerable malodors arise from the toilet bowl itself: rotting organic matter such as seaweed and krill. Some toilets use freshwater rather than seawater for flushing. While this may not be practical for the bluewater cruiser, on other boats it may make a lot of sense.

We used a VacuFlush toilet for several years and found it only required several pints of water per flush; when the freshwater tank could be refilled at a nearby dock, "wasting" potable water on toilet flushing wasn't a big deal.

Peggy Hall, author of "Get Rid of Boat Odors: A Boat Owner's Guide to Marine Sanitation Systems and Other Sources of Aggravation and Odor," is well-known for her expertise in marine sanitation. Hall recommends shutting the seacock when leaving the boat, pumping the bowl dry, and then pouring a quart of fresh water into the bowl and pumping that through the system. She says, "...this routine when leaving the boat will solve most odor problems."

INLINE DEODORIZERS

There are a number of inline chemical dispensers that treat the seawater between the intake seacock and toilet pump. A crude metering device allows a small amount of a blue tablet to dissolve into the flush water—sort of like the giant in your toilet bowl. The chemicals are supposed to be nontoxic, biodegradable and not harmful to the environment. These disinfectant/deodorizers also seem effective. (For more on this, see Chapter 4.)

HOLDING TANK TREATMENTS

There are innumerable tank additives—chemicals, bacteria and enzymes—formulated to deal with holding tank odors. Some simply mask it, others break down and emulsify solids.

In tests, we've found Yara Chemical's Odorlos, Camco's Advanced Enzyme Formula, and Thetford's Eco-Smart to be effective.

Waste contains aerobic (needs oxygen to survive) and anaerobic (lives without oxygen) bacteria, and only the latter is malodorous. If the waste is well ventilated with fresh air, the aerobic bacteria will overcome the anaerobic bacteria and the holding tank won't smell. A 5/8" or 3/4" vent hose no more than 3' long and without sharp bends will help. Off-the-shelf vent filters we've found to be effective are the Big Orange 5/8-inch and the Sealand SaniGard 5/8-inch.

MAINTENANCE

Everything gets old and deteriorates over time. But with regular, proper maintenance of the sanitation system, you can keep the head odor-free. Some good rules of thumb:

► Rebuild the toilet pump periodically.

► Empty and rinse the holding tank and hoses with fresh water, and replace hoses you suspect are permeated with malodor.

► One way to identify failed hose is to rub a clean cloth over it and sniff it every foot. Subjective sensory tests—a technique more formally known as organoleptic testing—do not, in general, produce quantitative results. And, of course, when it comes to identifying specific sources of sewage aroma, it's not easy to find willing noses (a phenomenon that's been described as recalcitrant organolepsis). Your crew, of course, will not hesitate to notify you of any general malodors in the cabin, nor will they hesitate to demand that you do something about it.

Contacts Directory

BEP MARINE INC. (Marinco), 770/226-9600, www.bepmarine.com

BIG ORANGE, 647/237-1355, www.bigorangefilter.com BOSWORTH, 888/438-1110, www.thebosworthco.com CAMCO, 800/334-2004, www.camco.net EARTH SAFE SANITATION SYSTEMS, 775/323-5990 FIREBOY-XINTEX, 866/350-9500, www.fireboy-xintex.com FORESPAR, 800/266-8820, www.forespar.com GROCO, 410/604-3800, www.groco.net HART SYSTEMS INC., 253/858-8481, www.thetanktender.com JABSCO, 978/281-0440, www.xylemflowcontrol.com JOHNSON PUMPS,

847/671-7867, www.johnson-pump.com

NATURE-ZYME, 888/376-2976, www.nature-zyme.com

RARITAN, 954/525-0378, www.raritaneng.com

SCAD TECHNOLOGIES INC., 631/754-1945, www.scadtech.com SEALAND (DOMETIC), 800/544-4881, www.dometic.com

SENSATANK (Touchsensor Technologies), 630/221-9000, www.westmarine.com

SNAKE RIVER ELECTRONICS, 800/456-4498, www.snake-river.org

SHIELDS MARINE (Teleflex), 877/663-8396, www.teleflexmarine.com

TANK-ETTE, 800/563-5947, www.tankette.com

THETFORD, 734/769-6000, www.thetford.com

TRIDENT, 800/414-2628, www.tridentmarine.com

TRIONIC, 262/692-6336, www.trionic.com

TRUDESIGN, www.trudesignplastics.com

UNIQUE DISTRIBUTING, 800/595-7136, www.uniquedistributing.com

VETUS, 410/712-0740, www.vetus.nl/us/

WEMA, 954/463-1075, www.wemausa.com

WHALE, 802/367-1091, www.whalepumps.com

YARA, www.yara.us