Blackwater Guide

A sanitation system can be functional, odor-free, and (mostly) worry-free—if you choose the right materials, equipment, and techniques for design and installation.

Text and photographs by Steve D'Antonio

In the last decade, onboard waste storage—the dreaded holding tank—has been refined, if not perfected. Now, odors can be largely eliminated thanks to the introduction of freshwater flush, hoses better able to resist permeation, and tank ventilation and aeration systems. Also, technology that enables flushing with a fraction of the water once required has reduced the size of holding tanks (or increased their effective volume). In short, today's sanitation systems are easier to install and maintain and are more reliable. And yet, when I board many vessels and open a bilge or lazarette hatch, my nostrils are assaulted by the acrid, unmistakable odor of effluent.

Crawling through these spaces I encounter what have become predictable sanitation system design and installation errors—flaws that could have been easily avoided during original installations. Most are correctable after the fact, although the significant effort and cost can subject vessel owners to a financial hit that they might rightfully question—particularly on a relatively new boat.

Boat builders and repairers should design, install, and maintain sanitation systems that work well, don't smell, and require minimal attention from users. I believe all those goals are readily achievable. (Note that for the purposes of this article, the term "sanitation system" covers all components other than toilets and their proprietary related parts.)

The Holding Tank

The holding, waste, or blackwater tank can make or break a sanitation system. Because the tank is likely the most difficult part to correct when done wrong, it reinforces the importance of proper design and selection.

The list of materials for holding tank fabrication includes stainless steel, aluminum, mild steel, and flexible bladders, as well as polyethylene (PE) and fiberglass reinforced plastic (FRP). In my experience, all metals, regardless of corrosion resistance, are incapable of enduring prolonged exposure to effluent, while bladders are prone to chafe failures and odor permeation. The "plastics," PE and FRP, on the other hand, are the most reliable and least likely to leak, provided they are

Above—*Holding tanks are the most important part of a sanitation system. They're also the most difficult parts to fix, so designing them correctly from the start is critical. In this example of a good design, a large holding tank's fittings are concentrated in a central location that also serves as an access port.*

designed and manufactured following a few simple guidelines.

PE tanks should be linear as opposed to cross-linked; the latter is typically used for fuel, while the former is appropriate for sanitation and potable-water applications. Wall thickness is critical: too thin and you can count on bulging or other distortion, which often leads to leaks at fittings, as well as permeation and odor. Therefore, thicker is better, with a minimum wall thickness of ⅜″ (9.5mm).

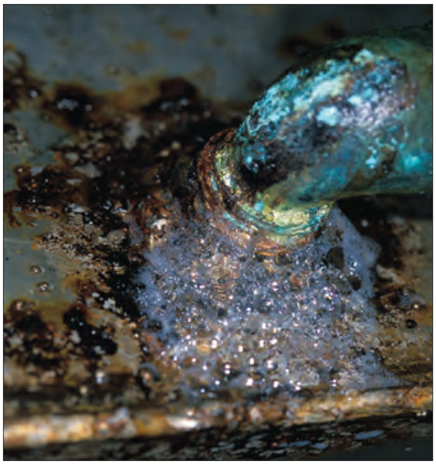
For decades, PE tanks have been built using a rotational mold system, which produces a seamless and consequently leak-free structure (with the exception of fittings). Rotomolded tanks cannot be baffled in the traditional sense (baffles add rigidity and reduce distortion and liquid movement—critical for larger tanks). However, tank manufacturers have come up with creative ways of adding baffle-like structures within these tanks, including "speed bumps" and cylinders that span and tie together opposing walls.

As good as this rotomolded system is, it has one drawback. As all boatbuilders know, molds lock in a design, which means you can have any PE tank you want, as long as it's the shape and size of a commercially available one. Fortunately, there are scores if not hundreds from which to choose, which makes it likely that one will fit, or nearly fit, the exact needs of a particular installation. That's not to say customized rotomolded tanks are out of the question, but they're probably not economically feasible.

While it has been around for some time, polyethylene welding has matured into a reliable technique for true custom fabrication, offering builders and refitters even more options. While PE does not lend itself to being bent, welding can produce complex shapes, so PE can, for instance, conform to curved hulls.

All tanks, regardless of their material, should be well supported; however, PE tanks, because of their inherent flexibility, must be *fully* supported, meaning they should be installed on a continuous shelf with no gaps or overhangs. Because effluent weighs roughly the same as water—8 lbs per gallon (0.96 kg per l)—shelves and securing structures must be robust, and no different than those used for any other tank. Tanks with integral mounting flanges have become popular in the past few years, making installation quicker and easier. Where such flanges are not available, tanks must be cribbed, strapped, or otherwise secured. Under no circumstances should uprights be installed between a tank and an overhead; they could exert pressure on the top of the tank. When strapping, care must be taken to avoid local loading and crushing or distorting the tank.

FRP tanks, on the other hand, are exclusively custom-built, as opposed to off-the-shelf. Resin, typically vinylester or epoxy, must be compatible with constant immersion in black-



Left—*Polyethylene tanks are rugged and durable, offering protection against corrosion. To ensure a successful installation, avoid bottom fittings if possible, and don't skimp on wall thickness, because that can lead to permeation, distortion, and leaks.*
Right—*The bubbles show that this stainless steel holding tank has failed a pressure test and thus reached the end of its life. Despite its otherwise solid reputation, stainless steel is prone to crevice corrosion when exposed to stagnant water, a problem exacerbated by effluent's extremely corrosive tendencies.*

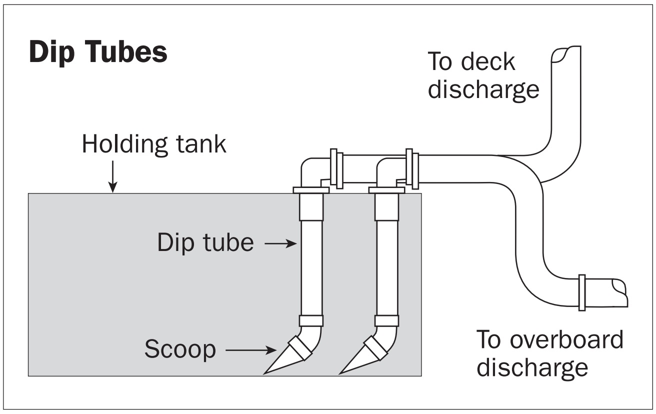
water. Some production builders choose FRP for waste, water, and diesel fuel tanks. While more costly than PE tanks, they offer experienced FRP fabricators several advantages that are tough to beat: FRP tanks are customizable and easy to install (to an extent they can be tabbed in place), and help maximize space. They're also durable; an FRP tank can be expected to last the life of the vessel.

Tank plumbing design is critical to the system's functionality and reliability. To avoid leaks and standing effluent within plumbing, all fittings should be located on the top surface of the tank. Traditionally, a single evacuation fitting was placed at the bottom of the tank for overboard discharge and deck pump-out. This was selected or controlled by isolation or Y-valves, or in some cases no valves at all. That approach, however, is falling out of favor, replaced by twin top-mounted dip or pickup tubes. A single, shared discharge fitting often requires more complex plumbing, such as a T-fitting, Y- or isolation valve, which is prone to leaks and may seize. These are unnecessary with twin pickups, which also offer a degree of redundancy in the event of a clog or failure of the pickup tube.

Fittings will vary depending on tank material. For fittings other than those molded in place or provided with the tank, most PE tank manufacturers offer bushing kits that allow installation in any location. If possible, avoid fittings on the tank side and bottom, where they might leak. (If they must be on the side, they should be as close as possible to the top.)

FRP tanks offer a few options. Fiberglass tubing can be permanently tabbed into the tank where desired; however, dip tubes should be removable to deal with clogs. (These can be installed in larger removable inspection plates; **see photo on page 38**.) The bushing system mentioned above serves here, provided the thickness of the tank's top does not exceed the bushing's design parameters. Alternatively, bronze or schedule 80 PVC plumbing can be installed, though the bond between FRP and metal or PVC is often tenuous. To eliminate the need for that bond, bronze or PVC should rely on a compression arrangement, similar to a through-hull fitting, rather than a resin-to-metal or PVC bond alone. Stainless steel should be avoided; it is far too susceptible to crevice corrosion, which is exacerbated by effluent's corrosive, oxygen-starved composition (inspection lids may be stainless steel).

Dip tubes should extend to within approximately 2″–3″ (51mm–76mm) of the tank bottom to facilitate as much effluent removal as possible. A variation on this utilizes an inverted scoop feature connected to a 90° fitting installed at the bottom of the dip tube (**see diagram below**). The narrow end of the scoop touches the tank bottom, which supports the tube. This is a particularly advantageous arrangement for long dip tubes. These dip tubes are available commercially, or they can be fabricated on site from PVC pipe.



Twin pickup tubes—one for overboard discharge and one for deck pump-out—make for a simpler installation by eliminating the complex plumbing needed for a single shared pickup. Dual pickups also have a degree of redundancy in the event of a clog.

Tank Ventilation

Because holding tanks contain effluent, they also contain highly concentrated noxious odors, which, if allowed to escape even in the smallest amount, are impossible to ignore. The primary reason the tank smell is so potent is because its oxygen-poor, anaerobic environment supports sulfur-producing bacteria with the familiar rotten-egg smell. Rather than trying to contain the strong odor of this colony, why not simply eradicate it? Oxygen is poisonous to anaerobic bacteria, so flooding the tank with fresh air will accomplish two things: dilution of the odors within the tank and elimination of the environment in which anaerobic bacteria thrive.

Ideally, holding tanks should be equipped with twin 1.5″-diameter (38mm) vent lines, preferably plumbed to opposite ends of the tank and then overboard. Avoid plumbing one of these fittings at or near the transom. The station wagon effect will create a vacuum in the tank, which will draw air in from the other fitting, particularly when the vessel is under way. While this effectively ventilates the tank, the air extracted from the tank will tend to linger in the stern area, which can be unpleasant while the boat is at rest. Instead, plumb these vents to the port and starboard hull sides to induce a slight pressure differential that encourages air movement through the tank. In my experience, once this air movement is established, odors within the tank diminish significantly, while odors outside, adjacent to the vents, are virtually eliminated.

Oversized vents of this sort also make it practically impossible for tanks to be damaged by aggressive pump-out systems, some of which are capable of pumping as much as 50 gpm (189 lpm), thereby subjecting the tank to crushing pressures of vacuum. If the tank is not equipped with at least one 1.5″ vent, consider installing a commercially available vacuum relief valve **(see photo on page 48)**, which is fitted directly into the tank top and will admit air into the tank if the vent is clogged or overwhelmed, while preventing any gas or liquid from escaping.

Anaerobic bacteria tend to congregate as far away from oxygen as possible: at the tank bottom. Moving air through the tank will minimize their formation; however, that movement will do little to ventilate or aerate the bottom of the tank. To address that area, you'll need to install a bubbler pump similar to one used to aerate the water in an aquarium. These can be made using a small, self-contained compressor, or a proprietary off-the-shelf tank aeration system may be used.

With this system operational at all times, oxygen is infused into the effluent via a dip tube that extends to the bottom of the tank, making it difficult for anaerobic bacteria to exist anywhere in the liquid. Modest but constant airflow also helps purge the tank, diluting remaining odors. This forced-air approach is effective in conjunction with the twin-vent system, even if only one or an undersized vent is installed.

By applying these ventilation techniques, I've found the need for activated charcoal vent-line filters is essentially eliminated. However, if one still wishes to use a filter, they are available for 1.5″-diameter hoses, and must be located above the top of the holding tank to ensure that they are never directly exposed to liquid during normal operation. But if a tank is overfilled, these filters will almost certainly be exposed to and ruined by effluent, and need to be replaced. In addition, they must be accessible for seasonal replacement. If the filter is located behind a removable bulkhead panel or hatch, a placard on or adjacent to the access should note the presence and replacement requirements of the filter within.

With custom tanks, it's up to the designer, but most off-the-shelf PE

__Below—__Small antisiphon valves can have a big impact on a sanitation system. They must be installed in serviceable locations, and vessel owners should be alerted to their periodic maintenance needs. Consider supplying a few spare valves like the one shown here with each installation. __Right—__An aeration system, feeding a constant stream of air into effluent within a holding tank.

tanks come equipped with an inspection port. While it's not a task any of us wishes to perform, being able to access the inside of a holding tank through an inspection port to, say, retrieve an object mistakenly flushed, is certainly an advantage.

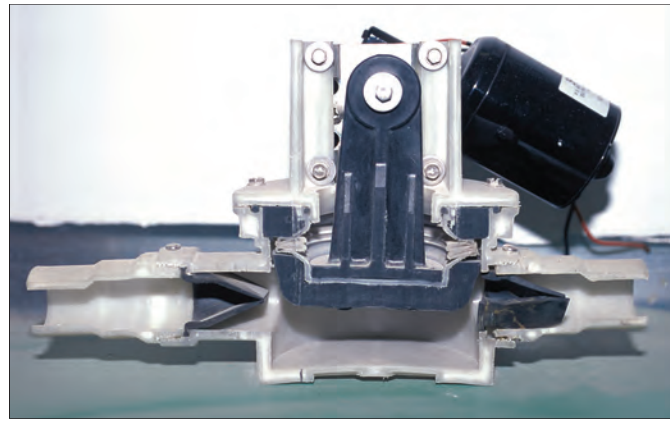
The final thought on holding tanks involves flushing. On many occasions I've successfully unclogged tank senders and dip tubes by filling a holding tank with water and allowing it to stand for a few hours, or be agitated while under way. Dissolving or dislodging can also be accomplished "manually" with fresh or salt water by running a washdown hose into the deck pump-out fitting (I use a funnel when doing this to avoid contaminating the hose end with effluent). Alternatively, plumbing for flushing can be permanently connected to a tank so it can be flushed with seawater from a deck wash pump simply by opening a valve. The discharge from this fitting should be directed at the float or sender mechanism. When I've installed these I have, on occasion, used a spring-loaded valve to prevent the tank from being overfilled.

Discharge Pumps

Rotary macerating pumps were once a mainstay of marine plumbing but are now less common, particularly on larger, longer-than 40′ (12.2m), vessels. While less costly than alternatives, the pumps have a tendency to jam from debris or disuse, as well as failing if run dry, creating frustration for many owners and crew.

Reciprocating diaphragm discharge pumps have become increasingly popular, thanks to their longevity, ability to be repaired and rebuilt, and resistance to damage from running dry. They have two potential problems: sensitivity to damage and a tendency to malfunction from back-pressure. This can occur if a discharge pump shares plumbing with a deck discharge fitting. The arrangement places a vacuum on the inlet side of the diaphragm pump, potentially inverting its

internal rubber valves, and rendering the pump inoperable until it is disassembled and the valves are pushed back into place or replaced. (Pump manufacturers recommend replacing



Left—*Macerating discharge pumps, once a mainstay in the industry, cost less than diaphragm pumps but are more prone to clogging and seizure. This installation relies on a bottom-draining tank plumbed with hose—a combination almost certain to lead to permeation and odor.* ***Middle***—*Diaphragm blackwater pumps have greatly improved the movement of effluent, proving far more reliable than macerating pumps.* ***Right***—*Another advantage is diaphragm pumps can be rebuilt; the most common replacement items are the duckbill valves, seen here at inlet and outlet fittings.*

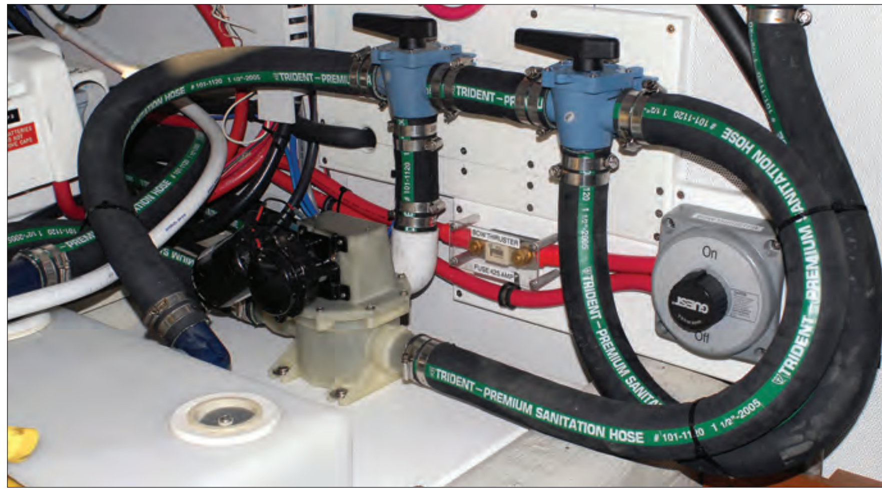
valves that have been inverted. But if replacements are unavailable, for a temporary fix I've pushed valves back into position using a broomstick or similar cylindrical object with a rounded end, which won't tear the rubber valves.) While isolating valves as well as the overboard seacock could prevent this from occurring, this adds complexity and sources for potential leaks. For this reason, these pumps should be plumbed to dedicated discharge lines, reducing the likelihood of valve inversion, while eliminating the need for additional valves.

Valve inversion often occurs when a pump of this type is inadvertently operated against a closed seacock. Doing so momentarily builds pressure in the discharge line; and when the pump can no longer overcome that pressure, it pushes back through the pump, inverting the valves. This can be averted by wiring the pump through a switch located on the overboard discharge seacock's handle (these are available from sanitation system manufacturers). The switch's contacts open when the valve's handle is closed, preventing the pump from operating.

Other worthwhile pump installation features include an electrical key or lockout mechanism to prevent unplanned effluent discharge from the holding tank, or to meet laws that mandate a means to prevent such discharges. Alternatively, many Y-valves and some seacocks are designed to accept padlocks.

An auto-stop feature also can be included in the sanitation system or in the toilet's own pump to prevent pumping effluent *into* a full holding tank, potentially damaging the tank, clogging the vent, and ruining the vent filter (if equipped). This relies on a simple float switch mechanism.

Finally, for applications where maximum redundancy is sought, such as for cruising and other vessels traveling far from support, or in charter applications, a second holding-tank discharge pump—electric or manual—makes excellent sense. In the case of a diaphragm pump, the spare can be plumbed in-line with the effluent flow, as effluent will pass through the duckbill valves with little difficulty, although the valves will see some wear. To avoid this, the spare pump can be plumbed in parallel, using isolation valves. In my experience, this approach requires regular cycling of the spare or off-line pump to avoid seizure or fouling of the duckbill and isolation valves. (The in-line arrangement is usually not subject to this problem.) Ideally, the "spare" pump should be purged with fresh water if possible. If a manual pump is used, one with a bronze (or nonmetallic) body is preferable to aluminum, which is far more prone to corrosion when exposed to effluent.



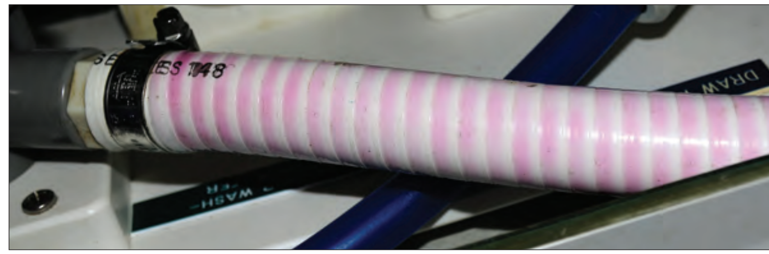
When designing and installing plumbing, keep in mind that all hose will eventually need to be replaced. Hose runs should be accessible, and, where possible, avoid low areas that will retain standing effluent.

Plumbing

Virtually every vessel I've been aboard relies on hose to move effluent from toilets to holding tanks, and from there overboard. While rigid PVC pipe is also an option, hose is chosen more often because it's flexible and easy to install. But it also has many drawbacks. Hose, regardless of its material or claimed longevity and warranty, must eventually be replaced. On many vessels, sanitation hoses are effectively entombed in joinerwork, indicating that builders give little thought to their replacement. I've undertaken these hose-refit projects, and they're daunting and costly. Additionally, the minimum bend radius for 1.5″ hose is roughly 8″ (203mm), which can be reduced considerably with PVC elbows. I am, therefore, making a case for using as much rigid PVC pipe as possible, preferably schedule 80 for maximum resistance to stress and vibration. Provided it's properly installed and well-supported, PVC pipe could potentially last as long as the vessel.

Hose should categorically not be used in certain situations, primarily where standing effluent cannot be avoided, such as in bottom-tapped holding tanks; and every effort should be made to avoid using it in the lines between discharge pumps and anti-siphon valves, and where sharp turns must be accommodated (for these areas, avoid mitered pipe connections; sweeps are preferred). Of course, rigid

Left—*Because this pipe nipple was not designed for a pipe-to-hose union, the connection failed, dumping the contents of a holding tank into the vessel's bilge.* ***Above***—*This 90° pipe-to-hose adapter fails on two counts: it's located at the bottom of the tank, and it uses hose.*



Left—*The debate continues over which hose material, PVC or EPDM, is best suited for effluent use and most resistant to permeation. One undeniable distinction is that PVC hose is susceptible to attack by solvents and alcohol-based fluids.* ***Right***—*This PVC hose has been permeated by propylene glycol, the pink fluid commonly used for winterizing. EPDM suffers no such limitations.*

PVC pipe should not be plumbed directly to seacocks, as this plumbing effectively becomes an extension of the seacock, thereby making it unlikely that the installation could continue to meet ABYC's 500-lb (226.8-kg), 30-second "survivability" guideline. Install sanitation/raw water-rated hose at seacock connections and wherever a failure would lead to raw-water flooding. Support for PVC pipe is critical to prevent stress and fracture, particularly where pipe is connected to hose. At these unions, the hose should always be fully immobilized so as not to apply any load to the rigid pipe.

For decades a debate has raged over which variety of sanitation hose is best. I've used flexible PVC-based and EPDM (ethylene propylene diene monomer M-class) rubber-based varieties, and generally have had better experience with the rubber-based, although that's far from definitive. Warranties are telling. They range anywhere from no warranty to five years. Some include labor, and some are pro-rated. Do your homework and choose carefully. One distinction worth noting is that most PVC-based hose is marked with the words "USE NO ALCOHOL OR PETROCHEMICAL BASED FLUIDS." I have seen PVC hose that appeared to have been permeated by common winterizing non-toxic antifreeze, turning the hose from white to pink. No EPDM hose I've encountered carries this warning.

Permeation can lead to more than just nasty odors. Mold and other bio-colonies thrive on the "nutrients" that pass through porous hoses. Hoses that exhibit such characteristics, odors or not, should be replaced.

Permeation is the word no boatbuilder or systems installer (or hose manufacturer for that matter) wants to hear where hose is concerned. In many of the cases where I've seen sanitation-hose permeation, it was the result of a system design that allowed effluent to pool in a hose. While sanitation systems that rely on vacuum or jet flushing are less susceptible to this problem, they are not immune, nor are standard flush sanitation systems. Make every effort to avoid such traps. While higher-quality hoses are more resistant to this phenomenon, hose sections in which traps are unavoidable should be replaced with PVC pipe.

If the odor of effluent in a cabin or utility space leads you to suspect that a hose is being permeated, start with a simple evaluation. The nonscientific approach calls for placing your nose directly against the suspected hose and sniffing. In most cases, it will be clear if the hose is the offender. If, however, the entire space is so contaminated that the sniff test is inconclusive, a more scientific approach is needed.

Rinse a well-used cotton washcloth or rag thoroughly to remove any surfactant or detergent scent; saturate it with chlorine-free hot water; wrap it around the suspect hose; leave it there for a minute or two, then remove it from the hose and immediately place it in a new Ziploc bag. Carry the bag off the boat, head upwind to a protected location, open the bag, and sniff. If you smell no effluent, it's unlikely the hose is permeated, at least not in that location.

A hose showing signs of growth or mildew is a clear indication it is permeated and needs to be replaced. (I've encountered mushrooms growing on permeated sanitation hose, a hydroponic effluent garden of sorts.)

Ever notice during a flight how the water bottle you open, empty, and reseal at 32,000 feet collapses by the time you land? This same phenomenon can act on a holding tank whose vent is clogged or undersized, particularly when being emptied by an aggressive dockside pump-out station. This can be avoided with the installation of a vacuum-relief valve, shown here.

To prevent siphoning, vented loops or antisiphon valves are required, particularly for direct overboard applications, such as from a toilet to a discharge seacock or from a holding tank to overboard. Vented loops are available in a variety of materials, including plastics and bronze. Unless prohibited by the manufacturer, both are suitable for sanitation applications. Once again, avoid stainless steel because of its susceptibility to crevice corrosion, which is exacerbated by effluent.

Regardless of their material, pipe-to-hose adapters should be internally chamfered to reduce flow resistance and prevent clogging. Avoid using polyurethane or other sealants at the interface between hoses and pipe-to-hose adapters. Something is wrong if sealant is needed to make this a liquid-tight joint: either the match between hose and adapter is poor, or the clamping mechanism is inadequate. If the fit between the two is tight, as it should be, diluted liquid dish detergent may be used to ease the fitting process.

Hoses should be double-clamped when possible. But if the barbed fitting beneath the clamp is too short to support dual clamps, a single clamp is adequate. I routinely see hose installers' seemingly maniacal insistence on double clamps, even when two cannot be properly supported. More often than not, the result is counterproductive: a damaged, crushed, or otherwise compromised hose.

Based on testing I've carried out, I believe it makes no difference whether clamps are installed with screws in the same or an opposed orientation. (Some professionals believe that when you install double clamps the screws of the two clamps should be oriented in opposite directions.) It's more important to install clamps so they can be accessed as easily as possible for re-torqueing in the future. It's also important that the clamps are not prone to stripping (choose ones with a solid, embossed rather than a perforated band), as sanitation hose tends to be thick-walled and stiff, particularly the EPDM variety. If the clamps are adjacent to a valve or other fitting that may require access, be certain the clamp ends do not present a laceration hazard. Clamp-end caps can make the installation safer.

Few liquids, including seawater, are as hard on valves as effluent is. For that reason they must be selected with care when designing sanitation systems. If a valve failure would result in seawater flooding, use only bronze or glass-reinforced plastic, and always place an American Boat & Yacht Council–compliant seacock between sanitation system plumbing and the

Strategically placed air fresheners are an indication of a defective sanitation system. Properly designed systems should have no odors to cover up.

water in which the vessel floats. Elsewhere within a sanitation system, heavy-duty, preferably schedule 80, PVC glass-reinforced plastic valves should isolate or divert waste. I find bronze valves more prone to seizure in sanitation systems, and PVC and plastic valves to be the least prone. The key to long, reliable valve life is regular exercise; valves should be cycled at least quarterly, which means they must remain accessible. Be certain your customers understand this requirement.

In an effort to prevent odors from migrating into the cabin, some installers choose to plumb the vent portion of a vented loop outside the accommodation space. While the intention is noble, the practice is often a recipe for failure. Vents should allow air to enter, not leave, the sanitation plumbing, which means that if odor is perceived at a vented loop, it's likely the vent is malfunctioning or worn out, or there is a nearby leak. Another problem with the remote-mount approach is that it requires installing a length of small-diameter hose between the loop and the vent. This hose, which is often PVC, is easily compromised by effluent that percolates up into it each time the system is pressurized, leaving behind residue and solids that eventually clog the hose, rendering the vent useless. Also, most small-diameter hoses, including clear PVC (the frequent material of choice), are susceptible to odor-permeation. Again, this well-intentioned approach will be counterproductive, as it's more likely that this setup will smell as well as fail to prevent a siphon from occurring.

For these reasons, antisiphon valves in sanitation systems, and elsewhere, must be installed where they can be easily viewed and serviced. They should be labeled, and the ball or duckbill valve within should be inspected and cleaned or replaced seasonally.

A variety of manufacturers offer proprietary sanitation system Y-valves with features ranging from adjustable output ports to locking handles. I have found those with small-diameter star-shaped handles to be more difficult to use, particularly if access is poor. I favor those with longer straight handles that offer greater leverage and ease of use.

Monitoring

Of all the onboard fluids, effluent is the most difficult to monitor. Conventional floats that work well in fuel and potable water invariably seize and jam or corrode inside the harsh environment of a holding tank.

Creative manufacturers have attacked this problem in various ways, including the use of reed switches, some of which are coated with a hydrophobic substance that essentially prevents

Blackwater tank monitoring is challenging because its senders live a harsh life and are likely to jam. One reliable system utilizes a simple approach: a series of lights to alert the user to a LOW, MID, and FULL tank. Senders should remain accessible for periodic service.

slippery solids from collecting on their surfaces. Others rely on ultrasonic technology, directing sound waves at the liquid surface, which reflects them back to a transducer. Still others rely on a burden tube arrangement that manually or electrically pumps air into a dip tube. While sight glasses can successfully monitor fuel and water tanks, unfortunately they are not an option for solids-rich effluent, although naturally translucent PE tanks have a pseudo sight glass–like effect.

I have yet to find a holding-tank monitor that is 100% reliable, or at least as reliable as equivalent fuel-tank senders, though some have shown promise. I've concluded that the most effective monitoring system, regardless of the technology, relies on an easily accessed sender that can be cleaned or replaced when necessary. It shouldn't take longer than five minutes to access a sender. If joinerwork has to be disassembled, or, worse, if a hole must be cut in a deck, it's not accessible enough.

Marine sanitation systems have a stinky reputation among boat owners, but with good reason. Far too many of these systems are haphazardly designed and installed, with too little thought given to reliability, odor mitigation, longevity, and ease of service. Today, the tools, materials, and knowledge exist to design sound, functional, and odor-free systems. PBB

***About the Author:** For many years a full-service yard manager, Steve now works with boat builders and owners and others in the industry as Steve D'Antonio Marine Consulting. He is an ABYC-certified Master Technician, and sits on that organization's Hull and Piping Project Technical Committee. He's also the technical editor of* Professional BoatBuilder.