PUMP DON'T DUMP

Sewage Holding Tank Systems for Recreational Boats

System Design • Equipment Selection
Installation • Maintenance

ABYC

Setting the Standards for Safer Boating

Other "Pump Don't Dump" program products include two brochures:
"A Boater's Guide to Sewage Pumpout"
and
"Boat Sewage Pumpout Facilities in Maryland"
developed by BOAT/US Clean Water Trust
and
"Making the Chesapeake Connection"
a video developed by Save Our Streams

"Sewage Holding Tank Systems
for Recreational Boats"
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A nonprofit organization, ABYC develops and publishes voluntary standards and recommended practices for the design and construction of recreational boats and their related equipment.

To order additional copies of this publication or other "Pump Don't Dump" program products, call the Maryland Department of Natural Resources, Boating Administration at (410) 974-2918.

Contents

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The American Boat & Yacht Council
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Compliance

Boat owners and repairers...

This booklet will help you install or upgrade sewage holding tank systems to be in compliance with existing laws governing marine sanitation devices (MSDs). You will find information on how to choose a system, sewage system design and the selection of system components, plus helpful tips for their installation and maintenance.

What is the law?

In response to growing fears of the "death" of our nation's treasured bodies of water, Congress enacted the Clean Water Act of 1972 (amended in 1987). This law addresses a wide spectrum of water pollution problems, including marine sewage. It prohibits the discharge of untreated sewage from boats in navigable U.S. waters including coastal waters for a distance of three miles offshore. The law further provides for "no discharge" by boats operated in enclosed lakes and reservoirs or in rivers not capable of interstate navigation. States may apply to the EPA to have certain other waters declared "no discharge zones" if discharge of treated sewage would be harmful. In short, boats with installed toilets must have an operable Coast Guard approved MSD designed either to hold sewage for pumpout ashore or for discharge in the ocean beyond the three mile limit, or to treat the sewage to Federal standards prior to discharge.

Why should you act now to comply with this law?

First of all, it is the law! All boats built since 1977 with installed toilets must have an operable approved type MSD. Since 1980, all boats (including those built before 1977) with

installed toilets must have an operable MSD. Nevertheless, boaters often bypass these systems and discharge untreated sewage directly overboard. If you flush your boat's toilet in violation of the law, you can assume that others do too.

The basis for arguments that boat sewage is "peanuts" compared to other sources of pollution, that holding tanks "stink," that there's no place to pump out, and that the law isn't being enforced anyway, is weakening fast in these changing times. These facts are clear:

- Growth in boating is placing an additional environmental strain on crowded recreational waters.
- Government and citizens' groups are working aggressively to contain and prevent all forms of water pollution.
- Government grant money is funding a tremendous increase in the number of pumpout facilities.
- Advancing technology has given us a wide range of "user friendly" sanitation system options.

Against this backdrop, it is not surprising that Congress is considering proposals that would increase fines for flushing raw sewage and provide states with incentives for enforcing current laws. Clearly, it's time for all boaters to "do the right thing."

What can you do now to comply with the law?

Boaters share a common desire to play in and on sparkling clean waters. We can choose to pollute or not to pollute. We can do the right thing now, take action, and obey the law! Good environmental citizenship will help assure our continued delight in clean waters. Use this booklet in choosing a marine sanitation device that best fits your needs.

What are your choices for compliance?

There are three types of Coast Guard approved marine sanitation devices (MSDs):

- Type I MSDs treat sewage so that the discharged effluent meets specified standards for bacteria content and contains no visible floating solids.

- Type II MSDs are similar, but must meet a higher standard of sewage treatment.

- Type III MSDs retain sewage for shore based disposal or discharge beyond the three mile offshore limit.

Boats 65 feet in length or less may install a Type I, II, or III device. Vessels over 65 feet must install a Type II or III MSD.

An approved system (Type I or II) will have a label verifying that it meets the Coast Guard regulations for design and construction and the Environmental Protection Agency (EPA) regulations and standards as required by the Clean Water Act. Holding tanks (Type III) do not require a certification label if they simply store sewage at ambient temperatures and pressures.

What system should you install?

If the boat is operated in waters designated for "No Discharge", you have only one choice...you must retain all sewage, treated or not, for disposal ashore. Choosing the system that works best will depend on several factors. The answers to a few questions about how the boat is

used should help you narrow the choices and determine optimal holding tank capacity:

- How many people are usually onboard for a trip?
- Is the boat used mostly for day trips or for longer periods and overnight cruises? Usually day trips do not generate much solid waste. Overnighting virtually guarantees it.
- Does the boat anchor out overnight or tie up in a marina? When dockside, will you use the marina toilets?
- Are pumpout facilities located conveniently nearby? Refer to State of Maryland directory for locations.
- What are the boat's design and space limitations for a MSD installation?
- Is the electrical power supply adequate for an electrically operated system?

System Design

What are some of the system design alternatives?

First, we'll look at some of the advantages and disadvantages of portable toilets and holding tanks in general. Later, we'll examine holding tank systems and their plumbing arrangements in greater detail.

Portable toilets

While a portable toilet is not technically considered a MSD under the law (since it is not "installed"), it may be the simplest, least expensive way to comply with the intent of the law.

Advantages:

- Requires minimal space.
- Low cost.
- Simplicity.
- Reliability.
- Can be emptied via suction wand at a pumpout facility.
- Can be emptied ashore if pumpout facility is not available.

Disadvantages:

- Limited capacity.

Holding tank systems

Holding tank systems vary in complexity depending on what they are designed to do. There are four basic arrangements:

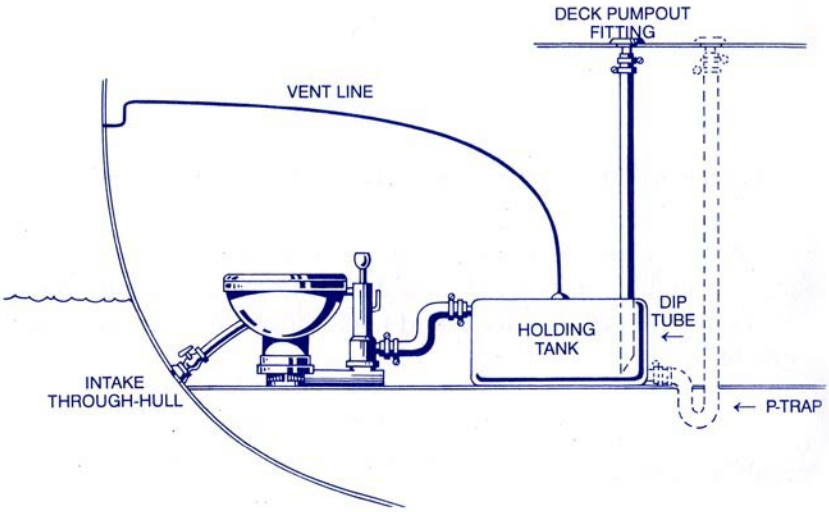


Fig. 1 – Deck pumpout only.

1. ***Deck pumpout only.*** The holding tank is installed in line between the toilet and the deck pumpout fitting. *(Fig. 1)*

Advantages:

- Allows use of existing toilet.
- Sewage goes directly into the tank.
- Simple to install.
- Minimal equipment requirements.
- Does not require a through-hull for discharge.

Disadvantages:

- External pump required to evacuate tank.

2. ***Overboard discharge option after the holding tank.*** A diverter "Y" valve is installed in the line between the holding tank and deck pumpout fitting to allow the tank's contents to be pumped overboard where legal (in the ocean beyond the three mile limit). The "Y" valve must be secured to prevent overboard discharge in the Chesapeake Bay and its tributaries. *(Fig. 2)*

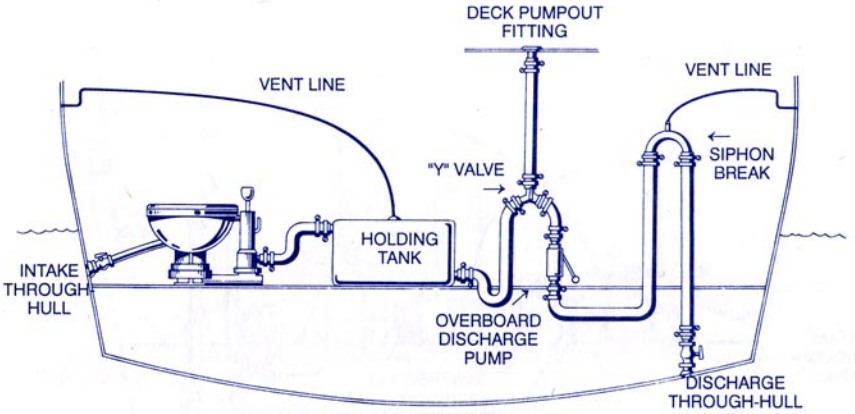


Fig. 2 – Overboard discharge option after the holding tank.

Advantages:

- All sewage is pumped into the holding tank.
- Boat will use pumpout facility in port. When beyond the three mile limit, untreated sewage can be pumped directly overboard. If a Type I or II sewage treatment system is installed, treated sewage can be pumped directly overboard as well, unless the boat is in "No Discharge" waters.

Disadvantages:

- None.

Note: A "Y" valve is not required in this option. The deck pumpout fitting and the overboard through-hull valve are normally pressure tight and will function alternately as selected. Use of a "Y" valve, however, will keep unused sections of hose or pipe from being unnecessarily "wet" (filled with sewage) and provide an additional safeguard against accidental overboard discharge. If a "Y" valve is not installed and secured when operating within the three mile offshore limit, the disharge through-hull valve must be so secured.

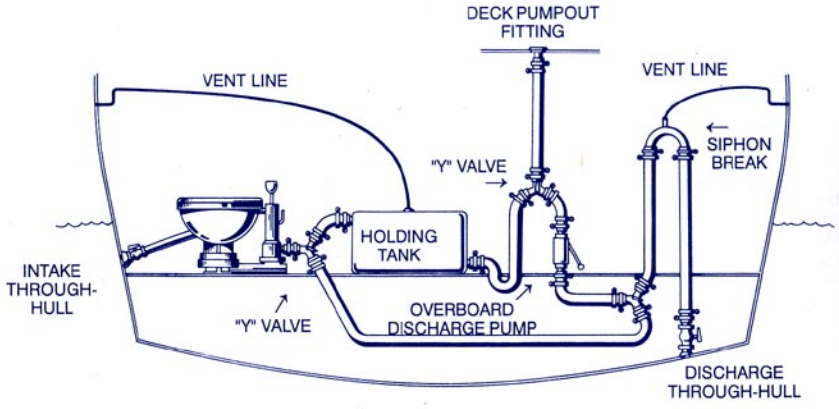


Fig. 3 – Overboard discharge options both before and after the holding tank.

3. ***Overboard discharge options both before and after the holding tank.*** "Y" valves are installed in line between the toilet and holding tank and between the holding tank and deck pumpout fitting. *(Fig. 3)*

Advantages:

- Flexibility in discharge options. "Y" valves must be secured to prevent overboard discharge of untreated sewage when operating inside the three mile offshore limits.

Disadvantages:

- Flexibility is offset by complexity.

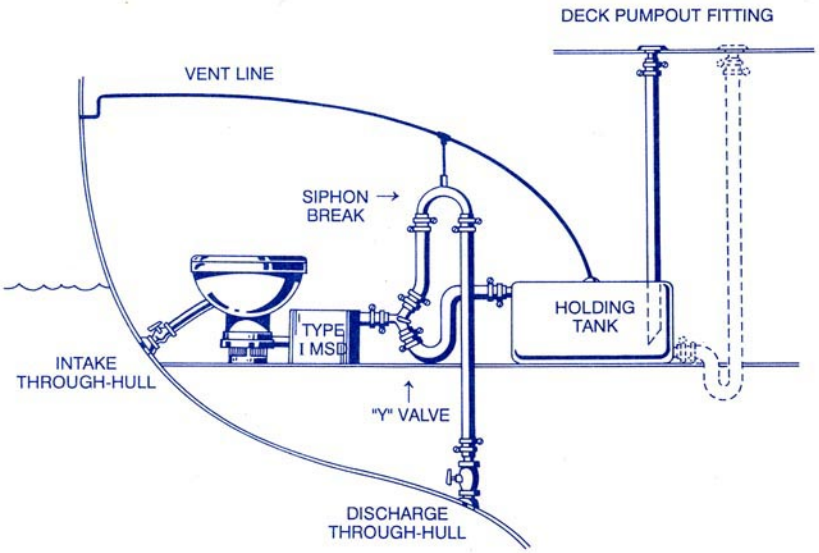


Fig. 4 – Overboard discharge option before the holding tank.

4. ***Overboard discharge option before the holding tank.*** When using a Type I or II treatment system, you should install a holding tank for use when boating in environmentally sensitive areas or when moored or dockside. A "Y" valve is installed in line between the treatment system and holding tank. *(Fig. 4)*

Advantage:

- If a Type I or II sewage treatment system is installed between the toilet and "Y" valve, treated sewage can be pumped directly overboard, unless the boat is in "No Discharge" waters.

Disadvantages:

- "Y" valve must be secured to prevent accidental illegal discharge.
- External pump is required to empty holding tank.

These four basic arrangements can be adapted depending on the number and type of toilet(s) installed and whether in-line waste treatment is desired. The next section on equipment selection addresses many of the options available.

Equipment Selection

How do you choose the right equipment for your installation?

Caution: Before making your final equipment selections, read the section in this booklet on "Installation Tips." Installation considerations may affect specific equipment choices.

Toilets

The type of toilet selected depends largely on the boat's size and electrical power supply as well as the owner's budget.

Caution: Seacocks at seawater intake and overboard discharge through-hulls should be closed whenever the boat is not in use...regardless of the type of toilet selected.

- **Manually operated toilets**

Advantages:

- Not dependent on power source.
- Dependable operation.
- Relative ease of installation; no electrical connections.
- Relatively low equipment and maintenance costs.

Disadvantages:

- User must flush wastes from the bowl using a manual pump.

- **Electric toilets**

  Advantages:
  - Ease of use.
  - Typically macerate solid wastes, reducing the possibility of clogged waste lines.
  - Macerated solid wastes are more effectively treated by disinfectants and deodorants.
  - Relatively easy to interface with a Type I or II MSD for automatic treatment.

  Disadvantages:
  - Rely on electrical power for flushing action. Manual backup, if provided, will permit system use if power is depleted or there is a malfunction.
  - More complex to install; higher cost.

- **Vacuum toilets**

  Advantages:
  - Ease of use.
  - Typically use less than a quart of water per flush, a real benefit for optimizing holding tank capacity.

  Disadvantages:
  - Require electricity to operate.

While seawater is most often used for flushing, some electric and vacuum systems recommend fresh water.

Caution: Flush water plumbing must be arranged to prevent contamination of the boat's potable fresh water supply (refer to ABYC standard H-23, Installation of Potable Water Systems).

Tanks

The size of the holding tank selected should be based on the boat's intended usage (day trips, weekend or extended cruises, etc.) and the number of people using the toilet. Some experts have estimated that the average effluent (sewage and flushing water) per person per day may be as low as three gallons; in many cases it will be higher.

Leakage typically occurs at fill, pump out and vent line connections. The more flexible the tank, the more difficult it is to maintain leak-free connections. Connection sites on a flexible tank must be reinforced to minimize the deformation of mating surfaces.

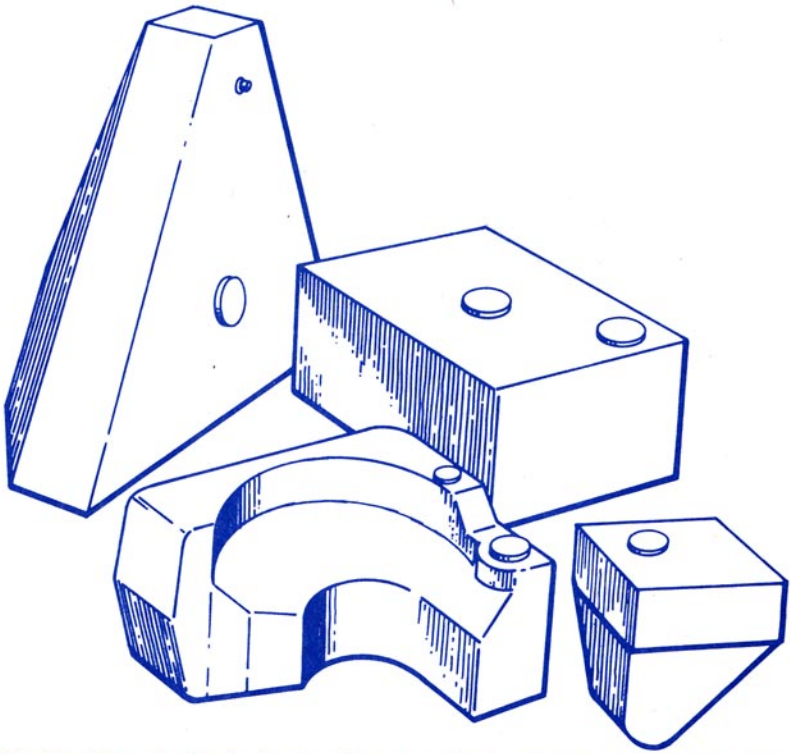


Fig. 5 – Plastic (polyethylene) tanks are readily available in a wide range of shapes and sizes.

• **Plastic (polyethylene) tanks** are rotationally molded and, therefore, have no seams. They typically have a wall thickness of 1/8, 1/4 or 3/8 inch. Wall thickness is key to a tank's structural rigidity and resistance to odor permeation. Odor permeation is more likely to occur in tanks with a wall thickness under 1/4". Thicker walled tanks offer greater rigidity and permeation resistance, and are generally well worth the price differential. *(Fig. 5)*

Advantages:

- Readily available in a wide range of shapes and sizes.
- Generally the least expensive option.
- Provides visual indication of tank content level.

Disadvantages:

- None.

• **Flexible tanks**

Advantages:

- Can often be used when other types of tanks will not fit in the space available.

Disadvantages:

- Susceptible to permeation.
- Susceptible to leakage due to chafing and to flexing at piping connections.

• **Fiberglass reinforced plastic (FRP) tanks**

Advantages:

- Highly resistant to permeation.
- Relatively inexpensive as a "do-it-yourself" project.

- Can be custom fit to the space available.

Disadvantages:

- Typically cost more than a plastic or flexible tank.

- **Metal tanks**

Advantages:

- Highly resistant to permeation.
- Easy to fabricate to space available.

Disadvantages:

- Susceptible to corrosion. Sewage, additives and cleaning agents may aggravate corrosion rates.

Tank level monitors and warning systems

Federal regulations (33 CFR 159.83) require that holding tanks have a means of indicating when the tank is more than 3/4 full by volume. A translucent plastic tank can meet this requirement if its location permits easy regular access for viewing contents level. Tank level monitoring systems are fairly simple to install. These typically include a sensor installed at the top of the tank and a small remote panel with a warning light that indicates when the tank is more than 3/4 full.

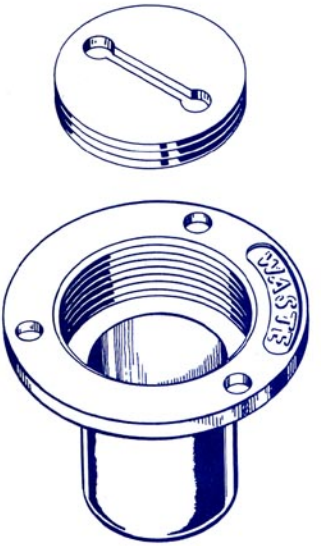
Seacocks and through-hulls

Toilet intake and overboard discharge lines should be equipped with seacocks (valves) to stop the inflow of seawater in the event of hose failure. A seacock is operated by a lever-type handle that gives clear indication whether the valve is open or closed. These seacocks should be readily accessible for maintenance and oriented so that their handles are easy to operate.

Seacocks and through-hulls are made of bronze or glass reinforced plastic. Both can be used successfully for toilet intake or overboard discharge lines. Bronze seacocks and both bronze and glass reinforced plastic ball valves may be used for toilet intake or overboard discharge lines. It's generally a good idea, however, to fit plastic valves on reinforced plastic through-hulls. Either glass reinforced plastic or bronze valves may be fitted to a bronze through-hull.

The use of gate valves, which are made of brass, should be avoided because they corrode rapidly and their stems tend to break.

Deck fittings



The Federal standard for a deck fitting for pumpout is 1 ½" inside diameter pipe thread. Most pumpout stations have adapters that will fit boats not so equipped.

The top surface of the deck fitting should be clearly and permanently labeled "Waste." Check to be certain that all of the boat's other deck fittings are labeled "Water" and "Gas" or "Diesel" as appropriate. *(Fig. 6)* You can ruin your whole day if you accidentally fill the waste tank with fuel or siphon out the fuel tank at the pumpout station!

Fig. 6 – The Federal standard for deck pumpout fittings is 1½" inside diameter thread.

Piping/hoses (intake, vent and discharge lines)

- **Rigid plastic (PVC) piping** comes in different thickness (strengths) known as schedules. Schedule 40, the standard for residential plumbing, works well for boats too. Structurally superior Schedule 80 pipe can also be used.

  Advantages:

  - Highly impermeable; will not corrode.
  - Resistant to chafe.
  - Readily available in hardware stores with a wide range of fittings.
  - Easily cut with a hacksaw; can be glued with PVC cement. Can be readily modified later if needed.
  - Virtually maintenance free.

  Disadvantages:

  - Susceptible to damage from flexing. Provide additional support and use flexible (rubber hose) connectors to reduce potential for damage.
  - Often takes longer to cut and fit rigid plastic PVC pipe in tight spaces than to run flexible hose.
  - The "nominal" size stamped on PVC piping differs considerably from the pipe's actual inside or outside diameter.
  - Subject to damage from freezing if not properly winterized.

- **Flexible hose.** Choose a hose made with one of the special compounds designed to minimize permeation of waste system odors. These are typically made of flexible PVC or rubber and labeled sanitation hose. The heavier the wall thickness, the greater the resistance to odor permeation. All waste lines should be smooth on the inside to avoid trapping waste and reinforced to prevent collapse. Rubber hose is generally more expensive, tends

to have a longer service life, and is easier to stretch over fittings than flexible PVC hose.

Advantages:

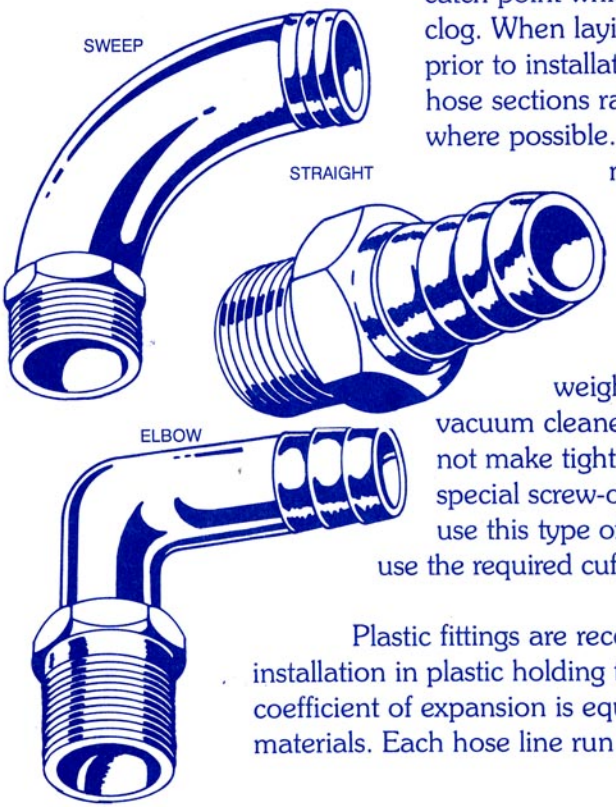
- May be easier to install in tight quarters.

Disadvantages:

- Susceptible to permeation.

Fittings

A wide variety of fittings (adapters, couplings, elbows, T-fittings, etc.) is available for use with either rigid PVC pipe or sanitation hose. Each fitting joint creates a potential sewage catch point which may lead to a clog. When laying out the system prior to installation, use curved hose sections rather than fittings where possible. Where a fitting must be used, "sweep" fittings are preferable to "elbows".



Some light-weight spiral ribbed vacuum cleaner-type hoses will not make tight joints without a special screw-on cuff fitting. If you use this type of hose, be sure to use the required cuffs.

Plastic fittings are recommended for installation in plastic holding tanks because the coefficient of expansion is equal for the two materials. Each hose line run to a tank fitting

Fig. 7 – Examples of pipe to hose adapters.

should be restrained (e.g., with a plastic wire tie or clamp) so that it will not put a strain on the fitting and perhaps eventually cause the tank to crack. *(Fig. 7)*

Sealants

Sealants can be applied to the mating surface of the adapter before fitting the hose.

Caution: Using adhesive type sealants will make removal of hoses for maintenance or replacement very difficult.

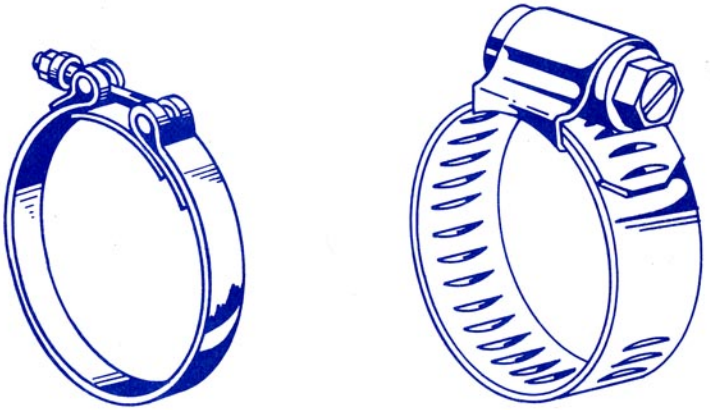


Fig. 8 – Hose clamps, regardless of style used, should be all stainless steel.

Clamps

Two hose clamps should be used at each waste system connection where space permits. Avoid clamps with nickel-plated screws that are susceptible to corrosion. Look for 100% stainless steel clamps. If a clamp is non-magnetic, it is probably 100% stainless steel. If it is slightly magnetic, it may be either a lower grade of stainless steel or nickel-plated. *(Fig. 8)*

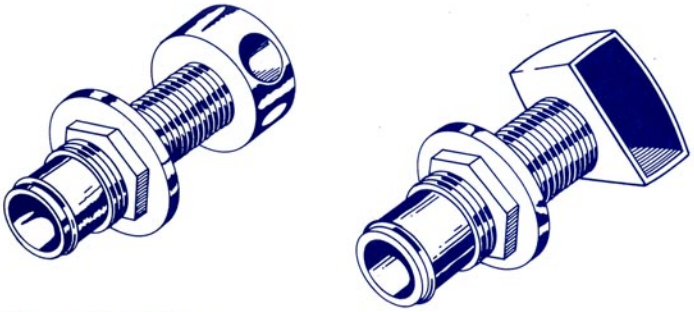


Fig. 9 – Vent fittings.

Vent fittings

These fittings are made of chrome plated zinc, brass, bronze, stainless steel or plastic. Overfilling the holding tank can force sewage into the tank vent line. A clogged vent line will be ineffective and can make it difficult, if not impossible, to pump out the tank at the pumpout station. Clogged vents can also lead to overpressurizing the tank causing leakage or rupture.

Vent line filters

A filter can be installed in the holding tank vent line to help control unpleasant odors. These filters will be most appreciated where a sewage system vent fitting is installed near the cockpit or an opening to accommodation spaces.

Siphon breaks (Vented loops)

The toilets on most boats are installed below the waterline. Any leakage past the toilet's suction or discharge valves can siphon water into the toilet, eventually sinking the boat if not discovered in time. It is, therefore, essential that a siphon break be installed on both the intake and discharge lines. A siphon break is formed by looping the line above the water level and installing a valve at the highest point so that air can be drawn

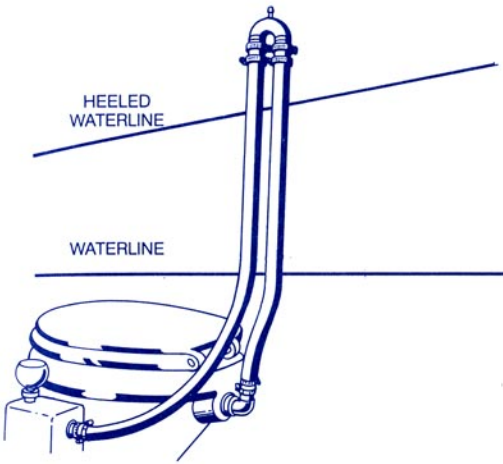


Fig. 10 – Siphon break fittings must be located above the maximum heeled waterline if they are to operate effectively.

into the line. As an additional safeguard, the toilet intake through-hull valve should be left in the closed position whenever the toilet is not in use. *(Fig. 10)*

Siphon breaks are typically made of cast bronze or glass reinforced plastic, which is not affected by corrosion. A simple one-way valve at the top of the siphon break will allow air to enter the line but prevent water or sewage from escaping. Larger vent valves are less susceptible to clogging than smaller valves. *(Fig. 11)*

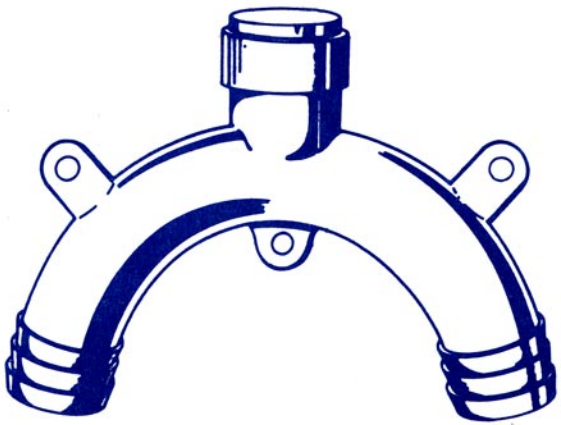


Fig. 11 – Siphon breaks have a one-way valve at the top to allow air to enter the line.

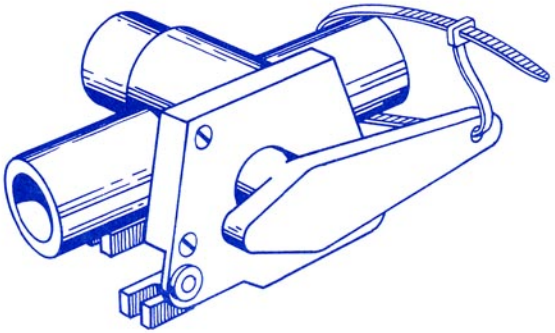


Fig. 12 – When operating within the three mile offshore limit, "Y" valves must be secured to prevent the discharge of sewage overboard. Acceptable methods of securing the valve include using a padlock or nonreusable wire tie wrap, or by removal of the valve handle.

"Y" valves

"Y" valves are used to direct waste overboard, into the holding tank or to a deck pump out fitting. Most "Y" valves used in sewage systems are made of plastic, however, bronze may also be used. Key attributes of a good "Y" valve include corrosion resistance, fully opening ports for minimal restriction to flow, ease of disassembly for maintenance, and a sturdy handle with positive stops. Make sure you can readily identify the closed position. *(Fig. 12)*

"Y" valves are not required at every piping juntion. In the system illustrated in Fig. 2, the deck pumpout fitting and the discharge through-hull valve are normally pressure tight and will typically function as selected. The advantage of using a "Y" valve at every junction is that positive diversion of sewage flow will keep unused sections of piping from remaining unnecessarily "wet" with sewage. "Y" valves also serve as additional safeguards against accidental overboard discharge.

"Y" valves must be used at junctions where, lacking a method of positive diversion, sewage would flow both to the overboard discharge piping and to the holding tank *(refer to Fig. 3 and 4)*.

Pumps

Ensure that all pumps are suited for use in sewage systems. Capacity is key to pump performance. Pumps may be made of bronze, aluminum or plastic. Bronze is frequently used in constructing rugged, high capacity pumps, while aluminum pumps are typically less expensive, but prone to corrosion. Plastic pumps are lighter and corrosion resistant, but also more likely to leak since some plastics can deform over time.

- **Diaphragm pumps**, sometimes used to flush the toilet, are frequently used to pump out the holding tank. They may be manual or electric.

  Advantages

  - Pass solids more readily than do piston pumps.
  - Can be run dry without damage.
  - Simpler design makes them less troublesome than piston pumps.

  Disadvantages

  - None in waste system applications.

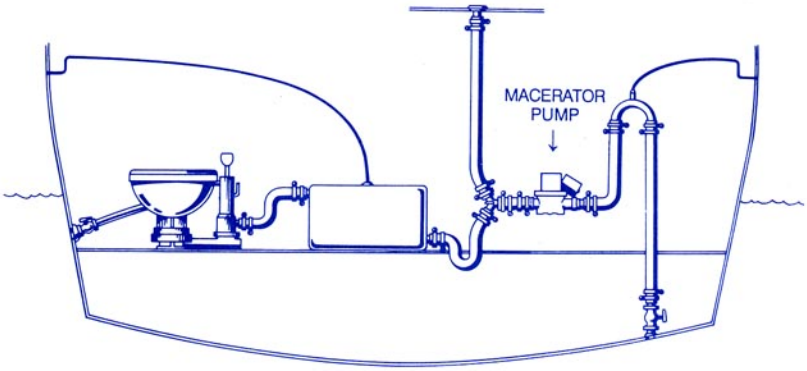


Fig. 13 – Macerator pumps can be used to break up and pump wastes from holding tanks for discharge in the ocean beyond the three mile limit.

- **Macerator pumps** are used to break up and pump wastes from many holding tanks. They may be installed inside or on top of the tank, or mounted separately. A macerator pump is not a Type I or II MSD; it does not treat sewage to reduce bacteria content. (Fig. 13)

  Advantages

  - Break up solid wastes, thereby minimizing the likelihood of clogged piping downstream.
  - When installed at the toilet, typically require less water for flushing than a manual pump — a plus when the holding tank is being used.

  Disadvantages

  - Require electrical power for operation.
  - Motor, shaft seal and/or impeller may burn up if pump is run dry.

Additives

A variety of additives are available to treat toilet and marine sewage odors and/or to help break down solid wastes. These are typically injected at the toilet intake line, at the toilet itself, or at an in-line sewage treatment device. The use of additives in conjunction with holding tank systems is not required. Deodorants may be desired to control odors produced by anerobic bacteria in holding tanks.

Caution: Tanks and system fittings may deteriorate from exposures to certain additives (household bleach, caustic cleaners, etc.). Make sure you use only those additives recommended for your particular marine sewage system and ensure that they are environmentally friendly as well.

Sewage treatment equipment

Type I MSDs, which treat sewage chemically or by other means, can also be installed in-line between the toilet and holding tank. If a "Y" valve is installed after the Type I MSD, treated sewage can be pumped overboard where it is legal to do so. Otherwise, the treated effluent can be pumped into the holding tank for pumpout ashore.

Advantages

- Treat, disinfect and deodorize sewage
- Decreased likelihood of contact with raw sewage.

Disadvantages

- High current draw.
- High cost relative to a basic holding tank system.

System design

- Think your system design through carefully and lay out piping and other system components before cutting anything. Check on each side of partitions or bulkheads to ensure that you will not be cutting into fuel or water tanks, wiring or piping, or into stringers that support the hull. If you must cut tabbing that holds bulkheads or partitions in place, provide additional reinforcement so that structural integrity is not compromised. *(Fig. 14)*

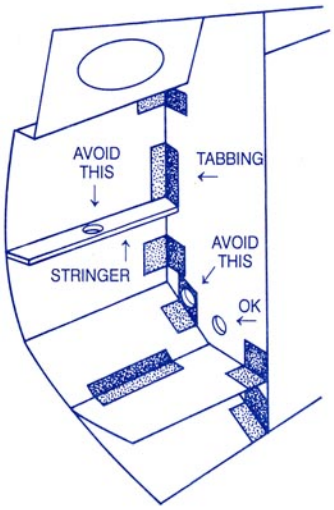


Fig. 14 – When running piping, avoid cutting into stringers or tabbing that support the hull so that structural integrity is not compromised.

- To reduce the likelihood of odor permeation, consider what will be "wet" (sewage filled) between pumpouts. Work toward reducing wet sections of piping. When wet sections are unavoidable, consider rigid PVC pipe rather than hose. Keep the number of connections to the minimum. Try to eliminate tight bends; use "sweeps" to minimize clogging. Provide for easy access to system fittings, connections, and components for maintenance.

Toilets

- Install per manufacturer's directions.

- Electrical wiring (if any) should comply with ABYC standards E-8, AC Electrical Systems in Boats, and E-9, DC Electrical Systems Under 50 Volts.

- Freshwater hookups must comply with ABYC standard H-23, Installation of Potable Water Systems, which requires physical separation of drinking water from the sewage system.

Holding tanks

- Examine the area where the tank is to be located. Ensure that the tank will not be punctured by sharp objects, such as protruding screws.

- Since sewage weighs approximately eight pounds per gallon, the contents of a 15 gallon waste tank can weigh up to 135 pounds. Tank supports and restraints must be adequate to hold the tank in place even under extreme operating conditions. Multiply the weight of the tank and its contents when full by a safety factor of two when estimating the total weight to be restrained. Here's the formula:

  (Weight of tank alone) + (Volume in gallons x 8 lbs.) x (Safety factor of 2) = Total weight to be restrained

- Plywood floors, bracing, chocks, straps, etc. may need to be reinforced to perform as required. Visualize the tank restraint system with your boat operating at full speed pounding into the waves (or running suddenly aground).

- To minimize the potential for chafe and corrosion, a nonabsorbent, nonabrasive material such as neoprene should be used between all tank supports, bracing, etc. and the tank itself. This is a must for metal tanks.

- Ideally, inlet and outlet fittings should be located at or near the top of the tank. This arrangement will facilitate repairs when needed, enable hoses to be self-draining and minimize permeation. If inlet and outlet fittings are installed at or near the bottom of the tank, hose permeation will occur more rapidly. Install a valve at the tank outlet to permit servicing of the discharge line without spilling sewage.

- If the discharge is located at or near the bottom of the tank, a rigid P-trap below outlet level in the outlet piping will allow the tank to be completely emptied. A dip tube will be required for top mounted discharge fittings *(refer to Fig. 1)*.

- Vent line fittings must be located at the uppermost point of the top surface of the tank if they are to operate effectively.

- When installing fittings in polyethylene tanks, follow the tank manufacturer's directions. The tank can be damaged by over tightening fittings at connection points. This type of damage may not be detected when making the connections, but will manifest itself later in leaks at cracks.

- Most polyethylene tanks have inspection ports (typically 3" in diameter). While there is an increased possibility of leaks and odors if ports are installed, a properly gasketed inspection port should reduce the likelihood of a problem. Inspection ports can be used to access the tank for cleaning. They also facilitate installation of a sewage level indicator.

- Install flexible tanks per manufacturer's directions. Bladder tanks used for holding sewage must have a vent line so that gasses produced by decomposing sewage can escape.

- Construct FRP tanks per resin manufacturer's recommendations.

Deck Fittings

- Once you have determined the location for the deck pumpout fitting, drill a pilot hole through the deck from inside the boat to avoid hitting interior wiring, etc.

- Remove core material (if any) around mounting hole; fill the resulting void with fiberglass filler.

- Bed deck fitting thoroughly to avoid water leakage to interior.

- Bolt the fitting through the deck. A screwed fitting can come loose from the repeated forces of connecting the deck fitting with a pumpout facility nozzle or adapter.

Piping/hose

- To minimize the likelihood of permeation and odors, keep hose runs as short and straight as possible. Avoid dips in the hose run which will remain "wet". Wherever practical, use rigid pipe below the level of the top of the holding tank since sewage will sit in this piping whenever the tank is full ("wet" hose will permeate more quickly). Use "sweeps" instead of elbows in connections wherever possible.

- Ensure that the holding tank vent line has a constant rise from the top of the tank to the vent fitting. Otherwise low spots may fill with sewage and act as a "U" trap, effectively plugging the vent. Vent line should be as short as possible.

- Heating the end of the hose and coating the pipe fittings with liquid soap as a lubricant will make fitting sections easier. Hot water, an electric hair dryer or heat gun can be used to soften the hose.

- Use cable ties or clamps to support piping along its entire run against movement laterally as well as vertically. This will help minimize the likelihood of loosening connections during stresses of boat operation, flexing, vibration or impact from gear stowed alongside. Visualize how a hose or pipe full of liquid might move under normal operating conditions (in response to vibration, wave action, heeling, etc.)

- Provide chafe protection where hose is run through bulkheads and at all support brackets or ties.

Fittings

- All waste system connections and fittings should be capable of being reached for inspection, removal or maintenance without removal of permanent boat structure.

- Before cementing a length of rigid PVC pipe to a fitting, use a solvent cleaner on the pipe and inside of the fitting before coating them with PVC cement. Immediately press the pipe home, twisting a half turn or so to spread the cement evenly. Hold the joint for about 30 seconds to give the cement a chance to set up; do not subject it to pressure for at least a half hour.

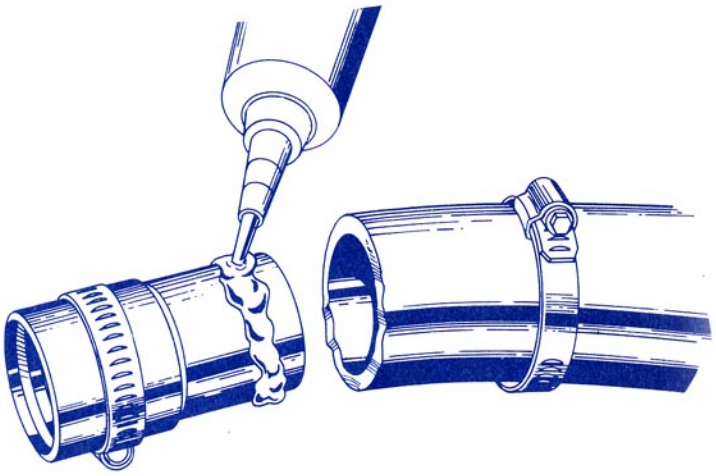


Fig. 15 – If a sealant is used when fitting a hose, it should be applied to the outer surface of the adaptor only.

Sealants

- If a sealant is used when fitting a hose, it should be applied to the outer surface of the adapter. Do not apply sealant to the inside of the hose; it will only be pushed farther inside by the adapter, where it will solidify and cause a blockage. *(Fig. 15)*

Clamps

- Do not overtighten clamps or they may cut into the hose. If this is the only way to stop a leak, the hose-to-adapter fit is not good enough, and one or the other should be changed. The use of two clamps at each connection (where space allows) will keep the hose in line with the adapter and lessen the likelihood of leaks.

- Make sure clamp mechanisms are offset from each other when tight. *(Fig. 16)*

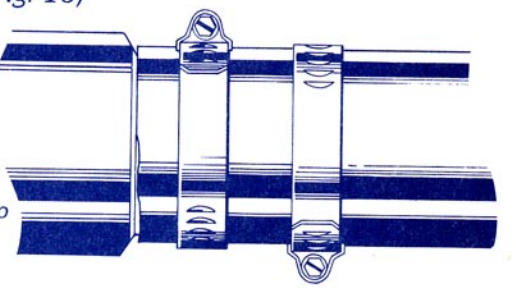


Fig. 16 – Proper hose clamp installation.

Vent fittings

- The holding tank vent fitting should be located above the holding tank and above the waterline at all angles of heel. It should also be no less than 24 inches from any opening into an accommodation space.

- If fitting is to be located in hull topsides, select a protected spot where it will not be subject to damage from pilings, etc.

- Form a gooseneck in the vent line above the vent fitting to prevent seawater from back flooding to the tank. This also may keep the vent line from kinking (refer to Fig. 1).

- Bed fitting to avoid water leakage into interior of boat.

Vent line filters

- Install per manufacturer's recommendations.

Siphon breaks

- A vented loop in the discharge line can allow foul odors into the boat. Run a small hose from the siphon break vent fitting to the holding tank vent line or to a separate

vent fitting located above the maximum heeled waterline. *(refer to Fig. 2)*

Pumps

- Consider pump manufacturers' requirements (if any) for discharge line rise and run.
- Diaphragm pumps should be mounted above the level of the top of the holding tank so that they will not be sewage filled when the tank is full. This will minimize permeation of the flexible diaphragm material.
- Electrical wiring (if any) should comply with ABYC standards E-8, AC Electrical Systems in Boats, and E-9, DC Electrical Systems Under 50 Volts.
- If pump is not installed above tank level, service valves should be provided to enable pump removal without releasing tank contents.

Sewage treatment equipment (Type I, II MSDs)

- Install per manufacturer's directions.
- Electrical wiring (if any) should comply with ABYC standards.
- Maintenance per manufacturer's instructions is essential to guard against malfunction and ensure sewage treatment in accordance with federal law.

Note: Test a newly installed system using colored water and soft food solids (overripe bananas work well) under normal boat operating conditions to be sure there are no leaks. Inspect entire system regularly for evidence of leaks.

System Maintenance

Toilets

- Do not flush paper towels or feminine hygiene products. They will clog waste system plumbing. Keep paper usage to a minimum. Some skippers require that nothing be flushed down a toilet that hasn't been eaten first!

- Toilet bowls should be cleaned periodically with water and a biodegradeable detergent that can then be flushed through the system. This should be followed with more water mixed with a little mineral or baby oil or one of many specialized marine toilet treatment products available to keep all rubber parts in good condition.

  Caution: Do not use toilet bowl cleaners, bleach, drain cleaner, or deodorants unless made specifically for marine toilets. These substances can attack and even destroy some waste system components and harm the environment.

- To discourage calcium buildup, periodically pour a cup of vinegar (a weak acid) into the toilet and allow it to sit before pumping the bowl dry. Left alone, calcium deposits will build up in valves and piping, and eventually clog the toilet. At that point, disassembly (and replacement of some parts) may be the only recourse.

- If marine life routinely gets into the toilet with the flushing water, install a strainer (external, internal or both) on the flush water intake line.

- A Teflon-based waterproof grease coating on a manual toilet's piston rod prolongs the life of the piston rod seal.

- All wire terminals on electric toilets should be checked periodically for corrosion and cleaned when necessary. Spray them with a corrosion inhibitor.

- Keep a toilet repair kit onboard with a full set of replacement seals. It's never an issue of "if" toilet seals will fail but "when."

- Improper winterizing can damage a toilet. You can't simply pump it dry and leave it. Water will be trapped in low spots in both the suction and discharge lines as well as in the pump housing. Instead, close the suction seacock, disconnect the hose, and dip it into a can of antifreeze. Use propylene glycol only; alcohol will swell up rubber parts. Pump the toilet until the antifreeze washes down the side of the bowl and flows out the discharge.

  Caution: Make sure antifreeze solution is environmentally friendly and compatible with sewage system components. Select one that will not attack plastic, rubber or metal components. Propylene glycol is generally recommended.

Holding tanks

- Rinse and flush the holding tank after each pumpout. This will help to dilute any residual sewage and, thereby, reduce odors.

- At the end of the boating season, pump out and rinse the tank before winterizing the waste system. As a rule, it is best to leave the system drained and dry.

- Keep the holding tank inspection port gasket greased to maintain its seal. Apply lubricant each time the port is opened and resealed.

Tank level monitors

- Wire terminals should be checked periodically for corrosion and cleaned when necessary. Spray them with a corrosion inhibitor.

Seacocks/through-hulls

- Service and lubricate periodically to assure ease of operation.

Deck fittings

- Lubricate threads at deck plate fitting.

Piping/hose

- To find out if hose permeation is the cause of persistent odors, rub a cloth on each hose section, then sniff it. If the cloth smells, the hose is permeated and must be replaced (plastic tanks can be checked for permeation in the same way). If the cloth doesn't smell, check each hose connection for leaks.

Clamps

- Check clamps periodically for corrosion and replace as indicated.

- Check that clamp edges are not cutting into hoses. This commonly happens when clamps are overtight.

Vent fittings

- Keep vent fitting opening(s) free of corrosion, insect nests or other material that may result in a clogged vent line.

Vent line filters

- For effective odor control, replace filters at the start of each boating season. They must also be replaced whenever the holding tank is overfilled (overpressurized) and sewage is forced up into the vent line.

Siphon breaks

- Unscrew the vent valve periodically and wash it with fresh water to prevent clogging.

Pumps

- Keep pump manufacturer's recommended spares kit on board.

- Consult owner's manual or manufacturer's data sheet for periodic maintenance requirements.

Sewage treatment equipment

- Consult owner's manual for periodic maintenance requirements.