

Toilet & Holding Tank Replacement on an Old Boat

Gene Jurrens, MTOA Member 1093
Motorsailer Sojourn (40 foot Island Trader)

Abstract: Smelly hoses and a leaky toilet, combined with a holding tank far too small for an inland waters cruising boat forced me to update the entire system. As always, I spent a significant amount of time researching the best and most odor-free solution possible. This article explains the findings of my research and the results after two seasons of practical on-the-water use. It works great, and I hope you find this article useful and informative!

Photos of M/S Sojourn, the host of my new toilet and holding tank system:



What Happened?

Every autumn in Minnesota, we prepare our boats for hard freezes with temperatures occasionally dropping to ten or twenty degrees below zero (Fahrenheit) during the winter. Most of the time our preparations pay off in that everything continues to work in the spring. Occasionally, a bit of water gets trapped somewhere and freezes, expanding in the process, and if it has nowhere to go, it will break through plastic and even metal¹. So while the old toilet & tank system were still operational on dry flush only (it leaked due to a freeze crack in wet flush), it was clearly time to replace the entire system.

Approach

Since I wanted to perform this project in a leisurely fashion, my approach was to install as much of the new system before decommissioning the old one. In that way, we would still have use of the old (slightly leaking) toilet, the old (far too small and rusting stainless steel) holding tank and the old (very smelly) hoses. Additionally, since the boat is currently being used in inland waters where dumping overboard is illegal, the fact that my Y-valve was frozen from years of lack of use did not impact the operation of the old system. It was clear, however, that before we venture offshore where dumping overboard is often the only alternative and legal that this Y-valve would need to be replaced.

However, in order to use this approach I needed to find an alternate location for the holding tank. This would be necessary in any event since the space where the old tank was installed was too small for the larger tank I wanted. By using this approach, I was able to procure and install the new tank, some of the electrical wiring (for the new manual AND electric toilet), and some of the hose runs before taking the old system out of commission. Then, one weekend of pulling out the old hoses and toilet saw the new system installed and working. After I got the new system working, then and only then did I pull the old tank out of the boat.

The Holding Tank

I chose a new tank with three objectives in mind. First, I wanted to install the largest tank that would fit. Second, I resigned myself to the fact that to get exactly what I wanted, I'd

¹ Ice is stronger than metal. Evidence was two hairline cracks in a through-hull fitting that almost sunk my boat when we put the boat back in the water in the spring. Apparently, a drop or two of water became trapped inside the heavy bronze fitting, and found its way out the only way it could—through the solid bronze wall of the fitting. These small cracks went unnoticed until approximately 400 gallons of water set off the high water alarm (in our absence from the boat).

have to get a custom tank, which wasn't much more expensive than a high quality standard tank. And third, I wanted an installation that would be as odor-free as possible.

Choosing a Tank Site

The tank had to be on the centerline of the boat to avoid ballast issues and as close to the head as possible to avoid long hose runs. My largest unused space on the centerline and close to the head was underneath our bed in the forward stateroom. While not entirely appealing intuitively, since I also had the objective of an odor-free installation, I judged my reticence to be unfounded. This site would get me within five feet of the Y-valve and through hull, and the head would be another four feet from there. While not ideal, I decided that it was a good compromise.

Choosing the Tank

The dimensions of the space defined the size of the tank. I used a cardboard template to simulate the height and length of the tank (since I would be sliding it into the space end on). Even then, when I received the tank, I had to trim an overhead stringer in order to get the tank into the space (I later epoxied that piece back into place, making the tank installation permanent). I also wanted the highest quality non-metallic tank I could find, and my research led me to prefer the high density polyethylene tank material. Additionally, I had read that multiple tank vents would significantly decrease the potential for odors since “flow through” ventilation encourages the growth of aerobic (good) bacteria and discourages the growth of anaerobic (bad & stinky) bacteria. And last, I wanted both the input to and the output from the tank on the same end of the tank. Because of these very specific requirements with respect to size, venting and feed hose locations, I knew I'd need to have a custom tank constructed.

Buying the Tank

I exchanged drawings and had several conversations with a knowledgeable engineer at Raritan Engineering². He reminded me that if we didn't get it right, and the tank arrived wrong, it was still mine; so needless to say, we exercised great care in the design of the tank. I appreciated that other than some initial dialog on the phone, much of our interaction was via email, my preferred method of communication. Here were the important design points for my installation:

1. 28 gallon tank as constrained by size of space into which it would be installed (replacing a 10 gallon tank and almost tripling my capacity)
2. All fittings were “spun welded” into the tank by the manufacturer per my specification with female threads into which you can screw either plastic or bronze hose barb fittings (I chose bronze – they looked beefy and I like beefy).
3. Two 1” vents (minimum is one ¾” vent – I wanted lots of ventilation and minimum odor). location of vent fittings (in my case, both were on the top surface of the tank as far forward as possible and as far apart as possible)
4. Location of the input hose fitting on the aft face of the tank centered close to the top of that surface (1-1/2” female threaded fitting)
5. Location of the pump out hose fitting on the aft face of the tank centered close to the bottom of that surface (1-1/2” female threaded fitting)

² http://www.raritanengineering.com/products/holding_tanks/custom_tanks.html

A Reliable Holding Tank Monitor

I chose to use a plastic tank and not a metal tank because I wanted an extremely reliable tank utilizing an equally reliable monitor. I feel the most reliable monitor is one that does not require a sensor to be inside the tank at all. With a plastic tank, I was able to use one of the capacitive foil strip sensors that are glued to the exterior of the tank that reads through the wall of the tank and reports status of contents on a tank monitor mounted in the head³. These are actually aluminum strips connected to wiring to the monitor panel via copper pads and a microcontroller. The aluminum strips, copper pads and microcontroller have adhesive backing that holds them to the side of the tank. Then a non-conductive spray adhesive, such as 3M 4693 was used to permanently seal these components to the exterior wall of the tank and to impede corrosion to the metallic sensor strips.

Choosing the Toilet

Our decision points included:

1. household size versus a marine size bowl
2. manual or electric or both or a vacuum style
3. Integrated macerator or not

Early in the decision process, we decided we wanted a toilet that we could flush electrically, or in the event of a power problem, we could flush manually. Once this decision was made, this significantly limited our subsequent choices. There just aren't more than a few toilets on the market in the moderate price range that offer both electrical and manual operation.

Then, since both Captain and Admiral are generously proportioned, especially below the equator, we debated whether we should go with a household size bowl instead of the smaller marine size. After simulating the greater depth, front to back, of a household size bowl in our head, we decided this would limit the remaining space in our head for other activities, such as getting in and out of the shower. For this reason, we decided that the marine size bowl on the original toilet worked adequately, and decided to stay with the smaller bowl.

And as for an integrated macerator, this simply wasn't an option if we wished to operate the toilet manually, so that was an easy choice. There are two reasons for a macerator. First, it condenses the volume of material going into the holding tank. This is especially important with smaller holding tanks. Since we were going with a larger tank this would be less of an issue. The second reason is to macerate material prior to dumping overboard, where it is legal and there are no other options. We already have one of those, so a macerator integrated into the head would have been unnecessary and redundant.

³ **Acu-gage Ultra-8 tank monitor** from Snake River Electronics of Pocatello, Idaho. This gauge will monitor the status of up to eight tanks. Additionally, programming can be ordered from Snake River for custom display such as the name of your vessel, a custom label for each tank, etc. There is a low level warning for water and fuel tanks, and a high level warning for holding tanks. It reads the level of contents in tenths.

When we take the boat to salt water and will cruise in areas where dumping overboard may be required, we have left sufficient space to install a Lectra-San⁴ unit, but that is a rather costly device and we decided not to install this until we planned on utilizing its capabilities.

There are very good vacuum style toilets on the market⁵ but we didn't like the noise it creates when flushing, and the vacuum seal can be problematic to fix while cruising if anything goes wrong, or at least that was our perception. So we chose not to go with that style toilet for those reasons.

In the end, we chose the Raritan Model PH II-E⁶. This unit operates electrically, or with the removal of one bolt and a cotter key, can be converted to manual operation in less than thirty seconds. It is just as straightforward to convert back to electrical operation by inserting a bolt and cotter key. We are still trying to determine our favorite operating mode. Electrical operation is convenient, but somewhat noisier than manual operation. It is nice to have the option.

This disadvantage of an electrical toilet operating on twelve volts DC, of course, is the additional installation effort and expense of rather heavy electrical wiring, solenoid⁷, breaker⁸ and momentary flush switch. The specific size of wire in this case must handle 25 amps of current and be of sufficient size to prevent significant voltage drop across its distance. The size required, therefore, is dependent on your installation, specifically the distance between the toilet motor and the battery to which it is connected. A detailed table for calculating wire size was included with the installation instructions of the toilet. Remember these distances are round trip distances. For example, if your toilet is a total of ten feet from the battery, you must calculate ten feet to the battery plus ten feet back from the battery. And this is not "as the crow flies". It is necessary to measure the actual path the wire will take.

Removing the Old Toilet

No magic here. Flush the entire system repeatedly, including several rinses pumping out the holding tank. The next part is best done with the boat out of the water. Open all through-hulls to let any remaining water

⁴ http://www.raritaneng.com/products/waste_treatment/lectrasan.html Lectra-san is a Coast Guard certified Type 1 marine sanitation device that through the use of a small electrical current and salt water treats waste material before dumping it overboard.

⁵ <http://www.sealandtechnology.com/vf.asp>. VacuFlush is one popular brand offered by Dometic Corporation – Sanitation Systems.

⁶ http://www.raritaneng.com/products/toilets/manual/ph_2.html. The Raritan Model PH II-E is the electric version, the PH II is the non-electric version. Basically, the PH II-E is a factory conversion of the PH II to become an electric toilet that can easily be converted back and forth to manual and vice versa. g

⁷ A high current **solenoid** is necessary so that only low current needs to be switched by the flush switch. This makes for a longer life for the switch as it is not constantly arcing high current every time you flush the toilet.

⁸ In this installation, a 25 amp breaker was required. I used a Blue Sea Systems breaker (<http://www.blueseas.com>).

or sewage left in the lines to drain out, but make sure you are not dumping waste onto the boat's storage site.

After removing and saving all serviceable hose clamps, I cut the old hoses off with a hack saw as they were cemented to the toilet and other fittings. Unbolt the toilet from its platform and remove. Inspect the platform for any rot. If it needs to be replaced, now is the time to do so. Mine had no leaks and was solid. I still chose to sand it down and re-varnish the platform. I also took the opportunity to paint the head sans toilet. This made the painting job considerably easier.

Removing the Old Holding Tank

Pump out and flush several times with fresh water (5-10 times!). Believe me; you will be thankful you've done this when it comes time to tip the old tank to get it out of its old resting place. As it turns out, I did not need to perform this rather gruesome task until the tank had pretty much dried up since I left it in place until long after the new system had been installed and was in use. Since each installation will be different, you may want to remove your old tank sooner versus later. Fortunately, my old tank was accessible by removing two floor boards in a hallway. Some will be buried under furniture, beds, etc.

Installing the New Holding Tank

Largest size that would fit through access hatch, and then had to cut a chunk of a beam out to get it in (later epoxied back in. Hold down straps, limber hole, vent hoses and through hull for cross ventilation – aerobic bacteria good – kills odors but need lots of air. Anaerobic bacteria cause odors but can only survive without air. Air is good. Source of tank and type of material. Fitting locations for specific installation. If tank is custom, its yours, so make very sure it will fit when it arrives (built just for you). Disadvantage of a custom tank. Advantage is you get exactly what you need (or want). Soaked fiddles in epoxy resin, then screwed into fiberglass floor and bulkhead.0020

Installing the New Toilet

Combo electric and manual – easily converted back and forthInteraction with heart interface. . Details of electrical installation including gauge of wire used and why, challenge and cost of BIG ring terminals, use marine wire (tinned stranded), breaker, solenoid (and why), how terminated near battery, momentary flush switch (see pic),

Installing New Hoses

How tough it is to get new hoses onto barbs – tricks like heat gun, hack saw getting old hoses off, etc. Include description of filter basket on flush water intake. Olive oil and silicon grease for smooth operation. Type of hoses, type of clamps and clamping. Tip – use appropriate socket instead of screw driver – tighter seal, and easier on both hands and clamps. Ensure shelf on which toilet sits is solid. If not, replace it before installing new toilet.





