An Idea for the Vented Volume Dilemma:

Do I drill a hole and thereby void the potentially life saving value of my US Coast Guard approved positive buoyancy tank in exchange for the structural protection it would offer my boat during the expansion and contraction of the air sealed within? Temperature transitions that happen during regular use, such as a cold night followed by a hot afternoon in the baking sun can be enough to cause problems. Atmospheric changes, such as a drive up a high altitude mountain pass for a weekend at an alpine lake, can also be enough to cause subtle damage that may be hard to diagnose and can even go unnoticed. In theory, a well sealed interior vapor barrier as good as epoxy creates an air-tight volume that can't be counted on to relieve stress on the structure caused by these pressure extremes. It doesn't take much pressure differential for a little bit of air, such as that contained in the back seat tanks of the PT11, to expand inside of its sealed compartment where it can then take advantage of a system's weakness. For example: a joint can be loaded from the "wrong" direction causing it to break or weaken or a thin spot in the epoxy barrier may form a hairline crack that allows water into the dry wood.

Drill a hole (and carefully seal the edges, of course) and the problem goes away, the expanding volume of air can rush in and out at will, all on its own, and maybe the hole is small enough that not much water is able to enter during the course of normal use. Water will eventually collect inside the compartment and will be very slow to evaporate under normal storage conditions. That moisture can linger long enough to create detrimental high humidity conditions and puddles in corners that are capable of exploiting any small cracks in your barrier coating or bondline. One option for large compartments that you might also want to use for storage is an inspection port, large enough to fit a hand and a peering eye. Small compartments that have little or no storage space can maintain some of the safety value from formerly watertight compartments by using smaller options: one inch diameter threaded drain plugs, small or large rubber stoppers, or a dizzying array of different types and sizes of pressure relief valves with countless different design, material, and complexity options.

There are a couple of downsides, beyond the USCG and safety issues at play, that having *any hole* in a buoyancy void can cause. The previously mentioned risks of moisture intrusion and cracking due to pressure changes don't completely go away. Plugs and hatches can be left in before driving up to the mountains, or closed and forgotten for months without being opened and thoroughly dried inside, and of course mechanical and rubber valves can fail in harsh and corrosive environments like those found in boats. Many other complicated measures have been thought up and tried, with varying success, all with the ultimate goal of keeping water out of compartments that need to remain sealed for safety, all while allowing for pressure change to be passively and reliably equalized.

The ideal solution would seem to have a few key features:

- allow enough air exchange to account for the most extreme pressure changes
- act passively (meaning it can't accidentally be left closed or open)
- eliminate (or minimize) water intrusion
- easy to install (for example, access only needed on one side of a bulkhead)
- easy to inspect for failure and replace (affordable may fall into this category as well)

Such a “valve” exists, and though it may strike some as unconventional, as their ubiquity is not well known, but there are many applications where ePTFE (expanded polytetrafluoroethylene) membrane valves have become commonplace. They are widely used to protect sensitive electronics by maintaining dry cavities in: the automotive industry, outdoor electronics like solar power equipment and telecom systems, heavy equipment, and even consumer electronics… Ever notice how nearly all new phones are completely waterproof?

The “valve” is a thin adhesive patch, made entirely out of ePTFE, that is either applied directly over a hole or held by a removable plastic housing. The membrane is just like the membrane laminated into your favorite Gore-Tex rain jacket or drysuit except much thicker, about 30 times thicker in most cases. In fact, GORE is the primary manufacturer of these products, typically working with 3M for adhesives. The interesting properties of this valve are ready to meet every requirement on our list of desires and then some. Current use in the automotive industry offers a great example of how we can use this technology. In fact, the product I explore below is available through a number of different direct-to-consumer online retailers.

A few words from opening page of the Technical Data Sheet (TDS) provided by GORE:

> *Outdoor enclosures are continuously exposed to harsh environments such as rainstorms, dust, sand and high winds. During changing environmental conditions, pressure can build inside a sealed enclosure, putting stress on seals. Over time stress causes seals to fail, which allows water, corrosive liquids, salt and particulates to enter the enclosure and damage the internal electronics.*
>
> *With proven performance for more than 25 years, GORE® Protective Vents are the leading solution for protecting your sensitive electronics. GORE® Protective Vents equalize pressure and reduce condensation by allowing air to flow freely into and out of sealed enclosures. At the same time, they provide a durable barrier to protect the electronics from contaminants. The result — improved reliability, increased safety and longer product life for your sealed electronic devices.*
>
> *The low-profile adhesive design is engineered to withstand environmental challenges and can be easily integrated into the inside or outside of an enclosure via a manual, semi or fully automated installation process.*

That sounds like a compelling opening argument to me. The TDS continues on to describe performance in juicy detail: airflow rates, adhesive types, environmental use cases, etc. Installation Guidelines: surface prep, handling, positioning, application pressure, and final inspection. Another section covers design guidelines for interior, exterior, and flush mounting. The list goes on! The important final section describes environmental testing performed and certificates obtained, which includes such tortures as *Flammability/UV Testing*, *High Temperature Cycling*, and *Cyclic Salt Fog Testing*.

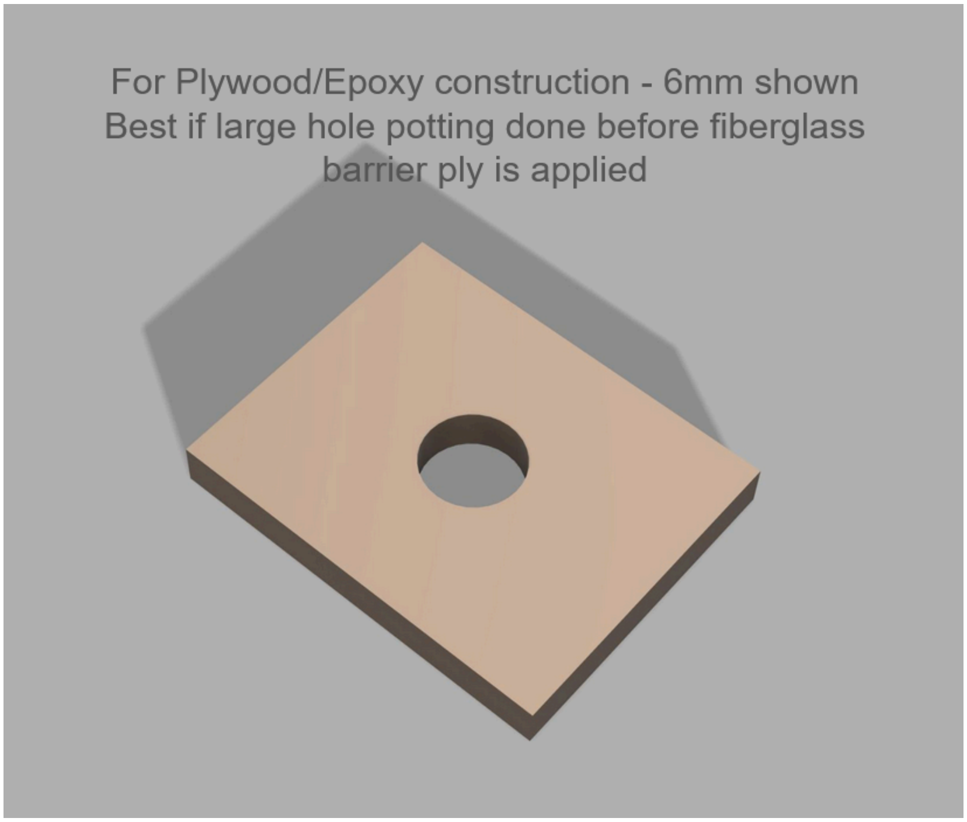
The Pitch: Use the mature technology of GORE ePTFE membrane adhesive vents as a super simple and reliable valve for the PT11 back seats and forward bulkhead cavities or other similar applications.

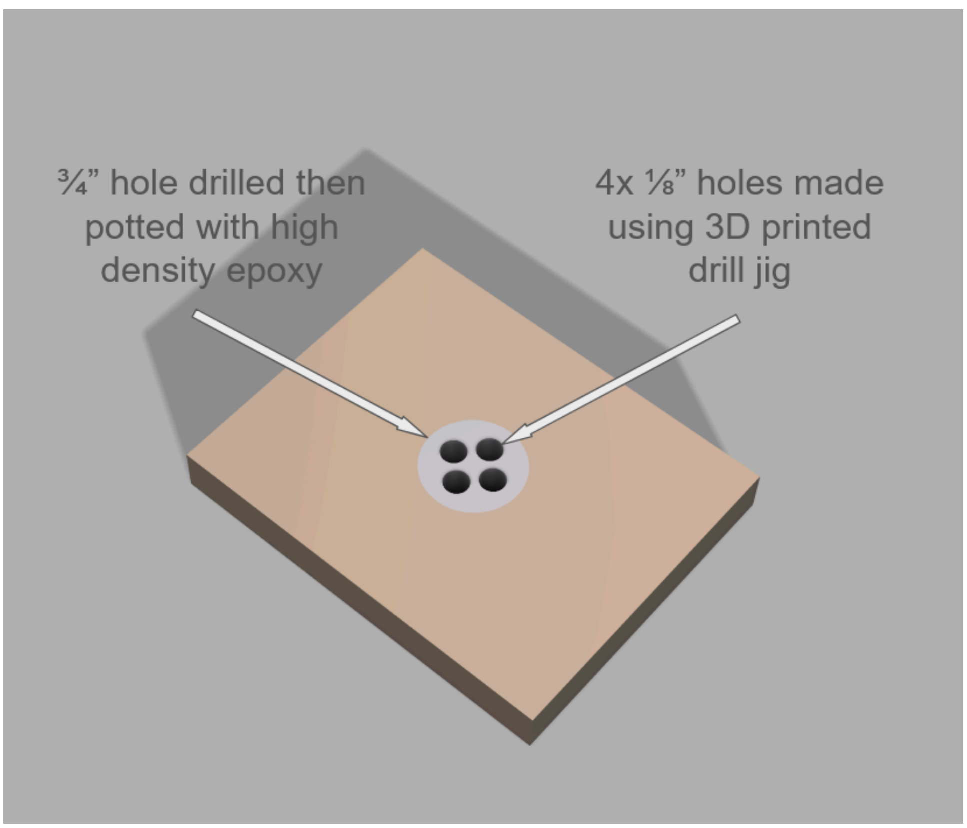
The Product: A 20mm diameter (~¾”) by 0.34mm thick (~1/64th”) circle of ePTFE membrane with a 3M adhesive backing. The adhesive coverage excludes a 10mm concentric patch at the center that makes up the area of the vent where air can pass through. The sheet of ePTFE is oleophobic, hydrophobic, UV resistant, and resistant to salt and many corrosive liquids. Perhaps the best part is the price for all of this near-wizardry; they cost around $2.13 cents each, plus shipping in a padded envelope.

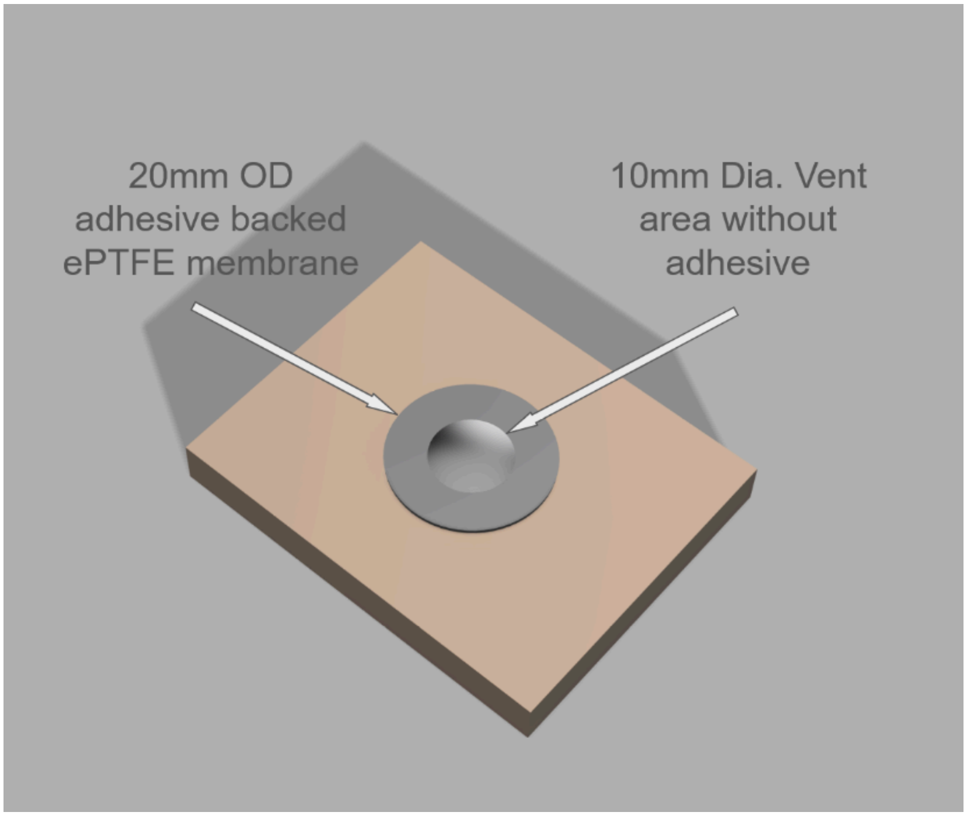
The Hole in the Structure: Unless the hole through the structure is really small, the 0.6cm2 area of breathable membrane is likely the flow limiting factor, so minimizing the size of hole in the structure would be best. Small holes allow less water in if the valve fails, thanks to the surface tension of water and fluid dynamics. Multiple holes in a tight group allow for some of the structure remaining between holes to support for the un-adhered span of ePTFE membrane, while maintaining good air flow and not excessive water flow. GORE recommends a pattern of four holes, packed in a square, under the 10mm vent area of the valve.

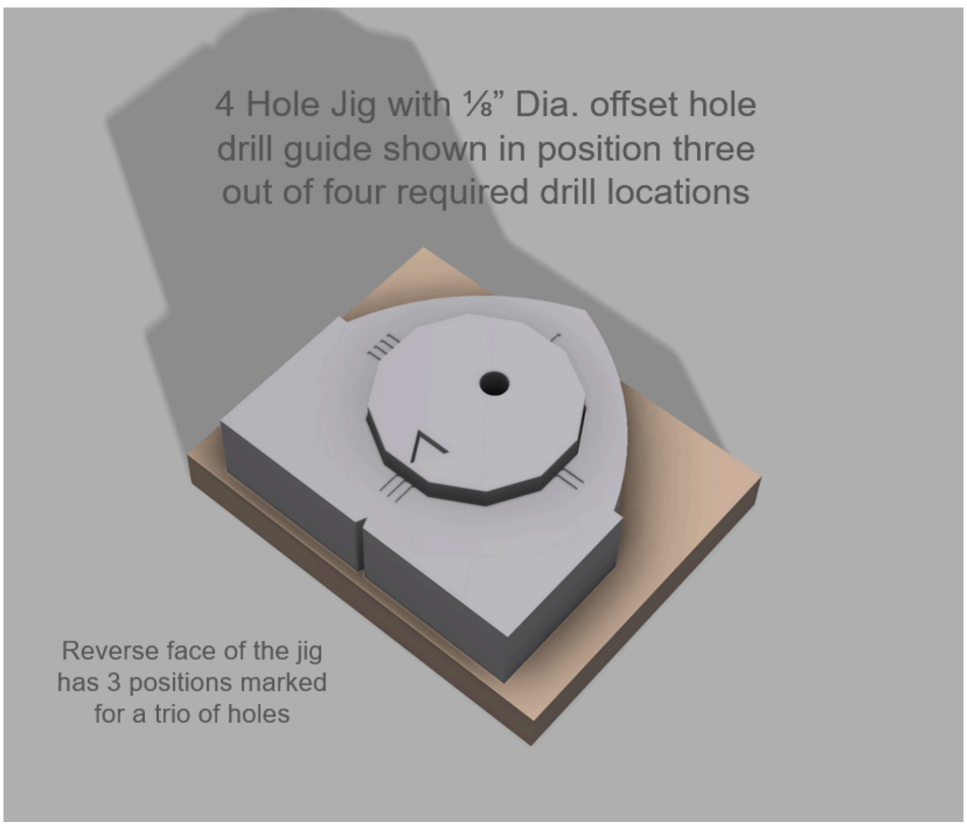
The Conclusion: Is this the do-all fix for every cavity venting problem on every boat? Not right now. More research and testing would be required before one could safely recommend applying this vent to flotation volumes larger and more critical than those found in a dinghy like the PT11 (research that I would love to do dig into). Trailer-sailer sizes come to mind as a next step; I believe an ePTFE adhesive vent system could be configured to work for volumes found in trailerable boats, and perhaps larger vessels, but this may not be exactly what it looks like. At this scale and on my own boat, however, I’m reasonably confident that the few rough calculations I’ve made have been enough to select and use a readily available product that will maintain enough safety margin *for my personal level of risk tolerance*. I hope to report back after some real-world testing. I plan to use the nesting dinghy I’m currently building on high alpine lakes, hot desert oasis reservoirs, and chilly PNW winters. I’ve even looked into shipping the nested package via air-freight for international adventures. The rapid and extreme altitude change of a cargo flight would almost certainly cause structural damage without venting. This vent will allow my boat to exhale a sigh of relief during these dynamic pressure changes and protect the structure from undue stress.

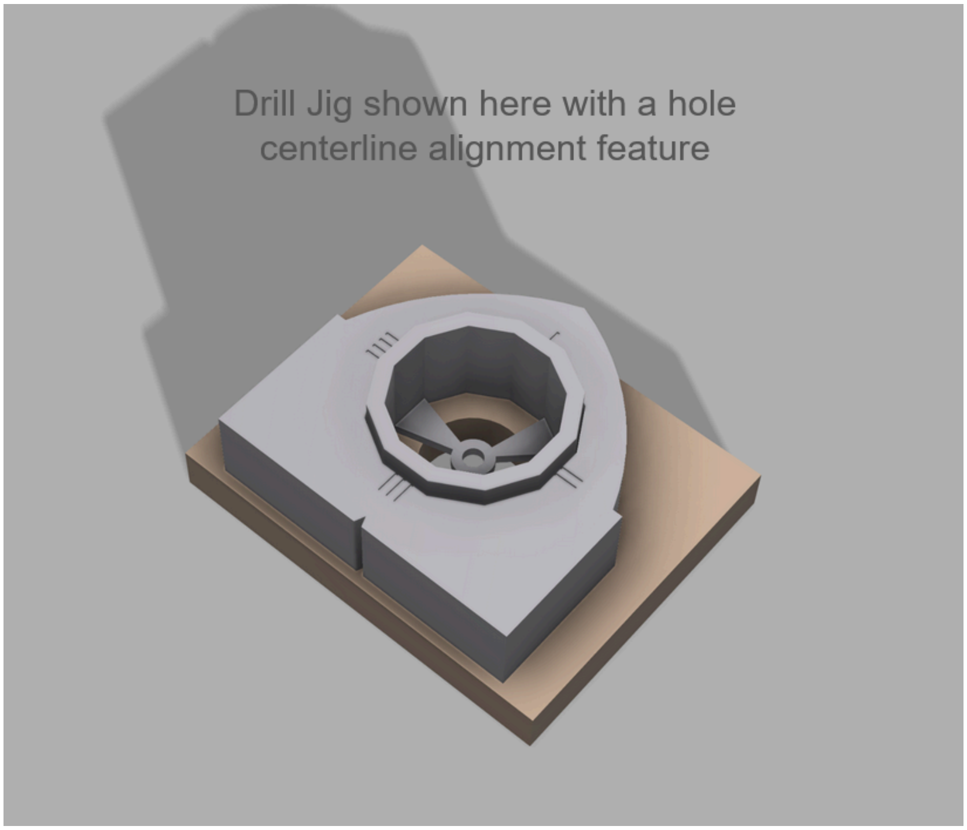
Cooper Parish - 12/12/2024


For Plywood/Epoxy construction - 6mm shown
Best if large hole potting done before fiberglass
barrier ply is applied


¾” hole drilled then
potted with high
density epoxy
4x ⅛” holes made
using 3D printed
drill jig


20mm OD
adhesive backed
ePTFE membrane
10mm Dia. Vent
area without
adhesive


4 Hole Jig with ⅛" Dia. offset hole
drill guide shown in position three
out of four required drill locations
Reverse face of the jig
has 3 positions marked
for a trio of holes


Drill Jig shown here with a hole
centerline alignment feature