MARINE TECHNOLOGY REPORTER

March/April 2023
www.marinetechnologynews.com

TROND
CRANTZ
Argeo is moving forward fast on autonomy & data

Digging for Data
Tim Janssen & Sofar's Epic Ocean Data Quest

Interview
Felix Schill, CTO Hydromea

The Rise of
Electric Work Class ROVs

Subsea Defense
The Sea Mine Conundrum

Lander Lab
Subsea Housings

Volume 66 Number 3

MANAGING WATER VAPOR IN SUBSEA HOUSINGS

By Kevin Hardy, Global Ocean Design LLC

Any closed fixed volume, such as a pressure case, sealed in a warm, moist environment such as a ship or dockside, will contain a quantity of water vapor. It's an invisible threat to your instrument.

As a housing descends deeper into a cold ocean, it cools. For a given amount of water vapor captured at the warm surface, the temperature in the deep sea can easily drop below the "dew point", the temperature at which the water vapor changes to liquid water. At the dew point, the relative humidity is 100%. (Figure 2.) No longer able to hold the water vapor as a gas, condensation forms on everything inside the housing: circuit boards, the backside of connectors, batteries, and viewports.

Thus, managing the dew point is high up the design checklist.

Ocean engineers must consider a means to proactively remove water vapor from a housing before deployment. It's important to remember in this discussion that it is water vapor we're trying to manage, not oxygen, nitrogen, CO2, or any other gas.

By reducing the amount of water vapor in the housing, the dew point can be lowered to well below the coldest temperatures expected in the subsea environment.

There are two primary approaches to reducing water vapor: 1) use of desiccants, and 2) dry air exchange. The simplest and safest of these is desiccants, and the one I've used successfully for decades in every ocean at any depth.

DESICCANTS

Desiccants are hygroscopic materials that bind water molecules on contact, reducing the amount of moisture in the air.

Desiccants can include a humidity indicator, which will change color with the degree of water saturation. One common indicator changes color from blue (fresh), to purple, to pink (used). This is very helpful in at-sea operations, giving a visual indication of remaining drying capacity to the person preparing the housing for deployment.

Desiccants themselves are chemically inert, and not HazMat (Hazardous Material). They can be carried on board commercial aircraft without concern, though it is advisable to have an MSDS to show the TSA what the granules are. The desiccant granules can also be recharged at sea in the galley oven following a simple procedure, so you'll never run out of the stuff that dries the housing interior air.

Reprinted with Permission from the March/April 2023 edition of Marine Technology Reporter www.marinetechnologynews.com

Figure 1

No surprise that marine air is moisture laden making condensation inside an undersea housing a real problem.

There are two methods of employing desiccants: 1) passive and 2) dynamic. I prefer the dynamic method as it means the instrument is ready to deploy immediately after the purging process is done.

The passive method involves strapping desiccant packs onto an interior frame using a cable zip tie. This approach relies on diffusion to bring water vapor into contact with the desiccant, which can take a few hours. If you have the time, this approach has a lot less steps involved.

MultiSorb Technologies <https://www.multisorb.com/>, DryPack Industries <http://www.drypak.com/>, McMaster-Carr <https://www.mcmaster.com/products/desiccant-bags/> and others make these packages in a variety of sizes (Figure 3).

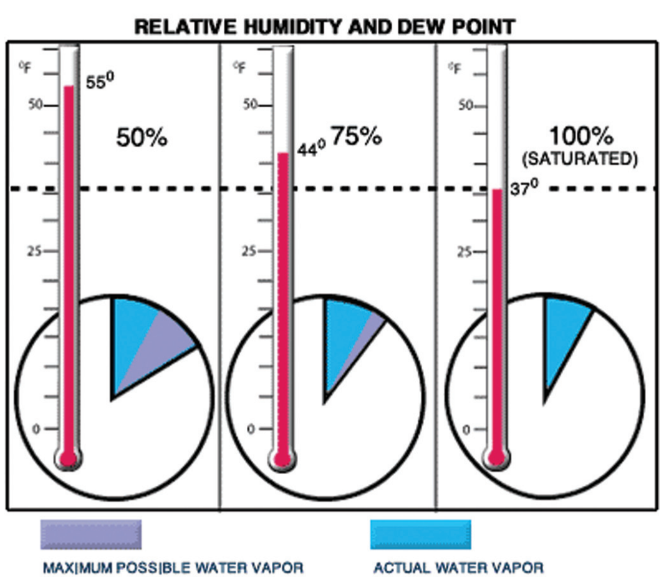
The dynamic method involves the use of a vacuum pump as part of a purge system to remove interior air. Care must be exercised to not damage any interior components by pulling too high a vacuum. A maximum of ½ atmosphere vacuum is recommended.

With half the air volume removed, half the water vapor is removed, and a partial vacuum is created inside the housing. A valve system allows the partial vacuum to draw external air back through a desiccant chamber, forcing it in contact with the desiccant granules, removing all the moisture. The dried air then enters the sealed housing, mixing with the residual interior air, thereby reducing the relative humidity on the interior.

The vacuum pump removes half the air for a second time. As half of the water vapor was removed the first time, half the remainder, or ¼ of the original water vapor, is removed. The valve system allows external air to be drawn back in by the interior partial vacuum, passing through the desiccant chamber, removing all water vapor, further reducing the interior relative humidity.

The vacuum pump removes half the air for a third time, removing half of the remaining moisture vapor, this time just 1/8 of the original amount of moisture vapor. At this point, 7/8 of the original moisture vapor has been removed, and the interior air is as dry as a desert.

I have successfully used this technique on deployments in all the world's oceans for decades, from inside the Arctic



U.S. Government, NASA, http://virtualskies.arc.nasa.gov

Figure 2

The relationship between relative humidity, temperature, and dew point is shown in this graphic. As the temperature falls, the air's ability to hold water vapor decreases.
At the dew point temperature, 37 °F in this example, condensation forms.

Photo courtesy of Multisorb

Figure 3

Desiccant packs are available in many sizes, in either indicating or non-indicating absorbent, selected for the volumetric size of the housing.

Circle to the bottom of a number of ocean trenches.

A passive desiccant pack or two zip tied to the inside frame are useful for capturing outgassing moisture from interior components such as printed circuit boards and cardboard covered battery packs. It's a double-check approach to controlling interior moisture.

With purge systems such as the Global Ocean Design Deck Purge Box (DPB-107), a vacuum leak test may be performed after the first draw down to ½ atmosphere. The vacuum gauge connected to the housing interior should show a static partial vacuum. If there is a slow loss of the vacuum, there is a leak somewhere. It could be the vacuum test unit, but it may be the housing itself.

A purge system based on dynamically drying the air using desiccants, such as the Global Ocean Design Deck Purge Box, Figure 4, is inherently safe. Once the interior pressure is equalized with the exterior pressure, the flow stops.

PURGE PORTS

Three purge port designs are currently in use: open port, self-sealing, and occasionally a pressure relief valve (PRV).

Of these, I prefer a self-sealing purge port, such as the Global Ocean Design PP-129 (Figure 5), as it leaves the interior vacuum at ½ atm, beneficially pre-loading the housing o-ring seals prior to deployment.

The self-sealing purge port includes a check valve that automatically closes when the purge system connector is disconnected. The self-sealing feature precludes moist exterior air from entering straight back through an open purge port, undoing all the work done to dry the interior air. The check valve provides the end-user with enough time to carefully clean, inspect and grease the final o-ring seal on the pressure proof cap. The check-valve will only seal against 10psi pressure by itself, so a pressure proof cap (PP-103) is required to protect the plastic valve from exposure to any ocean pressure.

One example of an open port purge port is found on EdgeTech releases. This purge port is simply a smooth bore with a small 1/16" diameter hole at the bottom that restricts air flow in and out of the housing. Before deployment a blanking plug with dual seals plugs the open port, restrained by a non-metallic crow's foot. An adapter fitting connects the housing to a purge system, including the Global Ocean Design Deck Purge Box. A vacuum leak test can be performed to check the seals are working as they should. Because there is no check valve in the purge port of the EdgeTech release, the end user is left with two choices for sealing.

The first is to allow the interior pressure of the release to equalize with the room ambient pressure, then remove the purge fitting, and plug the purge port. Since the interior/ex-

Photo courtesy of Global Ocean Design

Figure 4

The patented Global Ocean Design Deck Purge Box (DPB-107) is compact, fully integrated, and dynamically dries the air during the purge process. A universal power supply allows operation in any port-of-call.

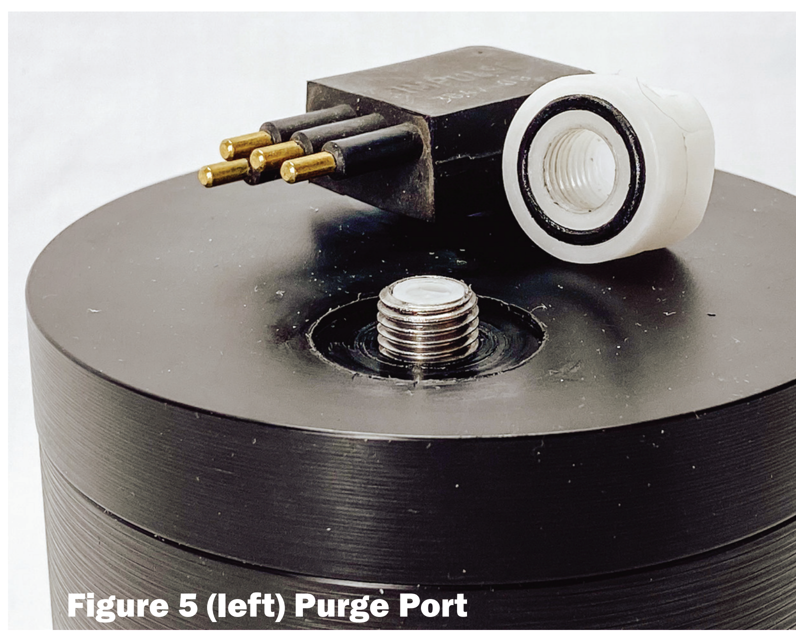


Figure 5 (left) Purge Port

The patented Global Ocean Design self-sealing purge port (PP-129), left, incorporates a check valve that closes when the purge system connector (PP-127), right, is disconnected. A pressure proof cap (PP-103) covers the purge port prior to deployment.

terior pressures are equal no air is being driven in or out of the housing over greased surfaces that might catch airborne debris. This is more manageable, and therefore preferred.

The less desirable method is to pull the purge fitting with a partial vacuum still inside the release. The end-user must be ready to quickly plug the purge port with the dual seal blanking plug before much air is drawn in by the interior partial vacuum. It's a game of Ready-Set-Go!

Pressure Relief Valves (PRV) are important for over-pressure relief, but I do not use them as a purge port for good reason. PRVs have a cracking and a resealing pressure. Due to hysteresis, these are not the same. When the interior pressure of a housing exceeds the exterior pressure by some preset value, the PRV opens to relieve the high interior pressure. But this also means there is now a direct opening in the pressure hull between the interior and exterior. Thus, the best, the only, position for a PRV is at the bottom of the pressure housing. Like an entrance hatch to an undersea habitat, put the door in the floor. Put it anywhere else and right where the cracking or resealing pressure equals the exterior pressure, water will surely dribble in through the open PRV. However, the floor is also where crumbs fall. Bits of stripped wire insulation, tiny bits of solder splatter, flecks of debris of all kinds fall towards the place where the greased seals of the PRV are located. It is impossible to clean, inspect and grease the final o-ring seal in a PRV used as a purge port, leaving the condition of the final seal uncertain. We are left to hope rather than having confidence in the final seal. For these reasons, I use PRVs for what they were first intended, as over-pressure relief.

DRY AIR EXCHANGE

Dry air exchange is also a dynamic method involving the use of a vacuum pump as part of a purge system to remove interior air. The partially evacuated housing is then back-filled with a dry gas such as nitrogen, SCUBA tank compressed air, or CO2. Three cycles, as described above, will remove 7/8 of the original amount of water vapor.

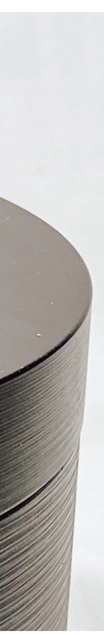
This method presents several obvious problems: 1) safety: it is possible to over-pressurize and rupture a housing; 2) HazMat: high-pressure bottles cannot be shipped full, requiring the bottles be filled at the operations site; 3) weight and handling: high-pressure bottles are heavy and cumbersome to move about, and require proper restraint on a ship; 4) differences in international standards for high-pressure fittings present a challenge to interfacing U.S. tanks to foreign fill systems, and 5) when the high-pressure bottles are empty, you're done.

In fairness, when I first arrived at Scripps, every group did dry nitrogen backfills. By the time I retired, however, no group did that any longer. We learned that it is water vapor we're trying to manage, not any other gas.

Good design and fastidious execution raise the odds of success in your favor.

ACKNOWLEDGEMENTS:

Jack McLaughlin, HydroAcoustics (Henrietta, NY), makers of the HLF-5 and other low frequency acoustic sources, taught me a lot in my early days about placement of check-valves and burst disks relative to bottom centerline, pressure compensation systems, non-circular o-ring seal design, open sump hydraulic systems, zinc oxide as a stainless-steel fastener lubricant, and different approaches to corrosion control of aluminum. Great engineer, wonderful fellow, fond memories.



Photos courtesy of Global Ocean Design

Figure 5 (right) Purge System Connector