Battery Installation

From the Masthead

Over the past few days, I've had feelings that alternate between… those I had after 9/11; those I had in 2008 and the early days of the Great Recession; and an impending hurricane or snow storm. Do we have enough cereal, milk, chocolate, pasta and toilet paper? About three weeks ago I sent out a missive to family members suggesting they have at least 30 days' worth of provisions on hand, and some cash. Some scoffed. As a gearhead and cruiser, I'm a firm believer in being prepared; everyone should have 30 days' worth of essentials on hand at all times, you just never know.

I returned from a trip to Malaysia and Taiwan about 10 days ago, and it is good to be home, but home, the United States, was never like this, it's truly uncharted territory. My advice to readers is to, once again, be prepared. If you are in the at-risk category, over 60, and/or with an underlying illness, then you should be hyper-vigilant, and I won't repeat all the things you've already read and heard about hand washing, avoiding contact etc. You know what to do. If you are not in the at-risk category don't panic, don't over-react, don't fear-monger. As it stands now it appears that about 85%

of those who contract Corona don’t seek or need medical attention. Which brings me to the next critical statistic, the number of cases is likely far higher than reported, which means the mortality ratio is very likely lower than reported, likely less than 1% (mortality for the flue is about 0.1%). Never the less, this isn’t the common flu, take this seriously, avoid unnecessary contact with others and crowds, and practice good hygiene, and all the other guidance you’ve now heard many times.

Most of you have 401k, ROTHs, and individual holdings in the market, I do. At first, I was looking at my portfolio every day, then every hour, and now I’m just not looking at all, while reminding myself that I have at least another ten years before retirement, and thus time to recover… I’m *not* offering investment advice, that’s a personal decision for each one of us based on circumstances, age and risk-tolerance, however, I did stick to my protocol of regular investment, and buying when the market is down, because I know this will pass, I know as a nation and an economy we will endure this, and we will recover. Back in 2011-12, when there was a glimmer of light at the end of the recession tunnel, I recall saying on several occasions, “Things are improving, but the marine industry will never be what it was, not in my lifetime”, and that might have applied to the overall national economy. I was mistaken, it rebounded in ways we could not have imagined. I’m reminded in times like this of two investment axioms, the market always drops faster than it rises, and it always rises, and exceeds where it was before the drop; and you don’t lose anything until you sell.

What does this mean for boat owners, buyers and the marine industry? I’m going to remain optimistic; because the onset of this event was so sudden and unprecedented, the recovery may also be rapid, or at least more rapid, we went into this with a solid foundation. I’ve been in this business for 32 years and have seen my share of crises, once again 9/11 comes to mind, it was sudden and traumatic. “Corrections”, are just that, a course correction for the industry, they stress-test marine firms, and while I wouldn’t wish that stress on any fellow business person, in the long run it likely makes the industry better and stronger, some of the weaker ones, those with too much debt and marginal products, may fall by the wayside, as they probably should, it’s natural and simply accelerated. In the words of Winston Churchill, “If you are going through hell, keep going.” We will get through this.

This month’s Marine Systems Excellence eMagazine article covers the subject of battery installations.

Battery Installation

A textbook battery installation, these batteries are securely clamped in place and will resist even the most violent sea

conditions.

A few years ago, I made a passage from northern Norway to Svalbard, an archipelago located about 600 miles from the North Pole. It ranks as one of the most tumultuous, unpleasant (and seasick-inducing) journeys I've ever made. I stood my watch, gripping the arms of the helm chair, as the bow plunged interminably into each oncoming head sea, ripping off wave tops that pelted the windscreen. During times like those, my mind races through all the vessel's critical systems, thinking of ways they could fail, ruptured stuffing boxes, wet and short-circuited wiring, breached hull to deck joints, steering ram leaks, and battery security… any one of which could result in the failure of a system and even foundering.

Heavy weather scenarios test all of a vessel's systems, and because of their mass, especially batteries.

What do the Standards Say?

It’s not often I differ with the well-established guidelines set forth by the American Boat and Yacht Council (ABYC). This, however, is one of a handful of exceptions. Among other things the Standard regarding battery installations details the amount a battery is allowed to move after it’s been installed, saying, “Batteries, as installed, shall be restrained to not move more than *one inch* in any direction when a pulling force of twice the battery weight is applied through the center of gravity of the battery as follows: vertically for a duration of one minute, and horizontally and parallel to the boat’s centerline, for a duration of one minute fore and one minute aft, and horizontally and perpendicular to the boat’s centerline for a duration of one minute to starboard and one minute to port.” In the scheme of things, just about any piece of equipment, particularly items that are this heavy, that is given this sort of latitude for movement, eventually comes to grief. If a battery moves with each head, or beam sea the vessel encounters, hundreds, or thousands of times in a given passage, the stress imparted to the battery, and the potential for chafe or loosening of cables and connections is very real indeed.

Battery support hardware should be retained with through bolts. If tapping screws must be used they should be the largest/longest that will be accommodated by the hardware and substrate.

Real-World Use

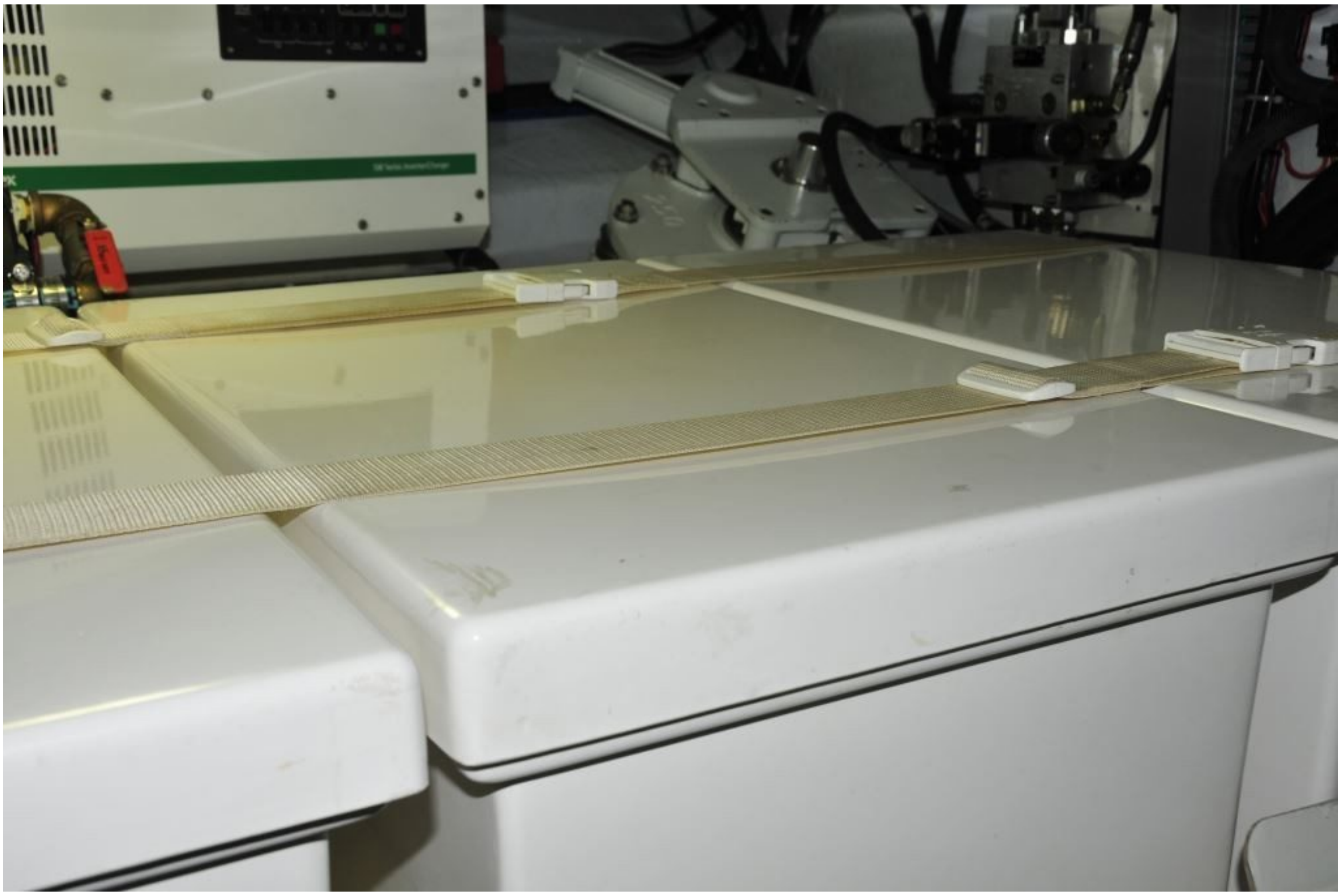
I conducted a sea trial aboard a 65+foot, pod-equipped planing vessel, off the coast of South Florida, in January. Seas were 6-8 feet with about a 10-12 second period, ideal for a real-world sea trial. I was below when we cleared the inlet and the helmsman, without warning, fire-walled the throttles; the boat leapt up on plane and rocketed along at 30 knots from wave to wave, it felt as if my feet were off, more than on, the sole, I was literally weightless as the vessel fell off wave tops. I weigh about 150 lbs.; think about what that's doing to the vessel's batteries (they were not fully immobilized), most of which weigh less than I do; they too will be alternately airborne, and slamming down with the added

G-force into the bottom of their box or shelf, *if allowed to move*.

Sailing vessels face similar battery-related issues, but in some cases even more challenging. While they may not zip along at 30 knots, they may be in conditions that lead to severe heeling, 90° or more in the event of a knock-down or capsize. A recent article published in Outside Magazine, about a vessel that was dis-masted 700 nm. west of Hawaii, described the knockdown by saying, “Stuff was flying everywhere. The battery came blasting out of the engine compartment and shot through the cabin like a rocket.” A properly secured battery should not go anywhere, virtually regardless of how violent the conditions; and batteries aboard sailing vessels should remain in place even when inverted.

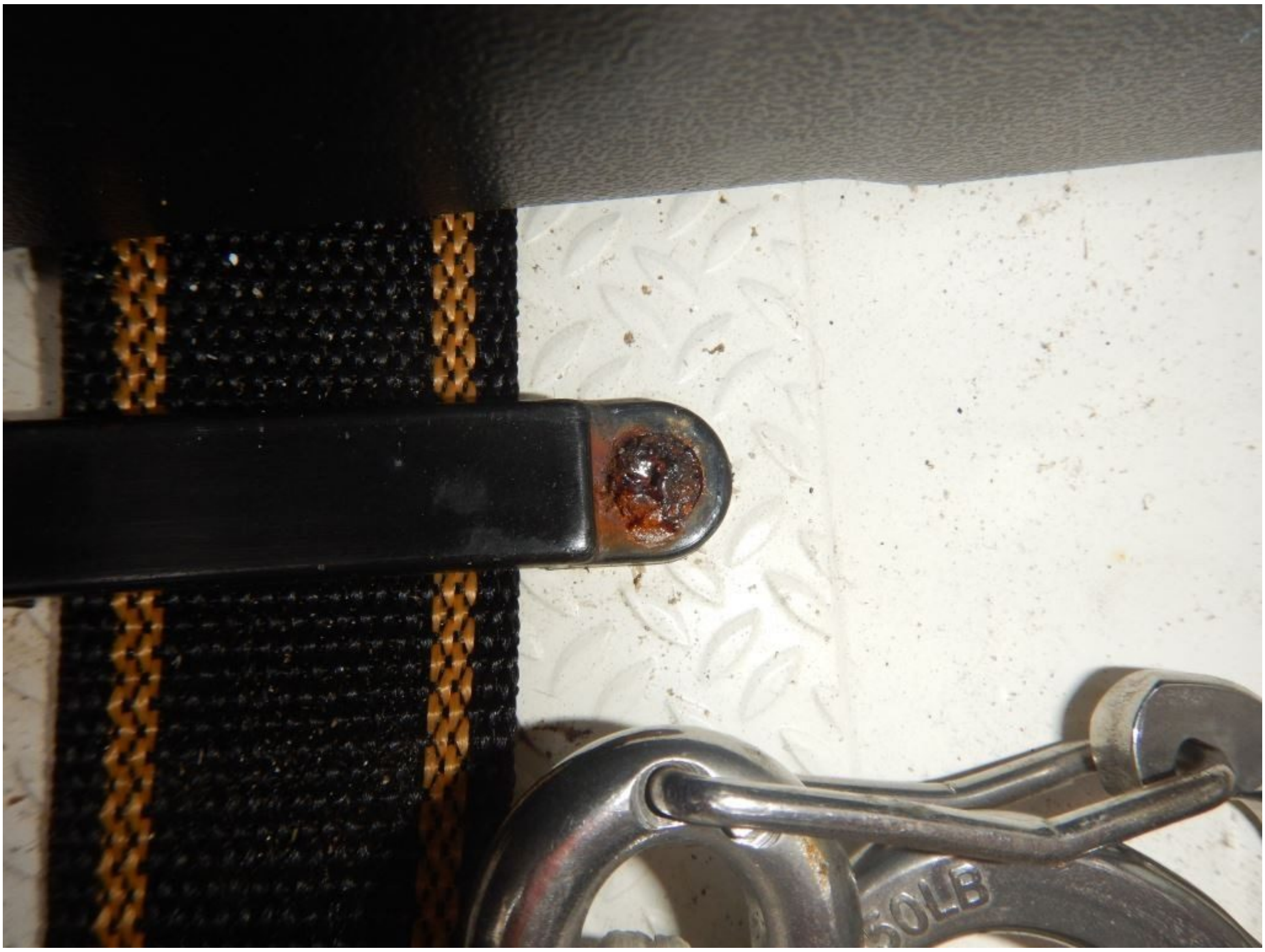
This Lithium Ion battery bank is retained by a single clamp-type strong back. The positive terminals should be insulated.

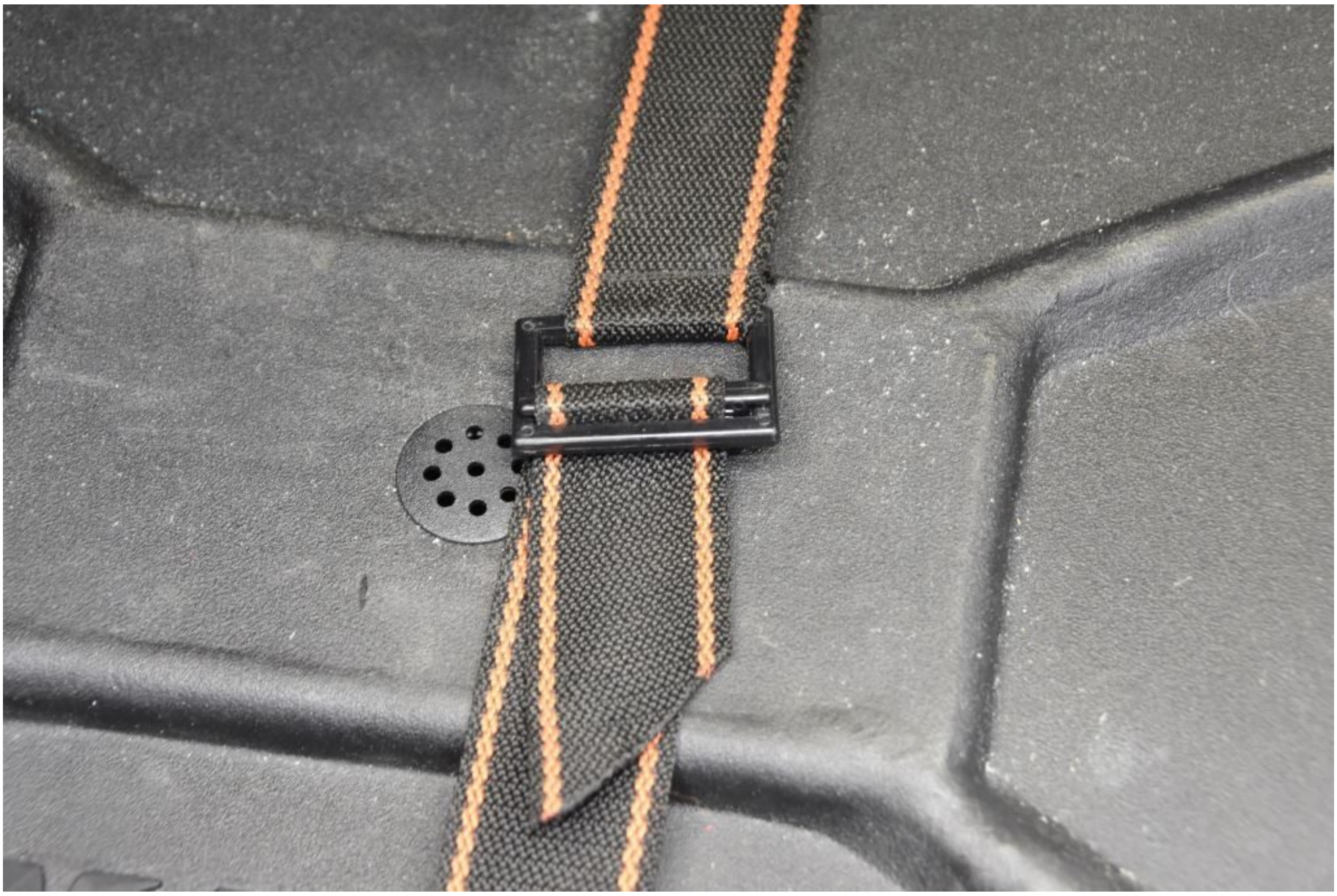
Based on my experience in both the boat yard and at sea, my preference is for complete immobilization of batteries. This can be accomplished with a clamp type strong back arrangement, or heavy ratcheting straps using stainless steel buckles, or using proprietary mounts.



Light-weight straps and buckles have no place securing large battery banks.

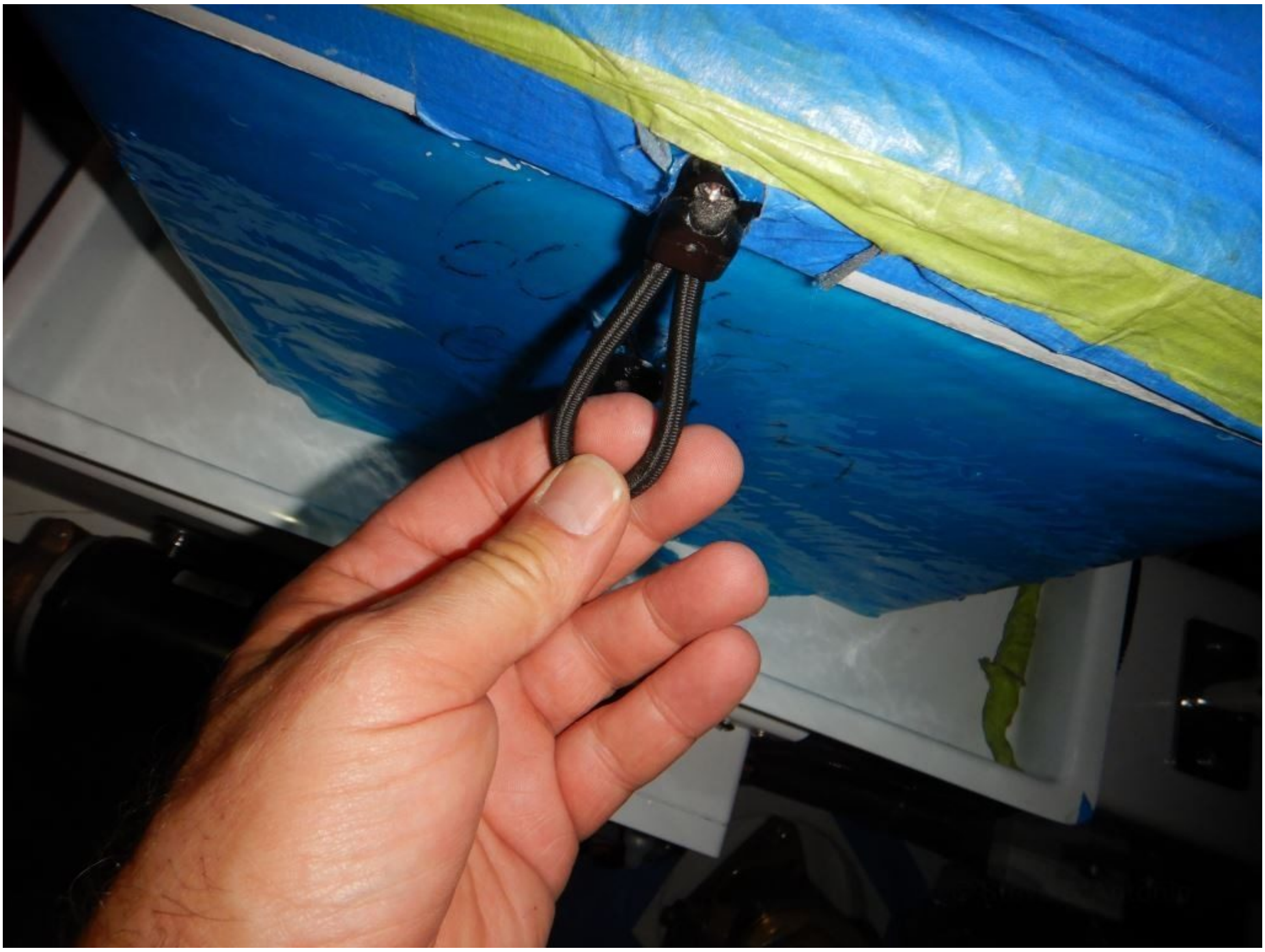
By the way, forget about using the wimpy nylon strap, with plastic two-piece buckle and strap eyes, you know, the one that always seems to be seized when you try to release it; while fine for a run about or tender, and perhaps not even then considering the movement and G forces encountered there, it’s simply inadequate for large batteries in seagoing vessels. Complete immobilization of batteries becomes more challenging when they are installed in boxes, particularly if the box is over-sized, as so many are. In those cases, shims must be installed, between the battery sides as well as the battery top and inside of the box lid.





Off the shelf budget battery box straps like the ones shown

here rely on mild steel screws, which quickly come to grief in a marine environment, and light weight buckles. This arrangement, especially for larger batteries, will almost certainly fail to pass the ABYC security test.



The elastic straps that hold this battery box's lid in place, and which are expected to keep the battery secure and stable within the box, are simply inadequate for the task.

<u>Boxes, Trays, Straps and Clamps</u>

Contrary to popular belief, compliance with ABYC Standards does not mandate that batteries be installed in boxes. In fact, unless they are of the flooded variety (referred to as flooded lead acid, or FLA), I'd argue they are better off without boxes, eliminating enclosures offers better ventilation and makes regular casual inspection far easier and thus far more likely. I like to be able to glance at a battery bank every time I'm in its vicinity, looking for signs of bulging, overheating, arcing, melting etc., if it's in a box that's not possible.

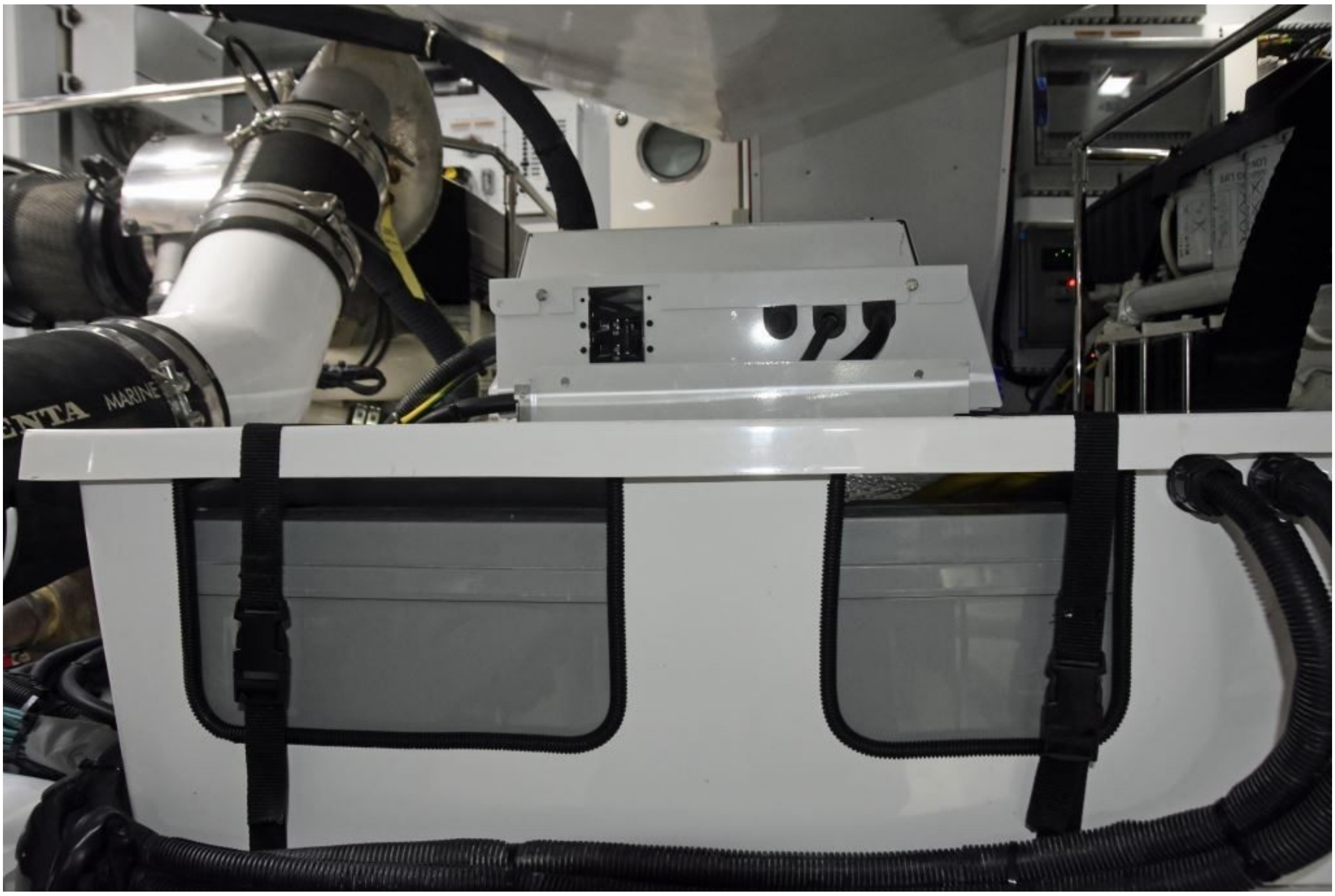
Installing batteries in boxes makes casual inspection impossible. As a result, problems like this corroded post are likely to linger until a failure occurs.

Once again, the Standards state, "Provision shall be made to contain incidental leakage and spillage of electrolyte. *NOTE: Consideration should be given to: 1. the type of battery installed (e.g. liquid electrolyte or immobilized electrolyte). 2. the boat in which the battery is installed (e.g. angles of heel for sailboats, and accelerations for powerboats)."* It makes little sense, therefore, to install a Gel, or AGM battery (these are often referred to as Valve Regulated Lead Acid, or VRLA) in a case since leakage is essentially impossible. Lithium Ion (currently the most common chemistry is Lithium Iron Phosphate, or LFP) batteries do utilize a liquid electrolyte, and although they are sealed and leakage is highly unlikely unless the case itself, some are plastic others aluminum, failed, it is possible. The electrolyte used in LFP batteries is, by the way, flammable.

Raw or painted timber is unsuitable for battery box material, it is quickly destroyed by leaking electrolyte.

Flooded batteries of course do benefit from containment; however, it is not required to be 100% containment, i.e. a box, it could be a liquid-tight tray. Having said that, flooded batteries do from time to time explode as a result of hydrogen, which is lighter than air and thus rises, accumulation and an internal or external arc, which makes 100% containment, a box with a lid, attractive. Trays are also susceptible to leakage when a vessel heels, making them less practical for FLA batteries aboard sailing vessels.

Flooded batteries do occasionally explode, like the one shown here. For that reason, full enclosure within a box does make good sense.



A box with large holes cut in the side somewhat defeats the purpose of containment. For flooded batteries boxes can make sense, otherwise their benefit is questionable.

Where batteries are installed in boxes, using the common shoe box lid design, the apex of the lid must be vented to allow hydrogen gas to escape, and this applies to FLA and VRLA batteries; as under over-charge conditions these can vent hydrogen gas. Batteries that are poorly secured are more likely to suffer from loose and arcing connections. Add that to a design whose boxes fail to vent hydrogen, and you have an explosion in the making.

Whatever material the batteries rest on, or in, it must be completely resistant to acid. Production polyethylene battery boxes or trays are suitable, as are fiberglass boxes or trays. However, timber is not suitable unless it is coated with resin *and fiberglass cloth.* Resin-coated timber alone is not acceptable, as the resin layer is too thin, and is invariably breached by the weight and abrasion of the battery. Timber exposed to battery acid will quickly deteriorate. Remember, especially for FLA batteries, the tray or box must be liquid-tight.

This battery box is too large for the battery (or the battery is too small for the box). Shims are needed to prevent it

from moving in all directions, including upwards. Note as well the fastener at the bottom of the box. This is problematic for flooded batteries as leaking electrolyte will attack the fastener; it’s also an ABYC violation.

Fasteners used to secure battery boxes or trays must not be installed in an area where they may come into contact with spilled electrolyte; they cannot be inside the box or tray, making a further case for the use of an external clamp or strap arrangement. On this point the battery type does not matter, FLA or VRLA, as it’s possible for either type of battery to be installed at some point in the future. Additionally, unless these are through bolts (most of the fasteners used for battery installations I encounter are tapping screws) it’s likely the installation will fail to meet above-mentioned static load test. For straps or clamp mechanisms, strap or pad eyes, again through bolts are preferred, and machine screws driven into taped fiberglass are also inadequate, as fiberglass does not lend itself to tapping. If tapping screws must be used the longest, broadest version that the hardware and substrate will accept should be used; carefully consider ABYC load requirements and ask yourself if you believe the fastening mechanism you are contemplating, or evaluating, will meet the standard.

Clamp arrangements prevent all battery movement, and are therefore ideal; note the heavy through-bolted eye bolts.

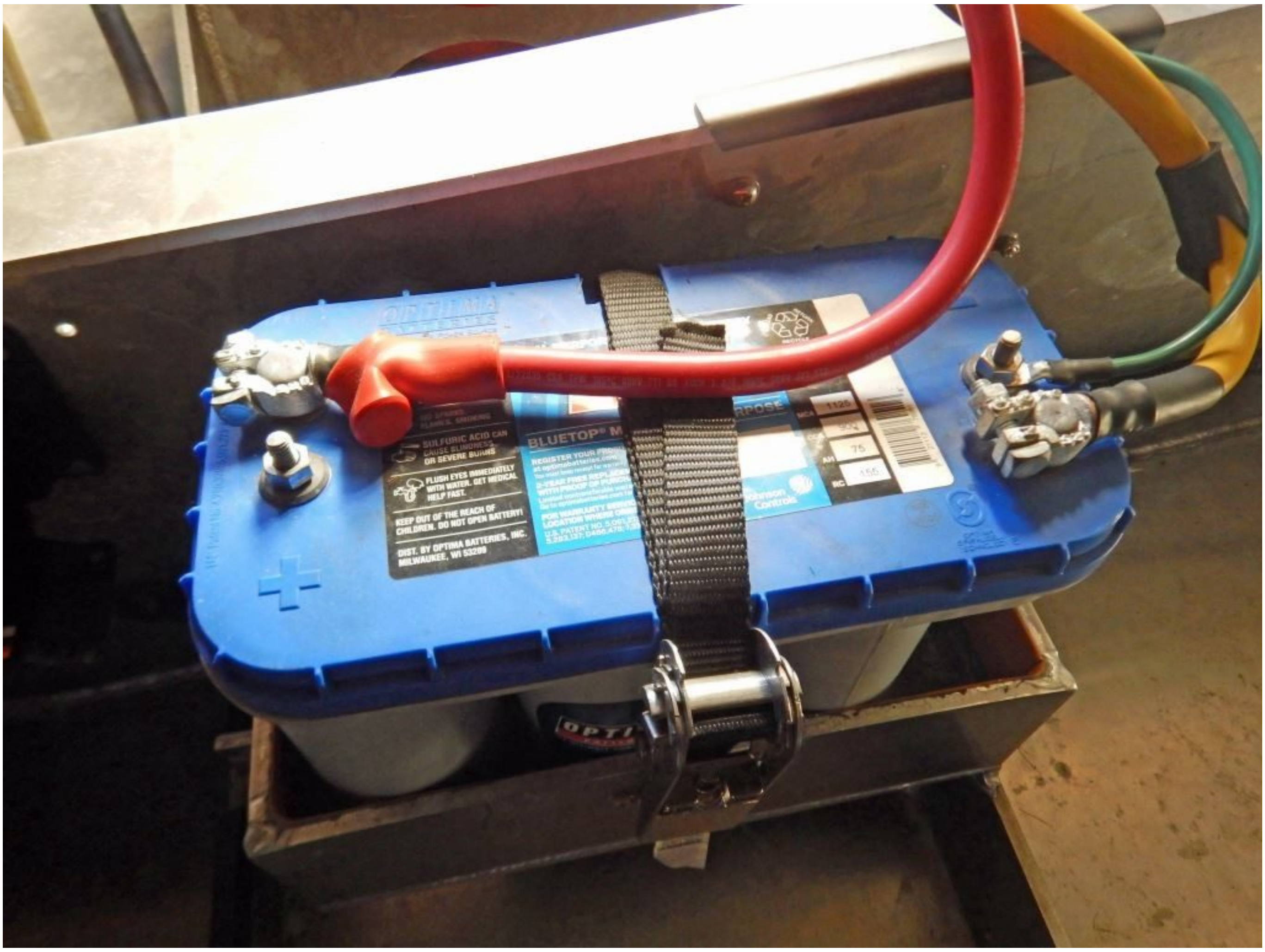
Clamp mechanisms, which often utilize vertical rods and a beam or strong back, should also rely on through bolting. The strong back should ideally be padded where it makes contact with the batteries, and made from a non-conductive material such as extruded fiberglass, an example trade version of which is called GPO3. If metal is used, it should be fully insulated to eliminate the possibility of a short circuit which, in a battery installation, could be catastrophic as there is no over current protection present.

This nicely-made fiberglass battery box has one fatal flaw; the lid forms an envelope in which hydrogen gas can become trapped. A few small holes in the top will easily remedy this problem.

While packing batteries tightly into cases, or just alongside each other for added support when clamped in place, may seem like a desirable approach, it has drawbacks and should be avoided. Batteries generate heat when being charged, especially when deeply discharged and using high output charge sources. Therefore, ideally, at least a ¼" (6mm) gap should exist between each battery, to facilitate heat dissipation.


PORT ENGINE
STARBOARD ENGINE
STARBOARD ENGINE

This battery box is secured with heavy duty straps, and shims have been attached to the inside of the lid to retain the battery.



Heavy duty ratcheting straps, with stainless buckles, can be used very effectively for battery hold-downs (the positive terminal on this battery should be insulated).

<u>Ventilation</u>

All FLA, VRLA and LFP batteries require ventilation, both for heat dissipation and to allow hydrogen vapors, and those produced by a malfunctioning lithium ion battery, to safely escape. The ABYC Standard E-10, Storage Batteries, offers these guidelines…

10.7.9 A vent system or other means shall be provided to permit the discharge from the boat of hydrogen gas released by the battery.

10.7.10 Battery boxes, whose cover forms a pocket over the battery, shall be vented at the uppermost portion of the *cover.*

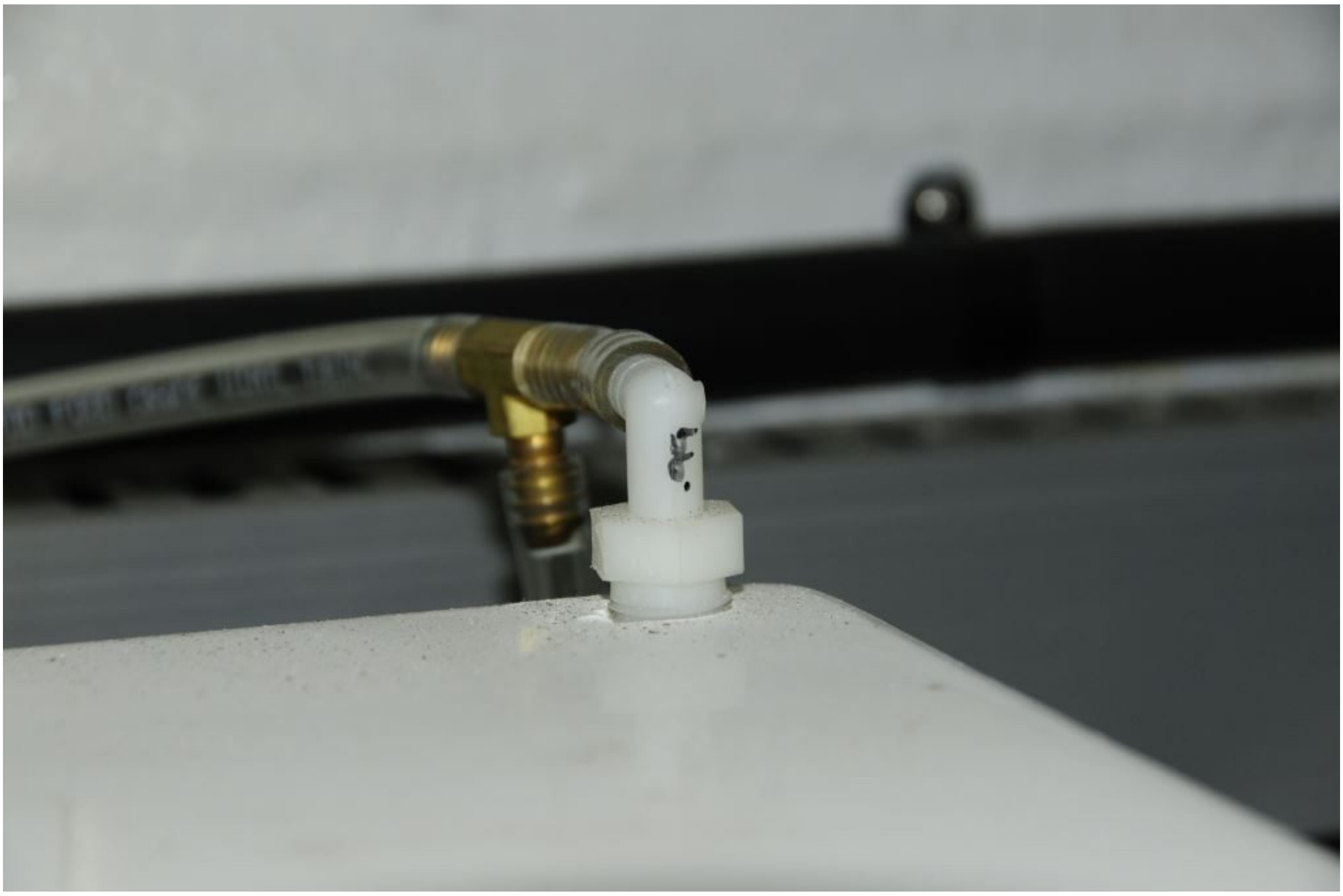
NOTE to 10.7.9 and 10.7.10: These requirements also apply to installations of all batteries whether they employ removable vent caps, non-removable caps, are "sealed" or "maintenance free" batteries, or have pressure regulated valve vent systems with immobilized electrolyte (gel and AGM batteries).

To prevent the possibility of short circuits, the material used for the clamp strong back should be non-metallic; the one shown here is extruded fiberglass.

The form this "vent system" takes can vary. Initially, as noted previously, it must allow hydrogen or other vapors to escape from a battery box or locker. Then, the vapors must be allowed to escape from the vessel. The assumption is, once hydrogen is allowed to escape into the cabin, it will continue to rise and exit via natural forms of ventilation. If the upper portions of the cabin are particularly air-tight, however, this may prove problematic, and the hydrogen gas may become trapped inside the vessel. While they are not designed to do so, carbon monoxide detectors will often sound in the presence of a heavy concentration of hydrogen gas, while off the shelf hydrogen gas detectors are readily available.

Batteries that fit tightly within a box, or strapped together side by side, are a double-edged sword, they may not move as much, however, ventilation between batteries is compromised.

One common vapor trap involves bow thrusters, in these battery installations, which are often located under a V berth, the mattress often helps to form a gas-tight seal at the top of that compartment, creating an envelope and the potential for the accumulation of hydrogen gas, which could be ignited by the thruster, HVAC unit, or other gear located in this space, which may not be ignition-protected. The vast majority of inverters are not ignition protected and thus they should not share confined compartments with batteries.



This battery box has been equipped with a remote ventilation

system. However, the tubing is not robust enough, it's too easily crushed or kinked, and in this case water is trapped within, which will impede extraction of hydrogen gas.

Some batteries, both FLA and VRLA, are equipped with ventilation ports, to which a tube or hose may be attached, which can then be plumbed to a weather deck, allowing vapors to exit from the battery directly to the atmosphere outside the vessel. Clear PVC tubing is often used for this purpose; however, it is far too crush, melt and kink-prone in my experience. Instead, I recommend using is crush-resistant 3/16" (4.7 mm) wall thickness, silicone rubber tubing.

Clamped-down batteries, and through-bolted supports, with generous ventilation gaps, an installation worthy of praise.

Certain lithium ion cells will out-gas, while others are certified to not out-gas (during normal operation.) The latter are vacuum sealed, and will only release pressure, and out-gas, during catastrophic events, or thermal runaway conditions, which constitutes a total failure of the battery. If the cells vent, this could lead to what is referred to as a "deconstruction" of the battery enclosure, something for which UL tests. Pressure build-up could lead to an explosion of the battery enclosure. The option for having a port or vent located on the outer case of the cells is, therefore, a consideration.

This venting port is an option from at least one LFP battery manufacturer, Lithionics; their UL Listed, and IP67 sealed, aluminum enclosures are equipped with a pressure balancing valve port, to which a high temperature silicone hose can be connected, and routed overboard. In the event of a runaway, it would convey the vaporized electrolyte, which usually forms a dense white cloud that would otherwise disperse within the vessel. Google <LiFePo4 crashtest> for an example of the potential volume and density of vapor cloud production.

Finally, every house or thruster battery bank installation should include smoke detection directly above the space. If batteries begin to overheat, a smoke detector will be your early warning, and first line of defense in defusing the situation. It's important that a smoke alarm be audible in the accommodation spaces, while underway, or while those aboard are asleep. Even better, utilize a system that provides text messaging should an alarm sound when the vessel is unattended. This may require the use of a central station alarm system like those available from Maretron, Sea Fire, Fireboy, Siren, BRNKL and others, or wirelessly interconnected household type alarms (some of which include remote alerting via Wi-Fi). For more on smoke alarm selection and installation see this article.

Batteries are all too often given no more than cursory attention when it comes to installation, and regrettably the ABYC Standards in this case simply aren't stringent enough to ensure safe, reliable, battery security. In ABYC's defense, their President, John Adey, often reminds me that the

Standards are the floor, not the ceiling.