Keeping Your Bilge Dry with Dripless Stuffing Boxes

Text and photos by Steve D’Antonio

From the Masthead

There are very few quotes that truly epitomize the attraction I have for boats, and the sea. Among my favorite is journalist E.B. White’s little-known, “If a man must be obsessed by something, I suppose a boat is as good as anything, perhaps a bit better than most. A small sailing craft is not only beautiful, it is seductive and full of strange promise and the hint of trouble.” I’d argue, of course, that it could be any craft, power or sail, large or small, her destination and from whence she hails, or the waters she plies matter not. White’s words embody what so many of us feel when we are afloat, and in a kingdom of our own. The “…hint of trouble” part is especially attractive to me, in that my goal is to help others avoid it, by making certain their vessels are seaworthy, reliable and safe.

I first encountered these lines over 30 years ago, while sailing aboard a 120-foot schooner, somewhere between Bermuda

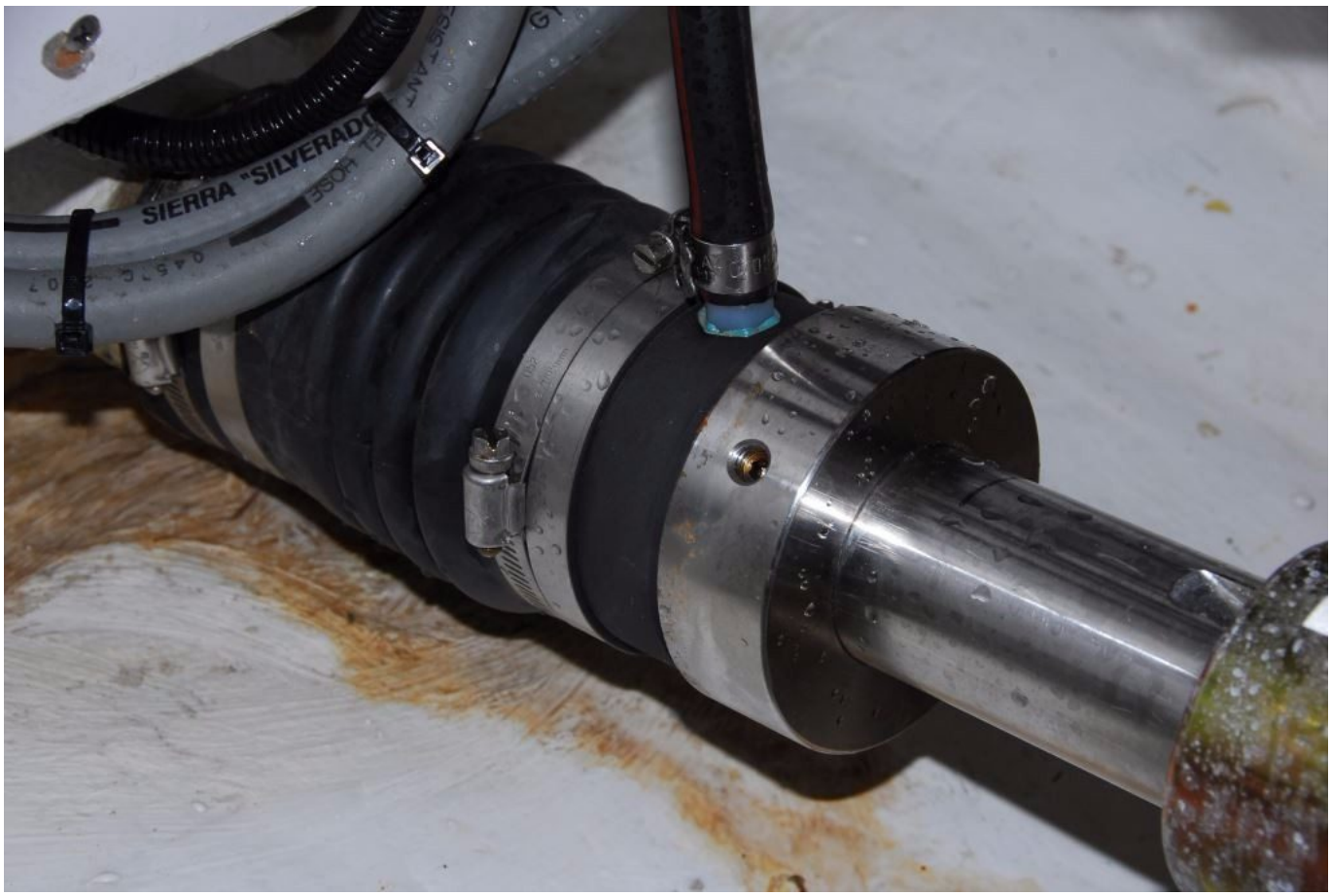
and the Windward Islands. R/V Westward departed from Woods Hole, on Cape Cod in October and the sea was unsettled almost from the moment we left the harbor mouth. I'm certain I was seasick until we turned due south nearly a week out; that's how I know I read these lines after leaving Bermuda on our starboard beam. Prior to that I had no interest in anything beyond standing my watch and trying to figure out the best way to keep food down. The ship's library included a compilation of short sea stories, one of which was White's, entitled, "The Sea and the Wind that Blows", first printed in 1963, along with the above quote. It's short, lovely and I recommend it highly.

I share these thoughts to remind readers that while I'm a gearhead, and I revel in all things technical, my love of boats extends beyond the engine room, bilges, plumbing, batteries, wiring and systems. In spite of my propensity towards seasickness, I enjoy being at sea; (I'm editing this column while seated in the pilothouse of a large cruising vessel) and there are few things I love more than a lone night watch. Above all else, I delight at the very thought of making landfall in strange and remote places, places that can only be accessed by a small craft.

This month's Marine Systems Excellence eMagazine covers the subject of dripless stuffing boxes, I hope you find it both useful and interesting.

A new tab has been added to the SDMC website, one which includes articles written by Steve for a variety of publications including Cruising World, Ocean Navigator, PassageMaker, Professional BoatBuilder, Prop Talk, Waterway Guide and others. Its categories include Boat Buying and Ownership Wisdom, Technical, Cruising, and Profiles and Reviews. New articles are being added on a weekly basis; you can access it here.

Dripless Stuffing Boxes; Avoid the Pitfalls, and Keep Your Bilge Dry



Face seals rely on the spring tension created by a bellows-type hose. The system is simple and effective.

In its traditional form the conventional stuffing box, discussed last month, carries out a vital role, allowing a spinning propeller shaft to pass from the inside to the outside of the hull, while keeping the water out. It has worked well and reliably aboard thousands of recreational, commercial and military vessels for over a century. It's simple, rugged and for the most part exceptionally reliable, although it requires routine maintenance, adjustment and periodic repacking. Varying designs and installations carry with them varying degrees of watertight integrity.

So what's not to like? The conventional stuffing box's one primary failing annoys many users to no end, so much so that

several manufacturers have attempted to improve on the design. Its flaw, albeit necessary and one some perceive as fatal, is its propensity, or necessity, to leak or drip. That drip, while irksome, serves a vital purpose, it ensures that the packing material within remains wet, lubricated and thus cool and long-lasting. Without this vital flow of cooling water, the packing will quickly overheat, which in turn leads to more profuse leakage and after some time the potential for accelerated shaft wear.

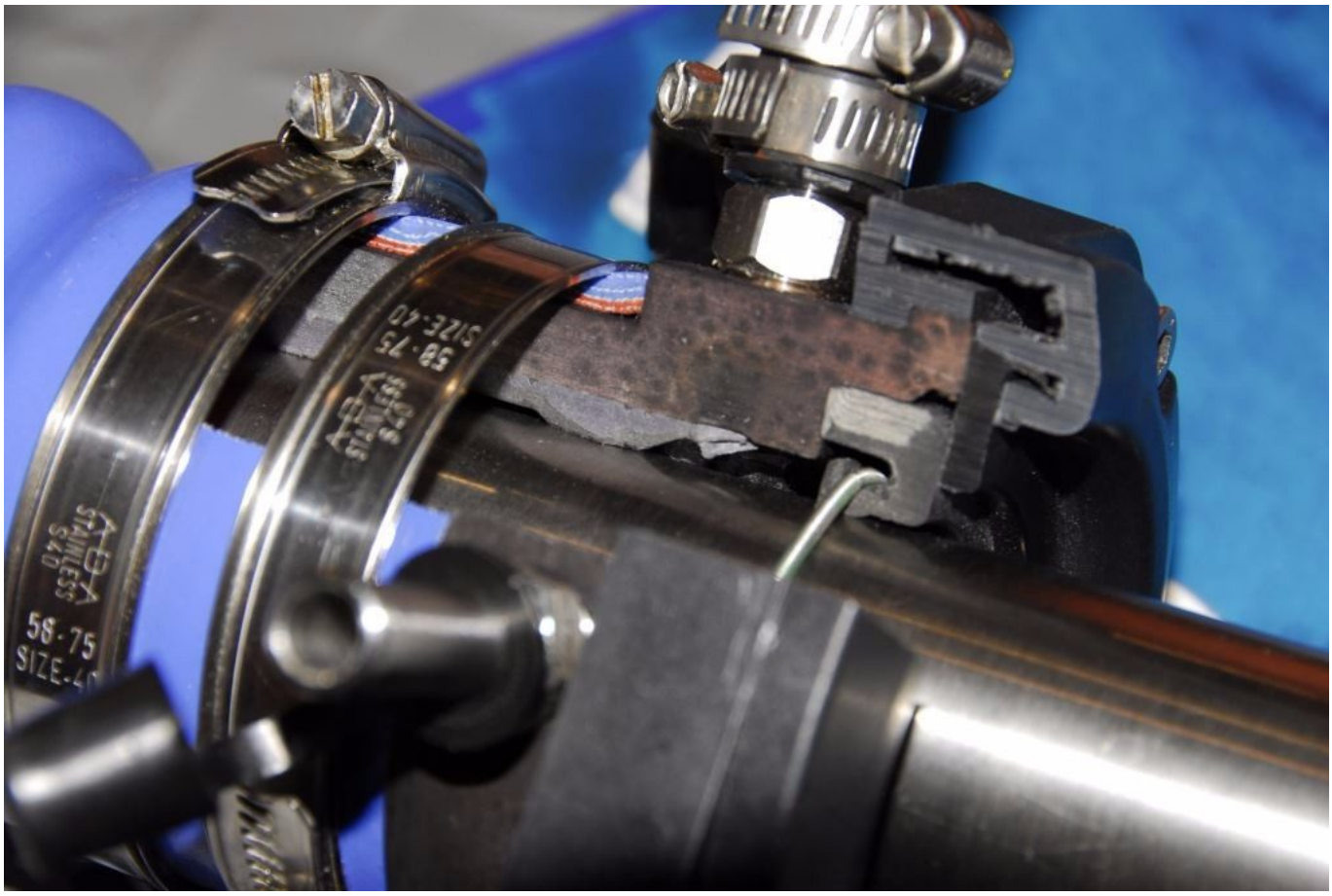
Dripless shaft seals should be dripless, they should not leak. In some cases they may leak slightly and initially until broken in, however, this should not last more than a few hours. If it does, something is wrong.

A range of alternative dripless stuffing boxes are available. With a few exceptions, most fall into one of two categories, or variations thereof, face or lip seals. Let me be clear for those who are trying to decide whether to go dripless or not,

a dry bilge enables a vessel operator to quickly identify trouble, as any water is too much water. Dripless stuffing boxes can help users achieve this goal, at a price. Read on.

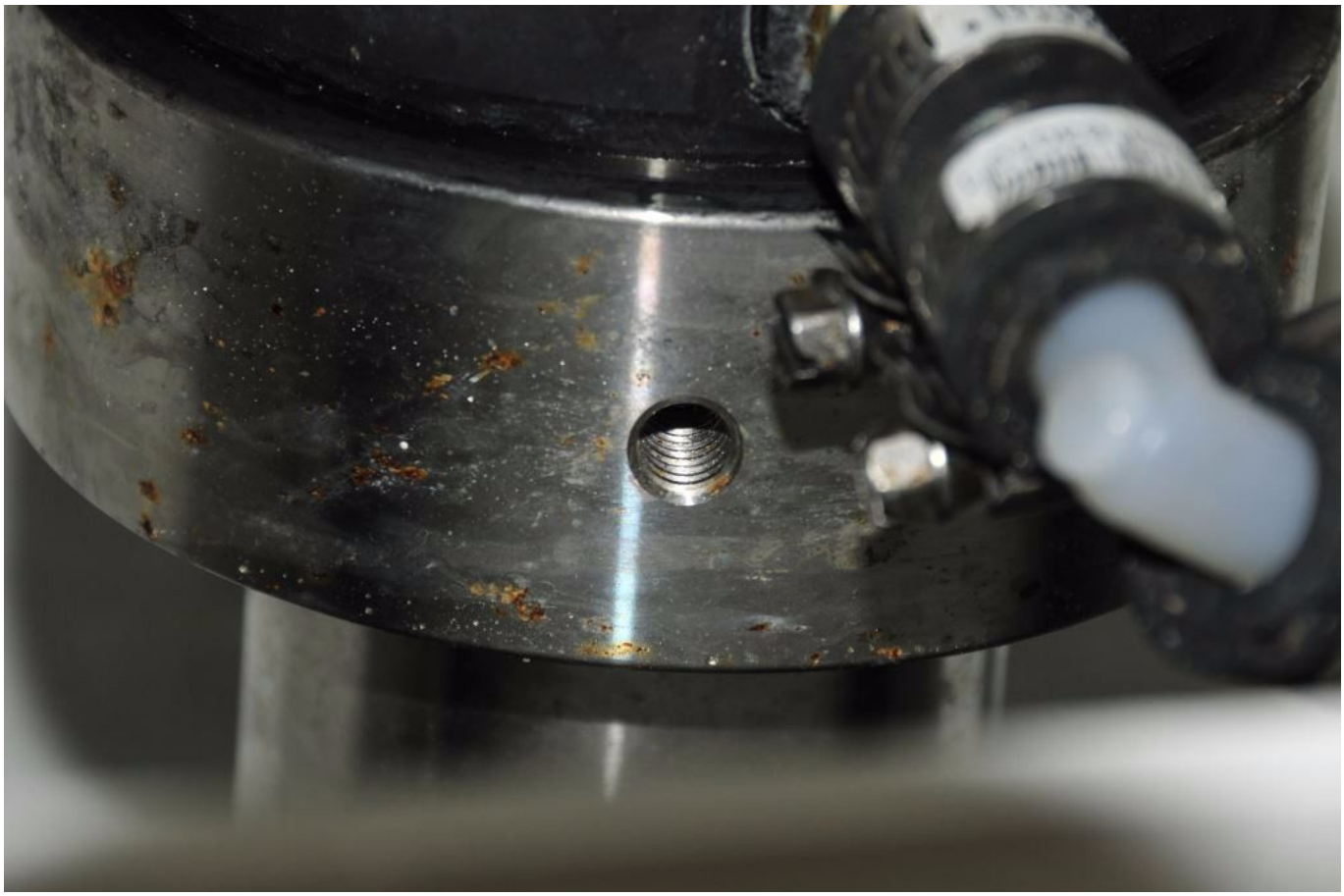
Face Seals

Face seals rely on an interface between a stationary component, most often carbon graphite, and a smooth, polished rotating stainless steel ring, the rotor, which is clamped to the shaft. The rotor is equipped with internal O rings, which establish a watertight seal between the rotor and shaft. In order for this to work, the shaft in the area where the rotor will reside must be relatively free of nicks, scratches, pitting or other defects. Used shafts should be cleaned following the manufacturer's instructions, between the end of the shaft and the area where the rotor will reside. Caution must be used when sliding the O ring-equipped rotor over the shaft's sharp keyway, tape is often placed over this to eliminate the possibility of damage. Because the O rings are stationary, they are *somewhat* tolerant of minor irregularities in he shaft surface.



A cut-away view of a lip seal. The self-centering "bearing" can be seen at the center, and the spring retainer for the lip seal to the right.

Slight pressure is applied between the rotor and stator using spring tension, this is typically built into the bellows-type stuffing box hose, which supports the stator. During installation the stainless ring is carefully positioned on the shaft so as to compress the spring/bellows by a pre-determined amount, thereby establishing the correct level of pressure between rotating and stationary components, and then retained in place using double-stacked cupped set screws (many of the installations I inspect lack the double set screws because installers assume the second set to be spares). Carbon graphite is tough, durable and abrasion resistant, and with just a slight film of water between it and the stainless steel ring, the system works quite well; in fact the design is ingenious in its simplicity.



Face seals rely on stacked set screws to secure the rotor. In many cases the second set screw is, like the one shown here, not installed.

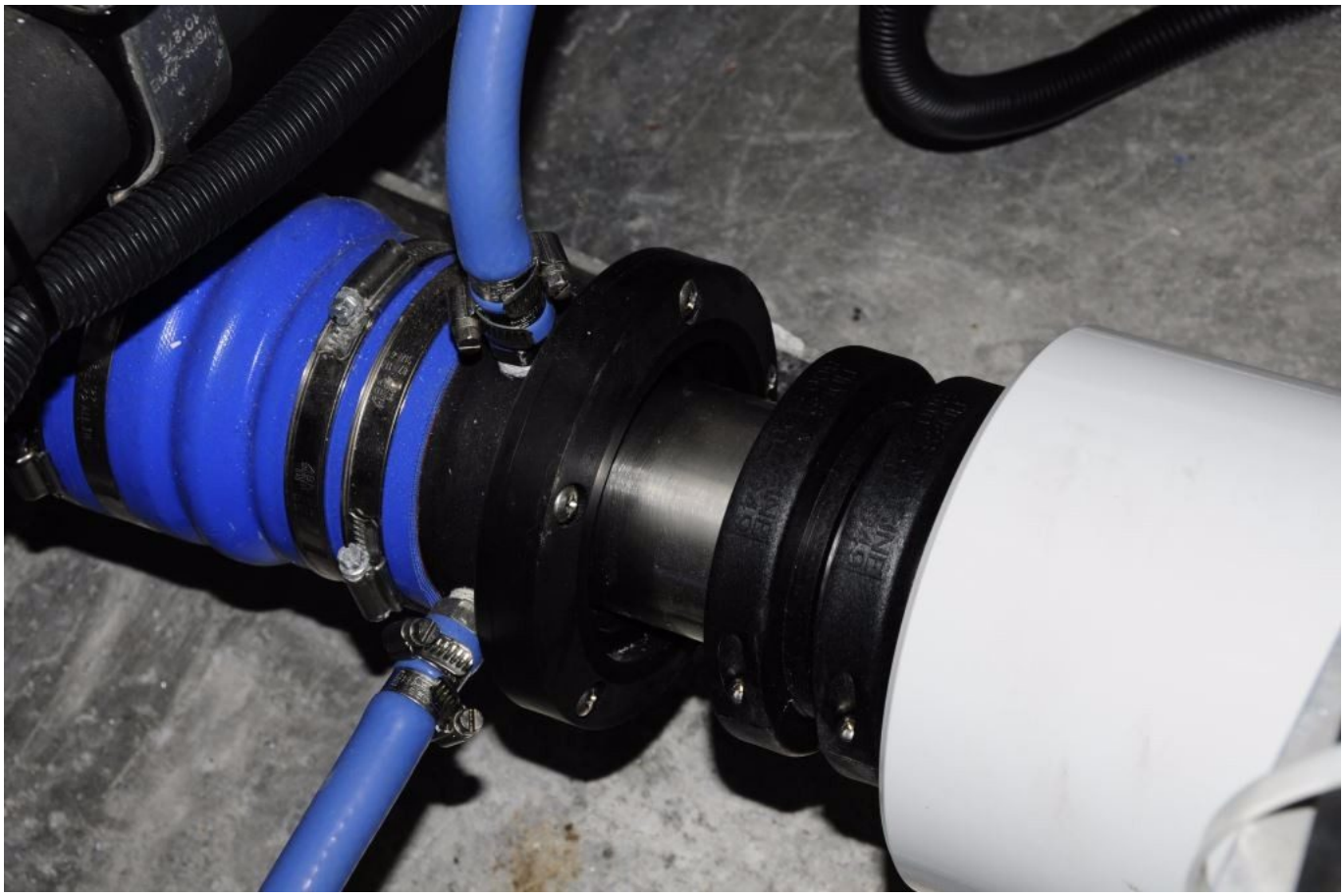
Ensuring that water film is always present is critically important to this seal's functionality, reliability and longevity. Even though the film between the seal surfaces is minute, water moving through the seal and bellows ensures it remains present and, in the process, absorbs and removes heat. Without it, these seals will quickly overheat and ultimately be ruined, which in turn leads to leakage.

ABYC Standards, in chapter P-6, Propeller Shafting Systems, make the following requirement for stuffing boxes, "Shaft seals shall be constructed so that, if a failure occurs, no more than two gallons of water per minute can enter the hull with the shaft continuing to operate at low speed", if the hose between the stuffing box and the shaft log fails, the flow rate will be a function of the gap between the shaft and

the shaft log, rather than any feature of the stuffing box itself. If, however, the seal itself fails, then the flow rate will be dictated by the gap between the stuffing box body and the shaft. It's a question worth asking the the manufacturer of the dripless stuffing box you are considering using.

Depending on the vessel's speed, water injection can be obtained from a pressurized source, i.e. the engine's raw water cooling circuit; from a forward-facing ram or scoop mounted to the hull; or it can simply be a passive "riser" that allows trapped air to escape, thereby ensuring the seal remains submersed. The latter is typically used only aboard slow-moving, displacement power and sailing, vessels. Above all else, the manufacturer's specific instructions for providing water, or releasing air, must be followed.

As an illustration of its longevity, when working as a young mechanic, as part of a repower project, I installed a face seal stuffing box on a yacht club launch. Years later I returned to visit my former workplace and decided to check on the engine as well as the seal. I reviewed the installation and it appeared very much the same as it did when I first installed it. Later on I inquired with the yard manager, "So how has that dripless shaft seal [they were new at the time] held up?" I asked. "What seal?" was his reply, which spoke volumes; the seal had been neither serviced nor adjusted since it was first installed (all stuffing boxes, dripless and conventional, should be inspected regularly); the engine's clock had just clicked over the 2000 hour mark. Such long-lived performance is not unusual for properly installed face seals; exceptional longevity is among their most noteworthy attributes.



Fort twin screw applications, dual water injection enables one engine to supply water to both seals when operating on one engine. The stuffing box shown here includes an optional second injection point, which is paralleled with the other shaft's stuffing box.

This sort of reliability can only be achieved, however, if the installation follows the manufacturer's instructions without deviation. A few of the more frequently violated installation guidelines (in addition to the aforementioned absent double set screws) involve incorrect compression of the bellows, resulting in too much or too little tension between the seal faces, and either leakage or overheating. If over compressed seals often overheat, and bellows over-ride their hose clamps, which can cause the former to chafe and leak. In my experience, if a face seal leaks, the first temptation of an installer, boat builder or vessel operator is to simply increase the tension, by further compressing the bellows, rather than attempting to deduce the actual cause of the leak,

which is unlikely to be tension-related if the seal was installed properly to begin with.

Failing to provide enough slack in the water injection hose, allowing the seal to “float” freely, or using a hose that is too stiff, can also lead to chronic leakage. While J2006 Marine Wet Exhaust hose works well for almost every other raw water application, it’s far too rigid for stuffing box water injection applications. Type B fuel, on the other hand, is both rugged and flexible and is well-suited to this role. For the ultimate in flexibility and longevity silicone hose can be used, however, it kinks easily, and thus it must be routed with care. Conventional PVC potable water hose should never be used for this application.

The hose used to supply water to the stuffing box must be flexible, however, PVC hose such as that used for potable water, shown here, should not be employed, as it lacks the necessary robustness for raw water use.

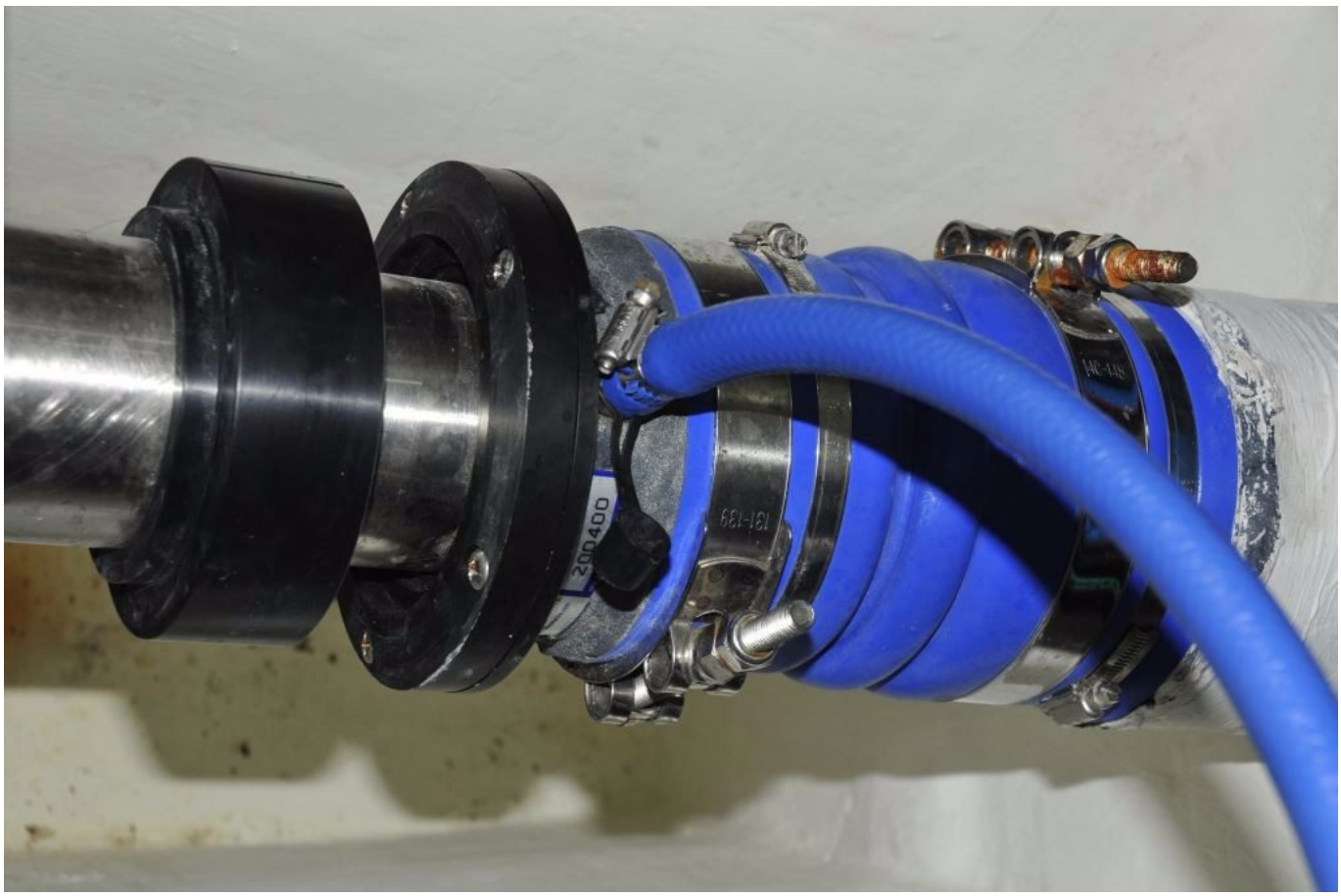
Another face seal installation issue worthy of mention is the relationship between the shaft and the shaft log, the tube through which the shaft passes. If the shaft is not parallel with and centered in the log, the seal faces will lack concentric and/or parallel alignment, and as a result they will have difficulty achieving a reliable watertight seal. I've encountered this scenario several times, and the stuffing box itself is often pointed to as the culprit, when in fact the problem lies with the original engine and shaft installation. Some small, two and three cylinder engines can also challenge both face and lip seals alike. Engines of this sort are known to vibrate considerably, especially at certain rpm 'sour' spots, and in doing so those oscillations are transmitted down the propeller shaft, which upsets the tension between the rotor and stator, or between lip and shaft, which in turn leads to leakage. This problem is exacerbated by engines that are in poor tune.

Because face seals rely on external spring tension to maintain their watertight seal, they are susceptible to upset, which will result in leakage. This can occur if gear, a wash bucket, fender or oar (all examples I've encountered), or misplaced foot, falls onto the bellows, dislodging the stator from the rotor, resulting in leakage. The effect is temporary, it lasts only as long as the object is resting on the stator. Loose gear around a propeller shaft is never desirable, regardless of the stuffing box type (I once saw the result of an encounter between a shore power cord and a shaft, the latter bent, the engine was pulled off its mounts, and the vessel flooded before it could be hauled). As a result of this upset susceptibility, my preference is for the installation of protection, in the form of a shelf or cover, over face seals.

Lip Seals

Yet another method of achieving a drip-free seal involves the use of a lip seal. Lip seals have been around for almost as

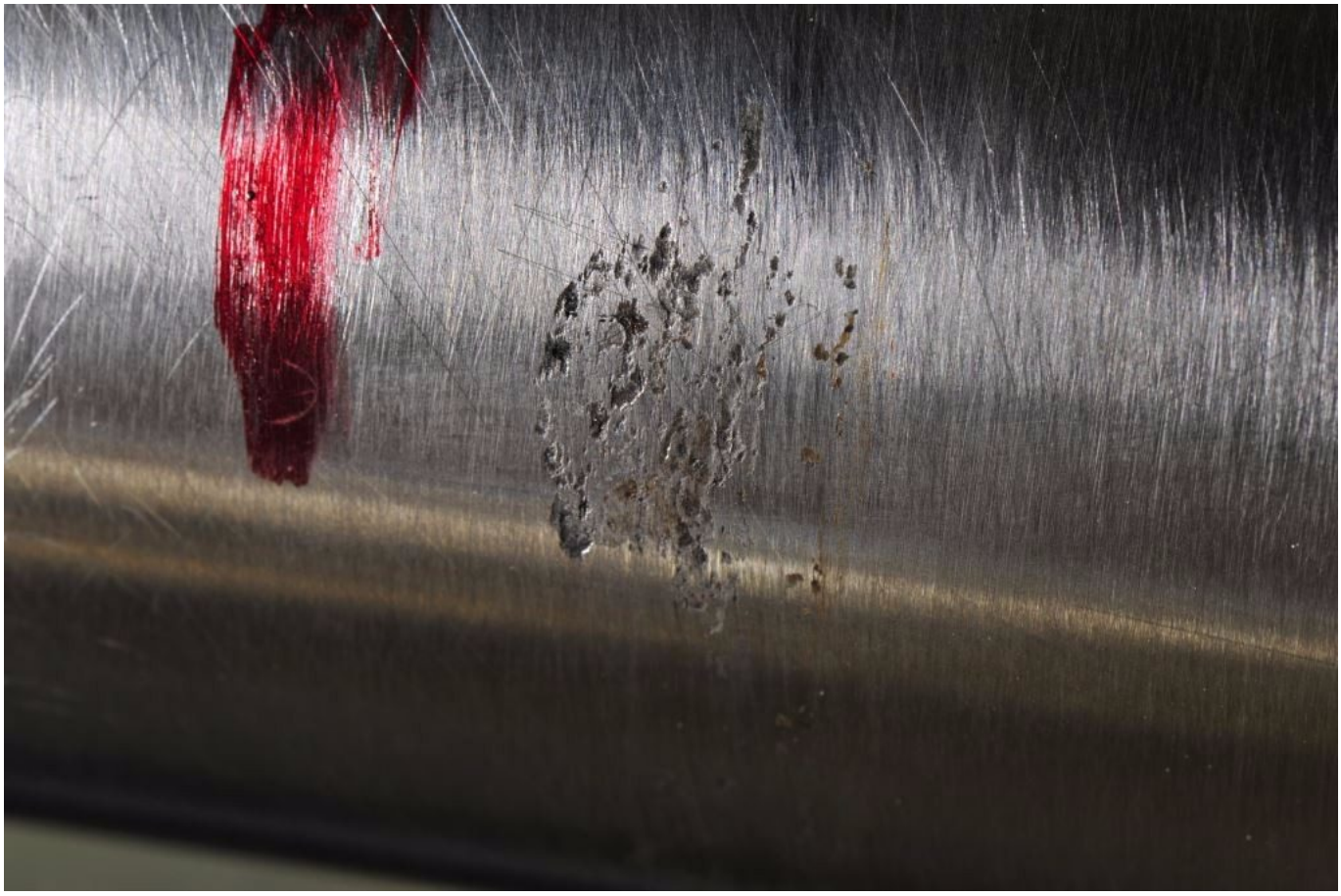
long as internal combustion engines; they are used to seal crank and transmissions shafts, keeping oil in and dust out, as well as in a variety of other industrial applications.



Lip seals like the one shown here are self-centering, they rely on the interface between the lip and the spinning shaft to make a watertight seal. The one shown here is equipped with a spare seal carrier, which retains and protects a set of replacement seals.

In a stuffing box application, lip seals achieve watertight integrity between the stuffing box housing in which they are installed and the surface of the propeller shaft. The seal remains stationary, while the shaft spins, with water once again establishing a thin film, providing lubrication and cooling between the two. For this reason, in order for such a seal to work, and much like the face seal, the shaft must be clean, smooth and free of *all* gouges, nicks, pitting or corrosion, at least in the comparatively small area where the

seal will make contact. A shaft whose surface is marred in almost any way is not a suitable candidate for a lip shaft seal, and unlike the face seal virtually any irregularities which cannot be polished away are too much. For after-market installations, shafts should be closely inspected for defects in the area where the seal will ride. If no substantial issues are found, the surface should be, once again, cleaned according to the manufacturer's instructions.



Prop shafts must be free of pitting or other irregularities where face seal O rings and especially lip seals reside, the latter are more sensitive to this issue. If the surface is not smooth, it will be difficult to achieve a watertight seal.

Lip seals frequently include an installation tool or hat; this is inserted between the shaft and seal during installation, which protects the seal from damage. These should be retained for future use – any time the shaft is removed they are needed

– they can be wire-tied near the stuffing box. Don’t forget to remove the hat before the vessel is launched, if you fail to do so the seal will leak until it is removed.

Lip seal stuffing boxes typically rely on an integral support mechanism that’s not unlike a shaft bearing. Made up of a synthetic material into which flutes or grooves have been cut to facilitate water flow, it centers and steadies the stuffing box on the shaft. As a result, this type of seal tends to be somewhat less sensitive to misalignment between the shaft and shaft log.

Like face seals, lip seal stuffing boxes are reliant on cooling water to provide lubrication and cooling. Unlike face seals, in most cases that water supply should be pressurized rather than passive, i.e. the seal must use an active water supply rather than a simple vent. For all seals, the water injection flow rate, some manufacturers specify a required minimum flow rate, should be verified at the time of installation and again periodically thereafter.

The water injection hose must be flexible enough to allow the a dripless stuffing box to float, if it's too rigid, or too short, it can side load the seal, causing it to leak.

Because of its small diameter, typically 3/8", it's not unusual for this supply to become clogged with silt or pieces from decaying zinc anodes located in heat exchangers (for this reason, some users prefer to tap water supplies prior to the heat exchanger). Being sensitive to, albeit to a lesser degree than face seals, side loading, lip seal injection hose must also be flexible, and it should of course meet the seal manufacturer's requirements. Like the face seal, lip seal stuffing boxes must be allowed to float freely, overly stiff hose or hose that leaves little or no slack will limit this necessary movement. When installed properly, with some variance for shaft rpm, lip seals can be expected to provide upwards of a thousand hours of leak-free service. Replacement

of the lip seal in this type of stuffing box requires that the shaft be separated from its coupling. While that doesn't necessarily require hauling the vessel, it's a task few do it yourselfers will undertake. For that reason it's desirable for spare seals, most installations include at least two, to be installed on the shaft, supported and protected by a proprietary carrier. These seals can be replaced while the vessel is afloat.

Tides Marine, the manufacturer of the Tides SureSeal, the most common lip seal stuffing box available at the time this was written, does not recommend the use of their product on engines with less than four cylinders. The reason for this caveat is the vibration inherent in one, two and three cylinder engines, which, at the right, or wrong, frequency can cause a momentary gap to develop between shaft and seal, which in turn will allow water to leak past the lip. I've seen Tide seals used on small auxiliary sail engines with no issues, however, if you choose that route, and you have a leak issue, you'll have no recourse with the manufacturer.

Keep the Heat Off

Regardless of which type of seal is used, temperature measurement remains the most accurate method of ensuring proper operation. Like conventional stuffing boxes, dripless seals should not operate at a temperature that is greater than approximately 40°F above that of the water in which the vessel is operating. While some seal manufacturers will technically approve of higher temperatures, in my experience such higher temperatures are often indicative of less than ideal water flow. While all stuffing boxes require exposure to water to remain lubricated and cool, dripless seals are exceptionally sensitive to interruption of water flow, and the heat this produces. This can occur if the water injection hose becomes clogged, as mentioned previously, if a vessel runs aground for instance, or if the stuffing box becomes air locked, which may occur when a vessel is launched; face seals should be bled or

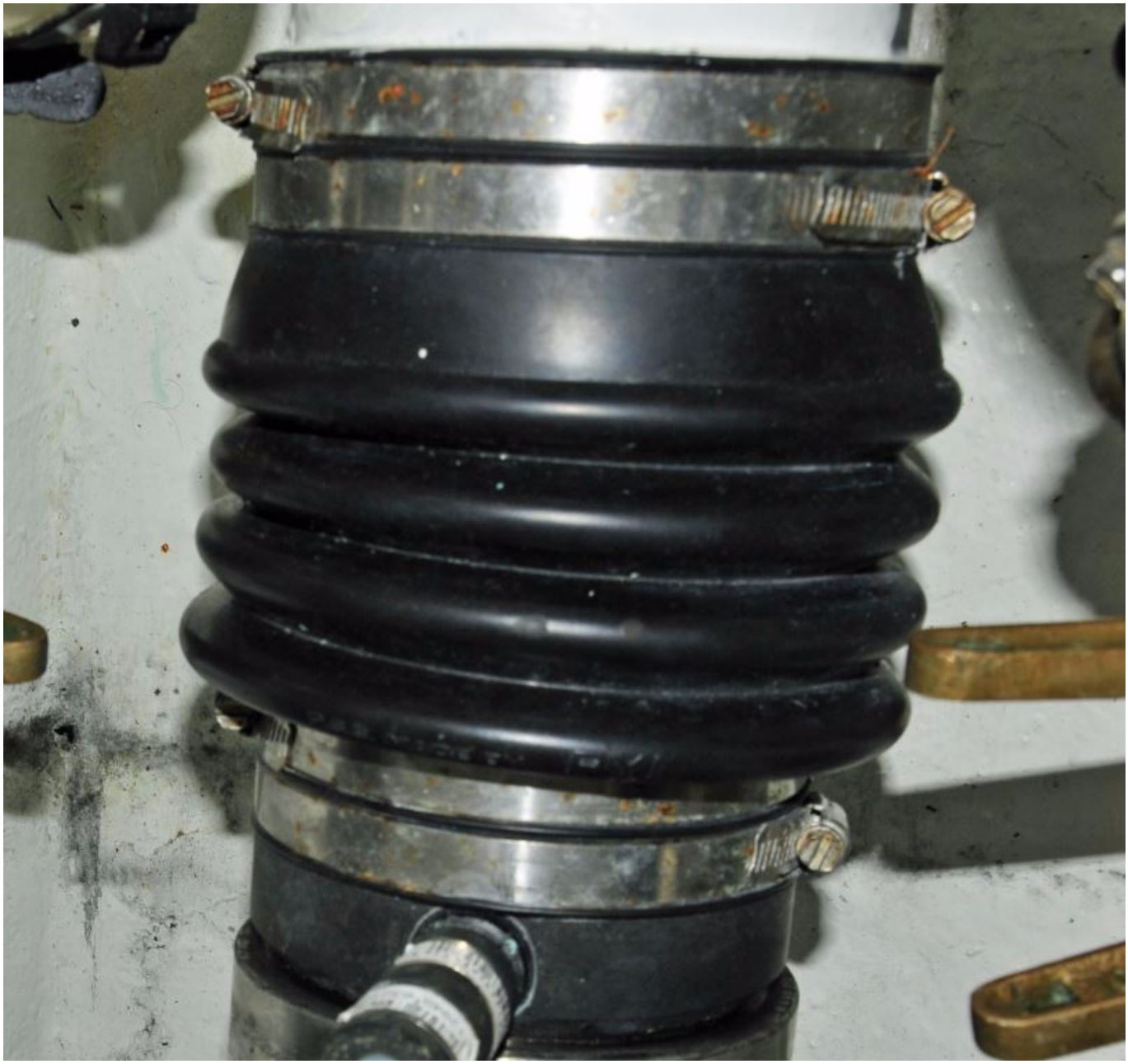
burped after each launching, and before the engine is placed in gear, to prevent this from occurring.

Temperature remains a valuable indicator of a seal's functionality, if it's significantly hotter than the water in which the vessel floats, it's almost certainly not receiving enough flow. If they get hot enough both lip and face seals will overheat, and fail, which will lead to leaking.

Variation on a Theme, Twin Screw

With one caveat, most twin screw installations, both lip and face seals should be equipped with parallel cooling water plumbing. This arrangement ensures that, when operating on one engine, a free-wheeling shaft's seal will remain lubricated and cool. The caveat involves the method by which water is drained from the engines' exhaust systems. If portions of the exhaust are higher than the engine's riser, then such a crossover method must include isolation valves to prevent flooding of the engine's cylinders. If you vessel is

equipped with such a crossover (or requires one), make sure you or a professional review the exhaust system design to determine if such flooding, when operation on one engine, is a possibility. Make certain as well you understand how these valves should be manipulated when operating on one engine (they should be labeled) and remember to open valves before once again operating normally, on two engines.



This bellows is over-compressed, so much so that it is over-riding its hose clamps, visible at the bottom of the image. Over-compression is problematic in and of itself, however, the bellows can also be damaged as it chafes against a clamp.

Related to this issue is the subject of towing. If a vessel is to be towed, in order to avoid stuffing box overheating, be absolutely certain to follow the protocol of the manufacturer. On at least two occasions I've encountered dripless stiffing boxes that overheated and rotated with the shaft during relatively brief tows. Shaft immobilization is typically not a practical alternative for most power vessels, the back-driving force created by the prop is substantial and often impossible to overcome on all but the smallest props.

In Summary

Dripless stuffing boxes; both lip and face seals, have made the advent of a dry bilge a reality. With less water in the bilge, corrosion and odors can be reduced, and with a normally dry bilge, any water that does make an appearance will, or should, immediately draw attention to itself.

I've installed, serviced and inspected hundreds of stuffing boxes of all types, conventional and dripless. All work well provided they are installed properly and maintained in accordance with manufacturer instructions. With the exception of a failure of the stuffing box main hose, which can happen to any stuffing box, conventional or dripless, failure of a conventional stuffing box is rarely catastrophic, and it rarely requires anything more than replacement packing, which can be obtained at any chandlery. On one at-sea repair opportunity, I used strips of cut-up T shirt lubricated with cooking lard.

Most dripless stuffing boxes rely on a ultra-flexible hose to allow the sealing portion of the assembly to align to and "float" on the shaft. If the shaft is not centered in the shaft log, or if the shaft vibrates excessively, leakage can result.

Because there's no free lunch, dripless stuffing boxes are at a greater risk of catastrophic failure, and when they do fail or simply leak, proprietary parts are almost always needed, which can pose a challenge for those cruising remotely. Those who fall into this category should carry vital spares; including the main hose, and spare seals, lip or face (conventional stuffing box users should of course carry packing material and replacement hose clamps). Spare rubber parts should be stored in an airtight bag away from heat and ozone, the latter is harmful to rubber and plastic and is generated by electric motors, and of course ozone generators. At least one dripless stuffing box manufacturers prohibits the use of ozone generators with their products, take heed to

this warning, I’ve witnessed the damaging effects of these devices on rubber and plastic components.

If you yearn for the proverbial dusty bilge, a dripless stuffing box is likely the only way you will achieve this goal. Make certain you, or whoever you entrust to install a dripless stuffing box, fully reads and understands the instructions, even if you, he or she has installed them in the past, as manufacturers update and change these guidelines. Finally, make certain you also understand service intervals, particularly bellows replacement, which may be required after a given number of years, regardless of use.