Water lifters

Is your exhaust system about to wreck your engine?

By Aussie Bray

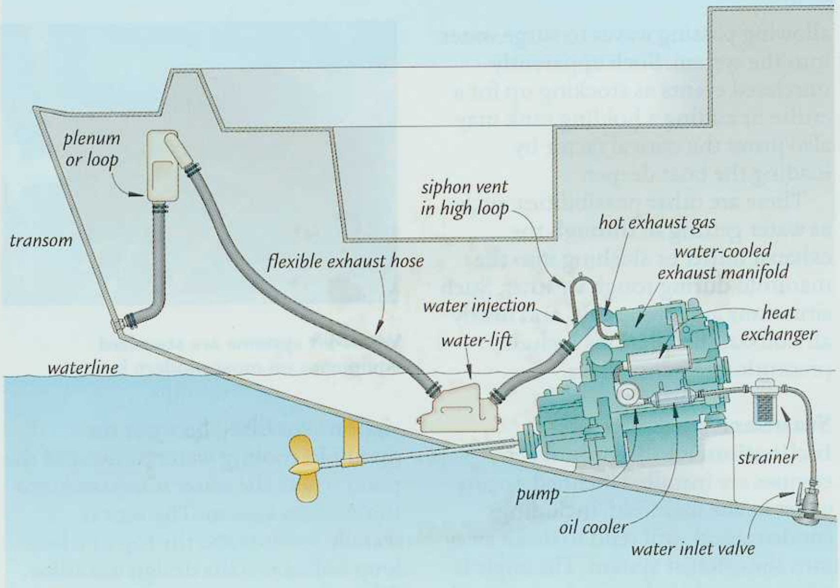


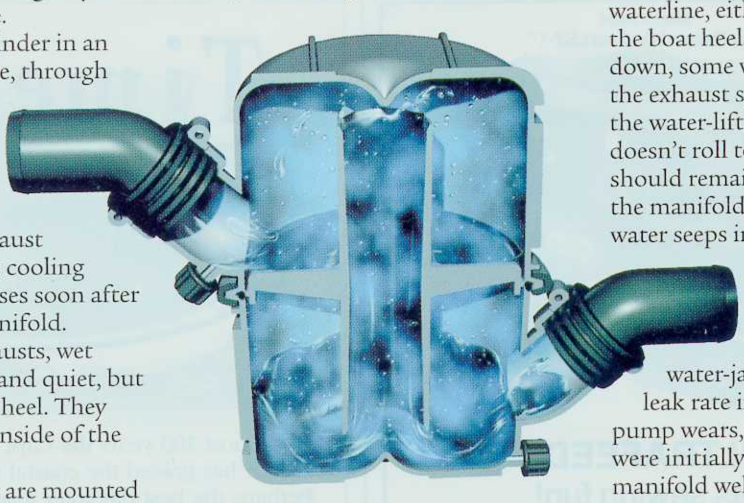
Fig 1: A typical wet-exhaust installation, with a siphon vent and plenum

Water-lift, or, as they are sometimes called, water-lock engine exhaust systems are standard equipment on most boats, and they usually work faultlessly. Note the word "usually." Wet-exhaust systems do develop some problems that can lead to serious engine damage if you don't catch them in time.

At the top of every cylinder in an engine is an exhaust valve, through which hot combustion gases are forced out into a common exhaust manifold that in turn opens into the exhaust system. Wet-exhaust systems mix the engine's cooling water into its exhaust gases soon after they exit the exhaust manifold. Compared with dry exhausts, wet systems are cheap, cool, and quiet, but they do have an Achilles heel. They potentially connect the inside of the engine to the sea.

Most sailboat engines are mounted near if not actually below the normal waterline and need a water-lift muffler to get the benefits of a wet exhaust. While the engine is running, the water-lift uses exhaust-gas pressure to force the injected cooling water up from its low point and out of the boat, well above the waterline. When the engine stops there is no exhaust pressure to expel water, and one of its exhaust valves is usually open. If additional water finds its way into the exhaust system, the internal water level inevitably rises until some seeps or sloshes into the cylinder.

Even tiny quantities of water inside an engine cause corrosion that makes it more difficult to start. A couple of teaspoons inside a cylinder can cause catastrophic problems on start-up. When a rapidly rising piston is prevented from reaching the top of its stroke by a slug of incompressible water, something has to break or bend. The net result is nearly always a terminally ill engine and the prospect of very expensive repairs.



Modern water-lifts are light, corrosion-free, and often incorporate baffles

Considering how engines are commonly installed and operated, it often takes only time and perhaps a bit of rough weather to expose an engine to this risk.

How does water get in?

In many cases the root problem is that the exhaust manifold is below the waterline, either permanently or when the boat heels. When an engine shuts down, some water always remains in the exhaust system and drains into the water-lift. Provided the boat doesn't roll too far, this quart or so should remain safely below the level of the manifold. Often, though, extra water seeps in via the saltwater cooling circuit, because of a failure of the siphon vent or through corrosion holes in water-jacketed manifolds. The leak rate increases as the cooling pump wears, and even systems that were initially installed with the manifold well above the waterline become more vulnerable with increased loading of the boat.

The final straw may be a long period of disuse, which allows the water to accumulate, or the effects of heeling, which forces the manifold farther below the waterline. Another possibility is that flexible impeller pumps may act as one-way valves,

Wet-exhaust systems can develop problems that can lead to serious engine damage if you don't catch them in time

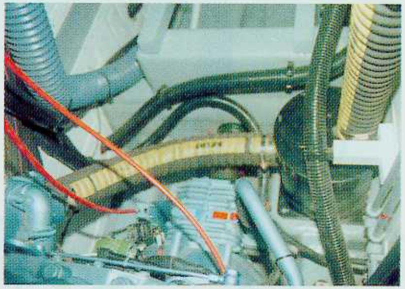
allowing passing waves to surge water into the system. Such apparently unrelated events as stocking up for a cruise or adding a holding tank may also prove the critical factor by loading the boat deeper.

There are other possibilities, such as water getting in through the exhaust outlet or sloshing into the manifold during rough weather. Such situations are foreseeable, and nearly all sailboat installations include precautions against them.

Standard precautions

Inclination. Ideally, propulsion engines are installed inclined, so any water in the manifold, including condensation, will tend to drain away into the exhaust system. The angle is often around 10 degrees, but you only have to observe a sailboat at sea to realize this defense is ineffective at least part of the time. Not only do waves make the boat pitch up and down; some designs actually sail bow-down even in calm water.

Siphon vents. Seawater cooling lines are usually provided with a siphon vent fitted between the manifold cooling-water outlet and the point where the water is injected into the exhaust system. The vent is usually mounted at the top of a hose loop well above the design waterline. When the engine stops the vent admits air into the loop, preventing water siphoning from the engine's raw-water cooling circuit into the exhaust system.



Water-lift systems are standard equipment on most modern boats

Aussie Bray

Many vents contain a valve that is held closed by water pressure when the engine is running and that connects to the air via a tube, the other end of which opens above the bilge (so that any leaking water doesn't spray around). This valve may stick, or the vent hose may be crushed or blocked. The siphon break is thus lost, and when the engine stops water may continue to seep through the pump and into the exhaust. Another kind of vent is permanently open; these avoid valving problems, allowing a small proportion of the cooling water to escape downward (without any low loops that might trap water) to discharge as a telltale. When the engine is running, flow from this (usually taken to a cockpit drain) visually confirms that the cooling system is getting water and that the siphon vent is not blocked.

Unfortunately, even when a siphon vent is open, water may still get past if it too gets below the outside water level. Mounting the vent high and on the centerline avoids this under ordinary circumstances, but increased loading reduces the initial reserve, and water may still seep past if the boat lies on its side—during a tidal stranding, for example.

Plenums. To prevent large seas from pushing water into the exhaust system outlet, a vertical plenum or gooseneck is often installed close to the outlet. The sudden increase in cross section and the right-angle bends prevent a slug of water from passing through the plenum, which drains between waves. A high loop in the exhaust hose is cheaper but less effective than a plenum. Either can admit water during a knockdown or rollover.

Reserve capacity. Many water-lifts have relatively limited reserve capacity before extra water starts to flood the system. This may prove critical if water does enter through the exhaust outlet, for example, or if the engine is cranked for long periods without starting. Small flexible-impeller pumps deliver up to 1 fluid ounce per revolution, so unsuccessful cranking may add several quarts per minute to the system. If carefully designed, an open siphon vent on the rising side of the loop can drain away water resulting from cranking before it reaches the water-lift.

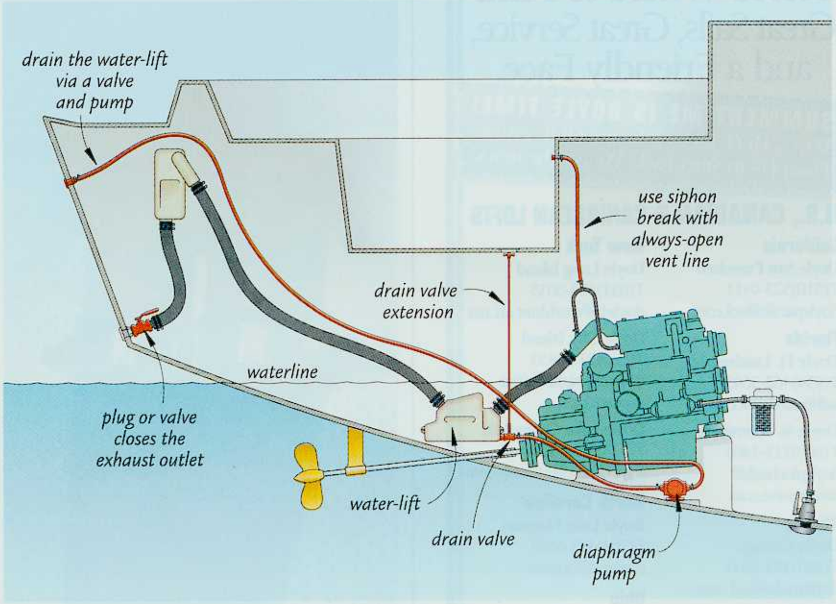
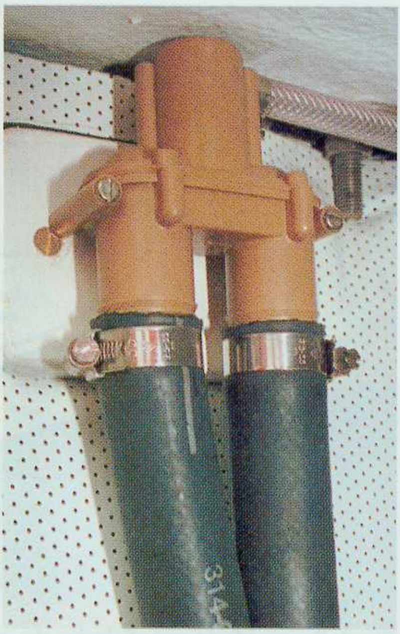


Fig. 2: By providing ways of closing the water inlet, sealing the exhaust outlet, and draining the system, many problems can be avoided

Sloshing. Some water-lifts incorporate flap valves, traps, or baffles to prevent water from sloshing back up towards the manifold when the boat pitches heavily, but many have no such precautions.

Risers. Most diesels are installed with a short downward bend attached



Siphon breaks should be mounted high up and near the centerline

to the aft end of the exhaust manifold, incorporating the water-injection connection. A minority are instead fitted with an upward bend leading to a vertical riser, topped with an inverted-U loop. This provides a steep barrier between the wet and dry parts of the exhaust system.

An above-the-waterline riser provides backup against failure of a siphon vent and normally prevents sloshing into the manifold, but unfortunately may introduce other problems. A riser may also be necessary to avoid excessive backpressure if the rise of a conventional water-lift installation would exceed 40 inches.

Risers tend to be heavy, and unless they are water cooled they can add significantly to heat and noise. If not isolated using a bellows, their weight and vibration may also damage the manifold casting. They can be water-jacketed, but this adds more weight and may eventually develop corrosion holes unless expensive alloys are used.

Perhaps most important, risers can trap water in the manifold, even if there is no manifold leak. With a conventional downward bend, any water from the water-lift that flows into the manifold during a heavy roll or knockdown should flow back as the boat rights itself, while the engine's exhaust ports are still above the manifold. With a riser some water may become trapped and then slosh into the engine when the boat rolls the other way.

What about reliability?

So despite the usual precautions, various factors can still lead to water entering the engine, and the risk increases when a combination of them come into play. Progressive loading down of the boat or failure to maintain the siphon vents may not result in any early-warning signs. But one day, maybe after a little rough weather or a prolonged absence, turning the starter key could precipitate a disaster.

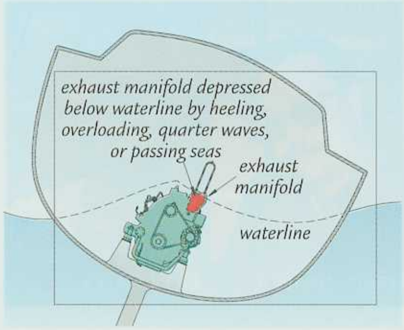
Even less cheering is the thought that even without any of these contributing factors, a well-maintained boat with all the above precautions built-in may still find its engine wrecked just when it might be sorely needed—following a severe knockdown and dismasting, for example. Even if no extra water finds its way into the system, there is usually enough present within a water-lift to cause havoc if the boat rolls far enough. If such possibilities concern you, you can consider more deliberate countermeasures.

Aussie Bray

Positive precautions

What more can you do to guard against exhaust-related disaster? A metal valve at the manifold outlet isn't the answer (apart from other considerations, it's unlikely to prove durable), but in addition to the changes to the exhaust system I've mentioned above, there are three things you can do that in combination will provide a relatively high level of protection when the engine is not running (**Fig. 2**).

- Close a valve in the engine's water-inlet line (and in any bleed line to the propeller tube if it joins the system close to or below the waterline).
- Provide a way to seal the exhaust outlet. If a bung on a lanyard isn't practical or aesthetically acceptable, then a large ball valve (not just a flap valve) somewhere near the outlet may be the solution. In rough weather, at least, this valve could be closed whenever the engine isn't running.
- Provide a way to drain the wet-exhaust system. Many water-lifts have a drain to get water out for winter storage, but it's often in an inconvenient location. This can be remedied by fitting a remotely operated drain valve, perhaps



Why a siphon break is essential: Sailboat engines are often below the waterline

interlocked with the starting circuit so that the engine cannot be accidentally started with the valve open. Another approach is a positive-displacement pump plumbed permanently to the outside of the boat.

It would be irksome to manually implement all three precautions every time the engine is stopped, but it is well worth making closing the inlet part of your routine. This is often done anyway, at least in port, by closing all seacocks when leaving a boat. Storing the starting key on the seacock handle is one way to remind yourself to open the valve again. Circuits that bleed off part of the cooling flow to flush the stern bearing or lubricate the shaft seal may need an extra valve, unless they can be supplied via, for example, a high loop (well above waterline) from the telltale hose.

Measures you take routinely are more reliable than those reserved for special occasions. But provided an accessible drain is fitted to the water-lift, all three of these suggestions could be implemented only when the need arises, as items on the "preparation for rough weather" list.

You could, of course, buy electric valve actuators, or manually operate the valves from a distance using push/pull cables or extension handles. Handles might also be electrically interlocked with the starting circuit so that the valves must all be in their correct positions before the engine can be started. Most people, however, won't be interested in creating such a complicated system.

Corrosion

Nothing lasts forever, and some things don't last nearly as long as we'd like. Corrosion is a hidden danger in wet-exhaust systems that needs to be considered as engines age. Most manifolds and injection bends last for decades, but electrolysis or a casting fault may lead to premature failure. Components that have been exposed to seawater for more than about five years should be removed, cleaned, and thoroughly inspected, regardless of engine hours. Internal engine zincs should be checked annually.

A final few words of caution, though. Don't tinker with an exhaust system unless you really know what you're doing—mistakes can be expensive, and an exhaust leak into the boat could kill people. Getting professional help will cost far less than getting a wrecked engine rebuilt.

Aussie Bray has circumnavigated on his self-built aluminum cutter, *Starship*.

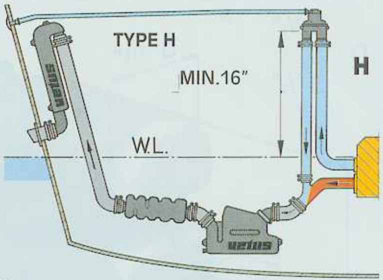
EXHAUST SYSTEMS WITH WATER INJECTION

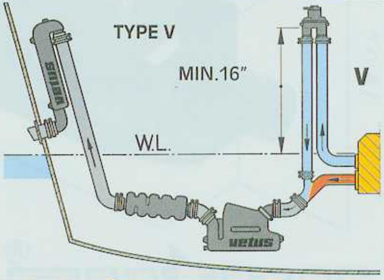
accessories for VETUS exhaust assemblies, for internal hose diameters of 1 3/16"-3 1/2"

VETUS AIR VENT

Air vent suitable for hoses of ø 1/2", 3/4", 1", and 1 1/4" I.D.
Material of housing: plastic

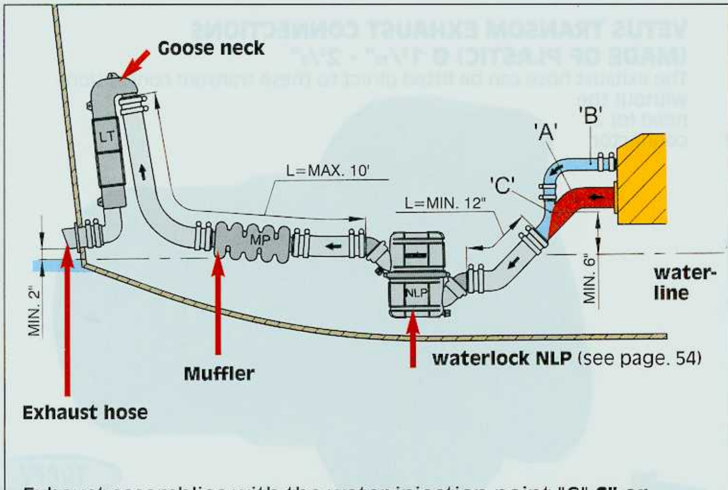
If the injection point of the cooling water line is situated at a height less than 6" above the waterline, then - when the engine is stopped - there is a risk that, as a result of siphoning, the cooling water may enter the engine. Such siphoning may be avoided by positioning a VETUS air vent into the cooling water tubing, appr. 16" above the waterline. There are two models to choose from: Model V has a pressure valve and is self contained. However it requires periodic maintenance to prevent clogging with salt crystals. Model H has a hose connection to the outside of the hull. There is a constant bleeed of cooling water through this hose whilst the engine is running. Model H comes complete with a skin fitting, hose clamps and 12 ft. of hose.



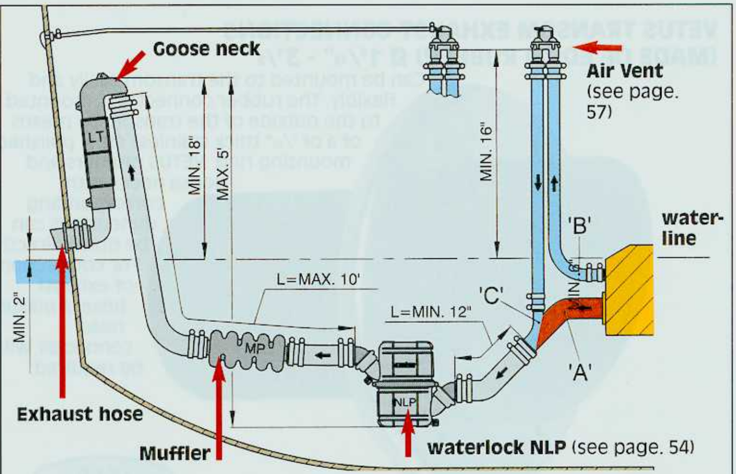


EXHAUST SYSTEMS WITH WATER INJECTION

from 1$^{13}/_{16}$" inside diameter up to 4" inclusive



Exhaust assemblies with the water injection point "C" **6" or more** above the waterline.

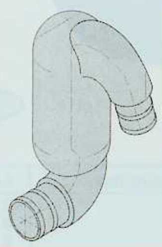


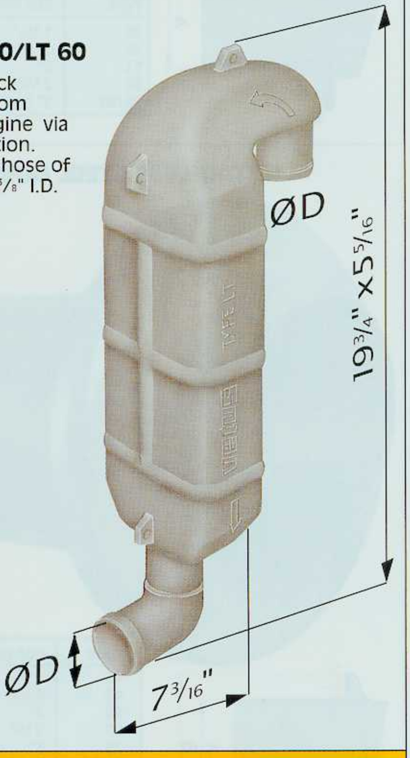
Exhaust assemblies with the water injection point "C" **less than 6"** above the waterline.

GOOSENECK
LT 40/LT 45/LT 50/LT 60

This plastic goose neck prevents seawater from entering into the engine via the transom connection. Available for exhaust hose of Ø 1 $^{9}/_{16}$", 1 $^{3}/_{4}$", 2" or 2 $^{3}/_{8}$" I.D.

For Goosenecks type LT, with connection diameters for Ø 2$^{9}/_{16}$", 3", 3$^{9}/_{16}$" or 4$^{5}/_{16}$", exhaust hose, please see page 60.





LP, but remain available for the time being.