Best Gas

A comprehensive guide to onboard installation, safety, and maintenance of liquified petroleum gas systems.

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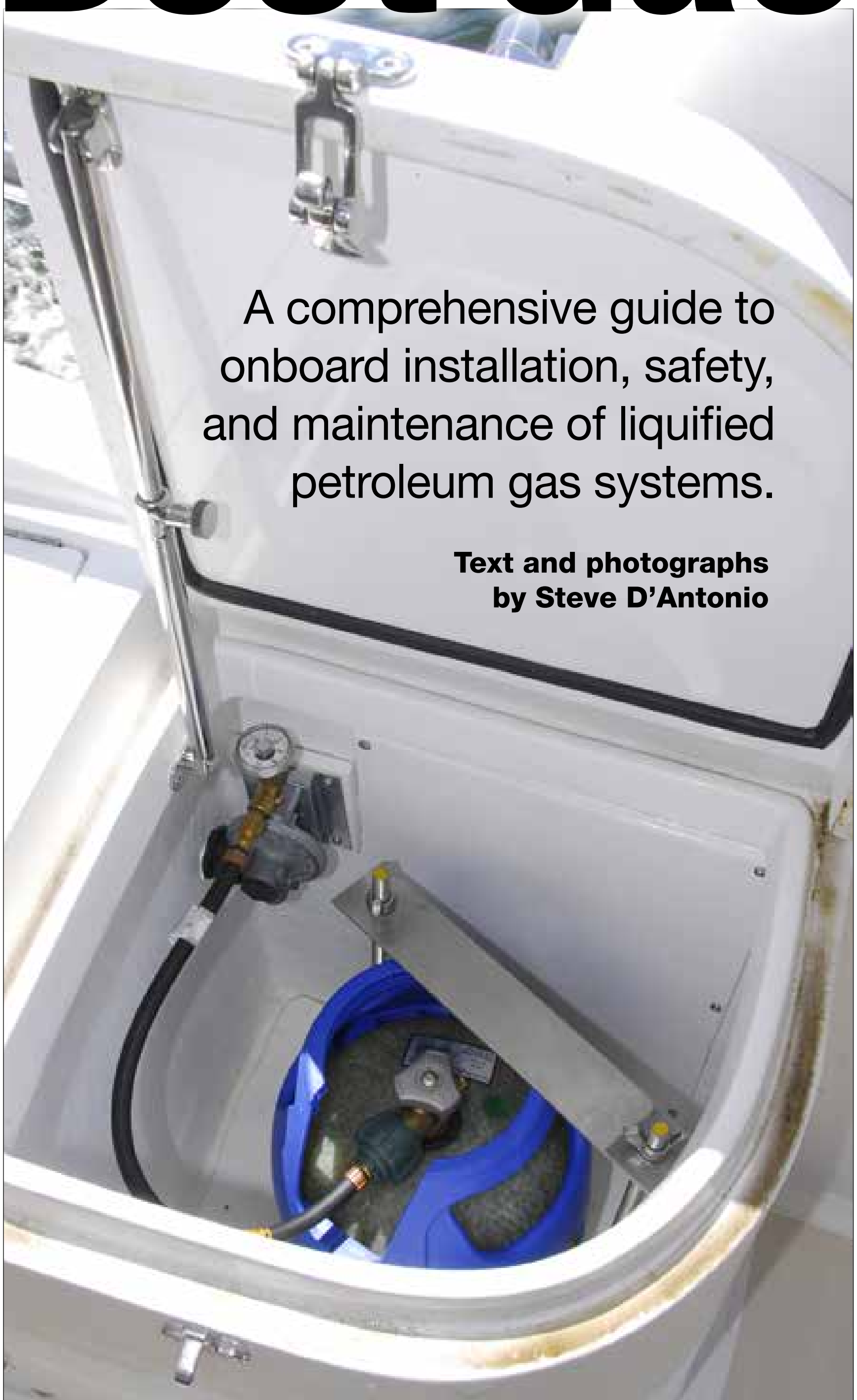

Liquid petroleum gas (LPG) installations, when carried out in accordance with ABYC and equipment manufacturer guidelines, can be safe and reliable. Here, a fiberglass tank is installed in a compliant locker with a horizontal gasketed and latched lid.

Despite suggestions to the contrary, the days of onboard liquefied petroleum gas (LPG) are not yet numbered. It's true that for many new build projects I work on, LPG stoves are being displaced by induction cooktops, many of which operate from the vessels' inverters. On the other hand, LPG is still an efficient, compact, and cost-effective means of both cooking and cabin heating, making it ideal for smaller vessels without gensets, and for infrequent users. Thus, I believe we will continue to design, sell, install, and service LPG systems on boats for many years to come.

At the same time, the volume of violations and safety issues I encounter indicates that installers and repairers often do not understand these systems, and that misunderstanding presents potential dangers. While rare, stories about shipboard LPG explosions causing serious injuries or fatalities are well known among professionals and boat owners.

At eight pages, the American Boat & Yacht Council (ABYC) chapter on LPG, A-1, is among the organization's shortest standards. Yet it isn't overly dramatic to suggest that your customers' lives may depend upon your knowledge of it. Motivated by that responsibility, and informed by the highlights that follow, you should carry out *at least* a cursory inspection of any LPG system on a vessel, regardless of your reasons for being aboard.

What Is LPG?

In 1912, LPG was discovered after Ford Model T owners reported that a full tank of gas would mysteriously shrink to seven-eights of a tank overnight. Dr. Walter Snelling, a chemist and explosives expert for the Bureau of Mines, found that one of gasoline's components was liquefied petroleum gas, and it had evaporated from the fuel tanks. After further research, propane was put to use for lighting and metal-cutting, and then for cooking after the Tappan Stove Company began producing gas ranges in 1927. The first Servel propane-powered refrigerators followed in 1928. (Though not widely practical for boats because they must always remain level, LPG refrigerators use no electricity or moving parts, and a small group of manufacturers supply them primarily to off-grid homes and remote locations.)

It's important to understand that LPG is not the same gas supplied to a home or business from a utility company through underground pipes and known variably as natural gas, street gas, or compressed natural gas (CNG). LPG for appliances and heating is stored in bottles or tanks, which are typically replenished by a delivery truck.

The primary differences between the two are their storage methods, their specific gravity, and their energy content. CNG does not liquefy easily, and thus it must be stored as a gas in cylinders under great pressure, approximately 2,500 psi (tanks resemble SCUBA bottles). CNG is lighter than air, which means leaked gas rises and usually won't accumulate in a bilge or a basement; however, it becomes flammable at roughly 5% concentration, so if it leaks into a confined, relatively airtight space, such as a boat or house, explosive limits can quickly be reached. While CNG gained a measure of popularity in the marine industry for a short time, CNG-equipped vessels are now rare. Storage bottles are heavy and cumbersome, and refilling stations are few.

LPG is a hydrocarbon derived from petroleum during the refining, or "cracking," of light crude oil. It possesses some unique characteristics that may require a little mind-bending to understand. As a two-phase liquid/vapor fuel, LPG "boils" at –44°F (–42°C), at normal atmospheric pressure. As the pressure is increased, as it is when an LPG tank is filled, the boiling point also increases. (It's similar to the inside of a pressure cooker, where increased pressure raises the boiling point of a liquid.) At approximately 100°F (37.8°C) and 180 psi, LPG becomes a liquid, which is why you can hear it sloshing around inside a partially full tank. When gas is drawn from the tank, the pressure of the vapor bubble trapped within the top of the tank momentarily drops, allowing a small amount of the liquid to boil off, which reequalizes the pressure of the vapor bubble, and the boiling ceases, until more gas is used (LPG tanks should never be completely filled with liquid). If the gas is used continuously, a state of equilibrium is reached where the vapor pressure within the tank remains constant as the liquid boils, typically between 100 psi and 250 psi, depending on the ambient temperature. For this reason, a pressure gauge *cannot* determine the quantity of fuel within an LPG tank; the pressure will remain more or less constant until the tank is all but empty. Fuel quantity should be determined by weight or through a liquid level gauge, which is an option well worth seeking out when purchasing tanks for customers (see, for example, my review of the LPG Gauge from Gaslox, which displays tank weight digitally, in "Editors' Picks: Top Gear" on ProBoat.com). Or, the fuel level can be observed through newer translucent-fiberglass tanks.

Many boat owners mistakenly think that the gauge used in LPG systems is designed to measure gas quantity, rather than pressure. The gauge is a mandatory component for leak detection, and owners should be made aware of this and taught how to read it.

Unlike CNG, LPG is about one-and-a-half times heavier than air. If it leaks from a tank or appliance, it will spill like liquid, with all but the smallest amounts settling in bilges or the bottoms of lockers and cabinets, particularly those whose bottoms are airtight and liquidtight.

Strictly speaking, LPG is nontoxic; however, in high enough concentrations it will displace enough air to make proper respiration impossible for humans and animals (particularly small animals with high metabolisms like the canaries once used in coal mines as methane "gas detectors"). Because LPG is odorless, the odorant ethanethiol was added to LPG refined in the U.S. beginning in the 1930s. That distinctive odor is now so well engrained in most adults that it has doubtless prevented the loss of thousands of lives.

One of LPG's greatest attributes for cooking and heating is its flame's intense heat, approximately 3,600°F (1,982°C). This, combined with the extremely rapid flame-propagation rate of 2,800′/853m per second (faster than most bullets travel), makes it extremely explosive and destructive. Also, its flammability threshold is a scant 2.4% to 9.6%, which means it doesn't take much LPG to sustain flame and/or an explosion. It ignites between 920°F and 1,120°F (493°C and 604°C)—any flame, spark, or glowing metal surface is easily this hot. The positive tradeoff is that it packs a lot of Btus into each gallon of liquid, approximately 91,500 Btus at 60°F (15.5° C) compared to CNG's 82,000 Btus, which is why even a small cylinder lasts so long.

Tanks and Valves

LPG tanks for marine applications come in a variety of shapes, sizes, materials, and configurations. Traditionally, the two most popular materials are steel and aluminum. Department of Transportation–approved fiberglass tanks have also been available for several years. These are virtually impervious to corrosion and rust, and are translucent, offering a built-in gas gauge of sorts, because the level of liquefied gas can be observed from the outside. In North America, steel tanks commonly used in marine applications are available in 4.25-, 11-, 14-, and 20-lb varieties (1.9, 5, 6.3, and 9-kg), while in aluminum the sizes are 6, 10, and 20 lb (2.7, 4.9, and 9 kg). Fiberglass tanks are currently available in 10-lb and 20-lb capacities for marine use. In all materials, more sizes exist for domestic and industrial applications.

LPG tanks carry a series of markings, the most important of which is the manufacture and recertification date at the bottom.

If you've looked at an LPG cylinder, you've probably wondered what all the letters and numbers stamped on the handle mean. For safety and installation, it's important to know at least some of these:

WCW, or **WC**, stands for water capacity weight. This is the weight of the tank if you filled it with water. Since LPG is about four-tenths the weight of water, determining the capacity of a cylinder requires only a little arithmetic (multiply by 0.42). One of the most common LPG cylinder sizes, 20 lbs, has a WCW designation of 48.

TW refers to the tare weight, nothing more than the weight of the empty tank. Anything more than the TW is LPG.

DT represents dip tube depth or length in inches. A dip tube is the tube that drops down into the tank from the underside of the valve. They come in lengths varying from 2.2″ to 7″ (56-178 mm), for tanks between 4.25 and 40 lbs (1.9–18.1 kg). Correct dip tube length is critical to avoid drawing liquid rather than vapor from a tank.

DOT, for Department of Transportation, means the cylinder met all specifications for LPG tank construction at the time it was manufactured. The DOT has jurisdiction over all portable LPG tanks—those that might be transported over the nation's highways—up to 100 lbs (45 kg) of propane capacity.

The **date code**, perhaps the most important figure of all, indicates when the cylinder was manufactured, for example, 8–99 or 12–06. DOT regulations require that the cylinder be "requalified," meaning that once 12 years have passed (10 years in Canada and five years for a composite tank),

*While more costly, aluminum tanks, on the **left,** are corrosion resistant and lighter than steel, while fiberglass tanks, **below,** are corrosionproof, lightweight, and translucent, enabling users to see the liquid within and thereby determine the quantity remaining.*

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the tank may be rehydrostatically tested and stamped with a new date, renewing its 12-year-inspection interval. For steel tanks, these tests are not common and typically not cost-effective. More likely is a visual inspection, which will provide a five-year-inspection period indicated by the letter *E* stamped after the previously expired manufacture date. (Any facility with a gas supply onsite must be certified to carry out inspections.) If the tank is severely rusted, corroded, or otherwise damaged, don't bother trying to recertify it; LP inspectors are typically conservative about this evaluation.

It's worth noting that steel, aluminum, and composite cylinders of the same capacity all possess different external dimensions, meaning they are not necessarily interchangeable.

A combination regulator, solenoid, and distribution manifold. Each tank is equipped with its own gauge for leak detection of lines beginning at the tank's valve-to-hose connection.

Beginning in October 1998, all new portable LPG cylinders with capacities between 4 lbs and 40 lbs (1.8 kg and 18 kg) had to be manufactured with overfill-prevention devices, or OPDs. These devices leave a vapor space of approximately 20% at the top of the tank to prevent gas or liquid from venting through the tank's pressure-release valve if the ambient temperature increases (for instance, the tank is filled on a cool morning and then left in the sun or placed in a hot storage locker). Liquid propane from an overfilled tank may also flow to appliances, causing excessive pressure and possible fire or explosion.

As of April 1, 2002, no U.S. LPG-filling facility should fill tanks in this capacity range unless the tanks are equipped with OPDs (with the exception of portable horizontal tanks manufactured before 1998, which are exempt). While this is probably old news to most yards and vessel owners,

Overfill-prevention valves, or OPDs, have an external right-hand acme thread, which accepts a hand-wheel hose fitting. Easy to install without tools, they are designed to melt and turn off the flow of gas in the event of a fire. If not properly tightened, they are prone to leakage.

several other safety measures occurred concurrently with the introduction of the OPD ordinance. These new valves also incorporate a positive seal mechanism that will prevent gas from free-flowing unless a hose is positively attached. This means that unlike the old-style valves, gas will not escape even if the tank is full and the valve is opened, *unless a hose is attached.* If the connection between the valve and the hose is not properly tightened, leaks can easily still occur, which is why proper gas lockers are so important. More on those below the next subhead.

The new valves also utilize an external, right-hand acme thread, as opposed to the old valve's internal, *left-hand* POL thread (turned counterclockwise to tighten), that is not only easier to use but also requires no tools. It works with new plastic couplings designed to melt and shut off the flow of gas in the event of a fire. Finally, OPD valves are equipped with an excess-flow feature that will prevent gas from flowing out of the cylinder if a supply hose or pipe suffers a catastrophic break. If, for example, a 40-lb (18-kg) anchor dropped on a copper tube, or a rubber hose melted during a fire, severing the LPG supply line, the new valve would detect the gas flowing at a much higher rate than normal and ideally stop the flow almost immediately. The excess-flow feature can be inadvertently triggered if the valve is opened rapidly.

Storage Requirements

The storage locker provisions are among the most difficult of ABYC's LPG standards to comply with. The guide leaves little room for variation or creativity, and rightfully so. When dealing with an invisible, explosive gas, the standards must be clear and exacting.

Far left—*A stand-alone locker with a horizontal lid holds two tanks and all related LPG gear and plumbing.* ***Left***—*Many integral lockers lack compliance because, among other things, the hatches are vertical; the one shown here leaves much to be desired.*

Although it seems self-evident, it's worth stating: The locker in which LPG tanks are stored must be vapor-tight from the hull interior. It can have no cracks, holes, seams, or gaps, no matter how small. It's easier to meet this standard with purpose-made, off-the-shelf lockers, which are often a single piece of fiberglass or roto-molded plastic, eliminating joints or seams. Conversely, lockers that are part of the vessel's structure, under a settee or within the coaming, for instance, are more apt to run afoul of this requirement, because they are often made from multiple components. A gastight seal must be made at every seam, as well as at all locations where tubes, hoses, and wires pass through the locker. This may be a purpose-made compression-type gland fitting, or a careful but liberal application of flexible sealant or caulk; I prefer the former as caulk can dry out or be easily dislodged.

Each locker must be vented at its lowest point with a minimum half-inch-inside-diameter (13mm) plumbing that travels continuously downward from the locker base and overboard without dips, rises, or loops, so that if any water were to enter this vent, it would not be trapped. The overboard outlet for the vent must be above the static waterline and at least 20″ (51cm) from *any* other breaches or openings to the hull interior. It should not vent inboard, even onto weather decks such as a cockpit or flybridge. The lid for the locker must open from the top—all vertical-door installations fail—be fully gasketed, latching, and should require no tools to access. Although it's not an outright requirement, the lid *should* open directly to the atmosphere. If the LPG locker is within a part of the boat's structure, in a sail locker or under a settee, for instance, its opening must be as close to the boat's locker opening as possible, and it must still be horizontal.

Many are surprised that the ABYC guidelines also cover tanks that are *not* in use. Tanks not plumbed to the vessel's LPG system must be stored in the same manner as active tanks. Thus, the LPG storage locker must be large enough to accommodate spares, empty tanks (which often retain some LPG), and small, portable camping cylinders. If multiple tanks are connected to the LPG system simultaneously, a shutoff valve or automatic check valve must be located between the tanks or at the cylinder manifold to prevent pressure feedback from other cylinders or potential leaks from a disconnected hose; purpose-made valves for multi-tank connections are readily available.

For existing designs, locker compliance can be challenging, because little can be done to rectify a vertical and, in this case, vented hatch.

Pay special attention to the hoses for LPG barbecues, where disconnected gas should *not* be able to flow from their connecting hoses. This is often achieved with a built-in needle valve that will allow gas flow only when the hose is connected to the appliance. Unfortunately, most portable barbecues do not incorporate this feature. All too often I'll open a valve (many are unlabeled) located in the LPG locker, and a whoosh of gas escapes from a disconnected hose. At the very least, the valve supplying this hose should be a fail-safe design—opened only by releasing a thumb lock—and not able to be inadvertently pushed open. A hose of this sort, and all fittings, must reside within the locker.

The LPG locker should not store any non-LPG-related gear. Additionally, disconnected tanks may be stored on deck, outside a dedicated locker, provided they are at least 20″ from any opening to the vessel's interior and if they and their associated plumbing, regulators, and valves are protected from the elements.

Plumbing

The gas regulator is an ingenious device, capable of delivering a constant supply of gas while stepping it down from more than 100 psi to barely 0.5 psi regardless of ambient temperature or barometric pressure. (In fact, when Jacques Cousteau perfected the first SCUBA apparatus, it utilized a natural gas regulator.) In marine applications, LPG regulators are typically aluminum, although many incorporate some ferrous alloy components. They must be protected from rain and seawater. If housed within a dedicated LPG locker, they can last for decades, provided the locker does not leak water and thus accumulate high humidity, which takes a toll on metallic tanks as well. Seasonally spraying the regulator and other metallic components in the locker with a light corrosion inhibitor will help protect them.

LPG systems must be equipped with a master shutoff valve that can be easily reached *from the vicinity of the*

A triangular knob identifies an overfill-prevention-device valve. As the name implies, these valves are designed to prevent tanks from being overfilled and then venting. LPG service facilities should not *refill a tank that does not have this valve.*

Left—*Unions or joints in LPG lines outside an LPG locker, including valves like the one shown here beneath a stove, are prohibited. While they may seem like a good idea, they push this installation into noncompliance.* ***Right***—*Not just any hose will do. For LPG, only hose specifically designed and marked for the application should be installed.*

appliance(s): however, no valves or plumbing unions are permitted outside the LPG locker (more on this in a moment). This is achieved with a remote DC LPG solenoid valve near appliance(s)—though not over or behind an appliance, forcing a user to reach over a stove or barbecue that's engulfed in flames, for instance. The switch activates the solenoid valve inside the LPG locker, controlling the gas supply at the source. The switch or control must also be equipped with a warning light to let the user know when the solenoid is active and gas may be flowing. Because these solenoids sometimes fail, you should recommend that owners keep a spare aboard. Without it, those aboard may be eating cold food until a new unit can be installed. Under normal operation, gas solenoid valves will become hot to the touch.

Transferring the gas from the LPG tanks to the appliances in a safe, reliable manner is of paramount importance. The plumbing itself may be annealed copper tubing conforming to standard K or L, ASTM B88-75a for seamless-copper water tube with a wall thickness of not less than 0.032″ (0.813mm). Hose must be specifically suited for LPG use, such as UL 21–compliant LP Gas Hose. (Note that hose approved for LPG is always labeled; ordinary gasoline or diesel fuel hose is not compliant.) The inside diameter (ID) of the hose is determined by the appliance it serves, the gas flow requirements, and the length of the run. Very large stoves or heaters, for instance, often require larger plumbing. While LPG plumbing may be as small as 0.25″ ID for small appliances, 0.375″ ID is the most popular, because of its robustness and the commonality of associated plumbing fittings.

End fittings for LPG plumbing must be durable, leakproof, and easily assembled, disassembled, and serviced. Copper tube should utilize "long nut" flare fittings, which are less prone to fracture. Threaded NPT or tapered pipe fittings must use a thread sealant specifically designed for LPG applications. LPG plumbing that utilizes hose may use swage terminals or field-assembled sleeve and threaded-insert flare terminals.

Combination pipe-to-hose adapters and hose clamps, while suitable elsewhere aboard, may not be used for LPG plumbing. Among the most often violated LPG protocol for plumbing is the installation of Ts, unions, valves, or other connections *outside* the LPG locker. This must *never* be done; no connections are permitted outside the LPG locker. The only exception to this rule is the transition between copper pipe and flexible hose for the gimbaled stoves typically used aboard sailing vessels.

Hose and copper tube must be well secured and protected. Straps or P clips should support plumbing runs at regular intervals, and hose should be protected from chafe where it passes through bulkheads or other structures. Avoid running hoses or copper tubes over stringers and frames, or through locker bottoms where they will be repeatedly stepped on or have gear placed or dropped on them.

Once LPG plumbing is installed, check for leaks. Gas professionals often pressurize new or repaired LPG plumbing with compressed air at approximately 5 psi, which is roughly 10 times the working pressure of the system. After it's pressurized, spray the system with a mixture of water and liquid dishwashing detergent (though

1—*The seal made around hoses or wires that pass through an LPG locker wall must remain gastight under all conditions. Clay or plumber's putty simply isn't up to that task.* ***2***—*Unions, T's, and other joints must not exist outside the LPG locker. Additionally, only long nut flare fittings should be used.* ***3***—*Regardless of their purpose, such as this one for a gutter drain hose, all LPG locker penetrations must be made permanently gastight.* ***4***—*Durable and not easily dislodged, a compression-style fitting is the most reliable means of passing hoses and wires through LPG locker bulkheads.*

not detergents containing ammonia, as it may damage brass fittings). Any bubbles indicate a potential gas leak. You should also permanently install a pressure gauge within the LP locker between the tank and before the regulator. Then, with all connections completed, the appliances turned off, and the solenoid valve opened or on, open the tank valve completely until the pressure gauge stops rising—between 100 psi and 200 psi. Then, close the valve. The gauge pressure should remain constant for at least three minutes but preferably 15 minutes or more. If the system will not hold pressure, check for leaks again with the soapy water solution.

The sole purpose of a pressure gauge is for leak detection; it's of little value if this protocol is not carried out regularly. Make certain your customers understand how to do this. I also check for leaks using this gauge-drop method every time a tank is replaced, as many leaks can be traced to an improperly tightened hose-to-tank connection.

Safety

The first line of defense is the owner or crew. As the professional, you should instruct them on how to react if they smell gas. Tell them to make sure the LPG is shut off using the tank's own manual valve, and to open all hatches, ports, and bilge access panels. Avoid using any electrical gear, and don't turn anything on or off (there have been reports of LPG explosions when equipment was switched *off* as well as on), except the main-battery-disconnect switches, which are nearly always ignition-protected and thus will not ignite flammable vapors. Owners and operators should be aware that it's difficult to remove large concentrations of LPG from a vessel's deep bilges unless the boat has an ignition-protected bilge-evacuation blower. While these are mandated aboard gasoline-powered vessels to safely remove fumes, ABYC standards do not require them aboard vessels equipped only with LPG. If engine-room blowers are ignition-protected and able to draw air *out* of the engine compartment, as they should, they may also be used to create a vacuum and to enable ventilation within those bilges.

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For galley stoves and barbecues with flat lids or with countertops that close over them, an off switch must be built into the system in case a user closes the lid and forgets to turn off the gas/flame, which would almost certainly cause a fire. Additionally, if a barbecue is installed over a locker, the two should be separated by a vapor barrier to prevent leaking gas from reaching the barbecue flame. Even if the vapor barrier is installed, having a fume detector beneath the barbecue makes good sense.

LPG barbecues present some special challenges. Among other things, if, as shown here, there is a flat lid (not designed to be closed with the flame on) rather than a hood, a switch should be installed that shuts off the gas when the lid is closed; and the burners must be equipped with a flame-failure device.

LPG is a dangerous carbon monoxide (CO) producer, able to generate excessive amounts under the right circumstances. Intensifying the danger is the fact that burning LPG increases the quantity of CO within a vessel's cabin. When the flame diminishes, it produces still more CO, further compromising the appliance's flame and creating a runaway effect.

At one time, I preferred CO detectors that rely on the vessel's own power rather than internal batteries. Today, however, CO detector batteries last longer. Internal battery units are also readily available, tend to be less expensive than hardwired units, and are clearly easier to install and replace. Expiration dates, typically five or 10 years, should be labeled on the outside of the unit. Some units are able to communicate with each other, which means if one detects CO, all units sound an alarm. If hardwired, the CO detector's circuit breaker must be one that cannot be easily turned off (such as the pop-out variety), or it should utilize a purpose-made lock or cover.

If fuses are used, be certain they are easily accessible, clearly labeled, and spares are available.

One final note on CO. I've heard many boat owners say, "I don't have LPG aboard, and if diesels produce virtually no CO, why do I need a CO detector on my diesel boat?" The answer is that one night they may be docked or rafted up to another boat whose gasoline-powered engine or generator is running. All it takes is a light breeze to blow the exhaust from the running engine into your neighboring cabin through open ports. For this reason, every boat with an enclosed cabin needs CO detectors in every accommodation space.

It's common for builders to install domestic appliances aboard larger power and sailing vessels, causing two potential issues for gas kitchen stoves. One, many gas kitchen stoves come from the manufacturer set up for CNG; their burners must be replaced for use with LPG. Two, the vast majority of domestic stoves I encounter aboard yachts lack a flame-failure device, a critical feature required for ABYC compliance. This device, included in most marine stoves, requires pressing a push button or knob and holding it for a few seconds after the flame lights. Doing so disables the flame-failure device until the burner heats up, allowing gas to flow. If the flame is extinguished, the device stops the flow.

Instead of this device, many domestic stoves utilize an automatic 120V igniter, which will ignite flowing gas whenever a flame is not present. While this may work well in a home environment, 120V is not always available aboard a boat. I can often defeat the igniter by simply turning off the 120V stove circuit breaker, which is separate from the DC solenoid-control circuit breaker. This arrangement also often relies on an inverter to supply 120V to the igniter when the vessel is at anchor and a generator is not running, adding yet another layer of complexity. Unfortunately, a flame-failure device cannot be retrofitted. The only practical solution short of changing the stove to a compliant domestic model is to install an LPG detector beneath the stove that automatically turns off the gas solenoid if gas is detected. Still, this is a half-measure; one which lacks ABYC compliance

The next line of defense is an electronic gas detector that detects LPG where its sensor is installed. Some annunciator units can work with multiple sensors, and they may also be interconnected with the gas solenoid, shutting it off if a leak is detected. Sensors should be installed below appliances, especially stoves, as well as in LPG lockers. The sensors are often delicate, so carefully select a suitable

Right—*Remote solenoid-valve controls should be located adjacent to, but not above, LPG equipment, stoves, heaters, and barbecues. If a fire occurs at the appliance, the user should not have to move closer to it to shut off the gas supply.* ***Far right—****LPG-leak sensors should be located beneath appliances and inside LPG lockers. Most sensors are delicate, making a toe kick installation like this a poor choice. Sensors should also be readily accessible for service without disassembling or removing appliances.*

location; toe kicks, for instance, are unsuitable. Monthly tests are easy with the gas from a butane lighter. Simply hold the lighter adjacent to the sensor and press the trigger without lighting the flame. Make certain sensors can be easily accessed for testing and replacement, ideally without the need for tools or disassembly of appliances or joinerwork.

While inherent and unavoidable risks are associated with LPG, as a professional it is up to you to ensure that your customers' onboard systems are installed and maintained to offer the greatest possible safety. Also, make sure owners fully understand how these systems work, and how to carry out regular leak tests.

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About the Author: *For many years a full-service yard manager, Steve now works with boat builders and owners and others in the industry as Steve D'Antonio Marine Consulting. He is an ABYC-certified Master Technician, and sits on that organization's Engine and Transmission and Hull and Piping Project Technical Committees. He's also the technical editor of* Professional BoatBuilder.