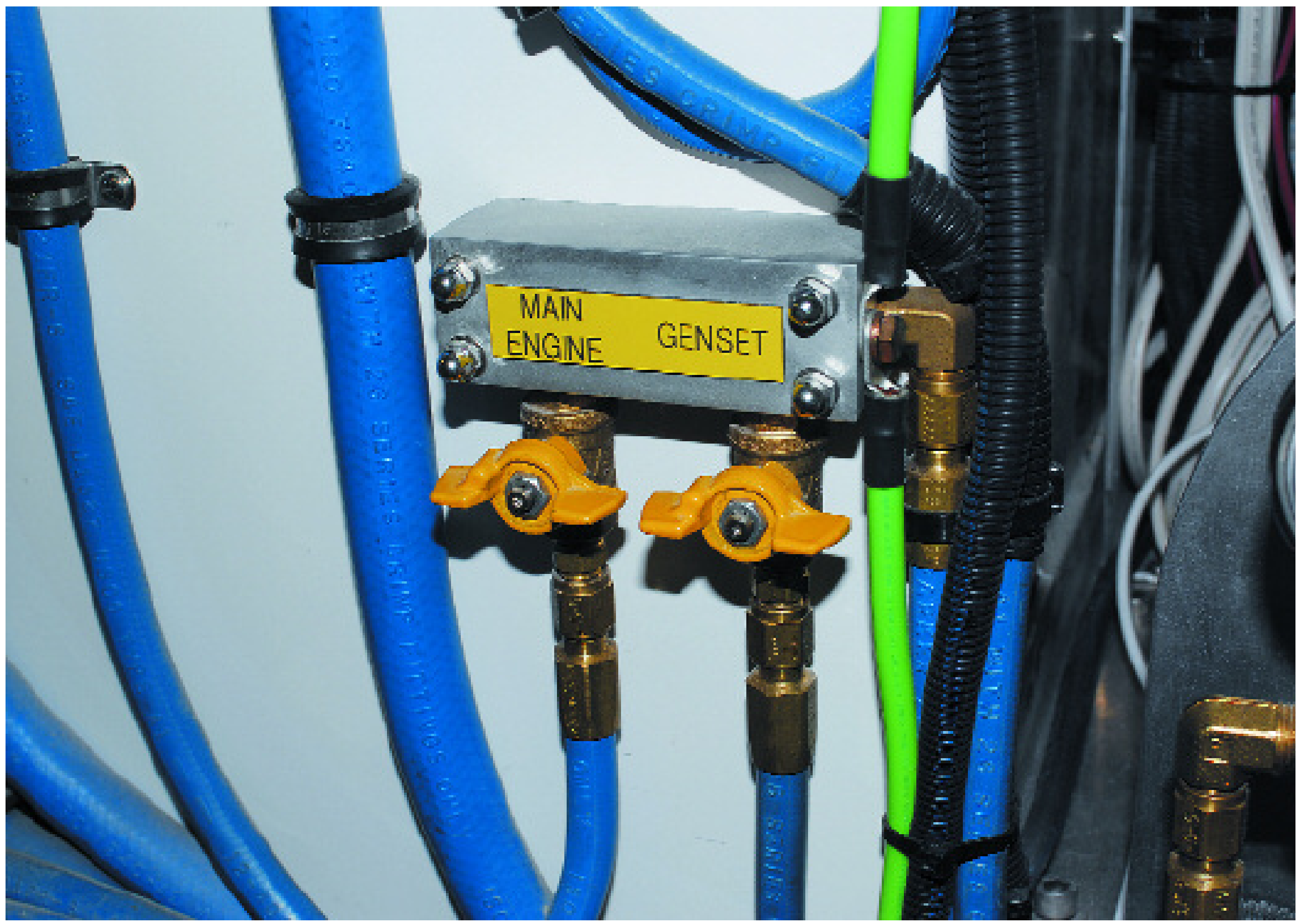
Story And Photography By STEVE C. D'ANTONIO

FUEL SYSTEM PLUMBING



In previous fuel system articles, I've discussed diesel fuel itself, filtration, and polishing system selection and installation, along with fuel tank design and construction. In this article, I'll delve into the subject of plumbing: the various hoses, tubes, and pipes that enable fuel to be safely and reliably supplied to and returned from fuel tanks, engines, generators, and other systems on your boat.

You may have an outstanding filtration and polishing system aboard, but no matter how clean your fuel, if you can't reliably move it from the tank to the systems that need it, it's of little use to you and your vessel. The plumbing arrangement that accomplishes this fuel transport must be well designed and securely installed. Plumbing that is well designed allows fuel to move from and return back to the tank without undue resistance or leaks. Such plumbing also has clear, easily understood labels on the valves that enable the user to select tanks for fuel draw or to isolate individual components (such as filters or tanks) for service. Fuel plumbing that is securely installed is robust enough to endure thousands of hours of vibration and movement with absolute reliability and without leaking fuel or air.

FLEXIBLE FUEL HOSE

Flexible "rubber" hose remains the most common medium for transporting fuel aboard the majority of small vessels, both recreational and commercial, and with good reason. Flexible fuel hose is inexpensive compared with rigid pipe, and it's easy to install. It can be routed around tanks, through bulkheads, and to and from manifolds, engines, and generators with relative ease.

Opposite page: In order to comply with ABYC guidelines, all metallic fuel system components, such as this stainless steel distribution priming manifold, must be connected to the vessel's bonding system. Above left and right: Securing fuel lines by using plastic wire ties is acceptable; however, it should be the exception rather than the rule, and plastic wire ties should never be used in locations where fuel lines pass over machinery with moving parts, such as engines and generators.

Although many types of hose can be used for fuel supply, return, fill, and vent lines, only a small number are appropriately suited and approved by the American Boat & Yacht Council for use aboard seagoing vessels. Only hose that is designated as USCG Type A, which complies with requirements set forth by SAE standard J1527 ("Marine Fuel Hoses"), should be used.

Hoses that meet this designation carry markings that include the manufacturer's name or trademark and the year in which the hose was manufactured. This labeling must be legible, permanent, and printed in block capital letters that stand a minimum of 1/8 inch tall. In addition, the labeling must be applied or embossed every 12 inches or more frequently.

Two varieties of Type A fuel hose are typically available, A1 and A2, the primary difference being their permeation resistance. (A1 is more permeation resistant than A2.) Practically speaking, larger hoses—those with an inside diameter of 1-1/2 inches or greater, such as those used for fill lines—often are designated as Type A2. Smaller-diameter hoses are usually A1. Most Type A2 hoses, including those used for fill applications, are wire reinforced to prevent kinking. A1 and A2 hoses carry the necessary 2.5-minute fire-resistance rating.

Many fuel hoses carry the coveted Type A designation, but there are differences in quality, durability, and price among manufacturers and their various model lines. The average "black" Type A fuel lines are multilayer and are reinforced with synthetic fabric. The jackets are designed to resist heat, petroleum products, fire, and ozone. Provided it is properly installed, this type of hose can be expected to last a minimum of 10 years under normal use.

Higher quality, "designer" hoses are manufactured by several companies; the de facto leaders in this field are Aeroquip (aeroquip.com) and Parker (Racor's parent company; www.parkerhose.com). The Parker Corporation, founded in 1918 by Arthur Parker,

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Top: Although bundling or colocating fuel lines with electrical cables, such as those shown here, is not prohibited by ABYC standards, it should be avoided where possible. An electrical short or fire could be exacerbated by burned or melted fuel lines. Above: Insulated metal P clips provide a secure, rugged means of routing fuel lines through machinery spaces. These clips will not degrade when exposed to heat, vibration, ozone, or leaking fuel.

developed a reputation for producing ultrareliable hydraulic hoses and fittings that were good enough for Charles Lindbergh's Spirit of St. Louis transatlantic flight. Parker also manufactures, among thousands of other products, Racor fuel filters. Aeroquip's founder, German emigrant and aeronautical engineer Peter Hurst, patented the first detachable, reusable hydraulic hose end fittings. The industrial/military-quality products offered by these companies exceed the already high quality of most black jacket Type A fuel hoses by including braided wire reinforcement beneath their outer jackets. These "super hoses" typically have a working pressure of at least 500psi and an impressive burst pressure of 1000psi or more, whereas the average black jacket hose carries a working pressure rating of about 100psi and a burst pressure rating of 250psi. Many of these super hoses, such as Parker's 221FR marine fuel and engine hose, are blue jacketed, and all are designed to use proprietary metallic end fittings.

Super hoses are extremely durable and virtually failure proof; I regularly see 20-year-old hoses of this variety still going strong. However, this ultrareliability comes at roughly double the price, and the specialized end fittings that these hoses require cost between $5 and $20 apiece, depending on the configuration and material used. (They are typically available in chromate-plated steel, brass, and stainless steel.) In addition, it takes specialized knowledge, experience, and tools to select and install super hoses. So is the investment in super hoses worth it? While Type A black jacket hose is far from inferior, if you seek maximum durability, reliability, and longevity, then the answer probably is yes. After all, if the hose lasts twice as long and you own the boat for that long or derive increased resale value, then the hose can pay for itself in this respect alone.

Fuel hose, regardless of whether it's A1 or A2, or blue or black jacketed, must be properly supported at regular intervals using corrosion-resistant materials. Many builders and yards default to the ubiquitous plastic wire or zip ties, those black or white bands that are utilized throughout vessels for securing a variety of items, including fuel lines and wiring. A word of caution is in order regarding plastic wire ties. In my experience, these should not be used to secure fuel lines or wiring, or anything else for that matter, above moving or rotating machinery, such as engines, pulleys, belts, and shafts. (ABYC prohibits their use in securing wiring above all moving machinery.)

In such places, an insulated *metallic* clip provides a more robust means of securing lines and cables. Often referred to as "P clips" because in profile they resemble the letter "P," these stainless steel or aluminum brackets are equipped with a soft, chafe-resistant, rubber-like insert that prevents them from cutting into or otherwise damaging the hoses and wires they support. The clips must be secured to the available substrate using an appropriately sized tapping screw or through-bolt. While plastic wire ties are convenient, they should be used with ample forethought and caution where fuel lines are concerned. In my opinion, P clips should be the primary means of supporting fuel lines, with wire ties being used sparingly or to augment P clips.

A final note on fuel line support and plastic wire ties: avoid using electrical cables as support for fuel lines (that is, don't wire-tie fuel lines to electrical cabling as a means of support). While this may seem self-evident, it's a common practice, particularly where both fuel hoses and electrical cables travel to engines and generators. It's convenient, to be sure, and while it's not yet prohibited by ABYC guidelines, better, safer, more secure means of supporting fuel lines exist in virtually every installation. In the event of an electrical short circuit or fire, it's best to keep fuel plumbing as far away as possible from heat and ignition sources such as electrical cables, particularly the larger-gauge cables used for starting and battery power distribution.

HOSE TERMINATIONS OR END FITTINGS

When a fuel hose is run from a tank or manifold to a filter, engine, or other piece of equipment, it must be properly terminated. Several options exist, including the common barb and hose clamp combination, a swaged sleeve, and a field-attachable sleeve that is paired with a threaded insert. Typically, the latter two arrangements are used with the aforementioned reinforced super hoses. (These hoses have a 100 percent wire braid beneath a nonmetallic jacket, not simply a helical wire support such as that used in raw-water and large-diameter fuel fill hoses.) All of these connections can be counted on to convey fuel in a reliable, leak-free fashion, provided they are properly selected and installed. Nearly all fuel hose termination failures, such as fuel and air (vacuum) leaks, can be attributed to improper selection of materials, incompatibility with a given hose (e.g., the wrong diameter fitting is used), or installation problems.

Barbs and hose clamps, by far the most common fuel line termination arrangement, are reliable and are available at nearly every ship's store. Plus, they have the advantage of being easily installed and serviced, even by those with limited mechanical abilities and experience (no special parts or tools are required). However, a few guidelines must be followed to achieve a long-lived, leak-free installation. Hose clamps must be properly sized in both length and band diameter. A hose with an outside

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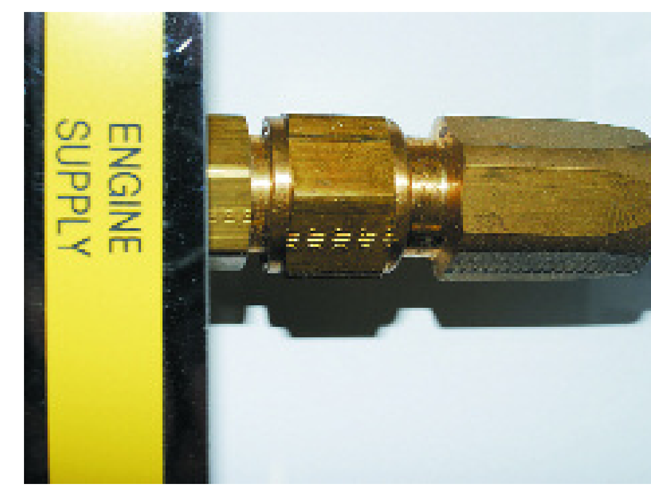

Top: All Parker/Racor fittings used on Turbine series filters are of the JIC variety, which means they have a flare angle of 37 degrees. Here, a cadmium-plated 90-degree fitting is connected to a brass field-attachable hose end. This makes for a virtually leakproof seal. Above: An assembled and installed field-attachable hose end. Notice the "JIC" nomenclature.

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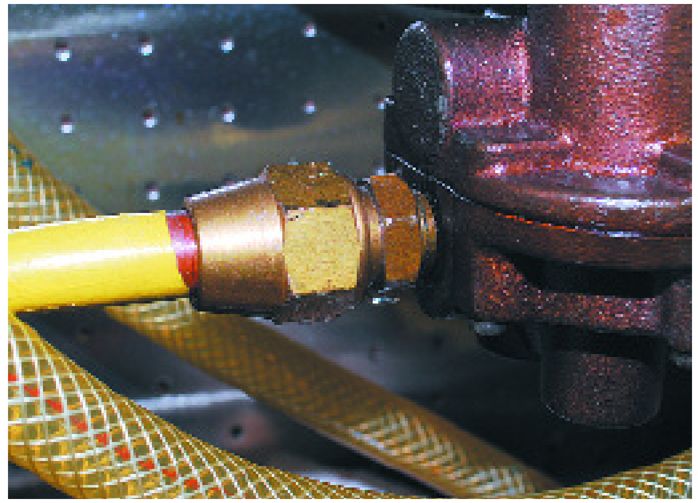

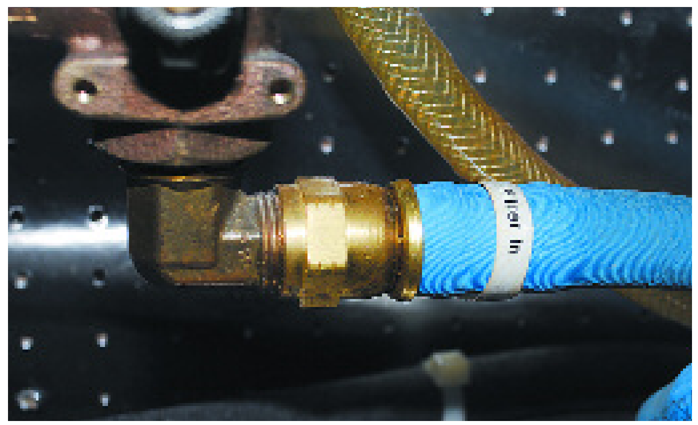

Above left: Cadmium-plated hose end fittings such as those shown on the left provide excellent corrosion resistance as well as a galvanically compatible means of connecting hoses to aluminum filter bodies. Where possible, it's best to avoid connecting brass fittings to aluminum fuel system components. Top right: Flare fittings are well suited for terminating copper fuel plumbing. Either short or long flare nuts may be used. The former is shown here. It should be noted that short flare nuts are prone to breakage when they are over-torqued. Above right: Fittings such as the one shown here, manufactured by Aeroquip and referred to as "Socketless," are designed to be used with Socketless-compatible hose and without hose clamps (using a clamp on these fittings may lead to premature hose failure). The double notches on the nut indicate a universal fitting, one that can be used with either 37- or 45-degree male connections. Parker makes a similar clampless hose fitting called Push-Lok, but the hoses used with Push-Lok fittings are proprietary and are not designed to carry fuel.

diameter (OD) of less than 7/16 inch should be paired with a clamp that has a minimum band diameter of 1/4 inch; hoses with ODs of 7/16–13/16 inch should use clamps with minimum band diameters of 5/16 inch; and a hose with an OD greater than 13/16 inch should use clamps with a minimum band diameter of 3/8 inch.

A pet peeve of mine is overly long clamps. Clamps that are too long for a given hose diameter not only look sloppy but also pose a laceration hazard, so take the time to select and install clamps that aren't longer than necessary. Clamps must be 1/4 inch or farther from the end of the hose and the end of the barb, and double clamps, if used, must not overlap or touch each other. That's right: contrary to popular belief, double clamps are not only *not* an ABYC requirement, they may at times be detrimental to the installation. (There are only two locations aboard your boat where ABYC guidelines call for the use of double clamps: on fuel fill and exhaust system hoses.)

Clamps that overlap often provide inadequate or uneven clamping pressure, while clamps that are placed too close to the end of the barb (which is under the hose, so it can't be seen) often will restrict or damage the hose when compressed. Therefore, forcing the use of two clamps for the sake of double clamping is simply unwise and unnecessary. It's preferable to use a single high-quality clamp on a hose, and a barb that is capable of properly supporting the clamp, as opposed to two undersized, overlapping, or improperly impinging hose clamps. And, because hose clamps must be installed no closer than 1/4 inch from the end of the hose and the end of the barb is located beneath the hose, double clamps often are impossible to install while meeting this end-spacing criteria.

Additionally, the height of the individual ridges on the hose barb, over which the hose is installed, must be a minimum of 0.015 inch tall. Fuel supply, distribution, and return hose should always be installed over proprietary hose barb plumbing and never over threaded pipe fittings, over smooth tube or pipe, or over barb ridges that are too short to afford a proper grip on the hose. (Fuel fill hoses are one exception to this rule; they may be installed over the smooth pipe sections that are often an integral part of fuel tanks and deck fill fittings.) If you opt for the barb and clamp route, which is perfectly acceptable, ensure that you meet the above guidelines in order to achieve a reliable, fluid-tight connection.

An integral component in the hose/barb/clamp termination process is the clamp itself, not all of which are created equal. Ordinary hose clamps, such as those used on many automobiles, in industrial applications, and, regrettably, on boats, simply are not up to the task of securing marine fuel hoses or any other hoses aboard your vessel. While garden-variety hose clamps typically utilize a stainless steel band, the screw often is made of ordinary rust-prone mild steel, in spite of the fact that many of these clamps are stamped with the words "ALL STAINLESS." Additionally, the threads of these clamps consist of a series of perforations cut into the band. Under load, and sometimes after even minor corrosion sets in, this type of band often will stretch and eventually fail. Once it does, the hose may separate from the barb. At the very least, it will leak fuel or air.

The alternative and preferred clamp, on the other hand, is truly all stainless, including the screw, and the threads are indentations or grooves within the considerably thicker band, rather than perforations. These clamps, available in 304 and 316 stainless steel, are virtually strip proof and corrosion proof. For fuel system applications, the 304 alloy clamps are adequate, while installations that are exposed to saltwater immersion or spray (for instance, fuel plumbing in open tenders or skiffs and stuffing boxes) should utilize the more corrosion-resistant 316 alloy clamps.

While hose barbs and clamps are capable of doing their duty where fuel line connections are concerned, a more rugged option exists. Swaged or threaded insert fittings, such as those commonly used in hydraulic applications, are steadily gaining popularity in the world of recreational marine fuel hose termination.

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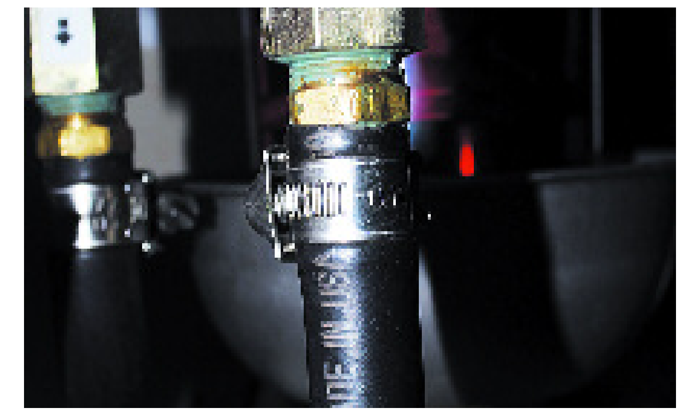

Top: Where the transition is made between rigid metallic pipe and hose (at the attachment point to the engine, for instance), the pipe must be completely immobilized to prevent movement- or vibration-induced fractures. Above: The most common method of terminating ordinary fuel hose is using a high-quality clamp and barb. This barb will fully accommodate only a single clamp, which is entirely acceptable provided it's all stainless steel and the band is not perforated.

(Commercial builders have used this method of fuel line termination for some time.) These fittings are attached to the hose end in one of two ways: with a one-time swage (a stainless or mild steel sleeve that is formed around the hose using a proprietary press) or with a threaded compression coupling that is mated to the hose using a field-assembled, compression-type threaded insert. Once attached to the hose, the end, a conical or "flared" threaded coupling, is then attached to mating and inversely flared fittings on tanks, filters, engines, and other plumbing components. The interconnection of these two flares is the secret behind their reliability.

This type of fitting was pioneered by the aviation industry just before the United States entered WWII. With the advent of war and mass aircraft production and

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the need for quick and easy field service, sometimes under fire, the popularity of these fittings grew, and many improvements were made to them. Their reliability was far greater than that of clamped fittings. (Oftentimes, the "clamps" in early aircraft applications were nothing more than twisted wire.) The current options for this type of hose termination, the majority of which have been developed and manufactured by the aforementioned Aeroquip and Parker Hannifin Corporations, are as near perfect as a design can be. The primary advantage of this type of system is that it is virtually leakproof if properly installed.

Because flared connections require no sealant or pipe dope, the threaded portion of the connection is straight rather than tapered and plays no part in making the liquid-tight seal other than affording mechanical compression. Little interpretation or innovation is required on the part of the installer, and because the threaded connections at the fitting's flared end are straight rather than tapered pipe, it's difficult to over- or under-tighten them. If sealant or tape is used on flared connections, it's likely to impair rather than improve the liquid-tight connection, and it reveals a lack of understanding of this type of plumbing connection on the part of the installer.

One important option does exist with these and other flared fittings, and that involves the angle of the cone found within the connection. Ordinary low-pressure connections, those with a pressure of 100psi or less, may be made using a 45-degree flare, while high-pressure applications typically call for a 37-degree flare angle. Because of its high-pressure capabilities, the 37-degree fitting, often referred to as a JIC (Joint Industrial Committee) fitting, is ideally suited for making virtually leakproof fuel connections. Is it overkill? Perhaps, but it takes no additional effort to use a JIC fitting versus a 45-degree connection, so there's little reason not to take the more reliable route.

Distinguishing these two fittings simply by the appearance of the flare angle is difficult if not impossible. However, for identification purposes, a flare gauge (an angled ruler of sorts) can be used, and both Aeroquip and Parker include a single notch in the outer hex portion of 45-degree female fittings. While any attempt to mix 45-degree and 37-degree fittings will almost certainly lead to leakage, *some* fittings may offer a dual seat that can reliably accept both angles (these are often marked with dual notches).

Left: Swaged fittings, such as the one shown on the right, are an alternative to field-attachable hose ends. They are not reusable in that they cannot be detached from the hose once compressed. An advantage is that they are available in stainless steel. Right: Threaded NPT pipe connections are among the least reliable where fuel systems are concerned. Threads should be sealed with a suitable liquid or paste compound such as Loctite 567, 515, or 518.

Does it matter whether the fittings you use are of the press-swaged variety or field assembled? Not really. In my experience both work well, provided all of the installation protocols are followed. The latter are reusable, a distinct advantage if you need to effect repairs in a distant port, while swaged fittings can be installed only once. (If your fuel system utilizes straight thread connectors, JIC or 45 degree, it's worthwhile to add a few lengths of a variety of fuel hose diameters, along with the appropriately sized reusable fittings, to your cruising spare parts kit.) Swaged fittings require the use of a specialized swaging machine for assembly, while most field-assembled fitting configurations only require the use of a proprietary mandrel set to prevent hose damage or internal flaps from being formed during the assembly process. Additionally, some field-assembled

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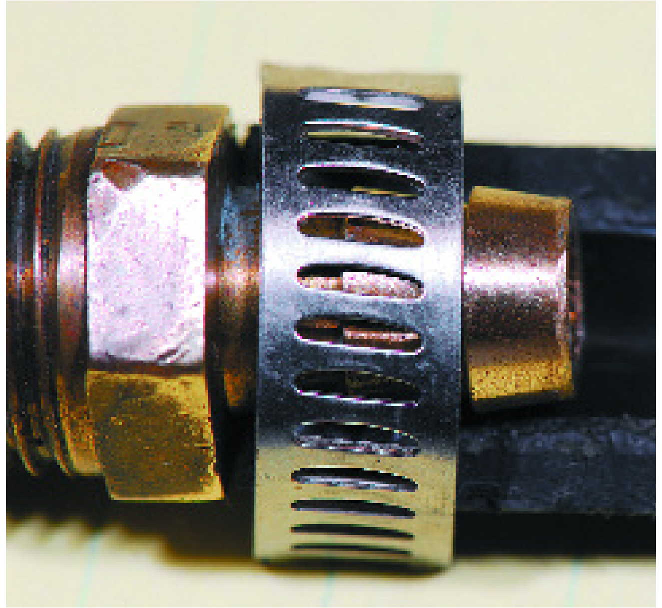
connections require the removal of a portion of the hose's jacket or inner tube to complete the assembly. These are referred to as skive hoses or skive fittings; hoses that do not require jacket removal are referred to as no-skive. Given the choice, I prefer the latter, because they can be assembled more quickly and easily.

There is another variety of reusable, field-attachable fittings that may be used with diesel fuel systems. These fittings are designed to simply push onto a hose without any clamps, swaging, or assembly mandrels. It sounds simple and enticing, but there are caveats for the use of such "push-on" fittings. The push-on fittings manufactured by Aeroquip are known as Socketless or FBV connectors. Through the use of an especially aggressive barb, the connector is able to grip the hose with a liquid-tight, low-pressure seal. Socketless connectors can be identified by a metallic collar that resides between the swivel portion of the connector and the hose, once installed. Aeroquip specifically recommends *against* using hose clamps with this type of connector, because it may lead to premature failure of the hose. Additionally, a Socketless connector may *only* be used with the appropriate Socketless hose (which is so marked). While a Socketless connector will fit into a variety of hoses, using the connector with anything other than the hose for which it has been designed may lead to leakage or connector-hose separation.

The reusable push-on connectors manufactured by Parker are called Push-Lok fittings. These are similar to Socketless connectors in that their barbs are capable of making fluid-tight connections with hoses that are specifically designed to be used with Push-Lok

A Parker field-assembled hose connector and the mandrel tool that's used to assemble it. These fittings are extremely durable and reliable and lend themselves to use in boat construction, repair, modification, and service work.



A cutaway view of a hose and barb assembly. It's important to note that the length of this barb prohibits the installation of double clamps.

connectors. However, Push-Lok hoses are not recommended for fuel applications. Therefore, different hoses must be used with Push-Lok connectors, which negates the fittings' effectiveness and reliability. The folks at Parker tell me there's no harm in using an ordinary hose clamp with Push-Lok connectors (which is not the case with Aeroquip Socketless connectors), so they *could* be used with non-Push-Lok, fuel-rated hoses, if clamped. Push-Lok connectors can be identified by their bright yellow plastic collars. Using a Push-Lok connector with an ordinary Type A fuel hose and no clamp, a common practice in the marine industry, is inappropriate and risks failure.

COPPER TUBE

In lieu of hose, or sometimes in addition to it, rigid pipe or tube may be used to distribute fuel to a boat's fuel system equipment. Copper tube, which is strong, durable, flexible, fire resistant, and long-lived, was once considered the gold standard for marine fuel systems. Because of its corrosion resistance and ruggedness, it may outlast a vessel's engines and even the vessel itself. Provided the tube's wall thickness is a minimum of 0.032 inch, it's considered acceptable by ABYC standards.

If copper tubing is used for fuel distribution and return plumbing, it is imperative that it be properly terminated and that a suitable length of flexible hose be used between the tubing and any machinery to which it's attached, such as engines and generators. In spite of copper's relative flexibility, it is susceptible to failure if repeatedly flexed. This is liable to occur in the section of tubing that bridges the gap between the tube's final mounting or hard point on the vessel (usually a stringer) and the flexible hose that attaches it to an engine or generator. In order to prevent work hardening and eventual fracture, the copper tube must be especially well secured to the vessel where it makes the transition to hose. Provided this is done, the hose will, unlike the copper tube, indefinitely absorb the engine's movement and vibration. Any movement of the copper tube in this region will compromise its reliability and lead to possible failure.

Termination of copper tubing can be accomplished only by flaring its ends and then attaching male flare fittings and other plumbing arrangements or by a process known as beading. Flare fittings, as mentioned earlier, are a strong and reliable way of terminating plumbing connections. In most cases, copper tube is single-flared using a 45-degree angle. This is more than adequate for copper fuel lines and typically results in a leak-free union. Some manufacturers and repair yards prefer to use a double flare, which essentially means the female cone is folded in on itself and then flared, resulting in a more flexible and thus more positive sealing face.

Beading involves the creation of a raised ring or bead just before the end of a section of tube. A hose placed over this bead and then clamped will be relatively reliable and leak free. (The bead's height must be a minimum of 0.015 inch, and the clamp must reside at least 0.25 inch beyond the bead and from the hose end.) This form of termination is not as secure as a flare fitting. Hoses for fuel distribution, supply, and return must never be placed over smooth, bead-free tubing, as this type of connection is highly susceptible to leakage and failure.

Based on the above description, it might sound as though copper tubing is one of the best materials for fuel plumbing. If it were not for one chemical factor, it would be. Unfortunately, copper alloys, along with lead, tin, and zinc, have the ability to hasten the oxidation of diesel fuel. Diesel fuel stored in copper or copper alloy tubing is more prone to forming insoluble sediments, gels, salts, and varnish. For this reason alone, copper is considered less than ideal for the storage and conveyance of diesel fuel. If your vessel is currently equipped with copper plumbing for fuel distribution, I'm not suggesting you immediately replace it, but you should be aware of the possible side effects and the role it might play in degrading the fuel contained in this portion of the system. (Isolated components made of copper, such as valves, elbows, or pipe nipples, because of their minimal surface area, are not an issue.) If you are having a new

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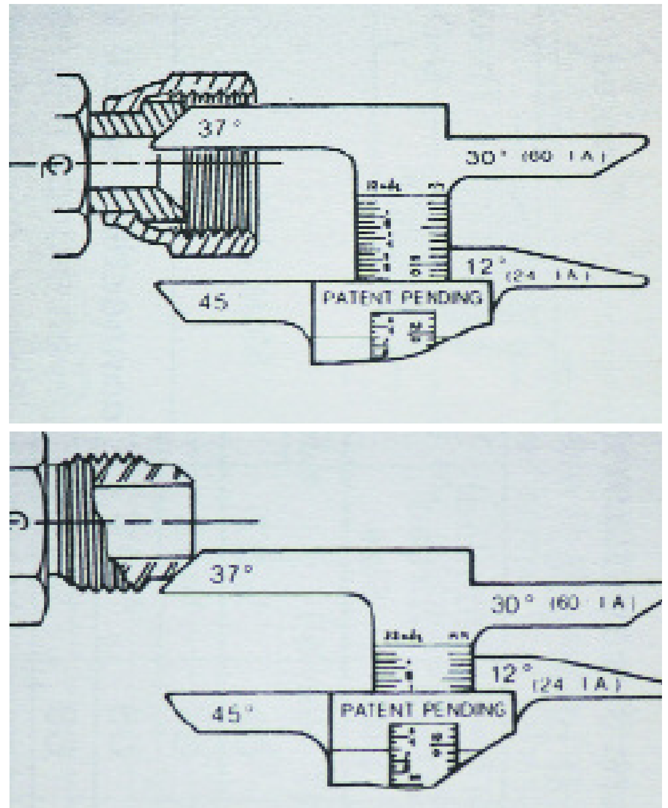

Images courtesy Aeroquip

These mechanical drawings detail the measurement of a fuel line flare fitting. Both 37- and 45-degree flare fittings may be used in fuel systems; however, the former are preferred, and the fittings typically are not interchangeable.

vessel built or are refitting an older one, high-quality, ABYC-compliant fuel hoses will provide service that is equal to what may be expected from copper without the oxidation woes.

OTHER PIPE

Pipes of other kinds also may be used for fuel systems, provided they meet certain criteria. While the strength and rigidity of pipe cannot be denied, its inflexibility can lead to failure. Thus, pipe should be used only in applications where it will not be subjected to flexing or extreme vibration. Any pipe used for fuel system plumbing must be a minimum of schedule 40 ("schedule" refers to pipe thickness) and must be made of ordinary carbon steel (which is sometimes called black iron and is rust prone), stainless steel, or aluminum. While copper and brass pipe are acceptable according to ABYC guidelines, use of these metals may lead to the aforementioned oxidation and sedimentation issues. A final caveat on the use of pipe: internally zinc-galvanized components should never be used for any diesel fuel system plumbing. Diesel fuel adversely reacts with zinc in much the same way it does with copper, leading to fuel oxidation and sediment formation.

Whether you use ordinary hose, designer hose, copper tube, or other pipe, it's virtually certain that some, if not most, of the connections will be made using tapered pipe threads. Otherwise known as NPT (for "national pipe thread"), this sealing arrangement is reasonably reliable and extremely common, although some manufacturers rate its ability to make leak-free connections as only fair or poor. It's used throughout most vessels and homes and in industry for everything from potable water and through-hull connections to sanitation systems and LP gas fittings. The thread arrangement is identifiable in that it's cone shaped; that is, the outside diameter of the threaded end increases as you move from the bitter end inward.

This type of threaded arrangement is considerably more likely to leak than flare or spot-face O-ring connections (highly desirable spot-face O-ring connections are used on Racor Turbine Series filters and some polishing systems). However, if a few precautions are taken, the reliability of NPT seals can be considerably enhanced. Begin by choosing, when available, a variation on the NPT theme: for example, a thread known as NPTF or Dryseal. This thread arrangement is virtually identical to NPT and virtually indistinguishable visually, but the subtle difference makes for a seal that officially requires no thread sealant. Dryseal threads are designed to intentionally distort, and thus seal more effectively, when assembled.

Whether you use NPT or NPTF fittings, carefully clean all of the threads before assembly using a solvent such as denatured alcohol, CRC Cleaner & Degreaser, or 3M General Purpose Adhesive Cleaner. This cleaning procedure will leave the threads free of grease, oil, and wax. Think these parts are already clean because you just bought them? Try this test: saturate a clean, lint-free white rag with one of the above-mentioned solvents, and then use it to wipe down the threads of a plumbing component that you believe is clean. You will almost certainly find black or gray residue on the rag. This is often a byproduct of the thread cutting, forging, or casting process, and the presence of residue will almost certainly compromise the effectiveness of any thread sealant you use.

For fuel system plumbing assembly, I prefer to use paste or liquid thread sealants, of which there are a large variety, rather than Teflon tape. I use sealants even on NPTF fittings. Teflon tape, while popular with many mechanics and do-it-yourselfers, is notorious for finding its way into fuel systems. If tape makes its way into a pump, valve, or filter, it nearly always leads to some type

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of failure. For average thread sealing jobs, a product called Leak Lock (www.highsidechem.com) works well. It's designed to seal pipe threads; however, it's not designed to fill large gaps or severely stripped, galled, spalled, or otherwise damaged threads. It works exceptionally well for diesel and gasoline plumbing, as well as for refrigeration, LP gas, potable water, and other plumbing requirements, although it's not recommended for use with alcohol. Thus far, I've seen no issue in using this product with E10 (10 percent ethanol/90 percent gasoline), but I suspect that it would not be appropriate for use with E85.

For more critical or stubborn thread sealing applications, Loctite Corporation (loctite.com) manufactures a range of specialized thread and flange sealants as well as thread locking compounds, some of which are quite tenacious and are capable of filling irregularities and gaps in poorly formed or damaged threads. If the threads on a fuel system plumbing component are damaged, the part should be discarded and replaced with an undamaged unit. However, if the threads on a fuel tank or manifold are damaged, for obvious economic reasons, it's worth considerable effort to effect a reliable seal. Fuel tank fittings often are pipe couplings that have been welded in place. Because of their configuration, the couplings are prone to distortion when welded and often become oval in the process. Enabling these threads to seal can be difficult or impossible, depending on the degree of deformation. This problem can be avoided by using, as mentioned in previous articles, flanged welding bosses rather than ordinary pipe couplings.

Loctite 567 is specifically designed for thread sealing in fuel plumbing and other applications. If greater gap filling is required, one of Loctite's flange sealants, such as 515 or 518, may be used. But be warned that these products cure in confined spaces in the absence of air and they do so very rapidly, sometimes during assembly if the components are not assembled quickly, and disassembly often requires the application of heat. Once installed and set, all of these thread sealants can be expected to do the job. If they fail to do so, it's more likely than not an issue with the sealing surfaces rather than the sealant. The sealing surfaces may be contaminated with fuel or other substances, or they may be deformed or damaged to the point of preventing an effective liquid-tight seal even with gap-filling flange sealants.

When properly designed, installed, and maintained, diesel fuel plumbing systems often are among the most reliable components aboard a cruising vessel. If yours isn't living up to expectations, it may be time for modifications or an all-out replacement.

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