Can You- Should You- Build Your Own Fiberglass Tanks?

by *Ken* Hankinson

Due to the litigious environment in today's society, I feel compelled to advise that fuel tanks used in boats-especially those used to store gasoline or alcohol-based fuels-be built by persons or firms specializing in the manufacture of marine tanks. These tank makers are no doubt familiar with the construction, installation, and testing recommendations (including pressure-impulse strength tests) published in the American Boat & Yacht Council's (ABYC) *Standards and Recommended Practices* **for** *Small Craft",* specifically Sections H-24 (Gasoline Fuel Systems), and H-33 (Diesel Fuel Systems). Your insurance company may require that your boat's tanks adhere to these recommendations or be otherwise "certified."

Basically, ABYC standards require that tanks be liquid- and vapor-tight, and withstand the effects of fuel, lube oil, bilge solvents, salt or fresh water, fire, or other hazards Tanks must show, in a certain manner, the maker's name and address, date made, tank capacity, material specification and thickness, fuel type to be used, maximum test pressure, and other incidental wording

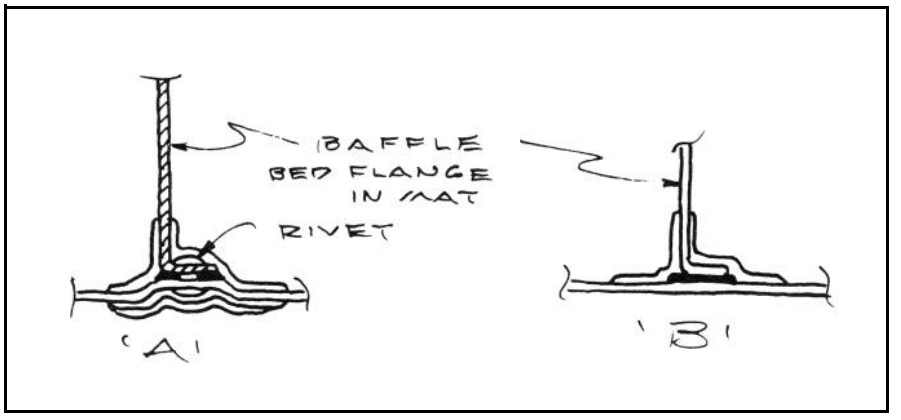


Figure 2 (left): Baffles are sometimes riveted in place as in "A," with mat applied inside and out. The method shown in "B" is simpler. In both, the baffles are bedded in mat.

one would probably have abandoned ship by then.

By implication it may seem that fire-retardant resins should be used for FRP tanks, but this is often overemphasized and not an ABYC requirement, although at one time it was a requirement under the old BIA standards. Gray claims that ordinary polyester resin will usually withstand the 2.5-minute fire exposure, and a coat of fire-resistant paint on the outside is optional if you need more peace of mind. Fire-retardant resinsare more expensive, not always easy to find, and more difficult to use, but are acceptable and may be required on large, commercial passenger-carrying craft.

For those not experienced in making FRP tanks and who want to know more about it, the following may prove of interest. Keep in mind, however, that properly made, tested, and maintained fuel tanks are probably a boat's most important safety feature. Also, remember that FRP tanks are not necessarily light in weight or inexpensive. Even if appealing at first thought by the do-it-yourselfer willing to work with resin and fiberglass, and who may not have the welding skills or equipment to make metal tanks, saving money by making one's own tank is not always sound advice.

Tank Configuration

One advantage of FRP tanks is that they can be made in virtually any shape to better use a given space. However, general tank size and shape may be provided on the plans by your boat's designer, and it is common for designers to assume the use of metal tanks. Unless otherwise approved by your boat's designer, at least the sizes given should be adhered to. The point is, don't add fuel capacity simply because the space may be available; it could upset the balance, safety, and performance of your boat. On existing boats, the tanks in place may be used as models for custom-made FRP replacement tanks.

Tanks usually require at least one baffle or "slosh plate" between the ends and/or sides to prevent the contents from surging, to improve strength, and to minimize noise. Baffles should be fitted where any distance exceeds approximately 30 inches so that tank intervals won't exceed 20 inches maximum, or so that a maximum of three cubic feet (about 20 gallons) exists between baffles.

Baffles can be closed or open, and with snipped corners for the passage of fluid and air **(Figure 1)**. If open, the opening should not be more than 30 percent of the baffle area. Generally, baffles should be the same thickness and structural configuration as the tank sides; in other words, as strong as the tank itself.

Some commercial boatbuilders use aluminum baffles riveted in place with extra FRP laid over these to prevent leaks (similar to **Figure 2A**). If used, such baffle fastenings should be no more than 3 inches apart; bed the area in mat and cover with mat on both sides to at least .20 inches thick, in any case.

Tank surfaces should be shaped so as not to trap moisture, especially on top around fittings (on gasoline tanks, fittings must be located on top), Thus tops should be domed, cambered, curved, or sloped rather than horizontally flat, which may tend to dish or droop (Figure 3). Curved, corrugated, or surfaces that are not otherwise flat make for a stronger tank. Flat surfaces are acceptable, but they should be inclined and made thick enough, or otherwise stiffened, to prevent bulg-

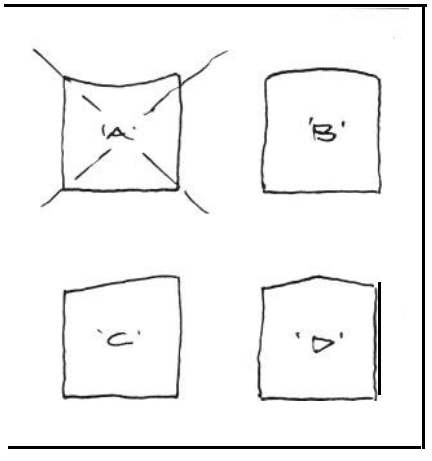
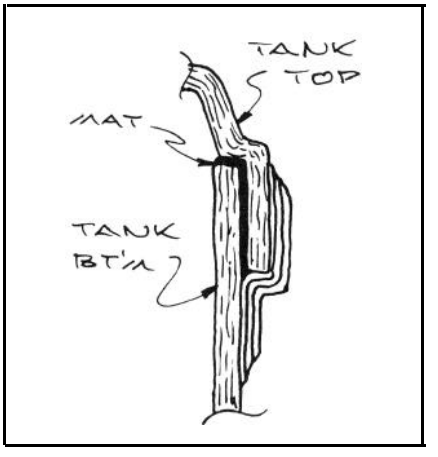


Figure 3 (left): Flat tank tops can droop as in "A," and trap moisture. They should be inclined as in "C" and stiffened. The shaped tops in "B" and "D" are better.

Figure 4 (right): This type of joint is sometimes used by professionals. The tank halves are not hard to make over male molds, but tank integrity depends on a sound seal between the halves, using plenty of resin-rich mat and additional layers on the outside.



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as listed in the standards.

The ABYC standards also discuss venting, fill fittings, installation methods, and the like. However, don't expect much in the way of information from the standards about fiberglass reinforced plastic (FRP) tank construction or design, especially compared to the more comprehensive information provided for metal tanks. It's not that the ABYC doesn't accept FRP tanks; they do, and in fact, major builders such as Bertram and Hatteras use UL-approved FRP tanks for both gasoline and diesel fuel. Furthermore, it's the personal opinion of ABYC Technical Director, Lysle Gray, that FRP is the best tank material, and he has the experience to back it up.

Gray was involved in making early FRP boat tanks some years ago. One such tank was inadvertently "tested" by a fire that devastated the facility where the tank was, but the tank itself survived virtually unscathed. Made with 1/8-inch skins of mat and woven roving on each side of a balsa core, the tank sustained charring damage to the outer skin, but the core and tank interior were not harmed. Resin was burned from the mat, while the charred woven roving seemed to act as a barrier which kept the core from burning, according to Gray.

When asked about the affect of heat on the core, Gray noted that damage may have occurred, which means that had a foam material such as PVC been used instead, it might have deformed or worse, resulting in other problems or possibly a complete failure of the tank.

Another report some years ago involved a similar blaze where an FRP tank containing gasoline in a boat survived and did not ignite, even when adjacent metal tanks in other boats exploded and burned.

As to why ABYC has little specific material on FRP tank design, it is probably because such tanks are often custom made, using any combination of various fiberglass materials, with or without cores. More to the point, the concern of ABYC is that such tanks meet their testing requirements, which include pressure and shock tests as well as withstanding fireexposure for at least 2.5 minutes. As Gray puts the case, on boats 50 feet or less in size, a fire that lasts this long makes a boat basically uninhabitable anyway, so it becomes academic that any tank withstand fire for much longer-every-

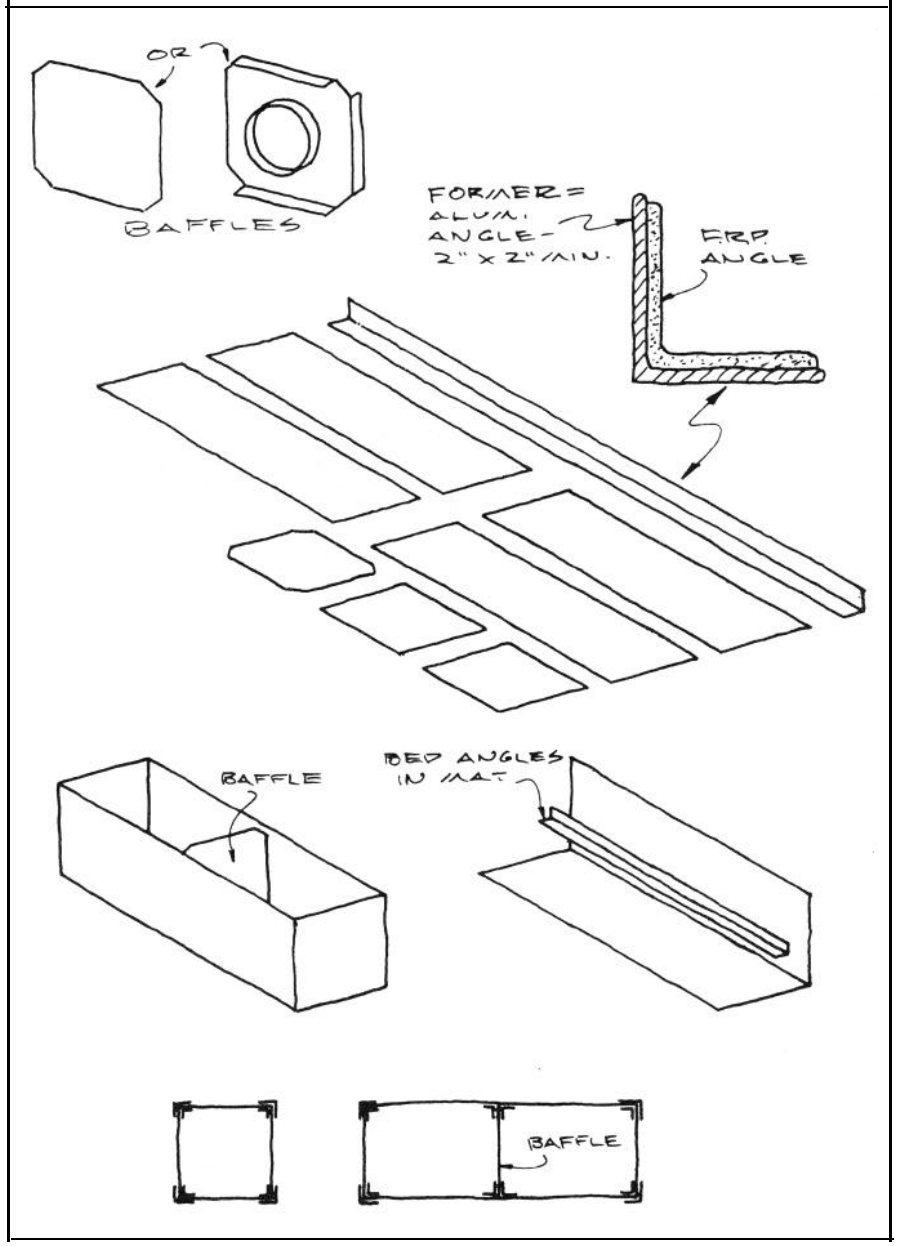

Figure 1 (above): Prefabricated fiberglass parts can be made and assembled to form simple *tanks. Bonding angles made in* an *aluminum* angle former *are used to join inside corners. Additional mat can be laid up in place* on *outside corners later. Sections show where these are located.*

** For* more *information* on *tank standards contact:* American *Boat & Yacht Council, Inc. (P.O. Box 747; 405 Headquarters Drive, Suite 3; Millersville, MD 21108; 301-923-3932) or American Bureau* of *Shipping (45 Eisenhower Drive; P.O. Box 910; Paramus, NJ 07653; 201-368-9100).*

ing when the tank is full.

Laminates and Thickness

As for thickness, ABYC gives no recommendations since strength generally can have as much to do with tank and laminate configuration as thickness. Thus the position of ABYC is that if a tank withstands the tests, it's thick enough. But as a general guide, the following can be used for thickness of solid FRP tanks assuming baffle spacings as noted previously:

To 60 gallons: .187"
60 to 120 gallons: .25"
Over 120 gallons: .3"

Unlike metal tanks, no extra thickness is necessary to allow for corrosion. The fiberglass content of the tank laminate compared to resin content should be at least 30 percent, which is about what you get with an all-mat laminate. However, the tank will be stronger and offer a somewhat higher glass content if the laminate is alternated with some sort of woven or non-woven roving. For example, two layers of 2-ounce mat alternated with two layers of 18-ounce woven roving makes a laminate about .18-inch thick. Always orient tank laminates so that the inside of the tank is mat.

American Bureau of Shipping (ABS) and Lloyd's rules recommend that the inside of FRP fuel tanks be covered with a minimum of 2-ounce mat *in addition* to the tank skin thickness used for strength purposes alone, but this may be overkill in the small boat. Furthermore, ABS also advises that inside corners of tanks be at least one inch in radius, but this may not be practical for smaller tanks made in certain ways. Regardless, corners should be as well radiused as possible.

What About Integral Tanks and Core Materials?

As for FRP tanks integral with an FRP hull, ABS rules recommend no integral tanks be fitted in way of, or employ, sandwich construction. For example, if sounding tube rods were used, they could puncture the skin and cause fuel to migrate into the hull core. In a similar vein, both ABS and ABYC recommend against integral tanks for gasoline, although such tanks for diesel fuel are acceptable. Nevertheless, many experts question the use of integral tanks in small boats in any case, claiming that maintenance, repair, and renewal are difficult if not impractical in many instances.

Otherwise, core materials are not necessarily frowned upon in making FRP tanks, but core-to-skin bonds can be problematical and there is more potential for voids by the inexperienced worker. Thus the introduction of cores into tank making adds some degree of cost, care, concern, and complexity. However, some builders use core materials for extra stiffening purposes once the laminate thickness above has been achieved with solid FRP alone.

Resins

FRP tanks are typically made with polyester resin. Although some procedures may call for finish sanding (a resin containing wax simplifies this), a laminating (wax-free) resin is preferable throughout tank lay-up. Otherwise the wax in finishing resin may interfere with interlaminar bonding and assembly, leading to possible leaks and delamination.

It is possible to finish up a tank exterior or interior with a coat of finishing resin, however, and if used inside, the amount of wax it contains is probably not enough to cause any fuel problems. It is paraffin and therefore compatible with the fuel, anyhow, so there's no need to sand. In any case, use it only as a final coating, or in the final exterior laminate, or where finish sanding is otherwise necessary.

Ortho polyester resins (sometimes called "general purpose" resins) can be used throughout the tank lay-up with the exception of inside the tank itself. Ortho resins are the least costly polyesters, but also poorest at chemical bonding and chemical resistance. Instead, somewhat costlier iso resins which offer improved chemical resistance are recommended, at least on the inside coating of the tank, and even perhaps on the exterior if the tank will be exposed to bilge water. Gasoline storage tanks used underground at service stations are made throughout with these superior resins, and if I had my choice in FRP tanks in my boat, I would use iso resins exclusively also; the extra cost is not worth mentioning.

For even better chemical resistance and integrity, resin companies sometimes advise coating with still costlier and more complex vinyl-ester resin on the inside of all tanks, but these are not usually mandatory. In any case, ABS recommends that such coatings on the inside of

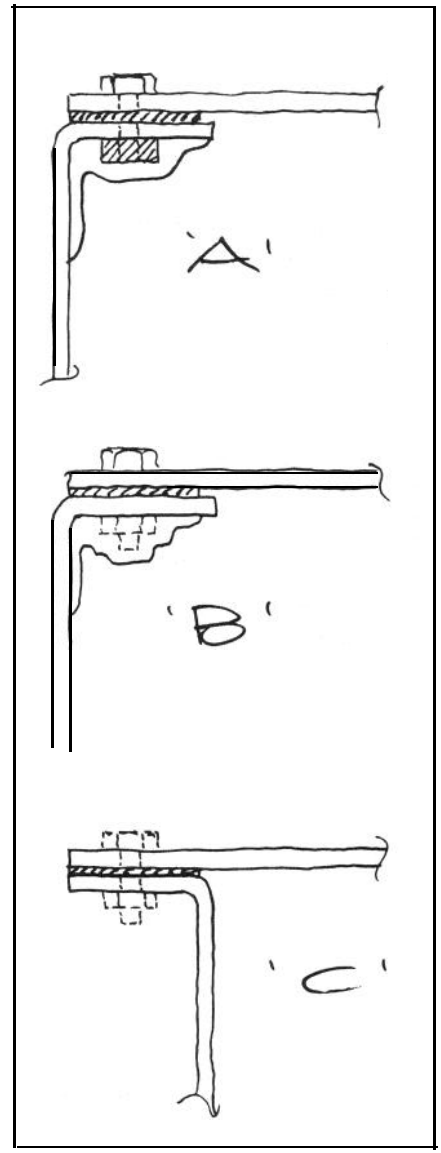

Figure 5 (above): Removable tank tops for diesel tanks require a neoprene or similar gasket between the top and the tank edge. A tapped metal strip is bonded under the flange in "A," while in "B," nuts are bonded in place for the screws instead. The outside flange in "C" is simpler and gives easier access, but takes up more room.

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tanks be no less than 20 mils (.020 inches) thick. A coating of similar thickness is also recommended on the tank top itself for durability. Any fiberglass used inside the tank, such as bonding angles at baffles, must be equally covered with resin. In short, tank interiors should be resin-rich to cover all pin holes and voids that could allow the fiberglass to wick fuel. For the same reason, any openings leaving exposed laminate edges must also be coated with additional resin.

Tank Construction Methods

FRP tanks are preferably made over a male mold rather than in a female mold. The reason is that it's easier to assure a super smooth, pinhole-free, resin-rich surface on the inside of the tank. Conversely, with tanks made inside female molds it's more difficult to build up a void-free resin coating inside and assure that the laminate is completely covered, let alone make a smooth surface. Fibers may shed, and if a wax-free resin is used, it may not cure completely and thus leach compounds into the fuel, with the potential to gum up the system, and possibly interfere with fuel delivery (extra filters may be advised).

With a male mold (usually a box-like appliance you can make yourself from smooth plywood, Masonite, or like material) outer comers must be gently rounded; inside corners of female molds will require corners to be built up with filler material to form radiuses-an added procedure and more work. Coat all mold surfaces generously with wax or similar release agent. Whether using a female or male mold, the resulting tank is a basic "box" into which baffles can be placed and a top applied. Regardless of the mold type, include several degrees of draft (inward slope) so the tank can be pulled easily from the mold later.

Silica ("Cabosil") is often added to the initial resin coat on the inside surface to thicken it. Care must be taken to keep from penetrating it when laying the fiberglass material into it; this can lead to future wicking and leaks. Thus once applied, let it set a while before laying on the first layer. Once this is done, additional layers can be applied continuously.

Some professional boatbuilders make male-molded tanks in two halves-top and bottom-joined in a "shoe box" configuration similar to Figure 4. In the areas of the joint, extra thickness is usually built up, with the halves bedded in resin-rich mat. Extra material is then applied

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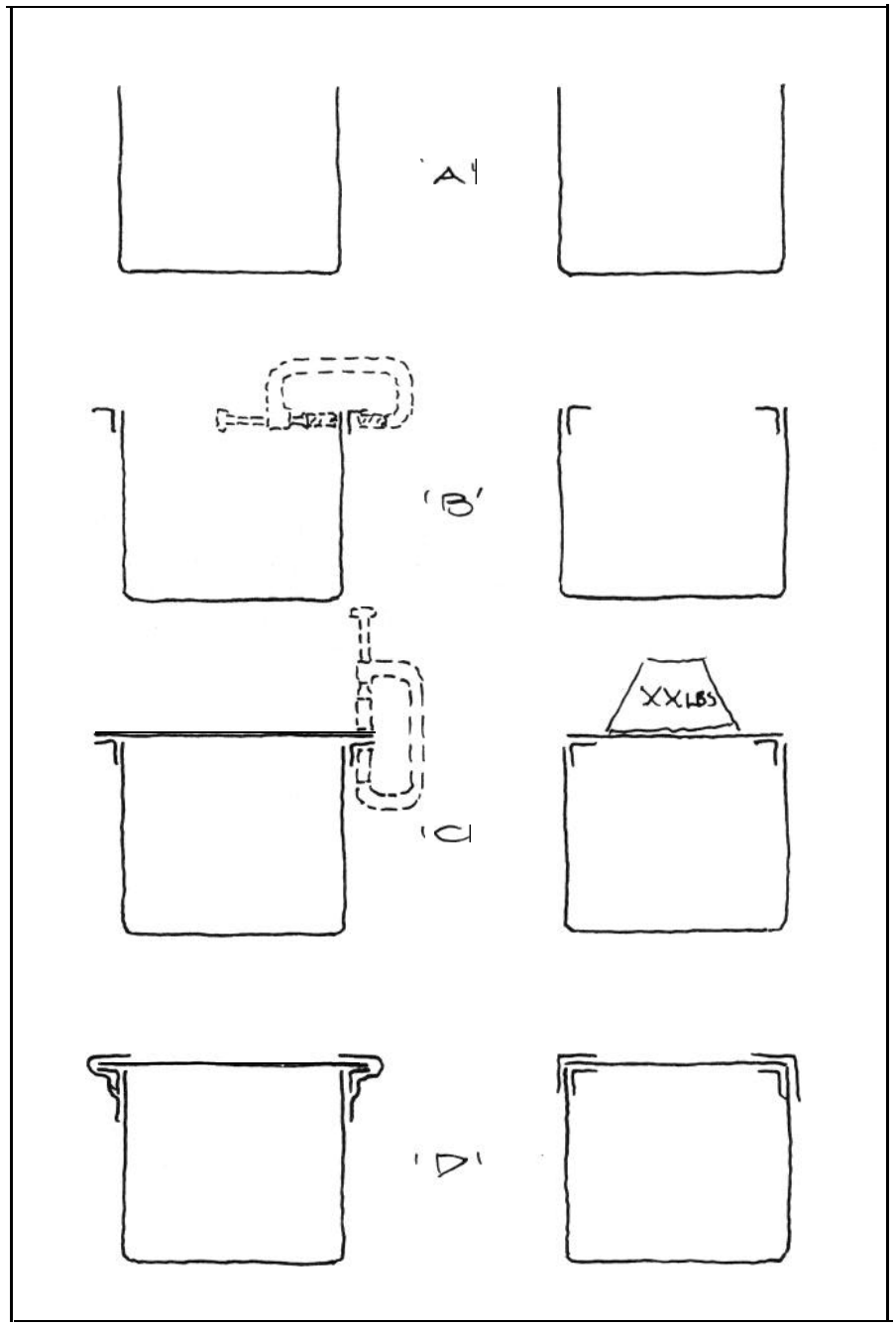
Vote: Some illustrations are based on those also presented on this subject in the book Fiberglass Boatbuilding For 4mateurs *by Ken Hankinson.*

Figure 6 (right): Permanent tank tops are required for *gasoline tanks. For a tank as shown in Figure 3, install pre-*formed *angles around the tank edge, either outside or inside. The top can then be clamped or weighted in* place *until the resin cures, using plenty* of *resin-rich mat at the junction, and extra layers on the exterior.*



to theoutside joint to seal it and form the completed tank. Such joints, however, can be tricky for the inexperienced.

The tank-making method shown in Figure 1 is best suited to fairly small tanks not subjected to high continuous stresses, such as in slower boats where tanks are near or aft of amidships, for example. It uses more-or-less flat sheet components (sides, ends, baffles, top,) which are then assembled using FRP bonding angles at the junctions. The flat sheet components can be laid up on a smooth, flat material such as wax-coated Masonite, Formica, metal, or even glass.

Materials are precut somewhat larger than the panel sizes desired and laid up on **the** surface after a generous coat of resin has been applied. Always start with mat first as this surface will be the inner tank surface. Allow laminates to cure, trim to size, and then assemble. It is not necessary to make the sheet parts to the finished thickness initially; additional layers can be applied on the outside once the tank has been assembled enough to form a box without a lid.

The prefabricated bonding angles used for assembly can be made from mat layers laid up in a 2-inch by 2-inch aluminum angle former or similarly shaped device well coated with wax. The angles should be at least as thick as the tank sides. Additionally, mat strips at least 4-inches or so wide can be laid up in place where comer reinforcement is necessary, or during assembly at any outside corner. Use temporary supporting members and a framing square to hold parts true in position during assembly. Any cured, mating surfaces are rough-sanded to assure sound bonds and solvent-wiped (acetone or lacquer thinner) first for sound secondary bonds. All preformed angles are bedded in resin-saturated mat.

Technically speaking, inside corners should always be radiused. However, the lack of an inner radius with this method is partly compensated for on the outside since the outside corners are radiused instead.

Angle flanges (2 inches wide, minimum) used to secure the tank top can face inside or outside, but make them extra thick and strong since much of the stress on the tank will be taken here. Outward **flanges** will allow easy removal if both are used to secure a removable tank top (Figures 5 and 6). But keep in mind that only diesel tank covers may be removable; gasoline tank tops must be sealed. Baffles within the tank can be bonded with bonding angles or fitted with flanges that are bedded in mat and later lapped with bonding strips of **mat.**

Where fittings will be located, double the laminate thickness for an area about twice thediameter or size of the fitting. With fittings, use take-up washers or fastenings which compress the laminate from *both* sides. Finally, bed fittings in neoprene gaskets, test the tank, and install it. ■