Pop-riveting an alu fuel tank

Riveted aluminum fuel tanks are smart. They're easy to build and superbly practical for the homebuilder since she can make them in whatever shape she needs.

Most folks shy away from this fabrication technique due to the high cost of Pro-Seal, still listed at more than $8/oz in the Aircraft Spruce catalog (P/N 09-38500 "2oz sealant" $17.85). But now that Thiokol's patents on polysulfide sealants have expired, seam-sealers that do equally well are available for pennies per pound instead of dollars per ounce. Life Industries is one such source. They make a line of polysulfide sealants for marine applications, including a two-part fuel-proof formulation used to calk fuel tanks & bilges.

With aluminum, the sealant-bonding question - getting the stuff to stick - is a no-brainer. Go to your local Home Depot and buy a quart of JASCO ‘Prep & Primer.' Or buy a quart of ‘AlumaPrep' from Aircraft Spruce. Same stuff, chemically speaking. Of course, the aviation-grade' alumaprep is dramatically more expensive.

Degrease then etch the panels you want the sealant to adhere to for thirty minutes in a solution of ‘Prep & Primer.' (The strength of the solution isn't critical. Anything from 1:1 to 3:1 works fine on clean aluminum. If using Alumaprep, follow their dilution instructions.) ‘Prep & Primer' is a phosphoric acid etchant made specifically for galvanized and aluminum surfaces. Scrub the etched surface with a Scotch-brite pad and neutralize with boiling water. The result will be a matte white finish.

To insure greater integrity of your rivet line, you may wish to use countersunk rivets. The dimple adds depth to the rivet line, making it stiffer without increasing its weight. The 120 degree dies you need for poppers are available from Airparts in Kansas City (www.airpartsinc.com) for about six dollars. And from other folks, too. The dies are used with your regular pop-rivet gun. Of course, if you have a lathe it takes only a few minutes to make such a set of dies and even un-hardened they'll last for several plane's-worth of dimples.

If you've never used flush-head poppers, run a few rows of sets before tackling the tank. The dimpling process *enlarges* the hole. The geometry here is subtle so be cool, work at the pilot-hole level, opening up the hole to rivet-size *after* you've dimpled & fitted the row. If you don't, the rivet will be too loose to pop; it'll just pull out. Be *very* careful when deburring as you'll be working on a corner instead of a flat. A file may be a better choice than a regular deburring tool. (These factors have probably contributed to the Conventional Wisdom that sez flush-head poppers don't work very well. They work just fine, but only when they fit the hole.)

With a pitch of about an inch, aluminum poppers provide more than adequate strength

for this application. Indeed, the stiffness of steel flush-head poppers dictates a minimum metal-depth of about forty thou. Anything thinner and you're liable to pull the popper through the hole before it can form a large enough shop-head to snap the mandrel.

You can buy flush-head aluminum poppers from J.C.Whitney in boxes of 500 for about $12. (JCW item# 14xx4090A, box of 500, $12.19) The short ones do fine for this type of job.

As with all poppers, be sure to wash them good in MEK prior to use. The manufacture of pop rivets always leaves some amount of lubricant on the finished product. That tiny trace of oil will interfere with the adhesion of the sealant (and of your zinc chromate, when using steel poppers on your other panels).

Steel poppers may be a wiser choice for attaching the flanged aluminum fitting for the tank's outlet. You may of course use steel button-head poppers for the entire tank if you wish. I like the flush-head aluminum jobbies for the seam-lines because they give me a stiffer joint at less weight.

If you prefer to use solid rivets you'll need to provide access for bucking the things. Wag Aero still sells sealed blind-nuts for a reasonable price (Cat# L-676-000 Pkg of 50 for $10.95) Sealed blind nuts are standard for fuel tanks. The threads of the screw are sealed away from the contents of the tank inside a little dome. Slosh the tank, you can still remove the access panel.

Tanks tend to violate the rule for panel size vs edge support so you'll probably want to pound an ‘X' bead into the four sides and the bottom. If the top of the tank is curved it will already be stiff enough but the sides & bottom will tend to be pretty wimpy, especially if you're using soft aluminum. (Almost anything will do for making a tank. Don't tell anyone but I've made tanks out of siding aluminum.)

If you don't understand what I'm talking about here, take a look at a steel Jerry can. Some guys like to roll such flutes into the panel but you can do perfectly well by making up a suitable groove or gap in a board, laying the panel across it and making several light passes along the groove with your rubber mallet.

Fuel tank is usually an irregular box. Occasionally an irregular cylinder. Cylinders support themselves but boxes don't. If the thing has corners, plan on adding a couple of baffles, not only to control the slosh but to stiffen the structure.

Rivet-on flanges for the filler and outlet are available from aircraft suppliers but since they are simple turnings they are easy enough to make if you have a lathe. And even if you don't. There are thousands of hobby-machinists on the Internet, their weapon of choice a little 7x10 lathe that's plenty big enough to whip out a set of fuel tank fittings.

To track down such folks just go to the appropriate Newsgroup – rec.crafts.metalworking is but one of dozens of such groups – post a message having ‘Help!' as the subject line, describe the job and tell them where you're located. The squeaking wheel gets the grease - keep shouting until you connect with someone in your area. Like all machinists - which is what these folks are... the size of the machine has nothing to do with it - he'll need an accurately dimensioned drawing to work from and you'll probably need to provide him with the stock. Applying sealants is messy as hell, especially Pro-Seal and the other polysulfides. Masking off the area to be sealed/riveted will help and you might want to consider PK's instead of clecos. Polysulfide sealant is close to the perfect adhesive, it'll stick to *anything*... and doesn't like to come off. (For dimpled holes you'll need the longer (ie, 3/8") PK's.) Grubby-up a PK, throw it away. You're out maybe two cents.

Give the surface to be sealed a final wipe-down with MEK (or whatever solvent is recommended for you sealant). Allow it to evaporate. Apply the sealant according to the instructions. Most call for a smooth, uniform coating on both surfaces. Not too thick, a few thousandths is all you'll need if your rivet-line is a good fit. And not too wide, about three-quarter of an inch, max. Most of this stuff cures by reaction with water vapor in the air, something present everywhere on our particular planet. Cure time is a function of the width of the sealant-line and the humidity in the air. (That's why the stuff is so popular with boaters – it cures underwater faster than out of it.) The two-part formulation cures faster than the no-mix stuff.

You only need about three ounces of sealant for a ten gallon tank, most of which will go on the flanges, your tools and your clothes. (If you've never used Pro-Seal before, buy a pint :-)

If you use the 2oz kits, the little tubes can be hard to handle without the matching gun, a $75 item. (Aircraft certified, right? :-) A dime's worth of Bondo will allow you to modify a regular calking gun to accept the 2oz aircraft-certified cartridges. If you want to go that route, I'll tell you how to make an adapter.

Aircraft Spruce also lists the stuff in pints [$37] and quarts [$74] but the secret to using bulk-packaged sealants is how to mix & apply the stuff without gluing yourself to the wall. The usual mix ratio is 10:1 and is fairly critical. The use of a ratio'd balance beam, baggies for one component and a Teflon cup for the other is a fairly common procedure. Once you've balanced the beam, pour the One-stuff from the Teflon cup into the Ten-stuff in the plastic baggie then seal up the baggie and mix the stuff by squishing the baggie, like colorizing oleomargarine in days of yore. (That's my yore, not your yore.) Once the color is uniform, snip a corner of the baggie and squeeze the stuff out like decorating a cake, using a scrap of metal as a palette knife to smooth the bead to a uniform thickness across the bond line.

Standard practice when using poppers with a sealed structure is to dip the degreased popper in the sealant just before you stick it in the hole and give it a little twist. Don't get too far ahead with the sticking & twisting before coming back and doing the popping. The structure should be perfectly secured with a PK in about every fourth hole giving you three poppers in a row. When you pop, always do the middle one first. Once it's popped some guys butter a smear of sealant into the mandrel hole but it's not necessary if you're going to slosh the tank.

After your tank is fabricated leave it alone for about three days, until the sealant is cured. After it has cured you can provide yourself with virtual 100% leak-free assurance by sloshing the tank with a PVA fuel tank sealant. J. C. Whitney will sell you a quart of the stuff for about thirty bucks. You need less than a pint but I haven't found anyone who'll sell me that small a quantity. As with the polysulfides, there are only a few companies that make fuel tank sealants and most use functionally identical formulations. The thirty dollar stuff from J.C.Whitney appears to be the same as the hundred dollar stuff with ‘aircraft-certified' on the label. Maybe it's not but it works the same.

Since your tank was already etched, the sloshing sealant is going to form a perfect bond. Plug the outlet, pour in the sloshing sealant (it's a creamy white stuff; the vehicle is MEK) seal up the inlet (I use a hose clamp and piece of inner tube) then commence rolling the tank over and around and up and down... but in a logical fashion. What you want to do is to flow the sloshing sealer over every part of the interior surface.

After sloshing the tank, drain the sealant back into its can and seal it up good. Remove whatever is plugging the drain so air can circulate through the tank, prop it so it can drip out then leave the thing to cure.

Takes about 24 hours.

When it's cured, get your light wand and your bore scope and whatever else you need and inspect the interior surface. It should have a uniform white coating.

The sealant is a form of PVA – polyvinylalcohol. Once cured, it is impervious to virtually all solvents, including gasoline, alcohol and water. I've used the J.C.Whitney stuff on steel, aluminum and fiberglas with excellent results (JCW "Alcohol resistant Gas Tank Sealer" item# 12xx8316Y each $28.99). How well it works depends largely on how well you've prepped the surface. Basic rule is to have it perfectly free of grease, including fingerprints. For aluminum, you need to provide some ‘tooth' to the surface, which is accomplished by the etchant (ie, the Prep & Primer stuff).

Lots of ‘expert' homebuilders damn such tanks with faint praise. Sure it works... but real fuel tanks are always welded, yadayadayada... Sure they are, Mr. Expert. (I invite those

experts to join me at FlaBob as we refurbish a P-51... and its riveted, sealed and sloshed fuel tanks.)

Your fuel system should have a strainer in the tank. Smartest one you can get is to ***MAKE YOUR OWN*** using a short length of 3003 aluminum tubing, slit about every quarter inch with a hobby saw. The typical hobby saw leaves a kerf about .028" wide, much smaller than the mesh of a cheap finger strainer. Cut enough slots to insure the thing will flow enough fuel.

The tank should be equipped with a shut-off valve. See the Northern Hydraulics catalog. Go to the same source for your gascolator. It ain't aviation-certified but it works and doesn't cost the earth.

Basic fuel tank plumbing is to keep a constant down-ward flow of fairly large diameter tubing from the tank to the gascolator. The idea here is that anything large enough to get through the strainer in the tank will *not* block the fuel line but will simply end up in the gascolator.

If you're flying a VW, a primer makes for easier starting. Since you hand-prop real engines, put the primer near the gascolator; no need to put any more fuel in the fuselage than absolutely necessary. Great Plains sells a good primer at a fair price.

For lo-buck builders, riveted, sealed and sloshed fuel tanks are a practical alternative to other methods of fabrication, their use so common we tend to forget others may not have heard of them.

-R.S.Hoover