Shay Tanks
Part II - Water Tank & Finishing Both Tanks

Nelson Riedel Nelson@NelsonsLocomotive.com

Initial: 7/18/03 Last Revised: 09/23/2005

The basic fuel tank was fabricated in Part I. The outer top and a finishing strip around the upper edge, fill hole and outlet pipe are required to complete that tank. Rather than finish the fuel tank I decided to bring the water tank to the same point as fuel tank and then finish both.

Water Tank: I already had a good start on the water tank because all the holes in the end pieces had been drilled using the fuel tank end piece as a drilling template. The next step was to drill the holes in the side pieces. Since the two sides are identical, they were tack soldered together so that all the holes could be drilled at the same time. It turned out that one side was slightly taller than the other so that after the two were soldered together, the edge of the high one was was filed down until both were equal height.

The hole drilling went pretty well and was completed in a couple hours with only a couple broken bits. It's a good idea to get a dozen 1/16" bits for this project. Once the holes are drilled it's back to the drill press to remove the burr on the exit side of each hole. I used a 1/4" counter sink for the deburring job. After using the counter sink a sharp wood chisel was run over the plate to removal any remaining small burrs.

The next step was to install the upper and lower rows of decorative rivets on the four panels. On the fuel tank I slipped the rivets into position, soldered them and then flattened the ends. This time I tried something different ---- inserted the rivets, cut them off as short as possible and then flattened the ends with a hammer. I hold the punch with the recess for the head in a vise pointing up, position the rivet head in the punch and use a small hammer to pound on the end of rivet shank to flatten it. One of the problems I found was that it's difficult to hit only one rivet with the hammer --- the 0.2" spacing is too close. (If an adjacent rivet is struck, it'll likely be knocked out.) This problem was solved by inserting every other rivet --- it was then easy hit only one rivet at a time. Once the first set of rivets were flattened, the remaining holes were filled and rivets flattened with out interference to or from the set already flattened.

Most the rivets on the fuel tank were a loose fit in the 1/16" holes. Some of the holes on the end plates that I drilled were such that the rivets were also a loose fit. This caused a problem if a couple dozen rivets were inserted and then the plate turned upside down to cut off and flatten the rivets --- the rivets fall out. This was solved by covering the heads with masking tape and then peeling the tape back one rivet at a time to put the head in the punch.

Most the rivet holes on the water tank were slightly smaller and the rivets had to be driven into the holes. The photo shows a set of rivet being installed. The needle nose pliers hold the rivets which are tapped with hammer. After a few rivets are partially inserted, the punch (on table to right) is used to drive the rivets all the way in. The plate is then turned over and the rivet shanks cut as short as possible with diagonal cutters. Then the punch is secured in vise pointing up, each rivet head is placed on punch (head down) and the end of the rivet is flattened with hammer. After the shanks are flattened, the same procedure is used for the missing rivets between those already installed.

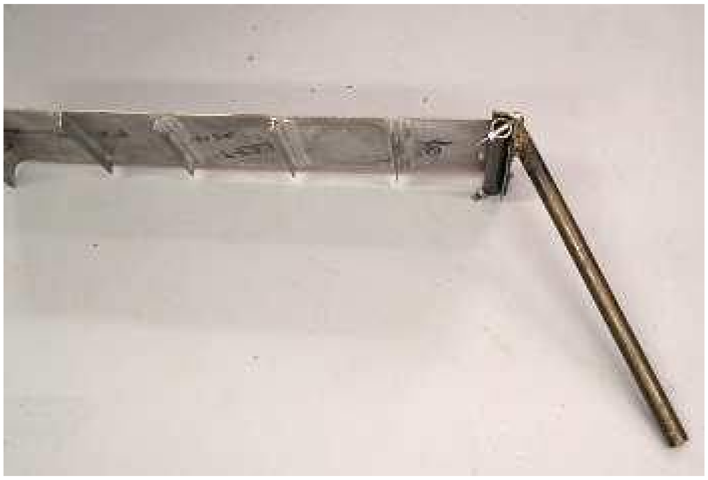
OK, why didn't I buy shorter rivets so I didn't have to cut them off? The real reason is that I wanted to buy only one size and I thought I needed the 1/8" to join two plates. However, if one has to dive in the rivets as shown above, anything shorter than 1/8" is probably too short to grasp with the needle nose pliers. In fact, the 1/8" is really too short to join the two .055" thick plates because it leaves only about 0.015" for clinching. Hanson Rivet suggest 0.062" clinching allowance for 1/16" rivets. The length seemed to work fine for me and since I ended up soldering everything, I doubt if they're be any problem.

Another question --- why didn't I drill the holes slight larger so that I would need to drive the rivet in? Turns out the next size number drill made the holes sloppy. I was very happy with the results with driving them in, even if it did take a bit more effort.

Some 600 rivets later the top and bottom rows (except at the corners) were all in place and flattened. The reinforcing angles were then cut, clamped to the sides or ends and the sides or ends used as templates to drill the

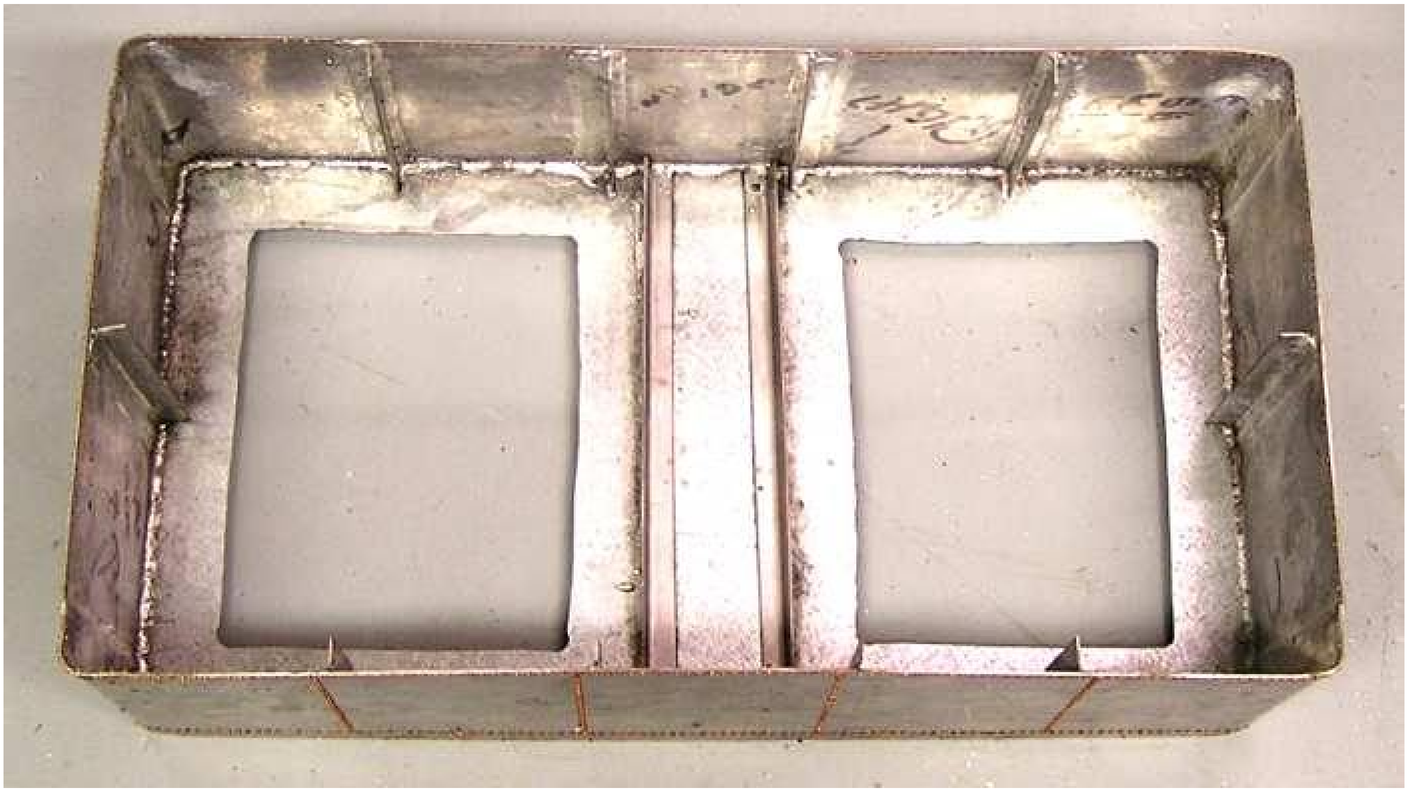
14 rivet holes for each angle. The angles were then riveted in place and soldered. The photos above show the four water tank panels at this point. The markings on the inside of the panels in the right photo are to help me match the sides and end panels.

There is a small amount of spring back after the bending tool is released so a handle was added to the angel to force a slight additional bend. If the angle is too great, the top and bottom will push the sides out and make the tank straight. On the other hand, it's nearly impossible to pull the sides in if the bend is less than 90 degrees. When making the last bend the threads stripped on one of the bolts. I put a stack of washers under a new nut --- the washers moving the nut out to good threads. Then the bolt broke. Fortunately, the stub was long enough so that new nut and fewer washers could be used. Next time need bigger bolts or thinner steel.



The ends were attached to the sides with a few #0 screws and then the rivets in the seams joining the ends and sides were installed. A half dozen rivets were done at each end of each of the seams joining the ends to the sides. The area near these rivets were then spot soldered. This was repeated this until all four seams were done. This provided stability to the unit. The remaining rivets were then installed in the seams, the seams soldered with the iron and then heated with the torch to get good flow into the seam. Next, the bends were modified at a couple of the corners by pounding on a block of steel placed on the panels so as not to ding them. This corrected the angles to 90 degrees. Next one corner was pressed to bring shape from a parallelogram into a rectangle. The width of the tank is 12 3/16", a bit wider than planned but OK since the floor is 12 7/16", slightly over the 12 3/8" specification. The length is 22 3/4", right on specification. Next time I'll move the bend lines out 1/16" on each end and cut the sides about 1/8" shorter. The final step was to install the missing rivets in the top and bottom rows at the bends.

The top and bottom were next. There will be two tops like with the fuel tank: the lower top soldered in and the upper finished top secured with a few screws. Large holes were cut in the lower top for access to the tank. Angles were riveted and soldered to the center of the lower top for additional support. The holes were cut with a saber saw --- and a little rough.



The inner top was installed first so that there was easy access to the under side for soldering. The iron was used first and care was taken to make sure solder flowed onto both the top and sides. The joint was then carefully heated the joint with the propane torch so that the solder just started to flow. This smoothed the surface of the solder and also caused it to flow into the joint. Some solder did flow through and stuck to the sides just above the top. This solder was easily removed with a burr in the Dremel running at a relatively slow speed.

The bottom was then carefully fitted with the smallest possible gaps. The tank was positioned bottom up, the sides clamped in where necessary and the bottom was then spot soldered a half dozen or so places to hold the bottom and sides in position. The tank was then turned over and positioned on a flat piece of particle board for soldering. The seams were fluxed and then soldered with the iron. The iron makes it possible to get some solder up on the sides and coat the stubs of the lower row of rivets. Next, the seam and just applied solder was fluxed again and then carefully heated with the propane torch. This caused the solder to flow into the seam and also smooth the surface of the solder. The second fluxing assured that the solder would flow into any uncoated surface. The next step was to test for leaks. There were two small leaks; one in a corner and and the other in the middle of one end. More flux, a little solder with the iron, more flux and a quick heat with the torch fixed them.

Upper Top - Both Tanks: The next task was to make the upper or finished tops. The tops were made such that there is a gap of about 0.025" on all sides. This should permit the top to be removed and reinstalled without scratching the paint. The photos show doing the fuel tank top.

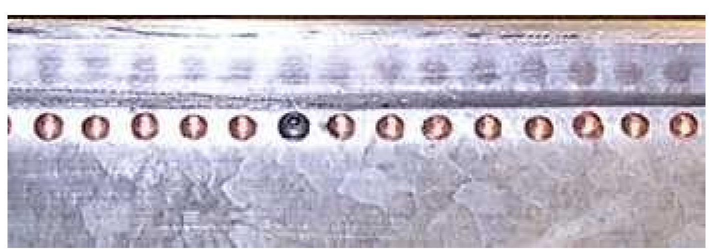
After the piece was cut, all edges were rounded and smoothed with a file. Next, the holes were made for the rivet detail using the same drilling fixture as used for the lower row of rivets on the sides (0.2" spacing). The holes for the corners were marked off by hand and center punched before drilling. The black marks in the photo are a reminder to not put rivets in those holes, screws will go in those holes. The holes were drilled and then a countersink used on the under side to both deburr the holes and make room for the flattened rivet end. The photo shows the setup used to start the rivets in the holes.

This photo shows driving the rivets all the way in. After the countersinking operation described above, the 1/16" drill was run through the holes again to remove the slight burr left by the countersink. Even with drilling the second time, the rivets are still a snug fit.

The panel is then turned over and the rivet head positioned in the punch and the end flattened with a hammer as shown on the right. With the counter sunk holes, the flattened rivet is nearly flush with the top. After the every other rivets were flattened, the rivets in-between were installed and flattened. This every other one scheme worked well with the poorly directed too fat hammer. Why didn't I use a smaller hammer? It would have been too light to effective smash the rivet ---

if I could hit it.

The top was then positioned with equal gaps on all sides as shown in photo. The packing is double strips of #80 garnet paper --- the thing most handy in the workshop. After the top was centered the 6 holes for the attachment screws were drilled and tapped for #1-72 button head cap screws.



This photo shows one of the button head cap screws that secure the top. The initial plan was to use #0-80 screws but they turned out to be too small. As you can see, the #1 screw is a close match to the 1/16" rivets.

This same process as described above was used to fabricate the water tank upper top.

Tender Floor: It was necessary to soft solder a 1/8" square CRS square trim strip to the underside of the outer edges of the floor tender before the tank could be

mounted. The floor is hot rolled steel that has a black coating , I think it's scale from the rolling process. This coating must be removed for the solder to stick. I ended up sanding the surface with 50 grit paper. The floor side of the joint was then center punched every inch or so. The punch mark dimples the surface slightly and provides clearance for the solder to flow into the joint. The mating surfaces were then cleaned with lacquer thinner to remove any oil or grease and the pieces clamped together as shown on the right. Flux was then brushed on the inside of the joint seam. The joint was heated from the underside and solder applied to the inside seam. The solder flowed into the seam in most places. More flux was brushed on and the piece heated again so that the solder would flow into the reaming parts of the joint.

Excess solder that flowed to the outside of the joint was filed off after everything cooled.

That's the top of the tender floor. It's attached to the outer frame channels with three 6-23 flat head screws on each side. The four smaller holes near the middle on the right are for the heads of the bolts that hold the hand pump. The two larger holes are for the outlet pipes.

That's the underside of the front of the water tank. The four small screws (6-32 stainless hex head) attach the hand pump. There is a stainless steel flat washer and neoprene washer under each head. The brass fittings are 1/8" NPT on the tank side and 1/4" tubing compression on the output side. There is a stainless washer and neoprene washer on each of these fittings too. The neoprene washers obtained from the local hardware store are to make a water tight seal.

This shows the inside front of the water tank with the hand pump in position. The small hex head screws (6-32 with stainless flat washer and neoprene washer) secure the tank to the floor. The large brass nut on the left is threaded 1/8" NPT and holds the low pressure outlet that will connect to the axel pump. (These nuts are available from McMaster - Carr.) The right fitting is identical except the inside of the fitting is threaded MTP 1/4"- 40. The end of the copper tube from the pump is also threaded MTP 1/4"-40 and screws into the outlet fitting.

Water Tank Fill Hatch: The water tank fill hatch was the next part. The hatch was made first and then the hole was cut in the top to match the hatch. First step was to measure the throw of the hand pump handle and make sure hatch was long enough. The pipe nipple used to form the bend is 1.35" OD. The strip is 1" wide and of same material as tank sides.

After getting the shape of the band correct, a 1/2" wide strip was clamped under the seam and the seam and strip soft soldered together.

Next. the strip and band were riveted together to make sure everything held together when the hatch was later soldered into the top.

Small brass hinges from the local hardware store were modified by removing the pin and reversing one side. This will allow the hinge to be hidden. The longer leg was also cut down to the same size as the shorter leg.

The top edge of the band was notched to so that the hinge is flush with the top. The hinge was attached with #0-80 button head cap screws. Notice the extra holes below the right hinge. Those are a mistake but will be under the top so no damage.

Next, the cover was cut slightly bigger than the band and fastened to the hinges.

The hole was then cut in tank upper top to match the band

The band was soldered to the top from the underside using soldering iron.

Finished hatch

Bead: The upper outside edges of the tanks are finished with a 1/4" X 1/8" half round bead. Four 3 ft lengths were purchased from Special Shapes. The fuel tank was done first since it is smaller and hopefully easier to learn with. The first step was to bend the half round in the shape of the tank. The areas to be bent were heated red hot and then quenched in cold water. The bead was then soft and easy to bend but hardened when worked so repeat heating was required. After the piece was in the correct shape the corners were heated and quenched again so it would be easy to modify the shape slighted when soldering on tank.

An area of the bead was clamped and the parts between the clamps soldered using the iron working from the top edge. The area was fluxed before soldering. The brass is a good conductor so it's possible to get the solder to flow the full width of the bead. After a section was soldered it was allowed to cool and then the tinned soldering iron was moved quickly over the edge and solder built up to a peak much like one would do on an auto body with body filler. After a section was soldered, the clamps were moved and the area previously under the clamps soldered. The perimeter of the tank was about 3 inches longer the a piece of bead so a small second piece was installed after soldering of the long piece was completed.

There was an excess of solder on the top seam after the soldering was completed. Most of this was removed by sanding with 80 grit paper wrapped around a 10 inch file. The sandpaper will cut the soft solder without damaging the brass or steel. A couple areas had indentions which were filled with solder again and then sanded again.

The final finish was made with 220 emery cloth (Note: This soft solder will quickly fill and ruin a file.)

That's the finished fuel tank on the right.

Fuel Tank Hatch: I wanted a fuel tank hatch that seals to keep the smelly fuel oil from splashing out. That's a standard 3/4" hex pipe cap with a small vent hole drilled in the center. The part mounted in the tank top is a 3/4" to 1/2" brass pipe bushing. The inside of the bushing was bored and the outside of the was turned smooth near the hex head. A small brass adaptor was fabricated using 1.375" brass bar stock. The inside was bored to mate with the bushing (~1.025"). A 1.187" step was turned in the outside to just clear the 1 3/16" hole punched in the top. (The punch was from my youth --- used to punch chassis holes for octal vacuum tube sockets.)

The bead was added to the water tank using the same process as used for the bead on the fuel tank. There are still a few things required such as the ladder, light and sand storage tanks for the water tank and the fuel tank must still be mounted to the cab floor. I'm leaving those till later. The following photo shows the tanks at this point.

Update- Baffle & Overflow: Several folks had questioned whether a baffle is required. The prototype has baffles for stability. I added one baffle in the middle of the water tank. It is attached to the side angles with a screw/nut on each side. There is a 1/4" gap at top and bottom.

Friend Dan Staron suggested an overflow to keep engineer's cushion dry if the tank is overfilled. I used an old piece of 3/4" copper pipe with male NPT adaptor on the end. A mating female adaptor was used as a nut on the under side. Photo on right shows baffle and overflow.

Update-Top Gasket: One inch wide strips of 1/16" cork were used as a top sealing gasket. The strips were cemented to the tops using a Permatex spray gasket cement. The red stuff in the photo is the Permatex.

Hindsight: Recall that I used material considerably thicker than suggested by Kenneth. The resulting tanks are very strong --- like a tank (armored vehicle). They are really heavy too. If I had it to do over I'd make the sides a few gauges thinner to ease the bending. It wouldn't hurt to make the top and bottom closer to Kenneth's recommendation either.

Update 3/29/04- Lower Outputs: I had the tender torn apart to mount some electrical items and decided to make a few modifications. Initially, the water outputs were via 1/8" pipe to 1/4" tube adaptors in the tank bottom. There are short pieces of tube and a compression nut on the end of the hoses. It was difficult to connect the hoses because the compression fittings were between frame members. The adaptors were lowered by installing a 1/8" coupling between each adaptor and the tank bottom. The photo of the tank blocked up from the tender floor shows the lowered adaptors.

Drain Valve: A drain valve was installed in the left front corner. The initial plan was to drain the tank by disconnecting the low pressure feed pipe. That however turned out to be inconvenient. The valve is a 1/4" pipe ball valve. There is a 1/4" to 1/8" reducing bushing and a 1/8" nipple at the upper end of the valve. The hole in the valve is smaller than the ID of 1/8" pipe so will probably replace this valve with one with a larger opening. The photo shows the drain valve. That's the coil used to relight the oil burner and the electrical switch panel underneath the right front of the tender.

Screen: After the tender was put back together the water pipes and pumps were checked for leaks. The axel pump didn't work right --- it wouldn't pump against any back pressure. Suspected a leaking valve so removed the pump valve assembly and found the little piece of copper at the top of the photo. It appears to be a chip pushed out of a hole ahead of a dull 1/8" drill.

A screen on the input to the axel and steam pumps seemed appropriate to prevent a reoccurrence. I had some old float valves from Triumph roadster carburetors shown in the middle of the photo. Pulled the screen off the valve and soldered it to a short length of 1/4" tube as shown in the lower part of the photo.

The tube slides into the output nipple in the tank floor as shown on the right. The tube is a loose fit but the screen is a larger diameter that keeps it from falling into the nipple. Some Permatex No 2 sealer was put on the tube to hold it in place. Nothing was done on the hand pump at this point.

Guess there is a lesson here ---- try to keep debris out of the tank.

Update 9/23/05: Quick Connect fittings were installed on the output water lines. See More Improvements.
End Update.

Shay Home

NLW Home