Get More Cooling Capacity From Your Radiator

By Phyllis Ridings-Murawski and Bud Warren

Just about anywhere there is a spirited conversation between auto engine enthusiasts, the topic will usually come around to water-cooled engines and how to accomplish the most efficient cooling through the radiator. Philosophies on automobile-engine conversions for aircraft can differ so much from race car engines that there is typically not a great deal that is useful from the drag strip days that would translate well when applied to aviation use; however, one of the tricks in Bud Warren's tool kit (from his old racing days) that is highly appropriate for use in aircraft is to modify the radiator in a way that can dramatically increase its cooling capacity. The old-timers refer to this customized radiator as a "three-pass" radiator, since the water in the cooling tubes will make three passes through the core, instead of one, after the modification is completed.

HOW IT'S DONE

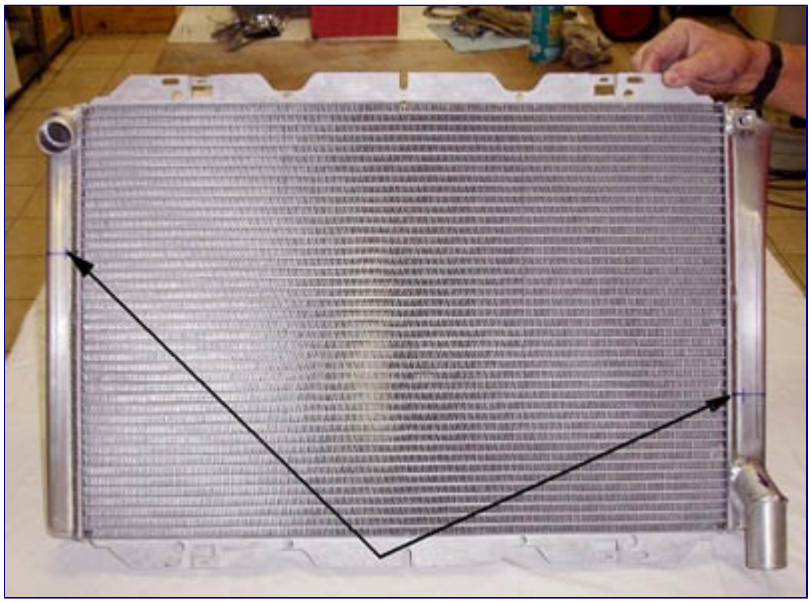
For this illustration we are using a new, all-aluminum, Chevrolet-style cross-flow radiator measuring 31 inches wide by 19 inches high by 3 inches thick, which can be purchased for around $200 from a racing speed shop. Two good online sources for off-the-shelf aluminum radiators suitable for this modification are StockCarParts.com and SummitRacing.com. Two-pass radiators can be purchased off-the-shelf, but you can achieve superior cooling by modifying your own stock radiator to a three-pass by following this procedure. So if you have access to a shop, are fairly handy, and are a pretty good aluminum welder or have a buddy who is, you can save money by doing the modifications yourself.

To understand the process, consider that prior to these modifications, water will enter the radiator through the inlet, trickle down into the water reservoir on the inlet side, and make its way rather passively (but still under pressure from the water pump) across the core and into the water reservoir on the outlet side of the radiator.

Our objective with this modification is to cause as much of the water as we can to route purposefully through specific sections of the radiator core once, twice, then a third time before it exits the outlet and back into the engine. The theory is that more of the water will spend more time in the core, which will exponentially increase cooling capacity. It is important to understand that when making this modification, a larger than normal radiator is needed, as this modification will add coolant flow restriction.

GETTING STARTED

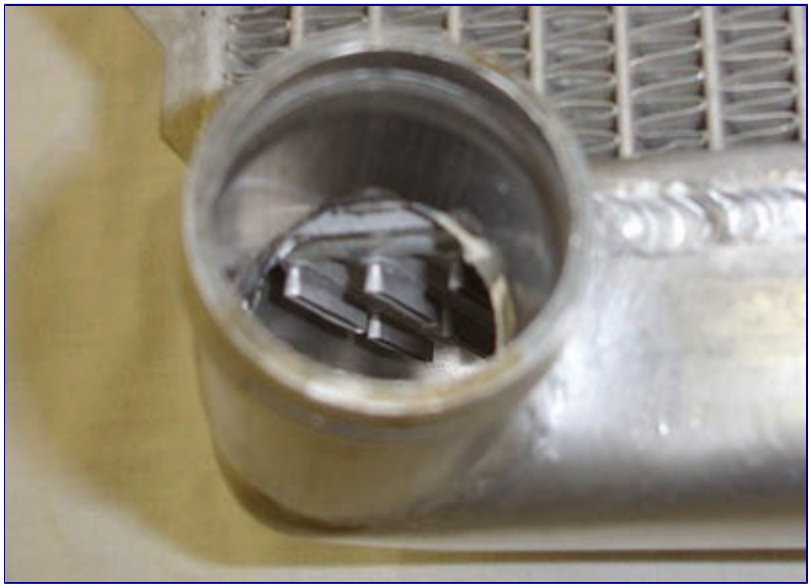
To create your own three-pass radiator, you will need to install two small baffles into the water tanks: one in the inlet side and one in the outlet side. To start, count the cooling tubes in your radiator, marking the sections into thirds. Mark your first cut at one-third of the way below the inlet and the second cut at one-third above the outlet.



The “before” shot, with the tanks marked for cutting. Larger view

CUTTING THE TANK

Use a square to keep your marks straight across the three sides of the tank and centered between the tubes to avoid placing a baffle in the middle of a cooling tube. Next, cross your mark approximately 1/4 inch to 3/8 inch from the weld on either side of the tank to indicate where your cut is to end. You will not cut all the way to the weld or through it.



The inside of both tanks is composed of a series of diagonal, rectangular tubes that allow the flow of coolant from one side of the radiator to the other. Larger view

Using a cutoff tool with an aluminum oxide wheel, start on one side and cut a straight line through the radius of the edge of the tank, remembering to stop at your crossed mark.



Larger view

Flip the radiator and then cut the other side, matching the slots you have cut across the width of the tank. Now you have a rather rough slot cut in the tank, so use a hacksaw blade or other tool to remove burrs. Repeat the process on the other side of the radiator at the remaining location that you have marked.

Note that if your radiator has its inlet and outlet on the same tank, you will be able to divide it only once, making it a two-pass instead of three-pass radiator. In this case, you will divide the cooling tubes in half and install only one baffle in the tank, which is still very much worth doing to gain cooling capacity.

Once you have finished your cuts, wipe any remaining ink marks off the radiator with paint thinner or any other non-oily cleaner. Do not use solvent or Varsol™ since it will contaminate the aluminum and will not weld properly. Use a Scotch-Brite™ wheel to dress and smooth the slots and prepare them for welding.

MAKING THE BAFFLES

Pre-fit a thin piece of rigid cardboard to the slot in the tank, fitting the depth first. You will need to notch both interior corners of the pattern for the baffle so that the notched areas will clear the weld on the inside of the tank.



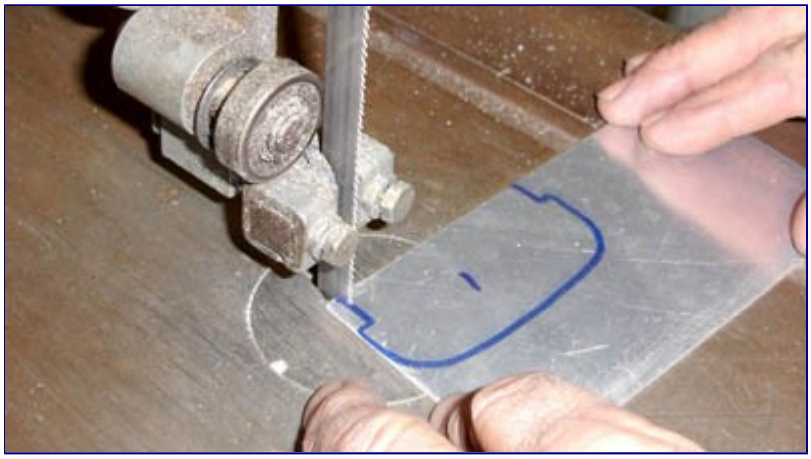
Larger view

Fit it so that the inside of the pattern fits flush with the inside of the tank. Since you will not be able to weld the baffle inside the tank, the better the fit the lower the incidence of water leaking past the baffle and the more the water will route where you want it to go. Next, mark the outside of the pattern about 1/8 inch larger than the actual tank outside dimension for easier handling of the aluminum baffle as you are welding it in place.



Larger view

You will need to cut a pattern for each slot, since each side of the radiator will be slightly different. Use 0.060 aluminum in 3003, 5005, or 6061, but do not use 2024 as it will not weld. You can use thicker material for the baffles if you like, as long as it fits in the slot.



Larger view

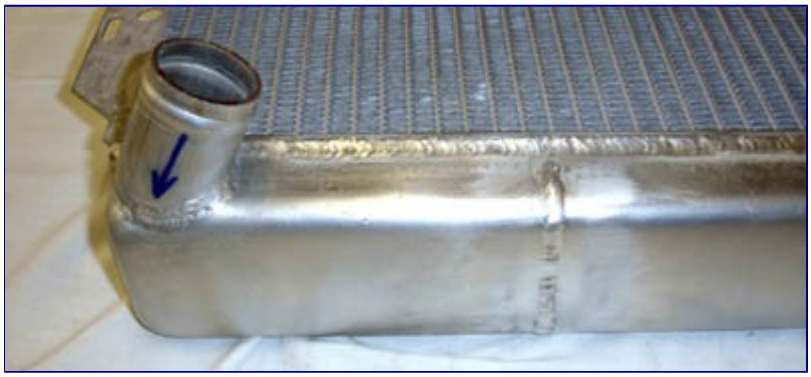
As you are welding, incorporate that 1/8-inch excess material into the bead as filler. You might want to practice on some scrap aluminum to be sure you get the temperature right before you weld the radiator.



Larger view

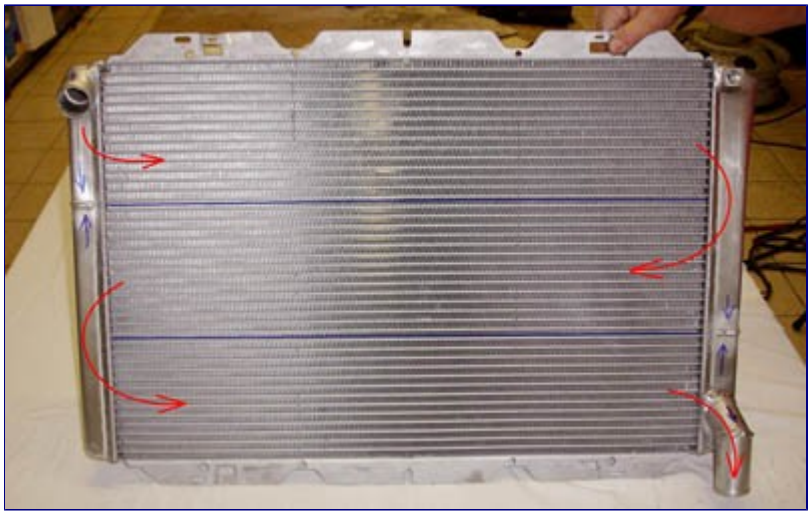
Be sure to weld from one side of the tank to just across the radius of the tank, then stop, flip the radiator over,

and weld from the direction of the tank weld again outward across the radius, then match the two beads in the middle. This will help to avoid distorting the tank or having it draw up in one direction. While welding, keep a nice tight bead and continually watch for pinholes and resolve them as you weld to avoid leaks later.



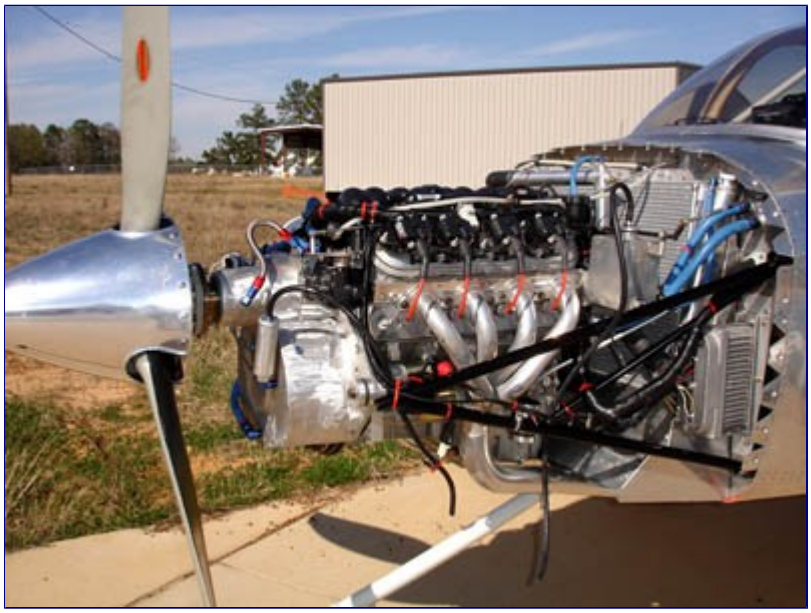
Use a soft wire brush to clean and check the weld. Larger view

Dress your welds with a small brass or stainless steel wire brush and inspect for pinholes and your project is finished. You now have a radiator that should dramatically increase your capacity to cool that auto engine in your airplane! In the early stages of testing our V-8 Chevy engine and the Geared Drives prop speed reduction unit (PSRU), we initially had a lot of engine cooling problems. We tried all kinds of double-core radiators, two-radiator configurations, electric cooling fans, you name it. After much frustration and heading back to the drawing board multiple times, we found the combination that worked the best for us with our water-cooled engines. We now experience ideal engine water temperatures in our aircraft using this radiator modification—without the use of any cooling fans.



Larger view

If you are experiencing engine water temperatures that are above the ideal, try making this modification to your radiator. If your engine water temperature continues to indicate higher than you would like, you may want to evaluate whether or not there is adequate fresh air circulating into your cowling and across the cooling fins of the radiator. By the way, we recommend that you do not use a thermostat in your airplane engine. Take the outer ring off the thermostat and place it back into the housing to slow the water flow, but throw the center of the thermostat away. Good luck with your radiator project, and thanks for letting us share one of our favorite tricks with you.



The finished product installed in one of Bud Warren's RV-10 firewall forward packages. Look for Bud, Phyllis, and the rest of the Geared Drives gang (including the pictured RV-10) at EAA AirVenture Oshkosh '09. Larger view