Cheap and Easy Pistons For Dummies

by Chan Stevens

As a newbie to competition, I noticed as I started venturing out beyond the more casual local/open meet circuit into regionals and (gasp) NARAM that the more serious competitors were typically using pistons. From a performance perspective, suffice it to say that there was a significant gap, and that my fanny was getting whupped. After my first NARAM, I spent the next couple of years figuring out how to close that gap.

A Cheap and Easy Piston ready for launch. The igniter leads are bent to extend out of the top of the piston tube for simple hookup.

Pistons, though, proved to be something I simply could not figure out. After a couple of years of poking through various R&D reports, as well as lots of dialog with fellow competitors at meets, I think I have finally managed to make a piston that is reliable, simple, and offers consistently superior performance. I'm not claiming anything here that is innovative or pioneering. In fact, the opposite is true—I am stealing shamelessly from much savvier rocketeers such as Peter and Bob Alway and members of Laünch Crüe (especially Chad Ring, Don Fent, Jim Stum, John Buckley, et al.). The concept of paying forward still dominates our hobby, and these folks have been kind enough to help me improve, even when it was clear that I might be in direct competition with them often in the same meet.

The type of piston described in this article is known as a zero volume piston launcher. It is available in kit form from Quality Competition Rocketry at http://www.cybertravelog.com/qcr/index.html. The kit consists of a piston rod, a piston head, some sort of centering ring "stop" or block, and an outer piston tube. Typically the piston rod is anchored to a launch rod or fixed stand. The piston tube is sized for the motor, meaning an 18mm motor would use a BT-20 piston tube. The rocket motor slips into the end of the piston tube. The igniter leads slip out over the top of the piston tube. When the motor lights, the gasses try to build pressure, but the sliding piston allows for a volume expansion instead. As the tube slides all the way up, the centering ring/stop catches on the bottom of the piston head, and the tube stops traveling. Since the volume can no longer expand, pressure builds up. In the next split second, the continued increase in pressure, plus the momentum of the rocket-plus-motor climbing vs. the now-stopped piston tube will cause the rocket to break free from the piston tube. See figure 1.

This approach offers a few advantages over regular flight. First, you can usually avoid launch lugs, as there are generally either fingers along the piston tube acting like a mini tower, or you get enough velocity while on the piston that the rocket is stable at separation. Second, by containing the gasses in the piston tube, you're wasting less of the motor's energy compared with flying off a blast deflector. Of course, this approach also has disadvantages. The separation from the piston tube can be clumsy, costing momentum and in some cases resulting in non-vertical trajectory (called tip-off). Also, especially if using guide fingers, the motor is initially lifting more weight than just the rocket—you're pulling along the piston tube as well as launch wires.

In my experience, this method boils down to an art form, trying to get the friction fit in the piston tube "just right." Too tight and you get little or no extra boost. Too loose results in non-vertical tip-off and you get little or no piston benefit. It can be a frustrating and steep learning curve, and performance is far from consistent.

In 1986, Jeff Vincent and Chuck Weiss introduced a method referred to as a "floating head piston." It works essentially the same as the zero volume piston method, but in this case the piston head is not attached to the piston rod. When the stop inside the bottom end of the piston tube hits the piston head, the piston tube continues to travel upward from the momentum, and ends up rising up and off the rod. The pressure continues to build inside the piston tube, though, and the rocket separates. See figure 2.

The floating head piston specifically addresses the issue of momentum loss in the regular zero volume piston, and it is less prone to tip-off. There is still the issue of having to get the right friction fit, but this is much less critical now as there is no deceleration from stopping the piston tube, so separation occurs at a higher velocity.

I have experienced approximately 25% failure rate using the zero volume method, compared to less than 5% failure rate using the floating head method. In fact, the floating head failures tend to be almost exclusively on boost gliders where the piston separation tends to fake the glider into thinking it's time to depart from the pod, so I avoid piston launching gliders (until I can debug this problem, which will probably require a better pod hook design). Additionally, I am finding that boosts are at least 15 to 20% higher using floating heads (the Vincent/Weiss study reported a 34% increase).

So, how do you go about making and using floating head pistons? Most of the designs I ran across had complex machined pistons, internal wiring involving soldered connectors, etc. Well, it can actually be pretty simple once you get your head around how they work, if you're willing to use cheap materials that might only last a few flights. Table 1 lists part dimensions and cross references for everything from Micro Maxx to 24mm. Yes, I admit it—I've actually used a piston to get an extra kick out of a 0.3 N-sec motor. Total cost is about $2 for materials.

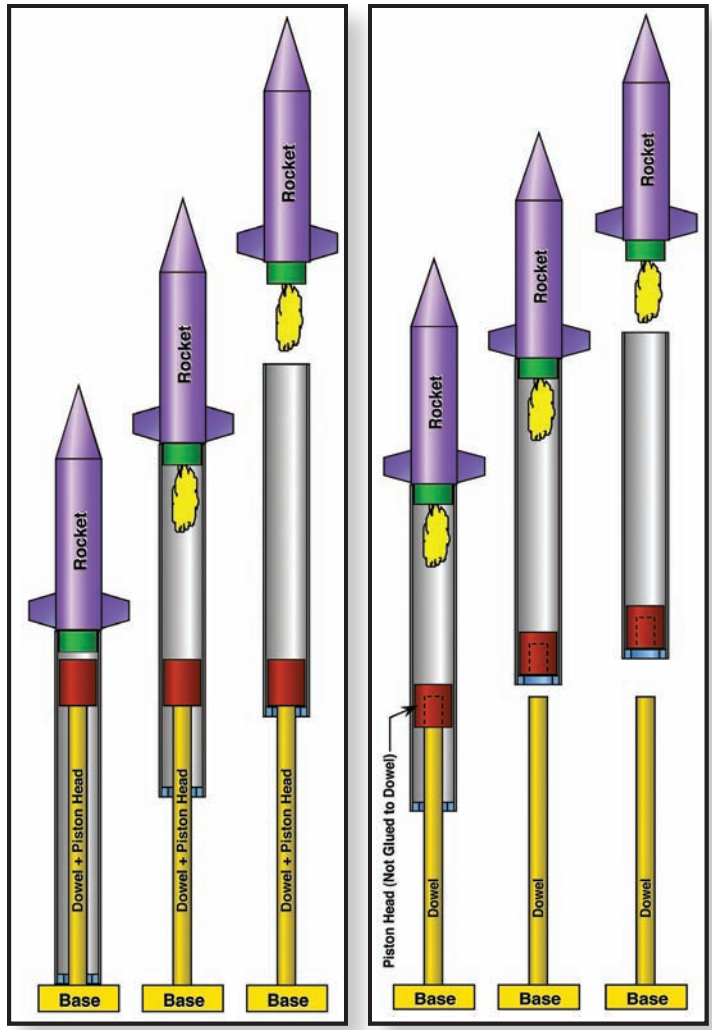
Table 1. Floating Head Piston Dimensions

Piston size:	6 mm	13 mm	18 mm	24 mm
Piston tube	BT-2+/2.5x8.5"	BT-5x17"	BT-20x17"	BT-50x17-34"
Head dia.	0.246	0.516	0.708	0.948
Coupler dia.	0.246	0.516	0.708	0.948
Stop ring O.D.	0.246	0.516	0.710	0.950
Stop ring I.D.	0.220	0.376	0.542	0.736
Dowel dia.	3/16"	3/8"	1/2"	11/16" or 3/4"

Start by making the piston tube. The piston tube is simply a regular body tube with a centering ring glued flush with one end, which we'll call the bottom. A good wood glue joint is in order here. The length of the tube should be at least 12" for smaller models, though I generally go with 17", since buying bulk tubes in 34" lengths yields 2 pieces per tube. Note that the Alway brothers did an excellent (first place) R&D report in 2005 establishing that for heavier models, such as egg lofters, longer pistons perform better than shorter ones, and they used 30" piston tubes. I typically also color the outside of my tube with red marker, which helps spotting it lying around the pad post-flight.

The piston consists of coupler stock, usually about ¾" to1" long, and a bulkhead disk. I typically make my disks out of basswood, and coat with a thin layer of epoxy so they don't get burned up. Glue the bulkhead to the top of the coupler (CA is probably your best bet). Once the glue has dried, sand down the outside surface of the piston cylinder nice and smooth with a good 300-400 grit paper. You might want to coat the outside of the coupler with CA first so that it doesn't swell/shrink in varying weather. Finally, I also like to put a centering ring inside the coupler flush with the bottom (peel off a layer or two of paper). This helps keep the piston aligned with the piston rod while in the tube.

Two piston heads made from coupler stock and bulkhead disks.



Left: Figure 1. Operation of a Zero Volume Piston Launcher.
Right: Figure 2. Operation of a Floating Head Piston Launcher.

Install the igniter and bend its leads back up along the rocket. Slide the floating piston head into the piston tube.

Now for the critical fit check and ensuing rework cycle. Take the completed piston, and slide it into the top end of the piston tube. It should slide up and down smoothly, but not too easily. A piston that slides up and down just from gravity is too loose. A piston that will not slide if you blow down the tube like a blow gun is too tight. Sand your piston down if too tight, or wrap it with a thin strip of Mylar tape if too loose.

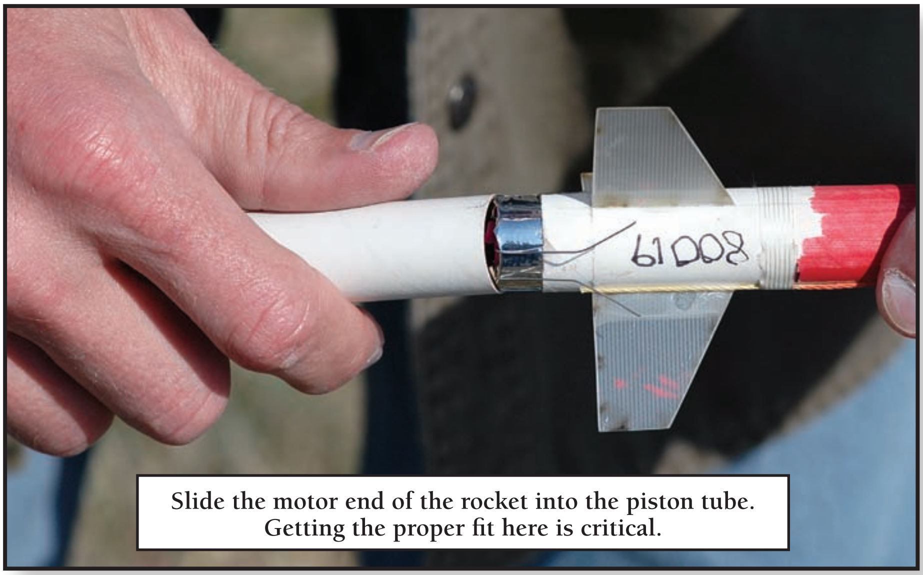
The final piece of the assembly is a wood dowel, though depending on diameter, a launch rod might suffice. The length of the dowel should be at least 6-12" longer than the piston tube.

Flight Prep

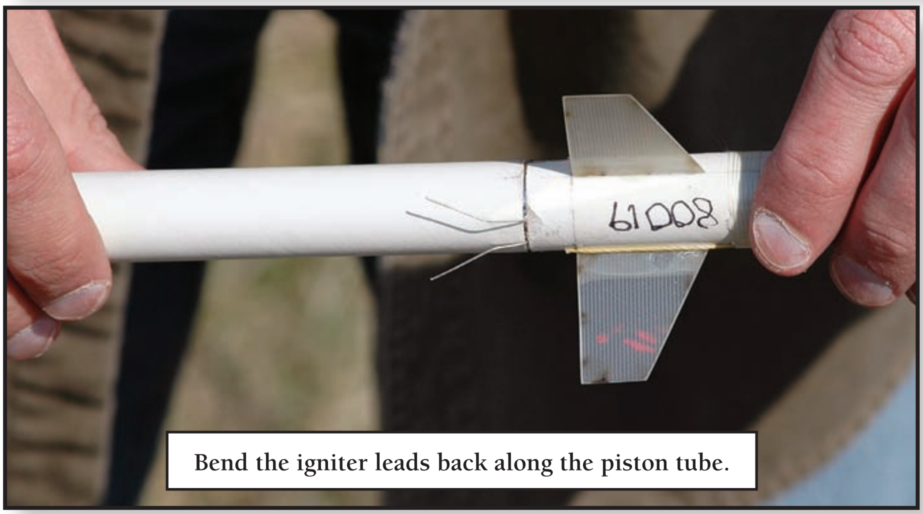
Slide the piston inside the piston tube, with the bulkhead up. Prepare your rocket and motor for flight, but make sure at least ¼" of the aft end of the motor is exposed. You won't be able to use a metal engine hook, so you'll need to friction fit the motor for retention. Insert the igniter and plug, then bend the igniter leads up the outer edge of the motor. Next, slip the motor into the piston tube, making sure the igniter leads remain exposed. It will probably be too loose and need a layer of Mylar tape. Judging the fit here is still a bit of an art form. I gently turn the piston-plus-rocket assembly upside-down. If the rocket comes off, it's too loose. If it's a major struggle getting the motor into the piston tube, that's an indication it's too tight.

Anchor the dowel either by attaching to a firm base or by tapping into the ground. Slide the rocket-plus-piston tube assembly onto the top of the dowel gently, until you feel the piston slide up and bump against the aft end of the motor.

Hook up the leads to the igniter, making sure there's plenty of slack. The leads will need to travel at least as far as the pis-



Slide the motor end of the rocket into the piston tube. Getting the proper fit here is critical.



Bend the igniter leads back along the piston tube.

ton tube length. If you don't have enough slack, you might wind up tugging on the rocket, causing tip-off.

Whether or not you fly with a tower is a matter of choice. If you have one, by all means use it, as that will improve the safety and reliability. If you don't have one and can't borrow one, you will likely be OK if you have used a long enough piston tube. I usually fly without a tower, but I have a high level of confidence that I have the right friction fit between the piston and motor. Starting out, if you don't have a tower your first few flights should be considered "heads up" flights and well away from crowds while you get a feel for the friction fit.

Count down and fire off as usual. Be careful of neck injuries from snapping your head back trying to track the flight! You will notice a much higher-velocity boost and incredible altitudes compared to regular rod/blast deflector launching. Be sure to pick up the piston/tube assembly, which has probably floated a few feet away from the dowel.

If you want absolutely peak performance on each flight, then discard the piston tube and possibly also the piston head after each flight. If you can settle for slightly lower performance, then push the piston all the way out of the tube, and clean off the outside edges. Clean out the residue inside the piston tube as well, then repeat the fit test for the piston into the tube. I rarely have to replace a piston, and have gotten as many as ten flights from a piston tube, though I have to occasionally trim off the top inch or so of the tube if it doesn't sufficiently clean up.

While pistons are clearly a competition oriented tool, I might also point out as a bit of a scale fan that they offer a benefit to sport models as well. By achieving sufficient velocity off the piston to be stable, you can avoid an unsightly launch lug or rail button that might detract from the appearance of that scale model. I also make sure I've packed a few pistons in the range box for those occasional "D'oh!" moments when I head out to the pad and realize, too late, that I forgot to glue on a launch lug.