ILLUSTRATED GUIDE TO MY FAVORITE WATER ROCKET CONSTRUCTION

by Gary Ensmenger, Inventor of Bigfoot Water Rocket Launcher

The best performing water rockets are constructed with 2 liter soda bottles. This size easily adapts to adding components such as Nose Cones and Slide-on Fin Assemblies. It has larger payload capacity of both air and water, so therefore can travel farther. This size rocket can easily travel 500 feet and reach speeds of 125 m.p.h. Soda Bottle plastic, called PETE (Polyethylene terephthalate), is an amazing lightweight structural plastic that makes perfect water rockets.

SAFETY TIP: Water rockets should be constructed from soda bottles that are as new as possible. Soda bottles will dry out & deteriorate with age and even faster when exposure to sun light, and outdoor elements. Aged soda bottles become brittle and have a higher likelihood of bursting. Fresh soda bottle are relatively safe.

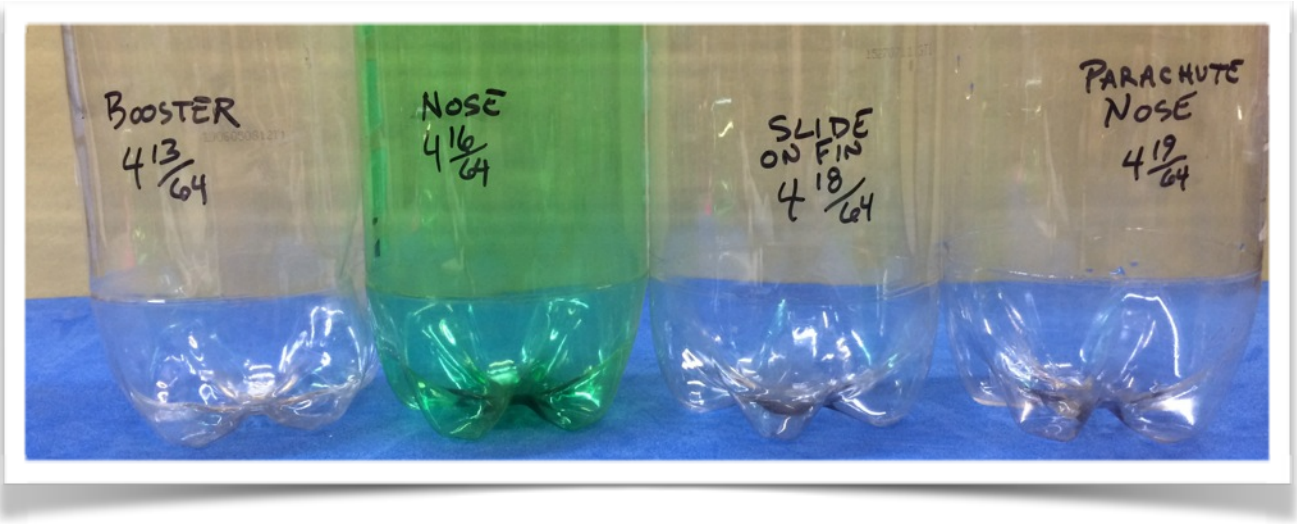
The key ingredients for water rockets are:

- SODA BOTTLES - at least 2 each (recommend 2 liters size works best)
- FIN MATERIAL - must be lightweight - rigid - waterproof Coroplast® sign material, also known as Fluted Plastic, common for political road signs, works well.]
- ADHESIVE - for joining fins to Booster rocket, or joining fins to slide on fin assembly, or a Nose Cone. ["3M™ Black (or Yellow) Super Weatherstrip and Gasket Adhesive" is the best performer.]
- WATER - usually about 1/3 full in Booster rocket & several ounces in Nose Cone.
- AIR - pressure range from 15 - 100 psi work on a Bigfoot Water Rocket Launcher.

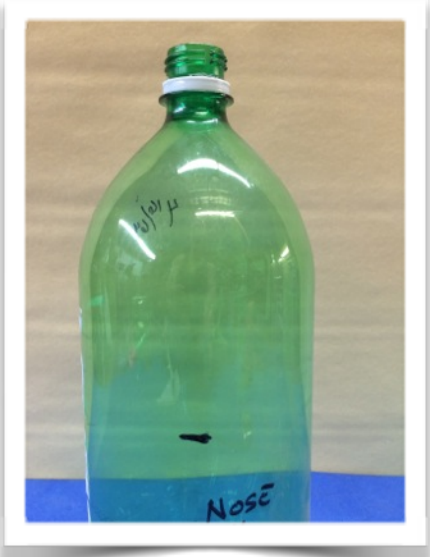
MEASURE THE BOTTLE DIAMETERS - The most important step in making a great water rocket is to measure the diameters of the empty soda bottles and to sort them by size. Most helpful is the Stanley Diameter Scale measuring tape model # 33-115 (LINK) available at Lowe's Hardware. [Flexible cloth/plastic dress maker tapes work well also]. The back side of the Stanley Diameter Scale measuring tape has a second scale for measuring diameters of round objects by wrapping the tape around the

circumference. It will measure in 1/64" increments. This bottle is 4-16/64". It's common to find bottles that range from 4-10/64" to 4-24/64".

SORT THE BOTTLES BY SIZE is next most important step. The smaller bottles will be the Boosters (the pressurized part of rocket). The larger bottles will be the Nose Cone or Slide-On Fin assembly. Nose Cones that are 3/64” larger are a good fit. If you are making a parachute



deployment, then even larger than 3/64” will work better.



MAKE A NOSE CONE: Notice (on left photo) a felt tip marking which is located 6 inches from the top (of neck).

MARK THE BOTTLE is next step. Included with the Bigfoot Water Rocket Launcher is a simple “Rocket Stand”, which is useful for various assembly procedures. In this case, I will use it pivot a bottle to draw a circumference circle at this 6” mark.
This 6” is just an example. Nose Cones could range from 4” to 10”.

Turn bottle upside down and insert on rocket stand. Using a felt tip marker and a steady rest for your hand, rotate bottle in one full circle. To cut, first pierce the sidewall of the rocket with a knife just enough of a slit to fit the tip of scissors to complete the circumference cut.

This particular Nose Cone had a diameter of 4-16/64”. The Booster had a diameter of 4-13/64”. The difference of 3/64” is an easy fit for one bottle to slide over the other with just a nominal

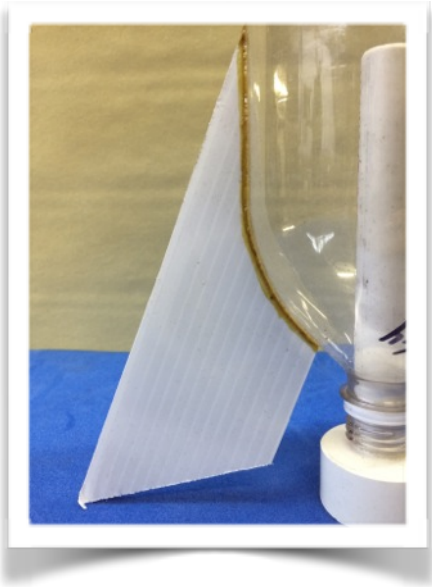
interference of friction. This would actually be a water tight fit when water was used for nose weight. Adding adhesive works good.

However, if the Nose Cone and Booster were the same diameter, it would be difficult to slide the nose over the Booster. The Booster would have to cave in and crumple to accommodate the Nose Cone. It would not hold water. Pre-measuring bottle diameters & sorting sizes are the most important keys to successful water rocket construction.

ATTACH THE FINS: Three fins per rocket is the optimal quantity. There are 3 basic methods of attaching fins to the Booster. The first two methods involve attaching the fins permanently to the booster. The advantage is simplicity and best for beginners. However, the major drawback is that in the event of a hard rocket landing (a crash), like a vertical "nose dive", then all the work & time spent on attaching the fins on the booster is most times lost.

One way to minimize booster casualties is to position and aim the launcher to shoot rockets at an angle. Farthest travel distances are achieved at 45 degree angle. Rockets landing on grass, sand, or water will survive better than concrete and asphalt. On vertical nose dives, landing in a body of water improves chance of survival. Developing a successful parachute system is really the only real sure way to protect longevity of rocket components.

1) The most common & simplest method is to attach the flat side of a fin to the lower flat side of the Booster. This is a permanent attachment to the Booster.



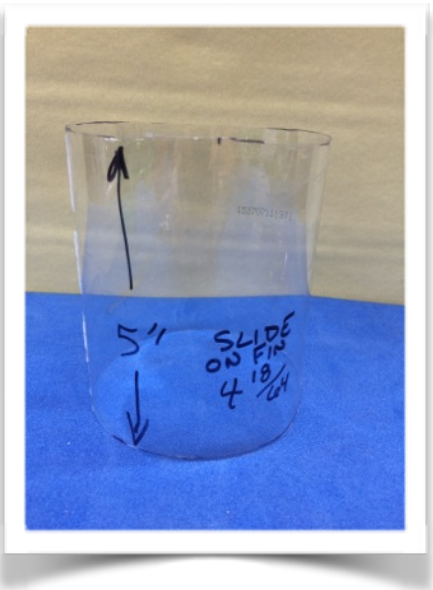
2) A structural improvement of the above method is to cut an arc out of the flat side of the fin which matches the curved shape of the lower portion of the Booster. This also is a permanent attachment to the Booster. By attaching on a curved working plane, the structural strength of the attachment between Fins and Booster is greater than attaching a flat Fin to a flat side of a Booster. This also lowers the center of gravity of the rocket, which is aerodynamically desirable. Just be careful not to position the fins so exceedingly low and close to the neck, that the fins will interfere with the launcher's trigger mechanism.

3) The versatile Slide-on Fin Assembly can be recycled and used on multiple Boosters. After a damaging crash landing, the Slide-on Fin Assembly often can be removed and re-installed on another Booster. Cellophane tape is used to position and secure the top edge of Slide-on Fin Assembly onto the Booster wall, so tape must be removed to slide off assembly.

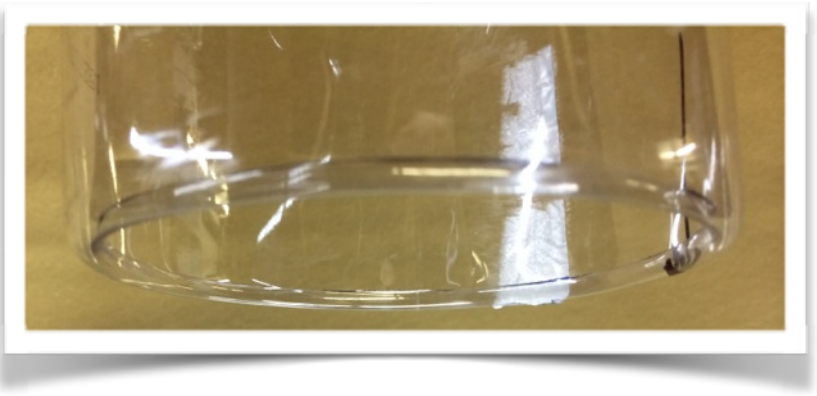
The construction of the Slide-on Fin Assembly is more involved because a 3rd component is added to the Booster and Nose Cone. A cylinder is made from a soda bottle by removing the nose and bottom. One end of this cylinder is heated and formed into curl to make a structural re-enforcement ring.

In this example, I picked a soda bottle with diameter of 4-18/64". This bottle is 5/64" larger than the Booster above. This size fits over about any future booster bottle stock.

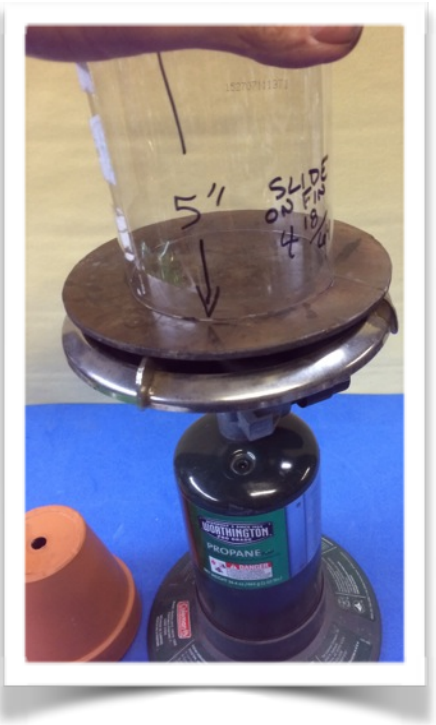
Again, I've used the rocket stand and a clay flower pot as a steady rest for holding the felt tip marker. I want to extract the inner 5" of straight cylindrical portion of the soda bottle. Using knife (to pierce) and scissors, cut off & remove the bottom and top of bottle.



HEAT FORMING THE RE-ENFORCEMENT RING: This is a procedure that take experience from trial and error. Once master, it's simple. First priority, do not get burnt! In this illustration I'm using a propane camping stove with a round steel plate resting on top, which was handy for taking these photos. I prefer using electric stove top (either cheap small portable single element or kitchen appliance) which is safer and less chance of mistakes and less chance of getting burnt because the heat is easily regulated and also the heat is restrained primarily to the metal plate. With the open flame, there is hot air pouring out the edges of the metal plate (this is the danger zone). Usually I recycle a worthless old dull circular saw blade. The larger and thicker



the circular saw blade, the more evenly dispersed the heat. An interesting phenomena is that when you expose the cut edge of PETE plastic to a hot metal plate, it will naturally curl inward. This is perfect for water rockets. The goal is to get just enough heat to cause the PETE plastic to soften and curl inwardly equally all the way around the circumference. You will very lightly push the PETE cylinder to “feed” the plastic onto the hot saw blade. If one side is curling, while another side is not, it is because you need to push down equally so the curl



forms all the way around. When the completed inward plastic curl forms, you will pull immediately from the heat and then quench the soft molten ring over a upside-down clay flower pot. The tapered portion of the flower pot that comes in contact with the molten PETE plastic needs to be about 4” in diameter. This particular flower pot was about 4-1/2” at the top. When the molten PETE plastic comes in contact with the flower pot, it quenches it into a perfect plastic circle.

One method for testing for the right temperature is to use one of the expendable cut off bottoms or noses. When you touch the PETE plastic to the right temperature metal plate the plastic will slowly curl. Bring the heat up slowly to the right temperature and then hold at that temperature. Do not just put it on hottest setting and burn the plastic. This test may save you from wasting the main body part for the Slide-on Fin Assembly.

When temperature is right, push plastic cylinder down evenly, with equal flat pressure onto the hot plate. If the curl is forming on one side only, adjust the downward pressure to encourage the uncurled side to curl. When the curl is completely around circumference, IMMEDIATELY lift off hot plate and push over clay flower pot and hold in that position for about 15 seconds.

This is a cross cut section of finished heat formed curl. This curl adds rigidity and structure to the Slide-on Fin Assembly. The curl will obviously go on the bottom side of rocket (towards the launcher's trigger).

The Best Adhesive:

For the past 20 years I have experimented with massive numbers of adhesives to attach water rocket components, such as fins and attaching Nose Cones. Many adhesives will form a skin over the PETE plastic, however it will easily peel off. The adhesive must also be the right hardness. If too brittle, it will break off during a landing. If too soft, with cause the fins to flutter in flight and slow speed of flying rocket.

Do not use hot melt glues.

I have had small luck with E6000, Shoe Goo, GE Silicon II, P L Premium construction adhesive. These glues have little initial tack, or they slump and drip with gravity. They can be used but the fins must be fixtured to hold them in place while the glue sets.

In 2013, I finally discovered the perfect water rocket adhesive. It is a Weatherstrip and Gasket Adhesive made by 3M. Buy at most local auto parts store. Best price I found was on amazon.com (about 50% savings)

This amazing adhesive comes in 2 colors, yellow and black:

3M™ Black Super Weatherstrip and Gasket Adhesive, 08008, 5 fl oz. 3M Id : 60-4550-5560-2

3M™ Yellow Super Weatherstrip and Gasket Adhesive, 08001, 5 fl oz. 3M Id : 60-4550-5559-4

Also available are smaller 2 fl oz tubes.

It instantly tacks together after putting a thin layer on both bottle and fin. After tacking the fin on the rocket, then add a corner fillet (a chamfer) in the corner on both sides of the fin, against the rocket. Let glue set for 24 hours and you have a perfectly attached fin.

3M™ Super Weatherstrip and Gasket Adhesive can also be used to attach the nose cone to the booster. I found it worked good by adding the adhesive all the way around the INSIDE circumference of the nose cone and all the way around the booster (just a tiny bit above where the nose cone edge will attach to the booster). Immediately push parts together will glue is wet. Remove bottle cap so air can get inside nose cone. Let is set for 24 hours.

Hope you learned some good tips. It has taken years of trial and error to get to this point of making great water rockets.

Please use caution -

1) Don't burn yourselves when curling PETE plastic.

2) Careful with using scissors and knifes when cutting PETE plastic.

3) Use plenty of ventilation when using solvent based glues.

4) Never point a pressurized water rocket at anything but the sky.

5) Make sure the water rocket will land in a safe zone, avoiding all people and property that may get damaged. What goes up, must come down.

6) Make sure there is an all clear before launching.

7) Never try to exceed 100 psi pressure.

8) When pressurizing and launching a water rocket, everyone must be at least 10 feet away.

9) Make sure all spectators are behind the line of the launcher.

10) Never use old soda bottles. Use fresh as possible.

11) When children are launching, have a supervisor use the 2nd trigger pin (with yellow string) to prevent launching before or during count down.

12) Always do a loud, audible count-down to make people aware of anticipated launch and associated blast noise.

13) Only use water and air.

Enjoy your water rocket launcher and learning how to make water rockets. Making water rockets is a great learning experience in planning and construction methods.

Making parachute deployment systems is an extremely rewarding challenge. FYI: most competition regulations prohibit the use of any metal parts.

Water Rockets can be used for the pure enjoyment of launching rocket or for learning applied physics and mathematics.