TUTORIAL: PRESSURE VESSELS AND REINFORCEMENT

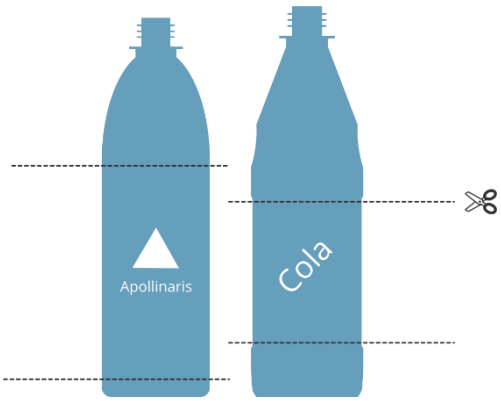
PDF WITH DETAILED INFORMATION AND MORE

PART 1: BUILDING PRESSURE VESSELS

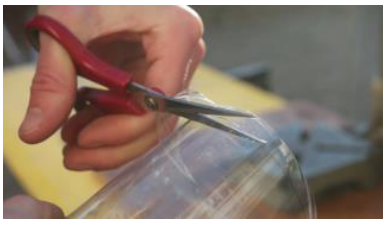
Before you can get started with the construction, you should definitely have an idea of how your water rocket will look like. We recommend you to take a look at our tutorial that explains the different methods of construction and what's important when it comes to building a water rocket. Regardless which method of construction you go for, the principle of building the pressure vessel is always the same: **Multiple plastic bottle sections are combined together**.

However, not all plastic bottles can be used for water rocketry. The bottles should be as strong as possible and should have a **long cylindrical section**. In this tutorial, we are using bottles from „Apollinaris", but these bottles maybe not be available to you, depending on your location.

There are many ways to combine the bottle sections. The most popular one is to **cut off some parts and glue them together** with polyurethane based adhesive. You can also put together multiple pressure vessels by using specific connectors.

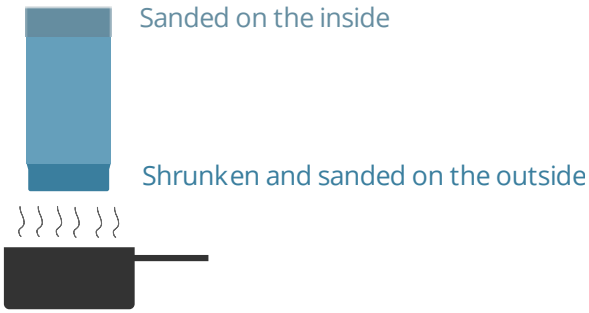


We are going to build a pressure vessel with six joints. However, the method of construction and the number of joints can be adjusted to your liking. But first of all, you have to prepare the bottles. Cut off both the lower and the upper sections from the bottles, but leave two bottles out and remove only the lower section from them but not the neck. When cutting off the sections, it is useful to **mark the areas with a pen** and a piece of paper. You can also use a jig consisting of a drilling machine and a cutter. It is very important to ensure an **even cutting edge**.



Shrinking bottle sections:

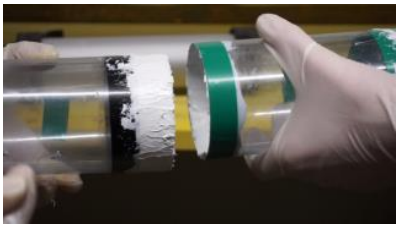
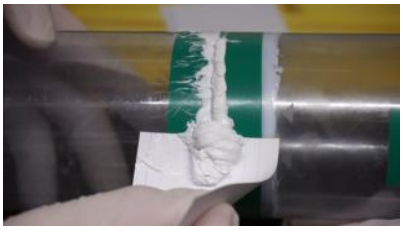
To combine the bottle sections, you have to **shrink them on one side**. The bottle type we use in this video is a little bit conical, and so we choose the slightly smaller side. But before you are ready to shrink the bottle, you have to turn it on a **hot iron**. To shrink it, just put the bottle sections in about 2.5cm or 1 inch deep **hot water**. Depending on the water temperature, the process will only take one or two seconds. If you wait too long the bottle will shrink too much. Always keep in mind that it is important that you shouldn't be able to put the sections together too easily. If this is the case, you should replace the section before continuing with the next step. Before you glue the bottle sections together, you have to sand the shrunken areas on the outside and the other bottle ends on the inside. Furthermore, you should also clean the bottle sections.



Sticking bottle sections together:

We recommend **polyurethane based adhesive** to glue the bottles together. But watch out: Not every adhesive is suitable for building water rockets. For example, we have good experience with PL Premium. Other adhesives like Sikaflex 11FC are very good to seal something - but not so much for holding together a rocket chamber. Nevertheless, you should choose this adhesive if you plan to reinforce your rocket with fiberglass or carbon fiber, because the reinforcement will hold the vessel together while the adhesive seals the joints . Thus, the pressure at launch can be increased up to 17 bars or 250 psi.

We recommend using a jig which holds the chamber in place. It is very important to **wear gloves**, because you should not come in contact with the adhesive. We also suggest opening all the windows. Now, you can start applying adhesive on the sanded bottle areas. Be very careful when sticking the sections together and **do not twist the sections while doing so**. You can reuse some of the excess glue for the next section. If you have joined all bottle sections together, rotate the pressure vessel to make sure it is not crooked.

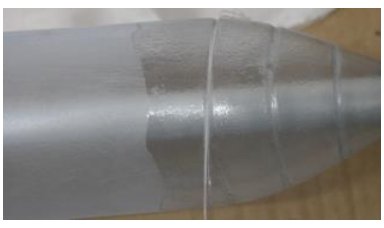




After that, **wait at least two or three days before you continue**. In case you don't plan to reinforce your rocket, you can now proceed with the pressure test. We explain how that works later in this tutorial. But if you plan to reinforce your rocket, we still have a lot of work to do: The whole chamber has to be sanded.

PART 2: REINFORCEMENT OF THE CHAMBER (OPTIONAL)

To start with the reinforcement of your pressure vessel, you have to cut the fiber glass to size. We recommend using two layers of fiber glass. That means that the textile has to be wrapped two times around the chamber. Thus, the dimensions of the required fiber glass are:
Length of the chamber x 6.4 bottle diameters

Be very careful when **cutting the fiberglass**, because you do not want to pull out fibers from the cloth. At both ends of the fiber glass, we cut in little stripes so that the reinforcement can fit tightly at the ends of the pressure vessel.
To reinforce your pressure vessel, you once again need a jig to hold the vessel in place. We simply use a PVC pipe for that. Don't forget to mask the bottle thread with a little bit of tape. The resin is mixed in the ratio given on the packaging. Keep in mind that you should wear gloves and open the windows. After that, the **resin can be applied to the pressure vessel** using a roller. In case the bottle type you use has any patterns or notches you can use single fibers to fill them and make the surface of the chamber more even.
Now you can start **wrapping the fiberglass on to the chamber.** For that, lay the cloth very carefully on the vessel. Use the roller to press the applied resin on the chamber trough the fiberglass until it's see-trough. Every now and then you may have to add some resin, especially at the second layer. However, keep in mind that you shouldn't use too much resin because that increases the weight of your rocket. Be very thorough at the ends of the pressure vessels. After completion, we suggest wrapping a single fiber around the thinnest part of the bottleneck. Wait at least a few days before continuing with the pressure test, we even recommend waiting a week. But that doesn't mean that you can't do anything in this time: You can remove protruding fibers and you can sand, if necessary, parts of the vessel using **wet and dry sandpaper**.


PART 3: PRESSURE TEST

Now that your pressure vessel is nearly finished, you just have to test it before you can use it for your water rocket. For that, fill the chamber almost completely with water and put it **behind a barrier**. You can use our launch pad to build up pressure, or you can build a dedicated system for it. A reinforced pressure vessel can hold **up to 18 bars or 260 psi**, most pressure vessels without reinforcement can hold about half that. However, that largely depends on how experienced you are and how conscientious you work. You should definitely test the chamber to a higher pressure than you plan to use it on your rocket. If your chamber has passed the test, it is ready to be used in your rocket.
