Buoyancy Theory

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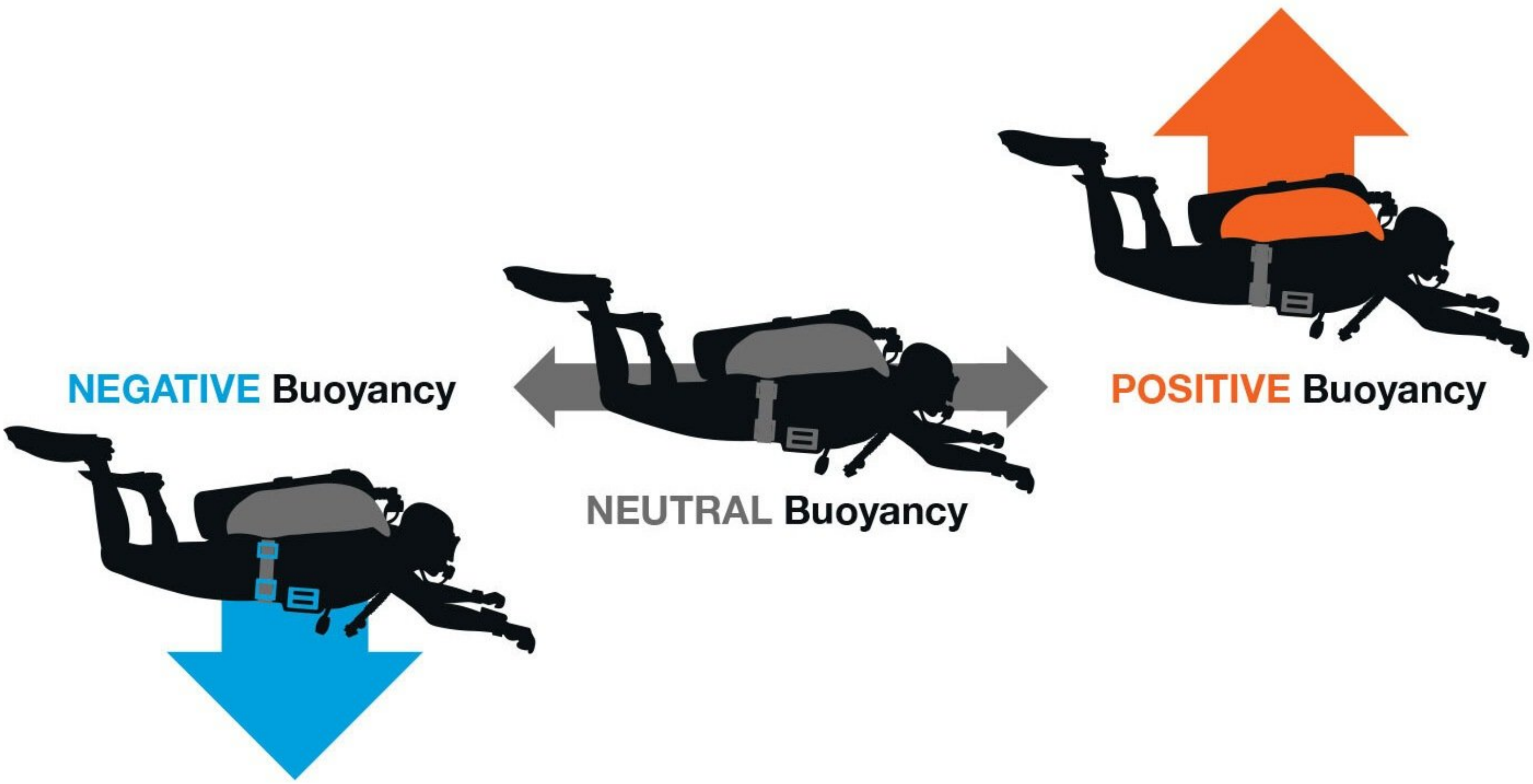

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INTRODUCTION

In most cases, you want your vehicle to be as close to neutrally buoyant as possible. A neutrally buoyant vehicle will neither rise nor sink in the water. If motors are not running, it will stay where it is in the water column.

Large work class ROVs and other vehicles that go into the ocean or other environment are usually slightly positively buoyant. That means they slowly rise if motors are not driving them down.

A slightly positive ROV in the real-world environment has a few advantages. If the tether gets completely cut, a slightly positive ROV will come back to the surface where it can be recovered.

ROVs operating near a muddy bottom don't want their thrusters pushing water down (thrusting the vehicle upward to compensate for negative buoyancy). That thrust will stir up the bottom mud and can make it impossible to see.

We recommend making a vehicle that is slightly positively buoyant if you plan to use it in the ocean or in a lake and neutrally buoyant if you are using it in a pool.

A neutrally buoyant ROV is easier to operate

Buoyancy & Ballast

Buoyancy is considered to be all the components that are less dense than water and will cause a vehicle to rise towards the surface when in the water.

Ballast is considered to be all the components that are denser than water and will cause a vehicle to sink towards the bottom when in water. In most cases all the components of your ROV will be ballast. PVC in the frame and motors are the main sources of ballast in an ROV.

Most often, flotation will be needed to offset the weight of the other components of your ROV. The tether can be a source of ballast as well. ROV teams may want to consider adding buoyancy every meter or so along their tether to offset its weight.

A lot of math and science goes along with trimming your ROV (i.e. adjusting the buoyancy, ballast, pitch and roll of the ROV.) You can learn more about buoyancy in the text book provided:

ROV Buoyancy Choices

There are a lot of different types of flotation that can be used in an ROV. A few different types are presented here but be creative. You may find another buoyancy solution works best for you.

There are lots of different ways to add buoyancy to your vehicle.

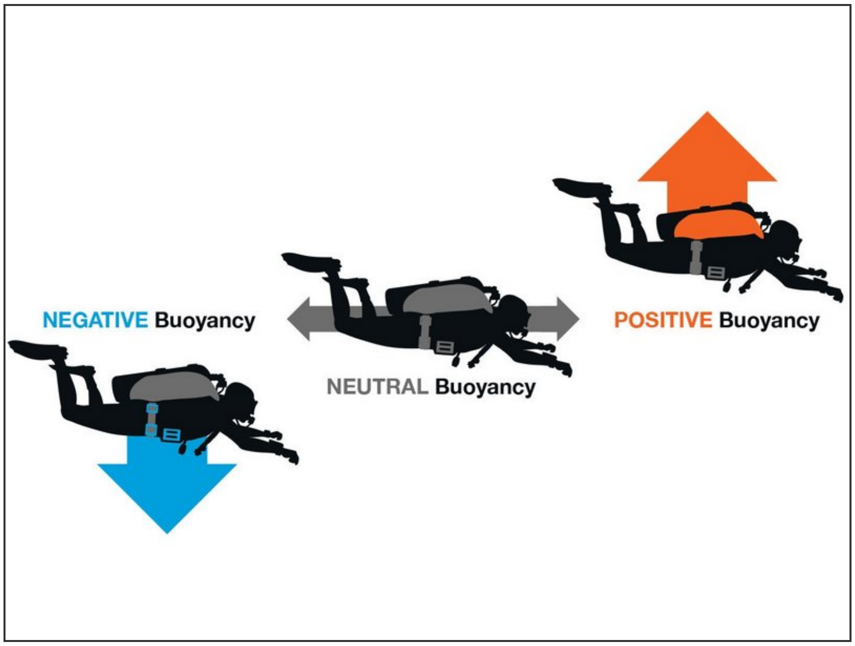
- Soft Foam (Pool noodles or pipe insulation foam): Pool noodles are soft, colourful foam that is fairly inexpensive and can be found at many local stores Pipe
- insulation foam is soft foam that is designed to fit around PVC and other pipes. It is fairly inexpensive and can be found at Home Depot and other hardware stores.

Both of these soft foam options can be cut with scissors and is very easy to work with. However, there is a drawback. Soft foam is soft. Soft foam will compress at depth as water pressure increases. It is generally okay down to 1.5 meters, but as an ROV descends deeper and deeper, the foam will compress and lose its buoyancy. At 3.5 meters of soft foam loses about half to two thirds of its buoyant property. Vehicles with soft foam at this depth can lose so much buoyancy from pressure that the motors can no longer return the ROV to the surface.

Larger Diameter Capped PVC: and other larger diameter PVC, with air inside, and with end caps glued to each end can also be used for flotation. The volume of air inside these rigid pipes provides a good amount of buoyancy. These pipes will not compress at pool depths but do be careful if you plan to go beyond 20 or 30 meters.

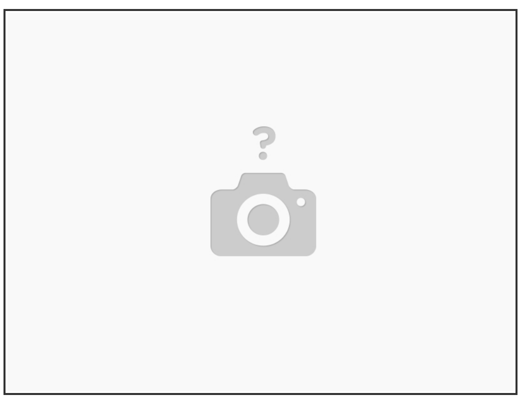
You may want to test your canisters to these greater depths before taking your ROV there. Using larger diameter pipe also allows you to use math to calculate exactly what lengths of pipe you will need. See the section below on how much flotation you will need to make your vehicle neutrally buoyant.

Step 1 — How much flotation will you need to make your vehicle neutrally buoyant?



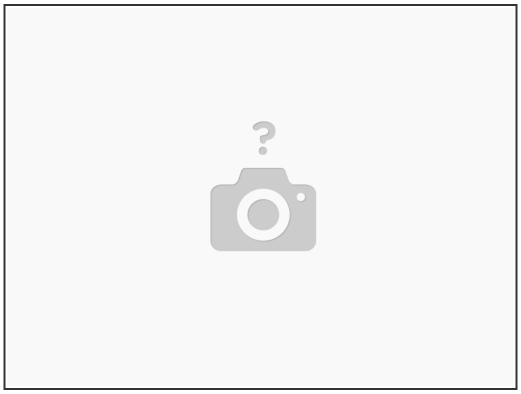
- Follow the steps below to find how to calculate the buoyancy of your ROV.

Step 2



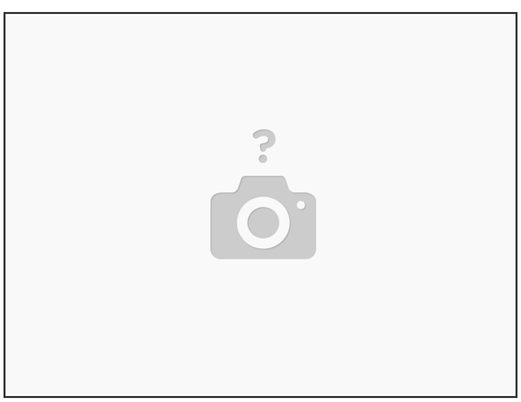
- Your ROV will not be neutrally buoyant and will most likely be negatively buoyant in water.
- Use a fish scale or spring scale to weigh your vehicle in water.
- Tie ropes or string to your vehicle, dip it so the ROV is completely underwater, then measure the weight. Make sure to keep your spring scale above the water, especially if it is an electronic scale. This will tell you the weight of your ROV in water (sometimes referred to as Wet Weight).

Step 3



- Now you can calculate the amount of flotation you will need to offset this weight.
- Air essentially weighs close to nothing (for our calculations here). So one cubic centimetre of air has a weight of 0 grams.
- One cubic centimetre of water weighs 1 gram.
- In water, one cubic centimetre of air will provide 1 gram of positive buoyancy.
- If your vehicle has a wet weight of 600 grams in water, you will need 600 cubic centimetres of air to offset that weight. (Remember to take into account the weight of the foam or cylinder you will be using, you need something to “enclose the air” and that something will have a weight.)

Step 4



- For further information on how to calculate the buoyancy of your ROV, refer to the video linked below, and the buoyancy document provided.
- Buoyancy: Calculating Force and Density with Archimedes' Principle

