

How to Build a Hydrophone

(Level: High School)

It was once thought that the ocean was a silent place. However, if you were to drop a hydrophone, or underwater microphone into the water, you would soon discover that the underwater world is quite noisy. A hydrophone picks up acoustic signals and then transfers the sounds into a receiver that allows you to hear them. Using the following instructions, you can build an inexpensive hydrophone. Use this hydrophone to hear sounds in an aquarium or local waterbody.

Acknowledgements:

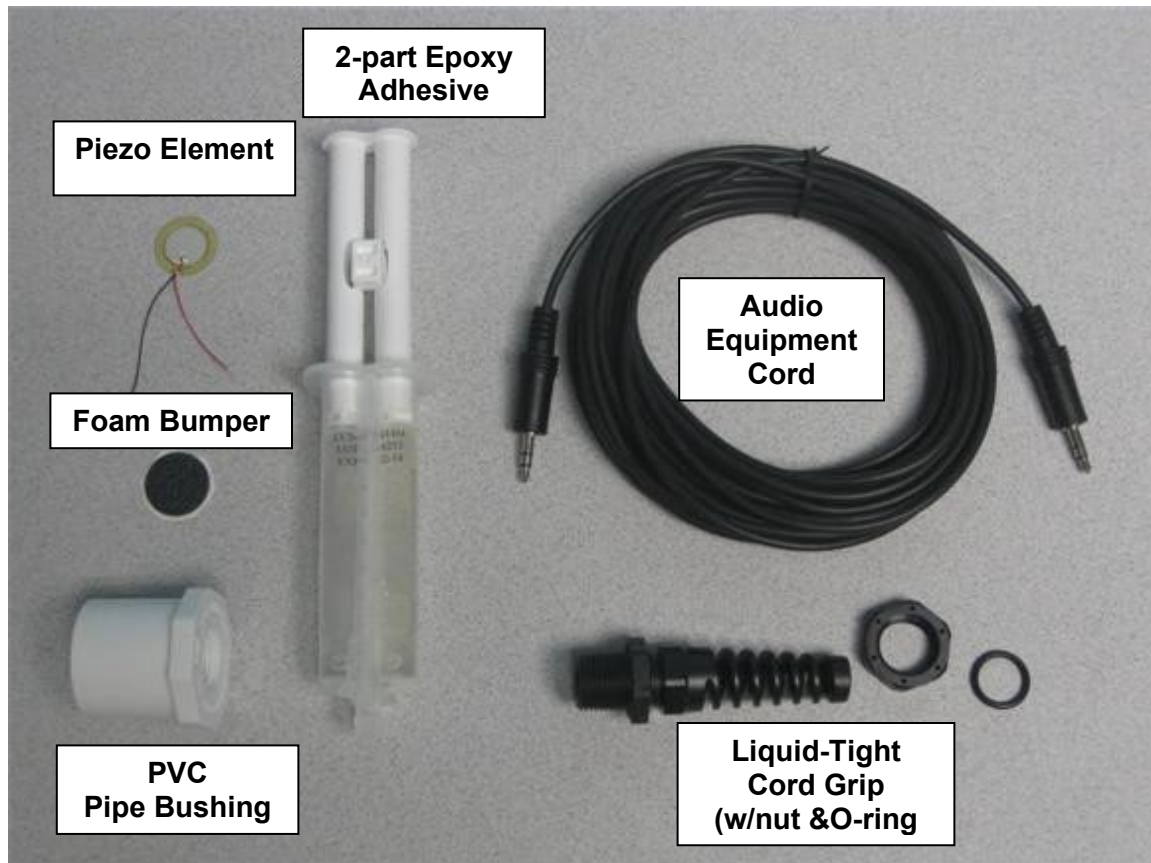
Kevin Hardy, Scripps Institute of Oceanography, introduced a “Build A Hydrophone” activity in 2000 which provided a material list, assembly schematics, glossary of terms and other valuable resources. This work is the basis for many subsequent hydrophone build activities, including this work completed by the Discovery of Sound in the Sea (DOSITS) team, at the University of Rhode Island, and a team from the Center for Ocean Sciences Education for Excellence, Technology and Engineering for Knowledge (COSEE-TEK), at the University of Connecticut: Kevin Joy, John Hamilton & Ivar Babb.

Hydrophone Activity References:

- Raven: Interactive Sound Analysis Software, The Cornell Lab of Ornithology, Bioacoustics Research Program ([Raven: Interactive Sound Analysis Software](#))
- Hardy, K. 2000. Build A Hydrophone. Scripps Institute of Oceanography/UCSD
- E. R. Vivas and B. L. Lopez (2011, March 12). Construction, calibration, and field test of a home-made, low-cost hydrophone system for cetacean acoustic research. Acoustical Society of America; Proceedings of Meetings on Acoustics, Cancun Mexico, 15-19 November 2010
- Peter Stephanishen, personal communication; University of Rhode Island, OCE 311 “Coastal Measurements and Applications”, Laboratory exercise, 2006.



Simple Hydrophone Design - Basic Material List



Hydrophone Components		
Description	Vendor	Part Number
Piezo Element	SparkFun	SEN-10293
Audio Equipment cord with 3.5mm Connectors (25')	McMaster-Carr	8317T15
2-Part Epoxy Adhesive in a Syringe	McMaster-Carr	7670A22
Adhesive-Backed Round Foam Bumper (100pk)	McMaster-Carr	8213K2
PVC Pipe Hex Reducing Bushing	McMaster-Carr	4880K826
Nylon Liquid-Tight Cord Grip (.08" - .24")	McMaster-Carr	69915K62
Amplifier Components (not shown above)		
Danelectro Honeytone N-10 Guitar Mini Amp*	Miscellaneous	
9Volt Battery for Audio Amplifier	Miscellaneous	
1/4" to 1/8" (or 3.5mm) adaptor	Miscellaneous	
Note: SparkFun (see www.sparkfun.com). McMaster-Carr (see www.mcmaster.com).		

Simple Hydrophone Design – Overview & Component Description

Hydrophone Components:

The hydrophone design has three major system components; 1) hydrophone container; 2) hydrophone cable; and 3) amplifier/speaker.



The **hydrophone container** is the underwater component of the system designed to provide a termination enclosure for the piezoelectric microphone (piezo) element and all associated electrical connections. The container is fabricated from a PVC pipe fitting and Nylon liquid tight cord grip. The PVC fitting provides the enclosure for the piezo element and electrical components. The cord grip secures the cable in the container and provides strain relief for the cable at the point of entry. 2-part epoxy adhesive is used to secure, insulate, and seal all electrical components and connections within the container.



The **hydrophone cable** carries the electrical signal, originating from the hydrophone container, to the audio amplifier or other surface equipment. The black PVC jacket of the hydrophone cable provides a watertight layer and the 3.5mm male plug connects the hydrophone to the surface-mounted audio amplifier.



Danelectro Honeytone N-10 Guitar Mini Amp (or similar amplifier/speaker). The Honeytone has a $\frac{1}{4}$ " input so you will need a $\frac{1}{4}$ " to $\frac{1}{8}$ " (or 3.5mm) adaptor.

Cable Selection and Length Considerations:

A 25' audio equipment cable, with 3.5mm ($\frac{1}{8}$ ") male connectors, is specified to provide a suitable cable length for hydrophone deployment for depths of 20'. Alternative cable lengths are available from the same supplier, so be sure to consider both the depth to which the hydrophone is to be deployed as well as the length of cable required to reach the audio amplifier and/or other surface equipment.

Note: Cables may have different configurations; Type 1 internally has white, red and yellow wires. This is a three-conductor cable and was used in these instructions. Type 2 has white and red wires and an un-insulated shield wire. This is known as a twisted shielded pair (TSP) cable. **If using the Type 2 cable, the un-insulated shield wire should be used in place of the yellow wire described within this document.**

Hydrophone Fabrication Steps

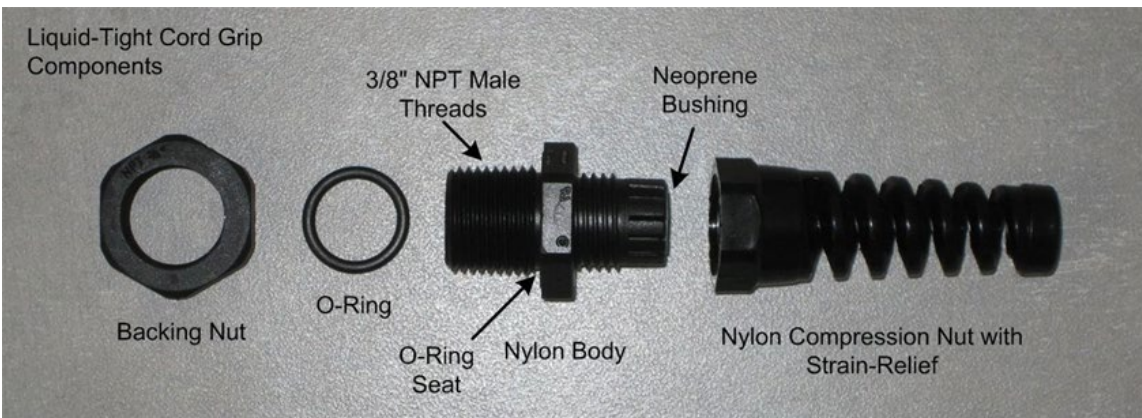
Recommended Tools:

- Ruler or tape measure
- Wire strippers (#26AWG to #12AWG)
- Adjustable or open-ended wrenches
- Small Philips head screwdriver
- Multimeter tool
- Scissors
- Tape (electrical or masking)
- Rubber gloves
- Cardboard box
- Paperclip(s)

Preparation of the Hydrophone Container:



1) If the liquid-tight cord grip came assembled with a backing nut threaded to the nylon body, remove the backing nut and set it aside, along with the O-ring. *The backing nut and O-ring are not required for this activity.*

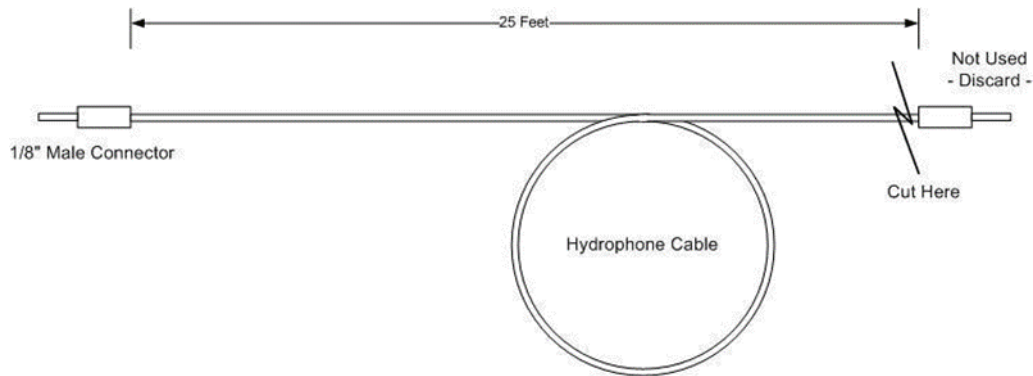


2) Thread the 3/8" NPT male threads of the nylon liquid-tight cord grip body into the PVC pipe bushing until the two units are properly secured.

NOTE: Thread the two components together by hand until they are "hand tight".

3) With a wrench tighten the fittings another 1-1/2 to 3 turns past hand tight. **However, do NOT tighten too tight or you will not be able to insert the hydrophone cable later in the build.**

Preparation of the Hydrophone Cable:



Single hydrophone cable from 25' audio cable with 3.5mm male to 3.5mm male connectors.

4) The audio cable is the “hydrophone cable”. Cut off **ONE** of the 3.5mm male connectors (at the ends of the cable) as close to end of the cable as possible. This will provide you with a single hydrophone cable of the maximum length having one 3.5mm male connector at one end and exposed leads/wires at the other.



5) Feed the cut end of the hydrophone cable through the cord grip end of the hydrophone container, and out the opening of the PVC pipe bushing.

6) Feed about 3 inches of cable through the opening to provide plenty of slack.

7) Working from the cut end of the hydrophone cable, strip back and remove approximately 3/4” of the outer cable jacket, exposing the individual leads/wires within. **NOTE:** The #12 or #14 AWG wire stripper works well for this task. **Be careful not to penetrate the insulation of the wires inside.**

8) Using the #26 AWG wire stripper, strip approximately 1/4” of insulation from the ends of all insulated wires. **If your cable is of the TSP type** (e.g. Type 2), having one un-insulated shield wire, gently separate all strands of this conductor from the two insulated wires and **twist the individual un-insulated wire strands together** forming one conductor.

9) Using the multimeter tool and the diagram below, identify and document the wire colors (or wire type) associated with the tip, ring and sleeve of the 3.5mm male plug (i.e. connector) attached to your hydrophone cable. Complete the empty cells of Table 1 (shaded in blue) to document the relationships for your specific cable.



Table 1.

3.5mm Male Connector	Hydrophone Cable Wire Color/Type	Piezo Element Wire Color
Tip (signal)		Red
Ring (unused)		
Sleeve (common)		Black

10) Set the multimeter to 200 Ohms (or lowest setting). Holding one multimeter probe in contact with the tip of the 3.5mm male connector, use the second multimeter probe to make contact with each of the exposed wire leads until you identify the conductor (e.g. wire) that is connected to the tip. If there is a connection, you should see a low resistance (e.g. less than 10 Ohms) register on the multimeter.

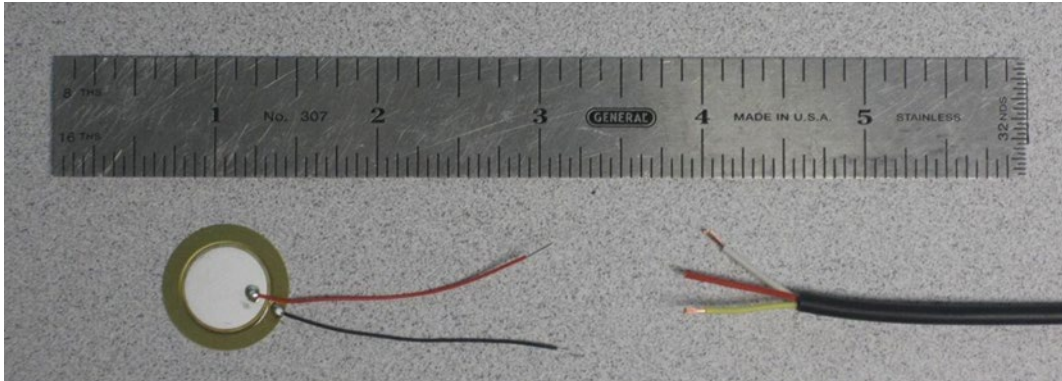
11) Once you identify the particular wire that registers on the multimeter, document the wire color or wire type (e.g. shield wire) in Table 1 (above).

12) Repeat this process for the ring and the sleeve of the 3.5mm male connector and complete the table.

NOTE: Even after you have identified a particular wire associated with the pin you are probing, it is a good idea to probe all remaining wires to ensure you see no continuity to other wires of your cable.

Termination and Electrical Connections of the Hydrophone Cable:

13) Working from the cut end of the hydrophone cable, and referencing Table 1, **snip off and discard the wire from your hydrophone cable associated with the ring of the 3.5mm male plug.** This wire is not required for the fabrication of your hydrophone as only two wires are used to carry the signal from the source piezo element.

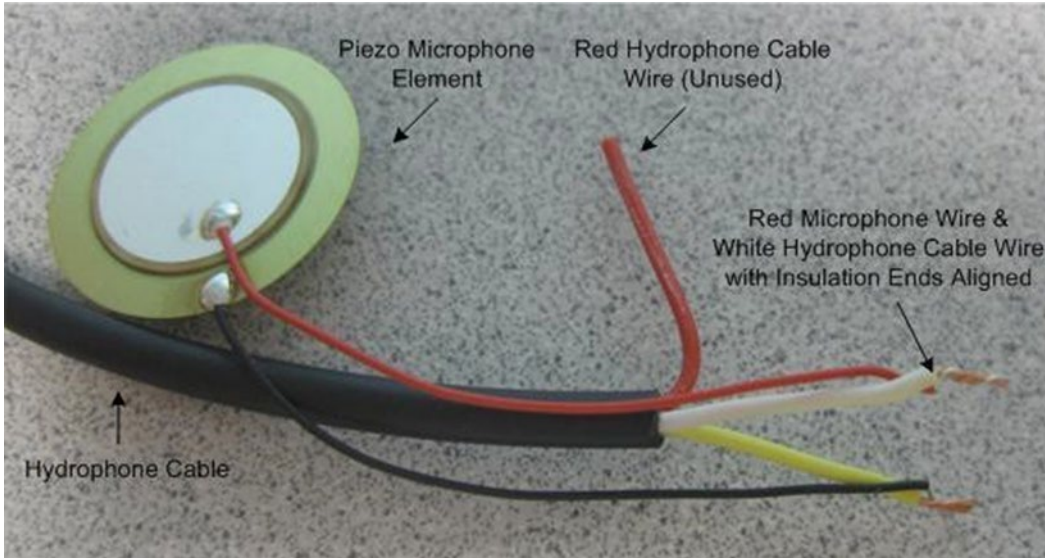


14) Strip back and remove approximately 3/4" of the outer cable jacket, exposing the individual wire leads within. **Be careful not to penetrate the inside wire insulation.**

15) Using a wire stripper, strip approximately 1/8" of insulation from the ends of the inside two wires.



PLEASE HAVE AN INSTRUCTOR CHECK YOUR WORK!



16) Working with the piezoelectric microphone element and hydrophone cable, and referencing Table 1, **match the red piezoelectric microphone element wire to the wire from the hydrophone cable associated with the tip of the 3.5mm male plug. Twist the exposed leads of these two wires securely together.** You will find that by holding both wires so they slightly cross one another, with their insulation ends aligned, you can twist the smaller wire of the piezo element tightly around the wire from the hydrophone cable forming a strong bond.

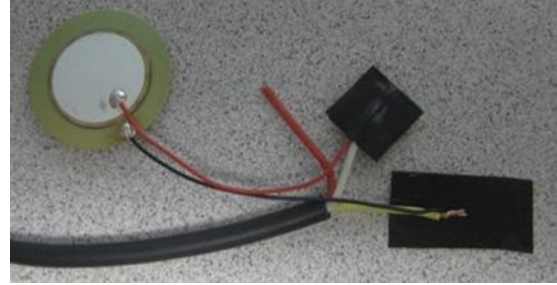
17) Once complete, test the integrity of the connection by gently pulling on the wires. If they separate from one another, repeat the process to ensure that a suitable mechanical connection is made.

18) Following the technique utilized in the previous step, and referencing Table 1, **match the black piezoelectric microphone wire to wire to the hydrophone cable associated with the audio plug's sleeve**, and twist the exposed leads securely together. Test this connection and repair if necessary.



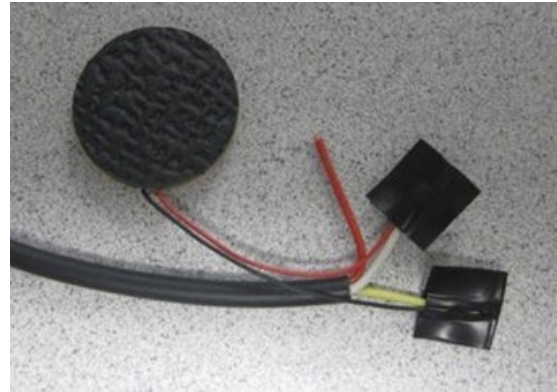
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19) Cut two strips of electrical tape to approximately 3/8" in length and fold over the ends of each wire pair to insulate the exposed wires from making contact with one another.

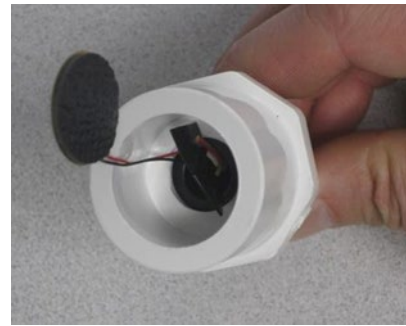


20) Peel the foam bumper from its backing paper and **stick the bumper over the ceramic (white) side** of the piezo element ensuring that the bumper is centered on the disc.

This bumper ultimately provides an air space in the final assembly in which the piezo element can vibrate.



21) With all connections made, and with the foam bumper in place, gently pull the hydrophone cable back through the nylon cord grip until the taped connections touch the bottom of the PVC bushing. **Do NOT pull beyond this point, or you will compress your wire connections and your hydrophone may not work properly.**



22) Holding the PVC bushing in one hand, **tighten the compression nut with strain relief fully against the nylon body of the liquid tight cord grip.** When fully tightened, no space should be visible between the two components of the cord grip and the hydrophone cable should be held securely in place. (you'll also see the neoprene squeeze in the center of the spiral part of the cord grip). You may need to use a wrench or vice grips to complete this step.

Testing Prior to Epoxy Fill:

23) Plug the 3.5mm male connector of the hydrophone cable into the input jack of the audio amplifier and turn the amplifier on to full power.

If the electrical connections have been made appropriately, tapping the piezo element will emit an audible sound from the audio amplifier.



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Potting the Hydrophone Component:

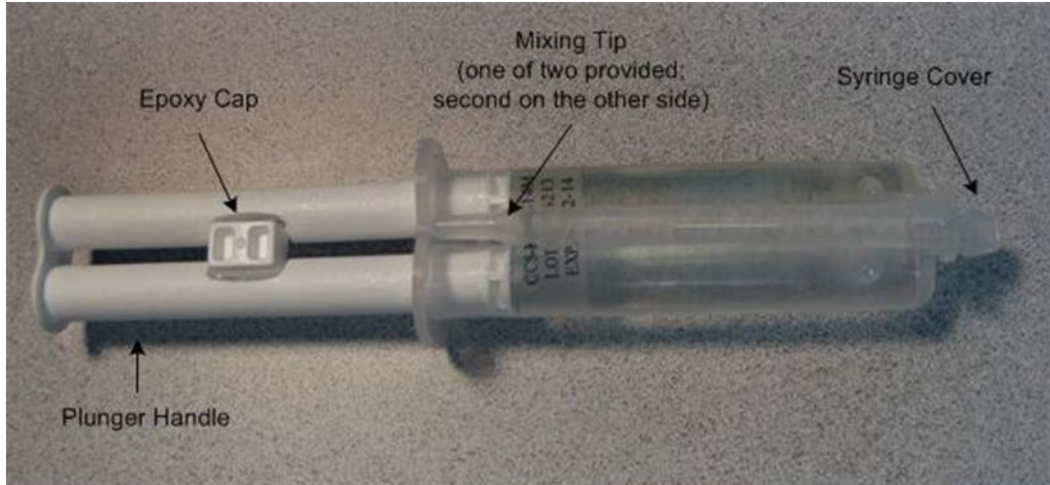
NOTE: It is necessary to support the hydrophone container upright and level when filling this component with the 2-part epoxy adhesive. It is recommended to use a bench vise, if available, to support the hydrophone container. If no such tool is available, a simple alternative of using a cardboard box for stability will work.

**** Please be careful with the epoxy in your workspace; the epoxy will harden quickly and is difficult to remove, so surfaces should be protected.**

24) To prepare a box to hold your hydrophone for filling, using scissors, cut a slit inward from one side of the box, followed by a small hole about the diameter of the nylon cord grip in the hydrophone assembly.



25) Use **rubber gloves** for protection when working with the 2-part epoxy adhesive.



26) Using scissors, cut away the tape securing the two mixing tips to the syringe body and set the tips aside for future use.

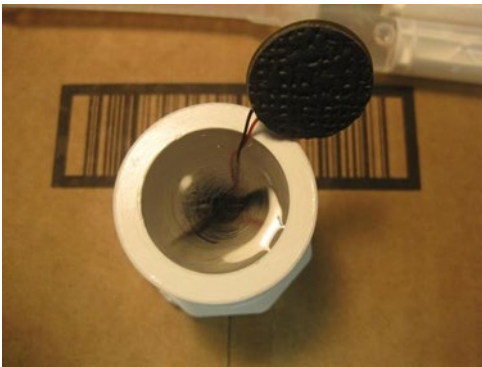
27) Pry the epoxy cap from between the plunger handles and set it aside for future use.

28) Holding the epoxy syringe in one hand, twist and break off the syringe cover to expose the opening of the two-chambers containing the 2-parts - epoxy resin and epoxy hardener. You may need to use pliers or vice grips to twist the cover off. **Avoid applying pressure to the plunger handle as this will cause the epoxy to be ejected from the syringe chambers.**

29) Install one of the mixing tips onto the open end of the syringe body. **Do not apply epoxy without the tip! The syringe tip will mix both parts of the epoxy.** Install the tip by pushing the rectangular end of the syringe tip inwards until it bottoms out against the syringe body, **twisting it to lock it securely in place.**

30) Start a timer to monitor your progress as you will have **approximately five minutes** from the initial injection of epoxy until the resin begins to harden.

31) Point the syringe into the bottom of the hydrophone container, centering it over the opening to the liquid-tight cord grip. Apply even pressure to the plunger handle to begin injecting the two-part epoxy into the bottom of the hydrophone container, filling all voids as you continue to spiral upwards and fill the PVC housing. Maintaining consistent pressure with a slight rotational motion will minimize air bubbles forming as the epoxy is injected into your hydrophone container. **Fill the hydrophone container to approximately 1/16" from the top** of the PVC bushing.



32) Gently bend the wires of the microphone element over and position the element bumper side (black side) down against the surface of the epoxy until it is parallel with the top of the PVC bushing. Depending on the speed with which you injected the epoxy, you should have a few minutes to **maneuver and position the element with a paper clip** to ensure it is centered and level with the surface of the PVC bushing. Do NOT leave the paper clip on too long, or it will get stuck in the epoxy (and when pulled, you will have a peak of epoxy. **NOTE:** You want a FLAT surface at the top!).

33) Once you feel the epoxy beginning to set, and **can no longer move the piezo element with ease, continue adding a second layer of epoxy over the surface of the element**, working in a circular motion from center **to the outer edge of the hydrophone container**. Working with care, you should be able to **add a thin layer extending slightly above, and across the entire surface of the hydrophone container**. Remove and discard the mixing tip from the epoxy syringe and seal the epoxy with the cap provided.



34) Allow the epoxy to cure for an additional 15 minutes before deploying in water for further testing.