

Simple Hydrophone Design

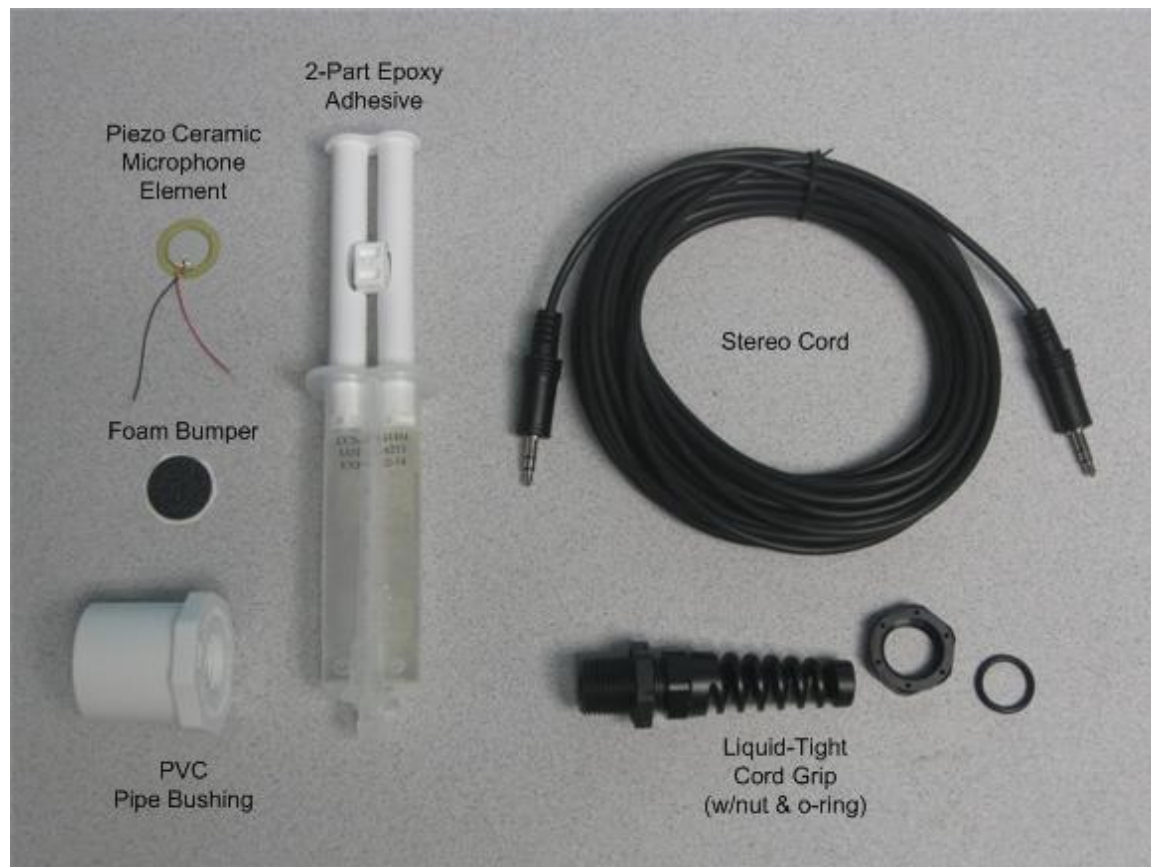
Adapted from: COSEE TEK ~ University of Connecticut



Last updated summer 2021 by Inner Space Center at URI/GSO

Discovery of Sound in the Sea
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Simple Hydrophone Design - Basic Material List



Hydrophone Components		
Description	Vendor	Part Number
Piezo Ceramic Microphone Element	SparkFun	SEN-10293
Stereo Cord with 3.5mm Connectors (25')	McMaster-Carr	
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*	Amazon	
9Volt Battery for Audio Amplifier	Miscellaneous	
1/4" to 1/8" (or 3.5mm) adaptor	Various	
MusiBaby M68 Portable Bluetooth Speaker rechargeable	Amazon	
Note: SparkFun is an online reseller of electronics & electrical supplies (see www.sparkfun.com). McMaster-Carr is an online reseller of industrial supplies (see www.mcmaster.com). Other vendors besides Amazon carry the recommended amps. Other brands may work as well, but these are tested and known to work well. Not all speakers will work. *Preferred		

Simple Hydrophone Design – Overview & Component Description

Hydrophone Components:

The hydrophone design presented through this activity demonstrates the use of simple and affordable components for the construction of a useful and functional scientific tool for acoustic research and education. The complete hydrophone system has been designed to offer a turnkey solution through the inclusion of 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 in which to house the piezoelectric microphone element as well as all associated electrical connections. This container is fabricated from a simple PVC pipe fitting and Nylon

liquid tight cord grip. The PVC fitting provides a suitable enclosure for the piezoelectric microphone element and electrical components, while the cord grip with strain-relief secures the hydrophone cable as it enters the hydrophone container and provides strain relief for the cable at this point of entry. 2-part epoxy adhesive is used to secure, insulate, and seal all electrical components and connections within this hydrophone container.



The hydrophone cable is the component of the system designed to carry 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 surrounding the individual conductors of the

hydrophone cable, while the 3.5mm male stereo plug provides an ideal means of connecting the hydrophone to the surface-mounted audio amplifier.

Cable Selection and Length Considerations:

A 25' stereo audio cable, with 3.5mm (1/8") male stereo connectors, has been specified within the material list for this activity in order to provide one option of suitable length and design to enable hydrophone deployment to depths of up to 20', while providing direct compatibility with the audio amplifier identified for surface connections. Alternative cables of this design are also available in

lengths from 1-1/2' to 50' from the designated supplier, while longer cables are available from alternative material suppliers.

As only one 3.5mm male connector is required for the construction of a single hydrophone, any similar audio cable, having 3.5mm male connectors at each end, can provide for one or two hydrophone builds. Therefore, in selecting the source cable for this activity, consider the length necessary to meet the needs of the application as well as the potential for dividing the cable into two segments, should multiple hydrophones be required. Ultimately, in determining the required length for any hydrophone cable, 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, if you purchase one of the six cable options from the material list, your cable may arrive in one of two different configurations; Type 1 has white, red and yellow wires. This is known as a three conductor cable and was the cable used in documenting/illustrating 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.**



The original hydrophon build used a Radio Shack Audio Amplifier/Speaker which has been discontinued. The build photos in this guide still use the Radio Shack speaker/amp but newer options are needed. In 2021 two speaker/amp combinations were used: Danelectro Honeytone N-10 Guitar Mini Amp and the MusiBaby M68 Mini Portable Bluetooth Speaker. The Honeytone is a great amp/speaker and has a lot of power. The Musibaby is rechargeable and very flexible as it has multiple inputs including a 3.5mm audio in port and Bluetooth. The Honeytone has a list price of around \$30 and the Musibaby lists for around \$40. The Honeytone has a 1/4" input so you will need a 1/4" to 1/8" (or 3.5mm) adaptor. Overall the Honeytone is a better amplifier for the hydrophone build.

Simple Hydrophone Design – Fabrication Steps

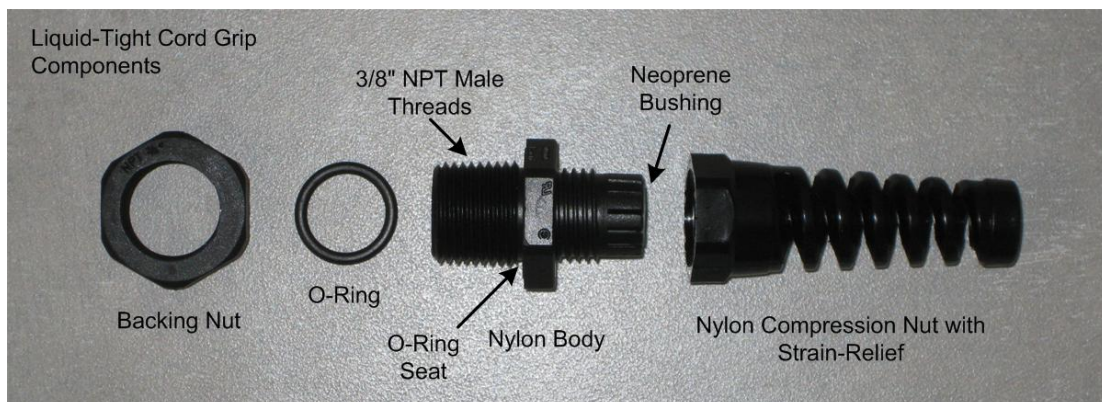
Recommended Tools:

1. Ruler or tape measure
2. Wire strippers (#26AWG to #14AWG)
3. Adjustable or open-ended wrenches
4. Small Philips head screwdriver
5. Multimeter tool
6. Scissors
7. Tape (electrical or masking)
8. Rubber gloves
9. Cardboard box
10. 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.



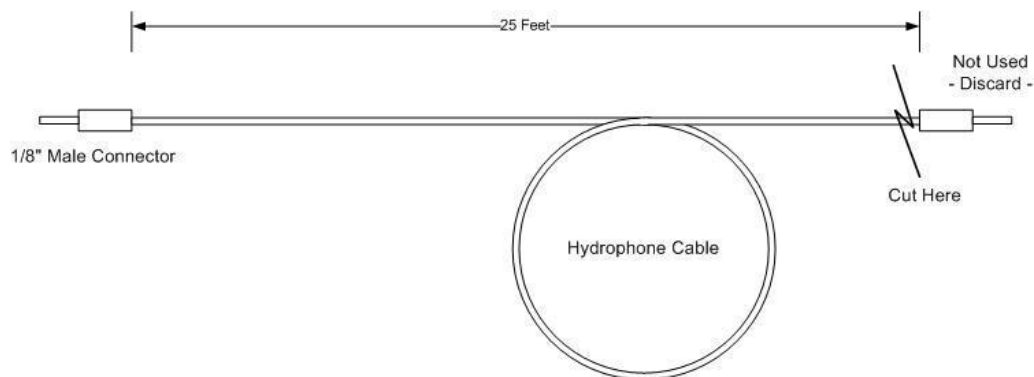
- 2) Thread the 3/8" NPT male threads of the nylon liquid-tight cord grip body into the PVC pipe bushing until the two units are properly secured.
 - a. Thread the two components together by hand until they are "**hand tight**".



- 3) With a wrench tighten the fittings another 1-1/2 to 3 turns past finger tight to complete the installation. 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:

- 4) The stereo audio cable is the "hydrophone cable". Cut off ONE of the 3.5mm male connectors (at the ends of the cable) as close to one 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 flying leads at the other.



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

- 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 to work with.



- 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 wire leads 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 referencing the diagram below, identify and document the wire colors (or wire type) associated with the tip, ring and sleeve of the 3.5mm male stereo plug (i.e. connector) attached to your hydrophone cable. Complete the empty cells of Table 1. below (shaded in blue) to assist you in documenting the relationship between connector pins and wire colors or wire type (e.g. shield wire) for your specific cable.



Table 1.

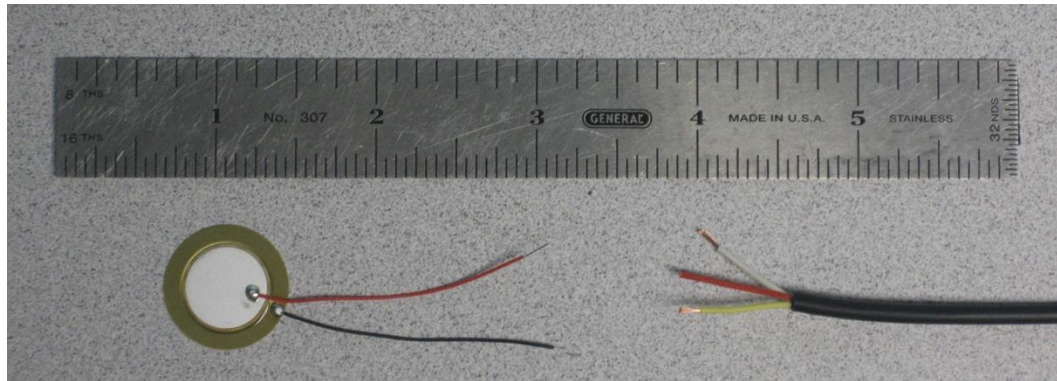
3.5mm Male Connector	Hydrophone Cable Wire Color/Type	Piezo Microphone Element Wire Color
Tip (signal)		Red
Ring (unused)		
Sleeve (common)		Black

- Holding one probe of the meter in contact with one of the pins on the 3.5mm male connector, use the second meter probe to make contact with each of the exposed wire leads until you identify the conductor (e.g. wire) that is connected to the pin you are probing.
- With the meter set to ohms, you should see a low resistance (e.g. less than 10 Ohms) when you make a connection across a common conductor, or you will hear an audible tone if your meter is set as such.

- Once you identify the particular wire that shows continuity to the pin you are probing, document the wire color or wire type (e.g. shield wire) in Table 1. and repeat the process for each of the remaining pins of the connector until you have completed the relationship 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:

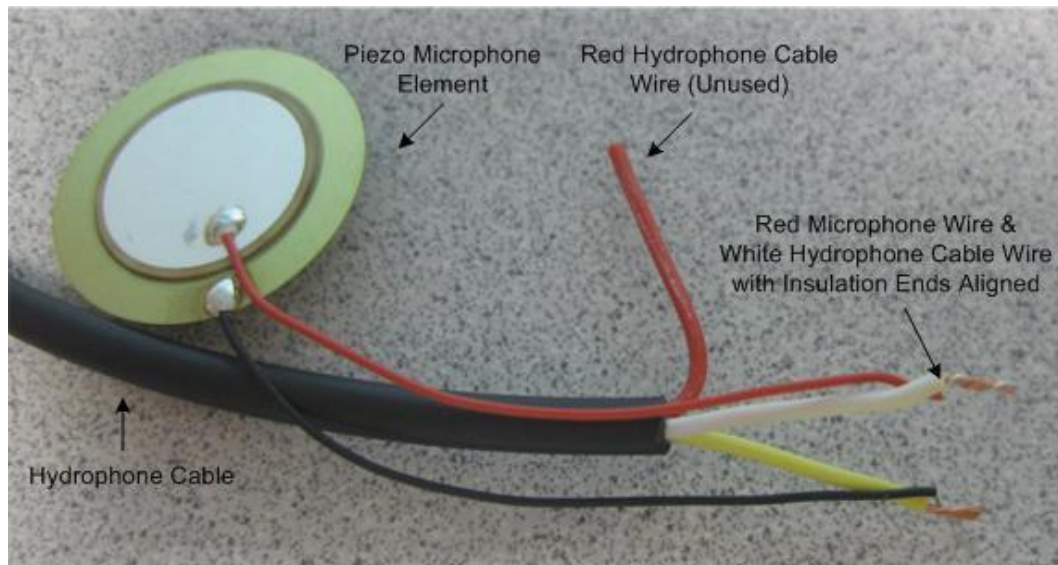
- 10) Working from the cut end of the hydrophone cable, and referencing Table 1. above, **snip off and discard the wire from your hydrophone cable that is associated with the ring of the 3.5mm male stereo plug.** This wire is not required for the fabrication of your hydrophone as only two wires are used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



- 11) Strip back and remove approximately 3/4" of the outer cable jacket (surrounding the entire cut end of the cable), exposing the individual wire leads within. **Be careful not to penetrate the insulation of the wires inside.**
- 12) Using a wire stripper, strip approximately 1/8" of insulation from the ends of the remaining two wires.



PLEASE HAVE AN INSTRUCTOR CHECK YOUR WORK!

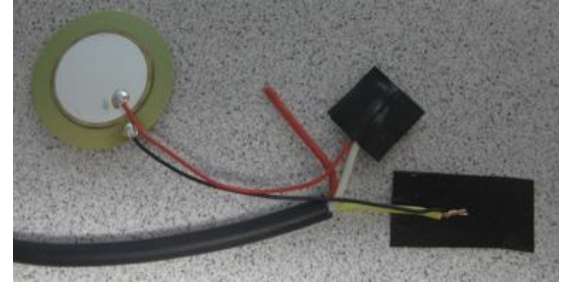


- 13) Working with the **piezoelectric microphone element** and **hydrophone cable**, and referencing Table 1. above, **match the red piezoelectric microphone wire to the wire from the hydrophone cable associated with the tip of the 3.5mm male stereo plug. Twist the exposed leads of these two wires securely 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 microphone element tightly around the wire from the hydrophone cable forming a strong bond.
- 14) 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.
- 15) Following the technique utilized in the previous step, and referencing Table 1., **match the black microphone wire to wire from the hydrophone cable associated with the stereo plug's sleeve**, and twist the exposed leads securely together. Test this connection in a similar fashion and repair if necessary.

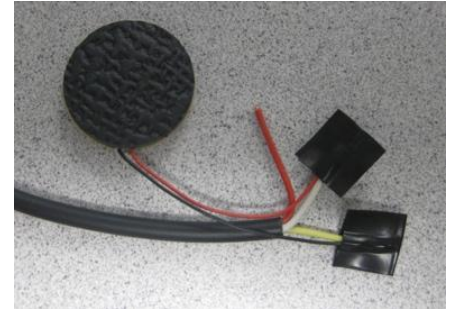


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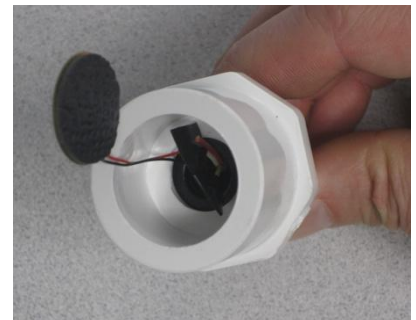
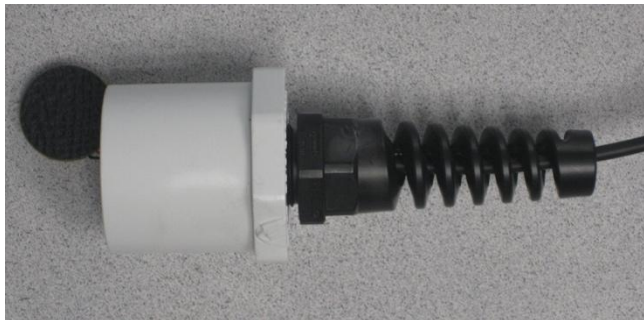
- 16) Cut two strips of electrical tape to approximately 3/8" in length and fold over the ends of each wire pair to insulate the exposed wires from making contact with one another.



- 17) Peel the foam bumper from its backing paper and **stick the bumper over the ceramic (white) side** of the piezoelectric microphone element ensuring that the bumper is centered on the disc.
- a. This bumper ultimately provides an air space in the final potted assembly in which the piezoelectric microphone element can vibrate.



- 18) 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.**



- 19) 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 gray 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:

- 20) 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.
 - a. **If the electrical connections have been made appropriately, tapping the piezoelectric microphone element will emit an audible sound from the audio amplifier.**



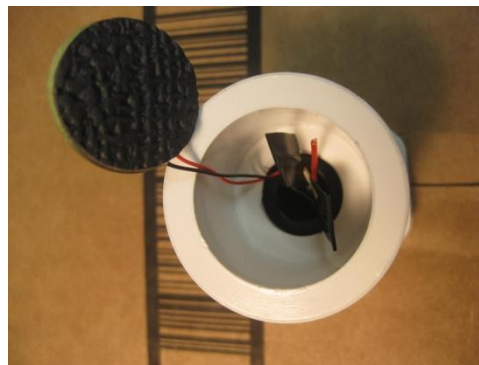
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Potting the Hydrophone Components:

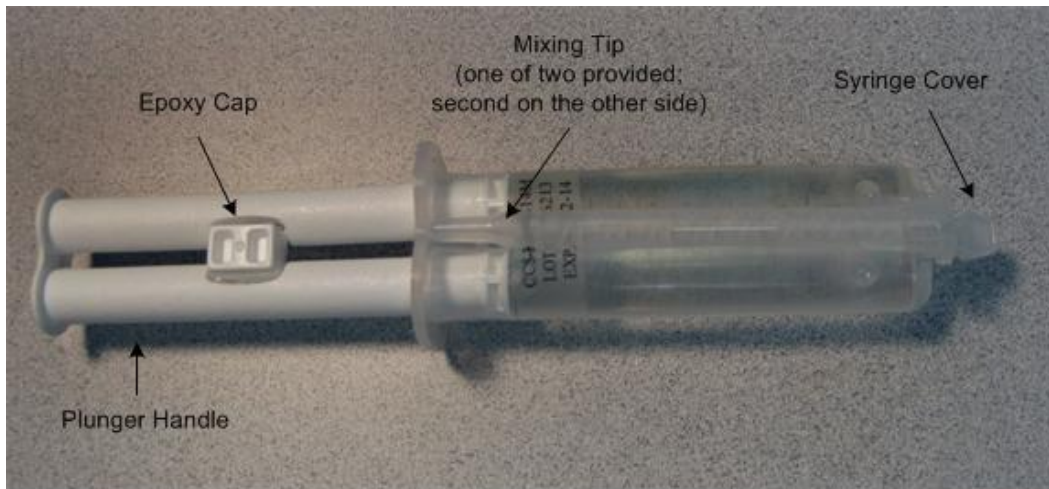
It is necessary to support the hydrophone container upright and level when filling this component with the 2-part epoxy adhesive as outlined in the following steps. It is recommended to use a bench vise or other suitable tool, if available, to support the hydrophone container. If no such tool is available, a simple alternative utilizing a cardboard box will work.

**** Please be careful with the epoxy and your workspace; the epoxy will harden to clear, difficult-to-remove resin, so surfaces should be protected if necessary.**

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

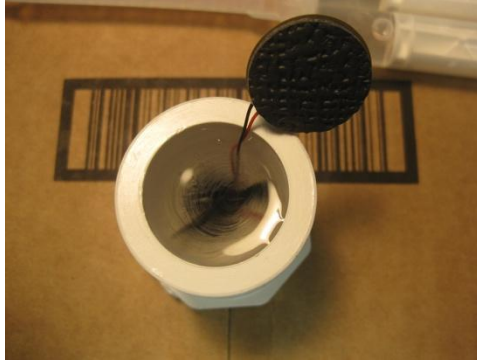


- 22) **Put on rubber gloves** to protect your hands prior to working with the 2-part epoxy adhesive.



- 23) Using scissors, cut away the tape securing the two mixing tips to the syringe body and set the tips aside for future use.
- 24) Pry the epoxy cap from between the plunger handles and set it aside for future use.
- 25) Holding the epoxy syringe in one hand, twist and break off the syringe cover to expose the opening of the two-chambers containing the 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.**
- 26) Install one of the mixing tips onto the open end of the syringe body. **Do not apply epoxy without the tip! You need to use the syringe tip as it 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.**
- 27) 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.
- 28) 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 ensure that minimal air bubbles are formed as the epoxy is injected into your hydrophone container. Fill the hydrophone container to approximately 1/16" from the top of the PVC bushing.



- 29) 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 you pull it up, you will have a peak of epoxy- note you want a FLAT surface at the top!)

- 30) **Once you feel the epoxy beginning to set up, and can no longer move the microphone 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.



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

Congratulations! You have just completed the fabrication and wiring of your hydrophone assembly and are now ready to experience underwater sounds.