A One-Charge Incubator for Inexpensive In-Field Analysis of Water Quality

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ENGINEERS WITHOUT BORDERS USA
GREATER AUSTIN CHAPTER

Abstract

The means of water quality assessment in international development efforts must be devoid of language dependence, inexpensive, and carried out in communities often far away from electrical grids.

Petrifilm(TM) is a common method to detect pathogens in water. However, Petrifilms should be incubated at 37°C for 24-48 hours to provide reliable results. Due to prohibitive costs and power requirements of commercial solutions, incubation is traditionally done in-field by taping Petrifilms against the skins of engineers. However, not only is this uncomfortable, it also creates multiple opportunities for generating erroneous results.

We have been driven to create a portable, battery-powered incubator that is rugged and reliable enough to use in the third world far from grid power.

We provide a set of open-source instructions that will allow anyone with modest DIY skills and readily available tools to construct and reliably use the portable incubator with a total cost under $200.

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Problem

Petrifilms produce quantitative microbial indicators and are commonly used by EWB-USA to assess water quality in the developing world. However, to produce reliable results, Petrifilms need to be properly incubated at 37°C for 24-48 hours (Fig. 1). **We provide a portable, reliable, and inexpensive in-field incubator.**

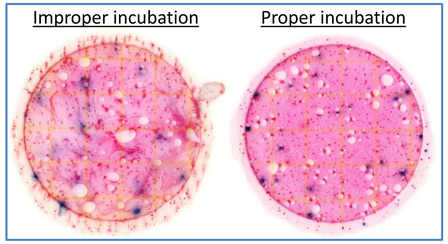


Figure 1. Petrifilms incubated on the body (left) show smeared colonies and dislodged gas bubbles, making quantification unreliable compared to incubation in an incubator (right). Coliform bacteria (red) and *E. coli* (blue) colonies associated with gas bubbles indicate fecal contamination within the sampled water source.

Materials

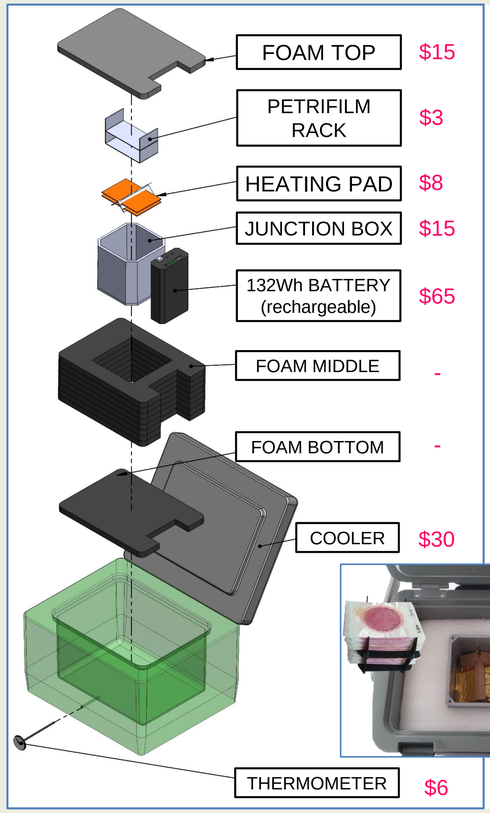


Figure 2. Exploded view of the portable incubator components. The bill of materials, including wiring (shown in Fig. 4) and basic tools (screwdriver, box cutter, glue, etc.) totals under $200.

Inset below: Top foam and junction box lid are removed, revealing heating elements and battery fit. (Petrifilm rack holding up to 50 films would be placed into the junction box).

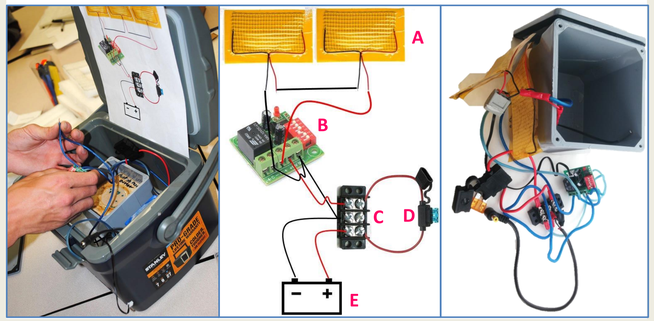
Incubator Assembly

Assembly time: 2 hours
Step 1: Cut foam, cardboard, and film rack according to templates.*
Step 2: Follow wiring diagram (Fig. 4) to create heating circuit.
Step 3: Drill thermometer hole in cooler and junction box.
Step 4: Place in foam, battery, and junction box into cooler.
Step 5: Add thermometer and secure with hot glue.
Step 6: Plug in circuit to battery.
Step 7: Turn on battery to use!

*Cutting templates and step-by-step photo instructions are available online (see Links).

Figure 3. The instrumentation team cuts foam using design stencils (March 2016).

Figure 4. Heating circuit is assembled (left) using the wiring diagram (center): Two heating pads (**A**) are regulated by a dipswitch thermostat (**B**) and connected to the battery (**E**) through a terminal block (**C**) and fuse (**D**). The circuit materials, excluding battery, totals $40 in cost and threads into the junction box after assembly (right).



Evolution of Prototypes

Figure 5. We iterated through many different designs, from a handheld Arduino-based incubator (too fragile, **A**), to a LCD shield and interior fan (too energy expensive, **B**), to others not pictured here, to our current design (meets design requirements stated in Abstract, **C**).

Incubator Performance Testing

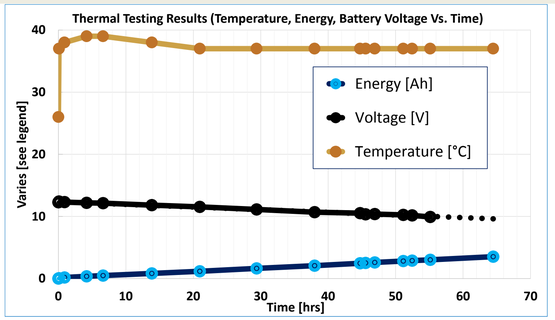


Chart 1. The results of incubator performance testing verify that the temperature within the junction box (inner chamber) is reliably held at 37°C for up to 64 hours on a single battery charge.

Figure 6. The team practices Petrifilm inoculation techniques (Oct 2016).

Conclusions

1. Unmet instrumentation needs for community projects led us to create EWB-USA's first dedicated **Instrumentation Group**.
2. We created a **portable and reliable Petrifilm incubator** for water quality analysis testing in the field for under $200:

- **Weighs 5 lbs. at less than 1 cubic feet for easy portability.**
- **Holds at 37°C ± 1°C for up to 64 hours on one battery charge.**
- Easy to assemble: Instructions & documentation online (see Links).
- Battery is standard USB: leftover power can charge cellphones, etc!

3. Future work:

- Improved incubator prototype focused on cost reduction (~$100).
- Possible alternative: wearable Petrifilm "tactical chest strap".

Useful Links

1. Step-by-step incubator assembly instructions, with photo documentation, templates, and links to purchase materials: http://bit.ly/petrifilmincubator
2. Our explanatory video (of a previous design, YouTube): http://bit.ly/incubatorvideo
3. Previous designs: http://github.com/EWB-Austin/petrifilm-incubator
4. 3M Petrifilms (3M website): http://bit.ly/petrifilm
5. 3M *E. coli*/Coliform Petrifilm explanatory video (YouTube): http://bit.ly/3mplatingvideo