

Abstract

Manually capping and uncapping test tubes is a time consuming task and also poses a risk of injury in the form of carpal tunnel syndrome. The current practice in many labs is to have a technician manually open and close test tubes in high volumes of up to 700 per day. Our client experiences this volume in their lab and wants to improve daily workflow by implementing a novel device that can automatically cap and uncapping these tubes. Ideally, time of the lab clinicians will be saved and the risk of developing carpal tunnel syndrome, as well as other injuries, will be heavily reduced.

Carpal Tunnel Syndrome

Carpal Tunnel Syndrome (CTS) is caused by the pinching of the median nerve in the wrist. About one-third of all occupational injuries are due to repetitive motion and/or exertion¹, and CTS results in more days away from work than any other workplace injury². The hand and wrist movements that cause CTS are biomechanically similar to those required to open small tubes, causing technicians to have an increased risk of developing musculoskeletal injuries such as this.



Figure 1. CTS visualization

Process

Current Procedure:

Technicians scan tubes and manually uncap all of the tubes, then place and order them into a test tube rack.

Goal:

Alleviate hand strain and wasted time present in the current process.



Figure 2. Lab technician uncapping tubes

Design Criteria

- Minimize size; should be able to fit in lab space of limited workspace
- Low maintenance
- Designed for heavy use; uncap and cap roughly 10,000 test tubes per month
- Must be more efficient/fast than manual individual uncapping and capping
- Compatible with various test tubes
- Easy to learn and teach how to use
- Prevent any cross-contamination

Final Design

Cone

- HDPE cone with 70° angle
- Dycem strips spaced evenly on interior

Dycem

- High coefficient of friction material
- Maintains sterility (no residues)
- Low cost

Mechanism

- Uses frictional force and a rotary motor to uncap test tubes
- Test tube caps can be easily discarded
- Push-sensitive and full on/off capabilities

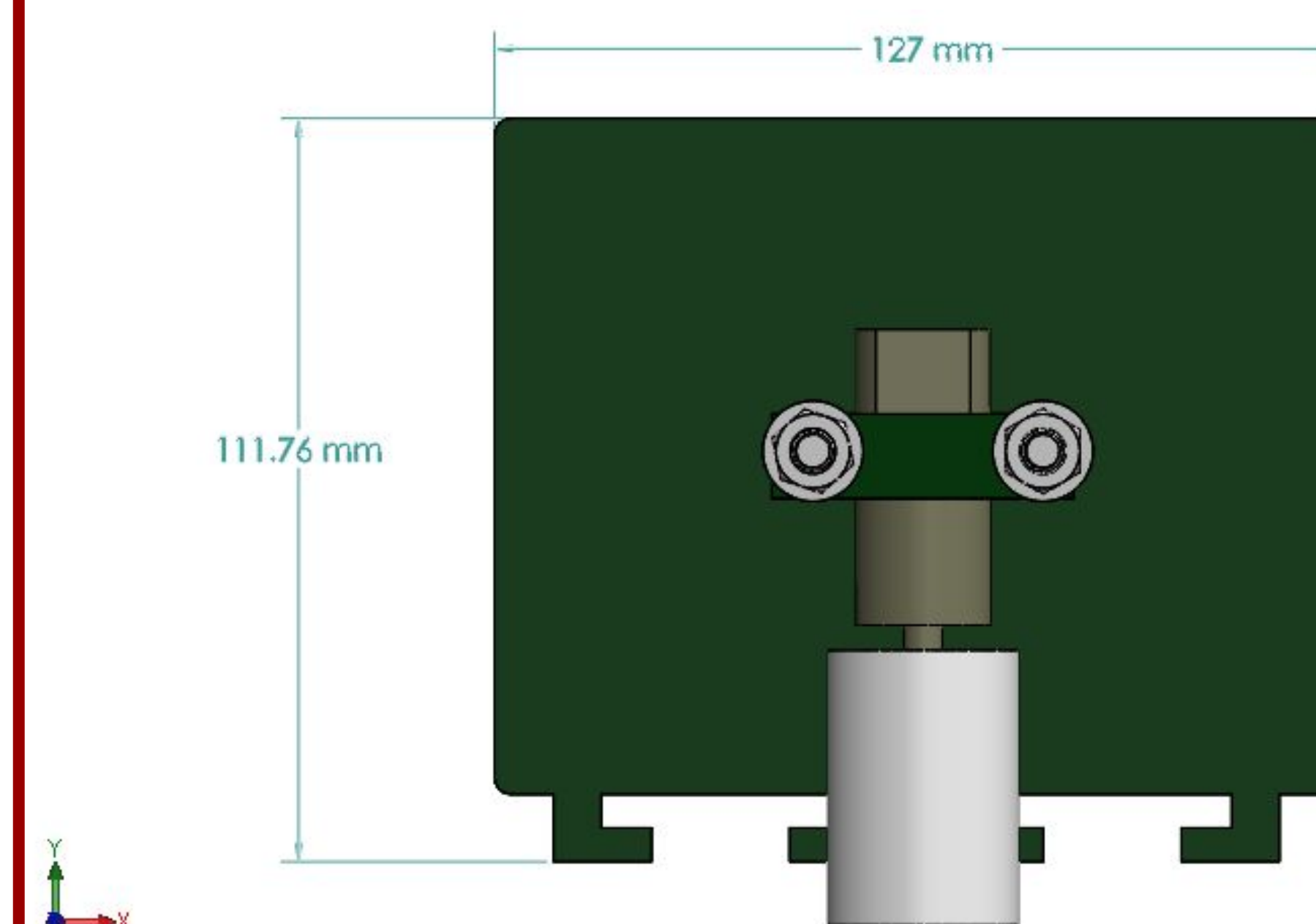


Figure 3. Front face

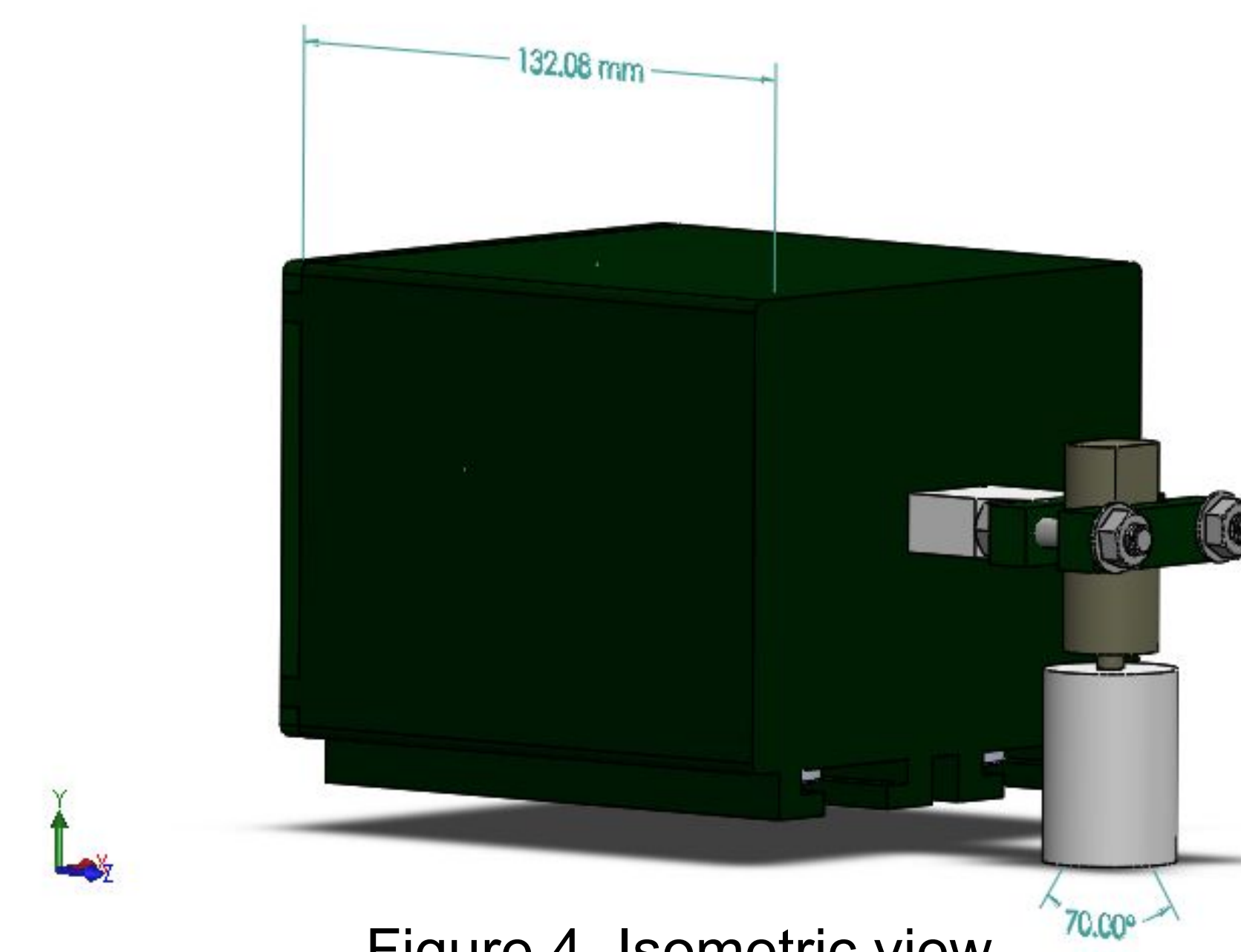


Figure 4. Isometric view

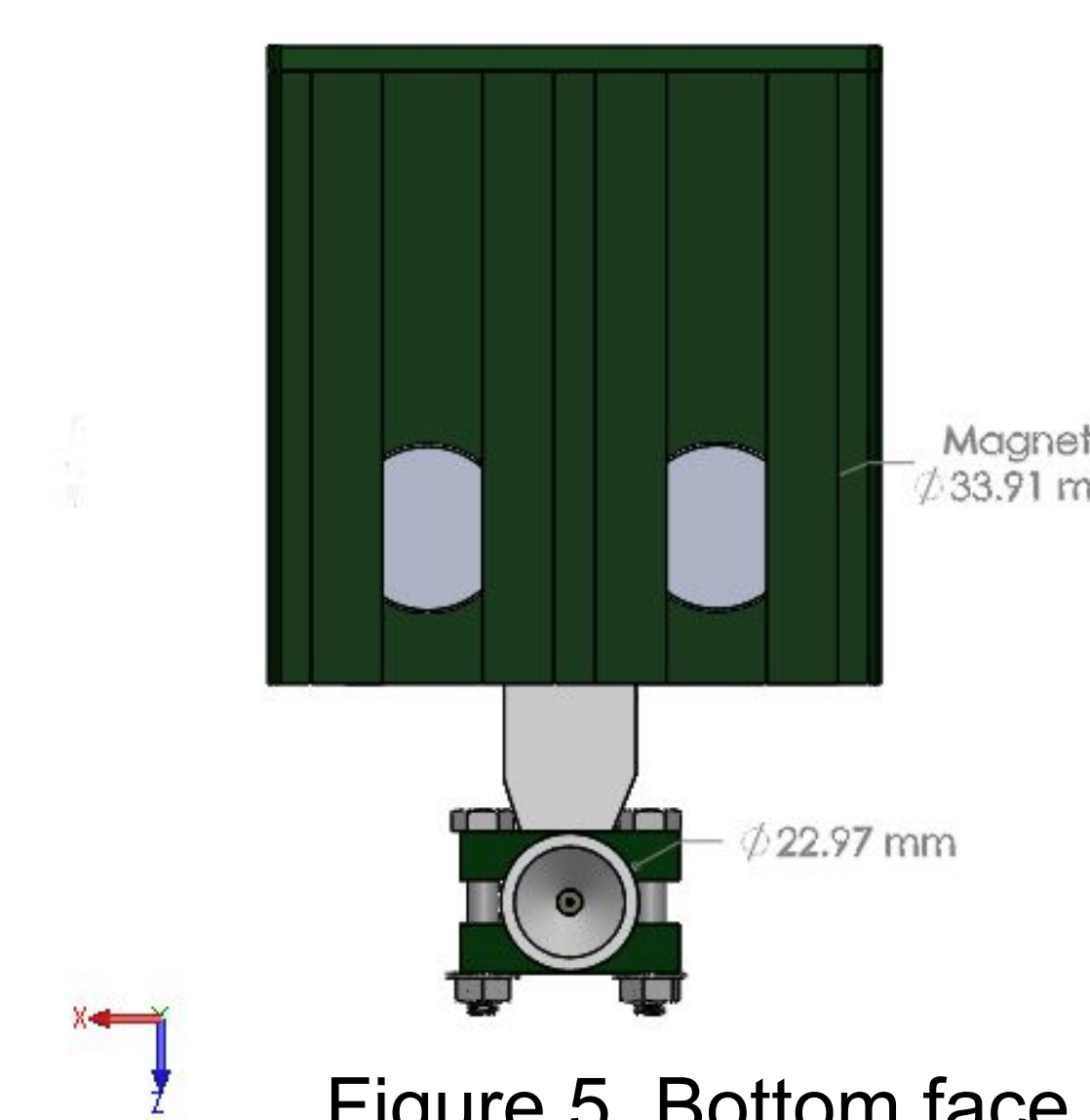


Figure 5. Bottom face

Testing & Results

Goal: Evaluate effectiveness and durability of the Uncapper

Procedure: Remove test tube caps repeatedly over extended period

Analysis: Torque required to remove cap from each type of test tube reported below. Calculated difference between manual and machine uncapping is an average per tube.

Torque Testing:

- Tube 1: 12.3 N*mm
- Tube 2: 6.5 N*mm
- Tube 3: 15.6 N*mm

Goal: Within 10% lower than manual uncapping time, which was found to be 1.62 seconds

Uncapper average for all tubes: 1.66 seconds

Total tubes uncapped: 1,000

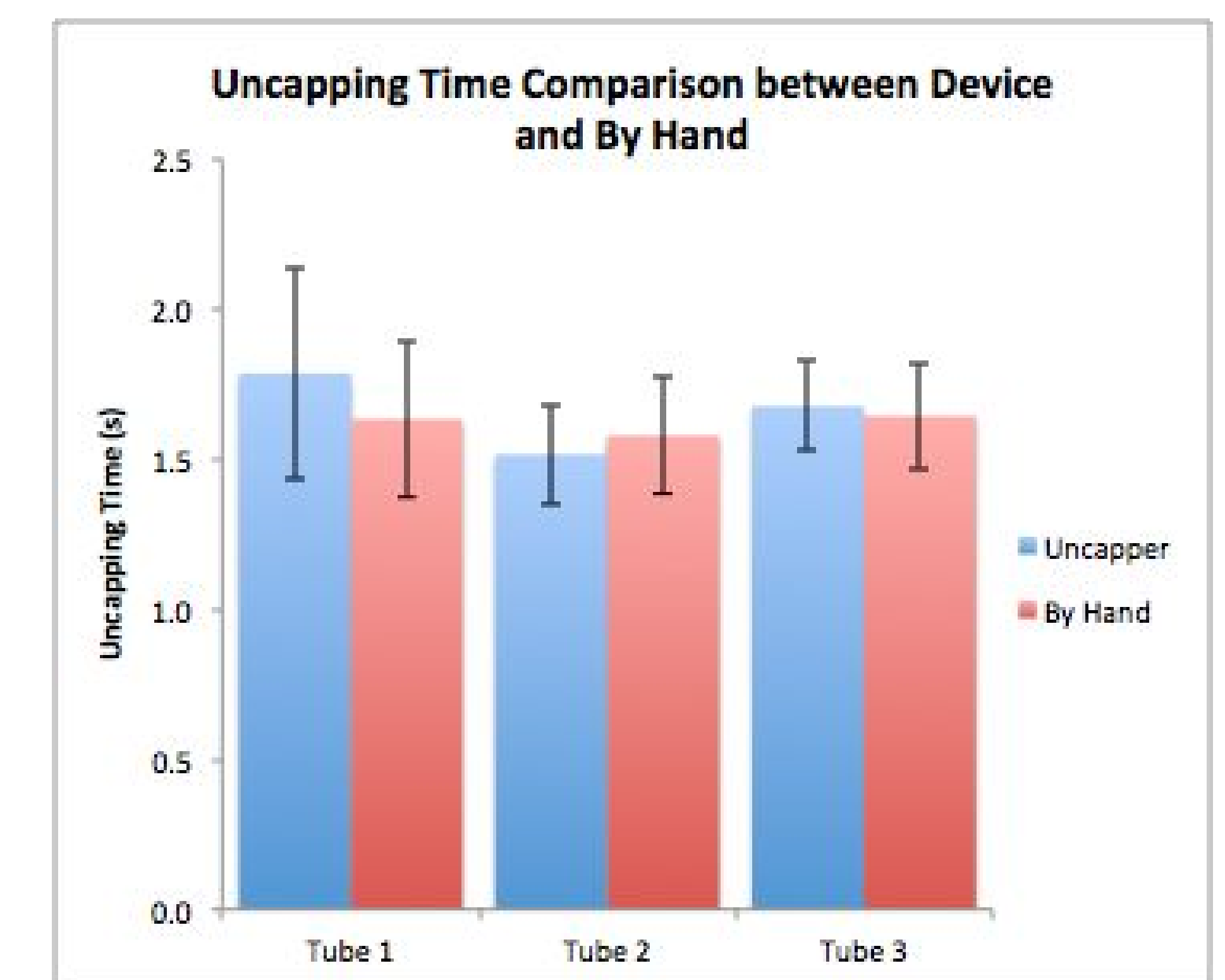


Figure 6: Testing results for three test tube types

Future Work

Capping Mechanism:

- Finalize method for test tube capping
- Iterate existing design to allow both capping and uncapping

Increase Functionality:

- Add additional motor to uncap multiple tubes at once
- Enable device to be hand-held

References & Acknowledgements

- [1] "Carpal Tunnel Syndrome Fact Sheet," *National Institute of Neurological Disorders and Stroke*, 28-Jan-2016. [Online]. Available: http://www.ninds.nih.gov/disorders/carpal_tunnel/detail_carpal_tunnel.htm. [Accessed: 17-Oct-2016].
- [2] R. Minnihan, "Carpal Tunnel Syndrome: A Rising Statistic Among Laboratory Workers," *Bioscience Technology*, 08-Apr-2003. [Online]. Available: <http://www.biosciencetechnology.com/article/2003/04/carpal-tunnel-syndrome-rising-statistic-among-laboratory-workers>. [Accessed: 17-Oct-2016].

A special thank you to Dr. Radwin and Dr. Yen for all the help and guidance they gave us.