Portable Sanitization Chamber

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Midpoint Report

Document

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1.0 INTRODUCTION

W.L. Gore & Associates needs a portable sanitization device that will decrease the bioburden levels of *Bacillus atrophaeus* past a certain threshold. Many devices today are used for sterilization, but that is not always what is needed in the medical field. W.L. Gore is looking for a device that is safe for all users, portable, reduces the level of bioburdens on various instruments and materials, cost efficient, and finishes the process in a certain time limit. This device would mainly be used in the medical field or in certain industries where sanitization is needed on a regular basis. The scope of the project described by W.L. Gore can be found in Appendix A.

The goal of the project is to develop a portable sanitization process that sanitizes bioburden amounts past acceptable levels. The design, testing, and manufacturing must not exceed $3,000 and the process must be safe to the user and environment under OSHA standards.

2.0 CONCEPT DESIGN

The final chosen design for the portable sanitization chamber is a dual process involving vaporized hydrogen peroxide (H_2O_2)/ Ultraviolet light. Both individual methods are used in the medical and industrial fields to sterilize a variety of objects. By combining both processes, there are two active disinfection methods at work. Additionally, this two-step photocatalytic process of using H_2O_2 followed by UVGI light, also creates free hydroxyl radicals, OH-, that are strong oxidizing agents. These hydroxyl radicals lack an electron, making them highly unstable, reacting with the first chemical they come into contact with. Organic contaminants are degraded almost entirely by the radicals, creating safe byproducts such as water, carbon dioxide, and various salts. These radicals degrade a variety of additional toxins such as: benzene, dichloroethylene, Freon 113, and various pesticides. The combined UV/ H_2O_2 process successfully inactivates *Bacillus atrophaeus* spores.

The materials selected for the chamber were chosen based off of compatibility with H_2O_2. Due to the strength of the materials (Modulus of Elasticity), aluminum was chosen to be used for the overall enclosure. This will also include the door, handle, hinges, rack, and any other small connecting pieces.

For additional pieces, including the H_2O_2 solution container, tubing, and nozzle: PVC and PTFE will be used. Both PVC and PTFE are highly inert materials.

Two UVGI light bulbs with a wavelength of 254 nm were chosen for the design in order to output enough UVGI light to sanitize the objects within the chamber. The bulbs were chosen based off the time it takes to achieve a 2 log reduction in the Bacillus spores. The TUV PL-L 95W bulb was chosen to be most effective for the design.

To keep the UV bulbs protected from the H_2O_2 gas, and additional dust and particles a glass sheet was chosen to cover the bulbs from the fogging compartment. Borosilicate, also known by the brand name Pyrex, is a highly UV-transmitting glass. By surrounding the cylindrical enclosure with a UV transmissive tube, such as borosilicate, the UV lights would be protected from the hydrogen peroxide and from dust and other potential threats, while the UV light still reaches the objects in the enclosure.

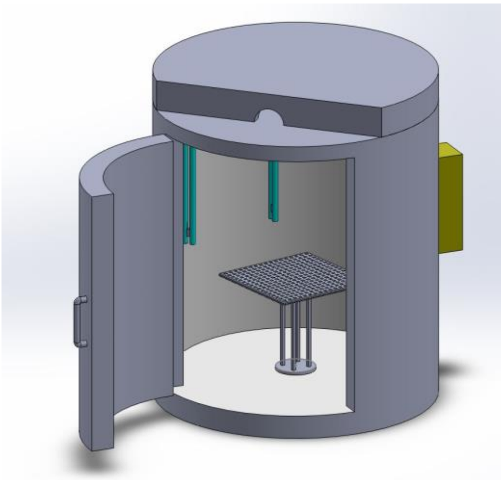

Figure 2.1: Original Design Model

3.0 Final Design

After additional research and testing, some changes were made to the overall design. The original design was a cylindrical shape, this was changed to a simple box design. A rectangular or cubic design will reduce the cost of manufacturing greatly and be much easier to add components to.

Figure 3.1: Final Design Picture- From front of chamber with door open

Figure 3.2: Final Design Picture- From side of chamber

Further research into the Borosilicate glass covers for the lighting showed that the glass was not UV transmissive until around 300nm. Because the lamp holders are not emitting UV light, any inert material can be used to protect the components from the H_2O_2 vapor. A dielectric grease, similar to that used in electrical auto components was chosen to cover the lamp holders and other exposed electrical parts.

The type of UVGI bulbs were also changed to further meet specifications. Four bulbs were used and mounted to the inside corners of the chamber. The ballasts were mounted directly onto the side chamber walls and wires were run through a hole to the outside of the chamber. Once the control system is configured, it will integrate the wiring for the lights and fogger to be set to a specific cycle.

Additionally, the fogging component was attached to the outside of the chamber. This modification was made for two main reasons. Attaching the fog machine to the outside of the chamber allows for easy access to the hydrogen peroxide container. This also keeps the electrical components on the inside of the fogger safe from the H_2O_2 vapor and possible corrosion. The fogger was bolted onto the the back and bottom sides of the chamber through the same holes that attach the walls to the frame. A small 4 inch long tube fits over the fogger nozzle and bends at a 90 degree angle, where it is inserted inside of the chamber.

Figure 3.3: Fogger attached to outside of chamber

4.0 Procedural Testing

Two different sets of spore testing will be run before the final spore testing. The first set of spores were tested on Sunday March 2, 2014. Three test papers were sent by the client, W.L. Gore, each strip containing a specific amount of *Bacillus atrophaeus* spores. The first test was run with only the UV lights running. The strip was set inside of the chamber with the lights running for 5 minutes. The second two strips were tested with both vaporized hydrogen peroxide and UV lights at different time lengths. The dual tests ran the fogging unit for 1 and 5 seconds, and then turned the UV lights on for 5 minutes. After testing, each strip was placed into a special container and mailed back to Gore for analysis. Using a process called serial dilution to count the number of active spores still present on each test strip. Results for the first round of testing are expected by Monday March 10, 2014.

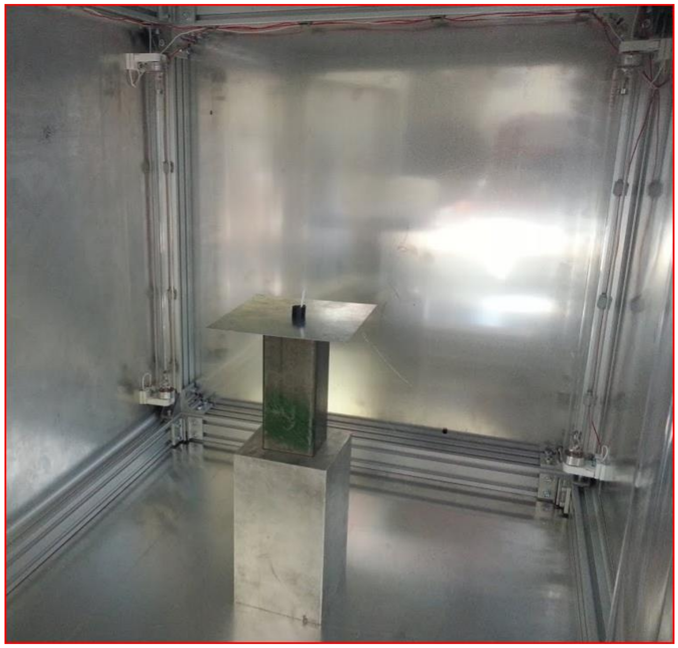

Figure 4.1: Testing spore strips inside chamber

Based on the individual test results, the fogger and light times will be tuned for optimal performance. In the case that little to no spores are inactivated, additional lights will be purchased and the concentration of hydrogen peroxide will be increased.

Additional tests will be run to assure safety. These tests will test the levels of H_2O_2 in the air around the chamber, and inside the chamber after running the fogger and lights. As per OSHA standards, the level of vaporized H_2O_2 may not exceed 1 ppm. Low level H_2O_2 testing strips were purchase that read levels from 0.2 to 2.0 parts per million. If vapor is escaping the chamber, silicon caulking will be used to further seal the walls and holes in the chamber.

5.0 Safety Assessment

Some safety concerns arose during the first round of testing procedures. The first thing to note is that the nozzle might be too hot for the vacuum tube. Smoke would occasionally come from the tube when it was attached to the nozzle. This could be fixed by using a metal pipe that can withstand the heat or dissipate it better than the vacuum tube that is currently being used. There also was no sealing where the wires came out of the side panel of the chamber. The last safety concern is that the door was not completely sealed. There was a sliver of light in between the sealant and the door. New sealant and new latches will be researched to see which would work best for this design.

6.0 Control System

The control system to create a fully automated process has been delayed. Although the Arduino microcontroller is in shop (**Figure 5.1)** and circuitry components are at hand, the relays switches have been found to be inadequate for this application.

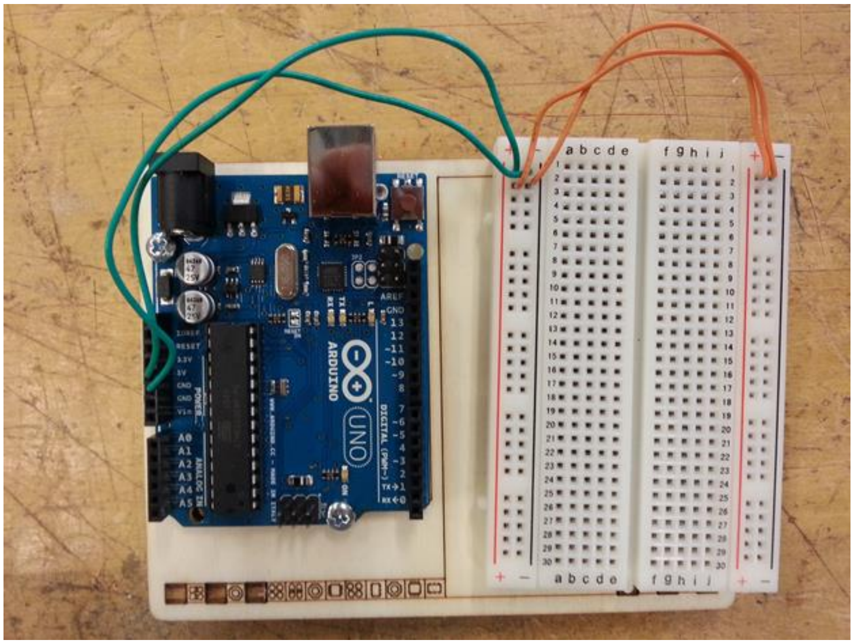

Figure 5.1: Arduino and breadboard

Connect 5 Voltages from the arduino to the positive column of the breadboard, and connect the ground from the arduino to the negative column of the breadboard as well.

The original relays selected (OMI -SS - 212L shown in **Figure 5.2**) are rated for 5 amperes and up to 240 Vac which is more than enough for this necessary uses. Complications with the relays resulted in consulting an electrical engineering expert to determine the issue. While these products are well rated, their switching voltage is a nominal 6 volts which is higher than the amount of voltage that the Arduino can provide through its digital pins. The consultant recommended a more compatible relay switch, one than can be controlled by the Arduino and is rated for the 120Vac applications. The new product can be seen in **Figure 5.3**, a two relay module that also contains digital pins compatible with Arduino control. Upon receiving the two module relay, the control system team can continue to create the logic and circuitry to integrate the lights and fogging machine.

Figure 5.2: Original relay

Figure 5.3: New two module relay

7.0 Project Plan

Figure 7.1 below shows the project plan for the semester. Tasks included for this semester are testing, operation manual, prototyping, and final design. Testing will be done on the hydrogen peroxide, UVGI, and control systems. Prototyping and testing is conducted by Ellie Nation and Lauren Kieffer. Jacob Blackburn and Robertson Beauchamp is in charge of design and building. The control system is being worked on by Angel Soto and Dangxian Zha. Unfortunately, some of the planned testing that was proposed was not able to be done. Currently the team is on track and just completed the testing provided by W.L. Gore. Next, final touches on the chamber need to be implemented such as safety concerns and aesthetic appeal.

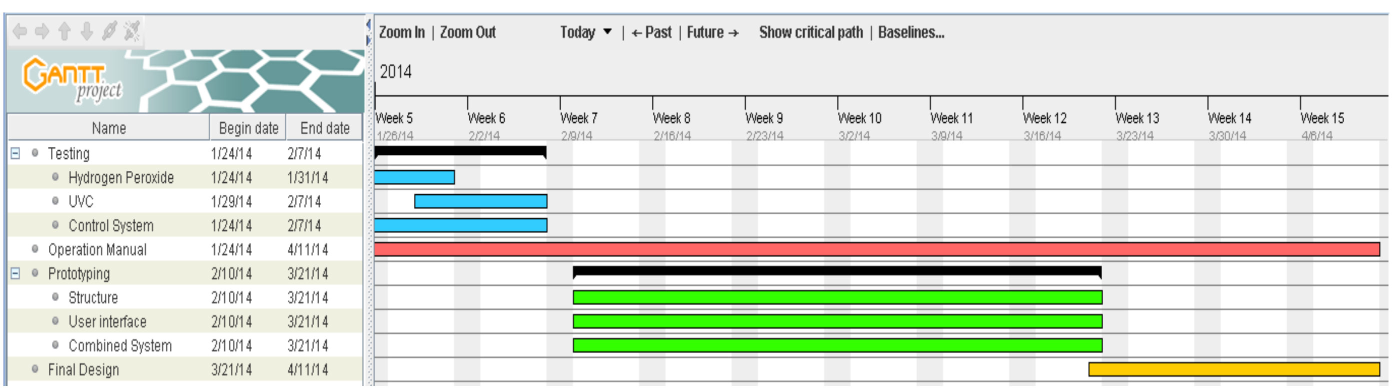

Figure 7.1: Project Plan

8.0 Conclusion
Completion of the physical build allows for a refocus of resources. Extensive testing in future test strips of *Bacillus atrophaeus* can be addressed to determine the most effective combination of processes. Design requirements regarding OSHA standards and user safety can be assessed and resolved. The control system integration shall proceed upon circuitry completion. The electrical components (UV bulbs and fogger) can then be codes to run based on the most effective series of tests from the strip results.

References
Relay. Digital image. *Www.allelectronics.com*. Electronics Corp, n.d. Web.

2 Channel 5V High Level Trigger Relay Module for Arduino. Digital image. *Http://www.miniinthebox.com*. Miniinthebox, n.d. Web.

APPENDIX: Project Description

Title: Portable Sanitization Chamber for Medical Manufacturing Use

Information on Project Sponsor:
At W. L. Gore & Associates, our products are designed to be the highest quality in their class and revolutionary in their effect. We resolutely live up to our product promises, and our associates address technical challenges with innovative, reliable solutions.

Our fluoropolymer products provide innovative solutions throughout industry, in next-generation electronics, for medical products, and with high-performance fabrics. We've repeatedly been named among the "100 Best Companies to Work For," in the U.S. by FORTUNE magazine, and our culture is a model for contemporary organizations seeking growth by unleashing creativity and fostering teamwork.

While we may be best known for our GORE-TEX® fabrics, all our products are distinguished in their markets. Our technologies and fluoropolymer expertise are unsurpassed.

We create next-generation cable assemblies and components for the electronics industry, set the standard for outerwear comfort and protection, solve difficult industrial problems with innovative materials and technology, and Gore medical products work in harmony with the body's own tissues to restore normal body function.

Scope of Work:
The scope of this project is to design and build a portable sanitization chamber for use in the medical industry. The chamber should sanitize various materials with complex geometry by

reducing the bioburden to less than routine final bioburden levels. A portable sanitization chamber could be used as an in line solution to reduce contamination during manufacturing, for sanitizing materials for entry into cleanrooms, or for entry into sterile hospital settings.

Portable Sanitization Chamber Requirements (provide appropriate justification for meeting requirements):

- SAFETY
  - No harmful materials
  - Users are not at risk of exposure to sanitizing source
  - Applicable OSHA safety standards met
- Cleanliness standard
  - Samples will be tested for bioburden levels before and after chamber use
- Ease of use
  - Short cycle time
  - Cycle ends automatically when complete
  - Easily transported by one person
- Materials to be sanitized (must not be adversely impacted by sanitization process)
  - Tackle Box
  - Cleanroom Approved Notebook
  - Hemostats

Desired Engineering Majors: Biomedical, Mechanical, and Electrical
Budget:
$3,000[1] to cover the cost of:
· Documentation (reports, presentation boards, etc.)
· Materials for testing and prototyping
· Construction of a working model

Deliverables: Detailed report, all engineering analysis, cost estimate to duplicate, drawing package, software files (if applicable), bill of materials, all receipts for purchases/expenses, and functional sanitization chamber.

Competition between Arizona Universities: This project is being sponsored by Gore at ASU and NAU. Gore will provide all team members a trip to Flagstaff Facility during the second semester for presentation to Gore team, at which time a winning design will be selected.