Portable Sanitization Chamber

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Progress 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.

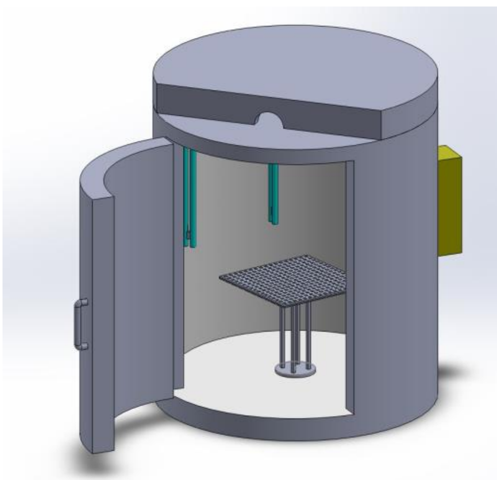

Figure 2.1: Original Design Model

3.0 DESIGN MODIFICATIONS

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.

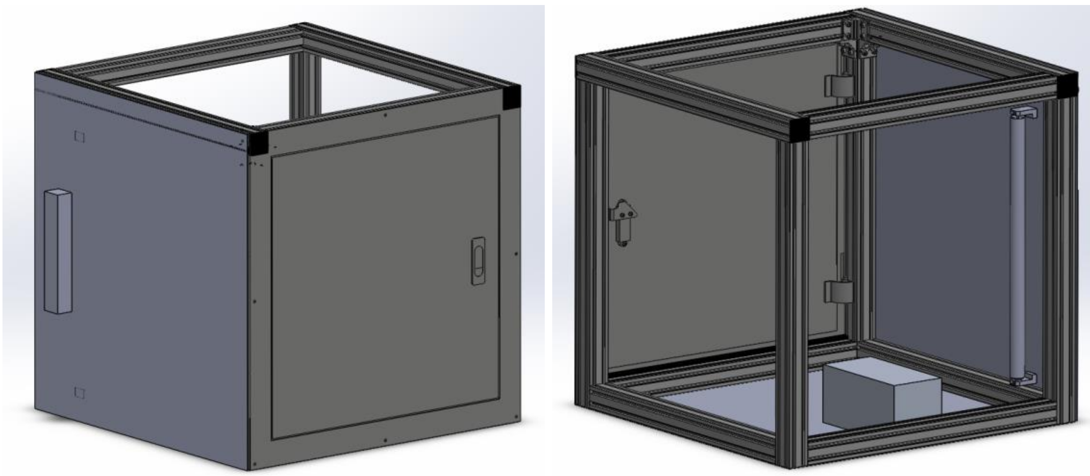

Figure 3.1: Final Design Model

(a) (b)

Further research into the Borosilicate glass covers for the lighting showed that the glass was not UV transmissive until around 300nm. The wavelength in which UVGI sanitization is most effective is at 254nm. Borosilicate glass was no longer a viable option to protect the bulbs, as it wasn't transmissive to UV light at the correct wavelength. Upon further research, there were only two types of glass that will allow UV light at 254 nm to penetrate. This glasses are fused quartz glass and fused silica. Both of these types of glass are extremely expensive, costing around $500 for a 6 inch by 6 inch sheet. Cost restraints would not allow for this expense so the design was changed to only add protective covers over the lamp holders, rather than the whole bulbs themselves. 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. The original bulbs required too much power, and the ballasts, used to hook up the bulbs were too expensive to use more than two bulbs. Instead, a slightly smaller and less expensive bulb was chosen, allowing for four total bulbs or more to be used. Refer to Appendix B for bulb specifications.

4.0 PROTOTYPING AND TESTING

Hydrogen peroxide testing is necessary to determine the amount of H_2O_2 that is in the chamber and to make sure the levels of H_2O_2 outside the chamber were safe and compliant with OSHA standards. OSHA standards measure how much H_2O_2 is in the air by parts per million (ppm). Two types of H_2O_2 testing strips were purchased, a low concentration (0.01-4.0 ppm), and a high concentration (0.0-30,000 ppm).

The high concentration strips were taped around different areas of the inside of the chamber to determine the concentrations of H_2O_2 throughout that chamber. It was found that using a 3% H_2O_2 solution, all of the strips within the chamber reached at least 10,000 ppm after ten seconds of running the fog machine. However, there were slight concentration variations in different locations in the container. Further testing will provide the best location to attach the fogging machine to the chamber for equal distribution.

The low concentration strips will be used once the actual chamber has been manufactured to ensure user safety. These strips will be placed on the outside of the chamber near the door, seals, and areas where potential leaks may be occurring. OSHA safety standards for vaporized hydrogen peroxide may not exceed 1 part per million. Testing the area around the chamber will ensure that the design is in compliance with OSHA and will not be harmful to the user.

UV testing is done using a device called a spectrometer. Spectrometers can read the specific wavelengths and amounts of light being emitted. Access to a spectrometer has been inquired through the chemistry and biology departments at NAU. These will be used to measure the amounts of light within the chamber to make sure there is enough UV light to sanitize. The spectrometer will also help with specific bulb placement within the chamber.

5.0 PROJECT PLAN

Figure 5.1 below shows the proposed project plan for the remainder of the semester. Tasks included in 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 will be conducted by Ellie Nation and Lauren Kieffer. Design modification will be finalized by Jacob Blackburn and Robertson Beauchamp. The control system will be worked on by Angel Soto and Dangxian Zha. The operation manual needed for the final design will be worked on throughout the semester.

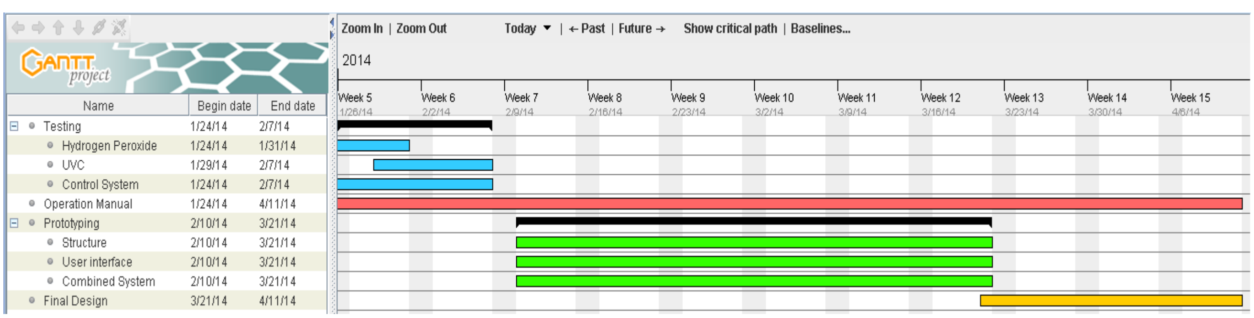

Figure 5.1: Project Plan

6.0 CONCLUSION

W.L. Gore is looking for a portable chamber that sanitizes the surface of given materials. *Bacillus atrophaeus* is the spore that will need to be reduced by one log in order to satiate standardized sanitary tests conducted by W.L. Gore. Five designs were researched including UV lights, infrared radiation, electron beams, chemical processes, and autoclaves. Chemical processes and UV lights were the two concepts that were chosen to be analyzed. From the engineering analysis, each design would work really well for the client. Upon further analysis, using the two processes together would work best. The total cost for all of the materials required for the project is estimated to be about $1300.

The final design will consist of both the UV light and chemical processes. These processes will be contained in a rectangular chamber that contains the UV lights. The chemical fogging machine will be installed on the inside of the rectangular chamber.

APPENDICES

APPENDIX A: 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.

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[1] Other resources may be provided as needed/justified.

Appendix B: Bulb Specifications

TUV T8

TUV 25W T8

TUV T8 lamps are double-ended UVC (germicidal) lamps used in professional water and air disinfection units. TUV T8 lamps offer almost constant UV output over their complete lifetime, for maximum security of disinfection and high system efficacy. Moreover, they have a long and reliable lifetime, which allows maintenance to be planned for in advance.

Product data

• General Characteristics

System Description	-
Cap-Base	G13
Bulb	T8 [T8]
Main Application	Disinfection
Useful Life	9000 hr

• Light Technical Characteristics

Color Designation (text)	-

• Electrical Characteristics

Watts	25 W
Lamp Wattage Technical	25.5 W
Lamp Voltage	48 V
Lamp Current	0.6 A

• Environmental Characteristics

Mercury (Hg) Content	2.0 mg

• UV-related Characteristics

UV-C Radiation	7 W

• Product Dimensions

Base Face to Base Face A	437.4 (max) mm
Insertion Length B	442.1 (min), 444.5 (max) mm
Overall Length C	451.6 (max) mm
Diameter D	28 (max) mm

• Product Data

Product number	292680
Full product name	TUV 25W 1SL
Short product name	TUV 25W 1SL/25
Pieces per Sku	1
eop_pck_cfg	25
Skus/Case	25
Bar code on pack	8711500641618
Bar code on case	8711500641625
Logistics code(s)	928039404005
eop_net_weight_pp	69.900 gr

Dimensional drawing