PORTABLE SANITIZATION CHAMBER

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Introduction

- W.L. Gore & Associates
- Portable Sanitization Chamber
- Decrease bioburden levels of *Bacillus atrophaeus*
- $3,000 budget

Client Needs

W.L. Gore is looking for a device that is:

- Safe for all users
- Portable
- Reduces the level of bioburdens on various materials
- Cost efficient
- Time efficient

GOAL

To develop a portable sanitization process that disinfects items to acceptable bioburden levels.

Problem Formulation

Design requirements are derived from client needs and the scope of the project as:

- Objectives
- Constraints

Contemporary sanitizing methods are compared against objectives to reveal feasible solutions.

Objectives

Objective	Definitive Justification	Units of Measurement
Reducing bioburden levels	Common pathogens and bacterias eliminated	%
Chemical exposure/residue	Concentration of substance in air space at 25°C and 1 atmosphere	mg/L, ppm
Material functionality retention	Process temperature	°C
System portability	System dimensions and weight	cm, kg
Comparatively inexpensive	Cost compared to similar devices within budget	dollars
Low cycle time	Cycle duration allows for immediate use of sanitized materials	minutes

CONSTRAINTS

- Ease of Use
  - Complies with door size standards (3’x3’x6’)
  - Acceptable cycle time (15 minutes)
  - Cycle ends automatically
- No Ethylene Oxide (EtO)
- Temperature less than 120°C

Sanitizing Methods

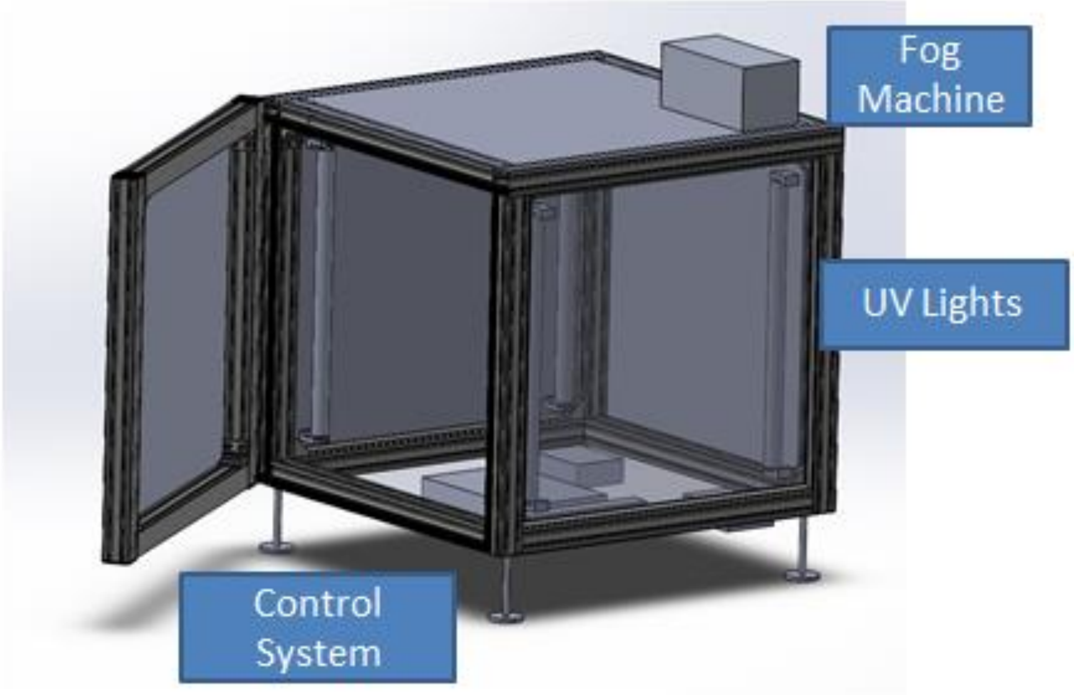
From research, numerous methods were found that sanitize and sterilize equipment in the food and medical field.

- Autoclave - Steam at high temperature and pressure
- Chemical spray - Exposure to germicidal chemicals
- Infrared light - Specific wavelength generates heat
- Laser exposure - Germicidal light for precision use
- Ultraviolet (UVC) light - Germicidal light exposure

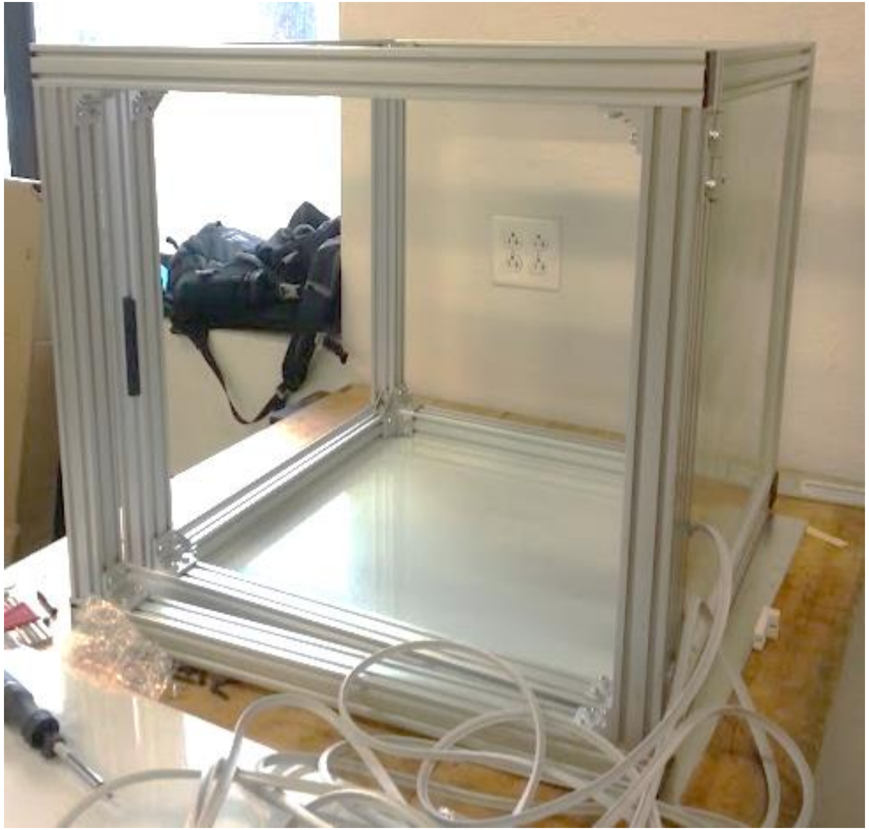
Proposed Design

- Dual process:
  - Vaporized hydrogen peroxide (H_2O_2)
  - UVC light
- Fog machine used to vaporize the H_2O_2
- UVC lights degrade H_2O_2 to safe levels
- Free hydroxyl radicals, OH-, that are strong oxidizing agents, degrade additional toxins.
- Aluminum chamber- not reactive with H_2O_2

Proposed Design

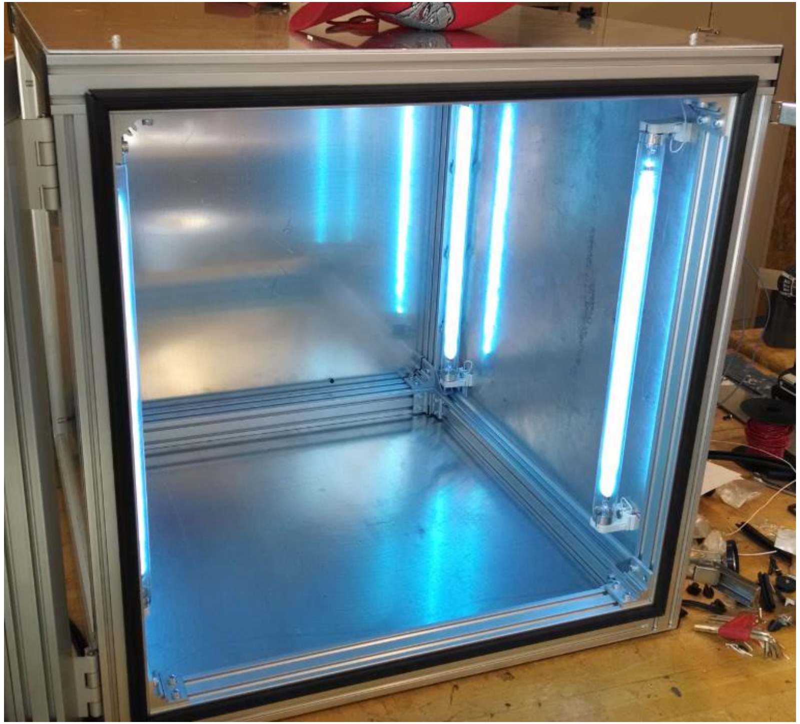


Prototype



PROTOTYPE

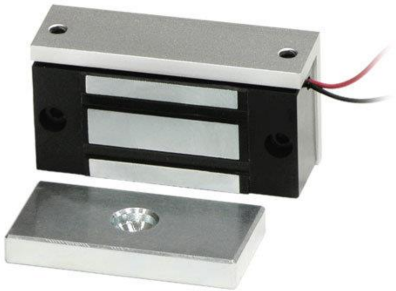
4 UVC lights installed



Fogging unit on the back panel

Safety Components

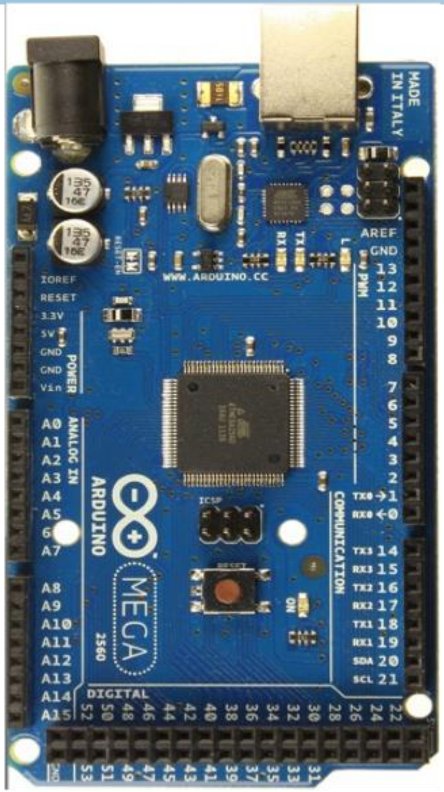
- Sealant around the door and panels
- Safety Switch
- Magnetic Lock
- PET Plastic window that protects user from UVC light
- Emergency Button



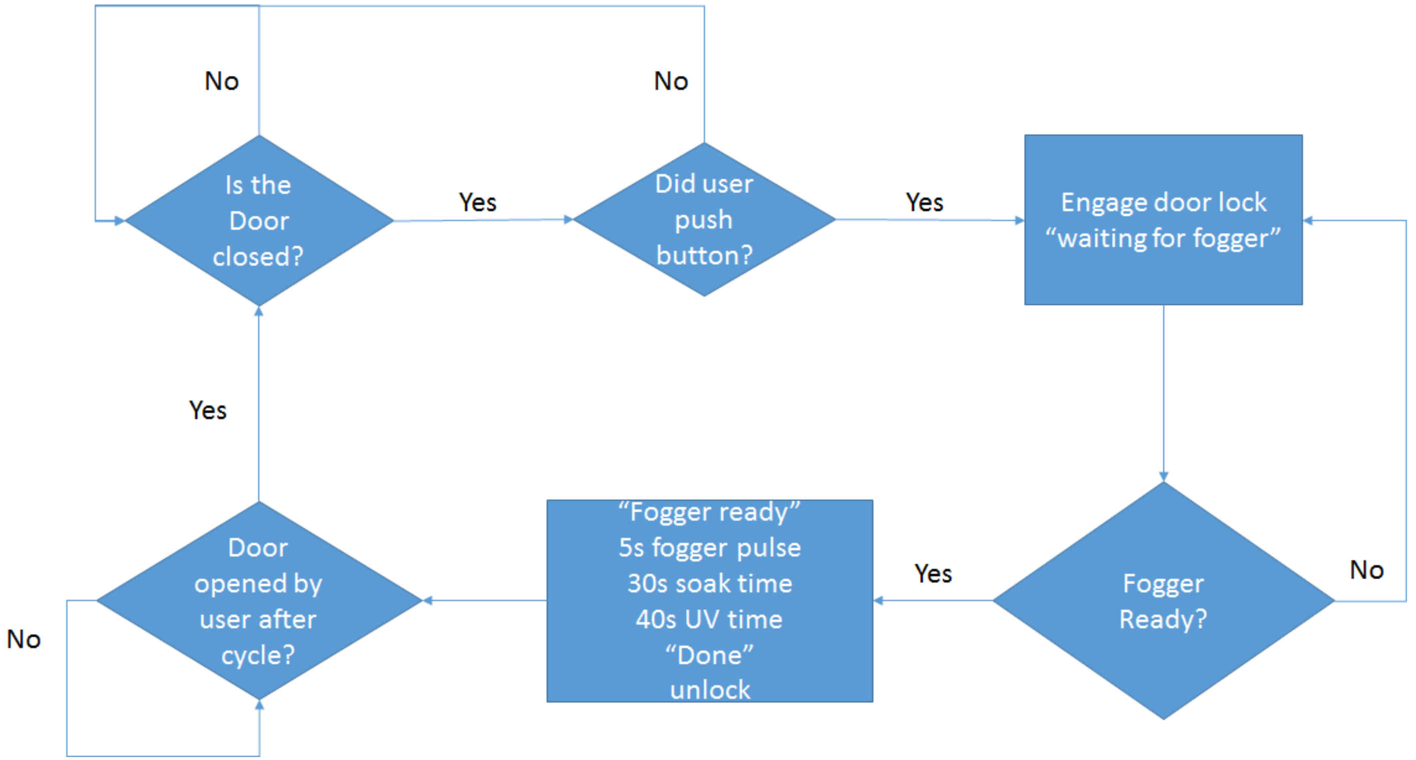
CONTROL SYSTEM

- Arduino Mega Microcontroller

- Will run code and logic for automated process and user interface

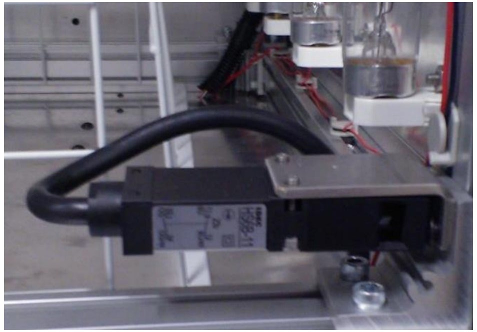


Logic Flow Chart



CONTROL SYSTEM

- Start Button
- Emergency Button
- Safety Switch
- Magnetic Lock
- Fog Machine
- UVC Lights
- LCD/LED



First Round of Testing

Run	Components	Time	Concentration	Results
1	H_2O_2 UV lights	none 5 minutes	N/A 4 light bulbs	78% of 1 log
2	H_2O_2 UV lights	30 seconds 5 minutes	0.5 mg/L 4 light bulbs	88% of 1 log
3	H_2O_2 UV lights	30 seconds 5 minutes	3 mg/L 4 light bulbs	93% of 1 log

Optimization

Factor	Level: Min	Level: Max
A. UV Light Intensity	4 light bulbs	8 light bulbs
B. UV Light Run Time	1 minute	5 minutes
C. H_2O_2 Concentration	0.5 mg/L	3 mg/L
D. H_2O_2 Soak Time	30 seconds	5 minutes

Factor	Level: Min	Level: Max
A. UV Light Run Time	1 minute	5 minutes
B. H_2O_2 Soak Time	30 seconds	5 minutes

Second Round of Testing

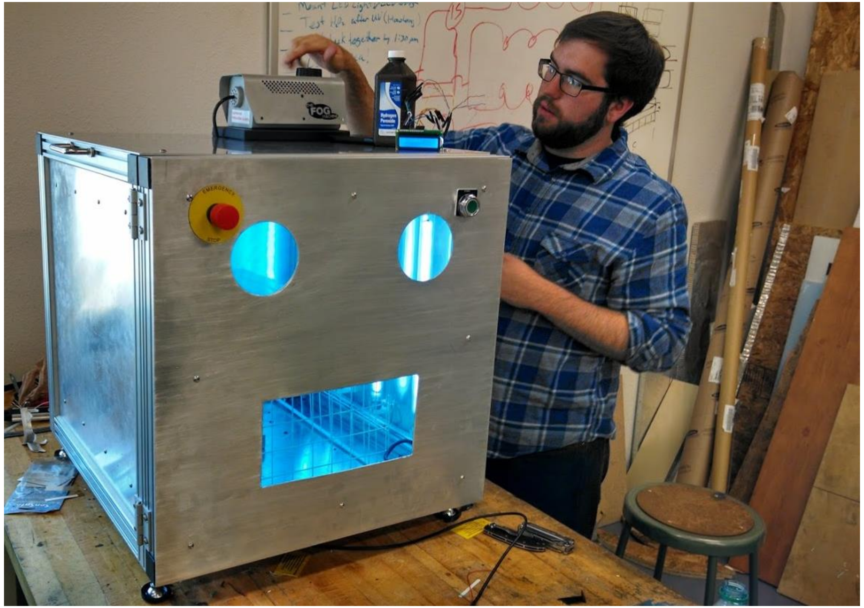
Run	Components	Time	Concentration	Results
4	H_2O_2 UV lights	30 seconds 60 seconds	3 mg/L 4 light bulbs	>10,000%
5	H_2O_2 UV lights	5 minutes 1 minute	3 mg/L 4 light bulbs	>10,000%
6	H_2O_2 UV lights	5 minutes 5 minutes	3 mg/L 4 light bulbs	>10,000%

Third Round of Testing

Run 7: Hemostat
Run 8:Tackle Toolbox
Run 9: Notebook

Run	Components	Time	Concentration	Results
7	H_2O_2 UV lights	30 seconds 40 seconds	3 mg/L 8 light bulbs	>10,000%
8	H_2O_2 UV lights	30 seconds 40 seconds	3 mg/L 8 light bulbs	3000%
9	H_2O_2 UV lights	30 seconds 40 seconds	3 mg/L 8 light bulbs	98% of 1 log

FINAL PROTOTYPE



Objectives and Constraints

Customer Requirements	Design Specifications	Reasoning and justification	Quantity or Pass/Fail	Actual
CLEANLINESS STANDARD reduce the bioburden levels	Process effectively inactivates *Bacillus atropheaus* spores	Medical studies measure contaminant levels in log units	1 log unit reduction	6 log reduction
SAFETY No harmful materials Users are not at risk of exposure to sanitizing source Applicable OSHA safety standards met	Physical components do not cause user harm	OSHA employee safety guidelines	pass/Fail	pass
	Chemical concentration	Allowable substance exposure from OSHA standard	H_2O_2: 1 ppm (8 hour exposure) 75 ppm short term	10-50 ppm short term
	Electrically grounded	User electrical guidelines from OSHA standards	pass/fail	pass

OBJECTIVES AND CONSTRAINTS

Customer Requirements	Design Specifications	Reasoning and justification	Quantity or Pass/Fail	Actual
EASE OF USE Short cycle time Cycle ends automatically when complete Easily transported by one person	Duration of process	Compared to common autoclave	15 minutes	1.5 minutes
	Control System	automatically executes process	pass/fail	pass
	weight	Human lifting average	75 lbs	80 lbs
	width	Fits through doorways and on counters	3 feet	2 feet
SANITIZE VARIOUS MATERIALS e.g. Tackle Box Cleanroom Notebook Hemostats	Temperature	Avoid melting of common polymers	120°c	<100 °C
	Does not saturate material	Prevents pourous materials from absorbing substances	pass/fail	pass
BUDGET	Cost to generate design prototype	Client specified	$3,000	<$2100

Cost Analysis

Sub-System	Components	Cost
Chamber		
	Frame	$536.94
	Al Panels	$180.00
	Door	$267.02
	Misc. and finishing hardware	$146.86
UV Lighting		
	Lights	$195.36
	Ballasts	$33.98
	Light holders/wiring	$49.22

Sub-System	Components	Cost
Fogger		
	Fog machine	$70.00
	Tubing/wiring/mounting HW	$41.23
	Testing materials	$64.33
Control system		
	Arduino (+kit)	$208.00
	Relays	$13.58
	Buttons/wiring	$85.94
	AC to DC transformer	$35.98
	Lock	$32.66
Total		$1,961.10

CONCLUSION

Through the testing and results, all but one of the requirements were met under the given constraints.

Other systems would be implemented such as a humidity sensor and UVC light check.

The size of the chamber is fully scalable and can be modified for smaller or larger applications allowing for more portability or larger items.

Further optimization testing would result in a shorter cycle time.

References

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Questions