Portable Sanitization Chamber

Project Proposal

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December 11, 2013

Overview

- Client
- Objectives & Constraints
- Project Plan
- Concepts
- Engineering Analysis
- Final Design

Client

- W.L. Gore & Associates, Inc.
- International Company
- Medical, fabrics, and other products
- Local office in Flagstaff, AZ
- Looking to prepare incoming engineers by sponsoring real-world application projects.

Need Statement

- The client currently has access to sterilization systems that use either harsh chemicals, or a large amount of heat that can damage various materials.
- The client needs a current sanitization device that is portable and safe for various materials such as plastics and papers.

Goal

- Develop a portable sanitization process that disinfects bioburden amounts past acceptable levels and is safe for various materials.

Objectives

- Sanitizes within regulation bioburden levels
- Chemical exposure and residue within regulated concentration
- Materials sanitized retain functionality
- Sanitization system characterizes portability
- Cost to produce is comparatively inexpensive
- Quick sanitization cycle time

Design Specifications

Design Specifications	Quantity or Pass/Fail
Process effectively elimiantes bacterial spores (e.g. Bacillus Atropheaus)	1 log unit reduction
Physical components do not cause user harm	pass/Fail
Chemical concentration	H_2O_2: 1.4 mg/m^3 No eye exposure to light
Electrically grounded Non-pinching hinge	pass/fail
Duration of process	20 minutes
Control System	pass/fail

Design Specifications	Quantity or Pass/Fail
Weight	35 kg
Footprint Area	1 m^2
Temperature	120°C
Stresses applied	2 Gpa
Does not saturate material	pass/fail
Substance covers every aspect of material	pass/fail
Cost to generate design prototype	$3,000

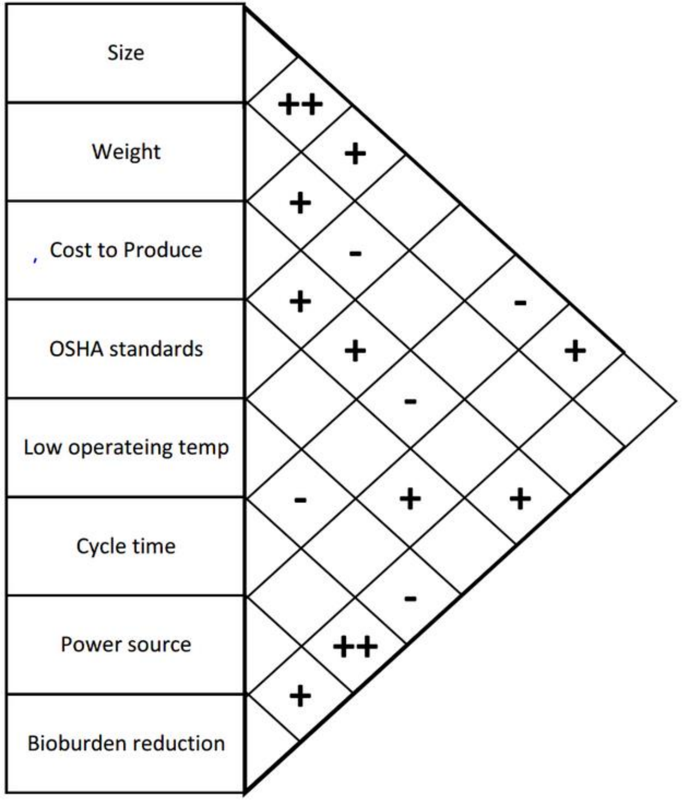
Operating Environment

- Sanitize test strips contaminated with *Bacillus atrophaeus* used to evaluate bioburden level reduction
- Hydrogen peroxide test strips placed within chamber proximity to monitor exposure levels

QFD

Customer Requirements	Importance out of 5	% Importance	Engineering Requirements								Benchmarks	
			Size	Weight	Cost to produce	OSHA standards	Low operating temp.	Cycle time	Power source	Bioburden reduction	Autoclaves	Vacuum Hydro peroxide vapor proc
Easily transported by one person	3.5	17%	9	3	1	1				3	x	
Low cost	3	14%	1	1	9	3	3	3	1	3	x	
Safe	5	24%	3	3	3	9			1	3	x	
Sanitizes a variety materials	5	24%	3		3		9	1	3	9		x
Short cycle time	3	14%	3		1	1	1	9	3	3	x	x
Cycle ends automatically	1.5	7%			3	1		9	9		x	x
	Importance		3.5	1.4	3.2	3.0	2.7	2.6	2.2	4.2		
	% Importance		15%	6%	14%	13%	12%	11%	10%	19%		
		units	m^2	kg	$	varies	°C	min	W	%		
		Engineering Targets	<1	<35	2500	Yes	<70	<30	<1000	>50		

House of Quality



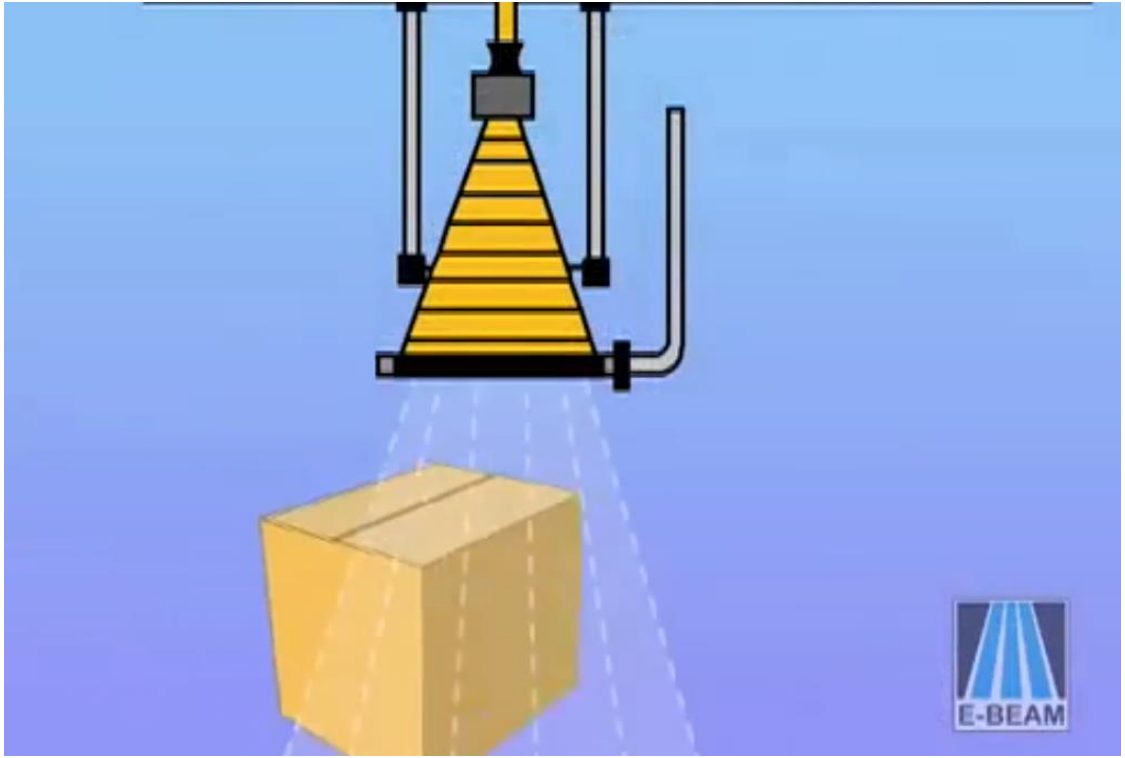
Autoclave

- Hot water sanitization
- Above 135 ^{o}C for at least 3 minutes
- Too hot for certain materials
- Water would deteriorate certain materials

Electron Beam

- Sanitizes through items

- Expensive
- Large scale

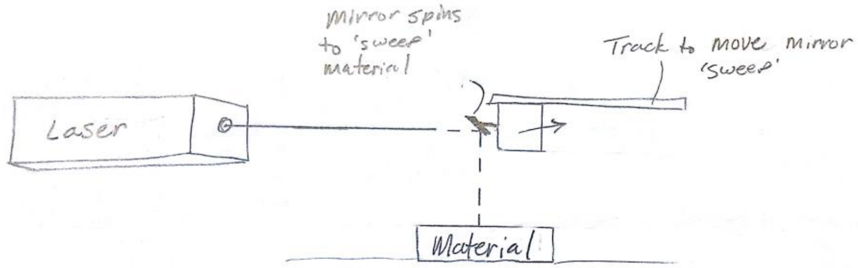


Courtesy of www.ebeamservices.com

Laser Sanitization

- Works with many materials

- Long cycle time
- Expensive



Infrared Radiation

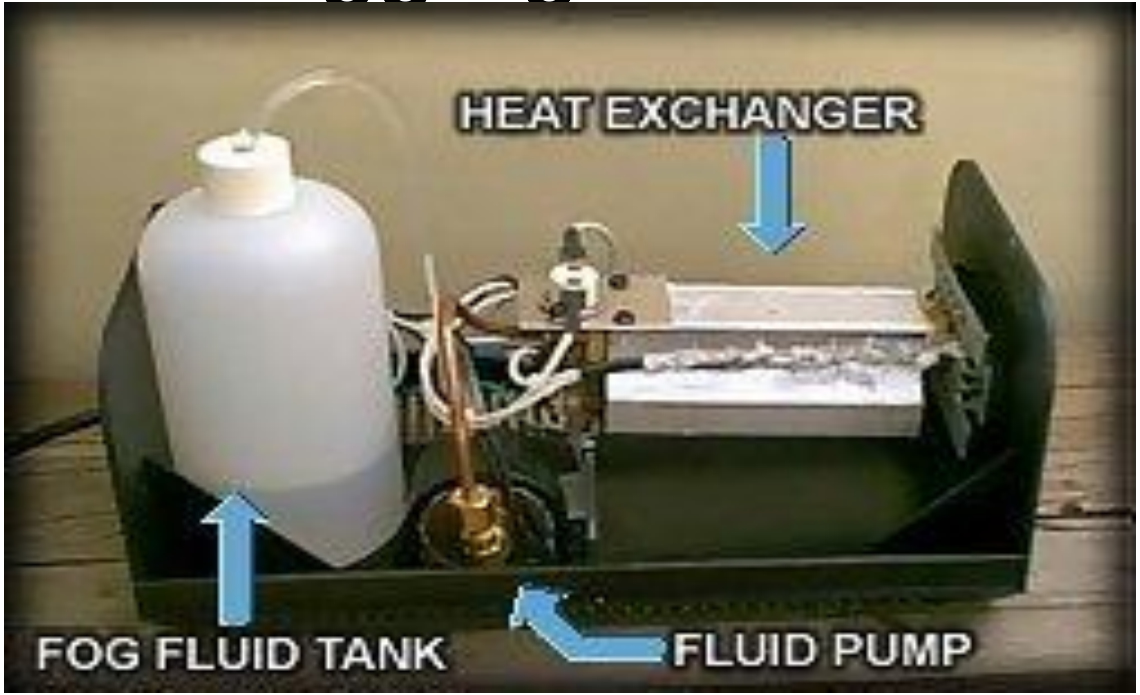
- Advantages:
  - Low cycle time
  - Compact
  - Minimum maintenance
  - Ease of use

- Disadvantages:
  - Cost to produce
  - Power required
  - Material incompatibility

Chemical Processes

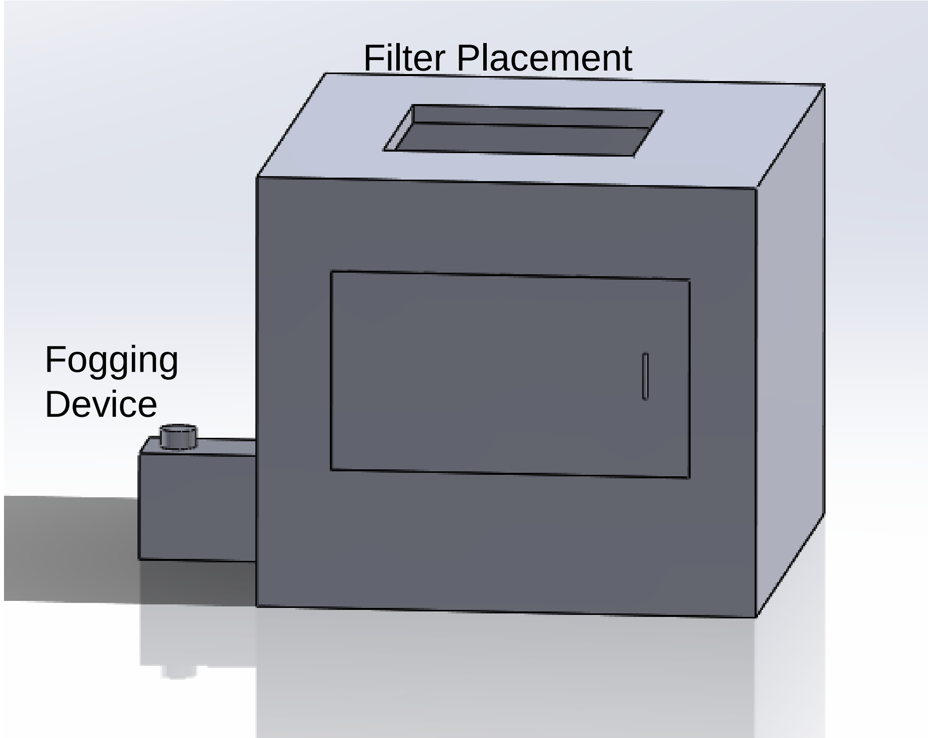
- Chemicals can kill 99% of bacteria
- Dry fog chemical sanitization
- Hydrogen Peroxide (H_2O_2) is a safe chemical
- Entire rooms can be cleaned in 15-30 minutes

Chemical Fogging



Courtesy of http://www.gotfog.com

Hydrogen Peroxide Fogging



Chemical Fogging

- 7% hydrogen peroxide solution
- Cold vapor is safe for materials sensitive to heat and water
- Filters must be used to break down H_2O_2

Material Selection

- Must be compatible with H_2O_2 at various concentrations.
- Aluminum, PVC and PTFE - No negative reactions
- Aluminum used for enclosure, door, handles, hinges, etc.
- PVC and PTFE used in fogging components, tubing and nozzle.

Ultraviolet Light

- Maximum kill potential 2-15 minutes
- Cost efficient
- Only sanitizes outer surface
- Bulbs must be regularly cleaned

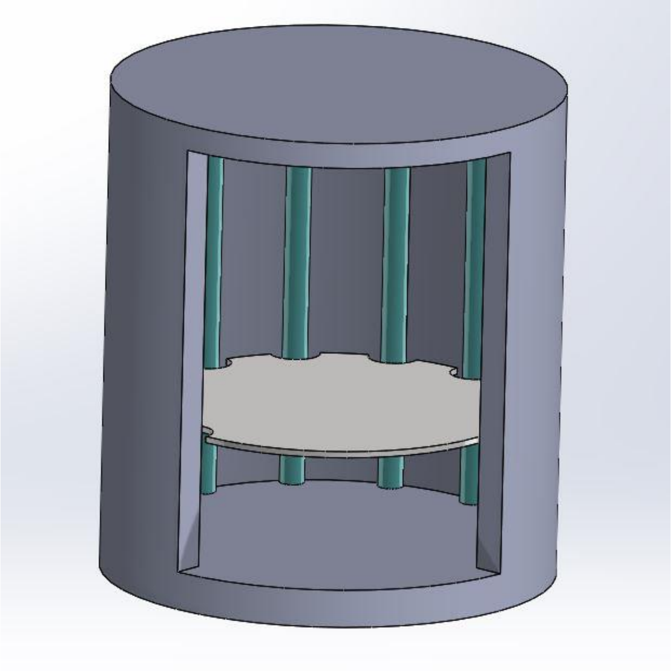
Ultraviolet Germicidal Irradiation

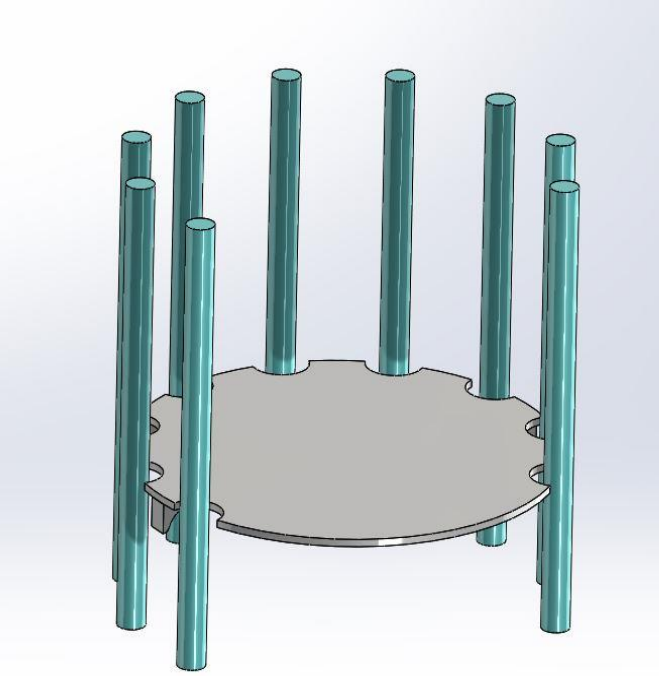
Bulb Model	Life (hr)	Lamp Wattage (W)	UV-C Radiation (W)	Length (cm)	Diameter (cm)	Weight (g)
TUV PL-L 95W	9000	95	27	53.5	3.8/1.8	134
TUV 18W 1SL	9000	18	4.5	60.4	2.8	100
TUV 10W SLV	9000	10	2.5	34.5	2.8	62
G25T8 (GE-T8)	7500	25	7	45.7	2.8	N/A

Ultraviolet Germicidal Irradiation

Bulb Model	Intensity (mW/cm^2)	Time For 2log (sec)	Time For 3-4log (sec)
TUV PL-L 95W	9.28	1.25	500.93
TUV 18W 1SL	1.56	7.45	2984.78
TUV 10W SLV	1.51	7.66	3068.78
G25T8 (GE-T8)	2.86	4.06	1626.01

Ultraviolet Model





Angel Soto

Weighting Characteristics

	Safety	Material	Maintience	Cycle Time	Cost	Power Required	Total + 1	
Safety		1	1	1	1	1	6	29%
Material	0		1	1	1	1	5	24%
Maintience	0	0		0	1	1	3	14%
Cycle Time	0	0	1		1	1	4	19%
Cost	0	0	0	0		1	2	10%
Power Required	0	0	0	0	0		1	5%

Decision Matrix

	Safety	Material Compatibility	Maintenance	Cycle Time	Cost	Power Required	Total
Autoclave	0	-1	1	1	1	-1	0.14
Chemical Process	0	1	0	1	1	1	0.57
Lasers	1	1	1	0	-1	1	0.62
Infrared Radiation	0	-1	1	1	0	-1	0.05
UV Light	1	1	0	0	1	1	0.67
Weights	29%	24%	14%	19%	10%	5%	

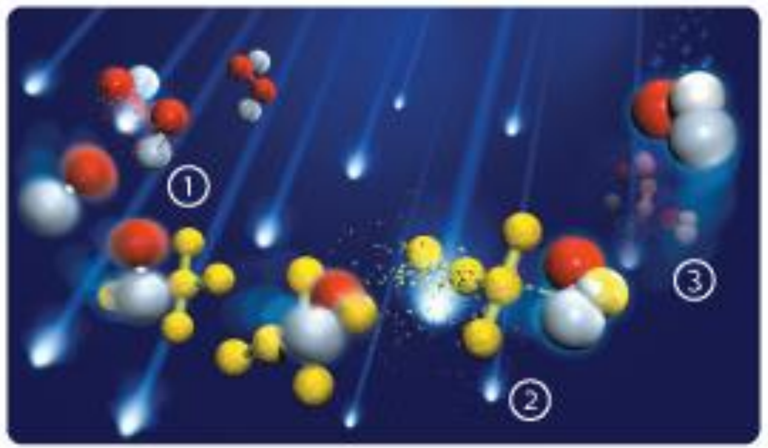
Combined UV/H_2O_2 Process

- Eliminates need for filter
- Creates free hydroxyl radicals, OH-, that are strong oxidizing agents.
- Radicals degrade additional toxins.
- Study shown this process inactivates *Bacillus atrophaeus* spores.

UV/H_2O_2 Process

The UV-Oxidation Process

1. UV converts hydrogen peroxide into highly reactive hydroxyl radicals.
2. The hydroxyl radicals attack and decompose contaminants.
3. At the same time, UV light disinfects



Courtesy of: www.trojanuv.com

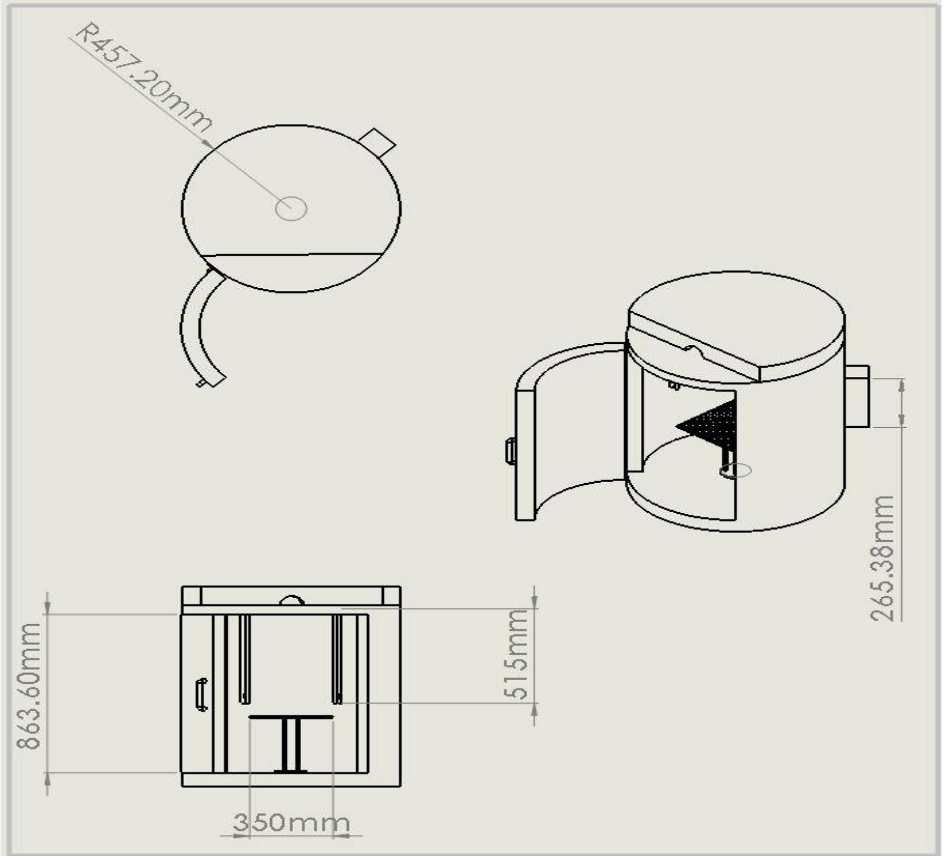
Material Selection

- Aluminum used for enclosure.
- PVC and PTFE used in fogging device.
- Borosilicate glass used in between enclosure and UV lights.
- High UV transmittance, protects bulbs from fog and dust.

Final Design

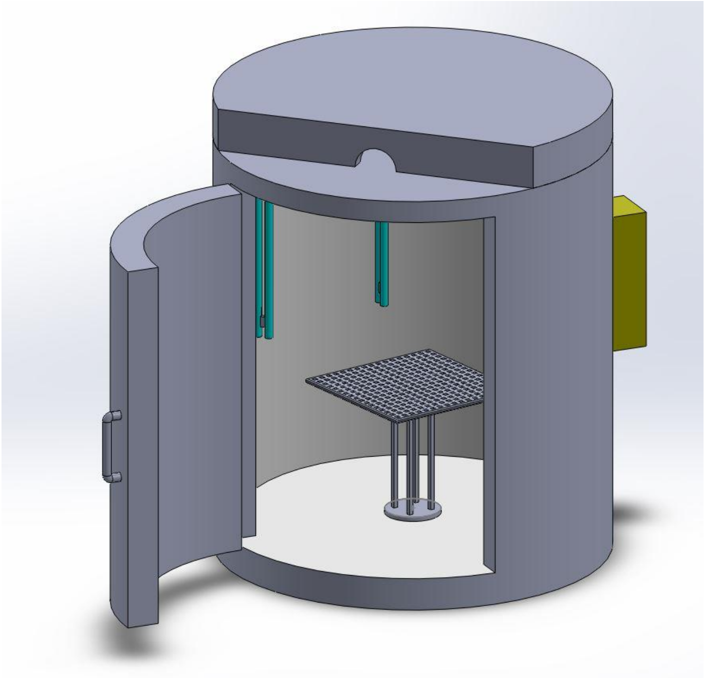
- Drawing highlights key dimensions

- Portability is achieved

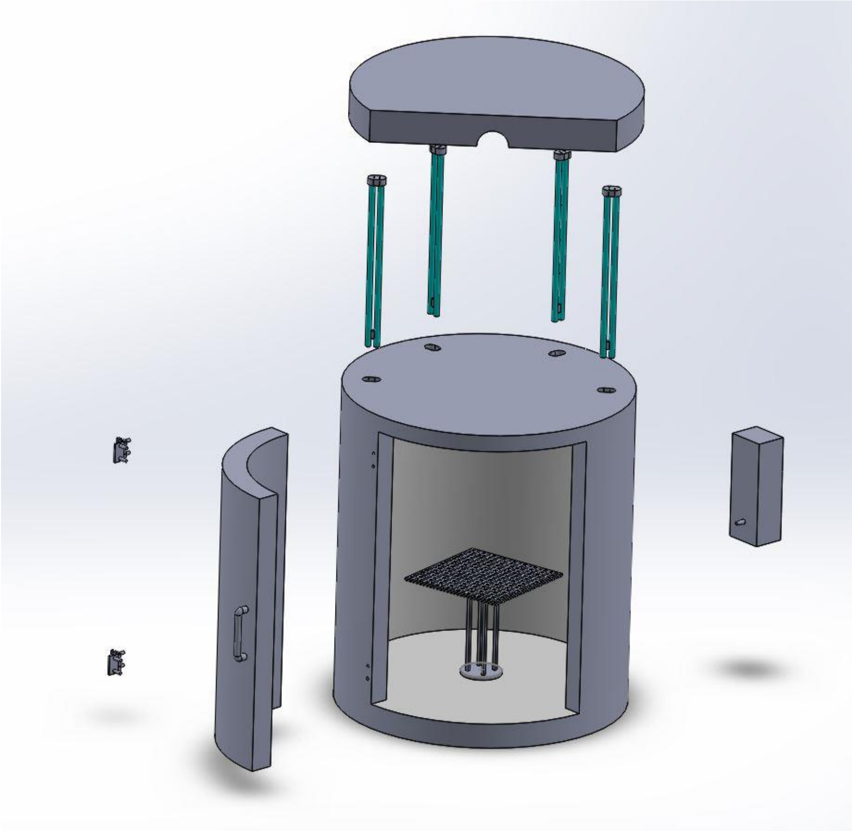


Final Design Model

3D Representation



Component View



Mass Calculation

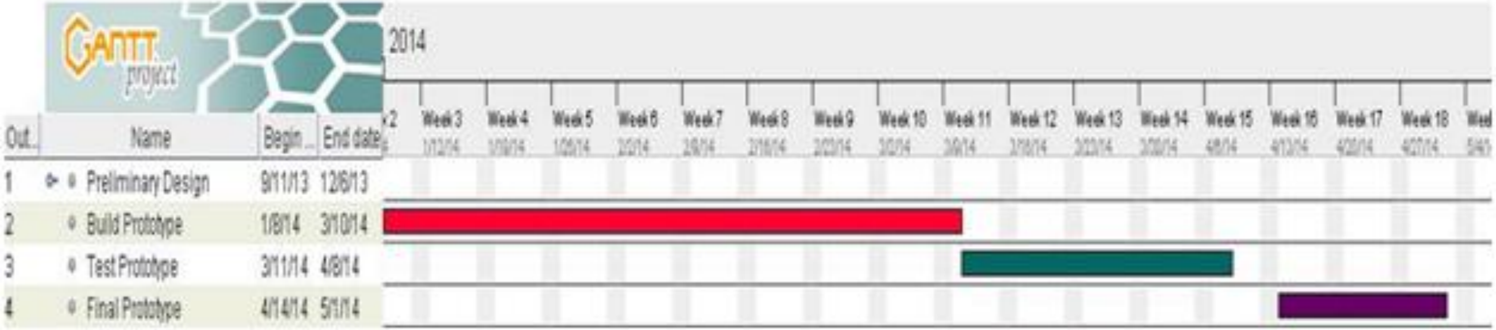
Parts	QTY	Unit Mass(kg)	Total Mass(kg)
Chamber	1	17.64	17.64
Rack	1	7.85	7.85
UV Lights	4	0.13	0.54
Lampholder	4	0.05	0.18
Ballast	4	0.45	1.82
Fog Machine	1	0.14	0.14
Misc. /Hardware	1	2.27	2.27
		Total mass(kg)	30.43

Cost

Type of Cost	Cost ($)
Bill of Material	1153.92
Manufacturing	190
Subtotal	1343.92
Man Power	22895
Total	24238.92

Project Plan

Project Plan



Conclusion

- The combined UV/H_2O_2 process achieves design specifications by reducing bioburden levels past a certain threshold.

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Questions?