Portable Sanitization Chamber

Engineering Analysis

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Overview

- Introduction
- Designs and Analyzations
  - UV Light
  - Chemical Spray
  - Lasers
- Conclusion

Introduction

- W.L. Gore & Associates
- Develop a portable sanitization process that decreases the bioburden levels on select materials to a certain threshold.
- Five Concepts
- Possibly combine processes

Design Specifications

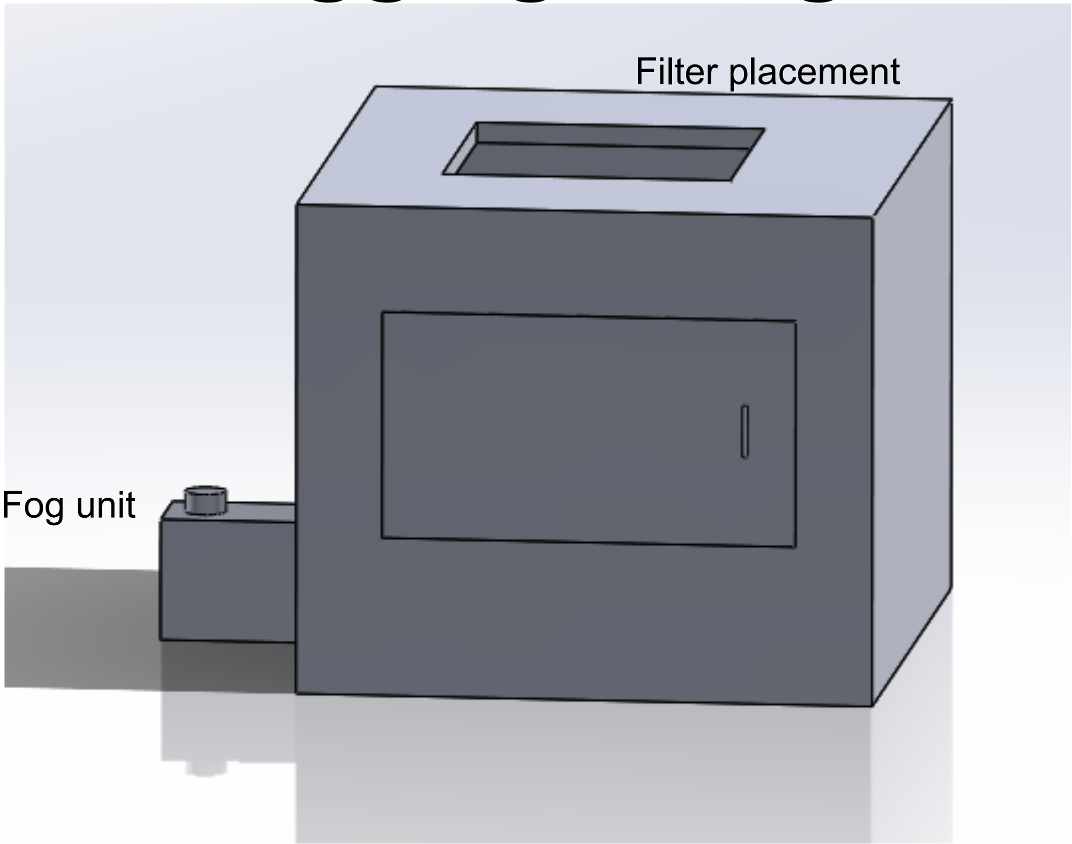
Design Specifications	Quantity or Pass/Fail
Process effectively elimiantes bacterial spores (e.g. Bacillus Atropheaus)	1 Log reduction
Physical components of chamber do not cause harm to user	Pass/Fail
Chemical concentration	H_2O_2: 1.4 mg/m^3 No eye exposure to light
Electrically grounded Non-pinching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

Design Specifications	Quantity or Pass/Fail
weight*	70 lbs
width	1 meter
Temperature	120°c
Stresses applied	2 Gpa
Does not saturate material	pass/fail
substance covers every aspect of material	pass/fail
Cost to generate	$3,000

Chemical Fogging

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

Chemical Fogging Design



Filters

- HEPA filters- useless for chemical breakdown.
- Activated Carbon filters- break down some chemicals, need to be replaced often.
- TiO_2 -photocatalytic oxidation using UV light, breaks down chemicals and bacteria.

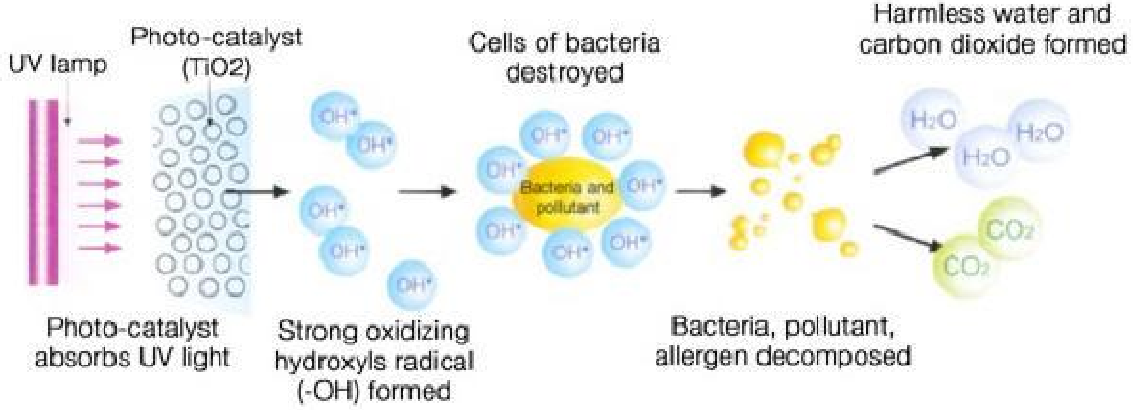


Photo courtesy of: www.peakpureaire.com

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.

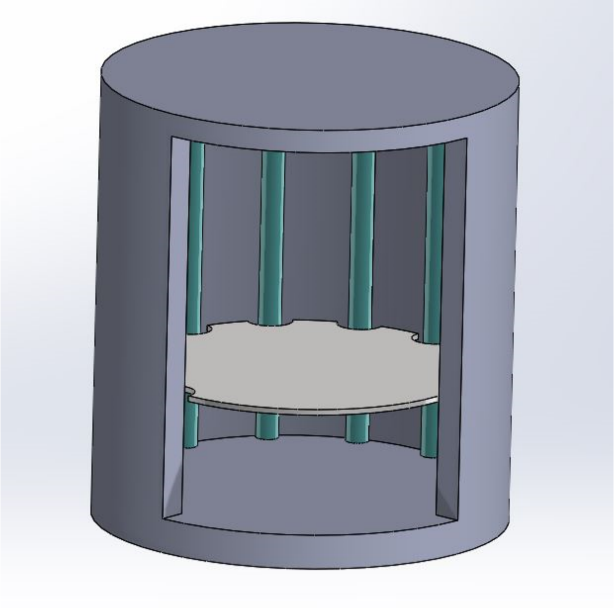
Ultraviolet Germicidal Irradiation

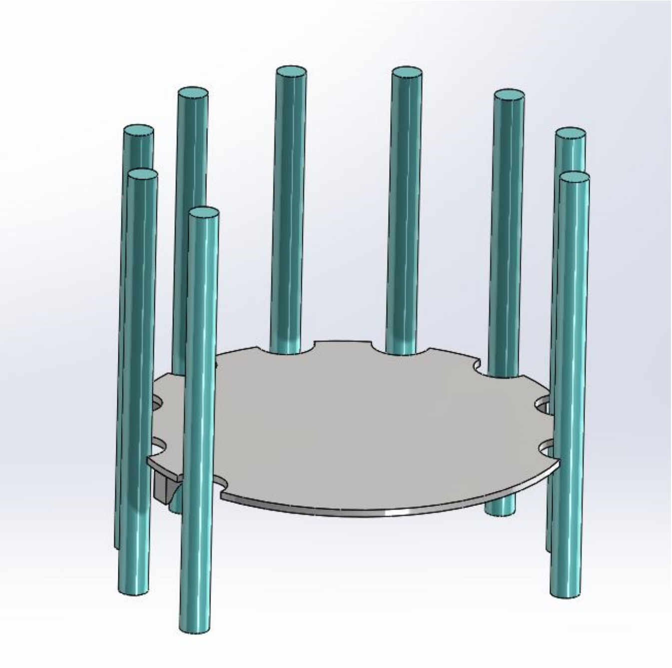
Bulb Model	Life (hr)	Lamp Wattage (W)	UV-C Radiation (W)	Length (cm)	Diameter (cm)	Weight (g)
TUV PL-L 95W	9000	95	27	53.5	3.8/1.8	134
TUV 18W 1SL	9000	18	4.5	60.4	2.8	100
TUV 10W SLV	9000	10	2.5	34.5	2.8	62
G25T8 (GE-T8)	7500	25	7	45.7	2.8	N/A

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 3D Model





UV-C Laser

- Still in development
  - only able to produce 1 mW continuous beam
- Use a bare aluminum Mirror to direct laser beam
  - no less than 90% reflectivity
- 1 mW beam needs only 0.095 secs to sterilize the area under beam
  - sounds fast, but if beam size is .05 cm diameter...

UV-C laser (1mW and 100mW)

1 mW laser (time to scan 8.5” x 11” area)

A(cm^2)	mW	I (mW/cm^2)	D	t(s)	t(m)	t(h)		90%	Reflectivity
0.001963	1	509.30	50	30240	504	8.40		560	
			100	60480	1008	16.80		1120	
			4000	2419200	40320	672.00		44800	

100 mW laser

A(cm^2)	mW	I (mW/cm^2)	D	t(s)	t(m)	t(h)		90%	Reflectivity
0.001963	100	50929.58	50	302.4	5.04	0.08		5.6	
			100	604.8	10.08	0.17		11.2	
			4000	24192	403.2	6.72		448	

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.

Material Selections

- 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.

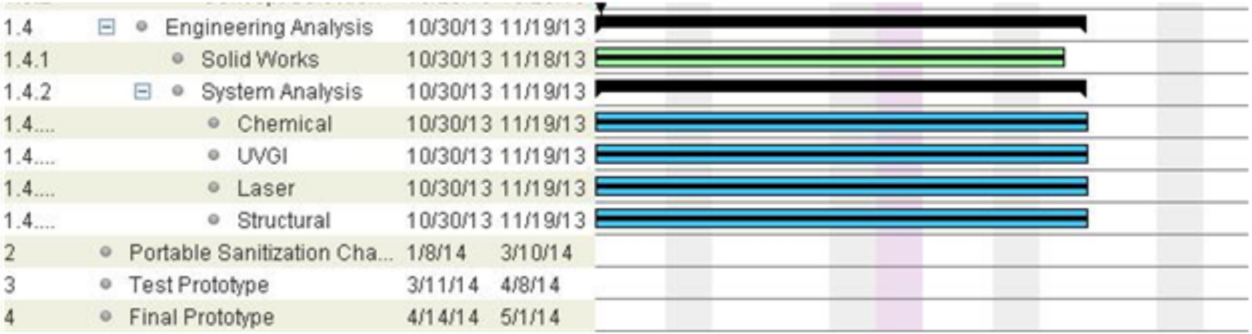
Mass Calculation for Combined UV/H2O2 Process

Interior Height	hi(m)	0.80	hi(ft)	2.62
Exterior Height	ho(m)	1.00	ho(ft)	3.28
Inside Plastic	di(m)	0.500	di(ft)	1.640
	t(m)	0.005	t(ft)	0.016
	do(m)	0.505	do(ft)	1.657
	Vs(m^3)	0.160	Vs(ft^3)	5.659
	Vm(m^3)	0.003	Vm(ft^3)	0.111
	ρ(kg/m^3)	2230	ρ(lb/ft^3)	139.21
	Mass(kg)	**7.04**	**Mass(lb)**	**15.52**
Spacing	s(m)	0.05	s(ft)	0.1640
Outside Aluminum	di(m)	0.555	di(ft)	1.821
	t(m)	0.010	t(ft)	0.033
	do(m)	0.565	do(ft)	1.854
	Vs(m^3)	0.251	Vs(ft^3)	8.854
	Vm(m^3)	0.0088	Vm(ft^3)	0.31
	ρ(kg/m^3)	2700	ρ(lb/ft^3)	168.56
	Mass(kg)	**23.75**	**Mass(lb)**	**52.36**

Total Mass of the Chamber

Materials	Mass(kg)	Mass(lb)	#	Subtotal Mass(kg)	Subtotal mass(lb)
Chamber	30.79	67.88	1	30.79	67.88
UV lights	0.1	0.22	8	0.80	1.76
Wires	0.1	0.22	1	0.10	0.22
Fog Machine	1.0	2.20	1	1.00	2.20
				Total Mass(kg)	**Total Mass(lb)**
				32.69	**72.07**

Project Plan



1.4	Engineering Analysis	10/30/13	11/19/13
1.4.1	Solid Works	10/30/13	11/18/13
1.4.2	System Analysis	10/30/13	11/19/13
1.4....	Chemical	10/30/13	11/19/13
1.4....	UVGI	10/30/13	11/19/13
1.4....	Laser	10/30/13	11/19/13
1.4....	Structural	10/30/13	11/19/13
2	Portable Sanitization Cha...	1/8/14	3/10/14
3	Test Prototype	3/11/14	4/8/14
4	Final Prototype	4/14/14	5/1/14

Conclusion

- UV Light and Chemical processes compliment each other
- The two concepts work better together than separately for what we need

References

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[2]Melanie Kito, Hi Nguyen, and John Tran, “Hydrogen Peroxide and UV Treatment”, 1998, http://www.calpoly.edu/~ceenve/enve/jsczechowski/enve436/projects/Hydro-Perox/H2O2-UV-Treatment.html, accessed on Nov. 12, 2013.

[3]Braz. J. Chem. Eng. vol.30 no.3 São Paulo July/Sept. 2013, “Inactivation of Bacillus atrophaeus spores in healthcare waste by UV light coupled with H_2O_2”, 2012

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