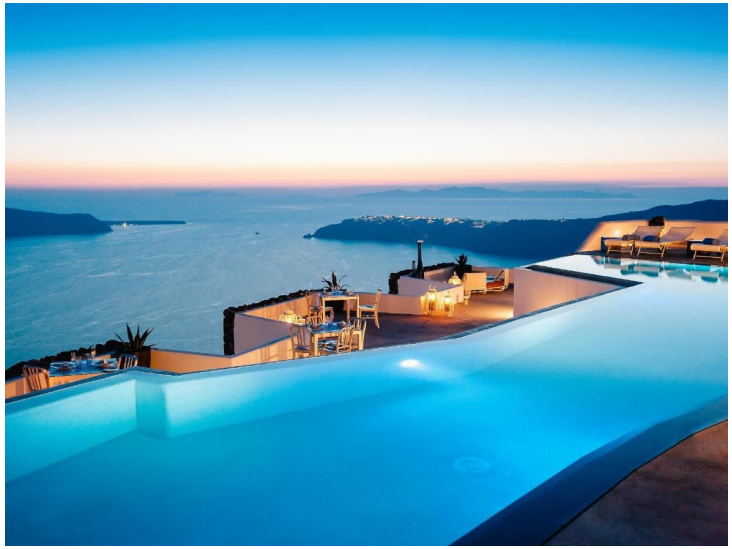


Hybrid UV Filter

Critical Design Review

Group 5: Pool Pals

November 12, 2021

Hybrid UV Filter
Preliminary Design Review
Presentation Outline

- Personnel
- Problem Statement
- Previous Proposed Design
- Current Proposed Design
- Material Selection
- Flow / UV Calculations
- Finite Element Analysis
- Conclusions

Hybrid UV Filter
Preliminary Design Review
Pool Pals Personnel

Erin McEneny

Emma Beard

Georgeanna Manos

Kerby Smithson

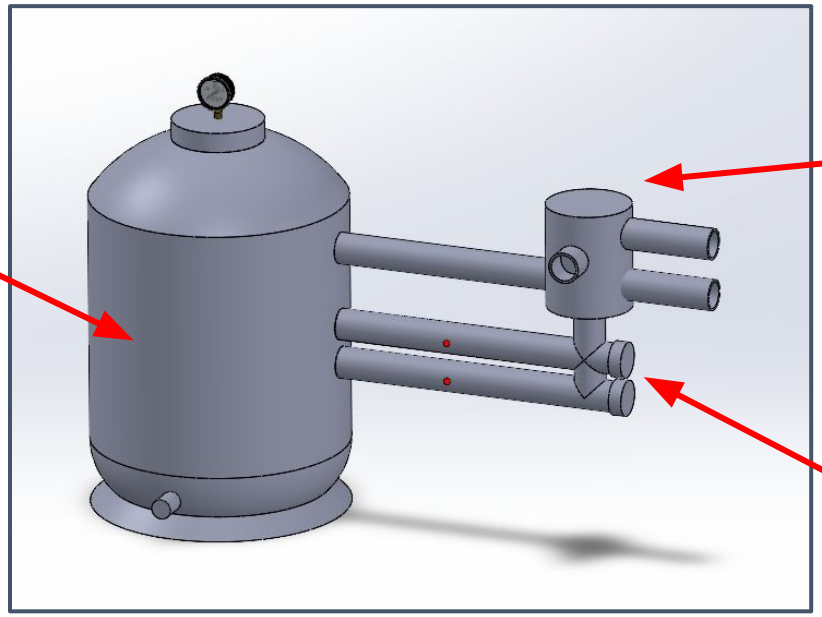
Brady Crepeau

Hybrid UV Filter
Preliminary Design Review
Problem Statement

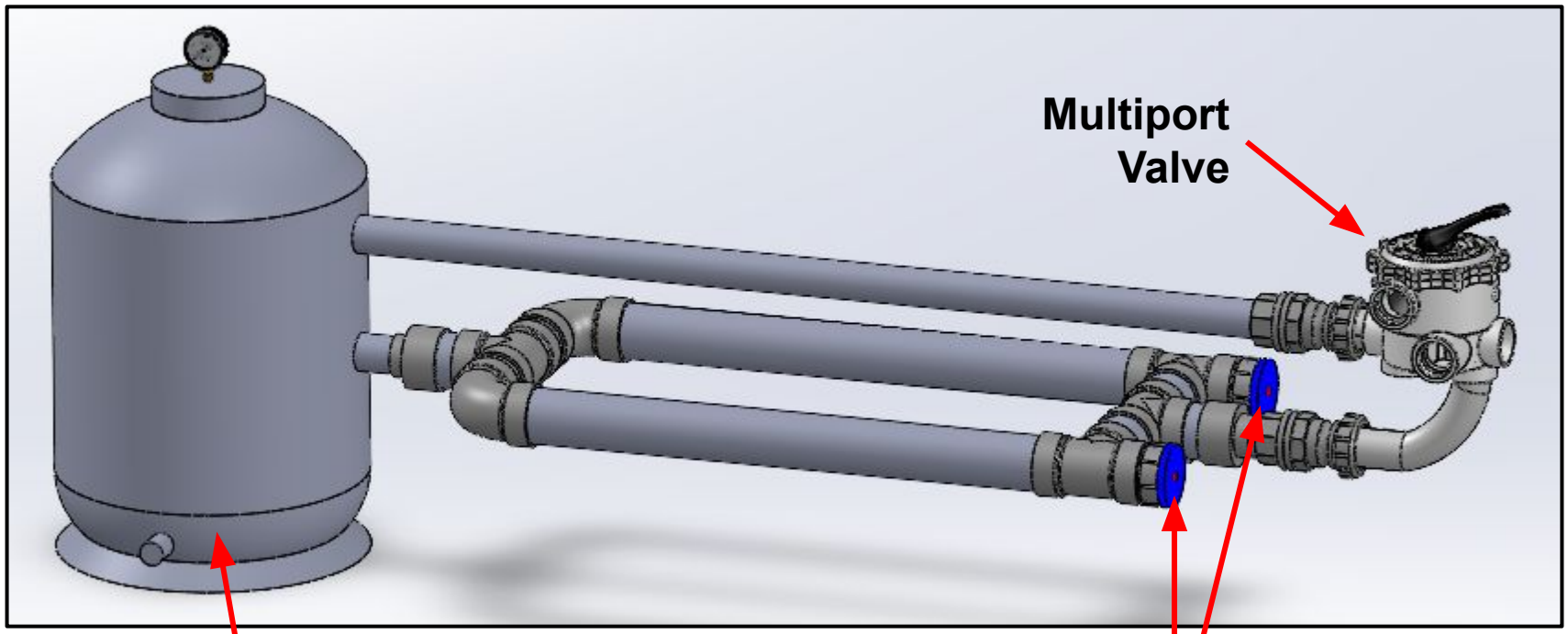
The goal of this project is to design and construct a hybrid pool filter for [redacted] that integrates both mechanical filtration and UV light sanitation. The system will demonstrate universal applicability while reducing the chemical additive requirements and structural footprint.

- Stay within an $800 budget
- Include UV light and mechanical filtration
- Implement visual indicator to show if UV lamp is on.
- Filter liquids adequately
- Accommodate serviceable/removable UV lamp and filter
- Monitor amount of pressure within system
- Sensor to detect UV light emittance

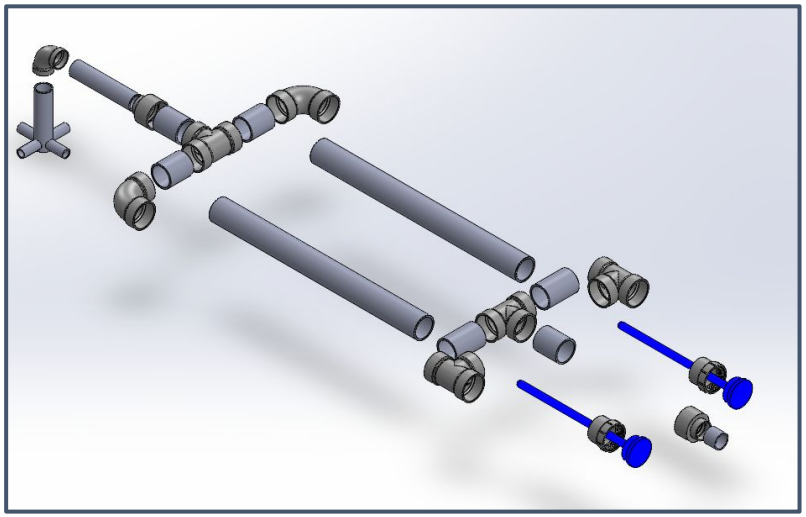
Hybrid UV Filter
Preliminary Design Review
Previous Proposed Design - PDR



Hybrid UV Filter
Preliminary Design Review
Current Proposed Design



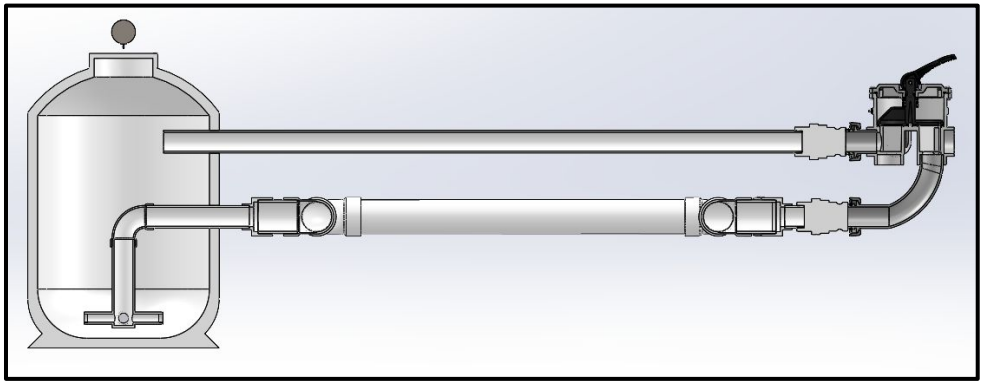
Hybrid UV Filter
Preliminary Design Review
Material Selection



Pipe, elbows, T's, multiport valve

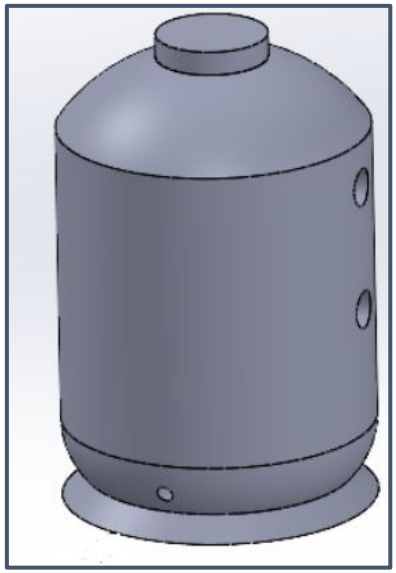
Use: PVC

- cost: $1.73/foot (d = 2")
- density: 1.38 g/cm^3
- elasticity: 3275 Mpa
- fatigue strength: 7.5 Mpa
- specific heat: 1005 J/kg*K



- No corrosion
- Industry standard

Hybrid UV Filter
Preliminary Design Review
Material Selection



Tank Shell

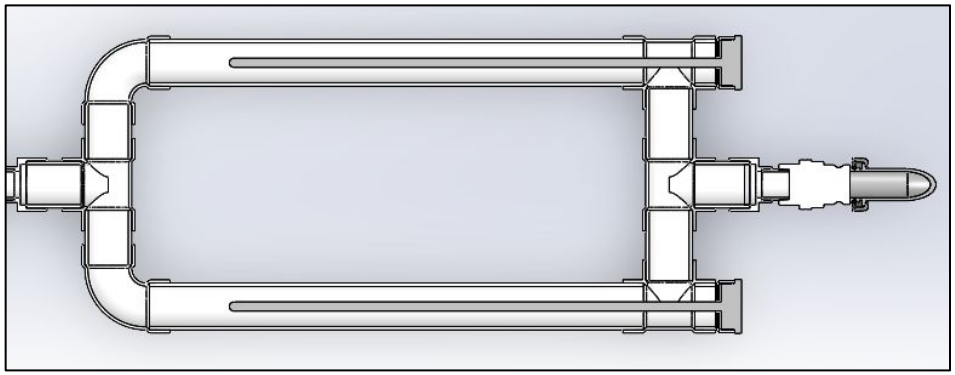
Use: Fiberglass Reinforced Polypropylene

- cost: $2.50-3.00/kg
- density: 0.675g/cm^3
- elasticity: 3.8-7.0 GPa
- fatigue strength: *Largely dependant on several structural factors*
- specific heat: 1920 J/kg*C

EasyClean Filter

- ❖ not corroded by water or chemicals
- ❖ industry standard

Hybrid UV Filter
Preliminary Design Review
Material Selection



Light bulb protective sleeve

Use: Quartz

- cost: *Dependant upon size of the sleeve (depends on bulb size we use)*
- density: 2.65g/cc
- elasticity: 44.4 GPa
- fatigue strength: 4.8*10^7 Pa
- specific heat: 670 J/kg*C

- ❖ corrosion resistant
- ❖ good medium for UV
- ❖ industry standard

Hybrid UV Filter
Preliminary Design Review
UV Lamp Selection

Philips TUV Amalgam XPT System

Low Pressure Amalgam Mercury Lamp

Benefits

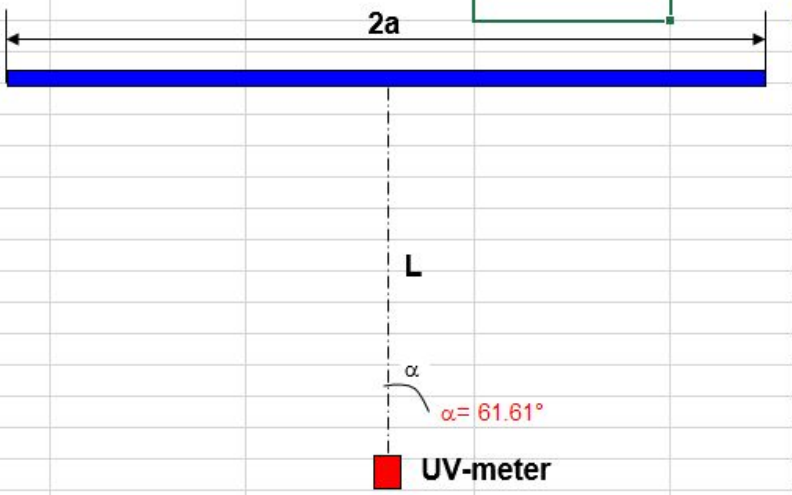
- UVC output per unit length is 1.5 to 3 times that of a standard LP mercury lamp
- Best performance over wide temperature range

Lamp selected:

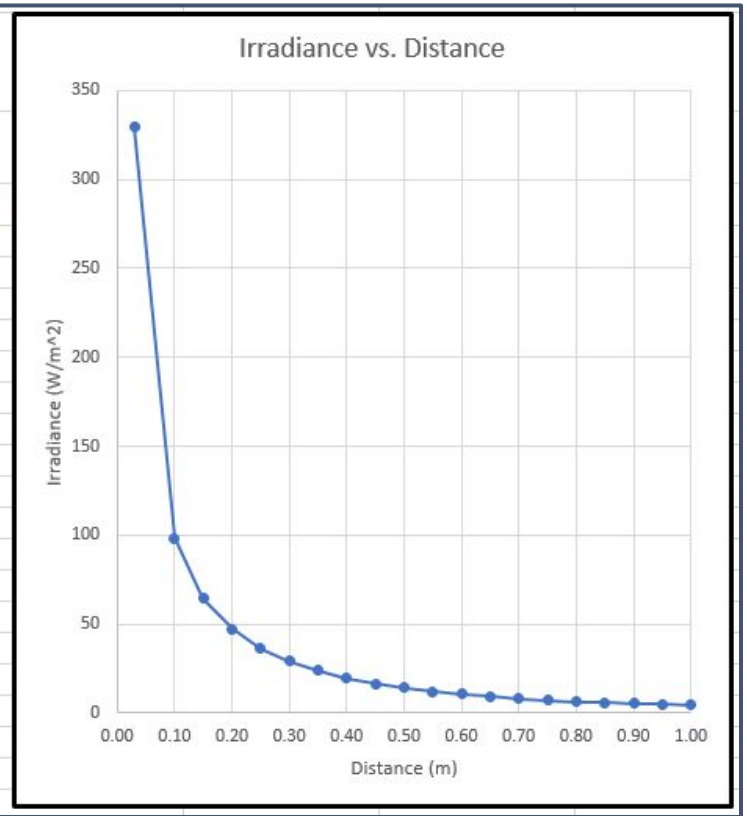
Type	Cap-Base	Dim. no	Technical Lamp Wattage (W)	Lamp Voltage (V)	Lamp Current (A)	UV-C[1] at 0h (W)	UV-C[1] at 100h (W)	Useful life[2] (h)	Depreciation at useful lifetime (%)	Irradiance at 1m (µW/cm²)*
130W XPT SE	G10.2Q	1	140	67	2,1	48	46	12000	15	465

Hybrid UV Filter
Preliminary Design Review
UV Calculations

Arc length 2a [m]	Measurement distance L [m]	UVC Flux [W]	
0.74	0.2	46	enter data in the grey-shaded cells

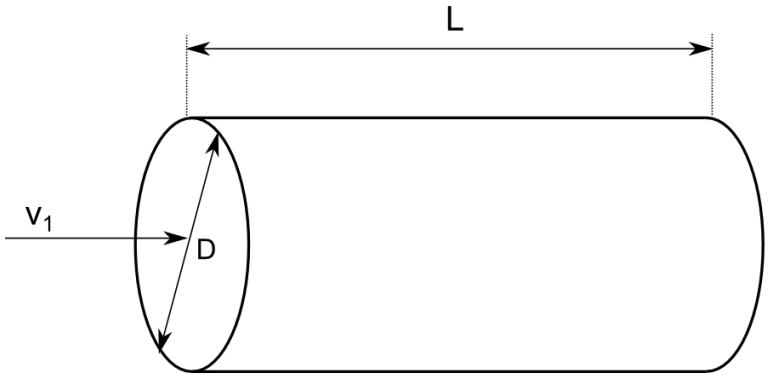


Distance	Irradiance
m	mW/cm^2
0.03	32.97
0.10	9.82
0.15	6.44
0.20	4.70
0.25	3.63
0.30	2.89
0.35	2.36
0.40	1.96
0.45	1.65
0.50	1.40
0.55	1.21
0.60	1.05
0.65	0.92
0.70	0.81
0.75	0.72
0.80	0.64
0.85	0.58
0.90	0.52
0.95	0.47
1.00	0.43



Hybrid UV Filter
Preliminary Design Review
Flow Calculations

System parameters
2” ID piping
3” pipe containing UV light
1” quartz sleeve
2 parallel chambers
50 gpm flow rate



$V = Q/A$

$Q = 50 \text{ gpm} = 0.111 \text{ ft}^3/\text{s}$

$A_{2\text{” Pipe}} = \pi/4 * (2/12)^2 = 0.0218 \text{ ft}^2$
$V_{2\text{” pipe}} = 0.111/0.0218 =$ **5.09 ft/s**

$A_{\text{UV Chamber}} = \pi/4 * [(3/12)^2-(1/12)^2] = 0.0436 \text{ ft}^2$
$V_{\text{UV Chamber}} = 0.111/(2*0.0436) =$ **1.28 ft/s**

$L_{\text{Pipe with UV Light}} = 3$ ft

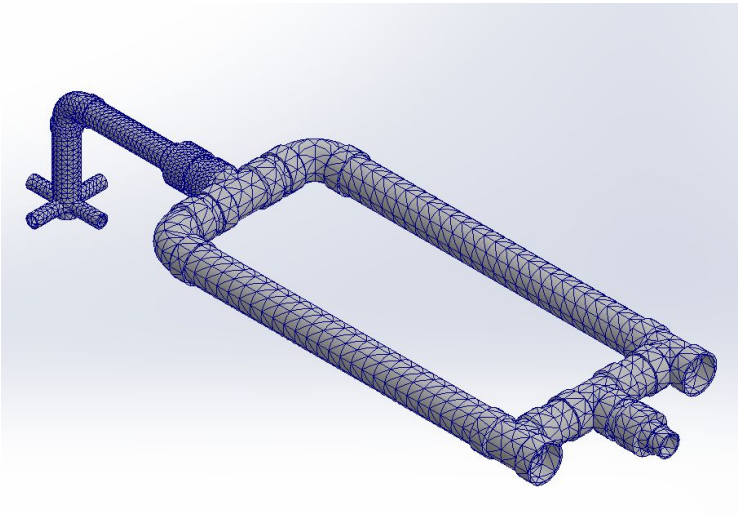
Contact time = 3 ft/1.28ft/s = **2.34 seconds**

Distance between lamp and
inner pipe surface = 28.6 mm = 1.13 in

Required contact time = Dose / Irradiance		
Target Dose *	60	mJ/cm^2
Irradiance from Design Lamp	32.25	mW/cm^2
Required contact time	**1.86**	**seconds**

* From Pool Water Treatment Advisory Group (PWTAG)

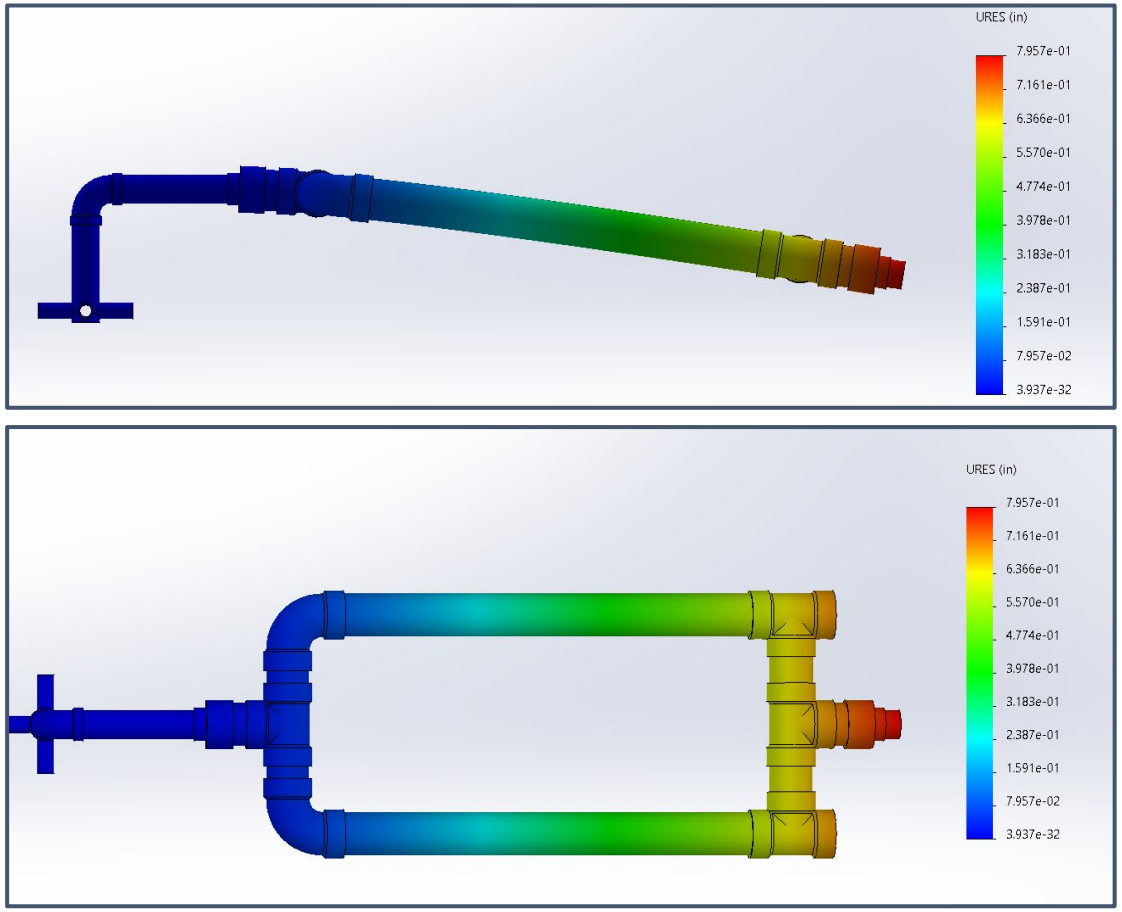
Hybrid UV Filter
Preliminary Design Review
Finite Element Analysis
Structural Analysis



- Structural Analysis using Solidworks Simulation to solve for
  - Displacement
  - Stress (von Mises)
  - Strain
- Forces Used:
  - 8lb force down on outlet pipe for multiport valve weight
  - Gravity
- Component Interactions
  - All pipes are bonded where they intersect
  - Pipes inside tank: ‘Fixed’ because of the structural support
- Mesh
  - Three different element sizes used
    - 0.49 in pipes inside tank
    - 0.408 in high stress area pipes
    - 1.29 in the rest

Hybrid UV Filter
Preliminary Design Review
Finite Element Analysis

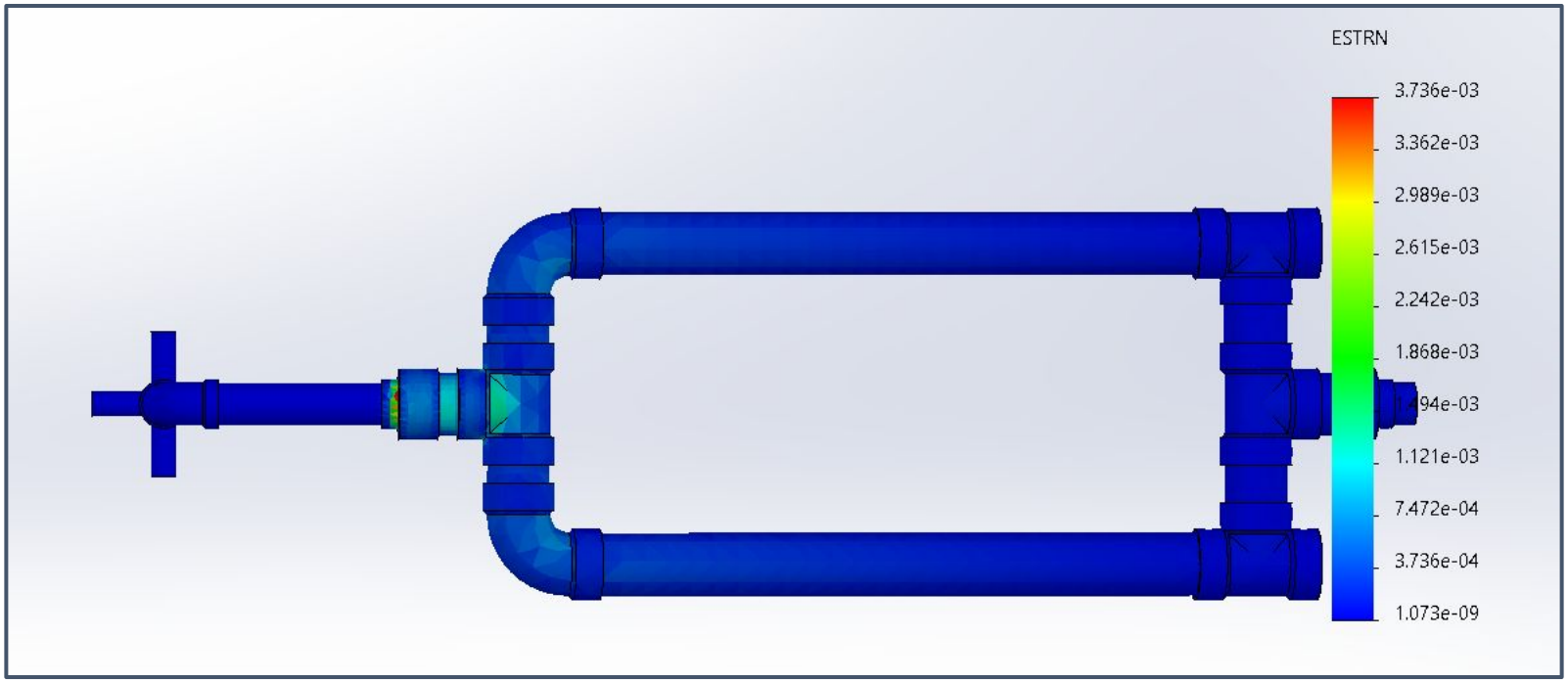
UV pipes without support - Displacement FEA



Max: 0.761 in
Min: 0 in

Hybrid UV Filter
Preliminary Design Review
Finite Element Analysis

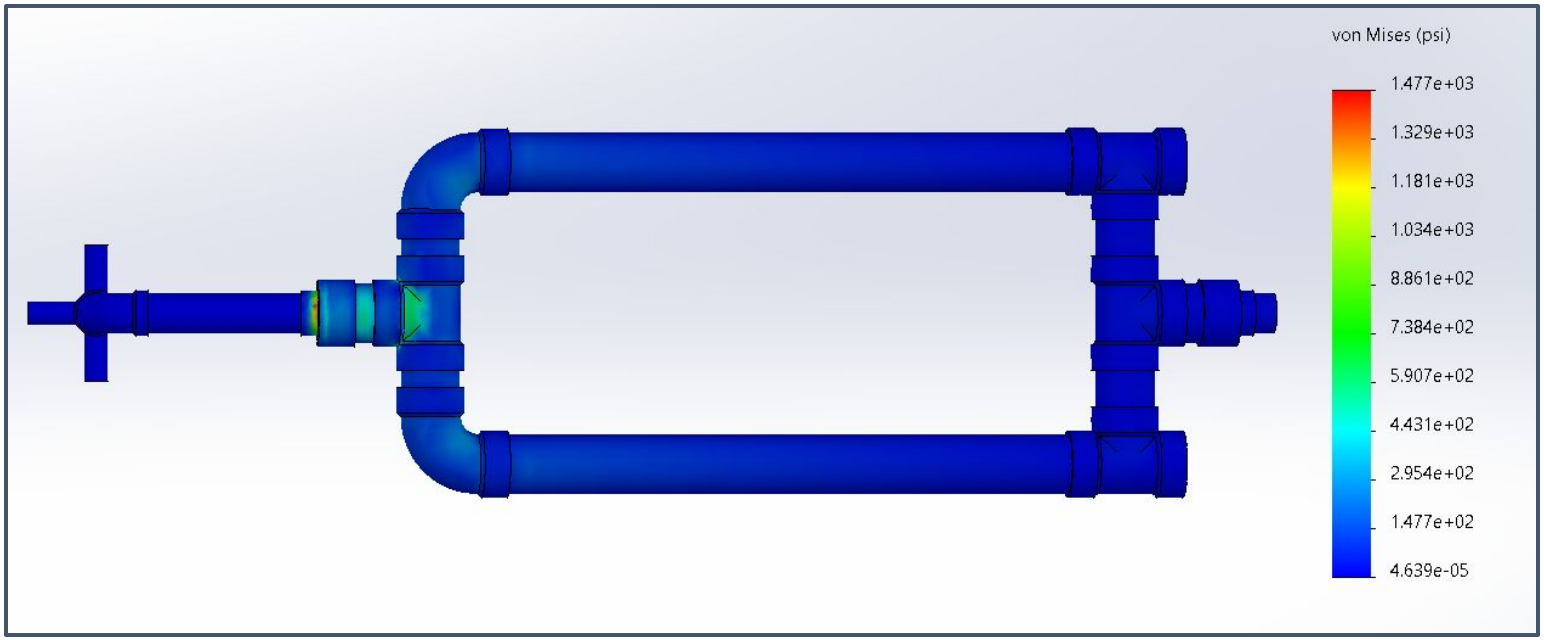
UV pipes without support - Strain FEA



Max: 0.0037
Min: 0

Hybrid UV Filter
Preliminary Design Review
Finite Element Analysis

UV pipes without support - Stress (von Mises) FEA



Max: 1477 psi
Min: 0 psi

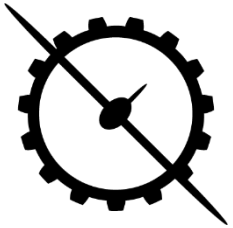
Hybrid UV Filter
Preliminary Design Review
Conclusions

Current Design:

- New design provides more even fluid distribution, more realistic scale
- Materials
- UV dose should be more than sufficient

Next Steps:

- Configure supports
- Find a LED UV lamp
- Figure out electrical/sensor details



Questions?

Hybrid UV Filter Preliminary Design Review Calculations

Assume (Pool Dimensions)
Length = 40 ft
Width = 20 ft
Avg. Depth = 6 ft
t = 12 hours = 720 minutes
= 43,200 seconds

Volume= 4,800 ft^3 = 36,000 gallons
50 gpm * 720 minutes = 36,000
Water changes per day = 1