

EPA Water Disinfection Project

Project # P07401

Solar Pasteurizer with Integrated Heat Exchanger
(SPIHX)

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Sang Lee

Elaine Aiken

Kellen Bucher

Sulen Gonc

Alex Kinlock

Nate La Croix

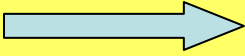
Drazen Hadzalic



Outline of Review

- Project Definition
 - Key subsystems
 - Key needs
 - Key specifications
- Concept Generation Process
 - Generation of solutions
 - Elimination / Combination of solutions
 - Description of system level concepts
- Concept Selection
 - Pugh's Method
 - Possible designs?
- Wrap up
 - Plans and Challenges ahead
 - Q&A

Subsystems

- Feedwater:
 - Untreated water supply to the unit
 - Pressure source
 - Manifold design
- Solar Collector:
 - Solar energy  Heat
- Heat Exchanger:
 - Transfer heat to incoming water
 - Heat transfer between outgoing and incoming water

Subsystems

- Flow / Temperature Regulation:
 - Control of flow within the system
 - Release of pasteurized water
- Air Regulation:
 - Control of air buildup within the system
- Minimizing Heat Loss:
 - Control of heat lost to the surroundings
 - Increase in efficiency
- Sediment Control:
 - Prevention of sediment buildup within the system

Key Needs

- Affordable
- Durable
- Ease of Use
- Effective Pasteurization
- Output

- Other variables kept in mind, not in focus

Key Needs

- Cost

- Fabrication

- Output

- Durability

- Usability

- Safety

Key Specifications

- Cost to manufacture

- % of total cost for imported parts

- % of component fabricated locally

- No. of parts imported

- Avg. daily potable output

- No. of moving parts

- Rating system based on ease of use

- Pathogen reduction

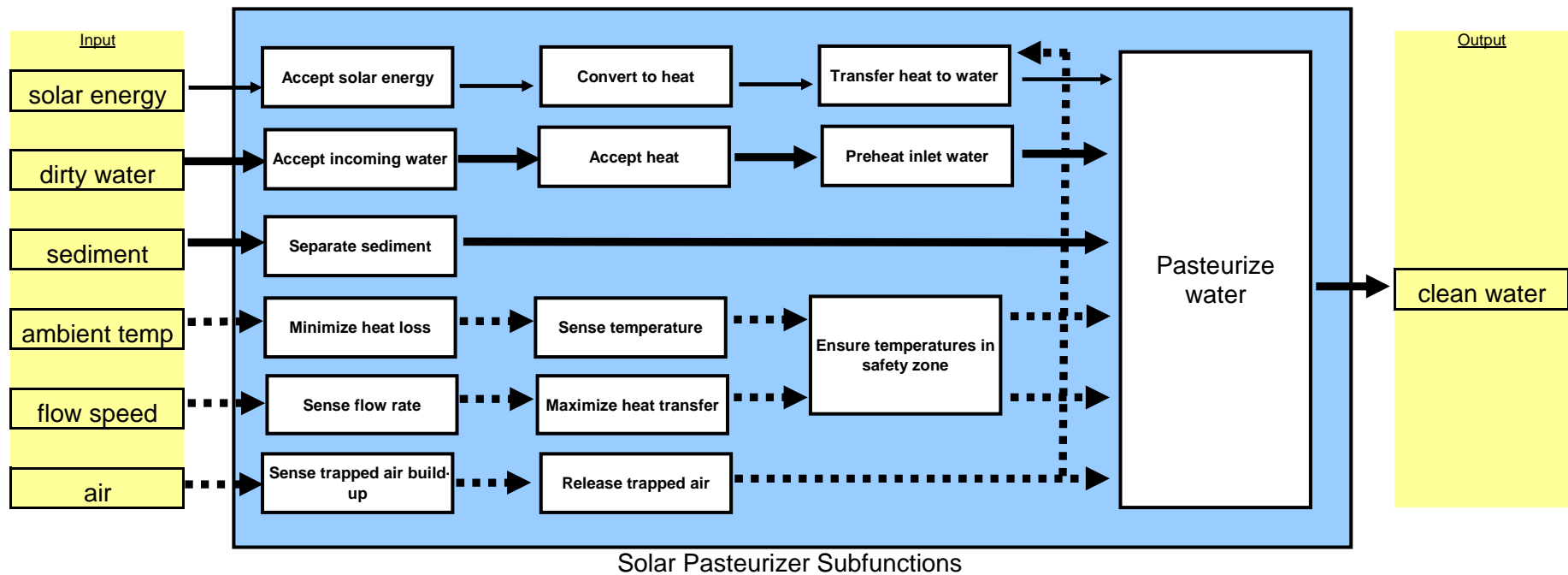
Outline of Concept Generation Process

- Listed important subfunctions by following subfunction diagram
- Brainstormed ideas
- Eliminated and combined concepts
- Conceptualized remaining concepts

Subfunction Diagram

Concept Generation - "Function Diagram"

- Energy
- Material
- ...→ Control / Feedback



Solutions to Subproblem of Accepting Feedwater

- Screened Hopper
- Plastic syphon
- Screened Trough
- Sedimentation Trough
- Bucket w/ dowel pins and spring loaded drain valve
- Bucket (manual feed)
- Screened bucket
- Lid
- Selective surface lidded container
- Funnel with coffee filter
- Funnel with two stage filter and lid
- Header w/ single threaded inlet to attach to existing pipeline

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- Similar ideas were combined into design
- Current idea Incorporates scenario of filling bucket manually as well as connecting to existing water line.

Solutions to Subproblem of Converting Solar Energy to Heat

- Glazed glass
- Double glazed glass
- Coated glass
- Bubble-wrap
- Two pieces of plastic with air in b/w
- Two corrugated plates w/ selective surface
- Glass-air-collector
- Glass-greenhouse gas-collector
- Dimpled-flat-dimpled assembly
- Mirrors focusing light to center
- Selective surface

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- Solar collectors use glazed glass and a selective surface
- With a flat plate collector a green house effect takes place

Solutions to Subproblem of Heat Exchanger

- Flat plate
- Tube within a tube
- Two fluid system w/ rotary shaft actuation
- Baffled shell
- Counter flow pipes
- Compact heat exchanger
- Evacuated tube collector

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Simplest designs that may drive down the cost

Solutions to Subproblem of Flow / Temperature Regulation

- Dimpled surface
- Single / Multiple thermostat valves
- Natural circulation
- Bimetallic strip
- Dual expanding metal plates
(expands to expose hole)
- Differential Pressure control valve
- Thermostatic mixing valve
(requires constant flowrate)

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Solutions to Subproblem of Minimizing Heat Loss

- Interior Insulation
- Exterior Insulation
(insulating jacket)
- Thermal mass
(brick)

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- *Most versatile design*
- *Fits with most integrated solar + heat exchanger designs*
- *Protected from ambient weather conditions*

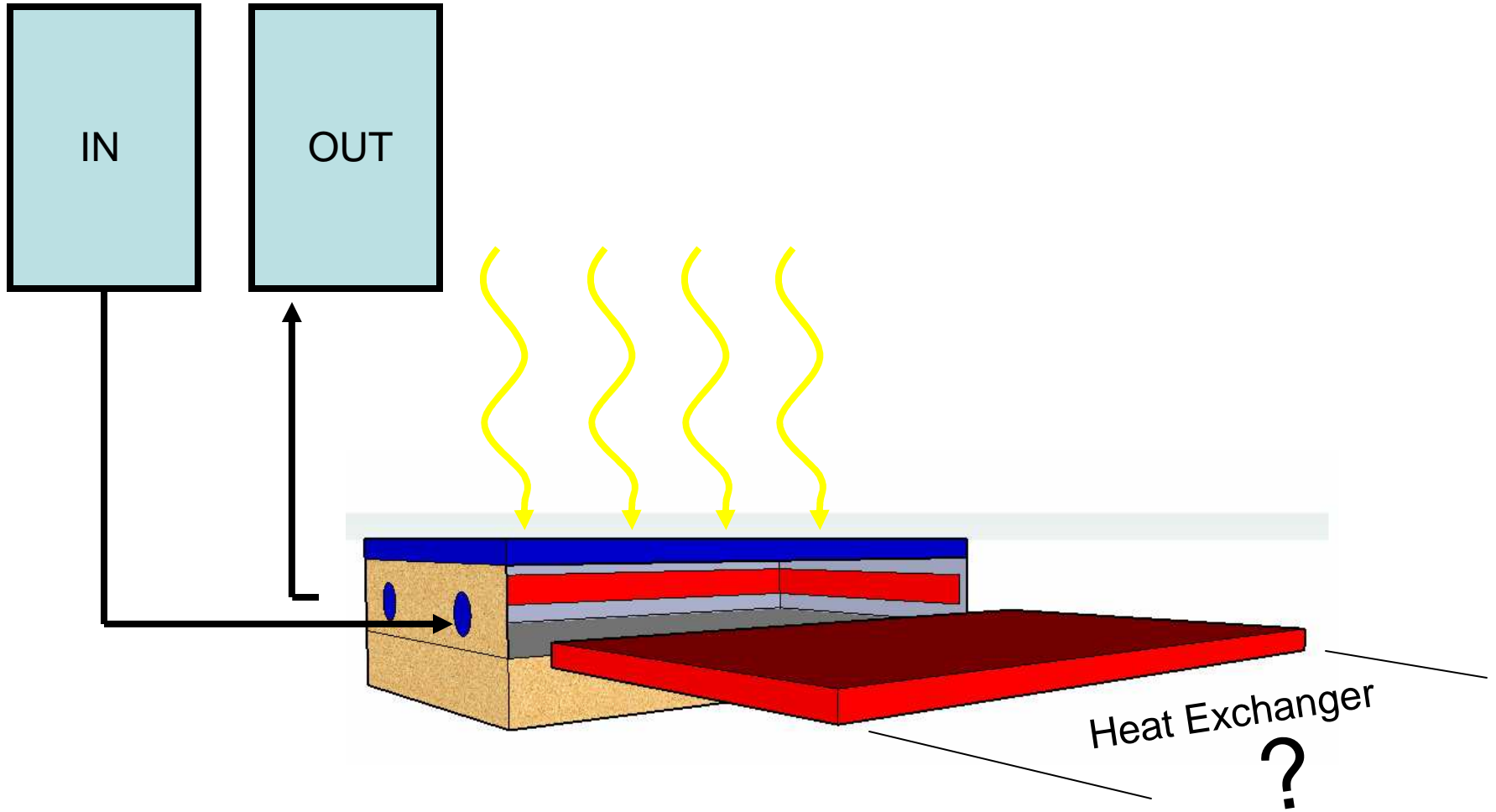
Solutions to Subproblem of Releasing Trapped Air

- Air lock mechanism
- Sightglass w/ manually operated poppet valve
- Floating air valve
- Deaerator

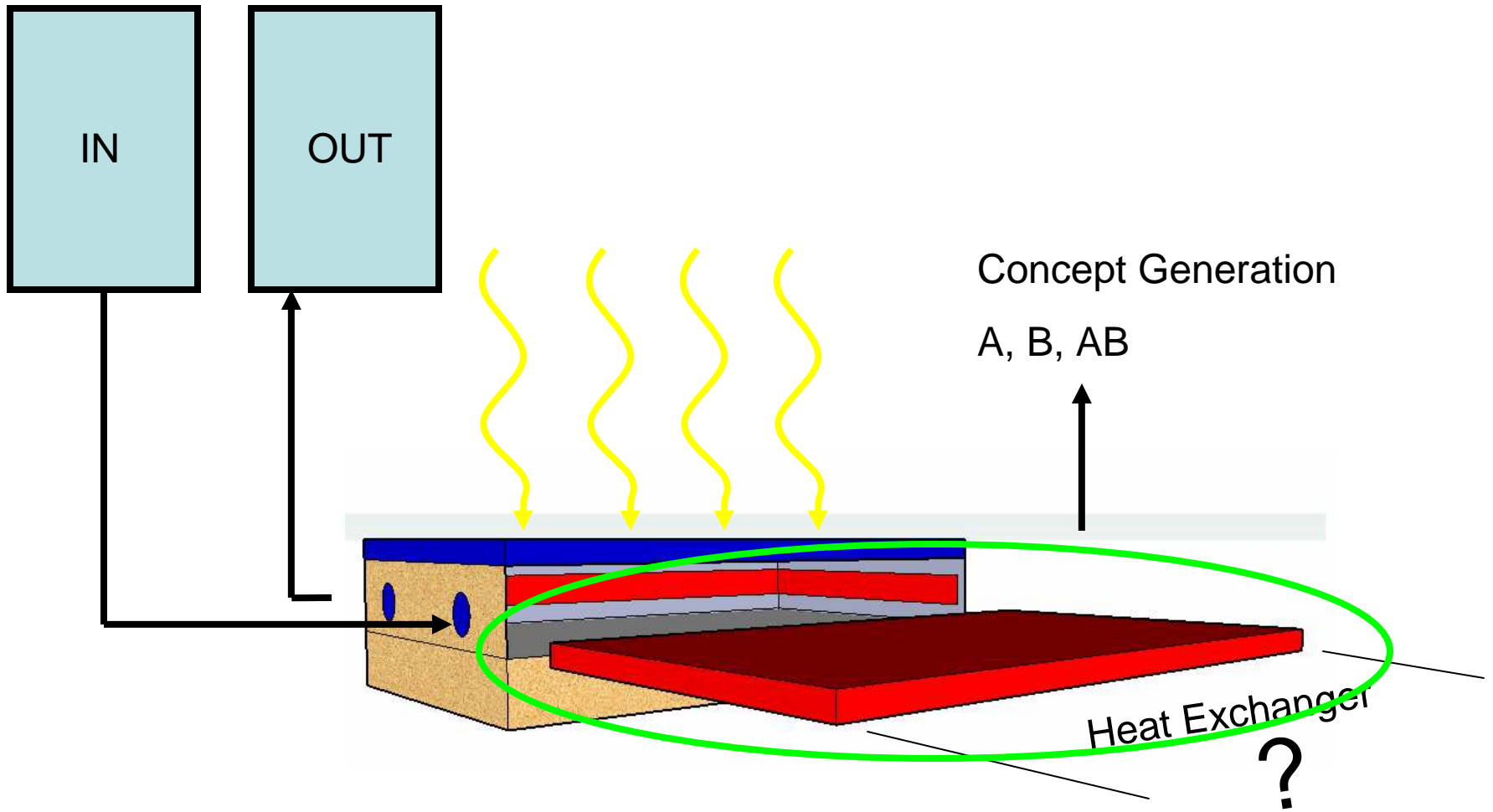
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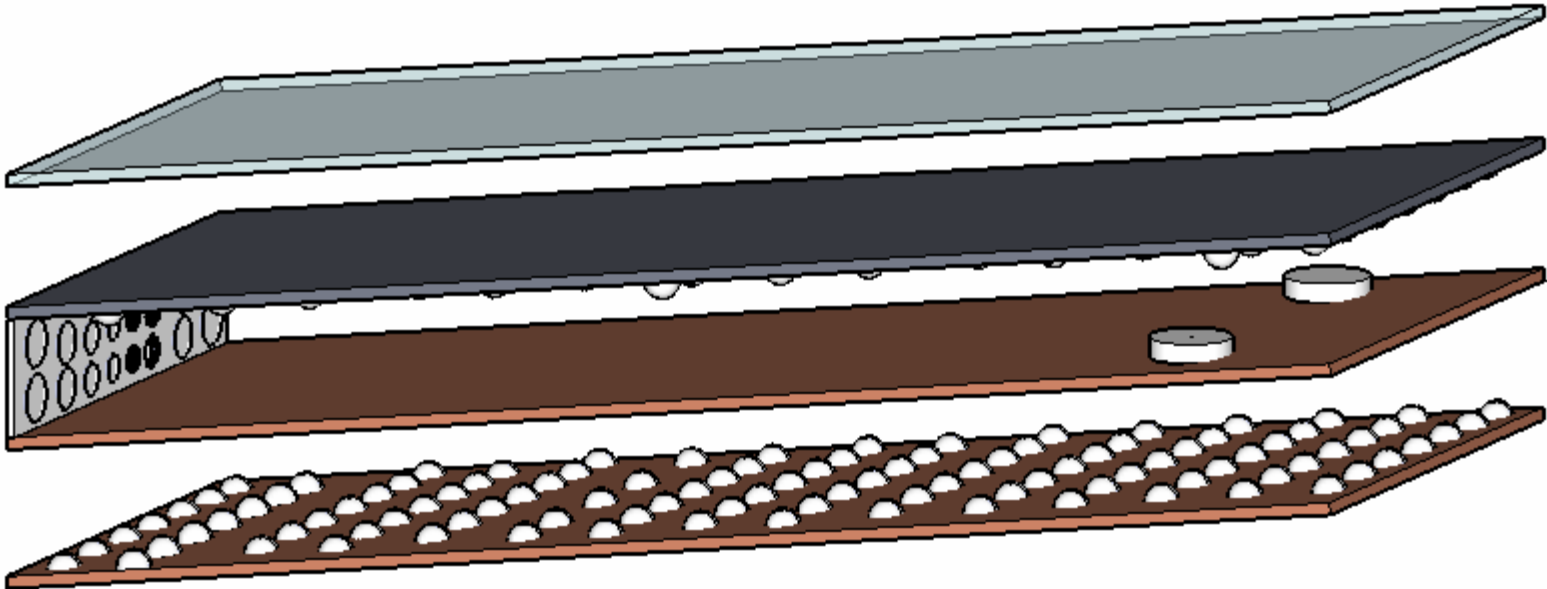
Design Overview



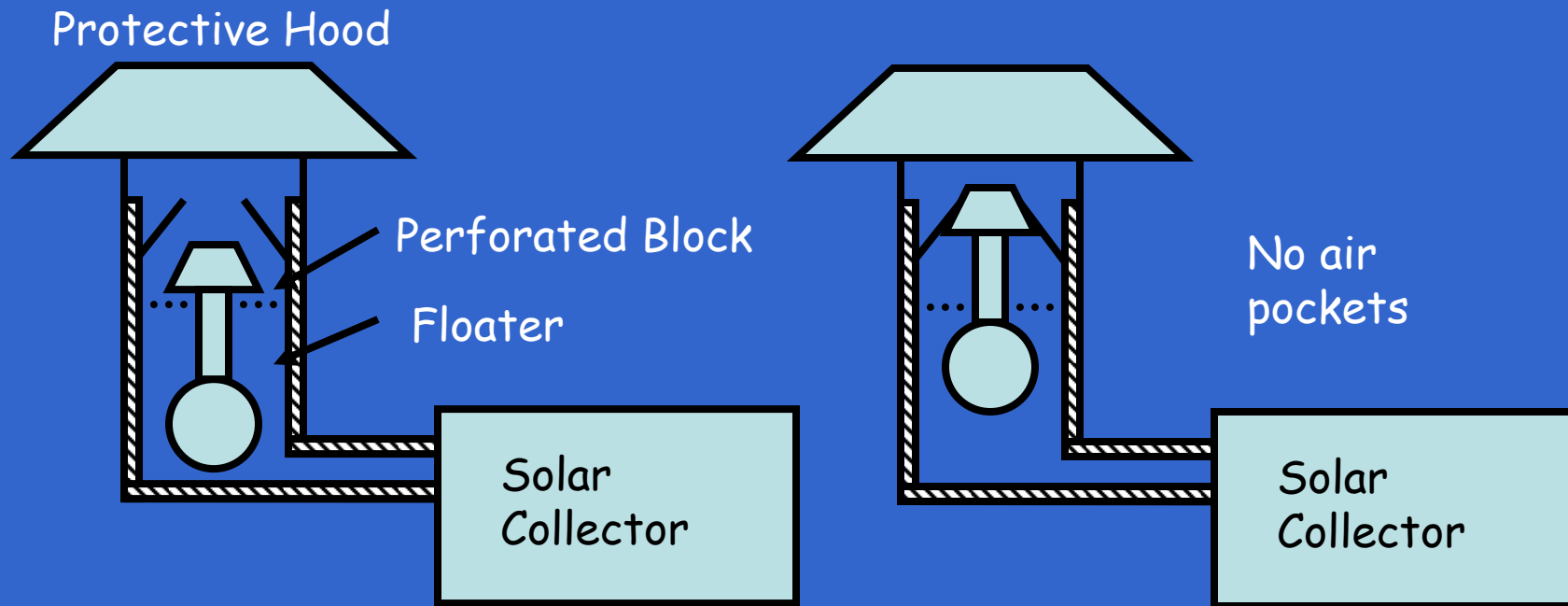
Design Overview



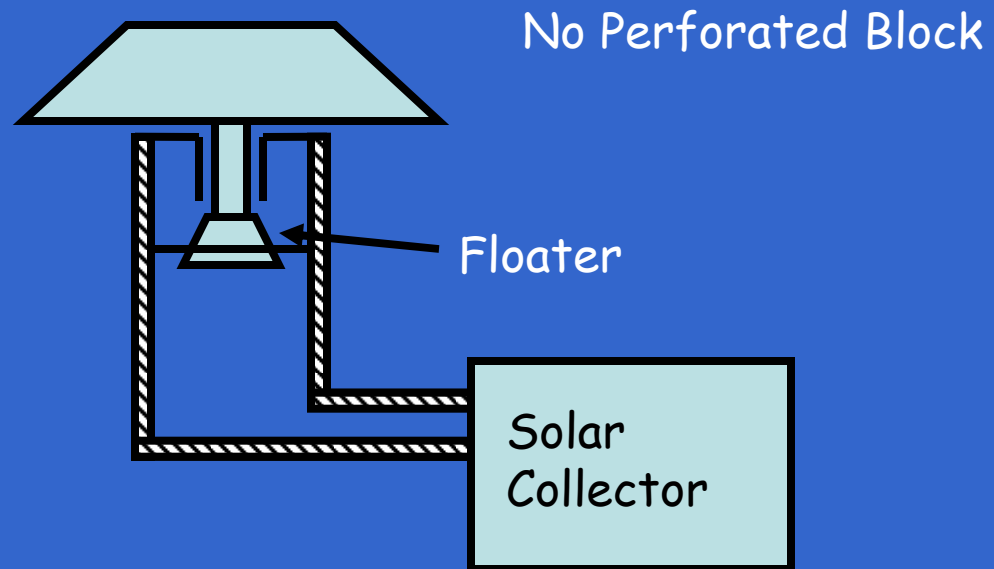
Concept A - Dimpled Surface



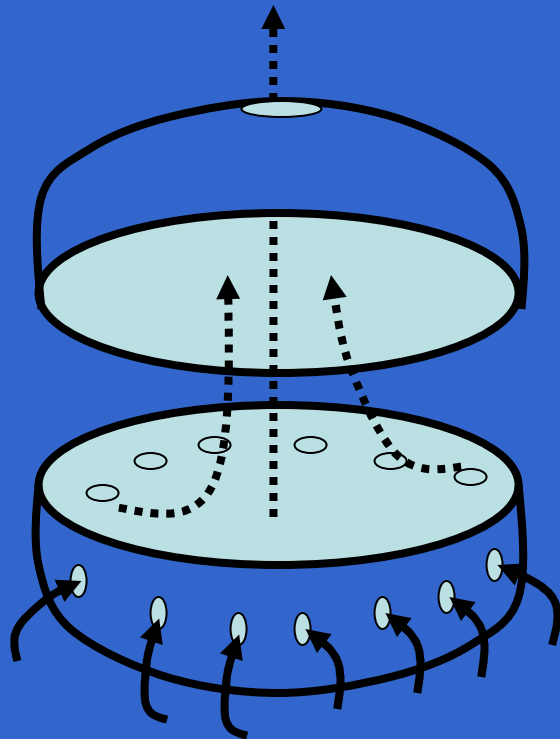
Detailed View of Floater Valve Designs for Air Regulation



Detailed View of Floater Valve for Air Regulation

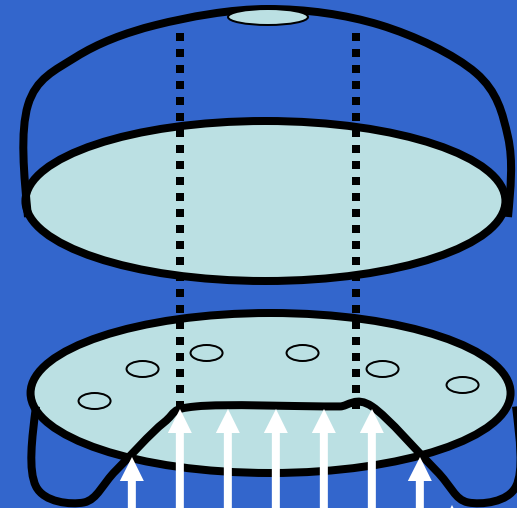


Detailed View of Floater Valve Designs for Air Regulation



air

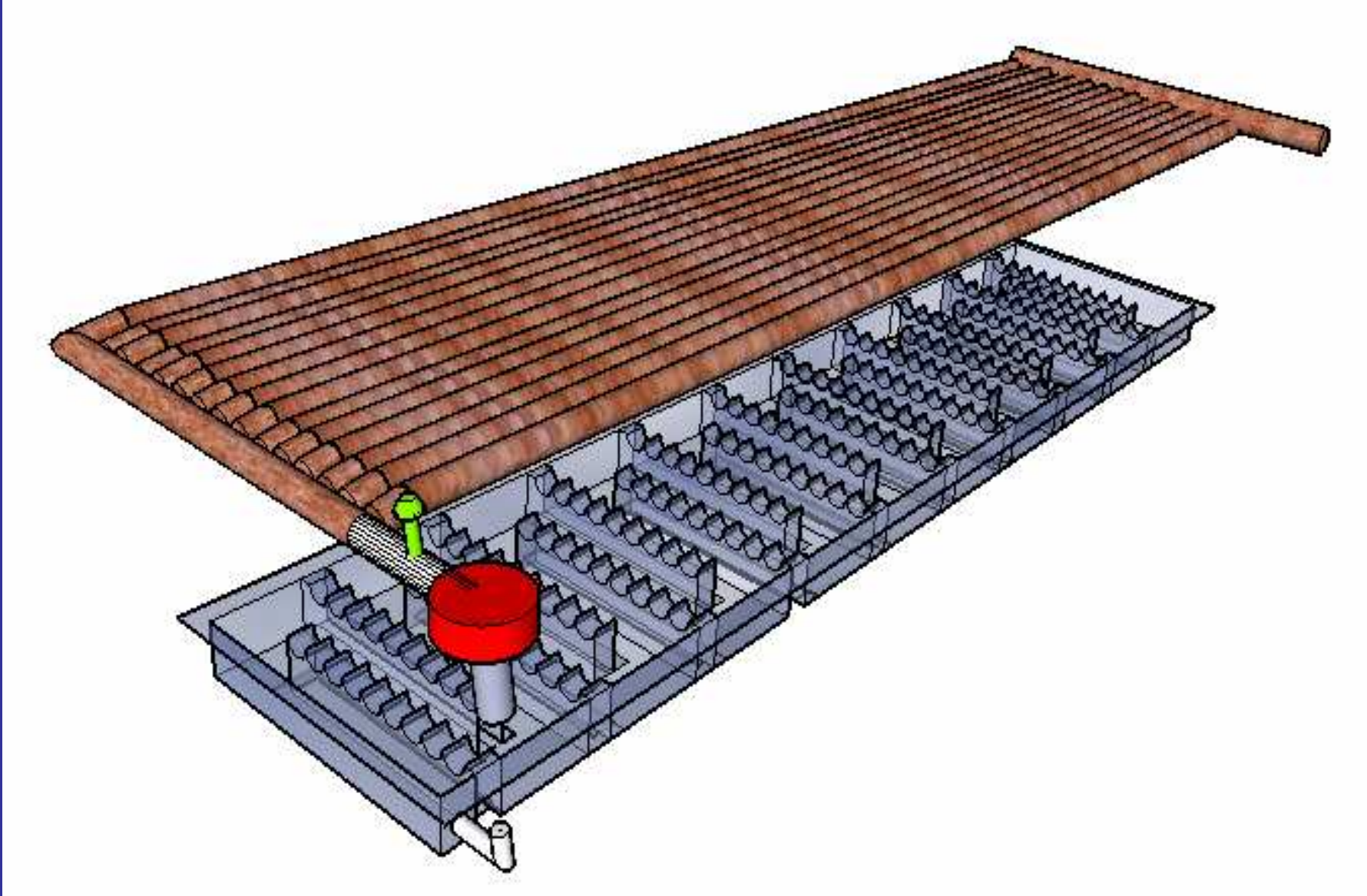
water



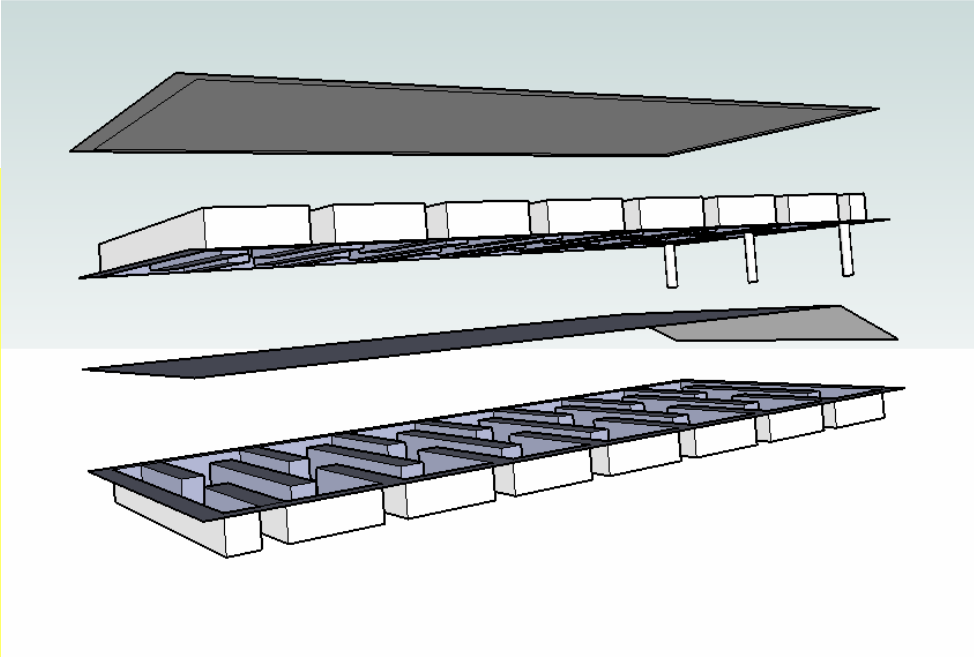
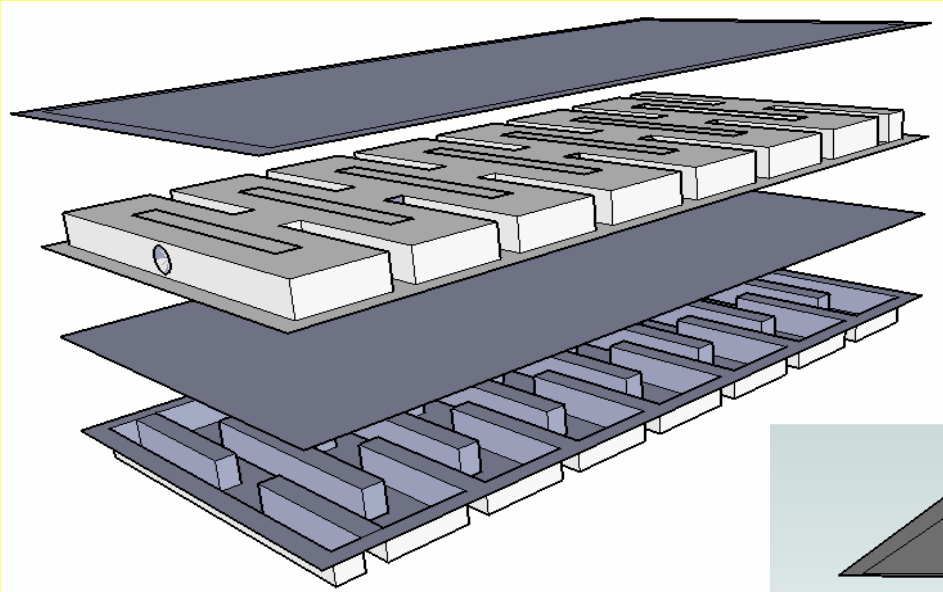
buoyant
forces

water

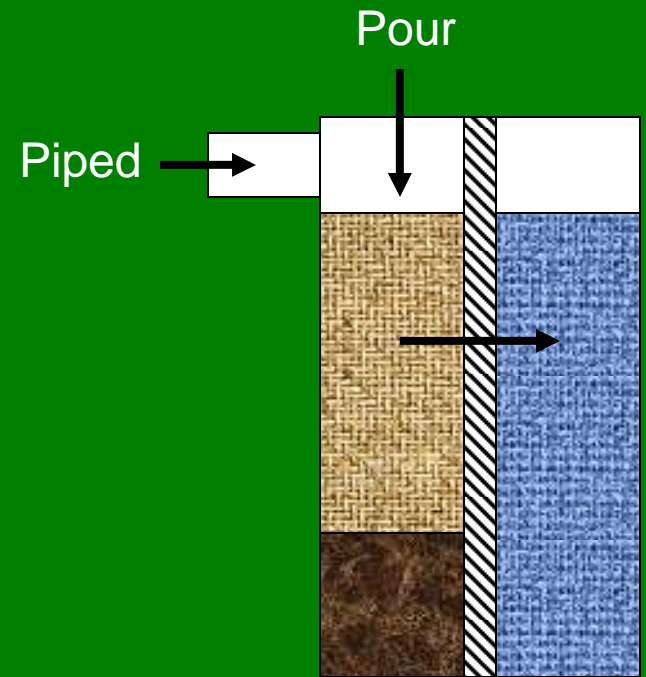
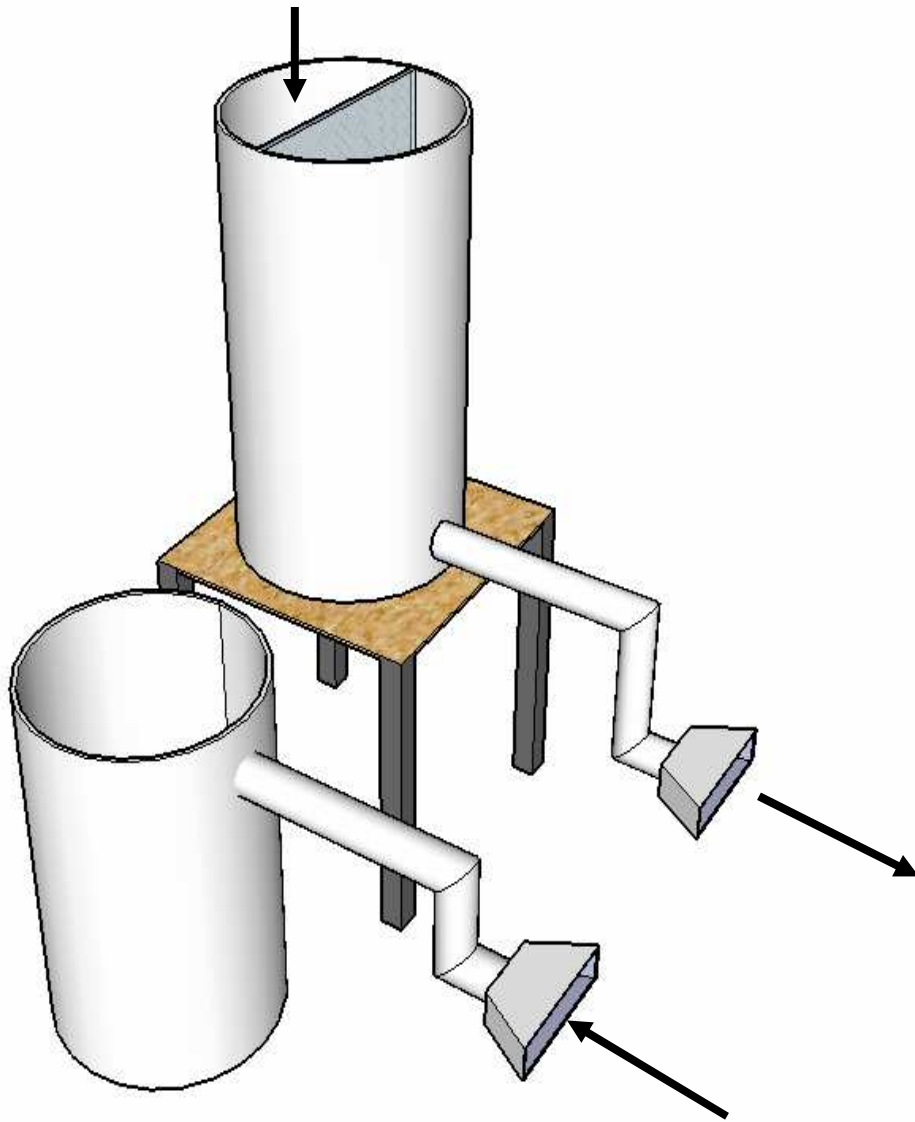
Concept B - Tube / Baffle



Concept AB - Baffle / Baffle



Feedwater Tanks - Sulen



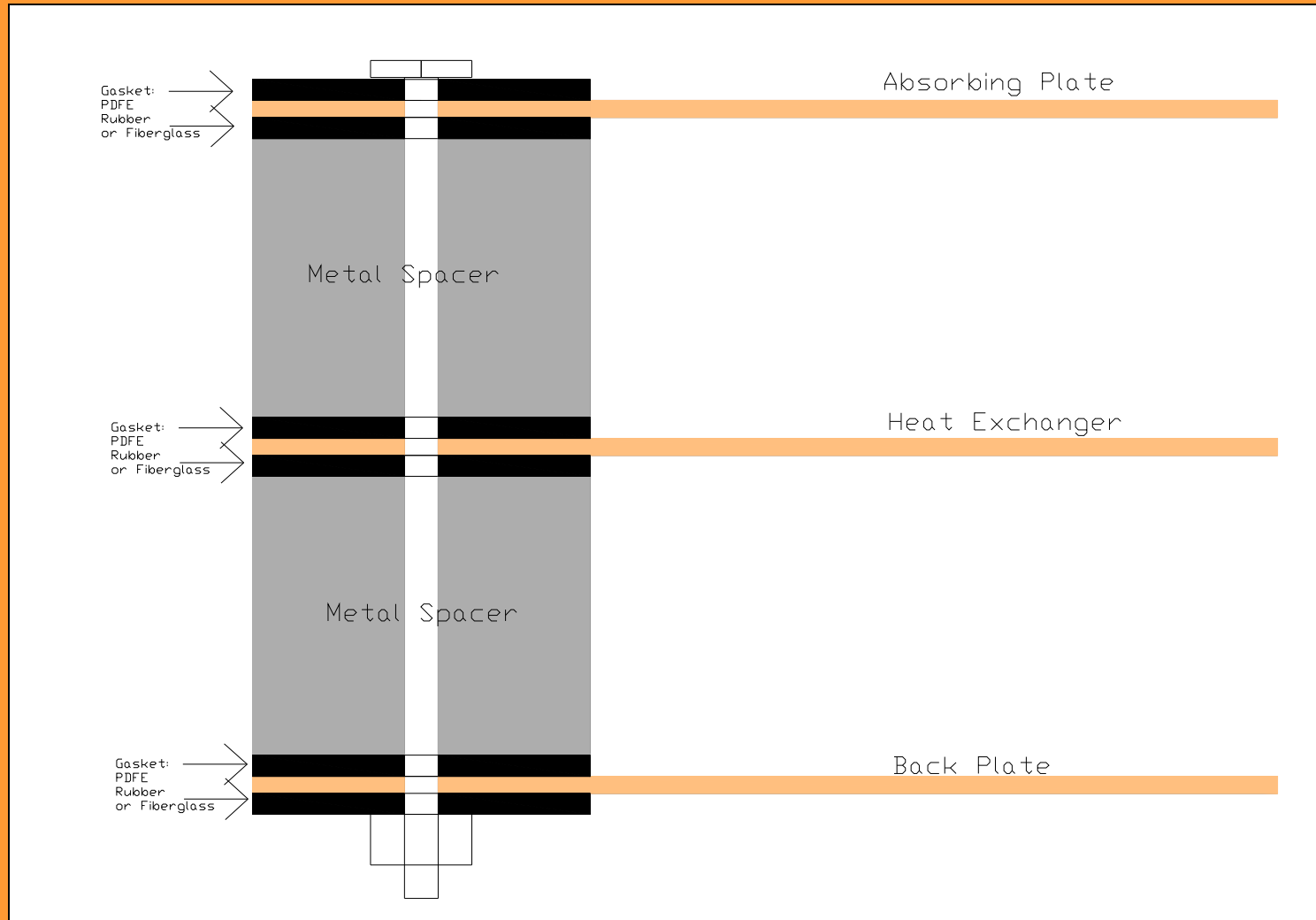
Enclosure

- Enclosure
 - Glass
 - Glazing
 - Air gap b/w heat exchanger & glass
 - Collector
 - Coating
 - Notches for “drop and place” (versatile enclosure)

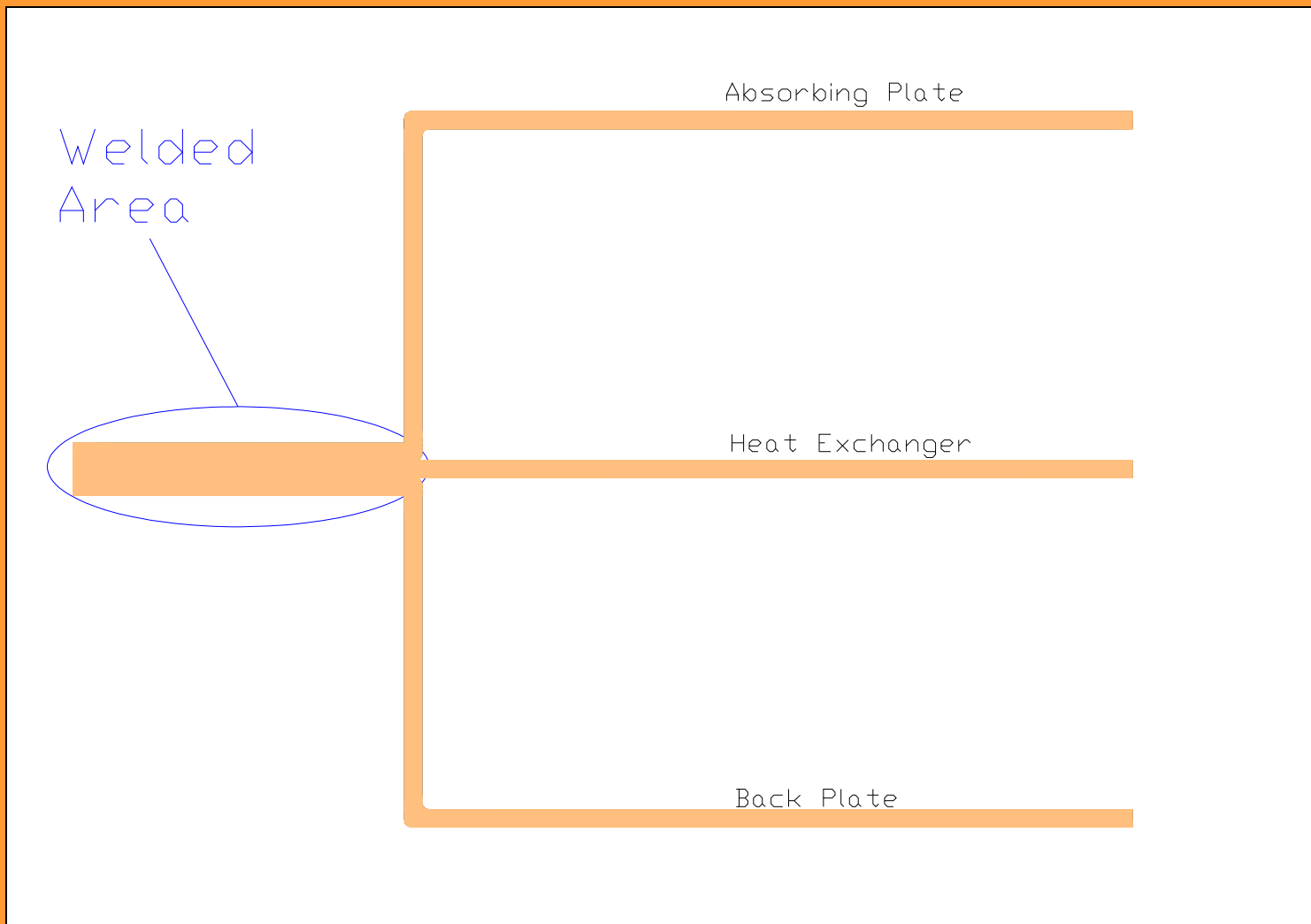
Insulation

- Essential to minimize heat loss
- Properties of main concentration:
 - Density
 - Thermal Conductivity
 - Thermal Diffusivity
- Materials to be considered:
 - Hardwoods (oak, maple)
 - Softwoods (fir, pine)
 - Fiberglass
 - Hard rubber
 - Cotton

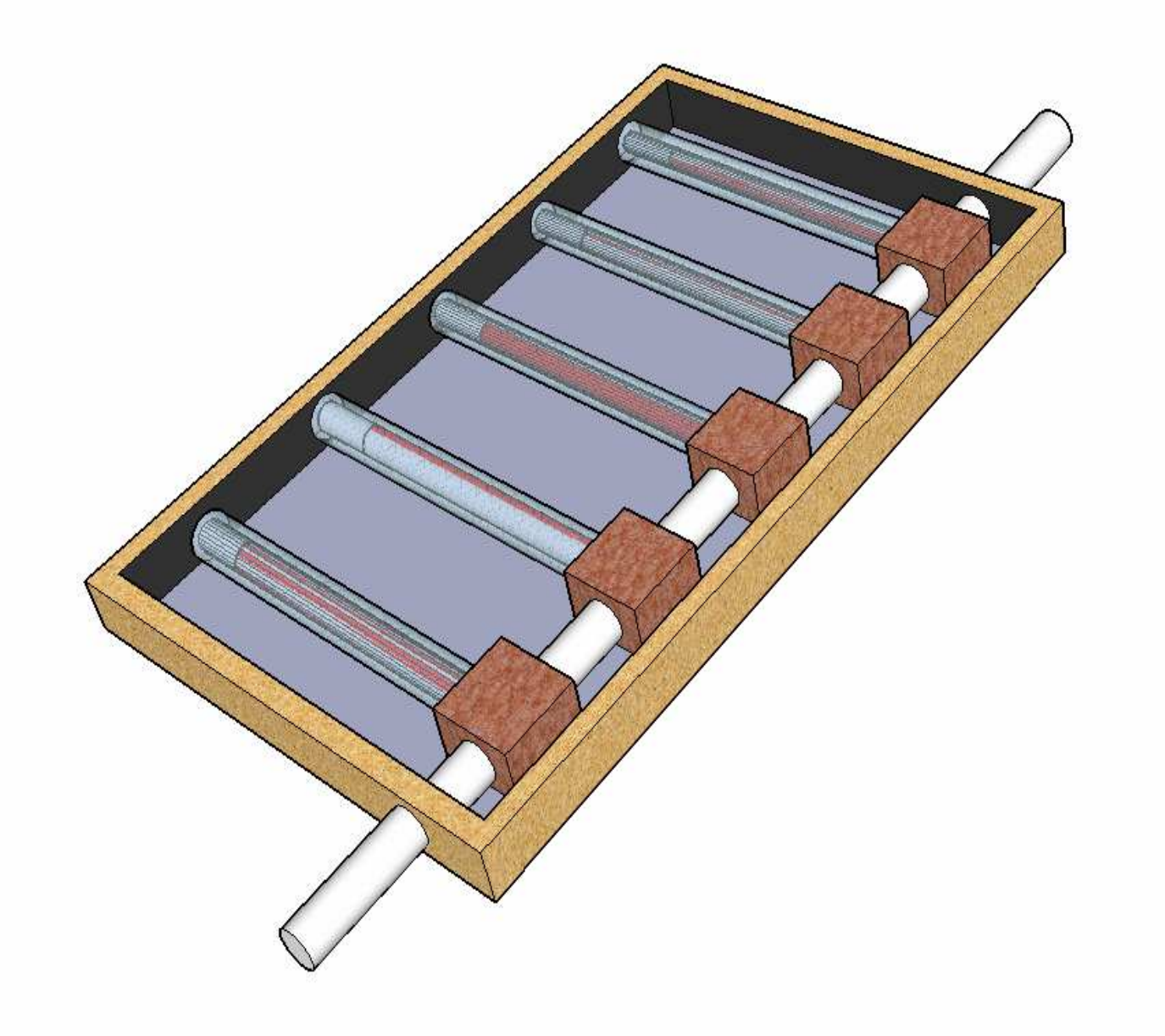
Pasteurizer sealing: Gaskets



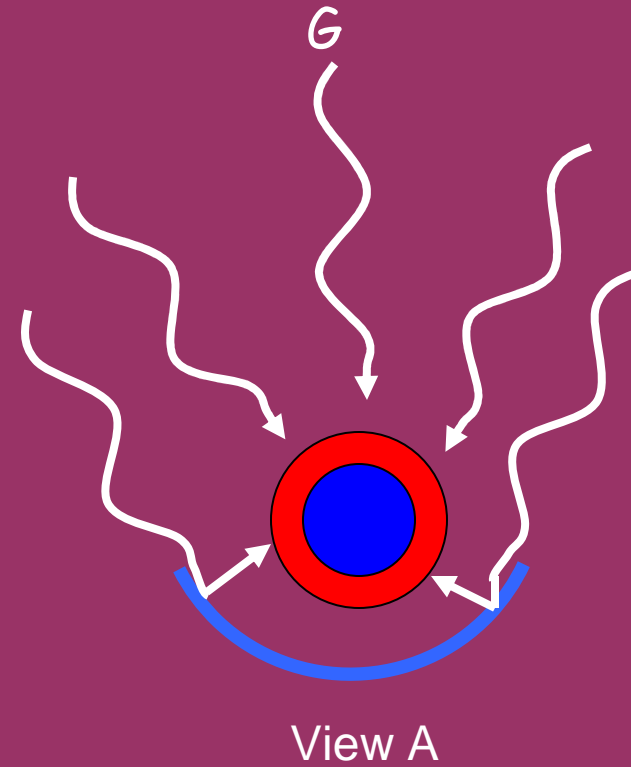
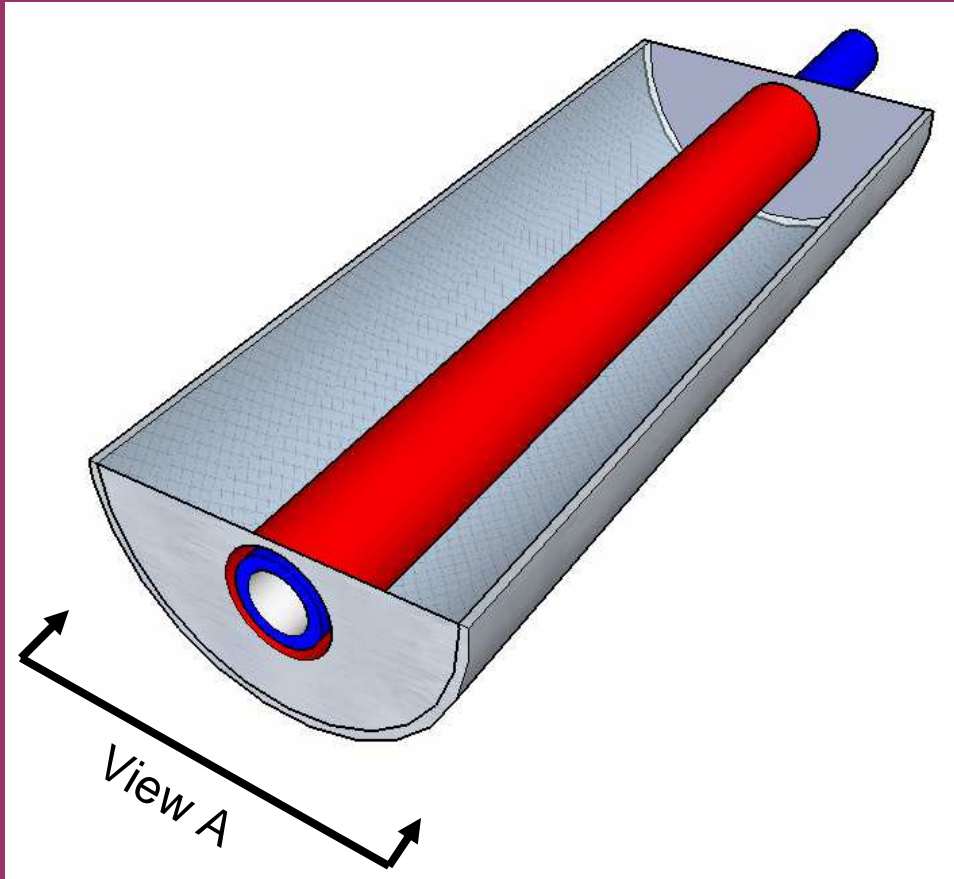
Pasteurizer Sealing via Welding



Concept C - Evacuated Tube

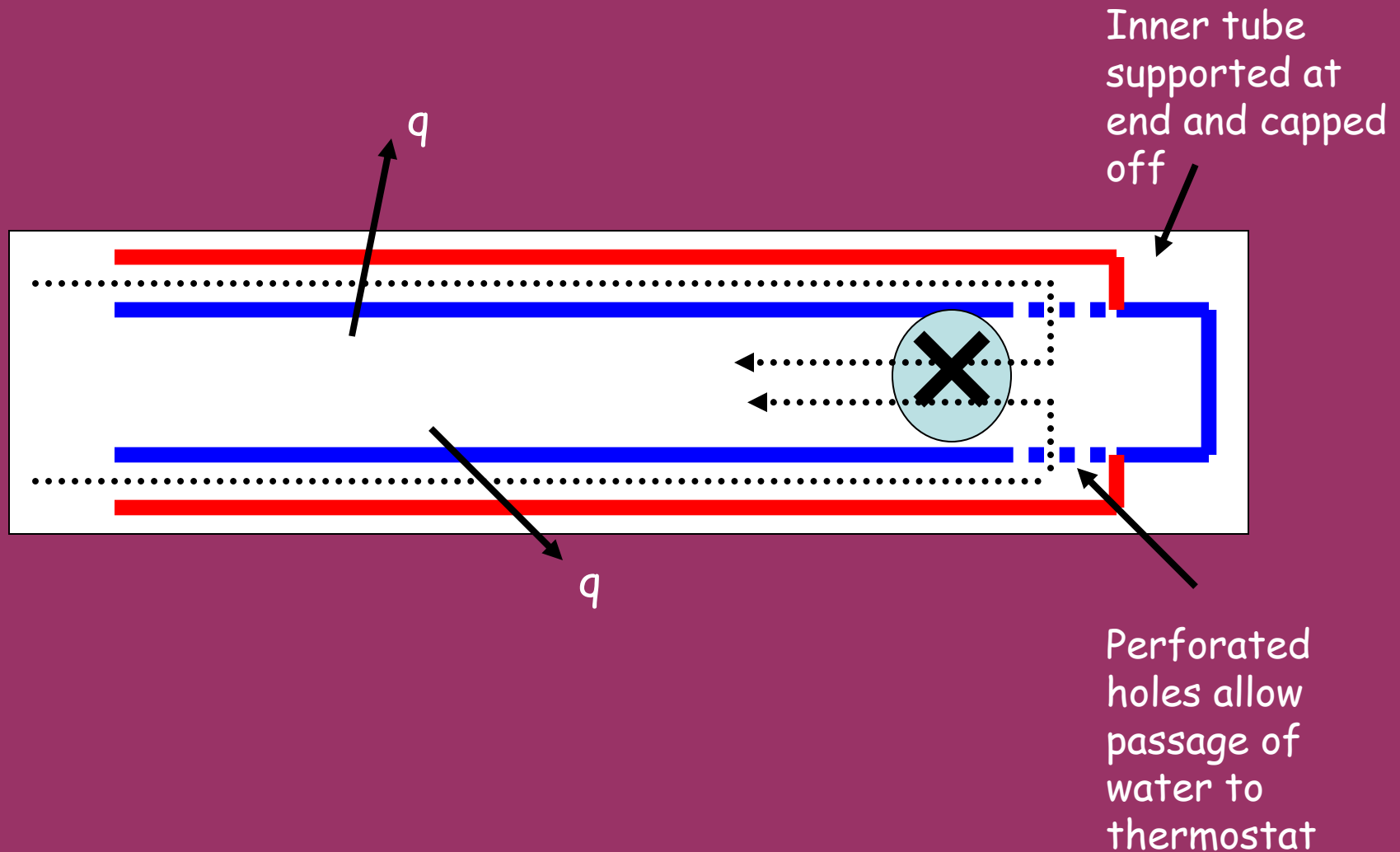


Concept D - Mirror & Tube within a Tube



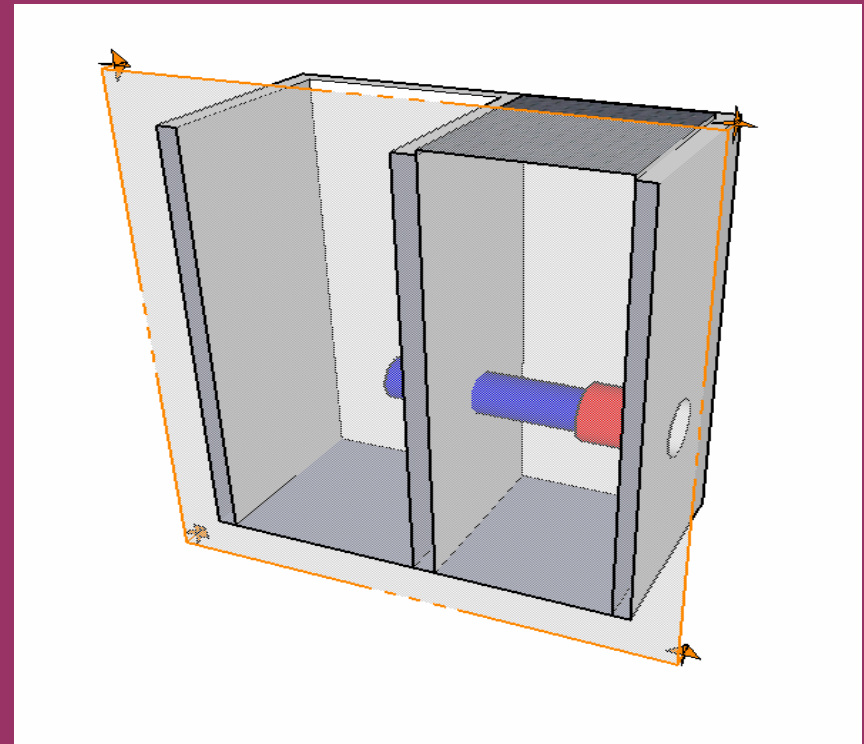
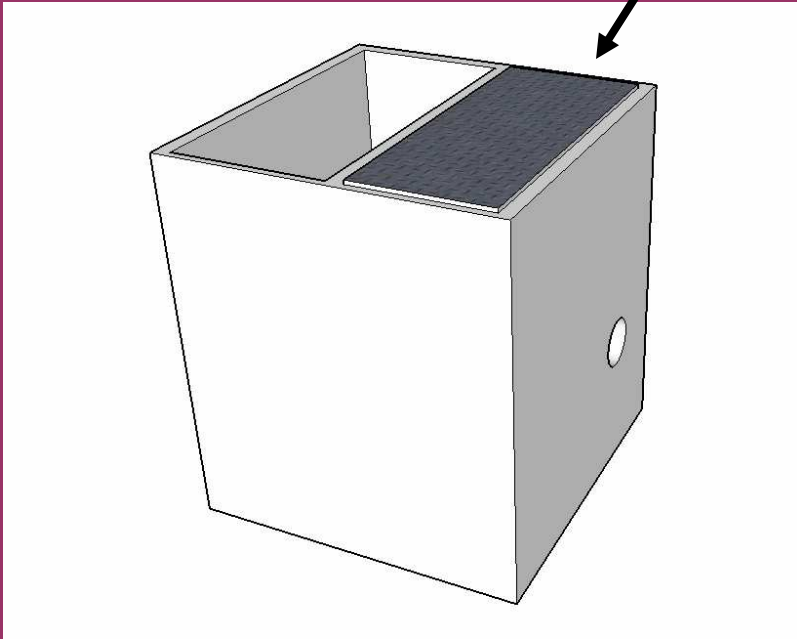
* The concentric tube design is best suited for focus of irradiation along the length of the pipe

Detailed View of Tube w/i a tube



Concept D - Tube in a tube Feed tank

Inlet filter



Pugh Chart

		Concepts									
		A		B		AB		D		E	
		Dimpled		Tube / Baffle		Baffle / Baffle		Evac. Tube		Mirrored	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Cost	17%	4	0.68	2	0.34	3	0.51	0.5	0.085	4.5	0.765
Easy to fabricate	13%	4.5	0.585	2	0.26	3	0.39	0.5	0.065	4	0.52
Easy to use	10%	3	0.3	3	0.3	3	0.3	3	0.3	1	0.1
Durability	10%	2	0.2	3	0.3	3	0.3	4	0.4	2	0.2
Maintenance	5%	1.5	0.075	1.5	0.075	1.5	0.075	3.5	0.175	3	0.15
Flow Distribution Complexity	5%	3	0.15	3	0.15	2	0.1	5	0.25	4	0.2
Output	15%	3	0.45	3	0.45	3	0.45	5	0.75	2	0.3
Heat exchanger effectiveness	10%	2.5	0.25	3	0.3	3	0.3	5	0.5	4	0.4
Air formation	5%	2.5	0.125	1	0.05	3	0.15	3	0.15	2	0.1
Design adaptability	10%	3	0.3	2.5	0.25	3	0.3	0.5	0.05	1	0.1
Total Score		3.12		2.48		2.88		2.73		2.84	
Rank		1		4		2		3		5	
Continue?		YES		NO		YES		NO		YES	

Wrap Up

- Plans Ahead
 - Decide on design
 - Engineering analysis
 - Test methods
- Challenges Ahead
 - Short project schedule
 - EPA Final Report due April 6th
 - Testing in Rochester
- Questions? Comments? Suggestions?