SRP EVAP

ME 486C Fall 2025

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Design Requirements

Table 1: Design Requirements Table

Customer Requirements	Engineering Requirements
CR1: Ability to control/maintain air temp	ER1: Precision of data collection
CR2: Ability to control/maintain water temp	ER2: Accuracy of sensors
CR3: Ability to control/maintain RH	ER3: Material durability and longevity
CR4: Ability to measure relative humidity	ER4: Geometric similarity
CR5: Ability to maintain convective flow regime	ER5: Similarity of Rayleigh number
CR6: Project stays within budget	ER6: Economic feasibility and practical implementation
CR7: Maintain water tightness	ER7: Adhere to scientific experimentation principles

Testing Summary

Table 2: Test Summary Table

Experiment	Relevant DR	Testing Equipment Needed	Other Resources
EXP 1– Flow Visualization	CR5: Natural Convection CR2: Heated Water CR1: Air Temperature Control	Outdoor incense Black backdrop Camera/Tripod Water Heater	Good weather (low wind)
EXP 2- Measurement & Precision of Collected Data with Arduino	ER1: Accurately Collect Data ER2: Sensor Accuracy	Arduino/breadboard Thermocouples Humidity sensors Load cells SD card	Excel access Power source
EXP 3- Relative Humidity	ER3: Closed lid CR1: Air Temperature Control CR2: Heated Water CR3: Accurately Control RH% ER2: Sensors reading	Dehumidifier Desiccant Arduino/breadboard SD card Water Heater	Power source
EXP 4- Siphon Functionality	CR8: Water Tightness ER1: Data Collection ER2: Sensor Accuracy	Graduated cylinder Vinyl tube Camera Tape measurer	N/A

Testing Summary

Table 2: Test Summary Table

Experiment	Relevant DR	Testing Equipment Needed	Other Resources
EXP 5- Ambient Open Test (Flagstaff)	CR4: Accurately Measure RH% CR5: Natural Convection CR7: Accurately Measure Water ER1: Data Collection ER5: Scalability of Rayleigh ER7: Scientific principals	Apparatus Arduino/Breadboard/sensors Siphon/Scale SD Card Desiccants	Good weather conditions
EXP 6- Ideal Scaled Conditions (Flagstaff)	CR1: Air Temperature Control CR2&3: Accurately Control H20 Temp and RH% CR4: Accurately Measure RH% and Temp CR5: Natural Convection CR7: Accurately Measure Water Loss ER1: Data Collection ER5: Scalability of Rayleigh ER6: Practicality ER7: Scientific principals	Apparatus Arduino/Breadboard/sensors Siphon/Scale SD Card Water tank heater Desiccants	Air temperature outside 45F Low humidity outside
EXP 7- Ambient Open Test (Phoenix)	CR4: Accurately Measure RH% CR5: Natural Convection CR7: Accurately Measure Water ER1&2: Data Collection ER5: Scalability of Rayleigh ER7: Scientific principals	Apparatus Arduino/Breadboard/sensors Siphon/Scale SD Card Desiccants	Good weather conditions

Load Cell Test

Figure 1: Load Cell with 3D Printed Mount

Test Summary:
- Will load cells be accurate?
- Equipment entails mount, load cells, 50g weight, and Arduino
- Weight variable is Isolated
- Goal is useable data to the thousandths decimal (ER1 & ER2)

Procedure:
- Upload code, tare load cell without weight, place known weight, confirm weight

Results:
- **Mean absolute error of ± .035 from 255 data points**
- **More error than we'd like**

Initial Humidity Test

Figure 2: Desiccant Packets in Apparatus

Figure 3: Dehumidifier

- Weight before use: 3.79 lbs
- Weight after use: 4.80 lbs

Question: How well can we control Humidity
Test: Ran three humidity control trials (1) operating a dehumidifier alone, (2) placing desiccant packets in the test area, and (3) running both simultaneously. Humidity sensors recorded the rate of moisture removal and the stability of each method.

Results

- With the roof on, overall humidity rose too high for any method to be effective.
- Dehumidifier: Provided a small reduction, but nowhere near enough to offset moisture buildup.
- Desiccant packets: Showed almost no noticeable impact on humidity levels.
- Combined setup: Still couldn't overcome the trapped humidity environment.

Demonstrated whether the apparatus could actively control RH%, which directly connects to customer requirements CR1–CR3.

Siphon Testing

Figure 4: Siphon

How accurate is the siphon?
Test: connected siphon for water transfer between tank and a graduated cylinder

Results:

- Siphon successfully transferred water from the main tank to the scale container having similar water levels
- Mass readings: Scale captured small, rapid changes in water level with good consistency.

Importance:
Verified whether the siphon method could capture tiny evaporation losses in a measurable way and Evaluates a big requirements: *precision of data collection* (ER1).

Temperature Testing (Water)

Figure 5: Hot Tube Heater 1

Figure 6: Hot Tube Heater 2

Test: Maintain a controlled water temperature with a hot-tub heater and track sensor readings to evaluate how quickly the system heats and how steady it stays.

- Filled the tank with a fixed water volume.
- Placed the hot-tub heater into the water and set the target temperature.
- Monitored heating rate with thermocouples and tracked how well the system maintained the set temperature.

Results:

- Water eventually reached the desired temperature but took 5-7 hours to heat up to 90°F.
- Once at temperature, the system stayed close to the setpoint, but small fluctuations still occurred.
- Effective for maintaining temperature, but not ideal for quick adjustments or rapid heating.

This determines whether the apparatus can maintain controlled water temperatures (CR2)

Temperature Testing (Air)

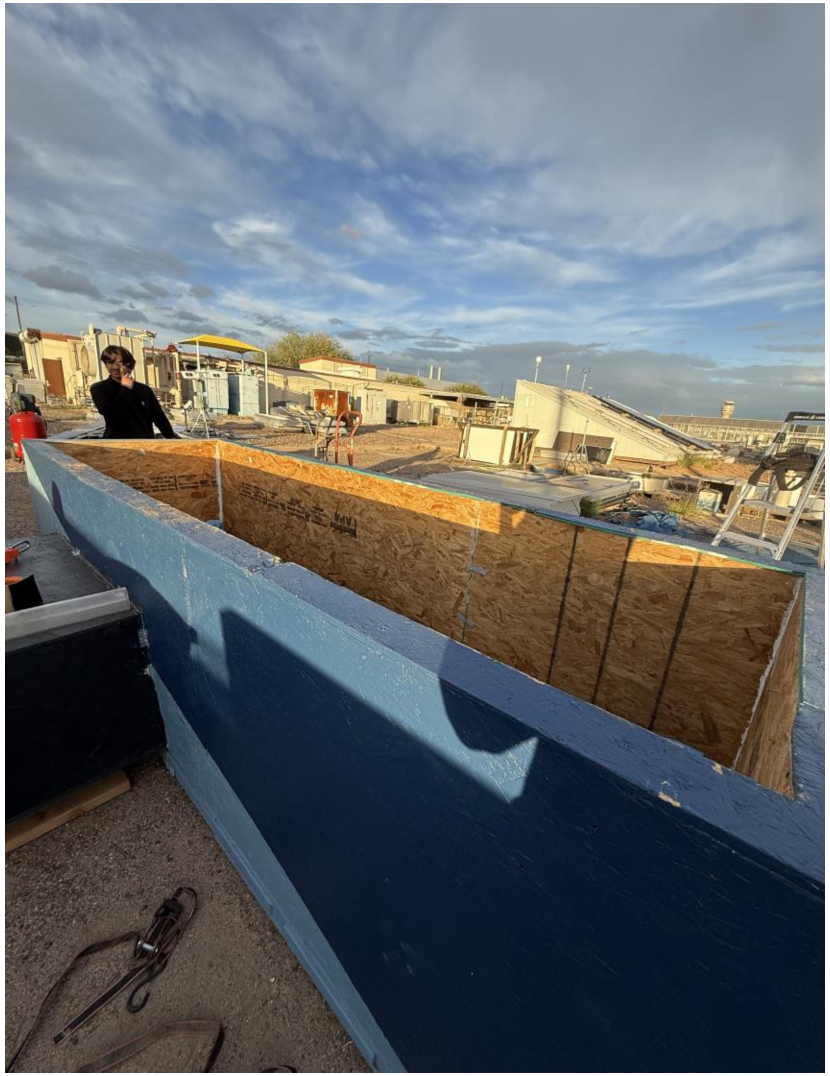

Figure 7: Apparatus Open Roof

Test: Used outdoor air to naturally warm or cool the inside atmosphere

- Exposed the apparatus to outdoor air with no active heating or cooling.
- Placed sensors inside to record how the internal air temperature responded to natural wind, sunlight, and ambient conditions.

Results:
- Temperature changes were slow and heavily dependent on outdoor conditions.
- We timed certain tests to match known weather patterns (cool mornings, warm afternoons, cool nights) to get clearer temperature trends.
- Difficult to repeat results because outside conditions constantly changed.

Importance:
Shows limitations when external temperatures aren't controllable

Specification Sheet

Table 3: CR Summary Table

Customer Requirements	CR Met (✓ or X)	Client Acceptable (✓ or X)
CR1: Ability to control/maintain air temp	X	✓
CR2 - Ability to control/maintain water temp	✓	✓
CR3: Ability to control/maintain RH	X	✓
CR4: Ability to measure relative humidity	✓	✓
CR5: Ability to maintain convective flow regime	✓	✓
CR6: Project stays within budget	✓	✓
CR7: Maintain water tightness	✓	✓

Specification Sheet

Table 4: ER Summary Table

Engineering Requirements	Target	Tolerance	Calculated/ Measured	ER Met (✓ or X)	Client Acceptable (✓ or X)
ER1: Precision of data collection	0.58 inches/day	±0.15 inches/day	W.I.P.	-	✓
ER2: Accuracy of sensors	±.5°C, ±3%RH ±0.02g	±0.1°C, ±1RH ±0.01g	±.5°C, ±2%RH ±0.02g	✓	✓
ER3: Material durability and longevity	6 months(full test semester)	±0.5 months	>6months	✓	✓
ER4: Geometric similarity	100%	-10%	100% for 45ft by 9ft section	✓	✓
ER5: Similarity of Rayleigh number	2x10^8 - 3.5x10^8	±1x10^8	8%	X	✓
ER6: Economic feasibility and practical implementation	≥ $5,740	No Tolerance	$5,155	✓	✓
ER7: Adhere to scientific experimentation principles	≥ 90% of tests follow planned	±5%	50%	X	✓

QFD

Project: Captsone SRP QFD													
Date: 9/4/2025		(Between 1 and 5, lowest rating to highest rating)											
		(0=N/A) (3 = weak) (6 = moderate) (9 = strong)											
System QFD													
	Technical Requirements (0,3,9)								Competition (1-5)				
Customer Needs	**Customer Weights**	Precision of data collection	Accuaracy of sensors	Material Durability & Longevity	Geometric Similarity	Similarity of Rayleigh number	Economic Feasibility & Practicial Implementation	Adhere to scientific experimentation principles	*Casa Blanca Canal Solar Project*	*Project Nexus*	*Gujarat Canal Solar Project*		
Ability to control/maintain air temp.	9	9	9	3	6	9	6	9	1	1	1		
Ability control/maintain water surface temp.	9	9	9	3	6	9	6	9	1	1	1		
Ability control/maintain relative humidity	9	9	9	3	6	9	6	9	1	1	1		
Ability to measure relative humidity	9	9	9	0	6	9	3	9	2	2	1		
Ability to maintain convective flow regime	9	6	9	3	9	9	9	9	1	1	1		
Project stays within budget	9	0	3	6	0	6	9	0	3	3	3		
Maintain water tightness	9	9	0	9	3	0	6	3	5	5	5		
Technical Requirement Units		in/day	°C, RH%	Years	N/A	N/A	$	N/A					
Technical Requirement Targets		0.58 in/day	±1 °C, ±3% RH, ±0.02g	6 months	100%	3.18*10^8	$5,740	90%					
Absolute Technical Importance		51	48	27	36	51	36	48					
Relative Technical Importance		1st	3rd	7th	5th	2nd	6th	4th					

Figure 8: QFD

Thank You!