NAU NORTHERN ARIZONA UNIVERSITY
Mechanical Engineering

ME486C-01
Vertical Farming

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Subject: ERs and TPs Revamp Memo"

The purpose of this memo is to communicate changes made to our engineering requirements. It is now required that the design is built using less money than originally planned. To meet this new requirement, we adjusted our design by utilizing wood for structural support instead of Unistrut. This design change will save several hundred dollars in expenses. The amount of grow troughs in the design has also been reduced to save money. A major engineering requirement change has been in our nutrient monitoring system. The original plan for monitoring macronutrients was that they would be monitored in real time and adjusted when necessary. However, such systems have economic and technical limitations. High precision instrument analysis is relatively expensive, and the durability and stability of ion sensors are still in the research stage. Currently it is very difficult to use the real-time measurement system for a single nutrient in the field. Therefore we, with limited budget and time, will focus on maintaining correct PH, electrical conductivity, and oxygen levels.

1 Customer Requirements (CRs)

Table 1: Customer requirements and Target engineering requirements.

Customer Requirements	Target Engineering Requirements
Sufficient lighting	200 PPFD
Maintain proper nutrient solution basicity	6.8 - 7.2 PH
Maintain water temperature	68°F-74°F
Support fish tank weight	Support 1300 lbs
Adequate flow rate	28 GPH
Minimal electrical operating cost	$60 per month
Small footprint	8 ft^2
Quiet	55 Decibels
Monitor flow rate	Alert @ flow rate < 5 GPH

2 Engineering Requirements (ERs)

2.1 ER #1: Electrical conductivity

2.1.1 ER #1: Electrical conductivity Target = .7.5 mS/cm [8]

The optimal nutrient solution electrical conductivity value for nutrient flow technique (NFT) found by the university of the Virgin Island is .7-.8 mS/cm

2.1.2 ER #1: Electrical conductivity Tolerance = +/-1

2.2 ER #2:Oxygen level

2.2.1 ER #2: Oxygen level - Target = 5ppm

Dissolved oxygen (DO) is critical to the beneficial nitrifying bacteria that convert fish waste into nutrients plants can use. To maintain good health and maximum growth, the DO level is dependent on the species of fish. In aquaponics systems, DO levels be maintained at 5 ppm or higher which is good to most of species.

2.2.2 ER #2: Oxygen level - Tolerance = 1.5ppm

The change of do level will not bring too much impact on the system, so the tolerance of do can be increased appropriately. Because Warmwater fish (e.g., bass, bluegill, and catfish) require about 5 ppm and coldwater fish (e.g., trout) require about 6.5 ppm of DO to maintain good health and maximum growth, the tolerance for DO is 1.5ppm.

2.3 ER #3 Photosynthetic photon flux density

2.3.1 ER #3: Photosynthetic photon flux density - Target = 200 PPFD

The lighting used in the design will be photosynthetic active radiation (PAR). PAR is light with wavelengths in the range of 400nm to 700nm.

2.3.2 ER #3: Photosynthetic photon flux density - Tolerance = +100mol m-2s−1

The metric used to quantify PAR is photosynthetic photon flux density (PPFD). The leafy greens we plan on growing require a PPFD of 200 [5].

2.4 ER #4 Power of hydrogen

2.4.1 ER #4: Power of hydrogen - Target = 7 PH

The concentration of hydrogen ions in the nutrient solution will be checked using the PH scale in order to satisfy the basicity requirements. The target PH is 7

2.4.2 ER #4: Power of hydrogen - Tolerance = +/- 2 PH

The upper limit upper limit of 7.2 and a lower limit of 6.8. This rage of PH levels will accommodate the three main living components of the system: fish, plants, and nitrifying bacteria [1].

2.5 ER #5 Water temperature

2.5.1 ER #5: Water temperature - Target = 71 ° Fahrenheit

The preferred temperature is 71°F.. Plant root zone optimal temperature is 71.6°F, temperature range for bacteria growth and productivity is 62.6°F- 93.2°F, and the tropical fish considered thrive at temperatures between 71.6°F - 89.6°F [2]. A water temperature of 71.6°F will satisfy these requirements. The fist tank will need to be cleaned regular to prevent the grow of bacteria.

2.5.2 ER #5: Water temperature - Tolerance = +/- 3°

Water will be kept at temperatures between 68°F 74°F

2.6 ER #6 Fish tank weight

2.6.1 ER #6: Fish tank weight - Target = 1300 pounds

The aquaponics system will house a 2ftx4ft fish tank. Calculations indicate that the water alone will weigh as much as 1260 lbs. To meet the fish tank support requirement the team will set the load carrying capacity target at 1300 lbs. This amount takes into account the weight of the tank itself and the weight of 90 gallons of water.

2.6.2 ER #6: Fish tank weight - Tolerance = +/- 25 pound

The upper limit is 1325 pounds and the lower limit is 1275 lbs.

2.7 ER #7 Volumetric flow rate cost

2.7.1 ER #7: Volumetric flow rate cost - Target = 5 gallons per hour

Studies have shown that leafy green plants grow well at flow rates near 5 gallons per hour [3]. This flow rate is also easily obtain by low cost pond and fountain pumps.

2.7.2 ER #7: Volumetric flow rate cost - Tolerance =5 gallons per hour

The volumetric flow rate should be maintained at 5 gallons per hour for optimal growth [3]. These target values will also be used to trigger the low flow rate alarm.

2.8 ER #8 Operation cost

2.8.1 ER #8: Operation cost - Target = $60

To meet the customer requirement of incurring minimal operating cost the target monthly operating cost has been set to $60

2.8.2 ER #8: Operation cost - Tolerance = +/- $5

The upper limit is $65 and a lower limit of $50.

2.9 ER #9 Footprint area

2.9.1 ER #9: Footprint area - Target = 8 sq. ft

A prominent customer requirement was requiring the least amount of space for operation. This requirement will be satisfied by targeting a footprint of 8 sq. ft

2.9.2 ER #9: Footprint area - Tolerance = +/- 4 sq ft

This size will make it possible to use the vertical farm in a variety of different places. The footprint upper limit is 12 sq. ft and the lower is 4 sq. ft. The maximum height has also been set to 8 because the average ceiling height in the U.S. is 8-9ft

2.10 ER #10 Operation noise

2.10.1 ER #10: Operation noise - Target = 50 Decibels

To meet the customer requirement of quiet operation the target operating noise has been set to 55 decibels (dB). This level was chosen because it is the same level has household appliances [4].

2.10.2 ER #10: Operation noise - Tolerance = +/- 5 Decibels

50 Decibels is the noise level of a large office. %0 decibels is also the noise level of refrigerator The noise level should be kept around this level so people at home or at work will not be disturbed by sound.

Table 2: Engineering requirements, targets, upper and lower limits.

Engineering requirement	Target value	Upper target limit	Lower target limit.
Electrical conductivity	.7-.8 mS/cm	1.5 mS/cm	.5 mS/cm
Oxygen level (ppm O2)	5 ppm O2	6.5 ppm O2	5 ppm O2
Photosynthetic photon flux density (mol m-2s−1)	200 PPFD	300 PPFD	200 PPFD
Power of hydrogen (PH)	7	7.2	6.8
Water temperature (° Fahrenheit)	71°	74°	68°
Fish tank support (pounds)	1300 lbs	1325 lbs	1275 lbs
Volumetric flow rate (gallons per hour)	5 gph	5 gph	5 gph
Monthly electrical operating cost (USD)	60 USD	65 USD	50 USD
Area (Sq ft)	8 sq. ft	12 sq. ft	4 sq. ft
Operation noise (Decibels)	50 dB	55 dB	45 dB
Monitor flow rate	28 gph	28 gph	28 gph

3 Testing Procedures (TPs)

3.1.1 1.1.1 Testing Procedure 1: Objective

To verify that each engineering requirement is met, various tests will take place after the assembly of the vertical design system. A simple test that will be accomplished is the operational check of the automated fish food dispenser. Since the feeding system can be set on a timer, a one-hour process to ensure the timing mechanism is functional and dependable.

3.1.2 1.1.2 Testing Procedure 1: Resources Required

Three feeding cycles will be set within the hour time frame. On a more extensive testing cycle is the electricity draw. To measure this area, the combination of a voltage meter and a plug-in wall energy consumption meter will be used across 24 hours. In addition to the power consumption analysis, lights will be measured periodically across 16 hours by a PAR meter. Flow rate will have to be tested and measured using a variation of the bucket-timer method. The bucket-timer method will be accomplished once after setup is complete with a continuous monitoring of the supply tank. Lastly, temperature will be monitored for one week through a combination of the in-tank thermometer and tank heater. The team will ensure each component is functional and adequately meets our engineering requirements. If the project budget does not fully cover the team design, components will be tested individually to verify its functionality for a home vertical farming system.

4 REFERENCES

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