

Pilot Plant Growth Room Standard Operating Procedures

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Warnings!

Workplace Practices

- Ensure you are following proper WHMIS safety procedures.
- Do not engage in risky behavior if working alone
- Keep the rooms clean and free of clutter and debris
- Ask for permission to enter a room if there is an active experiment
- If you see ambient CO₂ levels are at a dangerously high level >10,000 ppm, immediately evacuate
- Make sure to wear safety glasses when adjusting the CO₂ supply

Safety Information

- The first aid kit is in the growth chamber hallway on the left top shelf
- There are two fire extinguishers: one in the very back of the pilot plant next to the eyewash station, and the other next to the first aid kit
- The eyewash station is in the very back of the pilot plant. It drains into a bucket, which needs to be emptied periodically
- There is a safety shower in the bathroom
- There are cleaning supplies in the closet immediately to the right of the entrance

Electrical Safety

- Ensure all electrical connections are in no danger of being near water
- Use GFCI power strips between wall sockets and hardware when possible
- Avoid daisy chaining as much as possible
- Contact Dr. Lefsrud if you trip a wall circuit

Emergency Contacts

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Growth Room Checklist

- Did you empty all of the water buckets from the condenser?
- Did you empty the water bucket from the eyewash station?
- Is CO₂ flow still on for each canister?
- Are all your environmental parameters correct?
- Are there water leaks from the hydroponic trays, tubes, or reservoirs?
- Refill all your humidifiers and ensure they turn on
- Are the A/Cs functioning properly?

1 Background

The Pilot Plant has four growth chambers with the ability to control essential important environmental parameters for growing plants, including temperature, humidity, and CO₂ via the use of a dedicated TrolMaster environmental controller for each room. Custom watering and lighting schedules can also be set on a per room basis.

1.1 Purpose

The main purpose of this document is to provide future users information and background both on how the rooms are constructed and how to operate them to effectively run experiments.

2 Material List

The hardware used to equip the rooms is shown in Table 1. Three rooms use the HCS-1 model while one room uses the HCS-3 model. The number of humidifiers can be added to any room based on the needs of the experiment.

Item	Quantity	Purpose	Manufacturer
Hydro-X Model HCS-1	3	Master Controller	TrolMaster
Hydro-X Model HCS-3	1	Master Controller	TrolMaster
Hydro-X MBS-TH	4	3-in-1 Sensor	TrolMaster
Hydro-X MBS-S8	4	CO ₂ Sensor	TrolMaster
Hydro-X DSH-1	4	Humidity Device Connection	TrolMaster
Hydro-X DSC-1	4	CO ₂ Device Connection	TrolMaster
Hydro-X DSP-1	X	Lighting/Pump Scheduling	TrolMaster
Split A/C Unit	4	Temperature Control	ForestAir
Humidifier	X	Humidity Control	Lacidoll / Levoit / Yokekon
CO ₂ Regulator	4	CO ₂ Control	Vivosun
CO ₂ Canister	2	CO ₂ Supply	Linde Gas

Table 1: Growth Room Hardware

3 Hydro-X Setup and Operation

The HCS-1 and HCS-3 differ slightly, but the procedure to connect sensors and devices as well as set your desired parameters are the same and can be found on the product manuals.

A single device or a power strip can be connected to any given device station. Consult the maximum current the device station can handle, or ensure that the power strip has ground fault circuit interrupters (GCFI) protection to ensure the circuit will trip automatically.

Figure 1 shows the wiring diagram for connecting sensors and device stations. Currently, each room is only equipped with a CO₂ sensor and a 3-in-1 sensor for temperature, humidity, and lighting. More than one type of the same sensor can be connected to the system, and their readings will be averaged, although there is a possibility that this can cause unstable readings.

Certain environmental controls are only on during the day period, such as CO₂, and therefore the lighting sensor simply senses the present of light.

Link to the manuals for the [HCS-1](#) and [HCS-3](#)

3.1 Exporting Data

Exporting data is done through a standard micro SD slot on each controller. The HCS-1 model has no internal storage; therefore, before the start of a trial, the SD card needs to already be inserted for the controller to log data. A new log file is created on the 1st and the 30th of every month, meaning data will need to be combined if these dates fall between a trial.

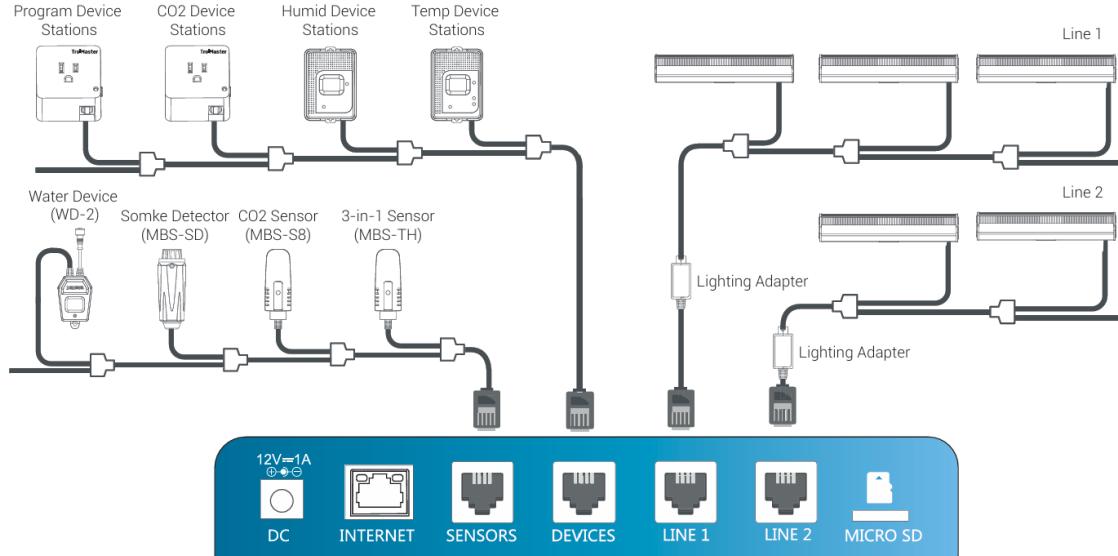


Figure 1: Sample wiring diagram from Hydro-X Manual

The HCS-3 model has internal storage, so at the end of a trial an SD card can be inserted and the environmental variables from a specific range of dates can be exported using the export function on the controller.

A link to a Github page for plotting the environmental data is linked here, with details on how to setup the file for plotting as the exported files from the HCS-1 and HCS-3 model are slightly different:

3.2 System Performance

System performance is reasonable overall, and humidity can be maintained at a stable level as high as 90%. CO₂ can be held at 1200 ppm minimum and potentially higher, but heightened levels over long periods of time can potentially be dangerous for humans. Figure 2 shows system performance for the three major environmental parameters from a trial conducted from November to December 2024.

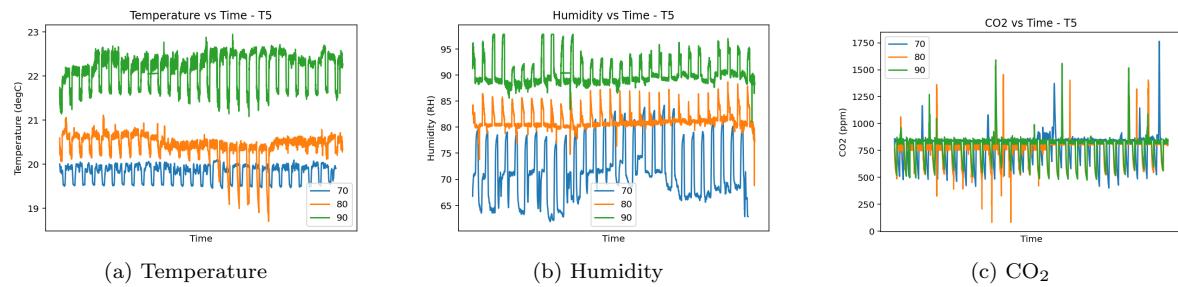


Figure 2: System performance over 30 days (November 2024–December 2024)

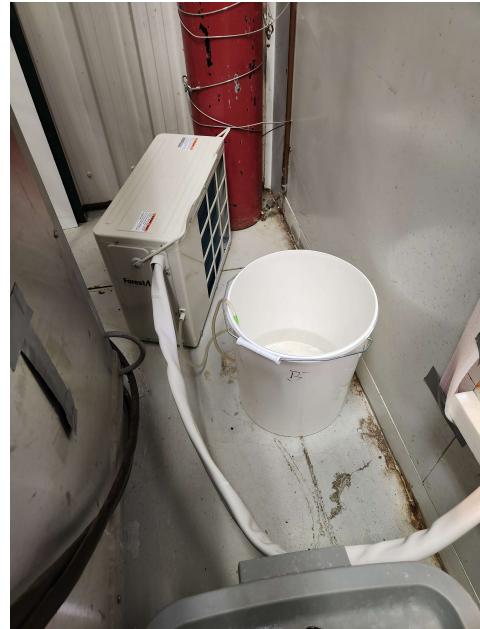
4 Environmental Control

4.1 Temperature

Temperature is controlled using a split air conditioner, which operates independently of the Hydro-X controllers. The inside unit is the compressor and the outside unit is the condenser. Both work in tandem to both cool and dehumidify the indoor space, and excess water that is condensed is drained from the outside unit into drainage buckets. These buckets need to be drained occasionally to prevent overfill, and the two buckets are shown in Figure 3.



(a) Drainage Bucket 1



(b) Drainage Bucket 2

Figure 3: Two drainage buckets from condensers

Note that the split-air units from ForestAir are notoriously unreliable and frequently fail for a myriad of reasons, either having reduced cooling efficiency or just no longer cooling at all. I've listed a few problems and their potential solutions here, but more often than not it is easier to just buy a new one and get a refund on the defective one. Attempts have been made to disassemble the system to diagnose the cause, but because of the hazards associated with coolant exposure this is not recommended. Below I've listed several possible issues and their potential causes and fixes. The manual can be found here for more details: [Link](#)

- *Issue:* Reduced Cooling Efficiency
 - *Solution 1:* There is freezing within the system due to some failure in flow or coolant. Drain the system following manufacturer instructions, then set it on ventilation mode for several hours to dry out the inside. Reassemble
 - *Solution 2:* The piping is tangled and therefore air is not being transported efficiently. Reconfigure the connection between the indoor and outdoor unit to ensure there is a smooth, untangled line
 - *Solution 3:* Filter needs to be cleaned. Remove and clean the filter with warm soapy water as per manufacturer's instructions.
- *Issue:* Rapid fluctuation in performance, going from high temperatures to low randomly
 - *Solution 1:* Turn it off for a few minutes, then turn it back on
 - *Solution 2:* Drain the system as per manufacturer instructions

- *Solution 3:* Remount the system such that there is a significant height difference between the indoor and outdoor unit (indoor should be higher)
 - *Solution 4:* Filter needs to be cleaned. Remove and clean the filter with warm soapy water as per manufacturer's instructions.
- *Issue:* No water draining from the condenser unit - indicates poor cooling efficiency
 - *Solution 1:* Clog or blockage in the system. Drain the system as per manufacturer instructions and untangle the connection line between indoor and outdoor unit. If not effective, most likely a malfunctioning pump and there's not much that can be done

4.2 Humidity

All humidifiers are controlled via the Hydro-X controller via the humidity device station. A power strip can be connected to this station, after which one or more humidifiers can be plugged in. Note that this only works with humidifiers that function in an on-off state, rather than a humidifier that has an independent controller. I have determined that in order to maintain humidity reliably for roughly 24 hours without refill, you will need two humidifiers for 70% , two humidifiers for 80%, and four humidifiers for 90% and above. Additional humidifiers can be added if available for further reliability.

Note for some humidifiers models, if you do not reinsert the water reservoir snugly, then it will not turn on and you will have to readjust the replacement of the reservoir.

Note that elevated humidity levels, especially at 90% and above can lead to mold growth.

4.3 CO₂

CO₂ is controlled using a CO₂ regulator connected to a CO₂ canister. The canister is delivered to Pilot Plant directly via Linde Gas, and you will need to contact Dr. Lefsrud if the supply ever runs out. The three rooms in the hallway all use one canister, while the fourth room next to the entrances has its dedicated canister. Each regulator has two tube connections: The first connects from the canister, while the second is routed to each room.

There are two CO₂ canisters: the first supplies the three rooms in the hallway and the second supplies the fridge growth room next to the entrance. The first canister has two valves to inform users the internal and outlet CO₂ pressure, indicating how much remaining CO₂ is in the canister and how much is being outputted respectively. Occasionally, there may be issues where CO₂ is not being supplied properly, in which case you will need to diagnose the regulators to ensure all the valves are open to allow for flow.



(a) Canister 1: Left dial is outlet pressure and right dial is internal pressure



(b) Canister 2: Single dial shows internal pressure

Figure 4: CO₂ Canisters

Make sure to wear safety glasses when working with adjusting the CO₂ supply!

In the case of potential leaks from the canister, fill a small squirt bottle with a little water and a lot of soap, then shake vigorously to form a very soapy solution. Squirt this on connection points and see if bubbles form to check for leaks. This should also be done periodically when the CO₂ cylinder is replaced to ensure no leaking post-installation. There is also an ambient CO₂ sensor with an electronic display (Figure 5) placed right outside the growth rooms. If the number reads dangerously high (>10,000 ppm) then evacuate immediately.



Figure 5: Ambient CO₂ Sensor

4.4 Lighting and Watering Schedule

Lighting schedule and watering schedule can be controlled using the program device stations, which function as generic timers that let you set an off schedule or a recycle schedule. Because LED fixtures tend to be the most power consumptive devices used in the growth rooms, it is recommended to connect a power strip that is equipped with GCFI to prevent damaging the system in case of a circuit trip.

5 General Notes

There are several power outlets outside each room that are used to power the hardware inside. The two outlets on the left side and right side are connected in series with each other, but otherwise are separate circuits. Avoid connecting high power consumption directly to these outlets, as tripping this circuit would require facilities to come and repair the connection, which could jeopardize your plant growth experiment.



Figure 6: Power outlets

Active monitoring of the rooms is essential for consistent environmental control. Ensure that you are checking in twice a day at minimum to ensure everything is functioning as it should.