MELiSSA

TECHNICAL NOTE

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Prototype Assembly Instructions

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1. Introduction

The information contained in this technical note outlines the secondary assembly procedures for the higher plant chamber at the University of Guelph. Primary assembly of the three main shell components was performed by Angstom Engineering at their facility, as well as at facilities of their subcontractors, in Cambridge, Ontario, Canada.

2. Proposal for Shell Shipment, Re-Assembly and Initial Verification at the CESRF

2.1. Shell Shipment to CESRF

Prior to shipment, Angstrom Engineering will separate the chamber into its three component modules (A, B, C). The air locks will remain mounted to modules A and C for shipment to Guelph and all the separated modules will remain on their rack supports. The air loft covers will be removed form their mounting. All connection plates are left in position as are the glass roof.

After dismounting/separation, the chamber will placed on wooden skids and wrapped with poly-film. Angstrom Engineering will then position, using a forklift, the chamber modules on a transport truck for shipment to the UoG CESRF. Transport time is expected to be ½ hour/

On the day of the prototype's arrival, UoG grounds personnel will move the prototype into the testing facility through the CESRF loading dock via fork-lift and will position the chamber in an assembly and testing space having clearance of not less than 1 m on all sides. The re-assembly and testing space will be the area of the growth facilities building immediately in front of the CESRF's SEC-2 Chambers. This area is under 24 hour security video surveillance and has appropriate power and water supplies necessary for prototype function.

Once in its re-assembly and testing position, the following shell re-assembly procedures will be undertaken, followed by shell verification.

After verification of the shell, delivery of associated final documentation by the sub-contractor is expected and final payment is released.

2.2. Shell Re-Assembly

The following procedures will be undertaken to re-assemble the prototype shell at the CESRF. The work will be performed under sub-contract by Angstrom Engineering with the assistance of the UoG CESRF staff. This procedure refers only to the re-assembly of components provided under sub-contract by Angstrom Engineering and qualified by the CESRF before shipment from Angstrom's Cambridge facilities to Guelph.

1. Upon arrival at the CESRF, the shell will be un-packaged, removed from the skids and examined for any shipping damage. Critical points for inspection include the integrity of the glass roofs, the side window, the air lock windows, gloves, interior air lock doors, the pressure compensation bags, the rotary feed-through shaft and the lamp reflector mounting plates of the lamp loft covers.
2. Once in its floor position and cleared of any shipping damages, the two end modules (A and C) of the chamber growing volume will be connected to the centre module (B). Visual inspection of the bolts and the sealing gasket will follow. The chamber modules will be free wheeling to allow for easy connection. It is expected that 4 individuals will be required to move the chamber modules on their wheels into position before connect. Once in position the chamber's extendable "feet" will be positioned to secure the assembled shell in place.
3. The two end air locks will be mounted on each of the end growing modules. Visual inspection of the bolts and the sealing gasket will follow to ensure a proper seal.
4. The lamp loft covers are then mounted on the main chamber growing volume. Lifting of the lamp covers will be done by the 4 shell assembly technicians. Inspection will ensure the loft covers are mounted securely and functional. The lamp and reflectors are not mounted at this point (see sub-system install below), although their proper fit was confirmed during the initial qualifying tests conducted by UoG at Angstrom.
5. The sensor connector/interface plates, which will have been mounted on the chamber shell prior to shipment will be visually inspected for any breaches in seal. All connections mounted on the plate are to be checked for secure fit and proper mount before conducting the shell integrity leak tests.
6. Once the chamber exterior shell is assembled, a final visual inspection will be completed to detect any breaches in seal.
7. Upon verification of no breaches in the exterior shell, the rail system for the hydroponics trays will be installed. Following rail install, the hydroponics drip capture trough will be installed. The rail system will be tested for smooth and easy movement using the 30 hydroponics growing trays filled with ballast representative of a chamber filled with crops and saturated Rockwool. The weight of ballast added for the test is reported in the chamber test results document.
8. Functional testing of the air lock's glove box and interior air-lock door follows. This test is to ensure that an operator can open and close the interior door with modest to minimal effort.
9. The air handling unit components will be checked for any displacement from their mountings during shipment. This includes the main centrifugal fan, the chilled water coil, the hot water coil and the rotary feed through shaft.
10. An inspection will also ensure that the connection between the blower shaft and the rotary feed-through shaft is sound.

2.3. Chamber Shell Integrity Leak Test

Following re-assembly of the shell at CESRF a passive $_{CO2}$ leakage test will be conducted to ensure proper connection and sealing of the shell modules and secure fits on the interface mountings and connection plates. The procedure outlined below is identical to that employed at Angstrom Engineering's facilities by UoG CESRF staff to qualify the shell before shipment to CESRF.

2.3.1. Equipment Required

1. Infra-red Gas Analyzer for $_{CO2}$, 0 – 3000 ppm range, on-board gas sampling pump with pressure compensation, 4-20mA output signal
2. C Size $_{CO2}$ tank (industrial grade) with regulator for supply to chamber
3. Mounted gas sampling port on the interface plate of the air handling unit . Gas sampling tubing is extended from the interior port to the volumetric centre of the chamber
4. Mounted gas sample return port on the interface plate of the air handling unit
5. Mounted bulkhead on the air handling unit interface plate for chamber $_{CO2}$ injection
6. Teflon tubing
7. Data logger (CR7)

2.3.2.Chamber Leak Test Readiness

1. The infra-red gas analyzer's (IRGA) sampling in port is connected, through Teflon tubing, to the $_{CO2}$ sampling port on the shell interface plate of the air handling unit. Tubing is extended to the volumetric centre of the chamber through the air handling unit duct work. The output signal of the analyzer is connected to the portable data logger set initially to 1 second sampling resolution. The sample out port of the IRGA is connected to the sample return port at the air handling unit interface plate, thereby closing a the sampling loop.
2. The $_{CO2}$ tank regulator is connected, through Teflon tubing, to the $_{CO2}$ injection port of the air handling unit interface plate. $_{CO2}$ supply on the regulator and tank is closed.
3. Two high powered fans are positioned within the chamber. One fan is facing the opposite air-lock and the second is positioned to blow air into the chamber's air return plenum. Turbulent air flow is confirmed. In the aforementioned leak tests, the chiller and hot water coils are mounted into position but not brought to operational readiness. The operational leakage test is run subsequent to these procedures to assess chamber shell integrity under operational temperature , air flow and humidity regimes.

4. Both interior air lock doors are left open (un-zipped). Both exterior air lock doors are closed and sealed
5. The IRGA is powered and the analyzer's reading of ambient CO_2 levels is confirmed.
6. It is confirmed that no obstruction to the chamber's temporary exhaust ports exist. These open sensor ports positioned on the interface plates are meant to prevent chamber over-pressure during CO_2 injection.
7. The regulator for CO2 supply is eased open to start air flow (maximum 50 psi)
8. IRGA readings are monitored and CO2 injection is closed at the regulator when the gas sample drawn from the chamber interior reads 1000 ± 100 ppm CO2.
9. The vent ports positioned on each module's interface plate are sealed
10. The CO2 supply remains closed during a period of 10 minutes for equilibration and interior air mixing by the fan
11. IRGA readings from samples drawn from the interior are logged during the equilibration and air mixing phases to provide information to be analyzed for preliminary assessments of CO2 mixing rates.
12. After the mixing period, the CO2 sample reading from the centre module is noted.
    a. If the CO2 reading is outside of low end tolerance (1000 - 100 ppm) the following occurs, iteratively;
        i. the temporary exhausts on each of the module's interface plates are opened and visual inspection confirms no obstruction
        ii. steps 6 through 12 are repeated but the equilibration time of step 10 may be shortened or lengthened depending on observed chamber mixing rates
    b. If the CO2 reading is outside of high end tolerance (1000 + 100 ppm)
        i. One of the exterior air lock door is opened to speed venting of the chamber. After venting and noted drops in CO2 readings to within tolerance, the air lock door is again closed and sealed
13. Once the CO2 concentrations within interior are within tolerance and stable, through iterations of steps 6-12, the gas supply tank and regulator are closed, disconnected from the chamber and the CO2 inlet line is sealed.
14. Visual inspect to ensure that there are no breaches in chamber shell seal, especially at open vent locations (step 9)

2.3.3.Passive CO2 decay

With CO2 levels within limits and the portable data logger set to 5 minute sampling intervals, the CO2 concentration in the chamber is allowed to passively decay (through any unknown shell leakage points) over a period of 48 hrs, or until the observed concentrations are less than 900 ppm, which ever comes first. Leakage rate is calculated from the slope of the 2nd order CO_2 concentration vs time decay profile at a concentration of 1000 ppm. Leakage rate is reported as a percentage of initial concentration (t=0) and assessed against the ESA specification.

If the shell integrity test indicates compliance with UoG requirements, sub-system integration begins and the operational leakage test follows.

3. Proposal for Sub-System Integration

3.1. Sensor Install

The procedures for sensor install are described in their respective sub-system assembly procedures. Sensor and hardware install are expected to be completed simultaneously using three staff.

3.2. Air Lock Subsystem Install

3.2.1.Equipment required for Air Lock A Sub-System Install

Lock A Purge In Solenoid Valve
Lock A Purge Vent Solenoid Valve
Lock A Pressure Sensor (P-A401)
Lock A Purge In Override Manual Ball Valve
Lock A Pressure Switch (P-Switch A)
(Air) Lock Passive Vent A
Door A Contact (Sensor) Upper
Door A Contact (Sensor) Lower
Door Open LED - A
Calibrated Air Tank (1000 ppm CO_2, 21% O_2, Balance Nitrogen)
Male-to-Male NPT to compression unions for solenoid valves (2 each solenoid, 4 total)
Male-to-Male NPT to compression union for manual ball valve (2 total)
Bulkhead Unions with viton o-rings for interface plates (2 total)
Stainless Plumbing (1.5 m total)
Teflon tubing (for temporary connection of calibrated air tank to Purge In Solenoid, 2m)
8-Pin sensor interface connector (2 total)
Wiring

3.2.2. Pre-Assembly Part Qualification and Testing

Prior to assembly, the following functional tests will be conducted on the functional parts of the air lock.

1. Functioning of all solenoids is confirmed by powering and providing a signal to the solenoids and confirming opening
2. The manual ball valve will be inspected for any obstruction

3. All sensors, including the contact and pressure sensors will be tested and calibrated
4. Functioning of the passive vent fittings is confirmed

3.2.3. Steps required for Air Lock A Sub-System Install

Prior to install of the air lock's subsystems, it should have been confirmed (as in the steps for chamber shell assembly) that the air locks are mounted and connected to the end modules. The interior air lock door should be left opened and folded into the chamber interior. This will reduce the chance of damage due to equipment drop during sub-system assembly.

1. Each of the Male-to-Male NPT to compression unions are connected to the upper and lower female fittings of each of the Lock A Purge In and Lock A Purge Vent solenoids and to the Purge In Override Manual Ball Valve. Teflon taping of the threads may be used to tighten seal.
2. A 10 cm length of stainless tubing is cut. The tubing is used to connect the outlet side of the Lock A Purge In solenoid compression fitting to the inlet of the Ball Valve. The compression fittings are tightened.
3. A 10 cm length of stainless tubing is cut and one end bent 90 degrees at 5 cm in.
4. The assembled Solenoid, Ball Valve combination is connected to the horizontally oriented stainless tubing connection. The valve assembly is rested on the air lock roof.
5. The 5 cm vertical section of the stainless tubing and valve assembly is connected to one of the bulkhead unions for the interface plate. Seal of the o-ring seat is confirmed at the interface plate.
6. A 10 cm section of stainless tubing is connected to the air lock though the remaining bulkhead unions for the interface plate. One end of the tubing is connected to the compression fitting on the bulkhead, and the other end connected to the compression fitting on the Lock A Purge Vent solenoid. A small section of stainless tubing may be connected to the outlet side of Lock A Purge Vent to direct the outflow. In its temporary configuration, the Purge Vent valve and tubing assembly is left in the vertical orientation with the pressure switch installed.
7. Teflon tubing is connected to the Lock A Purge Vent solenoid and fitting assembly to the regulator of the calibrated air supply. The supply at the tank should remain off.
8. The Air Lock A Passive Vent valve is connected to the interface plate and sealed with a viton o-ring.
9. The contact sensors are mounted to the exterior door and the LED indicator lights is connected to the circuit. Proper functioning is confirmed
10. The air lock pressure sensor is positioned in the air lock interior and wired to the 8-pin connector.

11. The mounted pressure switch (dry contact) and pressure sensor are connected to the controller.

3.2.4. Equipment required for Air Lock C Sub-System Install

The equipment required for install of the Air-Lock B are identical to those described above for air lock A, but with the following addition'

3-Way ball valve directing flow to either the Purge In of Airlock A or the same of Airlock C.

3.2.5. Pre-Assembly Part Qualification and Testing

Prior to assembly, the same qualifying tests for equipment installed on airlock B are completed as for air lock A.

3.2.6. Steps required for Air Lock C Sub-System Install

The install of parts for airlock C is the same as was described above for airlock A.

At the CESRF a manual 3-way valve will be installed on the calibrated air tank to direct flow to either Airlock A or C during the purge operation. This configuration saves on the need for a second regulator and tank. Such provisions should be considered for the MPP.

3.3. Hydroponics Install

3.3.1. Equipment required for Hydroponics Sub-System Install

Compression t-fitting
Mounting rack for hydroponics stock tanks
* The assembled irrigation manifold is a water cascade system consisting of 2 nylon t-style fittings, and an elbow for each growing tray. Each delivery spout is assembled and connected to the main delivery line according to the following diagram.

3.3.2. Pre-Assembly Part Qualification and Testing for Hydroponics Sub-System

Prior to assembly, the following qualifying tests for equipment installed on the hydroponics system are performed;

1. All solenoids are tested for proper functioning by providing an external (ie: initially independent from the controller) power and signal supply. At the time of this functional test, all Male-to-Male fittings are connected to the solenoids to form the solenoid assembly.
2. Functioning of all manual ball valves is confirmed. At this time all male-to-male fittings are connected to the ball valves to form the ball valve assembly
3. The integrity of all fittings is confirmed prior to mount.
4. Before install, the functioning of all level sensors is confirmed by filling the stock and condensate tanks with solution at two levels (representing hi and low). The mounting level of the sensors will be selected so as to provide indication when levels rise above 90% of tank capacity (1.8 L of 2.0 L capacity) and 10% of capacity (0.2 L).
5. The integrity of the irrigation trays and irrigation drain tray is confirmed (breach in welds, leaks)
6. Operation of the pumps (irrigation and condensate) is confirmed with draw from external reservoirs for a minimum of a ten minutes pump run time.
7. The main irrigation flow sensor is tested and, if not done at the factory, calibrated
8. Functioning of the levels is confirmed and the pH and EC sensors calibrated

3.3.3. Steps required for Hydroponics System Install

Installation of Stock and Acid/Base Tanks and Delivery Assembly

Acid Tank (A203)
Base Tank (A204)
Stock A Tank (A205)
Stock B Tank (A206)
Hi and Low Level Sensor for Acid Tank
Hi and Low Level Sensor for Base Tank
Hi and Low Level Sensor for Stock A Tank
Hi and Low Level Sensor for Stock B Tank
Acid Inject Solenoid
Acid Manual Valve
Base Inject Solenoid
Base Manual Valve
Stock A Inject Solenoid
Stock A Manual Valve
Stock B Inject Solenoid
Stock B Manual Valve
Male-to-Male NPT to compression unions for solenoid valves (2 each solenoid, 10 total)
Male-to-Male NPT to compression union for manual ball valve (2 each valve, 10 total)
Bulkhead compression unions for tank drains (4 total)
Nylon Bulkhead Unions with viton o-rings for pressure equilibration lines (6 total)

Compression t-fittings for pressure equilibration lines
Bulkhead Unions with viton o-ring for pressure equilibration line to chamber interior
Teflon tubing (10 m)

1. Each of the stock (A and B), acid and base storage tanks are to be drilled to accommodate mounting of the bulkhead compression unions into their bottom. The bulkheads are mounted in the reservoirs so as to minimize protrusion into the reservoirs' bottom volume. Gravity draining of the entire stock tank volume needs to be promoted.
2. The lids of each of the stock, acid and base tanks are drilled to accommodate the bulkhead compression unions for the pressure equilibration lines. The bulkheads re then mounted and seal confirmed.
3. After functional verification (above) the high and low level sensors are mounted in each of the reservoirs and sealed
4. The solenoid assembly is mounted to the each of the tanks by connection of 5 cm lengths of Teflon tubing from the compression fitting of the tank bulkhead to the compression fitting of the solenoid assembly. The tank and mounted solenoid assembly are positioned on the mounting rack. If required, a section of stainless tubing may be used as a sleeve for the Teflon tubing to promote rigidity and block light.
5. The ball valve assembly for each tank is connected to the tank and solenoid assembly by compression fitting and a suitable length of Teflon tubing. Steel sleeves may also be used. The length of tubing required (specifying the distance between the solenoid and ball valve assemblies) is to be determined in accordance with the dimensions of the mounting rack and the spacing of the fittings mounted on the reservoir's interface plate.
6. The bulkhead unions for delivery of acid, base and stocks are mounted on the reservoir interface plate and connected to their respective ball valve assemblies using the compression fitting and Teflon tubing. Sleeves may also be used.
7. With each of the tanks assembled and connected to the reservoir interface plate, the remaining pressure equilibration lines are connected to the bulkheads positioned on the lids of each tank and, using the t-fittings, connected to the pressure equilibration bulkhead positioned on the man chamber growing volume interface plate.

Installation of Reservoir Cooling Coil Assembly

Nutrient Reservoir
Reservoir chiller line
Reservoir Chilled Water Inlet Solenoid
Reservoir Chiller Manual Override Valve

1. 3 m section of stainless or Teflon plumbing is coiled and positioned in the reservoir to create the reservoir chiller coil.
2. The inlet and outlets of the coil are connected with compression fitting to the bulkheads positioned on the reservoir.
3. A section of Teflon tubing is connected to the outlet fitting and connected to facility drain
4. A section of Teflon tubing is connected to the inlet fitting on the reservoir and connected to the ball valve assembly. The ball valve assembly is in turn connected to the reservoir chilled water solenoid and ultimately to the facility chilled water supply
5. A flow through loop for hydroponics system cooling is therefore established. A by-pass loop will be considered depending on the degree to which chilled water is needed in the reservoir during subsequent functional and operational testing of the chamber.

Installation Reservoir Assembly

Main Irrigation Pump
Irrigation Flow Sensor
Irrigation Manual Override Valve A
Irrigation Manual Override Valve B
Irrigation By-Pass Manual Shut-Off Valve
Nylon Bulkhead Unions with viton o-rings for reservoir interface plates (10 total)
Irrigation Trays

1. The main irrigation pump is mounted on the aluminium plate on the bottom of the chamber's carriage, adjacent to the outlet port of the reservoir.
2. Once mounted the main irrigation pump is connected with a section of polypropylene tubing to the irrigation feed bulkhead fitting on the reservoir to the pump's inlet compression fitting
3. The compression fitting on the outlet side of the main irrigation pump is connected with a section of polypropylene to a compression 3-way fitting
4. A 30 cm section of tubing is connected to one of open compression ports on the 3-way fitting. This section of tubing is then connected to the irrigation by-pass needle valve assembly. The outlet side of the needle valve assembly is connected to the mix return bulkhead on the reservoir
5. A 7 m length of tubing, forming the main irrigation line, is connected to the second open port on the 3-way fitting and run to the irrigation inlet bulkhead on the chamber interface plate located under module A. The irrigation line is trimmed to the desired length.
6. The irrigation drain assembly, which includes the irrigation drain manual override ball valve, is mounted on the interface plate positioned under module C. A section

of 5 cm diameter tubing is connected between the drain assembly and the interface plate on the reservoir.

Installation of Reservoir Sensors

Nutrient Reservoir Temperature Sensor
Nutrient Reservoir pH Sensor
Nutrient Reservoir EC Sensor
Irrigation Trays
8-Pin sensor interface connector
Wiring

1. The pH sensor is mounted with its bulkhead onto the interface plate of the reservoir to a depth of not more than that corresponding to 25% of the reservoir's volume capacity.
2. The EC sensor is mounted with its bulkhead onto the interface plate of the reservoir to a depth of not more than that corresponding to 25% of the reservoir's volume capacity.
3. The low level sensor for the reservoir is mounted at a depth corresponding to 25% of the reservoir's volume capacity.
4. The high level sensor for the reservoir is mounted at a depth corresponding to 75% of the reservoir's volume capacity.

Installation of Condensate Collection Assembly

Condensate Tank
Hi/Low Level Sensors for Condensate Tank
Condensate Pump

1. The condensate reservoir is positioned below the chamber and adjacent to the condensate return line bulkhead leading from the drip tray of the chilled water coil.
2. The condensate return compression fitting is connected to a bulkhead installed on the condensate reservoir.
3. The hi and low level condensate reservoir sensors are mounted at a depth corresponding to the height at 75% and 25% of the condensate reservoir's volume.
4. The condensate pump is mounted on the aluminium plate adjacent to the main irrigation pump
5. The condensate pump inlet is connected to the bulkhead positioned on the reservoir lid. The condensate pump outlet is connected to the condensate return bulkhead positioned on the main hydroponics reservoir

Installation of the Irrigation Manifold Assembly

Assembled Irrigation Manifold (C201)*
Irrigation Drain (C202)
Mounted rail system for tray conveyer

1. The main inlet line of the irrigation manifold assembly is connected to the irrigation inlet bulkhead positioned on the interface plate below Module A.
2. The irrigation manifold is positioned in the chamber and mounted in a level fashion so that the outlet spigots are positioned over each irrigation tray. The manifold spans the length of the chamber and does not move with the tray conveyer. Therefore, in mounting, care should be taken to ensure equitable spacing between outlet spigots of the manifold and the centre of the irrigation trays. 30 trays are accommodated within the chamber.

Connection of Sensors and Actuators to Intermediate Panel

1. Install of the hydroponics system is complete upon connection of all sensors and actuator wires to the intermediate panel – this includes control and common wires for all injection solenoids, output, power and common lines for sensors (EC, pH, level). Power for the condensate and main irrigation pump is connected to the facility supply and the control signal and common wires to the intermediate panel.

3.4. Air Handling Subsystem Install

3.4.1.Equipment required for Air Handling Sub-System Install

Main centrifugal fan
Rotary feed through shaft
Fan motor
Variable Frequency Drive
Pulley and belt for motor and fan connect
Chill Coil
Hot Coil
Chilled water valve assembly
Hot water valve assembly
Chill Coil temperature sensor
Hot water coil temperature sensor
Hot water supply line temperature sensor
Chill water supply temperature sensor
Hot water exit temperature sensor

Chill water exit temperature sensor
Growing volume temperature sensors (3 per module)
Growing volume humidity sensor (1 per module)

3.4.2.Pre-Assembly Part Qualification and Testing for the Air Handling Sub-System

1. All temperature and humidity sensor functioning are verified against a reference sensor before install
2. All valves and valve assembly functions are confirmed
3. Fluid leak testing of the hot and chilled water coils is performed using the installed supply lines
4.

3.4.3.Steps required for Air Handling Sub-System Install

1. Before shipment, the hot and chilled water coils were mounted and the main centrifugal fan is mounted into position and connected to the inside pole of the rotary feed through shaft
2. The chilled water supply line of the facility is connected to the chilled water valve assembly using a compression fitting. The outlet of the by-pass line is connected back to the main chilled water supply line
3. The hot water supply line of the facility is connected to the hot water valve assembly using a compression fitting. The outlet of the by-pass line is connected back to the main hot water supply line
4. The water supply lines sensors for booth inlet and exit (hot and cold) are mounted to the supply lines using a compression 3-way fitting
5. The motor is mounted on the aluminium plate resting below module C
6. The top pulley for the outside pole of the rotary feed-through shaft is mounted and connected to the pulley mounted on the motor. A belt is connected to the pulleys according to the manufacturer's (Delhi's) instructions
7. Power to the motor is connected and the VFD is connected to the intermediate panel box
8. Temperature and humidity sensors for the inside growing volume are mounted in position and connected, via 8-pin connectors mounted in the interface plate to the intermediate panel box
9. The coil temperature sensors are mounted on the surface of the hot and chilled water coils and connected to the intermediate panel box
10. Water return lines for the coils are connected to the facility's drain
11. The air flow sensor is mounted in the air flow plenum and connected to the intermediate box

3.5. Gas Sampling and Analysis Sub-System Install

3.5.1. Equipment required for Gas Sampling and Analysis Sub-System Install

Infrared Gas Analyzer for CO_2
Mass Flow Controller for CO_2 injection
Paramagnetic analyzer for O_2
CO_2 redundant valve

3.5.2. Pre-Assembly Part Qualification and Testing for the Gas Sampling and Analysis Sub-System

1. The infrared gas analyzer and paramagnetic analyzer are calibrated
2. Proper functioning of the mass flow controller is confirmed prior to install

3.5.3. Steps required for the Gas Sampling and Analysis Sub-System Install

1. The infrared gas analyzer sampling port is connected via compression fitting to the bulkhead on the interface plate positioned in the air handling unit box
2. The infrared gas analyzer exhaust (sample return) port is connected to the sample return bulkhead positioned on the interface plate positioned on the air handling unit box
3. A sample line is extended from the compression fitting of the interior side of the sampling bulkhead to the main growing volume of the chamber
4. The paramagnetic gas analyzer sampling port is connected via compression fitting to the bulkhead on the interface plate positioned in the air handling unit box
5. The paramagnetic gas analyzer exhaust (sample return) port is connected to the sample return bulkhead positioned on the interface plate positioned on the air handling unit box
6. A sample line is extended from the compression fitting of the interior side of the paramagnetic analyzer's sampling bulkhead to the main growing volume of the chamber
7. The signal output of each analyzer is connected directly to the controller
8. A section of stainless steel tubing is connected to the compression fitting on the CO_2 inlet bulkhead positioned on the interface plate which is mounted on the air handling unit box
9. The manual, redundant CO_2 valve is connected to the above line
10. A section of stainless steel tubing is used to connect the manual redundant CO_2 valve to the CO_2 mass flow controller
11. A pure CO_2 tank and regulator is connected to the mass flow controller using a section of stainless steel tubing

3.6. Lighting Sub-System Install

3.6.1. Equipment required for the Lighting Sub-System Install

6 x 600 W HPS lamps with remote ballasts
3 x 400 W MH lamps with remote ballasts
3 x PAR sensors (one per module)

3.6.2. Pre-Assembly Part Qualification and Testing for the Lighting Sub-System

1. The proper functioning of lights is tested after mounting in the air loft

3.6.3.Steps required for the Lighting Sub-System Install

1. Using the supplied clips, the reflector and lamp assembly of each lamp is connected to the mounting plate on the lamp loft covers. Each module consists of 2 x HPS and 1 MH.
2. The lamps are positioned so the point of peak intensity coincides with the horizontal centre of the growing volume
3. The power supplies for the lamps are connected, to the lamps though the feed-through glands on the air loft cover to the ballasts mounted adjacent to the chamber.
4. The power inlet supply to the ballasts is connected to the intermediate panel. If required, high power contactors intercept the power supply lines and the controller.
5. Each PAR sensor is mounted in the centre of the growing volume using threaded rods fastened to the steel support frames of the glass panels. The mounting height of each PAR sensor is adjusted to about 40 cm above the growing tray tops
6. The PAR sensor wires are connected, vi 8 pin connectors to the intermediate connection panel
7. Power supplies to the air loft fans (mounted prior to shipment) are connected to the intermediate panel and through relays/contactors to the controller.

3.7. Control System Install and Connection

During the assembly procedures described above, all sensors and actuators were wired to the intermediate electrical panel. Control system install involves the connection of each sensor and actuator wire to the control panel terminals. Data log is set and confirmed. No feedback control is established during the assembly phase (see functional testing).

3.8. Functional Test Preparation and Consumables List

This step aims to gather all consumables required for functional testing and may be included, instead in the test plan.

4. Proposal for Shell Shipment, Re-Assembly and Structural Integrity Verification at the MPP

The chamber will ship to the MPP in the same configuration as it arrived in the CESRF, with the exception that all interior mounted sensor wires will remain connected to the 8-pin interface connection and the intermediate electrical panel. This means that the procedures described above (with limited exception for permanently mounted sensors) will be required to be repeated on site at the MPP. This includes modification to accommodate connection to the MPP water and power supplies.

5. Estimated Time to Completion

It is estimated that the chamber assembly phase, embodied by those procedures described above will require 3 – 4 weeks (at both the CESRF and the MPP).