MELiSSA

TECHNICAL NOTE

Sub-Systems Technical Specifications

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1. Introduction

This document provides an overview of the sub-systems specifications for the prototype chamber. The bulk of the information is provided on companion CDs which provide an exhaustive part list and specifications (EXCEL database), CAD and PDF images of all part and sub-system CAD drawings and photographic images of all parts. Detailed specification sheets for parts not custom made are also provided.

The test in this document is provided to give a brief overview of the prototype sub-systems. The reader should consult the companion CDs for more detailed specifications.

CD -1: HPC Prototype Parts Specifications and Equipment Database

CD -2: HPC Prototype Sub-System and Part CAD Drawings

CD -3: HPC Prototype Sub-System and Part Photographic Images

CD -4: HPC Prototype Part Detailed Specifications Sheet

2. Overview of the Prototype and General Specifications

2.1. Prototype Dimensions

At the MELISSA general working meeting held 29/30 November 2001, it was decided, initially, that three crops be selected for production trials within the MPP. The selected species were wheat (*Triticum aestivum* L.), lettuce (*Lactuca sativa* L. cv. Grand Rapids) and beet (*Beta vulgaris* cv. Detroit Medium Red). These crops are representatives of plants with varying harvest index (edible biomass/total biomass, dwb) and mineral composition. As such, they each provide a unique challenge to the first compartment of the MELiSSA loop.

From empirical productivity values obtained from controlled environment trials of beet and lettuce (CESRF) it was determined that 15m^2 of crop production space (5 m^2 per chamber) would suffice in meeting the biomass production target based on a 20% of one-person-day diet (edible dwb basis).

The dimensions of the chamber are therefore determined as follows:

Table 2.1-1. HPC Prototype Dimensions

Dimension	Value

Total available production space	5 m^2
Chamber Length	6 m
Air lock length (each, including interior door)	0.50 m
Interior chamber/air-lock width	1 m
Exterior chamber width (maximum room access width)	1.651 m
Width of air handling envelope (total for both chamber sides)	0.10 m, 0.05 m each side
Chamber insulation width with aesthetic covering (each chamber side and trim)	0.20 m

According to the layout of the HPC prototype housing facility within the MPP, these dimensions would allow for a total end clearance of 12 – 6 m = 6 m (3 m either end, less benches and analytical system bay). The clearance on one side of the chamber may be seen in **Error! Reference source not found.**2.4-2. In the final proposed configuration, one long side of the chamber is exposed (to promote logistical tasks) and the other positioned against the facility wall or an adjacent HPC.

2.2. Materials

The materials used for construction of the chamber were selected so as to minimize off-gassing. They are also expected to be non-toxic to higher plants. A list of materials and their uses is shown below. This list applies to wetted parts on equipment not specifically mentioned below.

Table 2.2-1. HPC materials, (1) Pure phenolic thermosetting resinous coating, (2) Fluoroelastomer heat resistant.

Chamber Part	Materials
Walls, floors, valves, air plumbing	Stainless steel 316
Roof, windows	Tempered glass
Liquid reservoirs and tubing	Polypropylene (PP)
Heat exchanger, motor parts, oxidation barriers	"Heresite"(1)
O-rings, solenoid seats	"Viton"(2)

2.3. Logistics

The chamber is designed so as to promote efficient horticultural practice while allowing for change out of technologies should there be a desire for an upgrade. Additionally, an access door with window have been included on the side of the chamber to facilitate chamber cleaning, diseased plant removal and other logistical tasks. Contact surfaces for the doors are sealed with Viton gaskets. The end air locks of the chamber are also fitted with glove boxes allowing access into the air lock interior when its external doors are closed. The glove boxes are positioned on the air lock access door so that the operator may easily reach across the air lock length (0,5 m).

2.4. Basic HPC structure

The chamber has two access areas (air-locks) located at each of its ends. One is to be used in the seeding procedure and the other to be used in harvesting the mature plants. This configuration allows for a staged culture strategy and dampens the CO_2 sequestration dynamic associated with canopy development.

The hardware necessary for the operation of the chamber is situated below the growing area and air locks so as to improve space utilization efficiency in the area dedicated to the HPCs within the Pilot Plant facility.

The prototype chamber is divided into five areas (A100 – A500). These include the lighting loft (A100), the hydroponics sub-system area (A200), the air handling volume (A300), chamber access (air lock) areas (A400) and the crop growing volume (A500) .

Missing : the list of process functions that will be allocated to a subsystem or system component : please include it for better understanding

The prototype subsystems are defined as the;

- Air-lock sub-system
- Atmospheric Control Sub-System
- Gas Analysis and Control Sub-System
- Hydroponics Sub-System
- Lighting Sub-System

The diagrams below provide and overview and schematics of the chamber:

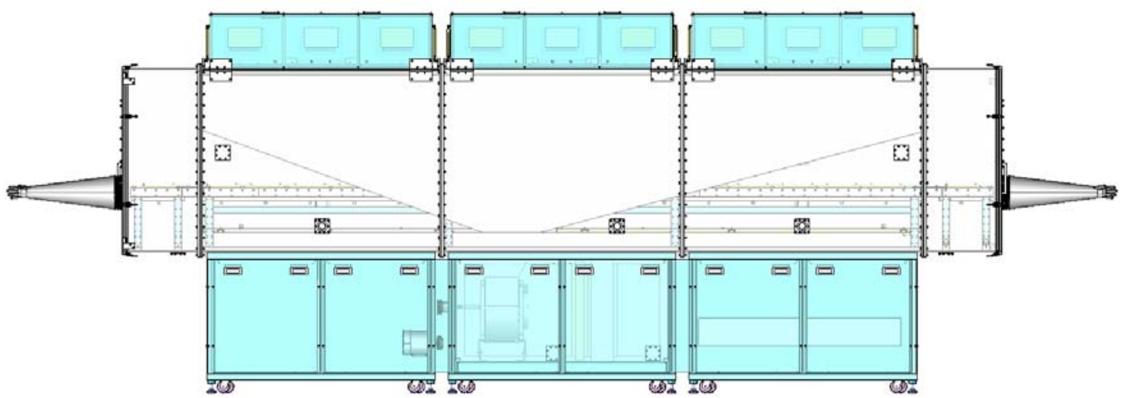
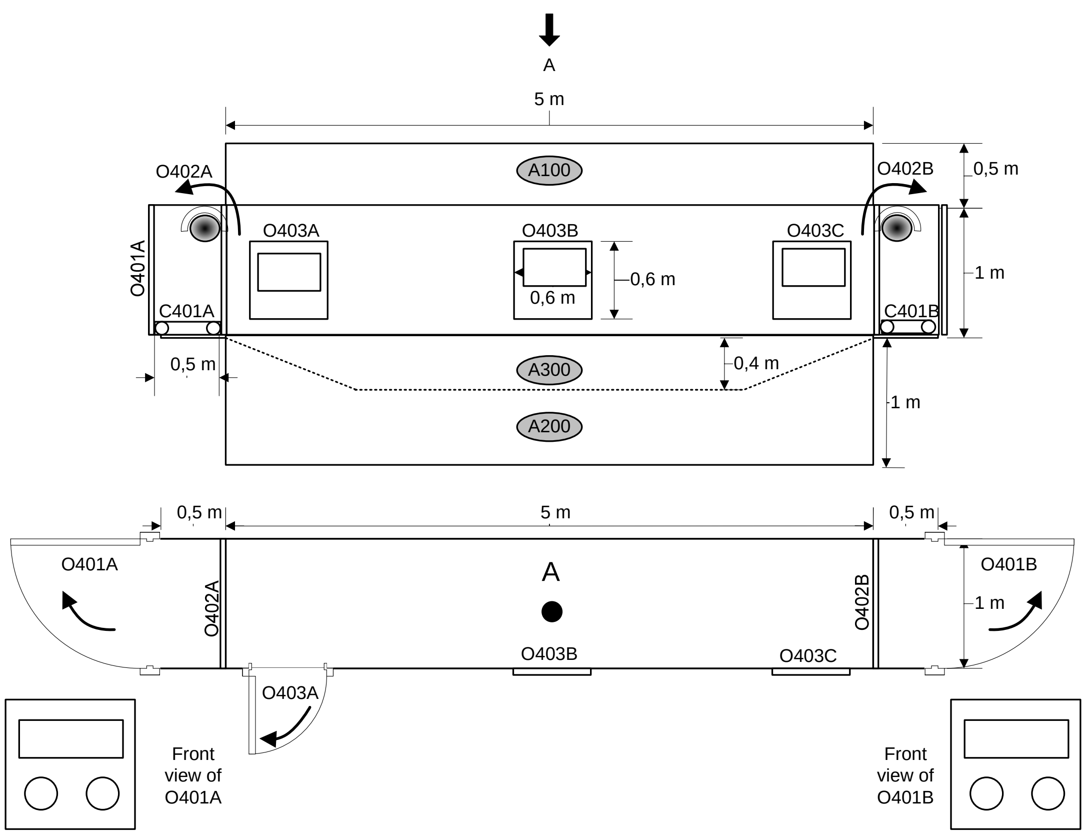


Figure 2.4-1. Schematic exterior view of the HPC prototype.



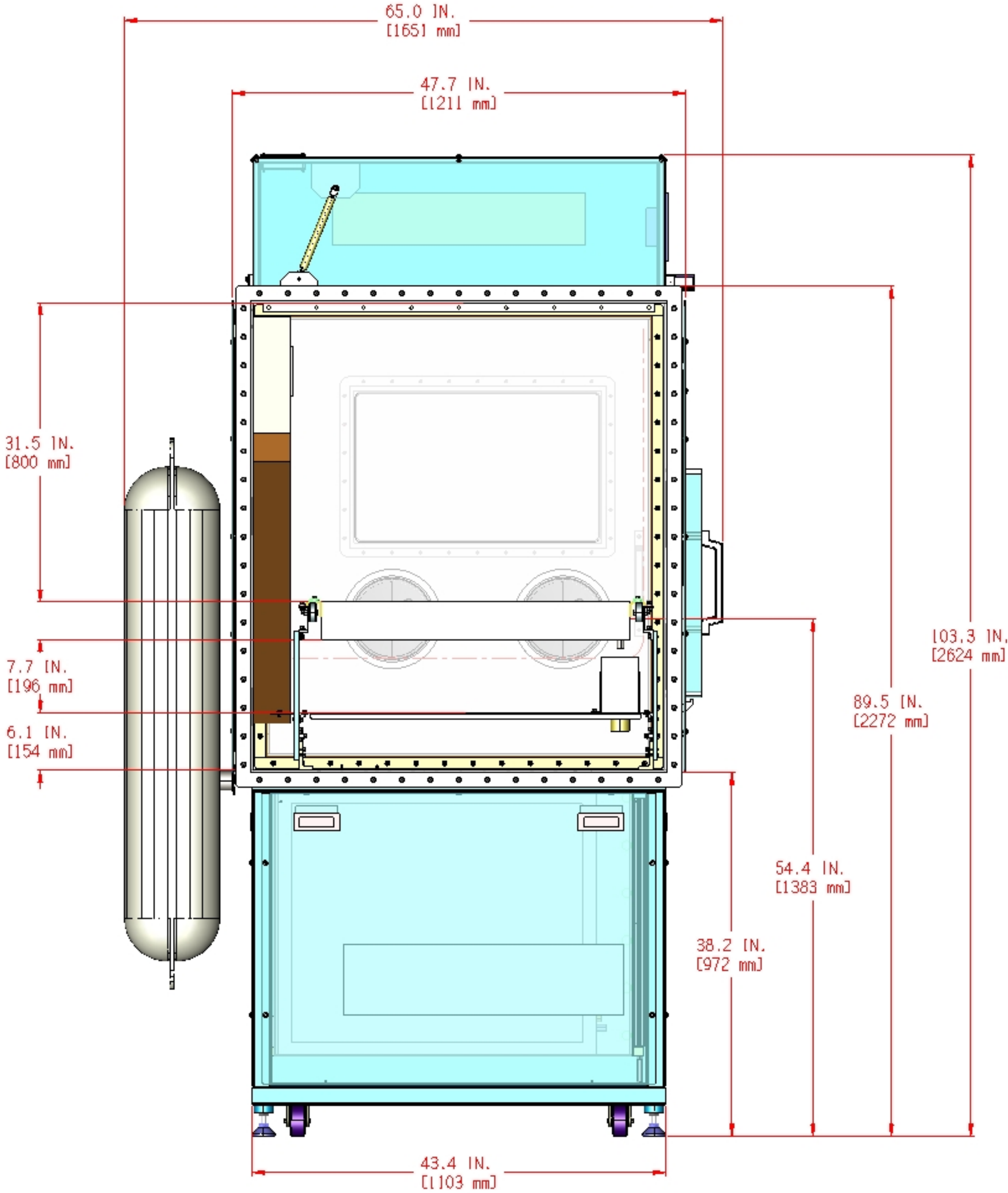


Figure 2.4-2. Dimensioned diagram of the HPC 1 Prototype.

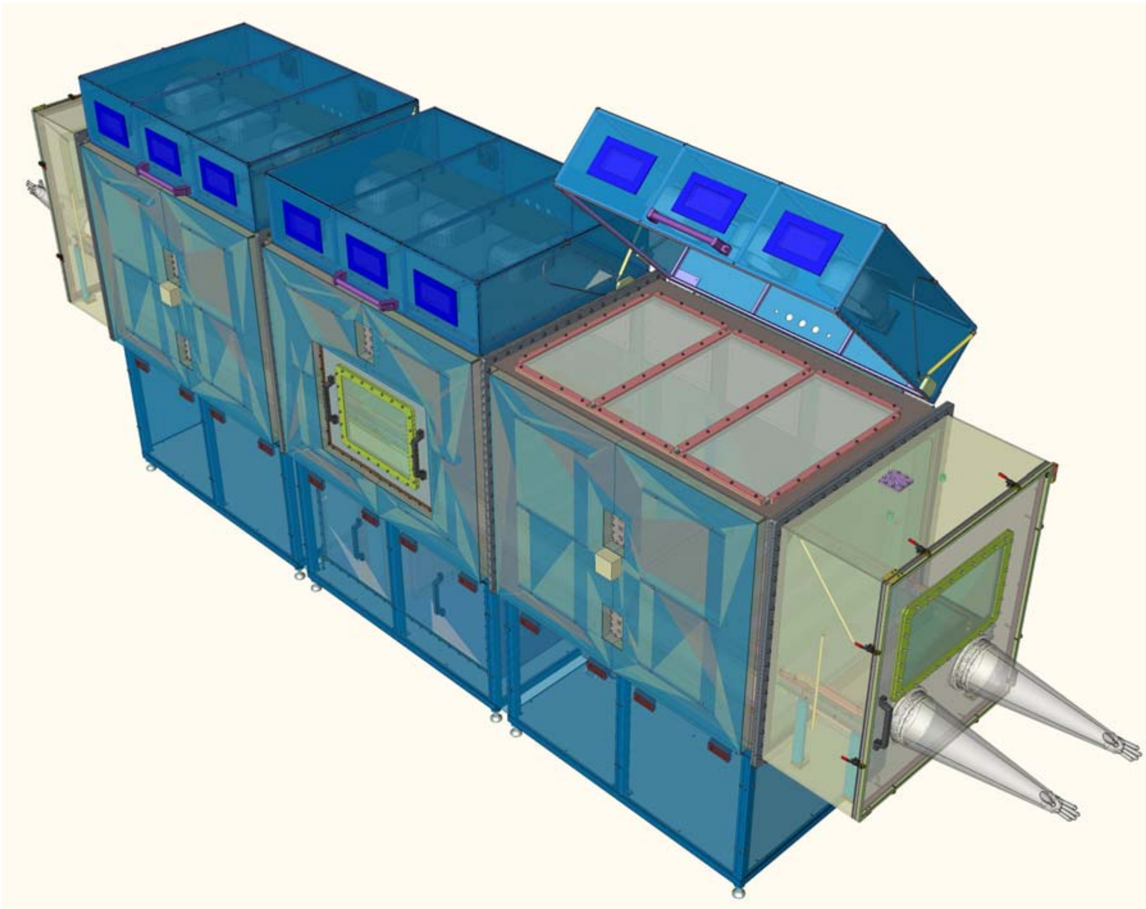


Figure 2.4-3. Exterior view diagram of the exterior of the higher plant chamber.

3. Functional Overview of the Prototype and Sub-System Diagrams

3.1. Air-Lock Sub-system

Access to the chamber growing area is gained through i) air-locks positioned at both chamber ends and ii) an access (exposed) on the chamber. The air locks are designed to reduce atmospheric leakage or cross contamination between the chamber interior and exterior during seeding and harvesting procedures. On the interior side of the air-lock there is a Teflon fabric door. The door is manually opened using a zipper. A diagrams of the air-locks is provided below.

During periodic cleaning of the HPC or to access the chamber interior in an emergency, the side panel may be opened. The access panel may be opened manually and will be fitted with gaskets and bolts/acorn nuts to ensure a seal against the exterior chamber wall when not in use. If chamber side panel is opened, the chamber will not remain sealed.

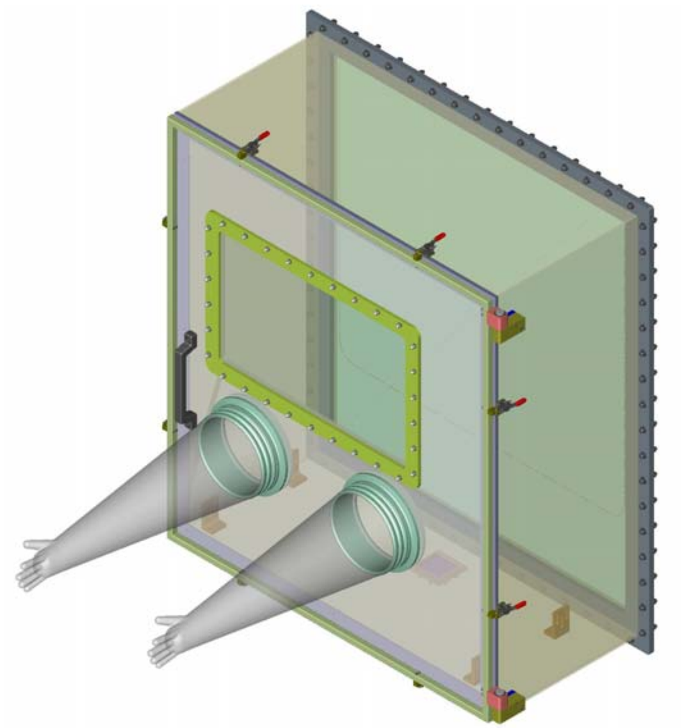


Figure 3.1-1. Exterior view of the prototype air lock. Shown are the gloves, window and latches.

3.2. Atmospheric Control Sub-System - Temperature, Humidity, Pressure and Composition

Air is conditioned for temperature and humidity and re-circulated inside the chamber. Externally supplied chilled water and hot water are to be circulated through sealed and "heresite" coated (baked oxidation barrier) heat (cold and hot) exchange coils mounted in an internal plenum at the base of the chamber. Condensate from the chilled water coil is to be collected on the condensate drip tray integrated into the chill water coil and is collected and measured in a condensate collection reservoir (20 L reservoir volume). The condensate water may then be pumped back into the hydroponics reservoir and/or to the crew compartment of the MELiSSA loop depending on demand.

A heresite coated main centrifugal blower is mounted in the plenum and distributes the air through a duct running the length and height of the back chamber wall and into the chamber growing interior from outlets mounted an the upper interior wall. Modulated hot water and chilled water proportional valves ensure temperature and dehumidification control of the aerial environment. The motor and variable frequency drive controller for the blower are positioned on the outside of the chamber and connected to the blower shaft using a rotary feedthough shaft.

The chamber is fitted with three 200 litre double sealed Teflon bags positioned on the side of the chamber. The Teflon bags serve as a passive approach to atmospheric pressure management in the chamber since they will expand or contract with variable atmospheric volume within the chamber growing interior as associated with programmed diurnal temperature fluctuations. The bags are connected to the chamber growing volume by means of custom designed fittings. The total temperature range influencing gas volume in the chamber represented by a single bag capacity of 200 L (nominally filled at 100L) is about ±6 degrees. Please recall required value to allow comparison.

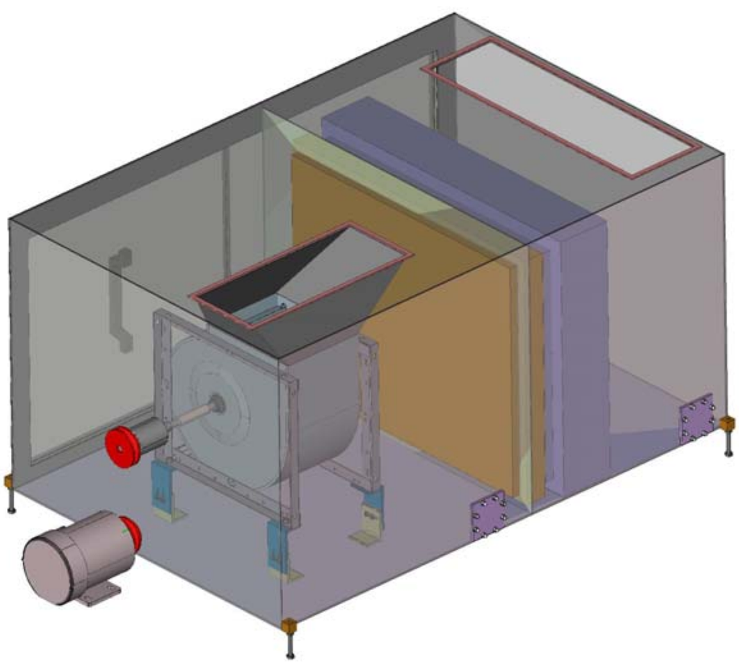


Figure 3.2-1. View of the air handling unit. Shown are the blower, hot and chilled water coils, the rotary fee-through shaft and the exterior mounted motor. The air intake is adjacent to the coils and the outlet is above the blower.

3.3. Gas Analysis Sub-System

The gas analysis sub-system primarily consists of an infra-red gas analyzer for CO2 and a paramagnetic analyzer for O2. Plumbing and fittings for gas sampling and return to the chamber interior also form part of this system.

The computer controller will maintain internal chamber CO_2 concentrations during the day-light hours so that any net carbon gain by the stand through photosynthetic activity is compensated for by injections from an external CO_2 tank. The tank may be commercially available bottled CO_2 or a reservoir of CO_2 collected from other MELiSSA compartments.

3.4. Hydroponics System Operation

The nutrient requirements for the plants are supplied in a hydroponics medium stored in a polypropylene nutrient solution reservoir mounted on the underside the chamber. The solution is pumped into the chamber to the head of sloped polypropylene growing trays (trays) using a water cascade system. The chamber has a total length of 6 m and can therefore accommodate up to 22 trays. The trays are designed to accommodate a variety of root media as a substrate for the hydroponics solution including Rockwool©, expanded clay (Lecca©) and newly developed biodegradable and inert media. The solution drains from each tray into a common collection trough via gravity. The collection trough (5m in length) then returns the solution back to the nutrient reservoir. The condition of the solution with respect to pH and electrical conductivity is monitored and adjusted continuously through measured injections of acid, base and/or various nutrient mixes.

No composition (removal or appearing of species) is expected due to plant growth ?

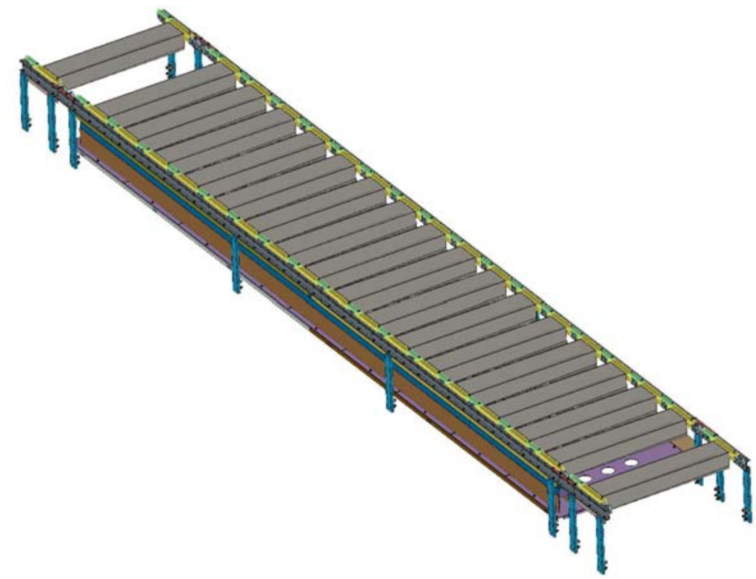


Figure 3.4-1. View of the plant growing tray conveyers.

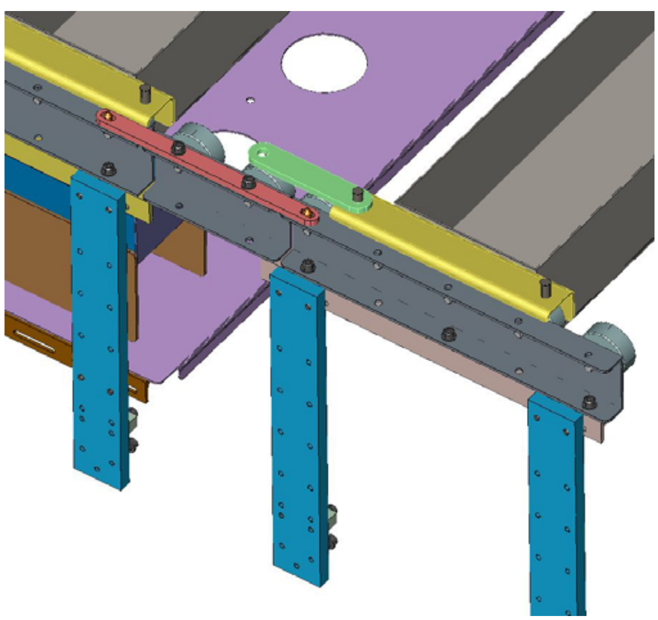


Figure 3.4-1. Detailed view of the plant growing tray conveyers.

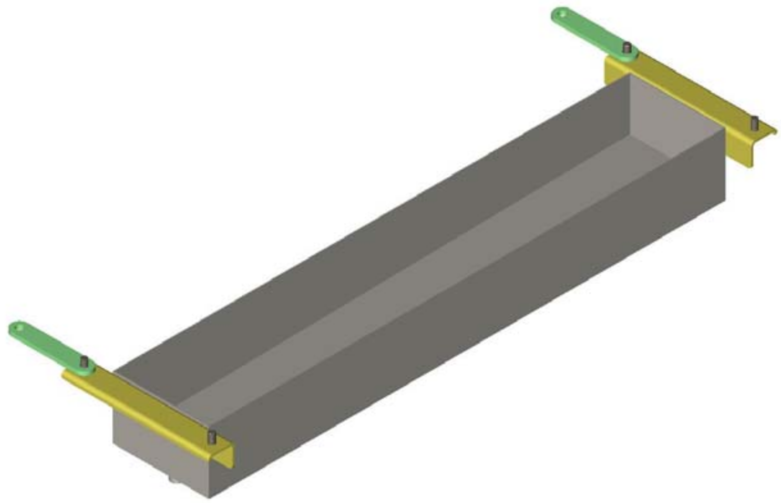


Figure 3.4-2. Detailed view of the plant growing trays.

3.5. Lighting System Operation

The plant growth chamber is equipped with 9 x 600W HPS and 3 x 400W MH lamps externally mounted overhead to provide illumination through a 10 mm tempered glass roof. Initially static ballasts will be used. This means that light intensity can not be attenuated through power supply regulation to the ballasts. Therefore, light intensity control will be discrete with binary (on/off) operation of the lamps to achieve desired illumination levels.

The lighting system includes a lamp loft with fans for temperature control. A diagram of the lamp loft assembly is provided below.

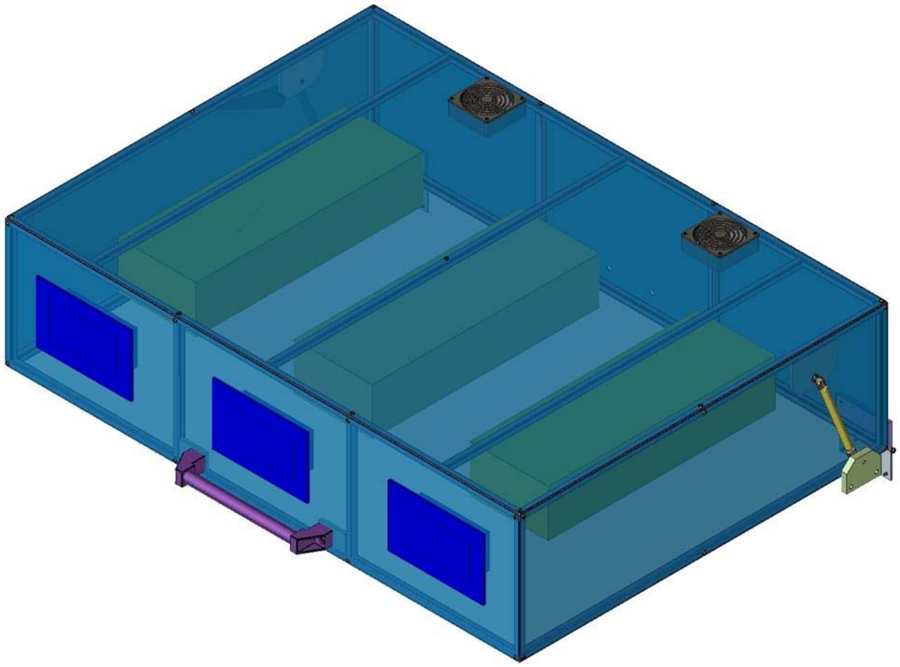


Figure 3.5-1. Lamp Loft cover. Shown are the exhaust fans and vents, hinges and support handle.

4. HPC Prototype Technical Specifications

The full set of HPC prototype technical specifications is provided on 4 companion CD-ROMS. The contents of the CD-ROMS are outlined below;

Companion CD-ROM 1 – Parts Specifications and Equipment Database

The first CD-ROM contains an EXCEL based database of all prototype chamber plant parts including mechanical hardware, sensors, actuators and fittings. Fields in the database include;

- Common name
- Part type classification (sensor, mechanical etc.)
- Quantity of parts supplied by CESRF
- Voltage specification
- Phase specification
- Frequency Specification
- Operational range
- Operational conditions tolerance
- Fitting sizes
- A list of allied parts
- Manufacturer
- Model number
- Supplier (if different from manufacturer)
- Weight
- Dimensions
- Materials of construction/wetted parts
- Name of linked CAD drawing file
- Name of linked photographic file

Companion CD-ROM 2 – CAD Drawings

The second CD-ROM contains PDF and CAD drawing files for all parts used in each sub-system, using the file naming convention supplied in the EXCEL database (above)

Companion CD-ROM 3 – Photographic Database

The third CD-ROM contains jpeg image files for all parts used in each sub-system, using the file naming convention supplied in the EXCEL database (above)

Companion CD-ROM 4 - HPC Detailed Specifications Sheet

These CD contains detailed specifications for all parts (fittings, mechanical, sensors etc.) not custom made. These sheets are in PDF format and are as supplied by the part manufacturer. For custom made parts, additional files are included to detail their specifications (e.g. water cascade water delivery system, hydroponics tank).