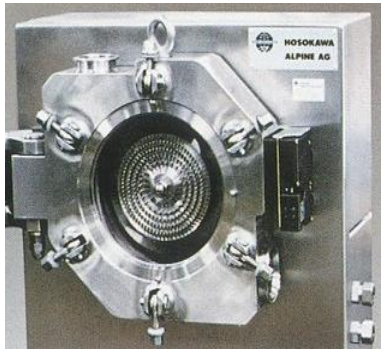
Development of a New Experimental Crew Compartment

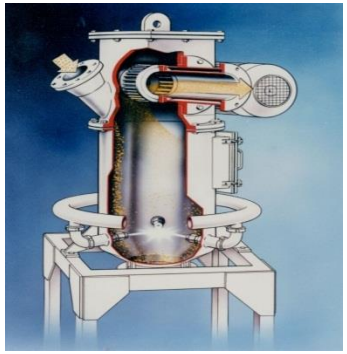
Adam Harper: Hosokawa Micron Ltd

Hosokawa Micron Ltd

Hosokawa Technologies

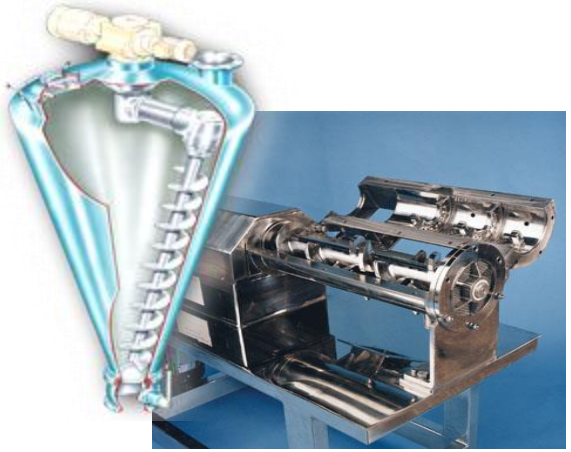


Impact Milling

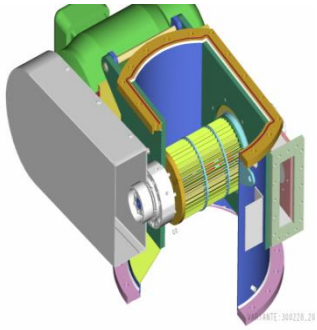


Jet Milling

Drying

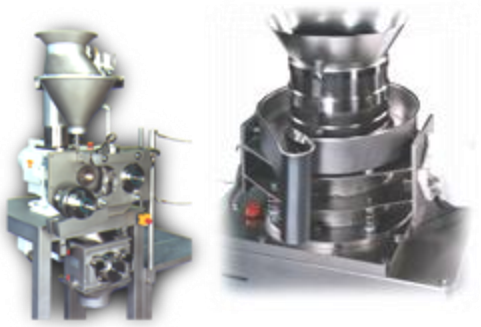


Mixing

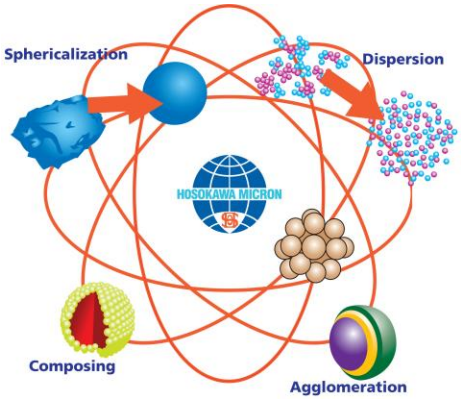


Air Classification

Screening



Agglomerating and Compacting



Nanotechnology and Particle Engineering

Hosokawa Containment

Drum Filling/Weighing

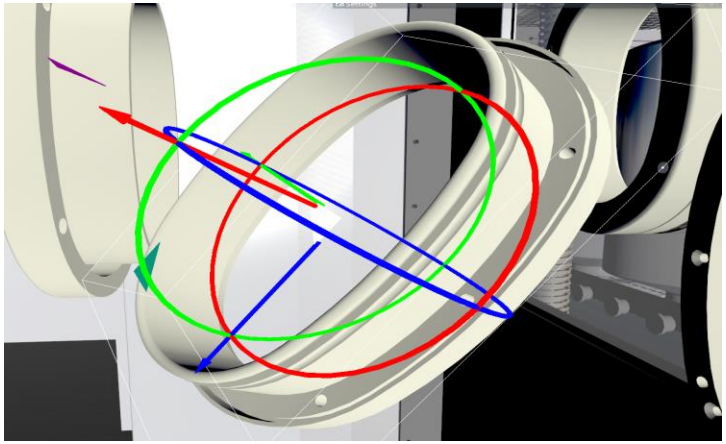
Laminar Flow Booths

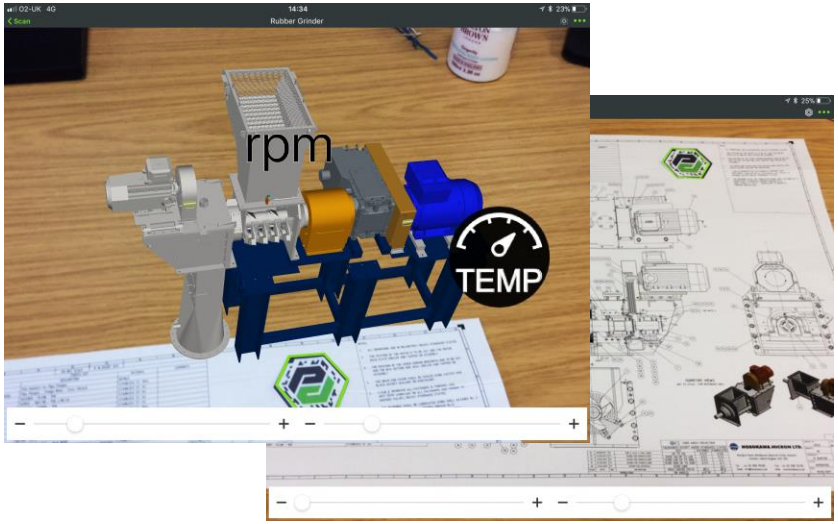
Downflow Booths

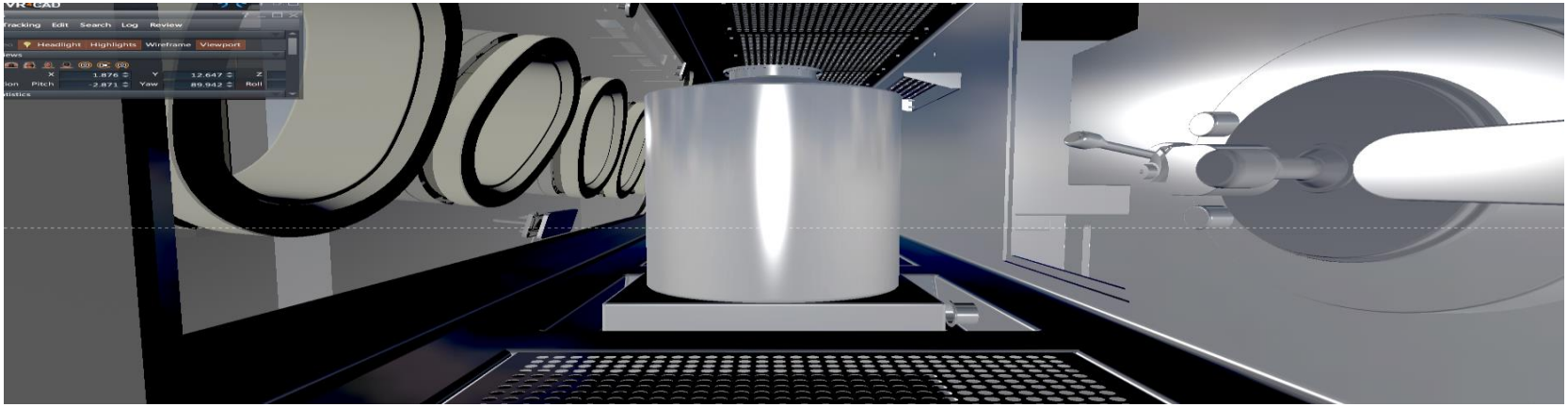
Gloveboxes/Isolators

Process Integrated Gloveboxes

Development of Virtual Reality Techniques







HOSOKAWA GEN4
Data Driven Manufacturing

Connected Systems

MELISSA

Digitised Assets (Multiple sites)

Condition Monitoring & Decision Analytics in the Cloud

Reports and data analysis

Anomaly detection & alarm management at the edge

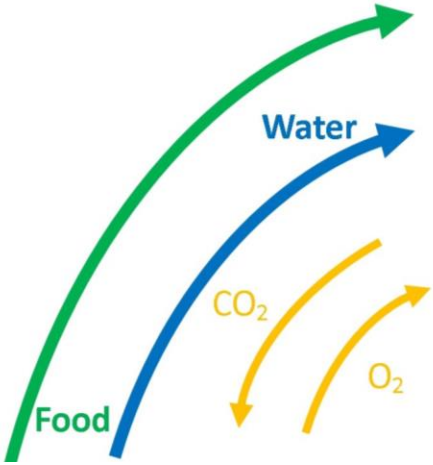
Role based alerts

Inspections & actions

Smart Mobile Apps
Diagnostics & trouble-shooting
Performance improvement advice
Trending plant operating data

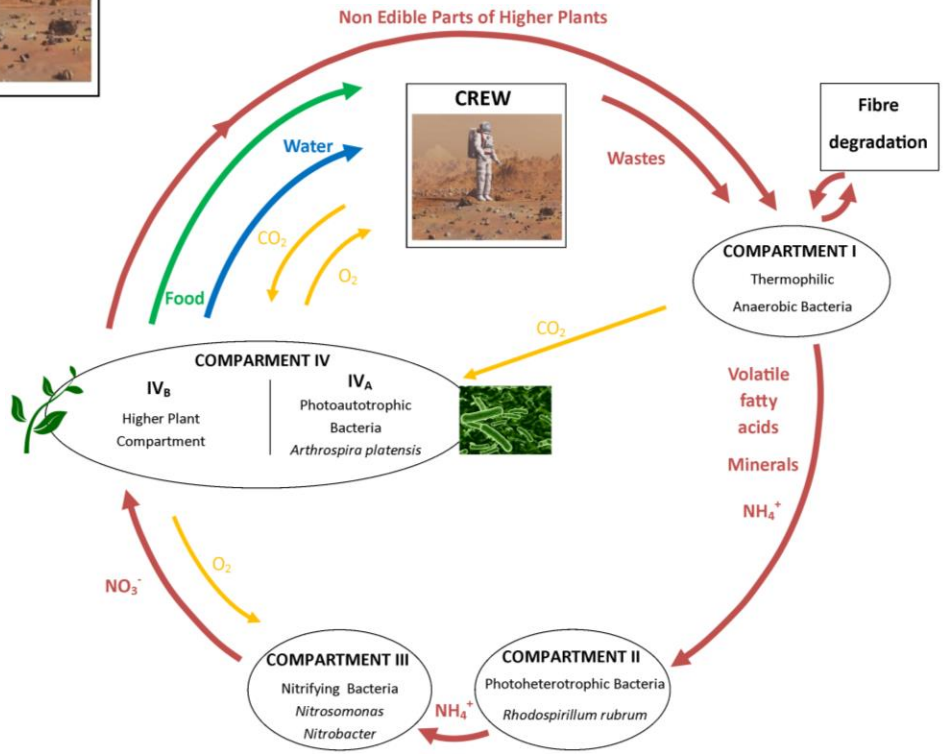
MELiSSA Crew Compartment

Development of a high containment isolator and gas loop system to provide a habitat for the development and demonstration of regenerative closed loop life support systems.



New experimental 'crew' compartment for integration into the MELiSSA Pilot Plant at UAB

Photoautotrophic Bacteria Arthrospira platensis



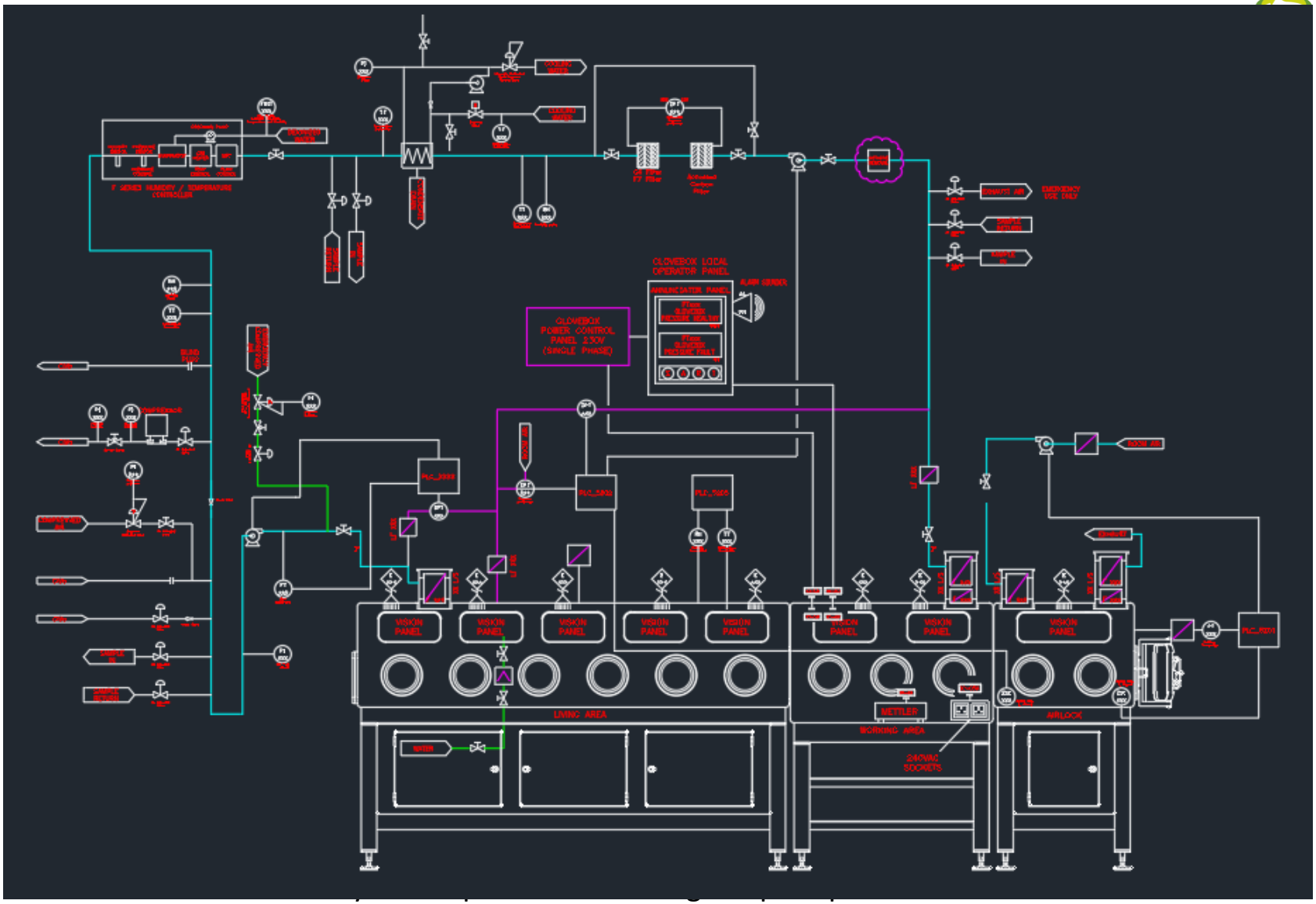
The ‘Crew’

One human equivalent to 40-60 rats (depending on species) with respect to O_2 consumption and CO_2 production

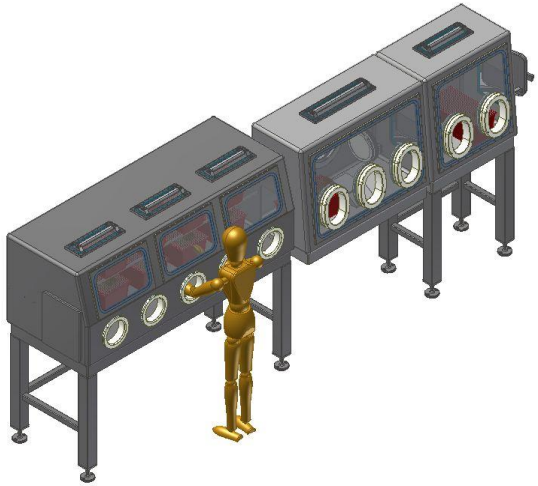
Key Design Requirements

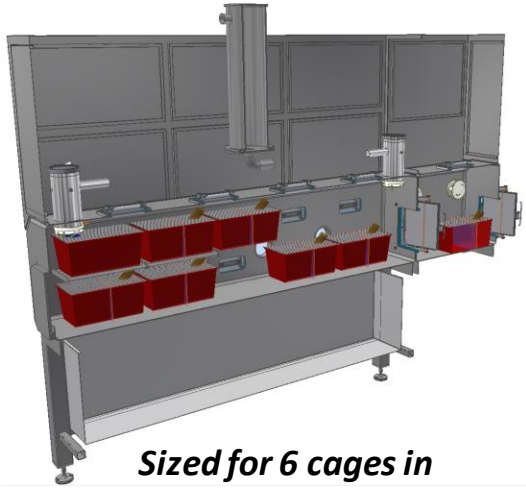
- 'GAS TIGHT' design
- Ensure comfort & welfare of the animals
- Good ergonomic design for laboratory personnel
- Connect isolator & gas loop to compartment IVa
- Ensure materials do not adversely affect experiment results
- Incorporate instrumentation for system control and recording of data
- Incorporate interlocks systems for safe operation
- Enable easy cleaning and decontamination

Preliminary Process Schematic (P&ID)

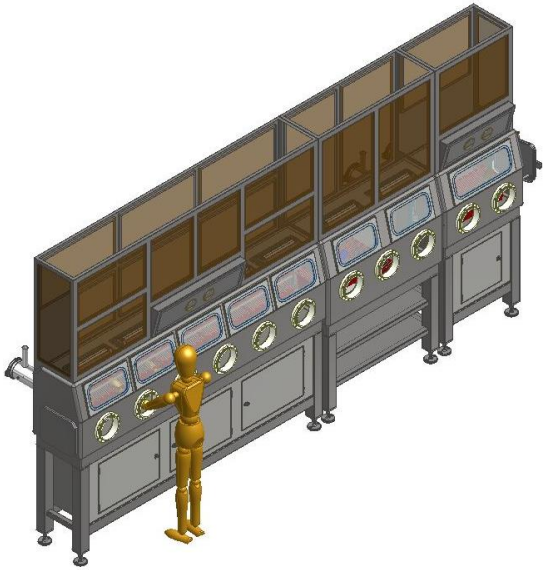


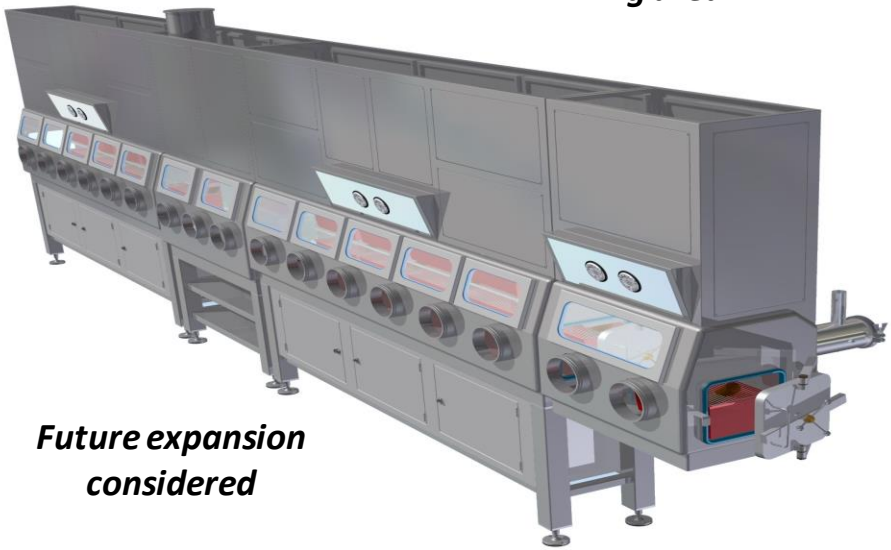
Early Concept Arrangements





Sized for 6 cages in living area





Future expansion considered

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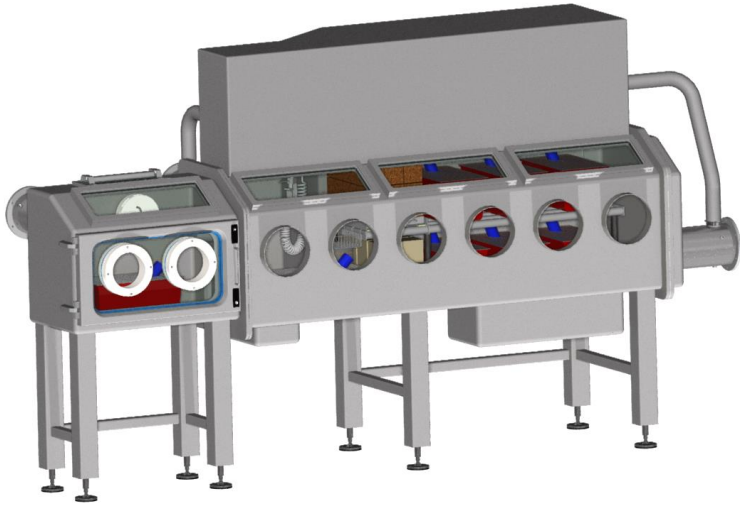
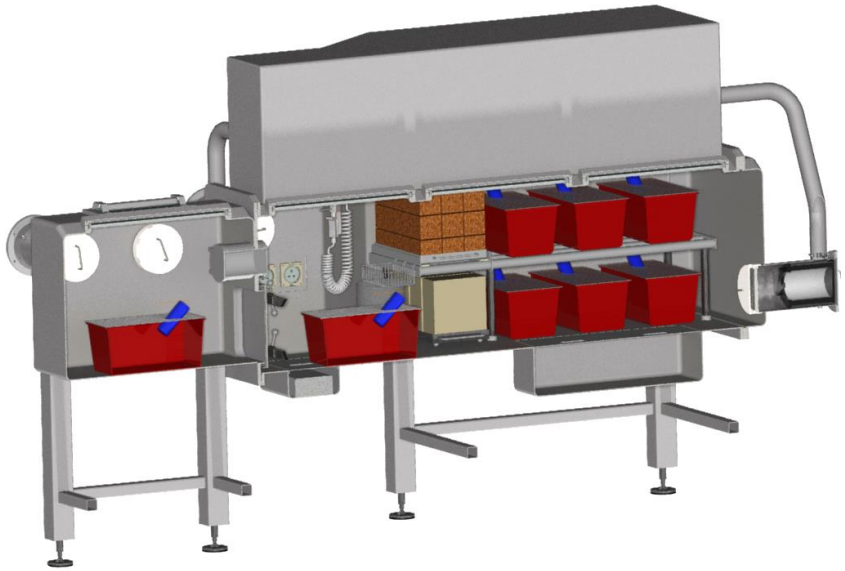
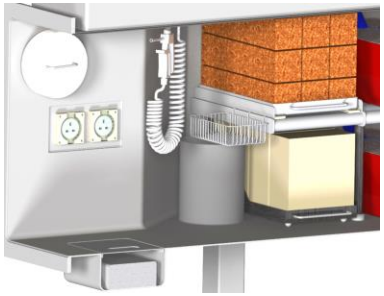
Isolator Design Development

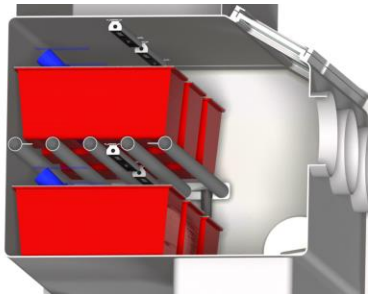




Transfer airlock

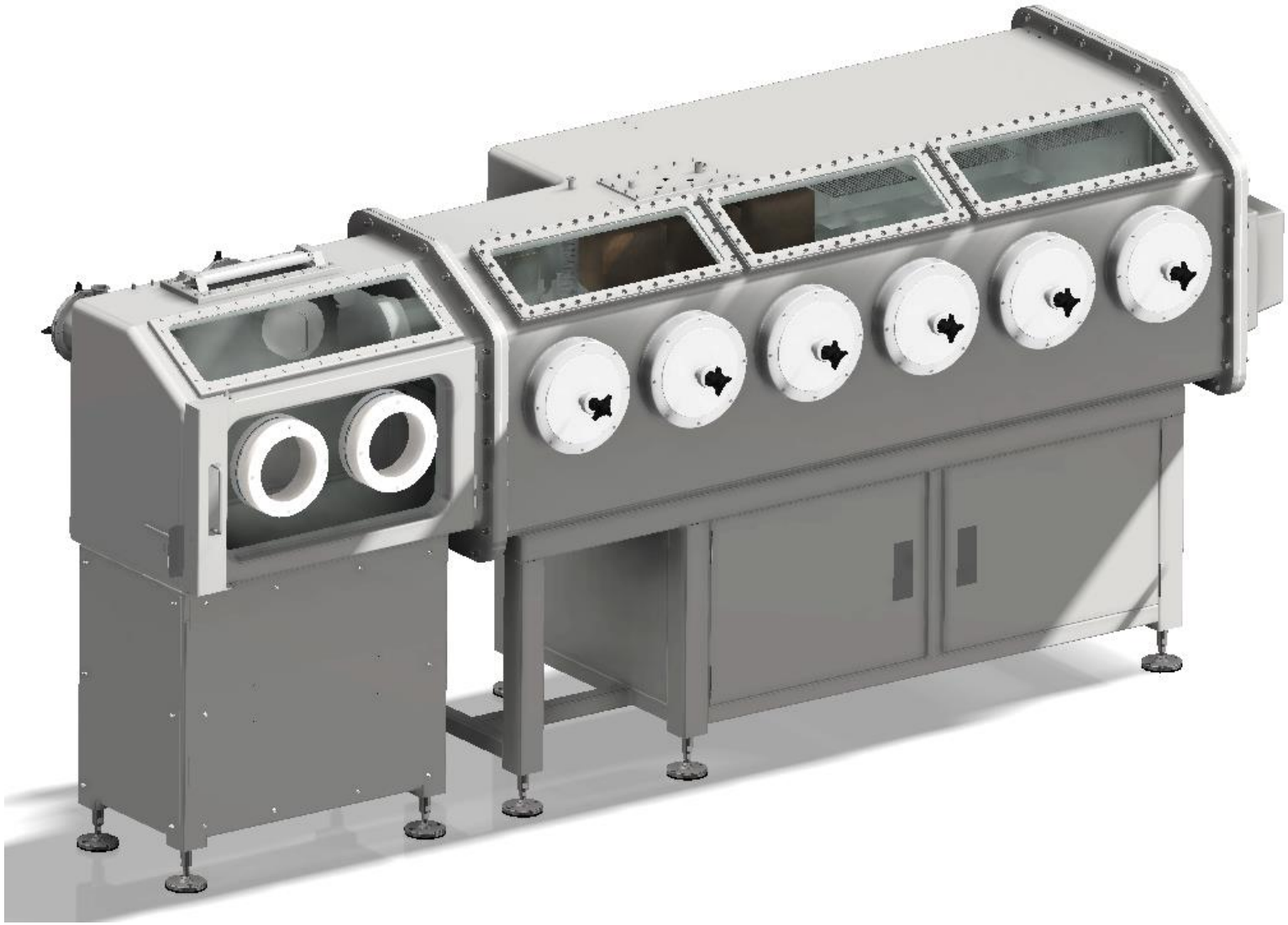


Food and Bedding Storage

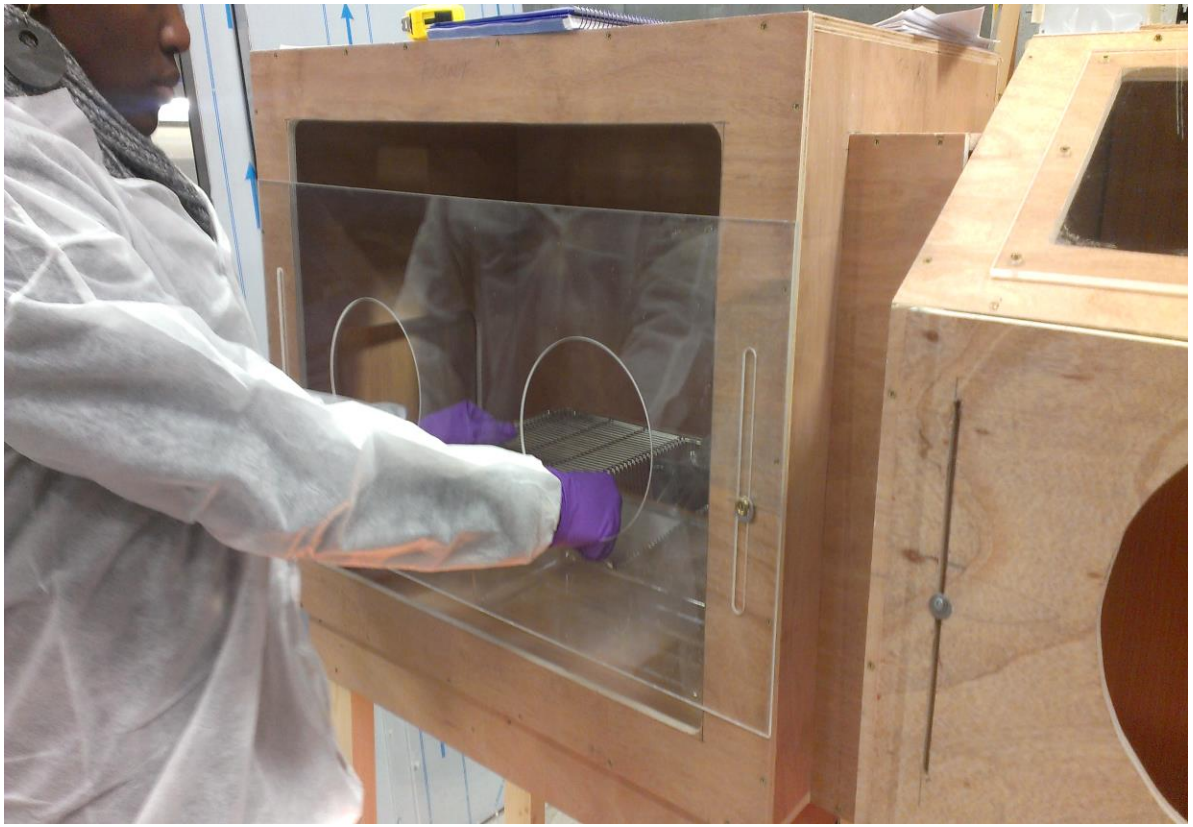


Living Area

Final Isolator Arrangement



Ergonomic Testing

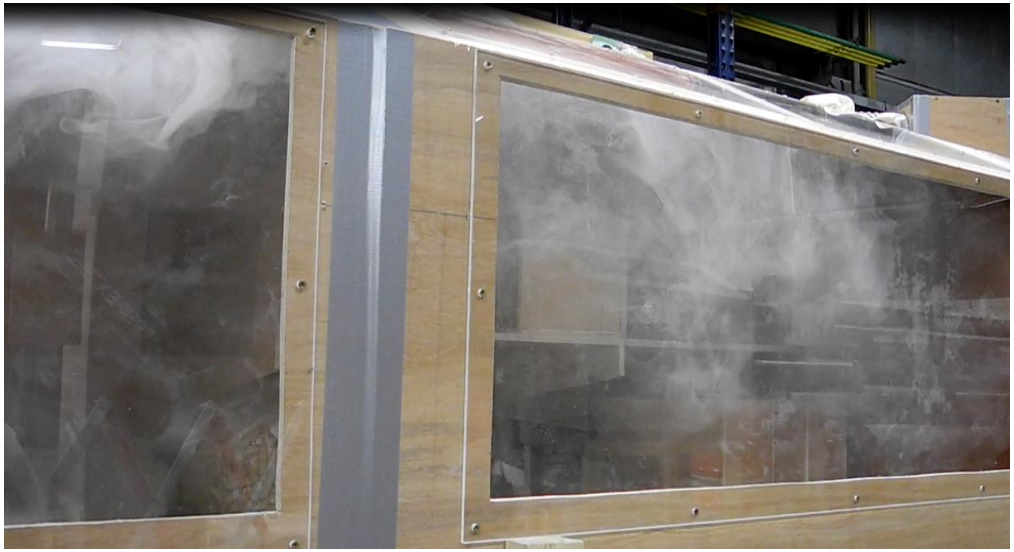


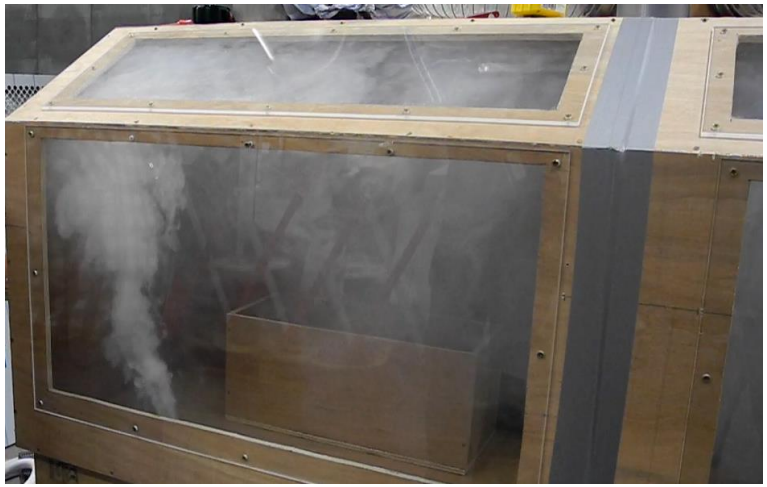
Wooden mock-up used for ergonomic testing and design verification

Smoke Testing

Smoke trials carried out using wooden mock-up to optimise airflow patterns

Smoke also injected directly into cages to evaluate the effectiveness of flushing contaminants





Gas Loop HVAC Design

System design allows control of the following parameters…

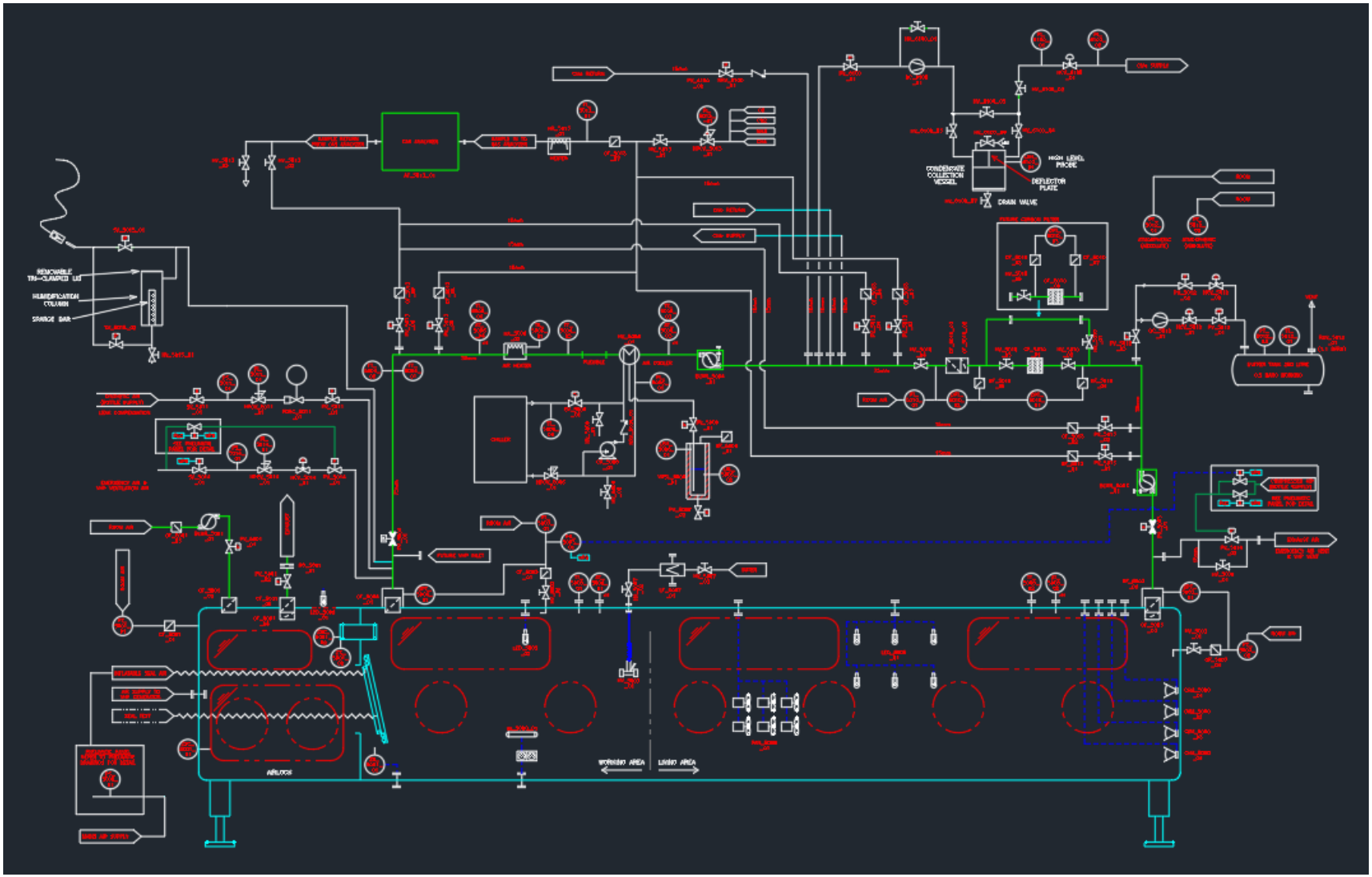
- Humidity
- Temperature
- Pressure
- Gas flow

All components designed to meet the same leak tightness criteria as the main isolator

During design the following influences on temperature and humidity levels were considered…

- Heat and moisture from animals
- Heat gain to/from room
- Heat gain from lights
- Heat gain from blower motors
- Temperature and moisture levels of gas returning from CIVa

Finalised System Design



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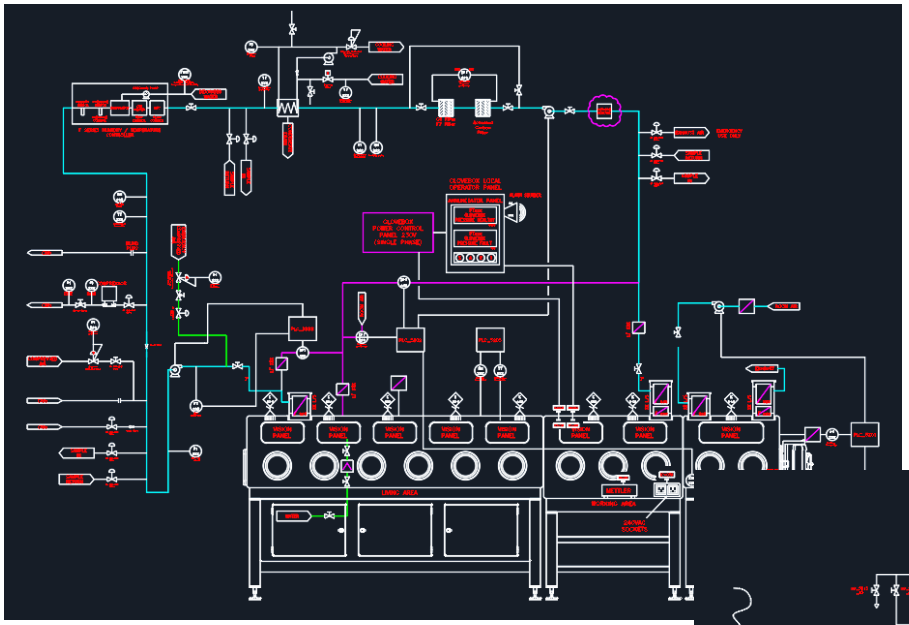
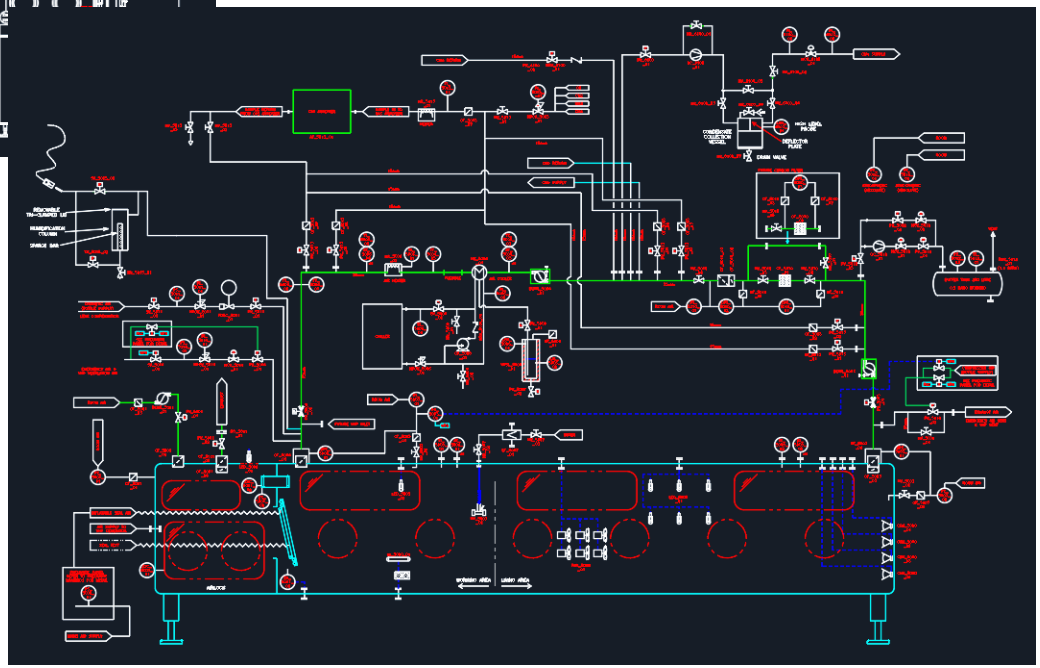
P&ID Design Development

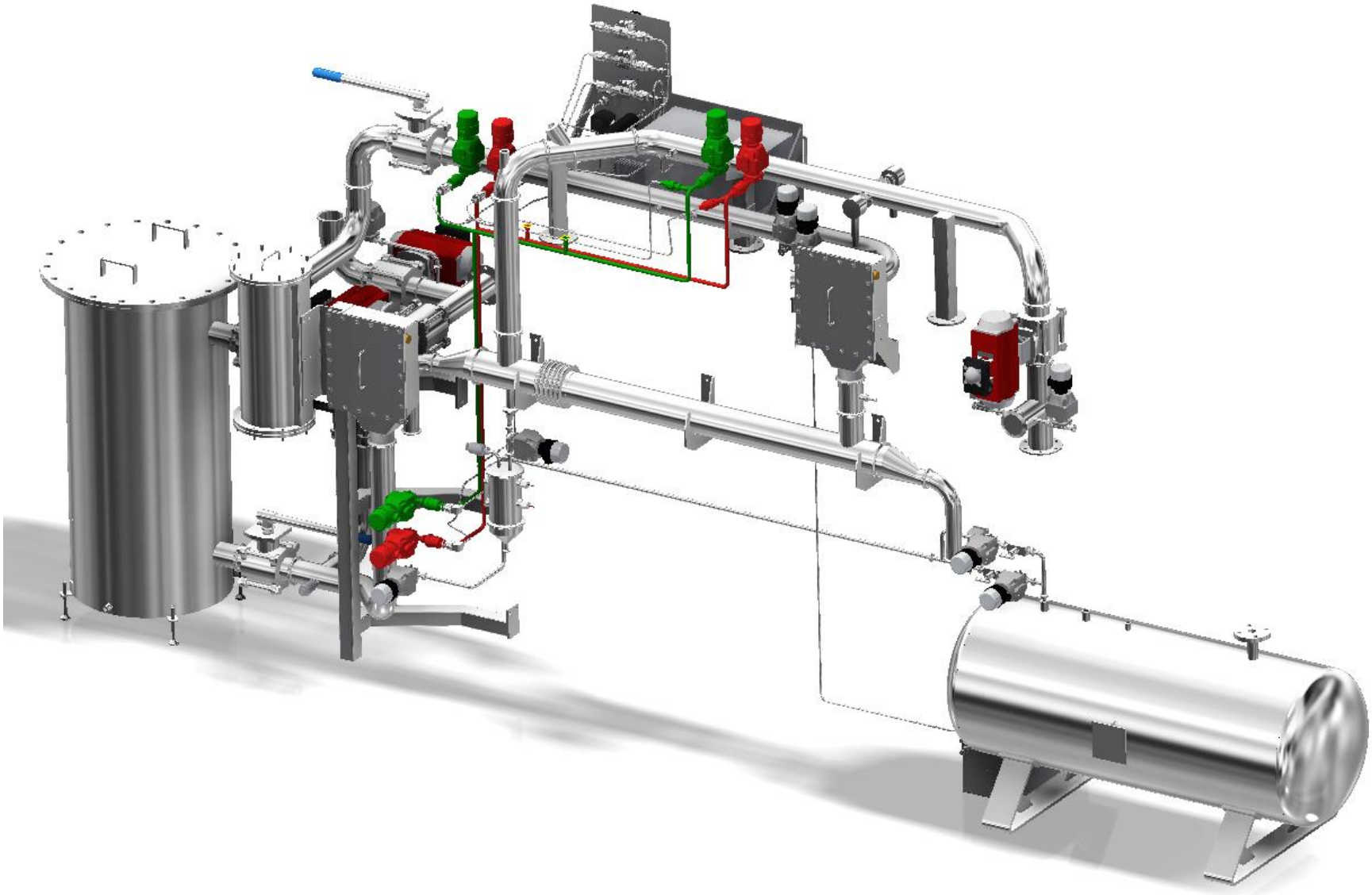


Revision 01

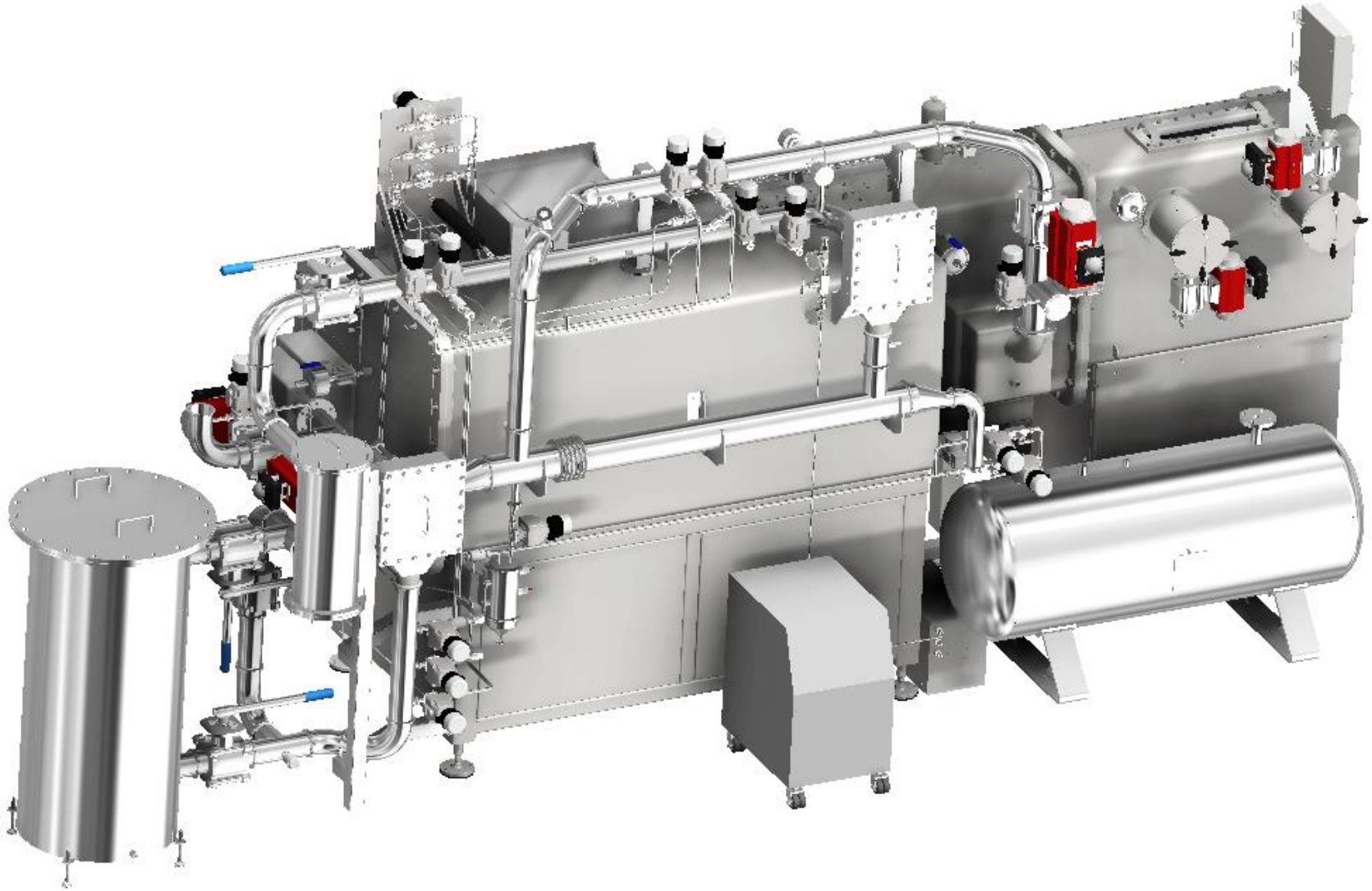
Revision 16



Gas Loop Design



Gas Loop/Isolator Integration



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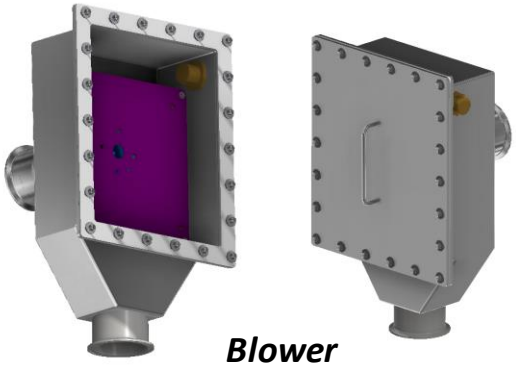
Gas Tight Design

Maximum allowable gas leakage is 0.03% vol/hr (equivalent to 30 Pa or 0.3mbar in 1 hour)

(Derived from the maximum allowable dilution of the internal atmosphere during an experiment without having a significant adverse effect on the results)

Class	Leakage %vol/hr	Leakage Pa/hr	Application
-	0.03	30	MELiSSA CV Isolator
1	0.05	50	Nuclear Glovebox
2	0.25	250	High Containment Isolator
3	1	1000	Standard Containment Isolator
4	10	10,000	Low Containment Isolator

Gas-tight Components



Blower

Condensate Collector

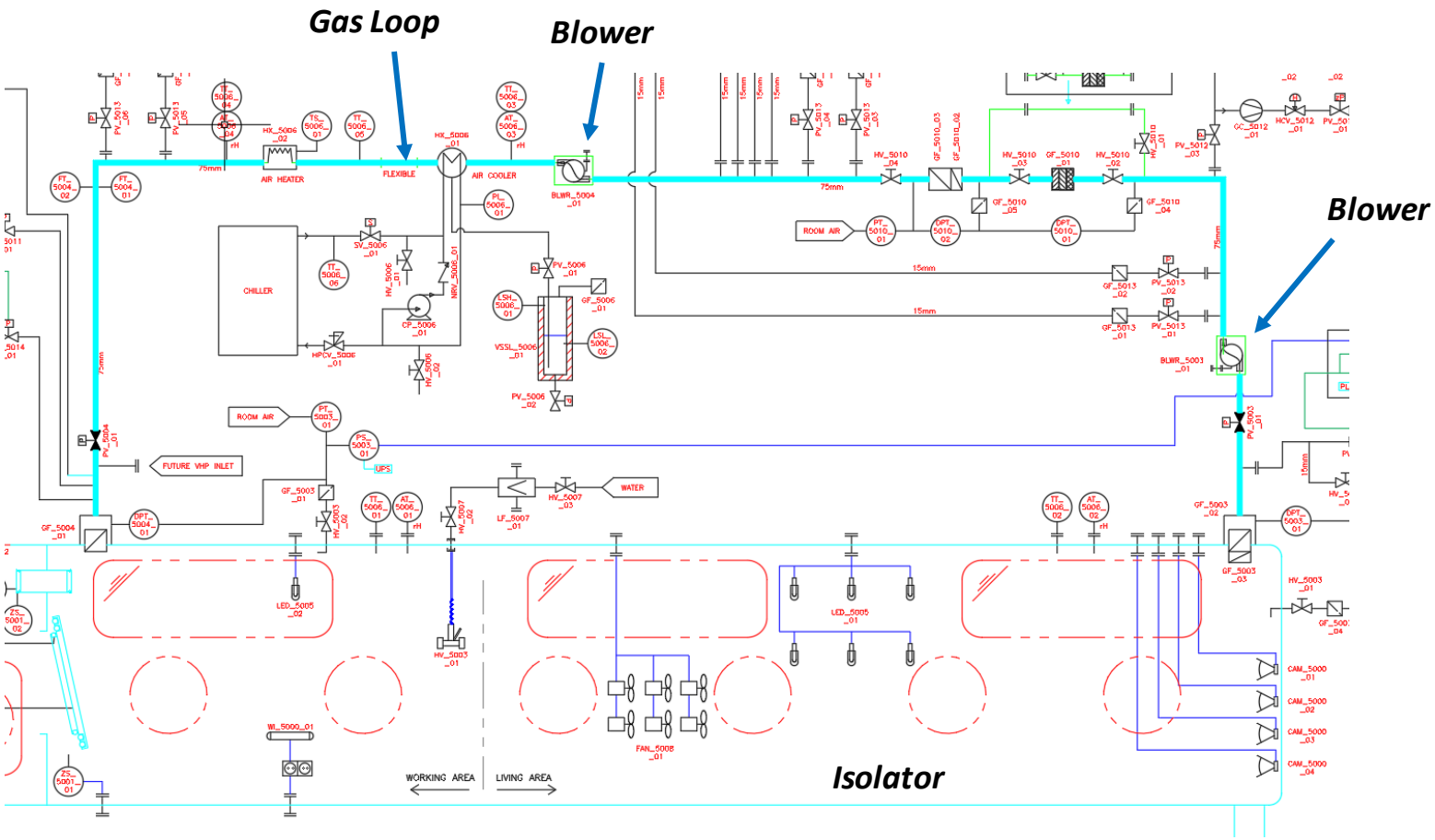
HEPA Filter

Carbon Filter

Heater

De-humidifier

System Pressure Management



- Pressures calculated for each part of the isolator and gas loop
- Internal system pressure kept positive but as low as possible to minimise leakage

Atmospheric Pressure Compensation

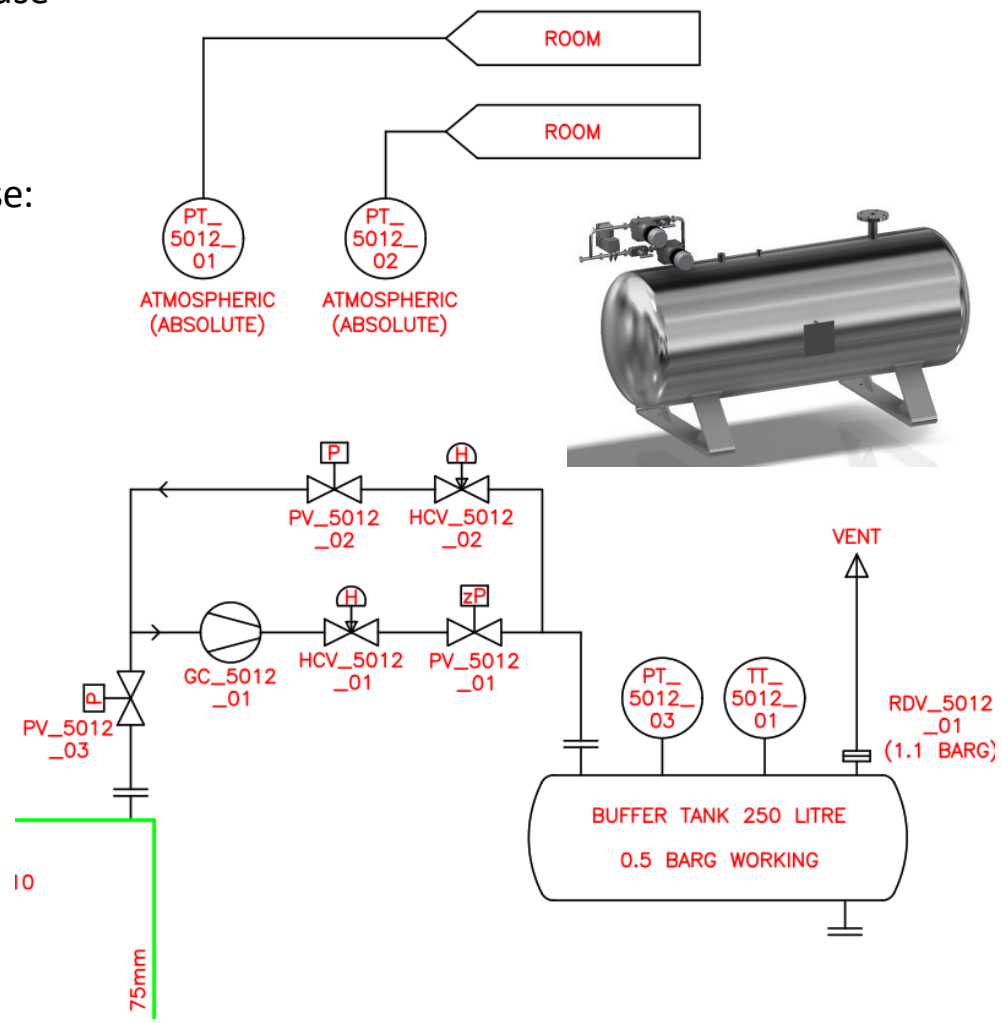
Changes in atmospheric pressure may cause under or over pressure in the system

Changes in differential pressure may cause:

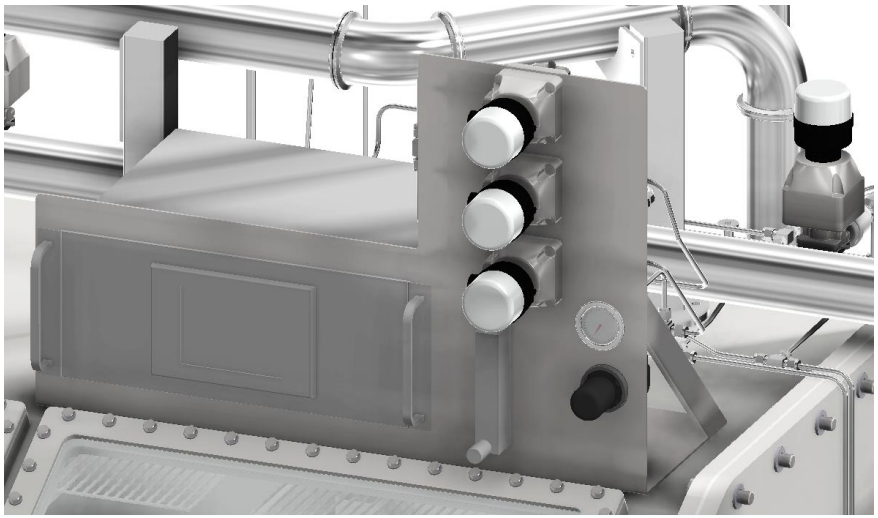
- damage to system
- excessive leakage
- difficulty for the operator (pressurised gloves)

Gas pumped into buffer tank or released back into gas loop depending on atmospheric pressure measurements

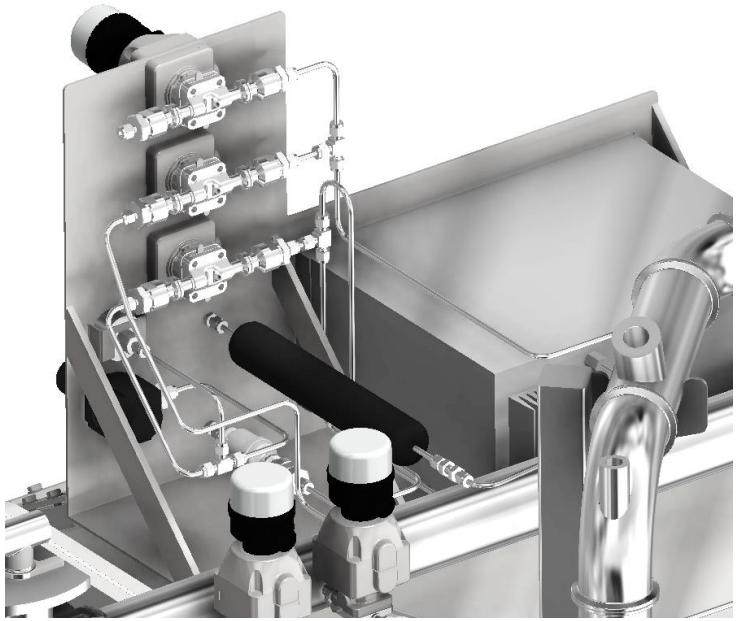
Historical meteorological data shows potential atmospheric pressure Changes in Barcelona



Gas Analysis



Gas from the Gas Loop piped to the analyser



Connections for calibration gas taken from compressed gas cylinders

Animal Welfare

Comfort and welfare of the animals was a key design consideration

System design takes into account all relevant regulations with respect to animal welfare

Universitat Autònoma de Barcelona

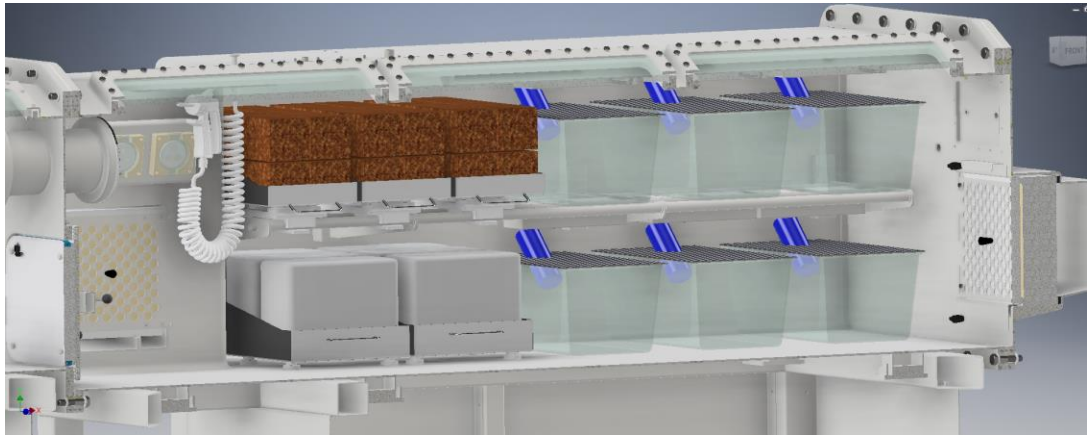
Animal Experimentation

Ethics Committee on Animal Experimentation (CEEA)

The following aspects were considered…

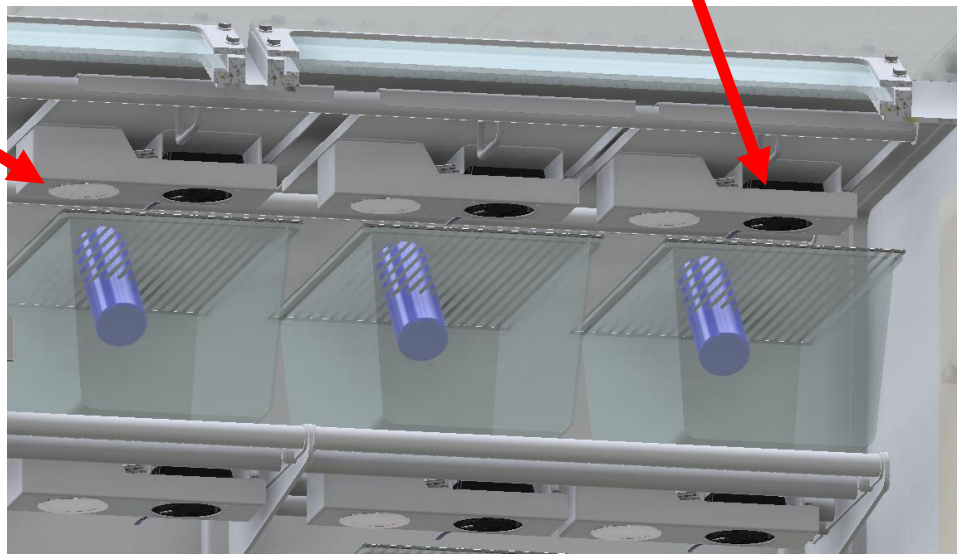
- Temperature
- Humidity
- Removal of contaminants and noxious gasses
- Noise levels
- Light levels

Animal Welfare



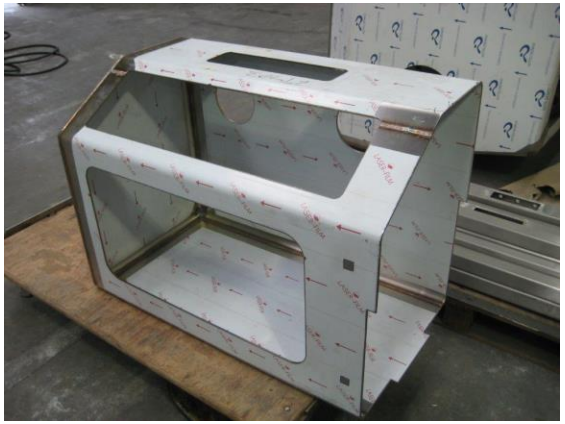
Individual cage cooling fans

Dimmable, diffused cage lighting to avoid shocking the animals



Lux level testing in the wooden mock-up

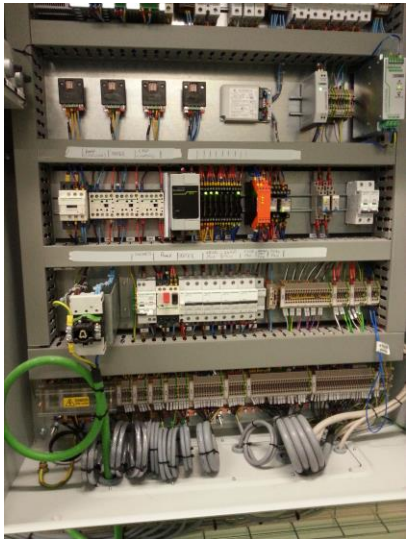
Manufacture



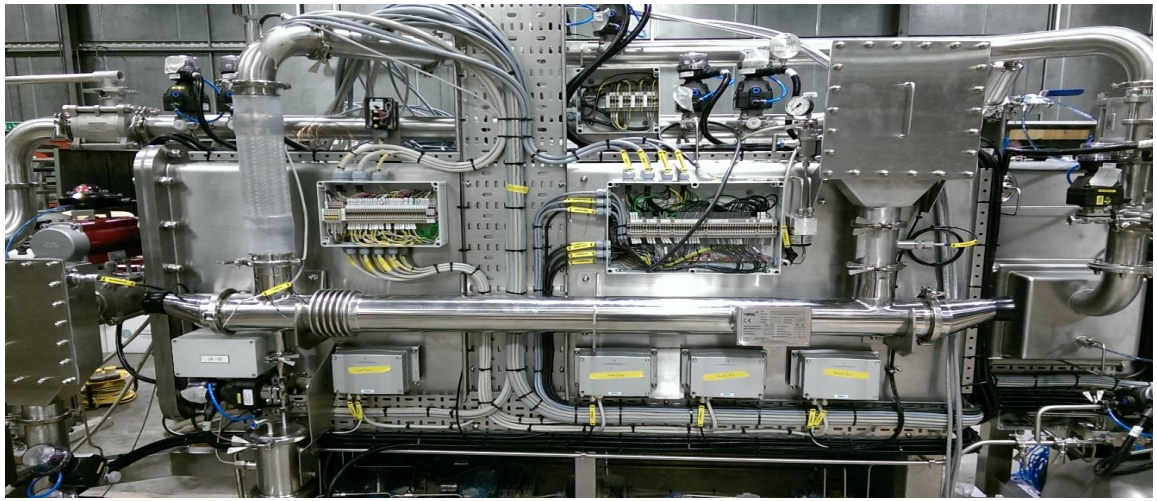
Isolator chamber and airlock during fabrication

Assembly - Isolator

Assembly – Electrical and Control System



Assembly – Gas Loop Integration



Leak Testing

Phase 1:	**Hosokawa Factory**	**Isolator**	**(Static Mode)**
Phase 2:	**Hosokawa Factory**	**Isolator and Gas Loop**	**(Static Mode)**
Phase 3:	**MELiSSA Pilot Plant**	**Isolator,**	**(Static Mode)**
Phase 4:	**MELiSSA Pilot Plant**	**Isolator and Gas Loop**	**(Static Mode)**
Phase 5:	**MELiSSA Pilot Plant**	**Isolator and Gas Loop**	**(Dynamic Mode)**

Static mode leak testing proves the integrity of the system components, seals etc…

Dynamic mode testing is carried out with full air recirculation and all connected equipment and systems in operation

Experimental results achieved during dynamic testing with a full 'crew' of animals will be presented by UAB

Leak Testing

Static leak testing carried out in generally in accordance with ISO 14644-7:2004 and ISO 10648-2:1994 using the 'pressure decay' method

Leak testing carried with both positive and negative internal pressures

Test Measurements:

- Chamber pressure (differential)
- Atmospheric pressure
- Internal temperature
- External temperature (ref. only)

Final pressure is corrected for changes in atmospheric pressure and internal temperature

- 0.1 mbar atmospheric change = 10 Pa internal pressure correction
- 0.01°C = 3.5 Pa internal pressure correction

Acceptance criteria: < 0.03% vol leakage/hr (30Pa/hr)

Arrival at UAB in Barcelona

Universitat Autònoma de Barcelona

Installation into MELiSSA Pilot Plant

Installation – Control System Wiring

Installation Complete

The Next Challenge: PaCMan

Plant Characterisation unit for closed life support system engineering, Manufacturing and testing

Some of the technology and solutions developed for the crew compartment are now being utilised for the PaCMan project.

A plant characterisation unit (PCU) will be designed and manufactured in conjunction with Enginsoft, Odys and Ciris for installation at the Universita degli Studi di Napoli Federico II

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