CONFIDENTIAL

EPAS n.v.
Eco Process Assistance
De Prijkels • Venecoweg 19 • B-9810 Nazareth
Tel. +32 9 381.51.30
Fax +32 9 221.82.18
www.epas.be • epas@epas.be

Flemish Institute for Technological Research

NTE SA

MELiSSA – Adaptation for Space

ESA contract 15671/01/NL/ND

TECHNICAL NOTE 72.8

Development of *Arthrospira* harvesting breadboard

Version : 1
Issue : 0

	Name	Signature
Prepared by:	Heleen De Wever Veerle Van Hoof	
Approved by:	Farida Doulami Dries Demey	

17 February 2004

DOCUMENT CHANGE LOG

Version	Issue	Date	Observation
1	0	03/10/03	Draft
2	1	17/02/04	Final

DISTRIBUTION LIST

Quantity	Company/Department	Name
4	ESA	Christophe Lasseur
1	EPAS	Farida Doulami
		Dries Demey
1	NTE	Joan Mas
1	Vito	Heleen De Wever
+ 3 copies library		Ludo Diels
		Chris Dotremont
		Etienne Brauns
1	GEPEA	Pascal Jaouen

CONTENT

LIST OF FIGURES

LIST OF TABLES

1. Introduction

In the framework of the project MELiSSA – Adaptation for Space, a breadboard had to be constructed that demonstrates the continuous harvest and washing of *Arthrospira* from Compartment IVa in the MELiSSA loop.

Based on experimental work and a trade-off, it was decided that the harvesting system should consist of an ultrasonic separation system, followed by an ultrafiltration step to recover the cells which pass through the ultrasonic system. In the overall concept, the permeate of the ultrafiltration step is further desalinated by electrodialysis, generating two streams: a desalinated diluate which can be used to wash the concentrated cell suspension and a concentrate enriched in salts which can be recycled to the photobioreactor in which *Arthrospira* is grown. It was agreed however, not to include the electrodialysis step in the breadboard and to perform washing steps with distilled water.

2. General description of the breadboard

The schematic presentation of the breadboard is given in Figure 1.

Several subunits can be distinguished:

- growth reactor
- buffer tank
- concentration tank for ultrasonic separation
- ultrasonic separation system with controller
- ultrafiltration (UF) unit

In general, the overflow of the growth reactor is collected in the buffer tank over a 1-day period. Once a day, the content of the buffer tank is transferred to the concentration tank where it is concentrated 10-fold by ultrasonic separation. The remaining cells in the clarified stream of the ultrasound system are further eliminated in the UF step. The permeate of the UF membrane is disposed of. The concentrate is recycled to the concentration tank by backwashing the UF with water. This backwash also constitutes the washing step of the algae since the concentrated algae suspension in the concentration tank is diluted again to the original volume. Then, the next concentration cycle by ultrasonic separation starts. Several subsequent washing steps can be performed until the salt concentration of the concentrated cell suspension has reached the desired final level.

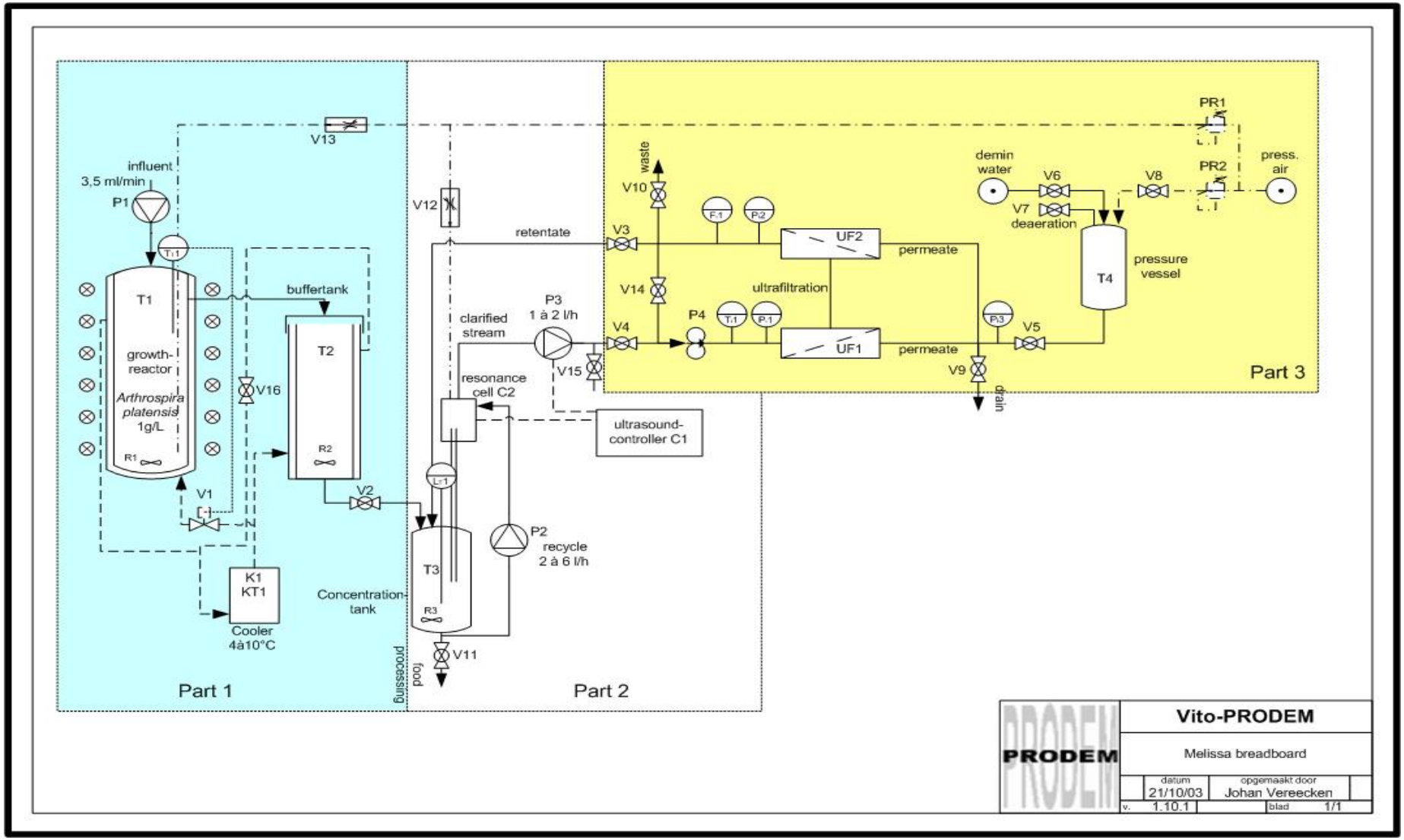

Figure 1. Schematic overview of harvesting system for *Arthrospira*

3. Constraints for design

In the design of the harvesting system, the following boundary conditions had to be taken into account:

- the overflow of the *Arthrospira* growth reactor has to be harvested and washed during one working day. Because harvest and washing occur sequentially, the time available per cycle is limited

- the concentration of the cells, coming out of the reactor, is around 1 g/l

- this suspension has to be concentrated by ultrasonic separation at least tenfold

- by diluting the concentrated cell suspension with distilled water and applying a next cycle of ultrasonic separation, the salt concentration of the cells can be decreased. Provided that cells are diluted each time with a factor of 10, it is estimated that 2 washing cycles are sufficient to reduce the salinity for food preparation. If the first concentration step and the subsequent two washing steps have to be performed in one working day, this implies that each cycle should be finished in about 2 h.

- the clarified stream coming out of the ultrasonic chamber, still contains some algae. The concentration is estimated to be around 50 mg/l. This stream will be concentrated about 20-fold by ultrafiltration. The recovered cells are then sent back to the ultrasonic system

According to the manufacturer's information, two types of ultrasonic separation systems are available in the desired flow range:

- a 50 l/d system

- a 200 l/d system

The cost of the 200 l/d system is too high for the available budget. This means that the 50 l/d system has to be used. In other words, at a flow of 2 l/h, the volume of cell suspension which can be tenfold concentrated in a 2-h period is 5 l. Therefore, the whole separation system needs to cope with a harvest of 5 l *Arthrospira* cells per day.

As a result, 5 l of cells are concentrated to a final volume of about 0.5 l and 4.5 l of clarified stream is going to the UF unit. In the UF, the clarified stream should be concentrated as much as possible, in order not to dilute the concentrated cell suspension too much, to which it will be returned. If the UF has to operate at a concentration factor of around 20, the 4.5 l volume needs to be reduced to 200 ml. The total dead volume of the ultrafiltration unit therefore needed to be approximately 200 ml.

Finally, growth of the algae in the bioreactor and collection of the overflow of cells is continuous. The concentration steps by ultrasonic separation and the washing steps occur batchwise because the amount of water needed to achieve a certain degree of desalination is much lower compared to continuous operation. Furthermore, the last step in the harvesting necessarily needs to be a batchwise concentration of cells. Otherwise, one would never obtain a concentrated cell suspension required for food processing.

4. Description of units

This paragraph contains a general description of the units and gives an overview of the sensors, actuators and vessels. Further details can be found on the datasheets and the manufacturer's information for each unit.

4.1 Part 1: Photoreactor and buffer tank

4.1.1 Growth reactor

The growth reactor is a photobioreactor. It is conceived as a double-jacketed glass reactor with an active volume of 5 l and an internal diameter of 11 cm, provided with:

- influent peristaltic pump
- magnetic stirrer
- 56 halogen lamps with dimmer: maximal light intensities of 300 W/m² can be provided
- temperature sensor and display: optimal temperatures are between 30 and 35°C
- temperature control via cooler: cooling liquid at 4°C is circulated to the photobioreactor to keep the temperature constant at a selected temperature between 30 and 35°C. The circulation of the cooling liquid is controlled by the temperature measurement in the photobioreactor and the valve v1.
- access opening for oxygen and pH measurements on top of the reactor

The overflow of the reactor is collected by gravity in a buffer tank.

4.1.2 Buffer tank

This is conceived as a double-jacketed INOX tank, which can be stirred mechanically. The buffer tank is kept at 4°C to avoid deterioration in biomass quality. The content of the buffer tank can be transferred by gravity to the concentration tank through a manual valve v2.

4.1.3 Sensors

Table 1. List of sensors for Part 1

Tag	Description	Type
T_T1	Measures the temperature inside photoreactor	Thermocouple

4.1.4 Actuators

Table 2. List of actuators for Part 1

Tag	Description	Type
KT1	Cooler temperature control	
P1	Influent pump to photoreactor	Peristaltic
R1	Mixer for photoreactor	Magnetic
R2	Mixer for buffertank	Mechanical
V1	Temperature controlled valve between reactor and cooler	Controlled 2-way valve
V2	Manually controlled valve between buffer tank and ultrasound system	2-way ball valve
V13	Manually controlled valve for air supply to photoreactor	2-way ball valve
V16	Manually controlled valve between cooler and buffer tank	2-way ball valve

4.1.5 Vessels

Table 3. List of vessels for Part 1

Tag	Description	Type
T1	Photoreactor	Glass
T2	Buffer tank	Inox
K1	Cooler	

4.2 Part 2: Ultrasound system

4.2.1 Concentration tank

Once per day the content of the buffer tank is transferred by gravity to the concentrate tank, in which the actual harvesting and washing steps take place.

The tank is constructed in PVC. Because the cell suspension volume varies between 5 l and 500 ml during a concentration cycle and the ultrasonic separation system has to be submerged in the cell suspension during the whole concentration cycle, the only option was a conic shaped bottom part. Therefore, a magnetic stirrer could not be used and a mechanical stirrer was inserted in the top of the tank.

A low level sensor is provided to indicate when the final concentrated suspension volume of 500 ml is reached. In that case, a visual alarm is given.

4.2.2 Ultrasonic separation

As mentioned before, an ultrasonic system with a capacity of 50 l/d was selected (Applitek). The system is mounted on top of the concentration tank. Two pumps are provided for recycling of the algae suspension and for removal of the clarified stream (harvest line). Standard equipment also includes a controller which is needed to provide:

- the appropriate power input
- the on/off time
- control on the operation of the harvest pump

The clarified stream is expected to contain 5% of the original cell suspension concentration, i.e. 50 mg/l. It is processed further by the ultrafiltration unit.

4.2.3 Sensors

Table 4. List of sensors for Part 2

Tag	Description	Type
L_T1	Low level sensor	Level switch

4.2.4 Actuators

Table 5. List of actuators for Part 2

Tag	Description	Type
P2	Recycle pump	Peristaltic
P3	Harvest pump ultrasound unit	Gear pump
C1	Ultrasound controller	
R3	Mixer for concentration tank	Mechanical
V11	Manually controlled valve to remove concentrated cells from the concentration tank	2-way ball valve
V12	Manually controlled valve for air cooling of resonance cell	2-way ball valve
V15	Manually controlled valve after ultrasound unit for sampling	2-way ball valve

4.2.5 Vessels

Table 6. List of vessels for Part 2

Tag	Description	Type
T3	Concentration tank	

4.3 Part 3: Filtration unit

The clarified stream coming from the ultrasonic system is sent to a UF unit. This stream contains approximately 50 mg/l cell suspension. The concentrate of the UF unit is sent back to the ultrasonic separation. As described earlier, each cycle should be finished in about 2 h. During each cycle, approximately 4.5 l has to be processed by the UF unit.

The following components were used in the UF unit :

- Two UF membranes ordered from TAMI Filtration. Type Céram inside, ATZ, 50 kD, 120 cm length, 3 channels, 10 mm outer diameter, 0.045 m^2 membrane area. Housing in stainless steel.
- Centrifugal pump (Verder, type V-MD 30C)
- Thermometer (temperature range 0-100°C)
- Three manometers in stainless steel (pressure range 0-4 bar)
- Flow meter polysulfon/PVC (flow range 50-500 l/h)
- PVC tank for demineralized water
- 9 valves

The operation of the ultrafiltration unit is described according to Figure 1.

Pump P4 will be turned on during the entire filtration process. Because of the pressure built up in the filtration loop, water will permeate through the membranes as long as clarified stream is transported from the ultrasound unit to the ultrafiltration loop. When the cell suspension in the ultrasound tank has reached the desired final volume, pump P3 will be shut down, and valves V4 and V9 will be closed. The demineralised water tank is filled with 4.5 l demineralised water which will be used to back flush the membranes. Pressure on the demineralised water tank will be increased with pressurized air and with pump P4 still running, the demineralised water will dilute the cell suspension in the ultrasound system (washing of the cells). The cell suspension that is still in the ultrafiltration loop is also transported to the concentration tank while at the same time the ultrafiltration loop is cleaned.

After the last washing cyle, the ultrafiltration loop Is flushed with demineralised water but the cells in the ultrafiltration loop are not sent back to the concentration tank but are wasted.

4.3.1 Sensors

Table 7. List of sensors for Part 3

Tag	Description	Type
Pi1	Pressure sensor before membranes	Manometer
Pi2	Pressure sensor after membranes	Manometer
Pi3	Pressure sensor on permeate flow	Manometer
Ti1	Temperature sensor	Pt100
Fi1	Flow meter	Flowthrough

4.3.2 Actuators

Table 8. List of actuators for Part 3

Tag	Description	Type
P4	Pump in recirculation loop	Magnetic gear pump
V3	Manually controlled valve in retentate recycle to ultrasound unit	2-way ball valve
V4	Manually controlled valve between ultrasound and filtration unit	2-way ball valve
V5	Manually controlled valve between demineralised water tank and membranes	2-way ball valve
V6	Manually controlled valve in water supply pipe to demineralised water tank	2-way ball valve
V7	Manually controlled valve for deaeration of demineralised water tank	2-way ball valve
V8	Manually controlled valve for air supply to demineralised water tank	2-way ball valve
V9	Manually controlled valve for permeate drain	2-way ball valve
V10	Manually controlled valve for retentate sampling	2-way ball valve
V14	Manually controlled valve in filtration recycling loop	2-way ball valve
UFD1	Frequency converter pump P4	
PR1	Pressure reducer	
PR2	Pressure reducer	

4.3.3 Vessels

Table 9. List of vessels for Part 3

Tag	Description	Type
T4	Demineralised water tank	

4.4 Operation of the units

Information on the operation of the different units can be found in the associated manual.

4.5 Picture of the constructed breadboard

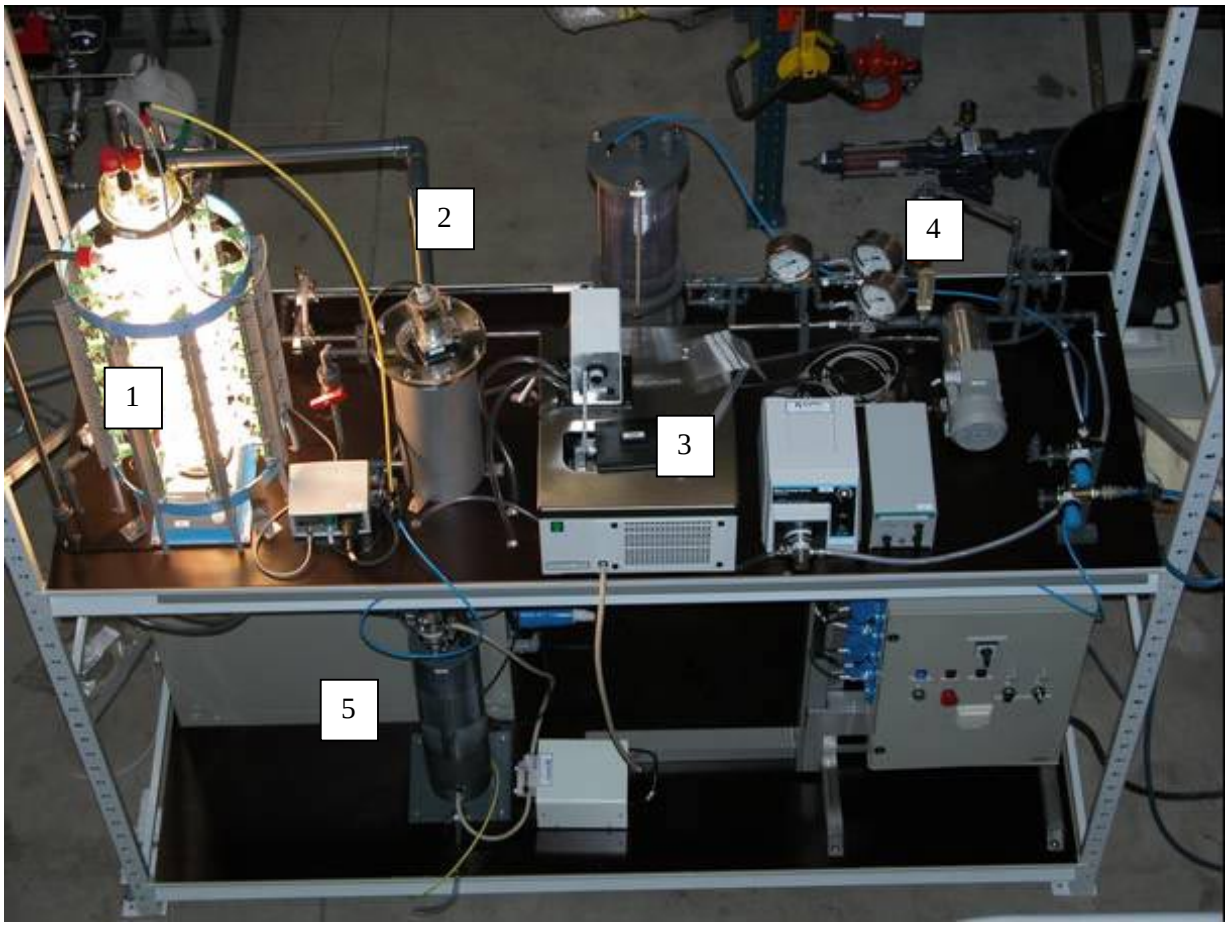

Figure 2. Overview of the breadboard. (1) photoreactor, (2) cooled buffer tank, (3) cooler, (4) membrane unit, (5) concentration tank with ultrasound system.

5. Sampling

The following sampling points are available:

- growth reactor/photoreactor: direct access via the top lid
- buffer tank: direct access via removable top lid or sampling via concentration tank immediately after transfer of the algae suspension from the buffer tank to the concentration tank
- concentration tank: direct access via top lid or sampling via valve V11
- harvest flow coming from ultrasound separation system (= feed to ultrafiltration unit): sampling via valve V15
- concentrate of ultrafiltration unit: sampling via valve V10
- permeate of ultrafiltration unit: sampling via valve V9

6. Adaptation for space

6.1 Compatibility with microgravity

Of the techniques in the breadboard, two processes are gravity dependent i.e. the transfer of the cell suspension from one tank to the next (from growth reactor to buffer tank and from buffer tank to concentration tank) and the ultrasonic separation. The dependency of cell transfer on gravity can of course be eliminated by using pumps.

For the ultrasonic separation, part of the separation process consists of a settling of aggregates. As described in technical note 72.7.3, the cell suspension is circulated from a reactor or tank through a resonance chamber back to the reactor at a given recirculation rate. A second pump operating at about one third of the recirculation rate, drags clarified water (= harvest) out of the chamber at the top. Acoustic forces retain the cells in nodal planes where they form loose clumps. As long as the ultrasonic field is switched on, the clumps are held stationary against the fluid drag in the chamber. However, to prevent clogging of the chamber with cells, the field needs to be switched off at regular time intervals. During that period, the pump in the harvest line is switched off and the aggregates settle due to gravitational forces.

To eliminate the dependency of ultrasonic separation on gravity, two approaches can be envisaged. On the one hand, a suction could be applied on the recirculation line to drag the aggregates back into the reactor when the ultrasonic field is switched off. On the other hand, a prime rate reverse pump can be used in the harvest line. It has the advantage that it automatically reverses the flow direction when the ultrasonic field is switched off. However, attention has to be paid to the fact that the resonance chamber may be completely empty of the cell suspension and part of the clear filtrate in the harvest tube may return into the chamber. Therefore, stop times should be sufficiently short.

6.2 Equivalent system mass considerations

As yet, the design of the harvesting system has not been optimised with respect to volume requirements. For space adaptation, attention will have to be paid to the reduction in the number of tanks needed, the possibility to combine different units in one, the time frame in which the harvesting and washing has to be finished, etc.

Operation of the breadboard is quite labor intensive. To reduce manpower requirement, the harvesting system will need to be automated to the highest possible degree. The collection of the growth reactor overflow in the buffer tank, the transfer of the harvest of one day to the concentration tank, the sequence of concentrating and washing steps and the operation, backwashing and cleaning of the ultrafiltration (UF) unit can easily be automated. When an electrodialysis unit is included in the final design for desalination of the UF permeate, automated control can be included for the electrodialysis process. When the optimal conditions for ultrasonic separation have been determined, automation of this unit should be possible as well. However, this would require on-line sensors for the continuous follow-up of the washout of cells from the resonance chamber.

Power consumption of the breadboard is high and will even increase when an electrodialysis unit is included in the harvest system, when analysers and controllers have to be added, etc. In a worst case scenario, currents are estimated to amount to 32 A at 380 V for the constructed breadboard.

6.3 Chemical consumption

The consumption of chemicals is mainly an item for the operation of the membrane filtration unit. Hydrodynamic conditions are chosen to reduce membrane fouling to the highest extent. Furthermore, a backwash with clean water is provided after each run in the present concept of the harvesting system with the double aim to wash the cell suspension and to reduce membrane fouling. Since membrane fouling is inevitable, cleaning will be necessary at some point. It was experimentally observed that the degree of irreversible algae binding to ceramic membranes was lower than for polymeric ones. Chosing for ceramic membranes also has the advantage that they can withstand higher temperatures than polymeric membranes. So it might be possible to use a heat treatment for membrane cleaning. The disadvantages are however that the weight of ceramic membranes is much higher and that more energy is consumed when heat treatment would be used for membrane cleaning. Additional tests should be performed on membrane cleaning to determine what is the optimal cleaning procedure and frequency.

In the breadboard, a continuous supply of chemicals is needed to prepare fresh Zarrouk medium. The overall harvest concept however included an electrodialysis step which would split the spent medium into a clean water flow which can be used in the next washing step of the algae suspension and a concentrated salt solution which can be used to prepare fresh medium to the photoreactor. This would significantly reduce salt consumption, although some chemicals would be needed for cleaning of the electrodialysis membranes and electrodes.

It is doubtful that growth of *Arthrospira* on full strength Zarrouk medium will occur in the final MELiSSA concept. A reduction in the salinity of the feed to compartment IV will of course be beneficial in terms of chemical consumption but can only be applied when the growth pattern of *Arthrospira* is not disturbed.

7. Component data sheets of the breadboard

	Component Data Sheet		
Made by:	EPAS	Checked by:	
Project ref:	Melissa3 - L2356	Document ref :	
Issue date:	2004-03-23	Revision date :	

Component reference	**KT1**
Description	Cooling bath temperature control
Type	C10
Sub-type	003-509
Model Number	1200301018058
Manufacturer	Thermo Haake
Sales office	Glasatelier Saillart
Function	Controls the bath cooler temperature
Remarks	

General Characteristics			
Power source	Electricity	Protection Class (IP)	30
Voltage (V)	230	Dimension (mm)	
Power input (W)	1550	Weight (kg)	
Power output (W)		Design Pressure (bar)	
Current draw (A)		Design Temperature (°C)	20
Fuse protection (A)	2 x 8A	Safety instructions	

Specific Characteristics			
Body materials			
Sealing materials			
Connector type			
Connector size			

Document references			
Component drawing		Certificates	
Input/output list		Guarantee period	
Electric Wiring Diagram		Guarantee documents	
Warning symbols		Manual reference	

Component Data Sheet

Made by:	EPAS	Checked by:	
Project ref:	Melissa3 - L2356	Document ref :	
Issue date:	2004-03-23	Revision date :	

Component reference	**K1**
Description	Cooling bath
Type	K15
Sub-type	002-4288
Model Number	1200300581009
Manufacturer	Thermo Haake
Sales office	Glasatelier Saillart
Function	Cooling of the algae bioreactor and the buffertank
Remarks	

General Characteristics

Power source	Electricity	Protection Class (IP)	20
Voltage (V)	230	Dimension (mm)	385 x 465 x 415
Power input (W)	2600	Weight (kg)	
Power output (W)		Design Pressure (bar)	
Current draw (A)	12	Design Temperature (°C)	
Fuse protection (A)	2 x 10A; 2 x 5A	Safety instructions	

Specific Characteristics

Body materials	SS
Sealing materials	
Connector type	
Connector size	

Document references

Component drawing		Certificates	
Input/output list		Guarantee period	
Electric Wiring Diagram		Guarantee documents	
Warning symbols		Manual reference	

Component Data Sheet

Made by:	EPAS	Checked by:	
Project ref:	Melissa3 - L2356	Document ref :	
Issue date:	2004-03-23	Revision date :	

Component reference	**UFD1**
Description	Frequency converter
Type	T-verter
Sub-type	E2 series
Model Number	
Manufacturer	Taian Electric Co, LTD
Sales office	Flowtec
Function	Controls pump P4
Remarks	

General Characteristics

Power source		Protection Class (IP)	
Voltage (V)		Dimension (mm)	
Power input (W)		Weight (kg)	
Power output (W)		Design Pressure (bar)	
Current draw (A)		Design Temperature (°C)	
Fuse protection (A)		Safety instructions	

Specific Characteristics

Body materials	
Sealing materials	
Connector type	
Connector size	

Document references

Component drawing		Certificates	
Input/output list		Guarantee period	
Electric Wiring Diagram		Guarantee documents	
Warning symbols		Manual reference	

Component Data Sheet

Made by:	EPAS	Checked by:	
Project ref:	Melissa3 - L2356	Document ref :	
Issue date:	2004-03-23	Revision date :	

Component reference	**P1**
Description	Peristaltic pump with easy load pumphead
Type	Masterflex L/S
Sub-type	Economy drive
Model Number	7554-85
Manufacturer	Barnant
Sales office	Applitek
Function	Influent pump
Remarks	

General Characteristics

Power source	Electricity	Protection Class (IP)	22
Voltage (V)	230	Dimension (mm)	220 x 180 x 135
Power input (W)		Weight (kg)	4,1
Power output (W)	37	Design Pressure (bar)	
Current draw (A)	0,9A	Design Temperature (°C)	0-40
Fuse protection (A)	T1,0	Safety instructions	

Specific Characteristics

Body materials	Painted Steel
Sealing materials	
Connector type	
Connector size	

Document references

Component drawing		Certificates	EN61010-1/A2 EN61326-1/A1
Input/output list		Guarantee period	
Electric Wiring Diagram		Guarantee documents	
Warning symbols		Manual reference	

Component Data Sheet

Made by:	EPAS	Checked by:	
Project ref:	Melissa3 - L2356	Document ref :	
Issue date:	2004-03-23	Revision date :	

Component reference	**P2**
Description	Peristaltic pump with easy load pumphead
Type	Masterflex L/S
Sub-type	Economy drive
Model Number	7554-85
Manufacturer	Barnant
Sales office	Applitek
Function	Recirculation pump
Remarks	

General Characteristics

Power source	Electricity	Protection Class (IP)	22
Voltage (V)	230	Dimension (mm)	220 x 180 x 135
Power input (W)		Weight (kg)	4,1
Power output (W)	37	Design Pressure (bar)	
Current draw (A)	0,9A	Design Temperature (°C)	0-40
Fuse protection (A)	T1,0	Safety instructions	

Specific Characteristics

Body materials	Painted steel
Sealing materials	
Connector type	
Connector size	

Document references

Component drawing		Certificates	EN61010-1/A2 EN61326-1/A1
Input/output list		Guarantee period	
Electric Wiring Diagram		Guarantee documents	
Warning symbols		Manual reference	

Component Data Sheet

Made by:	EPAS	Checked by:	
Project ref:	Melissa3 - L2356	Document ref :	
Issue date:	2004-03-23	Revision date :	

Component reference	**P3**
Description	Gear pump with easy load pumphead
Type	Micropump
Sub-type	
Model Number	75211-55
Manufacturer	Barnant
Sales office	Applitek
Function	Recirculation pump
Remarks	Pumphead : GJ-N21.JF1SA

General Characteristics

Power source	Electricity	Protection Class (IP)	23
Voltage (V)	230	Dimension (mm)	292 x 203 x 184
Power input (W)		Weight (kg)	5
Power output (W)	0,075	Design Pressure (bar)	
Current draw (A)	1,1A	Design Temperature (°C)	0-40
Fuse protection (A)	T1,6	Safety instructions	

Specific Characteristics

Body materials	ABS case, irridite-coated aluminium chassis
Sealing materials	
Connector type	
Connector size	

Document references

Component drawing		Certificates	EN61010-1/A2 EN61326-1/A1
Input/output list		Guarantee period	
Electric Wiring Diagram		Guarantee documents	
Warning symbols		Manual reference	

Component Data Sheet

Made by:	EPAS	Checked by:	
Project ref:	Melissa3 - L2356	Document ref :	
Issue date:	2004-03-23	Revision date :	

Component reference	**P4**
Description	Magnetic gear pump
Type	MDG-R15P
Sub-type	
Model Number	12200923
Manufacturer	Iwaki
Sales office	Flowtec
Function	Circulation in membrane loop
Remarks	

General Characteristics

Power source	Electricity	Protection Class (IP)	55
Voltage (V)	Δ 230V	Dimension (mm)	
Power input (W)	180	Weight (kg)	
Power output (W)		Design Pressure (bar)	
Current draw (A)	0,9	Design Temperature (°C)	
Fuse protection (A)		Safety instructions	

Specific Characteristics

Body materials	
Sealing materials	
Connector type	
Connector size	

Document references

Component drawing		Certificates	
Input/output list		Guarantee period	
Electric Wiring Diagram		Guarantee documents	
Warning symbols		Manual reference	

Component Data Sheet

Made by:	EPAS	Checked by:	
Project ref:	Melissa3 - L2356	Document ref :	
Issue date:	2004-03-23	Revision date :	

Component reference	**Ultrasound cell**
Description	Acoustic resonator assembly
Type	50 L
Sub-type	50 L/day
Model Number	
Manufacturer	Applisens
Sales office	Applitek
Function	Algae harvest system
Remarks	

General Characteristics

Power source	electricity	Protection Class (IP)	
Voltage (V)	1 x 230V	Dimension (mm)	177 x 97
Power input (W)	10 W	Weight (kg)	1,5
Power output (W)		Design Pressure (bar)	4
Current draw (A)		Design Temperature (°C)	130
Fuse protection (A)		Safety instructions	

Specific Characteristics

Body materials	Body: SS316 L, cuvette: pyrex glass
Sealing materials	silicone
Connector type	½" tri-clamp, 6 mm and 10 mm barbed fitting
Connector size	

Document references

Component drawing		Certificates	
Input/output list		Guarantee period	
Electric Wiring Diagram		Guarantee documents	
Warning symbols		Manual reference	

Component Data Sheet

Made by:	EPAS	Checked by:	
Project ref:	Melissa3 - L2356	Document ref :	
Issue date:	2004-03-23	Revision date :	

Component reference	**Ultrasound controller**
Description	
Type	APS 990 Controller
Sub-type	
Model Number	Z299005020
Manufacturer	Applisens
Sales office	Applitek
Function	Controls the ultrasound resonance cell and the harvest pump
Remarks	

General Characteristics

Power source	electricity	Protection Class (IP)	
Voltage (V)	1 x 240	Dimension (mm)	130 x 130 x 305
Power input (W)	150	Weight (kg)	3,5
Power output (W)	10	Design Pressure (bar)	
Current draw (A)		Design Temperature (°C)	
Fuse protection (A)	2 A slow blow 250V	Safety instructions	

Specific Characteristics

Body materials	
Sealing materials	
Connector type	
Connector size	

Document references

Component drawing		Certificates	
Input/output list		Guarantee period	
Electric Wiring Diagram		Guarantee documents	
Warning symbols		Manual reference	

Component Data Sheet

Made by:	EPAS	Checked by:	
Project ref:	Melissa3 – L2356	Document ref :	
Issue date:	2004-03-23	Revision date :	

Component reference	**R1**
Description	Magnetic stirrer
Type	MR3000
Sub-type	
Model Number	504-00011-00-1
Manufacturer	Heidolph
Sales office	Glasatelier Saillart
Function	Stirring of the algae bioreactor
Remarks	

General Characteristics

Power source	Electricity	Protection Class (IP)	30
Voltage (V)	230	Dimension (mm)	2400 x 155 x 120
Power input (W)	25	Weight (kg)	2,4
Power output (W)		Design Pressure (bar)	
Current draw (A)		Design Temperature (°C)	0-40
Fuse protection (A)		Safety instructions	

Specific Characteristics

Body materials	Polyamide coat housing; active surface: 1.4301; polyester front panel
Sealing materials	
Connector type	
Connector size	

Document references

Component drawing		Certificates	
Input/output list		Guarantee period	
Electric Wiring Diagram		Guarantee documents	
Warning symbols		Manual reference	

Component Data Sheet

Made by:	EPAS	Checked by:	
Project ref:	Melissa3 - L2356	Document ref :	
Issue date:	2004-03-23	Revision date :	

Component reference	**R2**
Description	Stirrer
Type	80 807 0
Sub-type	80 807 019
Model Number	
Manufacturer	Crouzet
Sales office	Breva
Function	Stirring of the buffertank
Remarks	

General Characteristics

Power source	Electricity	Protection Class (IP)	
Voltage (V)	24 DC	Dimension (mm)	
Power input (W)	17	Weight (kg)	0,800
Power output (W)		Design Pressure (bar)	
Current draw (A)		Design Temperature (°C)	40
Fuse protection (A)		Safety instructions	

Specific Characteristics

Body materials	
Sealing materials	
Connector type	
Connector size	

Document references

Component drawing		Certificates	
Input/output list		Guarantee period	
Electric Wiring Diagram		Guarantee documents	
Warning symbols		Manual reference	

Component Data Sheet

Made by:	EPAS	Checked by:	
Project ref:	Melissa3 - L2356	Document ref :	
Issue date:	2004-03-23	Revision date :	

Component reference	**R3**
Description	Stirrer
Type	80 807 0
Sub-type	80 807 019
Model Number	
Manufacturer	Crouzet
Sales office	Breva
Function	Stirring of the concentration tank
Remarks	

General Characteristics

Power source	Electricity	Protection Class (IP)	
Voltage (V)	24 DC	Dimension (mm)	
Power input (W)	17	Weight (kg)	0,800
Power output (W)		Design Pressure (bar)	
Current draw (A)		Design Temperature (°C)	40
Fuse protection (A)		Safety instructions	

Specific Characteristics

Body materials	
Sealing materials	
Connector type	
Connector size	

Document references

Component drawing		Certificates	
Input/output list		Guarantee period	
Electric Wiring Diagram		Guarantee documents	
Warning symbols		Manual reference	