EMCS CW/RW Requirements Integration Report

N-USOC-REQ-025

Issue 1

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Summary

The CW/RW Experiment was conducted on the International Space Station from March 30th 2008 through May 23rd 2008. Several seeds in 3 ECs germinated in the CW/RW Experiment on orbit but at the end most seedlings had wilted, and only four plants in one EC barely survived until harvest.

From the very start of the experiment, a problem with watering was evident. Failure analysis of the hardware which was returned on 1J has in retrospect shown that faulty connections of the Quick Disconnects, QDs, on 2 RBLSS modules most likely were the cause of the watering issues. Due to the watering problem which either led to a complete lack of germination or poor growth of the seedlings, the PI Team decided to change a number of Experiment Requirements like illumination, watering and gravity stimuli. The Operations Team tried as far as possible to fulfill the PI Team's changed requests. The discussed solutions had not been tested on ground to a satisfactory degree, and unforeseen issues arose as a consequence of this when the changed requirements were implemented.

The problems encountered during the CW/RW Experiment on-orbit have been documented in the NASA PAR and ESA SPR Systems. Resolution of the open issues will be posted in the same systems.

Table of Contents

Acronyms

1xg	The level of gravity found on earth
AD	Applicable Document
CM	Configuration Management
CW/RW	Cell Wall / Resist Wall
EC	Experiment Container
EM	Engineering Model
EMCS	European Modular Cultivation System
ERM	Experiment Reference Model
ESA	European Space Agency
EUE	Experiment Unique Equipment
FM	Flight Model
GM	Ground Model
H/W	Hardware
ISS	International Space Station
N-USOC	Norwegian User Support and Operations Centre
PCC	Plant Cultivation Chamber
PA	Product Assurance
PI	Principal Investigator
PIM	Payload Integration Manager
PM	Project Manager
QA	Quality Assurance
QD	Quick Disconnect
RBLSS	Rotor Based Life Support System
RH	Relative Humidity
RD	Reference Document
URC	User Requirements Collection

Applicable and reference documents

Applicable Documents

	Doc. Number	Issue/Date	Rev	Title
AD01	N-USOC-REQ-007	06.07.07	1	EMCS CWRW Integration Requirements Document
AD02	N-USOC-ICD-004	D		N-USOC to CW/RW Interface Control Document
AD03	N-USOC-MAN-004	31.03.06		EMCS Ground Models Usage Process Plan
AD04	EMEX-RP-MULT-02-EADS	11.12.03		"EMCS-Experiments, Multigen Part 1 Design Report" (EADS)
AD05	EMCS-MA-4000-002-DCR	12.11.04	2	"EC User Handbook"
AD06	RP_30193_PR_02	06.10.05		"EMCS Experiments Multigen-1 Design Report CCN04" (Prototech)
AD07	EMEX_MA_MULT_01_PRO	15.05.06	D	"EMCS Multigen 1 PCC 1 – User's Manual"
AD08	EMEX_PR_MULT_04_PRO_A	05.12.06	A	Procedure for filtering of Zeolite
AD09	N-USOC-PRO-004	16.01.2008	1	CW/RW Seed Set Up Procedure
AD10	POIF-1005	Oct. 2007	C	Payload Operation Handbook Volume 2
AD11	N-USOC-MAN-004	31.03.2006	D2	EMCS Ground Models Usage Process Plan

Reference Documents

RD	Document Number	Date	Issue	Title
RD01	Test N-USOC-TR-25	08.01.2008	1	EMCS ERM CW/RW Test Report - Biocompatibility (Germination Test)
RD02	Test N-USOC-TR-28	12.02.2008	1	EMCS ERM Cell Wall/ Resist Wall Test Report – Science Test
RD03	Test N-USOC-TR-29	26.02.2008	1	EMCS EM CW/RW Re-watering Verification Test Report
RD04	N-USOC-NOT-HS-002	15.02.2008	1	PCC Watering Strategy for the CWRW Experiment
RD05	N-USOC-PRO-005	27.02.2008	2	CW/RW Flight Sample/ Hardware Packing, Transport and Check-Out Procedure

1. Scope

1.1 Purpose

This document describes the results and a validation of the CW/RW Experiment Requirements Integration Process performed by N-USOC. The integration was based on the Experiment Requirements documented in the CW/RW Integration Requirements Document (AD01) as well as Test Plans, Appendix 1, which identified requirements that had to be tested by the PI-team at N-USOC in the EMCS Ground Models, either to verify that the requirements could be met or to optimize integration into the EMCS facility.

1.2 Document Overview

The scope of the document is summarized in section 1; the CW/RW experiment scientific objective and experiment flow are described in Section 2. Section 3 contains a summary and a validation of how the Experiment Requirements were integrated pre-experiment (3.1, 3.2 & 3.3), during the experiment (3.4) and post-experiment (3.5). Section 4 identifies Payload Anomalies and incidents which led to alteration of Experiment Requirements. Section 5 summarizes the conclusion of the integration.

2. Introduction

2.1 Scientific Objective

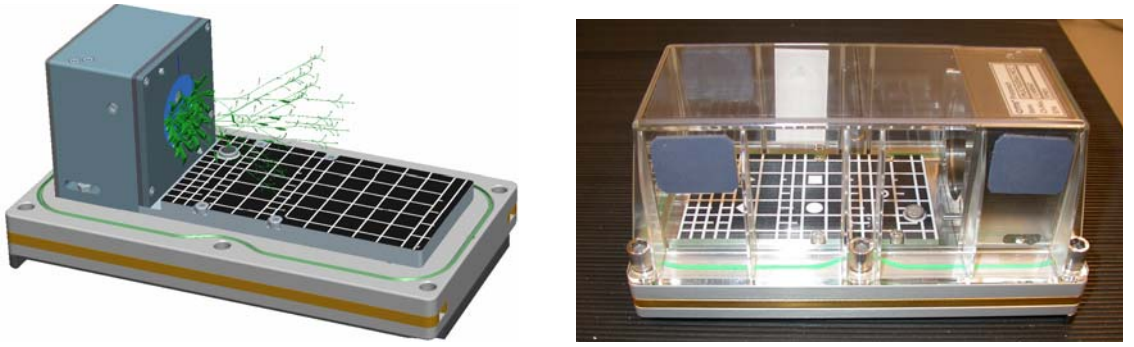
Cell wall:
Cell walls of plants play a crucial role in forming supporting tissue in stems so they can grow in an upright position. Different types of cell wall components, such as cellulose, xyloglucan and lignin, are all involved in wall dynamics which give this type of support to plant tissue. It is expected that the metabolism and gene expression of a number of these substances is highly sensitive to gravity. And one wished therefore to examine the gene expression of these cell-wall related gene families in a micro-gravity environment. By using *Arabidopsis Thaliana,* the goal was to identify gene sets which play a role in gravity-dependant formation of supportive tissue in plants.

Resist wall:
Plants have two major responses to gravity; roots experience gravitropism (they grow downwards), and the shoot experiences resistance to the gravitational force by growing upwards. Little information about resistance to the gravitational force has been obtained compared to gravitropism.

The hypothesis is that the mutual dependency between microtubules, the plasma membrane and the cell wall in plants is responsible for gravity resistance. *Arabidopsis* mutants that are defective, in various ways, of forming these cellular components show distorted growth on earth. However, it was expected that such mutants are rescued and can grow and develop normally as wild types under microgravity in space. Therefore it was desirable to cultivate these mutant strains under microgravity and at 1 g conditions on orbit, for comparison with the wild type. When retrieving the plants to earth, changes in expression of genes involved in formation of microtubules, plasma membrane and cell walls could also be analyzed.

2.2 Experiment Unique Equipment

The CW/RW Experiment Unique Equipment (EUE) consisted of a Plant Cultivation Chamber (PCC)(AD07) which is an advanced flower pot that monitors the humidity in the growth medium and adds water when the delta pressure in the growth media is below a defined level. A reference sheet was located on the base-plate of the Experiment Container (EC) (Figure 2.1).



A B

Figure 2.1 CW/RW A; Plant Cultivation Chamber (PCC) and Reference Sheet assembled on an Experiment Container (EC) Base plate, B; EC with EC Cover

The growth support consisted of Zeolite (ZeoPro) with propylene felt (PP-felt) on the top.

2.3 CW/RW Operational Scenario

The CW/RW Operational Timeline as planned before experiment start is outlined in figure 2.2. The CW/RW pre-flight operations and experiment as performed is documented in chapters 3.3 and 3.4. All samples were mounted on ground and the crew operations on board involved EMCS generic Crew Procedures (EMCS EC replace, EMCS Water Reservoir replace, EMCS Valve movements, EMCS Power Switch configuration and Clean Up activities post-experiment) and CW/RW specific Crew Procedures (CW/RW KFT MELFI Retrieval, CW/RW MSG Set-UP, CW/RW Harvest in MSG etc.).

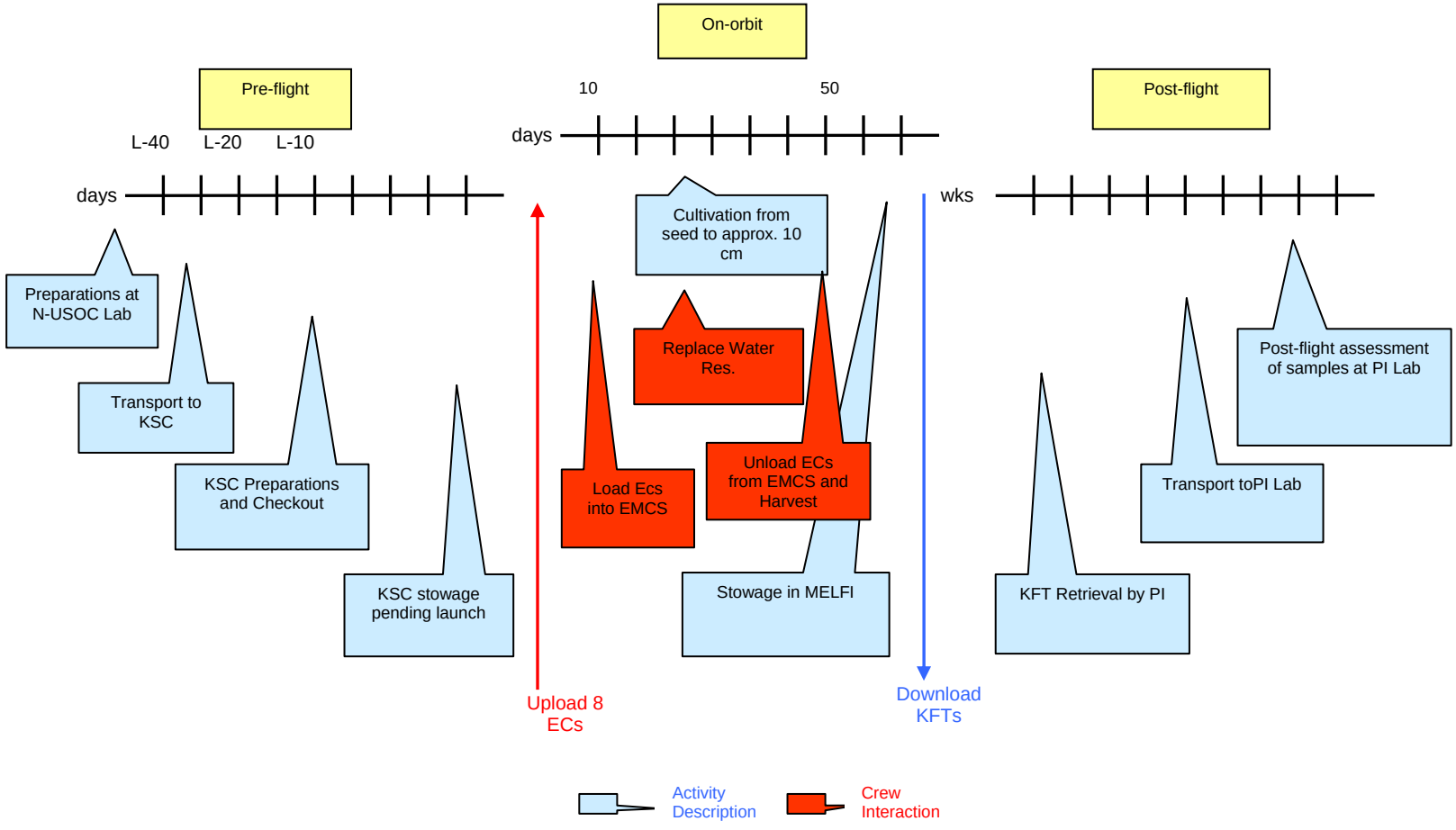


Figure 2.2 CW/RW Pre-flight, on-orbit and retrieval timeline as planned before experiment start.

3. The Experiment Requirement Integration Process as Performed

The CW/RW Experiment's Integration Requirements are documented in the CW/RW Integration Requirements Document, N-USOC-REQ-007 (AD01). The current document summarizes the actual products developed during the Integration phase and describes in which way different requirements were met on orbit. The CW/RW Integration and Real Time Operations Flow with time aspects, responsible parties and resulting products can be seen in table 3.1.

For further details on scientific status after execution of the experiment, reference is made to reports made by the ESA Mission Science Office (ESA MSO) Team and the Principal Investigator Team.

Table 3.1 CWRW Integration and Real Time Operations Flow with time aspects, responsible parties and resulting products.

Consolidation, Integration and Real Time Ops	**Start**	**End**	**Responsible**	**Product**
Requirements Consolidation phase			N-USOC	Consolidation List
Integration Requirements Document		29.03.07	N-USOC	EIRD
CW/RW Test Campaign	17.09.07	09.01.08		Test Reports
Requirement input to NASA POIC			N-USOC	URC, ground rules & Constraints, Payload Regulations
Experiment Sequence Test (EST)	19.02.08	21.02.08	N-USOC	EST Report
Flight Sample Set-Up	15.01.08	21.01.08	PI	Flight samples, Current Report
EC Check-out	21.01.08	25.01.08	IOT, HFIT, IPLAT	Verified ECs, Report by IOT, HFIT, IPLAT
Transport/Handover	03.03.08	10.03.08	N-USOC	Samples handed over to NASA, Current Report
Real Time Operations	29.03.08	23.05.08	N-USOC	Current Report, CW/RW Change Request Log, OSRs

3.1 CW/RW Integration Testing in EMCS Ground Models

As part of the Experiment Integration 4 tests were performed in the EMCS Ground Models at N-USOC. A summary of these tests can be seen in table 3.2. All activities involving usage of the EMCS ground models were coordinated within the "EMCS GM Activity Working Group" with participants from ESA, IOT, PI and N-USOC as described per AD11. Test Procedures were developed by N-USOC and reviewed and signed by participants of the EMCS GM Activity Working Group. Test reports were prepared by N-USOC after test finalization, and the reports were reviewed and signed by the same participants of the EMCS GM Activity Working Group.

Table 3.2: The table summarizes CW/RW tests performed in the EMCS Ground Models, test facility, test objective, start and end date, and test report number.

Test	Test objective	Facility	Test Objective	Start	End	Report
1	Science Test	ERM	The Arabidopsis thaliana seeds from wild type, mutants and GUS GM should germinate and develop 10 cm high stems within 50 days. • Criteria 1: Germination Rate: Group 1; Wild, Wild GM and Mutant lefty; Average 80% of seeds (7 seeds of total 9 seeds/ PCC) Group 2; Mutant hmg; Average 50% of seeds (3 seeds of total 6 seeds /PCC) • Criteria 2: Stem evolution Rate: Group 1; Wild, Wild GM and Mutant lefty; ; Average around 60% of Mini Lid (3 stems of 5 Lid/PCC) Group 2; Mutant hmg; Average around 50% of Mini Lid (1 stems of 2 Lid / PCC)	September 19th	November 7th	N-USOC-TR-28
2	Recycling Test	EM	Optimize the CW/RW watering strategy when operating the ECs with mature plants and utilizing the EMCS water recycling mode (channel excess water from dehumidifier to humidifier and EC).	November 5th	November 14th	N-USOC-TR-24
3	Biocompatibility (Germination) Test	ERM	Test and verify the functionality/performance of the CW/RW PCC/ECs when cultivating Arabidopsis thaliana from seed to early development of shoot • Test and verify biocompatibility of the CW/RW PCC/ECs when cultivating Arabidopsis thaliana from seed to early development of shoot	December 11th	December 20th	N-USOC-TR-25
4	Rewatering/ Verification Test	EM	• Verify the control strategy for automatic water supply to the PCC • Validate the different regulating schedules with the selected set points • Confirm the estimated water budget with the selected automatic watering control strategy	January 31st	February 18th	N-USOC-TR-29

3.2 CW/RW Experiment Sequence Test (EST)

The tests were finally reviewed during the Experiment Sequence Test (EST) (from February 19th to February 21st) which was a compressed table-top of all procedures and products related to the CW/RW Experiment. The main conclusion from the EST was that the EST was a success and that all parties recommended continuing with CW/RW Flight preparations, with some necessary updates to procedures and products. Considerations mentioned in the EST Report can be seen in table 3.3.

Table 3.3 Considerations discussed during the CW/RW EST and documented in the EST Report.

Objectives		Comment
1	The EMCS CW/RW tests and the schedules have been evaluated to meet the scientific objectives in EMCS: "to support stem development of the 4 different Arabidopsis thaliana wild type, *hmg*, GUS-Wild, *lefty* under the environmental condition requested by PI."	N-USOC-TR-25 (RD01), N-USOC-TR-28 (RD02), N-USOC-TR-29 (RD03) The testing which has been performed in the EM has covered the whole duration of the experiment in sequences. The Water Strategy and Water Budget estimation (N-USOC-NOT-HS-002) (RD04) is a result of these tests. Schedules used during these tests will be the basis for The Flight Schedules for the CW/RW experiment on orbit. Some alterations need to be made for the schedules to be made applicable for the whole run, positions watering etc. These Flight schedules are not complete and are an open issue which will be closed before flight. NOTE: As part of the EST or Pre-EST testing there has not been performed a start to end sequence test of the experiment run in the EMCS GM using the EMCS schedules that shall be used in Flight with the parameter setting defined in the Water Strategy and Water Budget.
1.1	*Arabidopsis thaliana* shall grow automatically from seed to approximately 10 cm in the EMCS Ground Models supported by the PCC.	Verified in Science Test N-USOC-TR-28 (RD02)
1.2	Seeds germinate in the ECs and confirm biocompatibility	Verified in Biocompatibility Test N-USOC-TR-25 (RD01)
1.3	Water is supplied to the Growth Pot after the initial watering by delta pressure early enough to support further growth of seedlings	Verified in N-USOC-NOT-HS-002 (RD04)
1.4	Water amount is sufficient to keep plants vigorous without sign of exsiccation	The critical phases of the experiment as identified in Muligen-1 have been tested in the EM, and based on this the water usage has been estimated and a water budget has been made. NOTE: The EMCS FM and EM are similar, but not identical, and may result in a higher water usage. In case of water shortage due to a potential difference in recycling compatibility between the FM and EM, a strategy has been found to ensure further growth of plants. N-USOC-NOT-HS-002
2	The transport procedures, the crew procedures and OCA message should have been evaluated to meet the PIs requirement and ensure optimal samples returned to the PIs lab.	OCA message will be finalized after growth development is established in real time. There are a few open issues regarding the Transport Procedures and the return of the hardware which will be closed shortly. These issues are regarded as normal open work.
3	The procedures will confirm that the EMCS models are kept under the correct configuration and the operation should be in accordance with the EC handbook and the EMCS User Manual applicable to this EST.	Verified during EST.
4	All NCRs with negative impact on CW/RW should be closed.	NCR-002 needs a minor update regarding the water-repellent properties after complete dry-out seen during Science Test. This was due to a human error (forgot to rewater before day 20) and will not occur on flight. (Automatic water strategy). This is regarded as normal open work.
5	All PARs with negative impact on CW/RW should be closed.	PAR-HW-006 needs further testing before closure. Testing was performed on EMCS FM on the 25th February 2008 and the results will be presented in the NASA PAR System under EMCS PAR- HW-006. The EST participants identified PAR-HW-006 as an impact on CW/RW operations. The EMCS generic Payload Anomalies will be handled separately.

3.3 Overall activities and products related to CW/RW Pre-flight Operations

Activities and products related to set-up of the EUE and samples are described in section 3.3.1. Activities and products related to transport of hardware from set-up location to KSC are described in section 3.3.2.

3.3.1 Set-Up and EUE Verification

The main activities related to preparations at N-USOC are listed in table 3.4. The related products and performance documents are referenced.

Table 3.4 CW/RW Sample preparation at N-USOC laboratory

Activity	Product	Procedure
Preparations at N-USOC by PI-Team	8 ECs and 8 PCCs	Integration performed by PD
	Set-up of 8 Growth Pots, growth support and seeds	N-USOC-PRO-004
	Implementation of 8 integrated Growth Pots into 8 PCCs	N-USOC-PRO-004
	Enclosure of ECs with integrated EUE	N-USOC-PRO-004
Final Verification by IOT	Leakage check and balancing of the 8 ECs with integrated EUE	
Sharp-edge inspection by HFIT	8 ECs with integrated EUE were inspected for sharp edges	EMCS-RP-0000-131-DOR
Approved labeling by IPLAT	Labels on the 8 ECs with integrated EUE were inspected	EMCS-RP-0000-131-DOR

Preparations at N-USOC were performed without any major deviations from procedure. The CW/RW EUE was assembled at N-USOC. The PCCs were filled with growth support before seeds, immobilization membranes, borosilicate doughnuts and mini lids were implemented (AD09). After PCC assembly and seed implementation the EC covers were mounted on the CW/RW EC Base plate. 8 ECs were prepared for the CW/RW Experiment and the CW/RW seed and EC Assignment list can be seen in table 3.5.

Table 3.5 CW/RW EC and seed assignment list as agreed prior to experiment execution

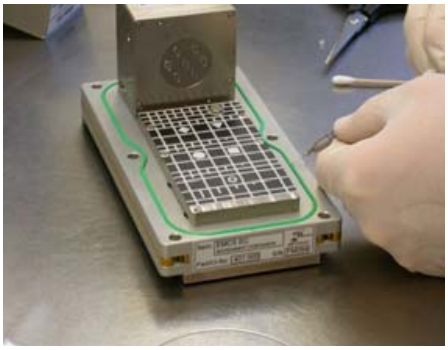
EC Location	Flight EC A1		Flight EC A3		Flight EC A2		Flight EC A4		Flight EC B1		Flight EC B3		Flight EC B2		Flight EC B4	
EC FM	92		94		95		96		97		98		99		100	
PCC FM	21		18		19		20		16		22		23		17	
mini-lid	**strain**	**num**	**strain**	**num**	**strain**	**num**	**strain**	**num**	**strain**	**num**	**strain**	**num**	**strain**	**num**	**strain**	**num**
1	WT	2	WT	1	WT	2	GUS	1	WT	2	WT	1	WT	2	GUS	1
2	WT	2	WT	1	WT	2	GUS	1	WT	2	WT	1	WT	2	GUS	1
3	lefty	3	WT	1	hmg	3	GUS	1	lefty	3	WT	1	hmg	3	GUS	1
4	lefty	3	WT	1	hmg	3	GUS	1	lefty	3	WT	1	hmg	3	GUS	1
5	lefty	3	WT	1	hmg	3	GUS	1	lefty	3	WT	1	hmg	3	GUS	1
6	lefty	3	WT	1	hmg	3	GUS	1	lefty	3	WT	1	hmg	3	GUS	1
7	lefty	3	WT	1	hmg	3	GUS	1	lefty	3	WT	1	hmg	3	GUS	1

The preparations are documented in the filled-in procedure PCC Assembly and Seed Set-Up Report (Appendix 2). Figure 3.1 A-D illustrates parts of the Set-Up.

A

B

C



D

Figure 3.1 Images from EUE Set-up at N-USOC

After Set-up and Assembly of the PCCs the ECs were subjected to a final verification by the Industrial Operator Team, IOT. The ECs were checked for leakage and were balanced and adjusted for centre of gravity. They were also checked for sharp edges by The Human Factors Implementation Team, HFIT, and the labeling was inspected by the Payload Label Approval Team, IPLAT. These processes that were performed by the IOT, HFIT and IPLAT were not part of N-USOC responsibility.

3.3.2 Transport and Checkout Activities

The main activities related to transport and checkout, are listed in table 3.6. The related products and performance documents are referenced and can be viewed in Appendix 3. The temperatures logged after set-up and until after the stowage at KSC pending launch can be viewed in Appendix 4.

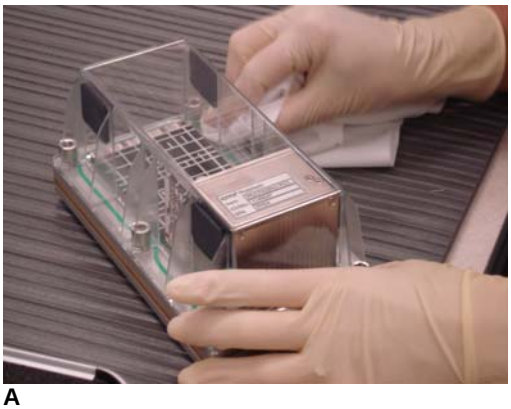
Table 3.6 CW/RW Transport to KSC, Check-out and Stowage pending launch

Activity	Product	Procedure
Transport to KSC	Transport boxes	
	Shipping papers	N-USOC-PRO-005
	Seed certificate	N-USOC-PRO-005
KSC Preparations and Checkout	8 ECs with integrated EUE	N-USOC-PRO-005
KSC Stowage pending launch	8 ECs with integrated EUE in transport bags	

The 8 assembled CW/RW ECs were surface cleaned, packed in Ziplock bags and placed in approved transport boxes BWH AZKE (95600) with protective foam (Plastazote) of more than 2.5 cm on all sides of the ECs (Figure 3.2). The integrated ECs were transported to KSC by Airplane. The ECs were not exposed to X-Rays at any time during the transport.

Figure 3.2 The CW/RW ECs were packed in Zip lock bags and transported in foam-coated transport-boxes per agreement with PD.

The check-out was performed at KSC March 6, 2008. The ECs were surface cleaned (figure 3.3A), and the ECs were placed in NASA approved Zip-lock bags (figure 3.3B). Sharp-edge and cleanliness inspections were performed. No anomalies were detected.



A

B

Figure 3.3 Surface cleaning of ECs and placed in NASA approved Zip-lock bags.

Late load of the samples (L-10) was required in order to avoid long time storage in EUE prior to Experiment start. The assembled CW/RW ECs were handed over to Flight Crew Office on March 10th, 2008 where they were packed in soft stowage before launch on March 11th, 2008 - 18 days prior to experiment start.

3.4 CW/RW On-orbit Operations

The CW/RW on-orbit activities are listed in table 3.7. The related products are referenced.

Table 3.7 Activities related to on-orbit CW/RW Cultivation and stowage

Activities	Product	Procedure
CW/RW KFT transfer to MELFI	Crew Proc: Initial insertion in MELFI	2.001 CELL WALL/RESIST WALL KFT INITIAL MELFI INSERT(MGUEEXPRSCWRWN001)
EMCS Preparation	Crew Proc: Opening of Gas Valve	2.024 EMCS Valve Movements for Ground Commanding (MGUEEXPRSEMCSN024)
Install CW/RW ECs in EMCS	Crew Proc: Replace Ref ECs with CW/RW ECs	2.005 EC Replacement (MGUEEXPRSEMCSN005)
Automatic hydration of seeds in EMCS	Schedules	
Water flow check due to lack of hydration	Crew Proc: Check water flow	4.002 EMCS Water Flow Checks (MGUEEXPRSEMCSC002)
EMCS Main Door Check	Crew involvement	Check Main door not closing correctly
Water Reservoir Stowage Check	Crew involvement	Check that the correct Water Reservoirs are installed
ER3/EMCS Preparation for H2O Res. Replace	Crew Proc: Turn Power Switches Off	2.028 EMCS Switch Configuration with Power off (MGUEEXPRSEMCSN028)
EMCS Water Reservoir Replace	Crew Proc: Replace Water Reservoir	2.011 EMCS Water Reservoir Replacement (MGUEEXPRSEMCSN011)
ER3/EMCS Preparation for restart of experiment run after H2O Res. Replace	Crew Proc: Turn Power Switches On	2.028 EMCS Switch Configuration with Power off (MGUEEXPRSEMCSN028)
EC Swap on Rotor A and B	Crew Proc: Exchange ECs A1 and A2 with ECs B1 and B2	2.004 Experiment Container Removal 2.003 Experiment Container Insertion
Retrieval of CW/RW KFTs from MELFI pre-Harvest	Crew Proc: KFT Retrieval from MELFI	2.003 Cell Wall Resist Wall KFT MELFI Retrieval (MGUEEXPRSCWRWN003)
Set-Up of MSG pre-Harvest	Crew Proc: MSG Set-up	2.002 Cell Wall Resist Wall MSG Set Up (MGUEEXPRSCWRWN002)
Harvest of CW/RW plants	OCA message and Crew Proc: Harvest of plants in MSG	2.004 CELL WALL/RESIST WALL HARVEST IN MSG (MGUEEXPRSCWRWN004)
Insertion of KFTs in MELFI after Harvest	Crew Proc: CW/RW KFT Insert in MELFI	2.005 Cell Wall/ Resist Wall KFT MELFI Insert (MGUEEXPRSCWRWN005)
Insertion of EMCS Ref ECs	Crew Proc: Replace CW/RW ECs with Ref ECs	2.005 EC Replacement (MGUEEXPRSEMCSN005)
EMCS Dry-Out	Schedules	
Preparation for hibernating EMCS	Crew Proc: Closing of gas valves	2.024 EMCS Valve Movements for Ground Commanding (MGUEEXPRSEMCSN024)
Stowage at -95 C in MELFI before packing in Double cold bags for Ascent	NASA responsible with N-USOC Support	

On March 30 2008, Crew inserted the CW/RW ECs in the EMCS positions as can be seen in table 3.5. Initial hydration of the EC A1, A2 and B1, B2 was attempted, and progressed very slowly. (The hydration attempt only resulted in a small increase in rh for EC B1). After a couple days it was clear that hydration of the first four ECs was non-functioning and potential causes were thought to be incorrect connections between EMCS RBLSS boxes, EMCS Water Reservoirs and EMCS ECs. Crew time was requested in order to verify correct configuration of EMCS Water Subsystem connections. Astronaut Garrett Reisman performed the EMCS Water Flow Checks on April 5 2008 and reported that he could not see any obvious failures.

After the Water Flow Checks, hydration of all ECs except EC B4 was attempted several times but showed little difference in PCC rh. The hydration of EC A1 was not sufficient to trigger the delta pressure sensor which indicates a full growth pot, it was however sufficient to lead to germination in A1 (April 11th.) These seedlings were in danger of drying out due to lack of water, and therefore workarounds were implemented. As a short term plan recycling mode was used (water from the dehumidifier was directed to the EC instead of waste) and the time period of light was reduced.

Crew time was needed again for trying to assess the hydration problems and Garrett performed the Water Reservoir stowage check. Even though he confirmed that the correct Water Reservoirs were installed, the troubleshooting activities already performed seemed to point out the EMCS Water Reservoirs as the most likely candidates for the hydration issues. Therefore, on April 22nd, the reservoirs were exchanged with new ones that were stowed on ISS.

After the reservoir replacement hydration attempts of the ECs was resumed, and hydration of position B1, B3 and B4 was deemed successful (delta pressure trigger). On April 26th and 27th germination was observed in position B3 and B4. Hydration of position A1, A2, A3, A4 and B2 was not successful and the seedlings in A1 were still in danger of drying out.

Due to the unsuccessful hydration in A1, Crew time was requested again, and this time to exchange two ECs on rotor A with two ECs on rotor B. The rationale for this request was that: After the Water Reservoir Replace, EC B1 was hydrated and indicated a full growth pot, but the seeds in this EC had not germinated. A probable cause was that the seeds had been added small amounts of water prior to the reservoir replace, but not sufficient to germinate, and after this they had deteriorated. This indicated that the position B1 could support hydration and it was proposed to exchange EC A1 with the EC B1 to rescue the small seedlings present in EC A1.

Crew was also asked to exchange EC A2 with EC B2 to support troubleshooting analysis of the hydration issue. The new positions of the CW/RW ECs after the EMCS CW/RW EC Exchange on May 5th can be seen in table 3.8. The green filling indicates positions were there were seedlings. An updated experiment database was also created to support the new EC configuration.

Table 3.8 CW/RW EC and seed assignment list after CW/RW EC Exchange

EC Location	Flight EC A1	Flight EC A2	Flight EC A3	Flight EC A4	Flight EC B1	Flight EC B2	Flight EC B3	Flight EC B4
EC FM	97	99	94	96	92	95	98	100
Seed Type	WT/lefty	WT/hmg	WT	GUS	WT/lefty	WT/hmg	WT	GUS

Hydration of the small seedlings present in position B1 was tried again but unfortunately without any indication of successful water supply. Figure 3.4 shows the seedlings in B1 two days after the last watering attempt. In Appendix 5 a summary of hydration for all ECs can be found.

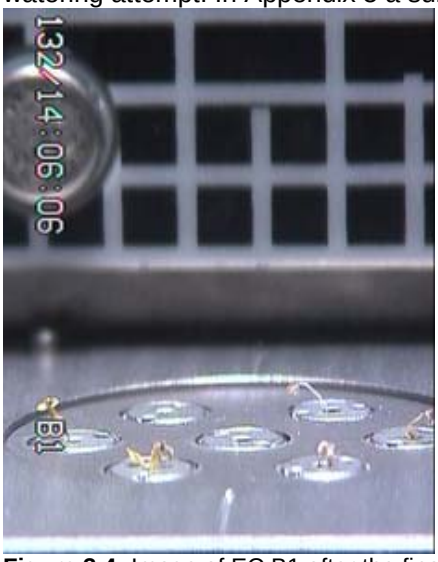


Figure 3.4: Image of EC B1 after the final watering attempt was performed on May 9th.

On April 30th and May 4th, although strongly advised against by N-USOC, ECs B3 and B4 were added 5 pulses of water on request from PI team. A delta pressure check in ECs B3 and B4 was also requested by PI-team to see if the seedlings needed water again on May 7th. It was advised against a delta pressure check by N-USOC because of the danger of flooding the bottom chamber. The delta pressure check was performed anyway, and when performing this check (15 seconds in Watering Mode) the dP triggered in both ECs indicating full growth pots. The check lead to water flooding the bottom chamber in EC B3 (PAR EMCS-HW-013) and the flow stopped. Attempts were made several times to start the humidity control in B3 but this failed. Due to no flow in this EC, the lights were switched off to avoid an increase in EC temperature. (Lights remained on in the other ECs.) After five days, and continued attempts, the humidity control in B3 was started successfully. This was however too late for the seedlings in B3, and they had wilted due too drowning, see figure 3.5.

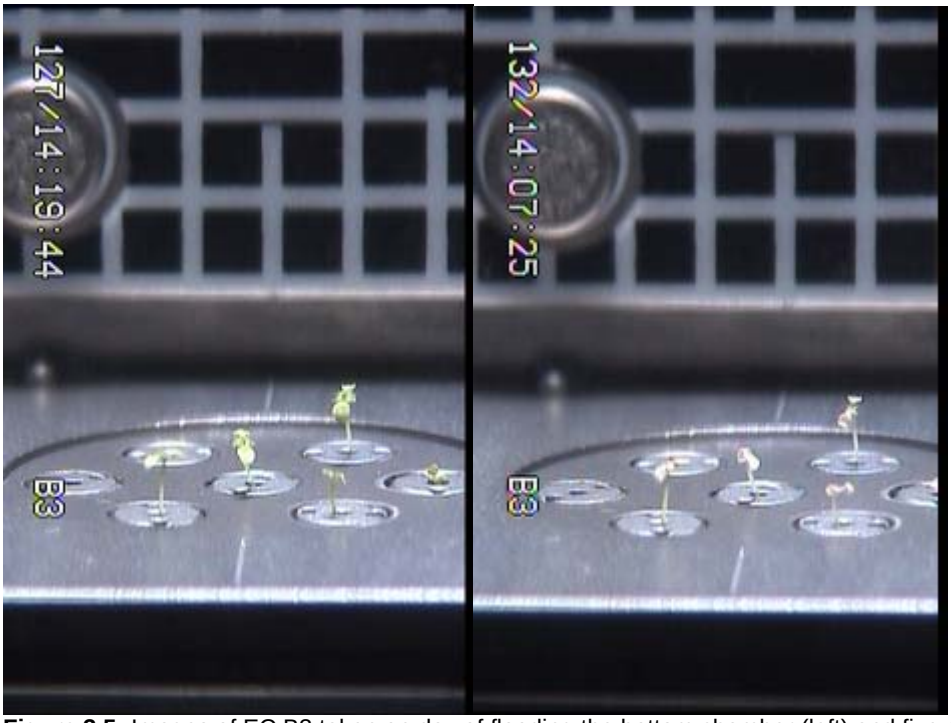


Figure 3.5: Images of EC B3 taken on day of flooding the bottom chamber (left) and five days later when flow was resumed in this position (right)

On May 13th the lights in position B4 were switched to FULL (from REDUCED) on day 20 after initial hydration. Rapid observation of EC B4 was also implemented (every 5 minutes). In the following week, images of B4 and sensory data indicated that water was needed. Several failed attempts were made to hydrate this position and reverse pumping was also attempted. (Reverse pumping is to suck water from the EC and pump it to the dehumidifier to remove any blocking particles or debris in the needles.) The light in B4 was also switched from full to reduced intensity and the temperature in the EMCS incubator was lowered to 20°C to avoid dehydration. Unfortunately there was no indication that B4 received water. Figure 3.6 shows EC B4 on May 15th looking healthy and the condition of B4 the week after. Due to the watering inability, JAXA decided to request an early harvest operation.

Figure 3.6: Images of EC B4 taken on May 15th and on May 22nd, after continued watering attempts.

On May 23rd, commands were sent to prepare the facility for harvest. Garrett Resimann stopped the CW/RW Experiment and initiated the harvest procedure. The CW/RW Experiment was concluded by harvest of plants in B3 (to 1 KFT with RNALater) and B4 (largest plants to 1 KFT with RNALater, small plant to KFT with formaldehyde). The KFT with formaldehyde was frozen for return immediately after harvest (MELFI to -95°C). In total, all ECs were removed from the EMCS and stowed, see table 3.9 for details. Dry-mode of the EMCS Facility was performed in the afternoon. After three days, the two KFTs with RNALater were relocated from +2 °C dewar in MELFI to -95 °C dewar in MELFI.

Table 3.9 CW/RW Harvest

EC No	Flight EC A1 (FM097)	Flight EC A2 (FM099)	Flight EC A3 (FM094)	Flight EC A4 (FM096)	Flight EC B1 (FM092)	Flight EC B2 (FM095)	Flight EC B3 (FM098)	Flight EC B4 (FM100)
Plant material to KFT	N/A-EC Stowed	N/A-EC Stowed and later returned on 1J for troubleshooting on ground	N/A-EC Stowed	N/A-EC Stowed	EC Stowed and later returned with 1J and harvested on ground	N/A-EC Stowed	1 KFT with RNALater	1 KFT with RNALater and 1 KFT with Formaldehyde
MELFI DEWAR	N/A	N/A	N/A	N/A	N/A	NA	+2 °C for three days than relocated to -95 °C dewar	RNALater:+2 °C for three days than relocated to-95 °C dewar Formaldehyde: Directly to -95 °C dewar

The experiment lasted for 47 days, but due to late germination, the plants were estimated 23 days at the time of harvest.

For more detailed information on sensory data like temperature, relative humidity, gas composition etc during experiment execution on-orbit telemetry files located on the N-USOC Drop-box server can be accessed upon request.

3.5 Overall activities related to CW/RW Post-flight Operations

The 3 KFTs were returned on shuttle 1J on June 14th in double cold bags and recovered by PI-representatives present at SLS. Some hardware was also returned to EADS Astrium for troubleshooting the watering issues seen during the CW/RW experiment run. Including: EC FM 099, Water Reservoir FM001 and RBLSS module FM008 which were all removed from the EMCS. Water Reservoir FM009, which had been used at the start of CW/RW and exchanged by crew, was also removed from stowage and returned on 1J. One additional EC, FM092 was returned for scientific reasons and on June 16th PI-rep performed harvesting from FM092. The KFTs and harvested material were shipped to Japan in cold boxes.

4. Payload Anomalies and incidents which led to altered Experiment Requirements

4.1 PAR Summary

There were a number of unplanned abruptions to the EMCS environmental control during the on-board Cell Wall Resist Wall Experiment run (table 4.1). The major impact on the science was caused by repeated problems with hydration of the ECs (EMCS-HW-0011), the airflow problem in EC B3 (EMCS-HW-0013) and the Automatic subsystems shutdown due to lost communication between the SPLC and the TCS (EMCS-SW-0007 and EMCS-SW-0009). In addition there were a lot of incidents where the EMCS SPLC lost communication with the Express Rack 3 Rack Interface Computer (RIC) (PAR EMCS-SW-0001). This was seen in form of Health & Status telemetry dropping out and in again for different intervals ranging from 1-2 seconds to several minutes.

Table 4.1 lists the PARs that were reopened or established during CW/RW.

PAR	Description of PAR and Impact on science and CW/RW Requirements [AD01]	Affected Requirement	Corrective act. and Work-arounds during CW/RW	Impact on CW/RW after implemented workarounds	Additional requirement affected after work-around
EMCS-SW-0001 Loss of EMCS HK/H&S Packages	Loss of images and other TM data for minutes –several hours on several occurrences.	**Obs. target and freq.** EIR_Exec_09	1. Power cycle EMCS SPLC. 2. Reduction in EMCS TM Packages for a period until the TM had stabilized.	1. Resumed environmental control and images Environmental control not effected.	**Gravity level** EIR-Exec-13 **Illumination** EIR-Exec-15 **Power-interruptions** EIR-Exec-31 **Obs. target and freq.** EIR-Exec-09
EMCS-SW-0002 EMCS SPLC-Subsystems Loss of Com.	Loss of environmental control and images for 1-2 hours. One occurrence. Unwanted triggering of the EMCS H/W safety circuit resulting in switching off the EMCS subsystems occurred due to spikes on the signal of the ACS O2 safety sensor. After a workaround developed during MULTIGEN-1 (i.e., decrease the O2 level to 21 % if above) no more triggerings occurred during MULTIGEN-1. After the move to Columbus no more spikes on the O2 signal could be found. However, one single unexplained triggering of the hardware safety circuit happened during the CWRW experiment.	**Gravity level** EIR-Exec-13 **Illumination** EIR-Exec-15 **Airflow** EIR-Exec-15 **Obs. target and freq.** EIR-Exec-09 **Power-interruptions** EIR-Exec-31	1. Start of EMCS Atmosphere Control System to reduce the level of PPO2 in EMCS to 21%.		

PAR	Description of PAR and Impact on science and CW/RW Requirements [AD01]	Affected Requirement	Corrective act. and Work-arounds during CW/RW	Impact on CW/RW after implemented workarounds	Additional requirement affected after work-around
EMCS-SW-0003 EMCS VPU Lockup	Loss of environmental control and images for 1-2 hours. Several occurrences. The EMCS VPU failed to communicate with the SPLC. The root cause has been identified. An EMCS application software update and VPU driver update is required to fix the problem and has been initiated. It shall be performed before the next experiment after CWRW.	**Obs. target and freq.** EIR-Exec-09	1. Power cycle of EMCS SPLC/VPU when VPU was locked in a busy state. 2. EMCS schedule to check and repair VPU lockups. A workaround to reset the VPU by ground commanding was developed during MULTIGEN-1 and improved during CWRW.	1. Resume VPU capability period with loss of environmental control. 2. Losing images during VPU lockup, no loss of environmental control. .	**Gravity level** EIR-Exec-13 **Illumination** EIR-Exec-15 **Power-interruptions** EIR-Exec-31 **Obs. target and freq.** EIR-Exec-09
EMCS-SW-0007 Unexpected Shutdown of EMCS Subsystems	The TCS was powered down by the SPLC because the SPLC did not receive TM from the TCS for 30 sec. All other subsystems were powered off simultaneously with the TCS as expected in such a case. The other subsystems sent nominal telemetry and the EMCS power draw was nominal until the power down, i.e., the TCS was still running nominally while no TM was received. Impact on experiments: loss of illumination and artificial gravity for a short timeframe.	**Gravity level** EIR-Exec-13 **Illumination** EIR-Exec-15	The subsystems could be nominally restarted after the incident.	1. Resumed environmental control and images Environmental control not effected.	**Gravity level** EIR-Exec-13 **Illumination** EIR-Exec-15 **Power-interruptions** EIR-Exec-31 **Obs. target and freq.** EIR-Exec-09
EMCS-SW-0008 EMCS SSL File Transfer and VPU Command Issue	Same as EMCS-SW-0003. The improvement of the VPU reset command sequence described in EMCS-SW-0003 was developed because it was found that the command queue can be blocked under special circumstances when using the original reset sequence.	**Obs. target and freq.** EIR-Exec-09	1. Power cycle of EMCS SPLC/VPU when VPU was locked in a busy state. 2. EMCS schedule to check and repair VPU lockups. A workaround to reset the VPU by ground commanding was developed during MULTIGEN-1 and improved during CWRW.	1. Resume VPU capability, period with loss of environmental control. 2. Loosing images during VPU lockup, no loss of environmental control. .	**Gravity level** EIR-Exec-13 **Illumination** EIR-Exec-15 **Power-interruptions** EIR-Exec-31 **Obs. target and freq.** EIR-Exec-09

PAR	Description of PAR and Impact on science and CW/RW Requirements [AD01]	Affected Requirement	Corrective act. and Work-arounds during CW/RW	Impact on CW/RW after implemented workarounds	Additional requirement affected after work-around
EMCS-SW-0009 Automatic subsystems shutdown due to lost communication between the SPLC and the TCS	The TCS was powered down by the SPLC because the SPLC did not receive TM from all subsystems connected to the NSP bus "incubator" for 30 sec. All other subsystems were powered off simultaneously with the TCS as expected in such a case. The subsystems connected to the other NSP busses and to the RS422 interface sent nominal telemetry and the EMCS power draw was nominal until the power down, i.e., the TCS was still running nominally while no TM was received. Impact on experiments: temporary loss of environmental controls. Remark: It is taken into consideration that a common cause led to the incidents described in EMCS-SW-0002, EMCS-SW-0008, EMCS-SW-0009.	**Obs. target and freq.** EIR-Exec-09	A restart of the EMCS subsystems was only successful after a power cycle of the SPLC.	1. Resume VPU capability, period with loss of environmental control. 2. Loosing images during VPU lockup, no loss of environmental control.	**Gravity level** EIR-Exec-13 **Illumination** EIR-Exec-15 **Power-interruptions** EIR-Exec-31 **Obs. target and freq.** EIR-Exec-09
EMCS-HW-0006 EMCS Humidity Control Issue	The efficiency of the dehumidifiers of RBLSS Modules FM005 and FM006 was reduced. Impact on experiments: a) limited water recycling capability, b) temporary clogging of air tube due to a water droplet	**Relative Humidity:** EIR_Exec_3		In all cases the air flow could be re-established after the droplet had evaporated.	-

PAR	Description of PAR and Impact on science and CW/RW Requirements [AD01]	Affected Requirement	Corrective act. and Work-arounds during CW/RW	Impact on CW/RW after implemented workarounds	Additional requirement affected after work-around
EMCS-HW-0010 Experiment Container B4 Not Responding Correctly	The digital input line to EC B4 could not be switched to HIGH at the beginning of the CWRW experiment. The implications were that it was not possible to set the Plant Cultivation Chamber (PCC), accommodated inside the EC, in Watering Mode. It was still possible to supply water to the EC, but it was not possible to use the PCC's delta-pressure sensor's triggering point to detect the water saturation point of the growth pot.	**Initial Hydration:** EIR_Exec_4	After a power cycle in the frame of the crew procedure "EMCS water flow checks" the digital line was working nominally again and failed later again. A checkout of this digital line shall be performed with an EMCS EC with reference insert.	Although impacted by PAR EMCS-HW-011, B4 (EC FM100) was the most successful regarding plant material.	-
EMCS-HW-0011 EMCS ECs Not Hydrating Properly	Incorrect mounting of Waste and Fresh Water Quick Disconnects on RBLSS Modules FM007 and FM008 identified. Impact on experiments that use the watering feature of EMCS (See Appendix 7 for details)	**Initial Hydration:** EIR_Exec_4 EIR_Exec_5 EIR_Exec_6 **Experiment duration:** EIR_Exec_7 **Main Experiment objective**	1. Tried to add Water-pulses by manual cmds. 2. Tried to use gravitational force to ease the hydration 3. Tried to recycle water from dehumidifiers to EC 4. Tried exceeded pumping time to force away eventual debris.	1. Germination was seen in EC FM092, FM098 and FM100. 2. The workarounds could not support the seedlings and early harvest was required	**Gravity level**: EIR_Exec_13 **Illumination:** EIR_Exec_15 **Harvesting:** EIR_Exec_17 EIR_Exec_18 EIR_Exec_19 **Main Experiment objective**
EMCS-HW-0013 Zero Airflow in EC B3	The water outlet filter of EC B3 was blocked due to too much water in the "bottom chamber" in the CWRW growth pot.	**Main Experiment objective**	After the water had evaporated the airflow could be restarted after 5 days and remained nominal.	The "flooding" of EC B3 (FM098) led to drowning of the seedlings in this position.	**Main Experiment objective**

4.2 Altered Requirements

From the 31 Requirements listed in AD01 for pre-experiment and experiment run approximately 15 were broken, in addition to the main experiment objective: It is desirable to cultivate wild type and mutant strains of *Arabidopsis thaliana* under microgravity and at 1 g conditions on orbit.

Table 4.2 summarizes all CW/RW Experiment Requirements which were changed or broken as a consequence of the anomalies mentioned in this section. Appendix 6 gives a detailed overview of all the executed changes during the CW/RW Experiment.

Table 4.2 CW/RW Experiment Run Requirements not met due to EUE or EMCS issues and further changed upon PI/ESA request.

Requirement AD01	**As in the IRD**	**Altered**	**Reasoning**	**Originator**
Hydration (AP03): 1)CWRW-EIR-Exec-04 2)CWRW-EIR-Exec-05 3)CWRW-EIR-Exec-06	1)Initial hydration shall provide each PCC with 13± 1 ml water 2) The EMCS EC position/EC/PCC EC Position A1 (*lefty*), EC Position A2 (*hmg*), EC Position B1 (*lefty*), EC Position B2 (*hmg*) will be watered at experiment run day 1. 3) The EMCS EC Position A3 (Wild), EC Position A4 (GM Wild), EC Position B3 (Wild), EC Position B4 (GM wild) shall be watered on the experiment run day 4.	1)There is no method to determine the actual water content in the growth pot 2) & 3) The hydration problem during the CW/RW experiment led to several initial hydration attempts in several positions and on various days. (Appendix 5)	Anomaly PAR-HW-0011	**Payload Anomalies PI/ESA**
Power-interruptions CWRW-EIR-Exec-31	CW/RW desires continuous power during the entire 53-day experiment run, but can withstand power interruptions for up to 5 hours during the first 43 days and up to 3 hours during the last 10 days of the experiment run.		Both Payload Anomalies and ISS Power limitations lead to periods of power interruptions. (For detailed descriptions of incidents of power interruptions and other interruptions to environmental stimuli, contact N-USOC).	**Payload Anomalies**
Main Experirment objective	By using Arabidopsis, the goal is to identify gene sets, which play a role in gravity-dependant formation of supportive tissue in plants. Therefore, it is desirable to cultivate these mutant strains up to reproductive stage under microgravity and at 1 g conditions on orbit, for comparison with the wild type. When retrieving the plants to earth, changes in expression of genes involved in formation of microtubules, plasma membrane and cell walls can also be analyzed.	No plants developed up to reproductive stage.	Anomaly PAR-HW-0011	**Payload Anomalies**
Temperature CWRW-EIR-Exec-08	Temperature inside the EMCS Experiment Containers during experiment execution shall be 23±1 °C.	On day 46 the temperature in the EMCS incubator was lowered to 20°C	To reduce dehydration of the plant in B4 (FM100)	**PI/ESA**

Illumination 1)CWRW-EIR-Exec-15 2) CWRW-EIR-Exec-16	1) Illumination during the experiment run is 16h/8h day (-night cycle (dark). 2)The light intensity should be 50 w/m2 for the first 20 days and 75w/m2 for the remaining days	Rotor A: Varying light duration and intensity Rotor B: Varying light duration and intensity See Appendix 6 for details	To reduce stress – lights off or reduced intensity To increase growth- continuous lights	**PI/ESA**
Gravity level 1) CWRW-EIR-Exec-13 2) CW/RW_EIR_Exec_5.1	1)Gravity level: rotor A - rotating (1xg) at the surface of PCC lid, rotor B - static (micro-g) 2) The Rotor A will stand still until watering is complete for ECs with WT and GM wild (day 4).	Rotor A: Varying g Rotor B: Varying g See Appendix 6 for details	ISS Power Issues. Hydration issues (EMCS-PAR-HW-011) led to hydration attempts at different g-levels.	**Payload Anomalies and ESA/PI agreement**
Experiment duration CWRW-EIR-Exec-07	The experiment duration is 43 days (+/-10 days).	The experiment lasted for 47 days, but due to late germination, the plants were estimated to 23 days at the time of harvest.	Inability to hydrate properly. Anomaly PAR-EMCS-HW-0011	**Payload Anomalies and ESA/PI agreement**
Observation target and frequency (AP03) 1) CWRW-EIR-Exec-09 2) CWRW-EIR-Exec-09.1	1) Each EC is observed by still image grabbing every 1 hour. 2) Two EC positions on each rotor (A1, A3, B1, B3), (lefty and WT) are observed every 6 minutes during shoot circumnutations period (5-10 days). EC position and timeframe for observation can be defined near real-time (3 day lookahead) in-flight. EC conditions should allow clear view of the emerging shoots. The still images are downloaded via telemetry.	1) Observation was prohibited upon several occasions. 2) There was no stem to observe	Payload anomalies; PAR-EMCS-SW-001, PAR-EMCS-SW-002, PAR-EMCS-SW-003, PAR-EMCS-SW-008, PAR-EMCS-SW-009 Due to the fact that in the end only one plant was growing in all of the ECs, resources were redirected to observation of this particular EC.	**Payload Anomalies and ESA/PI agreement**
Harvesting (AP03) 1)CWRW_EIR_Exec_17 2)CWRW_EIR_Exec_18 3)CWRW_EIR_Exec_19	1) The samples from Rotor A (rotating, 1xg) shall be retrieved first by the crew after the experiment stop 2) EMCS CW/RW samples from Rotor A must be removed from the EMCS ECs, fixated and placed into MELFI for preservation within 1.5 hours after the crew removes the ECs from the EMCS. 3) EMCS CW/RW samples from Rotor B must be removed from the EMCS ECs, fixated and placed into MELFI immediately after samples from EMCS Rotor A have been inserted into MELFI and within 1.5 hours after the crew removes the ECs from the EMCS.	1) & 2) There were no plants on the A rotor for harvest. 3) The CW/RW Experiment was concluded by harvest of plants in B3 and B4. In total, all ECs were removed from the EMCS.	Inability to hydrate led to very few plants to harvest. Payload anomalies; PAR-EMCS-HW-0011	**Payload Anomalies and ESA/PI agreement**

4.3 Main Reason for Failure

The investigation of EMCS and CW/RW hardware returned on 1J led to the final conclusion to the main reason for failure of the CW/RW experiment (ref. Appendix 7- Failure Analysis): "On EMCS RBLSS MODULE FM008 the Quick Disconnects (QDs) towards fresh and waste water reservoir were swapped, meaning

• "QD 10-N Fresh" at RBLSS was equipped with a **female** QD (thus fitting into **waste** QD of the water Reservoir and vice versa:
• "QD 12-N Waste" at RBLSS was equipped with a **male** QD (thus fitting into **fresh** QD of the water Reservoir

As it was confirmed by the supplier (OHB), the same discrepancy is most likely present on FM007 which was also used during CWRW, and which is still mounted in the EMCS FM on rotor A.

Development of the failure
Following the history of CWRW the following happened:
• At the beginning of CWRW the humidity (RH-) control of all ECs were started with 50% setting. Due to the QD swap, no fresh water could be supplied to the humidifiers (which was not immediately recognized, because they contain sufficient water to supply 50% humidity for quite a long time). However, the wrong connection led to an accumulation of an air/water mixture (90% air, 10% water volume) in the fresh water reservoir (instead of waste), because the dehumidifier is drained every 3 hours.
• In parallel to RH control the initial watering of EC/PCC was commanded, starting with positions A1/A2 (B1/B2). These positions now tried to get water from fresh reservoir, but in fact were connected to waste reservoir which nominally did not contain free water at the beginning of an experiment. So these positions only received the small amount of 1-5 ml water which was contained in the tubes.
• Initial watering of positions A3/A4 (B3/B4) was started several days later. Since these positions were connected correctly, they tried to get water from fresh reservoir, but received only an air/water mixture, which was partly sufficient for triggering the p-sensor in the PCC. However, on a long term, since the trapped air in the fresh water reservoir increased by the RH control, the supply could not be supported sufficiently, and the plants dried out.
• After the unsuccessful trial of seven ECs, the water reservoirs were exchanged. Before the water reservoir exchange no position could be hydrated at all. This can be quantitatively proven, because the watering of A3/A4 (B3/B4) positions followed much later than the 1+2 positions.
• After the exchange there was a partial success in watering (B1/B3/B4). Since B3/B4 watering followed immediately the water reservoir exchange, only some air was collected in the fresh water reservoir, and the positions could receive some water. B1 did not show a proper triggering, but a kind of "partial" triggering, which is explained by a mixture of air with some water which led to this behavior. A4 was also watered quite soon after water reservoir exchange, but did obviously not get sufficient water due to included air. A3 was watered much later, and suffered also from air inclusion in the fresh water reservoir."

5. Conclusion

One of the difficulties of the Cell Wall Resist Wall experiment Integration was the late delivery of CW/RW test hardware. CW/RW is one of the longest experiments ever conducted in the EMCS on the ISS, and the test plan was affected by the length of the experiment. The EST was performed as a Table-Top, so the full experiment run with 8 ECs was thus not performed due to time constraints.

No problems were encountered during flight preparations at N-USOC, hardware check-out, transport to KSC or CW/RW experiment handover to NASA.

During CW/RW experiment execution on orbit 15 of the 31 CW/RW Experiment Requirements were changed or broken, and the main experiment objective of germination and growth in 56 PCC Lid holes was not met.

Many of the CW/RW experiment requirements were initially broken due to Payload and EUE anomalies and limitations. The investigation of EMCS and CW/RW hardware returned on 1J led to the final conclusion to the main reason for failure of the CW/RW experiment: On EMCS RBLSS MODULE FM008 the Quick Disconnects (QDs) towards fresh and waste water reservoir were swapped. As it was confirmed by the supplier (OHB), the same discrepancy is most likely present on FM007 which was also used during CWRW.

As an attempt to optimize the remainders of the experiment, the PI team and ESA agreed upon changes to the original experiment requirements. In order to implement these changes several actions were taken which had been tested on ground only to a limited degree. On some of these occasions implementation of the changed requirements were tested and advised against but led to unfortunate consequences like flooding of the EC B3 bottom chamber, which in turn led to the seedlings in this position to perish.

All in all the Cell Wall Resist Wall Experiment unfortunately failed in spite of all the time and effort that was dedicated to making it a success. The reason for this was most likely due to two faulty mounted EMCS RBLSS Modules.

Appendices

Appendix 1 – Cell Wall Resist Wall Test Plan

CW/RW Test Plan

Table 1: The table summarizes planned CW/RW tests in the EMCS Ground Models, with details on test objectives, test facility, comments, resources needed, start and end date, test manager and outcome.

Test	Test objective	Facility	Comment	H/W, S/W and resources	Start	End	Test Man. & Assistance	Status
1	Science Test	ERM	Verify the duration time of the experiment. (When stems have reached height of 10 cm - Approximately 50 days.)	Schedules Test Procedure 2 M-ECs	September 19th	November 5th	S.E.O. H.S.	
2	Recycling Test	EM	Transfer mature plants from ERM after the ST to the EM. Verify the ability of the EM to support growth of mature plants. (PAR HW-0006) Dehumidifier issues.	Schedules Test Procedure 2 ST M-ECs	November 5th	November 14th	A.G. G.A.	
3	Germination/ Hydration test	EM	When will recycling start after the initial watering? Around day seven: Switch to watering Mode once a day for 20 seconds (schedule to be started manually). Based on the Delta Pressure and Flow one has to decide if watering is necessary. (Plan is needed for how to interpret different variable of pressure and flow.) Who will decide if watering is necessary?) Venting of roots? Verify Schedules.	Schedules Test Procedure 2 C-FMs	December 3rd	December 21st	A.G. G.A. C.B. W.S. (G.R.)	
4	Germination Test	ERM	Verify the ability of FMs to support germination.	Schedules Test Procedure 6 C-FMs 1 C-QM	December 10th	December 17th	S.E.O. A.G. K.M. W.S. C.B. (G.R.)	
5	Run 2	EM	Biological: Repetition/ Optimization of Germination/Hydration/Recycling Test. Technical Test: PAR HW-0006 PAR SW-0001, SW-0003	Schedules Test Procedure 4 M-ECs	January 9th	January 20th?	G.A W.S	
6	EST	Table Top	Verify functionality of all procedures for set-up and transport, all EMCS schedules, all crew procedures, etc	Schedules Test Procedure	January / February	February	S.E.O. M.R.	
7	Technical Testing	ERM	PAR HW-0006	TBD	November 5th January 10th	November 14th February 5th		
8	Technical Testing	FM	PAR HW-0006, SW-0001	TBD	December			

CW/RW Test Plan Timeline

Table 2: The table illustrates the CW/RW test plan timeline, including dates reserved for RT Set-Up and Experiment execution on orbit. Green blocks represent planned tests, pink blocks represent set-up for flight and orange blocks represent Real Time Operations.

Event		September-07	October-07	November-07	December-07	January-08	February-08	March-08
Test 1								
Test 2								
Test 3								
Test 4								
Test 5								
Test 6								
Test 7				TBD		TBD		
Test 8					TBD			
RT Set-Up								
Exp. run on orbit								

Planned CW/RW Tests Flight preparations Experiment execution on orbit

Appendix 2 - Filled in “PCC Assembly and Seed Set-Up Report”

Cell Wall/ Resist Wall
PCC Assembly and Seed Set-Up Report

Date:

Prepared by	Maja Rostad ……....
Checked by	Suzanne Øverlie ..... ….....
	Håkon Svare.....
	Motoshi Kamada.....
Approved by	Kazuhiko Nishitani…….....
	Takayuki Hoson……
	Toru Shimazu.....
Quality Assurance	Maja Rostad..... .....
N-USOC Project Management	Knut Fossum.....
EMCS PIM	Ulrich Kübler……..
Document type	Report

CIRiS (Center for Interdisciplinary Research in Space),
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Table of Contents

Change Record

Issue	Date	Page(s)	Description of change	Release

1 Documents

1.1 Applicable Documents

AD	Document Number	Date	Issue	Title
AD01	EMCS-MA-4000-002-DCR	12.11.04	2	"EC User Handbook"
AD02	CWRW ISR	16.02.07	0	EMCS Cell Wall & Resist Wall INTEGRATED SCIENCE REQUIREMENTS DOCUMENT
AD03	N-USOC-REQ-007	06.07.07	1	"EMCS CW/RW (Cell Wall/Resist Wall) Integration Requirement Document"
AD04	N-USOC-PRO-002	20.06.07	1.3	"Multigen-1 PCC Assembly and Seed Set-Up Procedure"
AD05	N-USOC-PRO-004	16.01.08	1	"CW/RW Seed Set Up Procedure"
AD06	EMEX-RP-MULT-02-EADS	11.12.03	2	" EMCS-Experiments, Multigen Part 1 Design Report" (EADS)
AD07	RP_30193_PR_02	06.10.05		"EMCS Experiments Multigen-1 Design Report CCN04" (Prototech)
AD08	EMEX_MA_MULT_01_PRO	14.12.07	E	"EMCS Multigen 1 PCC 1 – User's Manual"

1.2 Reference Documents

RD	Document Number	Date	Issue	Title

2 List of Abbreviations

AD	Applicable Document
EC	Experiment Container
FM	Flight Model
H/W	Hardware
ISS	International Space Station
JAXA	Japan Aerospace Exploration Agency
N-USOC	Norwegian User Support and Operation Centre
PCC	Plant Cultivation Chamber
PI	Principal Investigator
QA	Quality Assurance
RD	Reference Document

3 Summary

The CWRW PCC assembly and seed set-up was performed at the Plant BioCentre in Trondheim, Norway from January 14th through 24th 2008. This document and its appendices cover the growth pot sterilization, filling of growth support, set-up of seeds, implementation of immobilization membrane, PCC assembly and mounting of EC cover.

4 Introduction

The objective of this set-up was to prepare 8 Cell Wall/ Resist Wall ECs with PCC and seeds for the Cell Wall/Resist Wall experiment according to given procedures [AD04 and AD05].

5 Personnel

Set-up Engineer
The set-up engineer was responsible for:
- performing set-up according to given procedures
- accuracy of the measured values

Set-up Manager
The set-up manager was responsible for:
- set-up articles and technical aspects of the set-up performance
- examination of disturbances
- set-up article integration and handling
- set-up performance
- evaluation of set-up results

Quality Assurance
The Quality Assurance representative was responsible for:
- surveillance of set-up equipment according to regulations as well as the set-up procedure application
- statement that the set-up articles to be set-up have passed all checks before set-up, including calibration
- checking the identification markings on the set-up articles
- supervision of set-up proceeding with respect to quality assurance aspects (i.e correct tracing of procedure variations and non-conformances

Table 1: Set-up personnel

Name	Affiliation	Contact info	Responsibility
Motoshi Kamada	JAXA	+81-29-868-3698	Set-up Engineer
Håkon Svare	N-USOC	+47-735-90162	Set-up Engineer
Suzanne Øverlie	N-USOC	+47-735-90181	Set-up Manager
Maja Rostad	N-USOC	+47-735-90179	Quality Assurance
Bjørnar Vasenden	Prototech	+47-555-74103	PCC Cleaning

6 Set-Up

The set-up was performed at the Plant BioCentre in Trondheim, Norway. 8 Flight ECs (FM092, FM094, FM095, FM096, FM097, FM098, FM099 and FM100) and 8 PCCs were first cleaned by Prototech after being utilized in CW/RW Biocompatibility test and CW/RW Germination/Hydration test before set-up.

Arabidopsis Thaliana seeds (Wild type, GM GUS, lefty and hmg) used for set-up was supplied by JAXA Science team and sterilized at N-USOC by Set-up Engineer Motoshi Kamada. The Zeolite used for the set-up was from the same batch as prepared for the Multigen-1 experiment and no new enrichment or filtration of Zeolite was performed during set-up of the CW/RW experiment.

Motoshi Kamada performed CW/RW growth pot sterilization, growth support filling, seed integration, implementation of immobilization membranes, borosilicate doughnuts and mini lids as described in AD04 and AD05. Assembly of the PCC and implementation of EC cover was performed by Håkon Svare.

The preparations and set-up are documented in the filled-in procedures “Multigen-1 PCC Assembly and Seed Set up Procedure” in Appendix 1 and “CW/RW Seed Set Up Procedure” in Appendix 2. Pictures illustrating parts of the Set-Up can be found in Appendix 3.

All changes and variations during set-up were collected in fill-in tables in the procedures and are summarized in Table 2.

Table 2: Changes and variations to the procedure [AD04].

Test step No	Test-step description	Remarks
1-3	Zeolite filtration and enrichment was done prior to Multigen-1 experiment. Same batch was used for this set-up	See N-USOC-PRO-002, Issue 1.3
5	Growth pots and growth pot lids were not marked	Unlike for Multigen-1, the growth pots for CW/RW Has the same configurations with 7-hole lids.
9	No need to use exsiccator because pot is left to dry in flow bench over night.	
10	Adjusted weight to 0g with growth pot + integration tool and Petri dish.	
16	Used both integration tool stamp and small spatula to get felt under the edge	
17-18 (between)	Put in top o-ring	This step was not included in the procedure
19	There is no reference rod in CW/RW lids. The lid with borosilicate was pressed down on a piece of cardboard to get the borosilicate into the recession	
29	After mounting the doughnut, the seed position was checked.	
30	A small amount of silicone was applied on the mini-lid male tread before it was put in the holes. Lids were then screwed in until leveled with PCC lid surface. Seed position was checked	Better precision of silicone appliance and minimize smearing of silicone.
33-31	Performed step 33 before step 31. Surface sterilized the inside of the EC cover, base plate, grid and PCC too.	
35	After implementing the PP-felt in the recession on the outside of the growth pot , the pot was pushed down in the PCC until the o-ring was aligned with the top of the PCC before applying grease to the o-ring	To avoid getting grease on PP-felt and also to prevent fibers from the felt to attach on the greased o-ring.
40	After applying silicone to green sealing frame, the EC cover was mounted on “backwards” and then opened for a visual inspection of imprint that the grease made to the cover to verify an even distribution along the sealing. After this the cover was mounted the correct way.	

7 Non-conformities

No NCR was opened as a result of the changes and variations listed in Table 2.

8 Results

The set-up was performed according to procedure AD04 and AD05 with changes and variations listed in Table 2.

9 Conclusion

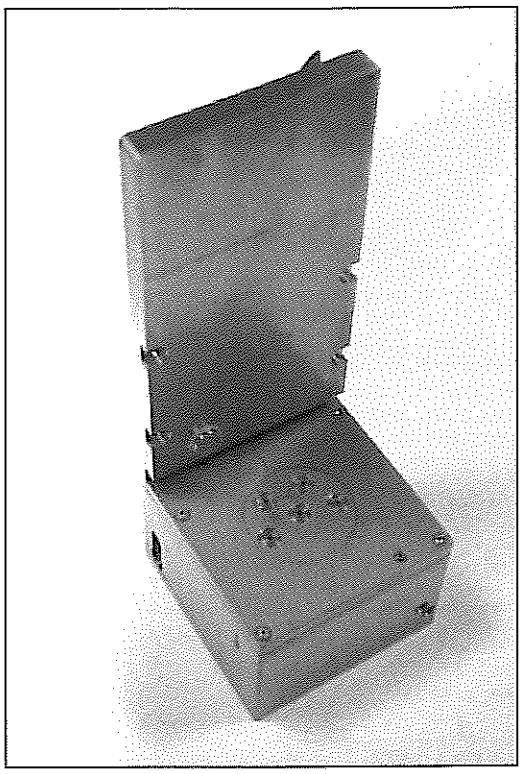
No negative effect on the performance of the Cell Wall/ Resist Wall experiment could be identified from the changes and variations listed in Table 2.

Appendix 1:

Filled in N-USOC-PRO-002 Multigen-1 PCC Assembly and Seed Set-Up Procedure, Issue 1.3

As performed during flight preparations.
14.01.07 - 24.01.07

Multigen-1
PCC Assembly and Seed Set-Up Procedure



Prepared by Carina Helle Berg

Reference
Issue 1.3
Date of Issue 20.06.2007
Document type Procedure

Approval

Title:		Issue:	
Multigen-1 PCC Assembly and Seed Set-Up Procedure		1.2	
Author:	**Signature:**	**Affiliation:**	**Date:**
Suzanne Øverlie	Suzanne Øverlie	N-USOC	16/5-07
Checked by:	**Signature:**	**Affiliation:**	**Date:**
Ann-Iren Kittang	Ann-Iren Kittang	N-USOC	16/5-07
Knut Fossum	Knut R. Fossum	N-USOC PM	16/5-07
Ulrich Kuebler		ESA EMCS PIM	
Approved by:	**Signature:**	**Affiliation:**	**Date:**
Wilfried Biemann		Astrium/IOT PA	
Claude Brillouet	14-05-07	ESA EUE PM	
Tor-Henning Iversen	Tor-Henning Iversen	Multigen-1 PI	16/5-07

Change Log

Reason for change:	Issue:	Date:	Page(s):	Paragraph(s)
Initial release	1	29.03.07		
Added check of Borosilicate water-absorbing capabilities	1.1	14.05.07	16, 19	Steps 20, 26
Minor changes in procedure for Zeolite nutrition enrichment	1.1	14.05.07	28	Step 1, 2
Deleted step in procedure for Zeolite nutrition enrichment	1.1	14.05.07	28	
Changed agent for securing mini lids to PCC Lid	1.1	14.05.07	19	Paragraph 7.1.6
Updated version of App. 2 added	1.1	14.05.07	33	
Added steps for weighing Zeolite	1.2	14.05.07	12,13	10, 14
Additional changes made to procedure in Appendix 1	1.2	14.05.07	28	

Log of Changes since Base-lining

Reason for change:	Issue:	Date:	Page(s):	Step(s)
Corrected reference to appendix	1.3	20.06.07	16	Step 21
Amount of MS Medium corrected	1.3	20.06.07	28	Step 6
Relocated step of dust particle removal to after enrichment. Changed method of removing dust particles	1.3	20.06.07	11	Step 1,4
Labeling of growth pots and Lids during the entire set-up	1.3	20.06.07	12	Step 5
Growth pot shall remain in sterile bench over night to be dried and not be transferred to exsiccator and heating cabinet	1.3	20.06.07	12	Step 8
Weighing of Growth Pot, not Zeolite	1.3	20.06.07	13, 14	Step 11, 14
Changed method of packing the Zeolite: the growth pot shall not be tapped against the surface of the work bench but rather be tapped with a blunt object until Zeolite is compressed	1.3	20.06.07	13	Step 12
Attaching the borosilicate paper in the recession of the Growth pot lid need not be performed in the sterile flow bench	1.3	20.06.07	16	Step 19
The cardboard for cutting the borosilicate for the Growth pot lid need not be sterile	1.3	20.06.07	16	Step 20
Specialized mini funnel is used to guide the seeds in place on the centre of the PP-felt instead of Glass funnel	1.3	20.06.07	17	Step 25
Add additional wiping of PCC Growth Pot lid to remove excess grease	1.3	20.06.07	20	Step 30
Add step to bring EC into the flow bench and surface sterilize them (both inside and outside) with ethanol	1.3	20.06.07	21	Step 33
Add implementation of circular autoclaved PP-felt in the bottom of the PCC	1.3	20.06.07	21	Step 34
Implement check of correct alignment of PP-felt on outside recession of growth pot	1.3	20.06.07	21	Step 35
Only three of four screws will be measured for torque since the tool was to big for the fourth position	1.3	20.06.07	22	Step 37
EC Sealing frame (green) will be inspected for dust particles and coated with a thin layer of Wacker Silicone High Vacuum Grease	1.3	20.06.07	23	Step 38, 39

Table of Contents

Abbreviations

EMCS	European Modular Cultivation Chamber
ERM	EMCS Reference Model
EC	Experiment Container
PCC	Plant Cultivation Chamber
PI	Principal Investigator
QA	Quality Assurance
ISS	the International Space Station
NASA	National Aeronautics and Space Administration
PVA	Polyvinyl Alcohol
MS	Murashige & Skoog Medium
PP	Polypropylene
ERD	Experiments Requirements Document
PD	Payload Developer

1 Scope

This document and its appendices cover the Multigen-1 PCC assembly, rinsing of Zeolite, filling of growth support, set-up of seeds and implementation of immobilization membrane. The document is based on input from Payload Developer (PD) and Principal Investigator (PI). The document has been changed since base lining/signature (Issue 1.2) according to the Change Log on page 3.

2 Documents

2.1 Applicable Documents

AD	Document Number	Date	Issue	Title
AD[01]	EMCS-MA-4000-002-DCR	12.11.2004		"EC User Handbook"
AD[02]	EMEX-RP-MULT -01-EADS	16.09.2003		"EMCS Experiments, Experiments Requirement Document Multigen Part-1"
AD[03]	EMEX-RP-MULT-02-EADS	11.12.2003		"EMCS-Experiments, Multigen Part 1 Design Report"
AD[04]	N-USOC-REQ-004	29.03.2007	1	"EMCS Multigen-1 Integration Requirements Document"
AD05	RP_30193_PR_02	06.10.2005		"EMCS Experiments Multigen-1 Design Report CCN04"
AD06	EMCS-PR-0000-007-DOR	21.06.2006	1	"EMCS EM System Start-Up and Stop Procedure"
AD07	EMEX_MA_MULT_01_PRO	15.05.2006	D	"EMCS Multigen 1 PCC 1 – User's Manual"
AD08	EMEX_PR_MULT_04_PRO_A	05.12.2006	A	Procedure for filtering of Zeolite
AD09	EMEX-RP-MULT-07-EADS	01.07.2004	A	EMCS Experiments Multigen Part 1 Interface Specifications
AD10	EMEX-RP-MULT-10-EADS	11.12.2005	C	EMCS Experiments P/L Specification Multigen Part 1

2.2 Reference Documents

RD	Document Number	Date	Issue	Title

3 Multigen-1 Experiment Design

The Multigen-1 Plant Cultivation Chamber (PCC) is accommodated inside the EMCS Experiment Container (EC), as shown in Figure 1.

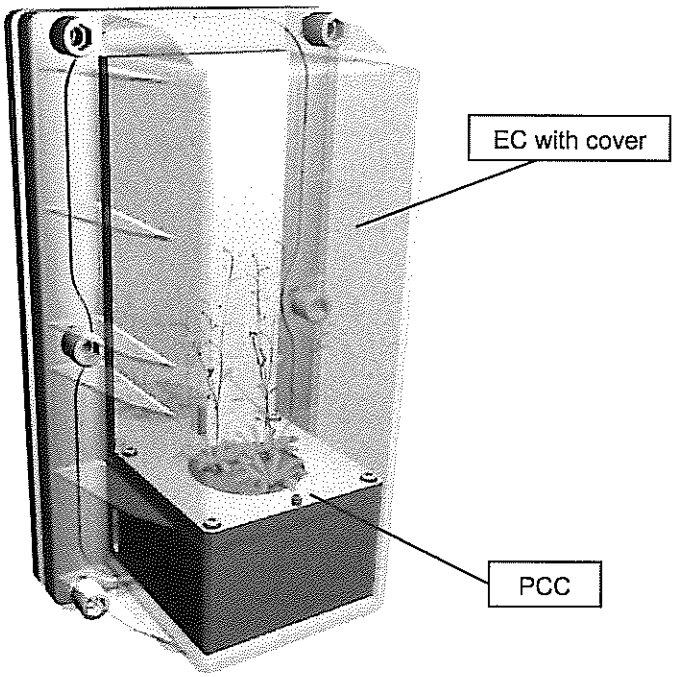


Figure 1: Multigen-1 Experiment implemented into EMCS EC

The PCC constitutes the Experiment Unique Equipment of the Multigen-1 Experiment. The PCC will maintain enclosed inside the Experiment Container (EC) at all times while on the International Space Station. The seeds will be implemented in the PCC and the PCC will be integrated in the EC on ground prior to handover to the National Aeronautics and Space Administration (NASA). Once implemented into the European Modular Cultivation System (EMCS) on the ISS the PCC with seeds will be hydrated automatically. The plants will automatically be dried out at the end of the experiment, removed from the EMCS while still inside the enclosed EC and dry stowed until return to ground.

4 Ground Support Requirements

Table 1 shows the Ground Support Requirements needed to set up the PCCs for flight.

Table 1: Ground Support Requirements for PCC set-up for flight

Ground Support Req.	Description	Amount	Available
MULT-1_GSR_01	Large workbench	1	√
MULT-1_GSR_02	Sterile flow bench	1	√
MULT-1_GSR_03	Chairs	2	√
MULT-1_GSR_04	Balance, Capacity 3 kg, accuracy 0.1 g	1	√
MULT-1_GSR_05	Ethyl alcohol (70%)	0.5 l	√
MULT-1_GSR_06	Ethyl alcohol (96%)	0.5 l	√
MULT-1_GSR_07	Spray bottle	1	√
MULT-1_GSR_08	Stereomicroscope	1	√
MULT-1_GSR_09	Pincers with micro tip, medium and large	3	√
MULT-1_GSR_10	Disposable gloves	1 box	√
MULT-1_GSR_11	Sterile filter paper for drying of PCC sponge		√
MULT-1_GSR_12	Exsiccator	1	N/A
MULT-1_GSR_13	Short glass pipette	1	√
MULT-1_GSR_14	Sterile pipette tips in pipette box	1 box	√
MULT-1_GSR_15	Pyrex beakers (8x50 ml, 12x250 ml)	20	√
MULT-1_GSR_16	Sterile water	4 l	√
MULT-1_GSR_17	Chlorine (25%)	2 dl	√
MULT-1_GSR_18	Q-tips	1 box	√
MULT-1_GSR_19	Eppendorf autopipette (10-25 µl range)	1	√
MULT-1_GSR_20	Cotton	1 bag	√
MULT-1_GSR_21	Scalpel	3	√
MULT-1_GSR_22	Autoclave bags	20	√
MULT-1_GSR_23	Lighter	1 box	√
MULT-1_GSR_24	Bensen burner	1	√
MULT-1_GSR_25	Card board for cutting of borosilicate	1	√
MULT-1_GSR_26	Small Spatula	1	√
MULT-1_GSR_27	Aluminum foil	1 m	√

5 Set-Up Articles

Table 2 shows the articles that are needed to set up the Multigen-1 PCC for flight.

Table 2: Set-up articles

#	Test Article name	Quantity	Supplied by	Serial #	Available
1	Multigen-1 Flight Model PCCs	8	EADS		V
2	Growth medium (Zeolite) per PCC	Ca 30 ml	PI		V
3	Diameter of PP-Felt per PCC	30 mm	PI		V
4	Diameter of Borosilicate per PCC	32 mm	PI		V
5	Polyvinyl Alcohole (PVA) per hole	10 µl	PI		V
6	PVA Moulding Tool	1	PI		V
7	Integration Tool Base	2	Prototech		V
8	Integration Tool Funnel (with screws)	2	Prototech		V
9	Integration Tool Stamp	1	Prototech		V
10	Mini Lid Attaching Tool	1	PI		V
11	Borosilicate Punching Tool	1	PI		V
12	Up-Side-Down Jig for PCC Lid	1	PI		N/A

6 Environmental Conditions during Experiment Set-Up

The ambient conditions within the laboratory for filling and assembly shall be in compliance with the values specified in the table below. It is recommended to keep the air humidity as low as possible to avoid early germination of the Arabidopsis seeds. The actual values shall be filled into table 3.

Table 3: Temperature, humidity, pressure and cleanliness during experiment set-up

	Nominal value	**Actual value**
Room temperature	22±3°C	22,5 - 25,0 °C
Relative Humidity	<40%	23 - 25 %
Pressure	Ambient	Ambient
Cleanliness	Sterile Flow Bench	Sterile Flow Bench

7 Procedure Steps

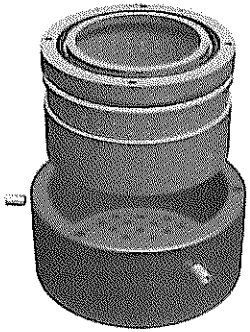
The PCC set-up is performed according to the steps in table 4.

Table 4: Experiment step by step description. (Note: All steps should be performed with gloves including the steps illustrated without gloves.)

Step	Step Description	Demo./Photo/Remark	Performed
	7.1 Assembly of PCC		1 2 3 4 5 6 7 8 9 10 11 12
	7.1.1 Assembly of Growth Pot (with Sponge) and Zeolite		
1	Filter Zeolite once through sieve with 1.0 mm mesh width. Filter Zeolite fraction below 1.0 mm pore size again through sieve with 0.5 mm mesh width.		N/A
2	Enrich Zeolite with pore size above 0.5 with Murashige & Skoog medium according to Appendix 1 (MS medium without Ammonia).		N/A
3	Filtrate Zeolite according to procedure (AD08/Appendix 2) in order to avoid particles with size less than 0.5 mm. Remove additional dust particles from batch above 0.5 mm by placing a vacuum cleaner underneath sieve.		N/A
4	Transfer filtered Zeolite to Pyrex beaker (50 ml) and place in heat sterilize cabinet at 170°C for 60 minutes.		Performed 15-23.01.08

Performed by:	Date:	Location:	Quality Assurance:
Håkon Svare	15.01.08 - 23.01.08	PBS	Maja Rostad

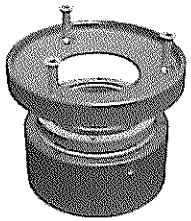
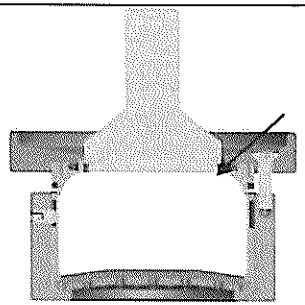
Table 4: Cont

Step	Step Description	Demo./Photo/Remark	Performed
5	Fixate sponge to bottom part of PCC Growth Pot according to Appendix 3, and label all growth pots and growth pot lids by marker that can be removed.		Bjørnar Vasenden mounted Sponge for ECs FM092, 094, 096, 097, 098 and 100. Håkon Svare mounted ECs FM095 and 099.
6	Sterilize the Growth Pot Sponge by submerging the pot in 25% chlorine (10 min). Rinse the sponge thoroughly in sterilized, deionised water (4 times, exchange of water each time) and carefully press out excess water with sterilized paper.		2 pots on 16.01.08 2pots on 17.01.08 2pots on 21.01.08 2pots on 23.01.08
7	Attach the Growth Pot to the Integration Tool Base inside the sterile flow bench. This must be done while sponge is still wet. The Growth Pot must be locked tightly to the Integration Tool Base with Integration Tool Base screws in order to press the sponge firmly against the bottom of the Integration Tool Base.		√ √ √ √ √ √ √ √
8	Leave Integration Tool Base with Growth Pot in sterile flow bench over night until the sponge is completely dry.		√ √ √ √ √ √ √ √

Bjørnar Vasenden (Step 5)
Håkon Svare (Step 5)
Motoshi Kamada (Step 6-8) | 14.01.08 - 23.01.08 | PBS | Maja Rostad

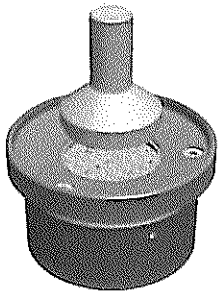
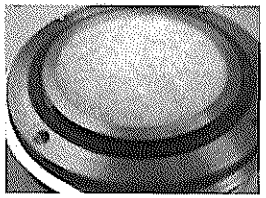
Performed by: | Date: | Location: | Quality Assurance:

Table 4: Cont

Step	Step Description	Demo./Photo/Remark	Performed
9	Remove Integration Tool Base with integrated Growth Pot from Exsiccator. Attach Integration Tool Funnel to Integration Tool Base with screws.		V V V V V V V V
10	Weigh the Growth Pot. Note down the weight.		V V V V V V V V
11	Fill the entire Growth Pot with Zeolite (enriched by PI, MS medium without Ammonia) via Integration Tool Funnel.		V V V V V V V V
12	Compress the Zeolite by carefully tapping the Integration Tool Base (with integrated Growth Pot) against the surface of the work bench. The tapping shall be performed until the Zeolite does not compress any more. If the level of Zeolite sinks below a certain level (marked with arrow), more Zeolite must be added. If the level of Zeolite does not sink down to the given level, remove some of the Zeolite with a spatula until the correct level (marked with arrow) is reached.		V V V V V V V V

Performed by:	Date:	Location:	Quality Assurance:
Motoshi Kamada	17.01.08 - 24.01.08	PBS	Maja Rostad

Table 4: Cont

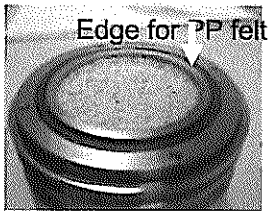
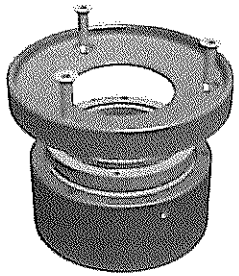
Step	Step Description	Demo./Photo/Remark	Performed 92	94	95	96	97	98	99	100				
13	Flatten the Zeolite in the Growth Pot by pressing the Integration Tool Stamp gently against the Zeolite until the stamp comes into contact with the edge of the Growth Pot. If the level of Zeolite does not reach the specific level during compression, some of the Zeolite must be removed by use of a small spatula. If the level of compressed Zeolite reaches below the defined level, more Zeolite must be added and the compression must be repeated.		V	V	V	V	V	V	V	V				
14	Weigh the growth pot. Note down the weight and verify that amount of Zeolite added to the growth pot did not exceed 29 gr.		27,058 g	27,01 g	27,058 g	27,069 g	27,039 g	27,01 g	27,069 g	27,079 g				
	7.1.2 Implementation of PP Felt on top of Zeolite													
15	Place PP-Felt in autoclave bag and autoclave at 120°C for 20 minutes. Transfer closed bag to heat cabinet for 50°C for minimum 60 minutes before transferring it to the flow bench.		ALL											

Motoshi Kamada (Step 13-14)

Håkon Svare (Step 15) | 14.01.08 - 24.01.08 | PBS | Maja Rostad

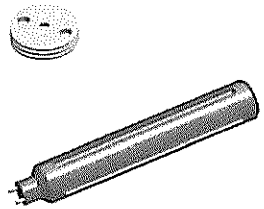
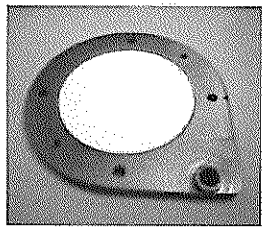
Performed by: | Date: | Location: | Quality Assurance:

Table 4: Cont

Step	Step Description	Demo./Photo/Remark	Performed										
16	Remove the PP-Felt from the autoclave bag. Place the PP-felt carefully on top of the compressed Zeolite without disturbing the plan/flat surface. The edge of the PP-Felt shall be carefully fitted under the edge (overhang) of the upper part of the Growth Pot. (Must be performed in sterile flow bench). (Illustration shows no Integration Tool Funnel, but the Integration Tool Funnel shall be attached to the Integration Tool Base at this time.)		V	V	V	V	V	V	V	V				
17	Detach Integration Tool Funnel from Integration Tool Base. The Growth Pot shall remain inside the Integration Tool Base.		V	V	V	V	V	V	V	V				

Performed by:	Date:	Location:	Quality Assurance:
Motoshi Kamada	17.01.08 - 24.01.08	PBS	Maja Rostad

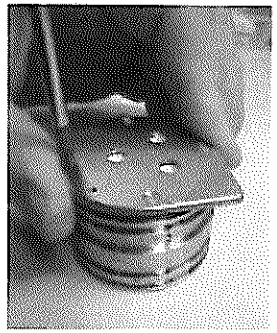
Table 4: Cont

Step	Step Description	Demo./Photo/Remark	Performed										
	7.1.3 Integration of Growth Pot Lid (with borosilicate membrane)												
18	If integrated in PCC Lid; Remove Mini Lids from PCC lid by use of Mini Lid Attaching Tool. (Can be performed outside the flow bench.)		V	V	V QA check	V	V	V	V QA check	V			
19	Place PCC-Lid on Up-Side-Down Jig on the working bench. Make sure Reference Rod is not harmed. Place circular sheet of borosilicate in the recession on the back of the PCC Lid. The borosilicate is 1/5 mm larger than the recession and must carefully be pressed down into the recession by use of a spatula. Remove small o-ring from water inlet. (Can be performed outside the flow bench.)		V	V	V QA check	V	V	V	V QA check	V			
20	Turn lid up-side-up and place it on a piece of cardboard. (Can be performed outside the flow bench.)		V	V	V QA check	V	V	V	V QA check	V			

Håkon Svare | 14.01.08 - 23.01.08 | PBS | Maja Rostad (FM085 and 099)

Performed by: | Date: | Location: | Quality Assurance:

Table 4: Cont

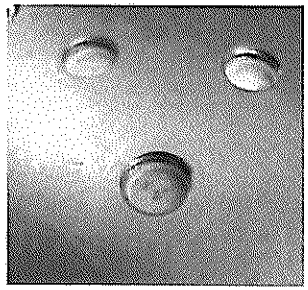
Step	Step Description	Demo./Photo/Remark	Performed
21	Cut holes in the Borosilicate with the Borosilicate Punching Tool as described in Appendix 5. The holes shall match the positions of the Mini Lids. (Can be performed outside the flow bench.)		V V V V V V V V
22	Place integrated PCC Lid in 250 ml Pyrex beaker, cover with aluminium foil and dry sterilize at 170°C for 60 minutes. (Treat a piece of Borosilicate cut-off similarly and place small droplets of water on it after sterilization, to verify its water-absorbing abilities.)		V V V V V V V V
23	Place PCC-Lid in proper position on Growth Pot and attach it with the four screws. (M2x5, DIN 965, 0.2 Nm)		V V V V V V V V

Håkon Svare (Step 21-22)

Motoshi Kamada (Step 23)

Performed by:	Date:	Location:	Quality Assurance:
	14.01.08 - 23.01.08	PBS	Maja Rostad

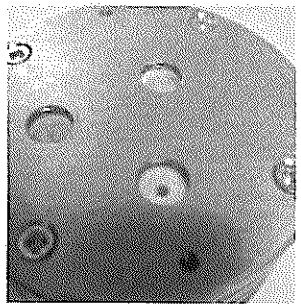
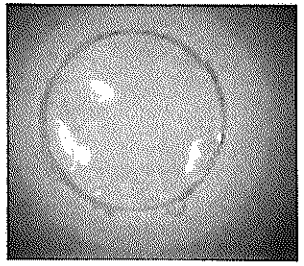
Table 4: Cont

Step	Step Description	Demo./Photo/Remark	Performed
	7.1.4 Integration of Arabidopsis seeds		
24	Place growth pot in stereomicroscope (washed with 70% ethyl alcohol) inside flow bench.		√ √ √ √ √ √ √ √
25	Place correct number of surface-sterilized Arabidopsis seeds on PP-Felt in PCC Lid holes. (Seeds have been sterilized in advance by the PI: Seeds are stirred in chlorine (25%, 4 min) with Tween 20 (Polyoxyethylene-sorbitan mono-laurate, Sigma, 5 µl) before being rinsed in sterile distilled water (change of water 4 times). After sterilization the seeds are dried on sterile filter paper.) Use specialized Mini Funnel to guide the seeds to the PP-felt "pocket" in the centre of the Mini Lid area. Place the seeds into the funnel with a micro tip pincer. Carefully adjust the seed placement with the micro tip if necessary.	 3 seeds/hole in lids with 5 holes, 1 seed/hole in lids with 3 holes	√ √ √ √ √ √ √ √

Motoshi Kamada | 17.01.08 - 24.01.08 | PBS | Maja Rostad

Performed by: | Date: | Location: | Quality Assurance:

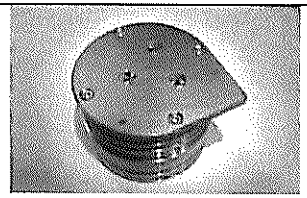
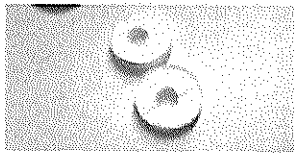
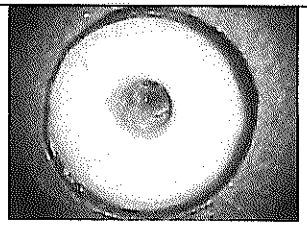
Table 4: Cont

Step	Step Description	Demo./Photo/Remark	Performed
	7.1.5 Integration of immobilization membrane (PVA) and borosilicate doughnuts		
26	Mould PVA Membranes for each lid hole according to Procedure in Appendix 4. (PVA must bee autoclaved.)		Performed 14-23 01 08
27	Use sterile micro tip pincer to attach PVA membrane on top of seeds. Press carefully the PVA membrane against the PP-Felt by use of a dedicated piston (5 mm diameter).		V V V V V V V V

Håkon Svare (Step 26)
Motoshi Kamada (Step 27)

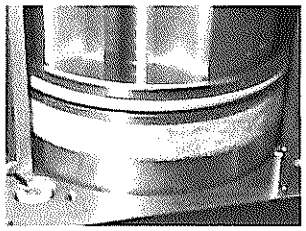
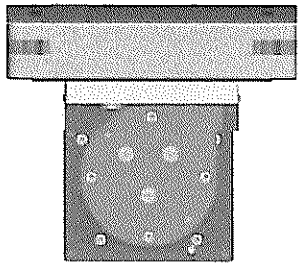
Performed by:	Date:	Location:	Quality Assurance:
	14.01.08 – 24.01.08	PBS	Maja Rostad.

Table 4: Cont

Step	Step Description	Demo./Photo/Remark	Performed
	7.1.6 Integration of Mini Lids and securing with Silicone Silicone Grease (Silicone High Vacuum Grease, Wacker)		
28	Make a small doughnut of dry-sterilized borosilicate by using the Borosilicate Punching Tool (Appendix 5). (Check water-absorbing capabilities of Borosilicate by adding droplets of water on the Borosilicate cut-off.)		V V V V V V V V
29	Mount the borosilicate doughnut and Mini Lids according to procedure in Appendix 5. (Mini Lids shall be sterilized by burning ethanol before being implemented into the Lid.) After attaching (screw) the Mini Lids with the Mini Lid Attaching Tool, the upper edge of the Mini Lids shall be about 1.5 mm above the surface of the PCC Lid.		V V V V V V V V
30	Apply the Mini Lid male thread with silicone (ca 0,1µl, the silicone should in advanced be filled into a syringe with a 1.2 mm short canula) evenly spread around the Mini Lid threads. Use the Mini Lid Attaching Tool and screw in the Mini Lids until levelled with the surface of the PCC lid. Wipe off excess silicone with a Q-tip and sterile dust-free paper tissue.		V V V V V V V V

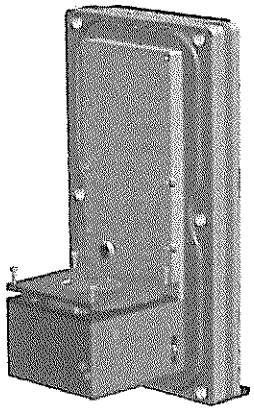
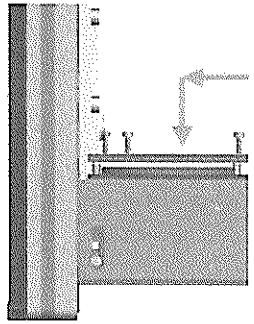
Performed by:	Date:	Location:	Quality Assurance:
Motoshi Kamada	17.01.08 – 24.01.08	PBS	Maya Rostad

Table 4: Cont

Step	Step Description	Demo./Photo/Remark	Performed
	7.1.7 Assembly of PCC		
31	Remove Integration Tool Base from Growth Pot.		V V V V V V V V
32	Implement small o-ring (sterilized) on water-nipple.		V V V V V V V V
33	Bring the EC into the Sterile flow bench and surface-sterilize it by wiping it with dust-free paper tissue with ethanol.		V V V V V V V V
34	Implement PP-felt (PPR443, pre-cut and autoclaved) in recession on the outside of the Growth Pot. Implement autoclaved PP-felt in the bottom part of the PCC by using gloved hands. (The felt should be pinned under the small edge of the circular opening above the grid in the PCC bottom.)		V V V V V V V V
35	Apply High Vacuum Grease (Wacker) to o-ring on the outside of the Growth Pot. Align the Growth Pot to the PCC according to the shown orientation. Mount the Growth Pot carefully by pushing it downwards into the Inner Pot. Special care should be taken not to damage the Growth Pot o-ring and the small water nipple o-ring when inserting. Make sure the PP-felt is in correct alignment with the Growth Pot outer Recession when guiding the Growth Pot into the PCC.		V V V V V V V V

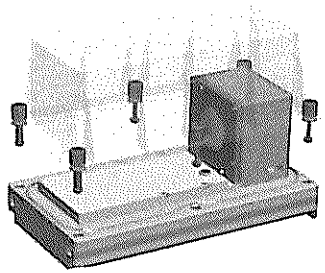
Performed by:	Date:	Location:	Quality Assurance:
Håkon Svare	17.01.08 - 24.01.08	PBS	Maja Rostad

Table 4: Cont

Step	Step Description	Demo./Photo/Remark	Performed
36	Mount the Locking Cover of the PCC by sliding it from the front above the two air pins, and then push it down to the PCC top surface.		V V V V V V V V
37	Fasten the Locking Cover to the PCC by use of four M2x6, DIN 912 screws using a 2mm Allen Key (0.2Nm ± 10% on three of the four screws).		V V V V V V V V

Performed by:	Date:	Location:	Quality Assurance:
Håkon Svare	17.01.08 - 24 01.08	PBS	Maja Rostad

Table 4: Cont

Step	Step Description	Demo./Photo/Remark	Performed										
38	Inspect the EC Sealing frame (green) for dust particles.		V	V	V	V	V	V	V	V			
39	Coat EC sealing frame (green) with silicone (Wacker Silicone High Vacuum Grease)		V	V	V	V	V	V	V	V			
40	Mount the EC cover according to EC User Handbook (AD01). (This must be performed minimum 2 hours after applying silicone on Mini Lids in order to allow for curing and off-gassing.)		V	V	V	V	V	V	V	V			

Performed by:	Date:	Location:	Quality Assurance:
Håkon Svare	17.01.08 - 24.01.08	PBS	Maja Rostad

8 Test Procedure Variation Fill-in

All changes and variations to the Procedure shall be documented in Table 5.

Table 5: Changes and variations to the procedure.

Test step No.	Test-step Description	Nominal Value	Tolerance	Actual Value	Remarks
1-3	Zeolite filtration and enrichment was done prior to Multigen-1 experiment. Same batch was used for this set-up.				N-USOC-PRO-002, Issue 1.3.
5	Growth pots and growth pot lids were not marked.				Unlike for Multigen-1, the growth pots for CW/RW has the same configurations with 7-hole lids.
9	No need to use exsiccator because pot is left to dry in flow bench over night				
10	Adjusted weight to 0g with growt pot + integration tool and peat dish.				
16.	Used both integration tool stamp and small spatula to get felt under the edge.				
Between 17-18	Put in top o-ring				
19	There is no reference rod. The lid with borosilicate was pressed down on a piece of cardboard to get the borosilicate into the recession.				
29.	After mounting the doughnut the seed position was checked				

14.01.08 - 24.01.08	PBS	Maja Rostad
Performed by: Date:	Location:	Quality Assurance:

Table 5: Cont.

Test step No.	Test-step Description	Nominal Value	Tolerance	Actual Value	Remarks
30	A small amount of silicone was applied on the mini-lid male head before it was put in the holes. Lids were then screwed in until levelled with PCC lid surface. Seed position was checked.				Better precision of silicone appliance and minimize smearing of silicone.
33-31	Performed step 33 before step 31. Surface sterilized the inside of the EC cover, base-plate, grid and PCC too.				
35	After implementing the PP-felt in the recession on the outside of the growth pot the pot was pushed down in the PCC until the o-ring was aligned with the top of the PCC before applying grease to the o-ring.				To avoid getting grease on PP-felt and also to prevent fibers from the felt to attach on the greased o-ring
40	After applying silicone to green sealing frame, the EC cover was mounted on "backwards" and then opened for a visual inspection of imprint that the grease made to the cover to verify an even distribution along the sealing. After this the cover was mounted the correct way.				

14.01.08 - 24.01.08	PBS	Maja Rostad
Performed by:	Date:	Location:	Quality Assurance:

9 Procedure Sign-off

All steps and activities described in the Procedure have been successfully performed.

Failures and non-conformities raised during procedure execution were listed in table 5.

Procedure sign-off:

Engineer — Date

Motoshi Kamada — 04. Feb. 2008

Quality Assurance — Date

Hajo Rostad — 04 February 2008

Engineer — Date

Håkon Svare — 04/02 – 2008

Appendix 1: Zeolite – Nutrition Enrichment

Appendix 1
Zeolite – Nutrition Enrichment

Prepared by	Suzanne Øverlie
Reference	
Issue	1.3
Date of Issue	23.05.2007
Status	
Document type	Procedure
Distribution	

1 Method for enriching the Zeolite with MS-media

The following procedure describes how to enrich 1 kg Zeolite with Murashige and Skoog medium (without ammonia).

Step	Step Description	Demonstration/Photo/Remark	Performed
1	Place 1l / 905 g dry, filtered Zeolite (ZeoPro, dried at 170°C for 60 min) in a large bowl (8-10l).		N/A
2	Dissolve 2.7 grams MS (MS without ammonia, Sigma 2909) per 3 dl distilled water. Make use of a magnetic stirrer while heating up to 90°C.		N/A
3	Transfer 1.5 dl MS-Medium to a Spray bottle.		N/A
4	Slowly spray MS-medium on the Zeolite while rotating the Zeolite-containing bowl. (Rotating the bowl is important to ensure proper distribution of MS to the Zeolite. Adding too much MS-medium to the Zeolite at the same time will cause lumping of particles and inhibit proper distribution of the nutrition.)		N/A
5	When there is no more MS-medium in the spray bottle and rotating the bowl has ensured that all the Zeolite is wet (visual inspection) transfer the wet, enriched Zeolite to a drying cabinet (50°C, min 5 hrs)		N/A
6	Perform step 3-5 with the last 1.5 dl of MS-medium.		N/A
7	Sieve the enriched Zeolite trough Sieve with 1 mm mesh width in order to separate lumped particles.		N/A

Grete Rasmaag	May 30/ June 11-07	N-USOC	Carina Helle Berg
Performed by:	Date:	Location:	Quality Assurance:

2 Test Procedure Variation Fill-in

All changes and variations to the Procedure shall be documented in Table 5.

Table 2: Changes and variations to the procedure.

Test step No.	Test-step Description	Nominal Value	Tolerance	Actual Value	Remarks
1-7	Performed prior to Multigen 1 experiment. Same batch used for CW/RW.				Date: May 30/June 11 - 07 By: Grete Rakvaag QA: Canna Helle Berg. Documented in filled in N-USOC-PRO-002 for Multigen-1 Set-up.

3 Procedure Sign-off

All steps and activities described in the Procedure have been successfully performed.

Failures and non-conformities raised during procedure execution were listed in table 2.

Procedure sign-off:

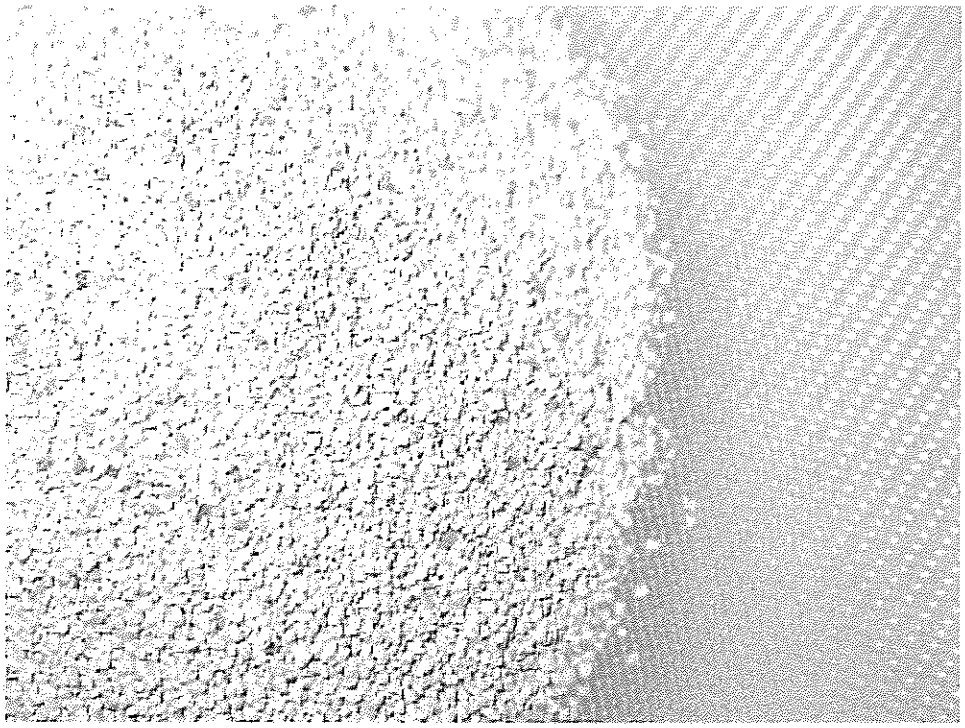
Engineer N/A ---------- Date ----------

Quality Assurance N/A ---------- Date ----------

Appendix 2: Procedure for filtering of Zeolite

EMCS - EXPERIMENTS

Procedure for Filtering of Zeolite



prototech

PROJECT

EMCS - EXPERIMENTS

TITLE

Procedure for Filtering of Zeolite

PREPARED BY:	Geir Omdal	Sign:	Date: 03.05.2007
CHECKED BY:	Bjørnar Vasenden	Sign:	Date: 03.05.2007
PRODUCT ASSURANCE:	Marian N. Melle	Sign:	Date: 03.05.2007
PROJECT MANAGEMENT:	Geir Omdal	Sign:	Date: 03.05.2007

ISSUE STATUS

The status list shows which chapters are included, which changes are introduced, valid issue and issued date.

Ch. no. / Page. no.	Change	Issue	Date
Ch.6, App. A and App. B	Editorial updates based on comments from ESA	B	03.05.2007

CONTENTS

1 SCOPE

This document describes a procedure to filter the Zeolite according to agreement from EMCS Experiment Batch-1 Multigen-1 Phase II Flight Safety Review, no Zeolite particles below 0.5mm in diameter.

Taken from MoM from EMCS Experiment Batch-1 Multigen-1 Phase II Flight Safety Review [RD1]:

"During the review the question arose if Zeolite would present a potential hazardous to the crew (e.g. the particles causing eye irritation). A response was immediately requested from the NASA JSC toxicologist. The response received stated that if the PO can assure JSC Toxicology and the PSRP that dusts have been eliminated and essentially all Zeolite particles in the flight samples with larger than 0.5 mm diameter, the Toxicity Hazard Level would be reduced to zero (non-hazard)"

2 REFERENCE DOCUMENTS

The following documents are referenced:

No	Reference	Title	Iss. Rev.	Date
RD1	Not available	MoM from EMCS Experiment Batch-1 Multigen-1 Phase II Flight Safety Review	A	27.06.2006

Table 2-1 Reference Documents

3 PARTICIPANTS REQUIRED

Personnel required:

Engineer
Responsible for:
- perform filtering according to procedure
- filling out step-by-step procedure

Quality Assurance Engineer
Responsible for:
- surveillance of the filtering and that filtering is performed according to procedure

Responsibility	Company / Dep.	Name
Engineer	Prototech	tbd
Quality Assurance Engineer	Prototech	Mrs. Marian N. Melle
Project Manager	Prototech	Mr. Geir Omdal

Table 3-1 Participants

4 EQUIPMENT LIST

No.	Equipment	Manufacturer	Model	Invent No.
1	Filter jig with mesh opening of 0.5mmx0.5mm	Prototech		

Table 4-1 Equipment List

5 DESCRIPTION

Filtering of Zeolite. No particles below 0.5mm in diameter

5.1 Equipment

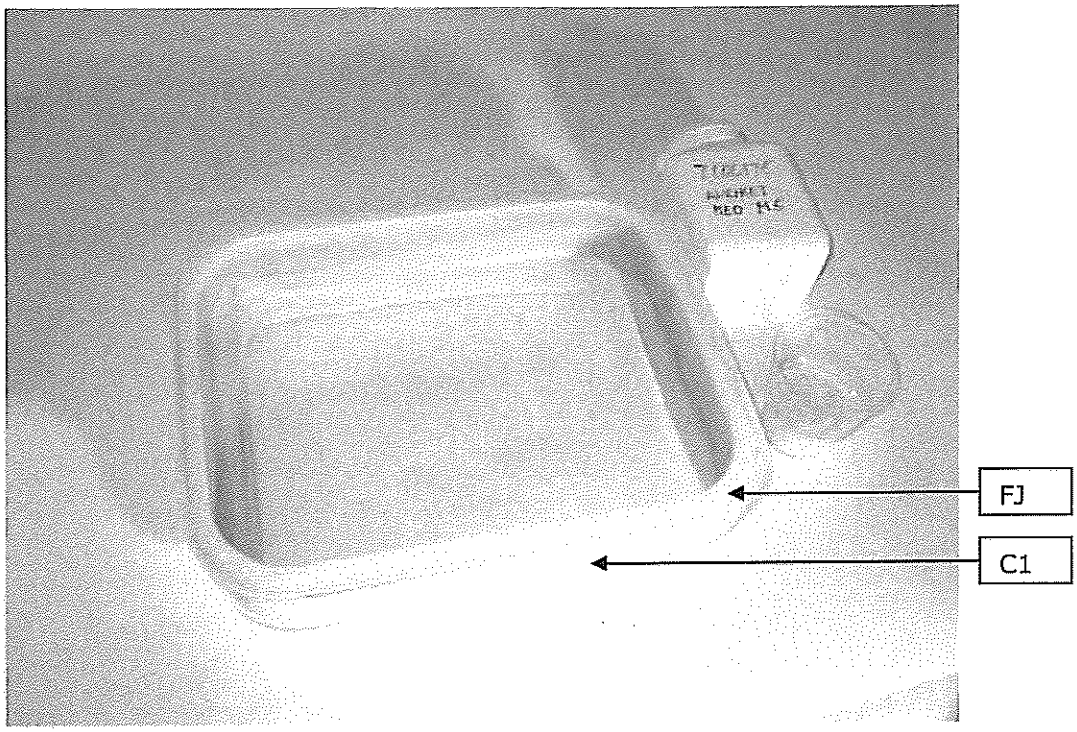
- **Filter jig (FJ)**: Filter jig with Propyltex (PP) felt with mesh opening of 0.5mmx0.5mm. SEFAR PP Felt article no. 05-500/36.

- **Container 1 (C1)**: One container (same size or bigger than Filter jig) collecting the Zeolite particles below 0.5mm in diameter.

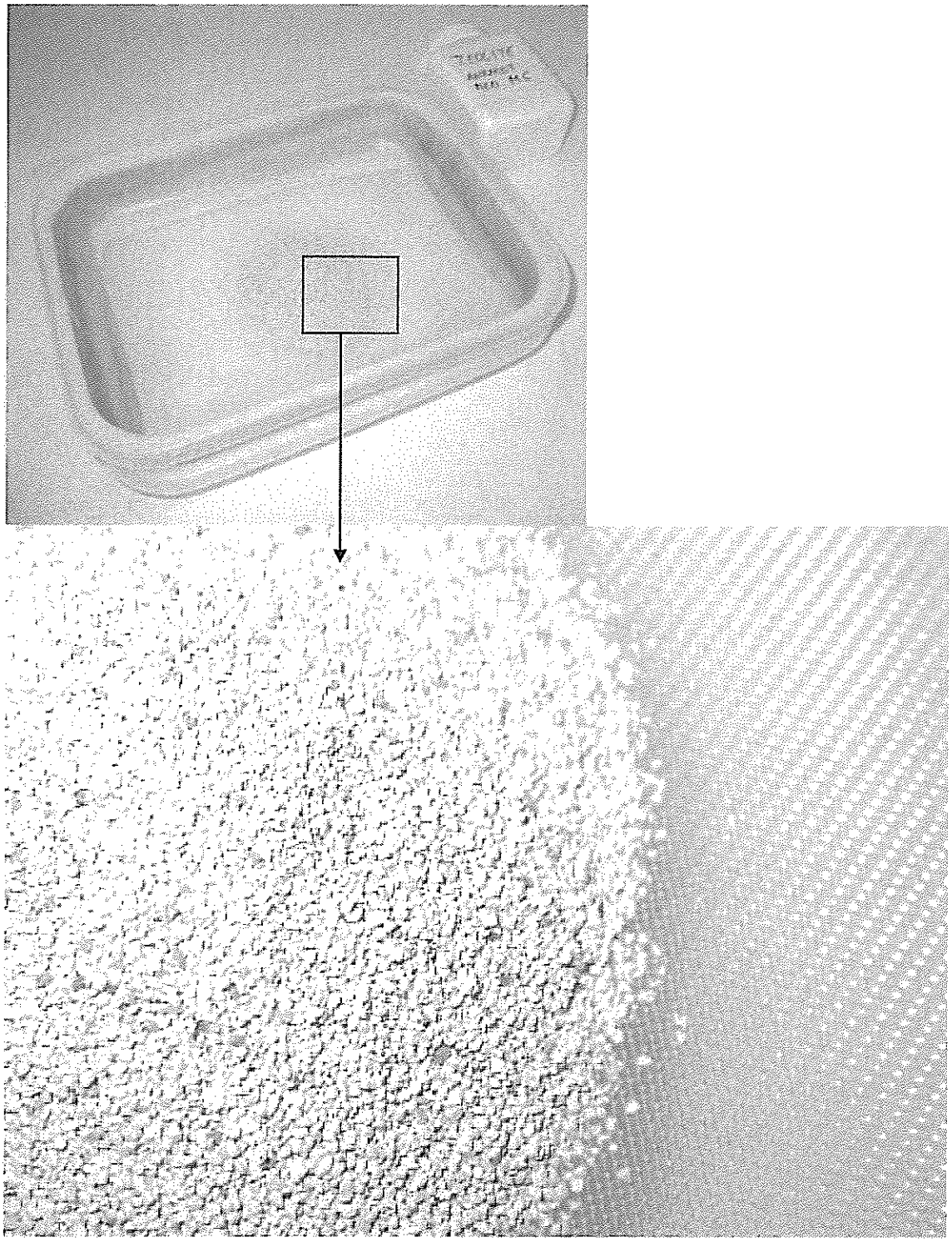
- **Container 2 (C2)**: One container or glass for collecting the filtered Zeolite

5.2 Filtering of Zeolite

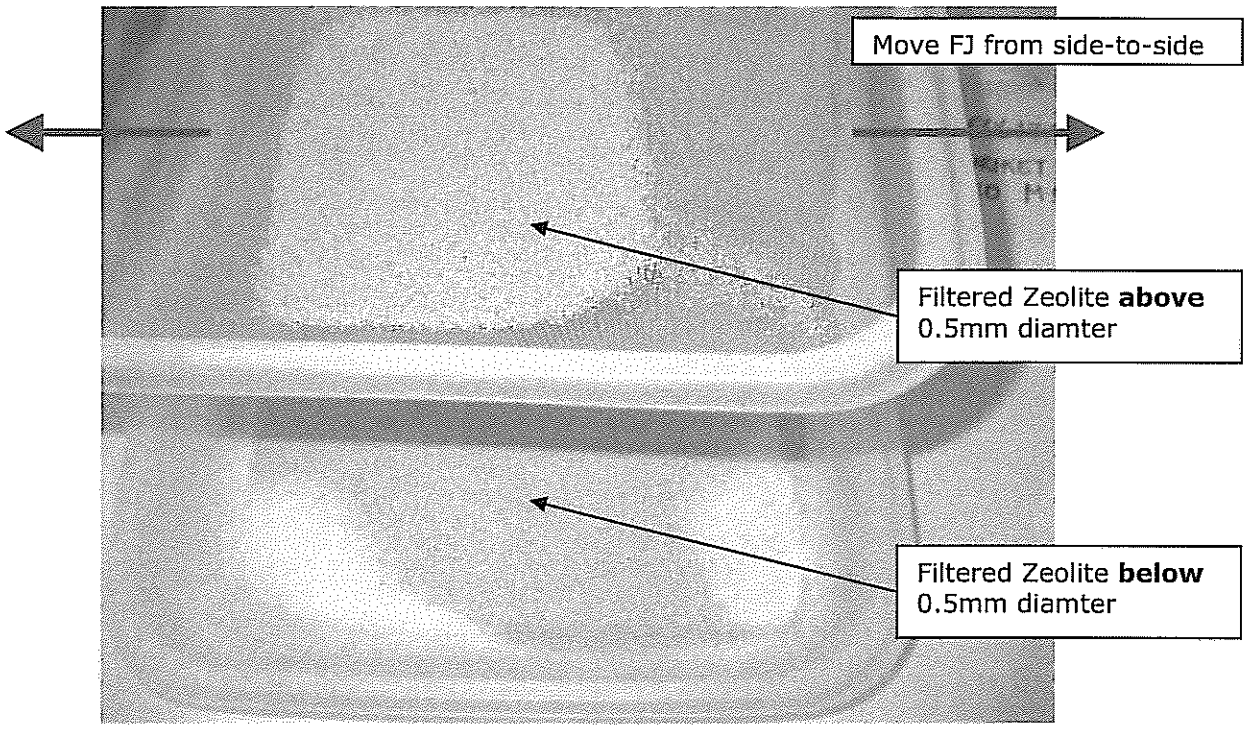
#1. Place C1 on a clean table and place FJ on top of C1. As shown in picture below.



#2. Pour unfiltered Zeolite into FJ (do not filter to much Zeolite at a time). See pictures below.

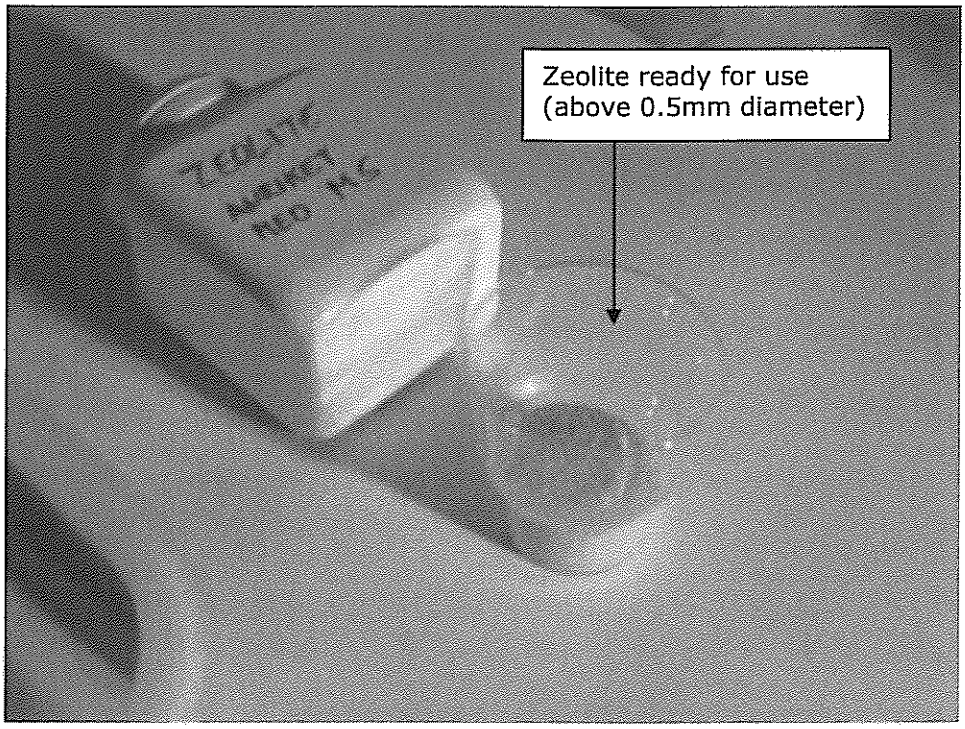


#3. Start filtering the Zeolite by moving the FJ from side to side by using your hands. See picture below. Continue this to you observe that no more Zeolite is falling through the mesh in the FJ. The QA engineer shall also observe and agree when the filtering is sufficient.



#4. Pour the filtered Zeolite (above 0.5mm diameter) into a clean container or glass. See picture below.

#5. The Zeolite is now finished filtered and ready for use. Filling of growth pot shall be done according to Growth Pot Filling Procedure (from Multigen-1 PI).



6 STEP BY STEP PROCEDURE

Step No.	Step-Description	Comments	P	N
	Preparations			
1.	fill out personnel in chapter 3			
2.	check equipment acc. to chapter 5.1 and fill out Equipment List in chapter 4			
	Filtering			
3.	Start filtering acc. to chapter 5.2			
4.	Perform step **#1**			
5.	Perform step **#2**			
6.	Perform step **#3**			
7.	Perform step **#4**			
8.	Perform step **#5**			
9.	Filtering finished			

Step No.	Step-Description	Comments	P	N
	Finishing			
10.	fill out and sign step by step procedure forms			
11.	fill out and sign Procedure Sign-off Sheet			

7 ACCEPT/ REJECT CRITERIA

The filtering is considered as successful if filtering has been performed according to procedure and no deviations / anomalies have occurred.

8 DEVIATION

All deviations to this procedure shall be recorded on the Procedure Deviation Sheet in Appendix A.

9 NONCONFORMANCES

All Non-Conformance shall be recorded in the Non-Conformance List in Appendix B.

10 PROCEDURE SIGN-OFF SHEET

Statement that the Zeolite has been filtered in accordance with the approved procedure to be signed and dated by Engineer, Quality Assurance Representative and Customer Representative (where applicable) in Appendix C.

11 TABLE LIST

APPENDIX A PROCEDURE DEVIATION SHEET

Step No.	Step - Description	P	N	Remarks
1-11	Performed prior to Multigen-1 experiment. Same batch used for CW/RW (N-USOC-PRO-002 Issue 1.3)			Date: May 30/ June 11-07 By: Grete Rakvaag, QA: Carina Helle Berg.

APPENDIX B NONCONFORMANCE LIST

NCR NO.	NCR DESCRIPTION	DATE GENERATED	DATE CLOSED

APPENDIX C PROCEDURE SIGN-OFF SHEET

Item_____

Part No._____, Serial No._____

has been filtered in accordance with the foregoing procedure.

ENGINEER: N/A Sign: _____ Date: _____

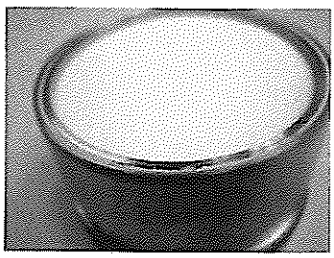
PRODUCT ASSURANCE: N/A Sign: _____ Date: _____

PROJECT MANAGEMENT: _____ Sign: _____ Date: _____

CUSTOMER REPRESENTATIVE:_____ Sign: _____ Date: _____
(where applicable)

Appendix 3: Fixation of Sponge on PCC Growth Pot

Appendix 3
Fixation of Sponge on PCC Growth Pot

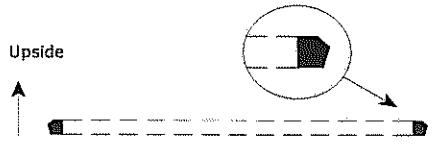
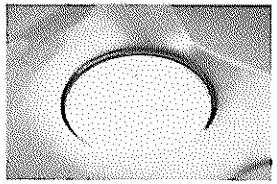


Prepared by	Suzanne Øverlie
Reference	
Issue	1.3
Date of Issue	23.05.2007
Status	
Document type	Procedure
Distribution	

1 Fixation of Sponge on PCC Growth Pot

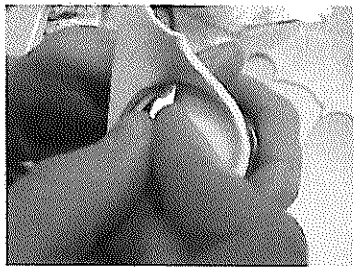
The following procedure describes how to implement the sponge in the bottom part of the Multigen-1 Plant Cultivation Chamber (PCC) Growth Pot. (For details see N-USOC-PRO-002.)

Table 1: Step-by-step description of procedure

Step	Step Description	Demonstration/Photo/Remark	Performed
1	Take a piece (approximately 6x6 cm) of Polyvinyl Alcohol (PVA) sheet material (thickness 2.0 mm)		
2	Wet material thoroughly and squeeze out all excess water		
3	Draw a circle on the PVA sheet with a soft pencil. Use outer rim of the Growth Pot as template.		
4	Cover Growth Pot bottom with wet PVA sheet and stretch evenly out by small force before attaching growth pot ring for fixation. The drawn circle shall be visible 3 mm on the outside of the Fixation Ring. The Fixation Ring is not symmetric. Make sure it faces the correct way relative to the Growth Pot.	 Observe the position of the ring before pushing down to fixate the sponge 	

Performed by: Bjornar Vasenden, Håkon Svare | Date: 14.01.08 and 23.01.08 | Location: PBS | Quality Assurance: Maja Rostad (FMC95and 099)

Table 1: Cont.

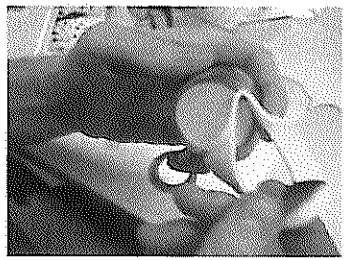
Step	Step Description	Demonstration/Photo/Remark	Performed
5	Cut loose excess sponge material by scalpel – roughly at first and then close to the rim.	 	

Bjørnar Vasenden
Hålon Svare

14.01.08 and 23.01.08 | PBS | Maja Rostad (FM095 and 099)

Performed by: | Date: | Location: | Quality Assurance:

Table 1: Cont.

Bjørnar Vasenden
Håkon Svare | 14.01.08 and 23.01.08 | PBS | Maja Rostad (FM095and099)

Performed by: | Date: | Location: | Quality Assurance:

2 Test Procedure Variation Fill-in

All changes and variations to the Procedure shall be documented in Table 5.

Table 2: Changes and variations to the procedure.

Test step No.	Test-step Description	Nominal Value	Tolerance	Actual Value	Remarks
1-5	Bjornar Vasendeu (Prototech) made and mounted sponges for ECs FM092, 094, 096, 097, 098 and 100. QA not present. Håkon Svare mounted for ECs FM095 and 099. QA present				

Performed by:	Date:	Location:	Quality Assurance:
Bjornar Vasendeu Håkon Svare	14.01.08 and 23.01.08	PBS	Maja Rostad

3 Procedure Sign-off

All steps and activities described in the Procedure have been successfully performed.

Failures and non-conformities raised during procedure execution were listed in table 2.

Procedure sign-off:

	Engineer	Date
FM095, FM099	Håkon Sagvolden	04/02 – 2008
	Quality Assurance	**Date**
FM095, FM099	Maja Rostad	04 February 2008
	Engineer	Date
FM092, FM094 FM096, FM097 FM098 and FM100	Rannveig Vasvenden	04.02.2008

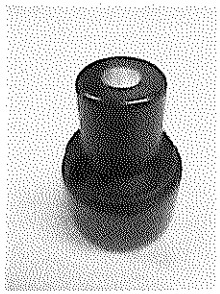
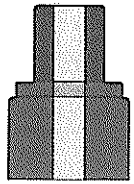
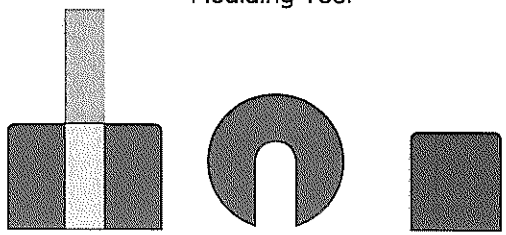
Appendix 4: Moulding and sterilization of PVA membrane

Appendix 4
Moulding and Sterilization of PVA Membrane

Prepared by	Suzanne Øverlie
Reference	
Issue	1.3
Date of Issue	23.05.2007
Status	
Document type	Procedure
Distribution	

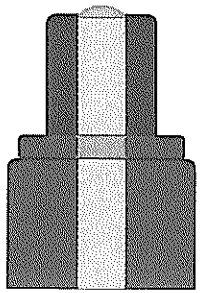
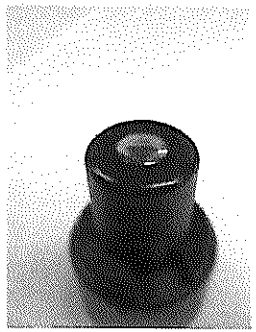
1 Moulding and sterilization of polyvinyl alcohol (PVA) Membrane

The following procedure describes how to mould the Polyvinyl Alcohol (PVA) membrane that will immobilize Arabidopsis seeds in the Multigen Plant Cultivation Chamber (PCC). One PVA membrane shall be made for each hole in the PCC lids (for details see N-USOC-PRO-002).

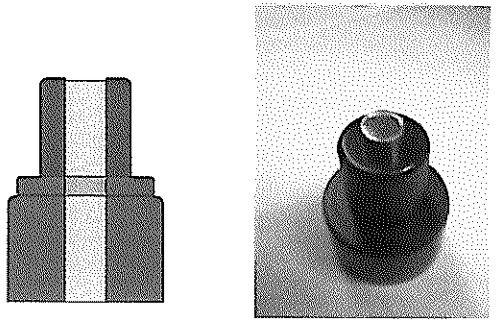
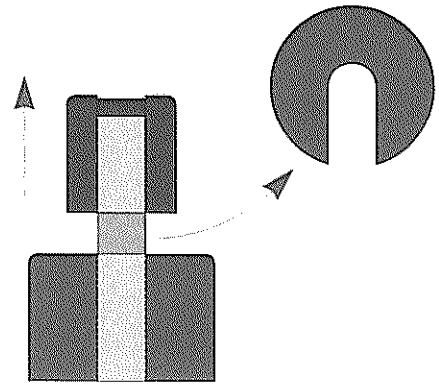
Step	Step Description	Demonstration/Photo/Remark	Performed
1	Use specialized Moulding Tool (Diameter of steel part 5.2 mm)	 PVA Moulding Tool Assembled  Parts of the PVA Moulding Tool  Base with Column of stainless steel; Spacer Ring; Column Casing	

Håkon Svare | 14.01.08 - 23.01.08 | PBS | N/A

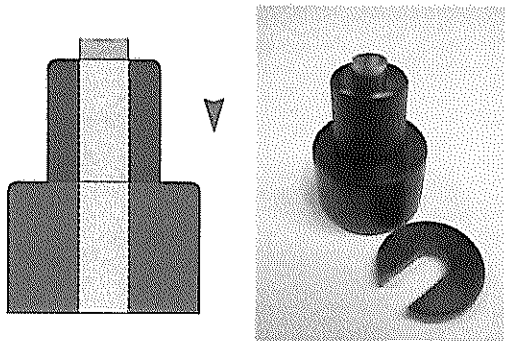
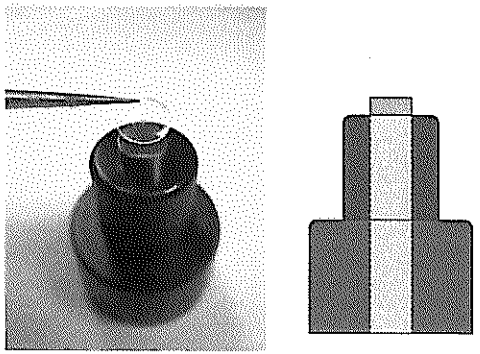
Performed by: | Date: | Location: | Quality Assurance:

Step	Step Description	Demonstration/Photo/Remark	Performed
2	Place droplet of PVA on PVA Moulding Tool. (Use pipette (Eppendorf Referee) with 10 µl of PVA solution ratio 1:5 with water).	 	
3	Spread the droplet around the edges of the Moulding Tool	 	

Performed by:	Date:	Location:	Quality Assurance:
Håkon Svare	14.01.08 - 23.01.08	PBS	N/A

Step	Step Description	Demonstration/Photo/Remark	Performed
4	Cure in oven at 45°C for about 20 minutes	 After curing	
5	Remove Spacer Ring and push Column Casing carefully upwards until PVA Membrane slips from column		

Performed by:	Date:	Location:	Quality Assurance:
Håkon Svare	14.01.08 - 23.01.08	PBS	N/A

Step	Step Description	Demonstration/Photo/Remark	Performed
6	Push Column Casing downwards		
7	PVA Membrane is now emancipated and can be removed from Column with a micro-tip pincer		
8	Distribute about 20 PVA Membranes evenly on a circular nitrocellulose filter paper in a glass Petri Dish (5 cm diameter).		

Performed by:	Date:	Location:	Quality Assurance:
Håkon Svare	14.01.08 - 23.01.08	PBS	N/A

Step	Step Description	Demonstration/Photo/Remark	Performed
9	Cover the PVA membranes with a new sheet of the same type of nitrocellulose filter paper.		
10	Shape a piece of cotton to fit into the Petri dish (size should be somewhat larger than the Petri dish volume).		
11	Apply 25 µl of water on the cotton before attaching the Petri dish Lid on to the Petri dish. (The purpose of the cotton piece is to apply small but evenly pressure on the nitrocellulose sheets and the PVA Membranes to make them stay in place.)		
12	Lock Petri dish Lid to Petri dish by using autoclave tape.		
13	Place closed Petri dish inside 500 ml glass jar with appurtenant lid and sealing.		
14	Tighten lid carefully to avoid any evaporated water in the autoclave to get in contact wit the PVA Membranes.		
15	Place the glass jar in an autoclave and sterilize at 120°C for 20 minutes.		

Performed by:	Date:	Location:	Quality Assurance:
Håkon Svare	14.01.08 - 23.01.08	PB S	N/A

2 Test Procedure Variation Fill-in

All changes and variations to the Procedure shall be documented in Table 5.

Table 2: Changes and variations to the procedure.

Test step No.	Test-step Description	Nominal Value	Tolerance	Actual Value	Remarks

Håkon Svare | 14.01.08 - 23.01.08 | PBS | N/A

Performed by: | Date: | Location: | Quality Assurance:

3 Procedure Sign-off

All steps and activities described in the Procedure have been successfully performed.

Failures and non-conformities raised during procedure execution were listed in table 2.

Procedure sign-off:

Engineer ---------- Håkon Sivertsen

Date ---------- 04/02-2008

Quality Assurance ---------- N/A

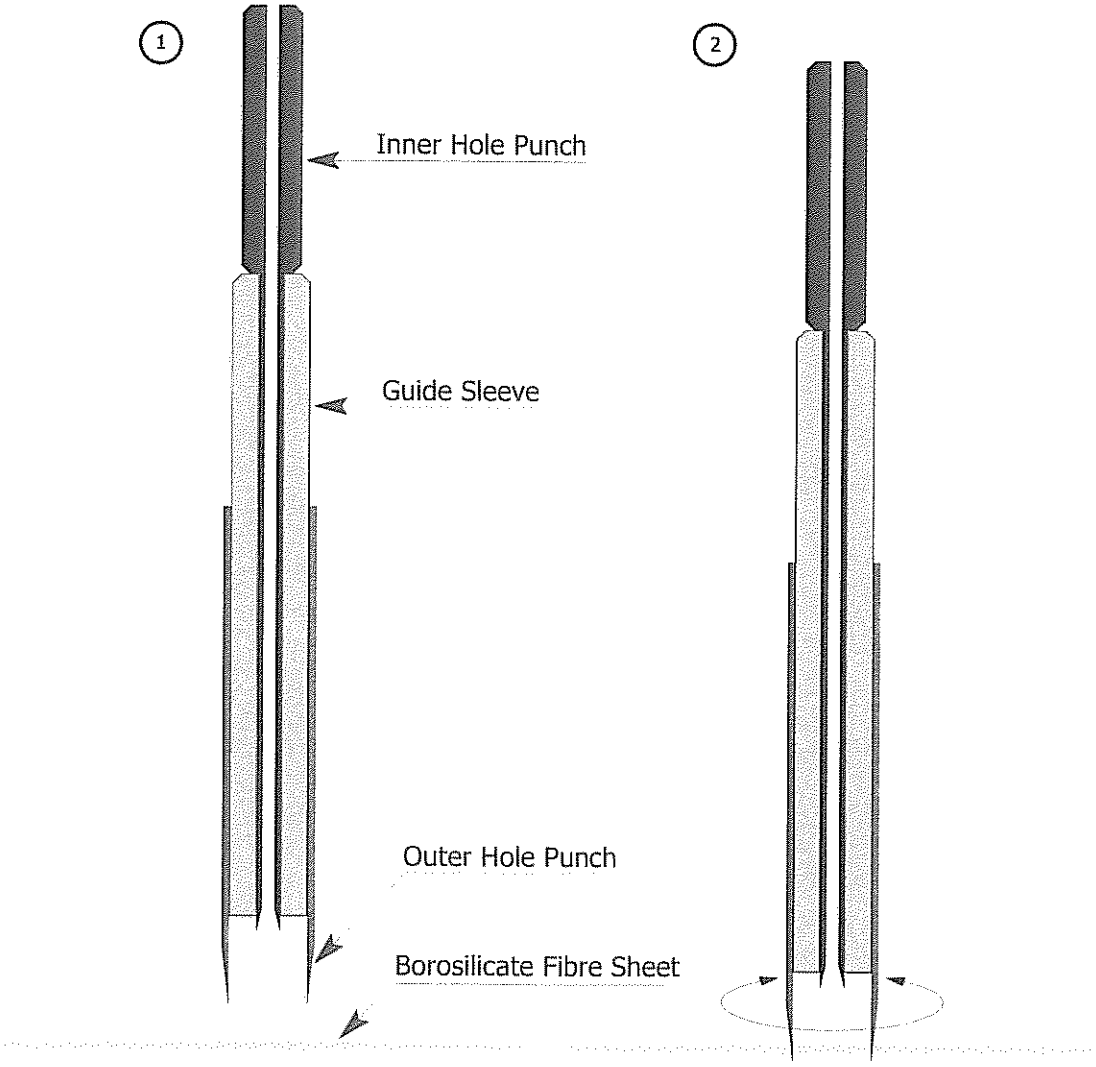
Date ----------

Appendix 5: Borosilicate cutting

Appendix 5
Borosilicate Cutting

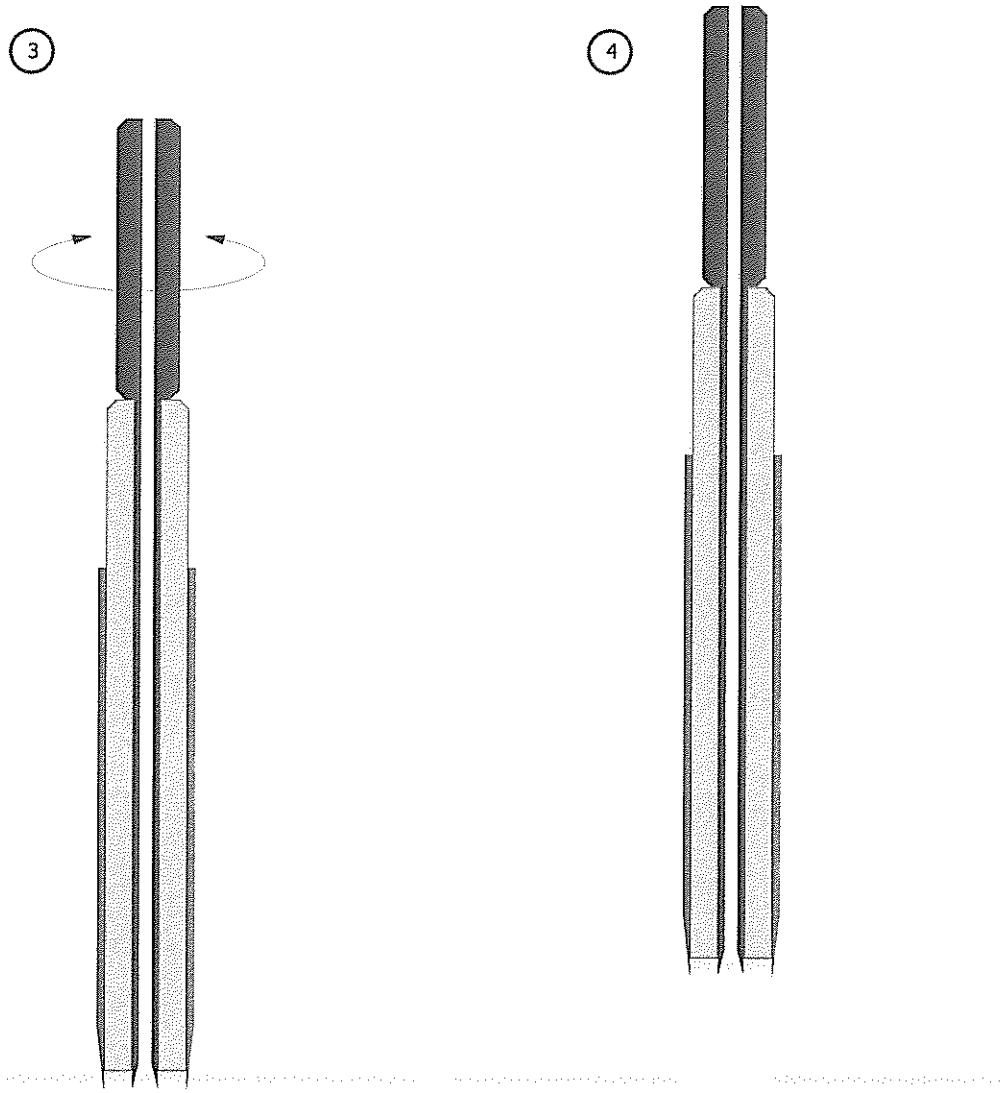
Prepared by	Håkon Svare
Reference	
Issue	1.3
Date of Issue	23.05.2007
Status	
Document type	Procedure
Distribution	

1 Procedure for Borosilicate Cutting



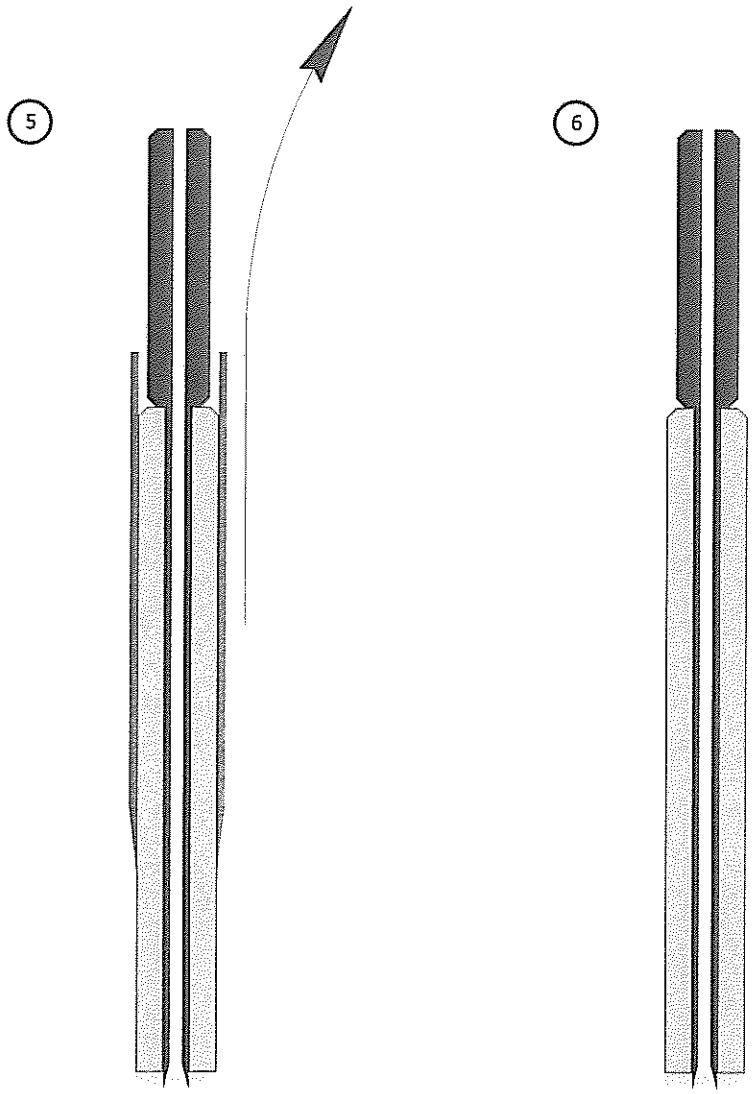
1/ Pick up the punching tool by the Outer Hole Punch and place it perpendicular to the Borosilicate Fibre Sheet.

2/ Penetrate the Borosilicate Fibre Sheet by gently pushing the Outer Hole Punch downwards while slowly rotating the Outer Hole Punch in both directions.



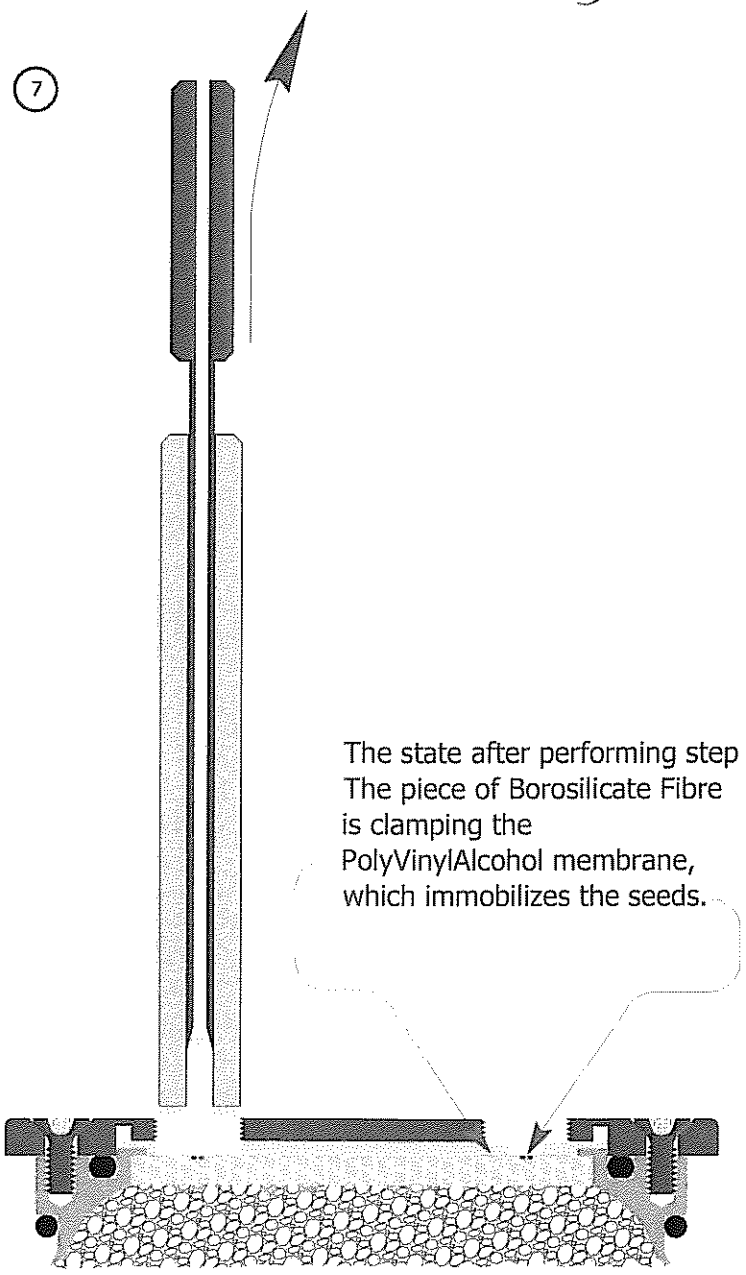
3/ Keep the punching tool stable and penetrate the Borosilicate Fibre Sheet again by gently pushing the Inner Hole Punch downwards while slowly rotating the Inner Hole Punch in both directions.

4/ Lift up the tool and confirm that the punched piece of Borosilicate Fibre remains fixed to the punching tool.

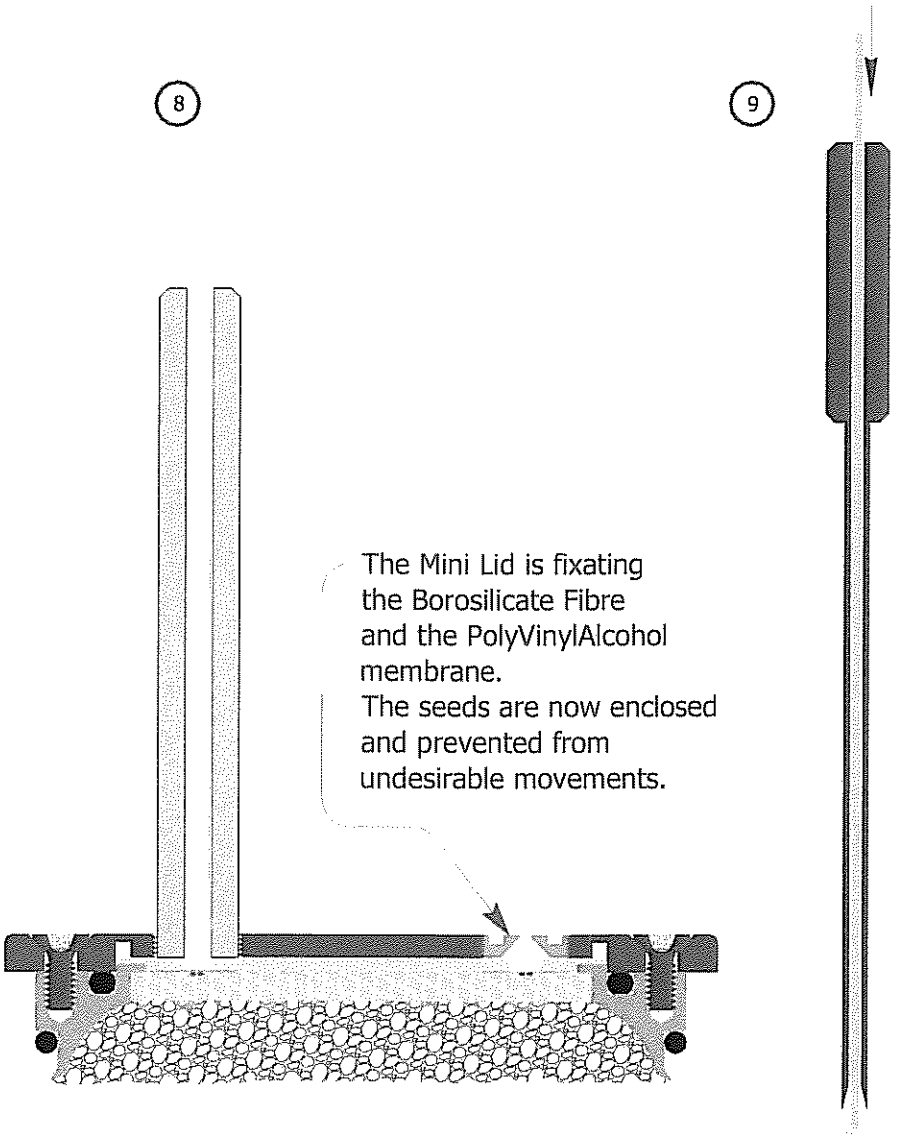


5/ Remove the Outer Hole Punch by sliding it upwards while holding the Guide Sleeve.

6/ Confirm that the punched piece of Borosilicate Fibre remains fixed to the punching tool.



7/ Move the Punching tool to the Growth Pot and place it in position above the mini lid hole in the Growth Pot Lid. Remove the Inner Hole Punch by sliding it upwards while keeping the Guide Sleeve in the accurate position above the mini lid hole.
Confirm that the punched piece of Borosilicate Fibre remains in the middle of the mini lid hole.



8/ Use the Guide Sleeve to gently depress the small doughnut shaped piece of borosilicate down in the mini lid hole. Use a stereomicroscope to confirm that the piece of borosilicate is evenly clamping the PVA membrane against the PolyPropylene felt and that the seeds are positioned in the middle the borosilicate hole. Finally the Mini Lid is mounted with the designated tool.

9/ Attention: Before the procedure can be repeated for the next mini lid hole position, the piece of borosilicate that remains fixed in the Inner Hole Punch must be removed using the thin rod of stainless steel to push it out.

2 Procedure Sign-off

All steps and activities described in the Procedure have been successfully performed.

Failures and non-conformities:

Procedure sign-off:

Engineer	Date
Natalia Kamocka	04. Feb. 2008
Quality Assurance	**Date**
Maja Rosstad	04 February 2008

Appendix 2:

Filled in N-USOC-PRO-004 CW/RW Seed Set Up Procedure, Issue 1.

CW/RW
Seed Set up Procedure

Prepared by	Suzanne Øverlie
Reference	
Issue	Issue 1
Date of Issue	16.01.2008
Status	
Document type	Procedure
Distribution	As described in Approval list, page 2

N-USOC, The Plant BioCentre,
Dragvoll Alle 38, N-7491 Trondheim

Approval

Title:	CW/RW Test Procedure CW/RW Seed Set Up	Issue:	~~Draft~~ 1

Author:	Signature:	Affiliation:	Date:
Suzanne Øverlie	Suzanne Øverlie	N-USOC	16/1-08
Checked by:	**Signature:**	**Affiliation:**	**Date:**
Ann-Iren Kittang	Ann-Iren Kittang	N-USOC	18/1-08
Knut Fossum	Knut R Fossum	N-USOC Manager	16/1-08
Motoshi Kamada	Motoshi Kamada	JAXA CW/RW Team Coordinator	16/1 - 08
Ulrich Kuebler		ESA/EMCS CW/RW PIM	
Wilfried Biemann	W. Biemann	Astrium/IOT PA	23 Jan 2008
Thomas Niedermaier		Astrium	
Approved by:	**Signature:**	**Affiliation:**	**Date:**
Toru Shimazu		JSF PI-Rep	

Change Log

Reason for Change:	Issue:	Date:

Approval

Title:	CW/RW Test Procedure CW/RW Seed Set Up	Issue:	Draft

Author:	Signature:	Affiliation:	Date:
Suzanne Øverlie		N-USOC	

Checked by:	Signature:	Affiliation:	Date:
Ann-Iren Kittang		N-USOC	
Knut Fossum		N-USOC Manager	
Motoshi Kamada		JAXA CW/RW Team Coordinator	
Ulrich Kuebler		ESA/EMCS CW/RW PIM	
Wilfried Biemann		Astrium/IOT PA	
Thomas Niedermaier		Astrium	

Approved by:	Signature:	Affiliation:	Date:
Toru Shimazu		JSF PI-Rep	16 Jan. 2008

Change Log

Reason for Change:	Issue:	Date:

Approval

Title:	CW/RW Test Procedure CW/RW Seed Set Up	Issue:	Draft

Author:	Signature:	Affiliation:	Date:
Suzanne Øverlie		N-USOC	

Checked by:	Signature:	Affiliation:	Date:
Ann-Iren Kittang		N-USOC	
Knut Fossum		N-USOC Manager	
Motoshi Kamada		JAXA CW/RW Team Coordinator	
Ulrich Kuebler		ESA/EMCS CW/RW PIM	
Wilfried Biemann		Astrium/IOT PA	
Thomas Niedermaier	T. Nied	Astrium	23 JAN 2008
Approved by:	**Signature:**	**Affiliation:**	**Date:**
Toru Shimazu		JSF PI-Rep	

Change Log

Reason for Change:	Issue:	Date:

Approval

Title:	CW/RW Test Procedure CW/RW Seed Set Up	Issue:	Draft

Author:	Signature:	Affiliation:	Date:
Suzanne Øverlie		N-USOC	

Checked by:	Signature:	Affiliation:	Date:
Ann-Iren Kittang		N-USOC	
Knut Fossum		N-USOC Manager	
Motoshi Kamada		JAXA CW/RW Team Coordinator	
Ulrich Kuebler		ESA/EMCS CW/RW PIM	
Wilfried Biemann		Astrium/IOT PA	
Thomas Niedermaier		Astrium	

Approved by:	Signature:	Affiliation:	Date:
Toru Shimazu		JSF PI-Rep	

Change Log

Reason for Change:	Issue:	Date:

Content

1 Applicable Documents

Applicable Documents

AD	Document Number	Date	Issue	Title
AD01	CW/RW ISR	16.02.07	0	EMCS Cell Wall & Resist Wall INTEGRATED SCIENCE REQUIREMENTS DOCUMENT
AD02	EMEX-RP-MULT-02-EADS	11.12.03		"EMCS-Experiments, Multigen Part 1 Design Report" (EADS)
AD03	RP_30193_PR_02	06.10.2005		"EMCS Experiments Multigen-1 Design Report CCN04"
AD04	N-USOC-REQ-007	06.07.2007	1	"EMCS CW/RW Integration Requirement Document"
AD05	EMCS-MA-4000-002-DCR	12.11.2004		"EC User Handbook"
AD06	EMCS-MA-0000-001-DOR	18.05.2006	2	"EMCS Payload User Manual"
AD07	EMEX_MA_MULT_01_PRO	14.12.2007	E	"PCC-1 User Manual"
AD08	EMCS-PR-0000-07-DOR	21.06.2006	1	"EMCS EM Systems Start-Up and Stop Procedure"
AD09	N-USOC-PRO-002	14.05.2007	1.2	"PCC Assembly and Seed Set-Up Procedure"

2 List of Abbreviations

EC	Experiment Container
EM	EMCS Engineering Model
EMCS	European Modular Cultivation System
PI	Principal Investigator
PA	Product Assurance
QA	Quality Assurance
ESA	European Space Agency
NASA	National Aeronautics and Space Administration
IOT	Industry Operator Team
N-USOC	Norwegian User Support and Operations Centre

3 Scope of Document

This document and the Multigen-1 PCC Assembly and Seed Set up Procedure [AD09], cover the CW/RW PCC set-up of seeds in the CW/RW FMs. This document is based on input from PI rep and JAXA CW/RW Team Coordinator.

The set up will be performed according to the Multigen-1 set up procedure except for the strains of *Aribidopsis Thaliana,* the positioning of seeds, number of holes in PCC Growth Pot lid, FM numbers and the implementation of the small o-ring which all differ from the Multigen-1 experiment. These differences are covered in chapter 4.

4 Differences from Multigen-1 Set Up Procedure

4.1 Seeds

This point replaces step 25 in the Multigen-1 PCC Assembly and Seed Set up Procedure [AD09] in the Cell Wall/Resist Wall Set Up.

4.1.2 Seed description

For Cell Wall/Resist Wall 4 different seed strains are used: *Arabidopsis thaliana* wild-type (WT), lefty, hmg, GUS GMO.

4.1.3 Sterilisation of the Seeds

Arabidopsis seeds in eppendorf tube

- Sterilized in 500ul of 70% ethanol for 5 min
- Washed with 500ul of sterilized water 1 time
- Soaked in 500ul of 2.5% sodium hypochlorite and 0.5% Tween 20 for 5 min
- Washed with 500ul of sterilized water 4 times
- Dried on sterilized filter paper

4.1.4 Seed set up in the CW/RW PCC Flowerpot

Table 1 shows the set up of the CW/RW EC Flight Models (EC FM) and PCC FM with the correct seed strains. The EC FM and PCC FM are given in row 1 and row 2 of Table 1. Figure 1 and 2 show minilid locations number in the CW/RW PCC flower pot where the different seed types are located. The minilid location number (from 1 to7) is found in column 2 in Table 1. In column 3 the strain names can be found and the number of seeds in the minilid is given (Num).

4.2 O-ring

This point replaces step 32 in the Multigen-1 PCC Assembly and Seed Set up Procedure [AD09] in the Cell Wall/Resist Wall Set Up.

4.2.1 Implementation of small o-ring

Implement the sterilized small o-ring on the Growth Pot Lid instead of on the water-nipple [AD07] 6.3.1 step 1 and 2. This is to prevent the o-ring from being damaged.

Table 1: CW/RW Seed Setup Configuration. 17/1 18/1 17/1 18/1

PCC set up	EC FM	92		94		95		96		97		98		99		100		67
	PCC FM	21		18		19		20		16		22		23		17		QM01 (Spare)
	mini-lid	Strain	Num	strain	num	strain	num	strain	num	strain	num	strain	num	strain	num	strain	num	strain
	1	WT	2	WT	1	WT	2	GUS	1	WT	2	WT	1	WT	2	GUS	1	
	2	WT	2	WT	1	WT	2	GUS	1	WT	2	WT	1	WT	2	GUS	1	
	3	lefty	3	WT	1	hmg	3	GUS	1	lefty	3	WT	1	hmg	3	GUS	1	
	4	lefty	3	WT	1	hmg	3	GUS	1	lefty	3	WT	1	hmg	3	GUS	1	
	5	lefty	3	WT	1	hmg	3	GUS	1	lefty	3	WT	1	hmg	3	GUS	1	
	6	lefty	3	WT	1	hmg	3	GUS	1	lefty	3	WT	1	hmg	3	GUS	1	
	7	lefty	3	WT	1	hmg	3	GUS	1	lefty	3	WT	1	hmg	3	GUS	1	
	integration	2008/1/22		2008/1/17		2008/1/23		2008/1/18		2008/1/22		2008/1/17		2008/1/23		2008/1/18		
Zeolite (g)		27,08 g		27,01g		27,08 g		27,09g		27,03g		27,01g		27,09g		27,07g		
EC whole weight (g)																		
Set up according to plan:		V		V		V 24. Jan		V		V		V		V 24. Jan		V		

Holes 1 and 2: 1 WT (old) + 1 WT (new) each

Only new WT

Holes 1 and 2: 1 WT (old) + 1 WT (new) each

Holes 1 and 2: 1 WT (old) + 1 WT (new) each

Only new WT

Holes 1 and 2: 1 WT (old) + 1 WT (new) each.

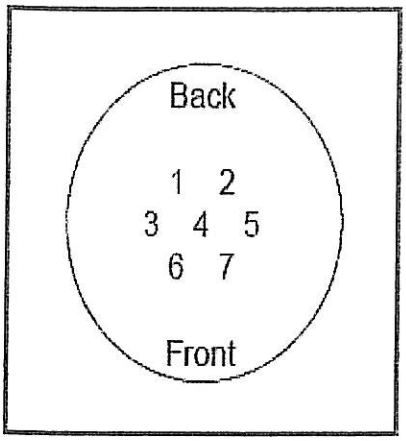


Figure 1: Number of holes in PCC lid

Number of seeds

WT: 7x2 + 4x4 = 30

GUS: 7x2 = 14

lefty: 15x2 = 30

hmg: 15x2 =30

Figure 2: Number of different types of seeds.

5 Test Procedure Variation Fill-in

All changes and variations to the Procedure shall be documented in Table 2.

Table 2: Changes and variations to the procedure.

Test step No.	Test-step Description	Nominal Value	Tolerance	Actual Value	Remarks

Table 2: Cont.

Test step No.	Test-step Description	Nominal Value	Tolerance	Actual Value	Remarks

6 Procedure Sign-off

All steps and activities described in the Procedure have been successfully performed.

Failures and non-conformities raised during procedure execution were listed in table 2.

Procedure sign-off:

Engineer

Motoshi Kamada

Motoshi Kamada (JAXA)

Date

04. Feb. 2008

Quality Assurance

Maja Rostad

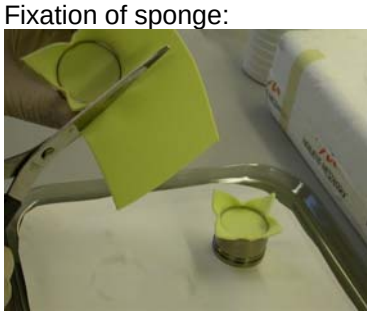
Maja Rostad (N-USOC)

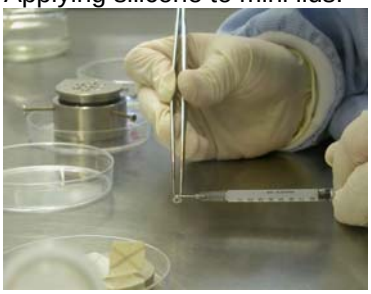
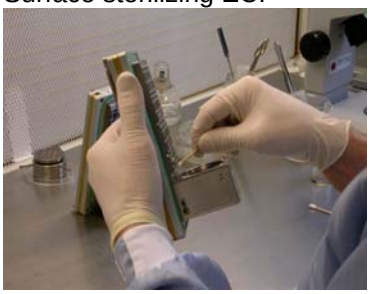
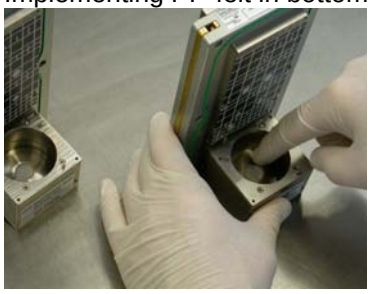
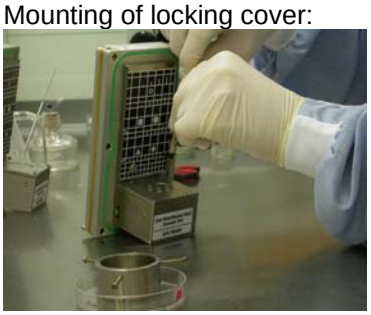
Date

04. February 2008

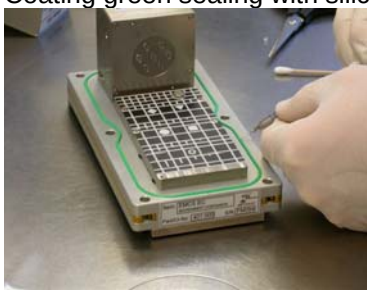
Appendix 3:

Pictures from CW/RW PCC Assembly and Seed Set-Up.

Fixation of sponge: 	Growth pot sterilization: 
Drying of the sponge: 	Filling of Zeolite: 
Implementing top PP-felt: 	Integration of top o-ring: 
Attaching growth pot lid: 	Integration of seeds: 

Implementing PVA membrane on seeds: 	Making doughnuts: 
Applying silicone to mini lids: 	Surface sterilizing EC: 
Implementing PP-felt in bottom of PCC: 	Implementing PP-felt around pot: 
Applying grease to o-ring around pot: 	Mounting of locking cover: 

Coating green sealing with silicone:



Appendix 3 - Flight Sample/H/W Packing, Transport and Checkout Procedure

CW/RW Flight Sample/Hardware Packing, Transport and Check-Out Procedure

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Prepared by	Maja Rostad
Reference	
Issue	2
Date of Issue	27.02.2008
Status	
Document type	Procedure
Distribution	As described in Approval list, page 2

CIRiS (Center for Interdisciplinary Research in Space),
NTNU Samfunnsforskning,
Dragvoll Alle 38, N-7491 Trondheim

Approval

Title:	**Issue:**
CW/RW Flight Sample/Hardware Packing, Transport and Check-Out Procedure	2

Author:	**Signature:**	**Affiliation:**	**Date:**
Maja Rostad		N-USOC	

Checked by:	**Signature:**	**Affiliation:**	**Date:**
Ann-Iren Kittang		N-USOC	
Knut Fossum		N-USOC Manager	
Toru Shimazu		JSF PI-Rep	
Ulrich Kuebler		ESA/EMCS CW/RW PIM	
Claude Brillouet		ESA PM	

Change Log

Reason for Change:	**Issue:**	**Date:**
Added letter of IOT insurance coverage, Import permit, V2 form and NASA Cover Letter	**2**	**27.02.2008**

Content

1 Applicable Documents

Applicable Documents

AD	Document Number	Date	Issue	Title
AD01	EMCS-MA-4000-002-DCR	12.11.2004		"EC User Handbook"
AD02	N-USOC-PRO-002	20.06.2007	1.3	"Multigen-1 PCC Assembly and Seed Set Up Procedure"
AD03	N-USOC-PRO-004	16.01.2008	1	"CW/RW Seed Set Up Procedure"
AD04	N-USOC-TR-027	13.02.2008	1	"Cell Wall/ Resist Wall PCC Assembly and Seed Set-Up Report"
AD05	EMCS-RP-4000-033-DOR	31.01.2008	1	"CWRW-EC Checkout and Inspection Report –Final Flight Preprations-"

2 List of Abbreviations

EC	Experiment Container
EM	EMCS Engineering Model
EMCS	European Modular Cultivation System
PI	Principal Investigator
PA	Product Assurance
QA	Quality Assurance
ESA	European Space Agency
NASA	National Aeronautics and Space Administration
IOT	Industry Operator Team
N-USOC	Norwegian User Support and Operations Centre
KSC	Kennedy Space Center

3 Introduction

The CW/RW hardware consists of the CW/RW Plant Cultivation Chambers (PCCs) integrated in the CW/RW Experiment Containers (ECs). The CW/RW ECs have been shipped from Astrium (FN,Germany) to Prototech, Bergen, Norway where the PCCs were implemented. The CW/RW ECs with implemented PCCs were then shipped from Prototech to the Norwegian User Support and Operations Centre (N-USOC, TRD, Norway). After arrival at N-USOC the CW/RW ECs with PCCs were utilized in CW/RW Biocompatibility test and CW/RW Hydration/germination tests. At the end of test period the ECs and PCC were cleaned by Prototech and finally surface sterilized by N-USOC set-up engineer.

In the period from 14th -24th of January 2008 one PI-team representative and one N-USOC engineer performed set up the PCCs with growth support and Arabidopsis seeds and closed the PCCs according to AD02 and AD03 as documented in AD04. IOT performed a final verification and leak-check of the ECs at N-USOC as documented in AD05.

Table 1 shows an overview of the needed documentation of the work performed at N-USOC as part of the CW/RW Flight Hardware preparation.

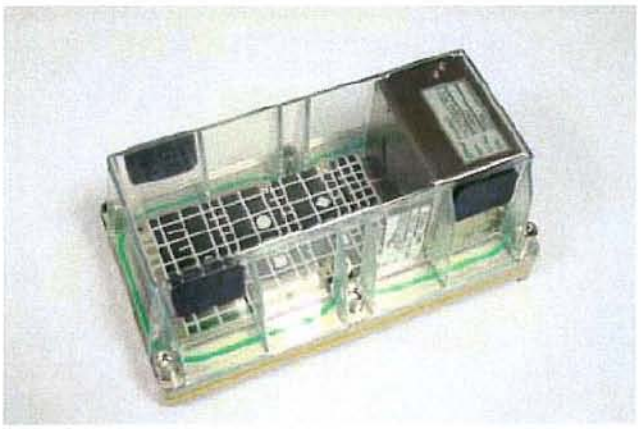


Figure 1: CW/RW Plant Culture Chamber implemented inside CW/RW Experiment Container (EC)

Table 1: Documentation of work performed at N-USOC as part of the CW/RW flight H/W preparation.

CW/RW PCCs Preparation at N-USOC	**Document Type**	**Provided by**	**Ref**	**Documentation attached**
Verification: Zeolite rinsed properly to avoid particles <0.5 mm (HMST)	Procedure	Prototech	Annex 1: Appendix 2 of Multigen-1 PCC assembly and seed set-up Procedure filled in for Multigen-1 flight set up in June/July 07	
Verification: material loaded exactly as listed in HMST	Certificates	CW/RW PIs	Annex 2: 4 Seed Certificates for Arabidopsis Seeds (WT, GM GUS, lefty and hmg)	
			Annex 3: Phytosanitary Certificates for Arabidopsis Seeds (WT, GM GUS, lefty and hmg)	
	V2 Form	Astrium QA	Annex 4: Verification- 2 Form	
Correct Growth support and seed installation and assembly of CW/RW PCCs	Report	N-USOC	N-USOC-TR-027 "Cell Wall/ Resist Wall PCC Assembly and Seed Set Up Report" AD04	
Final verification of ECs by IOT	Report	IOT	EMCS-RP-4000-033-DOR "CWRW-EC Checkout and Inspection Report -Final Flight Preparations-" AD05	
Plant seed import permit	Form	NASA	Annex 5: Seed Import Permit	
NASA Cover letter, Pro-forma invoice, Shipping/packing list			Annex 6: NASA Cover Letter, Pro-forma invoice and Shipping/packing list.	

4 Scope

This document contains the specialized plan and dedicated fill-in procedures for verifying:

1. Correct packing at N-USOC into dedicated transport boxes
2. Handling during transport from N-USOC to KSC
3. Correct check out before handover at SSL (Space Science Laboratory) at KSC

5 Procedure detailed plan

5.1 Personnel

The personnel required for this Procedure, and their associated responsibilities are listed in Table 2.

Engineer
The engineer is responsible for:

- operation of measuring instrumentation, data acquisition, data handling, data recording
- identification and compilation of data sheet
- personnel to be present in the set up area
- the accuracy of the measured values
- data report

Manager
The manager is responsible for:

- articles and technical aspects of the set up performance
- examination of disturbances
- article integration and handling
- set up performance
- providing of reports

Quality Assurance
The Quality Assurance representative is responsible for:

- surveillance of equipment according to regulations as well as the procedure application
- statement that the set up articles to be used have passed all checks
- checking the identification markings on the articles
- supervision of proceeding with respect to quality assurance aspects (i.e. correct tracing of procedure variations and non-conformances)

Table 2: Personnel

Name	Affiliation	Contact info	Responsibility	Present
Suzanne Øverlie	N-USOC	+47 735 90181	Packing engineer	
Suzanne Øverlie Håkon Svare Arve Grønnevik	N-USOC N-USOC N-USOC	+47 735 90181 +47 735 90162 +47 735 96095	Transportation engineer	
N/A	N/A	N/A	QA	

5.2 Location

The procedure applies for all the activities that will take place in the laboratory at N-USOC (Trondheim, Norway) and at Kennedy Space Center (KSC, Florida, USA).

5.3 Equipment needed

Table 3 states the equipment needed for the execution and completion of this procedure.

Table 3: Equipment needed for this procedure

Equipment	**Provided by**			
	N-USOC	**PI**	**Astrium**	**KSC**
CW/RW ECs with PCCs and samples prepared as documented in AD04		PCC Assembly and samples	ECs and PCCs	
Lint free tissue to clean the ECs				x
Isopropanol for cleaning of ECs				x
Temperature logger	x			
Transport boxes with foam	x			
Disposable gloves		x		x

5.4 Environmental Conditions

Table 4 Shows the nominal environmental values expected during packing, transport and check-out. Actual values shall be noted down.

Table 4: Procedure environmental conditions

Parameters	**Nominal values**	**Actual values**		
		Packing	**Transport**	**Check-out**
Temperature	22°C (+/- 3°C)			
Relative Humidity	<40%			
CO_2-consentration	Ambient			
Pressure	Ambient			

5.5 Duration

Packing at N-USOC will take 2 hours. Duration of transport from N-USOC to KSC will be about 1 day and the checkout at KSC 2 days.

6 Procedure Description

The procedure is divided in 3 parts described below. The CW/RW ECs and EUE has been pre-treated according to procedures AD02 and AD03 as reported in AD04.

Packing Procedure at N-USOC

The CW/RW ECs with integrated PCCs will be photographed and individually packed in zip-lock bags (provided by NASA) at N-USOC. The ECs in ziplock bags will be installed in three aluminum transport boxes covered with foam. 3 ECs are installed in box 1 and 2 (S/N FM092, FM094-FM095) in Box 1 and S/N FM096-FM098 in Box 2) and two ECs are installed in box 3 (S/N FM099-FM100). A temperature logger is placed inside each box.

The boxes are stored at ambient temperature 22°C (+/- 3°C).

Transport Procedure from N-USOC to KSC

The CW/RW ECs with samples will be transported in aluminum-framed boxes with foam. Transportation from N-USOC to KSC will be achieved by car and airplane. The boxes will be hand carried during the flights, and the following requirements shall be obtained:

* The boxes must be handled with care
* The boxes shall be transported at ambient temperature, 22°C (+/- 3°C)
* The boxes shall be transported at ambient pressure (1 atm)

Checkout Procedure at KSC

If the ECs are not cleaned according to NASA requirements at handover to SSL, N-USOC representatives will clean the ECs at KSC.

The CW/RW flight ECs (S/N FM092, FM094-FM100) will be inspected at KSC after transport from N-USOC to ensure:

* Everything looks like it did before the transport
* All surfaces are clean
* Protective sheet will be removed from EC Covers

6.1 Procedure Equipment

6.1.1 Article List

Table 5: Article List

#	Article Name	Quantity	Supplied by	Serial Number	Remarks	Available
1.0	CW/RW ECs with PCCs and samples, cleaned and placed in zip lock bags	8	ECs; PD PCCs; PD PCC assembly, growth medium and samples; PI and N-USOC representatives and N-USOC EC Check; IOT	FM092, FM094- FM100		
2.0	Aluminium-framed transport-boxes with foam for CW/RW ECs	3	N-USOC	BWH AZKE 95600		

6.1.2 Equipment List

Table 6: Equipment List

#	Article Name	Quantity	Supplied by	Serial Number	Remarks	Available
	A) Packing Procedure at N-USOC **B) Transport Procedure N-USOC to KSC**			N-USOC- PRO-005		
1.0	Temperature logger	3	N-USOC	N/A		
2.0	Disposable gloves	20	N-USOC	N/A	Powder free	
3.0	Transport boxes with foam	3	N-USOC	N/A		
	C) Checkout Procedure at KSC			N-USOC- PRO-005		
1.0	Temperature Logger	3	N-USOC	N/A		
2.0	Isopropanol	50 ml	KSC	N/A		
3.0	Lint free tissue	8	KSC	N/A		
4.0	Disposable gloves					

7 Procedure Fill-in

All actual test steps are listed in Table 7.

Table 7: Procedure Fill-in

Step	Procedure -step	Additional Description	Performed	Remarks
	Packing Procedure at N-USOC			
1	Install 3 CW/RW ECs into Transport Box #1	ECs (S/N FM092, FM094-FM-095) in Ziploc bags	✓	Jaxa temp logger in side of briefcase
2	Install Temperature logger in Transport Box #1		✓	Start 29/2 kl. 1400 - End 6/3 kl. 2020
3	Fill in log sheet for CW/RW EC FM092, FM094-FM095		✓	
4	Place Log Sheet for EC FM092, FM094-FM095 in Transport Box #1		✓	All paper in Transport Box 3
5	Close Transport Box #1		✓	
6	Install 3 CW/RW ECs into Transport Box #2	ECs (S/N FM096-FM098) in Ziploc bags	✓	Jaxa temp logger in bottom of briefcase
7	Install Temperature logger in Transport Box #2		✓	Start 29/2 kl 1400 - End 6/3 kl 2020
8	Fill in log sheet for CW/RW EC FM096-098		✓	
9	Place Log Sheet for EC S/N FM096-098 in Transport Box #2		✓	Box 3
10	Close Transport Box #2		✓	
11	Install 2 CW/RW ECs into Transport Box #3	ECs (S/N FM099-FM100) in Ziploc bags	✓	

12	Install Temperature logger in Transport Box #3		✓	Start at 1400 end 6/3 kl. 20[illegible]
13	Fill in log sheet for CW/RW EC FM099-FM100		✓	
14	Place Log Sheet for EC S/N FM099-FM100 in Transport Box #3		✓	
15	Close Transport Box #3		✓	
Step	**Procedure -step**	**Additional Description**	**Performed**	**Remarks**
	B) Procedure fro Transport from N-USOC to KSC			
1	Store the 3 transport boxes at ambient temperature	22°C (+/- 3°C).	✓	
2	Transport the 3 transport boxes by car to the air port	Avoid temperatures out of the 22°C (+/- 3°C) range.	✓	
3	Hand-carry the 3 transport boxes with ECs with samples on airplane	-Avoid temperatures out of the 22°C (+/- 3°C) range. -The transport boxes may be opened for inspection (security/costumes) - The ECs must not be opened at any time	✓	
4	Transport the 3 transport boxes by car to KSC	Avoid temperatures out of the 22°C (+/- 3°C) range.	✓	
	C) Checkout Procedure at KSC			
1	Visual inspection of CW/RW ECs with PCCs		✓	
2	Check all EC surfaces for cleanliness		✓	
3	If new cleaning is needed (requested by NASA), use isopropanol and lent-free tissue		✓	
4	Remove protective foil on EC covers		✓	
5	Place the ECs in NASA provided zip lock bags		✓	

8 Procedure Variation Fill-in

All changes and variations to the Procedure fill-in procedures shall be documented in Table 8.

Table 8: Procedure variation fill-in

Step No.	Procedure -step Description	Nominal Value	Tolerance	Actual Value	Remarks

9 Failures during Process

All failures and non-conformities during preparation shall be recorded in Table 8.

10 Success Criteria

The procedure will be deemed successful if performance of all steps (Table 7) has been properly executed and no deviations have been observed.

11 Procedure Sign-off

All steps and activities described in the Procedure have been successfully performed with test equipment and articles as stated in Table 5 and Table 6.

Failures and non-conformities raised during performance of the procedure were:

Procedure sign-off:

Engineer: Håkon Svare — Date: 6/3-2008

Engineer: Suzanne Quarli — Date: 6/3-2008

Engineer: ---------- — Date: ----------

Annex 1: Filtration of Zeolite as performed prior to Multigen-1 experiment flight set up June/July 2007.

EMCS - EXPERIMENTS

Procedure for Filtering of Zeolite

prototech

PROJECT

EMCS - EXPERIMENTS

TITLE

Procedure for Filtering of Zeolite

PREPARED BY:	Geir Omdal	Sign:	Date: 03.05.2007
CHECKED BY:	Bjørnar Vasenden	Sign:	Date: 03.05.2007
PRODUCT ASSURANCE:	Marian N. Melle	Sign:	Date: 03.05.2007
PROJECT MANAGEMENT:	Geir Omdal	Sign:	Date: 03.05.2007

ISSUE STATUS

The status list shows which chapters are included, which changes are introduced, valid issue and issued date.

Ch. no. / Page. no.	Change	Issue	Date
Ch.6, App. A and App. B	Editorial updates based on comments from ESA	B	03.05.2007

CONTENTS

1 SCOPE

This document describes a procedure to filter the Zeolite according to agreement from EMCS Experiment Batch-1 Multigen-1 Phase II Flight Safety Review, no Zeolite particles below 0.5mm in diameter.

Taken from MoM from EMCS Experiment Batch-1 Multigen-1 Phase II Flight Safety Review [RD1]:

"During the review the question arose if Zeolite would present a potential hazardous to the crew (e.g. the particles causing eye irritation). A response was immediately requested from the NASA JSC toxicologist. The response received stated that if the PO can assure JSC Toxicology and the PSRP that dusts have been eliminated and essentially all Zeolite particles in the flight samples with larger than 0.5 mm diameter, the Toxicity Hazard Level would be reduced to zero (non-hazard)"

3 PARTICIPANTS REQUIRED

Personnel required:

Engineer
Responsible for:
- perform filtering according to procedure
- filling out step-by-step procedure

Quality Assurance Engineer
Responsible for:
- surveillance of the filtering and that filtering is performed according to procedure

Responsibility	Company / Dep.	Name
Engineer	Prototech	~~tbd~~ Grete Rakvaag
Quality Assurance Engineer	Prototech	Mrs. ~~Marian N. Meile~~ Y. H. Berg
Project Manager	Prototech	Mr. Geir Omdal

Table 3-1 Participants

4 EQUIPMENT LIST

No.	Equipment	Manufacturer	Model	Invent No.
1	Filter jig with mesh opening of 0.5mmx0.5mm	Prototech		
2	Container 1			
3	Container 2			
4	Pyrex beaker			

Table 4-1 Equipment List

5 DESCRIPTION

Filtering of Zeolite. No particles below 0.5mm in diameter

5.1 Equipment

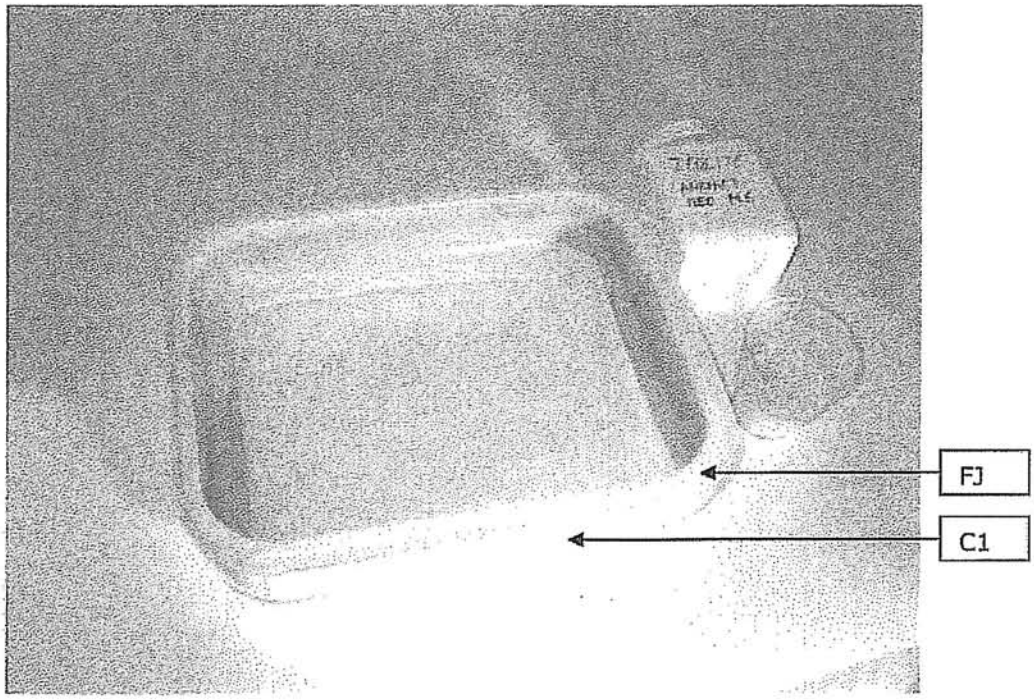
- **Filter jig (FJ)**: Filter jig with Propyltex (PP) felt with mesh opening of 0.5mmx0.5mm. SEFAR PP Felt article no. 05-500/36.

- **Container 1 (C1)**: One container (same size or bigger than Filter jig) collecting the Zeolite particles below 0.5mm in diameter.

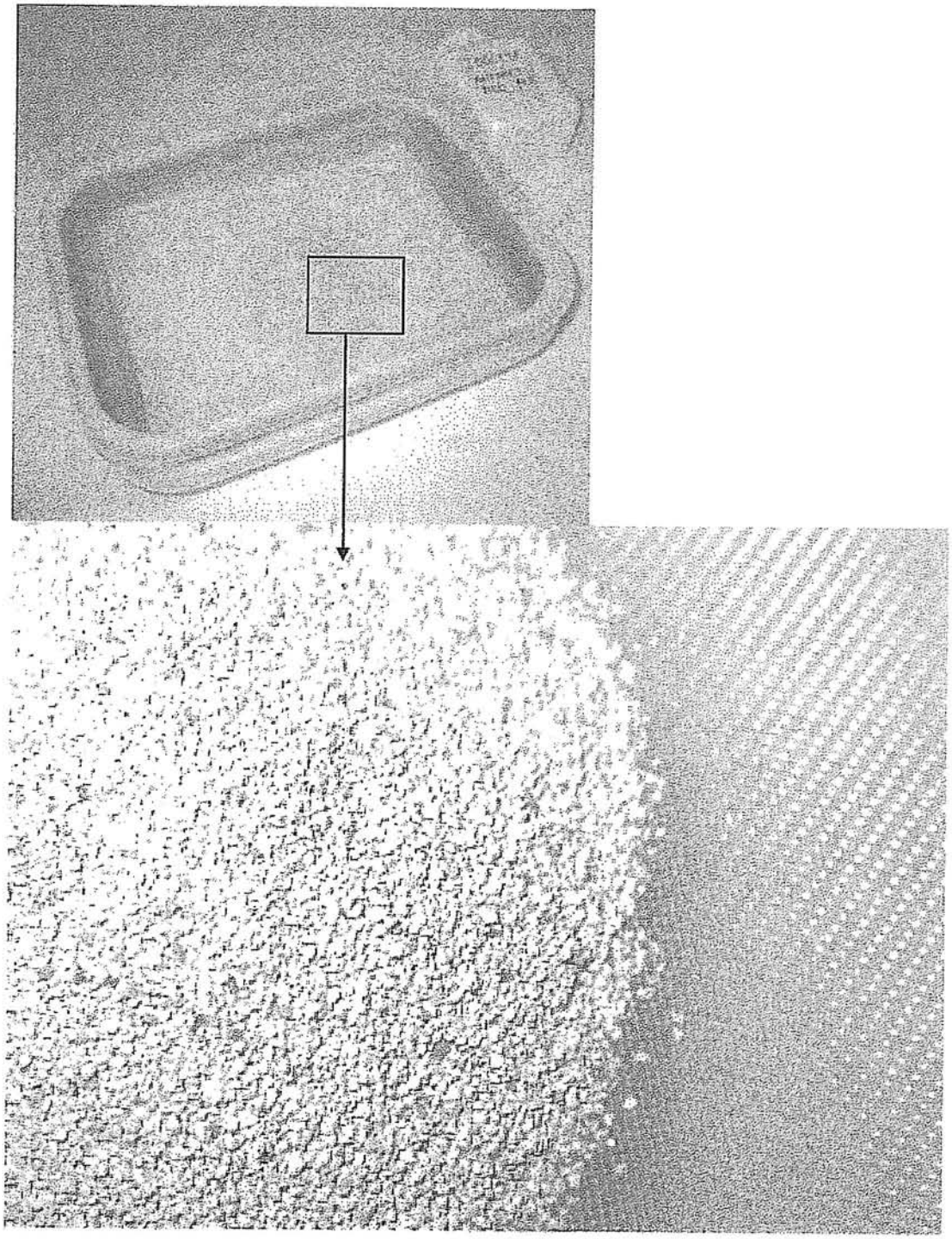
- **Container 2 (C2)**: One container or glass for collecting the filtered Zeolite

5.2 Filtering of Zeolite

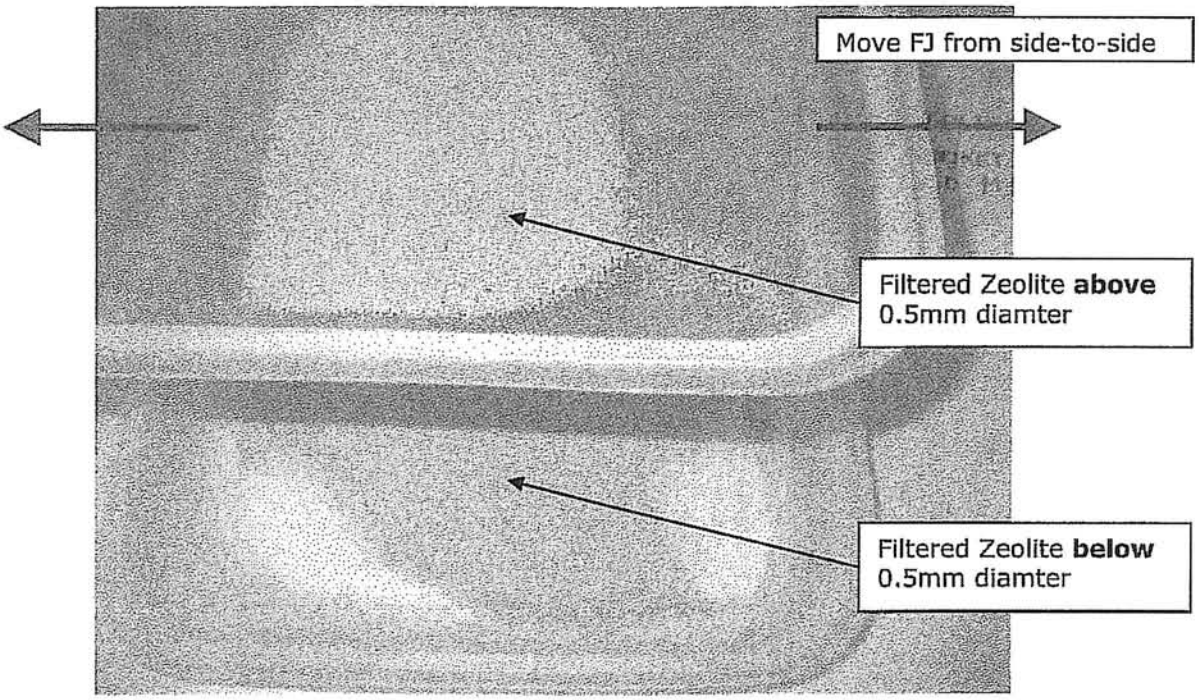
#1. Place C1 on a clean table and place FJ on top of C1. As shown in picture below.



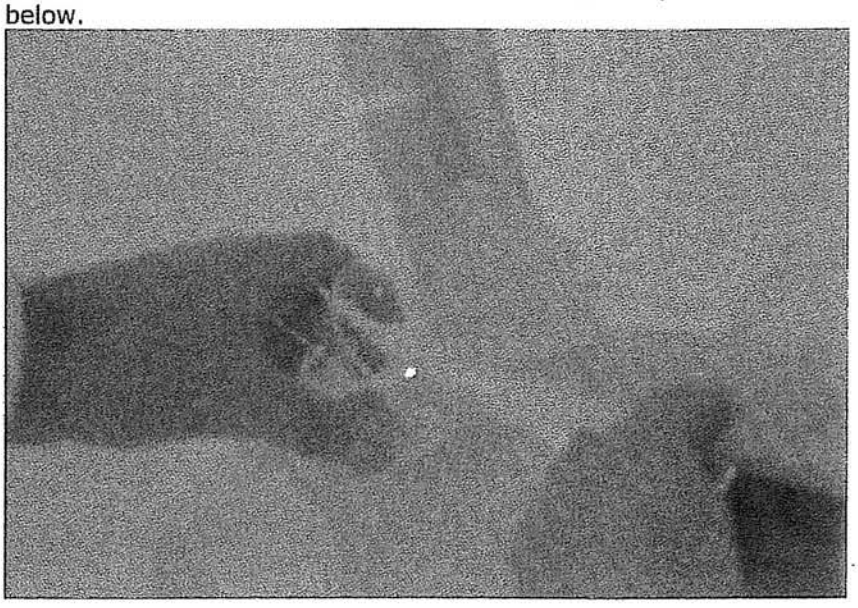
#2. Pour unfiltered Zeolite into FJ (do not filter to much Zeolite at a time). See pictures below.



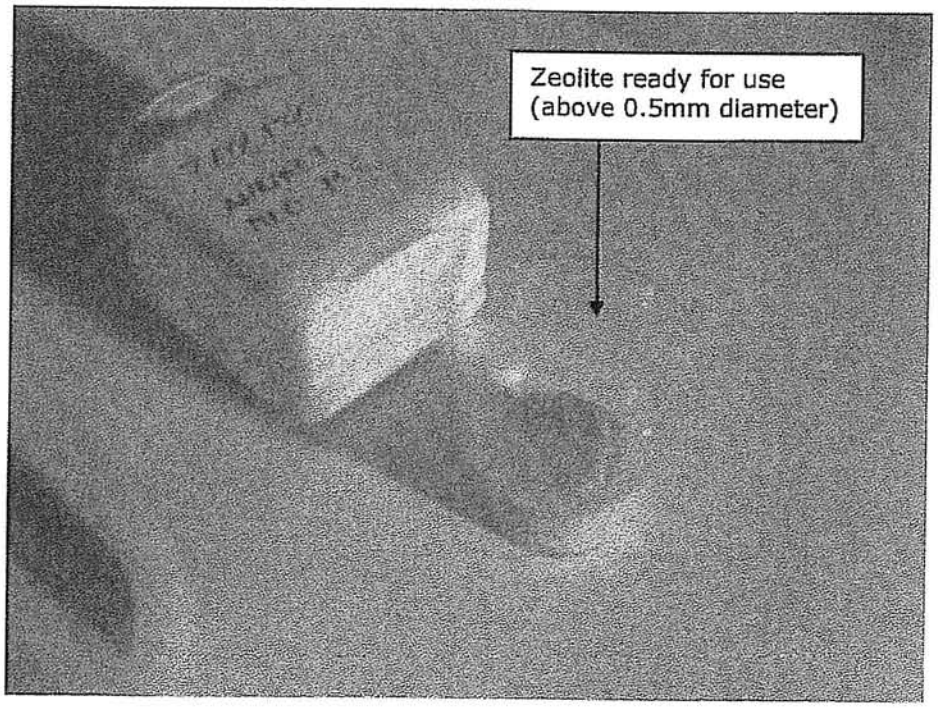
#3. Start filtering the Zeolite by moving the FJ from side to side by using your hands. See picture below. Continue this to you observe that no more Zeolite is falling through the mesh in the FJ. The QA engineer shall also observe and agree when the filtering is sufficient.



#4. Pour the filtered Zeolite (above 0.5mm diameter) into a clean container or glass. See picture below.



#5. The Zeolite is now finished filtered and ready for use. Filling of growth pot shall be done according to Growth Pot Filling Procedure (from Multigen-1 PI).



6 STEP BY STEP PROCEDURE

Step No.	Step-Description	Comments	P	N
	Preparations			
1.	fill out personnel in chapter 3		ok	
2.	check equipment acc. to chapter 5.1 and fill out Equipment List in chapter 4		ok	
	Filtering			
3.	Start filtering acc. to chapter 5.2		ok	
4.	Perform step **#1**		ok	
5.	Perform step **#2**		ok	
6.	Perform step **#3**		ok	
7.	Perform step **#4**		ok	
8.	Perform step **#5**		ok	
9.	Filtering finished		ok	

Step No.	Step-Description	Comments	P	N
	Finishing			
10.	fill out and sign step by step procedure forms		ok	
11.	fill out and sign Procedure Sign-off Sheet		ok	

7 ACCEPT/ REJECT CRITERIA

The filtering is considered as successful if filtering has been performed according to procedure and no deviations / anomalies have occurred.

8 DEVIATION

All deviations to this procedure shall be recorded on the Procedure Deviation Sheet in Appendix A.

9 NONCONFORMANCES

All Non-Conformance shall be recorded in the Non-Conformance List in Appendix B.

10 PROCEDURE SIGN-OFF SHEET

Statement that the Zeolite has been filtered in accordance with the approved procedure to be signed and dated by Engineer, Quality Assurance Representative and Customer Representative (where applicable) in Appendix C.

11 TABLE LIST

APPENDIX A PROCEDURE DEVIATION SHEET

Step No.	Step - Description	P	N	Remarks

APPENDIX B NONCONFORMANCE LIST

NCR NO.	NCR DESCRIPTION	DATE GENERATED	DATE CLOSED

APPENDIX C PROCEDURE SIGN-OFF SHEET

Item_____

Part No._____, Serial No._____

has been filtered in accordance with the foregoing procedure.

ENGINEER: GRETE RAKVAAG Sign: Grete Rakvaag Date: May 31/June 11 - 07

PRODUCT ASSURANCE: CARINA H.BERG Sign: Carina H. Berg Date: May 31/June 11 - 07

PROJECT MANAGEMENT: _____ Sign: _____ Date: _____

CUSTOMER REPRESENTATIVE:_____ Sign: _____ Date: _____
(where applicable)

Annex 2: Certificate of Arabidopsis Thaliana Seeds. Separate certificates for Wild Type, GM GUS, mutant lefty and mutant hmg.

TOHOKU

Tohoku University
Aobayama
Aoba-ku
Sendai
JAPAN 980-8578
Phone: +81-22-795-6700
Fax: +81-22-795-6669

January 28th 2008

The following information is submitted in support of shipment of seeds by Norwegian University of Science & Technology (NTNU).

The name of supplier is Professor Kazuhiko NISHITANI, Tohoku University, Sendai, JAPAN
The name of contact person for supplier is: Professor Kazuhiko NISHITANI
The name of the seed is ***Arabidopsis thaliana***
The variation is Columbia, Col-0
The seed stock was harvested December 20, 2007
Production number is 2007-02
The seeds are untreated.

The seeds will be received by Motoshi KAMADA, JAXA

Regards,

K. Nishitani

Professor Kazuhiko NISHITANI, Tohoku University
Aobayama, Aoba-ku, Sendai, Japan 980-8578
Phone:+81-22-795-6700
Fax: +81-22-795-6669
e-mail: nishitan@mail.tains.tohoku.ac.jp

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January 28th 2008

The following information is submitted in support of shipment of seeds by Norwegian University of Science & Technology (NTNU).

The name of supplier is Professor Kazuhiko NISHITANI, Tohoku University, Sendai, JAPAN
The name of contact person for supplier is Professor Kazuhiko NISHITANI
The name of the seed is ***Arabidopsis thaliana***
The variation is Columbia, Col-0
The seed stock was harvested December 20, 2007
Production number is 2007-02

The seeds have been treated as follows:

Genetically modified seeds are generated by transgenic Arabidopsis plants expressing promoter GUS fusion genes. Briefly, 3 kb 5'-upstream regions of AtCesA4 gene was amplified from genomic DNA of *A. thaliana* Col. by PCR and cloned in-frame upstream of the GUS gene constructs (Jefferson et al. 1987). This was followed by transformation into A. thaliana Col. via *Agrobacterium tumefaciens* C58 strain using the floral-dip transformation technique (Clogh et al. 1998).

The seeds will be received by Motoshi KAMADA, JAXA

Regards,

K. Nishitani

Professor Kazuhiko NISHITANI, Tohoku University
Aobayama, Aoba-ku, Sendai, Japan 980-8578
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JAPAN 558-8585

Phone: +81-66605-2577
Fax: +81-66605-2577

January 18th 2008

The following information is submitted in support of shipment of seeds by Norwegian University of Science & Technology (NTNU).

The name of supplier is Professor Takayuki HOSON, Osaka-city-univ, Osaka, Japan
The name of contact person for supplier is Professor Takayuki HOSON.
The name of the seed is *Arabidopsis thaliana*
The variation is Columbia, Col-0
The seed stock was harvested October 15, 2007
Production number is H-2007-02
The seeds are untreated.

The seeds will be received by Motoshi KAMADA, JAXA

Regards,

Motoshi Kamada.

Mr. Motoshi KAMADA, JAXA
2-1-1 Sengen, Tsukuba-shi, Ibaraki, JAPAN 305-8505
Phone:+81-29-868-3698
Fax: +81-29-868-3956
e-mail: kamada.motoshi@jaxa.jp

Osaka city University
3-3-138 Sugimoto
Sumisyoshi-ku
Osaka
JAPAN 558-8585

Phone: +81-66605-2577
Fax: +81-66605-2577

January 18th 2008

The following information is submitted in support of shipment of seeds by Norwegian University of Science & Technology (NTNU).

The name of supplier is Professor Takayuki HOSON, Osaka-city-univ, Osaka, Japan
The name of contact person for supplier is Professor Takayuki HOSON.
The name of the seed is *Arabidopsis thaliana*
The variation is Columbia, Col-0
The seed stock was harvested October 15, 2007
Production number is L-2007-02
The seeds are untreated.

The seeds will be received by Motoshi KAMADA, JAXA

Regards,

Motoshi Kamada.

Mr. Motoshi KAMADA, JAXA
2-1-1 Sengen, Tsukuba-shi, Ibaraki, JAPAN 305-8505
Phone:+81-29-868-3698
Fax: +81-29-868-3956
e-mail: kamada.motoshi@jaxa.jp

Annex 3: Phytosanitary Certificate for Arabidopsis Thaliana Seeds. One combined certificate for Wild Type, GM GUS, mutant lefty and mutant hmg.

PHYTOSANITARY CERTIFICATE

PLANT PROTECTION SERVICE
MINISTRY OF AGRICULTURE, FORESTRY AND FISHERIES
JAPANESE GOVERNMENT

TO: PLANT PROTECTION ORGANIZATION(S) OF Kingdom of Norway **No.** 250072117

I. DESCRIPTION OF CONSIGNMENT

1.Name and address of exporter	2.Declared name and address of consignee	
Toru Shimaszu. 2-20-11, Midori, Nishitokyo-shi, Tokyo, JAPAN.	Suzanne Overlie. The Plant Biocenter, NTNU, N-7491 Norway.	
3.Number and description of packages 1 Case.	4.Distinguishing marks NONE	
5.Place of origin Japan.	6.Declared means of conveyance Hand Baggage.	7.Declared point of entry Trondheim, Norway.
8.Name of produce and quantity declared 0.4 g Arabidopsis Seeds. 1) *Arabidopsis thaliana* Columbia wild type 2) *Arabidopsis thaliana* Columbia *lefty* mutant 3) *Arabidopsis thaliana* Columbia *lung* mutant 4) *Arabidopsis thaliana* Columbia Transgenic:promoter:: GUS	9.Botanical name of plants *Arabidopsis thaliana*	

This is to certify that the plants, plant products or other regulated articles described herein have been inspected and/or tested according to appropriate official procedures and are considered to be free from the quarantine pests specified by the importing contracting party and to conform with the current phytosanitary requirements of the importing contracting party, including those for regulated non-quarantine pests.

II. ADDITIONAL DECLARATION

XXXXXX

III. DISINFESTATION AND / OR DISINFECTION TREATMENT

10.Date	11.Treatment	12.Chemical (active ingredient)
XXXXX	XXXXX	XXXXX
13.Duration and temperature XXXXX	14.Concentration XXXXX	15.Additional information XXXXX

(Stamp of Organization)

16.Place of issue
Yokohama Plant Protection Station
(Narita) ,Japan

17.Date
January 20th, 2008

18.Name of authorized officer
Masaharu Kojima

M. Kojima
(Signature)

No financial liability with respect to this certificate shall attach to the Ministry of Agriculture, Forestry and Fisheries, Japan or to any of its officers or representatives.

Annex 4: Verification – 2 form

To: From:Astrium ST Fax:+49 7545 8-+49 7545 ZTOPCALL at:00-01-25-17:35 Doc:190 Page:001

JSC Toxicology Group

Environmental Factors Branch
John T. James, Ph.D., Toxicology Lead
NASA Johnson Space Center, SF23 - Houston, TX 77058 - FAX: 281-483-3058

TO: **Mr. Wilfried Biemann,**
Astrium GmbH, TOQ5,
+49-7545-8 4225

FROM: **Dr. Shannon Langford**
U.S. Toxicologist, 25-Progress
Voice: 281-483-2137
Pager: 877-305-0566

DATE: **25-Jan-2008**

SUBJECT: Verification Step 2 (V-2) Form for As Loaded Materials listed in the Hazardous Materials Summary Table (HMST)

PSRP Policy: The JSC Payload Safety Review Panel allows experiment containers to be loaded only with materials in amounts and concentrations less than or equal to those listed in the final HMST for that container or with materials in the same HMST approved for other containers of the same experiment. The levels of containment of the materials must be consistent with the Hazard Level assigned.

Instructions: The V-2 form is to be completed at the time that the materials are loaded into their flight hardware or as soon as feasible thereafter. Please mark up the verified V-1 HMST, noting all deletions, reduced amounts or concentrations, changes in location in the experiment system, or any other allowed changes. The mark-ups to the HMST should accurately reflect the materials that are actually loaded.

The responsible party will sign the V-2 form and check the appropriate box to indicate whether corrections have been made to the HMST. Then e-mail a scanned version (preferred) of this form and the HMST pages with corrections, to Shannon.d.langford@nasa.gov). If the HMST does not require any mark-ups, only the signed V-2 form needs to be returned. Contact the toxicologist if you have any questions.

V-2 for STS-123

TEST MATERIAL / CHEMICAL DATA VERIFICATION STEP-2

Please check one box below and fill in the blanks:

☐ The materials loaded are exactly as listed in the verified V-1 HMST for this payload.

☑ The materials loaded are consistent with the PSRP policy stated above; deletions/corrections are marked on the attached verified V-1 HMST for this payload.

Signature: Motoshi Kamada Date: 22 Feb 2008

Print Name: Motoshi KAMADA

Organization: JAXA

Experiment Acronym/Name: CWRW - EHCS

Role associated with the Payload Experiment: Science coordinator

Telephone: +81-29-868-3698 Fax: +81-29-868-3956

STS-123 / 1JA

HAZARDOUS MATERIALS SUMMARY TABLE (HMST)

To ISS JEM

Verification Status
V-1: *Data Verified by P.I.*
V-2:

Expt /Hdwr Acronym: **CWRW-EMCS**

Expt Name: **Cell Wall Resist Wall - European Modular Cultivation System**

Part #s OpNom	HMST Record # Expt Subsystem Label or ID	Chemicals or Biological Materials	Maximum Concentration	Maximum Volume or Amount	Principal Toxic Hazards	Tox Haz Level	Medical Protocol	Flammability	BioSafety Level	*Record update history* Contact Person/ Comments
Part #: 401060 OpNom: TBD	HMST Record #: 123-014 Subsystem: Plant Cultivation Chamber (PCC) Label: EMCS Experiment Container	*Arabidopsis thaliana* Columbia w/t	N/A	104 seeds from the 4	Tox Haz Level: Possible eye and/or respiratory irritation from fine particles of dry Zeolite. SSL: Ref. memo SF24-07-014	1	Eye, Inhalation			*Last modified: 1/22/08* Contact: Motoshi Kamada, JAXA, kamada.motoshi@jaxa.jp , +81-29-868-3698. Amy Haas, amy.@boeing.com This experiment will be conducted in the European Modular Cultivation System (EMCS) in Plant Cultivation Chambers (PCC). JSC Micro memo # SF24-07-014
		Arabidopsis thaliana Columbia *lefty* mutant	N/A	7 to 19 seeds per PCC 8 PCCs total						
		Arabidopsis thaliana Columbia *lmg1* mutant	N/A							
		Arabidopsis thaliana Columbia Transgenic: promoter:: GUS	N/A							
		Ethylene (produced during germination)	trace	trace						
		Carbon dioxide (produced during germination)	trace	trace						
		Zeolite (Zeoponics) (0.5 - 1.0 mm particles)	100%	240 mm³ 30 mm³/PCC 8 PCC						
		Plant growth supplement (Murashige and Skoog Mixture)	100%	0.8 g 0.1 g/PCC x 8 PCC						
		Polyvinyl alcohol (PVA)	100%	0.08ml 0.01ml /PCC x 8 PCC						

ok

Annex 5: Seed Import Permit

APHIS Animal and Plant Health Inspection Service

Plant Protection & Quarantine

United States Department of Agriculture
Animal and Plant Health Inspection Service
4700 River Road
Riverdale, MD 20737

Permit to Import Plant or Plant Products For Experimental Purposes

Departmental 1

This permit was generated electronically via the ePermits system

PERMITTEE NAME:	Tom Erdman	**PERMIT NUMBER:**	PDEP-08-00045
ORGANIZATION:	NASA	**APPLICATION NUMBER:**	P588-080219-004
ADDRESS:	CAPPS Warehouse Bldg., M6-698 867-2199 Mail Stop SK-FL Kennedy Space Center, FL 32899	**DATE ISSUED:**	02/19/2008
MAILING ADDRESS:	CAPPS Warehouse Bldg., M6-698 867-2199 Mail Stop SK-FL Kennedy Space Center, FL 32899		
PHONE:	(321) 867-2199	**DATE REVISED:**	**02/20/2008**
FAX:	(321) 867-7108	**EXPIRES:**	**02/19/2009**

PORTS OF ENTRY: FL, Orlando

Under the conditions specified, this permit authorizes the following:

Article(s)	Countries of Origin	Plant Parts	Grown in U.S.	Intended Use
Arabidopsis thaliana	Japan	Seed	No	Analysis of plant response to micro-gravity onboard the International Space Station

SPECIAL INSTRUCTIONS TO INSPECTORS

NONE

Permit Number PDEP-08-00045

THIS PERMIT HAS BEEN APPROVED ELECTRONICALLY BY THE FOLLOWING PPQ HEADQUARTER OFFICIAL VIA EPERMITS. **Karen Brady**	DATE **02/20/2008**

WARNING: Any alteration, forgery or unauthorized use of this Federal Form is subject to civil penalties of up to $250,000 (7 U.S.C. § 7734(b)) or punishable by a fine of not more than $10,000, or imprisonment of not more than 5 years, or both (18 U.S.C. § 1001)

APHIS Animal and Plant Health Inspection Service

Plant Protection & Quarantine

PERMIT CONDITIONS

This permit authorizes the importation of the listed articles, under the conditions specified below. A copy of this permit (including all conditions) must accompany all shipments authorized under this permit.

1. The seeds shall be selected from apparently disease and pest-free sources; free of weed seeds (including noxious weed seeds, soil, and other prohibited matter; securely packaged to prevent loss in transit; and shall be hand-carried to the approved port(s) by the permittee, or his representative. The plant materials shall be declared on the traveler's Customs declaration form and presented, along with a copy of this permit, to a representative of Plant Protection and Quarantine (PPQ) or by a Customs and Border Protection, Agriculture Quarantine Inspection (CBP-AQI) at the time of baggage inspection.

2. Upon arrival in the United States, the samples will be inspected by PPQ or CBP-AQI. If the samples are found apparently free from exotic plant pests, diseases, soil, and other prohibited matter, they will be returned for delivery to Kennedy Space Center, Florida.

3. The seedlings will be grown on an zeolite substrate in orbit on the ISS for 14 days. The imported plant materials may not be distributed to any person without permission from this office.

4. At the conclusion of the tests, all imported plant materials are to be returned to Japan in un-opened experiment containers.

END OF PERMIT CONDITIONS

Permit Number PDEP-08-00045

THIS PERMIT HAS BEEN APPROVED ELECTRONICALLY BY THE FOLLOWING PPQ HEADQUARTER OFFICIAL VIA EPERMITS.	DATE
Karen Brady	**02/20/2008**

WARNING: Any alteration, forgery or unauthorized use of this Federal Permit is subject to civil penalties of up to $250,000 (7 U.S.C. § 7734(b)) or punishable by a fine of not more than $10,000, or imprisonment for not more than 5 years, or both (18 U.S.C. § 1001)

Annex 6: NASA Cover Letter, pro-forma invoice, packing and shipping list and IOT insurance coverage

National Aeronautics and Space Administration
John F. Kennedy Space Center
Kennedy Space Center, Florida 32899

REFERENCE:

Harmonized Tariff Schedule of the United States Heading 9808.00.8000 *("Goods certified by it to the Commissioner of Customs to be imported for the use of the National Aeronautics and Space Administration or for the implementation of an international program of the National Aeronautics and Space Administration, including articles to be launched into space and parts thereof, ground support equipment, and uniquely associated equipment for use in connection with an international program of the National Aeronautics and Space Administration, including launch service agreements.")*

U. S. Note 1 of Subchapter VIII of Chapter 98
("With respect to Subheading 9808.00.80, goods brought into the customs territory of the United States by the National Aeronautics and Space Administration from space or from a foreign country as part of an international program of the National Aeronautics and Space Administration shall not be considered an importation, and an entry of such materials shall not be required.")

March 3, 2008

To: Customs Officials / Transportation Security Officials

Suzanne Overlie, employee from Norwegian User Support & Operations Centre in Trondheim, Norway, will be delivering N-USOC-NOT-SEO-003 experiment hardware (as identified on attached invoice) which is needed as part of the European Modular Cultivation System (EMCS) facility which will be used to perform biological/life sciences experiments. The N-USOC-NOT-SEO-003 experiment hardware is scheduled to fly aboard STS-123 Endeavour on International Space Station Mission #1J/A with an anticipated launch date of March 11, 2008 from Kennedy Space Center, Florida.

Suzanne Overlie, Passport # 26011775, is intending to be traveling on the flights listed below:

03/03/08 KLM KL1172 from Trondheim Airport Wærnes, Norway (TRD) to Amsterdam (AMS)
MartinAir MP #635 from Amsterdam (AMS) to Orlando, Florida (MCO)

The N-USOC-NOT-SEO-003 experiment hardware is valued at US$821,872.00 will be either hand carried, checked as baggage, or checked as cargo by Suzanne Overlie. A "DO NOT OPEN" label is affixed to the containers. Opening the containers will render the experiment useless.

The N-USOC-NOT-SEO-003 experiment hardware is authorized for duty-free entitlement under HTSUS Number 9808.00.8000 and entry-free entitlement under U.S. Note 1 (replicated in "Reference" box above). Additionally, a Permit to Import Plant or Plant Products for Experimental Purposes, number PDEP-08-00045, issued on 02/20/2008 by United States Department of Agriculture, is attached.

If you have any questions concerning this matter, please feel free to contact me at the number below or:

Rose Ogden at 321-867-1963 or on her personal cell at 321-720-2949
Manabu Ishii at 321-867-1763

Sincerely,

Lesley Carroll
NASA Transportation Officer
321-867-2975

NTNU
Social Research Ltd.

N-USOC

Dated: 15.01.2008 Our ref: N-USOC-NOT-SEO-003 Your letter dated: Your Ref:

PROFORMA-INVOICE

Shippers name:	Suzanne Øverlie
Address:	Dragvoll Alle 38
City:	7034 Trondheim
Country:	Norway
Contact person:	Suzanne Øverlie
Phone number:	+47 73 59 01 81/ +47 92 09 56 17

Receivers name:	Transportation officer, NASA
Address:	CAPPS warehouse Bldg M6-698 867-2199 Mail Stop SK-FL Kennedy Space Centre, FL 32899
State:	Florida
Country:	USA
Contact person:	Thomas Erdman or T. Renee Atkinson
Phone number:	321-867-2199 / 321-867-6611

Description of goods	No. of items	Packing	Weight	Value (US Dollar)
Seeds of *Arabidopsis thaliana* Divided in: 30 Wild type seeds 14 GM GUS seeds 30 Lefty mutant seeds 30 hmg mutant seeds	104	Transport Box 1, 2 and 3	-	-
Experiment Containers S/N FM092, FM094-FM095	3	Transport box 1	8,7 kg	308202$
Experiment Containers S/N FM096-FM098	3	Transport box 2	8,7 kg	308202$
Experiment Containers S/N FM099-FM100	2	Transport box 3	6,9 kg	205468$
Total		3 boxes	24,3 kg	821872$

Invoice (value) for customs purpose only, no commercial value, no payments

Reason for shipment:
The equipment belongs to the European Space Agency (ESA Contract Ref: ESTEC Contract 18279/04/NL/SH) and is transported from Norway (Trondheim) to USA – FL Kennedy Space Centre for flight of the EMCS Cell Wall/ Resist Wall Experiment on the Space Shuttle STS-123 (1 J/A).

Country of origin: Germany/Norway/Japan
Date: March, 2008

Signature of shipper: Suzanne Øverlie

NTNU
Social Research Ltd.

N-USOC
Norwegian User Support and Operations Centre

Dated: 15.01.2008 Our ref: N-USOC-NOT-SED-004 Your letter dated: Your Ref:

Shipping/Packing List

Transport to:
Transportation officer
CAPPS warehouse Bldg M6-698
Kennedy Space Centre, FL 32899

Mark for Tom Erdman 867-2199 Mail Stop SK-PL
Phone number: 321-867-2199/321-867-6611

Box No.	Box Size (cm)	Quantity	Part No or Part Description	Picture
1	44x32x15.7	33 3	Seeds of *Arabidopsis thaliana* (Inside the Plant Cultivation Chambers (PCC)) 11 Wild Type seeds 7 GM GUS seeds 15 Mutant (Lefty) seeds Experiment Containers (EC) with installed Plant Cultivation Chambers (PCC) CI No. S/N FM092, FM094-FM095	
2	44x32x15.7	33 3	Seeds of *Arabidopsis thaliana* (Inside the Plant Cultivation Chambers (PCC)) 11 Wild Type seeds 7 GM GUS seeds 15 Mutant (hmg) seeds Experiment Containers (EC) with installed Plant Cultivation Chambers (PCC) CI No. S/N FM096-FM098	
3	44x32x15.7	38 2	Seeds of *Arabidopsis thaliana* (Inside the Plant Cultivation Chambers (PCC)) 8 Wild Type seeds 15 Mutant (Lefty) seeds 15 Mutant (hmg) seeds Experiment Containers (EC) with installed Plant Cultivation Chambers (PCC) CI No. S/N FM099-FM100	

Adress
NO-7491 Trondheim

Location
Dragvoll Alle 38

Tel: +47 73 59 01 81
Fax: +47 73 59 01 77
Org No. NO 974 767 880

The cargo is transported in three aluminum frame boxes (see example image below for model type) covered with foam on the inside. Transport box 1 and 2 contain three Experiment Containers (ECs) each (FM092, FM094-FM095 and FM096-FM097), while Transport Box 3 contains two ECs (FM099-FM100).

Transport box 1:
Inside FM092 there are a total of 7 *Arabidopsis thaliana* Wild Type seeds placed in 7 holes in the lids of the Plant Cultivation Chambers (PCCs).
Inside FM094 there are a total of 7 *Arabidopsis thaliana* GM GUS seeds placed in 7 holes in the lids of the Plant Cultivation Chambers (PCCs).
Inside FM095 there are a total of 4 *Arabidopsis thaliana* Wild Type seeds and 15 *Arabidopsis thaliana* mutant (lefty) seeds placed in 7 holes in the lids of the Plant Cultivation Chambers (PCCs).

Transport box 2:
Inside FM096 there are a total of 4 *Arabidopsis thaliana* Wild Type seeds and 15 *Arabidopsis thaliana* mutant (hmg) seeds placed in 7 holes in the lids of the Plant Cultivation Chambers (PCCs).
Inside FM097 there are a total of 7 *Arabidopsis thaliana* Wild Type seeds placed in 7 holes in the lids of the Plant Cultivation Chambers (PCCs).
Inside FM098 there are a total of 7 *Arabidopsis thaliana* GM GUS seeds placed in 7 holes in the lids of the Plant Cultivation Chambers (PCCs).

Transport box 3:
Inside FM099 there are a total of 4 *Arabidopsis thaliana* Wild Type seeds and 15 *Arabidopsis thaliana* mutant (lefty) seeds placed in 7 holes in the lids of the Plant Cultivation Chambers (PCCs).
Inside FM0100 there are a total of 4 *Arabidopsis thaliana* Wild Type seeds and 15 *Arabidopsis thaliana* mutant (hmg) seeds placed in 7 holes in the lids of the Plant Cultivation Chambers (PCCs).
The ECs are closed and can not be opened. The seeds can not bee seen as they are implemented inside the PCCs. Each of the ECs wil be kept inside a transparent Ziplock bag which allows visual inspection.

NTNU
Social Research Ltd.

N-USOC
Norwegian User Support and Operations Centre

Adress
NO-7491 Trondheim

Location
Dragvoll Alle 38

Tel: +47 73 59 01 81
Fax: +47 73 59 01 77
Org.No. NO 974 767 880

Description of containment and transport for Cell Wall/ Resist Wall experiment

Material Usage:
The 104 Arabidopsis thaliana var. Columbia, Col-0 seeds (which includes 30 wild type (WT), 14 gene modified (GM) GUS, 15 lefty mutants and 15 hmg mutants), will be used in an experiment named EMCS Cell Wall/ Resist Wall. This experiment is an ESA (European Space Agency) and JAXA (Japan Aerospace Exploration Agency) sponsored experiment to be performed in the European Columbus lab on-board the International Space Station (ISS), under an ESA - NASA agreement. The experiment is planned to fly on Space Shuttle 1 J/A planned for a 2008 March launch. The final handover at KSC, Florida is planned for March, 2008.

Containment:
The entire collection of 104 Arabidopsis thaliana var Columbia, Col-0 seeds (which includes 30 wild type (WT), 14 gene modified (GM) GUS, 15 lefty mutants and 15 hmg mutants) will at ALL TIME, including germination phase, be contained within a minimum of one layer of containment. For the transport to/inside US, to the ISS the seeds will be within Experiment Containers (see figure 1) providing one layer of containment. After germination of seeds inside the Experiment Containers, the plant material will be removed from the enclosed Experiment Container inside a Microgravity Science Glovebox onboard the ISS, and put into Kennedy Fixation Tubes (see figure 2) where the plant material will be kept within one layer of containment until it is returned to Japan.

The Seeds are installed in the Experiment Containers at the Norwegian User Support and Operation Center (N-USOC) located the Plant Biocentre (NTNU) in Trondheim, Norway.

Transport:
The samples will be handcarried to Kennedy Space Centre in foam coated suitcases (see figure 3). (By car from Trondheim to Trondheim Airport Værnes, by Airplane from Trondheim Airport Værnes to Orlando Sanford Airport, by car from Orlando Airport to NASA Kennedy Space Centre, FL.)

At arrival at NASA Kennedy Space Centre (KSC), FL the enclosed Cultivation Chambers will be stored under the custody of NASA KSC under agreed ground handling procedures

The same will be the case for Kennedy Fixation Tubes after return to Earth (US, KSC) before samples are transported to Japan.

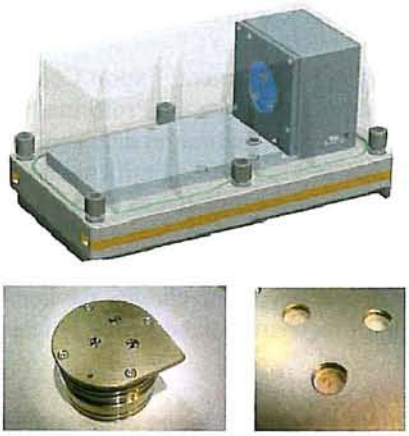


Figure 1. The Arabidopsis seeds installed in the enclosed Experiment Container.

Figure 2. Kennedy Fixation Tubes showing how the plant samples will be contained in fixation liquids. The KFTs have sets of 3 o-rings to contain the samples.

Dear Ms. Rostad,

The Integrated Operations Team/ Astrium herewith authorizes the N-USOC to initiate and perform the transport of the CW/RW EUE - packed in 3 boxes at a total recurrency value of US $ 821872 - from the N-USOC in Trondheim to NASA/ Kennedy Space Center, Florida. The transport is fully insured by the EADS N.V. Insurance Policy for the ESA Manned Space Programme against all risks of physical loss of or damage to property during transportation and storage in transit.
NASA/ KSC (CAPPS Transportation Management/ Export Control) needs to be notified in due time prior to arrival (3-4 days) and provided with the Proforma Invoice, Flight #, name of the traveller, Date of Birth, country, issue date, expiration date and Passport # in order for them to prepare a "Verification of Duty-free and Entry-free Entitlement for NASA Shipments" which will then be forwarded electronically back to the traveller to enable Customs processing at the traveller's US gateway airport (where the traveller processes through US Customs). To avoid paying US duties and taxes on the hand carried item(s) - up to 25% of the value of the item(s) - depending on how the Customs officer decides to classify the item(s), the traveller will be responsible to apply for the support request for handcarried articles to NASA in the time frame indicated above.

Note: Handcarrying of Hardware in aircraft passenger compartments should be avoided to the maximum extent possible due to recently increased security measures on flights to the U.S.
Please contact rose.m.ogden@boeing.ksc.nasa.gov concerning the Duty-Free Entitlement.

Best regards,

Manfred Nordhoff

ISS Product Support

ASTRIUM Space Transportation

Tel.: 0421-539-4189

Fax: 0421-539-5782

Appendix 4 - CWRW Temperatures logged during transport

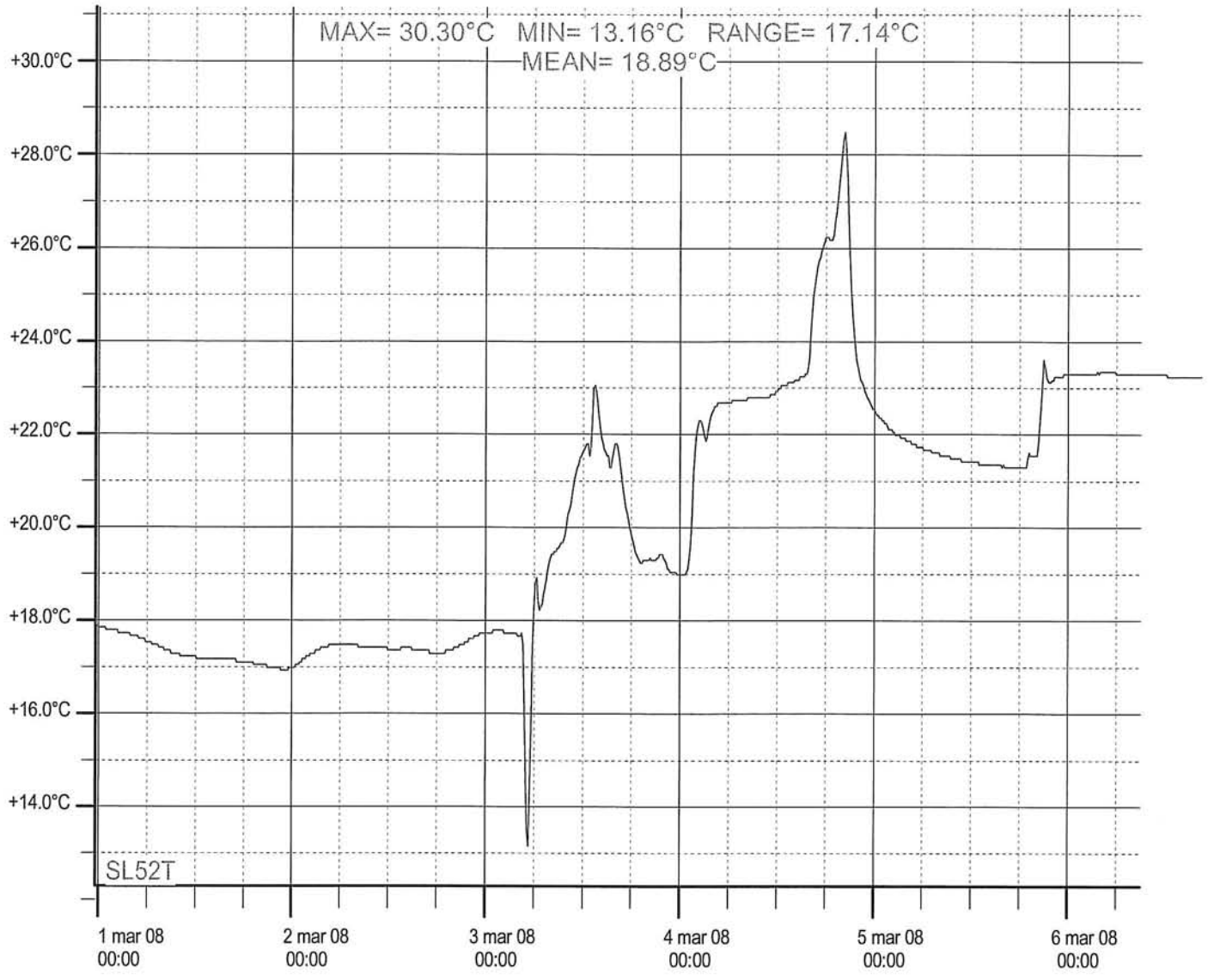
CWRW Box1: EC092, EC09, EC095

SL52T Standard print, printed on fredag 16 mai 2008 at 13:40:55

Logger Serial No.:	4700000005068D41	**Lo Alarm Setpoint:**	-40.0°C
Total readings since new:	21532	**Hi Alarm Setpoint:**	+85.0°C
Sample Rate:	10 mins	**Alarm(s) Triggered:**	No
Logged readings:	4096	**Calibration due:**	Not Set
Issue Time/Date:	29 feb 2008 - 9:56:49 AM	**Graph Start:**	29 feb 2008 - 11:38:00 PM
		Graph Stop:	6 mar 2008 - 9:00:00 AM

Owner Manifest: Not Set
User Manifest 1: CWRW Box1 EC092, EC094, EC095
User Manifest 2: logger 3

Signature 1:	.....	**Signature 2:**	.....
Print Name:	.....	**Print Name:**	.....
Date:	.....	**Date:**	.....



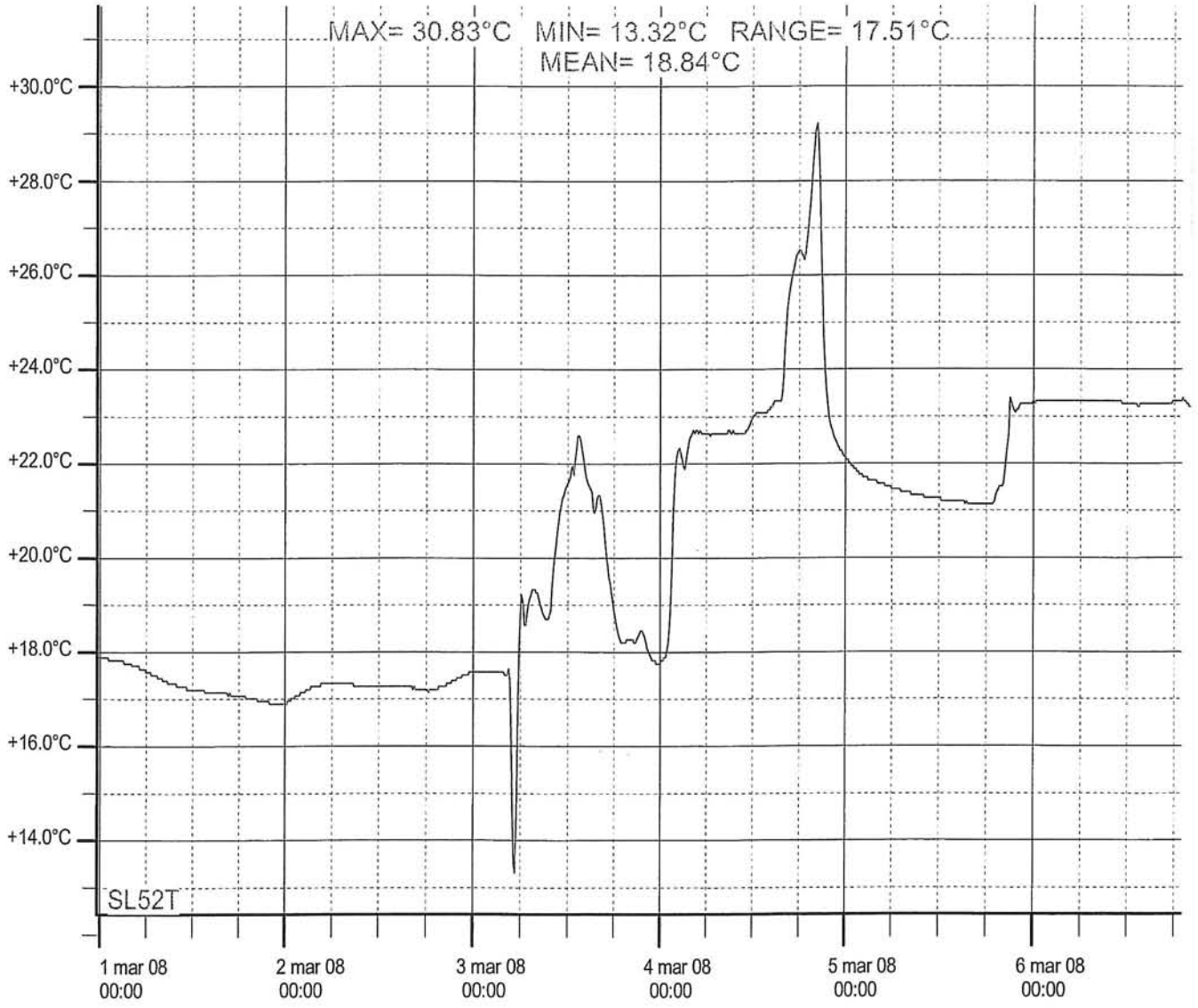
CWRW Box2 EC096, EC097, EC098

SL52T Standard print, printed on fredag 16 mai 2008 at 13:54:09

Logger Serial No.:	66000000050EE941	**Lo Alarm Setpoint:**	-40.0°C
Total readings since new:	25676	**Hi Alarm Setpoint:**	+85.0°C
Sample Rate:	10 mins	**Alarm(s) Triggered:**	No
Logged readings:	4096	**Calibration due:**	Not Set
Issue Time/Date:	29 feb 2008 - 9:58:11 AM	**Graph Start:**	29 feb 2008 - 11:38:00 PM
		Graph Stop:	6 mar 2008 - 7:00:00 PM

Owner Manifest: Not Set
User Manifest 1: CWRW Box2 EC096, EC097, EC098
User Manifest 2: Logger 4

Signature 1:	.....	**Signature 2:**	.....
Print Name:	.....	**Print Name:**	.....
Date:	.....	**Date:**	.....



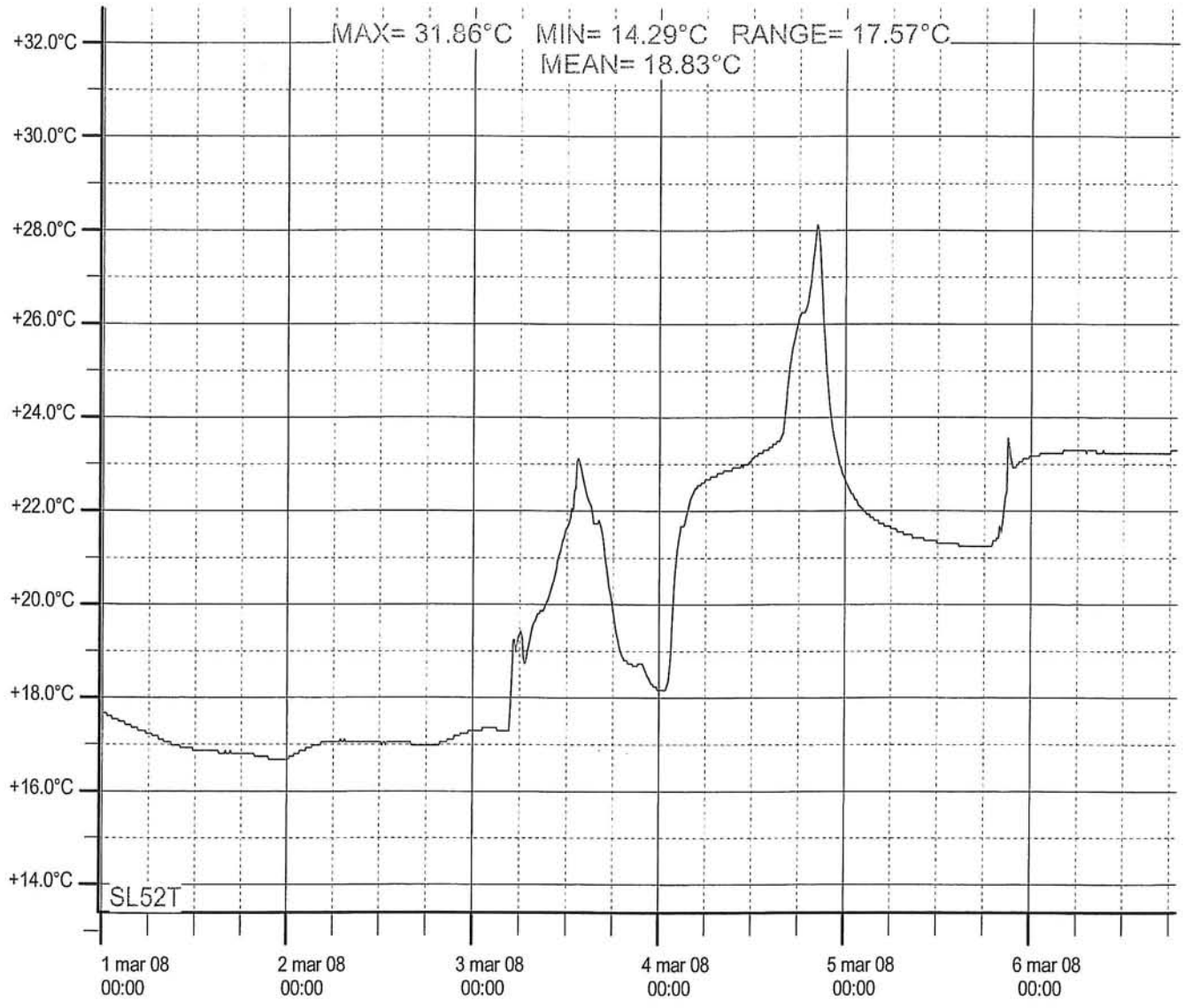
CWRW Box3 EC099, EC100

SL52T Standard print, printed on fredag 16 mai 2008 at 14:01:27

Logger Serial No.:	C8000000050B6041	**Lo Alarm Setpoint:**	-40.0°C
Total readings since new:	25343	**Hi Alarm Setpoint:**	+85.0°C
Sample Rate:	10 mins	**Alarm(s) Triggered:**	No
Logged readings:	4096	**Calibration due:**	Not Set
Issue Time/Date:	29 feb 2008 - 9:59:33 AM	**Graph Start:**	29 feb 2008 - 11:38:00 PM
		Graph Stop:	6 mar 2008 - 7:00:00 PM

Owner Manifest: Not Set
User Manifest 1: CWRW Box3 EC099, EC100
User Manifest 2: Logger 5

Signature 1:	.....	**Signature 2:**	.....
Print Name:	.....	**Print Name:**	.....
Date:	.....	**Date:**	.....



Appendix 5 - CWRW Hydration Summary

	A1	A2	A3	A4	B1	B2	B3	B4
GMT 090-091	Normal hydration sch, **93** pulses. Resat counter to 30				Normal hydration sch, **92** pulses. Resat counter to 30			
GMT091	Pump running continuously for 2 min+B29							
GMT091	92-30=**62 pulses** Resat counter to 0				91-30=**61 pulses** Resat counter to 30			
GMT091	**39 pulses** Resat counter to 0				64-30=**34 pulses** Resat counter to 0			
GMT091	Pump running continuously for 2 min				Pump running continuously for 2 min			
GMT091	**50 pulses**				**45 pulses**			
GMT091		**32 pulses** Resat counter to 0				**32 pulses** Resat counter to 0		
GMT092		**94 pulses** Resat counter to 0				**94 pulses** Resat counter to 0		
GMT092		**100 pulses** Sch stopped automatically				**100 pulses** Sch stopped automatically		
GMT094				(Drained de-humidifier to Waste 3 min)				
GMT094				(Drained humidifier to de-humidifier 2 min)				
GMT096	Power-down for crew activity EMCS Water Flow Checks	Power-down for crew activity EMCS Water Flow Checks	Power-down for crew activity EMCS Water Flow Checks	Power-down for crew activity EMCS Water Flow Checks	Power-down for crew activity EMCS Water Flow Checks	Power-down for crew activity EMCS Water Flow Checks	Power-down for crew activity EMCS Water Flow Checks	Power-down for crew activity EMCS Water Flow Checks
GMT098	**95 pulses** Resat counter to 0				**93 pulses** Resat counter to 0			
GMT098	**100 pulses** Sch stopped automatically				**100 pulses** Sch stopped automatically			
GMT098	Patches water pulses to 60 sec	Patches water pulses to 60 sec	Patches water pulses to 60 sec	Patches water pulses to 60 sec	Patches water pulses to 60 sec	Patches water pulses to 60 sec	Patches water pulses to 60 sec	Patches water pulses to 60 sec
GMT098	Counter set to 25 to avoid rapid pulsing. Hydration performed in AOS only. Sch stopped automaticcaly at 100 pulses. **75 pulses given**				Counter set to 25 to avoid rapid pulsing. Hydration performed in AOS only. Sch stopped automaticcaly at 100 pulses. **75 pulses given**			
GMT099	Patches water pulses back to 15 sec	Patches water pulses back to 15 sec	Patches water pulses back to 15 sec	Patches water pulses back to 15 sec	Patches water pulses back to 15 sec	Patches water pulses back to 15 sec	Patches water pulses back to 15 sec	Patches water pulses back to 15 sec
GMT099	Pumps water from fresh to waste in 1xg on Box 1 Rotor A to fill tubes from H2O to RBLSS with water (3 min Pump1, 1 min pump 2)	Pumps water from fresh to waste in 1xg on Box 1 Rotor A to fill tubes from H2O to RBLSS with water (3 min Pump1, 1 min pump 2)						
GMT099	**100 pulses** (sch stopped automatically)							
GMT100		**100 pulses** (sch stopped automatically)						

GMT102					Pumps water from fresh to waste in 1xg on Box 1 Rotor B to fill tubes from H2O to RBLSS with water (3 min Pump1, 1 min pump 2)			
GMT102	Hydration in **0.8xg** started, **100 pulses given**. Sch stopped automatically						Hydration in **0xg** started, **100 pulses given**. Sch stopped automatically	
				Hydration in **0xg** started, **100 pulses given**. Sch stopped automatically	Hydration in **0.8xg** started, **100 pulses given**. Sch stopped automatically			
GMT103			Hydration in **0.8xg** started, **93 pulses given**. Sch stopped automatically				Hydration in **0.8xg** started, **93 pulses given**. Sch stopped automatically	
GMT103		Hydration in **0.8xg** started, **73 pulses given**. Sch stopped manually at this point				Hydration in **0.8xg** started, **73 pulses given**. Sch stopped manually at this point		
				Hydration in **0.8xg** started, **75 pulses given**. Sch stopped automatically				
	Water pump run for 1 min then 5 min pause, 5 repetitions. No change of valve config between the pulses.							
	Started hydration schedule. **26 pulses** given. Resat counter to 99							
	100 pulses-99+26=**27 pulses given**. Sch stopped automatically							
Total amount of pulses per GMT106	**741 pulses**	**399**	**93**	**175**	**600**	**299**	**193**	**0**
GMT107	Started hydration schedule - **125** rapid pulses, **75** slow							
GMT113	Started hydration schedule, **97** pulses given. Resat counter to **30**				Started hydration schedule, **95** pulses given. Resat counter to **30**			
GMT114	98-30=**68 pulses** given. Resat counter to 25				99-30=**69 pulses** given. Resat counter to 25			
GMT114	100-25=**75 pulses** given				100-25=**75 pulses** given			

GMT114			Could not be hydrated due to low airflow				Started hydration schedule with counter set to -24. A total of **57** pulses given and **dP threshhold reached!**	
GMT114		Started hydration schedule with counter set to -24. A total of **124** pulses given		Started hydration schedule with counter set to -24. A total of **125** pulses given		Started hydration schedule with counter set to -24. A total of **124** pulses given		Started hydration schedule with counter set to -24. A total of **89** pulses given and **dP** threshhold reached!
GMT115					Started hydration schedule with counter set to -24. Resat counter to 71 when it reached 96.Let it run to 100. A total of **146** pulses added.		Added water pulses with ADDWATB3. 20 pulses given.	Added water pulses with ADDWATB4. 19 pulses given.
GMT116			Started hydration schedule. A total of **XX** pulses given		Started hydration schedule with counter set to -24. A total of **90** pulses given and **dP treshhold is reached!**			
GMT116					Added water pulses with ADDWATB1. 19 pulses given.			
GMT116						Started hydration schedule with counter set to -24. A total of **125** pulses given		
GMT117						Manual pumping 10 times 1 minutes, valves switched between each pulse		
						Started hydration schedule with counter set to -24. Resat counter to 25 when it reached 96. A total of 121 pulses added.Resat counter to 69 when it was at 98. Let run to 100. A total of **225** pulses given.		
GMT119						Pumping for 5 minutes without switching the valves between the 5 1 minute pulses		
GMT119						Started hydration schedule . Resat counter to -47 after 3 pulses.A total of **82** pulses were given.		
GMT121	Performed one 5 minute pulse for preparation of hydration of A1						Added **5** water pulses manually	Added **5** water pulses manually
GMT121	Started hydration schedule with counter set to-49 after the first pulse. A total of 61 pulses given.							
GMT124							Added **5** water pulses manually	Added **5** water pulses manually

GMT126	**EC relocated to position B1**	**EC relocated to position B2**			**EC relocated to position A1**	**EC relocated to position A2**		
GMT126					Started hydration schedule with counter set to -24. Resat counter to -18 when it reached 7. Resat counter to 78 when it was on 28. Schedule continued to 100 pulses. A total of **99** pulses were given.			
GMT127					Started hydration schedule with counter set to -49. Resat counter to 78 when it reached 28. A total of **99** pulses were given.			
GMT128	Started hydration schedule with counter set to -49. Resat counter to 83 when it reached 28. A total of **94** pulses were given.					Started hydration schedule with counter set to -49. Resat counter to 83 when it reached 28. A total of **94** pulses were given.		
GMT128							dP check performed. PCC full of water. Bottom-chamber flooded	dP check performed. PCC full of water.
GMT130					1 long 4 minutes pulse before starting initial hydration			
GMT130					Initial hydration started, **100** rapid pulses given.			

Appendix 6 - CWRW Implemented changes

EC position	Description of change	Reason for change	Originator	Date of submission	Due date	Status	Related PAR
B2	Power-down of Subsystems required	Digital line in EC B2 not responding	PD	GMT090	GMT090	Implemented GMT090	PAR-HW-010
A1	Reset water pulse counter to 30	dP did not trigger within the very first 93 pulses	PD/PI-Rep	GMT091	GMT091	Implemented GMT091	PAR-HW-011
A1	Keep the pump running for 2 minutes before starting the hydration schedule over again	dP did not trigger within the first 155 pulses (93+92-30)	PD/PI-Rep	GMT091	GMT091	Implemented GMT091	PAR-HW-011
A1	Reset water pulse counter to 0	dP did not trigger within the first 194 pulses (155+39)	PD/PI-Rep	GMT091	GMT091	Implemented GMT091	PAR-HW-011
A1	Keep the pump running for 2 minutes before starting the hydration schedule over again	dP did not trigger within the first 244 pulses (194+50)	PD/PI-Rep	GMT091	GMT091	Implemented GMT091	PAR-HW-011
A1	Reset water pulse counter to 0	dP did not trigger within the first 244 pulses (194+50)	PD/PI-Rep	GMT091	GMT091	Implemented GMT091	PAR-HW-011
A2	Reset water pulse counter to 0	dP did not trigger within the very first 32 pulses	PD/PI-Rep	GMT91	GMT091	Implemented GMT091	PAR-HW-011
A2	Reset water pulse counter to 0	dP did not trigger within the first 126 pulses (94+32)	PD/PI-Rep	GMT91	GMT091	Implemented GMT091	PAR-HW-011
A2	Reset water pulse counter to 0	dP did not trigger within the first 226 pulses (126+100)	PD/PI-Rep	GMT91	GMT091	Implemented GMT091	PAR-HW-011
B1	Reset water pulse counter to 30	dP did not trigger within the very first 92 pulses	PD/PI-Rep	GMT91	GMT091	Implemented GMT091	PAR-HW-011
B1	Reset water pulse counter to 30	dP did not trigger within the very first 153 pulses (92+91-30)	PD/PI-Rep	GMT91	GMT091	Implemented GMT091	PAR-HW-011
B1	Reset water pulse counter to 0	dP did not trigger within the very first 187 pulses (153+64-30)	PD/PI-Rep	GMT91	GMT091	Implemented GMT091	PAR-HW-011
B1	Keep the pump running for 2 minutes before starting the hydration schedule over again	dP did not trigger within the very first 187 pulses (153+64-30)	PD/PI-Rep	GMT091	GMT091	Implemented GMT091	PAR-HW-011
B2	Reset water pulse counter to 0	dP did not trigger within the very first 32 pulses	PD/PI-Rep	GMT91	GMT091	Implemented GMT091	PAR-HW-011
B2	Reset water pulse counter to 0	dP did not trigger within the first 126 pulses (94+32)	PD/PI-Rep	GMT92	GMT092	Implemented GMT091	PAR-HW-011
B2	Reset water pulse counter to 0	dP did not trigger within the first 226 pulses (126+100)	PD/PI-Rep	GMT92	GMT092	Implemented GMT091	PAR-HW-011
A1	Request for **Crew Activity** EMCS Water flow Checks	dP did not trigger within the first 244 pulses (194+50)	PD/PI-Rep	GMT092	GMT096	Implemented GMT096	PAR-HW-011
A2	Request for **Crew Activity** EMCS Water flow Checks	dP did not trigger within the first 226 pulses	PD/PI-Rep	GMT092	GMT096	Implemented GMT096	PAR-HW-011
B1	Request for **Crew Activity** EMCS Water flow Checks	dP did not trigger within the first 232 pulses (187+45)	PD/PI-Rep	GMT092	GMT096	Implemented GMT096	PAR-HW-011
B2	Request for **Crew Activity** EMCS Water flow Checks	dP did not trigger within the first 244 pulses (194+50)	PD/PI-Rep	GMT092	GMt196	Implemented GMT096	PAR-HW-011
All	Request GN2 on GMT096	O2 safety level is at a level where it is advisable to add GN2 to avoid O2 Sensor peaks which could lead to EMCS Subsystems power-off	PD	GMT096	GMT096	Implemented GMT096	PAR-HW-011

EC position	Description of change	Reason for change	Originator	Date of submission	Due date	Status	Related PAR
All	Request for **Crew Activity** EMCS Main Door Check		PD	GMT097	GMT097	Implemented GMT097	PAR-HW-012
A1	Reset water pulse counter to 0	dP did not trigger within the first 339 pulses (244+95)	PD/PI-Rep	GMT098	GMT098	Implemented GMT098	PAR-HW-011
A1	Patch water pulses to 60 sec instead of 15 sec	dP did not trigger within the first 439 pulses (339+100)	PD/PI-Rep	GMT098	GMT098	Implemented GMT098	PAR-HW-011
A1	Add 75 "slow" pulses	dP did not trigger within the first 439 pulses (339+100)	PD/PI-Rep	GMT098	GMT098	Implemented GMT098	PAR-HW-011
B1	Reset water pulse counter to 0	dP did not trigger within the first 325 pulses (232+93)	PD/PI-Rep	GMT098	GMT098	Implemented GMT098	PAR-HW-011
B1	Patch water pulses to 60 sec instead of 15 sec	dP did not trigger within the first 425 pulses (325+100)	PD/PI-Rep	GMT098	GMT098	Implemented GMT098	PAR-HW-011
B1	Add 75 "slow" pulses	dP did not trigger within the first 425 pulses (325+100)	PD/PI-Rep	GMT098	GMT098	Implemented GMT098	PAR-HW-011
A1	Patch water pulses back to 15 sec instead of 60 sec	Hydration not successful with larger water pulses and these might pose a treat if hydration suddenly should work. dP did not trigger within the first 514 pulses (439+75)	PD/PI-Rep	GMT099	GMT099	Implemented GMT099	PAR-HW-011
A1	Pump water from fresh to waste in 1xg on Box 1 on Rotor A (3 min for Pump1, 1 min for Pump2)	Attempt to fill tubes from H2O Reservoir to RBLSS with water	PD/PI-Rep	GMT099	GMT099	Implemented GMT099	PAR-HW-011
A1	Restart hydration schedule and let it run to 100 pulses	dP did not trigger within the first 514 pulses	PD/PI-Rep	GMT099	GMT099	Implemented GMT099	PAR-HW-011
A2	Pump water from fresh to waste in 1xg on Box 1 on Rotor A (3 min for Pump1, 1 min for Pump2)	Attempt to fill tubes from H2O Reservoir to RBLSS with water	PD/PI-Rep	GMT099	GMT099	Implemented GMT099	PAR-HW-011
B1	Patch water pulses back to 15 sec instead of 60 sec	Hydration not successful with larger water pulses and these might pose a treat if hydration suddenly should work. dP did not trigger within the first 500 pulses (425+75)	PD/PI-Rep	GMT099	GMT099	Implemented GMT099	PAR-HW-011
A1	Request crew time for EC swap in case hydration of A1 in 0.8xg does not work. Refer to Scenarios_EMCSCWRWTeam_GMT102_ls2	If hydration of A1 in 0.8xg does not work there is no need to perform the EC swap.	PI-Rep	GMT100		Not implemented	PAR-HW-011
A2	Restart hydration schedule again and let it run to 100 pulses	dP did not trigger within the first 226 pulses	PD/PI-Rep	GMT100	GMT100	Implemented GMT100	PAR-HW-010
All	Switch off lights in all ECs	In the ECs which are dry there is no need to keep illumination active as there is no chance of germination. In the Ecs which are proven humid we do not want to keep lights and ventilation on as this might increase the chance of dry-out, both of the seeds and of the PP-felt and Borosilicate. PP-felt and Borosilicate might become water repellant if exposed to water, then dried up and the re-watered.	PD/PI-Rep	GMT100	GMT100	Implemented GMT100	PAR-HW-011
All	Request for file uplink	New database file needed in case ECs A1 and A2 will be swapped with A3 and A4	EMCS Ops	GMT101	GMT101	Implemented GMT101	PAR-HW-011
A1	Perform normal hydration schedule again in 0.8xg, 100 pulses	Hydration might progress better if gravity is helping unclogging tubes or filters. dP did not trigger within the first 614 pulses (514+100)	PD/PI-Rep	GMT102	GMT102	Implemented GMT102	PAR-HW-011

EC position	Description of change	Reason for change	Originator	Date of submission	Due date	Status	Related PAR
B3	Perform normal hydration schedule in 0xg, 100 pulses	Hydration did not progress nominally in the other EC positions	PD/PI-Rep	GMT102	GMT102	Implemented GMT102	PAR-HW-011
A4	Perform normal hydration schedule in 0xg, 100 pulses	Hydration did not progress nominally in the other EC positions	PD/PI-Rep	GMT102	GMT102	Implemented GMT102	PAR-HW-011
B1	Perform normal hydration schedule in 0.8xg, 100 pulses	Hydration did not progress nominally in the other EC positions	PD/PI-Rep	GMT102	GMT102	Implemented GMT102	PAR-HW-011
B1	Pump water from fresh to waste in 1xg on Box 1 on Rotor B (3 min for Pump1, 1 min for Pump2)	Attempt to fill tubes from H2O Reservoir to RBLSS with water	PD/PI-Rep	GMT102	GMT102	Implemented GMT102	PAR-HW-011
A3	Perform normal hydration schedule in 0.8xg, 93 pulses	Hydration did not progress nominally in the other EC positions	PD/PI-Rep	GMT102	GMT102	Implemented GMT103	PAR-HW-011
B3	Perform normal hydration schedule in 0.8xg, 93 pulses	Hydration did not progress nominally in the other EC positions	PD/PI-Rep	GMT103	GMT103	Implemented GMT103	PAR-HW-011
A2	Perform normal hydration schedule in 0.8xg, 73 pulses	Hydration did not progress nominally in the other EC positions	PD/PI-Rep	GMT103	GMT103	Implemented GMT103	PAR-HW-011
B2	Perform normal hydration schedule in 0.8xg, 73 pulses	Hydration did not progress nominally in the other EC positions	PD/PI-Rep	GMT103	GMT103	Implemented GMT103	PAR-HW-011
A4	Perform normal hydration schedule in 0.8xg, 75 pulses	Hydration did not progress nominally in the other EC positions	PD/PI-Rep	GMT103	GMT103	Implemented GMT103	PAR-HW-011
All	Request for file uplink	New database file needed in case EC A1 will be swapped with A3	EMCS Ops	GMT102	GMT102		PAR-HW-011
A1	Let the water pump run for 1 min then 5 minutes wait, repeat 5 times without changing valve settings between each repetition	dP did not trigger within the first 614 pulses	PD/PI-Rep	GMT103	GMT103	Implemented GMT102	PAR-HW-011
A1	Restart hydration schedule again. Let run for 26 pulses then set counter to 99	dP did not trigger within the first 714 pulses (614+100)	PD/PI-Rep				PAR-HW-011
A2	Perform normal hydration schedule again in 0.8xg, 100 pulses	Hydration might progress better if gravity is helping unclogging tubes or filters. dP did not trigger within the first 326 pulses (226+100)	PD/PI-Rep	GMT103	GMT103	Implemented GMT103	PAR-HW-011
A4	Perform normal hydration schedule again in 0.8xg, 100 pulses	Hydration might progress better if gravity is helping unclogging tubes or filters. dP did not trigger within the first 100 pulses	PD/PI-Rep	GMT103	GMT103	Implemented GMT103	PAR-HW-011
B1	Perform normal hydration schedule again in 0.8xg, 100 pulses	Hydration might progress better if gravity is helping unclogging tubes or filters. dP did not trigger within the first 500 pulses	PD/PI-Rep	GMT103	GMT103	Implemented GMT103	PAR-HW-011
B3	Perform normal hydration schedule again in 0.8xg, 100 pulses	Hydration might progress better if gravity is helping unclogging tubes or filters. dP did not trigger within the first 100 pulses	PD/PI-Rep	GMT103	GMT103	Implemented GMT103	PAR-HW-011
A1	Stop rotation of Rotor A after 0.8xg hydration attempts	The only germinated seedlings are on the A-rotor at the moment and it does not make sense to run 1xg on tis rotor when there are no plants on rotor B which could be grown in micro-g	PI-Rep	GMT104	GMT104	Implemented GMT104	PAR-HW-011
A2	Stop rotation of Rotor A after 0.8xg hydration attempts	The only germinated seedlings are on the A-rotor at the moment and it does not make sense to run 1xg on tis rotor when there are no plants on rotor B which could be grown in micro-g	PI-Rep	GMT104	GMT104	Implemented GMT104	PAR-HW-011

EC position	Description of change	Reason for change	Originator	Date of submission	Due date	Status	Related PAR
A3	Stop rotation of Rotor A after 0.8xg hydration attempts	The only germinated seedlings are on the A-rotor at the moment and it does not make sense to run 1xg on tis rotor when there are no plants on rotor B which could be grown in micro-g	PI-Rep	GMT104	GMT104	Implemented GMT104	PAR-HW-011
A4	Stop rotation of Rotor A after 0.8xg hydration attempts	The only germinated seedlings are on the A-rotor at the moment and it does not make sense to run 1xg on tis rotor when there are no plants on rotor B which could be grown in micro-g	PI-Rep	GMT104	GMT104	Implemented GMT104	PAR-HW-011
A1	Command Reduced illumination to A1 5 hours every day (instead of the 16 as planned)	During last hydration attempts seedlings were discovered in EC A1! The request of only 5 hours light per day is made in order to avoid dry-out of seedlings in A1 as they do not get enough water but have started growing	PI-Rep	GMT104	GMT104	Implemented GMT104	PAR-HW-011
All	Request **Crew Activity** for crew to perform verification of which Water Reservoirs are in stowage	Part of Facility Failure Investigation	PD	GMT103	GMT105	Implemented GMT105	PAR-HW-011
A1	Run water pump in A1 min 5 times with 5 minutes wait between each pump activation. Do not switch valves between each pulse.	Part of Facility Failure Investigation	PD	GMT105	GMT105	Implemented GMT105	PAR-HW-011
A1	Start initial hydration schedule again (25 rapid pulses, 2 slow pulses)	Part of Facility Failure Investigation	PD/PI-Rep	GMT105	GMT105	Implemented GMT105	PAR-HW-011
All	Observation of current draw during valve switching	In order to verify if the valves are actually switching when commanded to, a request was forwarded where the current draw should be monitored closely while switching valves in all 12 valves connected to the RBLSS-boxes on rotor A	PD	GMT109	GMT110	Implemented GMT110	
All	Request for internal EMCS Video	The VPU was non-responding at the moment and the PI-team requested RT Video in order to check the status of teh plants	PI-Rep	GMT110	GMT111	Implemented GMT111	
All	Request for **Crew Activity** H2O Res Replace	Part of Facility Failure Investigation	PD/PI-Rep	GMT109	GMT113	Implemented GMT113	PAR-HW-011
All	Request for photographs during the H2O Res Replace **Crew Activity**	Since the LabCam in Columbus has quite bad resolution the MRB has requested the crew to take manual images of rotor A and rotor B when pullsed out to the half-way stop	MRB	GMT112	GMT113	Implemented GMT113	
B3	Request to add 5 water pulses to B3 and B4	Leaves seem to be folding, which indicated that the plants need water	PI-Rep	GMT121	GMT121	Implemented GMT121	PAR-HW-011
B4	Request to add 5 water pulses to B3 and B4	Leaves seem to be folding, which indicated that the plants need water	PI-Rep	GMT121	GMT121	Implemented GMT121	PAR-HW-011
All	Request for File Uplink	New LIGHTS schedule which does not contain the bug which switches B3 and B4 to recycling mode when lights are turned off	EMCS Ops	GMT119	GMT121	Implemented GMT121	
All	Request for **Crew Activity** EC Swap	Swap ECs from positions A1/A2 to B1/B2	PI-Rep/PD	GMT123	GMT126	Implemented GMT125	PAR-HW-011
All	Request for File Uplink	Database file needed after the EC Swap activity on GMT125	EMCS Ops	GMT123	GMT126	Implemented GMT125	PAR-HW-011
All	EMCS Power cycle and File Transfer GMT126		EMCS Ops/PD	GMT124	GMT126	Implemented GMT125	PAR-HW-011

EC position	Description of change	Reason for change	Originator	Date of submission	Due date	Status	Related PAR
All	Request for File Uplink	9 new files including EVENT schedules, LIGHTS schedules and a SETUP file	EMCS Ops	GMT124	GMT127	GMT128	
A1	Perform 70%-set-point test to verify if the dehumidifier gets water from fresh when it needs so. Destination should be waste for 5 days	Part of Facility Failure Investigation	PD/MRB	GMT127	GMT127	Implemented GMT130	PAR-HW-011
A2	Perform 70%-set-point test to verify if the dehumidifier gets water from fresh when it needs so. Destination should be waste for 5 days	Part of Facility Failure Investigation	PD/MRB	GMT127	GMT127	Implemented GMT130	PAR-HW-011
A3	Perform 70%-set-point test to verify if the dehumidifier gets water from fresh when it needs so. Destination should be waste for 5 days	Part of Facility Failure Investigation	PD/MRB	GMT127	GMT127	Implemented GMT130	PAR-HW-011
A4	Perform 70%-set-point test to verify if the dehumidifier gets water from fresh when it needs so. Destination should be waste for 5 days	Part of Facility Failure Investigation	PD/MRB	GMT127	GMT127	Implemented GMT130	PAR-HW-011
B1	Perform hydration of B1 again, 100 rapid pulses	The plants in B1 might still be alive but suffering from to little water.	PI-Rep	GMT127	GMT127	Implemented GMT127	PAR-HW-011
A1	Perform initial hydration again, 75 rapid pulses, 25 slow pulses	Check if hydration progresses nominally after EC Swap	PD	GMT127	GMT128	Implemented GMT128	PAR-HW-011
B2	Perform initial hydration again, 75 rapid pulses, 25 slow pulses	Check if hydration progresses nominally after EC Swap	PD	GMT127	GMT128	Implemented GMT128	PAR-HW-011
B3	Perform dP check 15 sec	Will determine if additional hydration is required	PI-Rep	GMT128	GMT128	Implemented GMT128	PAR-HW-013
B4	Perform dP check 15 sec	Will determine if additional hydration is required	PI-Rep	GMT128	GMT128	Implemented GMT128	PAR-HW-013
B3	Attempt to restart airflow in EC B3	Airflow stopped during dP check as water was pressed into the PCC bottom chamber and blocked the EC baseplate filter	PI-Rep/PD	GMT128	GMT128	Implemented GMT128	PAR-HW-013
B3	Switch off lights in B3	Lights switched off since we have no airflow in this EC	PI-Rep	GMT128	GMT128	Implemented GMT128	PAR-HW-013
B3	Switch on lights in B3 (continuously on)	After discussions within the PI-team the risk of developed "heat pockets" shall be taken as illumination is ver important for tha plants at this stage	PI-Rep	GMT129	GMT129	Implemented GMT129	PAR-HW-013
B1	Perform hydration of B1 again, one 4 minutes long pulse before giving 100 rapid pulses via INITWAT schedule	The plants in B1 might still be alive but suffering from to little water.	PI-Rep	GMT129	GMT130	Implemented GMT131	PAR-HW-011
B4	Implement increased venting in B4	The plants are quite big and the humidity inside the EC volume is constantly at about 100 now.	PI-Rep	GMT129	GMT130	Implemented GMT131	
B4	Increase light intensity from reduced to full	Plants in B4 are noew 20 days old and can tolerate full intensity. This will hopefully speed up the growth process and give stems for harvesting.	PI-Rep	GMT134	GMT134	Implemented GMT134	
B4	Implement frequent observation of plants in B4	As part of collaboration with Mulitgen-1 PI frequent observation of rosette leave movements have been approved by JAXA.	PI-Rep	GMT133	GMT137	ImplementedGMT137	
B4	Increase the ventilation rate in B4 to constant	Condence can be seen on the PCC Lid, below the plant leaves	PI-Rep	GMT135	GMT137	ImplementedGMT137	

EC position	Description of change	Reason for change	Originator	Date of submission	Due date	Status	Related PAR
B4	Perform dP check of the PCC 10 sec	Since ventilation rate will be increased it will be good to verify that the PCC has sufficient water, in order to avoid dry-out	PI-Rep	GMT135	GMT137	ImplementedGMT137	
B4	Start recirculation of water	The plants are now approximately 22 days old and ground testing pre-experiment showed that the plants need recirculation at this stage	PI-Rep	GMT135	GMT137	ImplementedGMT137	
All	(JIT) File uplink via OCA of CWRW Reference Material for FAM Activity			GMT134	GMT140	Implemented GMT140	
All	(JIT) CWRW Procedure Changes			GMT134	GMT140	Implemented GMT143	
B4	Request for file uplink	New schedule file for frequent observation of B4	EMCS Ops	GMT 133	GMT136	Implemented GMT136	
B4	Request for file uplink	New schedule file for frequent observation of B4, as bug was found the files which were uplinked yesterday	EMCS Ops	GMT137	GMT137	Implemented GMT137	
B4	Request hydration of B4, 5 pulses	Plant movements (as can be seen via frequent image aquisition) seem to be stagnated	PI-Rep	GMT139	GMT139	Implemented GMT139	EMCS-HW-011
B4	Request hydration of B4, 5 pulses	Plant movements (as can be seen via frequent image aquisition) seem to be stagnated, and did not restart after being given 5 water pulses	PI-Rep	GMT139	GMT139	Implemented GMT139	EMCS-HW-011
B4	Request hydration of B4, 5 pulses	Plant movements (as can be seen via frequent image aquisition) seem to be stagnated, and did not restart after being given 10 water pulses	PI-Rep	GMT139	GMT139	Implemented GMT139	EMCS-HW-011
B4	Perform hydration of B4 by water pump service, 4x5 pulses + 15 pulses	Plant movements (as can be seen via frequent image aquisition) seem to be stagnated, and did not restart after being given 15 water pulses yesterday. dP check can not be used as dig line 2 can not be switched	PI-Rep	GMT140	GMT140	Implemented GMT140	EMCS-HW-011 EMCS-HW-013
B4	Perform manual pumping of water to B3, 3x3 minutes	Plant movements (as can be seen via frequent image aquisition) seem to be stagnated, and did not restart after being given 35 pulses this morning	PI-Rep	GMT140	GMT140	Implemented GMT140	EMCS-HW-011 EMCS-HW-013
B4	Perform reverse pumping of water from EC B4 3 times; pump water from EC B4 to dehumidifier 2x1 minute, then pump 2 minutes from EC B4 to fresh. Perform forward pumping between each of the three reverse pumpings.	Plant movements (as can be seen via frequent image aquisition) seem to be stagnated, and did not restart after being given 35 pulses and 3x3 minutes yesterday	PI-Rep/PD	GMT141	GMT141	Implemented GMT141	EMCS-HW-011 EMCS-HW-013
B4	Perform reverse pumping of water from EC B4 2 times; pump water from EC B4 to dehumidifier 2 minutes, and 3 minutes from EC B4 to dehumidifier. Perform 3 min forward pumping between the two reverse pumpings.	Plant movements (as can be seen via frequent image aquisition) seem to be stagnated, and did not restart after being hydrated after reverse pumping yesterday	PD	GMT142	GMT142	Implemented GMT142	EMCS-HW-011 EMCS-HW-013
B4	Switch lights in B4 off for some hours, lower temperature set-point to 20 degrees C, switch illumination on in reduced mode. Reduce ventilation mode to xxxx	Illumination intensity, temperatures and ventilation should be reduced in order to avoid dry-out of the plants which apparently does not get any water	PD	GMT142	GMT142	Implemented GMT142	EMCS-HW-011 EMCS-HW-013
B4	Request for **Crew Activity** rescheduling for early harvest	Plants are not receiving any water and should be harvested before thay dry-out completely	PI-Rep	GMT142	GMT145	Implemented GMT144	EMCS-HW-011 EMCS-HW-013

EC position	Description of change	Reason for change	Originator	Date of submission	Due date	Status	Related PAR
B4	Keep illumination on reduced continuously for the rest of the experiment	Illumination is important for potential further plant development and should be activated even though the risk of further dry-out of the plants is increased by this	PI-Rep	GMT143	GMT143	Implemented GMT145	EMCS-HW-011 EMCS-HW-013

Appendix 7 - Failure Analysis - Report SPR-283

Titel:
Title:

Failure Analysis and Recovery Report (SPR-0283)

Dokumenten Typ:
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Autor: Prepared by:	R. Born 14.8.08	**Org. Einh.:** Organ. Unit:	TO 53	**Unternehmen:** Company:	EADS Astrium
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1 INTRODUCTION

This report summarizes the result of the activities, based on the Trouble Shooting Plan, /RD6/ to find the root cause for the failed watering of CWRW ECs. After inspection and intensive testing of all returned parts, inspection of four returned MULTIGEN-ECs, analysis of CWRW water commanding sequence, the root cause could be clearly identified

The attached as-run procedure describes all activities in detail. The main results are summarized below.

2 REFERENCE DOCUMENTS

RD1 EMCS-RP-0000-124-DOR, issue 3, Fault-Tree Analysis
RD2 EMCS-MA-0000-004-DOR, issue 4, Water Reservoir Filling Procedure
RD3 EMCS-PR-0000-006-DOR, issue 2, RBLSS Module Maintenance Procedure
RD4 EMCS-TP-4000-007-DOR, issue 2, EC Functional Performance Test Procedure
RD5 N-USOC-PRO-002
RD6 EMCS-PL-0000-010-DOR, issue 1, Trouble Shooting and Recovery Plan, SPR-0283
RD7 EMCS-TP-4000-029-DOR, issue 1, CWRW-EC Leak Test Procedure
RD8 EMCS-PR-0000-010-DOR, issue 1, RBLSS QD Exchange Procedure
RD9 EMCS-TP-0000-135-DOR, issue 1, RBLSS System Proof Test Procedure

3 SUMMARY OF RESULTS

The returned parts:

S/N	ITEM	CI No.	CWRW-history
FM092	EMCS EC	401 000	initially on Pos. A1; germination, but no successful watering; finally on Pos. B1, watering retrial not successful
FM099	EMCS EC	401 000	initially on Pos. B2, no successful watering; finally on Pos. A2, watering retrial not successful
FM001	EMCS WATER RESERVOIR	223 200	second mission after refurbishment; mounted on rotor A in exchange with FM008; no successful watering
FM009	EMCS WATER RESERVOIR	223 200	first mission; initially mounted on rotor B; no successful watering; during CWRW exchanged with FM002

did not show any failure or deviation from design which could lead to the observed behaviour.

In addition it could be shown that the RBLSS-rotor I/F, the rotor itself, and the rotor-EC I/F is functional, because the returned ECs were wet, and the water collected in the filters was visibly clean. This rules out a potential blocking of the septum or other parts of this section.

However EMCS RBLSS MODULE FM008, CI #223 100 first mission; which had been mounted on EMCS FM rotor B1/B2, and achieved no successful watering there during CWRW, showed a major discrepancy during incoming inspection of 1J returned items at KSC: The Quick Disconnects (QDs) towards fresh and waste water reservoir were swapped, meaning

- "QD 10-N Fresh" at RBLSS was equipped with a **female** QD (thus fitting into **waste** QD of the water Reservoir and vice versa:
- "QD 12-N Waste" at RBLSS was equipped with a **male** QD (thus fitting into **fresh** QD of the water Reservoir

As it was confirmed by the supplier (OHB), the same discrepancy is most likely present on FM007 which was also used during CWRW, and which is still mounted in the EMCS FM on rotor A.

Development of the failure

Following the history of CWRW the following happened:

- At the beginning of CWRW the humidity (RH-) control of all ECs were started with 50% setting. Due to the QD swap, no fresh water could be supplied to the humidifiers (which was not immediately recognized, because they contain sufficient water to supply 50% humidity for quite a long time). However, the wrong connection led to an accumulation of an air/water mixture (90% air, 10% water volume) in the fresh water reservoir (instead of waste), because the dehumidifier is drained every 3 hours.

- In parallel to RH control the initial watering of EC/PCC was commanded, starting with positions A1/A2 (B1/B2). These positions now tried to get water from fresh reservoir, but in fact were connected to waste reservoir which nominally did not contain free water at the beginning of an experiment. So these positions only received the small amount of 1-5 ml water which was contained in the tubes.

- Initial watering of positions A3/A4 (B3/B4) was started several days later. Since these positions were connected correctly, they tried to get water from fresh reservoir, but received only an air/water mixture, which was partly sufficient for triggering the p-sensor in the PCC. However, on a long term, since the trapped air in the fresh water reservoir increased by the RH control, the supply could not be supported sufficiently, and the plants dried out.

- After the unsuccessful trial of seven ECs, the water reservoirs were exchanged. Before the water reservoir exchange no position could be hydrated at all. This can be quantitatively proven, because the watering of A3/A4 (B3/B4) positions followed much later than the 1+2 positions.

- After the exchange there was a partial success in watering (B1/B3/B4). Since B3/B4 watering followed immediately the water reservoir exchange, only some air was collected in the fresh water reservoir, and the positions could receive some water. B1 did not show a proper triggering, but a kind of "partial" triggering, which is explained by a mixture of air with some water which led to this behaviour. A4 was also watered quite soon after water reservoir exchange, but did obviously not get sufficient water due to included air. A3 was watered much later, and suffered also from air inclusion in the fresh water reservoir.

Fault-Tree Analysis

The QD swap was already mentioned as a potential root cause in the FTA /RD1/, and so included in the crew inspection activity to recover EMCS. Unfortunately this failure was not detected at this opportunity.

4 RECOVERY

For RBLSS FM008 the QD repair was already done during the trouble shooting activities.

The following actions are still to be made:

- Exchange of one QD at RBLSS FM008 (thread is slightly worn)
- Repair activity for RBLSS FM007, according to RD8

5 APPENDIX: REPORT ON TROUBLE SHOOTING OF NOT PROPERLY HYDRATED ECS (SPR-0283)

EMCS-RP-0000-151-DOR, iss. 1

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Trouble Shooting of not properly hydrated ECs (SPR-0283)

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Group (Version-related):

Thema:
Subject:

Kurzbeschreibung:
Abstract:

Autor: Prepared by:	R. Born/W. Biemann	**Org. Einh.:** Organ. Unit:	TO53/TOQ 5	**Unternehmen:** Company:	EADS Astrium
Geprüft: Agreed by:	T. Niedermaier i.A.	**Org. Einh.:** Organ. Unit:	TO 53	**Unternehmen:** Company:	EADS Astrium
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Table of Contents

1 INTRODUCTION

This report describes in detail the trouble shooting proceedings, based on the Trouble Shooting Plan, /RD6/, which were undertaken to find the root cause for the failed watering of CWRW ECs.

2 REFERENCE DOCUMENTS

RD1 EMCS-RP-0000-124-DOR, issue 3, Fault-Tree Analysis
RD2 EMCS-MA-0000-004-DOR, issue 4, Water Reservoir Filling Procedure
RD3 EMCS-PR-0000-006-DOR, issue 2, RBLSS Module Maintenance Procedure
RD4 EMCS-TP-4000-007-DOR, issue 2, EC Functional Performance Test Procedure
RD5 N-USOC-PRO-002
RD6 EMCS-PL-0000-010-DOR, issue 1, Trouble Shooting and Recovery Plan, SPR-0283
RD7 EMCS-TP-4000-029-DOR, issue 1, CWRW-EC Leak Test Procedure
RD8 EMCS-PR-0000-010-DOR, issue 1, RBLSS QD Exchange Procedure
RD9 EMCS-TP-0000-135-DOR, issue 1, RBLSS System Proof Test Procedure

3 RETURNED ITEMS

After use in EMCS the following items were returned from ISS to ASTRIUM, and used for inspections and test as part of the trouble shooting for SPR-283:

S/N	ITEM	CI No.	CWRW-history
FM092	EMCS EC	401 000	initially on Pos. A1; germination, but no successful watering; finally on Pos. B1, watering retrial not successful
FM099	EMCS EC	401 000	initially on Pos. B2, no successful watering; finally on Pos. A2, watering retrial not successful
FM001	EMCS WATER RESERVOIR	223 200	successfully used on earlier mission, second mission after refurbishment; mounted on rotor A in exchange with FM008; no successful watering
FM009	EMCS WATER RESERVOIR	223 200	first mission; initially mounted on rotor B; no successful watering; during CWRW exchanged for FM002
FM008	EMCS RBLSS MODULE	223 100	first mission; mounted on rotor B, connected to pos. B1/B2; no successful watering

4 COMBINED TESTS WITH RBLSS, EC, WATER RESERVOIR

4.1 RBLSS GSE Start-up Sequence

Start-up of RBLSS-GSE (OHB owned equipment):

1. Connect RBLSS connectors P12 and P14 with GSE harness
2. Power on both GSE computers (no matter sequence) and wait for start-up (takes approx. 2 minutes)
3. Switch on Breadboard E-Box
4. Double-click on icon ‘Breadboard-MCS_GSE’

Switch off OHB-GSE:

1. Exit Breadboard-MCS_GSE program

2. Switch off Breadboard E-Box
3. Switch off Rotor-computer (Trend): Type at Keyboard:
   <Alt+Strg+Entf> <Enter>
   <Enter>
   <Enter>
   <Alt+F4> <Enter>
   Press computer button (off)
4. Switch of GSE-Computer (Hyundai)

4.2 Characteristics of returned RBLSS

As returned from ISS the EMCS RBLSS MODULE, FM008, with wrongly integrated Quick Disconnects, as documented in SPR-283, was subjected to tests to demonstrate its performance during the CWRW experiment.
In the following two subparagraphs the actual physical activity is described. So when water is sucked from "waste" this is the actual physical activity resulting from a watering from fresh command during CWRW, and pumping into "fresh" is the actual physical activity resulting from a pumping into "waste" command during CWRW. A circuit diagram of the RBLSS with attached circuitry to EC and Water reservoir is given as Fig. 4.2 below including a note on the reversion of the waste and fresh water connections.

4.2.1 Sucking from "Waste"

Water was pumped from waste water reservoir through RBLSS to the RBLSS-rotor-I/F QD01 resp. QD04 (QD opened by counterpart). As to be expected in consequence of the swapped QDs no water was supplied.

Path 6:

Waste -> V1 (ON) - PW1 (ON) - V2 (OFF) - V3 (ON) -> QD01 (opened by counterpart-QD)

Waste -> V4 (ON) - PW2 (ON) - V5 (OFF) - V6 (ON) -> QD04 (opened by counterpart-QD)

No.	Test	Water Reservoir; outlet	RBLSS Module; outlet	Note
1	water service, path 6	FM009; QD10	FM008; B2 (QD04)	flight configuration, except Rotor I/F and EC
2	water service, path 6	FM009; QD09	FM008; B1 (QD01)	

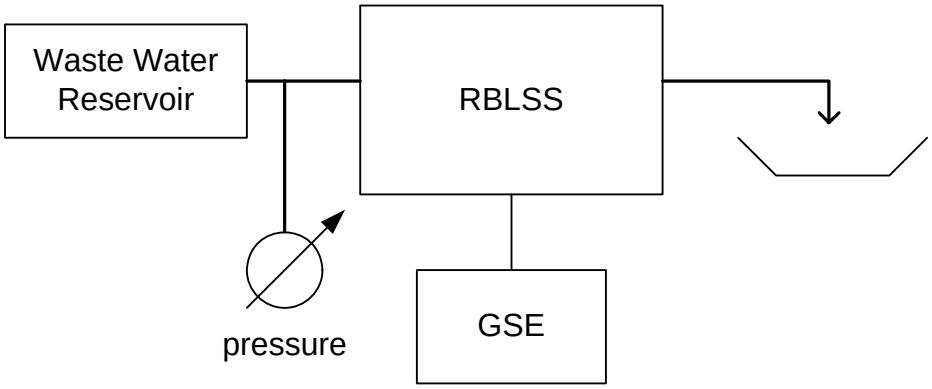

Figure 4-1: Setup for water supply test with wrong QDs

No.	Step	actual value
1	start “EC water service” 1 pulse	behavior as expected: no delta-pressure*; no water
2	start “EC water service” 5 pulse	behavior as expected: no delta-pressure*; no water
3	start “EC water service” 3 pulse	behavior as expected: no delta-pressure*; no water
		*) not considering offset delta pressure when connecting the QDs (spring loaded volume change)

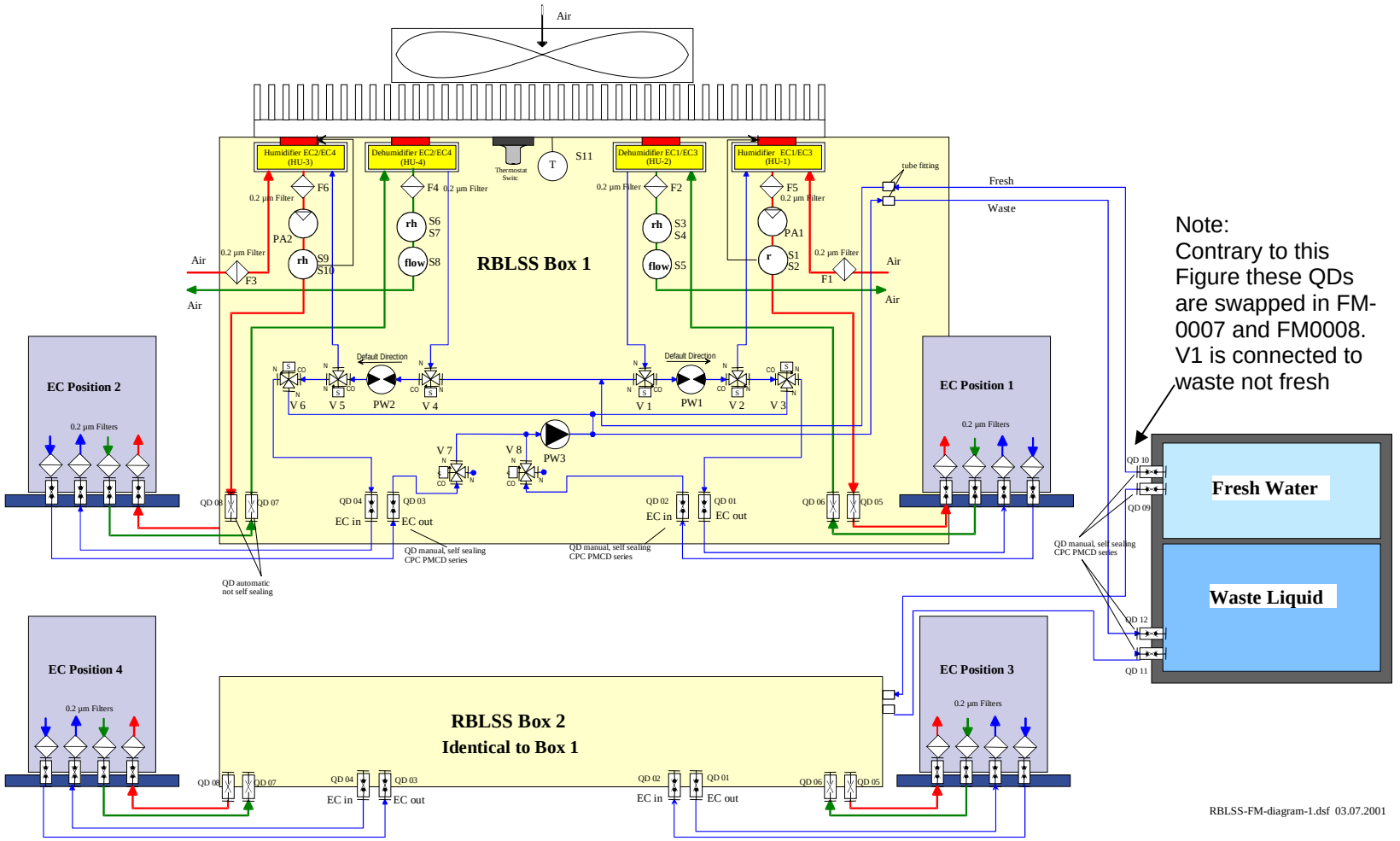

Figure 4-2: Circuit Diagram EMCS RBLSS

4.2.2 Pumping into "Fresh"

Air was pumped into fresh water reservoir through RBLSS via RBLSS-QD12-S into Fresh Water Reservoir. As expected by the swapped QD failure, the water bag, containing trapped air volume, was blown up and the pressure increased by compressing the air in the bag (Figure 4-4)

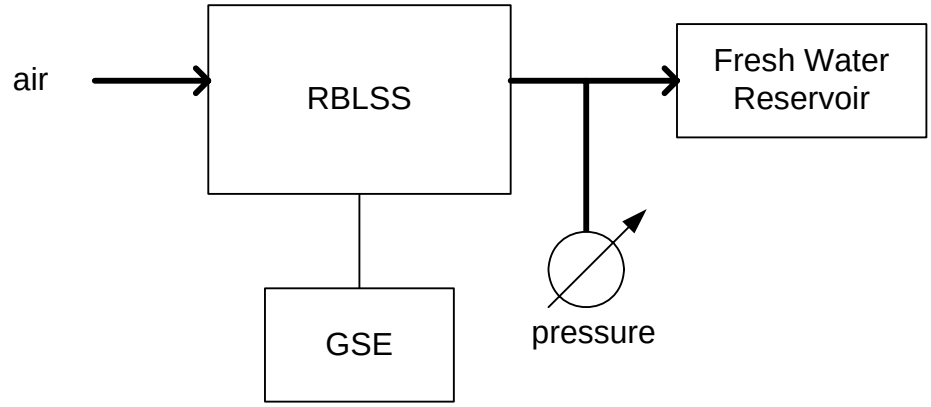

Figure 4-3: Setup for water removal test with wrong QDs

QD10-N (opened by counterpart) -> V1 (ON) - PW1 (ON) - V2 (OFF) - V3 (OFF) --> QD12-S -->Fresh

No.	Test	Water Reservoir; outlet	RBLSS Module; outlet	Note
1	water service, path 6	FM009; QD10	FM008; B2 (QD04)	flight configuration, except Rotor I/F and EC

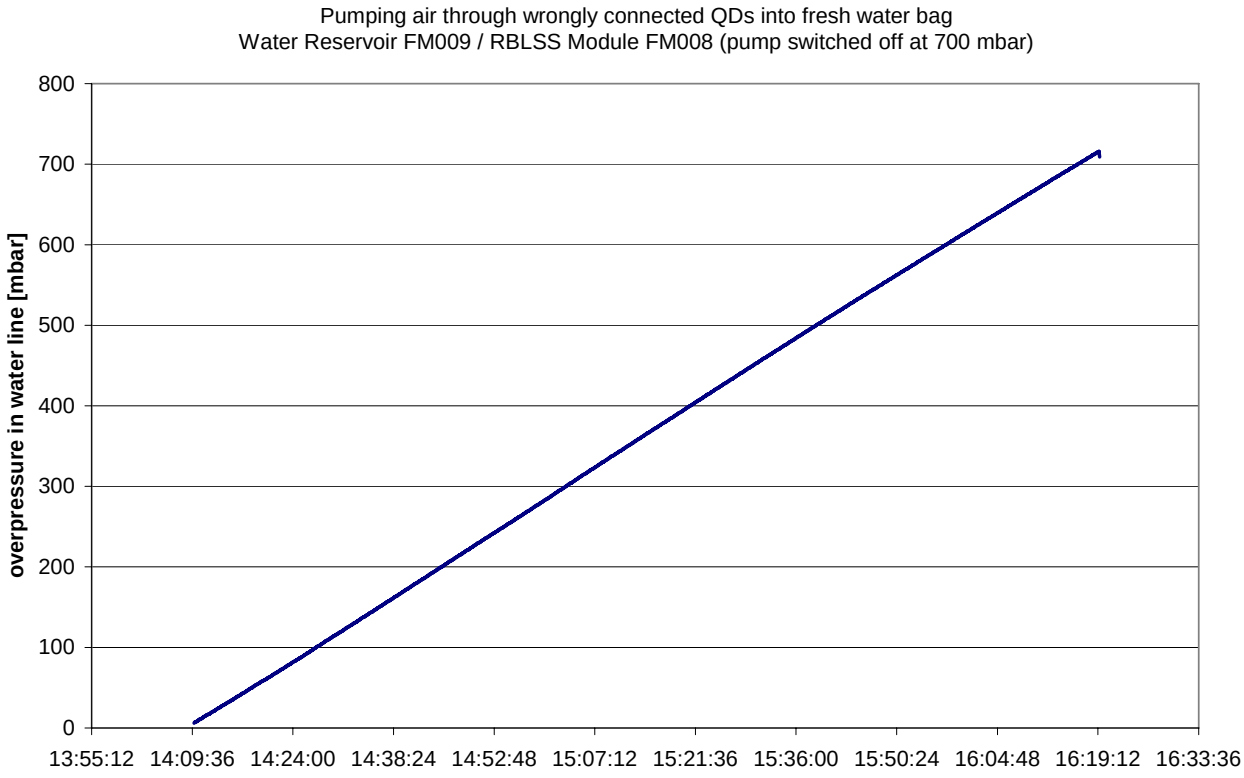

Figure 4-4: Pressurization of fresh water bag, when pumping air into it (simulation of what happened during CWRW when A1/A2 (B1/B2) dehumidifier were drained)

4.3 Water supply to EC

4.3.1 End-to End Test with EC FM092

Setup according to Figure 4-5. EC FM092 has no PCC mounted. Therefore a syringe is installed to collect fresh water entering the EC. Initially the EC is not mounted (during filling of lines). The Water Reservoir is oriented with fresh water bag upside (keeps air bubble inside bag).

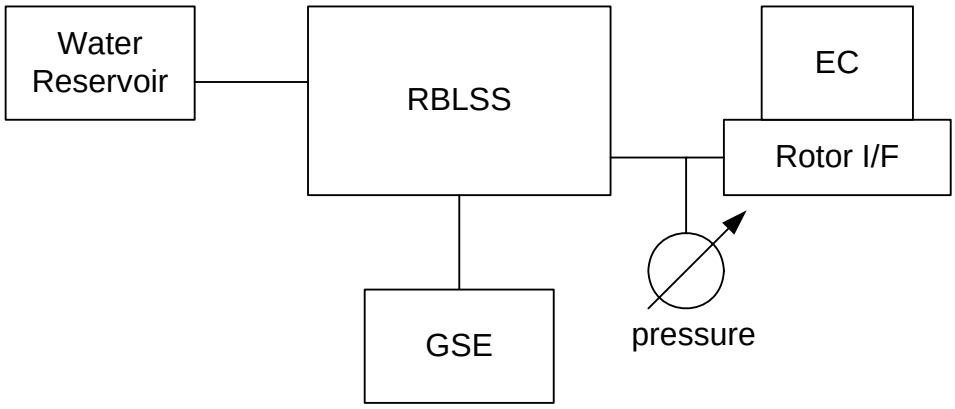

Figure 4-5: Setup for combined test with EC092 (without PCC)

Test	Water Reservoir; outlet	RBLSS Module; outlet	Rotor I/F Adapter	EC	Note
water service, path 6	FM009; QD10	FM008; B2 (QD04)	S/N 10	FM092	without PCC (syringe as reservoir)

Test Equipment

- Rotor I/F adapter S/N 10, adjusted to worst case tolerances (low interface, high rails)
- pressure sensor
- tube kit
- RBLSS GSE (OHB)

Test Sequence

No.	Step	Result
1.	Fill water lines to EC by pumping water from Water Reservoir via RBLSS to Rotor-I/F adapter (the septum will be opened with the septum push tool, until water comes out permanently)	ok, 3 pulses = 4 ml needed to fill
2.	Weigh Water Reservoir	1280.7 gr
3.	Weigh EC	1139.3 gr
4.	Mount EC to Rotor I/F	ok
5.	Start p-sensor recording	ok
6.	At GSE start water service to EC, 1 pulse (=1minute pumping), wait 1 minute	ok (1 pulse = 83 sec!!)
7.	At syringe read out total volume and collected water volume	total: 1.1 ml water: ≈0.05
8.	Repeat step 6 (2nd pulse)	ok
9.	At syringe read out total volume and collected water volume	total: 2.5 water: 1.0

10.	Repeat step 6 (3rd pulse)	ok
11.	At syringe read out total volume and collected water volume	total: 3.9 water: 2.2
12.	Repeat step 6 (4th pulse)	ok
13.	At syringe read out total volume and collected water volume	total: 5.2 water:3.5
14.	Repeat step 6 (5th pulse)	ok
15.	At syringe read out total volume and collected water volume	total: 6.6 water: 5.0
16.	Dismount and weigh EC	1145.4 gram (6.1 gram added -> 6.6-5.0=1.1 gram in filter)
17.	Mount EC again	ok
18.	Turn Rotor-I/F with EC 180 deg top down	ok
19.	Repeat step 6 (6th pulse)	ok
20.	At syringe read out total volume and collected water volume	total: 8.0 water: 7.0
21.	Repeat step 6 (7th pulse)	ok
22.	At syringe read out total volume and collected water volume	total: 9.4 water: 8.3
23.	Repeat step 6 (8th pulse)	ok
24.	At syringe read out total volume and collected water volume	total: 10.8 water: 9.7
25.	-> syringe was emptied (start at zero)	ok
26.	Repeat step 6 (9th pulse)	ok
27.	At syringe read out total volume and collected water volume	total: 1.3 water: 1.2
28.	Repeat step 6 (10th pulse)	
29.	At syringe read out total volume and collected water volume	total: 2.6 water: 2.5
30.	-> at GSE RH-ctrl. switched to 50% (source=DH)	ok
31.	Repeat step 6 (11th pulse)	
32.	At syringe read out total volume and collected water volume	total: 4.2 water: 4.1
33.	Repeat step 6 (12th pulse)	
34.	At syringe read out total volume and collected water volume	total: 5.5 water: 5.3 air bubble from RH loop passes the filter
35.	Repeat step 6 (13th pulse)	
36.	At syringe read out total volume and collected water volume	total: 7.1 water: 6.8
37.	Dismount and weigh EC	1146.7 gram (7.4 gram added -> 7.4-6.8=0.6 gram in filter)
38.	Weigh Water Reservoir as reference	1263.8 gr -> 16.9 gr removed from fresh

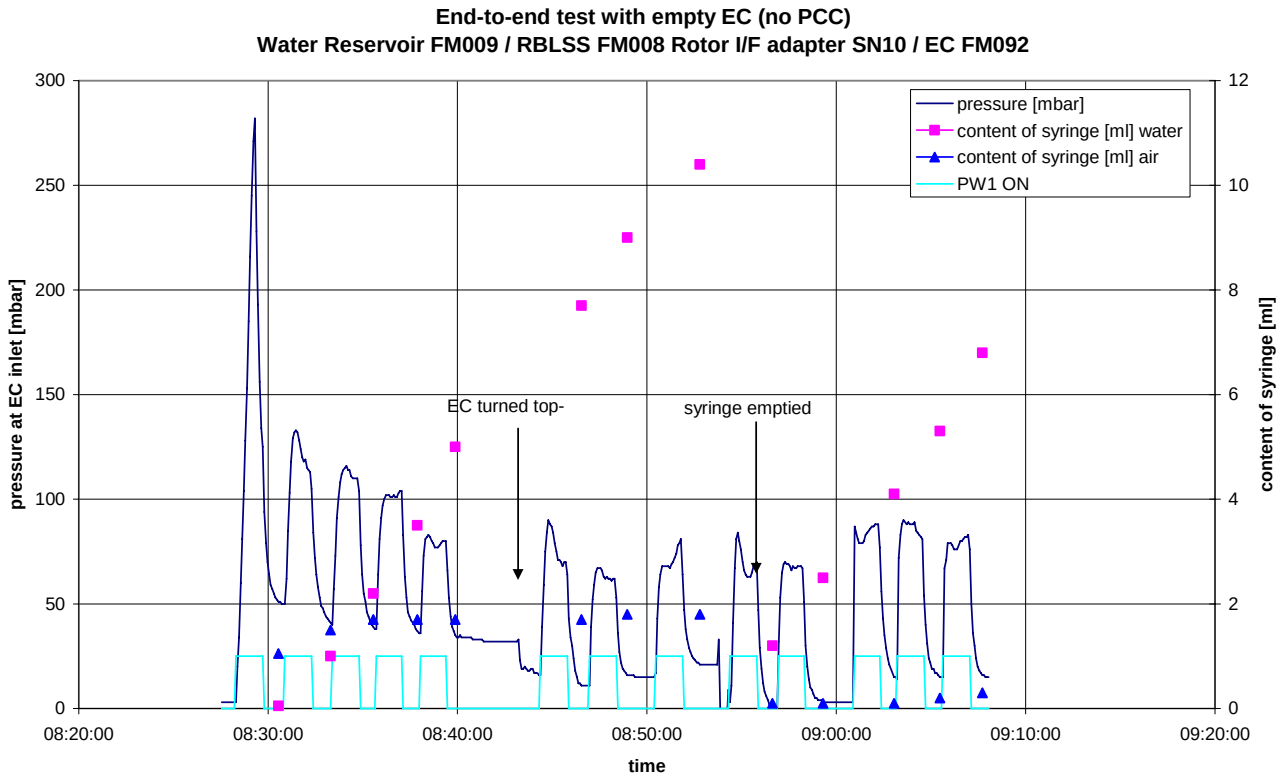

Figure 4-6: Result of water supply test without PCC

4.3.2 End-to End Test with EC FM099

Setup according to Figure 4-7. EC FM099 is in original flight configuration with PCC mounted, orientation: EC horizontal, top-side down. Since the water tubes are still filled from the previous test, no initial filling is required. The Water Reservoir is oriented with fresh water bag upside (keeps air bubble inside bag). Since the RBLSS delivers a controlled flow of approx. 400 ml/min, but the PCC requires 200 ml/min, the EC is by-passed and the flow to EC measured with an external flow meter.

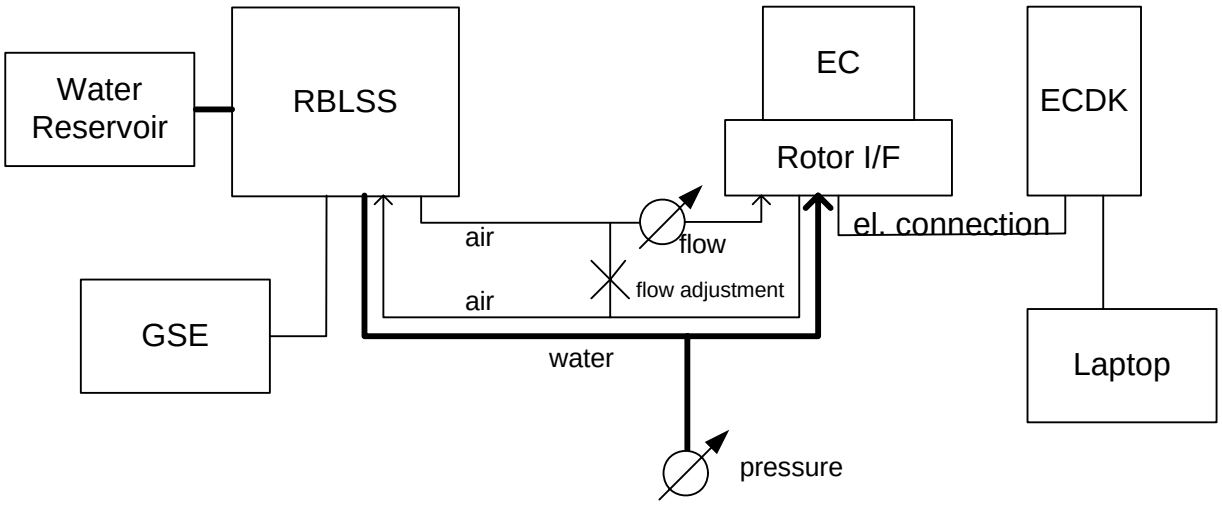

Figure 4-7: Setup for combined test with EC099 (with PCC)

Test	Water Reservoir; outlet	RBLSS Module; outlet	Rotor I/F Adapter	EC	Note
water service, path 6	FM009; QD10	FM008; B2 (QD04)	S/N 10	FM099	with PCC

Test Equipment

- Rotor I/F adapter S/N 10, adjusted to worst case tolerances (low interface, high rails)
- pressure sensor
- tube kit
- RBLSS GSE (OHB)
- ECDK only for electrical connection of EC

Test sequence

No.	Step	Result
39.	Weigh Water Reservoir	1246.4 g
40.	Weigh EC	1729.7 g
41.	Mount EC to Rotor I/F and turn it accordingly	Ok
42.	Connect EC connector	Ok
43.	Start ECDK (+recording)	Ok
44.	Start external air pump with by-pass to achieve a flow of about 180-200 ml/min (set voltage approx. 2.9V)	Ok
	ECDK:	
45.	Switch EC Power ON	ok
46.	Set Digital Input 4 = 0 (4 at ECDK = 3 at FM etc.)	ok
47.	Set Digital Input 5 = 0	ok
48.	Set Digital Input 4 = 1	ok
49.	Set Digital Input 4 = 0	ok
50.	Set Digital Input 4 = 1	ok
51.	Set Digital Input 4 = 0	ok
52.	Set Digital Input 4 = 1	ok
53.	Set Digital Input 4 = 0	ok
54.	Set Digital Input 4 = 1	ok
55.	Set Digital Input 4 = 0	ok
56.	Start p-sensor recording	ok
	Next steps will be repeated until p-sensor "triggers"	
57.	Note pulse no. in Pulse Record below	ok for each pulse
58.	***ECDK:*** Set Digital Input 2 = 1	ok for each pulse
59.	***ECDK:*** Set Digital Input 3 = 1	ok for each pulse
60.	***ECDK:*** Wait 10 seconds, then read Analog 3 and note it in Pulse Record; if pressure increases >1V, exit the loop	ok for each pulse; triggering at pulse 56
61.	***ECDK:*** Set Digital Input 3 = 0	ok for each pulse
62.	***ECDK:*** Set Digital Input 2 = 0	ok for each pulse
63.	***GSE:*** "Valve Switching"-tab: switch valves B1V4 and B1V6 = **ON**	ok for each pulse
64.	***GSE:*** "Pump Switching"-tab: switch water pump B1PW2= **ON for 15 seconds**; observe water/bubbles entering EC and note estimated volume in Pulse Record	ok for each pulse
65.	***GSE:*** "Pump Switching"-tab: switch water pump B1PW2=**OFF** (B1PA2 remains ON!)	ok for each pulse
66.	***GSE:*** "Valve Switching"-tab: switch valves B1V4 and B1V6 = **OFF**	ok for each pulse

67.	Wait 1 minute (for the first 25 pulses); wait 5 minutes (for the remaining pulses)	ok for each pulse
	ECDK:	
68.	Set Digital Input 3 = 0	ok
69.	Set Digital Input 2 = 0	ok
70.	Set Digital Input 4 = 1	ok
71.	Set Digital Input 5 = 1	ok
72.	Switch EC Power = OFF	ok
73.	switch air pump OFF	ok
74.	Dismount and weigh EC+PCC	1741.6 g -> delta-m = 11.9 g
75.	Weigh Water Reservoir as reference	1232.8 g -> delta-m = 13.6 g

Pulse Record

Pulse #	**pressure (analog 2) [mV]**	**estimated water volume in EC**		**Pulse #**	**pressure (analog 2)**	**estimated water volume in EC**
12.08.2008	delta-t = 1min			13.08.2008	p / RH PCC	
1	770	0.2		41	812 / 2720	6.7
2	770	0.3		RH-ctrl 50% 5 minutes on (only RBLSS to generate air bubble)		
3	776	0.3		42	817 / 2343	6.9
4	781	0.3		43	813 / 2290	7.1
5	780	0.5		44	815 / 2239	7.3
6	777	0.7		45	830 / 2207	7.5
7	770	0.9		46	833 / 2181	7.7
8	778	1.1		47	847 / 2173	7.8
9	781	1.2		48	855 / 2143	7.8
10	806	1.2		49	866 / 2152	7.8
11	837	1.5		50	880 / 2153	7.9
12	855	1.7		51	885 / 2121	8.1
13	842	1.9		52	893 / 2117	8.3
14	833	2.1		53	893 / 2117	8.5
15	827	2.3		54	916 / 2108	8.7
16	829	2.5		55	922 / 2095	8.9
17	826	2.7		56	**1051** / 2093	9.1
18	819	2.9		57	1300 / 2113	9.1*)
19	823	3.1		after 5 minutes:		
20	818	3.3			1500->2000 increasing	*) delta weight = real value = 11.9 g -> 0.1625 ml/pulse
21	819	3.5				
22	824	3.7				
23	819	3.9				
24	815	4.1				
25	819	4.3				
26	819	4.5				
RH-ctrl 50% 4 minutes on (only RBLSS to generate air bubble)						
	delta-t=5 min					
27	809	4.7				
28	811	4.9				
29	809	5.1				
30	796	5.3				
31	800	5.4				
32	790	5.4				

Pulse #	pressure (analog 2) [mV]	estimated water volume in EC		Pulse #	pressure (analog 2)	estimated water volume in EC
33	803	5.4				
34	806	5.4				
35	806	5.5				
36	814	5.7				
37	818	5.9				
38	810	6.1				
39	796	6.3				
40	818	6.5				
interrupted for today						

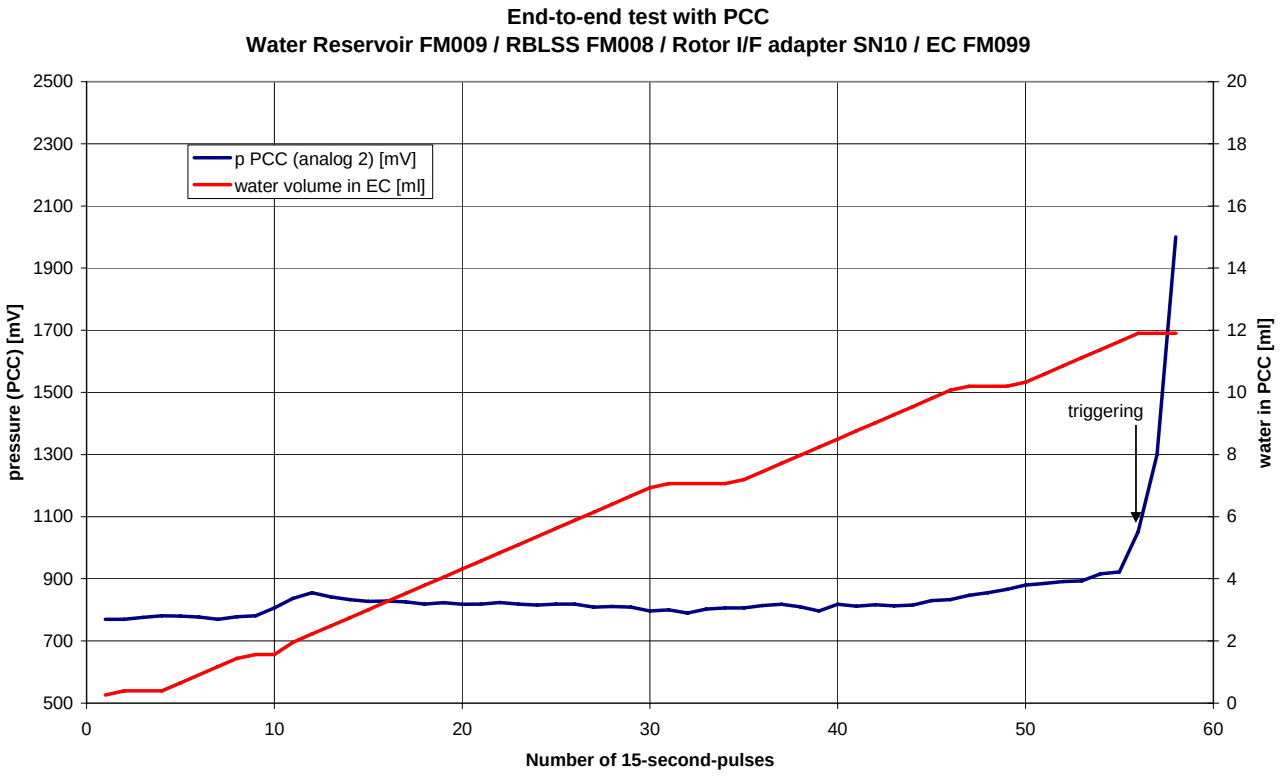

Figure 4-8: Result of water supply test with PCC (number of pulses until p-sensor increase)

5 EXPERIMENT CONTAINERS

5.1 EC FM099

5.1.1 Before opening bottom plate

Before opening the bottom plate the water interfaces were inspected. The septa were protruding for 0.4 mm on both interfaces.

5.1.2 Bottom plate and PEEK plate removed

performed acc. to EMCS-MA-4000-004-DOR, issue 2, sections 4.1 and 6.

After removal of bottom plate (Figure 5.1), the septum holder of 'supply' I/F was removed and inspected. The inner side was wet (some droplets on the surface), which means that water passed the rotor I/F and the septum towards EC (Figure 5.2). After removal of the PEEK plate, the filter assembly was found to be correctly installed. The water supply filter (upper side = outlet towards PCC) was wet. Some water could also be seen on

the PEEK plate (Figure 5.3). However, the channel towards PCC, as well as the drill hole between septum and filter assembly was dry. The channel could be dried by air which shares this way after passing the filter or it was never wetted. In any case it indicates that only a small amount of water (<1ml) entered the EC.

The air supply filter was dirty from air pump dust (Figure 5.3).

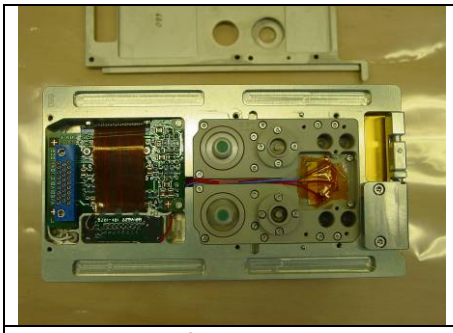

Figure 5.1

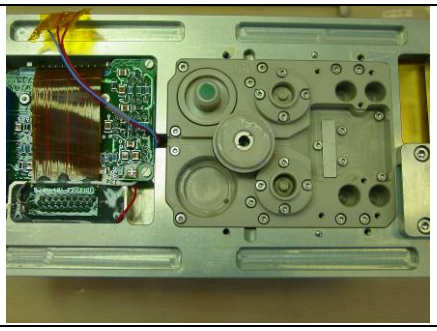

Figure 5.2

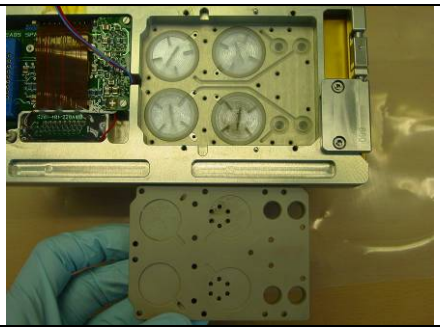

Figure 5.3

The flat sealing was not removed, and after inspection the PEEK and -bottom plate were mounted again.

5.2 EC FM092

5.2.1 Before opening bottom plate

Before opening the bottom plate the water interfaces were inspected. The septa were protruding for 0.4 mm on both interfaces.

5.2.2 Bottom plate and PEEK plate removed

performed acc. to EMCS-MA-4000-004-DOR, issue 2, sections 4.1 and 6.

After removal of bottom plate the septum holder of ‘supply’ I/F was removed and inspected. The inner side was partly filled with water (Figure 5.4), which means that water passed the rotor I/F and the septum towards EC (Figure 5.5). After removal of the PEEK plate, the filter assembly was found to be correctly installed. The water supply filter (upper side = outlet towards PCC) was wet (Figure 5.6). Some water could also be seen on the PEEK plate (Figure 5.5) and in the EC inlet hole (Figure 5.7). However, the channel towards PCC, as well as the drill hole between septum and filter assembly was dry. The channel could be dried by air which shares this way after passing the filter.

The air supply filter was dirty from air pump dust (Figure 5.3).

Figure 5.4

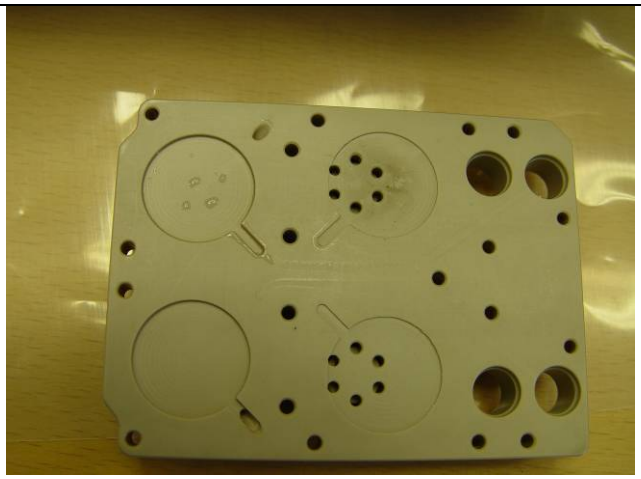

Figure 5.5

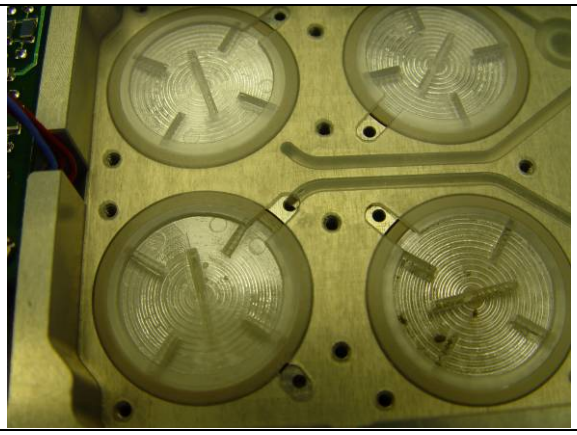

Figure 5.6

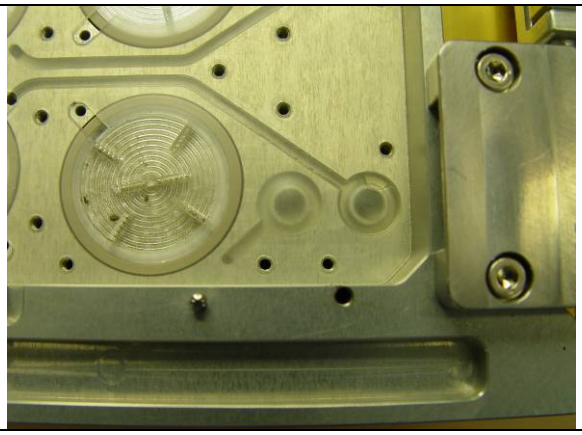

Figure 5.7

The flat sealing was not removed, and after inspection PEEK and -bottom plate were mounted again.

5.2.3 PCC

The EMCS EC with integrated PCC has been returned with 1J. On 28.7.2008 EC FM092 was opened in the presence of Astrium-PA (W. Biemann), ESA (S. Hinderer, M. Zell), JAXA (Prof. Yoda san). In this PCC germination took place and the seedlings were removed at KSC by JAXA representative.

The PCC was disassembled acc. to N-USOC-PRO-002, issue 1.

1. **removal of locking cover**
2. **removal of growth pot with PCC lid (Fig. 1, 2, 3)**

Fig. 1

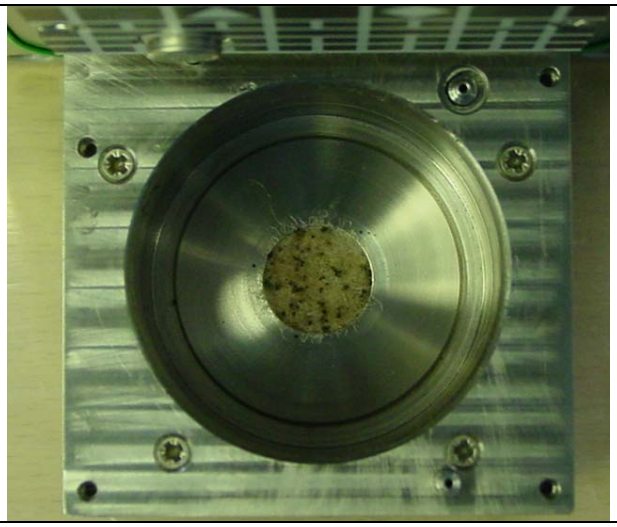

Fig. 2

The o-rings at lid and water inlet hole are properly installed and undamaged. Inside the growth pot dark/black particles (biological origin?) were found, especially on

- the borosilicate layer (Fig. 5, 6)
- the sponge (Fig. 12)
- the PCC felt (Fig. 9)
- the felt at air inlet (mainly towards growth pot) (Fig. 3, 4)
- the zeolithe (Fig. 10)

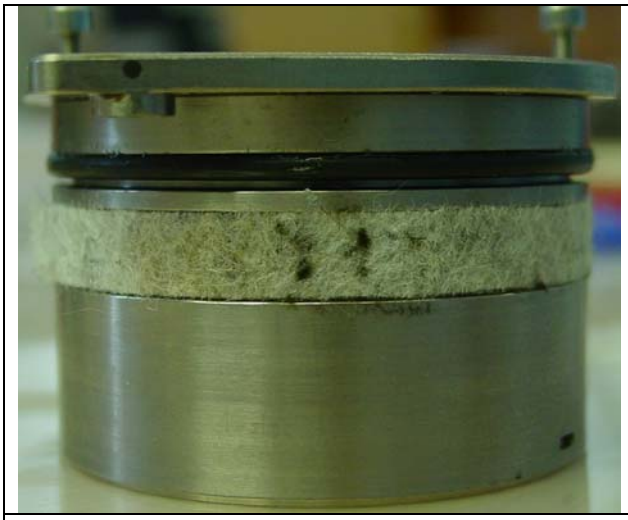

Fig. 3

Fig. 4 - air inlet felt (left)

3. removal of air inlet felt (Fig. 4)

Dark/black colour visible, mainly towards inside of PCC (Fig. 3, 4)

4. removal of PCC lid (Fig. 5, 6)

The borosilicate layer shows dark/black particles. No further inspection, whether also seeds are visible. Donuts are properly installed and undamaged. The o-ring at water nipple is properly installed and undamaged, wet (Fig. 8).

5. removal of donuts (Fig. 6)

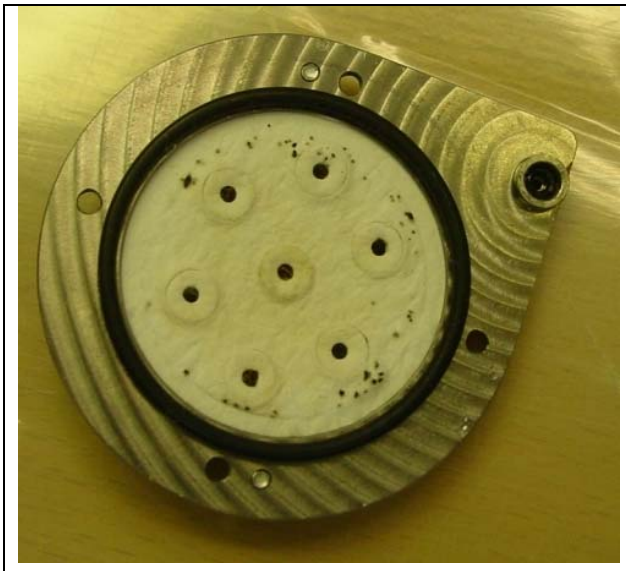

Fig. 5

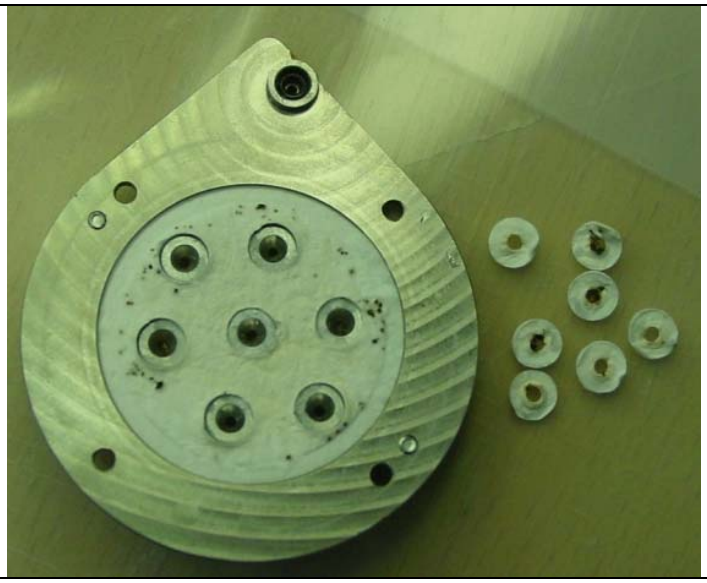

Fig. 6

6. removal of borosilicate layer (Fig. 6, 7)

The PDA membranes are completely dissolved.

Fig. 7

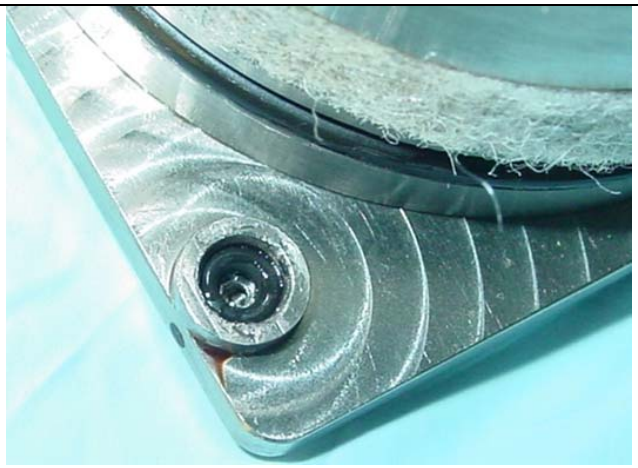

Fig. 8

7. removal of PP felt (Fig. 9, 10)

Zeolithe, touching the felt, sticks on surface is a bit humid, as well as the borosilicate

Fig. 9

Fig. 10

8. emptying and collection of growth pot zeolithe granulate (Fig. 4, 11)

Zeolithe is removed and collected carefully with a spatula. Beside some brownish grains, there are also dark/black coloured ones visible. Where the zeolithe is humid, it sticks together. Top 5 mm are loose (but can easily be separated). Sticking increases radially from the center towards the wall.

After emptying the PCC, some zeolithe still sticks on the air inlet holes (Fig. 11). The sponge is wet and bacl particles are visible (Fig. 12).

Fig. 11

Fig. 12

9. removal of bottom chamber lid (Fig. 13, 14)

The bottom chamber is completely dry. The borosilicate layers incl. mesh are properly installed. The pressure sensor hole is also covered by the borosilicate

Fig. 13

Fig. 14

10. weighing of growth pot incl. PP felts, PVA sponge

All parts were dried for 24 hours at 50 °C with weighing before and after drying. The following weight losses were measured: Zeolith: 2.3 gram, sponge: 0.2 gram, felt: 0.0 gram

6 WATER RESERVOIRS

6.1 FM001

Inspection of external surfaces and QDs showed no damages on housing and QDs.

After opening of Water Reservoir an air bubble was seen in the fresh water bag. This confirmed that air/water was pumped into the fresh bag during dehumidifier draining of the EC positions A1/A2 as to be expected for the case of swapped QDs at the RBLSS Module FM007.

No corrosion was found inside or outside the waste housing. This confirmed that the new material and surface treatment shows better corrosion protection than the original design.

The waste sponge was removed. It was humid, but did not contain squeezable water, which is compliant with the analysis of 0...12 g expected contents with the swapped -QDs of RBLSS Module FM008 and FM007 (see Table 6-1).

The fresh water bag was emptied and 227 g of water were collected. This is compliant with the initial filling volume of 230 g and the analysis of the QD swap, where it was derived that almost no water could have been used during operation of CWRW (expected value was between 182 and 254 g, see Table 6-1).

No blockage or any other failure could be found.

The Water Reservoir was closed again using the original parts and it is regarded ready for filling before launch.

Figure 6-1: FM001: with waste sponge

Figure 6-2: FM001: waste sponge removed

6.2 FM009

No damage was found on housing and QDs.

After opening of Water Reservoir an air bubble could be identified in the fresh water bag. This confirmed that air/water was pumped into the fresh bag during dehumidifier draining of the EC on rotor B as to be expected for the case of swapped QDs at the RBLSS Module FM007.

Corrosion was found inside and outside the waste housing, as already known from Water Reservoirs FM003, FM004, FM007.

The upper housing and fixation nuts have to be replaced by new material and surface treatment as already done for FM001, FM002, see SPR-253.

The waste sponge was removed. It was found humid, and 6.1 g water could be squeezed which is compliant with the analysis of 0...24 g expected for the case of the swapped RBLSS-QDs (Table 6-1).

The fresh water bag was kept in the original flight state for later use in the end-to-end test (see chapter 4.2/4.3). Calculated fresh water content from overall weight is 201 g (a proper value in comparison to the expected value of between 184 and 254 g acc. Table 6-1).

No blockage or any other failure was found.

The Water Reservoir was closed again using the original parts and it is regarded ready for filling before launch.

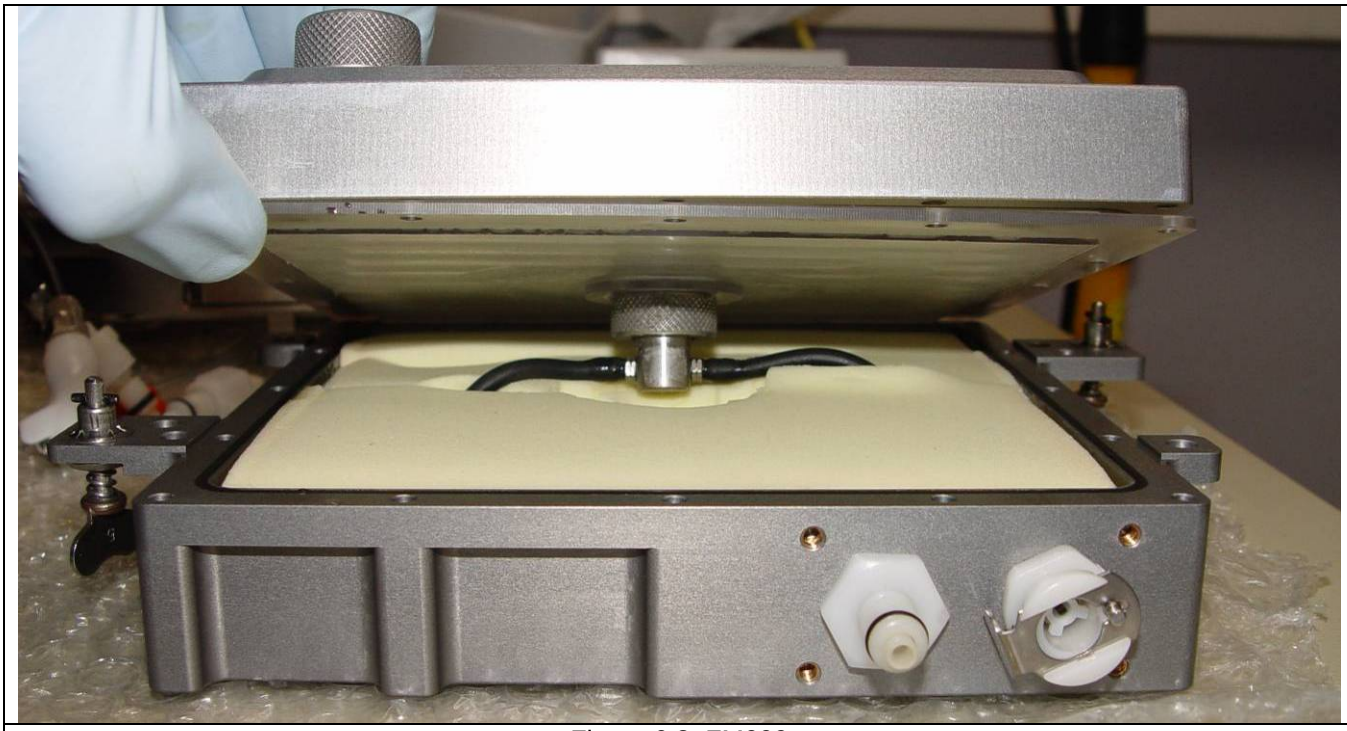

Figure 6.3: FM009

Table 6-1: Analysis of CWRW water budget in [gram], calculated from the number of commanded pulses; only blue/red values are relevant: positive = amount put into reservoir, negative = taken from reservoir

		seconds	pulses	before WR exchange			after WR exchange		
				FM008	FM008 waste	FM008 fresh	FM001	FM001 waste	FM001 fresh
A1	Fresh to HU	5989	99,8	2287	-30,49333333		3702	-49,36	
	Fresh to EC	26603	1773,5	19641	-261,88		6962	-92,82666667	
	Fresh to Waste	180	3,0	180	-2,4	2,4	0	0	0
	DH to HU	1145	19,1	254			891		
	DH to EC	15984	266,4	8734			7250		
	DH to Waste	17661	294,4	6107		12	11554		12
	HU to DH	897	15,0	0			897		
A2	Fresh to HU	0	0,0	0	0		0	0	
	Fresh to EC	8810	587,3	6743	-89,90666667		2067	-27,56	
	Fresh to Waste	60	1,0	60	-0,8	0,8	0	0	0
	DH to HU	379	6,3	379			0		
	DH to EC	4	0,1	3			1		
	DH to Waste	22751	379,2	10425		12	12326		12
	HU to DH	1342	22,4	0			1342		
A3	Fresh to HU	0	0,0	0		0	0		0
	Fresh to EC	3073	204,9	1539		-20,52	1534		-20,4533333
	Fresh to Waste	0	0,0	0	0	0	0	0	0
	DH to HU	124	2,1	124			0		
	DH to EC	0	0,0	0			0		
	DH to Waste	23480	391,3	11059	12		12421	12	
	HU to DH	815	13,6	752			63		
A4	Fresh to HU	0	0,0	0		0	0		0
	Fresh to EC	4997	333,1	2927		-39,0266667	2070		-27,6
	Fresh to Waste	0	0,0	0		0	0		0
	DH to HU	381	6,4	129			252		
	DH to EC	1	0,0	1			0		
	DH to Waste	25782	429,7	10046			15736		
	HU to DH	1907	31,8	561			1346		
				Summe	-373,48	-32,3466667		-157,7466667	-24,0533333
				FM009	FM009 waste	FM009 fresh	FM002	FM002 waste	FM002 fresh
B1	Fresh to HU	2291	38,2	2041	-27,21333333		250	-3,333333333	
	Fresh to EC	27135	1809,0	13568	-180,9066667		13567	-180,8933333	
	Fresh to Waste	250	4,2	180	-2,4	2,4	70	-0,933333333	0,93333333
	DH to HU	0	0,0	0			0		
	DH to EC	19464	324,4	5435			14029		
	DH to Waste	16662	277,7	7700		12	8962		12
	HU to DH	1277	21,3	0			1277		
B2	Fresh to HU	0	0,0	0	0		0	0	
	Fresh to EC	14544	969,6	5083	-67,77333333		9461	-126,1466667	
	Fresh to Waste	60	1,0	60	-0,8	0,8	0	0	0
	DH to HU	126	2,1	0			126		
	DH to EC	5	0,1	3			2		
	DH to Waste	25821	430,4	10439		12	15382		12
	HU to DH	1271	21,2	0			1271		
B3	Fresh to HU	767	12,8	0		0	767		-10,2266667
	Fresh to EC	4590	306,0	3191		-42,5466667	1399		-18,6533333
	Fresh to Waste	70	1,2	0	0	0	70	0,933333333	-0,93333333
	DH to HU	1917	32,0	131			1786		
	DH to EC	131	2,2	0			131		
	DH to Waste	24411	406,9	10384	12		14027	12	
	HU to DH	1134	18,9	0			1134		
B4	Fresh to HU	2420	40,3	0		0	2420		-32,2666667
	Fresh to EC	4226	281,7	0		0	4226		-56,3466667
	Fresh to Waste	70	1,2	0		0	70		-0,93333333
	DH to HU	2686	44,8	0			2686		
	DH to EC	5932	98,9	0			5932		
	DH to Waste	22776	379,6	10430			12346		
	HU to DH	1235	20,6	0			1235		
				Summe	-267,0933333	-15,3466667		-298,3733333	-94,4266667

7 RBLSS MODULE FM-007

7.1 Inspection and Functional Test

A major discrepancy was found during incoming inspection at KSC of items returned on 1J:
RBLSS Module FM-007 Quick Disconnects (QDs) towards fresh and waste water reservoir were swapped, meaning

- "QD 10-N Fresh" at RBLSS was equipped with a **female** QD (thus fitting to **waste** QD of the water Reservoir
- "QD 12-N Waste" at RBLSS was equipped with a **male** QD (thus fitting to **fresh** QD of the water Reservoir

The function of pumps, valves and performance of RH control were tested in the following sequence:

No.	Step	nominal value	actual value
1	Switch on and off all valves one after the other	audible 'click'	click
2	Switch on and off air pumps one after the other	flow rate at GSE >0.3 l/min	PA1: 0.38 l/min PA2: 0.41 l/min
3	Switch on and off all water pumps (default direction) one after the other	rotation visible and in correct direction	rotation visible in correct direction
4	Switch on RH control 50% on pos 1 and 2 and wait until equilibrium is reached	HU approaches to 50%; DH approaches to 40%	ok

The filter housing F1 to F6 were inspected. Filters look clean without degradation.

During all tests (see chapter 4) it was found that the RBLSS Module is working completely nominally. Therefore no further disassembly or investigations were made with the stand-alone RBLSS.

The QD swap described above has dramatic consequences on all EC positions of each rotor (it was confirmed by OHB that not only RBLSS FM008 but also FM007 are concerned). Due to this swap all positions are connected in an unfavourable way, as shown in Figure 7-1b, compared to the correct connection, Figure 7-1a:

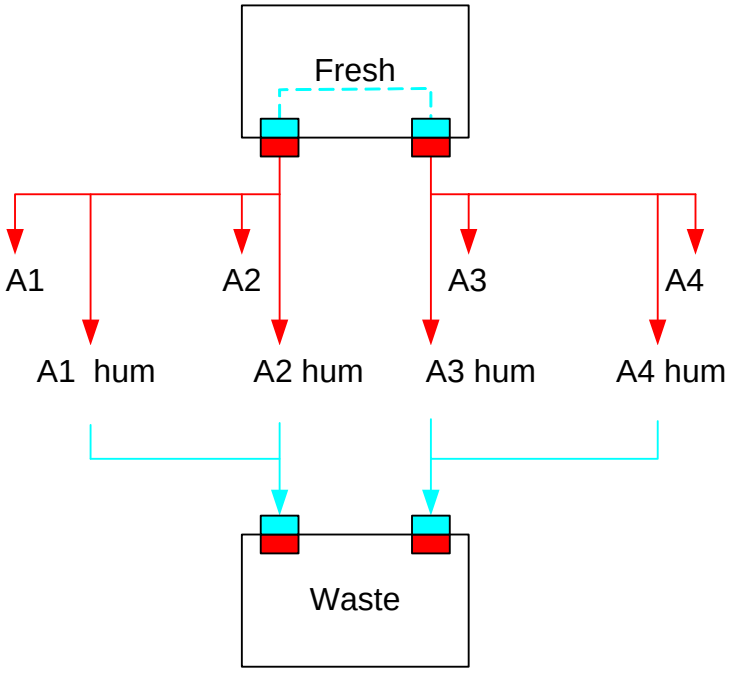

Figure 7-1a: correct connection of water supply to EC and to/from RH control: A1 to A4 and the RH loops are supplied from fresh water bag; drained water from RH loops is collected in the waste compartment

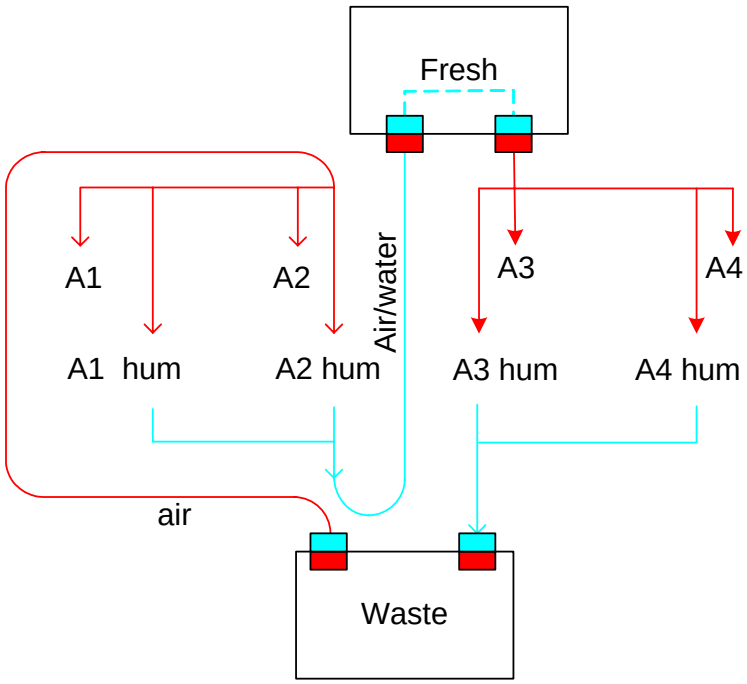

Figure 7-1b: Wrong connection after QD swap: From positions A1/A2 RH loops an air/water mixture (but mainly air) is pumped into the fresh water bag; this air/water mixture is then supplied to the correctly connected positions A3/A4; Supply to A1/A2 and RH loops is connected to waste compartment, which does not contain free water.

7.2 Correct RBLSS QDs by swapping “Fresh” and “Waste”

a) The QDs of FM-007 were exchanged to correct positions according to RD8.

RBLSS FM007- still in orbit- is also affected and shall be repaired.

b) It was found that the thread of the male QD of FM008 was slightly worn. ***Therefore this QD shall be replaced by a new one.***

8 INSPECTION OF MULTIGEN-EXPERIMENT CONTAINERS

Inspections of the Multigen Experiment Containers from the previous EMCS mission can support trouble shooting for the CWRW ECs, as the latter are electrically identical, and mechanically only deviate in a few holes in the PCC lid, i.e. water and air channels are the same.

All 8 MULTIGEN ECs were hydrated, thus serving as a successful reference. Four of these ECs, FM055 to FM058, were returned to Astrium.

During MULTIGEN these ECs were mounted in the following rotor positions:

Rotor A	**A1**	**A2**	**A3**	**A4**
EC		FM055		FM056
RBLSS Module	FM001		FM006	
Rotor B	**B1**	**B2**	**B3**	**B4**
EC		FM058	FM057	
RBLSS Module	FM005		FM004	

Observations of MULTIGEN-ECs (returned ECs are highlighted):

EC S/N	Rotor Position	PCC S/N	PCC holes	Main off-nominals
FM052	A1	FM04	3	germination; sacrificed as water reservoir to drain the waste
FM055	**A2**	**FM02**	**3**	**plants; partly no flow**
FM053	A3	FM05	3	germination, dried out
FM056	**A4**	**FM10**	**5**	**partly no flow, germination, dried out**
FM054	B1	FM08	5	germination; no venting possible (dig line failure); plants dried out
FM058	**B2**	**FM09**	**3**	**triggered after 200 pulses; germination, dried out**
FM057	**B3**	**FM11**	**5**	**no germination**
FM059	B4	FM12	5	germination, dried out

EC FM055 to FM057 were opened from the bottom, the filter side, for inspection, and found to be in proper condition with filters still wet about 9 months after the end of MULTIGEN 1 processing in EMCS. The PCCs were not dismounted. This inspections gave no clue on the insufficient performance during the MULTIGEN 1 experiment in EMCS.

EC FM058 was not opened and used as returned to ground for a hydration test in the same set-up as described in chapter 4.3 as a pre-test to the end-to-end test with EC FM099.

9 ACRONYMS

EC	Experiment Container
EUE	Experiment Unique Equipment (experiment related hardware inside EC)
GSE	Ground Support Equipment
HX	Heat exchanger
PCC	Plant Culture Chamber
QD	Quick disconnect
RBLSS	Rotor-based life support system
RH	relative humidity